

BioE 1310 - Review 6 - Other 1/16/2017

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

your signature

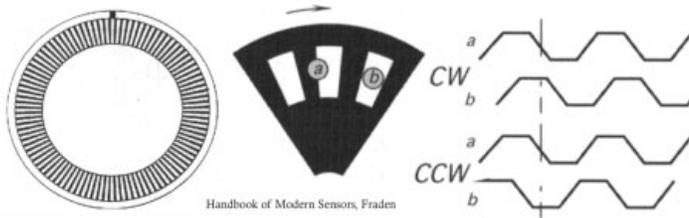
1. The following are true about batteries *except*
 - A. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
 - B. A practical alternative to batteries is the Super-Capacitor, which simply stores charge without a chemical reaction.
 - C. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.
 - D. Alkaline batteries should not be disposed of in the ordinary garbage because they contain mercury.
 - E. Batteries depend on a difference in electron affinity between two different elements.

2. Regarding energy in electronic circuits, which of the following is *false* (or all are true)?
 - A. The energy stored in a battery is commonly stated in units of “ampere-hours”, but the voltage of the battery must also be known to convert this into joules.
 - B. All are true.
 - C. Energy is stored in an inductor in the magnetic field created by the current, as described by the equation $E = \frac{1}{2}LI^2$, and may be retrieved by harnessing the current to do work.
 - D. Power (Energy/Time) in the form of heat is produced in a given resistor as described by the equation $P = I^2R$, and may not be efficiently retrieved as electrical power.
 - E. Energy is stored in a capacitor in the charge difference between the plates, as described by the equation $E = \frac{1}{2}CV^2$, and may be retrieved by discharging the capacitor.

3. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*,
 - A. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting “termination” with a simple resistor to prevent reflections.
 - B. In some antennas, high frequency current can enter or leave through a single wire, in apparent contradiction of Kirchhoff’s current law.
 - C. Coaxial and paired cables used to transmit over a distance are modeled as an infinite number of inductances along the cable and capacitances between the two conductors in the cable.
 - D. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
 - E. Currents tend to concentrate at the center of the wire rather than near the surface.

4. The following are true about batteries *except*
- A. A practical alternative to batteries is the Super-Capacitor, which simply stores charge without a chemical reaction.
 - B. Batteries depend on a difference in electron affinity between two different elements.
 - C. Batteries are rated in ampere-hours because $\text{current} \times \text{time} = \text{energy}$.
 - D. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
 - E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.
5. The following are always true about a conducting closed box *except* (or all are true).
- A. Bringing an external charge near the conducting box causes opposite charges to accumulate at that end of the box, canceling any electric field inside the box caused by the external charge.
 - B. It is also known as a “Faraday Cage.”
 - C. All are true.
 - D. The magnetic field inside the box will be zero.
 - E. The electric field inside the box will be zero.
6. The following are true about impedance matching in a cable for high frequency *except*, or all are true.
- A. It can be accomplished with a single terminating resistor at the characteristic impedance of the cable.
 - B. It can be accomplished with a transformer to match the impedance to that of the load.
 - C. Improper impedance matching causes reflections of high frequency waves.
 - D. All are true.
 - E. It can be accomplished with a quarter-wavelength section of wire, which creates two reflected waves out of phase with each other.
7. The following are true about the Huygens Principle *except*, or all are true.
- A. It accounts for phenomena such as the apparent bending of light past the edges of an aperture, which is not explained by the particle quality of light.
 - B. It results in constructive and destructive interference (null points) from integration over an aperture.
 - C. All are true.
 - D. It permits waves of any shape to be broken into an infinite number of spherical waves.
 - E. It states that each point of an advancing wave front is, in fact, the center of a fresh disturbance

8. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. All are true.
- B. Two optical sensors, *a* and *b* are positioned 90° out of phase.
- C. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.
- D. The encoder uses quadrature to determine the direction of motion of the wheel.
- E. This is an absolute, not incremental, encoder.

9. The following are true regarding electric motors *except*, (or all are true).

- A. Ultrasonic motors can be made very small, and rely on a traveling wave in the stator to push the rotor in one direction or the other.
- B. A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be controlled.
- C. They convert electrical power into mechanical power with less than 100% efficiency.
- D. The standard DC motor relies on a commutator to switch power in one or more rotating electromagnet within a permanent magnetic field
- E. All are true.

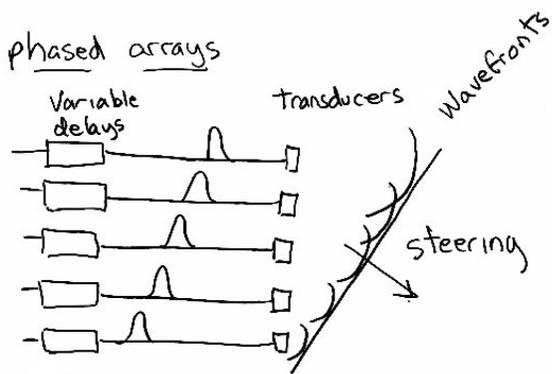
10. The following are true about the carotid pulse meter that you built in the lab *except*, (or all are true).

- A. All are true.
- B. A D-flip-flop is configured as a “one-shot” to keep the number of positive edges per carotid pulse down to one.
- C. Changes in carotid pressure cause movement in the speaker that creates a current, which is converted to a voltage by an operational amplifier (op amp) configured as a current-to-voltage converter.
- D. The circuit oscillates because of feedback through the electrical activity of cells in the wall lining of the carotid artery, picked up in the coil of the speaker.
- E. The BLIP is used to measure the number of milliseconds between each carotid pulse cycle, so that changes in the carotid pulse rate may be seen from one pulse to the next.

11. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*, (or all are true)

- A. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- B. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting “termination” with a simple resistor to prevent reflections.
- C. Effects due to wavelength are unimportant because of Kirchoff’s current and voltage laws.
- D. The skin effect causes currents to concentrate near the surface, rather than at the center, of wires.
- E. All are true.

