# PHYSICS 231 - Solution Key to Test 3

1a. The energy is $\frac{1}{2}mv^2$. It is doubled if $v \to \sqrt{2}v$. The radius is

$$R = \frac{mv}{|q|B}$$

so $R \propto v$ and $R \to \sqrt{2}R$.

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.

2a. The flux is

$$\Phi = BA\cos\phi$$

The angle $\phi$ is between the perpendicular to CD and the $y$-axis, so $\phi = 35^o$. So

$$\Phi = 1.8 \times 0.30 \times 0.40 \times \cos 35^o = 0.177\ Wb$$

2b. The force is

$$\vec{F} = I\vec{L} \times \vec{B}$$

We have $\vec{L} = -(0.40\ m)\,\hat{k}$ and $\vec{B} = -(1.8\ T)\,\hat{j}$, so

$$\vec{F} = (1.8\ N)\,\hat{k} \times \hat{j} = -(1.8\ N)\,\hat{i}$$

The magnitude is $F = 1.8$ N and it points in the negative $x$-direction.

3a. At $P$, $I_1$ creates a magnetic field into the page and of magnitude

$$B_1 = \frac{\mu_0 I_1}{2\pi r_1} = \frac{4\pi \times 10^{-7} \times 4}{2\pi \times (0.40 + 0.30)} = 1.14 \times 10^{-6} T$$

At $P$, $I_2$ creates a magnetic field pointing out of the page and of magnitude

$$B_2 = \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi \times 10^{-7} \times 5}{2\pi \times 0.30} = 3.33 \times 10^{-6} T$$

The net magnetic field at $P$ has magnitude

$$B = B_2 - B_1 = 2.19 \times 10^{-6} T$$

and points out of the page (since $B_2 > B_1$).

3b. The two currents are in opposite directions, so the force is repulsive (points north).

The magnitude is $F = I_1 LB$, where

$$B = \frac{\mu_0 I_2}{2\pi r} = \frac{4\pi \times 10^{-7} \times 5}{2\pi \times 0.40} = 2.50 \times 10^{-6} T$$

Therefore, $F = 4 \times 2.5 \times 2.5 \times 10^{-6} = 2.50 \times 10^{-5} N$

4a. $\mathcal{E} = vBL = 4.5 \times 1.5 \times 0.20 = 1.35\ V$ The current is

$$I = \frac{\mathcal{E}}{R} = \frac{1.35}{3.5} = 0.39\ A$$

4b. $F_{ext} = F_{mag} = ILB = 0.39 \times 0.20 \times 1.5 = 0.117$ N.