Q1.
Two strings, string 1 with a linear mass density of 1.75 g/m and string 2 with a linear mass density of 3.34 g/m are tied together, as shown in **FIGURE 1**. Both the strings are under same tension. Two pulses are sent simultaneously in opposite directions at string joint point A. What should be string length L_1 if the pulses are to reach the ends of the strings simultaneously?

Fig#
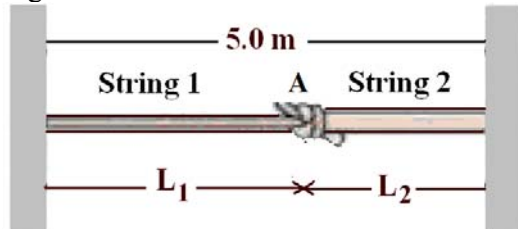
A) 2.90 m
B) 1.55 m
C) 2.01 m
D) 3.33 m
E) 3.10 m

Q2.
A pipe consists of a fixed part and an insertable tube that can be pulled in and out. A vibrating tuning fork is held next to the pipe as shown in **FIGURE 2**. As the insertable tube is slowly pulled out, the sound from the tuning fork creates standing waves in the pipe when its total length L is 42.5 cm, 56.7 cm and 70.9 cm. What is the frequency of the tuning fork? Assume $v_{sound} = 343$ m/s.

Fig#
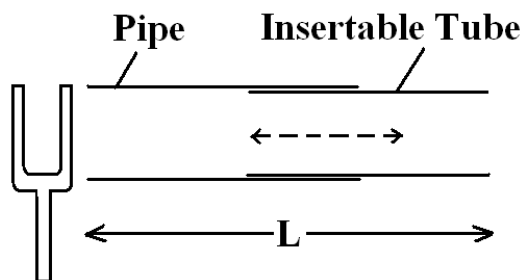
A) 1.21 kHz
B) 1.00 kHz
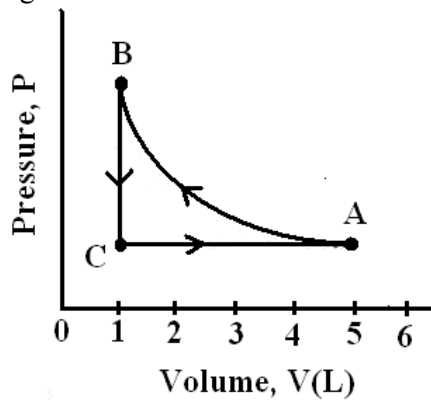C) 1.11 kHz
D) 2.22 kHz
E) 2.55 kHz

Q3.
400 g of water at 20.0 °C is placed inside a 500 W microwave oven for heating. How much liquid water remains in the microwave after heating for 20.0 min?

A) 193 g
B) 122 g
C) 101 g
D) 265 g
E) 233 g

Q4.
An ideal gas undergoes the cyclic process ABCA shown in **FIGURE 3,** where AB is an isotherm. The pressure at A is 60.0 kPa. Find the net work done in the cycle.

Fig#

A) −243 J
B) +110 J
C) −101 J
D) +432 J
E) −545 J

Q5.
A shallow lake contains 98.0×10^3 kg of water. In winter it is entirely frozen to ice. By how much does the entropy of the ice increase when the ice, already at 0 °C, melts and then heats to a temperature of 15.0 °C?

A) 1.42×10^8 J/K
B) 1.11×10^8 J/K
C) 1.00×10^8 J/K
D) 2.32×10^8 J/K
E) 3.55×10^8 J/K

Q6.
Two massless metal spheres are suspended near each other from insulating threads. One sphere is charged; the other sphere is neutral. Which of the following statements describes the situation?

A) The spheres will attract each other.
B) The spheres will not exert an electrostatic force on each other.
C) The spheres will repel each other.
D) It is difficult to determine the type of force between the spheres.
E) None of the answers.

Q7.
A small sphere has a mass of 5.00×10^{-3} kg and carries a charge of 6.00 μC. What magnitude of electric field will balance the weight of the sphere so that it is suspended motionless above the ground?