12. The following statements are true about the diagram below depicting transmission by ultrasound transducers, *except*, (or all are true)

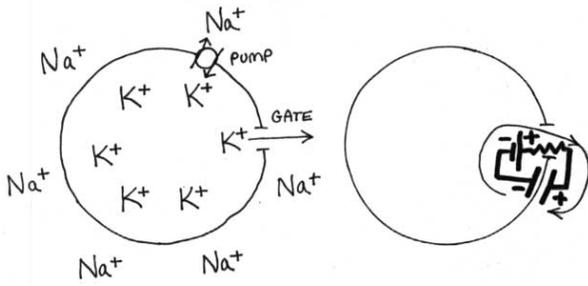


- A. All are true
- B. Changing the delays to the transmission of pulses to the individual transducers can control the focus and direction of the resulting wavefronts.
- C. The fact that a plane wave can be created by a series of spherical waves is an expression of Huygen's principle.
- D. The transducers may be crystals operating via the piezoelectric effect.
- E. The optical equivalent of the particular operation shown is the prism.

13. The following are true with regard to the piezoelectric transducer, *except*, (or all are true)

- A. All are true.
- B. It converts displacement (from a force) into voltage.
- C. It can act as electromechanical tuning fork, with an accurate resonant frequency.
- D. It is a passive device and cannot oscillate on its own.
- E. It converts voltage into displacement (through a force).

14. For the schematic below, representing the resting potential of a neuronal cell, all of the following are true *except* (or all are true)

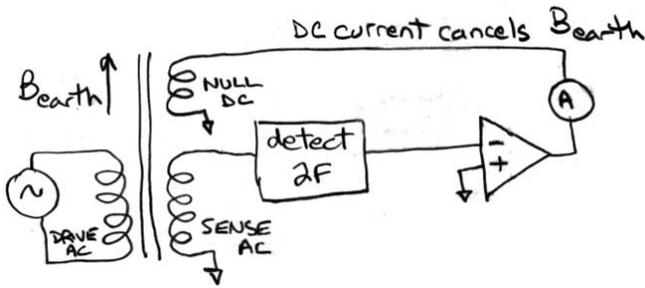


- A. Potassium concentrations are much higher inside the cell, and sodium concentrations are much higher outside the cell.
- B. Charge is stored on the membrane (represented by the capacitor), whose hydrophobic interior is an effective insulator between the “plates” of the internal and external ionic solutions.
- C. The “pump” generates a negative internal potential (represented by the battery) by excreting positive sodium ions.
- D. Entropy drives potassium out through a gate (represented by the resistor) that is specific to that ion and will not let sodium pass.
- E. All are true.

15. The following are true about thermocouples, *except*,

- A. They are extremely predictable by basic properties of physics, as opposed to thermistors.
- B. They take advantage of the voltage produced between two metals as a function of temperature.
- C. They are often used in pairs, with one reversed and used as a reference at a known temperature.
- D. They require a solution to carry ions between the two different metal electrodes.
- E. They are commonly stacked into “thermopiles” to produce enough power to keep the valve open in a water-heater, as long as the gas pilot remains lit.

16. For the circuit represented by the schematic below, which of the following is *false* (or all are true)?



- A. The second harmonic “2F” is only detected when there is asymmetry between the first and second half of the fundamental period in the signal “Sense AC”.
- B. All are true
- C. The system uses feedback to eliminate even harmonics in the signal “Sense AC”.
- D. The system depends on the fact that transformers are non-linear at high enough field strength due to saturation of the iron core.
- E. The detected external magnetic field (e.g. B_{earth}) is cancelled by a D.C. current, when the circuit is functioning properly, and this current (as measured by ammeter “A”) is therefore proportional to that external magnetic field.

17. The following are true about batteries *except*

- A. Batteries depend on a difference in electron affinity between two different elements.
- B. The cathode of a battery is that terminal from which electrons leave the battery.
- C. A practical alternative to batteries in some applications is the super-capacitor, which simply stores charge without a chemical reaction.
- D. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
- E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.

18. Which of the following is (are) true about Hall effect sensors?

- I - They detect magnetism by the voltage created orthogonal the direction of a current within a conductor.
- II - They are relatively inexpensive and ubiquitous.
- III - They are among the most sensitive means of detecting magnetic fields.

- A. II
- B. I and III
- C. I, II and III
- D. II and III
- E. I and II

19. The following are true about batteries *except*

- A. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.
- B. Batteries are rated in ampere-hours as well as by their voltage, because current \times voltage \times time = energy.
- C. Batteries depend on a difference in electron affinity between two different elements.
- D. Lead-Acid batteries are particularly useful because they can deliver large currents.
- E. Alkaline batteries are advantageous because they are rechargeable.

20. The following statements are true about the equilibrium potential ξ_{ion} as determined by the Nernst equation *except*, (or all are true)

$$\xi_{ion} = \pm 60\text{mV} \log_{10} \frac{[\text{ion}]_{in}}{[\text{ion}]_{out}}$$

- A. The “ \pm ” in the Nernst equation reflects to the fact that the polarity of ξ_{ion} depends on the polarity of the ion in question.
- B. It accounts for the ability of cells to change the potential stored on their membranes by opening and closing ion-specific gates.
- C. The equilibrium potential results from the effects of entropy favoring the redistribution of ions towards more equal concentrations inside and outside the cell.
- D. All are true.
- E. A positive ion with higher concentration outside the cell, such as is the natural state for sodium in the body, leads to a positive ξ_{Na^+} .

21. The following are true regarding Huygens’ Principle *except*, (or all are true).

- A. It explains how where a plane wave hits the edge of an aperture, it behaves more like a spherical wave and “bends around” the edge.
- B. All are true.
- C. It explains how interference patterns are formed when a plane wave encounters an aperture.
- D. It explains phenomena of light that are not attributable to its “particle” nature.
- E. It can be stated as follows: Each point of an advancing wave front is in fact the center of a fresh disturbance.

22. The following are true regarding thermocouples *except*.

- A. They are used in hot-water heaters to keep the gas-valve open to the pilot light only as long as the pilot flame is lit.
- B. They are inherently more accurate than thermistors, which are more dependent on the particular shapes of the resistive material.
- C. They are used to measure temperature by the variability of their resistance.
- D. They operate based on the voltage generated at the contact between two dissimilar metals due to differences in electron affinity, which varies with temperature.
- E. They are sometimes used in pairs when extreme accuracy is required, with one thermocouple kept at a known temperature.

