PH 221 Homework Assignment Chapter on Magnetism– 26 Problems Total

1. Calculate the magnitude of the magnetic force that results when a wire cable $(\mathrm{L} = 360.\,\mathrm{m})$ is carrying a current $(\mathrm{i} = 300.\,\mathrm{A})$ within the Earth's magnetic field which has a magnitude of $(\mathrm{B} = 5.50 \text{ x } 10^{-5}\ \mathrm{T})$ and the magnetic field makes an angle $(\theta = 67.0°)$ with the current in the wire.

Solution for Problem 1

2. A horizontal wire is $3.34\ \mathrm{m}$ long and it is carrying a current of $7.68\ \mathrm{A}$ which is directed due South. The Earth's magnetic field has a strength of $5.78 \text{ x } 10^{-5}\ \mathrm{T}$ in this spot on the Earth's surface. The magnetic field in this spot makes a dip angle of $49.0°$ with this wire. What is the magnitude of the magnetic force on this wire?

Solution for Problem 2

3. The mass density of copper is $\rho_{\mathrm{m-Cu}} = 8.96 \text{ x } 10^3\ {}^{\mathrm{kg}}/_{\mathrm{m}^3}$. A 12-gauge wire has a diameter of $2.05 \text{ x } 10^{-3}\ \mathrm{m}$. 12-gauge copper wire can carry a max current of $20.0\ \mathrm{A}$. Assume the Earth's magnetic field in this region is horizontal pointing in the due North direction with a field strength of $5.00 \text{ x } 10^{-5}\ \mathrm{T}$. It is desired to have the wire "float" in the air against gravity.

(a) In which direction must the current be directed to have the magnetic force balance the gravitational force?

(b) How much current is required for this "floating" to happen?

(c) Is this possible?

Solution for Problem 3

4. A long straight wire stretches along the y axis and it carries a current of $6.50\ \mathrm{A}$ in the positive y direction $\widehat{(+\jmath)}$. The wire is surrounded by a constant uniform magnetic field which can be expressed as:

$$\vec{\mathrm{B}} = \left(-0.48\ \widehat{(\imath)} - 0.27\ \widehat{(\jmath)} + 0.83\ \widehat{(\mathrm{k})}\right)\mathrm{T}$$

Determine the magnetic force per unit length acting on this wire.

Solution for Problem 4

5. A length of wire is $4.00\ \mathrm{m}$ long and carries a current of $11.2\ \mathrm{A}$. The wire is surrounded by a constant magnetic field. When the wire lies along the x- axis, the magnetic force is measured to be

$$\overrightarrow{F_{B1}} = 6.27\ \mathrm{N}\ (\hat{\jmath}) + 28.2\ \mathrm{N}\ (\hat{k})$$

When the wire lies along the z axis, the magnetic force is determined to be:

