1. (6 points) In the circuit below, assume the switch has been closed for a very long time. What is the current delivered by the capacitor just after the switch is opened? $\mathcal{E} = 12.0$ V, $R_1 = 3.00$ Ω, $R_2 = 2.00$ Ω, $R_3 = 6.00$ Ω, $C = 9.00$ μF.

   (A) 2.40 A

   (B) 0.600 A

   (C) 2.67 A

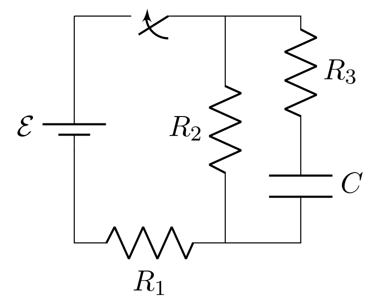
   (D) 0.500 A

   (E) 1.50 A

   (F) 2.00 A

   (G) 1.33 A

   (H) 0.667 A



Points Per Response:
A: 2
B: 6
C: 1
D: 2
E: 4
F: 1
G:
H:

2. (6 points) What is the potential energy stored in the capacitor just before the switch is opened?

   (A) 104 μJ

   (B) 648 μJ

   (C) 233 μJ

   (D) 352 μJ

   (E) 824 μJ

   (F) 442 μJ

Points Per Response:
A: 6
B: 4
C: 4
D:
E:
F:

3. (4 points) A parallel plate capacitor is fully charged and then disconnected from the battery. If the separation between the plates is decreased, what happens to the electric field between the plates?

(A) The electric field decreases in magnitude.

(B) The electric field increases in magnitude.

(C) The magnitude of the electric field stays constant.

(D) It is impossible to tell with the given information.

Points Per Response:
A:
B:
C: 4
D:

4. (6 points) In the following circuit, all the resistors have identical resistors R. What is the equivalent resistance of the circuit?

(A) $\frac{5}{12}R$

(B) R

(C) $6R$

(D) $\frac{12}{5}R$

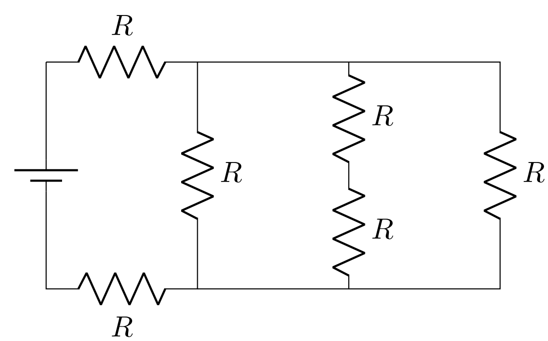
(E) $\frac{4}{9}R$

(F) $\frac{9}{4}R$

(G) $\frac{3}{8}R$

(H) $\frac{8}{3}R$

Points Per Response:
A: 3
B:
C:
D: 6
E:
F:
G:
H:



5. (6 points) In the circuit below all resistors have a resistance of 6.0 Ω and the battery emfs are labeled. The three currents have also been labeled along with their directions. What is the current labeled I_3 based on its predicted direction?

   (A) $+0.63$ A

   (B) -0.63 A

   (C) $+0.50$ A

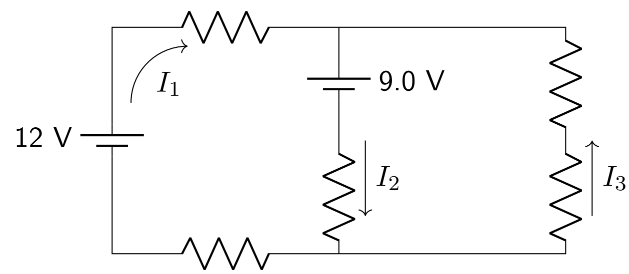
   (D) -0.50 A

   (E) $+1.0$ A

   (F) -1.0 A

   (G) $+0.33$ A

   (H) -0.33 A



Points Per Response:
A: 5
B: 6
C: 3
D: 2
E:
F:
G:
H:

6. (4 points) Which unit vector below represents the initial direction of the deflection of the positively charged particle as it enters the magnetic field? Pay attention to the direction of the magnetic field and the coordinate axes as drawn in the figure.