23. The following are true about batteries *except*, or all are true.

- A. Lead-Acid batteries are particularly useful because they can deliver large currents.
- B. Batteries are rated in ampere-hours as well as by their voltage, because $\text{current} \times \text{voltage} \times \text{time} = \text{energy}$.
- C. Alkaline batteries, though not rechargeable, are advantageous because they are non-toxic to the environment and are inexpensive.
- D. Batteries depend on a difference in electron affinity between two different elements.
- E. All are true.

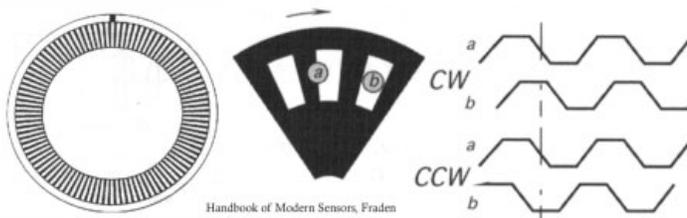
24. The following are true about thermocouples, *except* (or all are true).

- A. They are extremely predictable by basic properties of physics, as opposed to thermistors.
- B. All are true.
- C. They are commonly stacked into “thermopiles” to produce enough power to keep the valve open in a water-heater, as long as the gas pilot remains lit.
- D. They are often used in pairs, with one reversed and used as a reference at a known temperature.
- E. They take advantage of the voltage produced between two metals as a function of temperature.

25. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*,

- A. The skin effect has currents concentrating near the surface, rather than at the center, of the wires.
- B. In some antennas, high frequency current can enter or leave through a single wire, in apparent contradiction of Kirchhoff’s current law.
- C. Coaxial and paired cables used to transmit over a distance are modeled as an infinite number of capacitances along the cable and inductances between the two conductors in the cable.
- D. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- E. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting “termination” with a simple resistor to prevent reflections.

26. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. Two optical sensors, *a* and *b* are positioned 90° out of phase.
- B. This is an incremental, not absolute, encoder.
- C. All are true.
- D. The encoder uses quadrature to determine the direction of motion of the wheel.
- E. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.

27. Which of the following is *not* true about the Lumped Parameter Model of the audio loudspeaker discussed in class?

- A. The mechanical property of compliance is represented in the model by a capacitor.
- B. The mathematics of complex impedance applies to the electrical portion of the model, but not to the mechanical portion.
- C. The mechanical property of mass is represented in the model by an inductor.
- D. The mechanical and electrical properties of the speaker may be “lumped” together because electrical current in the voice coil causes force in the speaker, and mechanical motion of the speaker generates electrical voltage in the voice coil.
- E. In the mechanical portion of the model, force is represented by voltage and motion is represented by current.

28. The following are true about thermocouples, *except* (or all are true).

- A. All are true.
- B. They are often used in pairs to measure temperature, with one reversed and used as a reference at a known temperature.
- C. When an externally generated current is pushed through two oppositely oriented thermocouples, heat may be transferred such that cooling occurs at one of the thermocouples.
- D. They are commonly stacked into “thermopiles” to produce enough power from a heat source to keep the valve open in a water-heater, as long as the gas pilot remains lit.
- E. They take advantage of the voltage produced between two metals as a function of temperature, which is extremely predictable by basic properties of physics.

29. Which of the following is (are) true about strain gauges?

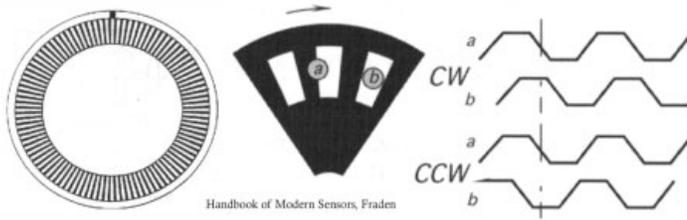
I - They contain a resistive material distributed in a back-and-forth pattern such that the overall length of the conductor is sensitive to a particular direction of stretch or compression.

II - They are commonly deployed as pairs in a Wheatstone bridge, with one strain gauge positioned so as not to change with force, to cancel variations in resistivity due to temperature.

III - They actually detect stress (force) directly, rather than strain (change in length).

- A. I, II and III
- B. I and III
- C. I and II
- D. II
- E. II and III

30. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. All are true.
- B. The encoder uses quadrature to determine the direction of motion of the wheel.
- C. This is an absolute, not incremental, encoder.
- D. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.
- E. Two optical sensors, *a* and *b* are positioned 90° out of phase, in terms of the slits in the wheel.

31. The following are true regarding electric motors *except*, (or all are true).

- A. Ultrasonic motors can be made very small, and rely on a traveling wave in the stator to push the rotor in one direction or the other.
- B. The standard DC motor relies on a commutator to switch power in one or more rotating electromagnet within a permanent magnetic field
- C. All are true.
- D. The standard DC motor includes a single rotating permanent magnet in a stationary magnetic field generated by a single coil fixed to the outside of the motor.
- E. A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be precisely controlled.

32. The following are true about resonance *except* (or all are true)

- A. The resonance of an *LCR* circuit, with the coil, capacitor, and resistor in series, is shortened with increasing *R*, since energy is dissipated by the resistor as heat.
- B. Resonance in a system with appropriate gain results in oscillation at the resonant frequency.
- C. If the Q-factor of a resonant system is high, this indicates a narrow bandwidth and that the system will resonate for a long time (compared to a system whose Q-factor is low).
- D. All are true
- E. The LASER is an example of a resonant system, with light bouncing back and forth between two mirrors stimulating further emission from atoms whose electrons have been pumped into an excited state.

