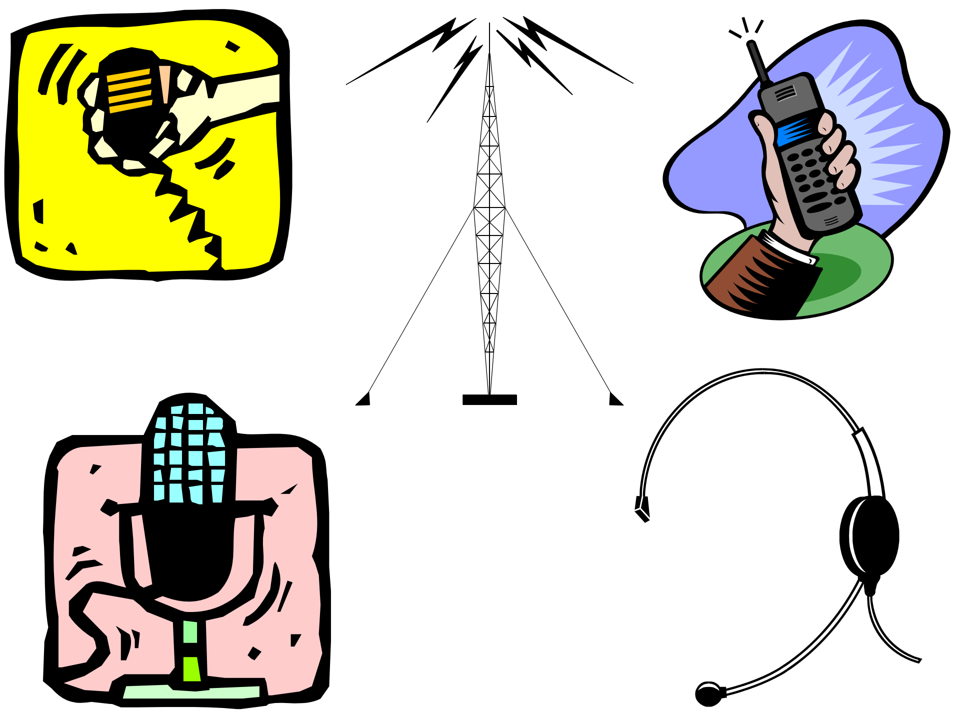
Extra Class Amateur Radio Course



INSTRUCTOR MANUAL

Sponsors: Mesilla Valley Radio Club & NMSU Amateur Radio Club

Extra Class Amateur Radio Course

Instructor Manual

Materials Prepared by:

Stephen Horan (AC5RI)

Materials Reviewed by:

Class Supervisor:

Class Materials Obtained from:

VEC Question Pool as distributed by the National Conference of Volunteer Examiner Coordinators; current as of 21 December 2007 and is valid July 1, 2008 through June 30, 2012

Band Plan as distributed by the American Radio Relay League

Table of Contents

Extra Class License: Course Outline

Weekend #1		
Electrical Principles - E5	Saturday #1 Morning	
Practical Circuits - E7	Saturday #1 Afternoon	
Commission Rules - E1	Sunday #1 Morning	
Operating Procedures - E2	Sunday #1 Afternoon	
Circuit Components - E6	Sunday #1 Afternoon	
Open Review	Sunday #1 Afternoon	
Weekend #2		
Antennas - E9	Saturday #2 Morning	
Propagation - E3	Saturday #2 Morning	
Amateur Radio Practices - E4	Saturday #2 Afternoon	
Signals & Emissions - E8	Saturday #2 Afternoon	
Open Review	Sunday #2 Morning	
Practice Exam	Sunday #2 Morning	
Exams	Sunday #2 Afternoon	

Note to Instructors

Instruction for the Extra Class course is structured around the exam pool questions. Preparation for instruction is, therefore, up to the instructors and the preparation will most likely include summary charts of the important topics and relationships plus examples to illustrate the concepts. Your role is to assist students in their understanding of the exam pool questions. The strength you bring to the class lies not in the magnitude of your technical knowledge, but in your extensive and practical experience as an Amateur Radio Operator. For the purpose of instruction, your role is that of an *Elmer*. As such, it will be helpful to illustrate with props and your operating experience in addition to being familiar with course structure and the course outline. Effective instruction should be adaptive instruction – instruction that seeks direction from student concerns and that effectively anticipates student questions and problems. Always encourage students to ask questions, no matter how minor they may seem.

Recommended instruction procedure is simple and straightforward. Each instructor is assigned a block of exam pool questions. Prior to the class weekend, you should review the associated questions. During the class weekend, you will begin your instruction by explaining the important concepts covered in the question pool. Once your overview is completed, ask students for questions. Following that, briefly expand upon any points brought out in the questions. Next, you should proceed to the appropriate question pool segment (identified in the course outline). You should read each question out loud and solicit class responses. If there is uncertainty among some or all class members on the correct answer, then provide a succinct explanation for the correct answer. Once the questions are completed, proceed to the next question pool segment. Please keep in mind, however, that the time allotted for instruction and question pools is precise. **Under NO circumstances** should you deviate from the allotted time periods for instruction and exam pool review. There is time for general review so write down any questions that may need further time for explanation at those open review times.

It is essential that you keep in mind the purpose of the course: to enable students with basic prior knowledge of electronics and an amateur radio General Class license to pass the Extra-level examination. This means a certain level of compromise. As much as we would like to imbue within each student a full and comprehensive understanding of every technical, operational, and regulatory element of Amateur Radio, we must accept the limitation of a two-weekend accelerated course. Try as we may, the best we can strive for is to provide sufficient instruction to ensure successful completion of the general-class exam element. In the process, though, we should strive to encourage and inspire each student to pursue more deeply the theory and practice of Amateur Radio.

Remember, above all else, that your effectiveness lies not in the depth of your technical expertise, but rather in the **passion and excitement** that you bring to your instruction and that you are able to convey to the students. Good luck and good rewards for taking your time to assist.

How to Study Guide

Given the short amount of time to prepare prior to the class and exam weekend, we have devised the following suggestions for being more efficient in the use of your time.

I. Become familiar with the material

Before you can study effectively, you need to know where you are going! To do this, look over the question pool and the explanations. The general format is the same on all amateur radio exams. See that there are "technical" parts, "operational parts", "safety parts", and "rules and regulations parts." Get a general sense for the flow of the material and the level of detail required. For the General Class exam, the level of electronics was relatively simple but more advanced than the Technician Class material. The Extra Class builds upon this but adds technical material necessary to understand a wider variety communications with more mathematical detail. It may be very helpful to have a calculator with trigonometric functions, square roots, and rectangular-to-polar coordinate conversion. The operational concerns are for a wider variety of modes than the General Class with an emphasis on satellite communications. The regulatory matters again deal with frequency privileges and operating modes. Additional rules covering the VE process are also emphasized

II. Assess what you already know and what is new

Based on your experience and knowledge of amateur radio, parts of the material will look familiar. Other parts, perhaps the detailed technical concepts, will be new. For now, try to concentrate on the new concepts and put less emphasis on the familiar concepts. Read through the familiar concepts to know what needs to be learned but do not put most of your energy there. All of them will be covered on the instructional tapes during the weekend class and you can concentrate at that time. Try to identify the areas that represent new concepts to you and place most of your energy there. The weekend class will also cover the concepts that are new to you but you want to make sure that you can anticipate where the taped instruction will be going and not have it surprise you.

III. Prioritize what is new to you

Depending upon your background and interests, some of the new concepts will be easily grasped and others will leave you really wondering what it's all about. Sort out the topic areas by level of difficulty to you. Give yourself some confidence by working through the concepts that seem easier to you and build yourself towards the really difficult concepts. Use study aids to help you track the key concepts that you need to learn and help you to become familiar with the concepts.

IV. Make a list of questions

For those concepts that are really causing you difficulty, write them down and bring your list to the weekend class. The instructors will have time set aside to spend with you to go over these concepts. Maybe their approach can give you the key to understanding the concept.

V. Make study aids

Some items, for example the frequency allocations, can be learned either through experience or by memorization. Depending upon the extent you have exercised your existing HF privileges, it may be easier to memorize the allocations. To make the memorization easier, make yourself a set of index cards with the allowable frequencies, power limits, and types of emissions allowed. This can also be done with the necessary equations for circuit performance, link design, power densities, or other concepts that you are trying to master. Review the index cards a few times each day until you feel more comfortable with the concepts. Do not try to memorize everything all in one sitting.

VI. Relax

Remember, you do not need to get a 100% to pass the exam! Do as well as you can in learning the concepts that you can grasp. Learn to recognize the answers placed there to distract you when reviewing the question pool. Do not put yourself under pressure to memorize everything. Be willing to tell yourself that you can write off a few questions that you just cannot get at this time and hope for the best when you get the real exam. You will have plenty of time after you get your General ticket to master the difficult concepts.

About the Exam

The FCC mandates that the question pool for the exam has a certain structure even if the FCC does not design the questions. The general method is to break the overall amateur radio license question pool into four major elements:

- Element 2 – Technician Class License
- Element 3 – General Class License
- Element 4 – Extra Class License

Then the theory elements are broken into sub-elements. The sub-elements are then divided into a varying number of sections depending upon the question pool designer's curriculum. Each section will have at least ten questions but some sections have over twenty questions! Each license exam for Elements 2 through 4 will use one and only question from each section regardless of the number of questions in the question pool for that section. Use this knowledge to help you to design your studying.

The following table shows how the question pool for the Extra Class license Element 4 is organized. The class is organized along the lines of the question pool structure with the ordering of the subsections being selected to account for the number of questions in the sub-element and the level of difficulty. In the class, you will see a code at the start of each question. The code will look like `E1A01`. This is decoded as

- E1 – Element 4, sub-element 1
- A – Section A of sub-element 1
- 01 – question 1 from section A.

The following table shows the question pool areas for Element 4 arranged by sub-elements.

During the actual exam, the test designers will randomly draw questions: one, and only one, question from each part of the sub-element. The wording will not be changed from that presented here. However, the order of the questions will be randomized as well as the order of the answers for the question.

Extra Class License Examination Question Pool - Element 4		
Sub	**Title**	**Sections**
E1	COMMISSION'S RULES	E1A - Operating Standards: frequency privileges for Extra Class amateurs; emission standards; automatic message forwarding; frequency sharing; FCC license actions; stations aboard ships or aircraft E1B - Station restrictions and special operations: restrictions on station location; general operating restrictions, spurious emissions, control operator reimbursement; antenna structure restrictions; RACES operations E1C - Station control: definitions and restrictions pertaining to local, automatic and remote control operation; control operator responsibilities for remote and automatically controlled stations E1D - Amateur Satellite service: definitions and purpose; license requirements for space stations; available frequencies and bands; telecommand and telemetry operations; restrictions, and special provisions; notification requirements E1E - Volunteer examiner program: definitions, qualifications, preparation and administration of exams; accreditation; question pools; documentation requirements E1F - Miscellaneous rules: external RF power amplifiers; Line A; national quiet zone; business communications; compensated communications; spread spectrum; auxiliary stations; reciprocal operating privileges; IARP and CEPT licenses; third party communications with foreign countries; special temporary authority
E2	OPERATING PRACTICES AND PROCEDURES	E2A - Amateur radio in space: amateur satellites; orbital mechanics; frequencies and modes; satellite hardware; satellite operations E2B - Television practices: fast scan television standards and techniques; slow scan television standards and techniques E2C - Operating methods, part 1: contest and DX operating; spread-spectrum transmissions; automatic HF forwarding; selecting an operating frequency E2D - Operating methods, part 2: VHF and UHF digital modes; packet clusters; Automatic Position Reporting System (APRS) E2E - Operating methods, part 3: operating HF digital modes; error correction
E3	RADIO WAVE PROPAGATION	E3A - Propagation and technique, part 1: Earth-Moon-Earth communications; meteor scatter E3B - Propagation and technique, part 2: transequatorial; long path; gray line; multi-path propagation E3C - Propagation and technique, part 3: Auroral propagation; selective fading; radio-path horizon; take-off angle over flat or sloping terrain; earth effects on propagation; less common propagation modes

Extra Class License Examination Question Pool - Element 4		
Sub	**Title**	**Sections**
E4	AMATEUR RADIO TECHNOLOGY AND MEASUREMENTS	E4A - Test equipment: analog and digital instruments; spectrum and network analyzers, antenna analyzers; oscilloscopes; testing transistors; RF measurements E4B - Measurement technique and limitations: instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of "Q"; instrument calibration E4C - Receiver performance characteristics, part 1: phase noise, capture effect, noise floor, image rejection, MDS, signal-to-noise-ratio; selectivity E4D - Receiver performance characteristics, part 2: blocking dynamic range, intermodulation and cross-modulation interference; 3rd order intercept; desensitization; preselection E4E - Noise suppression: system noise; electrical appliance noise; line noise; locating noise sources; DSP noise reduction; noise blankers
E5	ELECTRICAL PRINCIPLES	E5A - Resonance and Q: characteristics of resonant circuits: series and parallel resonance; Q; half-power bandwidth; phase relationships in reactive circuits E5B - Time constants and phase relationships: R/L/C time constants: definition; time constants in RL and RC circuits; phase angle between voltage and current; phase angles of series and parallel circuits E5C - Impedance plots and coordinate systems: plotting impedances in polar coordinates; rectangular coordinates E5D - AC and RF energy in real circuits: skin effect; electrostatic and electromagnetic fields; reactive power; power factor; coordinate systems
E6	CIRCUIT COMPONENTS	E6A - Semiconductor materials and devices: semiconductor materials (germanium, silicon, P-type, N-type); transistor types: NPN, PNP, junction, power; field-effect transistors: enhancement mode; depletion mode; MOS; CMOS; N-channel; P-channel E6B - Semiconductor diodes E6C - Integrated circuits: TTL digital integrated circuits; CMOS digital integrated circuits; gates E6D - Optical devices and toroids: vidicon and cathode-ray tube devices; charge-coupled devices (CCDs); liquid crystal displays (LCDs); toroids: permeability, core material, selecting, winding E6E - Piezoelectric crystals and MMICS: quartz crystals (as used in oscillators and filters); monolithic amplifiers (MMICs) E6F - Optical components and power systems: photoconductive principles and effects, photovoltaic systems, optical couplers, optical sensors, and optoisolators

Extra Class License Examination Question Pool - Element 4		
Sub	**Title**	**Sections**
E7	PRACTICAL CIRCUITS	E7 - Digital circuits: digital circuit principles and logic circuits: classes of logic elements; positive and negative logic; frequency dividers; truth tables E7B - Amplifiers: Class of operation; vacuum tube and solid-state circuits; distortion and intermodulation; spurious and parasitic suppression; microwave amplifiers E7C - Filters and matching networks: filters and impedance matching networks: types of networks; types of filters; filter applications; filter characteristics; impedance matching; DSP filtering E7D - Power supplies and voltage regulators E7E - Modulation and demodulation: reactance, phase and balanced modulators; detectors; mixer stages; DSP modulation and demodulation; software defined radio systems E7F - Frequency markers and counters: frequency divider circuits; frequency marker generators; frequency counters E7G - Active filters and op-amps: active audio filters; characteristics; basic circuit design; operational amplifiers E7H - Oscillators and signal sources: types of oscillators; synthesizers and phase-locked loops; direct digital synthesizers
E8	SIGNALS AND EMISSIONS	E8A - AC waveforms: sine, square, sawtooth and irregular waveforms; AC measurements; average and PEP of RF signals; pulse and digital signal waveforms E8B - Modulation and demodulation: modulation methods; modulation index and deviation ratio; pulse modulation; frequency and time division multiplexing E8C - Digital signals: digital communications modes; CW; information rate vs. bandwidth; spread-spectrum communications; modulation methods E8D - Waves, measurements, and RF grounding: peak-to-peak values, polarization; RF grounding
E9	ANTENNAS AND TRANSMISSION LINES	E9A - Isotropic and gain antennas: definition; used as a standard for comparison; radiation pattern; basic antenna parameters: radiation resistance and reactance, gain, beamwidth, efficiency E9B - Antenna patterns: E and H plane patterns; gain as a function of pattern; antenna design (computer modeling of antennas); Yagi antennas E9C - Wire and phased vertical antennas: beverage antennas; terminated and resonant rhombic antennas; elevation above real ground; ground effects as related to polarization; take-off angles E9D - Directional antennas: gain; satellite antennas; antenna beamwidth; losses; SWR bandwidth; antenna efficiency; shortened and mobile antennas; grounding E9E - Matching: matching antennas to feed lines; power dividers E9F - Transmission lines: characteristics of open and shorted feed lines: 1/8 wavelength; 1/4 wavelength; 1/2 wavelength; feed lines: coax versus open-wire; velocity factor; electrical length; transformation characteristics of line terminated in impedance not equal to characteristic impedance E9G - The Smith chart E9F - Transmission lines: characteristics of open and shorted feed lines: 1/8 wavelength; 1/4 wavelength; 1/2 wavelength; feed lines: coax versus open-wire; velocity factor; electrical length; transformation characteristics of line terminated in impedance not equal to characteristic impedance
E0	SAFETY	E0A - Safety: amateur radio safety practices; RF radiation hazards; hazardous materials

Exam Day

The license exam for the Extra Class license is given at the conclusion of the class. The exam will only cover the Element 4 questions from the Extra Class license pool. For the purposes of this class, we will assume that all of the students already hold a General Class license or have the CSCE for the General license.

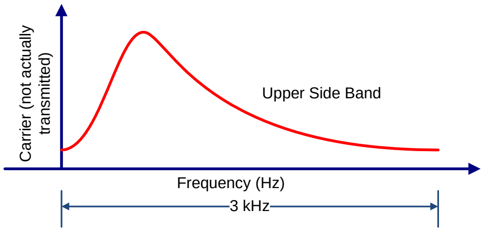
What do you need to bring with you for the exam? Be sure to have the following items physically with you when the exam starts:

- ☐ several sharpened pencils and an eraser
- ☐ a photo-ID or other valid forms of identification, preferably with photographs (ask the VE team what constitutes alternative identification if a photo-ID such as a driver’s license is not available)
- ☐ a copy of your current license or your listing from the FCC data base (visit http://www.arrl.org/fcc/fcclook.php3 or an equivalent site) and/or any CSCEs that are valid (less than one year old) that you need to establish credit for other examination elements
- ☐ you may also wish to bring a calculator that has the capability to compute squares and square roots, trigonometric functions, and rectangular-to-polar coordinate conversion; be sure that there are no exam-related formulas stored in the calculator’s memory.

You will have all of the time you need to complete the exam. Do not rush. Read each question carefully and be sure to indicate the correct answer. There is no penalty for guessing. If you must guess, try to eliminate as many choices as possible for the question and then select the remaining answer that seems the most correct to you.

Subelement E1 -- Commission's Rules

E1A01 (D) [97.301, 97.305]
When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies will result in a normal USB emission being within the band?
A. The exact upper band edge
B. 300 Hz below the upper band edge
C. 1 kHz below the upper band edge
D. 3 kHz below the upper band edge



The regulations within Part 97 state that any station's emissions "resulting from modulation must be confined to the band or segment available to the control operator. Emissions outside the necessary bandwidth must not cause splatter or keyclick interference to operations on adjacent frequencies." Therefore, if the control operator is near the band edge, the operator must know how close the transmitter can be tuned to the band edge. Since USB modulation is approximately 3 kHz wide, the transmitter needs to be tuned 3 kHz *below* the upper band edge as in Answer **D**. The other choices would allow the transmission to spill outside the band.

E1A02 (D) [97.301, 97.305]
When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies will result in a normal LSB emission being within the band?
A. The exact lower band edge
B. 300 Hz above the lower band edge
C. 1 kHz above the lower band edge
D. 3 kHz above the lower band edge

This question is the mirror image of the previous question. Based on the previous question, the control operator ought to tune the transmitter 3 kHz above the lower band edge as in Answer **D**. The other choices will permit the emission to spill over the band limit.

E1A03 (C) [97.301, 97.305]
With your transceiver displaying the carrier frequency of phone signals, you hear a DX station's CQ on 14.349 MHz USB. Is it legal to return the call using upper sideband on the same frequency?
A. Yes, because the DX station initiated the contact
B. Yes, because the displayed frequency is within the 20 meter band
C. No, my sidebands will extend beyond the band edge
D. No, USA stations are not permitted to use phone emissions above 14.340 MHz

The upper edge of the phone segment on the 20-meter band is 14.350 MHz. This CQ is just below the permitted band limit in the US and less than 3 kHz from the band edge. If you were to answer the CQ, your return signal would extend beyond the permitted band edge so you cannot legally answer the CQ as stated in Answer **C**.

```
E1A04 (C) [97.301, 97.305]
With your transceiver displaying the carrier frequency of phone signals, you
hear a DX station's CQ on 3.601 MHz LSB. Is it legal to return the call using
lower sideband on the same frequency?
A. Yes, because the DX station initiated the contact
B. Yes, because the displayed frequency is within the 75 meter phone band
      segment
C. No, my sidebands will extend beyond the edge of the phone band segment
D. No, USA stations are not permitted to use phone emissions below 3.610 MHz
```

The lower edge of the phone segment on the 80-meter band in the US is 3.600 MHz. This CQ is just above the permitted band limit in the US and less than 3 kHz from the band edge. If you were to answer the CQ, your return signal would extend beyond the permitted band edge so you cannot legally answer the CQ as stated in Answer **C**.

```
E1A05 (C) [97.305]
Which is the only amateur band that does not permit the transmission of phone
or image emissions?
A. 160 meters
B. 60 meters
C. 30 meters
D. 17 meters
```

If you inspect the authorized emissions table in Part 97, you will see that the 30-meter band has the entire band dedicated to RTTY and data and no phone or image transmissions. Answer **C** is the right choice here.

```
E1A06 (B) [97.303]
What is the maximum power output permitted on the 60 meter band?
A. 50 watts PEP effective radiated power relative to an isotropic radiator
B. 50 watts PEP effective radiated power relative to a dipole
C. 100 watts PEP effective radiated power relative to an isotropic radiator
D. 100 watts PEP effective radiated power relative to a dipole
```

The rules in Part 97 state that on the 60-meter band, amateur transmissions “shall not exceed an effective radiated power (e.r.p) of 50 W PEP. For the purpose of computing e.r.p. the transmitter PEP will be multiplied with the antenna gain relative to a dipole or the equivalent calculation in decibels.” This regulation is expressed in Answer **B**.

```
E1A07 (D) [97.303]
What is the only amateur band where transmission on specific channels rather
than a range of frequencies is permitted?
A. 12 meter band
B. 17 meter band
C. 30 meter band
D. 60 meter band
```

The Part 97 rules state that on 60-meters an “amateur station ... may only transmit single sideband, suppressed carrier, (emission type 2K8J3E) upper sideband on the channels 5332 kHz, 5348 kHz, 5368 kHz, 5373 kHz, and 5405 kHz.” The 60-meter band is the only one in the amateur service with this type of specific channelization so Answer **D** is the correct response.

E1A08 (C) [97.303]
What is the only emission type permitted to be transmitted on the 60 meter band by an amateur station?
A. CW
B. RTTY Frequency shift keying
C. Single sideband, upper sideband only
D. Single sideband, lower sideband only

As we saw in the previous question, amateurs are only permitted to use USB on 60-maters. This makes Answer **C** the correct response.

E1A09 (A) [97.301]
Which frequency bands contain at least one segment authorized only to control operators holding an Amateur Extra Class operator license?
A. 80/75, 40, 20 and 15 meters
B. 80/75, 40, 20, and 10 meters
C. 80/75, 40, 30 and 10 meters
D. 160, 80/75, 40 and 20 meters

If you look at the frequency band authorization for the various license classes in part 97, you will see that Extra Class operators have specific segments allocated on the 80/75, 40, 20, and 15 meter bands. This matches Answer **A**.

E1A10 (B) [97.219]
If a station in a message forwarding system inadvertently forwards a message that is in violation of FCC rules, who is primarily accountable for the rules violation?
A. The control operator of the packet bulletin board station
B. The control operator of the originating station
C. The control operators of all the stations in the system
D. The control operators of all the stations in the system not authenticating the source from which they accept communications

All message forwarding system is based on trusting that received messages are properly formatted. The regulations in Part 97 state that for "stations participating in a message forwarding system, the control operator of the station originating a message is primarily accountable for any violation of the rules in this part contained in the message." Answer **B** conforms to the rules so it is the correct choice for this question.

E1A11 (A) [97.219]
What is the first action you should take if your digital message forwarding station inadvertently forwards a communication that violates FCC rules?
A. Discontinue forwarding the communication as soon as you become aware of it
B. Notify the originating station that the communication does not comply with FCC rules
C. Notify the nearest FCC Field Engineer's office
D. Discontinue forwarding all messages

The FCC would want the problem fixed as quickly as possible (first action to be taken). The Part 97 regulations state that the control operator in this case is "responsible for discontinuing such communications once they become aware of their presence." In this situation, answer **A** is the correct choice.

E1A12 (A) [97.11]
If an amateur station is installed on board a ship or aircraft, what condition must be met before the station is operated?
A. Its operation must be approved by the master of the ship or the pilot in command of the aircraft
B. The amateur station operator must agree to not transmit when the main ship or aircraft radios are in use
C. It must have a power supply that is completely independent of the main ship or aircraft power supply
D. Its operator must have an FCC Marine or Aircraft endorsement on his or her amateur license

In Part 97, the regulations covering this situation state that "the installation and operation of an amateur station on a ship or aircraft must be approved by the master of the ship or pilot in command of the aircraft." This rule is covered in Answer **A**.

E1A13 (B) [97.5]
When a US-registered vessel is in international waters, what type of FCC-issued license or permit is required to transmit amateur communications from an on-board amateur transmitter?
A. Any amateur license with an FCC Marine or Aircraft endorsement
B. Any amateur license or reciprocal permit for alien amateur licensee
C. Only General class or higher amateur licenses
D. An unrestricted Radiotelephone Operator Permit

The regulations in Part 97 covering this situation state that the "station apparatus must be under the physical control of a person named in an amateur station license grant ... or a person authorized for alien reciprocal operation ... before the station may transmit on any amateur service frequency from any place that is ... Within 50 km of the Earth's surface and aboard any vessel or craft that is documented or registered in the United States ...." Answer **B** matches the regulations.

E1B01 (D) [97.3]
Which of the following constitutes a spurious emission?
A. An amateur station transmission made at random without the proper call sign identification
B. A signal transmitted in a way that prevents its detection by any station other than the intended recipient
C. Any transmitted bogus signal that interferes with another licensed radio station
D. An emission outside its necessary bandwidth that can be reduced or eliminated without affecting the information transmitted

In Part 97, as spurious emission is defined as an "emission, or frequencies outside the necessary bandwidth of a transmission, the level of which may be reduced without affecting the information being transmitted." Answer **D** is the choice matching the regulations.

```
E1B02 (D) [97.13]
Which of the following factors might cause the physical location of an amateur
station apparatus or antenna structure to be restricted?
A. The location is in or near an area of political conflict, military
      maneuvers or major construction
B. The location's geographical or horticultural importance
C. The location is in an ITU zone designated for coordination with one or more
      foreign governments
D. The location is significant to our environment, American history,
      architecture, or culture.
```

In Part 97, the regulations state that restrictions might occur if the station is placed "on land of environmental importance or that is significant in American history, architecture or culture...." Answer **A** is the choice matching the rules.

```
E1B03 (A) [97.13]
Within what distance must an amateur station protect an FCC monitoring
facility from harmful interference?
A. 1 mile
B. 3 miles
C. 10 miles
D. 30 miles
```

The FCC requires that a "station within 1600 m (1 mile) of an FCC monitoring facility must protect that facility from harmful interference." Answer **A** is the correct choice in this situation.

```
E1B04 (C) [97.13, 1.1305-1.1319]
What must be done before placing an amateur station within an officially
designated wilderness area or wildlife preserve, or an area listed in the
National Register of Historical Places?
A. A proposal must be submitted to the National Park Service
B. A letter of intent must be filed with the National Audubon Society
C. An Environmental Assessment must be submitted to the FCC
D. A form FSD-15 must be submitted to the Department of the Interior
```

In a previous question, we saw that this case may require special restrictions. In particular, an Environmental Assessment must be submitted to the FCC as given in Answer **C**.

```
E1B05 (B) [97.15]
What height restrictions apply to an amateur station antenna structure not
close to a public use airport unless the FAA is notified and it is registered
with the FCC?
A. It must not extend more than 300 feet above average height of terrain
      surrounding the site
B. It must be no higher than 200 feet above ground level at its site
C. There are no height restrictions because the structure obviously would not
      be a hazard to aircraft in flight
D. It must not extend more than 100 feet above sea level or the rim of the
      nearest valley or canyon
```

In this situation, Part 97 states that owners "of certain antenna structures more than 60.96 meters (200 feet) above ground level at the site or located near or at a public use airport must notify the Federal Aviation Administration and register with the Commission as required by part 17 of this chapter." This formulation is captured in Answer **B**.

E1B06 (A) [97.15]
Which of the following additional rules apply if you are installing an amateur station antenna at a site within 20,000 feet of a public use airport?
A. You may have to notify the Federal Aviation Administration and register it with the FCC
B. No special rules apply if your antenna structure will be less than 300 feet in height
C. You must file an Environmental Impact Statement with the EPA before construction begins
D. You must obtain a construction permit from the airport zoning authority

As we saw in the previous question, the FAA may also need to be notified and the antenna must be registered with the FCC as indicated in Answer **A**.

E1B07 (A) [97.15]
Whose approval is required before erecting an amateur station antenna located at or near a public use airport if the antenna would exceed a certain height depending upon the antenna's distance from the nearest active runway?
A. The FAA must be notified and it must be registered with the FCC
B. Approval must be obtained from the airport manager
C. Approval must be obtained from the local zoning authorities
D. The FAA must approve any antenna structure that is higher than 20 feet

This is a restatement of the previous question so you should be able to spot Answer **A** as the correct choice.

E1B08 (D) [97.121]
On what frequencies may the operation of an amateur station be restricted if its emissions cause interference to the reception of a domestic broadcast station on a receiver of good engineering design?
A. On the frequency used by the domestic broadcast station
B. On all frequencies below 30 MHz
C. On all frequencies above 30 MHz
D. On the interfering amateur service transmitting frequencies

The Part 97 regulation for this situation states that if "the operation of an amateur station causes general interference to the reception of transmissions from stations operating in the domestic broadcast service when receivers of good engineering design, including adequate selectivity characteristics, are used to receive such transmissions, and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 p.m. to 10:30 p.m., local time, and on Sunday for the additional period from 10:30 a.m. until 1 p.m., local time, upon the frequency or frequencies used when the interference is created." This means that the control operator may not use those amateur frequencies causing the interference as mentioned in Answer **D**.

E1B09 (B) [97.3]
What is the Radio Amateur Civil Emergency Service (RACES)?
A. A radio service using amateur service frequencies on a regular basis for communications that can reasonably be furnished through other radio services
B. A radio service of amateur stations for civil defense communications during periods of local, regional, or national civil emergencies
C. A radio service using amateur service frequencies for broadcasting to the public during periods of local, regional or national civil emergencies
D. A radio service using local government frequencies by Amateur Radio operators for civil emergency communications

The Part 97 definition of RACES (radio amateur civil emergency service) is that it is a “radio service using amateur stations for civil defense communications during periods of local, regional or national civil emergencies.” Answer **B** matches the Part 97 definition.

```
E1B10 (C) [97.407]
Which amateur stations may be operated in RACES?
A. Only those club stations licensed to Amateur Extra class operators
B. Any FCC-licensed amateur station except a Technician class operator's
      station
C. Any FCC-licensed amateur station certified by the responsible civil defense
      organization for the area served
D. Any FCC-licensed amateur station participating in the Military Affiliate
      Radio System (MARS)
```

The Part 97 regulations state that no “station may transmit in RACES unless it is an FCC-licensed primary, club, or military recreation station and it is certified by a civil defense organization as registered with that organization, or it is an FCC-licensed RACES station.” Answer **C** is the choice that matches the regulations.

```
E1B11 (A) [97.407]
What frequencies are normally authorized to an amateur station participating
in RACES?
A. All amateur service frequencies otherwise authorized to the control
      operator
B. Specific segments in the amateur service MF, HF, VHF and UHF bands
C. Specific local government channels
D. Military Affiliate Radio System (MARS) channels
```

Part 97 states that the “frequency bands and segments and emissions authorized to the control operator are available to stations transmitting communications in RACES on a shared basis with the amateur service.” Answer **A** matches the regulations.

```
E1B12 (B) [97.407]
What are the frequencies authorized to an amateur station participating in
RACES during a period when the President's War Emergency Powers are in force?
A. All frequencies in the amateur service authorized to the control operator
B. Specific amateur service frequency segments authorized in FCC Part 214
C. Specific local government channels
D. Military Affiliate Radio System (MARS) channels
```

The regulations in Part 97 state that in this situation, “RACES stations and amateur stations participating in RACES may only transmit on the following frequency segments:

(1) The 1800-1825 kHz, 1975-2000 kHz, 3.50-3.55 MHz, 3.93-3.98 MHz, 3.984-4.000 MHz, 7.079-7.125 MHz, 7.245-7.255 MHz, 10.10-10.15 MHz, 14.047-14.053 MHz, 14.22-14.23 MHz, 14.331-14.350 MHz, 21.047-21.053 MHz, 21.228-21.267 MHz, 28.55-28.75 MHz, 29.237-29.273 MHz, 29.45-29.65 MHz, 50.35-50.75 MHz, 52-54 MHz, 144.50-145.71 MHz, 146-148 MHz, 2390-2450 MHz segments;

(2) The 1.25 m, 70 cm and 23 cm bands; and

(3) The channels at 3.997 MHz and 53.30 MHz may be used in emergency areas when required to make initial contact with a military unit and for communications with military stations on matters requiring coordination.”

Answer **B** is the short version of this regulation.

```
E1B13 (C) [97.407]
What communications are permissible in RACES?
A. Any type of communications when there is no emergency
B. Any Amateur Radio Emergency Service communications
C. Authorized civil defense emergency communications affecting the immediate
      safety of life and property
D. National defense and security communications authorized by the President
```

The regulations in Part 97 state that all “communications transmitted in RACES must be specifically authorized by the civil defense organization for the area served. Only civil defense communications of the following types may be transmitted ... (2) Messages directly concerning the immediate safety of life of individuals, the immediate protection of property, ...” Answer **C** is the choice that is consistent with the regulations.

```
E1C01 (D) [97.3]
What is a remotely controlled station?
A. A station operated away from its regular home location
B. A station controlled by someone other than the licensee
C. A station operating under automatic control
D. A station controlled indirectly through a control link
```

Answer **D** matches the Part 97 definition for remote control which is the “use of a control operator who indirectly manipulates the operating adjustments in the station through a control link to achieve compliance with the FCC Rules.”

```
E1C02 (A) [97.3, 97.109]
What is meant by automatic control of a station?
A. The use of devices and procedures for control so that the control operator
      does not have to be present at a control point
B. A station operating with its output power controlled automatically
C. Remotely controlling a station's antenna pattern through a directional
      control link
D. The use of a control link between a control point and a locally controlled
      station
```

The Part 97 rules allow for automatic control which is the “use of devices and procedures for control of a station when it is transmitting so that compliance with the FCC Rules is achieved without the control operator being present at a control point.” This makes Answer **A** the correct choice.

```
E1C03 (B) [97.3, 97.109]
How do the control operator responsibilities of a station under automatic
control differ from one under local control?
A. Under local control there is no control operator
B. Under automatic control the control operator is not required to be present
      at the control point
C. Under automatic control there is no control operator
D. Under local control a control operator is not required to be present at a
      control point
```

A we can see from the previous question, the formulation in Answer **B** matches the wording of the regulations.

E1C04 (B) [97.109]
When may an automatically controlled station retransmit third party communications?
A. Never
B. Only when transmitting RTTY or data emissions
C. When specifically agreed upon by the sending and receiving stations
D. When approved by the National Telecommunication and Information Administration

The Part 97 regulations covering this situation state that "[n]o station may be automatically controlled while transmitting third party communications, except a station transmitting a RTTY or data emission. All messages that are retransmitted must originate at a station that is being locally or remotely controlled." Answer **B** matches the regulations.

E1C05 (A) [97.109]
When may an automatically controlled station originate third party communications?
A. Never
B. Only when transmitting an RTTY or data emissions
C. When specifically agreed upon by the sending and receiving stations
D. When approved by the National Telecommunication and Information Administration

As we can see from the previous question, automatically controlled stations may not originate third party messages. This makes Answer **A** the correct choice.

E1C06 (C) [97.109]
Which of the following statements concerning remotely controlled amateur stations is true?
A. Only Extra Class operators may be the control operator of a remote station
B. A control operator need not be present at the control point
C. A control operator must be present at the control point
D. Repeater and auxiliary stations may not be remotely controlled

As given in Answer **C**, the Part 97 regulations state that "[w]hen a station is being remotely controlled, the control operator must be at the control point."

E1C07 (C) [97.3]
What is meant by local control?
A. Controlling a station through a local auxiliary link
B. Automatically manipulating local station controls
C. Direct manipulation of the transmitter by a control operator
D. Controlling a repeater using a portable handheld transceiver

Part 97 defines local control as the "use of a control operator who directly manipulates the operating adjustments in the station to achieve compliance with the FCC Rules." Answer **C** matches the definition.

E1C08 (B) [97.213]
What is the maximum permissible duration of a remotely controlled station's transmissions if its control link malfunctions?
A. 30 seconds
B. 3 minutes
C. 5 minutes
D. 10 minutes

Answer **B** matches the Part 97 regulation which states that in this case, the station control must make provisions that "are incorporated to limit transmission by the station to a period of no more than 3 minutes in the event of malfunction in the control link."

E1C09 (D) [97.205]
Which of these frequencies are available for automatically controlled ground-station repeater operation?
A. 18.110 - 18.168 MHz
B. 24.940 - 24.990 MHz
C. 10.100 - 10.150 MHz
D. 29.500 - 29.700 MHz

The regulations in Part 97 state that a "repeater may receive and retransmit only on the 10 m and shorter wavelength frequency bands except the 28.0-29.5 MHz, 50.0-51.0 MHz, 144.0-144.5 MHz, 145.5-146.0 MHz, 222.00-222.15 MHz, 431.0-433.0 MHz, and 435.0-438.0 MHz segments." Only the frequency range given in Answer **D** meets these restrictions.

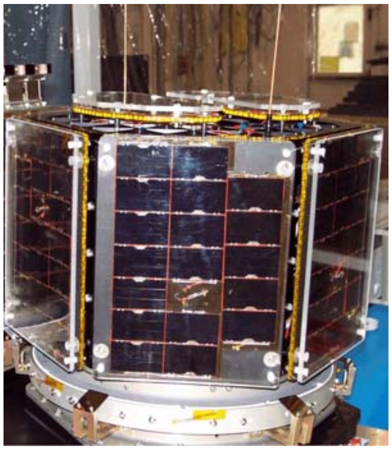
E1C10 (B) [97.113]
What types of amateur stations may automatically retransmit the radio signals of other amateur stations?
A. Only beacon, repeater or space stations
B. Only auxiliary, repeater or space stations
C. Only earth stations, repeater stations or model crafts
D. Only auxiliary, beacon or space stations

The FCC regulations state that no "amateur station, except an auxiliary, repeater, or space station, may automatically retransmit the radio signals of other amateur station." Answer **B** lists the permitted station types.

E1D01 (A) [97.3]
What is the definition of the term telemetry?
A. One-way transmission of measurements at a distance from the measuring instrument
B. A two-way interactive transmission
C. A two-way single channel transmission of data
D. One-way transmission that initiates, modifies, or terminates the functions of a device at a distance

Answer **A** has the definition found in Part 97: telemetry is a "one-way transmission of measurements at a distance from the measuring instrument."

E1D02 (C) [97.3]
What is the amateur-satellite service?
A. A radio navigation service using satellites for the purpose of self-training, intercommunication and technical studies carried out by amateurs
B. A spacecraft launching service for amateur-built satellites
C. A radio communications service using amateur stations on satellites
D. A radio communications service using stations on Earth satellites for weather information gathering



The amateur satellite service uses amateur stations on satellites so Answer **C** is the right choice.

A university-built satellite using amateur radio technology for communications. The satellite is approximately 1 ft tall and 1.5 ft across. It uses amateur HT's for the radio communications.

E1D03 (B) [97.3]
What is a telecommand station in the amateur satellite service?
A. An amateur station located on the Earth's surface for communications with other Earth stations by means of Earth satellites
B. An amateur station that transmits communications to initiate, modify or terminate certain functions of a space station
C. An amateur station located more than 50 km above the Earth's surface
D. An amateur station that transmits telemetry consisting of measurements of upper atmosphere data from space

Part 97 defines a telecommand sation as an "amateur station that transmits communications to initiate, modify or terminate functions of a space station." Answer **B** matches this definition.

E1D04 (A) [97.3]
What is an Earth station in the amateur satellite service?
A. An amateur station within 50 km of the Earth's surface for communications with amateur stations by means of objects in space
B. An amateur station that is not able to communicate using amateur satellites
C. An amateur station that transmits telemetry consisting of measurement of upper atmosphere data from space
D. Any amateur station on the surface of the Earth

Answer **A** matches the definition for an earth station found in Part 97. An earth station is an "amateur station located on, or within 50 km of, the Earth's surface intended for communications with space stations or with other Earth stations by means of one or more other objects in space."

```
E1D05 (C) [97.207]
What class of licensee is authorized to be the control operator of a space
station?
A. Any except those of Technician Class operators
B. Only those of General, Advanced or Amateur Extra Class operators
C. A holder of any class of license
D. Only those of Amateur Extra Class operators
```

Part 97 makes it clear that "any amateur station may be a space station. A holder of any class operator license may be the control operator of a space station, subject to the privileges of the class of operator license held by the control operator." Therefore, Answer **C** is the correct choice.

```
E1D06 (A) [97.207]
Which of the following special provisions must a space station incorporate in
order to comply with space station requirements?
A. The space station must be capable of effecting a cessation of transmissions
      by telecommand when so ordered by the FCC
B. The space station must cease all transmissions after 5 years
C. The space station must be capable of changing its orbit whenever such a
      change is ordered by NASA
D. The station call sign must appear on all sides of the spacecraft
```

Space station control operators must realize that the FCC requires that a "space station must be capable of effecting a cessation of transmissions by telecommand whenever such cessation is ordered by the FCC." Answer **A** matches this requirement.

```
E1D07 (A) [97.207]
Which amateur service HF bands have frequencies authorized to space stations?
A. Only 40m, 20m, 17m, 15m, 12m and 10m
B. Only 40m, 20m, 17m, 15m and 10m bands
C. 40m, 30m, 20m, 15m, 12m and 10m bands
D. All HF bands
```

The frequency bands for a space station are listed in Part 97. "The following frequency bands and segments are authorized to space stations:

(1) The 17 m, 15 m, 12 m, and 10 m bands, 6 mm, 4 mm, 2 mm and 1 mm bands; and

(2) The 7.0-7.1 MHz, 14.00-14.25 MHz, 144-146 MHz, 435-438 MHz, 1260-1270 MHz, and 2400-2450 MHz, 3.40-3.41 GHz, 5.83-5.85 GHz, 10.45-10.50 GHz, and 24.00-24.05 GHz segments."

From this list, we can spot Answer **A** as the correct choice.

```
E1D08 (D) [97.207]
Which VHF amateur service bands have frequencies available for space stations?
A. 6 meters and 2 meters
B. 6 meters, 2 meters, and 1.25 meters
C. 2 meters and 1.25 meters
D. 2 meters
```

Using the previous question as a guide, we can see that only the 2-meter band is in the permitted list so Answer **D** is the correct choice among those given.

```
E1D09 (B) [97.207]
Which amateur service UHF bands have frequencies available for a space
station?
A. 70 cm
B. 70 cm, 23 cm, 13 cm
C. 70 cm and 33 cm
D. 33 cm and 13 cm
```

Using the list from the Part 97 regulations, we can see that Answer **B** matches the list from the choices given.

```
E1D10 (B) [97.211]
Which amateur stations are eligible to be telecommand stations?
A. Any amateur station designated by NASA
B. Any amateur station so designated by the space station licensee
C. Any amateur station so designated by the ITU
D. All of these choices are correct
```

Part 97 states that "[a]ny amateur station designated by the licensee of a space station is eligible to transmit as a telecommand station for that space station, subject to the privileges of the class of operator license held by the control operator." Answer **B** matches the rules.

```
E1D11 (D) [97.209]
Which amateur stations are eligible to operate as Earth stations?
A. Any amateur station whose licensee has filed a pre-space notification with
      the FCC's International Bureau
B. Only those of General, Advanced or Amateur Extra Class operators
C. Only those of Amateur Extra Class operators
D. Any amateur station, subject to the privileges of the class of operator
      license held by the control operator
```

This is similar to the telecommand case. Part 97 specifies that "[a]ny amateur station may be an Earth station. A holder of any class operator license may be the control operator of an Earth station, subject to the privileges of the class of operator license held by the control operator." Answer **D** is the choice that matches the regulations.

```
E1D12 (B) [97.207]
Who must be notified before launching an amateur space station?
A. The National Aeronautics and Space Administration, Houston, TX
B. The FCC's International Bureau, Washington, DC
C. The Amateur Satellite Corp., Washington, DC
D. All of these answers are correct
```

The licensing of a space station is a rather involved process. Part 97 states that the "license grantee of each space station must make two written pre-space station notifications to the International Bureau, FCC, Washington DC 20554. Each notification must be in accord with the provisions of Articles S9 and S11 of the ITU Radio Regulations." This makes Answer **B** the correct choice.

```
E1E01 (D) [97.509]
What is the minimum number of qualified VEs required to administer an Element
4 amateur operator license examination?
A. 5
B. 2
C. 4
D. 3
```

The VE requirement is the same for all license classes and not just the Extra examination. Part 97 stipulates that each "examination for an amateur operator license must be administered by a team of at least 3 VEs at an examination session coordinated by a VEC." Answer **D** is the right choice.

```
E1E02 (C) [97.523]
Where are the questions for all written US amateur license examinations
listed?
A. In FCC Part 97
B. In an FCC-maintained question pool
C. In the VEC-maintained question pool
D. In the appropriate FCC Report and Order
```

Do not look for the question pool in a physical location. Part 97 states that the authorized "VECs must cooperate in maintaining one question pool for each written examination element." The question pool can be found in cyberspace at http://www.ncvec.org/. Answer **C** is the correct choice for this question.

```
E1E03 (A) [97.523]
Who is responsible for maintaining the question pools from which all amateur
license examination questions must be taken?
A. All of the VECs
B. The VE team
C. The VE question pool team
D. The FCC's Wireless Telecommunications Bureau
```

As can be seen from the previous question, all VECs are responsible so Answer **A** is the correct choice.

```
E1E04 (C) [97.521]
What is a Volunteer Examiner Coordinator?
A. A person who has volunteered to administer amateur operator license
      examinations
B. A person who has volunteered to prepare amateur operator license
      examinations
C. An organization that has entered into an agreement with the FCC to
      coordinate amateur operator license examinations
D. The person that has entered into an agreement with the FCC to be the VE
      session manager
```

An organization may qualify to be a VEC if it meets this criterion listed in Part 97: "No organization may serve as a VEC unless it has entered into a written agreement with the FCC." Answer **C** matches this regulation.

```
E1E05 (B) [97.525, 97.3]
What is a VE?
A. An amateur operator who is approved by three or more fellow volunteer
      examiners to administer amateur license examinations
B. An amateur operator who is approved by a VEC to administer amateur operator
      license examinations
C. An amateur operator who administers amateur license examinations for a fee
D. An amateur operator who is approved by an FCC staff member to administer
      amateur operator license examinations
```

The VECs and not the FCC are the organizations to certify VE's. The Part 97 regulations state that no "VEC may accredit a person as a VE if:
(1) The person does not meet minimum VE statutory qualifications or minimum qualifications as prescribed by this

part;
(2) The FCC does not accept the voluntary and uncompensated services of the person;
(3) The VEC determines that the person is not competent to perform the VE functions; or
(4) The VEC determines that questions of the person's integrity or honesty could compromise the examinations.
Answer **B** is the best choice for this question.

```
E1E06 (A) [97.509]
What is a VE team?
A. A group of at least three VEs who administer examinations for an amateur
      operator license
B. The VEC staff
C. One or two VEs who administer examinations for an amateur operator license
D. A group of FCC Volunteer Enforcers who investigate Amateur Rules violations
```

We saw in question E1E01 that a VE team is a group of three VE's who administer the examinations. This makes Answer A the correct choice.

```
E1E07 (C) [97.509]
Which of the following persons seeking to become VEs cannot be accredited?
A. Persons holding less than an Advanced Class operator license
B. Persons less than 21 years of age
C. Persons who have ever had an amateur operator or amateur station license
      suspended or revoked
D. Persons who are employees of the federal government
```

The rules on accrediting VE's in Part 97 state that each "VE must:
(1) Be accredited by the coordinating VEC;
(2) Be at least 18 years of age;
(3) Be a person who holds an amateur operator license of the class specified below:
(i) Amateur Extra, Advanced or General Class in order to administer a Technician Class operator license examination;
(ii) Amateur Extra or Advanced Class in order to administer a General Class operator license examination;
(iii) Amateur Extra Class in order to administer an Amateur Extra Class operator license examination.
(4) Not be a person whose grant of an amateur station license or amateur operator license has ever been revoked or suspended."
Of the choices given, Answer **C** corresponds to an operator that cannot be accredited.

```
E1E08 (D) [97.5091, 97.525]
Which of the following best describes the Volunteer Examiner accreditation
process?
A. Each General, Advanced and Amateur Extra Class operator is automatically
      accredited as a VE when the license is granted
B. The amateur operator applying must pass a VE examination administered by
      the FCC Enforcement Bureau
C. The prospective VE obtains accreditation from a VE team
D. The procedure by which a VEC confirms that the VE applicant meets FCC
      requirements to serve as an examiner
```

There is not a specific phrase in the Part 97 regulations covering this. However, by looking at the regulations covered in the previous questions on VE's you should be able to piece together that VE accreditation process is basically where a VEC affirms that the proposed VE meets all of the FCC requirements. Answer **D** is the best choice among those given to answer this question.

```
E1E09 (A) [97.509]
Where must the VE team be while administering an examination?
A. All of the administering VEs must be present where they can observe the
      examinees throughout the entire examination
B. The VEs must leave the room after handing out the exam(s) to allow the
      examinees to concentrate on the exam material
C. The VEs may be elsewhere provided at least one VE is present and is
      observing the examinees throughout the entire examination
D. The VEs may be anywhere as long as they each certify in writing that
      examination was administered properly
```

Answer A is the choice that is in compliance with the Part 97 regulations which state that each “administering VE must be present and observing the examinee throughout the entire examination.”

```
E1E10 (C) [97.509]
Who is responsible for the proper conduct and necessary supervision during an
amateur operator license examination session?
A. The VEC coordinating the session
B. The FCC
C. Each administering VE
D. The VE session manager
```

As we saw in the previous question, each administering VE is responsible in this situation. This makes Answer **C** the correct choice.

```
E1E11 (B) [97.509]
What should a VE do if a candidate fails to comply with the examiner's
instructions during an amateur operator license examination?
A. Warn the candidate that continued failure to comply will result in
      termination of the examination
B. Immediately terminate the candidate's examination
C. Allow the candidate to complete the examination, but invalidate the results
D. Immediately terminate everyone's examination and close the session
```

The Part 97 regulations state that the “administering VEs are responsible for the proper conduct and necessary supervision of each examination. The administering VEs must immediately terminate the examination upon failure of the examinee to comply with their instructions.” Answer **C** matches the regulations.

```
E1E12 (C) [97.509]
To which of the following examinees may a VE not administer an examination?
A. Employees of the VE
B. Friends of the VE
C. The VE's close relatives as listed in the FCC rules
D. All these answers are correct
```

The VE’s must avoid the appearance of a conflict of interest. Therefore, Part 97 requires that no “VE may administer an examination to his or her spouse, children, grandchildren, stepchildren, parents, grandparents, stepparents, brothers, sisters, stepbrothers, stepsisters, aunts, uncles, nieces, nephews, and in-laws.” Answer **C** summarizes this regulation.

```
E1E13 (A) [97.509]
What may be the penalty for a VE who fraudulently administers or certifies an
examination?
A. Revocation of the VE's amateur station license grant and the suspension of
      the VE's amateur operator license grant
B. A fine of up to $1000 per occurrence
C. A sentence of up to one year in prison
D. All of these choices are correct
```

The Part 97 regulation covering this situation states that no “VE may administer or certify any examination by fraudulent means or for monetary or other consideration including reimbursement in any amount in excess of that permitted. Violation of this provision may result in the revocation of the grant of the VE's amateur station license and the suspension of the grant of the VE's amateur operator license.” Answer **A** matches this regulation.

```
E1E14 (C) [97.509] [edited, was E1F19, edited]
What must the VE team do with the examinee's test papers once they have
finished the examination?
A. The VE team must collect and send them to the NCVEC
B. The VE team must collect and send them to the coordinating VEC for grading
C. The VE team must collect and grade them immediately
D. The VE team must collect and send them to the FCC for grading
```

The VE’s responsibility under Part 97 state that upon “completion of each examination element, the administering VEs must immediately grade the examinee's answers. The administering VEs are responsible for determining the correctness of the examinee's answers.” Answer **C** states the regulation.

```
E1E15 (B) [97.509]
What must the VE team do if an examinee scores a passing grade on all
examination elements needed for an upgrade or new license?
A. Photocopy all examination documents and forwards them to the FCC for
      processing
B. Three VEs must certify that the examinee is qualified for the license grant
      and that they have complied with the VE requirements
C. Issue the examinee the new or upgrade license
D. All these answers are correct
```

When an examinee receives a passing grade, Part 97 states that the “3 VEs must certify that the examinee is qualified for the license grant and that the VEs have complied with these administering VE requirements.” Answer **B** captures this regulation.

```
E1E16 (A) [97.509]
What must the VE team do with the application form if the examinee does not
pass the exam?
A. Return the application document to the examinee
B. Maintain the application form with the VEC's records
C. Send it to the FCC
D. Destroy the application form
```

When an examinee does not pass, Part 97 states that the VE team “must return the application document to the examinee and inform the examinee of the grade.” Answer **A** is the correct choice.

