Q1.
A transverse sinusoidal wave travelling on a string is given by: $y(x,t) = 0.150 \sin(15.7x - 50.3t)$ (SI units). At a certain instant, point **A** is at the origin, and point **B** is the closest point to **A** along the *x* axis where the motion is 60.0^o out of phase with the motion at **A**. What is the distance between points **A** and **B**?

A) 0.0667 m
B) 0.133 m
C) 0.267 m
D) 6.28 m
E) 3.14 m

Q2.
Two identical sound sources emit sound waves of wavelength **λ** and are separated by a distance **d**. What is the lowest non-zero value of **d** for which constructive interference occurs everywhere along the line that passes through the two sources? Consider only points which do not lie between the two sources.

A) λ
B) λ/4
C) 2λ
D) λ/2
E) 4λ

Q3.
A 200-g ice cube at 0.0 ^oC is dropped into 350 g of water at 20 ^oC. What is the temperature of the mixture when it reaches thermal equilibrium?

A) 0.0 ^oC
B) –13 ^oC
C) +24 ^oC
D) –24 ^oC
E) +13 ^oC

Q4.
An ideal monatomic gas undergoes an isobaric process at a pressure of 80 kPa from an initial volume of 20 L to a final volume of 50 L. What is the change in the internal energy of the gas?

A) 3.6 kJ
B) 2.4 kJ
C) 4.0 kJ
D) 7.0 kJ
E) zero

Q5.
Four moles of an ideal monatomic gas undergo a free expansion to twice the initial volume. What is the change in the entropy of the gas in the process?

A) 23 J/K
B) 29 J/K
C) 35 J/K
D) 17 J/K
E) 0

Q6.
An electron and a proton are fixed. The direction of the electric field halfway between the electron and the proton

A) is toward the electron
B) is toward the proton
C) cannot be determined because the field is zero
D) depends on the distance between the two particles
E) is perpendicular to the line joining the two particles

Q7.
A conducting spherical shell has an outer radius of 0.75 m and a net charge of zero. A point charge ***q*** is placed at the center of the shell. The electric field just outside its surface is 992 N/C pointing radially toward the center of the sphere. What is the charge on the inner surface of the shell?

A) +62 nC
B) –62 nC
C) +31 nC
D) –31 nC
E) zero

Q8.
In a certain region of space, a uniform electric field is in the positive *x* direction. A particle with negative charge is moved from $x = 20$ cm to $x = 60$ cm. Which of the following statements is **CORRECT**?

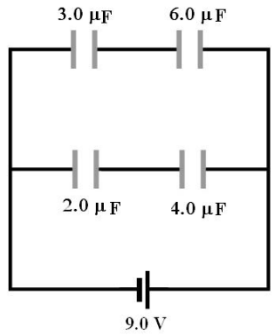
A) The potential energy of the charge increases.
B) The potential energy of the charge decreases.
C) The potential energy of the charge remains the same.
D) The particle moves to a region of higher electric potential.
E) The particle moves to a point of the same electric potential.

Q9.
Two electrons are initially far way from each other. They are projected toward each other, with each having a speed of 1.0×10^3 m/s. At what separation between the electrons will they momentarily stop?

A) 0.25 mm
B) 1.3 cm
C) 0.32 mm
D) 1.8 cm
E) 0.65 cm

Q10.
For the combination of capacitors shown in **FIGURE 1**, what is the potential difference across the 4.0-μF capacitor?

Fig#



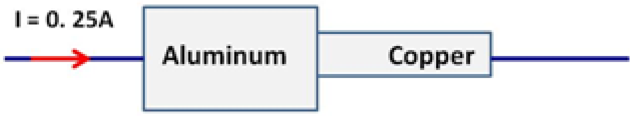
A) 3.0 V
B) 6.0 V
C) 7.5 V
D) 9.0 V
E) 4.5 V

Q11.
A 5.00-mV voltage is applied to a copper rod, initially at 20.0 °C, resulting in a current I_o. When the rod is heated to a temperature T_x, the current is reduced to $I_o/3$. If the temperature coefficient of resistivity of copper is $\alpha = 4.10 \times 10^{-3}$ K^{-1}, what is the temperature (T_x) of the rod? Assume that the dimensions of the rod do not change.