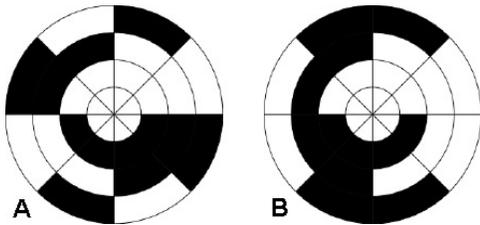
33. The following are true regarding voltage standing waves, *except*,

- A. They can be created by two sinusoidal voltage waves of equal amplitude traveling in opposite directions on the same piece of wire.
- B. They can exhibit *null points*, locations at which destructive interference between traveling waves sum to zero volts at all times.
- C. They can be avoided in coaxial and paired cables by “termination” with a resistor at the cable’s *characteristic impedance* to prevent reflections.
- D. They are called “standing” waves because the voltage at a given location remains constant over time.
- E. They generally become important with high frequencies ($> 10^6$ Hz) at which voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.

34. The following are true about strain gages *except*

- A. They are often used in a Wheatstone bridge circuit, in which strain effects multiple gages differentially, to compensate for temperature
- B. They measure applied force only through the resulting change in the length of the strain gage.
- C. They are often mounted on a cantilever, such that bending the cantilever changes the length of the strain gage.
- D. They contain a very thin wire printed on a non-rigid surface such that the length of the wire changes length preferentially with strain in a particular direction.
- E. They depend on the piezo effect.

35. The following are true about the figure below *except*



- A. The encoders in both Figs. A and B contain representations of every binary number one can construct with only 3 bits.
- B. These are both absolute optical encoders.
- C. Eight unique sectors are identified in Fig. B with only one bit changing between any two adjacent sectors.
- D. The encoder in Fig. A suffers from the possibility of misreads at transitions between one sector and an adjacent sector.
- E. The encoder in Fig. B cannot determine the direction of rotation.

36. The following are true regarding Linear Actuators, *except*, (or all are true).

- A. All are true.
- B. A solenoid with a magnetized plunger is capable of generating a force on that plunger in either direction by reversing the direction of the current in the coil.
- C. In most commercial solenoids, the coil is stationary and a non-magnetized iron plunger moves.
- D. Voice coils are generally faster than solenoids because the moving element is lighter, but they create weaker forces because the coils generally have fewer turns.
- E. In a voice coil, the permanent magnet is stationary and the coil moves.

37. The following are true regarding Radiation Detectors, *except*

- A.** The terms “gamma radiation” and “x-rays” are essentially interchangeable, meaning exactly the same thing.
- B.** Scintillation counters depend on the creation of many light photons from a single high-energy photon as it passes through a substance such as sodium chloride.
- C.** A Geiger Muller tube applies a high voltage across an inert gas, whose ionization by a high-energy photon produces a current.
- D.** A scintillation counter may employ a photomultiplier tube, which can detect very few photons by a cascade of electrodes across a high voltage
- E.** Solid-State Radiation Detectors detect high-energy photons using reverse-biased PIN diodes, which contain an un-doped “intrinsic” (I) layer between the usual P and N layers.

38. The following are true regarding electric motors *except*, or all are true.

- A.** A synchronous AC motor rotates at a rate locked to the driving AC voltage, without requiring the active switching used in DC motors.
- B.** A servomotor uses feedback from a position sensor to control the motor to achieve a desired position.
- C.** A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be controlled.
- D.** All are true.
- E.** The standard DC motor relies on mechanical switches (brushes and a commutator) or sensors (such as Hall effect) to switch power to one or more electromagnets with the proper timing to ensure continued rotation.

39. The following are true about strain gages *except*, (or all are true)

- A.** They contain a very thin wire printed on a non-rigid surface such that the total length of the wire changes preferentially with strain in a particular direction.
- B.** They are often used in a Wheatstone bridge circuit, in which strain effects multiple gages differentially, to compensate for temperature
- C.** They measure applied force only through the resulting change in the length of the strain gage.
- D.** They are often mounted on a cantilever, such that bending the cantilever changes the length of the strain gage.
- E.** All are true.

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1. The following are true about batteries *except*

- A. Alkaline batteries should not be disposed of in the ordinary garbage because they contain mercury.
- B. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
- C. Batteries depend on a difference in electron affinity between two different elements.
- D. A practical alternative to batteries is the Super-Capacitor, which simply stores charge without a chemical reaction.
- E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.

Explanation: Alkaline batteries may now be disposed of in the ordinary garbage without ecological impact because they no longer contain mercury.

[*circuits0052.mcq*]

2. Regarding energy in electronic circuits, which of the following is *false* (or all are true)?

- A. All are true.
- B. Energy is stored in a capacitor in the charge difference between the plates, as described by the equation $E = \frac{1}{2}CV^2$, and may be retrieved by discharging the capacitor.
- C. Energy is stored in an inductor in the magnetic field created by the current, as described by the equation $E = \frac{1}{2}LI^2$, and may be retrieved by harnessing the current to do work.
- D. The energy stored in a battery is commonly stated in units of “ampere-hours”, but the voltage of the battery must also be known to convert this into joules.
- E. Power (Energy/Time) in the form of heat is produced in a given resistor as described by the equation $P = I^2R$, and may not be efficiently retrieved as electrical power.

Explanation: I kid you not.

[*circuits0150.mcq*]

3. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*,

- A. Currents tend to concentrate at the center of the wire rather than near the surface.
- B. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting “termination” with a simple resistor to prevent reflections.
- C. Coaxial and paired cables used to transmit over a distance are modeled as an infinite number of inductances along the cable and capacitances between the two conductors in the cable.
- D. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- E. In some antennas, high frequency current can enter or leave through a single wire, in apparent contradiction of Kirchhoff’s current law.

Explanation: The skin effect has currents concentrating near the surface, rather than at the center, of the wires.

[*circuits0193.mcq*]

4. The following are true about batteries *except*

- A. Batteries are rated in ampere-hours because current \times time = energy.
- B. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
- C. Batteries depend on a difference in electron affinity between two different elements.
- D. A practical alternative to batteries is the Super-Capacitor, which simply stores charge without a chemical reaction.
- E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.

Explanation: current \times voltage \times time = energy. The voltage in the batter is assumed, which is why ampere-hours can be used to represent the energy in a batter.