E1E17 (A) [97.519]
What are the consequences of failing to appear for re-administration of an examination when so directed by the FCC?
A. The licensee's license will be cancelled
B. The person may be fined or imprisoned
C. The licensee is disqualified from any future examination for an amateur operator license grant
D. All of the above

Part 97 states that the FCC may "[c]ancel the operator/primary station license of any licensee who fails to appear for readministration of an examination when directed by the FCC, or who does not successfully complete any required element that is readministered." Answer **A** captures this regulation.

E1E18 (A) [97.527]
For which types of out-of-pocket expenses may VEs and VECs be reimbursed?
A. Preparing, processing, administering and coordinating an examination for an amateur radio license
B. Teaching an amateur operator license examination preparation course
C. No expenses are authorized for reimbursement
D. Providing amateur operator license examination preparation training materials

While VE's cannot be paid to administer the examinations, Part 97 allows that "VEs and VECs may be reimbursed by examinees for out-of-pocket expenses incurred in preparing, processing, administering, or coordinating an examination for an amateur operator license." Answer **A** meets this regulation.

E1E19 (A) [97.509, 97.527]
How much reimbursement may the VE team and VEC accept for preparing, processing, administering and coordinating an examination?
A. Actual out-of-pocket expenses
B. The national minimum hourly wage for time spent providing examination services
C. Up to the maximum fee per examinee announced by the FCC annually
D. As much as the examinee is willing to donate

Part 97 states that no "VE may administer or certify any examination by fraudulent means or for monetary or other consideration including reimbursement in any amount in excess of that permitted." What is permitted? The out-of-pocket expenses mentioned in the previous question. This makes Answer **A** the correct choice.

E1E20 (C) [97.509]
What is the minimum age to be a volunteer examiner?
A. 13 years old
B. 16 years old
C. 18 years old
D. 21 years old

As we saw in E1E07, the minimum age to be a VE is 18 years so Answer **C** is the correct choice.

E1F01 (B) [97.305]
On what frequencies are spread spectrum transmissions permitted?
A. Only on amateur frequencies above 50 MHz
B. Only on amateur frequencies above 222 MHz
C. Only on amateur frequencies above 420 MHz
D. Only on amateur frequencies above 144 MHz

Spread spectrum transmissions are special cases. Part 97 says that "no SS modulation emission may be transmitted on any frequency where SS is not specifically authorized." Part 97 shows spread spectrum as being allowed on UHF frequencies and higher. These are above 222 MHz so Answer **B** is the right choice.

E1F02 (A) [97.5]
Which of the following operating arrangements allows an FCC-licensed US citizen to operate in many European countries, and alien amateurs from many European countries to operate in the US?
A. CEPT agreement
B. IARP agreement
C. ITU reciprocal license
D. All of these choices are correct

The CEPT agreement allows reciprocal agreements between US and European amateurs which makes Answer **A** the correct response.

E1F03 (B) [97.5]
Which of the following operating arrangements allow an FCC-licensed US citizen and many Central and South American amateur operators to operate in each other's countries?
A. CEPT agreement
B. IARP agreement
C. ITU agreement
D. All of these choices are correct

The IARP agreement allows reciprocal agreements between US and Central and South American amateurs which makes Answer **B** the correct response.

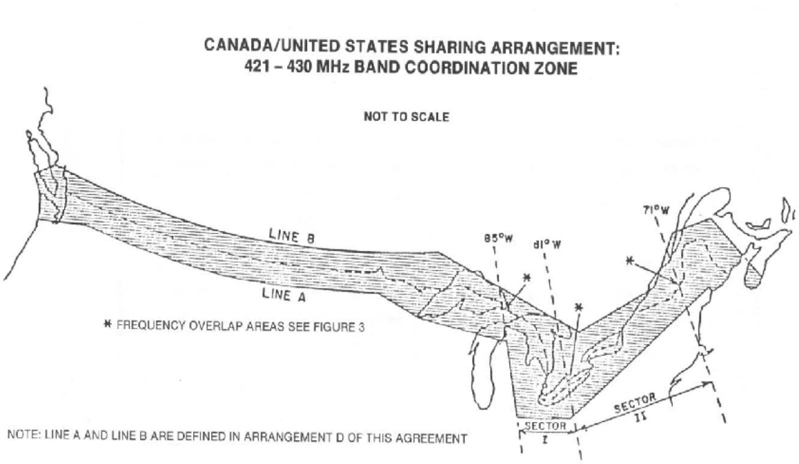
E1F04 (B) [97.315]
What does it mean if an external RF amplifier is listed on the FCC database as certificated for use in the amateur service?
A. The RF amplifier may be marketed for use in any radio service
B. That particular RF amplifier may be marketed for use in the amateur service
C. All similar RF amplifiers produced by other manufacturers may be marketed
D. All RF amplifiers produced by that manufacturer may be marketed

Part 97 states that any "external RF power amplifier appearing in the Commission's database as certificated for use in the amateur service may be marketed for use in the amateur service." Therefore Answer **B** is the correct response.

E1F05 (A) [97.315]
Under what circumstances may a dealer sell an external RF power amplifier capable of operation below 144 MHz if it has not been granted FCC certification?
A. It was purchased in used condition from an amateur operator and is sold to another amateur operator for use at that operator's station
B. The equipment dealer assembled it from a kit
C. It was imported from a manufacturer in a country that does not require certification of RF power amplifiers
D. It was imported from a manufacturer in another country, and it was certificated by that country's government

In Part 97, this situation is covered by the regulation which states that the sale is permitted when the "amplifier is purchased in used condition by an equipment dealer from an amateur operator and the amplifier is further sold to another amateur operator for use at that operator's station." Answer **A** matches this condition.

E1F06 (A) [97.3]
Which of the following geographic descriptions approximately describes "Line A"?
A. A line roughly parallel to and south of the US-Canadian border
B. A line roughly parallel to and west of the US Atlantic coastline
C. A line roughly parallel to and north of the US-Mexican border and Gulf coastline
D. A line roughly parallel to and east of the US Pacific coastline



The graphic illustrates Line A. As can be seen, it is basically a line parallel to the US-Canadian boarder so Answer **A** is the right choice.

E1F07 (D) [97.303]
Amateur stations may not transmit in which of the following frequency segments if they are located north of Line A?
A. 440 - 450 MHz.
B. 53 - 54 MHz
C. 222 - 223 MHz
D. 420 - 430 MHz

Part 97 stipulates that no "amateur station shall transmit from north of Line A in the 420-430 MHz segment." This makes Answer **D** the correct choice.

```
E1F08 (C) [97.3]
What is the National Radio Quiet Zone?
A. An area in Puerto Rico surrounding the Aricebo Radio Telescope
B. An area in New Mexico surrounding the White Sands Test Area
C. An area surrounding the National Radio Astronomy Observatory
D. An area in Florida surrounding Cape Canaveral
```

The National Radio Quiet Zone is defined in Part 97 as the "area in Maryland, Virginia and West Virginia Bounded by 39[deg] 15[min] N on the north, 78[deg] 30[min] W on the east, 37[deg] 30[min] N on the south and 80[deg] 30[min] W on the west." This is the area surrounding the National Radio Astronomy Observatory as given in Answer **C**.

```
E1F09 (D) [97.113]
When may the control operator of a repeater accept payment for providing
communication services to another party?
A. When the repeater is operating under portable power
B. When the repeater is operating under local control
C. During Red Cross or other emergency service drills
D. Under no circumstances
```

The general principle stated in Part 97 is that "No amateur station shall transmit ... Communications for hire or for material compensation, direct or indirect, paid or promised, ..." This makes Answer **D** the best choice among those given.

```
E1F10 (D) [97.113]
When may an amateur station send a message to a business?
A. When the total money involved does not exceed $25
B. When the control operator is employed by the FCC or another government
      agency
C. When transmitting international third-party communications
D. When neither the amateur nor his or her employer has a pecuniary interest
      in the communications
```

The general principle stated in Part 97 is that "No amateur station shall transmit ... Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer. ...." This makes Answer **D** the best choice among those given.

```
E1F11 (A) [97.113]
Which of the following types of amateur-operator-to-amateur-operator
communications are prohibited?
A. Communications transmitted for hire or material compensation, except as
      otherwise provided in the rules
B. Communications that have a political content, except as allowed by the
      Fairness Doctrine
C. Communications that have a religious content
D. Communications in a language other than English
```

Based on the previous two questions, you should be able to spot that Answer **A** is the one that matches the regulations in part 97.

E1F12 (D) [97.311]
FCC-licensed amateur stations may use spread spectrum (SS) emissions to communicate under which of the following conditions?
A. When the other station is in an area regulated by the FCC
B. When the other station is in a country permitting SS communications
C. When the transmission is not used to obscure the meaning of any communication
D. All of these choices are correct

Each of the statements made in Answers A, B, and C are correct statements so the best choice is Answer **D**.

E1F13 (C) [97.311]
What is the maximum transmitter power for an amateur station transmitting spread spectrum communications?
A. 1 W
B. 1.5 W
C. 100 W
D. 1.5 kW

The regulations in Part 97 state that for SS communications, the “transmitter power must not exceed 100 W under any circumstances.” Answer **C** has the correct maximum power.

E1F14 (D) [97.317]
Which of the following best describes one of the standards that must be met by an external RF power amplifier if it is to qualify for a grant of FCC certification?
A. It must produce full legal output when driven by not more than 5 watts of mean RF input power
B. It must be capable of external RF switching between its input and output networks
C. It must exhibit a gain of 0 dB or less over its full output range
D. It must satisfy the FCC's spurious emission standards when operated at its full output power

There are many restrictions of RF power amplifiers in Part 97. The restrictions start with “the amplifier must satisfy the spurious emission standards ... when the amplifier is ... Operated at its full output power ....” Answer **D** captures this part of the regulations.

E1F15 (B) [97.201]
Who may be the control operator of an auxiliary station?
A. Any licensed amateur operator
B. Only Technician, General, Advanced or Amateur Extra Class operators
C. Only General, Advanced or Amateur Extra Class operators
D. Only Amateur Extra Class operators

The regulations in Part 97 state that a “holder of a Technician, Technician Plus, General, Advanced or Amateur Extra Class operator license may be the control operator of an auxiliary station, subject to the privileges of the class of operator license held.” Answer **B** is the one that is closest to the regulations.

```
E1F16 (C) [97.117]
What types of communications may be transmitted to amateur stations in foreign
countries?
A. Business-related messages
B. Automatic retransmissions of any amateur communications
C. Communications incidental to the purpose of the amateur service and remarks
      of a personal nature
D. All of these choices are correct
```

Answer **C** captures the Part 97 regulation that states "[t]ransmissions to a different country, where permitted, shall be limited to communications incidental to the purposes of the amateur service and to remarks of a personal character."

```
E1F17 (A) [1.931]
Under what circumstances might the FCC issue a "Special Temporary Authority"
(STA) to an amateur station?
A. To provide for experimental amateur communications
B. To allow regular operation on Land Mobile channels
C. To provide additional spectrum for personal use
D. To provide temporary operation while awaiting normal licensing
```

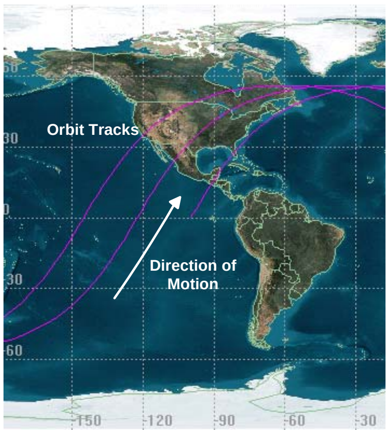
On the FCC's Web site, they state that the "Federal Communications Commission (FCC) grants Special Temporary Authority (STA) to permit immediate or temporary operation of certain private radio facilities during emergencies or other urgent conditions. STA may be granted in the following circumstances:

1. In emergency situations, such as natural disasters
2. To permit restoration or relocation of existing facilities to continue communication service
3. To conduct tests to determine necessary data for the preparation of an application for regular authorization
4. For a temporary, non-recurring service where a regular authorization is not appropriate
5. In other situations involving circumstances which are of such extraordinary nature that delay in the institution of temporary operation would seriously prejudice the public interest.

Answer **A** is the only circumstance that would meet the requirements for an STA.

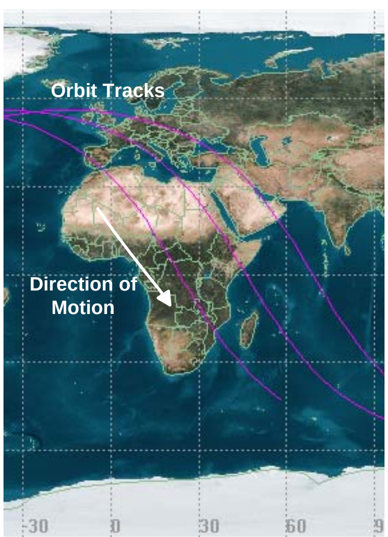
Subelement E2 - Operating Practices and Procedures

E2A01 (C)
What is the direction of an ascending pass for an amateur satellite?
A. From west to east
B. From east to west
C. From south to north
D. From north to south



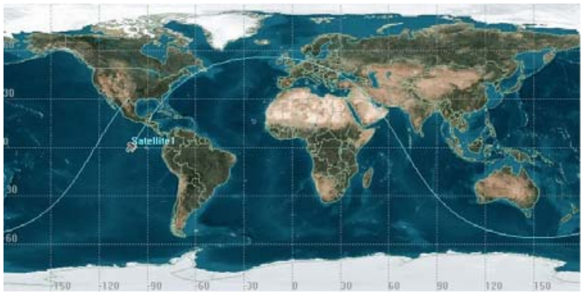
Ascending and descending are defined for a satellite's motion referenced to the equator. Only the north or south motion is important and not the east-west motion. If the satellite is moving from south to north, then it makes an ascending pass so the correct answer is **C**. Answer D is a descending pass.

E2A02 (A)
What is the direction of a descending pass for an amateur satellite?
A. From north to south
B. From west to east
C. From east to west
D. From south to north



As we saw in the previous question, we only need be concerned with north and south orbital motions. Descending is a north-to-south motion so the correct choice is answer **A**. Answer D is an ascending pass.

E2A03 (C)
What is the orbital period of a satellite?
A. The point of maximum height of a satellite's orbit
B. The point of minimum height of a satellite's orbit
C. The time it takes for a satellite to complete one revolution around the Earth
D. The time it takes for a satellite to travel from perigee to apogee



The period is the time it takes a satellite to complete one orbit so the correct choice is answer **C**. The maximum height of an orbit is the apogee so answer A is incorrect. The minimum height of an orbit is the perigee so answer B is incorrect. The time from apogee to perigee is one-half an orbit so it is incorrect as well.

E2A04 (B)
What is meant by the term "mode" as applied to an amateur radio satellite?
A. The type of signals that can be relayed through the satellite
B. The satellite's uplink and downlink frequency bands
C. The satellite's orientation with respect to the Earth
D. Whether the satellite is in a polar or equatorial orbit

In satellite operations, there are sever modes possible. In particular, this question is asking about communications modes in the satellites. The following table summarizes the modes to be remembered.

Mode	**Satellite Receiving**	**Satellite Transmitting**
V/H	VHF	HF
U/V	UHF	VHF
V/U	VHF	UHF
L/U	L-Band	UHF

Answer **B** captures the sense of the communications modes so be sure to choose this answer.

E2A05 (D)
What do the letters in a satellite's mode designator specify?
A. Power limits for uplink and downlink transmissions
B. The location of the ground control station
C. The polarization of uplink and downlink signals
D. The uplink and downlink frequencies

As we can see from the table in Question E2A04, the modes designate the uplink and downlink frequencies used in the communications. Answer **D** matches this usage.

E2A06 (A)
On what band would a satellite receive signals if it were operating in mode U/V?
A. 432 MHz
B. 144 MHz
C. 50 MHz
D. 28 MHz

Using the table in Question E2A04, the satellite would receive on the UHF band. Of these choices, only the 432 MHz of Answer A is in the UHF so it is the frequency to choose. Note: this frequency does not match the recommended satellite frequency in the Band Plan for 70 cm.

E2A07 (D)
Which of the following types of signals can be relayed through a linear transponder?
A. FM and CW
B. SSB and SSTV
C. PSK and Packet
D. All these answers are correct

Since each of the signals mentioned in Answers A, B, and C can be relayed through a linear transponder, the correct response is Answer **D**.

E2A08 (B)
What is the primary reason for satellite users to limit their transmit ERP?
A. For RF exposure safety
B. Because the satellite transmitter output power is limited
C. To avoid limiting the signal of the other users
D. To avoid interfering with terrestrial QSOs

The satellite illustrated in Question E1D02 generated only 15 W and allocated 5 W to the communications system. This may be an extreme example but it illustrates the concept. Satellites have limited power and so they must limit their EIRP. This makes Answer **B** the best choice among those given.

E2A09 (A)
What do the terms L band and S band specify with regard to satellite communications?
A. The 23 centimeter and 13 centimeter bands
B. The 2 meter and 70 centimeter bands
C. FM and Digital Store-and-Forward systems
D. Which sideband to use

L Band is also known as the 23 cm band while S Band is also known as the 13 cm band so Answer **A** is the correct answer to choose.

E2A10 (A)
Why may the received signal from an amateur satellite exhibit a rapidly repeating fading effect?
A. Because the satellite is rotating
B. Because of ionospheric absorption
C. Because of the satellite's low orbital altitude
D. Because of the Doppler effect

Satellite designers often spin the satellite to improve its pointing stability so a rapid fading effect can be due to a rotating satellite and answer **A** is the right choice.

```
E2A11 (B)
What type of antenna can be used to minimize the effects of spin modulation
and Faraday rotation?
A. A linearly polarized antenna
B. A circularly polarized antenna
C. An isotropic antenna
D. A log-periodic dipole array
```

It is impossible to have a strictly nonpolarized antenna so answer A is eliminated. The antenna in answer D is a directional antenna so spin modulation could be a problem which makes this answer a bad choice as well. The two reasonable choices here are answers B and C. Do not be distracted by answer C since an isotropic antenna radiates in all direction, it might seem to be a good choice. However, this ignores the polarization orientation which might be affected by spin modulation. The best choice among the answers given is answer **B** since circular polarization will not be affected by the spin of the satellite.

```
E2A12 (D)
What is one way to predict the location of a satellite at a given time?
A. By means of the Doppler data for the specified satellite
B. By subtracting the mean anomaly from the orbital inclination
C. By adding the mean anomaly to the orbital inclination
D. By calculations using the Keplerian elements for the specified satellite
```

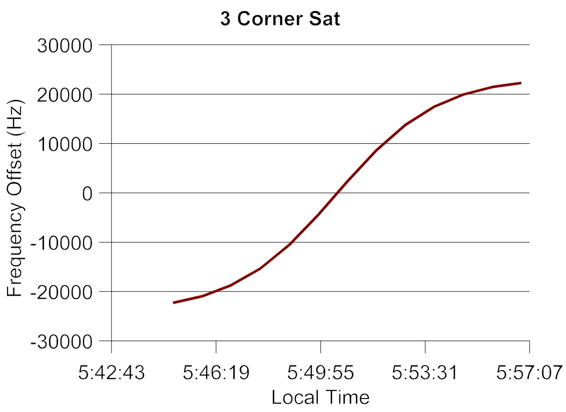
Doppler data alone will not tell the user how to find the satellite so answer A is incorrect. Answers B and C are technobabble to the satellite analyst. Only answer **D**, of the choices given, can be used to find the satellite. The Keplerian elements for a satellite are given in the box.

```
AO-10
1 14129U 83058B 07360.87514120 .00000219 00000-0 10000-3 0 04569
2 14129 025.9518 238.8531 6043489 084.8473 337.1960 02.05867970184531
```

```
E2A13 (B)
What type of satellite appears to stay in one position in the sky?
A. HEO
B. Geosynchronous
C. Geomagnetic
D. LEO
```

This is a quick way to describe a Geosynchronous (or Geostationary or GEO) satellite. Answer **B** is the right choice.

```
E2A14 (B)
What happens to a satellite's transmitted signal due to the Doppler Effect?
A. The signal strength is reduced as the satellite passes overhead
B. The signal frequency shifts lower as the satellite passes overhead
C. The signal frequency shifts higher as the satellite passes overhead
D. The polarization of the signal continually rotates
```



The Doppler effect causes frequency shifts in the received signal as shown in the graphic. The sense of the frequency shift is that it starts "high" and drops lower as the satellite goes overhead. This effect is captured in Answer **B**.

```
E2B01 (A)[edited]
How many times per second is a new frame transmitted in a fast-scan (NTSC)
television system
A. 30
B. 60
C. 90
D. 120
```

This is one of those questions whose answer must be memorized if your are not familiar with fast-scan TV (the type of TV used in commercial broadcast). The correct choice is 30 frames a second as in answer **A**. Be careful with answer B because that is the frequency of the AC in the normal power system. Answers C and D are merely to distract you.

```
E2B02 (C)
How many horizontal lines make up a fast-scan (NTSC) television frame?
A. 30
B. 60
C. 525
D. 1080
```

This is the next question in a series about fast-scan TV whose answer must be memorized if you are not familiar with fast-scan TV. The correct answer is 525 as in answer **C**. Be careful because answer A is the response to the previous question and answer B is the power frequency. Answer D is just a distraction.

```
E2B03 (D)
How is an interlace scanning pattern generated in a fast-scan (NTSC)
television system?
A. By scanning two fields simultaneously
B. By scanning each field from bottom to top
C. By scanning lines from left to right in one field and right to left in the
      next
D. By scanning odd numbered lines in one field and even numbered ones in the
      next
```

Yet another question on fast-scan TV. The TV system uses an alternating pattern from one scan to the next so answer **D** is the correct choice. The other suggested answers do not tell how TV scans are done so they are here to distract you.

E2B04 (B)
What is blanking in a video signal?
A. Synchronization of the horizontal and vertical sync pulses
B. Turning off the scanning beam while it is traveling from right to left or from bottom to top
C. Turning off the scanning beam at the conclusion of a transmission
D. Transmitting a black and white test pattern

A blanking signal blanks the screen so answers B and C are the best answers to choose from. The blanking signal occurs at the end of each scan so answer **B** is the right choice. Answer C is not correct because it only occurs at the end of the transmission. Answers A and D are just to distract you.

E2B05 (C)
Which of the following is an advantage of using vestigial sideband for standard fast scan TV transmissions?
A. The vestigial sideband carries the audio information
B. The vestigial sideband contains chroma information
C. Vestigial sideband reduces bandwidth while allowing for simple video detector circuitry
D. Vestigial sideband provides high frequency emphasis to sharpen the picture

A vestige implies a little bit of the original is left over. In this case, vestigial side band is basically single side band with a vestige of the second side band left. This technology achieves much of the bandwidth reduction goal of SSB but the technology required to demodulate the signal is much simpler than that needed for pure SSB. Answer C captures these technical goals.

E2B06 (A)
What is vestigial sideband modulation?
A. Amplitude modulation in which one complete sideband and a portion of the other sideband is transmitted
B. A type of modulation in which one sideband is inverted
C. Narrow-band FM transmission achieved by filtering one sideband from the audio before frequency modulating the carrier
D. Spread spectrum modulation achieved by applying FM modulation following single sideband amplitude modulation

As we described in the previous question, vestigial side band is SSB with a vestige of the second sideband also transmitted as described in Answer **A**.

E2B07 (B)
What is the name of the video signal component that carries color information?
A. Luminance
B. Chroma
C. Hue
D. Spectral Intensity

Color information is carried in the chroma signal so look for Answer **B**.

E2B08 (D)
Which of the following is a common method of transmitting accompanying audio with amateur fast-scan television?
A. Frequency-modulated sub-carrier
B. A separate VHF or UHF audio link
C. Frequency modulation of the video carrier
D. All of these choices are correct

Since each method listed in Answers A, B, and C is in common use, the best choice is Answer **D**.

E2B09 (D)
What hardware, other than a transceiver with SSB capability and a suitable computer, is needed to decode SSTV based on Digital Radio Mondiale (DRM)?
A. A special IF converter
B. A special front end limiter
C. A special notch filter to remove synchronization pulses
D. No other hardware is needed

Modern computer-based technology makes many modes easily accessible. As in Answer **D**, no other equipment is needed for DRM!

E2B10 (A)
Which of the following is an acceptable bandwidth for Digital Radio Mondiale (DRM) based voice or SSTV digital transmissions made on the HF amateur bands?
A. 3 KHz
B. 10 KHz
C. 15 KHz
D. 20 KHz

The key to answering this question is to notice in the question statement that the emission is based on voice. With that clue, you should be able to spot the 3 kHz of Answer **A** as the correct choice.

E2B11 (B)
What is the function of the Vertical Interval Signaling (VIS) code transmitted as part of an SSTV transmission?
A. To lock the color burst oscillator in color SSTV images
B. To identify the SSTV mode being used
C. To provide vertical synchronization
D. To identify the callsign of the station transmitting

You need to remember that the VIS code is to identify the SSTV mode being used as indicated in Answer **B**.

E2B12 (D)
How are analog slow-scan television images typically transmitted on the HF bands?
A. Video is converted to equivalent Baudot representation
B. Video is converted to equivalent ASCII representation
C. Varying tone frequencies representing the video are transmitted using FM.
D. Varying tone frequencies representing the video are transmitted using single sideband

If you remember that FM is generally not used on the FM bands while SSB is used very frequently, you should be able to remember that SSB of Answer **D** is the right choice.

E2B13 (C)
How many lines are commonly used in each frame on an amateur slow-scan color television picture?
A. 30 to 60
B. 60 or 100
C. 128 or 256
D. 180 or 360

Here we start a series of technical specification questions about slow-scan television. The correct choice of 128 or 256 is given in answer **C**. The others are to distract you.

E2B14 (A)
What aspect of an amateur slow-scan television signal encodes the brightness of the picture?
A. Tone frequency
B. Tone amplitude
C. Sync amplitude
D. Sync frequency

In SSTV, the tone frequency encodes the brightness of the picture so Answer **A** is the correct choice.

E2B15 (A)
What signals SSTV receiving equipment to begin a new picture line?
A. Specific tone frequencies
B. Elapsed time
C. Specific tone amplitudes
D. A two-tone signal

As we saw in E2B12, tone frequencies are used to encode the picture for transmission in SSTV. Therefore the answer "specific tone frequencies," as listed in Answer A, is the method used to signal the beginning of a new picture line.

E2B16 (D)
Which of the following is the video standard used by North American Fast Scan ATV stations?
A. PAL
B. DRM
C. Scottie
D. NTSC

The video standard used in fast scan ATV and commercial broadcast is the "NTSC" standard. This makes Answer **D** the correct choice to answer this question.

E2B17 (A)
Which of the following is NOT a characteristic of FMTV (Frequency-Modulated Amateur Television) as compared to vestigial sideband AM television?
A. Immunity from fading due to limiting
B. Poor weak signal performance
C. Greater signal bandwidth
D. Greater complexity of receiving equipment

Here we are looking for a *false* statement. Each of the statements in answers B, C, and D is true when comparing FM to VSB television transmission so they are not the right answer here. Answer **A** is a false statement so it is the right choice to answer this question.

E2B18 (B)
What is the approximate bandwidth of a slow-scan TV signal?
A. 600 Hz
B. 3 kHz
C. 2 MHz
D. 6 MHz

As we saw in E2B12, SSB transmission is used. This make sit easy to remember that it uses about the same bandwidth as SSB phone or about 3 kHz. Answer B is the right choice for the answer.

E2B19 (D)
On which of the following frequencies is one likely to find FMTV transmissions?
A. 14.230 MHz
B. 29.6 MHz
C. 52.525 MHz
D. 1255 MHz

If you wish to try FMTV, look around 1255 MHz as indicated in Answer D.

E2B20 (C)
What special operating frequency restrictions are imposed on slow scan TV transmissions?
A. None; they are allowed on all amateur frequencies
B. They are restricted to 7.245 MHz, 14.245 MHz, 21.345, MHz, and 28.945 MHz
C. They are restricted to phone band segments and their bandwidth can be no greater than that of a voice signal of the same modulation type
D. They are not permitted above 54 MHz

We have been hinting about this restriction in the earlier questions. As we saw, the SSTV signals need to be similar to a phone emission in bandwidth so Answer **C** is the right choice.

E2B21 (B) [NEW, adapted from E2B16]
If 100 IRE units correspond to the most-white level in the NTSC standard video format, what is the level of the most-black signal?
A. 140 IRE units
B. 7.5 IRE units
C. 0 IRE units
D. -40 IRE units

You might suspect that if white were 100 IRE units then black must be 0 IRE units but that is not the case. Black is set a bit higher than that at 7.5 IRE units. This makes Answer **B** the right choice.

E2C01 (A)
Which of the following is true about contest operating?
A. Operators are permitted to make contacts even if they do not submit a log
B. Interference to other amateurs is unavoidable and therefore acceptable
C. It is mandatory to transmit the call sign of the station being worked as part of every transmission to that station
D. Every contest requires a signal report in the exchange

Each of the statements in Answers B, C, and D is either incorrect or bad amateur practice. Therefore, Answer **A** is the best choice to answer this question.

```
E2C02 (A)
Which of the following best describes "self spotting" in regards to contest
operating?
A. The generally prohibited practice of posting one's own call sign and
      frequency on a call sign spotting network
B. The acceptable practice of manually posting the call signs of stations on a
      call sign spotting network
C. A manual technique for rapidly zero beating or tuning to a station's
      frequency before calling that station
D. An automatic method for rapidly zero beating or tuning to a station's
      frequency before calling that station
```

During a contest, it is generally against the rules to solicit contacts. The practice of “self spotting” can be thought of as a form of soliciting contacts hence the practice is prohibited as given in Answer **A.**

```
E2C03 (A)
From which of the following bands is amateur radio contesting generally
excluded?
A. 30 meters
B. 6 meters
C. 2 meters
D. 33 cm
```

Generally 30 meters, with its limited operating modes available and need to avoid interference with other services, is not a contesting band. This makes Answer A the right choice.

```
E2C04 (D)
On which of the following frequencies is an amateur radio contest contact
generally discouraged?
A. 3.525 MHz
B. 14.020 MHz
C. 28.330 MHz
D. 146.52 MHz
```

The National Simplex Calling Frequency on 2 meters at 146.52 MHz is not a good location to conduct a contest QSO since it is reserved in the Band Plan for other uses. Be sure to choose Answer **D** as the correct response.

```
E2C05 (B) [97.301]
Which of the following frequencies would generally be acceptable for U.S.
stations to work other U.S. stations in a phone contest?
A. 5405 kHz
B. 14.310 MHz
C. 50.050 MHz
D. 146.52 MHz
```

The only choice that is in the phone section of the band and not the simplex calling frequency is the choice of 14.310 MHz as given in Answer B.

E2C06 (C)
During a VHF/UHF contest, in which band segment would you expect to find the highest level of activity?
A. At the top of each band, usually in a segment reserved for contests
B. In the middle of each band, usually on the national calling frequency
C. In the weak signal segment of the band, with most of the activity near the calling frequency
D. In the middle of the band, usually 25 kHz above the national calling frequency

Since there is no “reserved segment” for contesting, you should be able to spot answer A as being a distraction. Here a bit of reasoning will get you to the right answer. For a contest, you will typically be trying to work weak signal stations so go to the weak signal part of the band as mentioned in answer **C** so that is the right choice. The middle of the band around the calling frequency might seem to be reasonable but not for contests.

E2C07 (A)
What is the Cabrillo format?
A. A standard for organizing information in contest log files
B. A method of exchanging information during a contest QSO
C. The most common set of contest rules
D. The rules of order for meetings between contest sponsors

If you start contesting, you will typically be requested to submit contest logs in Cabrillo format. Answer **A** matches this term.

E2C08 (A)
Why are received spread-spectrum signals resistant to interference?
A. Signals not using the spectrum-spreading algorithm are suppressed in the receiver
B. The high power used by a spread-spectrum transmitter keeps its signal from being easily overpowered
C. The receiver is always equipped with a digital blanker circuit
D. If interference is detected by the receiver it will signal the transmitter to change frequencies

Spread spectrum will tend to reject signals not aligned with its spreading code so Aanswer **A** is the right choice. While spread spectrum signals are power limited, this reasoning in answer B is not true so it is eliminated. Answer C does not really describe what is happening technically so it is not a good choice. Answer D would make for a good receiver but it does not explain spread spectrum.

E2C09 (D)
How does the spread-spectrum technique of frequency hopping (FH) work?
A. If interference is detected by the receiver it will signal the transmitter to change frequencies
B. If interference is detected by the receiver it will signal the transmitter to wait until the frequency is clear
C. A pseudo-random binary bit stream is used to shift the phase of an RF carrier very rapidly in a particular sequence
D. The frequency of the transmitted signal is changed very rapidly according to a particular sequence also used by the receiving station

Frequency hopping deals with changing the carrier frequency at the transmitter. The answer in choice **D** is the only one that explains how frequency hopping spread spectrum works so it is the right answer here. Answer A would be a nice feature if one could invent a popular-priced transceiver that works this way. Answer B is best done by the operators but it is not a transceiver feature. Answer C is direct sequence spread spectrum so it is close to the desired answer here but not the right kind of spread spectrum for this question.

```
E2C10 (D)
Why might a phone DX station state that he is listening on another frequency?
A. Because the DX station may be transmitting on a frequency that is
      prohibited to some responding stations
B. To separate the calling stations from the DX station
C. To reduce interference, thereby improving operating efficiency
D. All of these choices are correct
```

Each of the statements in Answers A, B, and C is a good reason which makes Answer **D** the best choice among those given.

```
E2C11 (A)
How should you generally sign your call when attempting to contact a DX
station working a "pileup" or in a contest?
A. Send your full call sign once or twice
B. Send only the last two letters of your call sign until you make contact
C. Send your full call sign and grid square
D. Send the call sign of the DX station three times, the words "this is", then
      your call sign three times
```

A “pileup” means that there are a great number of operators trying to work that station. To give everyone a fair shot at making the QSO, efficiency is required. In this case, only send your call sign once or twice as suggested in Answer **A**.

```
E2C12 (B)
In North America during low sunspot activity, when signals from Europe become
weak and fluttery across an entire HF band two to three hours after sunset,
what might help to contact other European DX stations?
A. Switch to a higher frequency HF band
B. Switch to a lower frequency HF band
C. Wait 90 minutes or so for the signal degradation to pass
D. Wait 24 hours before attempting another communication on the band
```

The “weak and fluttery after sunset” condition indicates that the band conditions are deteriorating. One can continue to operate by changing frequencies. In this case, you wish to operate at a lower frequency because the MUF has moved lower as well so answer **B** is the correct choice. Answer A is moving the frequency in the wrong direction so this is not a good choice.

```
E2D01 (B)
What does "command mode" mean in packet operations?
A. Your computer is ready to run packet communications software
B. The TNC is ready to receive instructions via the keyboard
C. Your TNC has received a command packet from a remote TNC
D. The computer is ready to be set up to communicate with the TNC
```

```
cmd:port
PORT      2
cmd:myc
MYCALL    W5GB-7/W5GB-7
cmd:f
FLOW      OFF
cmd:conm
CONMODE   TRANS
cmd:
```

Example TNC commands and responses

Even if you are not familiar with the operation of TNCs, the right answer to this question should be easy to spot. Only choices B and C refer to a command situation, hence the "CMD:". Answer **B** is the correct choice since it is the standard packet station command mode prompt. Answer C is incorrect because commands only go to the TNC and not your computer.

```
E2D02 (A)
What is the definition of "baud"?
A. The number of data symbols transmitted per second
B. The number of characters transmitted per second
C. The number of characters transmitted per minute
D. The number of words transmitted per minute
```

A baud is defined as "A unit of signaling speed equal to the number of discrete signal conditions, variations, or events per second." (See http://www.atis.org/tg2k/). This makes Answer **A** the correct defintion.

```
E2D03 (A)
Which of the follow is true when comparing HF and 2-meter packet operations?
A. HF packet typically uses FSK with a data rate of 300 baud; 2-meter packet
      uses AFSK with a data rate of 1200 baud
B. HF packet and 2-meter packet operations use different codes for information
      exchange
C. HF packet is limited to Amateur Extra class amateur licensees; 2-meter
      packet is open to all but Novice Class amateur licensees
D. HF and 2-meter packet operations are both limited to CW/Data-only band
      segments
```

If you have been operating on the various packet modes, you will recognize that HF tends to use FSK while 2-m tends to use AFSK. Answer **A** matches these typical operating modes.

```
E2D04 (C)
What is the purpose of digital store-and-forward functions on an Amateur
satellite?
A. To upload operational software for the transponder
B. To delay download of telemetry until the satellite is over the control
      station
C. To store digital messages in the satellite for later download by other
      stations
D. To relay messages between satellites
```

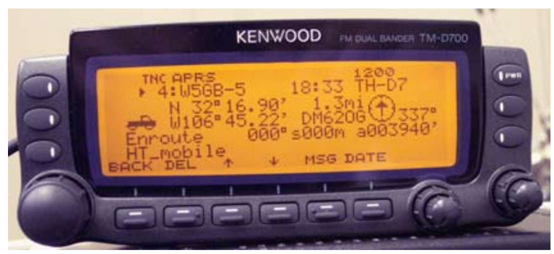
Because satellite pass over various users on the earth, they make for convenient mail box drops for messages. This is known as store and forward communications and it is properly described in answer **C** so this is the best choice for this question. As suggested in answer D, the messages could, eventually, be sent between satellites but this does not happen on a regular basis at this time so this is not a good choice for the right answer.

E2D05 (B)
Which of the following techniques is normally used by low-earth orbiting digital satellites to relay messages around the world?
A. Digipeating
B. Store-and-forward
C. Multi-satellite relaying
D. Node hopping

Since LEO satellites cannot see large segments of the world at once, messages need to be sent via store and forward mode which allows receivers to pick up their messages from the satellite "mail box" as the satellite flies overhead. This makes answer **B** the best choice among those given. Digipeating in answer A is an immediate mode so if the receiver cannot see the satellite at that moment, the message is lost. Answer C would be a great service if it existed but this capability does not exist in current amateur satellite systems so this is not a good choice. Answer D works on the ground but not in satellites themselves so this choice is also a distraction.

E2D06 (B)
Which of the following is a commonly used 2-meter APRS frequency?
A. 144.20 MHz
B. 144.39 MHz
C. 145.02 MHz
D. 146.52 MHz

APRS radio tuning



APRS message

The typical VHF band frequency for APRS operation is 144.39 so the correct choice here is answer **B**. The other answers are to see if you are familiar with APRS.

E2D07 (A)
Which of the following digital protocols is used by APRS?
A. AX.25
B. 802.11
C. PACTOR
D. AMTOR

The APRS system is based on the amateur AX.25 packet protocol so answer **A** is the right choice. Answer B is the 802.11 wireless communications protocol found in the commercial telecommunications industry and it is not used on amateur frequencies. Answers C and D are amateur digital modes but APRS does not use them so they are eliminated here.

E2D08 (D)
Which of the following types of packet frames is used to transmit APRS beacon data?
A. Connect frames
B. Disconnect frames
C. Acknowledgement frames
D. Unnumbered Information frames

Here, you need to remember that beacon data is information data that is sent on a periodic basis. In the AX.25 protocol, this type of data is sent in an information frame so answer **D** is the right choice here. Beacons are not connected-mode services so answers A and B are not correct. Beacon data does not get an acknowledgment so answer C is not a good choice either.

E2D09 (D)
Under clear communications conditions, which of these digital communications modes has the fastest data throughput?
A. AMTOR
B. 170-Hz shift, 45 baud RTTY
C. PSK31
D. 300-baud packet

For fastest throughput in these conditions (assumed to be error-free transmission), the highest data rate is needed. Of the choices given, 300-baud packet has the highest throughput so answer **D** is the right choice. PSK31 has a data rate of 31 bits per second so this is not a good choice. Both AMTOR and RTTY have data rates below 100 bps so these are slower as well.

E2D10 (C)
How can an APRS station be used to help support a public service communications activity?
A. An APRS station with an emergency medical technician can automatically transmit medical data to the nearest hospital
B. APRS stations with General Personnel Scanners can automatically relay the participant numbers and time as they pass the check points
C. An APRS station with a GPS unit can automatically transmit information to show a mobile station's position during the event
D. All of these choices are correct

APRS transmitters can send limited amounts of data so they would not be good choices for sending medical data in an emergency so answer A is not a good choice. APRS stations do not need General Personal Scanners (whatever they are) for sending information so answer B is not a good choice. Answer **C** fits with typical APRS capabilities so it is the best choice among those listed. Since answers A and B are eliminated, answer D is also eliminated.

E2D11 (D)
Which of the following data sources are needed to accurately transmit your geographical location over the APRS network?
A. The NMEA-0183 formatted data from a Global Positioning System (GPS) satellite receiver
B. The latitude and longitude of your location, preferably in degrees, minutes and seconds, entered into the APRS computer software
C. The NMEA-0183 formatted data from a LORAN navigation system
D. Any of these choices is correct

Each of the methods listed in Answers A, B, and C will work so the best choice is Answer **D**. An example of the NMEA messages is shown below.

$GPGGA,171805.00,3216.90988,N,10645.24164,W,1,04,3.58,1195.8,M,-26.1,M,,*57

time Latitude Longitude Altitude

$GPGLL,3216.90396,N,10645.23970,W,171817.00,A,A*78

Latitude Longitude time

$GPRMC,171832.00,A,3216.89847,N,10645.23717,W,1.773,144.70,281207,,,A*72

time Latitude Longitude Date

```
E2E01 (B)
What is a common method of transmitting data emissions below 30 MHz?
A. DTMF tones modulating an FM signal
B. FSK/AFSK
C. Pulse modulation
D. Spread spectrum
```

Here, you need to know that data is frequently sent via Frequency Shift Keying (FSK) techniques which makes Answer B the choice of interest. FSK is common on the HF bands so answer **B** is the right choice. AFSK is more commonly encountered on VHF and UHF bands.

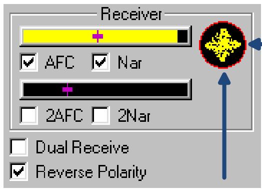
```
E2E02 (A)
What do the letters FEC mean as they relate to digital operation?
A. Forward Error Correction
B. First Error Correction
C. Fatal Error Correction
D. Final Error Correction
```

The telecommunications industry has FEC as a standard acronym for Forward Error Correction so answer **A** is the right choice. Be careful as you read the order of the answers because a quick reading may cause you to select the wrong answer.

```
E2E03 (C)
How is Forward Error Correction implemented?
A. By the receiving station repeating each block of three data characters
B. By transmitting a special algorithm to the receiving station along with the
      data characters
C. By transmitting extra data that may be used to detect and correct
      transmission errors
D. By varying the frequency shift of the transmitted signal according to a
      predefined algorithm
```

There are several different ways to realize FEC in the various digital modes. The one thing that they all have in common is that extra data is transmitted to provide the error detection and correction function. Answer **C** matches this operational principle.

E2E04 (A)
What is indicated when one of the ellipses in an FSK crossed-ellipse display suddenly disappears?
A. Selective fading has occurred
B. One of the signal filters has saturated
C. The receiver has drifted 5 kHz from the desired receive frequency
D. The mark and space signal have been inverted



Most RTTY software uses a pair of ellipses to indicate tuning accuracy. With the propagation effect known as "frequency selective fading", a small region of the radio spectrum undergoes a deep fade as if a narrow filter has been applied. This is what can make one of the ellipses in the terminal unit disappear so answer **A** is the correct choice.

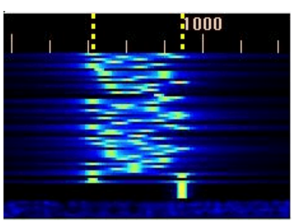
E2E05 (D)
How does ARQ accomplish error correction?
A. Special binary codes provide automatic correction
B. Special polynomial codes provide automatic correction
C. If errors are detected, redundant data is substituted
D. If errors are detected, a retransmission is requested

"ARQ: Abbreviation for automatic repeat-request. Error control for data transmission in which the receiver detects transmission errors in a message and automatically requests a retransmission from the transmitter. Note: Usually, when the transmitter receives the ARQ, the transmitter retransmits the message until it is either correctly received or the error persists beyond a predetermined number of retransmissions." (See http://www.atis.org/tg2k/). Answer **D** matches the standard definition.

E2E06 (C)
What is the most common data rate used for HF packet communications?
A. 48 baud
B. 110 baud
C. 300 baud
D. 1200 baud

Since we are being asked about the HF bands, the data rate will need to be low to match the available bandwidth. If you remember from the General Class studies, there were different maximum rates allowed as a function of band. Here, you need to know that 300 baud is the common rate (not a maximum rate allowed) on HF so answer **C** is the right choice. The other rates are to distract you.

E2E07 (B)
What is the typical bandwidth of a properly modulated MFSK16 signal?
A. 31 Hz
B. 316 Hz
C. 550 Hz
D. 2 kHz



MFSK16 is relatively narrow-band compared with SSB or FM. The correct answer is 316 Hz as in answer **B**. Answer A is similar to that for PSK31 so it is not a correct choice. Answers C and D are too wide for MFSK16.

```
E2E08 (B)
Which of the following HF digital modes can be used to transfer binary files?
A. Hellschreiber
B. PACTOR
C. RTTY
D. AMTOR
```

Hellschreiber, RTTY, and AMTOR were all designed to send printed text as their primary operating modes so answers A, C, and D are not good choices here. PACTOR can be used for binary file transport so answer **B** is the best choice among those given.

```
E2E09 (D)
Which of the following HF digital modes uses variable-length coding for
bandwidth efficiency?
A. RTTY
B. PACTOR
C. MT63
D. PSK31
```

In a sense, PSK 31 works like Morse Code in that each character is given a length depending upon its frequency of use in text messages. This results in variable-rate codes for characters. PSK31, as in Answer D, uses this methodology.

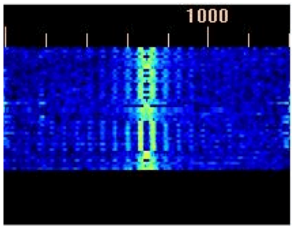
```
E2E10 (C)
Which of the following HF digital modes use error-correction coding?
A. MFSK16
B. RTTY
C. QPSK
D. All of these answers are correct
```

This is a slightly misleading question the way the answers are phrased. Technically, QPSK or Quadrature Phase Shift Keying, is a digital modulation format where two bits are sent simultaneously. In PSK31, there is a “QPSK mode” where data and error-correcting bits are sent together. That is the sense of Answer **C** when its lists QPSK as an error correcting mode.

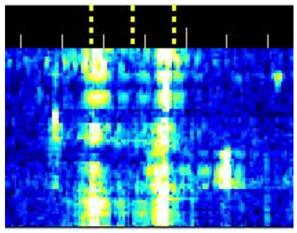
```
E2E11 (D)
What is the Baudot code?
A. A code used to transmit data only in modern computer-based data systems
      using seven data bits
B. A binary code consisting of eight data bits
C. An alternate name for Morse code
D. The International Telegraph Alphabet Number 2 (ITA2) which uses five data
      bits
```

For this question you need to know that a Baudot code is a digital code using 5 bits so you should be able to spot answer **D** as the right choice.

E2E12 (C)
Which of these digital communications modes has the narrowest bandwidth?
A. MFSK16
B. 170-Hz shift, 45 baud RTTY
C. PSK31
D. 300-baud packet



BPSK



RTTY

This is related to the earlier question. PSK31 has a bandwidth of approximately 50 Hz so it is the narrowest of those given and answer **C** is the right choice.

