

Q1.

A transverse sinusoidal wave travels along a stretched string that has a linear mass density of 5.00 g/m. The amplitude of the wave is 5.00 cm, its frequency is 80.0 Hz, and the tension in the string is 22.0 N. What is the average power transmitted by this wave?

- A) 105 W
- B) 195 W
- C) 285 W
- D) 254 W
- E) 512 W

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Q2.

The maximum pressure amplitude that the human ear can tolerate is 28 Pa. What is the corresponding displacement amplitude for sound waves in air at a frequency of 2.0 kHz? [The speed of sound in air is 340 m/s, and density of air is 1.2 kg/m<sup>3</sup>]

- A) 5.5 μm
- B) 8.3 μm
- C) 2.2 μm
- D) 11 μm
- E) 4.2 μm

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Q3.

How much ice at - 10 °C must be mixed with 0.20 kg of water, initially at 20 °C, in order for the final equilibrium temperature to be 0 °C with all the ice melted? [specific heat of ice = 2220 J/kg.K]

- A) 47 g
- B) 63 g
- C) 85 g
- D) 75 g
- E) 12 g

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Q4.

In an adiabatic process, the temperature of one mole of an ideal monoatomic gas is decreased from 500 K to 400 K. What is the work done in the process?

- A) 1.25 kJ by the gas
  - B) 1.25 kJ on the gas
  - C) 2.08 kJ by the gas
  - D) 2.08 kJ on the gas
  - E) zero
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Q5.

In which of the following, is the entropy change per cycle negative?

- A) a perfect refrigerator
- B) a Carnot refrigerator
- C) a real refrigerator
- D) a Carnot heat engine
- E) none of the other answers

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Q6.

Two particles of charges  $q_1 = + 3.0 \mu\text{C}$  and  $q_2 = - 27 \mu\text{C}$ , are fixed 10 cm apart. How far from  $q_1$  should a third charge be located so that the net electrostatic force on it, due to  $q_1$  and  $q_2$ , is zero?

- A) 5.0 cm
- B) 15 cm
- C) 20 cm
- D) 10 cm
- E) 25 cm

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Q7.

A proton with a speed of  $4.0 \times 10^6$  m/s moves in a uniform electric field of magnitude  $3.8 \times 10^3$  N/C. The field is acting to decelerate the proton. How far does the proton travel before it is brought momentarily to rest?

- A) 22 m
- B) 5.6 m
- C) 33 m
- D) 44 m
- E) 11 m

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Q8.

A solid insulating sphere has a radius of 20 cm, and a uniform charge density of  $3.0 \text{ nC/m}^3$ . What is the magnitude of the electric field at a distance of 40 cm from the center of the sphere?

- A) 5.6 N/C
- B) 4.4 N/C
- C) 6.3 N/C
- D) 7.1 N/C
- E) 8.9 N/C

Q9.

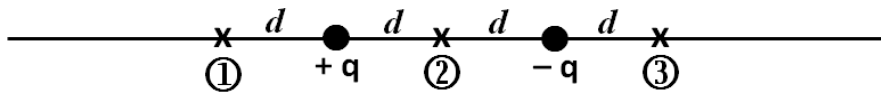
A point charge  $Q = + 1.5 \mu\text{C}$  is located at the origin. Point A is at  $x = + 1.0 \text{ m}$ , and point B is at  $x = + 3.0 \text{ m}$ . How much work needs to be done by an external agent to move a charge  $q = - 1.0 \mu\text{C}$  from A to B?

- A) + 9.0 mJ
- B) - 9.0 mJ
- C) + 4.5 mJ
- D) - 4.5 mJ
- E) zero

Q10.

Two point charges ( $+q$  and  $-q$ ) are fixed on a line, as shown in **FIGURE 1**. Rank the electric potentials at points 1, 2, 3; greatest first.

Fig#



- A) 1, 2, 3
- B) (1 and 3) tie, then 2
- C) 3, 2, 1
- D) 2, then (1 and 3 tie)
- E) 2, 3, 1

Q11.

