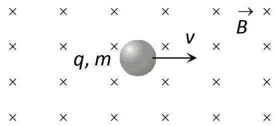
MAGNETIC EFFECTS OF CURRENT-3

[Motion of a charged particle in Magnetic field]

Force On a Charged Particle in Magnetic Field

If a particle carrying a positive charge q and moving with velocity v enters a magnetic field B then it experiences a force F which is given by the expression $\vec{F} = q(\vec{v} \times \vec{B}) \Rightarrow F = qvB\sin\theta$

where $\vec{v} =$ velocity of the particle, $\vec{B} =$ magnetic field



(1) **Zero force :** Force on charged particle will be zero (*i.e.* $F = 0$) if

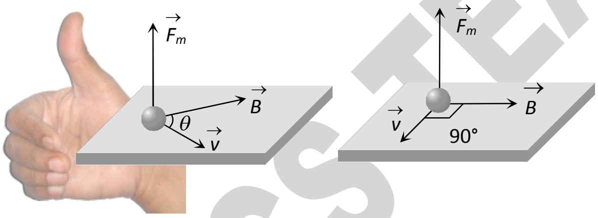
(i) No field *i.e.* $B = 0 \Rightarrow F = 0$

(ii) Neutral particle *i.e.* $q = 0 \Rightarrow F = 0$

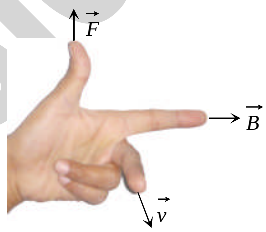
(iii) Rest charge *i.e.* $v = 0 \Rightarrow F = 0$

(iv) Moving charge *i.e.* $\theta = 0^o$ or $\theta = 180^o \Rightarrow F = 0$

(2) **Direction of force :** The force $\vec{F}$ is always perpendicular to both the velocity $\vec{v}$ and the field $\vec{B}$ in accordance with Right Hand Screw Rule, though $\vec{v}$ and $\vec{B}$ themselves may or may not be perpendicular to each other.



Direction of force on charged particle in magnetic field can also be find by Fleming's Left Hand Rule (FLHR).

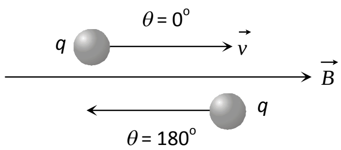


Here, *First finger* (indicates) $\rightarrow$ Direction of magnetic field

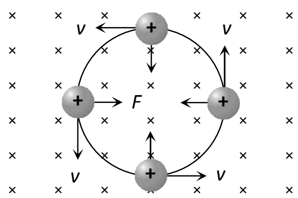
Middle finger $\rightarrow$ Direction of motion of positive charge or direction, Opposite to the motion of negative charge. *Thumb* $\rightarrow$ Direction of force

Trajectory of a Charged Particle in a Magnetic Field

(1) **Straight line :** If the direction of a $\vec{v}$ is parallel or antiparallel to $\vec{B}$, $\theta = 0$ or $\theta = 180^o$ and therefore $F = 0$. Hence the trajectory of the particle is a straight line.



(2) **Circular path :** If $\vec{v}$ is perpendicular to $\vec{B}$ *i.e.* $\theta = 90^o$, hence particle will experience a maximum magnetic force $\boldsymbol{F_{max} = qvB}$ which act's in a direction perpendicular to the motion of charged particle. Therefore the trajectory of the particle is a circle.

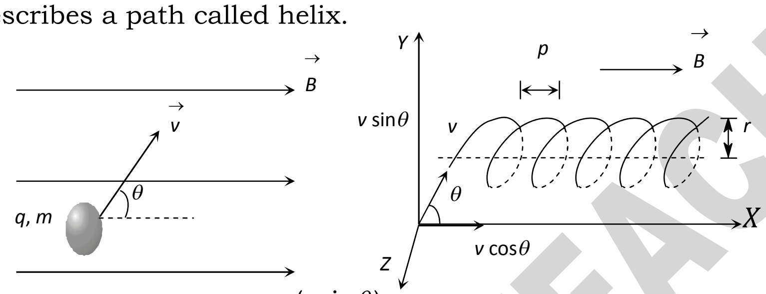


(i) In this case path of charged particle is circular and magnetic force provides the necessary centripetal force *i.e.* $qvB = \frac{mv^2}{r}$ $\Rightarrow$ radius of path $r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$

where p = momentum of charged particle and K = kinetic energy of charged particle (gained by charged particle after accelerating through potential difference V) then $p = mv = \sqrt{2mK} = \sqrt{2mqV}$

(ii) If T is the time period of the particle then $T = \frac{2\pi m}{qB}$ (*i.e.*, time period (or frequency) is independent of speed of particle).

