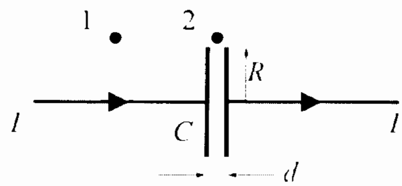
There are 10 multiple choice questions. Select the correct answer for each one and mark it on the bubble form. Each question has only one correct answer. (2 marks each)

1. A constant current, I, is supplied for a brief time to charge a parallel plate capacitor. The capacitor has circular plates of radius R with a gap d ($d << R$). Point 1 is at a distance $R + d$ from the wire, and point 2 is at a distance $R + d$ from the centre of the capacitor.



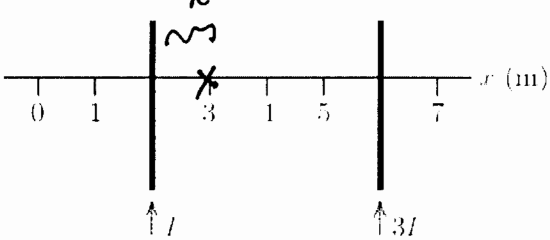
   (a) $B_1 < B_2$
   (b) $B_1 = B_2$
   (c) $B_1 > B_2 > 0$
   (d) $B_2 = 0$
   (e) Not enough information to answer

2. A beam of electrons is sent horizontally down the axis of a tube to strike a fluorescent screen at the end of the tube. On the way, the electrons encounter a magnetic field directed vertically upward. The spot on the screen will therefore be deflected:

   (a) upward
   (b) downward
   (c) to the right as seen from the electron source
   (d) to the left as seen from the electron source
   (e) not at all

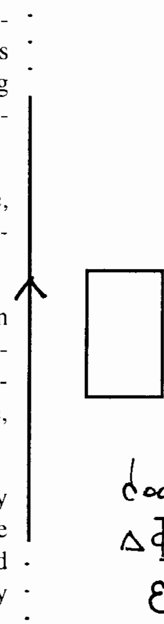
3. Two long straight current-carrying parallel wires cross the x axis and carry currents I and $3I$ in the same direction, as shown. At what value of x is the net magnetic field zero?

$\frac{3}{4-x} = \frac{1}{x}$ $x = 1$



   (a) 0
   (b) 1m
   (c) 3 m
   (d) 5m
   (e) 7m

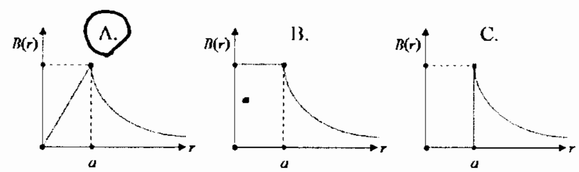
4. Consider a long wire running in the vertical direction with a rectangular loop of wire beside it as shown. Which of the following situations would result in a clockwise induced current in the loop?



   (a) A current in the long wire, directed upward, is increasing in magnitude.
   (b) With a constant current in the long wire directed upward, the loop is moved toward the top of the page, parallel to the long wire.
   (c) The loop is held stationary and the long wire, while carrying a constant upward current, is moved away from the loop.

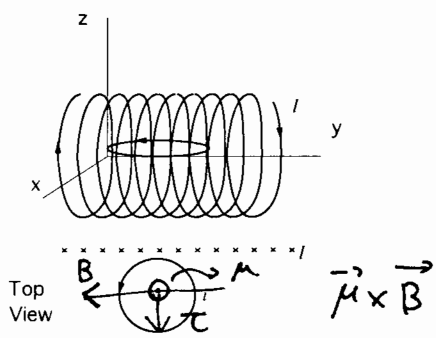
down = c.w.
$\Delta\Phi = +$
$\mathcal{E} = -$!
= c.w.

5. A long, straight wire of radius a carries a steady current I. The graph of magnetic field strength $B(r)$ as a function of perpendicular distance r from the centre of the wire is:



The next two questions relate to the situation described below.

A tiny wire loop with n turns of radius a, each carrying a counterclockwise current i, is placed inside a solenoid as shown. The solenoid has N turns, radius b, length d, and carries a current I.



6. What is the direction of the torque on the loop?

   (a) $+\hat{x}$
   (b) $-\hat{x}$
   (c) $-\hat{y}$
   (d) $+\hat{z}$
   (e) $-\hat{z}$

7. What is the magnitude of the torque on the loop?

   (a) $\mu_0 abiInN/d$
   (b) $\mu_0 \pi a^2 iInN/d$
   (c) $\mu_0 \pi^2 a^2 b^2 iInN/d$
   (d) $\mu_0 \pi a(i/I)nN/d$
   (e) $\mu_0 \pi (a/b)^2 iI(n/N)$

   $\mu = n\pi a^2 \cdot i$
   $B = \mu_0 \frac{N}{d} I$
   $|\mu||B| = \tau$

8. An inductor, capacitor and a resistor are in series with an ac sine-wave voltage source with frequency ω. The reactance of the inductor with inductance L is $X_L = \omega L$. The reactance of the capacitor with capacitance C is $X_C = 1/\omega C$. Under which condition is the current from the generator in phase with the emf (voltage)?

   (a) $X_C = R$
   (b) $X_C + X_L + R = 0$
   (c) $X_C + X_L = 0$
   (d) $X_L = R$
   (e) $X_C = X_L$

   $\tan\phi = 0$
   $X_L = X_C$
   $\omega L = \frac{1}{\omega C}$

9. In the Faraday's Law experiment you did in class, which of the following describes your qualitative results when the oscilloscope channel 1 displays the voltage across the resistor attached to the *field coil* and channel 2 displays the emf from the *pick-up coil.*

   (a) When channel 1 displays a square wave, channel 2 displays a square wave
   (b) When channel 1 displays a square wave, channel 2 displays a triangle wave
   (c) When channel 2 displays a square wave, channel 1 displays a triangle wave
   (d) When channel 2 displays a sine wave, channel 1 displays a square wave
   (e) When channel 1 displays a sine wave, channel 2 displays a triangle wave

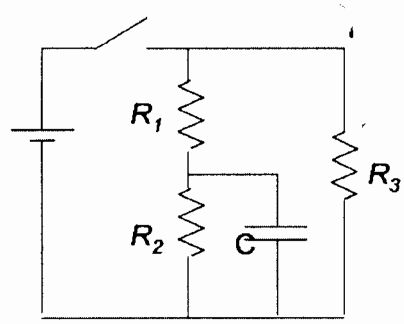
10. A capacitor, in series with a resistor, is being charged. At the end of 10 ms the charge on its positive plate is half the final value. The time constant for the process is about

    (a) 0.43 ms
    (b) 2.3 ms
    (c) 6.9 ms
    (d) 10 ms
    (e) 14 ms

    $V = V_0(1 - e^{-\frac{t}{\tau}})$
    $\frac{1}{2} = 1 - e^{-\frac{t}{\tau}}$
    $\frac{10\,ms}{\tau} = \ln(\frac{2}{1})$
    $\frac{10\,ms}{\ln 2} = \tau$
    $14.42\,ms = \tau$

There are four written problems. Show all your work to get full credit.

11. The values of all circuit elements are given in the figure. The capacitor is initially uncharged. Then, at time $t = 0$, the switch is closed.



E = 6 V
$R_1 = R_2 = R_3 = 10\ \Omega$
$C_1 = 1\ \mu F$

(a) Calculate the current through the battery immediately after the switch is closed.

$$I(t=0) = \frac{V_0}{(R_1R_3/R_1+R_3)} = \frac{6\,V}{5\,\Omega} = \boxed{1.2\,A}$$

(b) Calculate the charge on the capacitor a long time after the switch is closed.

Vc = Vb R2/(R1+R2) = 6V/2 = 3 V
Q=CVc = (1μF)(3V) = 3 μC

(c) A long time after the switch has been closed, it is re-opened. What is the time constant for discharging the capacitor?

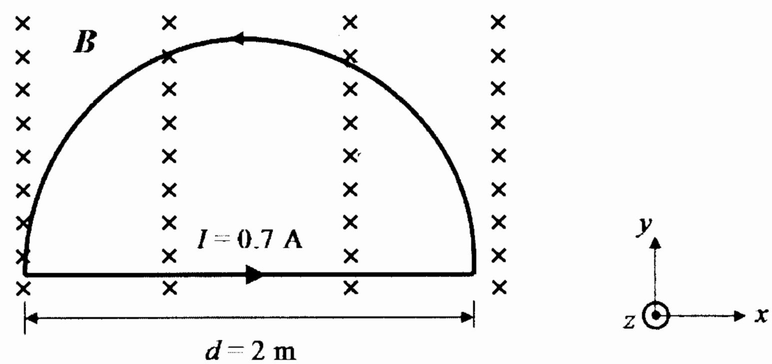
~~$\tau = 20$~~

$R_{eq} = \frac{20}{3}$

$(1\,\mu F)\left(\frac{20}{3}\,\Omega\right)$

$\boxed{= 6.\bar{6}\,\mu sec}$

12. A semi-circular loop consisting of one turn of wire is placed in the xy plane. A constant magnetic field of magnitude $B = 1.7$ T points along the negative z-axis (into the page), and a current $I = 0.7$ A flows counter-clockwise as viewed from the positive z-axis.



(a) Find the magnitude and direction of the net magnetic force on the circular section of the loop.

$F_{tot} = 0 \longrightarrow I\ell B = F$

$(0.7)(1.7)(2) = \boxed{2.38\,N}$

(b) Calculate the magnetic dipole moment of this loop.

$\mu = NIA$

$= (0.7)(\pi)(1m)^2$

$= \boxed{1.1\ \frac{Nm}{T}}$

Out of paper, in the z direction.

