Exam 2 — Physics 241
November 11, 2003

1. Please print your name on the top edge of the op-scan sheet.
2. Use a #2 pencil to fill in your full name, your student identification number, your recitation division number, and finally the answers for problems 1–12.
3. One (both sides) 8 1/2" x 11" crib sheet is allowed. It must be hand-written.

Useful equations and constants:

$$d\vec{B} = \frac{\mu_0 i}{4\pi}\frac{d\vec{\ell}\times\vec{r}}{r^3} \qquad \oint \vec{B}\cdot d\vec{s} = \mu_0 i_{enc} \qquad F = q\vec{v}\times\vec{B} \quad F = i\vec{\ell}\times\vec{B}$$

$$\vec{\tau} = \vec{\mu}\times\vec{B} \qquad \mu = NiA \qquad \frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi d} \qquad d\varepsilon = -Bv d\ell \qquad N\phi_B = Li$$

$$\oint \vec{E}\cdot d\vec{s} = -\frac{d\phi_B}{dt} \qquad \varepsilon = -N\frac{d\phi_B}{dt} \qquad \phi_B = BA$$

$$U_E = \frac{1}{2}CV^2 \qquad V = \varepsilon(1-e^{-t/RC}) \qquad i = \frac{\varepsilon}{R}e^{-t/RC} \qquad q = q_0 e^{-t/RC}$$

$$U_B = \frac{1}{2}Li^2 \qquad V = \varepsilon(1-e^{-Rt/L}) \qquad i = \frac{\varepsilon}{R}(1-e^{-Rt/L}) \qquad \omega_0 = \sqrt{\frac{1}{LC}}$$

$$\omega' = \sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}} \qquad \varepsilon_m = i_m Z \qquad Z = \sqrt{R^2+(X_L-X_C)^2} \qquad X_L = \omega L \qquad X_C = \frac{1}{\omega C}$$

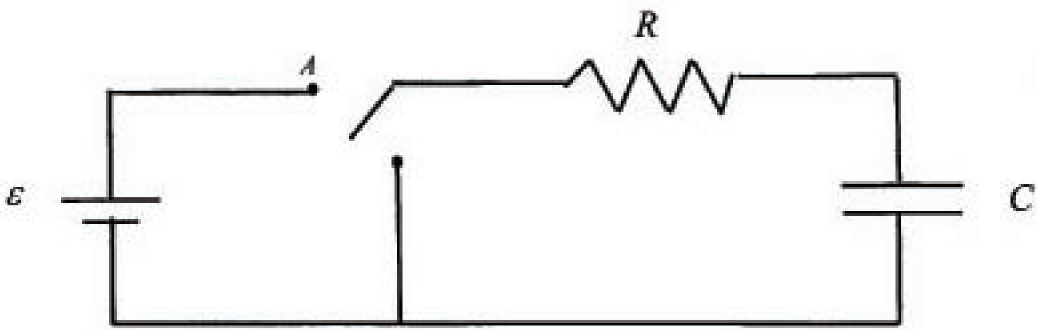
$$\tan\phi = \frac{X_L - X_C}{R} \qquad P_{av} = \frac{1}{2}\frac{(\varepsilon_m)^2}{Z}\cos\phi \qquad \bar{S} = \frac{1}{\mu_0 c}\frac{(E_m)^2}{2}$$

$$\mu_0 = 4\pi\times10^{-7}\, T\cdot m/A \qquad \varepsilon_0 = 8.85\times10^{-12}\frac{C^2}{N\cdot m^2}$$

$$e = 1.6\times10^{-19}C \qquad m_p = 1.67\times10^{-27}kg$$

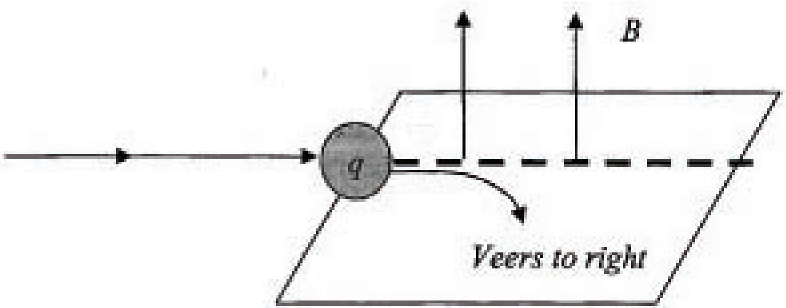
$$\mu(micro) \Rightarrow 10^{-6} \qquad n(nano) \Rightarrow 10^{-9} \qquad p(pico) \Rightarrow 10^{-12}$$

1. A circuit for charging a capacitor is shown below. The switch is thrown to position A at $t=0$. The circuit has elements $\varepsilon=12V$, $R=100\ \Omega$ and $C=10\mu F$. How long does it take for the capacitor to be charged to 99.9 percent of its final charge?



