Use three significant figures. NEATNESS COUNTS!!! Box answers.

Conceptual Questions. Circle the BEST answer.

1. If we wanted to cancel the Earth’s magnetic field by running an enormous current loop around the equator, the current loop would be directed:
   a. east to west
   b. west to east
   c. north to south

2. What is the current direction in the loop?
   A. Out of the page at the top of the loop, into the page at the bottom.
   B. Out of the page at the bottom of the loop, into the page at the top.

3. A square loop of copper wire is pulled through a region of magnetic field. Rank in order, from strongest to weakest, the pulling forces \( F_a \), \( F_b \), \( F_c \), and \( F_d \) that must be applied to keep the loop moving at constant speed.

   A. \( F = F > F = F \)
   B. \( F > F = F > F \)
   C. \( F > F > F > F \)
   D. \( F > F > F = F \)
   E. \( F > F > F > F \)

4. A square conductor moves through a uniform magnetic field. Which of the figures shows the correct charge distribution on the conductor?

5. Rank in order, from largest to smallest, the time constants \( \tau_a \), \( \tau_b \), and \( \tau_c \) of these three circuits.

   A. \( \tau > \tau > \tau \)
   B. \( \tau > \tau > \tau \)
   C. \( \tau > \tau > \tau \)
   D. \( \tau > \tau > \tau \)
   E. \( \tau > \tau > \tau \)
Short problems. Show work, box answers, circle best answer.

6. If the maximum $E$-component of an electromagnetic wave is 600 V/m, what is the maximum $B$-component?
   a. 1.4 T
   b. $1.8 \times 10^{-5}$ T
   c. $2.0 \times 10^{-6}$ T
   d. $1.0 \times 10^{-3}$ T
   e. $1.6 \times 10^{-10}$ T

7. What is the average value of the magnitude of the Poynting vector $\mathbf{S}$ at 1 meter from a 100-watt lightbulb radiating in all directions?
   a. 1 W/m$^2$
   b. 4 W/m$^2$
   c. 2 W/m$^2$
   d. 8 W/m$^2$
   e. 12 W/m$^2$

8. How much electromagnetic energy is contained in each cubic meter near the Earth’s surface if the intensity of sunlight under clear skies is 1000 W/m$^2$?
   a. $3.3 \times 10^{-6}$ J
   b. 3.3 J
   c. 0.003 J
   d. $10^{-4}$ J
   e. $3.0 \times 10^5$ J

9. At a distance of 10 km from a radio transmitter, the amplitude of the $E$-field is 0.20 volts/meter. What is the total power emitted by the radio transmitter?
   a. 10 kW
   b. 67 kW
   c. 140 kW
   d. 245 kW
   e. 21 kW

10. What is the maximum radiation pressure exerted by sunlight in space ($S = 1350$ W/m$^2$) on a highly polished silver surface?
    a. $1.4 \times 10^{-2}$ Pa
    b. 0.12 Pa
    c. $9.0 \times 10^{-6}$ Pa
    d. $4.5 \times 10^{-5}$ Pa
    e. $2.3 \times 10^{-6}$ Pa
1. The figure shows a cross section of three parallel wires each carrying a current of 20 A. The currents in wires A and B are out of the paper, while that in wire C is into the paper. If the distance $R = 5.0$ mm, what is the magnitude of the force on a 2.0-m length of wire A? Draw a vector diagram showing the individual and net fields at A and direction of the net force. You may do it on the diagram.

a. 23 m
b. 64 mN
c. 32 mN
d. 46 mN
e. 55 mN
2. What is the magnitude of the magnetic field at point P if \( a = R \) and \( b = 2R \)? Use Biot-Savart to derive your solution. Be complete.

a. \( \frac{\mu_0 I}{6R} \)

b. \( \frac{3\mu_0 I}{16R} \)

c. \( \frac{\mu_0 I}{12R} \)

d. \( \frac{\mu_0 I}{16R} \)

e. \( \frac{\mu_0 I}{32R} \)
3. Before the switch is closed in the figure, the potential across the capacitor is 200 V. At some instant after the switch is closed, the instantaneous current is 0.70 A. What is the energy in the capacitor at this instant? Show how the units work out. (Hint: Use energy!!)

\[ U = 200 \text{ V}, \quad I = 0.70 \text{ A} \]

\[ E = \frac{1}{2} CU^2 \]

\[ E = \frac{1}{2} \times 40 \times 10^{-6} \times (200)^2 \]

\[ E = 0.49 \text{ mJ} \]

a. 49 mJ
b. 31 mJ
c. 80 mJ
d. 0.13 J
e. 62 mJ
4. A copper rod slides on two conducting rods of negligible resistance in a uniform 0.42 T magnetic field as shown. The rod starts at point A and moves to the right at a speed of 0.40 m/s.

a) Find the average emf induced in the triangle ABC after 5.00 seconds.
b) If the resistance in the rod is 6 Ω, what is the magnitude and direction of the induced current?
c) Find the magnetic force on the rod at t = 5 seconds.
5. A very long solid cylindrical conductor of radius 5.00 mm carries a current of 50 A parallel to its axis. This current density is non-uniformly distributed over a cross section of the conductor and varies with the radius as \( J = \frac{\alpha}{r} \). Use Ampere’s Law to determine the magnitude of the magnetic field at a point that is 2.0 mm from the axis of the conductor. Sketch the situation, labeling everything. Be COMPLETE! Show how the units work out in your final calculation of B.