[*circuits0280.mcq*]

5. The following are always true about a conducting closed box *except* (or all are true).

- A. The magnetic field inside the box will be zero.
- B. It is also known as a “Faraday Cage.”
- C. Bringing an external charge near the conducting box causes opposite charges to accumulate at that end of the box, canceling any electric field inside the box caused by the external charge.
- D. The electric field inside the box will be zero.
- E. All are true.

Explanation: The magnetic field does not have to be zero. Mu-metal can be used to reduce magnetic fields but not eliminate them.

[*circuits0281.mcq*]

6. The following are true about impedance matching in a cable for high frequency *except*, or all are true.

- A. All are true.
- B. It can be accomplished with a single terminating resistor at the characteristic impedance of the cable.
- C. It can be accomplished with a transformer to match the impedance to that of the load.
- D. It can be accomplished with a quarter-wavelength section of wire, which creates two reflected waves out of phase with each other.
- E. Improper impedance matching causes reflections of high frequency waves.

Explanation:

[*circuits0284.mcq*]

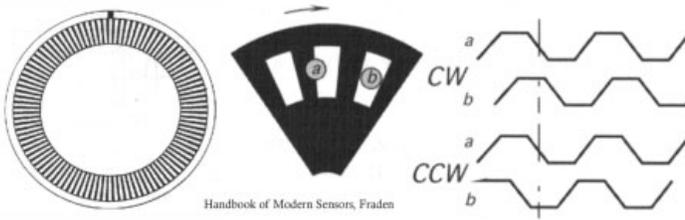
7. The following are true about the Huygens Principle *except*, or all are true.

- A. All are true.
- B. It results in constructive and destructive interference (null points) from integration over an aperture.
- C. It states that each point of an advancing wave front is, in fact, the center of a fresh disturbance
- D. It accounts for phenomena such as the apparent bending of light past the edges of an aperture, which is not explained by the particle quality of light.
- E. It permits waves of any shape to be broken into an infinite number of spherical waves.

Explanation:

[*circuits0285.mcq*]

8. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. This is an absolute, not incremental, encoder.
- B. Two optical sensors, *a* and *b* are positioned 90° out of phase.
- C. All are true.
- D. The encoder uses quadrature to determine the direction of motion of the wheel.
- E. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.

Explanation: This is an incremental encoder, and must keep track of a count and direction to determine accrued motion from an arbitrary starting place.

[*circuits0294.mcq*]

9. The following are true regarding electric motors *except*, (or all are true).

- A. All are true.
- B. Ultrasonic motors can be made very small, and rely on a traveling wave in the stator to push the rotor in one direction or the other.
- C. The standard DC motor relies on a commutator to switch power in one or more rotating electromagnet within a permanent magnetic field
- D. A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be controlled.
- E. They convert electrical power into mechanical power with less than 100% efficiency.

Explanation: All are true.

[*circuits0295.mcq*]

10. The following are true about the carotid pulse meter that you built in the lab *except*, (or all are true).

- A. The circuit oscillates because of feedback through the electrical activity of cells in the wall lining of the carotid artery, picked up in the coil of the speaker.
- B. Changes in carotid pressure cause movement in the speaker that creates a current, which is converted to a voltage by an operational amplifier (op amp) configured as a current-to-voltage converter.
- C. The BLIP is used to measure the number of milliseconds between each carotid pulse cycle, so that changes in the carotid pulse rate may be seen from one pulse to the next.
- D. All are true.
- E. A D-flip-flop is configured as a “one-shot” to keep the number of positive edges per carotid pulse down to one.

Explanation: Answer A is gibberish.

[*circuits0296.mcq*]

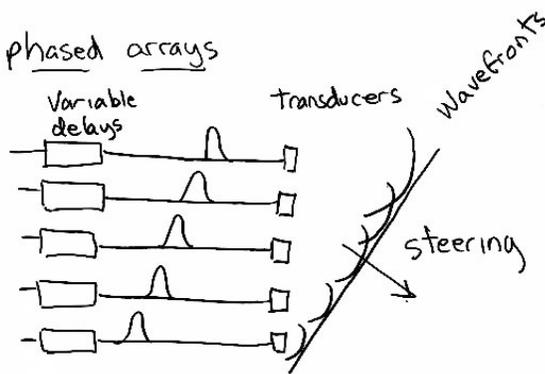
11. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*, (or all are true)

- A. Effects due to wavelength are unimportant because of Kirchoff's current and voltage laws.
- B. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting "termination" with a simple resistor to prevent reflections.
- C. The skin effect causes currents to concentrate near the surface, rather than at the center, of wires.
- D. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- E. All are true.

Explanation: Specifically because of Answer D, effects due to wavelength *become* important at high frequencies, making Kirchoff's current and voltage laws invalid over "nodes" consisting of wires whose length approaches the wavelength.

[*circuits0297.mcq*]

12. The following statements are true about the diagram below depicting transmission by ultrasound transducers, *except*, (or all are true)



- A. All are true
- B. The fact that a plane wave can be created by a series of spherical waves is an expression of Huygen's principle.
- C. The optical equivalent of the particular operation shown is the prism.
- D. Changing the delays to the transmission of pulses to the individual transducers can control the focus and direction of the resulting wavefronts.
- E. The transducers may be crystals operating via the piezoelectric effect.

Explanation: All are true.

[*circuits0298.mcq*]

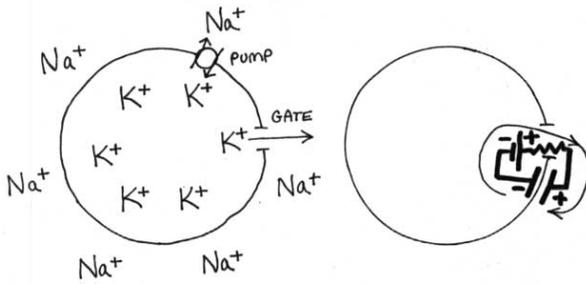
13. The following are true with regard to the piezoelectric transducer, *except*, (or all are true)

- A. All are true.
- B. It converts displacement (from a force) into voltage.
- C. It converts voltage into displacement (through a force).
- D. It can act as electromechanical tuning fork, with an accurate resonant frequency.
- E. It is a passive device and cannot oscillate on its own.

Explanation: All are true.