(a) 6.91 ms
(b) 0.99 ms
(c) 0.0001 ms
(d) 0.001 ms
(e) 0.0691 ms

2. A particle of unknown charge q and unknown mass m moves at a speed $v=4.8\times10^6$ m/s in the +x-direction into a region of constant magnetic field. The field has magnitude B=0.5 T and is orientated in the +y-direction. The particle is deflected in the +z-direction and traces out a fragment of a circle of radius R=0.1m. What is the sign of the charge and what is its ratio of q/m?

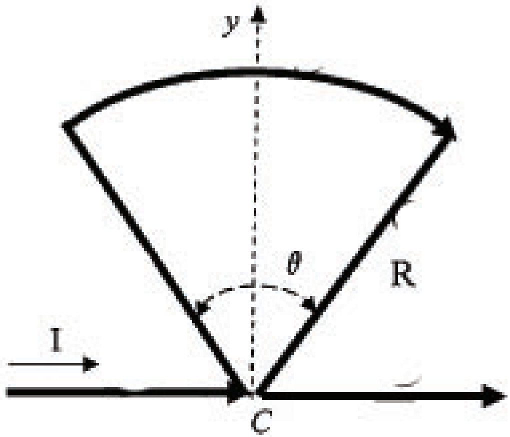


(a) Neutral, q/m=0
(b) Negative, q/m=1.4×10^{-8} C/Kg
(c) Positive, q/m=1.4×10^{8} C/Kg
(d) Negative, q/m=9.6×10^{7} C/Kg
(e) Positive, q/m=9.6×10^{7} C/Kg

3. A loop of wire carrying a current has a magnetic dipole moment $\mu = 5\times10^{-4}$ A·m^2. Initially, the vector μ makes an angle of 90^0 with a 0.5 T magnetic field. As it turns to become aligned with the field, the **work done by the field** is:

(a) 0 J
(b) 2.5×10^{-4} J
(c) -2.5×10^{-4} J
(d) 1.0×10^{-4} J
(e) -1.0×10^{-4} J

4. Calculate the magnitude of the magnetic field at the point C=(0,0) for the current loop shown below. The loop consists of two straight portions and a circular arc of radius R, which subtends an angle $\theta=\pi/2$ at the center of the arc. Ignore the contribution of the current in the short arcs near the origin (0,0).

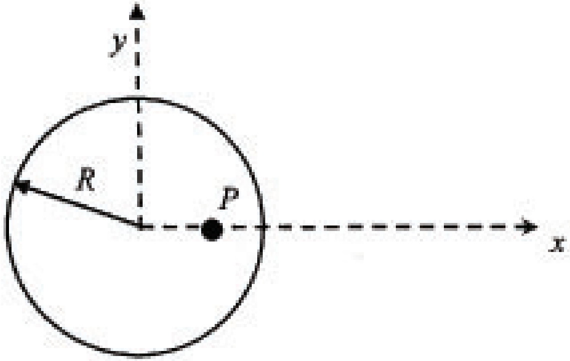


(a) $B=\mu_0 I/(8\pi R)$
(b) $B=\mu_0 I/(2\pi R)$
(c) $B=\mu_0 I/(8R)$
(d) $B=\mu_0 I/(2R)$
(e) $B=\mu_0 I/(4R)$

5. Two parallel infinite wires 4 cm apart carry currents of 2A and 4A respectively in the same direction. The force per unit length in N/m of one wire on the other is:

(a) 1×10^{-3} N/m repulsive
(b) 1×10^{-3} N/m attractive
(c) 4×10^{-5} N/m repulsive
(d) 4×10^{-5} N/m attractive
(e) None of these

6. A long straight wire (radius R= 3mm) carries a constant current distributed uniformly over a cross section perpendicular to the axis of the wire. If the current density is $j = 100 A/m^2$ in the $-z$ direction, what is the magnitude and direction of the magnetic field B at the point P located 2 mm from the axis of the wire along the x-axis? (Note that the +z axis points out of the page).

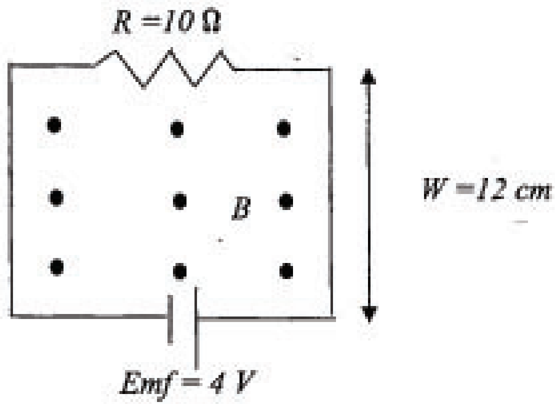


(a) 2×10^{-8} T in the +y-direction
(b) 2×10^{-8} T in the −y-direction
(c) 1.3×10^{-7} T in the +y-direction
(d) 1.3×10^{-7} T in the −y-direction
(e) None of these

