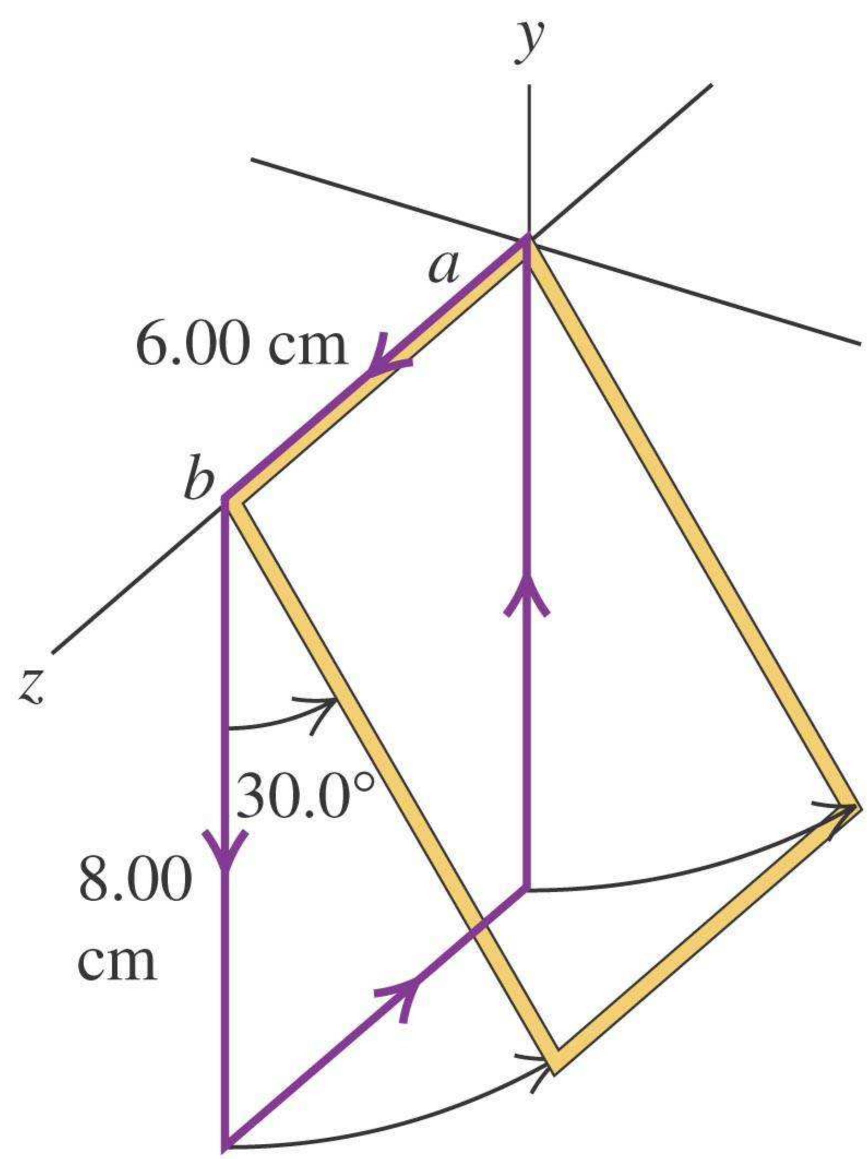
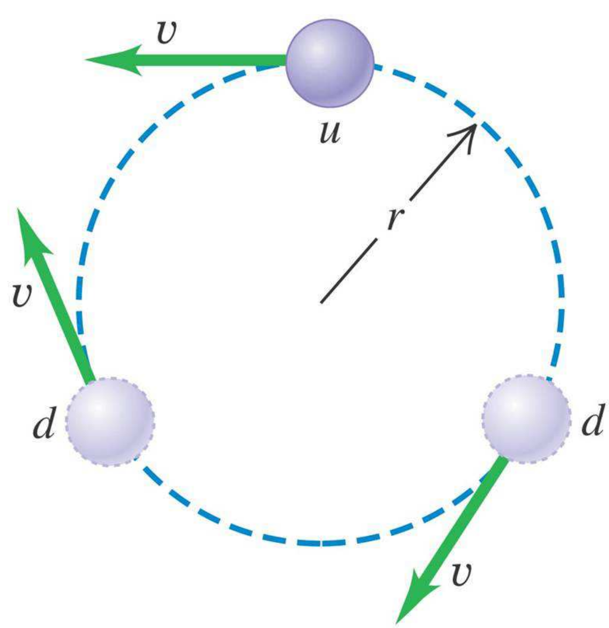
# PHYS 161
## Summer 2012
## Homework Assignment #6
## Due July 13