A) 508 °C
B) 488 °C
C) 60.0 °C
D) 6.70 °C
E) 20.0 °C

Q12.
A copper (Cu) rod and an aluminum (Al) rod of the same length and different cross sectional areas are connected in series as shown in **FIGURE 2**. The resistivities and cross sectional areas are: $\rho_{Cu} = 1.69 \times 10^{-8}$ Ω.m, $\rho_{Al} = 2.75 \times 10^{-8}$ Ω.m , A_{Al} = 0.400 cm^2, A_{Cu} =0.200 cm^2. The ratio of the magnitude of the electric field along the aluminum rod to that along the copper rod (E_{Al} / E_{Cu}) is

Fig#



A) 0.814
B) 3.25
C) 1.23
D) 1.00
E) 2.00

Q13.
A 6.00-V ideal battery is used to power a device whose resistance is 200 Ω. If the battery can move a charge of 240 C, how long will it last?

A) 2.22 hours
B) 0.556 hours
C) 35.6 hours

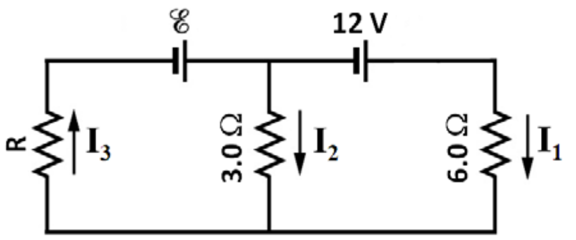
D) 8.89 hours
E) 11.8 hours

Q14.
A 0.20-A current flows across a metallic rod of length 1.0 m when connected to a 1.0-V battery. The rod is then cut into four identical pieces each having a length of 0.25 m, which are then connected in parallel to the same 1.0-V battery. The new current delivered by the battery is

A) 3.2 A
B) 0.40 A
C) 0.80 A
D) 0.050 A
E) 0.72 A

Q15.
In the circuit of **FIGURE 3**, the current I_1 = 3.0 A. What is the value of current I_3?

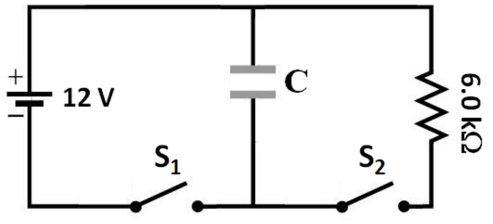
Fig#



A) 5.0 A
B) 1.0 A
C) 13 A
D) 7.0 A
E) 6.0 A

Q16.
A capacitor of capacitance **C** is connected to a 12-V battery, as shown in **FIGURE 4**. First, switch **S2** was open, and switch **S1** was closed until the capacitor is fully charged. Then, **S1** is open and **S2** is closed. If the voltage across the capacitor decays and reaches 6.0 V after 0.10 s, the capacitance **C** is equal to

Fig#

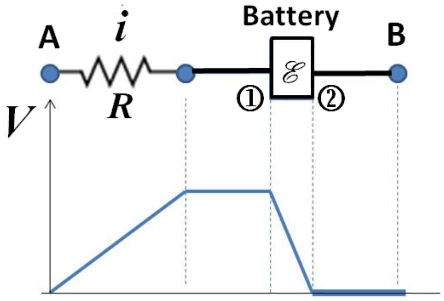


A) 24 μF
B) 11 μF
C) 14 μF
D) 140μF
E) 47 μF

Q17.

FIGURE 5 shows a portion of an electric circuit that includes a battery connected in series to a resistor of resistance *R*. Considering the variation of the electric potential along the circuit shown in the figure, which one of the following statements is **CORRECT**?

Fig#



A) The current in *R* flows to the left and the positive terminal of the battery is at point 1.
B) The current in *R* flows to the left and the positive terminal of the battery is at point 2.
C) The current in *R* flows to the right and the positive terminal of the battery is at point 1.
D) The current in *R* flows to the right and the positive terminal of the battery is at point 2.
E) The current is zero.

Q18.

A positive charge **q** is moving with velocity $\vec{\mathbf{v}}$ in a uniform external magnetic field $\vec{\mathbf{B}}$. The charge **q** experiences maximum magnetic force if

A) The direction of $\vec{\mathbf{v}}$ is perpendicular to the direction of $\vec{\mathbf{B}}$.
B) The direction of $\vec{\mathbf{v}}$ is the same as the direction of $\vec{\mathbf{B}}$.
C) The direction of $\vec{\mathbf{v}}$ is opposite to the direction of $\vec{\mathbf{B}}$.
D) The direction of $\vec{\mathbf{v}}$ makes an angle of 45^o with the direction of $\vec{\mathbf{B}}$.
E) The direction of $\vec{\mathbf{v}}$ makes an angle of 135^o with the direction of $\vec{\mathbf{B}}$.

Q19.