$$\overrightarrow{F_{B2}} = -28.2\ \mathrm{N}\ (\hat{\imath})$$

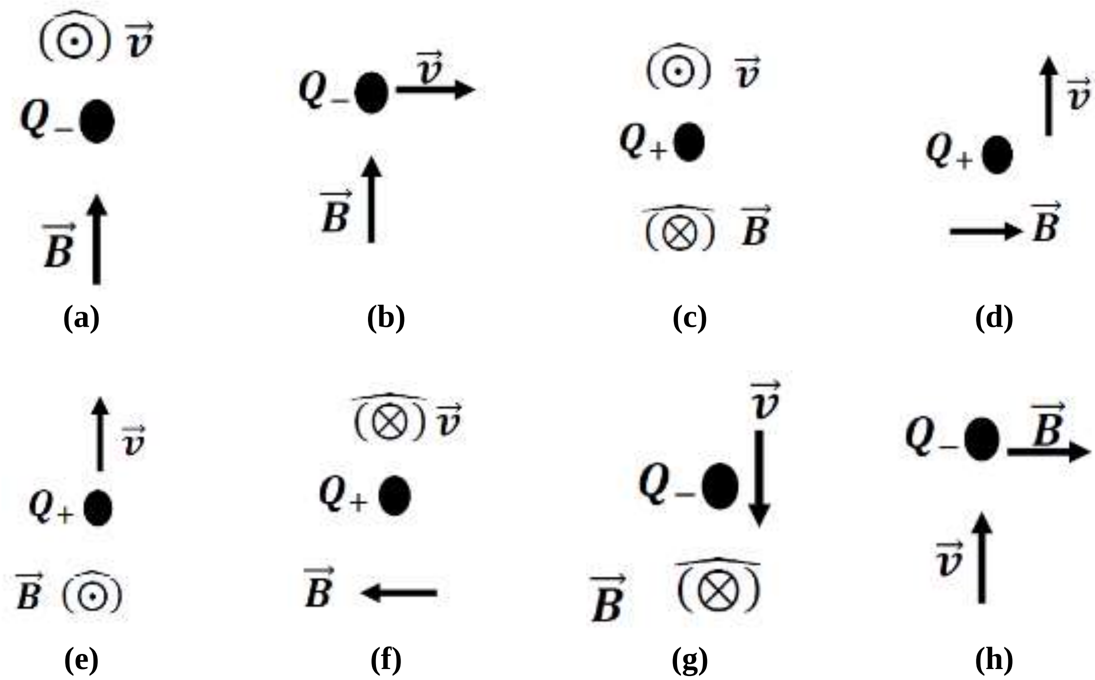
Determine the magnetic field $\vec{B}$.

Solution for Problem 5

6. Alpha particles have a charge $Q_\alpha = +2e = 3.20 \times 10^{-19}\mathrm{C}$ and a mass $m_\alpha = 6.64 \times 10^{-27}\ \mathrm{kg}$. During a radioactive process known as alpha particle decay they leave a sample with speeds of approximately $1.60 \times 10^{7}\ \mathrm{m}/\mathrm{s}$. What magnetic field strength would be required to make them travel in a circular path of radius $0.110\ \mathrm{m}$?

Solution for Problem 6

7. In the table below, determine the direction of the magnetic force acting on the charges moving in the direction shown in the magnetic field shown. Reminder that $(\widehat{\otimes})$ means into the plane of the paper, while $(\widehat{\odot})$ means out of the plane of the paper.



Solution for Problem 7

8. An electron beam has an average electron velocity of $v_{e^-} = 2.92 \text{ x } 10^6 \, {}^{m}/_{s}$. There is a magnetic field which is directed perpendicular to the direction of the velocity. The magnetic field strength is $B = 5.78 \text{ x } 10^{-3} \text{ T}$.

(a) What is the field strength of an electric field that is directed perpendicular to both the magnetic field and the velocity, so that the electrons pass through undeflected?

(b) If the electric field were removed, what is the radius the electron would have as it makes circles due to the magnetic field?

Solution for Problem 8

9. A singly charged helium atom (an ion) has a mass $m_{He} = 6.65 \text{ x } 10^{-27} \text{ kg}$ is making circular orbits ($R = 4.12 \text{ x } 10^{-2} \text{ m}$)in a magnetic field of strength $B = 0.456 \text{ T}$.

(a) What is the velocity of the helium ion?

(b) If the ion was initially at rest, what accelerating voltage was used to bring it up to this speed?

(c) What is the period of the ion's rotation around the circles?

Solution for Problem 9

10. Consider an object with a mass (m), charge (Q), moving along a circle of radius (R) due to a perpendicular magnetic field (B).

(a) Derive an expression for kinetic energy in terms of the four quantities mass (m), charge (Q), radius (R) and magnetic field (B).

(b) Derive an expression for angular momentum in terms of the four quantities mass (m), charge (Q), radius (R) and magnetic field (B).

Solution for Problem 10

11. An electron has a velocity

$$\overrightarrow{\mathbf{v}_{e^-}} = \left(-\mathbf{9.03}\,(\hat{\imath}) + \mathbf{3.56}\,(\hat{k})\right) \mathbf{x}\ \mathbf{10^5}\ {}^{\mathbf{m}}/_{\mathbf{s}}$$

In a magnetic field given by

$$\vec{\mathbf{B}} = \left(\mathbf{0.356}\,(\hat{\imath}) - \mathbf{0.267}\,(\hat{\jmath}) + \mathbf{0.751}\,(\hat{k})\right) \mathbf{T}$$

Determine the magnitude and direction of the magnetic force acting on the electron.

