1) The plane of a rectangular loop of wire with a width of 5.0cm and a height of 8.0cm is parallel to a magnetic field of magnitude 0.21T. The loop carries a current of 6.6A. (Book 27.42)
   a) What torque acts on the loop?
   \[ \tau = IBA \sin \phi = IBwh \sin(90) = 0.0055 \text{ Nm} \]
   b) What is the magnetic moment of the loop?
   \[ \mu = IA = Iwh = 0.026 \text{ Am}^2 \]
   c) What is the maximum torque that can be obtained with the same total length of wire carrying the same current in this magnetic field?
   \[ \tau = \frac{IB(w+h)^2}{\pi} = 7.5(10^{-3}) \text{ Nm} \]

2) An electron and a proton are each moving at 850 km/s in perpendicular paths as shown in the figure. At the instant they are at the positions shown in the figure. (Book 28.8)
   a) Find the magnitude and direction of the total magnetic field they produce at the origin.
   \[ B_p = \frac{\mu_0 q_e (-v) \sin(90)}{4\pi 4(10^{-9})} \]
   \[ B_e = \frac{\mu_0 q_e v \sin(90)}{4\pi 5(10^{-9})} \]
   \[ B_x = \frac{\mu_0 q_e v}{4\pi} \left( \frac{1}{4(10^{-9})} - \frac{1}{5(10^{-9})} \right) = -1.39 \text{ T} \]
   (Negative means it is going into the page)
b) Find the magnitude and direction of the magnetic field the electron produces at the location of the proton.

\[ B_e = \frac{\mu_0}{4\pi} \frac{-q_e v \sin\left(\frac{\pi}{1.3986}\right)}{\sqrt{[4(10^{-9})]^2 + [5(10^{-9})]^2}} = -2.59(10^{-4}) \text{ T} \]

(Notice that the angle between the velocity vector and r-hat)

c) Find the magnitude of the total magnetic force and the total electrical force that the electron exerts on the proton.

\[ F_{\text{electric}} = \frac{kq_e^2}{r^2} = \frac{kq_e^2}{\left(\sqrt{41(10^{-9})}\right)^2} = 5.62(10^{-12}) \text{ N} \]

\[ F_{\text{magnetic}} = qv \times B = qvB \sin(\phi) = qv \frac{\mu_0}{4\pi} \frac{-q_e v \sin\left(\frac{\pi}{1.3986}\right)}{\sqrt{[4(10^{-9})]^2 + [5(10^{-9})]^2}} = 3.52(10^{-17}) \text{ N} \]

3) A long, straight wire lies along the y-axis and carries a current 8.00 A in the -y-direction. In addition to the magnetic field due to the current in the wire, a uniform magnetic field \( B \) with magnitude \( 1.5 \times 10^{-6} \text{ T} \) is in the +x-direction. What is the net magnetic field at the following points? (Book 28.19)

a) \([0,0,1] \text{ m}\)

\[ B_i = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 8}{2\pi (1)} = 1.6(10^{-6}) \text{ T (} -x \text{ direction)} \]

\[ B_{\text{tot}} = B_i - B_0 = 1(10^{-6}) \text{ T (} -x \text{ direction)} \]

b) \([1, 0, 0] \text{ m}\)

\[ B_i = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 8}{2\pi (1)} = 1.6(10^{-6}) \text{ T (} +z \text{ direction)} \]

\[ B_{\text{tot}} = \sqrt{B_i^2 + B_0^2} = 2.19(10^{-6}) \text{ T (} \theta = 46.8^\circ \text{ from } +x \text{ to } +z) \]

c) \([0, 0,-0.25] \text{ m}\)
\[ B_i = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 8}{2\pi (0.25)} = 6.4 \times 10^{-6} \, T \ (\text{+x direction}) \]

\[ B_{\text{tot}} = B_0 + B_i = 7.9 \times 10^{-6} \, T \ (\text{+x direction}) \]