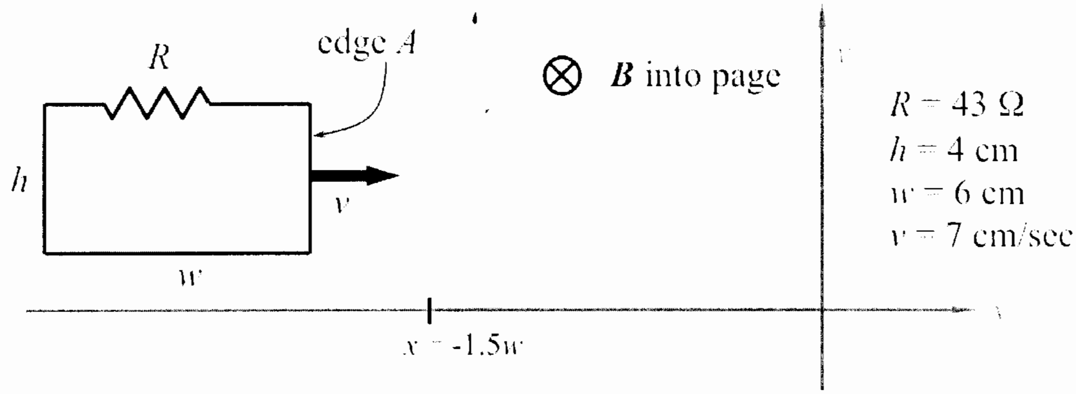
(c) What is the torque on the loop?

$\vec{\mu} \times \vec{B} = \vec{\tau}$

$(1.1\ \frac{Nm}{T})(1.7)\sin(180°)$

$= 0$ n•m

13. A rectangular wire loop of height h, width w, and net electrical resistance R lies in the xy plane. As shown in the figure below, there is a region of space at $-1.5w < x < 0$ in which there is a magnetic field pointing in the $-z$ direction. In order to determine the magnitude of this field, a student pulls the wire loop through the magnetic field region at a constant velocity v in the $+x$-direction, and measures the current I induced in the loop during this process.



(a) If, when the leading edge, A, of the loop is located at $x_A = -w$, the student measures a current of 20×10^{-6} A, what is the magnitude, B, of the magnetic field?

$\mathcal{E} = v\ell B$, $I = \frac{\mathcal{E}}{R}$

$$B = \frac{IR}{v\ell h} = \frac{(43\,\Omega)(20\times10^{-6}\,A)}{(.7\times10^{-2}\,m/s)(4\times10^{-2})} = \sim 3.07\times10 \sim \quad 0.307\,T$$

(b) What is the direction of the current flow? Explain your answer.

$\Delta\Phi = $ (−) down $= \leftrightarrow$ ccw

counter-clockwise current

(c) What is the magnitude of the force with which the student needs to pull it assuming no air resistance or friction?

$F = I\ell B$ ($\ell \to h$)

$= (20\times10^{-6}\,A)(0.04\,m)(0.307)$

$= 2.46\times10^{-5}\,N$

14. A plane electromagnetic wave in a vacuum is given by

$\vec{E} = 5(\hat{\imath} + \hat{k})\sin(\frac{2\pi}{\lambda}y + 4\pi \times 10^{15}t)$ V/m

$\vec{B} = \vec{B}_0 \sin(\frac{2\pi}{\lambda}y + 4\pi \times 10^{15}t)$ T

$f = 2\times10^{15}$

$\lambda = \frac{3\times10^{8}}{2\times10^{15}} = 1.5\times10^{-7}$ m

(a) What are the values of ω, k and $|\vec{E}_0|$?

$\omega = 4\pi\times10^{15}$ $\frac{rad}{sec}$ $k = \frac{2\pi}{\lambda}$ $\frac{2\pi}{1.5}\times10^{+7}$ $|\vec{E}_0| = 5\sqrt{2}$ N/C

(b) In what direction does the wave propagate? How do you know?

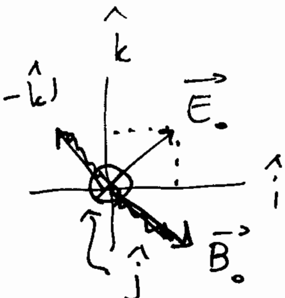
negative

(c) What is $\vec{B}_0$? (magnitude and direction)

$|B_0| = (3\times10^{-8})(5\sqrt{2})/3\times10^{8} = 2.35\times10^{-8}$ T.

$= 2.12\times10^{9}$

$\vec{B}_0 = \frac{2.35\times10^{-8}}{\sqrt{2}}(\hat{i}-\hat{k}) = 1.67\times10^{-8}(\hat{i}-\hat{k})$



(d) What is the wavelength in metres?

$\vec{E}_0 \times \vec{B}_0 = +\hat{j}$

also $\hat{k}\times\hat{i} = \hat{j}$

$\lambda = 1.5\times10^{-7}$ m

$\hat{k}\times\hat{i} = \hat{j}$

(e) Describe the polarization state as accurately as you can. (Specify angles if linear, or handedness if circular or elliptical.)

45° – from $\hat{k}$. (linear)