Solution for Problem 11

12. An electron feels the strongest magnetic force when it is traveling with a velocity $\left(\overrightarrow{v_{e^-}} = 1.73 \text{ x } 10^6 \ ^{\text{m}}/_{\text{s}} \,(\widehat{\text{South}})\right)$. The magnetic force is described by $\left(\overrightarrow{F_B} = 7.72 \text{ x } 10^{-13} \text{ N } (\widehat{\text{Up}})\right)$. What is the magnitude and direction of the magnetic force?

Solution for Problem 12

13. A proton experiences a magnetic force described by

$$\overrightarrow{F_B} = \left(-7.21\,(\widehat{\jmath}) + 2.34\,(\widehat{k})\right) \text{ x } 10^{-13} \text{ N}$$

When it travels through a magnetic field given by

$$\vec{B} = 1.45\,T\,(\widehat{\imath})$$

Determine the velocity vector for the proton.

Solution for Problem 13

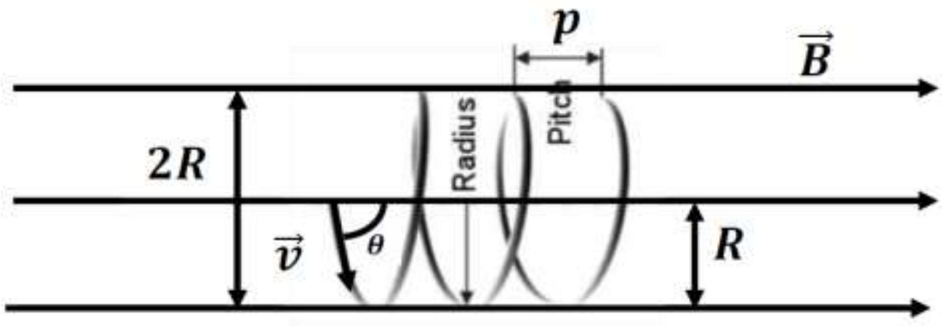
14. Calculate the magnitude of the magnetic force acting on an airplane that is flying with an air speed $(\text{v} = 146.\,^{\text{m}}/_{\text{s}})$ through the Earth's magnetic field which has a strength $(\text{B}_\text{E} = 4.75 \text{ x } 10^{-4} \text{ T})$ and is directed perpendicular to the direction of the plane's velocity. Friction with the air has added a net charge $(\text{Q} = 2.40 \text{ x } 10^{-2} \text{ C})$.

Solution for Problem 14

15. A cable carrying power for a subway system carries a current $(\text{i} = 456.\,\text{A})$ in the West direction. The Earth's magnetic field has a field strength $(\text{B}_\text{E} = 5.00 \text{ x } 10^{-5} \text{ T})$ which is directed North and has a dip angle $\left(\theta_{\text{Dip}} = 18.0°\right)$. Calculate the magnetic force on a 10.0 m length of the power cable.

Solution for Problem 15

16. A proton enters a uniform magnetic field $(\mathrm{B} = 0.128\ \mathrm{T})$ with a speed $(\mathrm{v} = 4.00 \times 10^6\ \mathrm{m}/\mathrm{s})$ at an angle$(\theta = 30.0°)$ to the direction of the magnetic field as shown below. The proton follows a helical path.



(a) Determine the radius(R) of the helix.

(b) Determine the pitch distance (p) of the helix.

Solution for Problem 16

17. Consider a singly ionized carbon dioxide molecule $\left(\mathrm{m}_{\mathrm{CO}_2} = 44.0\ \mathrm{Amu}\right)$ is traveling from east to west at height of $20.0\ \mathrm{km}$ above the equator. At that altitude, the Earth's magnetic field is found to be $\overrightarrow{\mathrm{B}_\mathrm{E}} = 1.14 \times 10^{-5}\ \mathrm{T}\ (\widehat{\mathrm{North}})$.

(a) Ignoring gravity and relativity, what is the speed of the carbon dioxide ion traveling with uniform circular motion?