[*circuits0303.mcq*]

14. For the schematic below, representing the resting potential of a neuronal cell, all of the following are true *except* (or all are true)



- A. The “pump” generates a negative internal potential (represented by the battery) by excreting positive sodium ions.
- B. All are true.
- C. Entropy drives potassium out through a gate (represented by the resistor) that is specific to that ion and will not let sodium pass.
- D. Charge is stored on the membrane (represented by the capacitor), whose hydrophobic interior is an effective insulator between the “plates” of the internal and external ionic solutions.
- E. Potassium concentrations are much higher inside the cell, and sodium concentrations are much higher outside the cell.

Explanation: The pump does not generate the potential direction, but rather creates the condition in which sodium ions are outside and potassium ions are inside the cell.

[*circuits0307.mcq*]

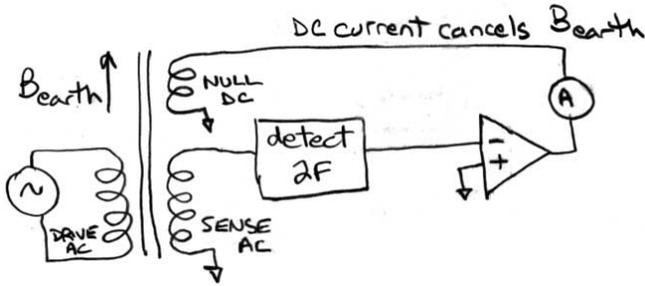
15. The following are true about thermocouples, *except*,

- A. They require a solution to carry ions between the two different metal electrodes.
- B. They take advantage of the voltage produced between two metals as a function of temperature.
- C. They are extremely predictable by basic properties of physics, as opposed to thermistors.
- D. They are often used in pairs, with one reversed and used as a reference at a known temperature.
- E. They are commonly stacked into “thermopiles” to produce enough power to keep the valve open in a water-heater, as long as the gas pilot remains lit.

Explanation: Answer A describes a battery, not a thermocouple.

[*circuits0309.mcq*]

16. For the circuit represented by the schematic below, which of the following is *false* (or all are true)?



- A. All are true
- B. The system depends on the fact that transformers are non-linear at high enough field strength due to saturation of the iron core.
- C. The second harmonic “2F” is only detected when there is asymmetry between the first and second half of the fundamental period in the signal “Sense AC”.
- D. The detected external magnetic field (e.g. B_{earth}) is cancelled by a D.C. current, when the circuit is functioning properly, and this current (as measured by ammeter “A”) is therefore proportional to that external magnetic field.
- E. The system uses feedback to eliminate even harmonics in the signal “Sense AC”.

Explanation: All are true.

[*circuits0310.mcq*]

17. The following are true about batteries *except*

- A. The cathode of a battery is that terminal from which electrons leave the battery.
- B. Lead-Acid batteries are particularly useful because they can deliver large currents and are rechargeable.
- C. Batteries depend on a difference in electron affinity between two different elements.
- D. A practical alternative to batteries in some applications is the super-capacitor, which simply stores charge without a chemical reaction.
- E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.

Explanation: The cathode of a battery is the (+) terminal through which electrons enter the battery.

[*circuits0311.mcq*]

18. Which of the following is (are) true about Hall effect sensors?

I - They detect magnetism by the voltage created orthogonal the direction of a current within a conductor.

II - They are relatively inexpensive and ubiquitous.

III - They are among the most sensitive means of detecting magnetic fields.

A. I and II

B. I, II and III

C. II and III

D. I and III

E. II

Explanation: Hall effect sensors are not particularly sensitive, compared to flux gate magnetometers or other means of measuring magnetism.

[*circuits0312.mcq*]

19. The following are true about batteries *except*

A. Alkaline batteries are advantageous because they are rechargeable.

B. Lead-Acid batteries are particularly useful because they can deliver large currents.

C. Batteries depend on a difference in electron affinity between two different elements.

D. Batteries are rated in ampere-hours as well as by their voltage, because current \times voltage \times time = energy.

E. A fuel cell differs from a battery by using a fuel, such as hydrogen and oxygen, in a continuous manner to produce electricity.

Explanation: Alkaline batteries are advantageous because they are non-toxic to the environment and are inexpensive. They are, however, not rechargeable.

[*circuits0344.mcq*]

20. The following statements are true about the equilibrium potential ξ_{ion} as determined by the Nernst equation *except*, (or all are true)

$$\xi_{ion} = \pm 60\text{mV} \log_{10} \frac{[\text{ion}]_{in}}{[\text{ion}]_{out}}$$

A. All are true.

B. A positive ion with higher concentration outside the cell, such as is the natural state for sodium in the body, leads to a positive ξ_{Na^+} .

C. The “ \pm ” in the Nernst equation reflects to the fact that the polarity of ξ_{ion} depends on the polarity of the ion in question.

D. The equilibrium potential results from the effects of entropy favoring the redistribution of ions towards more equal concentrations inside and outside the cell.

E. It accounts for the ability of cells to change the potential stored on their membranes by opening and closing ion-specific gates.

Explanation: All are true.

[*circuits0347.mcq*]

21. The following are true regarding Huygens' Principle *except*, (or all are true).

- A. All are true.
- B. It explains phenomena of light that are not attributable to its "particle" nature.
- C. It can be stated as follows: Each point of an advancing wave front is in fact the center of a fresh disturbance.
- D. It explains how where a plane wave hits the edge of an aperture, it behaves more like a spherical wave and "bends around" the edge.
- E. It explains how interference patterns are formed when a plane wave encounters an aperture.

Explanation: All are true.

[*circuits0350.mcq*]

22. The following are true regarding thermocouples *except*.

- A. They are used to measure temperature by the variability of their resistance.
- B. They operate based on the voltage generated at the contact between two dissimilar metals due to differences in electron affinity, which varies with temperature.
- C. They are inherently more accurate than thermistors, which are more dependent on the particular shapes of the resistive material.
- D. They are used in hot-water heaters to keep the gas-valve open to the pilot light only as long as the pilot flame is lit.
- E. They are sometimes used in pairs when extreme accuracy is required, with one thermocouple kept at a known temperature.

Explanation: They are used to measure temperature as described in B.

