9. The moving proton acts the same as a current, except that the force on the proton has the magnitude $F = qvB\sin(\text{theta})$. The direction of the force is determined by the right-hand rule for currents. Remember, if this were an electron, you would have to use the left-hand rule.

    a. $F_1 = (1.6 \times 10^{-19}\ \text{C})(5.0 \times 10^{6}\ \text{m/s})(0.135\ \text{T})\sin(90^{o}) = 1.1 \times 10^{-13}\ \text{N}$.
    b. $F_2 = (1.6 \times 10^{-19}\ \text{C})(5.0 \times 10^{6}\ \text{m/s})(0.135\ \text{T})\sin(50^{o}) = 0.83 \times 10^{-13}\ \text{N}$.
    c. There is no force since the $\sin(0^{o})$ is zero.

    In each case, point your fingers along **B** to the right in the plane of the page, with your thumb in the direction of v. Since your palm faces into the page, that is the direction of the force.

11. As shown in your text on page 428, a charged particle moving perpendicular to a field follows a circular path of radius $r = mv/qB$. The mass of the sodium ion is $m = 23 \times 1.66 \times 10^{-27}$ kg and carries a charge of $+e$. If the ion has a speed $v = 3 \times 10^{4}$ m/s, and is in a circular orbit of 0.20-m radius, then

    $B = (23 \times 1.66 \times 10^{-27}\ \text{kg})(3 \times 10^{4}\ \text{m/s})/(1.6 \times 10^{-19}\ \text{C})(0.20\ \text{m}) = 0.036\ \text{T}$.

15. Although starred, this is an easy problem if we use ratios. Recall that for a charged particle moving perpendicular to a magnetic field, the path is circular, with an orbital radius $r = mv/qB$. Since m,v and q are constants, the radius is proportional to the mass. Therefore, $r_2/r_1 = m_2/m_1$, or $r_2 = 9.00(37/35) = 9.51$ cm. Notice that in dealing with ratios, we don't have to change cm to m.

17. Two forces act on the charged particle as it passes through the crossed fields. Consider a charge $+q$ moving with the beam. The force on $+q$ due to the electric field **E** acts downward along the direction of the field. The force on the moving charge due to the magnetic field **B** acts upward according to the right-hand rule. If the two forces exactly balance each other, the charge $+q$ will not be deflected. If the velocity is too small, the force due to the magnetic field is insufficient to balance the force due to the electric field. If the velocity is too great the magnetic force will dominate. Balance is achieved when the two forces are equal. In other words, $qE = qvB$. The charge q cancels and we find the condition for balance to be $v = E/B$.

19. A long straight wire carrying a current I has a **B** field surrounding it, as described on page 430 of your text. The strength of the field is small in general. It is given by the equation

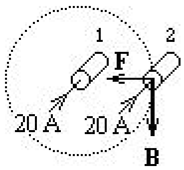
    $B = (\text{mu}_0 I)/(2\ \text{pi}\ r)$

Simple substitution gives the answer I = 60 A.

20. The two wires, are shown endwise, with identical currents of I = 20 A each going in the same direction into the page. Each current creates its own **B** field of concentric clockwise circles around the wire. The field that each wire creates has an effect on the other wire. Part of the field created by wire 1 is shown, that part that passes through the spot where the other wire is located. This field is pointing downward at the position of the second wire. The magnitude of the field of wire 1 at the position of wire 2 is (units are suppressed).

    a. $$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi\times 10^{-7})20}{2\pi(0.05)} = 8.0\times 10^{-5}\ \text{T}$$
    b. The resulting force acting on the second wire is to the left, according the right-hand rule and has the magnitude
       $F = ILB$, giving F/L = (20 A)(8.0 x 10^{-5} T) = 1.6 x 10^{-3} N.

       If you were to repeat the question by finding the force on wire 1, the answer would be 1.6 x 10^{-3} N to the right. In other words the two wires attract each other.



21. The two wires are shown below, endwise.

    a. Each wire carries a current of 20 A into the page. As in problem 20, each wire has an associated **B**-field consisting of clockwise rings around the wire. Clearly, at a point midway between the two wires, the magnetic fields of wire 1 and wire 2 are identical in magnitude but opposite in direction. Thus the net magnetic field strength is zero.

    b. On the other hand, if the currents are in opposite directions, the two fields add. Assuming the left-hand wire has current into the page, and the right-hand wire has current out of the page, the net **B**-field is downward. The magnitude of the field from each wire at the point midway between them is

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi\times 10^{-7})20}{2\pi(0.025)} = 1.6\times 10^{-4}\ \text{T}$$

Thus, the net field has a magnitude of twice the field of one wire or 3.2 x 10^{-4} T.