PHYSICS 231 - Solution Key to Sample Test 3

1a. From $\vec{F} = q\vec{v} \times \vec{B}$, we have $F = 0$ if $\vec{v}$ is parellel to $\vec{B}$. So q will experience no force if it moves along a magnetic field line.

1b. All turns in the coil carry the same current. Therefore, neighboring turns carry currents in the same direction and so they attract each other. The attractive forces bring turns closer to each other and the whole spring contracts.

1c. From $\mathcal{E} = -\frac{d\Phi}{dt}$, we have $\mathcal{E} = 0$ if Φ is constant. One way to achieve this is if $\Phi = 0$ during the rotation. This can be done if you orient the loop along $\vec{B}$ and rotate it around a field line, so it remains along $\vec{B}$.

2a.

$$F = ILB = 500\ N$$

The direction is along the velocity of the bar.

2b. From $F = ma$,

$$a = \frac{F}{m} = 20\ m/s^2$$

2c. Distance $x = \frac{1}{2}at^2$, speed $v = at$, so

$$s = \frac{v^2}{2a} = 2.5\ m$$

3a. The two straight segments produce no magnetic field, because P is on the same straight line as the segments.

The inner (outer) semicircle produces a magnetic field pointing out of (into) the sheet of paper.

3b. A circle of radius r produces a field

$$B = \frac{\mu_0 I}{2r}$$

at its center. A semicircle produces half of this field at its center of curvature. So at P, we have

$$B = \frac{1}{2}\frac{\mu_0 I}{2a} - \frac{1}{2}\frac{\mu_0 I}{2b} = 2.1 \times 10^{-7} T$$