A) 8.17×10^3 N/C
B) 5.22×10^3 N/C
C) 3.11×10^3 N/C
D) 9.27×10^3 N/C
E) 9.55×10^3 N/C

Q8.
A solid insulating sphere of radius $a = 5.00$ cm carries a net positive charge of $Q = 3.00$ μC uniformly distributed throughout its volume. Concentric with this sphere is a conducting spherical shell with inner radius $b = 10.0$ cm and outer radius $c = 15.0$ cm, as shown in **FIGURE 4**. The shell has net charge $q = -1.00$ μC. Find the surface charge density on the outer surface of the conducting shell.

Fig#
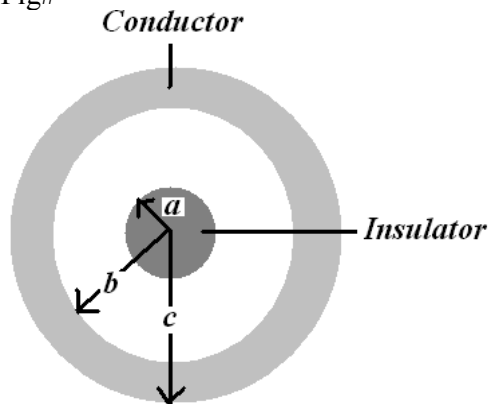
A) $+ 7.07$ μC/ m^2
B) -7.07 μC/ m^2
C) -5.25 μC/ m^2
D) $+5.25$ μC/ m^2
E) $+2.22$ μC/ m^2

Q9.
A spherical conductor of radius $R_1 = 30.0$ cm is charged to 20.0 kV. When it is connected by a long, very thin conducting wire to a second electrically neutral conducting sphere of radius R_2 located far away, its potential drops to 12.0 kV. What is the value of R_2? Assume $V = 0$ at infinity.

A) 20.0 cm
B) 10.0 cm
C) 15.0 cm
D) 35.0 cm
E) 40.0 cm

Q10.
A positive charge is released from rest and moves along an electric field line. Which of the following statements describes the situation correctly?

A) This charge moves to lower potential and loses potential energy.
B) This charge moves to lower potential and gains potential energy.
C) This charge moves to higher potential and loses potential energy.
D) This charge moves to higher potential and gains potential energy.
E) None of the answers.

Q11.
A parallel plate capacitor with 1.00 μF capacitance consist of two square plates of aluminum filled with a dielectric material of dielectric constant $\kappa = 5.00$. If the plates are separated by 0.100 mm, find the length of each edge of the plate.

A) 1.50 m
B) 1.00 m
C) 1.31 m
D) 2.50 m
E) 3.55 m

Q12.
FIGURE 5 shows the electric potential along length of a cylindrical metallic wire
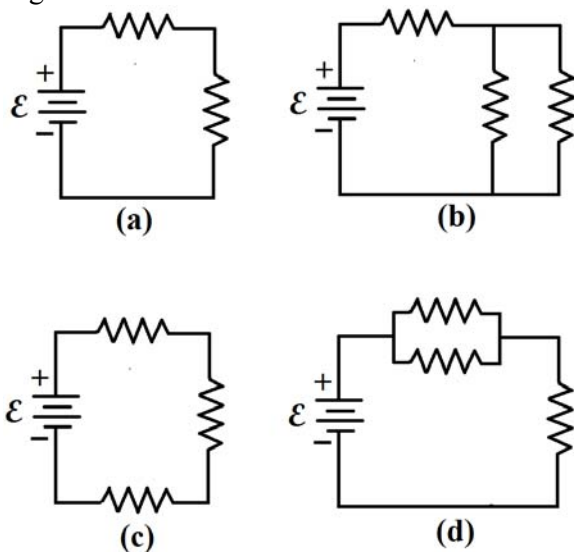($\rho = 5.6 \times 10^{-8}$ $\Omega \cdot$m). What is the magnitude of the current density in the wire?

Fig#
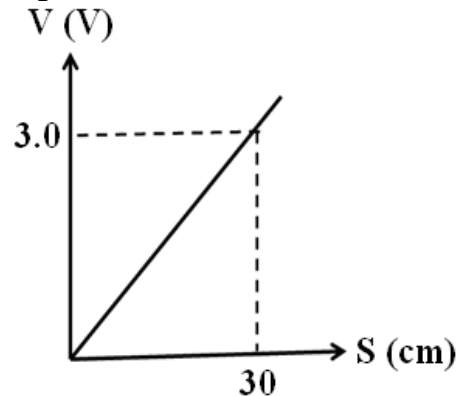
A) 1.8×10^8 A/m^2
B) 2.5×10^6 A/m^2
C) 4.4×10^8 A/m^2
D) 1.1×10^5 A/m^2
E) 5.5×10^9 A/m^2

Q13.
Rank the circuits shown in **FIGURE 6** according to the **current** through the emf ε in the
circuits, **minimum to maximum**. All the resistors have the same value of resistance.