Subelement E3 -- Radio Wave Propagation

```
E3A01 (D)
What is the approximate maximum separation along the surface of the Earth
between two stations communicating by moonbounce?
A. 500 miles if the moon is at perigee
B. 2000 miles, if the moon is at apogee
C. 5000 miles, if the moon is at perigee
D. 12,000 miles, as long as both can "see" the moon
```

Given the great distance to the moon, atmospheric refraction, mutual lunar visibility etc., the best general answer that the question designers could come up with is answer **D**. Answers A, B, and C are more typical for atmospheric propagation and not reflecting off the moon.

```
E3A02 (B)
What characterizes libration fading of an earth-moon-earth signal?
A. A slow change in the pitch of the CW signal
B. A fluttery irregular fading
C. A gradual loss of signal as the sun rises
D. The returning echo is several Hertz lower in frequency than the transmitted
      signal
```

Libration fading is caused by irregularities in the surface of the moon and changing viewing angle as the moon moves relative to the radio operators. This will be indicated by a fade in the signal as mentioned in answer **B** so that is the right choice here. It does not change the pitch of the CW signal so answer A is not correct. It is not a function of the sun angle so answer C is also incorrect. The libration motion does not cause a Doppler shift so answer D is not correct either.

```
E3A03 (A)
When scheduling EME contacts, which of these conditions will generally result
in the least path loss?
A. When the moon is at perigee
B. When the moon is full
C. When the moon is at apogee
D. When the MUF is above 30 MHz
```

Path loss is proportional to distance so it is natural that the least distance will cause the least path loss. Distance to the moon is not tied with the phase of the moon so answer B is not relevant. The MUF is determined by the conditions in the ionosphere which is not normally related to the moon (even at full moon) so answer D is also eliminated. When the moon is at perigee, it is closest to the earth so answer **A** is the right choice. When the moon is at apogee, it is furthest away and the path loss will be the largest.

```
E3A04 (D) edited A
What type of receiving system is desirable for EME communications?
A. Equipment with very wide bandwidth
B. Equipment with very low dynamic range
C. Equipment with very low gain
D. Equipment with very low noise figures
```

Since the moon is far away and the path loss is usually very large, the transmitter and receiver must be specialized for the task. If the transmitter has a very wide bandwidth, it will have a large amount of background noise swamping the signal making Answer A a bad choice. Since the returning signal will be very weak, a receiver with low dynamic range will not pick up the signal so answers B and C are not a good choices. Equipment with a low noise figure has the best chance of receiving the signal, all other things being equal. Therefore, answer **D** is the best choice among those given.

```
E3A05 (A)
What transmit and receive time sequencing is normally used on 144 MHz when
attempting an EME contact?
A. Two-minute sequences, where one station transmits for a full two minutes
      and then receives for the following two minutes
B. One-minute sequences, where one station transmits for one minute and then
      receives for the following one minute
C. Two-and-one-half minute sequences, where one station transmits for a full
      2.5 minutes and then receives for the following 2.5 minutes
D. Five-minute sequences, where one station transmits for five minutes and
      then receives for the following five minutes
```

This is another one of the operating best practice standards that will need to be memorized if you do not normally operate in this mode. The correct protocol is given in answer **A**. The others are distractions. Be careful with answer C because that is the standard for UHF contacts.

```
E3A06 (C)
What transmit and receive time sequencing is normally used on 432 MHz when
attempting an EME contact?
A. Two-minute sequences, where one station transmits for a full two minutes
      and then receives for the following two minutes
B. One-minute sequences, where one station transmits for one minute and then
      receives for the following one minute
C. Two-and-one-half minute sequences, where one station transmits for a full
      2.5 minutes and then receives for the following 2.5 minutes
D. Five-minute sequences, where one station transmits for five minutes and
      then receives for the following five minutes
```

As we saw above, VHF uses 2-minute contact standards. For UHF, the standard protocol is 2.5-minutes as in answer **C**. Be careful of the VHF standard in answer A. Answers B and D are distractions.

```
E3A07 (B)
What frequency range would you normally tune to find EME stations in the 2
meter band?
A. 144.000 - 144.001 MHz
B. 144.000 - 144.100 MHz
C. 144.100 - 144.300 MHz
D. 145.000 - 145.100 MHz
```

If you consult the band plan, you will see that there is an EME reservation in the weak signal part of the 144 MHz band so the correct choice is answer **B**. Be careful because there is a SSB EME reservation at 144.1 MHz but answer C extends into other modes than EME so this is not as good a choice as answer B. Answers A and D are for other uses so they are not good choices here.

E3A08 (D)
What frequency range would you normally tune to find EME stations in the 70 cm band?
A. 430.000 - 430.150 MHz
B. 430.100 - 431.100 MHz
C. 431.100 - 431.200 MHz
D. 432.000 - 432.100 MHz

The EME portion of the UHF band is in the 432 to 432.1 MHz band so the correct answer is **D**. The other frequencies are for other uses so they are not good choices here.

E3A09 (A)
When a meteor strikes the Earth's atmosphere, a cylindrical region of free electrons is formed at what layer of the ionosphere?
A. The E layer
B. The F1 layer
C. The F2 layer
D. The D layer

The E region of the ionosphere is the layer associated with meteor scatter propagation so the correct answer is **A**. The other ionospheric layers are not associated with meteor scatter so they are not correct choices for this question.

E3A10 (C)
Which range of frequencies is well suited for meteor-scatter communications?
A. 1.8 - 1.9 MHz
B. 10 - 14 MHz
C. 28 - 148 MHz
D. 220 - 450 MHz

The bulk of the meteor scatter contacts seem to be made at 6 meters and 2 meters so the best choice among those given is answer **C**. The other frequency bands are not optimal for meteor scatter contacts.

E3A11 (C)
What transmit and receive time sequencing is normally used on 144 MHz when attempting a meteor-scatter contact?
A. Two-minute sequences, where one station transmits for a full two minutes and then receives for the following two minutes
B. One-minute sequences, where one station transmits for one minute and then receives for the following one minute
C. 15-second sequences, where one station transmits for 15 seconds and then receives for the following 15 seconds
D. 30-second sequences, where one station transmits for 30 seconds and then receives for the following 30 seconds

This is similar to the EME questions earlier. With meteor scatter, the effect is short lived (we’re talking meteors here) so a 2-minute or even a 1-minute sequence might not allow a QSO to happen and answers A and B are not good choices. Answer **C** is the correct protocol so that is the right choice here.

E3B01 (A)
What is transequatorial propagation?
A. Propagation between two points at approximately the same distance north and south of the magnetic equator
B. Propagation between any two points located on the magnetic equator
C. Propagation between two continents by way of ducts along the magnetic equator
D. Propagation between two stations at the same latitude

Transequatorial means across the equator so answers C and D are eliminated. The correct definition is given in answer **A** so that is the right choice. Answer B would be an east-west path and not a north-south path so it is incorrect.

E3B02 (C)
What is the approximate maximum range for signals using transequatorial propagation?
A. 1000 miles
B. 2500 miles
C. 5000 miles
D. 7500 miles

The correct choice here is 5000 miles as in answer **C**. The others are to distract you.

E3B03 (C)
What is the best time of day for transequatorial propagation?
A. Morning
B. Noon
C. Afternoon or early evening
D. Late at night

Afternoons and early evenings are the best time for transequatorial propagation so answer **C** is the best choice for this question. The other times are not optimal for this propagation mode so they are not good choices here.

E3B04 (A)
What type of propagation is probably occurring if an HF beam antenna must be pointed in a direction 180 degrees away from a station to receive the strongest signals?
A. Long-path
B. Sporadic-E
C. Transequatorial
D. Auroral

If you are pointing 180º away from the nominal direction, then you are going the long 'way around so "long path" in Answer **A** is the right choice. For sporadic-E propagation, one needs to point at the ionization region, wherever that may be, so answer B is not correct. For transequatorial, the pointing is generally north-south but in the direct direction so this is not a good choice either. For auroral, one points north so answer D is not a good choice either.

```
E3B05 (C)
Which amateur bands typically support long-path propagation?
A. 160 to 40 meters
B. 30 to 10 meters
C. 160 to 10 meters
D. 6 meters to 2 meters
```

Since UHF tends to be line of sight, answer D is not a good choice. The MF and HF bands are improved by long-path propagation. Answers A and B are included in answer C so answer **C** is the best choice for this question.

```
E3B06 (B)
Which of the following amateur bands most frequently provides long-path
propagation?
A. 80 meters
B. 20 meters
C. 10 meters
D. 6 meters
```

We eliminate answer D since it is too high of a frequency. Most amateurs can only afford a modest antenna either due to cost or space restrictions which will have relatively small gain. This is difficult to achieve on 80 meters so that is not a good choice. 20 meters is a better choice than 10 meters since it is a world-wide band open all day so answer **B** is the best choice for this question.

```
E3B07 (D)
Which of the following could account for hearing an echo on the received
signal of a distant station?
A. High D layer absorption
B. Meteor scatter
C. Transmit frequency is higher than the MUF
D. Receipt of a signal by more than one path
```

An echo is a time-delay version of the signal from a longer path. Answer **D** is a correct description of this effect. Long path is not usually caused by aurora so answer C is not a good choice. Answer A will not cause an echo but a wandering signal across the band so this is not a good choice. A spurious emission will cause a copy of the signal at a different frequency but without an echo so this is also not a good choice.

```
E3B08 (D)
What type of propagation is probably occurring if radio signals travel along
the terminator between daylight and darkness?
A. Transequatorial
B. Sporadic-E
C. Long-path
D. Gray-line
```

Gray-line propagation is associated with the earth's terminator (the line between day and night on the surface of the earth) so answer **D** is the right choice here. Answers A, B, and C are not associated with the terminator so they are not the right choice here.

E3B09 (A) [edited A]
At what time of day is gray-line propagation most prevalent?
A. At sunrise and sunset
B. When the sun is directly above the location of the transmitting station
C. When the sun is directly overhead at the middle of the communications path between the two stations
D. When the sun is directly above the location of the receiving station

For gray-line propagation, the signal travels along the terminator, the line marking the sunrise and sunset regions of the earth. This makes answer A the right choice for this question. Answers B, C, and D describe conditions in full sunlight so they are not good choices.

E3B10 (B)
What is the cause of gray-line propagation?
A. At midday, the sun, being directly overhead, superheats the ionosphere causing increased refraction of radio waves
B. At twilight, solar absorption drops greatly, while atmospheric ionization is not weakened enough to reduce the MUF
C. At darkness, solar absorption drops greatly, while atmospheric ionization remains steady
D. At mid afternoon, the sun heats the ionosphere, increasing radio wave refraction and the MUF

Gray-line propagation occurs along the sunset line so answers A and D can be eliminated since they deal with conditions during the daylight hours. Answer C is incorrect because ionization decreases at night. Answer **B** is the right choice for this question.

E3B11 (C)
What communications are possible during gray-line propagation?
A. Contacts up to 2,000 miles only on the 10-meter band
B. Contacts up to 750 miles on the 6- and 2-meter bands
C. Contacts up to 8,000 to 10,000 miles on three or four HF bands
D. Contacts up to 12,000 to 15,000 miles on the 2 meter and 70 centimeter bands

Since UHF and VHF bands tend to be line of sight, we can eliminate answers B and D for this question. Gray-line propagation is open on several HF bands so answer **C** is the right choice for this question

E3C01 (D)
What effect does auroral activity have on radio communications?
A. Signals experience long-delay echo
B. FM communications are clearer
C. CW signals have a clearer tone
D. CW signals have a fluttery tone

Auroras can cause propagation impairments so answers A, B and C can be eliminated since they would imply that auroras make things better. The correct choice is answer **D** since that is consistent with a propagation impairment.

E3C02 (C)
What is the cause of auroral activity?
A. Reflections in the solar wind
B. A low sunspot level
C. The emission of charged particles from the sun
D. Meteor showers concentrated in the northern latitudes

Auroras are highly correlated with sunspot activity but the sunspots themselves do not cause auroras so answers A and B are eliminated. Meteors do not cause auroras so answer D is eliminated as well. However, the charged particles coming from the sun that are associated with sunspots do cause the auroras so answer **C** is the right choice.

E3C03 (D)
Where in the ionosphere does auroral activity occur?
A. At F-region height
B. In the equatorial band
C. At D-region height
D. At E-region height

The auroras occur mostly in the E region so answer **D** is the right choice. There is no equatorial band so answer B can be eliminated. Answers A and C are to distract you.

E3C04 (A)
Which emission mode is best for auroral propagation?
A. CW
B. SSB
C. FM
D. RTTY

Auroral propagation works best with a narrow-band signal so answer **A** is the best choice since CW has the narrowest bandwidth of the choices given. The other choices have wider bandwidth and can be affected more by the characteristics of auroral propagation.

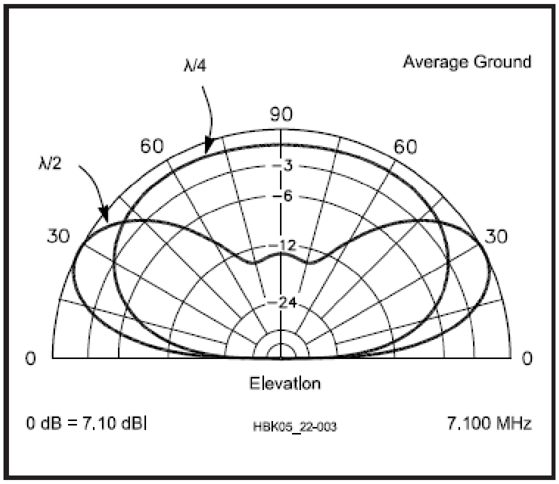
E3C05 (B)
What causes selective fading?
A. Small changes in beam heading at the receiving station
B. Phase differences in the received signal caused by different paths
C. Large changes in the height of the ionosphere
D. Time differences between the receiving and transmitting stations

Selective fading is due to two copies of the same signal arriving at the receiver along separate propagation paths so that they are slightly out of phase with each other. This causes a destructive interference due to the slight phase difference so the correct choice is answer **B**. Answer A is called a pointing error and not a selective fade so it is not the right choice. Answer C is a band collapse and not a narrow frequency fade so it is not the right choice either. Since most rigs do not have a clock built in, answer D is a silly distraction.

E3C06 (A)
How much farther does the VHF/UHF radio-path horizon distance exceed the geometric horizon?
A. By approximately 15% of the distance
B. By approximately twice the distance
C. By approximately one-half the distance
D. By approximately four times the distance

Atmospheric refraction is a 15% level effect so the correct choice is answer **A**. The others are to distract you.

```
E3C07 (B)
How does the radiation pattern of a 3-element, horizontally polarized beam
antenna vary with height above ground?
A. The main lobe takeoff angle increases with increasing height
B. The main lobe takeoff angle decreases with increasing height
C. The horizontal beam width increases with height
D. The horizontal beam width decreases with height
```



The general effect is illustrated in the graphic for a dipole but he 3-element beam will act in a similar way: as the height above the ground increases, the takeoff angle decreases. This makes Answer **B** the correct choice.

Source: 2005 ARRL Handbook, Ver. 9. CD, Chap. 22.

```
E3C08 (B)
What is the name of the high-angle wave in HF propagation that travels for
some distance within the F2 region?
A. Oblique-angle ray
B. Pedersen ray
C. Ordinary ray
D. Heaviside ray
```

This is one of those arcane facts that you can use to amaze your Ham friends: the correct answer is a Pedersen Ray as in answer **B**. There is a Heaviside Layer which is basically the E-layer in the ionosphere but not a Heaviside ray so answer D is to confuse you.

```
E3C09 (C)
What effect is usually responsible for propagating a VHF signal over 500
miles?
A. D-region absorption
B. Faraday rotation
C. Tropospheric ducting
D. Moonbounce
```

Moonbounce will allow VHF propagation over 500 miles but it is not the usual means of doing so, making answer D not the best choice here.   If you think about it, absorption by the D region will not give long propagation so answer A does not make a good choice. Faraday rotation will change the relative phase of the signal but not improve propagation so answer B is not a good choice either. However, ducting, as in answer **C**, will provide the enhanced propagation so this is the best choice among those given.

E3C10 (B)
How does the performance of a horizontally polarized antenna mounted on the side of a hill compare with the same antenna mounted on flat ground?
A. The main lobe takeoff angle increases in the downhill direction
B. The main lobe takeoff angle decreases in the downhill direction
C. The horizontal beam width decreases in the downhill direction
D. The horizontal beam width increases in the uphill direction

This is similar to the earlier question. Think of the downhill direction as providing extra height to the antenna. Based on the previous performance, we would expect that the take-off angle will decrease in that direction. This makes Answer B the right choice.

E3C11 (B)
From the contiguous 48 states, in which approximate direction should an antenna be pointed to take maximum advantage of auroral propagation?
A. South
B. North
C. East
D. West

This question is as obvious as it seems. Auroras occur over the north magnetic pole so if you are in the northern hemisphere, point your antenna north as in answer **B**. The other choices are so see if you are easily confused.

E3C12 (B)
As the frequency of a signal is increased, how does its ground wave propagation change?
A. It increases
B. It decreases
C. It stays the same
D. Radio waves don't propagate along the Earth's surface

Ground wave propagation is strongly frequency dependent and the propagation distance decreases with frequency so the correct answer is **B**. Answer A is just the opposite of the correct effect. Answers C and D are wrong so they can be eliminated.

E3C13 (A)
What type of polarization does most ground-wave propagation have?
A. Vertical
B. Horizontal
C. Circular
D. Elliptical

Typical ground wave propagation is vertically polarized so the correct answer is **A**. The others are to see if you understand propagation basics.

E3C14 (D)
Why does the radio-path horizon distance exceed the geometric horizon?
A. E-region skip
B. D-region skip
C. Auroral skip
D. Radio waves may be bent

Radio waves undergo refraction, which is a bending. This makes the radio horizon about 15% further than the geometric horizon. Therefore, the correct choice is answer **D**. This question is concerned with line-of-sight propagation and not reflections off the ionosphere. Therefore, answers A, B, and C are not relevant here.

Subelement E4 -- Amateur Radio Technology and Measurements

E4A01 (C)
How does a spectrum analyzer differ from a conventional oscilloscope?
A. A spectrum analyzer measures ionospheric reflection; an oscilloscope displays electrical signals
B. A spectrum analyzer displays the peak amplitude of signals; an oscilloscope displays the average amplitude of signals
C. A spectrum analyzer displays signals in the frequency domain; an oscilloscope displays signals in the time domain
D. A spectrum analyzer displays radio frequencies; an oscilloscope displays audio frequencies

Answer A is technobabble and really is engineering nonsense so it can be eliminated from consideration. Answers B and C are very similar so be careful when reading them. Answer **C** has the correct relationship: spectrum analyzer for the frequency domain and oscilloscope for the time domain so this is the correct choice. Answer B has the components reversed so this is not a correct choice. Also be careful with answer D because it does indicate how the instruments are typically used. However, this is not the best choice since this is not the only way in which these instruments can be used so answer C is the better choice.

E4A02 (D)
Which of the following parameters would a typical spectrum analyzer display on the horizontal axis?
A. SWR
B. Q
C. Time
D. Frequency

The spectrum analyzer shows frequency on the horizontal axis (*x-axis*) so answer **D** is the correct choice. Answer A, amplitude, is given on the vertical (*y-axis*) so this is an incorrect choice. Voltage, in answer B is related to amplitude so this would be on the y-axis if this were an oscilloscope so this is also a wrong answer. Resonance is not shown on a spectrum analyzer so answer C is eliminated from consideration.

E4A03 (A)
Which of the following parameters would a typical spectrum analyzer display on the vertical axis?
A. Amplitude
B. Duration
C. SWR
D. Q

As we just saw, the vertical axis of the spectrum analyzer shows signal amplitude so answer **A** is the correct choice here. We know that the frequency is shown on the horizontal axis so answer C is not a correct choice. Time, answer D, is shown on the horizontal axis of the oscilloscope so this is also not a correct choice here. Duration is not shown on a spectrum analyzer so answer B is also not a correct choice.

E4A04 (A)
Which of the following test instruments is used to display spurious signals from a radio transmitter?
A. A spectrum analyzer
B. A wattmeter
C. A logic analyzer
D. A time-domain reflectometer

Spurious signals are frequency-domain concepts so a spectrum analyzer as in answer **A** is the right choice. A wattmeter as in answer B will give signal strength but not display those frequencies so it is not a good choice. A logic analyzer of answer C is for displaying digital baseband signals so it cannot meet the needs here. A time-domain reflectometer is typically used for testing the characteristics and identify faults in cables not transmitters so answer D will not identify spurious signal components in the frequency domain.

```
E4A05 (B)
Which of the following test instruments is used to display intermodulation
distortion products in an SSB transmission?
A. A wattmeter
B. A spectrum analyzer
C. A logic analyzer
D. A time-domain reflectometer
```

This question is similar to the previous one in that we are looking at a frequency domain measurement so the spectrum analyzer of answer **B** is the correct choice. Using the same logic as the previous question, a wattmeter as in answer A will give signal strength but not display those frequencies so it is not a good choice. A logic analyzer of answer C is for displaying digital baseband signals so it cannot meet the needs here. A time-domain reflectometer is more used for testing cables and not IMD so answer D is not a good choice.

```
E4A06 (D)
Which of the following could be determined with a spectrum analyzer?
A. The degree of isolation between the input and output ports of a 2 meter
      duplexer
B. Whether a crystal is operating on its fundamental or overtone frequency
C. The spectral output of a transmitter
D. All of these choices are correct
```

Each of the measurements listed in Answers A, B, and C can be made with a spectrum analyzer so the best choice to answer this question is Answer D.

```
E4A07 (B)
Which of the following is an advantage of using an antenna analyzer vs. a SWR
bridge to measure antenna SWR?
A. Antenna analyzers automatically tune your antenna for resonance
B. Antenna analyzers typically do not need an external RF source
C. Antenna analyzers typically display a time-varying representation of the
      modulation envelope
D. All of the above
```

The statements in Answers A and C are not true so they are not good choices. The antenna analyzer typically does not need an external RF source so Answer B is the right choice.

```
E4A08 (D)
Which of the following instruments would be best for measuring the SWR of a
beam antenna?
A. A spectrum analyzer
B. A Q meter
C. An ohmmeter
D. An antenna analyzer
```

As we saw in the last question, an antenna analyzer, as in Answer **D**, would be a good choice to measure the SWR of a beam antenna.

E4A09 (C)
Which of the following is most important when adjusting PSK31 transmitting levels?
A. Power output
B. PA current
C. ALC level
D. SWR

If you operate PSK31, one of the first things you learn to do to prevent signal splatter is to set your input signal strength from the computer so that the ALC meter level does not move. Answer **C** is chosen because the ALC is very important in preventing spurious emissions.

E4A10 (D)
Which of the following is a useful test for a functioning NPN transistor in an active circuit where the transistor should be biased "on" ?
A. Measure base-to-emitter resistance with an ohmmeter; it should be approximately 6 to 7 ohms
B. Measure base-to-emitter resistance with an ohmmeter; it should be approximately 0.6 to 0.7 ohms
C. Measure base-to-emitter voltage with a voltmeter; it should be approximately 6 to 7 volts
D. Measure base-to-emitter voltage with a voltmeter; it should be approximately 0.6 to 0.7 volts

When a NPN transmitter is "on," its base-to-emitter voltage will be approximately 0.7 V so Answer D is the correct choice.

E4A11 (A)
Which of the following test instruments can be used to indicate pulse conditions in a digital logic circuit?
A. A logic probe
B. An ohmmeter
C. An electroscope
D. A Wheatstone bridge

A logic probe measures digital logic states so the correct choice is Answer **A**. Answers B, C, and D are used for measuring analog signals and not digital pulses so they are not good choices here.

E4A12 (B)
Which of the following procedures is an important precaution to follow when connecting a spectrum analyzer to a transmitter output?
A. Use high quality double shielded coaxial cables to reduce signal losses
B. Attenuate the transmitter output going to the spectrum analyzer
C. Match the antenna to the load
D. All of these choices are correct

Typical spectrum analyzers can tolerate input signal strengths less than 1 W while the signal coming from your transmitter could be as strong as 1.5 kW. Even QRP transmitters may be too strong for most spectrum analyzers. Therefore, as in Answer **B**, you will probably need to attenuate the transmitter output prior to connecting it to the spectrum analyzer input.

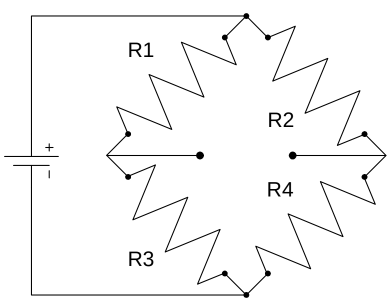
```
E4B01 (B)
Which of the following is a characteristic of a good harmonic frequency
marker?
A. Wide tuning range
B. Frequency stability
C. Linear output amplifier
D. All of the above
```

A good harmonic frequency marker needs to have a high degree of frequency stability as indicated in Answer **B**.

```
E4B02 (B)
Which of the following factors most affects the accuracy of a frequency
counter?
A. Input attenuator accuracy
B. Time base accuracy
C. Decade divider accuracy
D. Temperature coefficient of the logic
```

If designed properly, the counter will only depend on the timing reference so Answer **B** is the right choice for this question. Answers A, C and D are not true for well-designed devices so these are not good choices.

```
E4B03 (C)
What is an advantage of using a bridge circuit to measure impedance?
A. It provides an excellent match under all conditions
B. It is relatively immune to drift in the signal generator source
C. The measurement is based on obtaining a null in voltage, which can be done
     very precisely
D. It can display results directly in Smith chart format
```



A bridge (or Wheatstone bridge) circuit attempts to null out the voltage difference between the both halves. Since this can be done very accurately, it makes a good means to measure impedance as in Answer **C**.

```
E4B04 (C)
If a frequency counter with a specified accuracy of +/- 1.0 ppm reads
146,520,000 Hz, what is the most the actual frequency being measured could
differ from the reading?
A. 165.2 Hz
B. 14.652 kHz
C. 146.52 Hz
D. 1.4652 MHz
```

Here we have a series of questions where the answer is basically computed the same way each time. In each case, notice that if you write the frequency in MHz then it will cancel with the ppm to make the math a bit easier. In full, we take 146,520,000 x (1 ÷ 1,000,000) = 146.52 Hz so answer **C** is the correct choice. The short cut method is 146.52 MHz x 1 ppm = 146.52 Hz so answer **C** is still correct. Answer A is a bad math mistake so it is eliminated from consideration. Answer B represents a +/- 100 ppm measurement so it is incorrect. Answer D represents a +/- 1000 ppm so it is incorrect as well.

E4B05 (A)
If a frequency counter with a specified accuracy of +/- 0.1 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?
A. 14.652 Hz
B. 0.1 MHz
C. 1.4652 Hz
D. 1.4652 kHz

Here we use the same mathematics as the previous question. To determine the reading, we take 146,520,000 x (0.1 ÷ 1,000,000) = 14.652 Hz so answer **A** is the correct choice. Answer B is a bad math mistake so it is eliminated from consideration. Answer C represents a +/- 0.01 ppm measurement so it is incorrect. Answer D represents a +/- 10 ppm so it is incorrect as well.

E4B06 (D)
If a frequency counter with a specified accuracy of +/- 10 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?
A. 146.52 Hz
B. 10 Hz
C. 146.52 kHz
D. 1465.20 Hz

Here we use the same mathematics again. To determine the reading, we take 146,520,000 x (10 ÷ 1,000,000) = 1465.2 Hz so answer **D** is the correct choice. Answer B is a bad math mistake so it is eliminated from consideration. Answer A represents a +/- 1 ppm measurement so it is incorrect. Answer C represents a +/- 1,000 ppm so it is incorrect as well.

E4B07 (D)
How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power?
A. 100 watts
B. 125 watts
C. 25 watts
D. 75 watts

You should be able to compute this one in your head! If 100 W is input and 25 W is reflected, then 75 W must be absorbed by the load. This matches Answer **D**.

E4B08 (A)
Which of the following is good practice when using an oscilloscope probe?
A. Keep the ground connection of the probe as short as possible
B. Never use a high impedance probe to measure a low impedance circuit
C. Never use a DC-coupled probe to measure an AC circuit
D. All of these choices are correct

Oscilloscope probes can pick up interfering signals that will influence measurements. A good way to reduce this from happening is to keep the ground lead as short as possible as indicated in Answer **A**.

E4B09 (C)
Which of the following is a characteristic of a good DC voltmeter?
A. High reluctance input
B. Low reluctance input
C. High impedance input
D. Low impedance input

Good DC voltmeters will have a high input impedance so Answer **C** is the right choice.

E4B10 (D)
What is indicated if the current reading on an RF ammeter placed in series with the antenna feedline of a transmitter increases as the transmitter is tuned to resonance?
A. There is possibly a short to ground in the feedline
B. The transmitter is not properly neutralized
C. There is an impedance mismatch between the antenna and feedline
D. There is more power going into the antenna

This is what happens when the antenna and transmitter are matched and we have maximum power transfer. In this case, the current to the antenna increases and there is more power going to the antenna as indicated in Answer **D**.

E4B11 (B)
Which of the following describes a method to measure intermodulation distortion in an SSB transmitter?
A. Modulate the transmitter with two non-harmonically related radio frequencies and observe the RF output with a spectrum analyzer
B. Modulate the transmitter with two non-harmonically related audio frequencies and observe the RF output with a spectrum analyzer
C. Modulate the transmitter with two harmonically related audio frequencies and observe the RF output with a peak reading wattmeter
D. Modulate the transmitter with two harmonically related audio frequencies and observe the RF output with a logic analyzer

Intermodulation distortion comes from non-linear effects in circuits. One way to find these non-linear effects is excite the circuit with a two-tone test where the tones are not harmonically related to each other and approximately 1 kHz apart. It is important that the tones be non-harmonically related such as 800 Hz and 1800 Hz, as indicated in Answer **B**.

E4B12 (D)
How should a portable SWR analyzer be connected when measuring antenna resonance and feedpoint impedance?
A. Loosely couple the analyzer near the antenna base
B. Connect the analyzer via a high-impedance transformer to the antenna
C. Connect the antenna and a dummy load to the analyzer
D. Connect the antenna feed line directly to the analyzer's connector

Answer **D** shows the correct way to make the connection: directly connect the antenna feed line to the analyzer.

```
E4B13 (A)
What is the significance of voltmeter sensitivity expressed in ohms per volt?
A. The full scale reading of the voltmeter multiplied by its ohms per volt
      rating will provide the input impedance of the voltmeter
B. When used as a galvanometer, the reading in volts multiplied by the
      ohms/volt will determine the power drawn by the device under test
C. When used as an ohmmeter, the reading in ohms divided by the ohms/volt will
      determine the voltage applied to the circuit
D. When used as an ammeter, the full scale reading in amps divided by
      ohms/volt will determine the size of shunt needed
```

The sensitivity units tell you how to understand the significance: multiple the sensitivity in ohms/volt by the input in volts and the result is in ohms which is the measurement of impedance. This makes Answer **A** the correct choice.

```
E4B14 (A)
How is the compensation of an oscilloscope probe typically adjusted?
A. A square wave is observed and the probe is adjusted until the horizontal
      portions of the displayed wave is as nearly flat as possible
B. A high frequency sine wave is observed, and the probe is adjusted for
      maximum amplitude
C. A frequency standard is observed, and the probe is adjusted until the
      deflection time is accurate
D. A DC voltage standard is observed, and the probe is adjusted until the
      displayed voltage is accurate
```

If you inject a square-wave signal, the horizontal portions will not stay flat if the probe is not properly adjusted. The square wave has many harmonics where a sinusoid has only one. This makes the square wave a better choice to check the adjustment as indicated in Answer **A**.

```
E4B15 (B)
What happens if a dip-meter is too tightly coupled to a tuned circuit being
checked?
A. Harmonics are generated
B. A less accurate reading results
C. Cross modulation occurs
D. Intermodulation distortion occurs
```

Answer **B** has the correct description of how a dip meter works so it is the correct choice for the right answer to this question. None of the effects mentioned in answers A, C, and D are the correct effects when the dip meter is too tightly coupled so they are not good choices for the right answer.

```
E4B16 (B)
Which of these factors limits the accuracy of a D'Arsonval-type meter?
A. Its magnetic flux density
B. Coil impedance
C. Deflection rate
D. Electromagnet current
```

A D'Arsonval meter uses an electric current to move the meter's indicator. Therefore, the coil impedance will affect the current flow and affect the meter's reading. Answer **B** is the correct choice for the answer.

E4B17 (C)
Which of the following can be used as a relative measurement of the Q for a series-tuned circuit?
A. The inductance to capacitance ratio
B. The frequency shift
C. The bandwidth of the circuit's frequency response
D. The resonant frequency of the circuit

The Quality Factor, *Q*, for a series resonant circuit is computed as $Q = 2\pi f_0 L/R = 2\pi f_0/B$. Here, f_0 is the resonant frequency of the circuit, *L* is the inductance, *R* is the resistance, and *B* is the circuit's bandwidth. In this circuit, as the bandwidth, *B*, increases, the *Q* decreases. Answer **C** is the best choice among those given here.

E4C01 (D)
What is the effect of excessive phase noise in the local oscillator section of a receiver?
A. It limits the receiver ability to receive strong signals
B. It reduces the receiver sensitivity
C. It decreases the receiver third-order intermodulation distortion dynamic range
D. It can cause strong signals on nearby frequencies to interfere with reception of weak signals

Generally, small amounts of phase noise will not affect the receiver's ability to receive strong signals so answer A is not a good choice. The receiver sensitivity is more determined by the receiver's amplifier design and not phase noise so answer B is not a good choice. Similarly, the IMD is more determined by amplifiers than phase noise so answer C is also not a good choice. Phase noise will affect the receiver's ability to demodulate signals – especially weak signals – so answer **D** is the best choice among those given for this question.

E4C02 (C)
Which of the following is the result of the capture effect in an FM receiver?
A. All signals on a frequency are demodulated
B. None of the signals could be heard
C. The strongest signal received is the only demodulated signal
D. The weakest signal received is the only demodulated signal

The FM capture effect is a good thing – provided the signal you want to receive is the one that is captured. The demodulation of the strongest signal is the correct definition of FM capture and it is given in answer **C** so this is the one to choose for this question. Be careful when reading the choices because Answer D has just the opposite case so this is not the right choice here.

E4C03 (C)
What is the term for the blocking of one FM phone signal by another, stronger FM phone signal?
A. Desensitization
B. Cross-modulation interference
C. Capture effect
D. Frequency discrimination

This question is asking the previous question in a different way so you should be able to pick out answer **C** as the right choice to answer this question. We already had questions on desensitization so you should be able to spot answer A as a distractor. Cross-modulation interference is not unique to FM receivers so answer B is not the best choice. The frequency discriminator is another name for the FM demodulator so answer D is not correct either.

E4C04 (D)
What is meant by the noise floor of a receiver?
A. The minimum level of noise at the audio output when the RF gain is turned all the way down
B. The equivalent phase noise power generated by the local oscillator
C. The minimum level of noise that will overload the RF amplifier stage
D. The equivalent input noise power when the antenna is replaced with a matched dummy load

Answers A and D are the only contenders here for being the correct answer since they deal with weak signal performance. The noise floor is not determined by the atmosphere but by the receiver internal electronics so answer **D** is the correct response and A is to distract you. The phase noise mentioned in answer B is important in the reception process but it does not determine the noise floor so this is not a good choice. Answer C is more in line with the opposite sense of the noise floor so this is not a good choice to answer this question either.

E4C05 (B)
What does a value of -174 dBm/Hz represent with regard to the noise floor of a receiver?
A. The minimum detectable signal as a function of receive frequency
B. The theoretical noise at the input of a perfect receiver at room temperature
C. The noise figure of a 1 Hz bandwidth receiver
D. The galactic noise contribution to minimum detectable signal

The value -174 dBm is the theoretical noise at the input of a perfect receiver at room temperature as in Answer **B**. This value is computed from 10 log((k_b 290 K)/1 mW) and k_b is Boltzmann's Constant of $1.380658\text{x}10^{-23}$ W/K-Hz).

E4C06 (D)
The thermal noise value of a receiver is -174 dBm/Hz. What is the theoretically best minimum detectable signal for a 400 Hz bandwidth receiver?
A. 174 dBm
B. -164 dBm
C. -155 dBm
D. -148 dBm

To find the theoretical signal strength that matches the noise level in the 400 Hz bandwidth, we need to find the received signal power that matches the noise floor. The received signal power would be P = -174 dBm/Hz + 10log(400 Hz) = - 148 dBm. Answer D has the correct computation result.

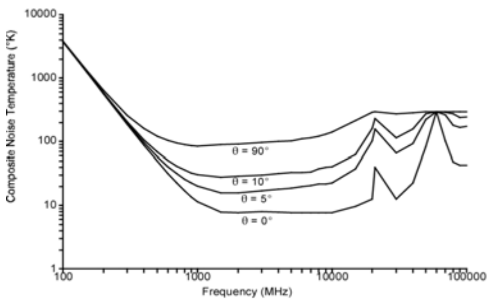
E4C07 (B)
What does the MDS of a receiver represent?
A. The meter display sensitivity
B. The minimum discernible signal
C. The multiplex distortion stability
D. The maximum detectable spectrum

There are some interesting meters here and it would be nice if some of them even existed! The correct choice for defining MDS is given in answer **B**. The other choices are technobabble to distract you.

E4C08 (B)
How might lowering the noise figure affect receiver performance?
A. It would reduce the signal to noise ratio
B. It would increase signal to noise ratio
C. It would reduce bandwidth
D. It would increase bandwidth

Of the choices given here, lowering the noise figure will increase the signal-to-noise ratio as in Answer **B**.

E4C09 (D)
Which of the following is most likely to be the limiting condition for sensitivity in a modern communications receiver operating at 14 MHz?
A. The noise figure of the RF amplifier
B. Mixer noise
C. Conversion noise
D. Atmospheric noise



As can bee see from the chart, at 14 MHz, the background noise in a receiver comes from atmospheric sources. This makes Answer **D** the correct choice.

E4C10 (B)
Which of the following is a desirable amount of selectivity for an amateur RTTY HF receiver?
A. 100 Hz
B. 300 Hz
C. 6000 Hz
D. 2400 Hz

We should remember that RTTY transmissions have bandwidths of a few hundred Hz so the 300 Hz of Answer **B** would be the best choice given the information in the question. Be careful with Answer A because it is narrower than the RTTY transmission would be too narrow for effective communications. Answer D might work for SSB and answer C is to distract you.

E4C11 (B)
Which of the following is a desirable amount of selectivity for an amateur single-sideband phone receiver?
A. 1 kHz
B. 2.4 kHz
C. 4.2 kHz
D. 4.8 kHz

Here, we need to remember that SSB phone has a transmission bandwidth of approximately 2400 Hz so answer **B** is the best choice among those given. Answer A is too narrow for phone emissions while answers C and D are too wide.

```
E4C12 (D)
What is an undesirable effect of using too wide a filter bandwidth in the IF
section of a receiver?
A. Output-offset overshoot
B. Filter ringing
C. Thermal-noise distortion
D. Undesired signals may be heard
```

Be careful with answer C because it is almost correct. A wider-than-necessary filter bandwidth will allow extra noise into the receiver but this is not generally referred to as a distortion (although it can be considered to be so in the most general sense). A certain undesirable effect is allowing in extra signals so answer **D** is the best choice among those given. Answer B is wrong because a proper IF filter bandwidth can have this problem by having a bad filter design. Answer A is to distract you.

```
E4C13 (C)
How does a narrow band roofing filter affect receiver performance?
A. It improves sensitivity by reducing front end noise
B. It improves intelligibility by using low Q circuitry to reduce ringing
C. It improves dynamic range by keeping strong signals near the receive
      frequency out of the IF stages
D. All of these choice are correct
```

The roofing filter is intended to filter out strong signals that could interfere with the desired signal as indicated in Answer **C**.

```
E4C14 (D)
Which of these choices is a desirable amount of selectivity for an amateur VHF
FM receiver?
A. 1 kHz
B. 2.4 kHz
C. 4.2 kHz
D. 15 kHz
```

Based on what we have seen in previous questions, we wish the filter to be approximately the bandwidth of the signal so answer **D** is the right choice. Answer A is too narrow so it is eliminated. Answer B might be good for an SSB signal so it is not good for FM signals. Answer C is too wide for SSB and too narrow for FM so it is eliminated as well.

```
E4C15 (D)
What is the primary source of noise that can be heard from an HF-band receiver
with an antenna connected?
A. Detector noise
B. Induction motor noise
C. Receiver front-end noise
D. Atmospheric noise
```

This is a restatement of E4C09. Knowing this, you should be able to spot Answer **D** as the right choice for this question.

```
E4D01 (A)
What is meant by the blocking dynamic range of a receiver?
A. The difference in dB between the level of an incoming signal which will
      cause 1 dB of gain compression, and the level of the noise floor
B. The minimum difference in dB between the levels of two FM signals which
      will cause one signal to block the other
C. The difference in dB between the noise floor and the third order intercept
      point
D. The minimum difference in dB between two signals which produce third order
      intermodulation products greater than the noise floor
```

The correct definition for a dynamic range in this sense is given as “In a transmission system, the ratio of (a) the overload level, i.e., the maximum signal power that the system can tolerate without distortion of the signal, to (b) the noise level of the system. Note: The dynamic range of transmission systems is usually expressed in dB.” (Source: http://www.atis.org/tg2k/). The definition which matches the standard definition is given in Answer **A**.

```
E4D02 (A)
Which of the following describes two types of problems caused by poor dynamic
range in a communications receiver?
A. Cross modulation of the desired signal and desensitization from strong
      adjacent signals
B. Oscillator instability requiring frequent retuning, and loss of ability to
      recover the opposite sideband, should it be transmitted
C. Cross modulation of the desired signal and insufficient audio power to
      operate the speaker
D. Oscillator instability and severe audio distortion of all but the strongest
      received signals
```

By looking at the previous computations, we see that the dynamic range is related to receiver sensitivity and noise floor levels. These do not affect the receiver oscillator so we can eliminate answers B and D from further consideration. Answers A and C both contain cross modulation effects which is true so we cannot eliminate either one at this point. Answer C is incorrect because the lack of dynamic range will not directly affect audio output power so this is not a good choice. The right choice is answer **A** since desensitization from adjacent signals would be a potential problem.

```
E4D03 (B)
How can intermodulation interference between two repeaters occur?
A. When the repeaters are in close proximity and the signals cause feedback in
      one or both transmitter final amplifiers
B. When the repeaters are in close proximity and the signals mix in one or
      both transmitter final amplifiers
C. When the signals from the transmitters are reflected out of phase from
      airplanes passing overhead
D. When the signals from the transmitters are reflected in phase from
      airplanes passing overhead
```

Reflecting signals off of airplanes is a form of multipath propagation when the geometry is right so we can eliminate answers A and D from consideration. The IM interference is a mixing process so Answer **B** has the correct definition. Answer C is close but not what is meant in the definition so it is a distraction for this question.

E4D04 (B)
What is an effective way to reduce or eliminate intermodulation interference between two repeater transmitters operating in close proximity to one another?
A. By installing a band-pass filter in the feed line between the transmitter and receiver
B. By installing a properly terminated circulator at the output of the transmitter
C. By using a Class C final amplifier
D. By using a Class D final amplifier

One may naturally think that installing some type of filter would cure the problem but not in this case because the "offending" transmitter will have a very strong signal in the desired pass band so that the interference will not be eliminated making Answer A a bad choice. Answer **B** has the correct remedy among the choices given to answer this question.

E4D05 (A)
If a receiver tuned to 146.70 MHz receives an intermodulation-product signal whenever a nearby transmitter transmits on 146.52 MHz, what are the two most likely frequencies for the other interfering signal?
A. 146.34 MHz and 146.61 MHz
B. 146.88 MHz and 146.34 MHz
C. 146.10 MHz and 147.30 MHz
D. 73.35 MHz and 239.40 MHz

The strongest IMD frequency components come from equations like: $f_{IMD} = 2f_1 \pm f_2$ and $f_{IMD} = 2f_2 \pm f_1$. Here, $f_1 = 146.52$ MHz and $f_{IMD} = 146.70$ MHz. In this particular case, the equations we need are : $f_{IMD} = 2f_1 - f_2$ and $f_{IMD} = 2f_2 - f_1$. Using the first of these, $f_2 = 2f_1 - f_{IMD} = 2 \times 146.52$ MHz - 146.70 MHz = 146.34 MHz which is found in answers A and B so we can eliminate answers C and D from further consideration. Using the second equation and some algebra, we have $f_2 = (f_1 + f_{IMD})/2$ = (146.52 MHz + 146.70 MHz)/2 = 146.61 MHz which is found in answer **A** so that is the correct choice among the answers given.

E4D06 (D)
If the signals of two transmitters mix together in one or both of their final amplifiers, and unwanted signals at the sum and difference frequencies of the original signals are generated, what is this called?
A. Amplifier desensitization
B. Neutralization
C. Adjacent channel interference
D. Intermodulation interference

Based on the previous question, you should be able to spot answer **D** as the correct choice given that the question describes the process used in the previous question to generate the right answer. The other effects are all real electronic terms but they do not apply here. As we saw before, desensitization has to do with strong adjacent signals, neutralization occurs in feedback loops, and adjacent channel interference is caused by another user's signal spilling over into your channel with or without any amplifier problems.

E4D07 (D)
Which of the following describes the most significant effect of an off-frequency signal when it is causing cross-modulation interference to a desired signal?
A. A large increase in background noise
B. A reduction in apparent signal strength
C. The desired signal can no longer be heard
D. The off-frequency unwanted signal is heard in addition to the desired signal

When there is cross-modulation interference, you will often be able to hear the undesired signal as well as the desired signal. This makes Answer **D** the best choice among those given.

E4D08 (C)
What causes intermodulation in an electronic circuit?
A. Too little gain
B. Lack of neutralization
C. Nonlinear circuits or devices
D. Positive feedback

The choices here are not very specific so the most that we can say, in general, is that IM is caused by non-linear effects so Answer **C** is the best choice to answer the question. Actually, too little gain is not the issue, it is the linearity of the circuit so answer A is not correct. Neutralization and positive affect feedback circuits but generally do not cause IM by themselves.

E4D09 (C)
What is the purpose of the preselector in a communications receiver?
A. To store often-used frequencies
B. To provide a range of AGC time constants
C. To improve rejection of unwanted signals
D. To allow selection of the optimum RF amplifier device

The preselector will increas sensitivity and assist in rejecting unwanted signals so Answer **C** is the best choice for the answer to this question.

E4D10 (C)
What does a third-order intercept level of 40 dBm mean with respect to receiver performance?
A. Signals less than 40 dBm will not generate audible third-order intermodulation products
B. The receiver can tolerate signals up to 40 dB above the noise floor without producing third-order intermodulation products
C. A pair of 40 dBm signals will theoretically generate the same output on the third order intermodulation frequency as on the input frequency
D. A pair of 1 mW input signals will produce a third-order intermodulation product which is 40 dB stronger than the input signal

Answer **C** has the correct interpretation: a pair of 40 dBm signals will theoretically generate the same output on the third order intermodulation frequency as on the input frequency.

E4D11 (A)
Why are third-order intermodulation products within a receiver of particular interest compared to other products?
A. The third-order product of two signals which are in the band is itself likely to be within the band
B. The third-order intercept is much higher than other orders
C. Third-order products are an indication of poor image rejection
D. Third-order intermodulation produces three products for every input signal

The thing to remember is that the third-order intermodulation products may be present within the band of interest. This means, choose Answer **A** as the choice to answer this question.

E4D12 (A)
What is the term for the reduction in receiver sensitivity caused by a strong signal near the received frequency?
A. Desensitization
B. Quieting
C. Cross-modulation interference
D. Squelch gain rollback

Desensitization, as in answer **A**, is the reduction in receiver sensitivity so this is the right choice to answer this question. Quieting, in answer B, is a good thing with FM receivers since it indicates that the FM receiver has locked onto the FM signal; however, it does not apply in this instance. Answer C is a bad problem with receiving another, unwanted signal, but it is not a reduction in receiver sensitivity so this is not the right answer either. Answer D is technobabble.

E4D13 (B)
Which of the following can cause receiver desensitization?
A. Audio gain adjusted too low
B. Strong adjacent-channel signals
C. Audio bias adjusted too high
D. Squelch gain adjusted too low

Generally, receiver desensitization occurs when another, strong signal, is close in frequency to the desired signal so answer **B** is the correct choice for this question. Audio gain and bias, as in answers A and C, do not affect the receiver but the output so these are not correct choices to answer this question. The squelch level can keep signals from being received by blocking a weak signal but that is not called desensitization but the squelch level so answer D is not correct for this question.

E4D14 (A)
Which of the following is a way to reduce the likelihood of receiver desensitization?
A. Decrease the RF bandwidth of the receiver
B. Raise the receiver IF frequency
C. Increase the receiver front end gain
D. Switch from fast AGC to slow AGC

As we have seen, desensitization occurs when there is a strong, unwanted signal near the desired signal. An effective way to remove the unwanted signal is the reduce the bandwidth of the receiver so that the unwanted signal is not longer sene by the receiver. Answer **A** matches this method.

E4E01 (A)
Which of the following types of receiver noise can often be reduced by use of a receiver noise blanker?
A. Ignition Noise
B. Broadband "white" noise
C. Heterodyne interference
D. All of these choices are correct

Receiver noise blankers can be used to remove ignition nose and other pulse-type noise sources. Answer **A** is the best choice among those listed.

E4E02 (D)
Which of the following types of receiver noise can often be reduced with a DSP noise filter?
A. Broadband "white" noise
B. Ignition noise
C. Power line noise
D. All of these choices are correct

DSP noise filters can be designed for each of the noise types listed in Answers A, B, and C so Answer **D** is the right choice for this question.

E4E03 (B)
Which of the following signals might a receiver noise blanker be able to remove from desired signals?
A. Signals which are constant at all IF levels
B. Signals which appear correlated across a wide bandwidth
C. Signals which appear at one IF but not another
D. Signals which have a sharply peaked frequency distribution

Signals correlated across a wide bandwidth can be removed with a receiver noise blanker so Answer **B** is the correct choice.