#1 The rectangular loop of wire shown in Fig. P27.77 has a mass of $0.25\,g$ per centimeter of length and is pivoted about side $ab$ on a frictionless axis. The current in the wire is $15.0\,A$ in the direction shown. Find the magnitude and direction of the magnetic field parallel to the y-axis that will cause the loop to swing until it makes a $30.0°$ with the $yz$-plane.



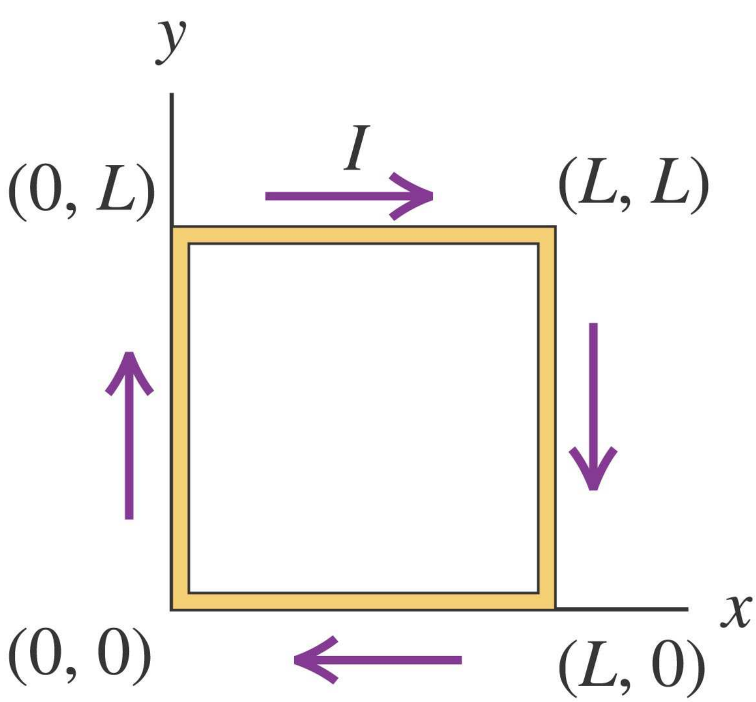
#2 **Quark Model of the Neutron.** The neutron is a particle with zero charge. Nonetheless, it has a nonzero magnetic moment with $z$-component $9.66 \times 10^{-27} A \cdot m^2$. This can be explained by the internal structure of the neutron. A substantial body of evidence indicates that neutron is composed of three fundamental particles called quarks: an up (u) quark, of charge $+2e/3$, and two down (d) quarks, each of charge $-e/3$. The combination of the three quarks produces a net charge of $2e/3 - e/3 - e/3 = 0$. If the quarks are in motion, they can produce a nonzero magnetic moment. As a very simple model, suppose the u quark moves in a counterclockwise circular path and the d quarks move in a clockwise circular path, all of radius $r$ and all with the same speed $v$. (a) Determine the current due to the circulation of the u quark. (b) Determine the magnitude of the magnetic moment due to the circulating u quark. (c) Determine the magnitude of the magnetic moment of the three-quark system. (Be careful to use the correct magnetic moment directions.) (d) With what speed $v$ must the quarks move if this model is to reproduce the magnetic moment of the neutron? Use $r = 1.20 \times 10^{-15}\, m$ (the radius of the neutron) for the radius of the orbits.