   (A) $+\hat{k}$

   (B) $-\hat{k}$

   (C) $+\hat{\imath}$

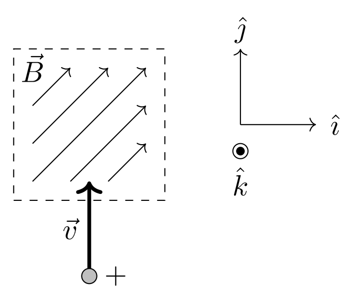
   (D) $-\hat{\imath}$

   (E) $+\frac{1}{\sqrt{2}}\hat{\imath}+\frac{1}{\sqrt{2}}\hat{\jmath}$

   (F) $+\frac{1}{\sqrt{2}}\hat{\imath}-\frac{1}{\sqrt{2}}\hat{\jmath}$

   (G) $-\frac{1}{\sqrt{2}}\hat{\imath}+\frac{1}{\sqrt{2}}\hat{\jmath}$

   (H) $-\frac{1}{\sqrt{2}}\hat{\imath}-\frac{1}{\sqrt{2}}\hat{\jmath}$



Points Per Response:
A: 3
B: 4
C:
D:
E: 1
F:
G:
H:

7. (6 points) A conducting rod of length L is free to slide on two parallel conducting bars, as shown in the figure below. Two resistors R_1 and R_2 are connected across the ends of the bars to form a loop. A constant magnetic field B is directed perpendicular into the page. An external agent pulls the rod to the left with a constant speed of v. Find the current through R_1.

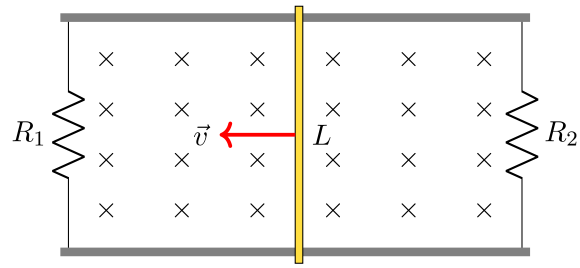
   (A) $\frac{BLv}{R_1}$

   (B) $\frac{BLv}{R_1 + R_2}$

   (C) $\frac{BLv(R_1 + R_2)}{R_1 R_2}$

   (D) BLv

   (E) $BLvR_1$



Points Per Response:
A: 6
B: 2
C: 4
D:
E:

8. (6 points) A current path shaped as shown in the figure below produces a magnetic field at P, the center of the arc. If the arc subtends an angle of 30.0°and the radius of the arc is 4.00 m, what are the magnitude and direction of the field produced at P if the current is 24.0 A?

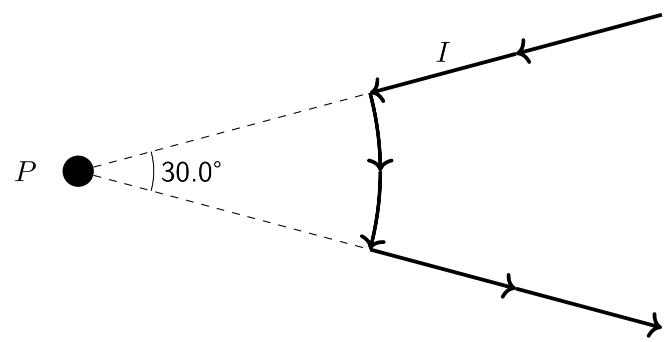
   (A) 3.14×10^{-7} T

   (B) 3.77×10^{-6} T

   (C) 4.83×10^{-7} T

   (D) 4.66×10^{-6} T

   (E) 0



Points Per Response:
A: 6
B: 3
C:
D:
E:

9. (6 points) In an ideal LC-circuit the charge on the capacitor can be defined by the function $q(t) = q_0 \sin(\omega t)$ where $q_0 = 320.0$ mC. The capacitor has a capacitance of 47.00 μF and the inductor has an inductance of 140.0 mH. What is the magnitude of the potential that would be measured across the inductor at the time $t = 3.000$ s?

   (A) 5112 V

   (B) 6796 V

   (C) 4891 V

   (D) 3348 V

   (E) 2764 V

   Points Per Response:
   A: 6
   B: 5
   C:
   D:
   E:

10. (6 points) The sun emits an average power of 3.86×10^{26} W and the distance from the sun to mars is 2.28×10^{6} km. Assuming the light is monochromatic, what is the amplitude of the magnetic field at the location of Mars?

    (A) 2.22×10^{-4} T

    (B) 1.11×10^{-4} T

    (C) 1.57×10^{-4} T

    (D) 3.15×10^{-4} T

    (E) 4.45×10^{-4} T

    Points Per Response:
    A: 6
    B:
    C:
    D: 4
    E: 4

11. (6 points) A circuit contains a battery and an inductor that is long enough to have an appreciable resistance. There are no other components to the circuit. When the circuit is connected it takes 0.750 seconds for the circuit to reach 40% of the maximum current. If the inductor has 5.00 H of inductance, what is the resistance of the inductor?