E4E04 (D)
How can conducted and radiated noise caused by an automobile alternator be suppressed?
A. By installing filter capacitors in series with the DC power lead and by installing a blocking capacitor in the field lead
B. By connecting the radio to the battery by the longest possible path and installing a blocking capacitor in both leads
C. By installing a high-pass filter in series with the radio's power lead and a low-pass filter in parallel with the field lead
D. By connecting the radio's power leads directly to the battery and by installing coaxial capacitors in line with the alternator leads

The correct technique is given in answer **D** so that is the right choice for this question. Answer A is not a good choice because the radio does not have a “field lead”. Answer B is wrong because one does not wish to have long power leads since that increases the noise pickup. Answer C is not a good choice since a high pass filter will tend to pass more noise.

```
E4E05 (B)
How can noise from an electric motor be suppressed?
A. By installing a ferrite bead on the AC line used to power the motor
B. By installing a brute-force AC-line filter in series with the motor leads
C. By installing a bypass capacitor in series with the motor leads
D. By using a ground-fault current interrupter in the circuit used to power
      the motor
```

The ground fault interrupter in answer D will help with electrical shorts but not electrical noise so this is not a good choice for this question. A capacitor in series will not filter noise so answer C is not a good choice. Answer A is not as good of a solution as answer **B** is so answer B is the best choice among those given for this question.

```
E4E06 (B)
What is a major cause of atmospheric static?
A. Solar radio frequency emissions
B. Thunderstorms
C. Geomagnetic storms
D. Meteor showers
```

Sunspots, as in answer A, and meteors, as in answer D, affect the ionosphere so if they cause tropospheric static, we are into the science fiction movie realm. Thunderstorms, as in answer **B**, are a well-know source of static so this is the correct choice for this question. If one has experience with aircraft, then one knows that they can have static problems but they generally do not generate enough static to affect users on the ground so answer C is not a good choice.

```
E4E07 (C)
How can you determine if line-noise interference is being generated within
your home?
A. By checking the power-line voltage with a time-domain reflectometer
B. By observing the AC power line waveform with an oscilloscope
C. By turning off the AC power line main circuit breaker and listening on a
      battery-operated radio
D. By observing the AC power line voltage with a spectrum analyzer
```

If there is no line noise when the AC is absent from the home, then one can look there for the noise source so answer **C** is the best choice among the alternatives given. Answers A, B, and D will not uniquely identify the source of the problem so they are not good choices for identifying the interference.

```
E4E08 (A)
What type of signal is picked up by electrical wiring near a radio
transmitter?
A. A common-mode signal at the frequency of the radio transmitter
B. An electrical-sparking signal
C. A differential-mode signal at the AC power line frequency
D. Harmonics of the AC power line frequency
```

This answer is as easy as it seems. If operating properly, the signal will be at the frequency of the transmitter so answer **A** is the correct choice. Answers B, C, and D would indicate major problems in either the transmitter or the power system so these are not good choices.

E4E09 (C)
What undesirable effect can occur when using an IF type noise blanker?
A. Received audio in the speech range might have an echo effect
B. The audio frequency bandwidth of the received signal might be compressed
C. Nearby signals may appear to be excessively wide even if they meet emission standards
D. FM signals can no longer be demodulated

The noise blanking circuitry may be ringing which will widen the pulses a bit. This makes Answer **C** the correct choice.

E4E10 (D)
What is a common characteristic of interference caused by a "touch controlled" electrical device?
A. The interfering signal sounds like AC hum on an AM receiver or a carrier modulated by 60 Hz FM on a SSB or CW receiver
B. The interfering signal may drift slowly across the HF spectrum
C. The interfering signal can be several kHz in width and usually repeats at regular intervals across a HF band
D. All of these answers are correct

Each of the choices given in Answers A, B, and C is a correct statement which makes Answer **D** the best choice to answer this question.

E4E11 (B)
What is the most likely cause if you are hearing combinations of local AM broadcast signals inside one or more of the MF or HF ham bands?
A. The broadcast station is transmitting an over-modulated signal
B. Nearby corroded metal joints are mixing and re-radiating the BC signals
C. You are receiving sky-wave signals from a distant station
D. Your station receiver IF amplifier stage is defective

Since the AM band is not the same as the amateur service band, there needs to be some object mixing the AM frequencies with another signal and having the resulting signal appear in the amateur band. Answer **B**, even though it sounds improbable, is the correct choice here.

E4E12 (A)
What is one disadvantage of using some automatic DSP notch-filters when attempting to copy CW signals?
A. The DSP filter can remove the desired signal at the same time as it removes interfering signals
B. Any nearby signal passing through the DSP system will always overwhelm the desired signal
C. Received CW signals will appear to be modulated at the DSP clock frequency
D. Ringing in the DSP filter will completely remove the spaces between the CW characters

A notch filter removes the components at a specific frequency. If the notch filter is removing interfering signals, it may also remove desired signals because a filter cannot be infinitely sharp. Answer **A** matches this reasoning.

E4E13 (D)
What might be the cause of a loud "roaring" or "buzzing" AC line type of interference that comes and goes at intervals?
A. Arcing contacts in a thermostatically controlled device
B. A defective doorbell or doorbell transformer inside a nearby residence
C. A malfunctioning illuminated advertising display
D. All of these answers are correct

Each of the choices given in Answers A, B, and C is a possibility which makes Answer **D** the best choice to answer this question.

E4E14 (C)
What is one type of electrical interference that might be caused by the operation of a nearby personal computer?
A. A loud AC hum in the audio output of your station receiver
B. A clicking noise at intervals of a few seconds
C. The appearance of unstable modulated or unmodulated signals at specific frequencies
D. A whining type noise that continually pulses off and on

If you place an AM radio near a computer you will hear all of the noise being emitted by the computer the whole time it is on. Of the choices given, Answer **C** is the best description of the computer noise that is generated.

Subelement E5 -- Electrical Principles

E5A01 (A)
What can cause the voltage across reactances in series to be larger than the voltage applied to them?
A. Resonance
B. Capacitance
C. Conductance
D. Resistance

Resistance, capacitance, and conductance are bulk properties of materials and individually, they do not cause the effect described in the questions so answers B, C, and D are not the correct choices to answer the question. Resonance is an interaction between components and it can cause the increase in voltage so answer **A** is the correct answer for this question.

E5A02 (C)
What is resonance in an electrical circuit?
A. The highest frequency that will pass current
B. The lowest frequency that will pass current
C. The frequency at which the capacitive reactance equals the inductive reactance
D. The frequency at which the reactive impedance equals the resistive impedance

An electrical circuit will pass some current (maybe close to zero) at all frequencies so answers A and B are not good choices to answer the question. The power factor is related to the phase difference between the voltage and the current so answer D is not phrased in a proper way to answer this question. The correct answer is given in answer **C** which describes the proper relationship between capacitive and inductive components.

E5A03 (D)
What is the magnitude of the impedance of a series R-L-C circuit at resonance?
A. High, as compared to the circuit resistance
B. Approximately equal to capacitive reactance
C. Approximately equal to inductive reactance
D. Approximately equal to circuit resistance

Next we have several questions about order-of-magnitudes estimates of circuit parameters. In a series circuit at resonance, the L and C parts mostly cancel so all that is left is the R part so the correct answer is **D**. Since the L and C components are mostly removed, we can eliminate answers B and C. Answer A is a silly distractor.

E5A04 (A)
What is the magnitude of the impedance of a circuit with a resistor, an inductor and a capacitor all in parallel, at resonance?
A. Approximately equal to circuit resistance
B. Approximately equal to inductive reactance
C. Low, as compared to the circuit resistance
D. Approximately equal to capacitive reactance

Just because we have changed to a parallel circuit, the basic principle does not change. In a parallel circuit at resonance, the L and C parts mostly cancel so all that is left is the R part so the correct answer is **A**. Since the L and C components are mostly removed, we can eliminate answers B and D. Answer C is a silly distractor.

E5A05 (B)
What is the magnitude of the current at the input of a series R-L-C circuit as the frequency goes through resonance?
A. Minimum
B. Maximum
C. R/L
D. L/R

This is one of those questions that you may just need to memorize the correct answer for. Here you need to know that the current is maximum so answer **B** is the correct choice among those given.

E5A06 (B) (Was E5A08; edited]
What is the magnitude of the circulating current within the components of a parallel L-C circuit at resonance?
A. It is at a minimum
B. It is at a maximum
C. It equals 1 divided by the quantity [2 multiplied by Pi, multiplied by the square root of (inductance "L" multiplied by capacitance "C")]
D. It equals 2 multiplied by Pi, multiplied by frequency "F", multiplied by inductance "L"

This may be another of those questions that you may just need to memorize the correct answer for. Here you need to know that the current is maximum so answer **B** is the correct choice and answer A is to confuse you.

E5A07 (A)
What is the magnitude of the current at the input of a parallel R-L-C circuit at resonance?
A. Minimum
B. Maximum
C. R/L
D. L/R

This question is the complement to the earlier one for series circuits. Here you need to know that the current is minimum so answer **A** is the correct choice and answer B is to confuse you with the previous questions.

E5A08 (C)
What is the phase relationship between the current through and the voltage across a series resonant circuit?
A. The voltage leads the current by 90 degrees
B. The current leads the voltage by 90 degrees
C. The voltage and current are in phase
D. The voltage and current are 180 degrees out of phase

At resonance, the current and voltage is in phase so answer **C** is the correct choice. The other choices are not correct for a resonant circuit so they are not proper choices to answer this question.

E5A09 (C)
What is the phase relationship between the current through and the voltage across a parallel resonant circuit?
A. The voltage leads the current by 90 degrees
B. The current leads the voltage by 90 degrees
C. The voltage and current are in phase
D. The voltage and current are 180 degrees out of phase

At resonance, the current and voltage is in phase so answer **C** is the correct choice. The other choices are not correct for a resonant circuit so they are not proper choices to answer this question.

```
E5A10 (A)
What is the half-power bandwidth of a parallel resonant circuit that has a
resonant frequency of 1.8 MHz and a Q of 95?
A. 18.9 kHz
B. 1.89 kHz
C. 94.5 kHz
D. 9.45 kHz
```

Here we have several questions dealing with the bandwidth of resonant circuits. The relationship between bandwidth, W, resonant frequency, f_r, and quality, Q, is $W = f_r/Q$. Using the numbers given, W = 1.8 MHz/95 = 18.9 kHz so answer **A** is the correct choice. Answers B has the right numbers but the decimal point is in the wrong place so be careful when reading the question on the test.

```
E5A11 (C)
What is the half-power bandwidth of a parallel resonant circuit that has a
resonant frequency of 7.1 MHz and a Q of 150?
A. 157.8 Hz
B. 315.6 Hz
C. 47.3 kHz
D. 23.67 kHz
```

Here we use the same relationship as the previous question to solve for the bandwidth. Using the numbers given, W = 7.1 MHz/150 = 47.4 kHz so answer **C** is the correct choice. The other answers are math errors to distract you.

```
E5A12 (C)
What is the half-power bandwidth of a parallel resonant circuit that has a
resonant frequency of 3.7 MHz and a Q of 118?
A. 436.6 kHz
B. 218.3 kHz
C. 31.4 kHz
D. 15.7 kHz
```

Here we use the same relationship as the previous question to solve for the bandwidth. Using the numbers given, W = 3.7 MHz/118 = 31.4 kHz so answer **C** is the correct choice. The other answers are math errors to distract you.

```
E5A13 (B)
What is the half-power bandwidth of a parallel resonant circuit that has a
resonant frequency of 14.25 MHz and a Q of 187?
A. 38.1 kHz
B. 76.2 kHz
C. 1.332 kHz
D. 2.665 kHz
```

Here we use the same relationship as the previous question to solve for the bandwidth. Using the numbers given, W = 14.25 MHz/187 = 76.2 kHz so answer **B** is the correct choice. The other answers are math errors to distract you.

E5A14 (C)
What is the resonant frequency of a series RLC circuit if R is 22 ohms, L is 50 microhenrys and C is 40 picofarads?
A. 44.72 MHz
B. 22.36 MHz
C. 3.56 MHz
D. 1.78 MHz

Here we have a series of question dealing with series resonant circuits. Remember, resonance occurs when the resistive and inductive parts cancel. From circuit theory, we learn that series RLC circuits have a resonant frequency at $f_r = 1/[2\pi(LC)^{½}]$. For this circuit, $f_r = 1/[2\pi(50x10^{-6}x40x10^{-12})^{½}]$ = 3.56 MHz. Answer C is the correct one while the other choices represent math errors.

E5A15 (B)
What is the resonant frequency of a series RLC circuit if R is 56 ohms, L is 40 microhenrys and C is 200 picofarads?
A. 3.76 MHz
B. 1.78 MHz
C. 11.18 MHz
D. 22.36 MHz

Here we have the next question dealing with resonant circuits. Using the same circuit theory, we compute the resonant frequency at $f_r = 1/[2\pi(40x10^{-6}x200x10^{-12})^{½}]$ = 1.78 MHz. Answer **B** is the correct one while the other choices represent math errors.

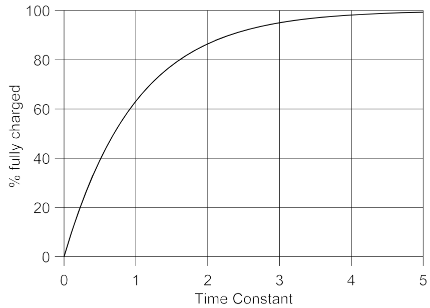
E5A16 (D)
What is the resonant frequency of a parallel RLC circuit if R is 33 ohms, L is 50 microhenrys and C is 10 picofarads?
A. 23.5 MHz
B. 23.5 kHz
C. 7.12 kHz
D. 7.12 MHz

Here we have the next question dealing with resonant circuits. Using the same circuit theory, we compute the resonant frequency at $f_r = 1/[2\pi(50x10^{-6}x10x10^{-12})^{½}]$ = 7.12 MHz. Answer **D** is the correct one while the other choices represent math errors. Be careful with answer C because it has the correct numbers but the MHz unit is replaced with kHz.

E5A17 (A)
What is the resonant frequency of a parallel RLC circuit if R is 47 ohms, L is 25 microhenrys and C is 10 picofarads?
A. 10.1 MHz
B. 63.2 MHz
C. 10.1 kHz
D. 63.2 kHz

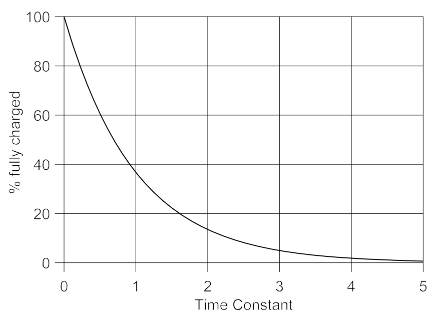
Here we have the next question dealing with resonant circuits. Using the same circuit theory, we compute the resonant frequency at $f_r = 1/[2\pi(25x10^{-6}x10x10^{-12})^{½}]$ = 10.1 MHz. Answer **A** is the correct one while the other choices represent math errors. Be careful with answer C because it has the correct numbers but the MHz unit is replaced with kHz.

E5B01(B)
What is the term for the time required for the capacitor in an RC circuit to be charged to 63.2% of the supply voltage?
A. An exponential rate of one
B. One time constant
C. One exponential period
D. A time factor of one



The curve shows a charging cycle for an RC circuit. This question is the definition of a time constant for a circuit so answer **B** is the correct choice for this question. All of the other choices are technobabble to distract you.

E5B02 (D)
What is the term for the time it takes for a charged capacitor in an RC circuit to discharge to 36.8% of its initial value of stored charge?
A. One discharge period
B. An exponential discharge rate of one
C. A discharge factor of one
D. One time constant



Charging or discharging does not matter. As the discharge curve shows, this question is still providing the definition of one time constant and the correct answer is **D**. All of the other choices are technobabble to distract you.

E5B03 (D)
The capacitor in an RC circuit is discharged to what percentage of the starting voltage after two time constants?
A. 86.5%
B. 63.2%
C. 36.8%
D. 13.5%

By looking at the discharge curve, we can see that after two time constants, the circuit has discharged to 13.5% of its full value so the correct answer is **D**. Answer C is the discharge level after one time constant so this is wrong. Answer B is the charging level after one time constant. Answer A matches the charging level after two time constants.

E5B04 (D)
What is the time constant of a circuit having two 220-microfarad capacitors and two 1-megohm resistors all in parallel?
A. 55 seconds
B. 110 seconds
C. 440 seconds
D. 220 seconds

In this parallel circuit, the total resistance is 500 kΩ. The total capacitance is 440 μF. The time constant is $\tau = RC$ = 500 kΩ x 440 μF = 220 seconds. The correct answer is then given in answer **D** and the others are math mistakes.

E5B05 (A)
How long does it take for an initial charge of 20 V DC to decrease to 7.36 V DC in a 0.01-microfarad capacitor when a 2-megohm resistor is connected across it?
A. 0.02 seconds
B. 0.04 seconds
C. 20 seconds
D. 40 seconds

First we need to find out how many time constants the discharge represents. 7.36 V is 36.8% of 20 V so the circuit has discharged by one time constant. The time constant for the circuit is RC = 2 MΩ x 0.01 μF = 20 milliseconds. This corresponds to answer **A** so that is the right choice for this question. Be careful with answer C because it has the right numbers but the wrong time units.

E5B06 (C)
How long does it take for an initial charge of 800 V DC to decrease to 294 V DC in a 450-microfarad capacitor when a 1-megohm resistor is connected across it?
A. 4.50 seconds
B. 9 seconds
C. 450 seconds
D. 900 seconds

Here, we use the same analysis as the previous question. First we need to find out how many time constants the discharge represents. 294 V is 36.8% of 800 V so the circuit has discharged by one time constant. The time constant for the circuit is RC = 1 MW x 450 mF = 450 seconds. This corresponds to answer C so that is the right choice for this question. Answers A has the right numbers but the wrong time units so be careful on the exam.

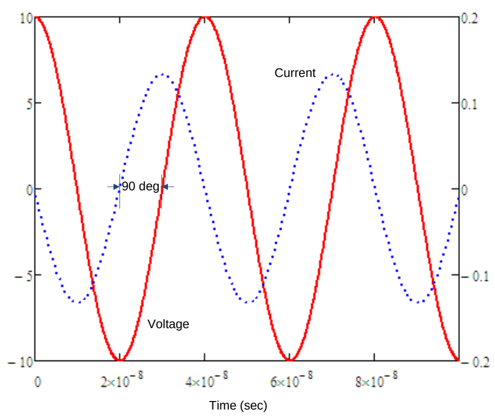
E5B07 (C)
What is the phase angle between the voltage across and the current through a series R-L-C circuit if XC is 500 ohms, R is 1 kilohm, and XL is 250 ohms?
A. 68.2 degrees with the voltage leading the current
B. 14.0 degrees with the voltage leading the current
C. 14.0 degrees with the voltage lagging the current
D. 68.2 degrees with the voltage lagging the current

The total reactance in this series configuration is 250 Ω - 500 Ω. Since the net reactance is negative or lagging, the phase angle needs in the answer to be negative so answers A and B are eliminated. Because the net reactance is smaller than the resistance, the phase angle needs to be less than 45° in magnitude so answer **C** seems to be the best choice. The phase angle between the voltage and the current is $\tan^{-1}$[-250 Ω/1000 Ω] = -14.0° which corresponds to answer **C**.

E5B08 (A)
What is the phase angle between the voltage across and the current through a series R-L-C circuit if XC is 100 ohms, R is 100 ohms, and XL is 75 ohms?
A. 14 degrees with the voltage lagging the current
B. 14 degrees with the voltage leading the current
C. 76 degrees with the voltage leading the current
D. 76 degrees with the voltage lagging the current

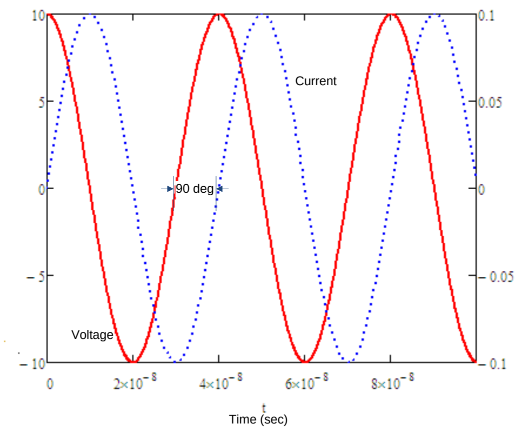
Here we have another example of this type of analysis. The total reactance in this series configuration is 75 Ω - 100 Ω. Since the net reactance is negative or lagging, the phase angle in the answer needs to be negative so answers B and C are eliminated. Because the net reactance is smaller than the resistance, the phase angle needs to be less than 45° in magnitude so answer **A** seems to be the best choice. The phase angle between the voltage and the current is $\tan^{-1}[-25\ \Omega/100\ \Omega] = -14.0°$ which corresponds to answer **A**.

E5B09 (D) was E5D06
What is the relationship between the current through and the voltage across a capacitor?
A. Voltage and current are in phase
B. Voltage and current are 180 degrees out of phase
C. Voltage leads current by 90 degrees
D. Current leads voltage by 90 degrees



In a capacitor, the current leads the voltage by 90° as shown in the graphic so the correct response is given in Answer **D**. Answer C corresponds to an inductor and not a capacitor as the question asks for so this is an incorrect choice. Answer A is for a resistor so this is an incorrect choice as well. Answer B is not for a either a R, L, or C.

E5B10 (A) was E5D07
What is the relationship between the current through an inductor and the voltage across an inductor?
A. Voltage leads current by 90 degrees
B. Current leads voltage by 90 degrees
C. Voltage and current are 180 degrees out of phase
D. Voltage and current are in phase



This is the complement to the previous question. In an inductor, the voltage leads the current by 90° as shown in the graphic so the correct response is given in Answer **A**. Answer B is for a capacitor so this is incorrect. Answer D is for a resistor so this is incorrect as well. Answer C is not for R, L, or C elements.

```
E5B11 (B) was E5D08
What is the phase angle between the voltage across and the current through a
series RLC circuit if XC is 25 ohms, R is 100 ohms, and XL is 50 ohms?
A. 14 degrees with the voltage lagging the current
B. 14 degrees with the voltage leading the current
C. 76 degrees with the voltage lagging the current
D. 76 degrees with the voltage leading the current
```

Back to the circuit analysis example. The total reactance in this series configuration is 50 Ω - 25 Ω. Since the net reactance is positive or leading, the phase angle in the answer needs to be positive so answers A and C are eliminated. Because the net reactance is smaller than the resistance, the phase angle needs to be less than 45° in magnitude so answer **B** seems to be the best choice. The phase angle between the voltage and the current is $\tan^{-1}$[25 Ω/100 Ω] = 14° which corresponds to answer **B**.

```
E5B12 (C) was E5D10
What is the phase angle between the voltage across and the current through a
series RLC circuit if XC is 75 ohms, R is 100 ohms, and XL is 50 ohms?
A. 76 degrees with the voltage lagging the current
B. 14 degrees with the voltage leading the current
C. 14 degrees with the voltage lagging the current
D. 76 degrees with the voltage leading the current
```

Here we have the next example of this type of analysis. The total reactance in this series configuration is 50 Ω - 75 Ω. Since the net reactance is negative or lagging, the phase angle in the answer needs to be negative so answers B and D are eliminated. Because the net reactance is smaller than the resistance, the phase angle needs to be less than 45° in magnitude so answer **C** seems to be the best choice. The phase angle between the voltage and the current is $\tan^{-1}$[-25 Ω/100 Ω] = -14.0° which corresponds to answer **C**.

```
E5B13 (D) was E5D11
What is the phase angle between the voltage across and the current through a
series RLC circuit if XC is 250 ohms, R is 1 kilohm, and XL is 500 ohms?
A. 81.47 degrees with the voltage lagging the current
B. 81.47 degrees with the voltage leading the current
C. 14.04 degrees with the voltage lagging the current
D. 14.04 degrees with the voltage leading the current
```

Here we have the next example of this type of analysis. The total reactance in this series configuration is 500 Ω - 250 Ω. Since the net reactance is positive or leading, the phase angle in the answer needs to be positive so answers

A and C are eliminated. Because the net reactance is smaller than the resistance, the phase angle needs to be less than 45° in magnitude so answer **D** seems to be the best choice. The phase angle between the voltage and the current is $\tan^{-1}[250\ \Omega/1000\ \Omega] = 14.04°$ which corresponds to answer **D**.

```
E5C01 (B)
In polar coordinates, what is the impedance of a network consisting of a
100-ohm-reactance inductor in series with a 100-ohm resistor?
A. 121 ohms at an angle of 35 degrees
B. 141 ohms at an angle of 45 degrees
C. 161 ohms at an angle of 55 degrees
D. 181 ohms at an angle of 65 degrees
```

Here we have a series of questions dealing with series resistance and rectangular-to-polar coordinate conversion. The total impedance is the sum of the resistive and reactive components: $Z = R + jXL = 100\ \Omega + j\,100\ \Omega = 141\ \Omega$ at an angle of 45 degrees. This corresponds to answer **B** so this is the right choice. The other choices are various math mistakes.

```
E5C02 (D)
In polar coordinates, what is the impedance of a network consisting of a
100-ohm-reactance inductor, a 100-ohm-reactance capacitor, and a 100-ohm
resistor all connected in series?
A. 100 ohms at an angle of 90 degrees
B. 10 ohms at an angle of 0 degrees
C. 10 ohms at an angle of 90 degrees
D. 100 ohms at an angle of 0 degrees
```

In this circuit, the total impedance is $Z = R + jXL - jXC = 100\ \Omega + j\,100\ \Omega - j\,100\ \Omega = 100\ \Omega$ at an angle of 0 degrees. This corresponds to answer **D** so this is the right choice. The other choices are various math mistakes.

```
E5C03 (A)
In polar coordinates, what is the impedance of a network consisting of a
300-ohm-reactance capacitor, a 600-ohm-reactance inductor, and a 400-ohm
resistor, all connected in series?
A. 500 ohms at an angle of 37 degrees
B. 900 ohms at an angle of 53 degrees
C. 400 ohms at an angle of 0 degrees
D. 1300 ohms at an angle of 180 degrees
```

In this circuit, the total impedance is $Z = R + jXL - jXC = 400\ \Omega + j\,600\ \Omega - j\,300\ \Omega = 500\ \Omega$ at an angle of 37 degrees (this makes a 3-4-5 triangle!**)**. This corresponds to answer **A** so this is the right choice. The other choices are various math mistakes.

```
E5C04 (D)
In polar coordinates, what is the impedance of a network consisting of a
400-ohm-reactance capacitor in series with a 300-ohm resistor?
A. 240 ohms at an angle of 36.9 degrees
B. 240 ohms at an angle of -36.9 degrees
C. 500 ohms at an angle of 53.1 degrees
D. 500 ohms at an angle of -53.1 degrees
```

In this circuit, the total impedance is $Z = R - jXC = 300\ \Omega - j\,400\ \Omega = 500\ \Omega$ at an angle of -53 degrees (another 3-4-5 triangle). This corresponds to answer **D** so this is the right choice. Be careful with answer C because is has the right magnitude but the wrong phase angle. The other choices are various math mistakes.

E5C05 (A)
In polar coordinates, what is the impedance of a network consisting of a 400-ohm-reactance inductor in parallel with a 300-ohm resistor?
A. 240 ohms at an angle of 36.9 degrees
B. 240 ohms at an angle of -36.9 degrees
C. 500 ohms at an angle of 53.1 degrees
D. 500 ohms at an angle of -53.1 degrees

In this circuit, the total impedance is $Z = 1/[(1/R) + (1/jXL)]$. The denominator is 1/300 Ω - j/400 Ω = 0.004167 Ω at an angle of -36.9 degrees. To find the impedance, we take the reciprocal of this which corresponds to 240 Ω at an angle of 36.9 degrees which is answer A so this is the right choice. Be careful with answer B because it has the correct magnitude but the wrong phase angle. The other choices are various math mistakes.

E5C06 (D)
In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance capacitor in series with a 100-ohm resistor?
A. 121 ohms at an angle of -25 degrees
B. 191 ohms at an angle of -85 degrees
C. 161 ohms at an angle of -65 degrees
D. 141 ohms at an angle of -45 degrees

In this circuit, the total impedance is $Z = R - jXC = 100\ \Omega - j\ 100\ \Omega = 141\ \Omega$ at an angle of -45 degrees. This corresponds to answer **D** so this is the right choice. The other choices are various math mistakes.

E5C07 (C)
In polar coordinates, what is the impedance of a network comprised of a 100-ohm-reactance capacitor in parallel with a 100-ohm resistor?
A. 31 ohms at an angle of -15 degrees
B. 51 ohms at an angle of -25 degrees
C. 71 ohms at an angle of -45 degrees
D. 91 ohms at an angle of -65 degrees

In this circuit, the total impedance is $Z = 1/[(1/R) - (j/XC)]$. The denominator is 1/100 Ω - j/100 Ω = 0.01414 Ω at an angle of 45 degrees. To find the impedance, we take the reciprocal of this which corresponds to 71 Ω at an angle of -45 degrees which is answer **C** so this is the right choice. The other choices are various math mistakes.

E5C08 (B)
In polar coordinates, what is the impedance of a network comprised of a 300-ohm-reactance inductor in series with a 400-ohm resistor?
A. 400 ohms at an angle of 27 degrees
B. 500 ohms at an angle of 37 degrees
C. 500 ohms at an angle of 47 degrees
D. 700 ohms at an angle of 57 degrees

In this circuit, the total impedance is $Z = R + jXL = 400\ \Omega + j\ 300\ \Omega = 500\ \Omega$ at an angle of 37 degrees. This corresponds to answer **B** so this is the right choice. The other choices are various math mistakes.

E5C09 (A)
When using rectangular coordinates to graph the impedance of a circuit, what does the horizontal axis represent?
A. The voltage or current associated with the resistive component
B. The voltage or current associated with the reactive component
C. The sum of the reactive and resistive components
D. The difference between the resistive and reactive components

The horizontal axis is the resistive axis so the correct answer is **A**. Answer B is the vertical axis. Answers C and D are technobabble and are incorrect.

E5C10 (B)
When using rectangular coordinates to graph the impedance of a circuit, what does the vertical axis represent?
A. The voltage or current associated with the resistive component
B. The voltage or current associated with the reactive component
C. The sum of the reactive and resistive components
D. The difference between the resistive and reactive components

The correct response is given in answer **B**. Answer A is for the horizontal axis. Answers C and D are technobabble to distract you.

E5C11 (C)
What do the two numbers represent that are used to define a point on a graph using rectangular coordinates?
A. The magnitude and phase of the point
B. The sine and cosine values
C. The coordinate values along the horizontal and vertical axes
D. The tangent and cotangent values

This answer is rather non-descript but the best choice among those given is answer **C**. Answers A and B both have nonsense axis names listed with correct axis names. Answer D is not used on a rectangular plot.

E5C12 (D)
If you plot the impedance of a circuit using the rectangular coordinate system and find the impedance point falls on the right side of the graph on the horizontal line, what do you know about the circuit?
A. It has to be a direct current circuit
B. It contains resistance and capacitive reactance
C. It contains resistance and inductive reactance
D. It is equivalent to a pure resistance

If the point is on the horizontal axis, it has no reactive component so the correct choice among those given is answer **D**. Answers B and C are incorrect because they include reactive components. Answer A is a distraction.

E5C13 (D)
What coordinate system is often used to display the resistive, inductive, and/or capacitive reactance components of an impedance?
A. Maidenhead grid
B. Faraday grid
C. Elliptical coordinates
D. Rectangular coordinates

The correct answer is **D**: rectangular coordinates.

```
E5C14 (D)
What coordinate system is often used to display the phase angle of a circuit
containing resistance, inductive and/or capacitive reactance?
A. Maidenhead grid
B. Faraday grid
C. Elliptical coordinates
D. Rectangular coordinates
```

This is similar to the previous question. As we have seen in this section, both rectangular and polar plots can be used so the correct answer is **D**. The other choices are incorrect for the same reasons as in the previous question.

```
E5C15 (A)
In polar coordinates, what is the impedance of a circuit of 100 -j100 ohms
impedance?
A. 141 ohms at an angle of -45 degrees
B. 100 ohms at an angle of 45 degrees
C. 100 ohms at an angle of -45 degrees
D. 141 ohms at an angle of 45 degrees
```

Here we need to convert this to polar coordinates. The total impedance is `141` Ω at an angle of -45 degrees so the correct answer is A. Answer D has the wrong phase angle. Answers B and C have math mistakes.

```
E5C16 (B)
In polar coordinates, what is the impedance of a circuit that has an
admittance of 7.09 millisiemens at 45 degrees?
A. 5.03 x 10 -E05 ohms at an angle of 45 degrees
B. 141 ohms at an angle of -45 degrees
C. 19,900 ohms at an angle of -45 degrees
D. 141 ohms at an angle of 45 degrees
```

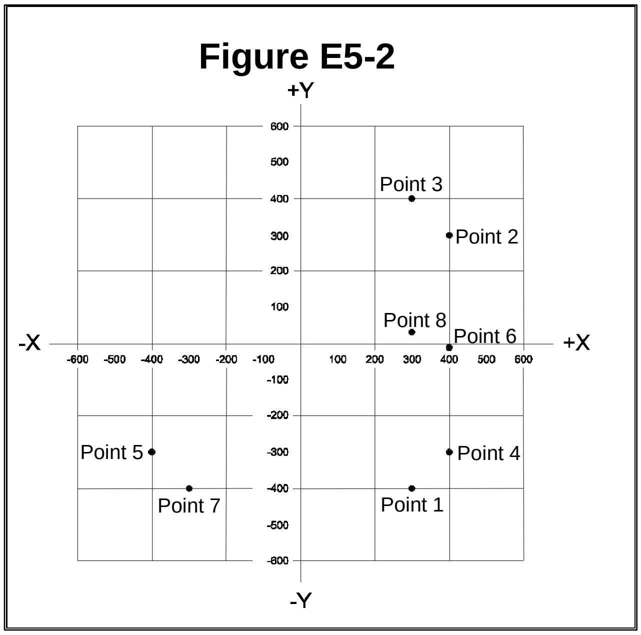
Impedance and admittance are reciprocal quantities so the magnitude is `1/0.00709 = 141` Ω. The phase angle is then -45 degrees. This makes answer B the correct choice. Answer D has the correct magnitude but the wrong phase. Answers A and C represent math mistakes.

```
E5C17 (C)
In rectangular coordinates, what is the impedance of a circuit that has an
admittance of 5 millisiemens at -30 degrees?
A. 173 - j100 ohms
B. 200 + j100 ohms
C. 173 + j100 ohms
D. 200 - j100 ohms
```

Here we use the same analysis as the previous question. The magnitude is `1/0.005 = 200` and the phase is 30 degrees. Converting this to rectangular coordinates gives 173 + j100 Ω. This corresponds to answer C. Answer A has the wrong phase angle so it is incorrect. Answers B and D have math mistakes.

E5C18 (B)
In polar coordinates, what is the impedance of a series circuit consisting of a resistance of 4 ohms, an inductive reactance of 4 ohms, and a capacitive reactance of 1 ohm?
A. 6.4 ohms at an angle of 53 degrees
B. 5 ohms at an angle of 37 degrees
C. 5 ohms at an angle of 45 degrees
D. 10 ohms at an angle of -51 degrees

In this circuit, the total impedance is Z = R + jXL - jXC = 4 Ω + j 4 Ω – j 1 Ω = 5 Ω at an angle of 37 degrees. This corresponds to answer **B** so this is the right choice. Answer C has the right magnitude but the wrong phase. The other choices are various math mistakes.



E5C19 (B)
Which point on Figure E5-2 best represents that impedance of a series circuit consisting of a 400 ohm resistor and a 38 picofarad capacitor at 14 MHz?
A. Point 2
B. Point 4
C. Point 5
D. Point 6

Some things to notice about this chart the will help with the questions in this section: (1) no actual R-L-C circuits will be found in quadrants II and III since regular passive resistors do not have a negative resistance; (2) purely resistive circuits will be found along the *x*-axis, purely inductive reactances will lie along the +*y*-axis while purely capacitive reactances will lie along the –*y*-axis; (3) if the circuit is in resonance, it will lie along the x-axis since the inductive and capacitive reactances cancel out; (4) if the circuit has a net inductive reactance, it will lie in quadrant I while if the circuit has a net capacitive reactance, it will lie in quadrant IV; (5) circuits in quadrant I have positive (leading) phase angles while those in quadrant IV have negative (lagging) phase angles; (6) if the magnitude of the resistance is greater than the magnitude of the net reactance, the phase angle will be less than 45° while if the magnitude of the net reactance is greater than the magnitude of the resistance, the phase angle will be greater than 45°.
In this question, the total impedance will be Z = 400 Ω -j/(2π(14 MHz)(38 pF)) = 400 Ω -j299 Ω. This corresponds to Point 4 on the chart so Answer B is the right choice.

E5C20 (B)
Which point in Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and an 18 microhenry inductor at 3.505 MHz?
A. Point 1
B. Point 3
C. Point 7
D. Point 8

The impedance of the circuit is Z = 300 Ω + j2π(18 μH)(3.505 MHz) = 300 Ω + j396.4 Ω. This corresponds to Point 3 on the graph so Answer **B** is the right choice.

E5C21 (A)
Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and a 19 picofarad capacitor at 21.200 MHz?
A. Point 1
B. Point 3
C. Point 7
D. Point 8

Back to capacitors and we compute the impedance as we did above. $Z = 300\ \Omega - j/(2\pi(21.200\ \text{MHz})(19\ \text{pF})) = 300\ \Omega - j395\ \Omega$. This corresponds to Point 1 on the chart so Answer **A** is the right choice.

E5C22 (A)
In rectangular coordinates, what is the impedance of a network comprised of a 10-microhenry inductor in series with a 40-ohm resistor at 500 MHz?
A. 40 + j31,400
B. 40 - j31,400
C. 31,400 + j40
D. 31,400 - j40

The impedance of the circuit is $Z = 40\ \Omega + j2\pi(10\ \mu\text{H})(500\ \text{MHz}) = 40\ \Omega + j31.42\ \text{k}\Omega$. This corresponds to Answer **A**.

E5C23 (D)
Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300-ohm resistor, a 0.64-microhenry inductor and an 85-picofarad capacitor at 24.900 MHz?
A. Point 1
B. Point 3
C. Point 5
D. Point 8

Now we combine all of the components. The total impedance is $Z = 300\ \Omega + j2\pi(0.64\ \mu\text{H})(24.900\ \text{MHz}) - j/(2\pi(24.900\ \text{MHz})(85\ \text{pF})) = 300\ \Omega + j100.13\ \Omega - j75.2\ \Omega = 300\ \Omega + j25\ \Omega$. This corresponds to Point 8 on the graph so Answer **D** is the right choice.

E5D01 (A)
What is the result of skin effect?
A. As frequency increases, RF current flows in a thinner layer of the conductor, closer to the surface
B. As frequency decreases, RF current flows in a thinner layer of the conductor, closer to the surface
C. Thermal effects on the surface of the conductor increase the impedance
D. Thermal effects on the surface of the conductor decrease the impedance

The skin effect is a frequency effect and not a thermal effect so answers C and D can be eliminated. The correct definition is given in answer **A** so this is the right choice. Answer B has the opposite relationship with frequency so it is incorrect.

```
E5D02 (C)
Why is the resistance of a conductor different for RF currents than for direct
currents?
A. Because the insulation conducts current at high frequencies
B. Because of the Heisenburg Effect
C. Because of skin effect
D. Because conductors are non-linear devices
```

Since the skin effect is a function of frequency, the ability to let current flow will be a function of frequency as well so answer **C** is the right choice to answer this question. If the insulation conducts as answer A suggests, then the use has a major problem so this is not a good choice. The Heisenberg effect of answer B is a technobabble term. Answer D is potentially a possible result but it does not generally explain the question so this is not a good choice.

```
E5D03 (C)
What device is used to store electrical energy in an electrostatic field?
A. A battery
B. A transformer
C. A capacitor
D. An inductor
```

A battery stores electrical energy in a chemical or other physical medium so answer A is not a good choice. A transformer changes electrical energy by using magnetic fields so this is not a correct answer either. An inductor also stores energy in a magnetic field so this is not a correct choice. The correct choice is the capacitor in answer **C**.

```
E5D04 (B)
What unit measures electrical energy stored in an electrostatic field?
A. Coulomb
B. Joule
C. Watt
D. Volt
```

Energy is measured in Joules so answer **B** is the right choice. Coulombs from answer A is a measure of charge so this is incorrect. Watts in answer C measure power so this is also incorrect. Volts in answer D measure electrical potential so this is also an incorrect choice.

```
E5D05 (B)
What is a magnetic field?
A. Current through the space around a permanent magnet
B. The space through which a magnetic force acts
C. The space between the plates of a charged capacitor, through which a
      magnetic force acts
D. The force that drives current through a resistor
```

Current through space is also known as lightening so answer A is not a correct choice. Answer C is a mixture of capacitor and inductor properties so this is incorrect as well. Answer D is a voltage so it is also an incorrect choice for this question. Among the choices given, the best response is given in answer **B**.

E5D06 (D)
In what direction is the magnetic field oriented about a conductor in relation to the direction of electron flow?
A. In the same direction as the current
B. In a direction opposite to the current
C. In all directions; omnidirectional
D. In a direction determined by the left-hand rule

The direction is defined mathematically using a cross-product relationship and the left-hand rule mentioned in answer **D** defines the flow direction so this is the correct choice for this question. Answers A, B and C are incorrect so they are not good choices.

E5D07 (D)
What determines the strength of a magnetic field around a conductor?
A. The resistance divided by the current
B. The ratio of the current to the resistance
C. The diameter of the conductor
D. The amount of current

The field is proportional to the current so the correct choice is answer **D**. Answers A and B are nonsense quantities so they are eliminated. The diameter of the conductor is important to the computation of the inductance but the current flow determines the field strength so this is not the best choice for the answer to this question.

E5D08 (B)
What is the term for energy that is stored in an electromagnetic or electrostatic field?
A. Amperes-joules
B. Potential energy
C. Joules-coulombs
D. Kinetic energy

Stored energy is potential energy so the correct answer is **B**. Answers A and C are technobabble to distract you. Kinetic energy is the energy of motion so answer D is not a correct choice.

E5D09 (D)
What is the term for an out-of-phase, nonproductive power associated with inductors and capacitors?
A. Effective power
B. True power
C. Peak envelope power
D. Reactive power

This is the definition for reactive power as in answer **D** so that is the right choice here. The effective power and peak envelope power in answers A and C are generally measured at the output of a transmitter and are not correct here. True power in answer B is associated with productive power so this is not correct for this question.

E5D10 (B)
In a circuit that has both inductors and capacitors, what happens to reactive power?
A. It is dissipated as heat in the circuit
B. It is repeatedly exchanged between the associated magnetic and electric fields, but is not dissipated
C. It is dissipated as kinetic energy in the circuit
D. It is dissipated in the formation of inductive and capacitive fields

The reactive power stays in the fields as in answer **B** so that is the correct choice. The power dissipated as heat is the characteristic of a resistive device so answer A cannot be correct. Electrical circuits do not have kinetic energy, unless you throw them, so answer C cannot be correct either. Answer D is not correct in that the establishment of the field is part of the initial transient response of the circuit.

```
E5D11 (A)
How can the true power be determined in an AC circuit where the voltage and
current are out of phase?
A. By multiplying the apparent power times the power factor
B. By dividing the reactive power by the power factor
C. By dividing the apparent power by the power factor
D. By multiplying the reactive power times the power factor
```

The correct procedure is given in answer **A** so that is the right choice for this question. Answer D is known as the apparent power and not the how power factor is used so it is incorrect. Answers B and C are not the correct procedure for using the power factor so they are incorrect.

```
E5D12 (C)
What is the power factor of an R-L circuit having a 60 degree phase angle
between the voltage and the current?
A. 1.414
B. 0.866
C. 0.5
D. 1.73
```

The power factor is the cosine of the angle so $Pf = \cos(60°) = 0.5$. This makes answer **C** the correct choice. Answers A and D cannot be valid power factors because they are greater than one. Answer B is a different phase angle.

```
E5D13 (B)
How many watts are consumed in a circuit having a power factor of 0.2 if the
input is 100-V AC at 4 amperes?
A. 400 watts
B. 80 watts
C. 2000 watts
D. 50 watts
```

Here we apply the power factor to compute the power from $P = V\ I\ Pf = (100)(4)(0.2) = 80\ W$. Answer **B** is the correct choice for this question. Answer A ignores the power factor so it is not a correct choice. The other choices have math mistakes in them.

```
E5D14 (B)
How much power is consumed in a circuit consisting of a 100 ohm resistor in
series with a 100 ohm inductive reactance drawing 1 ampere?
A. 70.7 Watts
B. 100 Watts
C. 141.4 Watts
D. 200 Watts
```

First we need to find the angle between the voltage and the current. The total impedance is $Z = 100\ \Omega + j\ 100\ \Omega = 141\ \Omega$ at an angle of 45°. The Power Factor will be $Pf = \cos(45°) = 0.71$. The power will be $P = I^2\ |Z|\ Pf = (1)(141)(0.71) = 99.7\ W$. Answer **B** is within the round-off error so this is the best choice to answer the question.

```
E5D15 (A)
What is reactive power?
A. Wattless, nonproductive power
B. Power consumed in wire resistance in an inductor
C. Power lost because of capacitor leakage
D. Power consumed in circuit Q
```

The apparent power in a reactive load is the reactive power which is Wattless so answer **A** is the correct choice. Do not be confused with answer B since it concerns a reactive element but this is not the definition of reactive power. Answer C is a concern in a circuit but, again, this is not the definition of reactive power. Answer D is a silly distraction.

```
E5D16 (D)
What is the power factor of an RL circuit having a 45 degree phase angle
between the voltage and the current?
A. 0.866
B. 1.0
C. 0.5
D. 0.707
```

Here we have a series of questions concerning power factor. The power factor is $\cos(\theta)$. In this case, $Pf = \cos(45°) = 0.707$ making answer **D** the correct choice. The other choices correspond to angles other than 45 degrees so they are incorrect.

```
E5D17 (C) was [E5H14]
What is the power factor of an RL circuit having a 30 degree phase angle
between the voltage and the current?
A. 1.73
B. 0.5
C. 0.866
D. 0.577
```

Another question concerning power factor. In this case, $Pf = \cos(30°) = 0.866$ making answer **C** the correct choice. The other choices correspond to angles other than 30 degrees so they are incorrect.

```
E5D18 (D)
How many watts are consumed in a circuit having a power factor of 0.6 if the
input is 200V AC at 5 amperes?
A. 200 watts
B. 1000 watts
C. 1600 watts
D. 600 watts
```

Here we apply the power factor to an actual computation. The power is $P = V\ I\ Pf = (200)(5)(0.6) = 600\ W$ as in answer **D**. Answer B is the power without the power factor applied so it is incorrect. The other choices represent math mistakes.

```
E5D19 (B)
How many watts are consumed in a circuit having a power factor of 0.71 if the
apparent power is 500 watts?
A. 704 W
B. 355 W
C. 252 W
D. 1.42 mW
```

Again we apply the power factor to the computation. The power is `P = (500)(0.71) = 355 W` as in answer **B**. The other choices are to distract you.

Subelement E6 -- Circuit Components

```
E6A01 (C)
In what application is gallium arsenide used as a semiconductor material in
preference to germanium or silicon?
A. In high-current rectifier circuits
B. In high-power audio circuits
C. At microwave frequencies
D. At very low frequency RF circuits
```

Given that our hobby deals with microwave-frequency communications at times, that should be a hint to you that answer **C** is the correct choice here. In answers A, B, or D, germanium or silicon is generally preferred to gallium arsenide for those applications so they are not good choices for the right answer.

```
E6A02 (A)
What type of semiconductor material contains more free electrons than pure
germanium or silicon crystals?
A. N-type
B. P-type
C. Bipolar
D. Insulated gate
```

If you remember your basic science, you will remember that electrons carry a negative charge or "N". Protons carry a positive charge or "P". If we have excess electrons, we have more "N" than we should so we have N–type material making answer **A** the correct choice. Answer B would correspond to having more positive charges so this is not a good choice to answer this question. Bipolar and insulated gate in answers C and D do not tell you what type of materials are being used so the are not good choices to answer the question.

```
E6A03 (C)
What are the majority charge carriers in P-type semiconductor material?
A. Free neutrons
B. Free protons
C. Holes
D. Free electrons
```

In P-type material, we have excess positive charge. Answer A is silly because neutrons do not carry a charge at all. Based on the previous question, we should be able to eliminate answer D because that is N–type material. Semiconductor material does not have free protons rattling around inside the crystal lattice (although, by analogy to the previous question it should – physics just does not work that way). This makes answer B a distraction to the correct choice which is answer **C**. Holes are the absence of negative charge so they act like positive charges in the material.

```
E6A04 (C)
What is the name given to an impurity atom that adds holes to a semiconductor
crystal structure?
A. Insulator impurity
B. N-type impurity
C. Acceptor impurity
D. Donor impurity
```

Since holes can gobble-up free electrons, they are known as "acceptors" which makes answer **C** the best choice among the answers given to correctly answer this question. Answer B is incorrect because N–type material adds electrons and not holes. Answer D is incorrect because “donors” alone does not specify if electrons or holes are added. Answer A is to distract you.

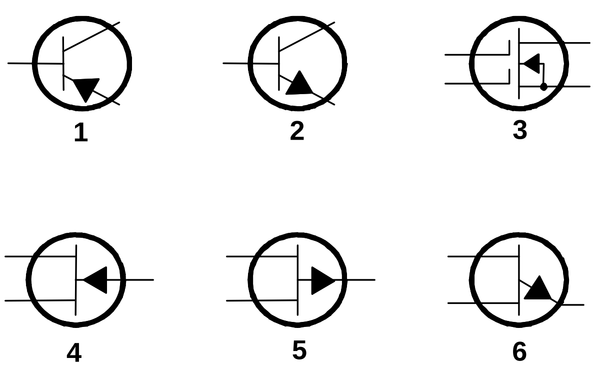
```
E6A05 (C)
What is the alpha of a bipolar junction transistor?
A. The change of collector current with respect to base current
B. The change of base current with respect to collector current
C. The change of collector current with respect to emitter current
D. The change of collector current with respect to gate current
```

This is one of those definitions that needs to be memorized if you do not work with bipolar transistors on a regular basis. The correct definition for alpha in bipolar transistors is given in answer **C**. Be careful with answer D because it looks similar. However, the bipolar transistor does not have a “gate” so this is an incorrect choice. The choices in answers A and B are set up to distract you.

```
E6A06 (B)
What is meant by the beta of a bipolar junction transistor?
A. The frequency at which the current gain is reduced to 1
B. The change in collector current with respect to base current
C. The breakdown voltage of the base to collector junction
D. The switching speed of the transistor
```

This is another one of those terms that may need to be memorized if electronics are not your specialty. The beta (β) is the change in collector current with respect to the base current and it is an important factor for bipolar transistors. The definition for beta is found in Answer **B**.

Figure E6-1



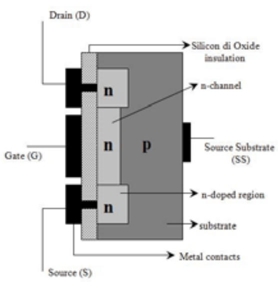

```
E6A07 (A)
In Figure E6-1, what is the schematic
symbol for a PNP transistor?
A. 1
B. 2
C. 4
D. 5
```

The PNP transistor symbol is Symbol #1 as given in Answer **A** so that is the correct choice. Answer B is for a NPN transistor. The other symbols in the figure are for various FET transistors and not bipolar transistors.

E6A08 (D)
What term indicates the frequency at which a transistor grounded base current gain has decreased to 0.7 of the gain obtainable at 1 kHz?
A. Corner frequency
B. Alpha rejection frequency
C. Beta cutoff frequency
D. Alpha cutoff frequency

This is the technical definition for the alpha cutoff frequency so answer **D** is the correct choice. Be careful with answer B because it has a similar-sounding response but it is incorrect. Answers A and C are to distract you.