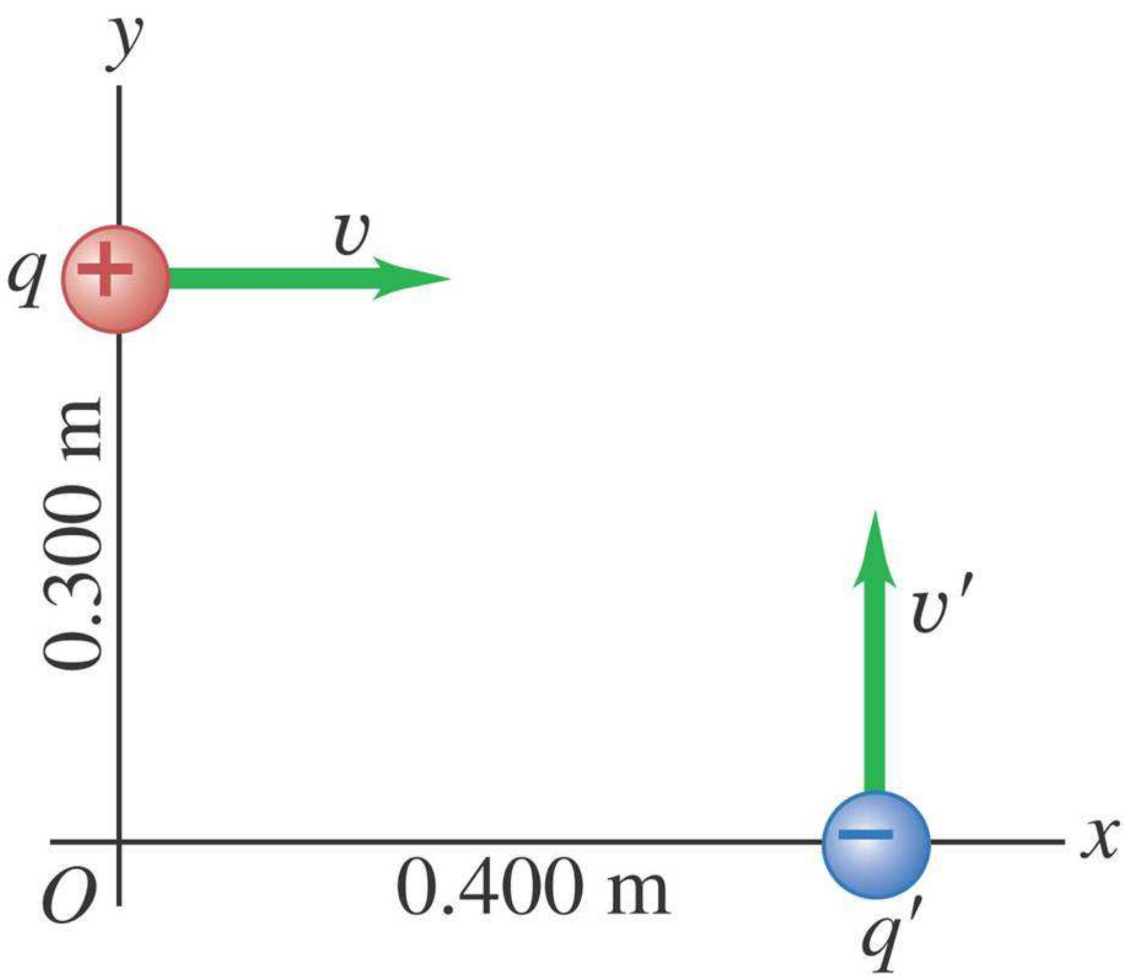
#3 **Force on a Current Loop in a Nonuniform Magnetic Field.** It was shown in section 27.7 that the net force on a current loop in a *uniform* magnetic field is zero. But what if $\overrightarrow{\mathbf{B}}$ is *not* uniform? Figure P27.85 shows a square loop of wire that lies in the $xy$-plane. The loop has corners at $(0,0)$, $(0,L)$,$(L,0)$, and $(L,L)$ and carries a constant current $I$ in the clockwise direction. The magnetic field has no $x$-component but has both $y$- and $z$-components: $\overrightarrow{\mathbf{B}} = (B_o z/L)\,\hat{\boldsymbol{\jmath}} + (B_o y/L)\,\hat{\mathbf{k}}$ where $B_o$ is a positive constant. Find the magnitude and direction of the net magnetic force on the loop for $L = 2.5\,mm$, $I = 2.5\,A$, and $B_o = 0.75\,T$.