[*circuits0351.mcq*]

23. The following are true about batteries *except*, or all are true.

- A. All are true.
- B. Lead-Acid batteries are particularly useful because they can deliver large currents.
- C. Batteries depend on a difference in electron affinity between two different elements.
- D. Batteries are rated in ampere-hours as well as by their voltage, because $\text{current} \times \text{voltage} \times \text{time} = \text{energy}$.
- E. Alkaline batteries, though not rechargeable, are advantageous because they are non-toxic to the environment and are inexpensive.

Explanation: All are true.

[*circuits0364.mcq*]

24. The following are true about thermocouples, *except* (or all are true).

- A. All are true.
- B. They take advantage of the voltage produced between two metals as a function of temperature.
- C. They are extremely predictable by basic properties of physics, as opposed to thermistors.
- D. They are often used in pairs, with one reversed and used as a reference at a known temperature.
- E. They are commonly stacked into "thermopiles" to produce enough power to keep the valve open in a water-heater, as long as the gas pilot remains lit.

Explanation: All are true

[*circuits0365.mcq*]

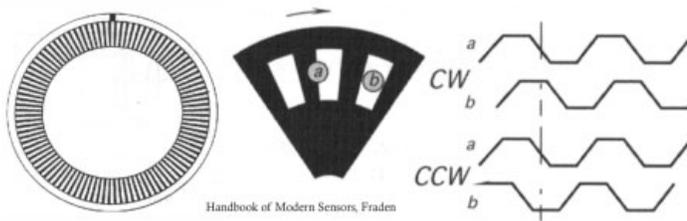
25. The following are true with regard to high frequency signals ($> 10^6$ Hz), *except*,

- A. Coaxial and paired cables used to transmit over a distance are modeled as an infinite number of capacitances along the cable and inductances between the two conductors in the cable.
- B. Coaxial and paired cables used to transmit over a distance exhibit a characteristic impedance, which is real, permitting “termination” with a simple resistor to prevent reflections.
- C. The skin effect has currents concentrating near the surface, rather than at the center, of the wires.
- D. Spatial considerations become much more important at higher frequencies because voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- E. In some antennas, high frequency current can enter or leave through a single wire, in apparent contradiction of Kirchhoff’s current law.

Explanation: Coaxial and paired cables used to transmit over a distance are modeled as an infinite number of *inductances* along the cable and *capacitances* between the two conductors in the cable.

[*circuits0366.mcq*]

26. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. All are true.
- B. Two optical sensors, *a* and *b* are positioned 90° out of phase.
- C. This is an incremental, not absolute, encoder.
- D. The encoder uses quadrature to determine the direction of motion of the wheel.
- E. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.

Explanation: This is an incremental encoder, and must keep track of a count and direction to determine accrued motion from an arbitrary starting place.

[*circuits0368.mcq*]

27. Which of the following is *not* true about the Lumped Parameter Model of the audio loudspeaker discussed in class?

- A. The mathematics of complex impedance applies to the electrical portion of the model, but not to the mechanical portion.
- B. The mechanical property of mass is represented in the model by an inductor.
- C. The mechanical property of compliance is represented in the model by a capacitor.
- D. The mechanical and electrical properties of the speaker may be “lumped” together because electrical current in the voice coil causes force in the speaker, and mechanical motion of the speaker generates electrical voltage in the voice coil.
- E. In the mechanical portion of the model, force is represented by voltage and motion is represented by current.

Explanation: The mathematics of complex impedance applies equally well to the electrical and mechanical portions. The electrical impedance of the loudspeaker demonstrates components due to both its electrical and mechanical properties.

[*circuits0369.mcq*]

28. The following are true about thermocouples, *except* (or all are true).

- A. All are true.
- B. They take advantage of the voltage produced between two metals as a function of temperature, which is extremely predictable by basic properties of physics.
- C. When an externally generated current is pushed through two oppositely oriented thermocouples, heat may be transferred such that cooling occurs at one of the thermocouples.
- D. They are often used in pairs to measure temperature, with one reversed and used as a reference at a known temperature.
- E. They are commonly stacked into “thermopiles” to produce enough power from a heat source to keep the valve open in a water-heater, as long as the gas pilot remains lit.

Explanation: All are true

[*circuits0396.mcq*]

29. Which of the following is (are) true about strain gauges?

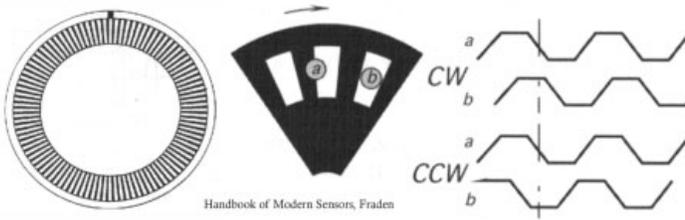
- I - They contain a resistive material distributed in a back-and-forth pattern such that the overall length of the conductor is sensitive to a particular direction of stretch or compression.
- II - They are commonly deployed as pairs in a Wheatstone bridge, with one strain gauge positioned so as not to change with force, to cancel variations in resistivity due to temperature.
- III - They actually detect stress (force) directly, rather than strain (change in length).

- A. I and II
- B. I, II and III
- C. II and III
- D. I and III
- E. II

Explanation: They actually detect *strain* directly (change in length) rather than stress (force) .

[*circuits0397.mcq*]

30. The diagram below shows an optical encoder of which all the following are true *except* (or all are true)



- A. This is an absolute, not incremental, encoder.
- B. Two optical sensors, *a* and *b* are positioned 90° out of phase, in terms of the slits in the wheel.
- C. All are true.
- D. The encoder uses quadrature to determine the direction of motion of the wheel.
- E. The waveforms show the signals from optical sensors *a* and *b* given motion in the clockwise (CW) and counter-clockwise (CCW) directions.

Explanation: This is an incremental encoder, and must keep track of a count and direction to determine accrued motion from an arbitrary starting place.