Three capacitors are connected in parallel. Each has plate area  $A$  and plate spacing  $d$ . What must be the spacing of a single capacitor of plate area  $A$  if its capacitance equals that of the parallel combination?

- A)  $d/3$
- B)  $d/2$
- C)  $3d/2$
- D)  $d/4$
- E)  $d/6$

Q12.

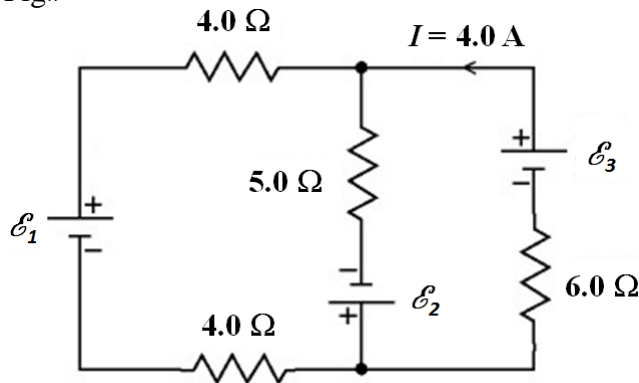
A steady current passes through a wire. The amount of charge that passes through the wire in 2.0 s is 1.8 C. How many electrons pass through the wire in 5.0 s?

- A)  $2.8 \times 10^{19}$
- B)  $1.1 \times 10^{19}$
- C)  $2.5 \times 10^{19}$
- D)  $1.9 \times 10^{19}$
- E)  $2.3 \times 10^{19}$

Q13.

In the circuit shown in **FIGURE 2**:  $\mathcal{E}_2 = 44 \text{ V}$  and  $\mathcal{E}_3 = 20 \text{ V}$ . Calculate the emf  $\mathcal{E}_1$ .

Fig#

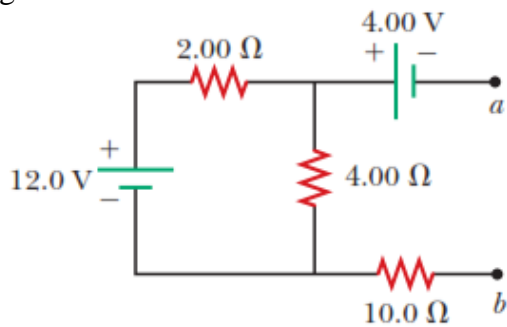


- A) 28 V
- B) 44 V
- C) 12 V
- D) 72 V
- E) 20 V

Q14.

Calculate the potential difference ( $V_b - V_a$ ) between points  $a$  and  $b$  in the circuit shown in **FIGURE 3**.

Fig#



- A) - 4.00 V
- B) + 3.00 V
- C) - 6.00 V
- D) + 1.50 V
- E) - 5.25 V

Q15.

A capacitor of capacitance  $C = 4.0 \text{ mF}$  is discharged through a resistor of resistance  $R = 4.0 \text{ k}\Omega$ . How long will it take the capacitor to lose half of its initial stored energy?

- A) 5.5 s
- B) 9.2 s
- C) 1.4 s
- D) 3.2 s
- E) 6.3 s

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Q16.

Several identical lamps are connected in parallel. What happens if one lamp burns out?

- A) The power dissipated in each of the remaining lamps will not change.
- B) The power dissipated in each of the remaining lamps will increase.
- C) The power dissipated in each of the remaining lamps will decrease.
- D) The current passing through each of the remaining lamps will decrease.
- E) The current passing through each of the remaining lamps will increase.

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Q17.

When two unknown resistors are connected in series with a battery, the battery delivers 225 W of electric power, and carries a total current of 5 A. For the same total current, 50 W is delivered when the resistors are connected in parallel. Determine the resistance of each resistor.

- A)  $3\Omega$ ,  $6\Omega$
- B)  $7\Omega$ ,  $7\Omega$
- C)  $9\Omega$ ,  $2\Omega$
- D)  $3\Omega$ ,  $8\Omega$
- E)  $6\Omega$ ,  $4\Omega$

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Q18.