E6A09 (A)
What is a depletion-mode FET?
A. An FET that exhibits a current flow between source and drain when no gate voltage is applied
B. An FET that has no current flow between source and drain when no gate voltage is applied
C. An FET without a channel so no current flows with zero gate voltage
D. An FET without a channel so maximum gate current flows



The technical definition for a depletion-mode FET is given in answer **A**. The other choices are to distract you from this definition.

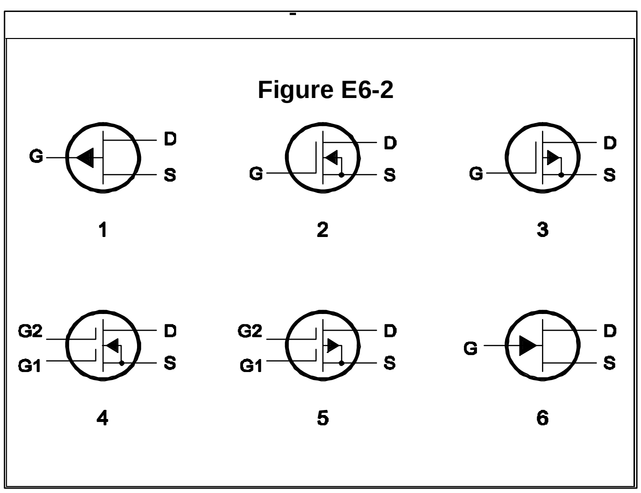


Figure E6-2

E6A10 (B) {Was E6A09}
In Figure E6-2, what is the schematic symbol for an N-channel dual-gate MOSFET?
A. 2
B. 4
C. 5
D. 6

Symbol 1 is a P-channel MOSFET, Symbol 2 is a single-gate N–channel MOSFET, Symbol 3 is a single-gate P–channel MOSFET, Symbol 4 is a dual-gate N–channel MOSFET, Symbol 5 is a dual-gate P–channel MOSFET, and Symbol 6 is a N-channel MOSFET. Therefore, the correct choice is answer **B**. The others are to distract you.

E6A11 (A)
In Figure E6-2, what is the schematic symbol for a P-channel junction FET?
A. 1
B. 2
C. 3
D. 6

Symbol 1 is a P-channel MOSFET, Symbol 2 is a single-gate N–channel MOSFET, Symbol 3 is a single-gate P–channel MOSFET, Symbol 4 is a dual-gate N–channel MOSFET, Symbol 5 is a dual-gate P–channel MOSFET, and Symbol 6 is a N-channel MOSFET. Therefore, the correct choice is answer **A**. The others are to distract you.

```
E6A12 (D)
Why do many MOSFET devices have built-in gate-protective Zener diodes?
A. To provide a voltage reference for the correct amount of reverse-bias gate
      voltage
B. To protect the substrate from excessive voltages
C. To keep the gate voltage within specifications and prevent the device from
      overheating
D. To reduce the chance of the gate insulation being punctured by static
      discharges or excessive voltages
```

Answer B is close to the right answer but it is not the best choice. The full reasoning is given in answer **D** so that is the best choice to answer this question. Answers A and C are to distract you.

```
E6A13 (C)
What do the initials CMOS stand for?
A. Common mode oscillating system
B. Complementary mica-oxide silicon
C. Complementary metal-oxide semiconductor
D. Complementary metal-oxide substrate
```

The correct meaning of the acronym is given in answer **C**. All of the other choices are distractions to confuse you.

```
E6A14 (C)
How does DC input impedance at the gate of a field-effect transistor compare
with the DC input impedance of a bipolar transistor?
A. They cannot be compared without first knowing the supply voltage
B. An FET has low input impedance; a bipolar transistor has high input
      impedance
C. An FET has high input impedance; a bipolar transistor has low input
      impedance
D. The input impedance of FETs and bipolar transistors is the same
```

The transistor impedance is a function of the materials and techniques used in their construction so answer A is not a good choice. The FET and bipolar transistors have different impedances so answer D is incorrect. The correct choice is answer **C**. Answer B is the reverse and incorrect.

```
E6A15 (B)
What two elements widely used in semiconductor devices exhibit both metallic
and nonmetallic characteristics?
A. Silicon and gold
B. Silicon and germanium
C. Galena and germanium
D. Galena and bismuth
```

Gold only shows metallic properties so answer A is not a correct choice. Galena is a form of lead ore which is metallic so answers C and D are out. As you may have been able to spot based on the other questions in this section, silicon and germanium in answer **B** is the correct choice.

```
E6A16 (B)
What type of semiconductor material contains fewer free electrons than pure
germanium or silicon crystals?
A. N-type
B. P-type
C. Superconductor-type
D. Bipolar-type
```

Bipolar-type is not a single configuration and bipolar transistors are made from silicon or germanium so answer D is not a good choice since it is not specific enough by itself. Answer C is a silly distraction since there are not superconducting semiconductors (at least at the local electronics store). Here, you need to know that the right answer is P-type so the correct choice is answer **B**. Answer A is incorrect because it has excess electrons.

```
E6A17 (B)
What are the majority charge carriers in N-type semiconductor material?
A. Holes
B. Free electrons
C. Free protons
D. Free neutrons
```

N–type semiconductors have an excess of electrons so the correct choice is answer **B**. Answer A is for P-type material so this is the wrong choice. As we saw before, semiconductor crystals do not have free protons and neutrons are neutral so answers C and D are just to distract you.

```
E6A18 (D)
What are the names of the three terminals of a field-effect transistor?
A. Gate 1, gate 2, drain
B. Emitter, base, collector
C. Emitter, base 1, base 2
D. Gate, drain, source
```

The correct naming of the terminals for a FET is given in answer **D** so that is the correct choice. Answer B has the names for the terminals of a bipolar transistor so be careful not to select this answer. Answers A and C are to distract you.

```
E6B01 (B)
What is the principal characteristic of a Zener diode?
A. A constant current under conditions of varying voltage
B. A constant voltage under conditions of varying current
C. A negative resistance region
D. An internal capacitance that varies with the applied voltage
```

Zener diodes have sometimes been called a "poor man's voltage regulator" because of their ability to maintain a constant voltage so answer **B** is the right choice to answer this question. Answer A has the voltage and current interchanged so it is a wrong choice. Answer C is for a tunnel diode so this is an incorrect choice as well. Answer D is not a characteristic of the Zener diode but the veractor diode.

```
E6B02 (C)
What is the principal characteristic of a tunnel diode?
A. A high forward resistance
B. A very high PIV
C. A negative resistance region
D. A high forward current rating
```

A tunnel diode is known for its negative resistance region so answer **C** is the right choice for this question. Diodes usually have a low forward resistance so answer A is not a good choice. Answers B and D can apply to any diode so they are not specific to tunnel diodes.

E6B03 (D)
What is an important characteristic of a Schottky Barrier diode as compared to an ordinary silicon diode when used as a power supply rectifier?
A. Much higher reverse voltage breakdown
B. Controlled reverse avalanche voltage
C. Enhanced carrier retention time
D. Less forward voltage drop

The characteristic to remember is that the Schottky barrier diode has less forward voltage drop than an ordinary diode. This makes Answer **D** the right choice.

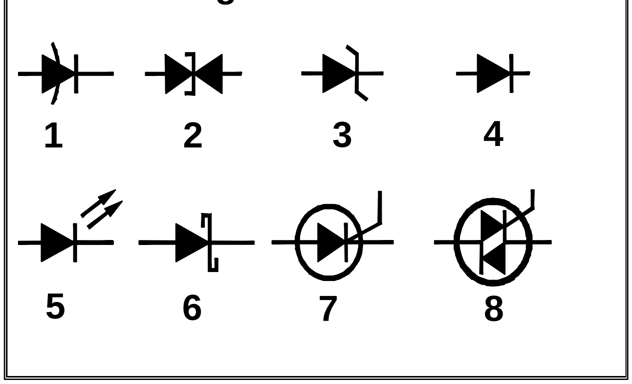
E6B04 (C)
What special type of diode is capable of both amplification and oscillation?
A. Point contact
B. Zener
C. Tunnel
D. Junction

Because of the negative resistance characteristics of tunnel diodes, they can be used to make both amplifiers and oscillators so answer **C** is the correct choice. The other diode types cannot make this claim so they are not good choices to answer the question.

E6B05 (A)
What type of semiconductor device varies its internal capacitance as the voltage applied to its terminals varies?
A. Varactor diode
B. Tunnel diode
C. Silicon-controlled rectifier
D. Zener diode

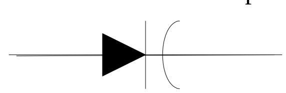
This is the definition of a veractor diode so answer **A** is the right choice. We already saw the definitions of Zener and tunnel diodes so we should be able to spot them as distractions for this question.

Figure E6-3



E6B06 (D)
In Figure E6-3, what is the schematic symbol for a varactor diode?
A. 8
B. 6
C. 2
D. 1

A varactor diode has a variable capacitor that is a function of the voltage across the device combined with the diode and knowing this makes it easy to spot Symbol 1 in Answer **D** as the right choice. Sometimes the varactor is drawn as this: to emphasize the capacitor.



E6B07 (D)
What is a common use of a hot-carrier diode?
A. As balanced mixers in FM generation
B. As a variable capacitance in an automatic frequency control circuit
C. As a constant voltage reference in a power supply
D. As a VHF / UHF mixer or detector

The correct use is in UHF and VHF mixers and detectors as in answer **D** so that is the best choice. Answer A may sound similar but the frequency range is not mentioned so it is not as good a choice. Answers B and C are to distract you.

E6B08 (B)
What limits the maximum forward current rating in a junction diode?
A. Peak inverse voltage
B. Junction temperature
C. Forward voltage
D. Back EMF

As the current flows, the junction will warm up so answer **B** is the correct reason. Answer A applies to reverse current so this is not a consideration here. Answer C does not hold here. Answer D applies to inductors so it is not a good choice here.

E6B09 (A)
Which of the following describes a type of semiconductor diode?
A. Metal-semiconductor junction
B. Electrolytic rectifier
C. CMOS-field effect
D. Thermionic emission diode

The correct answer is given in answer **A**.

E6B10 (C)
What is a common use for point contact diodes?
A. As a constant current source
B. As a constant voltage source
C. As an RF detector
D. As a high voltage rectifier

Point contact diodes are used in RF detection circuits so answer **C** is the correct choice. Answers A and B are often done with other types of circuits. Answer D is often done with silicon diodes.

E6B11 (B)
In Figure E6-3, what is the schematic symbol for a light-emitting diode?
A. 1
B. 5
C. 6
D. 7

The LED emits light so use the arrows coming from the diode to key into Symbol 5 in Answer **B** as the right choice.

E6B12 (D)
How are junction diodes rated?
A. Maximum forward current and capacitance
B. Maximum reverse current and PIV
C. Maximum reverse current and capacitance
D. Maximum forward current and PIV

Junction diodes are rated by their maximum forward current and peak inverse voltage (PIV). This makes Answer **D** the correct choice among those given.

E6B13 (C)
What is one common use for PIN diodes?
A. As a constant current source
B. As a constant voltage source
C. As an RF switch
D. As a high voltage rectifier

If you start building RF hardware, you will probably encounter a PIN diode at some point being used as an RF switch so answer **C** is the correct choice for this question. PIN diodes are not used as sources so answers A and B are not good choices. Answer D is a bit too generic to be useful so it is not a good choice.

E6B14 (B)
What type of bias is required for an LED to produce luminescence?
A. Reverse bias
B. Forward bias
C. Zero bias
D. Inductive bias

The LED "glows" when the junction is forward biased so answer **B** is the right choice here. A LED is a junction diode so it does not work when the junction is reversed biased so answer A is not a good choice. Answers C and D are technobabble to try to confuse you.

E6C01 (C)
What is the recommended power supply voltage for TTL series integrated circuits?
A. 12 volts
B. 1.5 volts
C. 5 volts
D. 13.6 volts

If you have experience with TTL logic, you will easily spot 5 V as the right answer so **C** is the correct choice for this question. Some new modern, non-TTL devices run as low as 1.5 V but not TTL so this is not a god choice. 12 V is typical for RS-232 connections but not TTL either so answer A is not a good choice.

E6C02 (A)
What logic state do the inputs of a TTL device assume if they are left open?
A. A logic-high state
B. A logic-low state
C. The device becomes randomized and will not provide consistent high or low-logic states
D. Open inputs on a TTL device are ignored

Open inputs to TTL logic are assigned a logic-one or high state so answer **A** is the right choice here. Answer B is just the opposite to try to trick you. Answer C may seem like a reasonable guess but it does not describe the action taken by the circuitry so it is not a good choice. Answer D is also to distract you.

```
E6C03 (A)
What level of input voltage is a logic "high" in a TTL device operating with a
positive 5-volt power supply?
A. 2.0 to 5.5 volts
B. 1.5 to 3.0 volts
C. 1.0 to 1.5 volts
D. -5.0 to -2.0 volts
```

TTL devices assign a logic-one to a rage of voltages. If the supply voltage is 5 V, then you should be able to spot answer D as a distraction. The correct choice is given by the voltage range in answer **A**. Answers B and C are to distract you.

```
E6C04 (C)
What level of input voltage is a logic "low" in a TTL device operating with a
positive 5-volt power-supply?
A. -2.0 to -5.5 volts
B. 2.0 to 5.5 volts
C. 0.0 to 0.8 volts
D. -0.8 to 0.4 volts
```

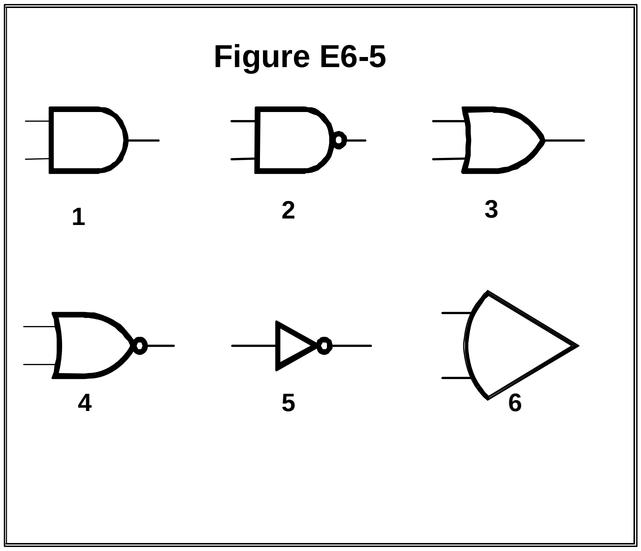
This is the complement to the previous question but now for the logic-low case. Since the supply voltage goes from 0 to 5 V, we can eliminate answers A and D since they go negative. The correct choice is 0 to 0.8 V as in answer **C**. Answer B is to try to trick you.

```
E6C05 (D)
Which of the following is an advantage of CMOS logic devices over TTL devices?
A. Differential output capability
B. Lower distortion
C. Immune to damage from static discharge
D. Lower power consumption
```

The big advantage to CMOS, especially with modern circuitry going to lower power supply voltages, is the lower power consumption of CMOS. Answer **D** is the right choice.

```
E6C06 (C)
Why do CMOS digital integrated circuits have high immunity to noise on the
input signal or power supply?
A. Larger bypass capacitors are used in CMOS circuit design
B. The input switching threshold is about two times the power supply voltage
C. The input switching threshold is about one-half the power supply voltage
D. Input signals are stronger
```

Answer D is incorrect since certain CMOS circuits can have small input signal levels. Answer A is incorrect because large capacitors are not required and they can be used in other designs as well. Answer B is silly since the voltage exceeds the available voltage. Answer **C** has the correct reasoning so this is the correct choice.



E6C07 (A)
In Figure E6-5, what is the schematic symbol for an AND gate?
A. 1
B. 2
C. 3
D. 4

Symbol 1 is an AND gate, Symbol 2 is a NAND gate, Symbol 3 is an OR gate, Symbol 4 is a NOR gate, Symbol 5 is a NOT gate, and Symbol 6 is a buffer. Therefore, the correct choice is answer **A**.

E6C08 (B)
In Figure E6-5, what is the schematic symbol for a NAND gate?
A. 1
B. 2
C. 3
D. 4

Symbol 1 is an AND gate, Symbol 2 is a NAND gate, Symbol 3 is an OR gate, Symbol 4 is a NOR gate, Symbol 5 is a NOT gate, and Symbol 6 is a buffer. Therefore, the correct choice is answer **B**.

E6C09 (B)
In Figure E6-5, what is the schematic symbol for an OR gate?
A. 2
B. 3
C. 4
D. 6

Symbol 1 is an AND gate, Symbol 2 is a NAND gate, Symbol 3 is an OR gate, Symbol 4 is a NOR gate, Symbol 5 is a NOT gate, and Symbol 6 is a buffer. Therefore, the correct choice is Answer **B**.

E6C10 (D)
In Figure E6-5, what is the schematic symbol for a NOR gate?
A. 1
B. 2
C. 3
D. 4

Symbol 1 is an AND gate, Symbol 2 is a NAND gate, Symbol 3 is an OR gate, Symbol 4 is a NOR gate, Symbol 5 is a NOT gate, and Symbol 6 is a buffer. Therefore, the correct choice is answer **D.**

E6C11 (C)
In Figure E6-5, what is the schematic symbol for the NOT operation (inverter)?
A. 2
B. 4
C. 5
D. 6

Symbol 1 is an AND gate, Symbol 2 is a NAND gate, Symbol 3 is an OR gate, Symbol 4 is a NOR gate, Symbol 5 is a NOT gate, and Symbol 6 is a buffer. Therefore, the correct choice is answer **C**.

E6D01 (D)
How is the electron beam deflected in a vidicon?
A. By varying the beam voltage
B. By varying the bias voltage on the beam forming grids inside the tube
C. By varying the beam current
D. By varying electromagnetic fields

The path that the electrons take in the vidicon is modified by an electromagnetic field so the correct choice to answer this question is answer **D**. The voltage can be varied to change the speed of the electrons but not the direction so answers A and B are incorrect. The beam current varies the number of electrons sent but not the direction so answer C is also incorrect.

E6D02 (D)
What is cathode ray tube (CRT) persistence?
A. The time it takes for an image to appear after the electron beam is turned on
B. The relative brightness of the display under varying conditions of ambient light
C. The ability of the display to remain in focus under varying conditions
D. The length of time the image remains on the screen after the beam is turned off

The CRT screen remembers the last image on it (that is why screen savers are important on computers) which is known as persistence. The correct choice is answer **D**. The other characteristics are interesting to know about the tube but they are not called persistence so they are not good choices to answer the question.

E6D03 (A)
If a cathode ray tube (CRT) is designed to operate with an anode voltage of 25,000 volts, what will happen if the anode voltage is increased to 35,000 volts?
A. The image size will decrease
B. The image size will increase
C. The image will become larger and brighter
D. There will be no apparent change

More is not always better! In this case, the image decreases and X-rays may also be produced so answer **A** is the correct choice (and a warning). Be careful with answer B because the image size is wrong but seems reasonable. Answer C is obviously incorrect as well because the image size is wrong and the interesting effects are not listed. Answer D is wrong too.

E6D04 (B)
Exceeding what design rating can cause a cathode ray tube (CRT) to generate X-rays?
A. The heater voltage
B. The anode voltage
C. The operating temperature
D. The operating frequency

The anode voltage controls the energy of the electrons so answer **B** is the correct choice. The other three choices do not affect the electron energy so they are not good answers for the question.

E6D05 (C)
Which of the following is true of a charge-coupled device (CCD)?
A. Its phase shift changes rapidly with frequency
B. It is a CMOS analog-to-digital converter
C. It samples an analog signal and passes it in stages from the input to the output
D. It is used in a battery charger circuit

Answer A has nothing to do with a CCD so it is not a good answer. A CCD is a type of analog-to-digital converter but it does not need to be CMOS so answer B is not a good choice. Answer **C** is a correct description of a CCD so this is the best choice to answer the question of the answers given here. A CCD is typically not used in a battery circuit so answer D is not a good choice either.

E6D06 (A)
What function does a charge-coupled device (CCD) serve in a modern video camera?
A. It stores photogenerated charges as signals corresponding to pixels
B. It generates the horizontal pulses needed for electron beam scanning
C. It focuses the light used to produce a pattern of electrical charges corresponding to the image
D. It combines audio and video information to produce a composite RF signal

Answer **A** has the correct description of CCD use so this is the right choice for this question. Answer B is more akin to a function in a CRT so this is not a good choice for this question. Since the CCD is an integrated circuit, it does not have the ability to focus light so answer C is not a correct choice. The CCD does not process audio or RF so answer D is not a correct choice.

E6D07 (B)
What is a liquid-crystal display (LCD)?
A. A modern replacement for a quartz crystal oscillator which displays its fundamental frequency
B. A display that uses a crystalline liquid to change the way light is refracted
C. A frequency-determining unit for a transmitter or receiver
D. A display that uses a glowing liquid to remain brightly lit in dim light

A LCD woks by light refraction so answer **B** is the correct choice. Answer D is an interesting concept but it does not describe an LCD so it is not a good choice. Answers A and C have nothing to do with LCDs and how they operate so they are just silly distractions for you.

E6D08 (D)
What material property determines the inductance of a toroidal inductor with a 10-turn winding?
A. Core load current
B. Core resistance
C. Core reactivity
D. Core permeability

The current and the resistance do not determine the intrinsic magnetic properties of the toroid so answers A and B can be eliminated from consideration. The toroid's permeability is the correct answer so answer **D** is the correct choice to answer the question. Answer C is to see if you know the meaning of the terms.

E6D09 (B)
What is the usable frequency range of inductors that use toroidal cores, assuming a correct selection of core material for the frequency being used?
A. From a few kHz to no more than 30 MHz
B. From less than 20 Hz to approximately 300 MHz
C. From approximately 1000 Hz to no more than 3000 kHz
D. From about 100 kHz to at least 1000 GHz

You will probably just need to memorize this one unless you have a great deal of familiarity with magnetic materials. The typical range is 20 Hz to 3000 MHz so answer **B** is the correct choice. The others look really close so be careful when reading the question.

E6D10 (B)
What is one important reason for using powdered-iron toroids rather than ferrite toroids in an inductor?
A. Powdered-iron toroids generally have greater initial permeabilities
B. Powdered-iron toroids generally have better temperature stability
C. Powdered-iron toroids generally require fewer turns to produce a given inductance value
D. Powdered-iron toroids have the highest power handling capacity

Since the toroid can become warm when the current is flowing, temperature stability is very important which makes answer **B** the best choice among those given. Ferrites generally have higher permeabilities so answer A is incorrect. Ferrite coils generally require fewer turns so answer C is also incorrect. Both are equally difficult to work with SMD's.

E6D11 (C)
What devices are commonly used as VHF and UHF parasitic suppressors at the input and output terminals of transistorized HF amplifiers?
A. Electrolytic capacitors
B. Butterworth filters
C. Ferrite beads
D. Steel-core toroids

The correct answer is ferrite beads so answer **C** is the right choice here. Electrolytic capacitors are not passive suppressors so answer A is not a correct choice. Butterworth filters are made out of RLC components and are not passive suppressors so answer B is not a good choice. Generally steel is not used as a toroid material so answer D is also not a good choice.

E6D12 (A)
What is a primary advantage of using a toroidal core instead of a solenoidal core in an inductor?
A. Toroidal cores contain most of the magnetic field within the core material
B. Toroidal cores make it easier to couple the magnetic energy into other components
C. Toroidal cores exhibit greater hysteresis
D. Toroidal cores have lower Q characteristics

The reason for using the toroid is to confine the magnetic field so answer **A** is the right choice. Answer B has an effect just the opposite of what is desired so this is not a good choice. Hysteresis is generally not a good property for this application so answer C is not a good choice. Answer D is irrelevant to the purpose of confining the magnetic field.

E6D13 (C)
How many turns will be required to produce a 1-mH inductor using a ferrite toroidal core that has an inductance index (A L) value of 523 millihenrys/1000 turns?
A. 2 turns
B. 4 turns
C. 43 turns
D. 229 turns

The correct design equation to use for ferrite cores is $N = 1000*SQRT(L/A_L)$. Plugging in the numbers gives N = 1000*SQRT(1/523) = 1000*SQRT(0.044) = 44 so answer **C** is the right choice. Answer D represents using (523/1) instead of (1/523). Answer B used the powdered iron formula and not the ferrite formula so this is incorrect. Answer A is to distract you.

E6D14 (A)
How many turns will be required to produce a 5-microhenry inductor using a powdered-iron toroidal core that has an inductance index (A L) value of 40 microhenrys/100 turns?
A. 35 turns
B. 13 turns
C. 79 turns
D. 141 turns

The correct design equation to use for powdered iron cores is $N = 100*SQRT(L/A_L)$. Plugging in the numbers gives N = 100*SQRT(5/40) = 100*SQRT(0.125) = 35 so answer **A** is the right choice. The other answers represent math mistakes.

E6D15 (D)
What type of CRT deflection is better when high-frequency waves are to be displayed on the screen?
A. Electromagnetic
B. Tubular
C. Radar
D. Electrostatic

Answers B and C are silly distractions for this question so they can be eliminated. The correct choice is answer **D**. Be careful because answer A can look correct if you read the choices too quickly.

E6D16 (C)
Which is NOT true of a charge-coupled device (CCD)?
A. It uses a combination of analog and digital circuitry
B. It can be used to make an audio delay line
C. It is commonly used as an analog-to-digital converter
D. It samples and stores analog signals

Each of the statements in answers A, B, and D is true for CCDs so they are not the right choice here where we are looking for a wrong answer. The correct "wrong" answer is **C**.

E6D17 (A)
What is the principle advantage of liquid-crystal display (LCD) devices over other types of display devices?
A. They consume less power
B. They can display changes instantly
C. They are visible in all light conditions
D. They can be easily interchanged with other display devices

The LCD is well known for its low power consumption so answer **A** is the correct choice for this question. Answers B, C, and D are all incorrect statements so they are not a good choice to answer this question.

E6D18 (C)
What is one reason for using ferrite toroids rather than powdered-iron toroids in an inductor?
A. Ferrite toroids generally have lower initial permeabilities
B. Ferrite toroids generally have better temperature stability
C. Ferrite toroids generally require fewer turns to produce a given inductance value
D. Ferrite toroids are easier to use with surface mount technology

Based on the design equations and the answer to a previous question, we should be able to spot answer **C** as the correct one. Answer A is wrong because ferrite toroids have higher permeabilities. Answer B is wrong because powdered iron has better temperature stability.

E6E01 (B)
Which of these filter bandwidths would be a good choice for use in a SSB radiotelephone transmitter?
A. 6 kHz at -6 dB
B. 2.4 kHz at -6 dB
C. 500 Hz at -6 dB
D. 15 kHz at -6 dB

SSB transmissions require around 2 kHz for proper signal filtering. Therefore, answer **B** is the right choice. Answer A is too wide for SSB because it is designed for DSB and would let in too much noise. Answer C is more like that found for CW transmissions so this is not a good choice. Answer D is more like FM so this is not a good choice for SSB.

E6E02 (C)
Which of these filter bandwidths would be a good choice for use with standard double-sideband AM transmissions?
A. 1 kHz at -6 dB
B. 500 Hz at -6 dB
C. 6 kHz at -6 dB
D. 15 kHz at -6 dB

Based on the last question, you should be able to spot the 6 kHz in answer **C** as the right choice because DSB takes twice the transmission bandwidth of SSB. Answers A and B are too narrow. Answer D is for FM so this is not correct for DSB.

```
E6E03 (D)
What is a crystal lattice filter?
A. A power supply filter made with interlaced quartz crystals
B. An audio filter made with four quartz crystals that resonate at 1-kHz
      intervals
C. A filter with wide bandwidth and shallow skirts made using quartz crystals
D. A filter with narrow bandwidth and steep skirts made using quartz crystals
```

Answer A is not correct because typically the lattice filter is not used on power supplies. Answer B is not correct because it does not need to have 4 crystals nor does it resonate at 1 kHz intervals. A lattice crystal has narrow bandwidth and not wide bandwidth so answer C is incorrect. Answer **D** is the correct description among those given so this is the right choice here.

```
E6E04 (D)
What technique is used to construct low-cost, high-performance crystal ladder
filters?
A. Obtain a small quantity of custom-made crystals
B. Choose a crystal with the desired bandwidth and operating frequency to
      match a desired center frequency
C. Measure crystal bandwidth to ensure at least 20% coupling
D. Measure crystal frequencies and carefully select units with a frequency
      variation of less than 10% of the desired filter bandwidth
```

Because of the crystal variations, answer A is not specific enough to ensure that the crystals are properly matched. Answer B is not a good choice because crystals are not rated with a bandwidth. Answer C is technobabble so this is a bad choice. Only answer **D** gives the correct procedure among the choices given.

```
E6E05 (A)
Which of the following factors has the greatest effect in helping determine
the bandwidth and response shape of a crystal ladder filter?
A. The relative frequencies of the individual crystals
B. The DC voltage applied to the quartz crystal
C. The gain of the RF stage preceding the filter
D. The amplitude of the signals passing through the filter
```

The crystal filter has the two crystals slightly offset in frequency so this sets the bandwidth of the overall filter. This makes answer **A** the correct choice to answer this question. The DC voltage will not be critical so answer B is not correct. Answer C does not come into the design of the filter so this is not a good choice. The amplitudes do not matter as long as the signal is above the noise floor so answer D is not relevant either.

```
E6E06 (A)
What is the one aspect of the piezoelectric effect?
A. Physical deformation of a crystal by the application of a voltage
B. Mechanical deformation of a crystal by the application of a magnetic field
C. The generation of electrical energy by the application of light
D. Reversed conduction states when a P-N junction is exposed to light
```

The piezoelectric effect is related to the deformation of the crystal and the voltage so answer **A** is the correct choice. Answer B is not this physical effect so this is not a correct choice. Answer C is a form of the photoelectric effect so this is not a correct choice. Answer D is technobabble.

E6E07 (A)
What is the characteristic impedance of circuits in which almost all MMICs are designed to work?
A. 50 ohms
B. 300 ohms
C. 450 ohms
D. 10 ohms

This is the first in a series of several questions about MMIC design. If you are not familiar with this technology, you will just need to memorize the correct answers. Since MMICs frequently interface with RF devices, you may suspect that the correct answer is 50 Ω as in answer A and that is the right choice. The other choices are to distract you.

E6E08 (B)
What is the typical noise figure of a monolithic microwave integrated circuit (MMIC) amplifier?
A. Less than 1 dB
B. Approximately 3.5 to 6 dB
C. Approximately 8 to 10 dB
D. More than 20 dB

MMICs have good noise figure performance in the 3 - 6 dB neighborhood so answer **B** is the correct choice among those given. Answer A would be wonderful if it were true for this class of device but it is too good. Answer C and D are worse performance.

E6E09 (D)
What type of amplifier device consists of a small pill-type package with an input lead, an output lead and 2 ground leads?
A. A junction field-effect transistor (JFET)
B. An operational amplifier integrated circuit (OAIC)
C. An indium arsenide integrated circuit (IAIC)
D. A monolithic microwave integrated circuit (MMIC)

Since we have been dealing here with MMIC devices, you might suspect that answer **D** is the correct choice and you would be right. The other choices are to distract you.

E6E10 (B)
What typical construction technique is used when building an amplifier for the microwave bands containing a monolithic microwave integrated circuit (MMIC)?
A. Ground-plane "ugly" construction
B. Microstrip construction
C. Point-to-point construction
D. Wave-soldering construction

Ugly is to be avoided in all construction projects so answer A is a bad choice for any type of project. MMIC construction typically uses microstrip techniques so answer **B** is the right choice. Answer D is used in commercial construction techniques so this is not a good choice.

```
E6E11 (A)
How is the operating bias voltage normally supplied to the most common type of
monolithic microwave integrated circuit (MMIC)?
A. Through a resistor and/or RF choke connected to the amplifier output lead
B. MMICs require no operating bias
C. Through a capacitor and RF choke connected to the amplifier input lead
D. Directly to the bias-voltage (VCC IN) lead
```

For this question, you need to know that answer **A** has the right method. The other choices are incorrect.

```
E6E12 (B)
What supply voltage do monolithic microwave integrated circuits (MMIC)
amplifiers typically require?
A. 1 volt DC
B. 12 volts DC
C. 20 volts DC
D. 120 volts DC
```

For this question, you need to know that a resistor is the component used so answer **D** is the right choice. Again, the others are to distract you.

```
E6E13 (C)
What is the most common package for inexpensive monolithic microwave
integrated circuit (MMIC) amplifiers?
A. Beryllium oxide packages
B. Glass packages
C. Plastic packages
D. Ceramic packages
```

Integrated circuits typically come in plastic and ceramic packages so answers C and D are the ones to consider. Integrated circuits do not typically come in glass or beryllium packages so answers A and B are eliminated. Of the two viable choices, plastic is less expensive than ceramic so answer **C** is the correct choice for this question.

```
E6F01 (B)
What is photoconductivity?
A. The conversion of photon energy to electromotive energy
B. The increased conductivity of an illuminated semiconductor
C. The conversion of electromotive energy to photon energy
D. The decreased conductivity of an illuminated semiconductor
```

The key here is the term conductivity as found in answers B and D. Photoconductivity increases conductivity so answer **B** is the correct choice. Be careful because answer D is the opposite and it is wrong. Answers A and C are to distract you.

```
E6F02 (A)
What happens to the conductivity of a photoconductive material when light
shines on it?
A. It increases
B. It decreases
C. It stays the same
D. It becomes unstable
```

Based on the previous question, we should be able to spot answer **A** as the correct choice. Answer B is the opposite and answers C and D are to distract you.

```
E6F03 (D)
What is the most common configuration for an optocoupler?
A. A lens and a photomultiplier
B. A frequency modulated helium-neon laser
C. An amplitude modulated helium-neon laser
D. An LED and a phototransistor
```

The correct definition for an optocoupler is given in answer **D** so that is the right choice. Answers B and C are interesting devices that have nothing to do with optocouplers so they are eliminated here.

```
E6F04 (A)
Which of the following is an optoisolator?
A. An LED and a phototransistor
B. A P-N junction that develops an excess positive charge when exposed to
      light
C. An LED and a capacitor
D. A P-N junction that develops an excess negative charge when exposed to
      light
```

Answer **A** shows that optoisolators and optocouplers are basically the same devices and this is the right choice for this question. Answers C and D are the circuit equivalent of technobabble. Answer B is also not relevant to this device.

```
E6F05 (B)
What is an optical shaft encoder?
A. An array of neon or LED indicators whose light transmission path is
      controlled by a rotating wheel
B. An array of optocouplers whose light transmission path is controlled by a
      rotating wheel
C. An array of neon or LED indicators mounted on a rotating wheel in a coded
      pattern
D. An array of optocouplers mounted on a rotating wheel in a coded pattern
```

The shaft encoder is based on optocouplers so answers A and C can be eliminated. The optocoupler is not mounted to the rotating wheel so answer C is not correct. The correct definition is given in answer **B** so that is the right choice.

```
E6F06 (D)
What characteristic of a crystalline solid will photoconductivity change?
A. The capacitance
B. The inductance
C. The specific gravity
D. The resistance
```

Light will not change the mass of the solid so the specific gravity in answer C is not a good choice. The capacitance and the inductance are also not affected by light hitting the solid so answers A and B are not correct choices either. The correct one is resistance as in answer **D**.

E6F07 (C)
Which material will exhibit the greatest photoconductive effect when illuminated by visible light?
A. Potassium nitrate
B. Lead sulfide
C. Cadmium sulfide
D. Sodium chloride

Common, inexpensive photodetectors for visible light are typically made from calcium sulfide and answer **C** is the best choice for this question. Lead sulfide, in answer B, is best for infrared light and not visible. The other choices are to distract you.

E6F08 (B)
Which material will exhibit the greatest photoconductive effect when illuminated by infrared light?
A. Potassium nitrate
B. Lead sulfide
C. Cadmium sulfide
D. Sodium chloride

Unless you deal with photodectors on a regular basis, all of the choices may seem good. Here you need to remember that lead sulfide, as in answer **B**, is the best choice for infrared. From the previous question, you know that cadmium sulfide in photodetectors is best for visible but here we wish to have IR.

E6F09 (A)
Which of the following materials is affected the most by photoconductivity?
A. A crystalline semiconductor
B. An ordinary metal
C. A heavy metal
D. A liquid semiconductor

Metals can be affected by photoconductivity but not as much as semiconductors so answers B and C can be eliminated. Liquid semiconductors are affected less than crystalline semiconductors so answer **A** is the best choice among those given.

E6F10 (B)
What characteristic of optoisolators is often used in power supplies?
A. They have low impedance between the light source and the phototransistor
B. They have very high impedance between the light source and the phototransistor
C. They have low impedance between the light source and the LED
D. They have very high impedance between the light source and the LED

Answer D cannot be correct because that would imply a circuit with two light sources and no detector. Answers A and C are incorrect because optoisolators have a high impedance. The technically correct reasoning is given in answer **B** so that is the correct choice for ths question.

E6F11 (C)
What characteristic of optoisolators makes them suitable for use with a triac to form the solid-state equivalent of a mechanical relay for a 120 V AC household circuit?
A. Optoisolators provide a low impedance link between a control circuit and a power circuit
B. Optoisolators provide impedance matching between the control circuit and power circuit
C. Optoisolators provide a very high degree of electrical isolation between a control circuit and a power circuit
D. Optoisolators eliminate (isolate) the effects of reflected light in the control circuit

The optoisolator is a very high impedance device so answer A cannot be correct. Optoisolators do not provide impedance matching so answer B cannot be correct either. Answer D is technobabble so it is not a good answer. The correct reasoning is given in answer **C** so that is the one to chose for this question.

E6F12 (D)
Which of the following types of photovoltaic cell has the highest efficiency?
A. Silicon
B. Silver iodide
C. Selenium
D. Gallium arsenide

Of the choices given, gallium arsenide has the highest efficiency so Answer **D** is the correct choice.

E6F13 (B)
What is the most common type of photovoltaic cell used for electrical power generation?
A. Selenium
B. Silicon
C. Cadmium Sulfide
D. Copper oxide

Even though gallium arsenide is most efficient, they are also very expensive. The silicon PV cells are less efficient but also less expensive so they are the most common. Answer **B** is the correct choice.

E6F14 (B)
B) What of the following is the approximate open-circuit voltage produced by a fully-illuminated silicon photovoltaic cell?
A. 0.1 V
B. 0.5 V
C. 1.5 V
D. 12 V

The approximate voltage is 0.5 V so Answer **B** is the correct choice.

E6F15 (C)
What absorbs the energy from light falling on a photovoltaic cell?
A. Protons
B. Photons
C. Electrons
D. Holes

The electrons absorb the energy so Answer **C** is the right choice for this question.

Subelement E7 -- Practical Circuits

```
E7A01 (C)
What is a bistable circuit?
A. An "AND" gate
B. An "OR" gate
C. A flip-flop
D. A clock
```

This is a circuit with two stable states that it toggles between and it is just a fancy name for a flip flop so answer **C** is the right choice to answer this question. Answers A and B are individual logic gates. Answer D is to further distract you.

```
E7A02 (C)
How many output level changes are obtained for every two trigger pulses
applied to the input of a "T" flip-flop circuit?
A. None
B. One
C. Two
D. Four
```

In this particular case, two pulses produce two output changes so answer **C** is the right choice. The other choices are to see if you know how a T flip-flop works.

```
E7A03 (B)
Which of the following can divide the frequency of pulse train by 2?
A. An XOR gate
B. A flip-flop
C. An OR gate
D. A multiplexer
```

A flip-flop can be used as a frequency divider so answer **B** is the right choice to answer this question. The other digital circuits cannot be used to divide the frequency so they are not good choices to answer this question.

```
E7A04 (B)
How many flip-flops are required to divide a signal frequency by 4?
A. 1
B. 2
C. 4
D. 8
```

Each flip flop has the ability to divide a signal be a factor of 2 so the answer to this question is $4 \div 2 = 2$. This makes answer **B** the right choice. The other choices are to distract you.

```
E7A05 (D)
Which of the following is a circuit that continuously alternates between two
unstable states without an external clock?
A. Monostable multivibrator
B. J-K Flip-Flop
C. T Flip-Flop
D. Astable Multivibrator
```

If you know your Greek, you will recognize “a” as meaning *not* and “stable” as being *stable* so the device goes between two unstable states and answer **D** is the correct choice. Answers A and B are not what is intended here. Answer C is not possible without more complicated logic circuits.

```
E7A06 (A)
What is a characteristic of a monostable multivibrator?
A. It switches momentarily to the opposite binary state and then returns,
      after a set time, to its original state
B. It is a clock that produces a continuous square wave oscillating between 1
      and 0
C. It stores one bit of data in either a 0 or 1 state
D. It maintains a constant output voltage, regardless of variations in the
      input voltage
```

The correct description is given in Answer **A** so this is the right choice. Electrically, answers B, C, and D are not correct descriptions so they are not good choices.

```
E7A07 (B)
What logical operation does an AND gate perform?
A. It produces a logic "0" at its output only if all inputs are logic "1"
B. It produces a logic "1" at its output only if all inputs are logic "1"
C. It produces a logic "1" at its output if only one input is a logic "1"
D. It produces a logic "1" at its output if all inputs are logic "0"
```

The following table may be useful to see how the logic gates work. By looking at the table, we should be able to determine that answer **B** is the correct description of an AND gate so this is the answer to choose.

Input 1	Input 2	AND	NAND	OR	NOR
0	0	0	1	0	1
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	0	1	0

```
E7A08 (D)
What logical operation does a NAND gate perform?
A. It produces a logic "0" at its output only when all inputs are logic "0"
B. It produces a logic "1" at its output only when all inputs are logic "1"
C. It produces a logic "0" at its output if some but not all of its inputs are
      logic "1"
D. It produces a logic "0" at its output only when all inputs are logic "1"
```

By using the table, we see that answer D is the one that matches the operation of a NAND gate.

```
E7A09 (A)
What logical operation does an OR gate perform?
A. It produces a logic "1" at its output if any or all inputs are logic "1"
B. It produces a logic "0" at its output if all inputs are logic "1"
C. It only produces a logic "0" at its output when all inputs are logic "1"
D. It produces a logic "1" at its output if all inputs are logic "0"
```

From the table, we see that answer **A** corresponds to the operation of the OR gate.

```
E7A10 (C)
What logical operation does a NOR gate perform?
A. It produces a logic "0" at its output only if all inputs are logic "0"
B. It produces a logic "1" at its output only if all inputs are logic "1"
C. It produces a logic "0" at its output if any or all inputs are logic "1"
D. It produces a logic "1" at its output only when none of its inputs are
      logic "0"
```

Again, using the table, we see that answer **C** correctly describes the NOR gate.

```
E7A11 (C)
What is a truth table?
A. A table of logic symbols that indicate the high logic states of an op-amp
B. A diagram showing logic states when the digital device's output is true
C. A list of inputs and corresponding outputs for a digital device
D. A table of logic symbols that indicates the low logic states of an op-amp
```

The table we just were using is a truth table and it is correctly described by answer **C**. Answer A is incorrect because TTs are used with digital logic and not op-amps. Answer B is incorrect because it only lists one of the possible outputs and not all of them. Answer D is incorrect because it is technobable.

```
E7A12 (D)
What is the name for logic which represents a logic "1" as a high voltage?
A. Reverse Logic
B. Assertive Logic
C. Negative logic
D. Positive Logic
```

In positive logic, a 1 is represented by a high voltage level so answer **D** is the right choice. Answer C is for negative logic systems so that is not a correct choice here. Answers A and B are not how logic levels are described.

```
E7A13 (C)
What is the name for logic which represents a logic "0" as a high voltage?
A. Reverse Logic
B. Assertive Logic
C. Negative logic
D. Positive Logic
```

This is the opposite of the previous case and a low level is used so answer **C** is the right choice. Answer D is for positive logic so it is incorrect here. Answers A and B are to distract you.

```
E7B01 (A)
For what portion of a signal cycle does a Class AB amplifier operate?
A. More than 180 degrees but less than 360 degrees
B. Exactly 180 degrees
C. The entire cycle
D. Less than 180 degrees
```

The Class AB amplifier conducts for more than 180 degrees but less than 360 degrees so answer **A** is the right choice. A Class B amplifier conducts for 180 degrees so answer B is incorrect here. The Class A amplifier conducts for the full cycle so answer C is also incorrect. The Class C amplifier conducts for less than 180 degrees so answer

D is also incorrect.

E7B02 (C)
Which class of amplifier, of the types shown, provides the highest efficiency?
A. Class A
B. Class B
C. Class C
D. Class AB

Of the choices given, the Class C amplifier has the highest efficiency followed by the Class B amplifier then the Class AB amplifier and finally the Class A amplifier. This makes Answer **C** the correct choice.

E7B03 (A)
Where on the load line of a Class A common emitter amplifier would bias normally be set?
A. Approximately half-way between saturation and cutoff
B. Where the load line intersects the voltage axis
C. At a point where the bias resistor equals the load resistor
D. At a point where the load line intersects the zero bias current curve

Operating the amplifier approximately between saturation and cutoff is a good place to operAte the Class A amplifier so Answer **A** is the best choice among those given.

E7B04 (C)
What can be done to prevent unwanted oscillations in a power amplifier?
A. Tune the stage for maximum SWR
B. Tune both the input and output for maximum power
C. Install parasitic suppressors and/or neutralize the stage
D. Use a phase inverter in the output filter

These oscillations are within the amplifier so answers A, B, and D are not good choices since they deal with connections to external equipment. Neutralization, in answer **C**, is the technique to remove oscillations within the circuitry so this is the best choice among those given.

E7B05 (B)
Which of the following amplifier types reduces or eliminates even-order harmonics?
A. Push-push
B. Push-pull
C. Class C
D. Class AB

This is a general rule of thumb type of question. In this case, the push-pull amplifier of answer **B** is the right choice. Answer A is to distract you with a similar name. The choice of the Class C and Class AB amplifier, by itself, will not prevent oscillations so answers C and D are not good choices.

E7B06 (D)
Which of the following is a likely result when a Class C rather than a class AB amplifier is used to amplify a single-sideband phone single?
A. Intermodulation products will be greatly reduced
B. Overall intelligibility will increase
C. Part of the transmitted signal will be inverted
D. The signal may become distorted and occupy excessive bandwidth

Since SSB needs a linear generation and recovery for proper demodulation, using a non-linear amplifier such as a Class C amplifier can cause some interesting distortions which makes answer **D** the right choice. Since the signal can become distorted, answer B cannot be a right choice. If the sidebands are inverted, you have other problems as well so answer C is not a good choice. Distortion of a signal will generally not decrease intermodulation products so Answer A is not a good choice.

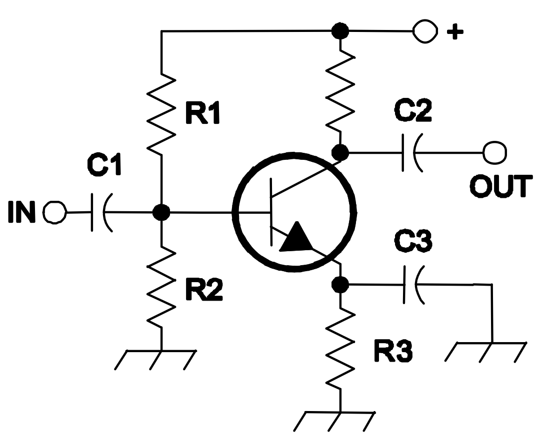
```
E7B07 (C)
How can a vacuum-tube power amplifier be neutralized?
A. By increasing the grid drive
B. By reducing the grid drive
C. By feeding back an out-of-phase component of the output to the input
D. By feeding back an in-phase component of the output to the input
```

Neutralization is usually performed by a negative, or out-of-phase, feedback signal from the output to the input. This makes answer **C** the right choice. Answer D has the signal flowing in the wrong direction so this is an incorrect choice. Answer B is incorrect because it is a positive feedback solution which can make things worse. Answer A is to distract you.

```
E7B08 (D)
Which of the following describes how the loading capacitor and tuning
capacitor are to be adjusted when tuning a vacuum tube RF power amplifier that
employs a pi-network output circuit?
A. The loading capacitor is set to maximum capacitance and the tuning
      capacitor is adjusted for minimum allowable plate current
B. The tuning capacitor is set to maximum capacitance and the loading
      capacitor is adjusted for minimum plate permissible current
C. The loading capacitor is adjusted to minimum plate current while
      alternately adjusting the tuning capacitor for maximum allowable plate
      current
D. The tuning capacitor is adjusted for minimum plate current, while the
      loading capacitor is adjusted for maximum permissible plate current
```

Unless you do this on a regular basis, this question will most likely require you to memorize the answer. The correct procedure is given in answer **D**. The other choices are just incorrect permutations on the relative roles of the components.

Figure E7-1




```
E7B09 (B)
In Figure E7-1, what is the purpose
of R1 and R2?
A. Load resistors
B. Fixed bias
C. Self bias
D. Feedback
```

Since R1 and R2 are attached to the base input and not the output, they are not load resistors so answer A is incorrect. The two resistors do set a fixed bias point for the base so Answer **B** is the right choice here. They do not self-bias the transistor so answer C is incorrect. They do not link the output to the input so they are not for feedback and answer D is also incorrect.

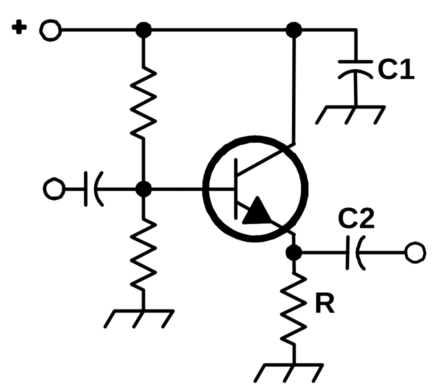
E7B10 (D)
In Figure E7-1, what is the purpose of R3?
A. Fixed bias
B. Emitter bypass
C. Output load resistor
D. Self bias

As we saw above, R1 and R2 form the fixed bias for the transistor so answer A cannot be correct. The capacitor C3 is the emitter bypass capacitor and this is not for emitter bypass (resistors are not typically used for bypass) so answer B is incorrect. The resistor is not part of the load so answer C is also incorrect. It does perform self bias functions so answer **D** is the correct choice.

E7B11 (C)
What type of circuit is shown in Figure E7-1?
A. Switching voltage regulator
B. Linear voltage regulator
C. Common emitter amplifier
D. Emitter follower amplifier

This is a transistor amplifier circuit and not a regulator so answers A and B are eliminated from further consideration. Since the emitter is grounded through the resistor, it is a common emitter configuration and answer **C** is the correct choice. It is not in an emitter follower configuration so answer D is incorrect.

Figure E7-2



E7B12 (A)
In Figure E7-2, what is the purpose of R?
A. Emitter load
B. Fixed bias
C. Collector load
D. Voltage regulation

Since the resistor is connected to the emitter which is where the output is takes, it is part of the emitter load so answer **A** is the right choice. It is not part of the fixed bias resistor pair so answer B is incorrect. The resistor is connected to the emitter and not the collector so answer C is incorrect. It does not regulate any voltages so answer D is to distract you.