    (A) 3.41 Ω

    (B) 1.47 Ω

    (C) 6.11 Ω

    (D) 0.819 Ω

    (E) 9.24 Ω

    (F) 4.61 Ω

    (G) 2.03 Ω

    (H) 1.11 Ω

Points Per Response:

A: 6
B: 3
C: 4
D: 2
E:
F:
G:
H:

12. (6 points) A thin ring of radius $a = 2.00$ cm is uniformly charged with a positive charge $Q = 25.0\ \mu$C. A point charge of $q = -12.0\ \mu$C is held at rest at a distance of $x = 4.00$ cm from the center of the ring along the axis. If q is released, what is the work done by the electric field to bring the point charge to the center of the ring?

(A) 74.6 J

(B) 60.4 J

(C) 135 J

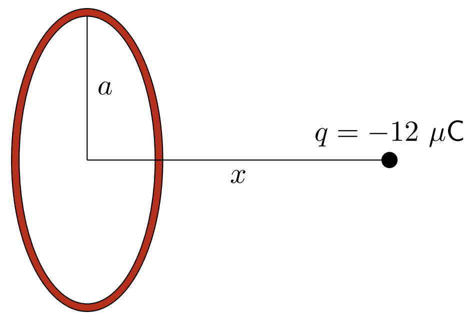
(D) 7.13 J

(E) 67.5 J

(F) 13.9 J

(G) 93.3 J

(H) 156 J



Points Per Response:

A: 6
B: 3
C: 2
D: 3
E: 2
F:
G:
H:

13. (6 points) Four identical charges Q and a fifth charge $-q$ are arranged as shown in the figure below. In this configuration, what is the magnitude of the electric force acting on $-q$?

(A) $\frac{kqQ}{\sqrt{2}a^2}$

(B) $\frac{kqQ}{a^2}$

(C) $\frac{kqQ}{2a^2}$

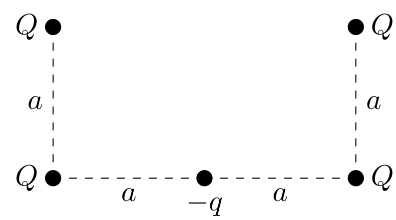
(D) $\frac{3kqQ}{a^2}$

(E) $\frac{4kqQ}{a^2}$

(F) $\frac{2kqQ}{a^2}$

(G) $\frac{\sqrt{2}kqQ}{a^2}$

(H) $\frac{3kqQ}{2a^2}$



Points Per Response:

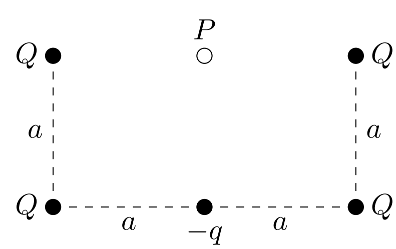
A: 6
B: 2
C:
D: 2
E:
F:
G:
H:

14. (2 points) What is the sign of the work done by the electric field to move the charge $-q$ in the previous problem from its original position to point P shown in the figure below? Note that P is in line with the top two charges.

(A) $W > 0$

(B) $W = 0$

(C) $W < 0$



Points Per Response:

A: 1
B: 2
C:

15. (6 points) A conducting wire of $L = 1.00$ m in length and $R = 1.00$ mm radius is uniformly charged with a total positive charge $Q = 100$ nC is placed in a concentric conducting tube of the same length. The tube is $t = 1.00$ mm thick, has the external radius of 3.00 mm, and it was initially uniformly charged with the same $Q = 100$ nC. What is the electric flux passing through an external concentric cylindrical surface T with radius 4.00 mm and a height of 1.00 mm? (Note that the answer is the same if the cylindrical surface T is a closed surface or an open surface that is just the curved part of a cylinder.)