A proton moves perpendicular to a uniform magnetic field  $\mathbf{B}$  at a speed of  $1.00 \times 10^7 \text{ m/s}$ , and experiences an acceleration of  $2.00 \times 10^{13} \text{ m/s}^2$  in the positive  $x$  direction when its velocity is in the positive  $z$  direction. Determine the magnetic field.

- A)  $-20.9 \hat{j}$  (mT)
- B)  $+20.9 \hat{j}$  (mT)
- C)  $+20.9 \hat{k}$  (mT)
- D)  $-20.9 \hat{k}$  (mT)
- E)  $+20.9 \hat{i}$  (mT)

Q19.

A proton moves in a circle of radius 5.10 cm in a 0.566 T magnetic field. What value of electric field could make its path a straight line?

- A)  $1.57 \times 10^6$  V/m
- B)  $2.41 \times 10^6$  V/m
- C)  $6.18 \times 10^6$  V/m
- D)  $9.21 \times 10^6$  V/m
- E)  $5.88 \times 10^6$  V/m

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Q20.

A coil with a magnetic dipole moment of  $1.45 \text{ A}\cdot\text{m}^2$  is oriented initially with its magnetic dipole moment antiparallel to a uniform 0.835 T magnetic field. What is the change in the potential energy of the coil when it is rotated  $180^\circ$  so that finally its magnetic dipole moment is parallel to the field?

- A)  $-2.42 \text{ J}$
- B)  $-6.12 \text{ J}$
- C)  $-1.10 \text{ J}$
- D)  $-5.30 \text{ J}$
- E)  $-7.08 \text{ J}$

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Q21.

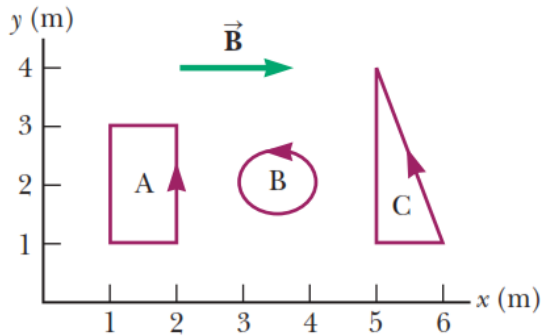
A wire carrying a 15-A current is directed along the positive  $x$  axis, and is perpendicular to a magnetic field. A magnetic force per unit length of 0.12 N/m acts on the wire in the negative  $y$  direction. Determine the magnetic field in the region through which the wire passes.

- A)  $+ 8.0 \hat{\mathbf{k}}$  (mT)
- B)  $+ 3.0 \hat{\mathbf{k}}$  (mT)
- C)  $+ 4.0 \hat{\mathbf{j}}$  (mT)
- D)  $- 4.0 \hat{\mathbf{j}}$  (mT)
- E)  $+ 3.0 \hat{\mathbf{i}}$  (mT)

Q22.

A uniform magnetic field exerts a torque on each of the current-carrying single loops of wire shown in **FIGURE 4**. The loops lie in the  $xy$ -plane, each carrying the same value of current in the directions shown. The magnetic field points in the positive  $x$ -direction. Rank the coils by the magnitude of the torque exerted on them by the field, from largest to smallest.

Fig#

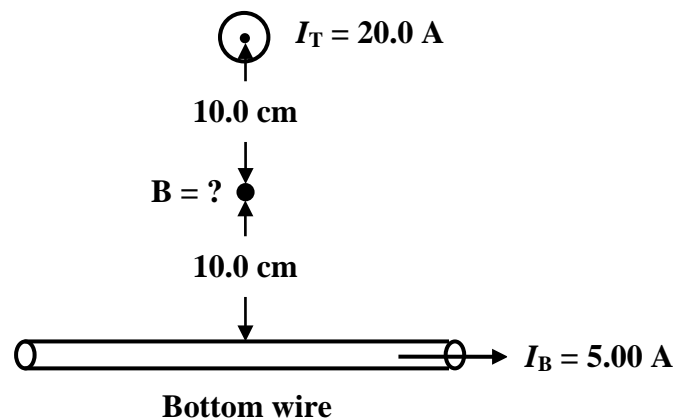


- A) A,C,B
- B) A,B,C
- C) B,A,C
- D) C,A,B
- E) B,C,A

Q23.