Fig#
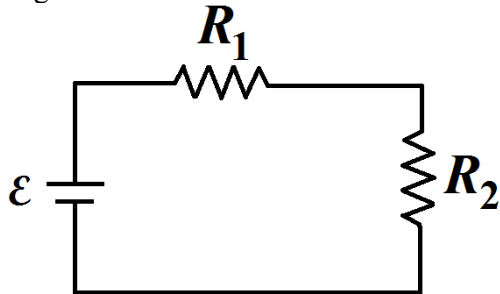

A) c, a , (b, d tie)
B) a ,b, c, d
C) b ,c, (d, a tie)
D) a, c , b, d
E) c, d, a, b

Q14.

For the circuit shown in **FIGURE 7**, $\mathcal{E}$=12.0 V and R_1=155 Ω. What should be the resistance of R_2 if the power dissipated in R_1 is 0.125 W?
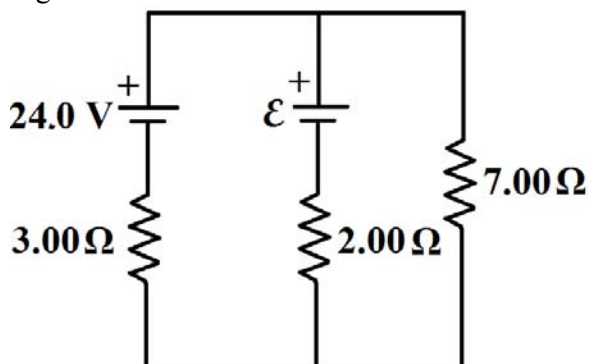
Fig#

A) 268 Ω
B) 126 Ω
C) 199 Ω
D) 366 Ω
E) 401 Ω

Q15.

What must be the emf $\mathcal{E}$ in **FIGURE 8** for the current through the 7.00 Ω resistor to be 1.80 A? Each emf source has negligible resistance.

Fig#

A) 8.60 V
B) 11.0 V
C) 6.66 V
D) 9.33 V
E) 5.11 V

Q16.

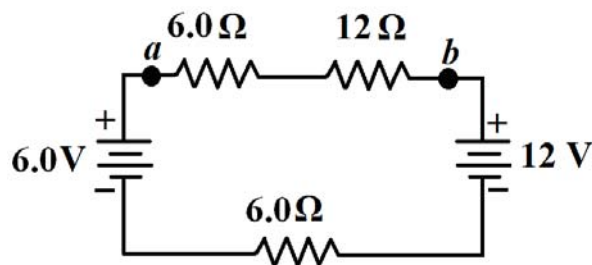A capacitor, when fully charged, holds 5.0 J of energy. It is then connected across a 10 kΩ resistor. After 2.0×10^{-2} s, the energy stored in the capacitor decreases to 2.0 J. What is the capacitance of the capacitor?

A) 4.4 µF
B) 1.1 µF
C) 2.5 µF
D) 5.7 µF
E) 8.9 µF

Q17.

Find the potential difference V_b-V_a in the circuit shown in **FIGURE 9**.

Fig#

A) 4.5 V
B) 5.1 V
C) 1.3 V
D) 2.2 V
E) 6.9 V

Q18.

A proton moves with a speed of 8.0×10^6 m/s along the +x-axis. It enters a region where there is a magnetic field of magnitude 2.5 T, directed at an angle of 60° to the +x-axis and lying in the xy plane. Calculate the initial magnetic force on the proton.

A) $+2.8 \times 10^{-12}$ $\hat{k}$ N
B) -2.8×10^{-12} $\hat{k}$ N
C) $+3.2 \times 10^{-12}$ $\hat{k}$ N
D) -3.2×10^{-12} $\hat{k}$ N
E) $+1.8 \times 10^{-12}$ $\hat{k}$ N

Q19.

