Problem 1

Model: Assume that the field is uniform. The wire will float in the magnetic field if the magnetic force on the wire points upward and has a magnitude *mg*, allowing it to balance the downward gravitational force.
Visualize: Please refer to Figure EX33.34.
Solve: We can use the right-hand rule to determine which current direction experiences an upward force. The current being from right to left, the force will be *up* if the magnetic field $\vec{B}$ points out of the page. The forces will balance when

$$F = ILB = mg \Rightarrow B = \frac{mg}{IL} = \frac{(2.0\times10^{-3}\ \text{kg})(9.8\ \text{m/s}^2)}{(1.5\ \text{A})(0.10\ \text{m})} = 0.131\ \text{T}$$

Thus $\vec{B}$ = (0.131 T, out of page).

Problem 2

Model: Assume that the magnetic field is uniform over the 10 cm length of the wire. Force on top and bottom pieces will cancel.
Visualize: Please refer to Figure EX33.35. The figure shows a 10-cm-segment of a circuit in a region where the magnetic field is directed into the page.
Solve: The current through the 10-cm-segment is

$$I = \frac{\text{E}}{R} = \frac{15\ \text{V}}{3\ \Omega} = 5\ \text{A}$$

and is flowing *down*. The force on this wire, given by the right-hand rule, is to the right and perpendicular to the current and the magnetic field. The magnitude of the force is

$$F = ILB = (5\ \text{A})(0.10\ \text{m})(50\ \text{mT}) = 0.025\ \text{N}$$

Thus $\vec{F}$ = (0.025 N, right).

Problem 3

Model: Two parallel wires carrying currents in opposite directions exert repulsive magnetic forces on each other. Two parallel wires carrying currents in the same direction exert attractive magnetic forces on each other.
Visualize: Please refer to Figure EX33.36.
Solve: The magnitudes of the various forces between the parallel wires are

$$F_{2\text{ on }1} = \frac{\mu_0 L I_1 I_2}{2\pi d} = \frac{(2\times10^{-7}\ \text{T m/A})(0.50\ \text{m})(10\ \text{A})(10\ \text{A})}{0.02\ \text{m}} = 5.0\times10^{-4}\ \text{N} = F_{2\text{ on }3} = F_{3\text{ on }2} = F_{1\text{ on }2}$$

$$F_{3\text{ on }1} = \frac{\mu_0 L I_1 I_3}{2\pi d} = \frac{(2\times10^{-7}\ \text{T m/A})(0.50\ \text{m})(10\ \text{A})(10\ \text{A})}{0.04\ \text{m}} = 2.5\times10^{-4}\ \text{N} = F_{1\text{ on }3}$$

Now we can find the net force each wire exerts on the other as follows:

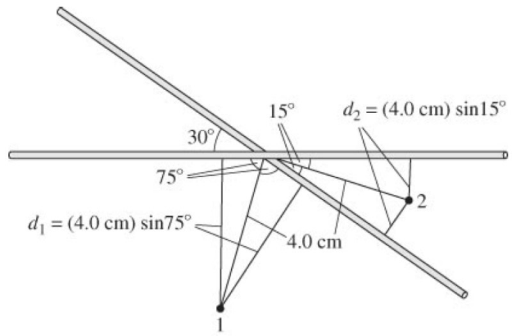
$$\vec{F}_{\text{on }1} = \vec{F}_{2\text{ on }1} + \vec{F}_{3\text{ on }1} = (5.0\times10^{-4}\hat{j})\ \text{N} + (-2.5\times10^{-4}\hat{j})\ \text{N} = 2.5\times10^{-4}\hat{j}\,\text{N} = (2.5\times10^{-4}\,\text{N, up})$$

$$\vec{F}_{\text{on }2} = \vec{F}_{1\text{ on }2} + \vec{F}_{3\text{ on }2} = (-5.0\times10^{-4}\hat{j})\ \text{N} + (+5.0\times10^{-4}\hat{j})\ \text{N} = 0\ \text{N}$$

$$\vec{F}_{\text{on }3} = \vec{F}_{1\text{ on }3} + \vec{F}_{2\text{ on }3} = (2.5\times10^{-4}\hat{j})\ \text{N} + (-5.0\times10^{-4}\hat{j})\ \text{N} = -2.5\times10^{-4}\hat{j}\ \text{N} = (2.5\times10^{-4}\,\text{N, down})$$

Problem 4

Model: Assume that the wires are infinitely long and that the magnetic field is due to currents in both the wires.
Visualize: Point 1 is a distance d_1 away from the two wires and point 2 is a distant d_2 away from the two wires. A right triangle with a 75° degree angle is formed by a straight line from point 1 to the intersection and a line from point 1 that is perpendicular to the wire. Likewise, point 2 makes a 15° right triangle.



Solve: First we determine the distances d_1 and d_2 of the points from the two wires:

$$d_1 = (4.0\text{ cm})\sin 75° = 3.86\text{ cm} = 0.0386\text{ m}$$

$$d_2 = (4.0\text{ cm})\sin 15° = 1.04\text{ cm} = 0.0104\text{ m}$$

At point 1, the fields from both the wires point up and hence add. The total field is

$$B_1 = B_{\text{wire 1}} + B_{\text{wire 2}} = \frac{\mu_0}{2\pi}\frac{I_1}{d_1} + \frac{\mu_0}{2\pi}\frac{I_2}{d_1} = \frac{\mu_0}{\pi}\frac{(5.0\text{ A})}{d_1} = \frac{(4\times10^{-7}\text{ T m/A})(5.0\text{ A})}{0.0386\text{ m}} = 5.2\times10^{-5}\text{ T}$$

In vector form, $\vec{B}_1 = (5.2\times10^{-5}$ T, out of page). Using the right-hand rule at point 2, the fields are in opposite directions but equal in magnitude. So, $\vec{B}_2 = \vec{0}$ T.

Problem 5

Model: A magnetic field exerts a magnetic force on a length of current-carrying wire. We ignore gravitational effects, and focus on the B effects.
Visualize: Please refer to Figure P33.67. The figure shows a wire in a magnetic field that is directed out of the page. The magnetic force on the wire is therefore to the right and will stretch the springs.
Solve: In static equilibrium, the sum of the forces on the wire is zero:

$$F_B + F_{\text{sp 1}} + F_{\text{sp 2}} = 0\text{ N} \Rightarrow ILB + (-k\Delta x) + (-k\Delta x) \Rightarrow I = \frac{2k\Delta x}{LB} = \frac{2(10\text{ N/m})(0.01\text{ m})}{(0.20\text{ m})(0.5\text{ T})} = 2.0\text{ A}$$

Problem 6

Model: The bar is a current-carrying wire in a perpendicular uniform magnetic field. The current is constant.
Visualize: Please refer to figure P33.68.
Solve: **(a)** The right-hand rule as described in section 33.8 requires the current to be into the page.
(b) The net force on the bar is $F = IlB$, and is constant throughout the motion. The acceleration of the bar is thus $\frac{F}{m} = \frac{IlB}{m}$. Using constant acceleration kinematics,

$$v_f^2 = v_0^2 + 2a\Delta s = (0\text{ m/s})^2 + 2\left(\frac{IlB}{m}\right)d \Rightarrow v_f = \sqrt{\frac{2IlBd}{m}}$$