Two long wires are oriented so that they are perpendicular to each other, as shown in **FIGURE 5**. What is the magnitude of the magnetic field at a point midway between them if the top one carries a current of 20.0 A, and the bottom one carries a current of 5.00 A?

Fig#

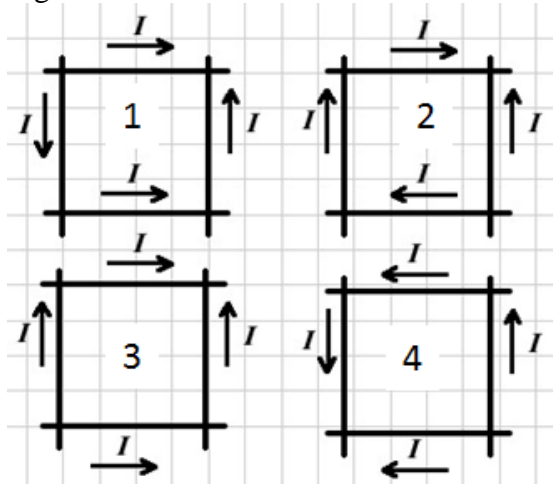


- A)  $4.12 \times 10^{-5}$  T
- B)  $5.22 \times 10^{-3}$  T
- C)  $3.02 \times 10^{-5}$  T
- D)  $7.47 \times 10^{-3}$  T
- E)  $6.25 \times 10^{-6}$  T

Q24.

**FIGURE 6** shows four different sets of wires that cross each other without touching. The magnitude of the current is the same in all four cases, and the directions of current flow are as indicated. For which configuration will the magnetic field at the center of the square formed by the wires be equal to zero?

Fig#



- A) 3
- B) 1
- C) 2
- D) 4
- E) The field is equal to zero in all four cases

Q25.

A wire with a weight per unit length of  $0.080 \text{ N/m}$  is suspended directly above a second parallel wire. The top wire carries a current of  $30 \text{ A}$ , and the bottom wire carries a current of  $60 \text{ A}$ . Find the separation between the wires so that the top wire will be held in place by magnetic repulsion.

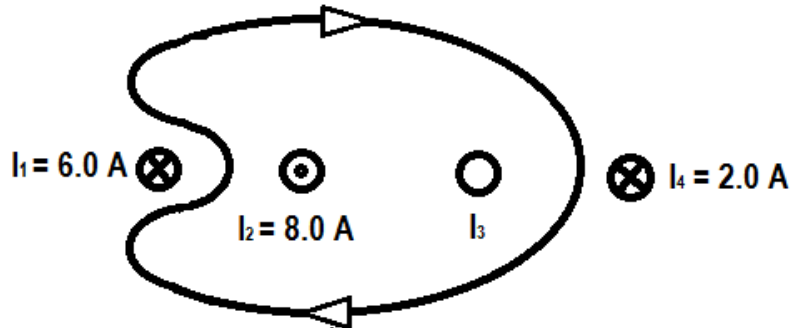
- A)  $4.5 \text{ mm}$
- B)  $2.1 \text{ mm}$
- C)  $5.3 \text{ mm}$
- D)  $7.5 \text{ mm}$
- E)  $1.7 \text{ mm}$



Q26.

The value of the line integral  $\oint \vec{B} \cdot d\vec{s}$  around the closed path in **FIGURE 8** is  $1.4 \times 10^{-5}$  T.m. What are the direction and magnitude of  $I_3$ ?

Fig#

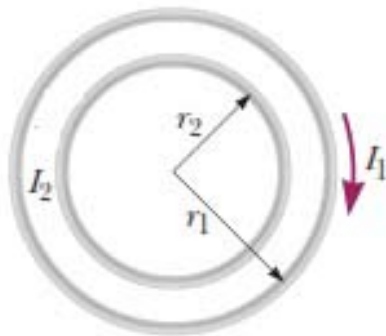


- A) 19 A, into the page
- B) 19 A, out of the page
- C) 3.1 A, out of the page
- D) 3.1 A, into the page
- E) 8.0 A, into the page

Q27.