(b) Is ignoring gravity a reasonable thing to do?

(c) Is ignoring relativity a reasonable thing to do?

Solution for Problem 17

18. A circular coil has a radius $(\mathrm{R}_\mathrm{C} = 20.0 \times 10^{-2}\ \mathrm{m})$ and is made of 25.0 loops of wire. The coil lies flat on the ground. In this region of the Earth, the Earth's magnetic field is found to be $5.40 \times 10^{-5}\ \mathrm{T}$ and points into the ground making an angle of $66.0°$ below the horizontal which is pointing due north. A current of $12.0\ \mathrm{A}$ is running around the coil in a counter-clockwise direction.

(a) Determine the torque acting on the coil due to the Earth's magnetic field.

(b) Which edge (north, south, east or west) is rising up from the ground?

Solution for Problem 18

19. Derive an expression relating the magnetic moment of an electron orbiting in a hydrogen atom to the angular momentum of the electron.

Solution for Problem 19

20. Consider a rectangular metallic strip which has a width $(\mathrm{w} = 4.50\mathrm{x}\ 10^{-2}\ \mathrm{m})$ and a thickness $(\mathrm{d} = 6.40\ \mathrm{x}\ 10^{-4}\ \mathrm{m})$. A current $(\mathrm{i} = 50.0\ \mathrm{A})$ flows through the strip. When the strip carrying the current is placed within a magnetic field $(\mathrm{B} = 0.961\ \mathrm{T})$ a hall voltage $(\varepsilon_{\mathrm{H}} = 7.02\ \mathrm{x}\ 10^{-6}\ \mathrm{V})$ is created across the strip.

(a) Determine the Hall Electric field in the strip.

(b) Determine the drift speed of the conduction electrons in the metallic strip.

(c) Determine the density of free electrons in the metallic strip.

Solution for Problem 20

21. Blood cells contain ions that provide a current when blood is moving. Applying a magnetic field across blood vessels, a Hall emf is created across the blood vessels. So, a simple blood flow meter can be made based on this phenomenon.

(a) What effect does the sign of the ions has on the emf induced across the blood vessel?

(b) If a magnetic field $(\mathrm{B} = 0.075\ \mathrm{T})$ is applied is applied to a vessel with a diameter $(\mathrm{D} = 0.0045\ \mathrm{m})$ produces a Hall voltage $(\varepsilon_{\mathrm{H}} = 9.80\ \mathrm{x}\ 10^{-5}\ \mathrm{V})$, what is the flow rate of the blood in the vessel?

Solution for Problem 21

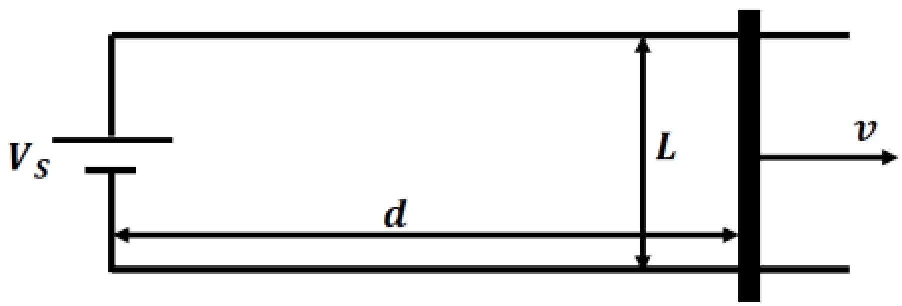
22. A mass spectrometer allows us to determine the percentages of various components of a material usually in a gaseous form. Two air pollutants are carbon dioxide $\left(\mathrm{m}_{\mathrm{CO_2}} = 44.01\ \mathrm{amu}\right)$ and propane $\left(\mathrm{m}_{\mathrm{C_3H_8}} = 44.10\ \mathrm{amu}\right)$. How large a radius of curvature would be needed for the two pollutants to be have a separation $(\Delta\mathrm{D} = 6.60\ \mathrm{x}\ 10^{-4}\ \mathrm{m})$ on either a piece of photographic film or the mass spectrometer detector?