E7B13 (A)
In Figure E7-2, what is the purpose of C2?
A. Output coupling
B. Emitter bypass
C. Input coupling
D. Hum filtering

The capacitor is connected to the output terminal and its job is output coupling so answer **A** is the right choice. Since this capacitor is not connected to ground, it is not performing an emitter bypass function so answer B is incorrect. The capacitor is not connected to the input so answer C is also incorrect. Since the capacitor is not part of the power supply network, its job is not to cure any hum by filtering.

E7B14 (C)
What is one way to prevent thermal runaway in a transistor amplifier?
A. Neutralization
B. Select transistors with high beta
C. Use degenerative emitter feedback
D. All of the above

Neutralization is used in removing feedback so Answer A is not a good choice for controlling thermal runaway. A high will also not prevent thermal problems so Answer B is not correct either. Since A and B are incorrect, Answer D must also be incorrect. Emitter feedback as in Answer **C** is the right choice.

E7B15 (A)
What is the effect of intermodulation products in a linear power amplifier?
A. Transmission of spurious signals
B. Creation of parasitic oscillations
C. Low efficiency
D. All of the above

The linear amplifier will do a good job of transmitting the intermodulation products so spurious signals will be generated as suggested in Answer **A**. Answers B and C are not properties of linear amplification.

E7B16 (A)
Why are third-order intermodulation distortion products of particular concern in linear power amplifiers?
A. Because they are relatively close in frequency to the desired signal
B. Because they are relatively far in frequency from the desired signal
C. Because they invert the sidebands causing distortion
D. Because they maintain the sidebands, thus causing multiple duplicate signals

The third-order intermodulation distortion products will be found close to the desired signal which makes Answer **A** the correct choice for this question.

E7B17 (C)
Which of the following is a characteristic of a grounded-grid amplifier?
A. High power gain
B. High filament voltage
C. Low input impedance
D. Low bandwidth

The grounded-grid amplifier configuration is one found in many amateur rigs. One of its primary advantages according to amplifier designers is the low input impedance so Answer **C** is the right choice among those given.

E7B18 (D)
What is a klystron?
A. A high speed multivibrator
B. An electron-coupled oscillator utilizing a pentode vacuum tube
C. An oscillator utilizing ceramic elements to achieve stability
D. A VHF, UHF, or microwave vacuum tube that uses velocity modulation

A klystron tube is known as a special vacuum tube that uses velocity modulation that can be used as an RF oscillator. This makes Answer **D** the correct choice for this question.

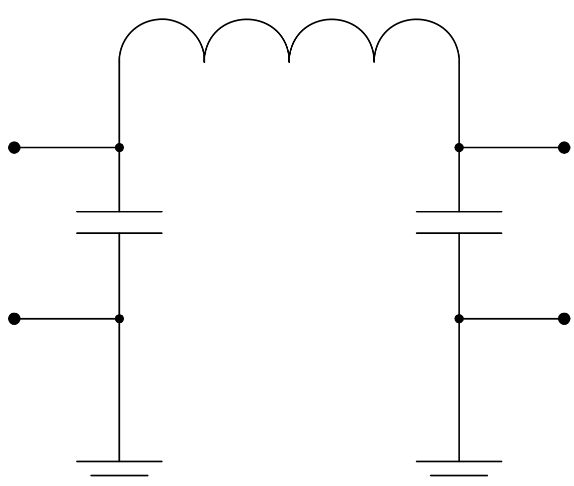
E7B19 (B)
What is a parametric amplifier?
A. A type of bipolar operational amplifier with excellent linearity derived from use of very high voltage on the collector
B. A low-noise VHF or UHF amplifier relying on varying reactance for amplification
C. A high power amplifier for HF application utilizing the Miller effect to increase gain
D. An audio push-pull amplifier using silicon carbide transistors for extremely low noise

A usualy definition for a parametric amplifier is that it is a mixer with gain. One of the parameters that is varied is a reactance. Answer B is the best choice among those given to answer the question.

E7B20 (A)
Which of the following devices is generally best suited for UHF or microwave power amplifier applications?
A. FET
B. Nuvistor
C. Silicon Controlled Rectifier
D. Triac

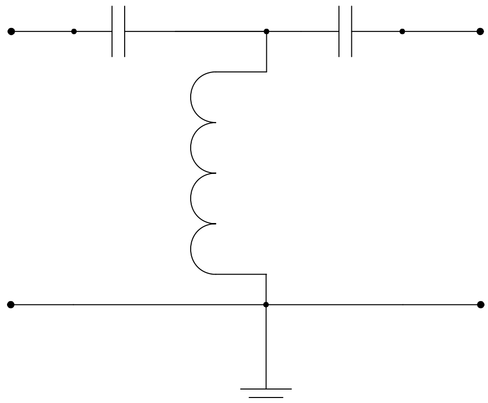
FET's are frequently used for UHF or microwave power amplifiers so Answer **A** is the right choice. Answers C and D are not active elements for making an amplifier so they can be eliminated as choices.

E7C01 (D)
How are the capacitors and inductors of a low-pass filter Pi-network arranged between the network's input and output?
A. Two inductors are in series between the input and output and a capacitor is connected between the two inductors and ground
B. Two capacitors are in series between the input and output and an inductor is connected between the two capacitors and ground
C. An inductor is in parallel with the input, another inductor is in parallel with the output, and a capacitor is in series between the two
D. A capacitor is in parallel with the input, another capacitor is in parallel with the output, and an inductor is in series between the two



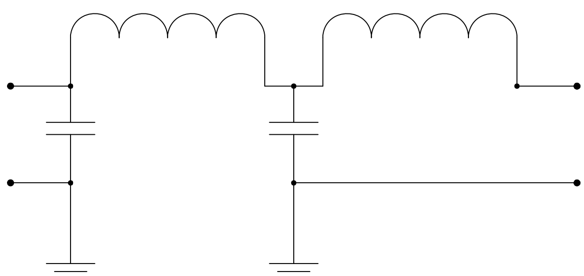
The low-pass Pi-network is arranged as in the graphic. This makes Answer **D** the correct choice. Notice that the correct configuration looks like the Greek letter π. **Remember:** capacitors tend to pass high frequencies and block low frequencies while inductors tend to pass low frequencies and block high frequencies. In the Pi-network LPF, the high frequencies are shunted to ground while the low frequencies pass through.

E7C02 (C)
A T-network with series capacitors and a parallel (shunt) inductor has which of the following properties?
A. It transforms impedance and is a low-pass filter
B. It transforms reactance and is a low-pass filter
C. It transforms impedance and is a high-pass filter
D. It transforms reactance and is a narrow bandwidth notch filter



The T-network described in the question is shown in the graphic. This is a form of high-pass filter in addition to transforming the impedance so Answer **C** is the right choice.

E7C03 (A)
What advantage does a Pi-L-network have over a Pi-network for impedance matching between the final amplifier of a vacuum-tube type transmitter and an antenna?
A. Greater harmonic suppression
B. Higher efficiency
C. Lower losses
D. Greater transformation range



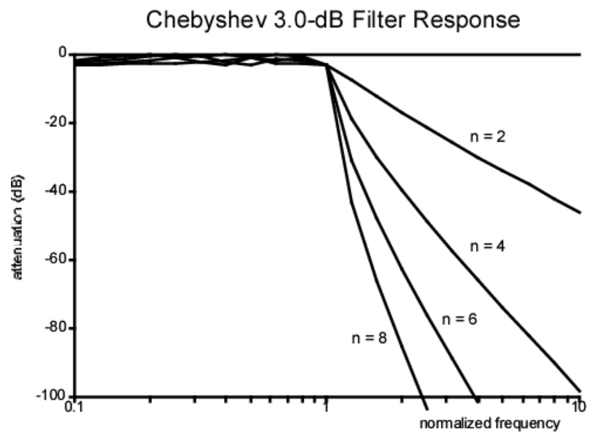
A Pi-L network is shown in the graphic. The additional inductor on the output leg gives the matching network additional harmonic suppression. This makes Answer **A** the correct choice.

E7C04 (C)
How does a network transform a complex impedance to a resistive impedance?
A. It introduces negative resistance to cancel the resistive part of an impedance
B. It introduces transconductance to cancel the reactive part of an impedance
C. It cancels the reactive part of an impedance and transforms the resistive part to the desired value
D. Network resistances are substituted for load resistances

If we go back to the graph for question E5C19, we can see that the pure resistances lie along the positive x-axis of the graph. A reactive component will displace the point above or below the x-axis. Therefore, to make a resistive impedance from a reactive impedance, you will need to introduce a cancelling reactive component. This is the method of Answer **C** so it is the correct choice for this question.

E7C05 (D)
Which filter type is described as having ripple in the passband and a sharp cutoff?
A. A Butterworth filter
B. An active LC filter
C. A passive op-amp filter
D. A Chebyshev filter

This is the classic description of a Chebyshev filter as shown on the right so answer **D** is the right choice to answer this question. Answer A is flat in the passband. Answers B and C do not describe any one filter family in particular so they are incorrect.



E7C06 (C)
What are the distinguishing features of an elliptical filter?
A. Gradual passband rolloff with minimal stop-band ripple
B. Extremely flat response over its passband, with gradually rounded stop-band corners
C. Extremely sharp cutoff, with one or more infinitely deep notches in the stop band
D. Gradual passband rolloff with extreme stop-band ripple

You need to remember that an elliptical filter has an extremely sharp cutoff with deep notches in the stop band as described in Answer **C**.

E7C07 (B)
What kind of audio filter would you use to attenuate an interfering carrier signal while receiving an SSB transmission?
A. A band-pass filter
B. A notch filter
C. A Pi-network filter
D. An all-pass filter

If the carrier is unmodulated, it will be very narrow in the frequency band and a notch filter can remove it with minimal harm to the SSB signal. This makes answer **B** the right choice. A band pass filter has its response function going the wrong way to remove a single component so this is not a good answer. Answer C is not specific enough. Answer D is not a good choice since it will not remove the component.

E7C08 (A)
What kind of digital signal processing audio filter might be used to remove unwanted noise from a received SSB signal?
A. An adaptive filter
B. A crystal-lattice filter
C. A Hilbert-transform filter
D. A phase-inverting filter

An adaptive filter can be built using DSP components so answer **A** is the best choice. A DSP cannot build a crystal filter so answer B is a bit silly. Answer C is for generating SSB but not filtering noise so this is not a good choice. Answer D will mess up the signal and not remove the nosie so this is not a good choice either.

E7C09 (C)
What type of digital signal processing filter might be used in generating an SSB signal?
A. An adaptive filter
B. A notch filter
C. A Hilbert-transform filter
D. An elliptical filter

If we wish to generate SSB, then the Hilbert transform can be realized using DSP components and answer **C** is the correct choice. Answer A is for noise removal and not SSB generation so this is incorrect. Answers B and D can be used for noise filtering as well but not modulation generation so they are incorrect choices as well.

E7C10 (B)
Which of the following filters would be the best choice for use in a 2-meter repeater duplexer?
A. A crystal filter
B. A cavity filter
C. A DSP filter
D. An L-C filter

The key to this question is understanding that the question pool examiners are making a few assumptions about the duplexer configuration. For example, that a single antenna will be used for both frequencies. The cavity will allow the isolation between the two frequencies necessary for the duplexer so answer **B** is the correct answer to the question. The other choices are not good filters to provide the dual frequency isolation so they are not good choices to answer the question.

E7C11 (D)
Which of the following is the common name for a filter network which is equivalent to two L networks back-to-back?
A. Pi-L
B. Cascode
C. Omega
D. Pi

Two L networks back to back would make a Pi network so choose Answer **D** for this question.

E7C12 (B)
What is a Pi-L network, as used when matching a vacuum-tube final amplifier to a 50-ohm unbalanced output?
A. A Phase Inverter Load network
B. A network consisting of two series inductors and two shunt capacitors
C. A network with only three discrete parts
D. A matching network in which all components are isolated from ground

As we saw in question E7C03, a Pi-L network has two series inductors and two shunt capacitors so Answer **B** is the right choice.

```
E7C13 (A)
What is one advantage of a Pi matching network over an L matching network?
A. Q of Pi networks can be varied depending on the component values chosen
B. L networks can not perform impedance transformation
C. Pi networks have fewer components
D. Pi networks are designed for balanced input and output
```

Of the choices given, having a variable Q as in Answer **A** is the correct statement so that is the correct choice to answer this question.

```
E7C14 (C)
Which of these modes is most affected by non-linear phase response in a
receiver IF filter?
A. Meteor Scatter
B. Single-Sideband Voice
C. Digital
D. Video
```

Of the choices given, digital communications are affected most by non-linearities. This makes Answer **C** the correct choice to answer this question.

```
E7D01 (D)
What is one characteristic of a linear electronic voltage regulator?
A. It has a ramp voltage as its output
B. It eliminates the need for a pass transistor
C. The control element duty cycle is proportional to the line or load
      conditions
D. The conduction of a control element is varied to maintain a constant output
      voltage
```

A linear voltage regulator is described by answer **D** so that is the correct answer for this question. Answer A is wrong because it would give a time-variable voltage output. A linear regulator does not have switching elements so answers B and C are incorrect.

```
E7D02 (C)
What is one characteristic of a switching electronic voltage regulator?
A. The resistance of a control element is varied in direct proportion to the
      line voltage or load current
B. It is generally less efficient than a linear regulator
C. The control device's duty cycle is controlled to produce a constant average
      output voltage
D. It gives a ramp voltage at its output
```

A switching regulator has a switching circuit as described in answer **C** so this is the correct answer for this question. Answer D would produce a time-variable output so this is not a good choice. Electrically, answers A and B are not associated with switching regulators.

```
E7D03 (A)
What device is typically used as a stable reference voltage in a linear
voltage regulator?
A. A Zener diode
B. A tunnel diode
C. An SCR
D. A varactor diode
```

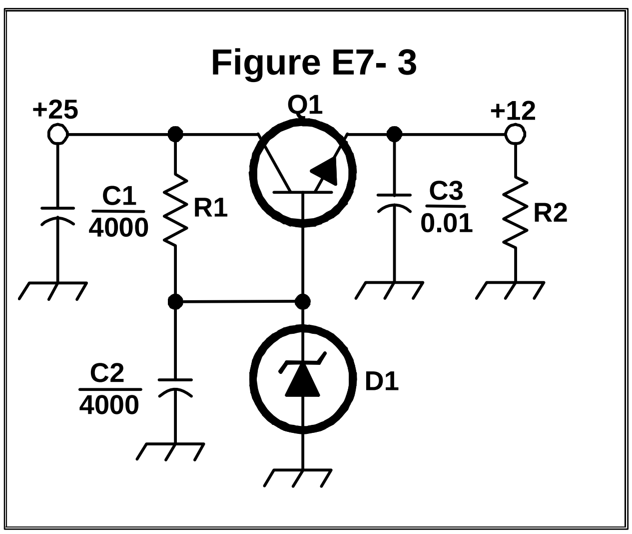
A Zener diode can provide a stable voltage reference so answer **A** is the right choice. The other diode types are not used to provide stable reference choices so they are not good choices to answer this question.

```
E7D04 (B)
Which of the following types of linear regulator makes the most efficient use
of the primary power source?
A. A constant current source
B. A series regulator
C. A shunt regulator
D. A shunt current source
```

Answers A and D are not regulators so they are not correct answers here. The correct answer is the series regulator - answer **B**. Answer C is for the next question.

```
E7D05 (D)
Which of the following types of linear voltage regulator places a constant
load on the unregulated voltage source?
A. A constant current source
B. A series regulator
C. A shunt current source
D. A shunt regulator
```

Answers A and C do not correspond to voltage regulators so they are eliminated from consideration. The correct choice is answer **D** - the shunt regulator. As we saw in the previous question, the series regulator is for a different application.




```
E7D06 (C)
What is the purpose of Q1 in the
circuit shown in Figure E7-3?
A. It provides negative feedback to
improve regulation
B. It provides a constant load for
the voltage source
C. It increases the current-handling
capability of the regulator
D. It provides D1 with current
```

It has nothing to do with generating feedback so answer A is not a good choice. The transistor is not connected to the output so it cannot be a constant load (besides it is the heart of the device), so answer B is also not a good choice. The transistor will allow more current to flow so answer **C** is a correct choice. It does not provide D1 with current so answer D is also a distraction for you.

```
E7D07 (A)
What is the purpose of C2 in the circuit shown in Figure E7-3?
A. It bypasses hum around D1
B. It is a brute force filter for the output
C. To self-resonate at the hum frequency
D. To provide fixed DC bias for Q1
```

The capacitor is to bypass any AC hum so answer **A** is the correct choice. The capacitor is not connected to the output so answer B cannot be correct. Answer C is not a good idea electrically so this is not a good choice. Answer

D is incorrect because one does not use capacitors for DC reference.

```
E7D08 (C)
What type of circuit is shown in Figure E7-3?
A. Switching voltage regulator
B. Grounded emitter amplifier
C. Linear voltage regulator
D. Emitter follower
```

This is not an amplifier circuit so answers B and D are eliminated. It is a linear voltage regulator making answer **C** the right choice. Answer A is to see if you recognize the circuit.

```
E7D09 (D)
What is the purpose of C1 in the circuit shown in Figure E7-3?
A. It resonates at the ripple frequency
B. It provides fixed bias for Q1
C. It decouples the output
D. It filters the supply voltage
```

Resonating at the ripple frequency is not a good idea so answer A is not a good choice. The capacitor does not bias Q1 so answer B is also incorrect. It is not connected to the output making answer C also incorrect. It does filter the supply voltage so answer **D** is the right choice.

```
E7D10 (A)
What is the purpose of C3 in the circuit shown in Figure E7-3?
A. It prevents self-oscillation
B. It provides brute force filtering of the output
C. It provides fixed bias for Q1
D. It clips the peaks of the ripple
```

C3 will take any high-frequency ripple that is coming from either the left or the right and shunts it to ground so answer **A** is the correct choice for this question. It does not filter the output so answers B and D are incorrect. It does not bias Q1 so answer C is also incorrect.

```
E7D11 (C)
What is the purpose of R1 in the circuit shown in Figure E7-3?
A. It provides a constant load to the voltage source
B. It couples hum to D1
C. It supplies current to D1
D. It bypasses hum around D1
```

R1 provides an electrical path to the input of D1 so answer **C** is the correct answer. Its intention is not to provide a source load so answer A is incorrect. Coupling hum to D1 is a bad idea electrically so answer B is not a good choice. Resistors do not bypass so answer D is also incorrect.

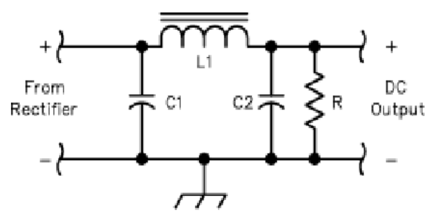
```
E7D12 (D)
What is the purpose of R2 in the circuit shown in Figure E7-3?
A. It provides fixed bias for Q1
B. It provides fixed bias for D1
C. It decouples hum from D1
D. It provides a constant minimum load for Q1
```

R2 does not bias Q1 so answer A is incorrect. Nor does it bias the diode D1 so answer B is incorrect. It has no capacitive properties so it will not bypass hum making answer C incorrect. It does provide a minimum load for Q1 so answer **D** is the correct choice.

E7D13 (B)
What is the purpose of D1 in the circuit shown in Figure E7-3?
A. To provide line voltage stabilization
B. To provide a voltage reference
C. Peak clipping
D. Hum filtering

The diode is a Zener diode and it is attempting to provide a fixed reference to the base of the transistor so answer **B** is the right choice for this question. Answer A sounds good but the Zeiner cannot do that by itself so this is not a good choice. Attached to the base of the transistor, the diode will not clip the signal so answer C is also incorrect. The diode does not remove hum so answer D is also incorrect.

E7D14 (C)
What is one purpose of a "bleeder" resistor in a conventional (unregulated) power supply?
A. To cut down on waste heat generated by the power supply
B. To balance the low-voltage filament windings
C. To improve output voltage regulation
D. To boost the amount of output current



The bleeder resistor, *R* in the figure, is part of the voltage regulation process and improves the performance so Answer **C** is the correct choice.

E7D15 (D)
What is the purpose of a "step-start" circuit in a high-voltage power supply?
A. To provide a dual-voltage output for reduced power applications
B. To compensate for variations of the incoming line voltage
C. To allow for remote control of the power supply
D. To allow the filter capacitors to charge gradually

A step-start circuit keeps capacitors from charging too quickly so Answer **D** is the right choice.

E7D16 (D)
When several electrolytic filter capacitors are connected in series to increase the operating voltage of a power supply filter circuit, why should resistors be connected across each capacitor?
A. To equalize, as much as possible, the voltage drop across each capacitor
B. To provide a safety bleeder to discharge the capacitors when the supply is off
C. To provide a minimum load current to reduce voltage excursions at light loads
D. All of these answers are correct

Each statement in Answers A, B, and C is correct so choose Answer **D** for this question.

E7D17 (C)
What is the primary reason that a high-frequency inverter type high-voltage power supply can be both less expensive and lighter in weight than a conventional power supply?
A. The inverter design does not require any output filtering
B. It uses a diode bridge rectifier for increased output
C. The high frequency inverter design uses much smaller transformers and filter components for an equivalent power output
D. It uses a large power-factor compensation capacitor to create "free" power from the unused portion of the AC cycle

Transformers can be quite heavy so if a design can use smaller transformers then the resulting power supply can be lighter and less expensive as given in Answer **C**.

E7E01 (B)
Which of the following can be used to generate FM-phone emissions?
A. A balanced modulator on the audio amplifier
B. A reactance modulator on the oscillator
C. A reactance modulator on the final amplifier
D. A balanced modulator on the oscillator

A balanced modulator is used with AM and not FM so answers A and D can be eliminated. The reactance modulator works with the oscillator so answer **B** is the right choice. Answer C is to distract you.

E7E02 (D)
What is the function of a reactance modulator?
A. To produce PM signals by using an electrically variable resistance
B. To produce AM signals by using an electrically variable inductance or capacitance
C. To produce AM signals by using an electrically variable resistance
D. To produce PM signals by using an electrically variable inductance or capacitance

Think: FM or PM and reactance modulators. This means that we can eliminate answers B and C since they deal with AM. Reactance deals with inductors and capacitors not resistors. This makes answer **D** the right choice.

E7E03 (C)
What is the fundamental principle of a phase modulator?
A. It varies the tuning of a microphone preamplifier to produce PM signals
B. It varies the tuning of an amplifier tank circuit to produce AM signals
C. It varies the tuning of an amplifier tank circuit to produce PM signals
D. It varies the tuning of a microphone preamplifier to produce AM signals

Phase modulators are not used to produce AM signals so we can eliminate answers B and D. The PM does not work at the microphone circuit level so answer A is not a good choice. Answer **C** correctly describes the circuit.

E7E04 (A)
What is one way a single-sideband phone signal can be generated?
A. By using a balanced modulator followed by a filter
B. By using a reactance modulator followed by a mixer
C. By using a loop modulator followed by a mixer
D. By driving a product detector with a DSB signal

SSB is a form of AM so look for the balanced modulator and answer **A** is the right choice. Answer B is more for

FM or PM generation so it is incorrect here. Answer C is technobabble. Answer D is more for a receiver than a transmitter so it is not a good choice.

```
E7E05 (D)
What circuit is added to an FM transmitter to proportionally attenuate the
lower audio frequencies?
A. A de-emphasis network
B. A heterodyne suppressor
C. An audio prescaler
D. A pre-emphasis network
```

This is the description of an FM pre-emphasis circuit so answer **D** is the right choice. Answer A is the matching circuit in the receiver so it is incorrect here. Answers B and C are technobabble.

```
E7E06 (A)
What circuit is added to an FM receiver to restore attenuated lower audio
frequencies?
A. A de-emphasis network
B. A heterodyne suppressor
C. An audio prescaler
D. A pre-emphasis network
```

This is the complement to the previous question and the de-emphasis circuit in answer **A** is the right choice. Answer D was for the transmitter so it is incorrect here. Answers B and C are just to distract you.

```
E7E07 (D)
What is one result of the process of mixing two signals?
A. The elimination of noise in a wideband receiver by phase comparison
B. The elimination of noise in a wideband receiver by phase differentiation
C. The recovery of the intelligence from a modulated RF signal
D. The creation of new signals at the sum and difference frequencies
```

Mixers produce sum and difference frequencies so answer **D** is the correct answer for this question. Mixers do not eliminate noise so answers A and B are eliminated. Mixers can be part of the recovery process of answer C but they do not have to be. Answer D is a better, more general statement.

```
E7E08 (C)
What are the principal frequencies that appear at the output of a mixer
circuit?
A. Two and four times the original frequency
B. The sum, difference and square root of the input frequencies
C. The original frequencies, and the sum and difference frequencies
D. 1.414 and 0.707 times the input frequency
```

The correct response is given in answer **C**. The other combinations are mathematically incorrect so they are just here to distract you.

```
E7E09 (A)
What occurs when an excessive amount of signal energy reaches a mixer circuit?
A. Spurious mixer products are generated
B. Mixer blanking occurs
C. Automatic limiting occurs
D. A beat frequency is generated
```

This is a good way to generate spurious signals and answer **A** is the right choice. Electrically, answers B, C, and D do not occur in this case.

```
E7E10 (B)
What is the process of detection?
A. The extraction of weak signals from noise
B. The recovery of information from a modulated RF signal
C. The modulation of a carrier
D. The mixing of noise with a received signal
```

The detection process is the recovery of the desired signal from a modulated RF signal as given in Answer **B**. Be careful with Answer A since it is an important part of the receiving process, however, by itself will not recover the desire signal so Answer B is the better choice. Answer C is for the transmitter so it is wrong here. Answer D is generally not desirable.

```
E7E11 (A)
How does a diode detector function?
A. By rectification and filtering of RF signals
B. By breakdown of the Zener voltage
C. By mixing signals with noise in the transition region of the diode
D. By sensing the change of reactance in the diode with respect to frequency
```

The diode performs rectification and RF filtering so answer **A** is the right choice. A Zener diode is not used so answer B is incorrect. Answer C is technobabble. Answer D is electrically incorrect.

```
E7E12 (C)
Which of the following types of detector is well suited for demodulating SSB
signals?
A. Discriminator
B. Phase detector
C. Product detector
D. Phase comparator
```

A discriminator is used for FM so Answer A is not a good choice. A product detector is a good method for recovering SSB so Answer **C** is the best choice among those given.

```
E7E13 (D)
What is a frequency discriminator?
A. An FM generator circuit
B. A circuit for filtering two closely adjacent signals
C. An automatic band-switching circuit
D. A circuit for detecting FM signals
```

A discriminator is found in the FM receiver so answer **D** is the right choice here. It is not in the transmitter so answer A is incorrect. Electrically, it has nothing to do with answers B and C so these are not good choices.

```
E7E14 (D)
Which of the following describes a common means of generating a SSB signal
when using digital signal processing?
A. Mixing products are converted to voltages and subtracted by adder circuits
B. A frequency synthesizer removes the unwanted sidebands
C. Emulation of quartz crystal filter characteristics
D. The phasing or quadrature method
```

The software in a DSP-based transmitter will emulate the actual hardware process of a real circuit. The SSB will most commonly be generated by the phasing or quadrature method as in Answer **D**.

```
E7E15 (C)
What is meant by "direct conversion" when referring to a software defined
receiver?
A. Software is converted from source code to object code during operation of
      the receiver
B. Incoming RF is converted to the IF frequency by rectification to generate
      the control voltage for a voltage controlled oscillator
C. Incoming RF is mixed to "baseband" for analog-to-digital conversion and
      subsequent processing
D. Software is generated in machine language, avoiding the need for compilers
```

Answers A and D are silly distractions to make you smile. The correct description of direct conversion is to take the incoming RF and mix it down to baseband. This step is then followed by analog-to-digital conversion and processing using a DSP. Answer **C** is the correct description.

```
E7F01 (D)
What is the purpose of a prescaler circuit?
A. It converts the output of a JK flip-flop to that of an RS flip-flop
B. It multiplies a higher frequency signal so a low-frequency counter can
      display the operating frequency
C. It prevents oscillation in a low-frequency counter circuit
D. It divides a higher frequency signal so a low-frequency counter can display
      the operating frequency
```

A prescaler is basically a frequency divider to allow a slower device to measure a high-frequency signal. This makes answer **D** the right answer for this question. Answer B is wrong because it does the opposite of the desired function. Answers A and C are electrically silly so they are not good choices.

```
E7F02 (B)
Which of the following would be used to reduce a signal's frequency by a
factor of ten?
A. A preamp
B. A prescaler
C. A marker generator
D. A flip-flop
```

Based on the previous question, you should be able to spot the prescaler in Answer **B** as the right choice. Earlier, we mentioned that a flip-flop could be used as a divider but that choice cannot be the right answer here because flip-flops only divide in power os two and 10 is not an integer power of two.

```
E7F03 (A)
What is the function of a decade counter digital IC?
A. It produces one output pulse for every ten input pulses
B. It decodes a decimal number for display on a seven-segment LED display
C. It produces ten output pulses for every input pulse
D. It adds two decimal numbers together
```

A decade counter works as indicated in answer **A** so this is the right choice for this question. There are devices to do the job listed in answer B but they are called display drivers and not decade counters so this is not a good choice.

Answer C is a silly distraction. And, even though it is called a counter, it cannot add numbers so answer D is incorrect.

```
E7F04 (C)
What additional circuitry must be added to a 100-kHz crystal-controlled marker
generator so as to provide markers at 50 and 25 kHz?
A. An emitter-follower
B. Two frequency multipliers
C. Two flip-flops
D. A voltage divider
```

Here, we need to divide the frequency by both two and four. This will require two flip-flops so answer **C** is the right choice. Answers A and D are nice circuits to have but they will not help here so they are not good choices. Answer B is incorrect because we need to divide the frequency and not multiply it.

```
E7F05 (B)
Which of the following circuits can be combined to produce a 100 kHz
fundamental signal with harmonics at 100 kHz intervals?
A. A 10 MHz oscillator and a flip-flop
B. A 1 MHz oscillator and a decade counter
C. A 1 MHz oscillator and a flip-flop
D. A 100 kHz oscillator and a phase detector
```

Since we desire to have factors of 10 in the frequency divisions, we cannot be using flip-flops making Answers A and C incorrect choices. Starting with a 1 MHz oscillator and a decade counter, we can generate the desired signals because they are factors of 10 from the 1 MHz source. This makes Answer **B** the correct choice among those given.

```
E7F06 (D)
Which of these choices best describes a crystal marker generator?
A. A low-stability oscillator that sweeps through a band of frequencies
B. An oscillator often used in aircraft to determine the craft's location
      relative to the inner and outer markers at airports
C. A crystal-controlled oscillator with an output frequency and amplitude that
      can be varied over a wide range
D. A crystal-controlled oscillator that generates a series of reference
      signals at known frequency intervals
```

A crystal oscillator has relatively high stability so answer A is eliminated. Answer B would be a useful device but a crystal oscillator would not do the job. The crystal oscillator usually does not have its output varied over a wide range so answer C is not a good choice. The best choice among this given is answer **D**.

```
E7F07 (D)
Which type of circuit would be a good choice for generating a series
harmonically related receiver calibration signals?
A. A Wein-bridge oscillator followed by a class-A amplifier
B. A Foster-Seeley discriminator
C. A phase-shift oscillator
D. A crystal oscillator followed by a frequency divider
```

Based on the past few questions, you should, be able to spot Answer **D** as the best choice among those given. The crystal oscillator will form the clock base and the divider will generate the harmonics.

E7F08 (C)
What is one purpose of a marker generator?
A. To add audio markers to an oscilloscope
B. To provide a frequency reference for a phase locked loop
C. To provide a means of calibrating a receiver's frequency settings
D. To add time signals to a transmitted signal

The marker generator is to calibrate frequency settings so answer **C** is the right answer for this question. Having a talking 'scope might be interesting but a marker generator will not do it so answer A is not a good choice. Other circuits are used for PLL reference so answer B is not a good choice. Answer D is not usually done and the marker is not tied to WWV so this is not a good choice either.

E7F09 (A)
What determines the accuracy of a frequency counter?
A. The accuracy of the time base
B. The speed of the logic devices used
C. Accuracy of the AC input frequency to the power supply
D. Proper balancing of the mixer diodes

If designed properly, the counter will only depend on the timing reference so answer **A** is the right choice for this question. Answers B, C and D are not true for well-designed devices so these are not good choices.

E7F10 (C)
How does a conventional frequency counter determine the frequency of a signal?
A. It counts the total number of pulses in a circuit
B. It monitors a WWV reference signal for comparison with the measured signal
C. It counts the number of input pulses occurring within a specific period of time
D. It converts the phase of the measured signal to a voltage which is proportional to the frequency

Answer A is close but it is not as good a description of the circuitry as is answer **C** which is the best choice among those given. Answer B is fine at the WWV frequencies but it is not generally useful so this is not a good choice. Answer D is not correct electrically

E7F11 (A)
What is the purpose of a frequency counter?
A. To provide a digital representation of the frequency of a signal
B. To generate a series of reference signals at known frequency intervals
C. To display all frequency components of a transmitted signal
D. To provide a signal source at a very accurate frequency

Answer A contains the correct description of a frequency counter. Answer B is a marker generator so this is not correct for this question. Answer C is a spectrum analyzer so it is not correct either. Answer D is a crystal-controlled oscillator which is not a correct choice for this question.

E7F12 (B)
What alternate method of determining frequency, other than by directly counting input pulses, is used by some frequency counters?
A. GPS averaging
B. Period measurement
C. Prescaling
D. D/A conversion

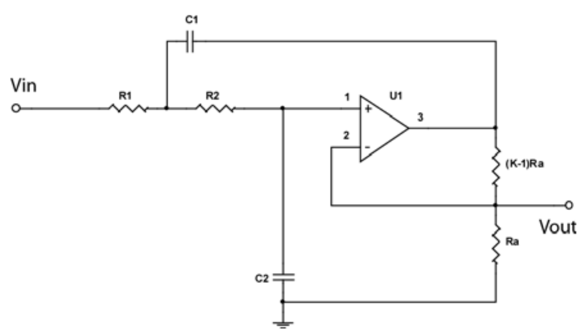
Here you need to remember that the period and the frequency are reciprocal quantities. If you measure the period, as in Answer **B**, then you have a measure of the frequency as desired. This is the best choice among those given. Answers A and D are silly distractions. You may be tempted to go with the prescaling of Answer B but that will not give as accurate a measurement so it is not the best choice.

```
E7F13 (C)
What is an advantage of a period-measuring frequency counter over a
direct-count type?
A. It can run on battery power for remote measurements
B. It does not require an expensive high-precision time base
C. It provides improved resolution of signals within a comparable time period
D. It can directly measure the modulation index of an FM transmitter
```

Answers B and D are incorrect statements. Answer A is irrelevant to the task at hand. Improved time resolution as in Answer **C** is a real advantage so this is the correct choice.

```
E7G01 (B)
What determines the gain and frequency characteristics of an op-amp RC active
filter?
A. The values of capacitors and resistors built into the op-amp
B. The values of capacitors and resistors external to the op-amp
C. The input voltage and frequency of the op-amp's DC power supply
D. The output voltage and smoothness of the op-amp's DC power supply
```

The active filter, like the one shown to the right, has its characteristics determined by the resistor and capacitor values external to the op-amp so answer **B** is the right choice. By analyzing the circuit, the op-amp characteristics do not enter in (at least in the ideal case), so answer A is incorrect. When designed right, the power supply will not affect the circuit so answers C and D are not good choices either.




```
E7G02 (C)
What causes ringing in a filter?
A. The slew rate of the filter
B. The bandwidth of the filter
C. The frequency and phase response of the filter
D. The gain of the filter
```

Of the choices given neither the slew rate, the bandwidth, or the gain can, by themselves, cause the filter to oscillate or ring so these are not good choices to answer the question. The filter’s frequency and phase response in the frequency domain will show if it has characteristics that lead to instabilities and ringing so answer **C** is the right choice here.

E7G03 (D)
What are the advantages of using an op-amp instead of LC elements in an audio filter?
A. Op-amps are more rugged and can withstand more abuse than can LC elements
B. Op-amps are fixed at one frequency
C. Op-amps are available in more varieties than are LC elements
D. Op-amps exhibit gain rather than insertion loss

Each of the statements in answers A, B, and C is individually untrue. Answer **D** is a true statement so this is the best choice to answer the question.

E7G04 (C)
Which of the following capacitor types is best suited for use in high-stability op-amp RC active filter circuits?
A. Electrolytic
B. Disc ceramic
C. Polystyrene
D. Paper dielectric

The paper dielectric capacitors are probably the least stable so answer D is not a good choice. Disc ceramic capacitors are inexpensive but not highly stable so answer B is also not a good choice. The best choice among answers C and A is the polystyrene of answer **C** so that is the one to answer this question.

E7G05 (A)
How can unwanted ringing and audio instability be prevented in a multi-section op-amp RC audio filter circuit?
A. Restrict both gain and Q
B. Restrict gain, but increase Q
C. Restrict Q, but increase gain
D. Increase both gain and Q

The correct solution is to restrict both the gain and the Q so answer **A** is the best choice to answer this question. Answers B, C, and D can each lead to ringing in the circuit by increasing either the Q or the gain, or both so these are not good choices to answer the question.

E7G06 (A)
What steps are typically followed when selecting the external components for an op-amp RC active filter?
A. Standard capacitor values are chosen first, the resistances are calculated, and resistors of the nearest standard value are used
B. Standard resistor values are chosen first, the capacitances are calculated, and capacitors of the nearest standard value are used
C. Standard resistor and capacitor values are used, the circuit is tested, and additional resistors are added to make any needed adjustments
D. Standard resistor and capacitor values are used, the circuit is tested, and additional capacitors are added to make any needed adjustments

Because there are a wider variety of resistor values to choose from, select the capacitor values first and then the resistor values. The correct procedure is given in answer **A** so this is the right choice for this question. Answer B is not the best choice, because you may need to iterate several times to find standard R and C values if you state with the resistors.. Answers C and D are used by many beginning designers but they do not produce nice, clean designs so they are not good choices.

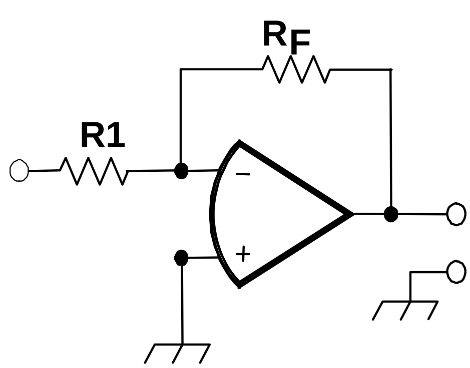
E7G07 (D)
Which of the following is the most appropriate use of an op-amp RC active filter?
A. As a high-pass filters used to block RFI at the input to receivers
B. As a low-pass filters used between a transmitter and a transmission line
C. For smoothing power-supply output
D. As an audio receiving filter

These filters are very good for audio frequency applications so answer **D** is the best choice among those given. They are not good RF filters so answers A and B are not good choices. They are not typically used in power supplies so answer C is not a good choice either.

E7G08 (D)
Which of the following is a type of active op-amp filter circuit?
A. Regenerative feedback resonator
B. Helical resonator
C. Gilbert cell
D. Sallen-Key

The Sallen-Key method of op-amp filter design is a methodical design technique that produces a good filter. Answer **D** is the correct choice for this question.

Figure E7-4



E7G09 (C)
What voltage gain can be expected from the circuit in Figure E7-4 when R1 is 10 ohms and RF is 470 ohms?
A. 0.21
B. 94
C. 47
D. 24

By doing the circuit analysis for this circuit, and assuming a "perfect" amplifier, then the voltage gain is Vout/Vin = -Rf/R1. Substituting in the resistor values and ignoring the voltage inversion, we see that the magnitude of the voltage gain is |G| = 470 Ω/10 Ω = 47. The correct choice is answer **C**. The others represent analysis mistakes.

E7G10 (D)
How does the gain of a theoretically ideal operational amplifier vary with frequency?
A. It increases linearly with increasing frequency
B. It decreases linearly with increasing frequency
C. It decreases logarithmically with increasing frequency
D. It does not vary with frequency

If the amplifier is "ideal" then there are no changes with frequency so the correct choice is answer **D**. Answers A, B, and C are designed to trick you.

E7G11 (D)
What will be the voltage of the circuit shown in Figure E7-4 if R1 is 1000 ohms, RF is 10,000 ohms, and 0.23 volts is applied to the input?
A. 0.23 volts
B. 2.3 volts
C. -0.23 volts
D. -2.3 volts

Here we can use the voltage gain equation that was given in the earlier equation. The output voltage is equal to -Rf/R1 times the input voltage. Using the numbers given here, Vout = -(10000 Ω/1000 Ω)(0.23 V) = -2.3 V. This makes answer **D** the correct choice. Be careful here. Answer B has the right magnitude but it is not the right polarity. Answers A and B have a factor of 10 missing.

E7G12 (C)
What voltage gain can be expected from the circuit in Figure E7-4 when R1 is 1800 ohms and RF is 68 kilohms?
A. 1
B. 0.03
C. 38
D. 76

Here we use the same analysis as before: `G = Vout/Vin = -Rf/R1`. Using the resistor values given, we find G = (68 kΩ/1800 Ω) = -38. Ignoring the minus sign, we choose answer **C** as the right choice for this question. The other choices represent analysis mistakes.

E7G13 (B)
What voltage gain can be expected from the circuit in Figure E7-4 when R1 is 3300 ohms and RF is 47 kilohms?
A. 28
B. 14
C. 7
D. 0.07

Another question using the same analysis: `G = Vout/Vin = -Rf/R1`. Using the resistor values given, we find G = (47 kΩ/3300 Ω) = -14. Ignoring the minus sign, we choose answer **B** as the right choice for this question. The other choices represent analysis mistakes.

E7G14 (A)
What is an operational amplifier?
A. A high-gain, direct-coupled differential amplifier whose characteristics are determined by components external to the amplifier
B. A high-gain, direct-coupled audio amplifier whose characteristics are determined by components external to the amplifier
C. An amplifier used to increase the average output of frequency modulated amateur signals to the legal limit
D. A program subroutine that calculates the gain of an RF amplifier

The key item to spot here is “differential amplification” because that is the basis for the operational amplifier. This makes answer **A** the correct choice for this question. Answer B is incorrect because it is limited to audio amplifier which is incorrect. Answer C is not how the components work - they do not change the output to the legal limit. Answer D is a segment of software and not a circuit so this is an incorrect choice.

E7G15 (C)
What is meant by the term "op-amp input-offset voltage"?
A. The output voltage of the op-amp minus its input voltage
B. The difference between the output voltage of the op-amp and the input voltage required in the immediately following stage
C. The potential between the amplifier input terminals of the op-amp in a closed-loop condition
D. The potential between the amplifier input terminals of the op-amp in an open-loop condition

Since the op-amp is a differential amplifier based on the voltages at the input terminals, answers C and D are the two choices to examine more carefully. The PLL is run in a closed-loop configuration so answer **C** is the right choice. Answer D is incorrect because it states an open-loop configuration.

E7G16 (D)
What is the typical input impedance of an integrated circuit op-amp?
A. 100 ohms
B. 1000 ohms
C. Very low
D. Very high

The theoretical op-amp has an infinite input impedance. A good approximation to this is “very high” as in answer **D** so that is the correct choice here. Answer C is the correct answer for the output and not the input so be careful here. The other answers are to try to distract you.

E7G17 (A)
What is the typical output impedance of an integrated circuit op-amp?
A. Very low
B. Very high
C. 100 ohms
D. 1000 ohms

The output is the opposite of the input and the op amp has a “very low” output impedance so answer **A** is the correct choice to answer the question. Be careful with answer B since that is the correct answer for the input and not the output. The other answers are to distract you.

E7H01 (D)
What are three major oscillator circuits often used in Amateur Radio equipment?
A. Taft, Pierce and negative feedback
B. Pierce, Fenner and Beane
C. Taft, Hartley and Pierce
D. Colpitts, Hartley and Pierce

A Taft oscillator is not a “major” oscillator so answers A and C are incorrect. That is in addition to negative feedback being used to damp oscillations. The “big three” are listed in answer **D** so that is the right choice to answer the question.

E7H02 (C)
What condition must exist for a circuit to oscillate?
A. It must have at least two stages
B. It must be neutralized
C. It must have a positive feedback loop with a gain greater than 1
D. It must have negative feedback sufficient to cancel the input signal

The generally, oscillator circuits are what is known as second-order circuits but that is not sufficient to cause oscillation so answer A is not a good choice. Neutralization is typically done to suppress oscillations so answer B is not a good choice. Answer D is related because negative feedback is typically used to suppress oscillations making this a bad choice. Only answer **C** contains required conditions in all oscillator circuits so this is the best choice among those given.

```
E7H03 (A)
How is positive feedback supplied in a Hartley oscillator?
A. Through a tapped coil
B. Through a capacitive divider
C. Through link coupling
D. Through a neutralizing capacitor
```

Here we have three questions on the operation of the various oscillators. In this case, the feedback is through a tapped coil so answer **A** is the right choice. The capacitive divider in answer B is for the Colpitts oscillator so it is incorrect here. The other two answers are to distract you.

```
E7H04 (C)
How is positive feedback supplied in a Colpitts oscillator?
A. Through a tapped coil
B. Through link coupling
C. Through a capacitive divider
D. Through a neutralizing capacitor
```

As we just saw, the tapped coil in answer A is for the Hartley oscillator so it is incorrect here. For a Colpitts oscillator, the feedback is through a capacitive divider so answer **C** is the right choice. The other two choices are to distract you.

```
E7H05 (D)
How is positive feedback supplied in a Pierce oscillator?
A. Through a tapped coil
B. Through link coupling
C. Through a neutralizing capacitor
D. Through a quartz crystal
```

We know that the tapped coil is for the Hartley oscillator so answer A is incorrect. Answers B and C are still just distractions. The correct choice is the crystal of answer **D**.

```
E7H06 (B)
Which type of oscillator circuits are commonly used in VFOs?
A. Pierce and Zener
B. Colpitts and Hartley
C. Armstrong and deForest
D. Negative feedback and Balanced feedback
```

There is a Zener diode but not a Zener oscillator so answer A is not a good choice. Armstrong and deForest are big names in FM but not VFOs so answer C is incorrect. Answer D is technobabble. The right choice is answer **B**, but you probably guessed that.

E7H07(C)
What is a magnetron oscillator?
A. An oscillator in which the output is fed back to the input by the magnetic field of a transformer
B. An crystal oscillator in which variable frequency is obtained by placing the crystal in a strong magnetic field
C. A UHF or microwave oscillator consisting of a diode vacuum tube with a specially shaped anode, surrounded by an external magnet
D. A reference standard oscillator in which the oscillations are synchronized by magnetic coupling to a rubidium gas tube

Magnetrons are based on vacuum tubes and can be found in UHF or microwave oscillators. This makes Answer C the correct choice.

E7H08 (A)
What is a Gunn diode oscillator?
A. An oscillator based on the negative resistance properties of properly-doped semiconductors
B. An oscillator based on the argon gas diode
C. A highly stable reference oscillator based on the tee-notch principle
D. A highly stable reference oscillator based on the hot-carrier effect

Since the Gunn diode oscillator is based on a Gunn diode, Answer **A** should be easy to spot as the correct choice because it is the only choice based on a semiconductor device.

E7H09 (C)
What type of frequency synthesizer circuit uses a stable voltage-controlled oscillator, programmable divider, phase detector, loop filter and a reference frequency source?
A. A direct digital synthesizer
B. A hybrid synthesizer
C. A phase locked loop synthesizer
D. A diode-switching matrix synthesizer

This is the description of a PLL synthesizer so answer **C** is the right choice for this question. The others do not use these components so they are incorrect choices.

E7H10 (A)
What type of frequency synthesizer circuit uses a phase accumulator, lookup table, digital to analog converter and a low-pass anti-alias filter?
A. A direct digital synthesizer
B. A hybrid synthesizer
C. A phase locked loop synthesizer
D. A diode-switching matrix synthesizer

A direct digital synthesizer uses these components so answer **A** is the right choice. Answer C is based on VCO circuitry so this is incorrect.

E7H11 (B)
What information is contained in the lookup table of a direct digital frequency synthesizer?
A. The phase relationship between a reference oscillator and the output waveform
B. The amplitude values that represent a sine-wave output
C. The phase relationship between a voltage-controlled oscillator and the output waveform
D. The synthesizer frequency limits and frequency values stored in the radio memories

The look-up table tells the processor how to make a sine wave so answer **B** is the right choice. Answer D might be useful information but it will not help to synthesize the waveform. The other answers are to distract you.

E7H12 (C)
What are the major spectral impurity components of direct digital synthesizers?
A. Broadband noise
B. Digital conversion noise
C. Spurs at discrete frequencies
D. Nyquist limit noise

Because of the approximations to the sine waves, harmonics at discrete frequencies arise so Answer **C** is the right choice to answer this question. Broadband noise is found in PLLs so answer A is incorrect here. Nyquist noise is a distraction for you so answer D is eliminated.

E7H13 (D)
Which of these circuits would be classified as a principal component of a direct digital synthesizer (DDS)?
A. Phase splitter
B. Hex inverter
C. Chroma demodulator
D. Phase accumulator

You need to remember that a DDS has a phase accumulator making Answer **D** the correct choice.

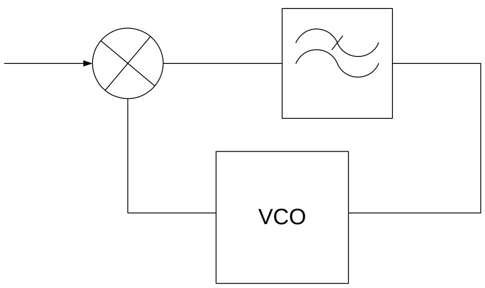
E7H14 (C)
What circuit is often used in conjunction with a direct digital synthesizer (DDS) to expand the available tuning range?
A. Binary expander
B. J-K flip-flop
C. Phase locked loop
D. Compander

Because the PLL has variable oscillator characteristics, it is the only device among those given that can assist a DDS with tuning. This makes Answer C the correct choice.

E7H15 (A)
What is the capture range of a phase-locked loop circuit?
A. The frequency range over which the circuit can lock
B. The voltage range over which the circuit can lock
C. The input impedance range over which the circuit can lock
D. The range of time it takes the circuit to lock

For a PLL, we will be concerned about the range of frequencies it can be tuned to. Answer A is the only choice that is concerned with this frequency tuning range so this is the right answer.

E7H16 (C)
What is a phase-locked loop circuit?
A. An electronic servo loop consisting of a ratio detector, reactance modulator, and voltage-controlled oscillator
B. An electronic circuit also known as a monostable multivibrator
C. An electronic servo loop consisting of a phase detector, a low-pass filter and voltage-controlled oscillator
D. An electronic circuit consisting of a precision push-pull amplifier with a differential input



A PLL circuit is illustrated in the graphic. It has a phase detector, a low-pass filter, and a VCO. Answer **C** matches this configuration.