(3) **Helical path :** When the charged particle is moving at an angle to the field (other than 0°, 90°, or 180°). Particle describes a path called helix.



(i) The radius of this helical path is $r = \frac{m(v\sin\theta)}{qB}$

(ii) Time period and frequency do not depend on velocity and so they are given by $T = \frac{2\pi m}{qB}$ and $\nu = \frac{qB}{2\pi m}$

(iii) The *pitch* of the *helix*, (*i.e.*, linear distance travelled in one rotation) will be given by $p = T(v\cos\theta) = 2\pi\frac{m}{qB}(v\cos\theta)$

(iv) If pitch value is p, then number of pitches obtained in length l given as

Number of pitches $= \frac{l}{p}$ and time required $t = \frac{l}{v\cos\theta}$

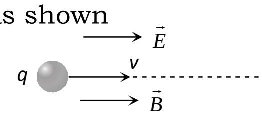
Lorentz Force

When the moving charged particle is subjected simultaneously to both electric field $\vec{E}$ and magnetic field $\vec{B}$, the moving charged particle will experience electric force $\vec{F_e} = q\vec{E}$ and magnetic force $\vec{F_m} = q(\vec{v}\times\vec{B})$; so the net force on it will be $\vec{F} = q[\vec{E} + (\vec{v}\times\vec{B})]$. Which is the famous 'Lorentz-force equation'.

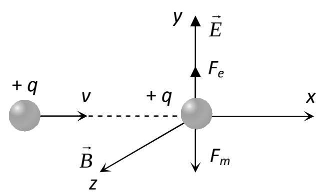
Depending on the directions of $\vec{v}, E$ and $\vec{B}$ following situations are possible

(i) **When $\vec{v}, \vec{E}$ and $\vec{B}$ all the three are collinear :** In this situation the magnetic force on it will be zero and only electric force will act and so $\vec{a} = \frac{\vec{F}}{m} = \frac{q\vec{E}}{m}$

(ii) The particle will pass through the field following a straight-line path (parallel field) with change in its speed. So in this situation speed, velocity, momentum and kinetic energy all will change without change in direction of motion as shown



(iii) **$\vec{v}, \vec{E}$ and $\vec{B}$ are mutually perpendicular :** In this situation if $\vec{E}$ and $\vec{B}$ are such that $\vec{F} = \vec{F_e} + \vec{F_m} = 0$ *i.e.*, $\vec{a} = (\vec{F}/m) = 0$



as shown in figure, the particle will pass through the field with same velocity, without any deviation in path.

And in this situation, as $F_e = F_m$ *i.e.*, $qE = qvB$ $v = E/B$

This principle is used in 'velocity-selector' to get a charged beam having a specific velocity.

Cyclotron

Cyclotron is a device used to accelerated positively charged particles (like, α-particles, deutrons *etc.*) to acquire enough energy to carry out nuclear disintegration *etc.*

It is based on the fact that the electric field accelerates a charged particle and the magnetic field keeps it revolving in circular orbits of constant frequency.

It consists of two hollow *D*-shaped metallic chambers D_1 and D_2 called dees. The two dees are placed horizontally with a small gap separating them. The dees are connected to the source of high frequency electric field. The dees are enclosed in a metal box containing a gas at a low pressure of the order of 10^{-3} *mm* mercury. The whole apparatus is placed between the two poles of a strong electromagnet *NS* as shown in fig. The magnetic field acts perpendicular to the plane of the dees.

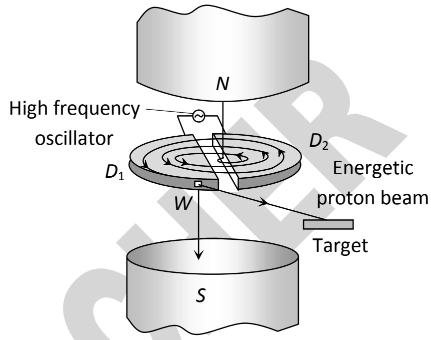


Fig. 21.33

(1) **Cyclotron frequency :** Time taken by ion to describe a semicircular path is given by $t = \frac{\pi r}{v} = \frac{\pi m}{qB}$, and it is independent of the speed of the particle.