[*circuits0398.mcq*]

31. The following are true regarding electric motors *except*, (or all are true).

- A. The standard DC motor includes a single rotating permanent magnet in a stationary magnetic field generated by a single coil fixed to the outside of the motor.
- B. Ultrasonic motors can be made very small, and rely on a traveling wave in the stator to push the rotor in one direction or the other.
- C. The standard DC motor relies on a commutator to switch power in one or more rotating electromagnet within a permanent magnetic field
- D. A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be precisely controlled.
- E. All are true.

Explanation: The motor described in (A) could not rotate. All DC motors involve some kind of switching of coils to change the magnetic field as the rotating element progresses.

[*circuits0399.mcq*]

32. The following are true about resonance *except* (or all are true)

- A. All are true
- B. If the Q-factor of a resonant system is high, this indicates a narrow bandwidth and that the system will resonate for a long time (compared to a system whose Q-factor is low).
- C. The resonance of an *LCR* circuit, with the coil, capacitor, and resistor in series, is shortened with increasing *R*, since energy is dissipated by the resistor as heat.
- D. Resonance in a system with appropriate gain results in oscillation at the resonant frequency.
- E. The LASER is an example of a resonant system, with light bouncing back and forth between two mirrors stimulating further emission from atoms whose electrons have been pumped into an excited state.

Explanation: All are true.

[*circuits0400.mcq*]

33. The following are true regarding voltage standing waves, *except*,

- A. They are called “standing” waves because the voltage at a given location remains constant over time.
- B. They can be avoided in coaxial and paired cables by “termination” with a resistor at the cable’s *characteristic impedance* to prevent reflections.
- C. They generally become important with high frequencies ($> 10^6$ Hz) at which voltages and currents are no longer considered to be the same everywhere in a given piece of wire at a given moment.
- D. They can be created by two sinusoidal voltage waves of equal amplitude traveling in opposite directions on the same piece of wire.
- E. They can exhibit *null points*, locations at which destructive interference between traveling waves sum to zero volts at all times.

Explanation: The waves are “standing” because they do not change location. The voltage at a given point (other than a null point) will, however, generally change with time.

[*circuits0401.mcq*]

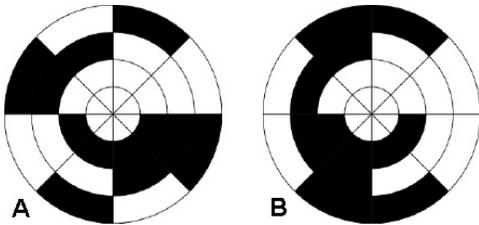
34. The following are true about strain gages *except*

- A. They depend on the piezo effect.
- B. They contain a very thin wire printed on a non-rigid surface such that the length of the wire changes length preferentially with strain in a particular direction.
- C. They are often used in a Wheatstone bridge circuit, in which strain effects multiple gages differentially, to compensate for temperature
- D. They are often mounted on a cantilever, such that bending the cantilever changes the length of the strain gage.
- E. They measure applied force only through the resulting change in the length of the strain gage.

Explanation: Strain gages do not depend on the piezo effect, in which a material generates a voltage from a displacement of charges in a lattice.

[*circuits0441.mcq*]

35. The following are true about the figure below *except*



- A. The encoder in Fig. B cannot determine the direction of rotation.
- B. These are both absolute optical encoders.
- C. Eight unique sectors are identified in Fig. B with only one bit changing between any two adjacent sectors.
- D. The encoder in Fig. A suffers from the possibility of misreads at transitions between one sector and an adjacent sector.
- E. The encoders in both Figs. A and B contain representations of every binary number one can construct with only 3 bits.

Explanation: The encoder in Fig. B can determine not only the direction of rotation, but also the absolute angle at any given time.

[*circuits0453.mcq*]

36. The following are true regarding Linear Actuators, *except*, (or all are true).

- A. All are true.
- B. In a voice coil, the permanent magnet is stationary and the coil moves.
- C. In most commercial solenoids, the coil is stationary and a non-magnetized iron plunger moves.
- D. Voice coils are generally faster than solenoids because the moving element is lighter, but they create weaker forces because the coils generally have fewer turns.
- E. A solenoid with a magnetized plunger is capable of generating a force on that plunger in either direction by reversing the direction of the current in the coil.

Explanation: All are true.

[*circuits0454.mcq*]

37. The following are true regarding Radiation Detectors, *except*

- A. The terms “gamma radiation” and “x-rays” are essentially interchangeable, meaning exactly the same thing.
- B. A Geiger Muller tube applies a high voltage across an inert gas, whose ionization by a high-energy photon produces a current.
- C. Scintillation counters depend on the creation of many light photons from a single high-energy photon as it passes through a substance such as sodium chloride.
- D. A scintillation counter may employ a photomultiplier tube, which can detect very few photons by a cascade of electrodes across a high voltage
- E. Solid-State Radiation Detectors detect high-energy photons using reverse-biased PIN diodes, which contain an un-doped “intrinsic” (I) layer between the usual P and N layers.

Explanation: X-rays are high-energy photons from the rapid deceleration of electrons in an x-ray tube. Gamma radiation is high-energy photons from nuclear decay.

[*circuits0455.mcq*]

38. The following are true regarding electric motors *except*, or all are true.

- A. All are true.
- B. A synchronous AC motor rotates at a rate locked to the driving AC voltage, without requiring the active switching used in DC motors.
- C. The standard DC motor relies on mechanical switches (brushes and a commutator) or sensors (such as Hall effect) to switch power to one or more electromagnets with the proper timing to ensure continued rotation.
- D. A stepper motor permits sequential switching of electromagnets within a permanent magnetic field in such a way that individual angular motions in desired directions can be controlled.
- E. A servomotor uses feedback from a position sensor to control the motor to achieve a desired position.

Explanation: All are true.

[*circuits0457.mcq*]

39. The following are true about strain gages *except*, (or all are true)

A. All are true.

B. They contain a very thin wire printed on a non-rigid surface such that the total length of the wire changes preferentially with strain in a particular direction.

C. They are often used in a Wheatstone bridge circuit, in which strain effects multiple gages differentially, to compensate for temperature

D. They are often mounted on a cantilever, such that bending the cantilever changes the length of the strain gage.

E. They measure applied force only through the resulting change in the length of the strain gage.

Explanation: All are true.

[*circuits0482.mcq*]