Solutions – PHYS 251 Final Exam (New Material) – Practice Test

1D

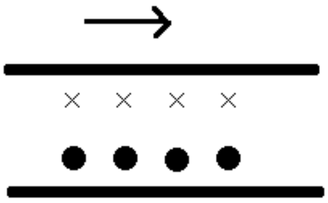
If we find the resultant velocity, v, its vector is 13 m/s. This can be plugged into the equation for magnetic force: F = qvB = 1.04 x 10^{-17} N, where q is the charge of an electron given on your data sheet as 1.60 x 10^{-19} C.

2C

The current in the wire will induce a magnetic field going into the page on the right side of the wire. This causes an induced current in the loop such that the induced current creates a magnetic field opposing the one from the wire (meaning that induced magnetic field from the loop must travel up out of the page). This would happen if the current in the wire were moving counterclockwise according to the right-hand rule.

3B

For each wire the direction of the magnetic field can be determined by pointing your thumb along the wire and curling your fingers in the direction of the field. Since both currents are parallel (and assuming the current moves to the right), the top wire produces a field going into the page, while the bottom wire makes a field going out of the page, as shown below:



This means that at the midway point, which is 0.2 m from each wire, the fields will oppose each other, and the net magnetic field will be the difference between the two. For a straight wire carrying current, the magnetic field at a distance, R, from the wire is:

$$\vec{B} = -\frac{\mu_0 i}{2\pi R}$$

Thus the net field will be $B_1 - B_2$:

$$\vec{B}_1 - \vec{B}_2 = \left(-\frac{\mu_0(4)}{2\pi(0.1)}\right) - \left(-\frac{\mu_0(5)}{2\pi(0.1)}\right) = 2 \times 10^{-6} T$$

4B

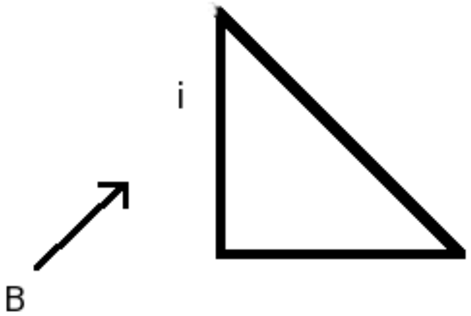
The equation for any circular loop is given by:

$$\vec{B} = -\frac{\mu_0 i}{2R} = 2.0 \times 10^{-5} T$$

However, since we are only dealing with half a loop, we will get half the amount of magnetic field, B/2, which equals 1.0 x 10^{-5} T.

5C

Based on the description given, the only way the right triangle can also be an isosceles triangle is if the other angles are both 45 degrees. Looking at the diagram below, we see that the magnetic field hits the two equal sides at a 45 degree angle.



For the vertical side, the component of the magnetic field that is perpendicular to the wire would be given by Bcos(45), and for the horizontal side it would be Bsin(45). Since the sine and cosine of 45 are equal this distinction doesn't matter, but it might matter for a different problem so it's good to be aware of it.

We can now use the equation for force caused by a magnetic field on a current carrying wire for each side:

$$\vec{F}_1 = i\vec{L} \times \vec{B} = iLB\cos(45) = 0.00247N$$
$$\vec{F}_2 = i\vec{L} \times \vec{B} = iLB\sin(45) = 0.00247N$$
$$F_{Total} = F_1 + F_2 = 0.00495N$$

6E

A somewhat interesting experiment, the magnet slows its decent due to the presence of an induced magnetic field that opposes the increasing flux of the magnet. This induced magnetic field is created by an induced current circling the cross-sectional circumference of the copper tube.

7E

If the magnetic field is in the z-axis, the only way it could rotate would be perpendicular to that axis, meaning that rotation could only happen around the x- or y- axis.

8A

If we say that into the page is positive, we can evaluate the changes in magnetic flux to see what direction the induced magnetic field would need to point.

A: No change in flux occurring so no induced current.