If T = time period of oscillating electric field then $T = 2t = \frac{2\pi m}{qB}$ the cyclotron frequency $\nu = \frac{1}{T} = \frac{Bq}{2\pi m}$

(2) **Maximum energy of particle :** Maximum energy gained by the charged particle $E_{\max} = \left(\frac{q^2B^2}{2m}\right)r^2$

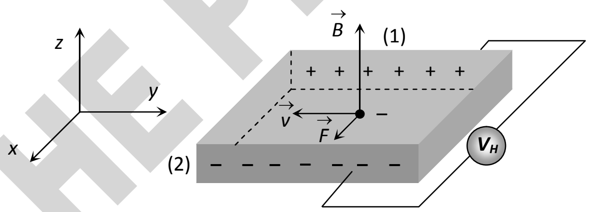
where r_0 = maximum radius of the circular path followed by the positive ion.

Hall Effect***

The Phenomenon of producing a transverse emf in a current carrying conductor on applying a magnetic field perpendicular to the direction of the current is called Hall effect.

Hall effect helps us to know the nature and number of charge carriers in a conductor.

Consider a conductor having electrons as current carriers. The electrons move with drift velocity $\vec{v}$ opposite to the direction of flow of current



Force acting on electron $F_m = -e(\vec{v} \times \vec{B})$. This force acts along *x*-axis and hence electrons will move towards face (2) and it becomes negatively charged.

Understanding Concept:-

1. Units of a magnetic field might be:

A. C.m/s B. C.s/m C. C/kg D. kg/C.s E. N/C.m

2. In the formula **F** = q (**v** x **B**) :

A. **F** must be perpendicular to **v** but not necessarily to **B**

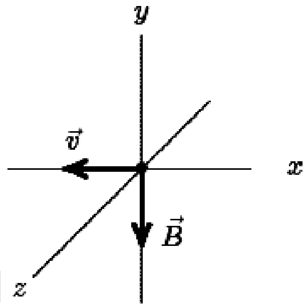
B. **F** must be perpendicular to **B** but not necessarily to **v**

C. **v** must be perpendicular to **B** but not necessarily to **F**

D. all three vectors must be mutually perpendicular

E. **F** must be perpendicular to both **v** and **B**

3. An electron moves in the negative x direction, through a uniform magnetic field in the negative y direction. The magnetic force on the electron is:



A. in the negative x direction

B. in the positive y direction

C. in the negative y direction

D. in the positive z direction

E. in the negative z direction

4. At any point the magnetic field lines are in the direction of:

A. the magnetic force on a moving positive charge

B. the magnetic force on a moving negative charge

C. the velocity of a moving positive charge

D. the velocity of a moving negative charge

E. none of the above

5. The magnetic force on a charged particle is in the direction of its velocity if:

A. it is moving in the direction of the field

B. it is moving opposite to the direction of the field

C. it is moving perpendicular to the field

D. it is moving in some other direction

E. never

6. A magnetic field exerts a force on a charged particle:

A. always

B. never

C. if the particle is moving across the field lines

D. if the particle is moving along the field lines

E. if the particle is at rest

7. The direction of the magnetic field in a certain region of space is determined by firing a test charge into the region with its velocity in various directions in different trials. The field direction is:

A. one of the directions of the velocity when the magnetic force is zero

B. the direction of the velocity when the magnetic force is a maximum

C. the direction of the magnetic force

D. perpendicular to the velocity when the magnetic force is zero

E. none of the above

8. An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:

A. zero B. up C. down D. east E. west

9. A magnetic field CANNOT:

A. exert a force on a charged particle

B. change the velocity of a charged particle

C. change the momentum of a charged particle

D. change the kinetic energy of a charged particle

E. change the trajectory of a charged particle

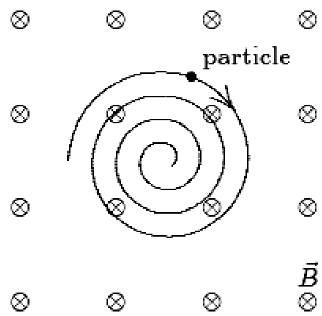
10. A proton (charge e), traveling perpendicular to a magnetic field, experiences the same force as an alpha particle (charge 2e) which is also traveling perpendicular to the same field. The ratio of their speeds, v_{proton}/v_{alpha}, is:

A. 0.5 B. 1 C. 2 D. 4 E. 8

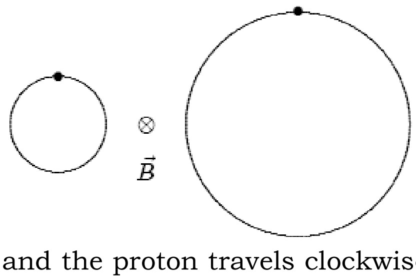
11. A hydrogen atom that has lost its electron is moving east in a region where the magnetic field is directed from south to north. It will be deflected:

A. up B. down C. north D. south E. not at all

12. A beam of electrons is sent horizontally down the axis of a tube to strike a fluorescent screen at the end of the tube. On the way, the electrons encounter a magnetic field directed vertically downward. The spot on the screen will therefore be deflected:
A. upward
B. downward
C. to the right as seen from the electron source
D. to the left as seen from the electron source
E. not at all
13. An electron (charge = -1.6×10^{-19} C) is moving at 3×10^5 m/s in the positive x direction. A magnetic field of 0.8T is in the positive z direction. The magnetic force on the electron is:
A. 0
B. 4×10^{-14} N, in the positive z direction
C. 4×10^{-14} N, in the negative z direction
D. 4×10^{-14} N, in the positive y direction
E. 4×10^{-14} N, in the negative y direction
14. At one instant an electron (charge = -1.6×10^{-19} C) is moving in the xy plane, the components of its velocity being $v_x = 5 \times 10^5$ m/s and $v_y = 3 \times 10^5$ m/s. A magnetic field of 0.8T is in the positive x direction. At that instant the magnitude of the magnetic force on the electron is:
A. 0 B. 2.6×10^{-14} N C. 3.8×1010^{-14} N D. 6.4×10^{-14} N
E. 1.0×10^{-13} N
15. At one instant an electron (charge = -1.6×10^{-19} C) is moving in the xy plane, the components of its velocity being $v_x = 5 \times 10^5$ m/s and $v_y = 3 \times 10^5$ m/s. A magnetic field of 0.8T is in the positive x direction. At that instant the magnitude of the magnetic force on the electron is:
A. 0 B. 3.8×10^{-14} N C. 5.1×10^{-14} N D. 6.4×10^{-14} N
E. 7.5×10^{-14} N
16. An electron travels due north through a vacuum in a region of uniform magnetic field **B** that is also directed due north. It will:
A. be unaffected by the field
B. speed up
C. slow down
D. follow a right-handed corkscrew path
E. follow a left-handed corkscrew path
17. At one instant an electron is moving in the positive x direction along the x axis in a region where there is a uniform magnetic field in the positive z direction. When viewed from a point on the positive z axis, it subsequent motion is:
A. straight ahead
B. counterclockwise around a circle in the xy plane
C. clockwise around a circle in the xy plane
D. in the positive z direction
E. in the negative z direction



18. A uniform magnetic field is directed into the page. A charged particle, moving in the plane of the page, follows a clockwise spiral of decreasing radius as shown. A reasonable explanation is:
A. the charge is positive and slowing down
B. the charge is negative and slowing down
C. the charge is positive and speeding up
D. the charge is negative and speeding up
E. none of the above



19. An electron and a proton each travel with equal speeds around circular orbits in the same uniform magnetic field, as shown in the diagram (not to scale). The field is into the page on the diagram. Because the electron is less massive than the proton and because the electron is negatively charged and the proton is positively charged:
A. the electron travels clockwise around the smaller circle and the proton travels counterclockwise around the larger circle
B. the electron travels counterclockwise around the smaller circle and the proton travels clockwise around the larger circle

C. the electron travels clockwise around the larger circle and the proton travels counterclockwise around the smaller circle
D. the electron travels counterclockwise around the larger circle and the proton travels clockwise around the smaller circle
E. the electron travels counterclockwise around the smaller circle and the proton travels counterclockwise around the larger circle