E7H17 (D)
Which of these functions can be performed by a phase-locked loop?
A. Wide-band AF and RF power amplification
B. Comparison of two digital input signals, digital pulse counter
C. Photovoltaic conversion, optical coupling
D. Frequency synthesis, FM demodulation

Because of the operational characteristics of a VCO, the PLL can be used as both a frequency synthesizer and a FM demodulator. Answer **D** correctly describes the correct choices.

E7H18 (B)
Why is a stable reference oscillator normally used as part of a phase locked loop (PLL) frequency synthesizer?
A. Any amplitude variations in the reference oscillator signal will prevent the loop from locking to the desired signal
B. Any phase variations in the reference oscillator signal will produce phase noise in the synthesizer output
C. Any phase variations in the reference oscillator signal will produce harmonic distortion in the modulating signal
D. Any amplitude variations in the reference oscillator signal will prevent the loop from changing frequency

If there is not a stable reference oscillator, then there will be phase noise in the frequency synthesizer output. This is correctly stated in Answer B.

E7H19 (C)
Why is a phase-locked loop often used as part of a variable frequency synthesizer for receivers and transmitters?
A. It generates FM sidebands
B. It eliminates the need for a voltage controlled oscillator
C. It makes it possible for a VFO to have the same degree of stability as a crystal oscillator
D. It can be used to generate or demodulate SSB signals by quadrature phase synchronization

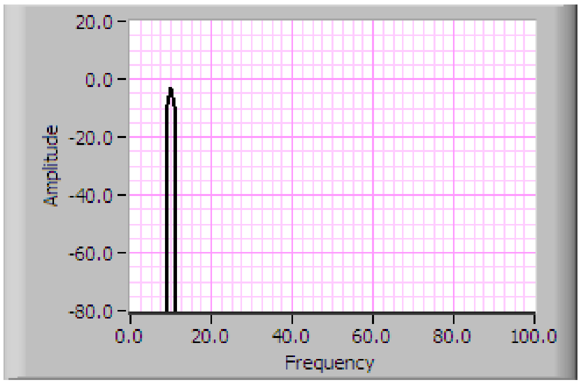
As we saw before, the crystal oscillator is a stable frequency reference. However, it is not really tunable over a wide range. The PLL is also a very stable oscillator circuit that is tunable so it can be used in receivers and transmitters. Answer C captures this usage.

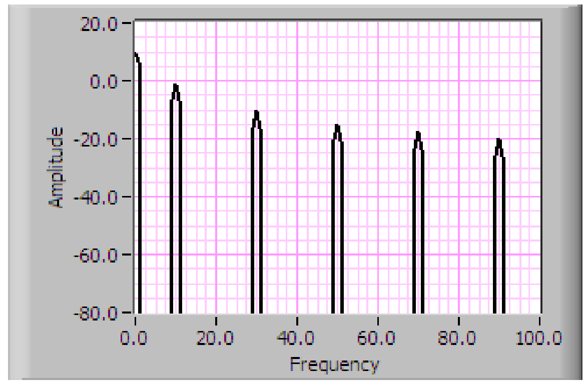
E7H20 (A)
What are the major spectral impurity components of phase-locked loop synthesizers?
A. Broadband noise
B. Digital conversion noise
C. Spurs at discrete frequencies
D. Nyquist limit noise

The PLL will have broadband noise so Answer **A** is the right choice. Since a PLL is analog, there will not be digital conversion noise as in Answer B. Answer C was for the direct digital synthesizers so this is incorrect here. Answer D is eliminated.

Subelement E8 -- Signals and Emissions

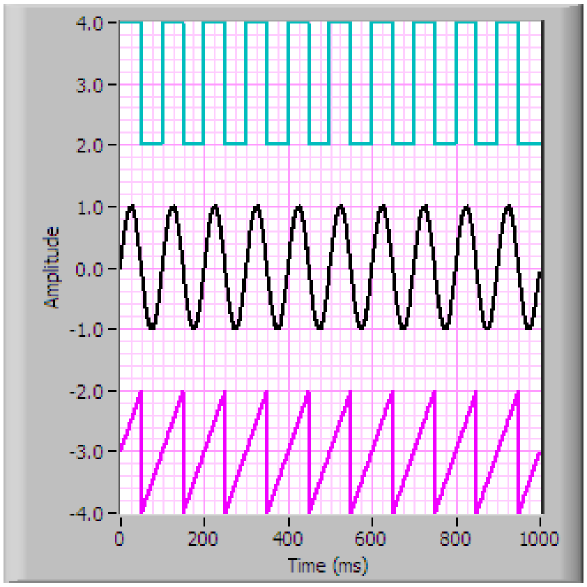
E8A01 (A)
What type of wave is made up of a sine wave plus all of its odd harmonics?
A. A square wave
B. A sine wave
C. A cosine wave
D. A tangent wave





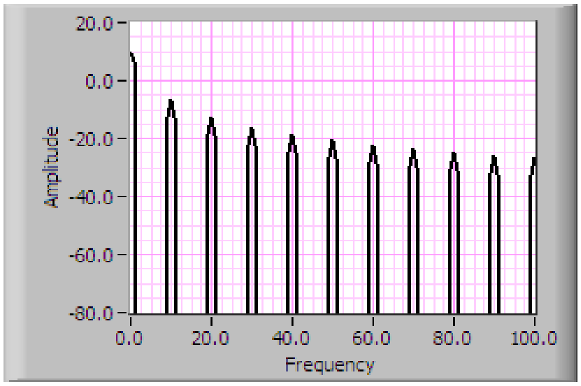
Here we need to understand how the waveforms will look on a spectrum analyzer. In questions E8A02, we will look at how a square wave, a sinusoid and a sawtooth waveform would look on an oscilloscope. In that graph, all three wave forms have the same frequency of 10 Hz. The fundamental frequency on a spectrum analyzer would look like the graph to the left: a single component at 10 Hz (the fundamental frequency). This is also the graph for a sinusoid (sine wave or a cosine wave of Answers B and C). If we apply a square wave to the input of a spectrum analyzer, then we get the graph on the right. Here, we see components at 10 Hz, 30 Hz, 50 Hz, 70 Hz, and on out to infinity. Since these are odd multiples of the fundamental frequency, the square wave is said to be made up of all odd harmonics so the correct answer is Answer **A**.

E8A02 (C)
What type of wave has a rise time significantly faster than its fall time (or vice versa)?
A. A cosine wave
B. A square wave
C. A sawtooth wave
D. A sine wave



The sawtooth waveform of Answer **C** is the bottom signal in the graph and that is the one being described by this question. The middle signal is a sinusoid (sine or cosine). The top signal is a square wave.

E8A03 (A)
What type of wave is made up of sine waves of a given fundamental frequency plus all its harmonics?
A. A sawtooth wave
B. A square wave
C. A sine wave
D. A cosine wave



Here we are back to how the waveforms will look on a spectrum analyzer. The setup is the same as we had with the square wave but this time we apply a sawtooth wave to the input of a spectrum analyzer and we get the graph on the left. Here, we see components at 10 Hz, 20 Hz, 30 Hz, 40 Hz, 50 Hz, 60 Hz, 70 Hz, and on out to infinity. Since these are both the even and the odd multiples of the fundamental frequency, the sawtooth wave is said to be made up of all harmonics so the correct answer is answer **A**. The square wave has just the odd harmonics while the sine and cosine wave have just a single harmonic so these choices are all incorrect.

E8A04 (C)
What is the equivalent to the root-mean-square value of an AC voltage?
A. The AC voltage found by taking the square of the average value of the peak AC voltage
B. The DC voltage causing the same amount of heating in a given resistor as the corresponding peak AC voltage
C. The DC voltage causing the same amount of heating in a resistor as the corresponding RMS AC voltage
D. The AC voltage found by taking the square root of the average AC value

Technically, the RMS value can be identified as the equivalent heating as a DC value so answer **C** is the correct choice to answer the question. Answer B is close but it identifies the peak AC value and not the RMS value so it is incorrect. Answer A is incorrect because it deals only with the peak value and not the whole range of values in the AC waveform. Answer D is technobabble so it is also incorrect.

E8A05 (D)
What would be the most accurate way of measuring the RMS voltage of a complex waveform?
A. By using a grid dip meter
B. By measuring the voltage with a D'Arsonval meter
C. By using an absorption wavemeter
D. By measuring the heating effect in a known resistor

This question is a variation on the previous question so we choose answer **D** as the correct choice among those given. Answer A is better for measuring the resonant frequency and not the RMS value so this is not a good choice. Answer B is just making an instantaneous voltage measurement which will not tell you the RMS value without more information. Answer C is meant to distract you by trying to make you think of an absorption wattmeter.

E8A06 (A)
What is the approximate ratio of PEP-to-average power in a typical voice-modulated single-sideband phone signal?
A. 2.5 to 1
B. 25 to 1
C. 1 to 1
D. 100 to 1

This is one of those "rules of thumb" that need to be memorized. The PEP will be larger than the average power for voice waveforms due to the shape of the voice waveform. This means that we can eliminate answer C since that would make them equal. The correct choice is answer **A** or 2.5:1. The other ratios are generally too large.

E8A07 (B)
What determines the PEP-to-average power ratio of a single-sideband phone signal?
A. The frequency of the modulating signal
B. The characteristics of the modulating signal
C. The degree of carrier suppression
D. The amplifier gain

The PEP to average power ratio is determined by the shape of the voice waveform so answer **B** is the correct choice for this question. The frequency of the modulating signal and the degree of carrier suppression do not enter into the computation so answers A and C are not correct. The amplifier power may seem like a reasonable choice but the amplifier, if fairly linear, will scale both equally so this is not a good choice to answer the question.

E8A08 (A)
What is the period of a wave?
A. The time required to complete one cycle
B. The number of degrees in one cycle
C. The number of zero crossings in one cycle
D. The amplitude of the wave

The period is the time to complete one cycle of the wave (regardless of its shape) so answer **A** is the right choice to answer this question. In question E8A02, each of the waveforms had a frequency of 10 Hz which makes the period of the waveform 100 ms. Answer B is the number of degrees in a circle but it is not a time measurement so it is incorrect. Answer C is a measure of the wave shape but it does not tell you any timing information without further information about the wave so this is not a good choice to answer the question. Answer D tells you how big the wave is but not anything dealing with timing so it is also incorrect.

E8A09 (C)
What type of waveform is produced by human speech?
A. Sinusoidal
B. Logarithmic
C. Irregular
D. Trapezoidal

Human speech is best characterized as an irregular waveform among the choices given so choose Answer **C** for this question.

E8A10 (B)
Which of the following is a distinguishing characteristic of a pulse waveform?
A. Regular sinusoidal oscillations
B. Narrow bursts of energy separated by periods of no signal
C. A series of tones that vary between two frequencies
D. A signal that contains three or more discrete tones

A pulse waveform is a narrow signal burst followed by no signal so Answer **B** is the right choice. The others can all be synthesized by a series of sinusoids so they will not produce a pulse as in the question.

E8A11 (D)
What is one use for a pulse modulated signal?
A. Linear amplification
B. PSK31 data transmission
C. Multiphase power transmission
D. Digital data transmission

There are several forms of pulse modulation: pulse code modulation, pulse position modulation, and pulse width modulation being common. They are used to encode digital numbers for transmission. In this particular question, the authors seem to be asking about the baseband representation of the digital signal and not the RF transmission. With interpretation, digital data transmission in Answer **D** is the preferred choice. PSK31 is a form of digital modulation but not at the baseband level for the data.

E8A12 (D)
What type of information can be conveyed using digital waveforms?
A. Human speech
B. Video signals
C. Data
D. All of these answers are correct

All of these waveforms can be encoded with some form of digital waveform so Answer **D** is the correct choice for this question.

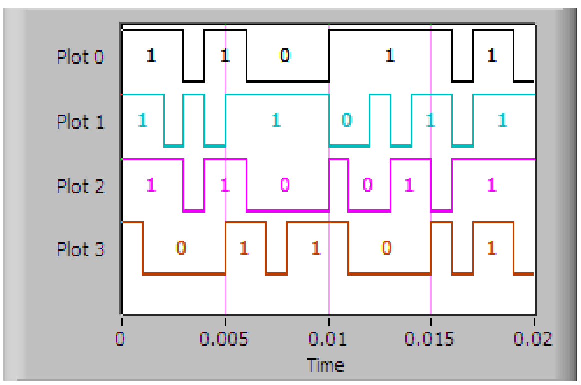
E8A13 (C)
What is an advantage of using digital signals instead of analog signals to convey the same information?
A. Less complex circuitry is required for digital signal generation and detection
B. Digital signals always occupy a narrower bandwidth
C. Digital signals can be regenerated multiple times without error
D. All of these answers are correct

Provided the signals are received correctly or have some form of FEC, digital signals can be regenerated without error as in Answer **C** so this is the correct choice. Answers A and B are not true statements which alos makes Answer D incorrect.

```
E8A14 (A)
Which of these methods is commonly used to convert analog signals to digital
signals?
A. Sequential sampling
B. Harmonic regeneration
C. Level shifting
D. Phase reversal
```

When analog signals are converted to digital signals they are sampled in a sequential manner as indicated in Answer **A**.

```
E8A15 (B)
What would the waveform of a digital data stream signal look like on a
conventional oscilloscope?
A. A series of sine waves with evenly spaced gaps
B. A series of pulses with varying patterns
C. A running display of alpha-numeric characters
D. None of the above; this type of signal cannot be seen on a conventional
      oscilloscope
```



A set of digital data waveforms is shown on the graphic. The series of pulses with varying patterns as given in Answer **B** is the best description among those given.

```
E8B01 (D)
What is the term for the ratio between the frequency deviation of an RF
carrier wave, and the modulating frequency of its corresponding FM-phone
signal?
A. FM compressibility
B. Quieting index
C. Percentage of modulation
D. Modulation index
```

Technically, the correct answer, **D**, is only true if a single tone is modulating the carrier. Otherwise, the modulation index is known as a deviation ratio when the input is a complicated signal such as a voice signal. Percent modulation is for DSB AM so this is not applicable to this question since we are dealing with FM. Quieting has to do with FM detection and not transmission so answer B is not a good choice for this question. Compression has to do with the baseband signal and not the FM signal so answer A is also not a good choice.

E8B02 (D)
How does the modulation index of a phase-modulated emission vary with RF carrier frequency (the modulated frequency)?
A. It increases as the RF carrier frequency increases
B. It decreases as the RF carrier frequency increases
C. It varies with the square root of the RF carrier frequency
D. It does not depend on the RF carrier frequency

Be careful with this tricky question. The modulation index is **not** a function of the specific carrier frequency so Answer **D** is the correct choice. The distraction answers are to see if you know the definition of the modulation index.

E8B03 (A)
What is the modulation index of an FM-phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency, when the modulating frequency is 1000 Hz?
A. 3
B. 0.3
C. 3000
D. 1000

Applying the definition given in question E8B01, we compute the deviation ratio as D = 3 kHz/1 kHz = 3. This makes answer **A** the correct choice. Answers B and C are off by factors of 10 so they are incorrect.

E8B04 (B)
What is the modulation index of an FM-phone signal having a maximum carrier deviation of plus or minus 6 kHz when modulated with a 2-kHz modulating frequency?
A. 6000
B. 3
C. 2000
D. 1/3

Applying the definition given in question E8B01, we compute the deviation ratio as D = 6 kHz/2 kHz = 3. This makes answer **B** the correct choice.

E8B05 (D)
What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz and accepting a maximum modulation rate of 3 kHz?
A. 60
B. 0.167
C. 0.6
D. 1.67

Again, we compute the deviation ratio as D = 5 kHz/3 kHz = 1.67. This makes answer **D** the correct choice.

E8B06 (A)
What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus or minus 7.5 kHz and accepting a maximum modulation frequency of 3.5 kHz?
A. 2.14
B. 0.214
C. 0.47
D. 47

You should be getting good at this by now. We compute the deviation ratio as D = 7.5 kHz/3.5 kHz = 2.14. This makes answer **A** the correct choice.

E8B07 (A)
When using a pulse-width modulation system, why is the transmitter's peak power greater than its average power?
A. The signal duty cycle is less than 100%
B. The signal reaches peak amplitude only when voice modulated
C. The signal reaches peak amplitude only when voltage spikes are generated within the modulator
D. The signal reaches peak amplitude only when the pulses are also amplitude modulated

For a pulse modulation system, the duty cycle will affect the output characteristics. This makes answer **A** the best choice among those given. Answers B, C, and D are all incorrect statements from a signal processing point of view so they are not good choices to answer the question.

E8B08 (D)
What parameter does the modulating signal vary in a pulse-position modulation system?
A. The number of pulses per second
B. The amplitude of the pulses
C. The duration of the pulses
D. The time at which each pulse occurs

PPM is described by the pulse position in time as in answer **D** so this is the right choice to answer this question. Answer C is PWM so this is incorrect. Answers A and B are to distract you.

E8B09 (A)
How are the pulses of a pulse-modulated signal usually transmitted?
A. A pulse of relatively short duration is sent; a relatively long period of time separates each pulse
B. A pulse of relatively long duration is sent; a relatively short period of time separates each pulse
C. A group of short pulses are sent in a relatively short period of time; a relatively long period of time separates each group
D. A group of short pulses are sent in a relatively long period of time; a relatively short period of time separates each group

Unless you are familiar with PWM systems, all of the choices may look reasonable. However, only answer **A** describes the usual protocol so this is the choice to remember. The other choices would produce systems that are harder to demodulate.

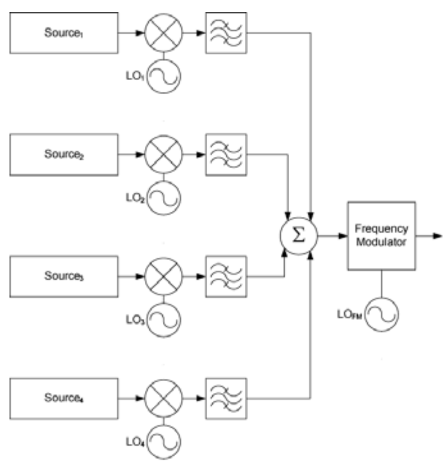
E8B10 (B)
What is meant by deviation ratio?
A. The ratio of the audio modulating frequency to the center carrier frequency
B. The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency
C. The ratio of the carrier center frequency to the audio modulating frequency
D. The ratio of the highest audio modulating frequency to the average audio modulating frequency

Based on the previous question, you should be able to spot answer **B** as the correct one because it deals with carrier deviation and the input audio signal. Notice that none of the other choices deal with carrier deviation from its unmodulated frequency so none of the other choices can be involved with deviation ratio.

E8B11 (C)
Which of these methods can be used to combine several separate analog information streams into a single analog radio frequency signal?
A. Frequency shift keying
B. A diversity combiner
C. Frequency division multiplexing
D. Pulse compression

We can combine several separate analog channels into a single information stream by using either time-division multiplexing or frequency-division multiplexing. Answer **C** is the right choice because it has one of these methods listed.

E8B12 (B)
Which of the following describes frequency division multiplexing?
A. The transmitted signal jumps from band to band at a predetermined rate
B. Two or more information streams are merged into a "baseband", which then modulates the transmitter
C. The transmitted signal is divided into packets of information
D. Two or more information streams are merged into a digital combiner, which then pulse position modulates the transmitter



The graphic shows the FDM process: signals are merged to form a composite baseband signal for the input to the transmitter. Answer **B** is the one with this description.

E8B13 (B)
What is time division multiplexing?
A. Two or more data streams are assigned to discrete sub-carriers on an FM transmitter
B. Two or more signals are arranged to share discrete time slots of a digital data transmission
C. Two or more data streams share the same channel by transmitting time of transmission as the sub-carrier
D. Two or more signals are quadrature modulated to increase bandwidth efficiency

Just as in FDM, each source is given a slice of the frequency domain, in TDM, each source is given a time slice for its data. Answer **B** is the correct choice to answer this question.

```
E8C01 (D)
Which one of the following digital codes consists of elements having unequal
length?
A. ASCII
B. AX.25
C. Baudot
D. Morse code
```

ASCII and Baudot codes are of fixed-length size so answers A and C are not correct. AX.25 is a packet format and not a data code so answer B is not a correct choice either. Of the choices given, Morse Code is a variable-length code so answer **D** is the best choice among those given.

```
E8C02 (B)
What are some of the differences between the Baudot digital code and ASCII?
A. Baudot uses four data bits per character, ASCII uses seven; Baudot uses one
      character as a shift code, ASCII has no shift code
B. Baudot uses five data bits per character, ASCII uses seven; Baudot uses two
      characters as shift codes, ASCII has no shift code
C. Baudot uses six data bits per character, ASCII uses seven; Baudot has no
      shift code, ASCII uses two characters as shift codes
D. Baudot uses seven data bits per character, ASCII uses eight; Baudot has no
      shift code, ASCII uses two characters as shift codes
```

You need to remember Baudot 5 : ASCII 7. This makes answer **B** the only one that has the right number of bits. The others are incorrect variations on these code lengths.

```
E8C03 (C)
What is one advantage of using the ASCII code for data communications?
A. It includes built-in error-correction features
B. It contains fewer information bits per character than any other code
C. It is possible to transmit both upper and lower case text
D. It uses one character as a shift code to send numeric and special
      characters
```

Only answer **C** is a correct statement among the choices given so this is the correct choice to answer this question. ASCII will detect errors but not correct them so answer A is incorrect. Answer B is incorrect because ASCII has more bits than Baudot, not fewer. Answer D is not true for ASCII.

```
E8C04 (D)
What is one of the differences between MT63 and PSK31?
A. MT63 is an FM signal; PSK31 is an AM signal
B. MT63 uses the Baudot code; PSK31 uses Varicode
C. MT63 requires less bandwidth for an equivalent bit rate than PSK31
D. MT63 incorporates error correction; PSK31 does not
```

Here, the pool designers are asking about the basic PSK31 mode. In this case, MT63 incorporates error correction while basic PSK31 does not so Answer **D** is the best choice among those given. As we saw in question E2E10, the design of PSK31 is to have an error correction mode using QPSK transmission but it is not frequently used in practice.

E8C05 (C)
What technique is used to minimize the bandwidth requirements of a PSK-31 signal?
A. Zero-sum character encoding
B. Reed-Solomon character encoding
C. Use of sinusoidal data pulses
D. Use of trapezoidal data pulses

This question applies to all digital transmission modes: to minimize occupied bandwidth, do not use square pulses but utilize sinusoidal-shaped pulses. As we saw in E8A01, square waves have many harmonics. The sinusoidal shaping reduces the amplitude of the harmonics. This makes Answer **C** the best choice among those given here. Answers A and D are silly distractions. Reed-Solomon coding will help correct errors but will not reduce bandwidth.

E8C06 (C)
What is the necessary bandwidth of a 13-WPM international Morse code transmission?
A. Approximately 13 Hz
B. Approximately 26 Hz
C. Approximately 52 Hz
D. Approximately 104 Hz

The rule of thumb estimate for the occupied bandwidth for Morse code is approximately 50 Hz so answer **C** is the right choice. The other choices are there to distract you.

E8C07 (C)
What is the necessary bandwidth of a 170-hertz shift, 300-baud ASCII transmission?
A. 0.1 Hz
B. 0.3 kHz
C. 0.5 kHz
D. 1.0 kHz

Perhaps the way to get the order of magnitude of the right answer is to add the 170 Hz shift to the 300 baud transition rate to get a bandwidth on the order of 500 Hz (0.5 kHz) so answer **C** is the best choice to answer this question. Answer A is silly so it can be eliminated. Answer B would be close if FSK were not being used. Answer D is too large.

E8C08 (A)
What is the necessary bandwidth of a 4800-Hz frequency shift, 9600-baud ASCII FM transmission?
A. 15.36 kHz
B. 9.6 kHz
C. 4.8 kHz
D. 5.76 kHz

Here, the expected bandwidth using the quick method of the previous question would give a bandwidth on the order of 15 kHz so answer **A** is the best choice among those given for FSK. The other choices are too narrow for FSK.

E8C09 (D)
What term describes a wide-bandwidth communications system in which the transmitted carrier frequency varies according to some predetermined sequence?
A. Amplitude compandored single sideband
B. AMTOR
C. Time-domain frequency modulation
D. Spread-spectrum communication

The keys here are the phrases “wide band” and “predetermined sequence.” This implies spread spectrum communication so answer **D** is the right choice. Answers A, B, and C are not much wider than the baseband signal so they do not qualify as spread spectrum in this sense so they are not correct choices to answer this question.

E8C10 (A)
Which of these techniques causes a digital signal to appear as wide-band noise to a conventional receiver?
A. Spread-spectrum
B. Independent sideband
C. Regenerative detection
D. Exponential addition

This is another way to describe the characteristics of spread spectrum communications so Answer **A** is the right choice.

E8C11 (A)
What spread-spectrum communications technique alters the center frequency of a conventional carrier many times per second in accordance with a pseudo-random list of channels?
A. Frequency hopping
B. Direct sequence
C. Time-domain frequency modulation
D. Frequency compandored spread-spectrum

This question gives the definition of Frequency Hopping Spread Spectrum (FHSS) so answer **A** is the correct choice to answer the question. Answer B is a form of spread spectrum but the carrier frequency is not changed so this is not a good choice to answer the question. Answer C is not spread spectrum so it is not a good choice. Answer D is technobabble so it can be eliminated.

E8C12 (B)
What spread-spectrum communications technique uses a high speed binary bit stream to shift the phase of an RF carrier?
A. Frequency hopping
B. Direct sequence
C. Binary phase-shift keying
D. Phase compandored spread-spectrum

This is the definition of Direct Sequence Spread Spectrum (DSSS) so answer **B** is the correct choice. Since the carrier is not changed, it cannot be FHSS as in answer A. Typically, DSSS is transmitted using BPSK so answer C is close to being right but it does not have to be sent by BPSK so this is not as good a choice as answer B. Answer D is technobabble.

```
E8C13 (D)
What makes spread-spectrum communications resistant to interference?
A. Interfering signals are removed by a frequency-agile crystal filter
B. Spread-spectrum transmitters use much higher power than conventional
      carrier-frequency transmitters
C. Spread-spectrum transmitters can hunt for the best carrier frequency to use
      within a given RF spectrum
D. Only signals using the correct spreading sequence are received
```

Answer A is technobabble so this is not a good choice. Answer B is not a requirement as SS-cell phone users will attest to. Answer C is not true of most SS devices so it is here to distract you as well. Only answer **D** has a valid reason listed.

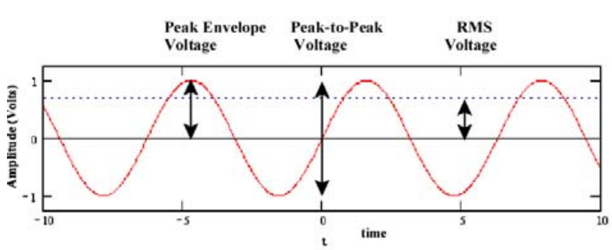
```
E8C14 (D)
What is the advantage of including a parity bit with an ASCII character
stream?
A. Faster transmission rate
B. The signal can overpower interfering signals
C. Foreign language characters can be sent
D. Some types of errors can be detected
```

Each ASCII character has a parity bit sent with the character. This parity bit can be used to detect odd numbers (1 , 3, or 5) of errors but not even numbers (2, 4, or 6). This makes Answer **D** the correct choice. Since a single error is the most probable type of error in ASCII transmission, this is usually a good method.

```
E8C15 (B)
What is one advantage of using JT-65 coding?
A. Uses only a 65 Hz bandwidth
B. Virtually perfect decoding of signals well below the noise
C. Easily copied by ear if necessary
D. Permits fast-scan TV transmissions over narrow bandwidth
```

JT-65 is an error detection correction coding method that was designed to be used with very weak signals such as those found in EME communications. This makes Answer B the advantage being asked for in this question.

```
E8D01 (A)  [was E8D02 edited]
What is the easiest voltage amplitude parameter to measure when viewing a pure
sine wave signal on an oscilloscope?
A. Peak-to-peak voltage
B. RMS voltage
C. Average voltage
D. DC voltage
```



Of the choices given, the peak-to-peak voltage, or the full span of the wave, is the easiest to measure so answer **A** is the best choice. To obtain RMS, one needs to measure peak voltage and divide by 1.414 so this is not easier. The average voltage is the same as the RMS so answer C is not correct. On a good scope, the DC is also easy to measure but the pool designers like answer A better so this is the right choice.

E8D02 (B) [was E8D03; edited
What is the relationship between the peak-to-peak voltage and the peak voltage amplitude in a symmetrical waveform?
A. 0.707:1
B. 2:1
C. 1.414:1
D. 4:1

These voltages are related by the 2:1 ratio so answer **B** is the right choice. The other ratios do not deal with these voltages so they are not correct choices.

E8D03 (A)
What input-amplitude parameter is valuable in evaluating the signal-handling capability of a Class A amplifier?
A. Peak voltage
B. RMS voltage
C. Average power
D. Resting voltage

Since class A amplifiers are fairly linear, the peak voltage will be the maximum stress on the amplifier. This makes answer **A** the best choice among those given. The RMS voltage is less than the peak so this is not as good a choice as answer A. Answers C and D are to distract you.

E8D04 (B)
What is the PEP output of a transmitter that has a maximum peak of 30 volts to a 50-ohm load as observed on an oscilloscope?
A. 4.5 watts
B. 9 watts
C. 16 watts
D. 18 watts

The PEP power is given by $V_{peak}^2/(2*R)$. Plugging in the numbers gives $30^2/(2*50) = 9$ W so answer **B** is the correct choice. Answer D leaves out the factor of 2 while answer A divides by an additional factor of two too many.

E8D05 (D)
If an RMS-reading AC voltmeter reads 65 volts on a sinusoidal waveform, what is the peak-to-peak voltage?
A. 46 volts
B. 92 volts
C. 130 volts
D. 184 volts

The peak voltage is computed by 1.414 times the RMS voltage and the peak-to-peak is twice that value. Plugging in the numbers, $V_{PP} = 2 \times 1.414 \times 65$ V = 184 V so answer **D** is the right choice. Answer C is incorrect because it leaves off the 1.414 factor. Answer B is incorrect because it divides by 1.414 rather than multiplying by it.

E8D06 (B) [replaces E8D07]
What is the advantage of using a peak-reading wattmeter to monitor the output of a SSB phone transmitter?
A. It is easier to determine the correct tuning of the output circuit
B. It gives a more accurate display of the PEP output when modulation is present
C. It makes it easier to detect high SWR on the feed-line
D. It can determine if any "flat-topping" is present during modulation peaks

The statements in Answers A, C, and D are not correct so do not choose them. Answer **B** is correct in that it gives a more accurate display of PEP when modulation is present.

```
E8D07 (C)
What is an electromagnetic wave?
A. Alternating currents in the core of an electromagnet
B. A wave consisting of two electric fields at right angles to each other
C. A wave consisting of an electric field and a magnetic field oscillating at
      right angles to each other
D. A wave consisting of two magnetic fields at right angles to each other
```

An electromagnetic wave has both an electric and magnetic component so answers B and D can be eliminated since they only have one component. Since the wave can exist in free space, answer A is too confining and it is wrong. Only answer **C** is a correct physical description so this is the right choice to answer this question.

```
E8D08 (D)
Which of the following best describes electromagnetic waves traveling in free
space?
A. Electric and magnetic fields become aligned as they travel
B. The energy propagates through a medium with a high refractive index
C. The waves are reflected by the ionosphere and return to their source
D. Changing electric and magnetic fields propagate the energy
```

From a physics point of view, only answer **D** has any sense to it. Answer A is incorrect because the components are always perpendicular. Truly free space has a low refractive index so answer B is incorrect. Answer C is physically silly too so it is not correct.

```
E8D09 (B)
What is meant by circularly polarized electromagnetic waves?
A. Waves with an electric field bent into a circular shape
B. Waves with a rotating electric field
C. Waves that circle the Earth
D. Waves produced by a loop antenna
```

The correct answer is that the waves have a rotating electric field so answer **B** is the right choice. All of the other choices are silly distractions.

```
E8D10 (D)
What is the polarization of an electromagnetic wave if its magnetic field is
parallel to the surface of the Earth?
A. Circular
B. Horizontal
C. Elliptical
D. Vertical
```

Polarization is defined in terms of the electric field and the two fields are perpendicular to each other. If the magnetic field is parallel to the surface then the electric field is perpendicular to the surface and the polarization is vertical as in answer **D**. Since this question is describing linear modulation, answers A and C are not valid here. Answer B is for the magnetic field so this is an incorrect choice.

E8D11 (A)
What is the polarization of an electromagnetic wave if its magnetic field is perpendicular to the surface of the Earth?
A. Horizontal
B. Circular
C. Elliptical
D. Vertical

Again, polarization is defined in terms of the electric field and the two fields are perpendicular to each other. If the magnetic field is perpendicular to the surface then the electric field is horizontal and the polarization is horizontal as in answer **A**. Since this question is describing linear modulation, answers B and C are not valid here. Answer D is for the magnetic field so this is not a correct choice.

E8D12 (A)
At approximately what speed do electromagnetic waves travel in free space?
A. 300 million meters per second
B. 186,300 meters per second
C. 186,300 feet per second
D. 300 million miles per second

If the question pool designers were thinking, they would have made the correct answer "C" but they did not! The speed of light is *approximated* by 300,000,000 meters per second so answer **A** is the right choice. Answer D has the wrong units (miles instead of meters so don't read this too quickly. Answer C almost has the English-unit equivalent but the units are wrong. Answer B is to distract you.

E8D13 (D)
What type of meter should be used to monitor the output signal of a voice-modulated single-sideband transmitter to ensure you do not exceed the maximum allowable power?
A. An SWR meter reading in the forward direction
B. A modulation meter
C. An average reading wattmeter
D. A peak-reading wattmeter

If we wish to avoid violating the power rules, then we need to monitor peak power as in answer **D** which makes this the right choice. Measuring the SWR will not tell us peak power so answer A is incorrect. Measuring the modulation will not tell us peak power so answer B is also incorrect. If we measured average power rather than peak power, we would be off by a factor of 2 so this is not a good choice to answer the question.

E8D14 (A)
What is the average power dissipated by a 50-ohm resistive load during one complete RF cycle having a peak voltage of 35 volts?
A. 12.2 watts
B. 9.9 watts
C. 24.5 watts
D. 16 watts

The correct answer is gotten by remembering that the average power is V_{RMS}^2/R. Plugging in the numbers, this gives $P = 35^2/(2*50) = 12.2$ Watts. This makes Answer **A** the correct choice. Answer C has a factor of 2 in the wrong place so it is not correct. Answers B and D have other math mistakes.

```
E8D15 (D)
If an RMS reading voltmeter reads 34 volts on a sinusoidal waveform, what is
the peak voltage?
A. 123 volts
B. 96 volts
C. 55 volts
D. 48 volts
```

The peak voltage is 1.414 times larger than the RMS voltage. In this case, that is 48 V so the correct choice is answer **D**. The other choices are silly math mistakes.

```
E8D16 (B)
Which of the following is a typical value for the peak voltage at a common
household electrical outlet?
A. 240 volts
B. 170 volts
C. 120 volts
D. 340 volts
```

What we call 120-V household electrical voltage is really the RMS value. Scaling that by 1.414 gives 170 V for the peak voltage at the wall socket. Answer **B** is the right choice. Be careful because the answer of 120 V is the RMS value. Also be careful because the question is asking for the peak and not peak-to-peak which would be 340 V and that is found in the next question.

```
E8D17 (C)
Which of the following is a typical value for the peak-to-peak voltage at a
common household electrical outlet?
A. 240 volts
B. 120 volts
C. 340 volts
D. 170 volts
```

As we just saw, the peak-to-peak value is 340 V so Answer **C** is the right choice. Answer D is the peak value so do not chose it here.

```
E8D18 (A)
Which of the following is a typical value for the RMS voltage at a common
household electrical power outlet?
A. 120-V AC
B. 340-V AC
C. 85-V AC
D. 170-V AC
```

By now you should be able to spot the correct choice as 120 V in Answer **A**.

```
E8D19 (A)
What is the RMS value of a 340-volt peak-to-peak pure sine wave?
A. 120-V AC
B. 170-V AC
C. 240-V AC
D. 300-V AC
```

Based on the previous questions, you should recognize this as the 120-V electrical socket case so Answer **A** is the correct choice.

Subelement E9 -- Antennas and Transmission Lines

E9A01 (C)
Which of the following describes an isotropic Antenna?
A. A grounded antenna used to measure earth conductivity
B. A horizontal antenna used to compare Yagi antennas
C. A theoretical antenna used as a reference for antenna gain
D. A spacecraft antenna used to direct signals toward the earth

Here, the definition of "isotropic," uniformly radiating in all directions, does not help you select the right answer. Because it cannot be perfectly attained in real life, it is more of a theoretical concept and the correct usage is given in answer **C** so that is the right choice. Answer A is technobabble so it can be ignored. Answer B may seem reasonable but the Yagi is compared with a radiator the transmits in all directions so this is not as good a choice as answer C. Answer D is often called a "space to ground antenna" which is typically not an isotropic antenna.

E9A02 (B)
How much gain does a 1/2-wavelength dipole have compared to an isotropic antenna?
A. 1.55 dB
B. 2.15 dB
C. 3.05 dB
D. 4.30 dB

This is one of those performance figures that you will probably need to memorize. The correct response is around 2 dB so answer **B** is the right choice here. The other answers are distractions to confuse you.

E9A03 (D)
Which of the following antennas has no gain in any direction?
A. Quarter-wave vertical
B. Yagi
C. Half-wave dipole
D. Isotropic antenna

By definition, an isotropic radiator transmits uniformly in all directions. The gain is a measure of departure from this uniform pattern. Therefore, the isotropic radiator in answer **D** is the right choice. The other antenna choices all have some degree of gain relative to the isotropic antenna.

E9A04 (A)
Why would one need to know the feed point impedance of an antenna?
A. To match impedances for maximum power transfer from a feed line
B. To measure the near-field radiation density from a transmitting antenna
C. To calculate the front-to-side ratio of the antenna
D. To calculate the front-to-back ratio of the antenna

You would normally desire to have as much of the available RF energy radiated as possible. This is accomplished, in part, by matching the antenna impedance to the source. Therefore, Answer **A** is the right choice to answer this question. The antenna pattern measurements described in answers B, C, and D are really not affected by the input impedance so they represent incorrect choices to answer this question.

E9A05 (B)
Which of the following factors determine the radiation resistance of an antenna?
A. Transmission-line length and antenna height
B. Antenna height and conductor length/diameter ratio, and location of nearby conductive objects
C. It is a physical constant and is the same for all antennas
D. Sunspot activity and time of day

The antenna transmission line length does not affect the intrinsic antenna radiation resistance so answer A is not a good choice. Answer C is physically incorrect so this is not a good choice either. Answer D is a silly distraction so it can be ignored. Answer **B** has two of the correct factors so this is the best choice among those given here.

E9A06 (C)
What is the term for the ratio of the radiation resistance of an antenna to the total resistance of the system?
A. Effective radiated power
B. Radiation conversion loss
C. Antenna efficiency
D. Beamwidth

The correct answer is the antenna efficiency so answer **C** is the correct choice here. The ERP describes how much signal power is actually radiated so answer A is incorrect. Answer B is not defined by the question statement so this is not a correct choice. Answer D is described by the spatial pattern of the antenna and not the resistance which makes this incorrect.

E9A07 (D)
What is included in the total resistance of an antenna system?
A. Radiation resistance plus space impedance
B. Radiation resistance plus transmission resistance
C. Transmission-line resistance plus radiation resistance
D. Radiation resistance plus ohmic resistance

The impedance of free space is a real physical concept but it is not included as part of the antenna radiation resistance so answer A is incorrect. There is not a transmission resistance so answer B is not a good choice. The transmission line is not part of the antenna so answer C is not correct. The correct factors are listed in answer **D** so this is the right choice.

E9A08 (C)
What is a folded dipole antenna?
A. A dipole one-quarter wavelength long
B. A type of ground-plane antenna
C. A dipole constructed from one wavelength of wire forming a very thin loop
D. A hypothetical antenna used in theoretical discussions to replace the radiation resistance

Answer A corresponds to a $\lambda/4$ dipole so this is not correct. Answer B is incorrect. Answer **C** has the right description so this is the one to choose. Answer D is technobabble so it can be eliminated.

E9A09 (A)
What is meant by antenna gain?
A. The numerical ratio relating the radiated signal strength of an antenna in the direction of maximum radiation to that of a reference antenna
B. The numerical ratio of the signal in the forward direction to that in the opposite direction
C. The ratio of the amount of power radiated by an antenna compared to the transmitter output power
D. The final amplifier gain minus the transmission-line losses (including any phasing lines present)

Gain is always the ratio of antenna radiation performance and answer **A** has the correct relationship so this is the one to choose. Answer B is the “front-to-back” ratio and not the antenna gain so it is not the right choice. Answer C sounds correct but it is not how gain is theoretically defined so it is not the right choice to answer the question. Answer D is useful for computing the radiated power but it is not the gain so this is not a correct answer either.

E9A10 (B)
What is meant by antenna bandwidth?
A. Antenna length divided by the number of elements
B. The frequency range over which an antenna satisfies a performance requirement
C. The angle between the half-power radiation points
D. The angle formed between two imaginary lines drawn through the element ends

Bandwidth is a frequency domain measurement so only answer **B** is a contender and this is the right answer for this question. Answers C and D cannot be right because they deal with angles (beamwidth) and not frequencies (bandwidth) so they are wrong. Answer A is technobabble.

E9A11 (B)
How is antenna efficiency calculated?
A. (radiation resistance / transmission resistance) x 100%
B. (radiation resistance / total resistance) x 100%
C. (total resistance / radiation resistance) x 100%
D. (effective radiated power / transmitter output) x 100%

The efficiency is given in terms of the radiation resistance and the total resistance so answer **B** is the correct formulation of the computation. There is not a transmission resistance so answer A is incorrect. Answer C has the order of the factors reversed so be careful with this incorrect choice. Answer D may sound good but it is not how the efficiency is computed so it is an incorrect choice.

E9A12 (A)
How can the efficiency of an HF quarter-wave grounded vertical antenna be improved?
A. By installing a good radial system
B. By isolating the coax shield from ground
C. By shortening the vertical
D. By reducing the diameter of the radiating element

The best thing to improve a grounded vertical antenna is to have a good ground radial system so answer **A** is the best choice among those given. Answers C and D will change the tuning of the vertical so these are not good choices. Answer B will probably make things worse by interrupting the system ground.

E9A13(C)
Which is the most important factor that determines ground losses for a ground-mounted vertical antenna operating in the 3-30 MHz range?
A. The standing-wave ratio
B. Base current
C. Soil conductivity
D. Base impedance

When you see ground losses, think "soil conductivity." The properties of the soil have a great deal to do with antenna operation which makes Answer **C** the right choice for this question.

E9A14 (A)
How much gain does an antenna have over a 1/2-wavelength dipole when it has 6 dB gain over an isotropic antenna?
A. 3.85 dB
B. 6.0 dB
C. 8.15 dB
D. 2.79 dB

A 1/2-wave dipole has a gain of 2.1 dB relative to an isotropic antenna. The gain relative to the dipole would then be 6 dB - 2.1 dB = 3.9 dB. From this, we can see that answer **A** is the right choice. Answer C adds the gain instead of subtracting it so it makes the computation incorrect. Answer B would be correct if the dipole had a gain of 0 dB instead of 2.1 dB. Answer D is to distract you.

E9A15 (B)
How much gain does an antenna have over a 1/2-wavelength dipole when it has 12 dB gain over an isotropic antenna?
A. 6.17 dB
B. 9.85 dB
C. 12.5 dB
D. 14.15 dB

Again, the 1/2-wave dipole has a gain of 2.1 dB relative to an isotropic antenna. The gain relative to the dipole would then be 12 dB - 2.1 dB = 9.9 dB. From this, we can see that answer **B** is the right choice. Answer D adds the gain instead of subtracting it so it makes the computation incorrect. Answer C would be correct if the dipole had a gain of 0 dB instead of 2.1 dB. Answer A is to distract you.

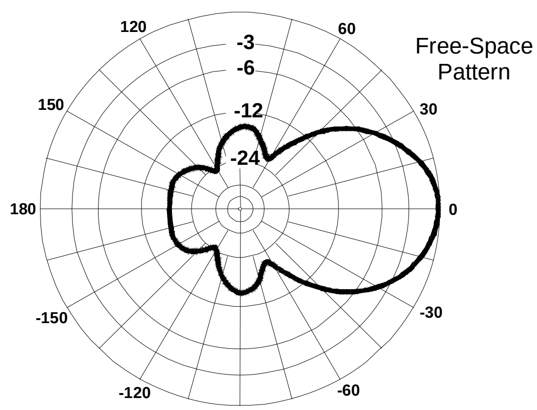
E9A16 (C) (was E9A20; edited)
What is meant by the radiation resistance of an antenna?
A. The combined losses of the antenna elements and feed line
B. The specific impedance of the antenna
C. The value of a resistance that would dissipate the same amount of power as that radiated from an antenna
D. The resistance in the atmosphere that an antenna must overcome to be able to radiate a signal

Answer D is a silly distraction so this is not a good answer for the question. The other three may look reasonable but only answer **C** is the one that meets the technical definition. Losses are usually given in dB and not resistance so answer A is not correct. Answer B is important to know but it is the electrical resistance and not the radiation resistance so it is incorrect.

```
E9B01 (C)
What determines the free-space polarization of an antenna?
A. The orientation of its magnetic field (H Field)
B. The orientation of its free-space characteristic impedance
C. The orientation of its electric field (E Field)
D. Its elevation pattern
```

The polarization is determined by the orientation of the electric field so answer **C** is the correct choice. Answer A is perpendicular to the E-field so it is an incorrect choice. Answers B and D are not directly concerned with the E field so they are not correct answers.

Figure E9-1




```
E9B02 (B)
In the antenna radiation pattern
shown in Figure E9-1, what is the
3-dB beamwidth?
A. 75 degrees
B. 50 degrees
C. 25 degrees
D. 30 degrees
```

By looking at the figure, the pattern drops to 3 dB at about +/- 25 degrees so the beamwidth is about 50 degrees. This makes answer **B** the correct choice. Answer C is one half the beamwidth so it is incorrect. Answers A and D are to distract you.

```
E9B03 (B)
In the antenna radiation pattern shown in Figure E9-1, what is the
front-to-back ratio?
A. 36 dB
B. 18 dB
C. 24 dB
D. 14 dB
```

The antenna gain at 0 degrees is 0 dB while the gain at 180 degrees is about half-way between -12 and -24 dB on this scale so let's say it is -18 dB. The front-to-back ratio would be $G_{front} - G_{back}$ = 0 dB - (-18 dB) = 18 dB. This makes answer **B** the correct choice since it corresponds to 18 dB. Answer D is the front-to-side ratio so it is incorrect for this question. Answer C would be the ratio at 120 degrees. Answer A is not on the graph.

```
E9B04 (B)
In the antenna radiation pattern shown in Figure E9-1, what is the
front-to-side ratio?
A. 12 dB
B. 14 dB
C. 18 dB
D. 24 dB
```

The antenna gain at 0 degrees is 0 dB while the gain at 90 degrees or 270 degrees is a bit less than -12 dB so let's say -14 dB. The front-to-side ratio would be $G_{front} - G_{side}$ = 0 dB - (-14 dB) = 14 dB. This corresponds to the 14 dB in answer **B** which is the right choice. Answer C is the front-to-back ratio so it is incorrect here. Answer D is the result for the 120 degree angle. Answer A is to distract you.

E9B05 (D)
What may occur when a directional antenna is operated at different frequencies within the band for which it was designed?
A. Feed-point impedance may become negative
B. The E-field and H-field patterns may reverse
C. Element spacing limits could be exceeded
D. The gain may exhibit significant variations

An antenna is part of an overall tuned circuit. The tuning is optimized for one frequency. If you move away from that frequency, then the tuning will not be as exact and gain variations will occur. If the system has a wide enough bandwidth, then the variation will be slight. If the system has a narrow bandwidth, the gain variation can be considerable. Answer **D** correctly captures this characteristic.

E9B06 (B)
What usually occurs if a Yagi antenna is designed solely for maximum forward gain?
A. The front-to-back ratio increases
B. The front-to-back ratio decreases
C. The frequency response is widened over the whole frequency band
D. The SWR is reduced

This is another “rule-of-thumb” question. In this case, the front-to-back ratio decreases as would be expected if the pattern is optimized for maximum forward gain. Answer **B** is the one with a correct statement. The other choices do not describe how the antenna behaves.

E9B07 (A)
If the boom of a Yagi antenna is lengthened and the elements are properly retuned, what usually occurs?
A. The gain increases
B. The SWR decreases
C. The front-to-back ratio increases
D. The gain bandwidth decreases rapidly

This is another "rule-of-thumb" question. Answer **A** is the one with a correct statement. The other choices do not describe how the antenna behaves.

E9B08 (C)
How does the total amount of radiation emitted by a directional (gain) antenna compare with the total amount of radiation emitted from an isotropic antenna, assuming each is driven by the same amount of power?
A. The total amount of radiation from the directional antenna is increased by the gain of the antenna
B. The total amount of radiation from the directional antenna is stronger by its front to back ratio
C. There is no difference between the two antennas
D. The radiation from the isotropic antenna is 2.15 dB stronger than that from the directional antenna

If you think about it, the antenna cannot manufacture RF signal within it. All the antenna can do is either lose signal or direct it to specific directions. The best an antenna can do is emit the same power as it receives regardless of antenna type. Answer **C** is correct because an ideal directional antenna radiates the same power as an ideal isotropic antenna.

E9B09 (A)
How can the approximate beamwidth of a directional antenna be determined?
A. Note the two points where the signal strength of the antenna is 3 dB less than maximum and compute the angular difference
B. Measure the ratio of the signal strengths of the radiated power lobes from the front and rear of the antenna
C. Draw two imaginary lines through the ends of the elements and measure the angle between the lines
D. Measure the ratio of the signal strengths of the radiated power lobes from the front and side of the antenna

The way most folks find beamwidth is to find the angular difference between the 3-dB points as was done in question E9B02. Answer **A** is the correct choice for this question.

E9B10 (B)
What type of computer program technique is commonly used for modeling antennas?
A. Graphical analysis
B. Method of Moments
C. Mutual impedance analysis
D. Calculus differentiation with respect to physical properties

Love your MoM! Answer **B**, the method of moments, is the usual method so this is the right choice to answer the question. Answer A is too general so it is not a good choice. Answer D is technobabble.

E9B11 (A)
What is the principle of a Method of Moments analysis?
A. A wire is modeled as a series of segments, each having a distinct value of current
B. A wire is modeled as a single sine-wave current generator
C. A wire is modeled as a series of points, each having a distinct location in space
D. A wire is modeled as a series of segments, each having a distinct value of voltage across it

The Method of Moments analysis technique uses segments and current values so Answer **A** is the right choice. Answer B is technobabble so it is eliminated. Answer C is meaningless without the current in the wire. Answer D is incorrect because it used voltage instead of current.