B: ΔB = +1 – 0 = +1

> This means the induced magnetic field must be -1 (out of the page) to oppose the existing change in flux. To make the induced magnetic field go out of the page, we curl our right hand fingers **counter-clockwise** and our thumbs point up out of the page.

C: Although there is a magnetic flux, it is constant, and thus no induced current.

D: ΔB = 0 – +1 = -1

> This means the induced magnetic field must be +1 (into the page) to oppose the existing change in flux. To make the induced magnetic field go into the page, we curl our right hand fingers **clockwise** and our thumbs point down into the page.

9E

A somewhat interesting experiment, the magnet slows its decent due to the presence of an induced magnetic field that opposes the increasing flux of the magnet. This induced magnetic field is created by an induced current circling the cross-sectional circumference of the copper tube.

10D

The Biot-Savart Law for magnetic fields from a current is used to determine the direction of the field. By pointing your thumb in the direction of the current, your fingers curl in the direction of the magnetic field. From this we determine that the two wires on the right going into the page will cancel each other out at point P (the top right wire produces a field to the left, and the bottom right wire produces an equal field to the right). The other wires both produce magnetic fields pointing right at point P.

11D
The equation relating radius with the variables given is:

$$r = \frac{mv}{qB}$$

Since velocity and magnetic field are constant, the only factors we need to consider are the mass, m, and the charge, q.
At first, it may seem that A and C are both good answer choices, however neither one takes into account both mass and charge at the same time. For example, the heavier ion, in answer choice A, may also have a greater charge, which negate any supposed increase in radius. Thus only answer choice D takes into account both charge and mass, and in the right proportions too.

12E
According to the right-hand rule, with current directed out of the page (+z axis), and magnetic field pointing up the page (+y axis), the resulting force on the wire points to the left (-x axis), which is the West direction.

13A
According to the relationship for torque acting on current-carrying loops in the presence of a magnetic field, the magnetic dipole moment will rotate until it is aligned with the magnetic field.

14D
Each unique electron transition emits a photon with a specific amount of energy. That amount of energy, corresponds to a specific frequency, and wavelength. So the question is really asking how many different transitions can it make.
The transitions from n(initial) to n(final) are as follows:
5 to 4, 5 to 3, 5 to 2, 5 to 1, 4 to 3, 4 to 2, 4 to 1, 3 to 2, 3 to 1, and 2 to 1.

15E
The energy of a photon is directly proportional to its frequency.

16C

By increasing the intensity, you increase the photons that are striking the metal per second, and thus you increase the number of electrons that are ejected per second, which is directly linked to an increase in current. Note that increasing intensity doesn't increase the energy of each photon (there's just more of them), and so the electrons will be ejected with the same speed (same kinetic energy).

17A

The initial polarized light, I_1, that passes through the first polarizer at a 45° angle will be reduced according to the equation:

$$I_2 = I_1 \cos^2(45^\circ) = I_1(1/\sqrt{2})^2 = I_1/2$$

After passing through the first polarizer, the light passes through the second polarizer, which is at a 45° angle to the first polarizer, to become:

$$I_3 = I_2 \cos^2(45^\circ) = I_2(1/\sqrt{2})^2 = I_2/2 = (I_1/2)/2 = I_1/4$$

18B

By using the equation below, we can determine the angle for the third order maximum:

$$y_m = L\tan\theta_p$$

$$\theta_p = \tan^{-1}\left(\frac{y_m}{L}\right) = \tan^{-1}\left(\frac{1.2}{2}\right) = 31^\circ$$

Using this angle we can determine the distance between slits:

$$a\sin\theta_p = p\lambda$$

$$a = \frac{p\lambda}{\sin\theta_p} = \frac{(3)(420\times10^{-9})}{\sin(31^\circ)} = 2.45\times10^{-6}m$$

Remember that this value represents the distance between each slit, and units of m/slit, which needs to be converted into slits/cm, as shown below:

$$\frac{2.45\times10^{-6}m}{slit} = \frac{2.45\times10^{-4}cm}{slit} = \frac{1\ \text{slit}}{2.45\times10^{-4}cm} = \frac{4082\ \text{slits}}{cm}$$