7. Two long solenoids (radii 20 mm and 30 mm respectively) carry the came current I, flowing in opposite directions. The smaller solenoid is mounted inside the larger, along a common axis. It is observed that there is a zero magnetic field within the inner solenoid. Therefore the inner solenoid must have X times as many turns per unit length as the outer solenoid, where X is:

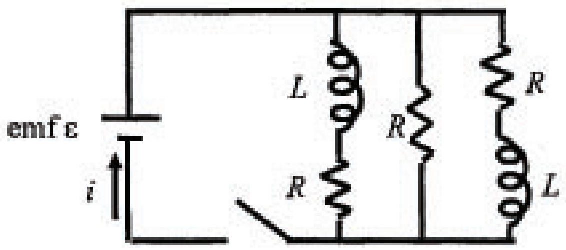
(a) 1
(b) 4/9
(c) 2/3
(d) 3/2
(e) 9/4

8. A square loop of wire measuring 12 cm by 12 cm has a battery of emf 4 V and a 10 Ohm resistor. A uniform magnetic field B points out of the page and is decreasing in magnitude at the rate of 150 T/s . The current in the circuit is:



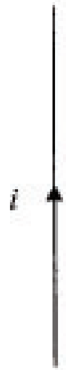
(a) 0.62 A, clockwise
(b) 0.22 A, clockwise
(c) 0.62 A, counterclockwise
(d) 0.22 A, counterclockwise
(e) 0 A

9. The figure below shows a circuit that contains three identical resistors with resistance $R = 9\ \Omega$, two identical inductors with inductance $L = 2.0$ mH and an ideal battery with emf ε =18V. What is the current i through the battery **just after** the switch is closed? What is the current i through the battery **a long time after** the switch has been closed?



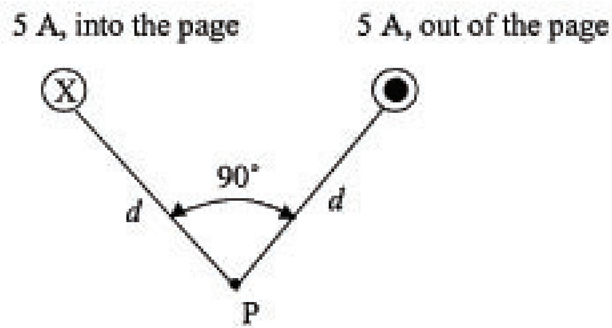
	just after	a long time after
(a)	3 A	2 A
(b)	6 A	6 A
(c)	2 A	2 A
(d)	6 A	2 A
(e)	2 A	6 A

10. A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries a constant current i, as shown below. While the wire is being moved toward the rectangle, the current in the rectangular loop is:



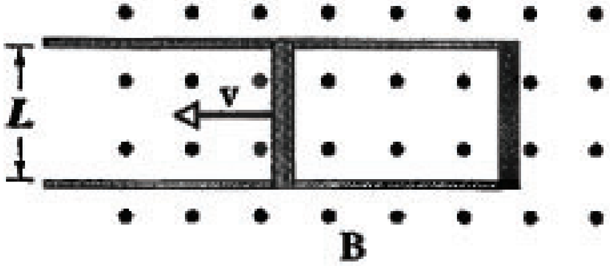
(a) Zero
(b) Clockwise
(c) Counterclockwise
(d) Clockwise on the left side and counterclockwise on the right side
(e) Counterclockwise on the left side and clockwise on the right side

11. Consider two parallel infinite wires, one carrying a current of 5 A out of the page, the other carrying a current of 5 A into the page. The point P is located such that if a line were drawn from P to each wire, then these lines would subtend an angle of 90 degrees, as shown below. Furthermore, the point P is at a distance *d* from each wire. What is the direction of the magnetic field at the point P?



(a) Up
(b) Down
(c) Left
(d) Right
(e) Into the page

12. A metal rod is forced to move with constant velocity v along two parallel metal rails, connected with a strip of metal at one end, as shown in the figure below. A magnetic field B = 0.5 T points out of the page. If the rails are separated by L = 20 cm and the speed of the rod is v = 10 cm/s, what is the emf generated? If the rod has a resistance of 5 ohms and the rails and connector have negligible resistance, what is the current I in the rod?



(a) emf=0.05 V, I=0.01 A
(b) emf=0.02 V, I=0.004 A
(c) emf=0.01 V, I=0.0 A
(d) emf=0.01 V, I=0.002 A
(e) emf=0 V, I=0 A

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1. A
2. E
3. B
4. C
5. D
6. D
7. A
8. C
9. E
10. C
11. B
12. D