*Hint:* The cross-product is distributive, *i.e.*,

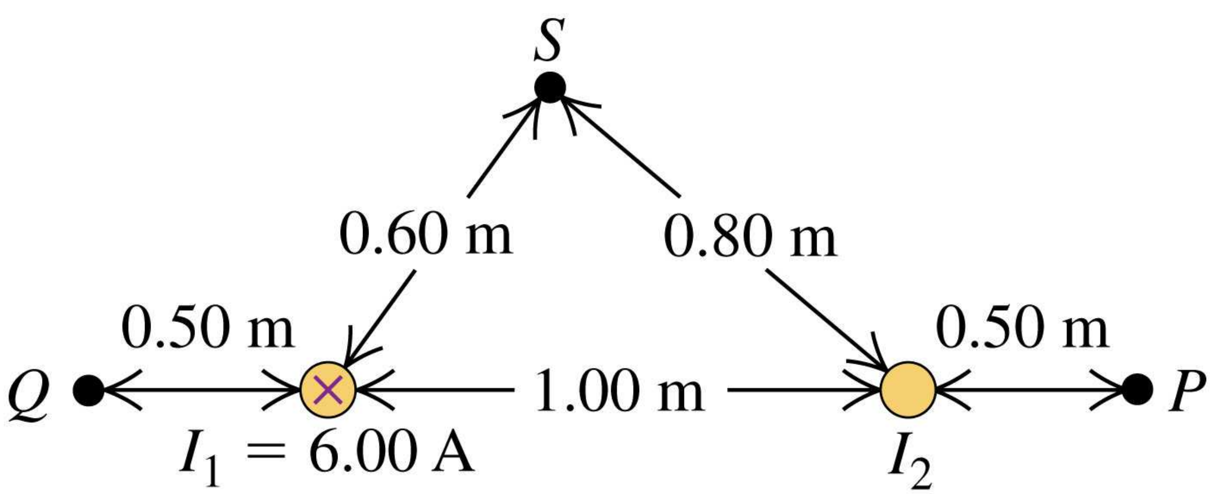
$$\overrightarrow{\mathbf{A}} \times \left(\overrightarrow{\mathbf{B}} + \overrightarrow{\mathbf{C}}\right) = \left(\overrightarrow{\mathbf{A}} \times \overrightarrow{\mathbf{B}}\right) + \left(\overrightarrow{\mathbf{A}} \times \overrightarrow{\mathbf{C}}\right).$$



