Name ______________________________ Date ______________

PH 102 Quiz 6 SOLUTION

1. An electron passes through a magnetic field without being deflected. What can you say about the angle between the magnetic field vector and the electron's velocity, if no other forces are present?

- ◯ They could be in the same direction
- ◯ They could be perpendicular
- ◯ They could be in opposite directions
- ⊗ Both the first and third are possible

The magnetic force is $\vec{\mathbf{F}}_B = \vec{\mathbf{v}} \times \vec{\mathbf{B}}$, or $F_B = qvB \sin\theta$ where θ is the angle between $\vec{\mathbf{v}}$ and $\vec{\mathbf{B}}$, so the magnetic force is always perpendicular to the electron's velocity. The only way the electron can go through the region of magnetic field and experience no deflection is if it feels no force - a deflection from a straight line path implies an acceleration, which implies a force. This can only be true if θ is 0 or 180° - the electron's velocity and the magnetic field vector have to be parallel, or in opposite directions.

2. What should happen to the length of a spring if a large current passes through it? (*Hint: Think about the current in neighboring spring coils.*

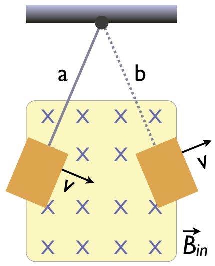
- ⊗ It shortens
- ◯ It lengthens
- ◯ Nothing

Think about the individual coils making up a spring. The current through segments of adjacent coils are parallel, and hence adjacent sections of the spring coils should experience an attractive force. Each coil of the spring attracts every other one, and the net result is that the spring should shorten.

3. The magnetic flux through a loop can change due to a change in:

- ◯ The area of the coil
- ◯ The strength of the magnetic field
- ◯ The orientation of the loop
- ⊗ All of the above

Magnetic flux is $\Phi_B = BA\cos\theta_{BA}$, where θ_{BA} is the angle between the loop area's normal and the magnetic field. A change in magnetic field or area clearly changes the flux Φ_B, as does changing the orientation of the loop in the field, which changes θ_{BA}.

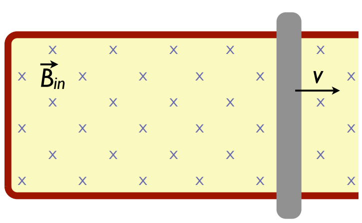


4. A flat metal plate swings at the end of a bar as a pendulum, as shown. When the pendulum is at position **a**, what are the directions of the induced currents and (magnetic) force on the bar, respectively?

- ⊗ Counterclockwise; to the left
- ◯ Clockwise; to the left
- ◯ Counterclockwise; to the right
- ◯ Clockwise; to the right

The effect of magnetic induction is to create currents which try to stop the *change* in magnetic flux. In this case, the magnetic flux is the field B_{in} going through the metal plate. The flux increases as the plate falls into the magnetic field, since more and more of the plate's area is exposed to the field. The resulting induction currents will try to stop the flux from increasing, which means slowing the plate's progress through the magnetic field. This means the force must be to the left. Put another way, the induced currents will try to create a field which will cancel out the existing B_{in} to stop the increase in flux, so the induced currents will create a field pointing out of the page. For this to be true, the currents must circulate counterclockwise.

Note that at position b, the situation is reversed - the currents should be clockwise, and the force to the left. Do you understand why?



5. A conducting bar slides on two fixed conducting rails with, a constant magnetic field pointing into the page. What are the directions of the induced current and the force on the bar, respectively?

- ⊗ Counterclockwise; to the left
- ◯ Clockwise; to the left
- ◯ Counterclockwise; to the right
- ◯ Clockwise; to the right

When the conducting rod moves to the right, this serves to *increase* the flux as time passes (A increases while B stays constant), so any induced current wants to stop this change and *decrease* the flux. Therefore, the induced current will act in such a way to oppose the external field (*i.e.*, the field due to the induced current will be opposite to the external field). This must be a **counterclockwise** current. Consistent with decreasing the overall flux, the force ont he bar must be to the left, attempting to impede the bar's progress and reduce the change in flux.