   (A) 22.6 Nm^2/C

   (B) 11.3 Nm^2/C

   (C) 2830 Nm^2/C

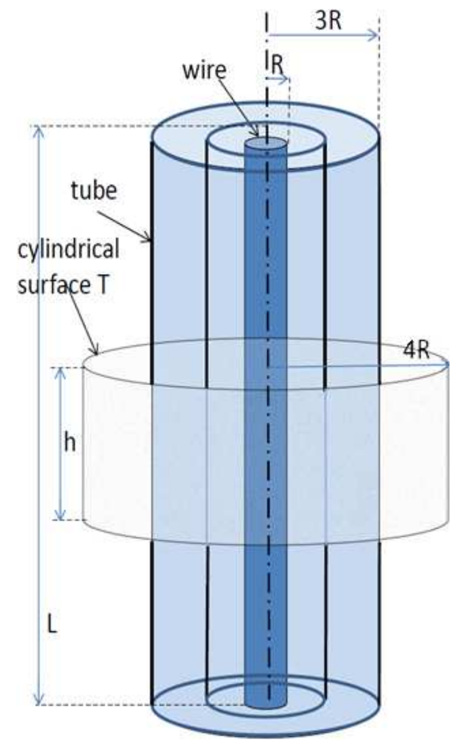
   (D) 4.52×10^{-2} Nm^2/C

   (E) 2.26×10^{-2} Nm^2/C

   (F) 1990 Nm^2/C

   (G) 622 Nm^2/C

   (H) 185 Nm^2/C



Points Per Response:
A: 6
B: 4
C:
D: 4
E: 2
F:
G:
H:

16. (4 points) Which of the following surfaces has the greatest flux through it?

    (A) S1

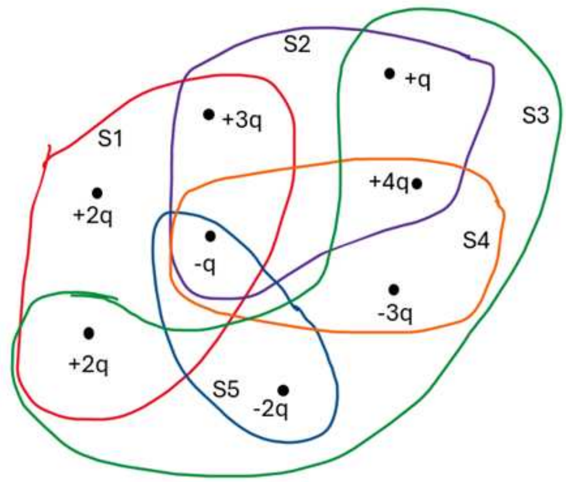
    (B) S2

    (C) S3

    (D) S4

    (E) S5

    (F) It is impossible to tell



Points Per Response:
A:
B: 4
C:
D:
E:
F:

17. (4 points) An EM wave has wave number k and angular frequency ω. At some instant in time, t and at position x, the electric field points along the $+y$-direction. If the wave travels in the $-z$-direction and the amplitude of the magnetic field is B_0, what is the vector equation for the magnetic field?

    (A) $\vec{B} = B_0 \sin(kz + \omega t)\,\hat{x}$

    (B) $\vec{B} = B_0 \sin(kz - \omega t)\,\hat{x}$

    (C) $\vec{B} = -B_0 \sin(kz + \omega t)\,\hat{x}$

    (D) $\vec{B} = -B_0 \sin(kz - \omega t)\,\hat{x}$

    (E) $\vec{B} = B_0 \sin(kx + \omega t)\,\hat{z}$

    (F) $\vec{B} = B_0 \sin(kx - \omega t)\,\hat{z}$

    (G) $\vec{B} = -B_0 \sin(kx + \omega t)\,\hat{z}$

    (H) $\vec{B} = -B_0 \sin(kx - \omega t)\,\hat{z}$

Points Per Response:
A: 4
B: 3
C: 3
D: 2
E:
F:
G:
H:

18. (4 points) A block of copper is set aside to make wire. The copper originally has cross-section A and length ℓ. If the copper block is of uniform resistivity and uniform density, but is stretched to double its original length, what happens to the resistance of the block? Assume the volume stays constant.

(A) Resistance is decreased by a factor of 8

(B) Resistance is decreased by a factor of 4

(C) Resistance is decreased by a factor of 2

(D) Resistance stays constant

(E) Resistance is increased by a factor of 2

(F) Resistance is increased by a factor of 4

(G) Resistance is increased by a factor of 8

Points Per Response:
A:
B:
C:
D:
E: 1
F: 4
G:

19. (6 points) At one instant, a 3.00 C charge has a velocity vector $\vec{v} = 900\hat{\imath}$ in a region of space with an electric field $\vec{E} = 600\hat{\jmath} + 700\hat{k}$ and a magnetic field $\vec{B} = 2.5\hat{k}$. All vectors are given in SI units. What is the magnitude of the force acting on this charge?

(A) 5380 N

(B) 8800 N

(C) 2770 N

(D) 6750 N

(E) 1790 N

(F) 2930 N

(G) 4880 N

(H) 7610 N

Points Per Response:
A: 6
B: 4
C: 2
D: 2
E: 4
F: 3
G:
H: