Name ________________________

Apr. 3, 2008

Phys 2020
Exam #2 — Spring 2008

1.	____________	(10)
2.	____________	(8)
3.	____________	(10)
4.	____________	(8)
5.	____________	(15)
6.	____________	(11)
7.	____________	(11)
8.	____________	(10)
9.	____________	(7)
MC	____________	(10)
Total	____________	(100)

Multiple Choice

Choose the best answer from among the four! (2) each.

1. 1 electron-volt equals

$\boxed{\textbf{a)}}$ 1.60×10^{-19} J

b) 1.60×10^{-19} W

c) 1.60×10^{-19} N

d) 1.60×10^{-19} J $\cdot$ s

2. If wires A and B are made of the same (conducting) material but wire B has twice the length and *half* the diameter of A, wire B's resistance is

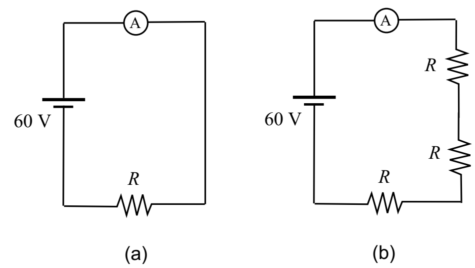
a) Half that of A

b) The same as that of A

c) 4 times that of A

$\boxed{\textbf{d)}}$ 8 times that of A

3. Compared to its reading in (a), the reading of the ammeter in (b) is



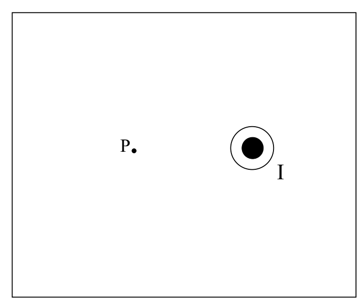
$\boxed{\textbf{a)}}$ $\frac{1}{3}$ as large.

b) The same.

c) 3 times as large.

d) 9 times as large.

4. At the right, I indicates a very long wire carrying a current I that comes out of the page. The magnetic field at point P points



a) Left.

b) Right.

c) Up.

$\boxed{\textbf{d)}}$ Down.

5. A uniform magnetic field can be created using (a)

a) Parallel conducting plates

b) A long wire.

$\boxed{\textbf{c)}}$ A solenoid.

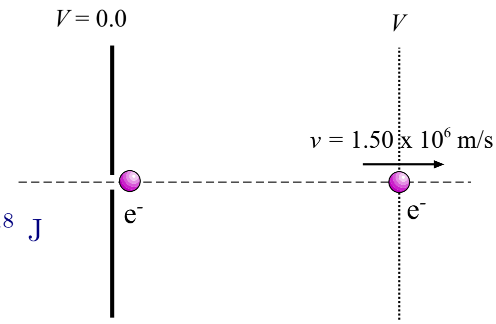
d) A wire loop with N turns.

Problems

Show your work and include the correct units with your answers!

1. An electron is accelerated from rest to a final speed of $1.50 \times 10^6 \frac{\mathrm{m}}{\mathrm{s}}$. It begins at a location where the electric potential is zero.

a) What is the final kinetic energy of the electron? (4)



$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}(9.11\times10^{-31}\ \mathrm{kg})(1.50\times10^6 \tfrac{\mathrm{m}}{\mathrm{s}})^2 = 1.02\times10^{-18}\ \mathrm{J}$$

b) What is the value of the electric potential (V) at the electron's final position? (Be sure to get the sign right.) (6)

By energy conservation, the gain in potential comes from a loss in (electric) potential energy. So from (a), $\Delta U = -1.02 \times 10^{-18}\ \mathrm{J}$. Since $\Delta U = q\Delta V$, then

$$\Delta V = \frac{\Delta U}{q} = \frac{(-1.02 \times 10^{-18}\ \mathrm{J})}{(-1.60 \times 10^{-19}\ \mathrm{C})} = 6.40\ \mathrm{V}$$

So since initial value of V is *zero*, the second value is $\boxed{+6.40\ \mathrm{V}}$. (A negative charge moves *toward* a region of higher potential.)

2. a) What is the capacitance of a capacitor which stores $1.0\,\mu\mathrm{C}$ of charge with a 12.0 V potential difference? (3)

Use $Q = CV$. Then

$$C = \frac{Q}{V} = \frac{(1.0 \times 10^{-6}\ \mathrm{C})}{(12.0\ \mathrm{V})} = 8.3 \times 10^{-8}\ \mathrm{F}$$

b) How much *energy* is stored in the capacitor under those conditions? (5)

$$U_C = \tfrac{1}{2}C(\Delta V_C)^2 = \tfrac{1}{2}(8.3 \times 10^{-8}\ \mathrm{F})(12.0\ \mathrm{V})^2 = 6.0 \times 10^{-6}\ \mathrm{J}$$

3. What is the length of a 0.60 mm diameter copper wire if it carries a 2.0 A current when connected to the terminals of a 9.0 V battery? [For the resistivity of copper, use $1.7\times10^{-8}\ \Omega\cdot\mathrm{m}$.] (10)

The resistance of the wire is

$$R = \frac{V}{I} = \frac{(9.0\ \mathrm{V})}{(2.0\ \mathrm{A})} = 4.5\,\Omega$$

and then use

$$R = \rho\frac{L}{A} \qquad \Longrightarrow \qquad L = \frac{RA}{\rho}$$

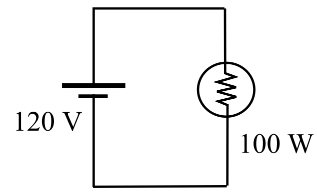
The cross-sectional area of the wire (radius $0.300\ \mathrm{mm}$) is

$$A = \pi r^2 = \pi(0.300 \times 10^{-3}\ \mathrm{m})^2 = 2.83 \times 10^{-7}\ \mathrm{m}^2$$

so then

$$L = \frac{(4.5\,\Omega)(2.83 \times 10^{-7}\ \mathrm{m}^2)}{(1.7 \times 10^{-8}\,\Omega \cdot \mathrm{m})} = 75\ \mathrm{m}$$

4. a) If a light bulb when connected across a 120 V potential difference dissipates 100 W, what is the resistance of the light bulb? (5)



The power is given by $P = VI$ so (getting the answer to (b) first!) we get

$$I = \frac{P}{V} = \frac{(100 \text{ W})}{(120 \text{ V})} = 0.83 \text{ A}$$

so from Ohm's law the resistance is

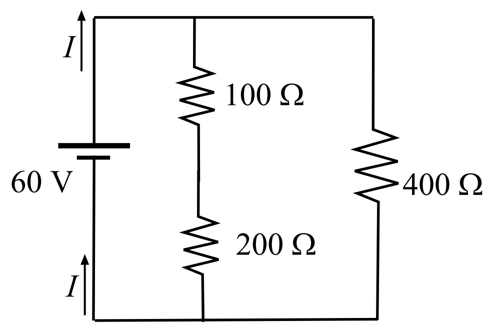
$$R = \frac{V}{I} = \frac{(120 \text{ V})}{(0.83 \text{ A})} = 144\,\Omega$$

b) What is the current in this light bulb when it is used? (3)

As found in (a), the current is $\boxed{0.83 \text{ A}}$.

5. In the circuit diagrammed at the right, find

a) The total current I. (6)



First, find the equivalent resistance of the circuit. The $100\,\Omega$ and $200\,\Omega$ resistors are in series and equivalent to a $300\,\Omega$ resistor. This is in parallel with a $400\,\Omega$ resistor so using the R_{parallel} formula, the equivalent resistance is

$$\frac{1}{R_{\text{eq}}} = \frac{1}{300\,\Omega} + \frac{1}{400\,\Omega} \qquad \Longrightarrow \qquad R_{\text{eq}} = 171\,\Omega$$

Then Ohm's law (applied to the entire equivalent circuit) gives

$$I = \frac{V}{R_{\text{eq}}} = \frac{(60.0 \text{ V})}{(171\,\Omega)} = 0.35 \text{ A}$$

b) The current in the $100\,\Omega$ resistor. (6)

The $100\,\Omega$ and $200\,\Omega$ resistors are in series (with $R_{\text{eq}} = 300\,\Omega$). The potential difference across this combination is 60.0 V. By Ohm's law the current in that branch is

$$I = \frac{V}{R_{\text{eq}}} = \frac{(60.0 \text{ V})}{(300\,\Omega)} = 0.20 \text{ A}$$

which is the same as the current in the $100\,\Omega$ resistor.

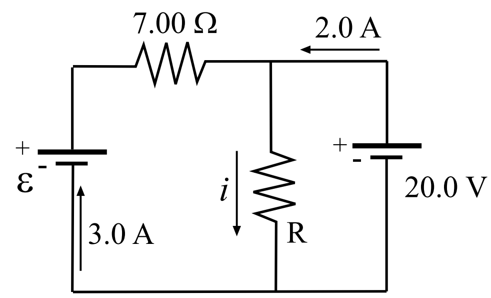
c) The current in the $400\,\Omega$ resistor. (3)

The potential difference across this one resistor is also 60.0 V. Then the current is

$$I = \frac{V}{R_{\text{eq}}} = \frac{(60.0 \text{ V})}{(400\,\Omega)} = 0.15 \text{ A}$$

Note that the currents in the two branches (as found in (b) and (c)) *do* add up to the total current as found in (a).

6. For the circuit shown at the right, use the Kirchoff rules to find (8)



a) The current in the central branch, i. (2)

There is a current of $3.0\ \mathrm{A}$ in the leftmost branch and a current of $2.0\ \mathrm{A}$ in the rightmost branch. These currents meet at the top junction; the junction rule then says that the current coming out of the junction is $\boxed{5.0\ \mathrm{A}}$, and that is the current i in the central branch.

b) The missing resistance R. (4)

The potential difference across this resistor is $20.0\ \mathrm{V}$; we have the current in this resistor, so from Ohm's law the value of R is

$$R = \frac{V}{i} = \frac{(20.0\ \mathrm{V})}{(5.0\ \mathrm{A})} = 4.0\,\Omega$$

c) The emf of the battery on the left, $\mathcal{E}$. (5)

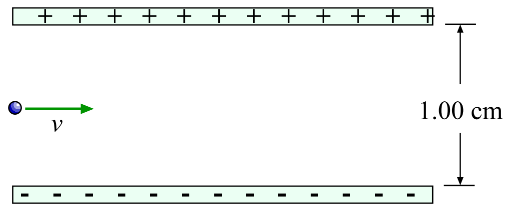
Taking either of the two loops that includes the battery on the left (and going around clockwise), we get:

$$+\mathcal{E} - (3.0\ \mathrm{A})(7.0\,\Omega) - (5.0\ \mathrm{A})(4.0\,\Omega) = 0$$

This gives:

$$\mathcal{E} = 51\ \mathrm{V}$$

7. An electron travels with speed $1.4 \times 10^7 \frac{\text{m}}{\text{s}}$ between the two parallel charged plates shown in the figure at the right. The plates are separated by 1.0 cm and are charged by a 200 V battery. There is also a uniform magnetic field which allows the electron to pass between the plates without being deflected.



a) What is the magnitude and direction of the electric force on the electron? (5)

The electric field points down and has magnitude

$$E = \frac{\Delta V}{d} = \frac{200 \text{ V}}{(1.0 \times 10^{-2} \text{ m})} = 2.00 \times 10^4 \, \frac{\text{N}}{\text{C}}$$

Then from $\mathbf{F} = q\mathbf{E}$ the *force* on the (negatively-charged) electron goes $\boxed{\text{up}}$ and has magnitude

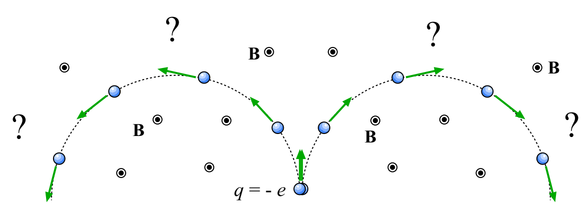
$$F = |qE| = (1.60 \times 10^{-19} \text{ C})(2.00 \times 10^4 \, \tfrac{\text{N}}{\text{C}}) = 3.2 \times 10^{-15} \text{ N}$$

b) What is the magnitude and direction of the uniform magnetic field? (6)

Consider the possible direction for $\mathbf{B}$ and find the results. If $\mathbf{B}$ points out of the page then the right-hand rule (for the negative charge!) give a force *upward* which is *not* what we want to cancel the electric force. If the $\mathbf{B}$ field goes $\boxed{\text{into the page}}$ then we do get a force on the electron which goes downward. If the electric and magnetic forces balance, then

$$qE = qvB \qquad \Longrightarrow \qquad B = \frac{E}{v} = \frac{(2.00 \times 10^4 \, \frac{\text{N}}{\text{C}})}{(1.4 \times 10^7 \frac{\text{m}}{\text{s}})} = 1.43 \times 10^{-3} \text{ T}$$

8. A particle with charge $-e$ and speed $1.28 \times 10^5 \frac{\text{m}}{\text{s}}$ enters a region where the magnetic field is uniform, and as shown here points out of the page; it has magnitude 0.20 T.



a) On which of the two circular paths shown will the charge travel? *You must fully explain your choice.* (4)

Considering the (negatively-charged) particle at the initial position shown and using the right-hand rule for the force, we find that the force on the charge is *to the left*. That is a force which points inward for the $\boxed{\text{left circular path}}$, and so that is the path on which the charge travels.

b) If the radius of the circular path is 8.00 cm find the mass of the particle. (6)

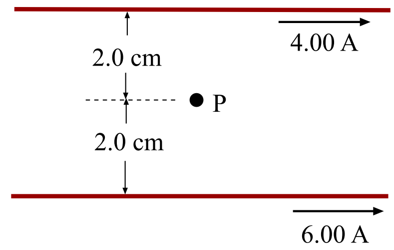
Using our relation for circular motion in a B field, we find:

$$r = \frac{mv}{qB} \qquad \Longrightarrow \qquad m = \frac{rqB}{v}$$

Plug in numbers:

$$m = \frac{(0.0800 \text{ m})(1.60 \times 10^{-19} \text{ C})(0.20 \text{ T})}{(1.28 \times 10^5 \frac{\text{m}}{\text{s}})} = 2.00 \times 10^{-26} \text{ kg}$$

9. Two parallel long wires carry current in the plane of the page as shown. What is the magnitude and direction of the magnetic field at the point P? (7)



Using the right-hand rule for the B field from a long wire, the upper wire gives a contribution at P which goes *into* the page. The lower wire gives a contribution which comes *out of* the page.

The magnitude of the top wire's field is

$$B_{\text{top}} = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}})(4.00\ \text{A})}{2\pi(0.020\ \text{m})} = 4.0 \times 10^{-5}\ \text{T}$$

The magnitude of the bottom wire's field is

$$B_{\text{top}} = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}})(6.00\ \text{A})}{2\pi(0.020\ \text{m})} = 6.0 \times 10^{-5}\ \text{T}$$

Adding these *vectorially* we find that the total field comes $\boxed{\text{out of the page}}$ and has magnitude

$$B_{\text{tot}} = B_{\text{bottom}} - B_{\text{top}} = 2.0 \times 10^{-5}\ \text{T}$$

You must show all your work and include the right units with your answers!

$$e = 1.60 \times 10^{-19}\ \text{C} \qquad F = K\frac{|q_1 q_2|}{r^2} \qquad K = 8.99 \times 10^9\ \frac{\text{N}\cdot\text{m}^2}{\text{C}^2} \qquad \epsilon_0 = 8.854 \times 10^{-12}\ \frac{\text{C}^2}{\text{N}\cdot\text{m}^2}$$

$$m_\text{e} = 9.11 \times 10^{-31}\ \text{kg} \qquad m_\text{prot} = 1.67 \times 10^{-27}\ \text{kg} \qquad g = 9.80\tfrac{\text{m}}{\text{s}^2} \qquad K = \frac{1}{4\pi\epsilon_0}$$

$$\mathbf{F} = m\mathbf{a} \qquad F = q\mathbf{E} \qquad E_\text{pt} = K\frac{|q|}{r^2} \qquad E_\text{par-pl} = \frac{Q}{\epsilon_0 A} = \frac{\sigma}{\epsilon_0}$$

$$K = \tfrac{1}{2}mv^2 \qquad \Delta U_\text{elec} = q\Delta V \qquad K_f + qV_f = K_i + qV_i \qquad V_\text{pt-ch} = K\frac{Q}{r}$$

$$E_s = -\frac{\Delta V}{\Delta s} \quad \text{or} \quad E = \frac{\Delta V}{d} \qquad Q = C\Delta V_C \qquad C = \frac{\kappa\epsilon_0 A}{d} \qquad U_C = \tfrac{1}{2}C(\Delta V_C)^2$$

$$I = \frac{Q}{\Delta t} \qquad V = IR \qquad P = \frac{\Delta E}{\Delta t} \qquad P = VI = I^2 R \qquad R = \rho\frac{L}{A}$$

$$R_\text{ser} = R_1 + R_2 + \cdots \qquad \frac{1}{R_\text{par}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \qquad \sum I_\text{in} = \sum I_\text{out} \qquad \Delta V_\text{loop} = \sum_i \Delta V_i = 0$$

$$\mu_0 = 4\pi \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}} \qquad B_\text{wire} = \frac{\mu_0 I}{2\pi r} \qquad B_\text{loop} = \frac{\mu_0 I}{2R} \qquad B_\text{coil} = N\frac{\mu_0 I}{2R} \qquad B_\text{sol} = \mu_0 I\frac{N}{L}$$

$$F = |qvB\sin\alpha| \qquad F = ILB\sin\alpha \qquad r = \frac{mv}{qB} \qquad m = \left(\frac{qr^2}{2V}\right)B^2 \qquad \tau = IAB\sin\theta$$

$$\frac{F_\text{par-wire}}{L} = \frac{\mu_0 I_1 I_2}{2\pi d} \qquad \mathcal{E} = vlB \qquad \Phi = AB\cos\theta \qquad \mathcal{E} = N\left|\frac{\Delta\Phi}{\Delta t}\right|$$

$$v_L = L\frac{\Delta i_L}{\Delta t} \qquad v_\text{em} = c = \frac{1}{\sqrt{\epsilon_0\mu_0}} \qquad \lambda f = c \qquad I = \frac{P}{A} = \tfrac{1}{2}c\epsilon_0 E_0^2 = \tfrac{1}{2}\frac{c}{\mu_0}B_0^2 \qquad I = \frac{P_\text{source}}{4\pi r^2}$$