Solution for Problem 22

23. An electric motor is powered by a $12.0\ \mathrm{V}$ power source has a square coil $(S = 0.050\ \mathrm{m})$ with $(\mathrm{N_{Coil}} = 50)$ turns of wire around the coil. The total resistance of the coil wire is $(\mathrm{R_{Coil}} = 48.0\ \Omega)$. The magnetic field surrounding the coil in the motor is $(\mathrm{B_{motor}} = 0.056\ \mathrm{T})$. What is the maximum torque acting on the coil?

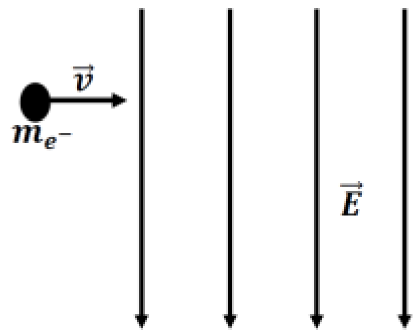
<u>Solution for Problem 23</u>

24. A "Rail Gun" is constructed by having two conducting rails which are powered by a voltage supply $(\mathrm{V_s} = 24.0\ \mathrm{V})$ which creates a current in the circuit composed of the rails and a bar that slides along the rails. The distance between the rails is $(\mathrm{L} = 0.250\ \mathrm{m})$. The rails are considered to have no resistance. The moveable bar has a resistance $(\mathrm{R} = 21.8\Omega)$ and a mass $(\mathrm{m} = 1.25 \times 10^{-3}\ \mathrm{kg})$. The magnetic field is applied either into or out of the plane of the paper. This field interacts with the current flowing through the bar providing a magnetic force that can accelerate the bar initially at rest. If the system is mounted vertically the bar could be launched as a projectile. For simplicity we will assume the motion is horizontal and the weight of the bar is supported by the rails. What is the direction and magnitude of the applied magnetic field that will produce a speed of $24.0\ \mathrm{m}/_\mathrm{s}$ after starting from rest and moving a distance $(\mathrm{d} = 2.00\ \mathrm{m})$



<u>Solution for Problem 24</u>

25. An electron is traveling to the right with a velocity ($\vec{v} = 5.78 \text{ x } 10^6 \ {}^{m}/_{s} \widehat{+i}$) when it enters a vertically oriented electric field ($\vec{E} = 9700 \ {}^{V}/_{m} \ \widehat{(-j)}$)as shown below.



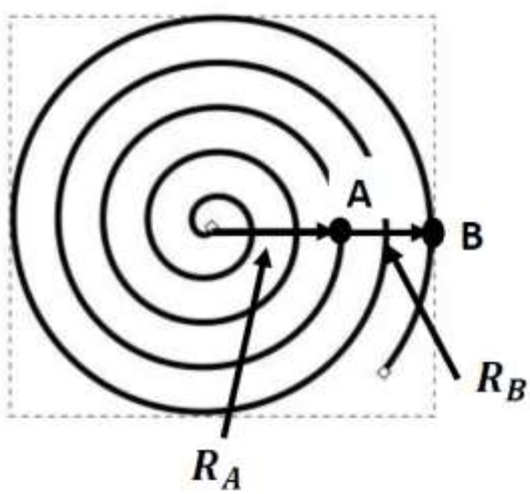
(a) In which direction (into or out of paper) should a magnetic field be placed to allow the electron to travel through the electric field without being deflected?

(b) What is the magnitude of the magnetic field which will keep the electron from being deflected?

(c) If the electric field were turned off, what would be the frequency of the circular orbits the electron will make with only the magnetic field present?

<u>**Solution for Problem 25**</u>

26. An electron is moving around a spiral track as indicated below. The magnetic field ($B = 0.190 \text{ T}$)is coming out of the paper forcing the electron to make the circles. The radius is changing as the energy of the electron is changing as it makes orbits. The radius at point A is given by ($R_A = 7.65 \text{ x } 10^{-3} \text{ m}$) and the radius at point B ($R_B = 12.3 \text{ x } 10^{-3} \text{ m}$) is given as. What is the change in kinetic energy going from Point A to Point B?



<u>**Solution for Problem 26**</u>

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