20. An electron is launched with velocity **v** in a uniform magnetic field **B**. The angle θ between **v** and **B** is between 0 and 90^0. As a result, the electron follows a helix, its velocity vector **v** returning to its initial value in a time interval of:
A. $2\pi m/eB$
B. $2\pi\ mv/eB$
C. $2\pi\ v \sin\theta/eB$
D. $2\pi\ mv \cos\theta/eB$
E. none of these

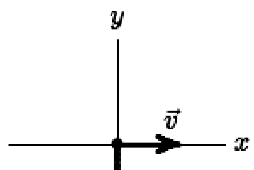
21. An electron and a proton are both initially moving with the same speed and in the same direction at 90^0 to the same uniform magnetic field. They experience magnetic forces, which are initially:
A. identical
B. equal in magnitude but opposite in direction
C. in the same direction and differing in magnitude by a factor of 1840
D. in opposite directions and differing in magnitude by a factor of 1840
E. equal in magnitude but perpendicular to each other.

22. An electron enters a region of uniform perpendicular **E** and **B** fields. It is observed that the velocity **v** of the electron is unaffected. A possible explanation is:
A. **v** is parallel to **E** and has magnitude E/B
B. **v** is parallel to **B**
C. **v** is perpendicular to both **E** and **B** and has magnitude B/E
D. **v** is perpendicular to both **E** and **B** and has magnitude E/B
E. the given situation is impossible

23. A charged particle is projected into a region of uniform, parallel, **E** and **B** fields. The force on the particle is:
A. zero
B. at some angle < 90^0 with the field lines
C. along the field lines
D. perpendicular to the field lines
E. unknown (need to know the sign of the charge)

24. A uniform magnetic field is in the positive z direction. A positively charged particle is moving in the positive x direction through the field. The net force on the particle can be made zero by applying an electric field in what direction?
A. Positive y B. Negative y
C. Positive x D. Negative x
E. Positive z

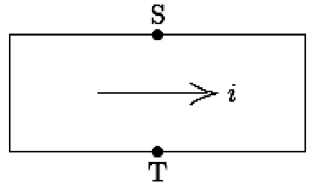
25. An electron is traveling in the positive x direction. A uniform electric field **E** is in the negative y direction. If a uniform magnetic field with the appropriate magnitude and direction also exists in the region, the total force on the electron will be zero. The appropriate direction for the magnetic field is:



A. the positive y direction
B. the negative y direction
C. into the page
D. out of the page
E. the negative x direction

26. An ion with a charge of $+3.2 \times 10^{-19}$ C is in a region where a uniform electric field of 5×10^4 V/m is perpendicular to a uniform magnetic field of 0.8T. If its acceleration is zero then its speed must be:
A. 0 B. 1.6×10^4 m/s C. 4.0×10^4 m/s D. 6.3×10^4 m/s
E. any value but 0

27. The current is from left to right in the conductor shown. The magnetic field is into the page and point S is at a higher potential than point T. The charge carriers are:



A. positive B. negative C. neutral D. absent
E. moving near the speed of light

28. Electrons (mass m, charge .e) are accelerated from rest through a potential difference V and are then deflected by a magnetic field **B** that is perpendicular to their velocity. The radius of the resulting electron trajectory is:
A. $(2eV/m)^{1/2}/B$ B. $B(2eV/m)^{1/2}$ C. $(2mV/e)^{1/2}/B$ D. $B(2mV)^{1/2}/e$
E. none of these

29. In a certain mass spectrometer, an ion beam passes through a velocity filter consisting of mutually perpendicular fields **E** and **B**. The beam then enters a region of another magnetic field **B'** perpendicular to the beam. The radius of curvature of the resulting ion beam is proportional to:
A. EB'/B B. EB/B' C. BB'/E D. B/EB' E. E/BB'

30. A cyclotron operates with a given magnetic field and at a given frequency. If R denotes the radius of the final orbit, the final particle energy is proportional to:
A. 1/R B. R C. R^2 D. R^3 E. R^4

31. J. J. Thomson's experiment, involving the motion of an electron beam in mutually perpendicular **E** and **B** fields, gave the value of:
A. mass of an electron B. charge of an electron C. Earth's magnetic field
D. charge/mass ratio for electrons E. Avogadro's number

32. A proton beam is going from north to south and an electron beam is going from south to north. Neglection the earth's magnetic field, the electron beam will be deflected
(A*) towards the proton beam (B) away from the proton beam
(C) upwards (D) downwards