The segment of a wire shown in **FIGURE 10** carries 2.5 A current from point a to b. The wire is in the xy plane and its sections are parallel to the coordinate axes. The segment is in a region that has a magnetic field $\vec{B}$ = 2.5 $\hat{k}$ T. Find the magnitude of the net force on the wire.

Fig#
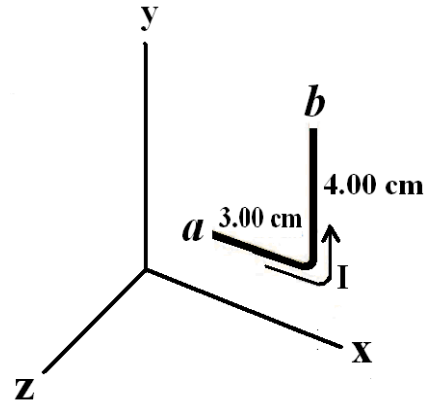
A) 0.31 N
B) 0.22 N
C) 0.11 N
D) 0.55 N
E) 0.61 N

Q20.
A proton undergoes uniform circular motion of radius 26.1 μm in a uniform magnetic field. The magnetic force on the proton has a magnitude of 1.60×10^{-17} N. What is the speed of the proton?

A) 5.00×10^2 m/s
B) 1.21×10^2 m/s
C) 2.59×10^2 m/s
D) 6.00×10^2 m/s
E) 6.55×10^2 m/s

Q21.
A circular coil consisting of 20 turns of wire lies in a region with a uniform magnetic field whose magnitude is 0.50 T. The normal to the plane of the coil makes an angle of 60° with the direction of the magnetic field. The radius of the coil is 4.0 cm and the wire carries a current of 3.0 A. What is the magnitude of the torque exerted on the coil?

A) 0.13 N·m
B) 0.31 N·m
C) 0.23 N·m
D) 0.050 N·m
E) 0.010 N·m

Q22.
Two long straight wires are parallel to each other and carry currents of different magnitudes. If the amount of current flowing through each wire is doubled, the magnitude of the force between the wires will be:

A) Four times the magnitude of the original force
B) Twice the magnitude of the original force
C) The same as the magnitude of the original force
D) Half of the magnitude of the original force
E) None of the answers

Q23.
The current-carrying wire loop in **FIGURE 11** lies in the xy and xz planes and carries current $i = 1.43$ A. The loop consists of a semicircle of radius $R_a = 10.0$ cm in the xy plane and another smaller semicircle of radius $R_b = 2.30$ cm in the xz plane. Find the magnitude of the net magnetic field at the common center P of the two semicircles.
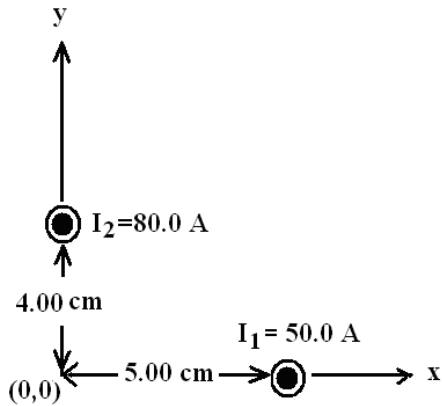
Fig#
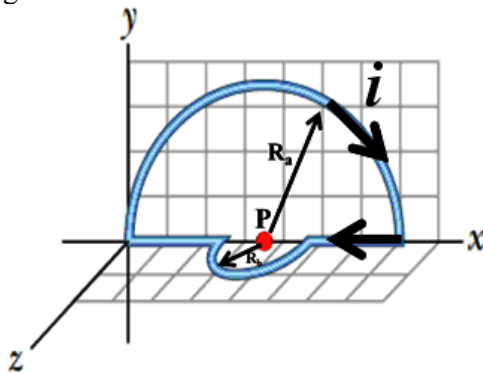
A) 20.0 µT
B) 15.0 µT
C) 10.0 µT
D) 25.0 µT
E) 35.0 µT

Q24.
Two long straight wires carry currents perpendicular to the xy plane, as shown in **FIGURE 12**. What is the magnitude of the net magnetic field at the origin?