E9B12 (C)
What is a disadvantage of decreasing the number of wire segments in an antenna model below the guideline of 10 segments per half-wavelength?
A. Ground conductivity will not be accurately modeled
B. The resulting design will favor radiation of harmonic energy
C. The computed feed-point impedance may be incorrect
D. The antenna will become mechanically unstable

One reason for decreasing the number of wire segments below 10 per half wavelength is that it improves the time required to run the analysis. The disadvantage is that the analysis is less precise. One way it may be less precise is in the computation of the feed-point impedance so Answer **C** is the best choice among those given.

E9B13 (C)
Which of the following is a disadvantage of NEC-based antenna modeling programs?
A. They can only be used for simple wire antennas
B. They are not capable of generating both vertical and horizontal polarization patterns
C. Computing time increases as the number of wire segments is increased
D. All of these answers are correct

The NEC is a method of moments-based analysis program. As the number of wire segments increases, the computation time also increases so Answer **C** is the right choice. Answers A and B are untrue statements so Answer D is also incorrect.

E9B14 (B)
What does the abbreviation NEC stand for when applied to antenna modeling programs?
A. Next Element Comparison
B. Numerical Electromagnetics Code
C. National Electrical Code
D. Numeric Electrical Computation

When you are out "NECing," you are running the "Numerical Electromagnetics Code" computer program. Answer **B** is the right choice.

E9B15 (D)
What type of information can be obtained by submitting the details of a proposed new antenna to a modeling program?
A. SWR vs. frequency charts
B. Polar plots of the far-field elevation and azimuth patterns
C. Antenna gain
D. All of these answers are correct

If you have a good modeling program, then each of the statements in Answers A, B, and C are correct so Answer **D** is the best choice.

E9C01 (D)
What is the radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed 180 degrees out of phase?
A. A cardioid
B. Omnidirectional
C. A figure-8 broadside to the axis of the array
D. A figure-8 oriented along the axis of the array

Generally, it is very difficult to make two antennas radiate in an omnidirectional pattern so answer B is not a good choice. Unless you are an antenna guru, you will probably need to memorize the correct result for each of the next few questions. The following table may help.

Spacing	**Feed Phase**	**Pattern**
½ wavelength	180 degrees	Figure 8 end-fire
½ wavelength	in phase	Figure 8 broadside
¼ wavelength	90 degrees	Cardioid
¼ wavelength	180 degrees	Figure 8 end-fire
¼ wavelength	in phase	Elliptical
⅛ wavelength	180 degrees	Figure 8 end-fire

The correct choice for this configuration is given in answer **D**. Answers B and C correspond to other configurations.

```
E9C02 (A)
What is the radiation pattern of two 1/4-wavelength vertical antennas spaced
1/4-wavelength apart and fed 90 degrees out of phase?
A. A cardioid
B. A figure-8 end-fire along the axis of the array
C. A figure-8 broadside to the axis of the array
D. Omnidirectional
```

This is similar to the previous question but now the phasing is 90 degrees instead of 180 degrees and the spacing is 1/4 wave instead of ½ wave. In this case, the pattern is the cardioid of answer **A** which makes this the right choice. Answers B and C are for other configurations. The omnidirectional choice is not a good one as we indicated above.

```
E9C03 (C)
What is the radiation pattern of two 1/4-wavelength vertical antennas spaced
1/2-wavelength apart and fed in phase?
A. Omnidirectional
B. A cardioid
C. A Figure-8 broadside to the axis of the array
D. A Figure-8 end-fire along the axis of the array
```

We can use the table again to find the right answer. In this case, the pattern is the figure-8 broadside of answer **C** which makes this the right choice. Answers B and D are for other configurations. The omnidirectional choice is not a good one as we indicated above.

```
E9C04 (B)
Which of the following describes a basic rhombic antenna?
A. Unidirectional; four-sided, each side one quarter-wavelength long;
      terminated in a resistance equal to its characteristic impedance
B. Bidirectional; four-sided, each side one or more wavelengths long; open at
      the end opposite the transmission line connection
C. Four-sided; an LC network at each corner except for the transmission
      connection;
D. Four-sided, each side of a different physical length
```

Here we have several questions about rhombic antennas. The correct description is given in answer **B** so that is the right choice. The terminated rhombic antenna will produce a unidirectional pattern but the length is one wavelength rather than 1/4 wavelength so answer A is not a good choice. A rhombic does not use LC circuitry so Answer C is not good choices either.

```
E9C05 (A)
What are the main advantages of a terminated rhombic antenna?
A. Wide frequency range, high gain and high front-to-back ratio
B. High front-to-back ratio, compact size and high gain
C. Unidirectional radiation pattern, high gain and compact size
D. Bidirectional radiation pattern, high gain and wide frequency range
```

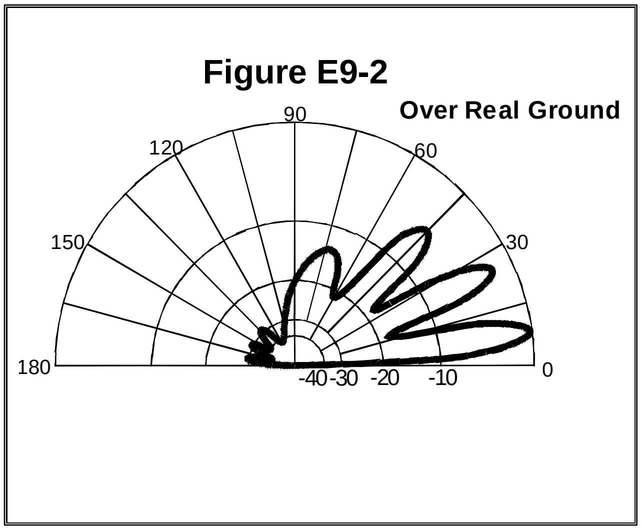
The choices here are a bit subtle. Having a high front-to-back ratio and a high gain are often advantageous to support radiating in a preferred direction or to prevent interference from off-axis sources. These are given in Answer **A** making it the right choice to answer the question. A rhombic does not necessarily have a compact size so answers B and C are not good choices.   Answer D is close but bidirectional is not always an advantage so answer A is a bit better choice than answer D.

```
E9C06 (C)
What are the disadvantages of a terminated rhombic antenna for the HF bands?
A. The antenna has a very narrow operating bandwidth
B. The antenna produces a circularly polarized signal
C. The antenna requires a large physical area and 4 separate supports
D. The antenna is more sensitive to man-made static than any other type
```

We just saw in the previous question that the rhombic has a wide frequency range which makes answer A an incorrect choice. We also saw in the previous question that the rhombic can have a high front back-to-back ratio which makes answers B an incorrect choice. Answer **C** lists two definite disadvantages so this is the correct choice for answering the question. An antenna cannot differentiate man-made static from natural static so Answer D is a bit silly.

```
E9C07 (B)
What is the effect of a terminating resistor on a rhombic antenna?
A. It reflects the standing waves on the antenna elements back to the
      transmitter
B. It changes the radiation pattern from bidirectional to unidirectional
C. It changes the radiation pattern from horizontal to vertical polarization
D. It decreases the ground loss
```

If answer A were true, it might damage the transmitter so this is not a good choice to answer the question. Answer **B** is the correct description so this is the right choice to answer the question. The resistor does not change the polarization state so answer C is not correct. Answer D is a silly distraction.



E9C08 (A)
What type of antenna pattern over real ground is shown in Figure E9-2?
A. Elevation
B. Azimuth
C. Radiation resistance
D. Polarization

Since this is one axis only and shows angles over one half the plane it is an elevation angle plot. This makes answer **A** the correct choice. If it were an azimuthal pattern, it would go around a full circle. One cannot obtain radiation resistance or polarization from the radiation pattern so Answers C and D cannot be a correct choice.

E9C09 (C)
What is the elevation angle of peak response in the antenna radiation pattern shown in Figure E9-2?
A. 45 degrees
B. 75 degrees
C. 7.5 degrees
D. 25 degrees

By looking at the pattern plot, we can see the largest lobe occurs at 7.5 degrees so that is the peak response. This makes answer **C** the correct choice to answer the question and the other choices are there to distract you.

E9C10 (B)
What is the front-to-back ratio of the radiation pattern shown in Figure E9-2?
A. 15 dB
B. 28 dB
C. 3 dB
D. 24 dB

The back lobes rise just above the -30 dB line and the maximum is at the 0 dB line. This will give a front-to-back ratio of 28 dB. This makes answer **B** the right choice. The other answers are to distract you.

E9C11 (A)
How many elevation lobes appear in the forward direction of the antenna radiation pattern shown in Figure E9-2?
A. 4
B. 3
C. 1
D. 7

The forward direction would be those lobes between 0 degrees and 90 degrees. The count is four so answer **A** is the right choice for this question. The others are incorrect counts.

E9C12 (D)
How is the far-field elevation pattern of a vertically polarized antenna affected by being mounted over seawater versus rocky ground?
A. The low-angle radiation decreases
B. The high-angle radiation increases
C. Both the high- and low-angle radiation decrease
D. The low-angle radiation increases

The seawater will have the effect of increasing the low-angle radiation so answer **D** is the right choice. Answer A is the opposite of the right answer so this is not a good choice. The other two choices are incorrect as well.

E9C13 (D)
When constructing a Beverage antenna, which of the following factors should be included in the design to achieve good performance at the desired frequency?
A. Its overall length must not exceed 1/4 wavelength
B. It must be mounted more than 1 wavelength above ground
C. It should be configured as a four-sided loop
D. It should be one or more wavelengths long

The correct rule of thumb for the Beverage antenna is greater than one wavelength in length so answer **D** is the correct choice. The other choices are not correct for this antenna type so they are incorrect answers.

E9C14 (B)
How would the electric field be oriented for a Yagi with three elements mounted parallel to the ground?
A. Vertically
B. Horizontally
C. Right-hand elliptically
D. Left-hand elliptically

This configuration produces horizontal polarization so answer **B** is the correct choice. The other choices are not produced in this configuration.

E9C15 (A)
What strongly affects the shape of the far-field, low-angle elevation pattern of a vertically polarized antenna?
A. The conductivity and dielectric constant of the soil in the area of the antenna
B. The radiation resistance of the antenna and matching network
C. The SWR on the transmission line
D. The transmitter output power

The biggest effect comes from the properties of the soil so answer **A** is the correct choice. The other factors deal more with the power delivered to the antenna and not the configuration of the radiation pattern so they are not good choices.

E9C16 (B)
What is an advantage of using an elevated-radial counterpoise with a vertical antenna?
A. It will reduce far-field ground losses when the antenna is operated over poor soil
B. It reduces near-field ground losses, compared to on-ground systems using more radials
C. It improves high-angle radiation when the antenna is used for path lengths under 500 miles
D. It lowers the radiation resistance of the system, making it more efficient

The correct answer is given in answer **B**. Since B is correct, answer D is incorrect. Answers A and C do not correctly describe the effect.

E9C17(C)
What is the main effect of placing a vertical antenna over an imperfect ground?
A. It causes increased SWR
B. It changes the impedance angle of the matching network
C. It reduces low-angle radiation
D. It reduces losses in the radiating portion of the antenna

If you go back to question E9C15, you will see that ground characteristics affect the low-angle radiation pattern. Given this, you should be able to spot Answer **C** as the correct choice for this question. The ground soil characteristics do not affect SWR so Answer A is not a good choice.

E9D01 (C)
How does the gain of a parabolic dish antenna change when the operating frequency is doubled?
A. Gain does not change
B. Gain is multiplied by 0.707
C. Gain increases 6 dB
D. Gain increases 3 dB

For a parabolic dish, the gain is proportional to the square of the frequency so if we double the frequency, we will raise the gain by a factor of four. In dB units, a factor of 4 is a gain of 6 dB. This makes answer **C** the correct choice for this question. Answer A is wrong. Answer B is dividing by the square root of 2 and not multiplying by 4 so it is also incorrect. Answer D is a change in gain by a factor of 2 and not a factor of 4 so it is also incorrect.

E9D02 (C)
What is one way to produce circular polarization when using linearly polarized antennas?
A. Stack two Yagis, fed 90 degrees out of phase, to form an array with the respective elements in parallel planes
B. Stack two Yagis, fed in phase, to form an array with the respective elements in parallel planes
C. Arrange two Yagis perpendicular to each other with the driven elements at the same point on the boom and fed 90 degrees out of phase
D. Arrange two Yagis collinear to each other, with the driven elements fed 180 degrees out of phase

Answer **C** has the correct configuration for making circular polarization with two Yagi antennas. The photo shows what the configuration looks like. Be careful with answer D because it looks similar to the right one but it has the wrong phase for the feed. The other two choices are silly configurations to distract you.

```
E9D03 (D)
How does the beamwidth of an antenna vary as the gain is increased?
A. It increases geometrically
B. It increases arithmetically
C. It is essentially unaffected
D. It decreases
```

The higher the gain, the more concentrated the antenna pattern. Therefore, the beamwidth will also decrease with an increasing gain. This makes answer **D** the correct choice to answer the question. Since answer D is correct, answer C cannot be true. Answers A and B are incorrect because the beamwidth scales with the square root of the gain and not geometrically or arithmetically.

```
E9D04 (A)
Why is it desirable for a ground-mounted satellite communications antenna
system to be able to move in both azimuth and elevation?
A. In order to track the satellite as it orbits the earth
B. So the antenna can be pointed away from interfering signals
C. So the antenna can be positioned to cancel the effects of Faraday rotation
D. To rotate antenna polarization to match that of the satellite
```

The azimuth and elevation movements allow the user to track the satellite as it moves in its orbit so Answer **A** is the right choice. In the figure on Question E9D02, the azimuth motor is in the four-legged stand that the antenna sits on. The elevation motor is attached to the cross bar between the antennas. Answer B is generally good but there is no guarantee that it will then point at the satellite so that is not a good choice. To cancel Faraday rotation, you generally rotate the antenna feed and not change the pointing so this is not a proper selection. If you use a circular Yagi, then you will not need to worry about the polarization changes.

E9D05 (A)
For a shortened vertical antenna, where should a loading coil be placed to minimize losses and produce the most effective performance?
A. Near the center of the vertical radiator
B. As low as possible on the vertical radiator
C. As close to the transmitter as possible
D. At a voltage node

The best place is near the center so answer **A** is the best choice to answer this question. Answer D is a silly distraction so it can be eliminated from consideration. Answers B and C will not work as well as answer A so they are not the correct answers.

E9D06 (C)
Why should an HF mobile antenna loading coil have a high ratio of reactance to resistance?
A. To swamp out harmonics
B. To maximize losses
C. To minimize losses
D. To minimize the Q

Without knowing much about antennas, you might guess that minimizing loss as in answer **C** would be a good pick and you would be correct. Usually maximizing loss is not a good idea so answer B is eliminated. Having a small Q is also not typically desired so answer D is not a good choice. Answer A is not necessarily true.

E9D07 (A)
What is a disadvantage of using a multiband trapped antenna?
A. It might radiate harmonics
B. It can only be used for single-band operation
C. It is too sharply directional at lower frequencies
D. It must be neutralized

A trap will radiate harmonics so answer **A** is the best choice among those given to answer this question. Answers B, C, and D are not true for traps so they are not correct choices to answer the question.

E9D08 (B)
What happens to the bandwidth of an antenna as it is shortened through the use of loading coils?
A. It is increased
B. It is decreased
C. No change occurs
D. It becomes flat

The bandwidth will decrease if loading coils are attached so answer **B** is the correct choice. Answer A is the opposite of the correct answer. Answer C is wrong since answer B is correct. Answer D is not as good an answer as B.

E9D09 (D)
What is an advantage of using top loading in a shortened HF vertical antenna?
A. Lower Q
B. Greater structural strength
C. Higher losses
D. Improved radiation efficiency

By looking at the choices, one would hope that answer **D** is the correct answer and it is. Answer C is not a good effect if it were true. Answer B is physically not true. Answer A is also not true.

E9D10 (A)
What is the approximate feed-point impedance at the center of a folded dipole antenna?
A. 300 ohms
B. 72 ohms
C. 50 ohms
D. 450 ohms

This is probably one of those questions whose answer you will need to memorize. The correct answer is 300 ohms so answer **A** is the choice to make. The other answers are to distract you.

E9D11 (D)
Why is a loading coil often used with an HF mobile antenna?
A. To improve reception
B. To lower the losses
C. To lower the Q
D. To cancel capacitive reactance

A coil is inductive so it can offset capacitive reactance and answer **D** is the right choice to answer this question. Answers A and B are consequences of balancing the capacitive reactance so they are not as good a choice as answer D. Answer C is just to distract you.

E9D12 (D)
What is an advantage of using a trapped antenna?
A. It has high directivity in the higher-frequency bands
B. It has high gain
C. It minimizes harmonic radiation
D. It may be used for multi-band operation

Electrically, answer A is incorrect. Answer B is not true so this is not a good choice. Answer C is also incorrect. Answer **D** is correct so this is the correct choice to answer this question.

E9D13 (B)
What happens at the base feed-point of a fixed-length HF mobile antenna as the frequency of operation is lowered?
A. The resistance decreases and the capacitive reactance decreases
B. The resistance decreases and the capacitive reactance increases
C. The resistance increases and the capacitive reactance decreases
D. The resistance increases and the capacitive reactance increases

Answer **B** contains the correct description of what happens electrically so this is the answer to choose for this question. The other three answers are permutations to distract you.

E9D14(B)
Which of the following types of conductor would be best for minimizing losses in a station's RF ground system?
A. A resistive wire, such as a spark-plug wire
B. A thin, flat copper strap several inches wide
C. A cable with 6 or 7 18-gauge conductors in parallel
D. A single 12 or 10 gauge stainless steel wire

For a RF ground, you generally do not want a resistive wire so Answer A can be eliminated. A 10 gauge wire might not have sufficient current carrying capacity so Answers C and D are not good choices. A flat copper strap as listed in Answer **B** will have the necessary current carrying capacity and minimal loss so this is the best choice among those given.

E9D15 (C)
Which of these choices would provide the best RF ground for your station?
A. A 50-ohm resistor connected to ground
B. A connection to a metal water pipe
C. A connection to 3 or 4 interconnected ground rods driven into the Earth
D. A connection to 3 or 4 interconnected ground rods via a series RF choke

A good ground system will have a firm, guaranteed, direct connection to earth ground. The way to guarantee this is with ground rods directly driven into the earth as given in Answer **C**. Resistors and chokes are not enhancers to this method so Answers A and D are not good choices. The water pipe is frequently mentioned but it is not to be preferred over a direct ground rod system.

E9E01 (B)
What system matches a high-impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center?
A. The gamma matching system
B. The delta matching system
C. The omega matching system
D. The stub matching system

This is the description of a delta match network so answer **B** is the correct choice to answer this question. A gamma match is for an unbalanced feed line so answer A is incorrect. A stub is a short section of transmission line so answer D is incorrect. The omega match is a distraction for you so answer C is eliminated from consideration.

E9E02 (A)
What is the name of an antenna matching system that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center?
A. The gamma match
B. The delta match
C. The omega match
D. The stub match

This is the description of the gamma match so answer **A** is the correct choice. The delta match is for high-impedance lines so answer B is incorrect. A stub is a short section of transmission line so answer D is incorrect. The omega match is a distraction for you so answer C is eliminated from consideration.

E9E03 (D)
What is the name of the matching system that uses a short perpendicular section of transmission line connected to the feed line near the antenna?
A. The gamma match
B. The delta match
C. The omega match
D. The stub match

This is a description of the stub matching network so answer **D** is the correct choice. A gamma match is for an unbalanced feed line so answer A is incorrect. The delta match is for high-impedance lines so answer B is incorrect. The omega match is a distraction for you so answer C is eliminated from consideration.

E90E04 (B)
What is the purpose of the series capacitor in a gamma-type antenna matching network?
A. To provide DC isolation between the feed-line and the antenna
B. To compensate for the inductive reactance of the matching network
C. To provide a rejection notch to prevent the radiation of harmonics
D. To transform the antenna impedance to a higher value

Electrically, a capacitor is used to cancel out inductive reactance in a matching network so Answer **B** is the proper choice to answer this question.

E9E05 (A)
How must the driven element in a 3-element Yagi be tuned to use a hairpin matching system?
A. The driven element reactance must be capacitive
B. The driven element reactance must be inductive
C. The driven element resonance must be lower than the operating frequency
D. The driven element radiation resistance must be higher than the characteristic impedance of the transmission line

For this type of match to work, the Yagi must be tuned so it has capacitive reactance so answer **A** is the right choice. Answer B is incorrect because the reactance is inductive rather than capacitive. Answer C and D are distractions.

E9E06 (C)
What is the equivalent lumped-constant network for a hairpin matching system on a 3-element Yagi?
A. Pi network
B. Pi-L network
C. L network
D. Parallel-resonant tank

The hairpin match is an inductive network (to cancel the capacitive feed we had earlier) so answer **C** is the best choice among those given. It is not a form of Pi network so answers A and B are incorrect. Answer D is also not the correct description so it is not a correct choice.

E9E07 (B)
What parameter best describes the interactions at the load end of a mismatched transmission line?
A. Characteristic impedance
B. Reflection coefficient
C. Velocity factor
D. Dielectric Constant

The mismatched line will have reflections at the end so the reflection coefficient makes the best description of what is happening electrically. Answer **B** is then the right choice to answer this question. The other choices are variables to characterize the transmission line as a whole but they will not directly tell you what the reflections are so they are not good choices to answer the questions.

```
E9E08 (D)
Which of the following measurements describes a mismatched transmission line?
A. An SWR less than 1:1
B. A reflection coefficient greater than 1
C. A dielectric constant greater than 1
D. An SWR greater than 1:1
```

If there is a mismatch, the SWR will be greater than 1:1 so answer **D** is the right choice for the answer to this question. A SWR less than 1:1 is not possible so answer A is not a good choice. The other two answers are to distract you.

```
E9E09 (C)
Which of these matching systems is an effective method of connecting a 50-ohm
coaxial cable feed-line to a grounded tower so it can be used as a vertical
antenna?
A. Double-bazooka match
B. Hairpin match
C. Gamma match
D. All of these answers are correct
```

This is an operational-experience type of question. For this case, you need to remember that the gamma match of Answer **C** is the right choice. `LOOK UP REASON WHY`

```
E9E10 (C)
Which of these choices is an effective way to match an antenna with a 100-ohm
terminal impedance to a 50-ohm coaxial cable feed-line?
A. Connect a 1/4-wavelength open stub of 300-ohm twin-lead in parallel with
      the coaxial feed-line where it connects to the antenna
B. Insert a 1/2 wavelength piece of 300-ohm twin-lead in series between the
      antenna terminals and the 50-ohm feed cable
C. Insert a 1/4-wavelength piece of 75-ohm coaxial cable transmission line in
      series between the antenna terminals and the 50-ohm feed cable
D. Connect 1/2 wavelength shorted stub of 75-ohm cable in parallel with the
      50-ohm cable where it attaches to the antenna
```

Here we have a 2:1 SWR problem so we will need a matching network that splits the difference and goes between the antenna and the feed line. With this in mind, we would want something with a 75 Ω impedance which means we can eliminate Answers A and B. When making this kind of match, we want the network in series between the antenna and the feed lin and not in parallel. This makes Answer **C** the correct choice.

```
E9E11 (B)
What is an effective way of matching a feed-line to a VHF or UHF antenna when
the impedances of both the antenna and feed-line are unknown?
A. Use a 50-ohm 1:1 balun between the antenna and feed-line
B. Use the "universal stub" matching technique
C. Connect a series-resonant LC network across the antenna feed terminals
D. Connect a parallel-resonant LC network across the antenna feed terminals
```

To properly use the matches in Answers A, C, and D, we need to know the electrical characteristics of the antenna and the feed line so these are not good choices. The best choice is the “magic” of the “universal stub” technique as in Answer B.

```
E9E12 (A)
What is the primary purpose of a "phasing line" when used with an antenna
having multiple driven elements?
A. It ensures that each driven element operates in concert with the others to
      create the desired antenna pattern
B. It prevents reflected power from traveling back down the feed-line and
      causing harmonic radiation from the transmitter
C. It allows single-band antennas to operate on other bands
D. It makes sure the antenna has a low-angle radiation pattern
```

When an antenna system has multiple driven elements, these elements must have the proper phase relationship between them to make the desired antenna pattern. The use of a phase line allows the individual elements to have the proper phase relationship between the elements to allow the pattern to take the desired shape. Answer **A** captures this reasoning.

```
E9E13 (C)
What is the purpose of a "Wilkinson divider"?
A. It divides the operating frequency of a transmitter signal so it can be
      used on a lower frequency band
B. It is used to feed high-impedance antennas from a low-impedance source
C. It divides power equally among multiple loads while preventing changes in
      one load from disturbing power flow to the others
D. It is used to feed low-impedance loads from a high-impedance source
```

The Wilkinson divider is a device that can be used as either a RF power splitter or a RF power combiner. As a power splitter, the output ports are isolated from each other so changes at one do not affect the others as indicated in Answer **C**.

```
E9F01 (D)
What is the velocity factor of a transmission line?
A. The ratio of the characteristic impedance of the line to the terminating
      impedance
B. The index of shielding for coaxial cable
C. The velocity of the wave in the transmission line multiplied by the
      velocity of light in a vacuum
D. The velocity of the wave in the transmission line divided by the velocity
      of light in a vacuum
```

The velocity factor divides the transmission speed in the line to that of free space so answer **D** is the correct choice to answer this question. Answer C is incorrect because it has multiple instead of divide. Answers A and B are intended to distract you.

E9F02 (C)
What determines the velocity factor in a transmission line?
A. The termination impedance
B. The line length
C. Dielectric materials used in the line
D. The center conductor resistivity

The line dielectrics determine the velocity factor so answer **C** is the correct choice. The other factors do not determine the velocity factor so they are there to distract you.

E9F03 (D)
Why is the physical length of a coaxial cable transmission line shorter than its electrical length?
A. Skin effect is less pronounced in the coaxial cable
B. The characteristic impedance is higher in a parallel feed line
C. The surge impedance is higher in a parallel feed line
D. Electrical signals move more slowly in a coaxial cable than in air

Electrically, the only statement that is true is answer **D** because the electromagnetic radiation moves slower in the line than free space. The other statements are untrue and are there to distract you.

E9F04 (B)
What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?
A. 2.70
B. 0.66
C. 0.30
D. 0.10

Answer A would cause your transmission line to glow blue because the waves would be exceeding the local speed of light so this is incorrect because it would imply a faster velocity. Answer **B** is the correct response so this is the right choice. Answers C and D are not typical velocity factors so they are there to distract you.

E9F05 (C) (was E9E10)
What is the physical length of a coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz? (Assume a velocity factor of 0.66.)
A. 20 meters
B. 2.3 meters
C. 3.5 meters
D. 0.2 meters

Answer A is incorrect because that is approximately the free space electrical wavelength. The 14.1 MHz frequency corresponds to a free-space wavelength of 21.3 meter. Since we wish to have a 1/4 wave line, the free-space length would be 5.3 meters. This is multiplied by the velocity factor to give 3.5 meters. This makes answer **C** the correct choice. Answers B and D are to distract you.

E9F06 (C)
What is the physical length of a parallel conductor feed line that is electrically one-half wavelength long at 14.10 MHz? (Assume a velocity factor of 0.95.)
A. 15 meters
B. 20 meters
C. 10 meters
D. 71 meters

Here we apply the same analysis as the previous question. The free-space wavelength is 21.3 meters. We desire a ½ wavelength line which would have a free-space length of 10.6 meters. This is multiplied by the velocity factor to give 10 meters. This makes answer **C** the right choice and the others just distractions for you.

E9F07 (A)
What characteristic will 450-ohm ladder line have at 50 MHz, as compared to 0.195-inch-diameter coaxial cable (such as RG-58)?
A. Lower loss
B. Higher SWR
C. Smaller reflection coefficient
D. Lower velocity factor

The ladder line will have a higher velocity factor than the co-ax so answer D is incorrect. The reflection coefficient is not a characteristic of the line so answers B and C are not correct choices. Answer **A** is a correct statement so this is the right choice to answer the question.

E9F08 (A)
What is the term for the ratio of the actual speed at which a signal travels through a transmission line to the speed of light in a vacuum?
A. Velocity factor
B. Characteristic impedance
C. Surge impedance
D. Standing wave ratio

From the previous questions, you should be able to recognize velocity factor, as in answer **A**, as the correct response for this question. The impedance is not described by wave velocity so answer B is not a correct choice. Answer C is to distract you. Answer D is not an intrinsic property of the line but how it reacts in a network so this is not a correct choice.

E9F09 (B)
What would be the physical length of a typical coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz? (Assume a velocity factor of 0.66)
A. 10 meters
B. 6.9 meters
C. 24 meters
D. 50 meters

Back to electrical wavelengths. The free-space wavelength is 41.6 meters. We desire a 1/4 wavelength line which would have a free-space length of 10.4 meters. This is multiplied by the velocity factor to give 6.9 meters. This makes answer **B** the right choice and the others just distractions for you.

E9F10 (C)
What kind of impedance does a 1/8-wavelength transmission line present to a generator when the line is shorted at the far end?
A. A capacitive reactance
B. The same as the characteristic impedance of the line
C. An inductive reactance
D. The same as the input impedance to the final generator stage

Here we have a series of questions with various line lengths and terminations. The following table gives a guide for how the lines operate under the various conditions.

Wavelength	Termination	Impedance
1/8 wavelength	shorted	inductive
1/8 wavelength	open	capacitive
1/4 wavelength	shorted	very high impedance
1/4 wavelength	open	very low impedance
½ wavelength	shorted	very low impedance
½ wavelength	open	very high impedance

From the table, we see that answer **C** is the right choice.

E9F11 (C)
What kind of impedance does a 1/8-wavelength transmission line present to a generator when the line is open at the far end?
A. The same as the characteristic impedance of the line
B. An inductive reactance
C. A capacitive reactance
D. The same as the input impedance of the final generator stage

From the table, we can see that the correct answer for this configuration is capacitive so answer **C** is the right choice.

E9F12 (B)
What kind of impedance does a 1/4-wavelength transmission line present to a generator when the line is open at the far end?
A. A very high impedance
B. A very low impedance
C. The same as the characteristic impedance of the line
D. The same as the input impedance to the final generator stage

From the table, we can see that the correct answer for this configuration is a very low impedance so answer **B** is the right choice.

```
E9F13 (A)
What kind of impedance does a 1/4-wavelength transmission line present to a
generator when the line is shorted at the far end?
A. A very high impedance
B. A very low impedance
C. The same as the characteristic impedance of the transmission line
D. The same as the generator output impedance
```

From the table, we can see that the correct answer for this configuration is a very high impedance so answer **A** is the right choice.

```
E9F14 (B)
What kind of impedance does a 1/2-wavelength transmission line present to a
generator when the line is shorted at the far end?
A. A very high impedance
B. A very low impedance
C. The same as the characteristic impedance of the line
D. The same as the output impedance of the generator
```

From the table, we can see that the correct answer for this configuration is a very low impedance so answer **B** is the right choice.

```
E9F15 (A)
What kind of impedance does a 1/2-wavelength transmission line present to a
generator when the line is open at the far end?
A. A very high impedance
B. A very low impedance
C. The same as the characteristic impedance of the line
D. The same as the output impedance of the generator
```

From the table, we can see that the correct answer for this configuration is a very high impedance so answer **A** is the right choice.

```
E9F16 (D)
What is the primary difference between foam-dielectric coaxial cable as
opposed to solid-dielectric cable, assuming all other parameters are the same?
A. Reduced safe operating voltage limits
B. Reduced losses per unit of length
C. Higher velocity factor
D. All of these answers are correct
```

Each of the statements in Answers A, B, and C is correct so Answer **D** is the right choice.

```
E9G01 (A)
Which of the following can be calculated using a Smith chart?
A. Impedance along transmission lines
B. Radiation resistance
C. Antenna radiation pattern
D. Radio propagation
```

Since a Smith chart is used to plot impedances. From this we can obtain the antenna radiation pattern so the correct answer is **C**.

E9G02 (B)
What type of coordinate system is used in a Smith chart?
A. Voltage circles and current arcs
B. Resistance circles and reactance arcs
C. Voltage lines and current chords
D. Resistance lines and reactance chords

The mnemonic for this question is R & R: resistance and reactance so answer **B** is the correct choice to answer the question. The other choices are to see if you know what a Smith chart is. Be careful with answer D because it has R & R but the resistance is on a circle and reactance is on an arc and not lines and chords.

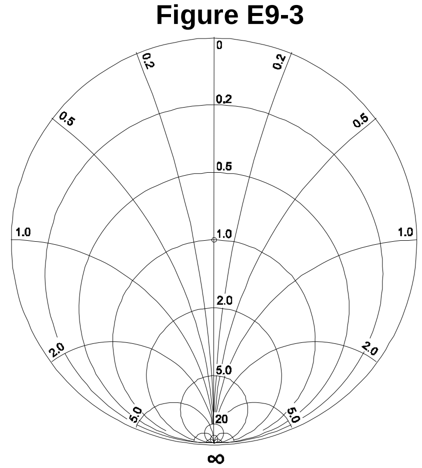
E9G03 (C)
Which of the following is often determined using a Smith chart?
A. Beam headings and radiation patterns
B. Satellite azimuth and elevation bearings
C. Impedance and SWR values in transmission lines
D. Trigonometric functions

Since a Smith chart is used to plot impedances, the correct answer is **C**. Answers A and B have different types of charts to plot that information. Circuit gain is typically plotted on log-log paper and not a Smith chart.

E9G04 (C)
What are the two families of circles and arcs that make up a Smith chart?
A. Resistance and voltage
B. Reactance and voltage
C. Resistance and reactance
D. Voltage and impedance

Since the Smith chart is related to impedances, the correct answer is **C** because that is the one dealing with resistance and reactance. The other choices all contain voltage which is incorrect for a Smith chart making these choices incorrect.

Figure E9-3



E9G05 (A)
What type of chart is shown in Figure E9-3?
A. Smith chart
B. Free-space radiation directivity chart
C. Elevation angle radiation pattern chart
D. Azimuth angle radiation pattern chart

The correct answer is **A** because this is a Smith chart. The other choices deal with antenna patterns so these are not correct choices because a Smith chart is not used to plot antenna patterns.

```
E9G06 (B)
On the Smith chart shown in Figure E9-3, what is the name for the large outer
circle on which the reactance arcs terminate?
A. Prime axis
B. Reactance axis
C. Impedance axis
D. Polar axis
```

If you noticed that the former questions always dealt with resistance and reactance, then you should be able to spot answer **B** as the right choice because that one has reactance. Be careful with answer C since we say that a Smith chart is generally used for impedance plotting but that is not the right term here.

```
E9G07 (D)
On the Smith chart shown in Figure E9-3, what is the only straight line shown?
A. The reactance axis
B. The current axis
C. The voltage axis
D. The resistance axis
```

If the last question asked about the reactance axis, then it should not surprise you to find that this question asks about the resistance axis and answer **D** is the correct choice. Answer A was for the previous question so be careful here. Since currents and voltages are not directly plotted on a Smith chart, answers B and C cannot be correct.

```
E9G08 (C)
What is the process of normalization with regard to a Smith chart?
A. Reassigning resistance values with regard to the reactance axis
B. Reassigning reactance values with regard to the resistance axis
C. Reassigning impedance values with regard to the prime center
D. Reassigning prime center with regard to the reactance axis
```

The correct definition is given in answer **C** because the prime center is the value used to normalize the other values. The other actions suggested by the other answers are not correct and hard to perform since the axis goes from zero to infinity.

```
E9G09 (A)
What third family of circles is often added to a Smith chart during the
process of solving problems?
A. Standing-wave ratio circles
B. Antenna-length circles
C. Coaxial-length circles
D. Radiation-pattern circles
```

The correct answer is **A** since the standing wave ratio will give a measure of impedance mismatch. As we have mentioned, the Smith chart is not an antenna output chart so answers B and D can be eliminated. Coaxial cables can have their characteristics plotted on a Smith but they do not form circles except in how they are wound up.

```
E9G10 (D)
What do the arcs on a Smith chart represent?
A. Frequency
B. SWR
C. Points with constant resistance
D. Points with constant reactance
```

As we saw above, the arcs are reactance arcs so we should be able to spot the correct choice in Answer **D**: constant reactance.

E9G11 (B)
How are the wavelength scales on a Smith chart calibrated?
A. In fractions of transmission line electrical frequency
B. In fractions of transmission line electrical wavelength
C. In fractions of antenna electrical wavelength
D. In fractions of antenna electrical frequency

The Smith chart is calibrated in terms of the electrical wavelength so be sure to choose Answer **B** for this question.

E9H01 (D)
What is the effective radiated power of a repeater station with 150 watts transmitter power output, 2-dB feed line loss, 2.2-dB duplexer loss and 7-dBd antenna gain?
A. 1977 watts
B. 78.7 watts
C. 420 watts
D. 286 watts

Working in dB units makes the computation easier. The net gain between the transmitter and the antenna output is G = -2 - 2.2 + 7 = 2.80 dB. This represents a loss of G = $10^{(0.1*2.8)}$ = 1.91. The radiated power is P = 150 W x 1.91 = 286 W. This makes the correct answer **D**.

E9H02 (A)
What is the effective radiated power of a repeater station with 200 watts transmitter power output, 4-dB feed line loss, 3.2-dB duplexer loss, 0.8-dB circulator loss and 10-dBd antenna gain?
A. 317 watts
B. 2000 watts
C. 126 watts
D. 300 watts

The net gain between the transmitter and the antenna output is G = -4 -3.2 -0.8 + 10 = 2 dB. The gain is G = 10 (0.1*2) = 1.58. The radiated power is P = 200 W x 1.58 = 317 W. This makes the correct answer **A**. Answer C represents a 2-dB loss and not a 2-dB gain. The other choices are distractions.

E9H03 (B)
What is the effective radiated power of a repeater station with 200 watts transmitter power output, 2-dB feed line loss, 2.8-dB duplexer loss, 1.2-dB circulator loss and 7-dBd antenna gain?
A. 159 watts
B. 252 watts
C. 632 watts
D. 63.2 watts

The net gain between the transmitter and the antenna output is G = -2 -2.8 -1.2 + 7 = 1 dB. The gain is G = 10 (0.1*1) = 1.26. The radiated power is P = 200 W x 1.26 = 252 W. This makes the correct answer **B**. Answer A represents a 1-dB loss and not a 1-dB gain. The other choices are distractions.

```
E9H04 (C)
What term describes station output (including the transmitter, antenna and
everything in between), when considering transmitter power and system gains
and losses?
A. Power factor
B. Half-power bandwidth
C. Effective radiated power
D. Apparent power
```

This question is asking for the definition of effective radiated power so answer **C** is the correct choice. The power factor in answer A is the phase angle between the voltage and the current so this is incorrect. The half-power bandwidth in answer B is bandwidth of a circuit so this is also incorrect. The apparent power in answer D is the product of the RMS current and voltage so this is also incorrect.

```
E9H05 (A)
What is the main drawback of a wire-loop antenna for direction finding?
A. It has a bidirectional pattern
B. It is non-rotatable
C. It receives equally well in all directions
D. It is practical for use only on VHF bands
```

Answer **A** has the correct reason for not using a wire-loop antenna; the pattern will not uniquely identify the direction. Answer B is incorrect so it can be eliminated. Answer C is not correct because it does not receive equally well - just in multiple directions. Answer D is also incorrect. Loops can be designed for higher frequencies.

```
E9H06 (C)
What is the triangulation method of direction finding?
A. The geometric angle of sky waves from the source are used to determine its
      position
B. A fixed receiving station plots three headings from the signal source on a
      map
C. Antenna headings from several different receiving stations are used to
      locate the signal source
D. A fixed receiving station uses three different antennas to plot the
      location of the signal source
```

To perform triangulation, one combines measurements from several diverse physical locations to isolate the transmitter location so answer **C** is the best choice among those given for this question. Answer A would require very expensive and highly-directional antennas, not generally available to amateurs. Answer B, as stated, might not really work since it probably has just one antenna so multiple path directions will not be discovered. Answer D is not as good a choice as answer C, as stated, because the antennas would need to be widely separated to have sufficient resolution.

```
E9H07 (D)
Why is an RF attenuator desirable in a receiver used for direction finding?
A. It narrows the bandwidth of the received signal
B. It eliminates the effects of isotropic radiation
C. It reduces loss of received signals caused by antenna pattern nulls
D. It prevents receiver overload from extremely strong signals
```

If you think about it, the receiver in the “fox hunt” will need to work with signals over a large power range as the hunter gets closer to the fox. Since the receiver has a limited reception signal range, an attenuator makes a convenient helper in extending the dynamic range of the receiver by attenuating signals from a nearby fox. This makes answer **D** the best choice for the right answer. An attenuator will not change the receiver bandwidth so answer A is not a good choice. Answer B does not make any technical sense so it is not a good choice either. Since attenuators will not overcome signal loss due to antenna pattern nulls, answer C is technically incorrect as well.

```
E9H08 (A)
What is the function of a sense antenna?
A. It modifies the pattern of a DF antenna array to provide a null in one
      direction
B. It increases the sensitivity of a DF antenna array
C. It allows DF antennas to receive signals at different vertical angles
D. It provides diversity reception that cancels multipath signals
```

If a DF antenna can receive a signal from all directions, it is hard to isolate which direct to concentrate on. If you can produce a null in a specific direction then that null can be used to isolate the direction to the source. A sense antenna provides this null in the DF antenna pattern. This makes Answer **A** the correct choice.

```
E9H09 (C)
What is a receiving loop antenna?
A. A large circularly-polarized antenna
B. A small coil of wire tightly wound around a toroidal ferrite core
C. One or more turns of wire wound in the shape of a large open coil
D. Any antenna coupled to a feed line through an inductive loop of wire
```

This question is another one that is as simple as it looks. Answer **C** is the correct description of the loop antenna. Circular polarization is generally created by the antenna feed and not the antenna so answer A is not a good choice. Answer B corresponds to an inductor of some type so this would not make a good antenna. Answer D is not correct.

```
E9H10 (D)
How can the output voltage of a receiving loop antenna be increased?
A. By reducing the permeability of the loop shield
B. By increasing the number of wire turns in the loop and reducing the area of
      the loop structure
C. By reducing either the number of wire turns in the loop or the area of the
      loop structure
D. By increasing either the number of wire turns in the loop or the area of
      the loop structure
```

The strength of the signal coming from a loop antenna is proportional to the area of the antenna and the number of turns - the voltage increases as both of these parameters increase. From this trend, we can see that answers B and C work opposite to the trend on at least one measure so they are not good choices for the answer to this question. Answer **D** has the increasing parameters both going in the right direction so this is the correct choice. Answer A is technobabble so it is not a good choice.

```
E9H11 (B)
Why is an antenna with a cardioid pattern desirable for a direction-finding
system?
A. The broad-side responses of the cardioid pattern can be aimed at the
      desired station
B. The response characteristics of the cardioid pattern can assist in
      determining the direction of the desired station
C. The extra side lobes in the cardioid pattern can pinpoint the direction of
      the desired station
D. The high-radiation angle of the cardioid pattern is useful for
      short-distance direction finding
```

An antenna with either a sharp peak or a sharp null is good for direction finding because the peak or null can be used to “point” to the RF source. Broad responses such as those in answer A are not good for direction finding because they are not directionally sensitive. Answer **B** has the correct justification for using a cardioid pattern so this is the best choice for this question. Answer C is not a good choice because a cardioid pattern does not have a sharp peak. Answer D is also not a good choice because a cardioid pattern does not have a high take-off angle.

```
E9H12 (B)
What is an advantage of using a shielded loop antenna for direction finding?
A. It automatically cancels ignition noise pickup in mobile installations
B. It is electro-statically balanced with against ground, giving better nulls
C. It eliminates tracking errors caused by strong out-of-band signals
D. It allows stations to communicate without giving away their position
```

As we have seen, having nulls in the DF antenna pattern is an important characteristic. Answer **B** captures this characteristic so it is the best choice among those given here.

Subelement E0 -- Safety

E0A01 (C)
What, if any, are the differences between the radiation produced by radioactive materials and the electromagnetic energy radiated by an antenna?
A. There is no significant difference between the two types of radiation
B. Only radiation produced by radioactivity can injure human beings
C. RF radiation does not have sufficient energy to break apart atoms and molecules; radiation from radioactive sources does
D. Radiation from an antenna will damage unexposed photographic film, ordinary radioactive materials do not cause this problem

Antenna radiation is much lower in energy than the radiation produces by radioactive sources. Radioactive sources produce radiation that can break apart atoms and molecules so Answer **C** is the correct choice to choose for this question. The statements in Answers A, B, and D are untrue.

E0A02 (B)
When evaluating exposure levels from your station at a neighbor's home, what must you do?
A. Make sure signals from your station are less than the controlled MPE limits
B. Make sure signals from your station are less than the uncontrolled MPE limits
C. Nothing; you need only evaluate exposure levels on your own property
D. Advise your neighbors of the results of your tests

Amateur best practice says that you should make sure that the signals from your station are lower than the uncontrolled MPE limits as given in Answer **B**.

E0A03 (D)
Which of the following would be a practical way to estimate whether the RF fields produced by an amateur radio station are within permissible MPE limits?
A. Use a calibrated antenna analyzer
B. Use a hand calculator plus Smith-chart equations to calculate the fields
C. Walk around under the antennas with a neon-lamp probe to find the strongest fields
D. Use a computer-based antenna modeling program to calculate field strength at accessible locations

To find out the RF levels, you need to know (or estimate) the field strength. Of the choices given, the computer modeling method is the best choices so Answer **D** is the correct answer.

E0A04 (C)
When evaluating a site with multiple transmitters operating at the same time, the operators and licensees of which transmitters are responsible for mitigating over-exposure situations?
A. Only the most powerful transmitter
B. Only commercial transmitters
C. Each transmitter that produces 5% or more of its maximum permissible exposure limit at accessible locations
D. Each transmitter operating with a duty-cycle greater than 50%

While we learned in the Technician Class that by good engineering practice, all transmitters should be involved in site evaluation. However, this question address the minimal legal requirements for site evaluation under OET

Bulletin 65. The formulation for the *minimum* requirements for the multiple station evaluation are given in Answer **C** so this is the best choice to answer this question. .

```
E0A05 (B)
What is one of the potential hazards of using microwaves in the amateur radio
bands?
A. Microwaves are ionizing radiation
B. The high gain antennas commonly used can result in high exposure levels
C. Microwaves often travel long distances by ionospheric reflection
D. The extremely high frequency energy can damage the joints of antenna
      structures
```

Each of the statements made in Answers A, C, and D are untrue. Microwaves can result in high exposure levels when combined with high gain antennas so Answer **B** is the right choice.

```
E0A06 (D)
Why are there separate electric (E) and magnetic (H) field MPE limits?
A. The body reacts to electromagnetic radiation from both the E and H fields
B. Ground reflections and scattering make the field impedance vary with
      location
C. E field and H field radiation intensity peaks can occur at different
      locations
D. All of these answers are correct
```

Each of the statements in Answers A, B, and C are correct so Answer **D** is the best choice.

```
E0A07 (D)
What is the "far-field" zone of an antenna?
A. The area of the ionosphere where radiated power is not refracted
B. The area where radiated power dissipates over a specified time period
C. The area where radiated field strengths are obstructed by objects of
      reflection
D. The area where the shape of the antenna pattern is independent of distance
```

The far-field zone is where the antenna pattern shape has stabilized and is now independent of distance as listed in Answer **D**.

```
E0A08 (C)
What does SAR measure?
A. Synthetic Aperture Ratio of the human body
B. Signal Amplification Rating
C. The rate at which RF energy is absorbed by the body
D. The rate of RF energy reflected from stationary terrain
```

The SAR is the rate at which radiation is absorbed by the body so Answer **C** is the right choice.

```
E0A09 (C)
Which insulating material commonly used as a thermal conductor for some types
of electronic devices is extremely toxic if broken or crushed and the
particles are accidentally inhaled?
A. Mica
B. Zinc oxide
C. Beryllium Oxide
D. Uranium Hexaflouride
```

This is probably one of those answers that you will need to memorize. The zinc oxide of Answer **C** is the correct choice. Answer D would be a bad choice because it would introduce a radioactive source to the problem.

```
E0A10 (A)
What material found in some electronic components such as high-voltage
capacitors and transformers is considered toxic?
A. Polychlorinated biphenyls
B. Polyethylene
C. Polytetrafluroethylene
D. Polymorphic silicon
```

The polychlorinated biphenyls in Answer **A** is the correct answer in case you did not catch this term in news stories over the past few years. Answer B is the material used in garbage bags. Answer C is teflon.

```
E0A11 (C)
Which of these items might be a significant hazard when operating a klystron
or cavity magnetron transmitter?
A. Hearing loss caused by high voltage corona discharge
B. Blood clotting from the intense magnetic field
C. Injury from radiation leaks that exceed the MPE limits
D. Ingestion of ozone gas from the cooling system
```

As you may remember from earlier questions, the klystron and magnetron are used as high-power transmitters. Whenever one is dealing with high transmission power, radiation injury is always a concern. You should be able to spot Answer **C** as the right choice.

Appendix – References and Tables

Band	Extra Authorization	Extra-Only Segment
80 meter	3500 – 3750 kHz	3500 – 3525 kHz
75 meter	3750 – 4000 kHz	3750 – 3775 kHz
40 meter	7000 – 7300 kHz	7000 – 7025 kHz 7150 – 7225 kHz
20 meter	14.000 – 14.350 MHz	14.000 – 14.025 MHz 14.150 – 14.175 MHz
15 meter	21.000 – 21.450 MHz	21.000 – 21.025 MHz 21.200 – 21.225 MHz

Complex Numbers: Rectangular Form	$Z = A + jB$ $A = \|Z\|\cos\theta$ $B = \|Z\|\sin\theta$
Complex Numbers: Polar Form	$Z = \|Z\|e^{j\theta}$ $\|Z\| = \sqrt{A^2 + B^2}$ $\theta = \tan^{-1}\left(\frac{B}{A}\right)$
Capacitive Reactance	$X_C = \frac{1}{j2\pi f_c C} = \frac{-j}{2\pi f_c C}$
Inductive Reactance	$X_L = j2\pi f_C L$

Web Sites	
Beacons	http://www.ncdxf.org
Propagation Bulletins	http://www.arrl.org/w1aw/prop can sign up there for e-mail delivery of bulletins
Solar Activity	http://www.sec.noaa.gov/today.html http://www.spaceweather.com/ http://www.sunspots.com
RF Safety	http://www.fcc.gov/oet/rfsafety/
FCC Amateur Radio Service	http://wireless.fcc.gov/services/amateur/
FCC Part 97	http://wireless.fcc.gov/rules.html

Digital Modes	
Web Site	**Contents**
http://www.aintel.bi.ehu.es/psk31.html	PSK 31 Home Page
http://www.qsl.net/zl1bpu/MFSK/	MFSK16 Home Page
http://users.mesatop.com/~ghansen/	HamScope control software for PSK31, MFSK16, RTTY
http://members.home.net/hteller/digipan/download.htm	DigiPan control software for PSK31
http://www.qsl.net/ae4jy/	WinPSK control software for PSK31
http://iz8bly.sysonline.it/Stream/index.htm	Stream control software for MFSK16
http://www.westmountainradio.com/	RigBlaster PC/rig control interface