Two coplanar and concentric circular loops of wire carry currents of  $I_1 = 6.0$  A and  $I_2 = 3.0$  A, as shown in **FIGURE 7**. If  $r_1 = 12$  cm. What are the value of  $r_2$  and the direction of  $I_2$  such that the net magnetic field at the center of the two loops is zero?

Fig#



- A)  $r_2 = 6.0$  cm, Counterclockwise
- B)  $r_2 = 6.0$  cm, Clockwise
- C)  $r_2 = 3.0$  cm, Counterclockwise
- D)  $r_2 = 3.0$  cm, Clockwise
- E)  $r_2 = 4.0$  cm, Counterclockwise

Q28.

A 10-turn square coil, with a resistance of  $0.60 \Omega$  and side length  $5.0 \text{ cm}$ , is placed in an external magnetic field, as shown in **FIGURE 9**. The magnetic field decreases uniformly from  $0.050 \text{ T}$  to zero in  $10 \text{ ms}$ . What is the current induced in the loop?

Fig#

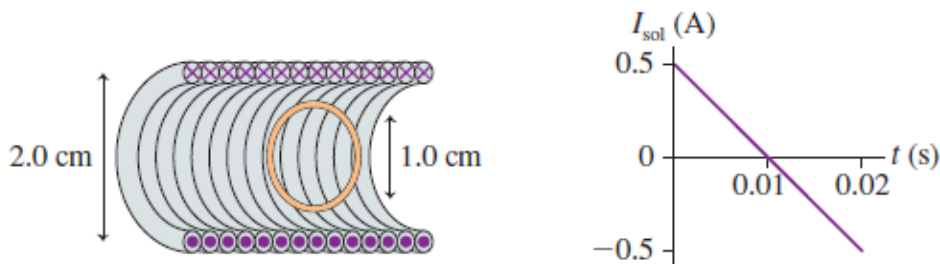


- A)  $0.21 \text{ A}$ , clockwise
- B)  $0.21 \text{ A}$ , counterclockwise
- C)  $0.42 \text{ A}$ , clockwise
- D)  $0.42 \text{ A}$ , counterclockwise
- E) Zero

Q29.

**FIGURE 10** shows a 50-turn coil, with a diameter of  $1.0\text{-cm}$ , inside a solenoid with a diameter of  $2.0 \text{ cm}$ . The solenoid is  $8.0 \text{ cm}$  long, has  $1200$  turns, and carries the current shown on the right in the figure. What is the magnetic flux through the coil at time  $t = 0$ ?

Fig#

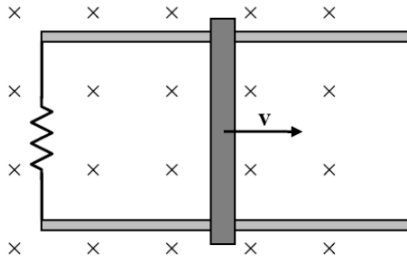


- A)  $3.7 \times 10^{-5} \text{ Wb}$
- B)  $4.2 \times 10^{-5} \text{ Wb}$
- C)  $5.3 \times 10^{-5} \text{ Wb}$
- D)  $8.1 \times 10^{-5} \text{ Wb}$
- E)  $1.2 \times 10^{-5} \text{ Wb}$

Q30.

A force  $F$  is applied to pull a conducting rod out of a magnetic field at constant speed  $v$  and power input  $P$ , as shown in **FIGURE 11**. The rod moves on conducting rails. The force is increased so that the constant speed of the rod is doubled to  $2v$ . What are the new force and power input?

Fig#



- A)  $2F$  and  $4P$
- B)  $2F$  and  $2P$
- C)  $4F$  and  $2P$
- D)  $4F$  and  $4P$
- E)  $2F$  and  $P$