A proton travels through both a uniform magnetic field $\vec{\mathbf{B}}$ and a uniform electric field $\vec{\mathbf{E}}$. The magnetic field is given by $\vec{\mathbf{B}} = 2.5\hat{\mathbf{i}}$ (mT). At one instant, the velocity of the proton is $\vec{\mathbf{v}} = 2.0\times10^3\hat{\mathbf{j}}$ (m/s) and the **net force** acting on it is zero. Find the electric field $\vec{\mathbf{E}}$ in units of V/m. Ignore the gravitational force on the proton.

A) $+5.0\hat{\mathbf{k}}$
B) $-5.0\hat{\mathbf{k}}$
C) $+5.0\hat{\mathbf{j}}$
D) $-5.0\hat{\mathbf{j}}$
E) $-5.0\hat{\mathbf{k}} + 5.0\hat{\mathbf{j}}$

Q20.

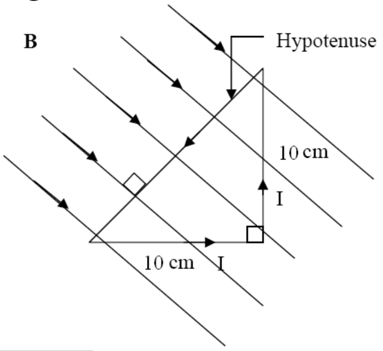
An electron of speed 2.0×10^7 m/s circles in a plane perpendicular to a uniform magnetic field. The radius of the orbit is 25 cm. The magnitude of the magnetic field is

A) 4.6×10^{-4} T

B) 1.6×10^{-6} T
C) 6.3×10^{-6} T
D) 2.0×10^{-5} T
E) 3.2×10^{-4} T

Q21.
A 100-turn coil, in the shape of a right triangle, has two equal sides. A current of 3.0 A passes through the coil. A uniform external magnetic field of magnitude 1.0 T is perpendicular to the hypotenuse of the coil, as shown in **FIGURE 6**. Find the magnitude of the total magnetic force on the coil.

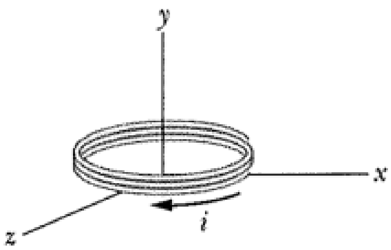
Fig#



A) zero
B) 30 N
C) 0.30 N
D) 0.60 N
E) 60 N

Q22.
The coil in **FIGURE 7** has its plane parallel to the *xz* plane, and carries current i = 1.0 A in the direction indicated. The coil has 8.0 turns and a cross sectional area of 4.0×10^{-3} m^2, and lies in an external uniform magnetic field that is given by $\vec{B} = -2.0\hat{i}$ (mT). Find the torque (in units of μN.m) on the coil due to the magnetic field $\vec{B}$.

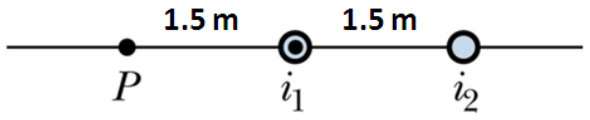
Fig#



A) $-64\hat{k}$
B) $+64\hat{k}$
C) $+12\hat{i}$
D) $-12\hat{i}$
E) $-64\hat{j}$

Q23.
FIGURE 8 shows cross sections of two long straight wires. The left hand wire carries current $\boldsymbol{i_1}$ = 5.0 A, directed out of the page. In order to produce a zero net magnetic field at point P, what should be the current $\boldsymbol{i_2}$?

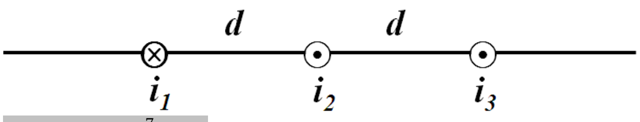
Fig#



A) 10 A, into the page
B) 10 A, out of the page
C) 2.5 A, into the page
D) 2.5 A, out of the page
E) 5.0 A into the page

Q24.
Three long parallel wires are arranged as shown in **FIGURE 9**, where **d** = 50 cm. The current into the page is $\boldsymbol{i_1}$ = 3.0 A. The currents out of the page are $\boldsymbol{i_2}$ = 0.25 A and $\boldsymbol{i_3}$ = 4.0 A. What is the magnitude of the net force per unit length acting on the wire carrying current $\boldsymbol{i_2}$ due to the currents in the other wires?