Fig#

y

$I_2 = 80.0$ A

4.00 cm

$I_1 = 50.0$ A

5.00 cm → x

(0,0)

A) 447 μT
B) 155 μT
C) 622 μT
D) 778 μT
E) 251 μT

Q25.
FIGURE 13 shows the cross sectional view of three conductors that carry currents perpendicular to the plane of the figure. The currents have magnitudes $I_1 = 4$ A, $I_2 = 6$ A and $I_3 = 2$ A in the directions shown. Four closed paths, labeled **a** through **d**, are shown. Rank the values of the line integrals $\oint \vec{B}.d\vec{s}$ for the four paths, **minimum to maximum**.

Fig#

$I_1 \otimes$

a

b

c $\odot I_3$

$I_2 \odot$

d
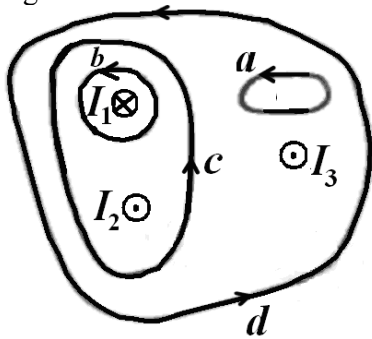
A) *b, a , c , d*
B) *a, b, c ,d*
C) *b, c, then d, a tie*
D) *a, c ,b, d*
E) *c, d, a, b*

Q26.
A long solenoid has 100 turns/cm and carries current i. An electron moves within the solenoid in a circle of radius 2.15 cm perpendicular to the solenoid axis. The speed of the electron is 1.25×10^7 m/s. Find the current i in the solenoid.

A) 26.3×10^{-2} A
B) 11.1×10^{-2} A

C) 15.8×10^{-2} A
D) 33.5×10^{-2} A
E) 39.1×10^{-2} A

Q27.
A long straight wire is in the plane of a circular conducting loop, as shown in **FIGURE 14**. The wires carries a constant current **I** in the direction shown. The circular loop starts moving to the left. The induced current in the circular loop is:

Fig#
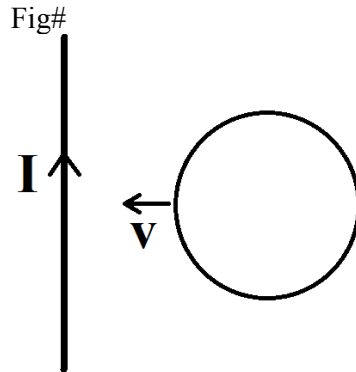
A) Counterclockwise
B) Clockwise
C) Zero
D) Undefined
E) None of the answers

Q28.
Consider a circular loop of radius R = 20 cm lying in the x-y plane in a uniform magnetic field $\vec{B}=(5.0\hat{i}+4.0\hat{j}+3.0\hat{k})$ T. Calculate the magnetic flux though the loop.

A) 0.38 Wb
B) 0.15 Wb
C) 0.62 Wb
D) 0.21 Wb
E) 0.92 Wb

Q29.
A 400-turn coil of total resistance 6.0 Ω has a cross sectional area of 30 cm^2. How rapidly should a magnetic field parallel to the coil axis change in order to induce a current of 0.30 A in the coil?

A) 1.5   T/s
B) 1.2   T/s
C) 1.1   T/s
D) 2.2   T/s
E) 2.8   T/s

Q30.
A conducting bar of length $l = 0.0300$ m, moves to the right on two conducting frictionless rails, as shown in **FIGURE 15**. A uniform magnetic field directed into the page has a magnitude of 0.100 T. The resistance of the resistor R = 5.00×10^{-3} Ω. At what constant speed should the bar be moved if the power dissipated in the resistor is 5.00×10^{-3} W?

Fig#
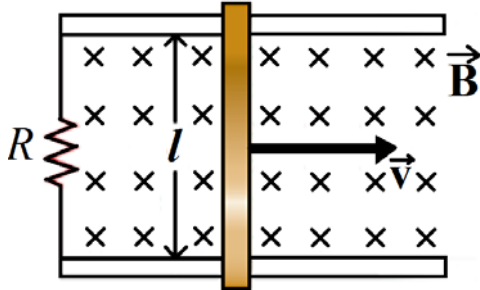
A) 1.67 m/s
B) 1.00 m/s
C) 1.33 m/s
D) 2.43 m/s
E) 3.53 m/s