33. A charge particle is moved along a magnetic field line. The magnetic force on the particle is
(A) along its velocity (B) magnetic field only (C) both of them (D*) none of them

34. A moving charge produces
(A) electric field only (B) magnetic filed only (C*) both of them (D) none of these

35. A particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by a the path described by the particle is proportional to
(A) the velocity (B) the momentum (C*) the kinetic energy (D) none of these

36. Two particles X and Y having equal charge, after being acceleration through the same potential difference circular paths of radii R1 and R2 respectively. The ratio of the mass of X to that of Y is -
(A) $(R_1/R_2)^{1/2}$ (B) R_1/R_2 (C*) $(R_1/R_2)^2$ (D) R_1R_2

37. A positively charged particle projected towards east os deflected towards north by a magnetic field. The field may be -
(A) towards west (B) towards south (C) upward (D*) downward

38. A charged particle is whirled in a horizontal circle on a frictionless table by attaching it to a string fixed at one point. If a magnetic field is switched on in the vertical direction, the tension in the string.
(A) will increase (B) will decrease (C) will remain the same
(D*) may increase or decrease

39. Which of the following particles will describe the smallest circle when projected with the same velocity perpendicular to a magnetic field ?
(A) electron (B) proton (C) He+ (D*) Li+

40. Which of the following particles will have minimum frequency of revolution when projected with the same velocity perpendicular to a magnetic field ?
(A*) electron (B) proton (C) He+ (D) Li+

41. Which of the following particles will have minimum frequency of revolution when projected with the same velocity perpendicular to a magnetic field ?
(A) electron (B) proton (C) He+ (D*) Li+

42. A beam consisting of protons and electrons moving at the same speed goes through a thin region in which there is a magnetic field perpendicular to the beam. The protons and the electrons
(A) will go undeviated
(B) will be deviated by the same angle will not separate
(C*) will be deviated by different angles and hence separate
(D) will be deviated by the same angle but will separate.

43. A charged particle moves in a uniform magnetic field. The velocity of the particle at some instant makes an acute angle with the magnetic field. The path of the particle will be.

(A) a straight line
(B) a circle
(C*) a helix with uniform pitch
(D) a helix with nonuniform pitch.

44. A particle moves in a region having a uniform magnetic field and a parallel, uniform electric field. At some instant, the velocity of the particle is perpendiculars to the field direction. The path of the particle will be

(A) a straight line
(B) a circle
(C) a helix with uniform pitch
(D*) a helix with nonuniform pitch.

45. An electric current i enters and leaves a uniform circular wire of radius a through diametrically opposite points. A charged particle q moving along the axis of the circular wire passes through its centre at speed u. The magnetic force acting on the particle when it passes through the centre has a magnitude

(A) $qv\frac{\mu_o i}{2\pi a}$
(B) $qv\frac{\mu_o i}{2a}$
(C) $qv\frac{\mu_o i}{a}$
(D*) zero

46. If a charged particle at rest experieces no electromagnetic force,

(A*) the electric field must be zero
(B) the magnetic field must be zero
(C) the electric field may or may not be zero
(D*) the magnetic field may or may not be zero

47. If a charged particle kept at list expreiences an electromagnetic force,

(A*) the electric field must not be zero
(B) the magnetic field must not be zero
(C) the electric field may or may not be zero
(D*) the magnetic field may no may not be zero

48. If a charged particle projected in a gravity-free room deflects,

(A) there must be an electric field
(B) there must be a magnetic field
(C*) both field cannot be zero
(D*) both fields can be nonzero

49. A charged particle moves in a gravity-free space without change in velocity. Which of the following is/are possible ?

(A*) $E = 0, B = 0$
(B*) $E = 0, B \neq 0$
(C) $E \neq 0, B = 0$
(D*) $E \neq 0, B \neq 0$

50. A charged particle moves along a circle under the action of possible constant electric and magnetic fields. Which of the following are possible?