Fig#



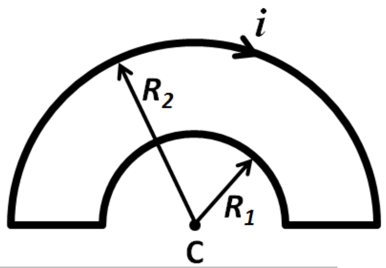
A) 7.0×10^{-7} N/m
B) 1.0×10^{-7} N/m
C) 1.8×10^{-7} N/m
D) 1.0×10^{-6} N/m
E) 2.4×10^{-7} N/m

Q25.
A long straight wire carrying a 3.0-A current enters a room through a window 2.0 m high and 1.5 m wide. The absolute value of the path integral $\oint \vec{B} \cdot \vec{ds}$ around the window frame is

A) 3.8×10^{-6} T.m
B) 2.5×10^{-7} T.m
C) 3.0×10^{-7} T.m
D) 2.0×10^{-7} T.m
E) 1.6×10^{-5} T.m

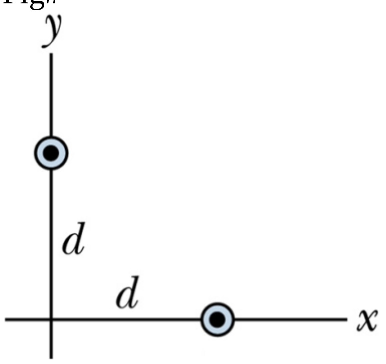
Q26.
A current is set up in a wire loop that is formed as shown in **FIGURE 10**, where R_1 = 2.0 cm and R_2 = 4.0 cm. The loop carries a current of 5.0 A, as shown in the figure. What is the magnetic field at the center of the loop (**C**)?

Fig#



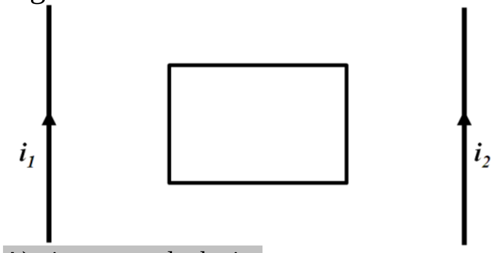
A) 3.9×10^{-5} T out of the page
B) 3.9×10^{-5} T into the page
C) 1.2×10^{-4} T out of the page
D) 1.2×10^{-4} T into the page
E) 7.9×10^{-5} T into of the page

Q27.
Two long wires are placed in the *xy* plane, as shown in **FIGURE 11**. Each wire carries a current of 1.5 A, directed out of the page. If the distance ***d*** = 3.0 m, what is the net magnetic field due to these wires at the origin?

Fig#


A) $(+0.10\hat{\mathbf{i}} - 0.10\hat{\mathbf{j}})$ (μT)
B) $(+0.10\hat{\mathbf{i}} + 0.10\hat{\mathbf{j}})$ (μT)
C) $(-0.10\hat{\mathbf{i}} - 0.10\hat{\mathbf{j}})$ (μT)
D) $(-0.10\hat{\mathbf{i}} + 0.10\hat{\mathbf{j}})$ (μT)
E) zero

Q28.
A conducting rectangular loop of wire is placed midway between two long straight parallel wires as shown in **FIGURE 12**. The wires carry currents i_1 and i_2, as indicated. If i_1 is increasing and i_2 is constant, then the induced current in the loop

Fig#


A) is counterclockwise
B) is zero
C) is clockwise

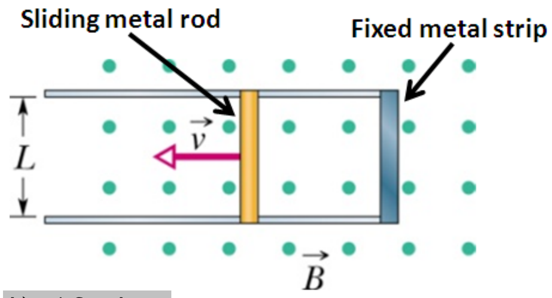
D) depends on the value of $i_1 - i_2$
E) depends on the value of $i_1 + i_2$

Q29.
A 10.0-m long copper wire, with a resistance of 5.00 Ω, is formed into a square loop and placed with its plane perpendicular to an external uniform magnetic field that is increasing at the constant rate of 10.0 mT/s, at what rate is thermal energy generated in the loop?

A) 0.780 mW
B) 3.20 mW
C) 4.35 mW
D) 2.50 mW
E) 2.10 mW

Q30.
In **FIGURE 13**, a metal rod, of resistance 15 Ω, is forced to move with constant velocity along two parallel metal rails, connected with a metal strip at one end. The rod moves in a uniform magnetic field of magnitude 0.50 T that points directly out of the page. If the rails are separated by L = 25 cm, and the speed of the rod is 0.55 m/s, what is the current in the rod?

Fig#



A) 4.6 mA, up
B) 4.6 mA, down
C) 6.9 mA, up
D) 6.9 mA, down
E) 2.3 mA down