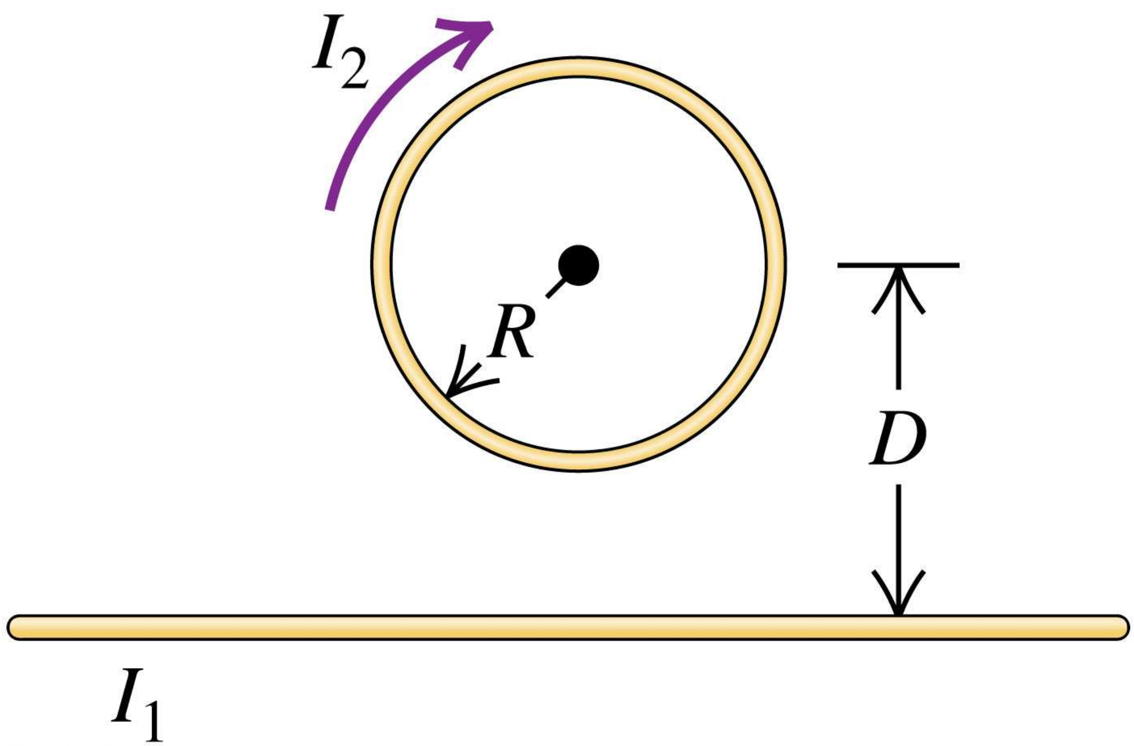
#4 A pair of point charges, $q = +75.0\,\mu C$ and $q' = -50.0\,\mu C$, are moving with speeds $v = 3.00 \times 10^5\,m/s$ and $v' = 6.50 \times 10^5\,m/s$. When the charges are at the locations shown in the figure, what are the magnitude and direction of (a) the magnetic field produced at the origin and (b) the magnetic force that $q'$ exerts on $q$?



#5 Two long, straight, parallel wires are 1.00 $m$ apart (Fig. P28.67). The wire on the left carries a current $I_1$ of 6.00 $A$ into the plane of the paper. (a) What must the magnitude and direction of the current $I_2$ be for the net field at point $P$ to be zero? (b) Then what are the magnitude and direction of the net field at $Q$? (c) Then what is the magnitude of the net field at $S$?



#6 A circular loop has radius $R$ and carries current $I_2$ in a clockwise direction. The center of the loop is a distance $D$ above a long, straight wire. (a) What is the direction of the current $I_1$ in the wire if the magnetic field at the center of the loop is zero? (b) Derive an equation for the magnitude of the current $I_1$. (c) Find the value of $I_1$ for $D = 2\,cm$, $R = 0.5\,cm$, and $I_2 = 3.0\,A$.



#7 A long, straight, solid cylinder, oriented with its axis in the $z$-direction, carries a current whose current density is $\overrightarrow{\mathbf{J}}$. The current density, although symmetrical about the cylinder axis, is not constant but varies according to the relationship

$$\overrightarrow{\mathbf{J}} = \begin{cases} \frac{3I_o}{\pi a^2}\left[1 - \left(\frac{r}{a}\right)\right]\hat{\mathbf{k}} & \text{for } r \leq a \\ 0 & \text{for } r \geq a \end{cases}$$

where $a$ is the radius of the cylinder, $r$ is the radial distance from the cylinder axis, and $I_o$ is a constant having units of amperes. (a) Show that $I_o$ is the total current passing through the entire cross section of the wire. (b) Using Amperes law, derive an expression for the magnetic field $B$ in the region $r \geq a$. (c) Obtain an expression for the current $I$ contained in a circular cross section of radius $r \leq a$ and centered at the cylinder axis. (d) Using Amperes law derive an expression for the magnitude of the magnetic field $B$ in the region $r \leq a$. How do your results in parts (b) and (d) compare for $r = a$?