(A) $E = 0, B = 0$
(B*) $E = 0, B \neq 0$
(C) $E \neq 0, B = 0$
(D) $E \neq 0, B \neq 0$

51. A charged particle goes undelflected in a region containing electric and magnetic field. It is possible that

(A*) $\vec{E} \parallel \vec{B}$, $\vec{v} \parallel \vec{E}$
(B*) $\vec{E}$ is not parallel to $\vec{B}$
(C) $\vec{v} \parallel \vec{B}$ but $\vec{E}$ is not parallel to $\vec{B}$
(D) $\vec{E} \parallel \vec{B}$ but $\vec{v}$ is not parallel to $\vec{E}$

52. If a charged particle goes unacceleration in a region containing electric and magnetic fields,

(A*) $\vec{E}$ must be perpendicular to $\vec{B}$
(B*) $\vec{v}$ must be perpendicular to $\vec{E}$
(C) $\vec{v}$ must be perpendicular to $\vec{B}$
(D) E must be equal to vB.

53. Two ions have equla masses but one is singly-ionized and other is douly-ionized. The are project from the same place in a uniform magnetic field with the same veloicty perpendicular to the field.

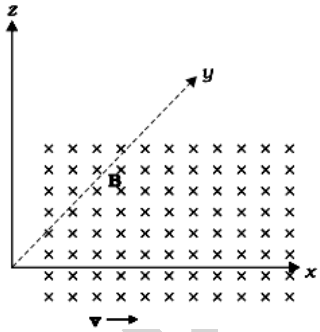
(A) Both ions will go along circles of equal radii.
(B*) The circle described by the single-ionized charge will have a radius double that of the other circle
(C) The two circles do not touch each other
(D*) The two circles touch each other

54. An electron is moving along the positive X-axis. You want to apply a magnetic field for a short time so that the electron may reverse its direction and move parallel to the negative X-axis. This can be done by applying the magentic field along.

(A*) Y-axis
(B*) Z-axis
(C) Y-axis only
(D) Z-axis only

55. Let $\vec{E}$ and $\vec{B}$ denote electric and magnetic fields in a frames S and $\vec{E}'$ and $\vec{B}'$ in another frame S' moving with respect to S at a velocity. Two of the following equations are wrong. Identify them.

(A) $B_y^1 + B_y + vE_2/c^2$
(B*) $E_y^1 + E_y + vB_2/c^2$
(C*) $B_y^1 + B_y + vE_2$
(D) $B_y^1 + B_y + vB_2$



56. If the magnetic field is parallel to the positive y-axis and the charged particle is moving along the positive x-axis (Fig.), which way would the Lorentz force be for (a) an electron (negative charge), (b) a proton (positive charge).

57. What is the radius of the path of an electron (mass 9 x 10^{-31} kg and charge 1.6 x 10^{-19} C) moving at a speed of 3 $\times 10^{7}$ m/s in a magnetic field of 6 x 10^{-4} T perpendicular to it? What is its frequency? Calculate its energy in keV. (1 eV = 1.6 × 10^{-19} J).

58. A cyclotron's oscillator frequency is 10 MHz. What should be the operating magnetic field for accelerating protons? If the radius of its 'dees' is 60 cm, what is the kinetic energy (in MeV) of the proton beam produced by the accelerator. (e =1.60 x 10^{-19} C, mp = 1.67 x 10^{-27} kg, 1 MeV = 1.6 x 10^{-13} J).

59. In a chamber, a uniform magnetic field of 6.5 G (1 G = 10^{-4} T) is maintained. An electron is shot into the field with a speed of 4.8 x 10^{6} m s^{-1} normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit.
(e = 1.6 × 10^{-19} C, m_e = 9.1×10^{-31} kg)

60. In Exercise 24 obtain the frequency of revolution of the electron in its circular orbit. Does the answer depend on the speed of the electron? Explain.

61. Answer the following questions:
(a) A magnetic field that varies in magnitude from point to point but has a constant direction (east to west) is set up in a chamber. A charged particle enters the chamber and travels undeflected along a straight path with constant speed. What can you say about the initial velocity of the particle?
(b) A charged particle enters an environment of a strong and non-uniform magnetic field varying from point to point both in magnitude and direction, and comes out of it following a complicated trajectory. Would its final speed equal the initial speed if it suffered no collisions with the environment?
(c) An electron travelling west to east enters a chamber having a uniform electrostatic field in north to south direction. Specify the direction in which a uniform magnetic field should be set up to prevent the electron from deflecting from its straight line path.

62. An electron emitted by a heated cathode and accelerated through a potential difference of 2.0 kV, enters a region with uniform magnetic field of 0.15 T. Determine the trajectory of the electron if the field (a) is transverse to its initial velocity, (b) makes an angle of 30° with the initial velocity.