PHYSICS

BOOKS - AAKASH SERIES

MAGNETISM

Examples

1. Two magnetic poles of strengths 40Am and 10 Am are separated by a distance of 20 cm in

air. Find the force between them. If the distance is reduced to 10 cm, find the force.

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2. Two magnetic poles, one of which is three times as strong as the other, exert on each other, a force equal to 3×10^{-3}N when separated by a distance of 10 cm. Find the strength of each pole.

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3. A N-pole of a very long magnetic needle is placed at a distance of 20 cm from a point 'P'. If the pole strength of the magnetic needle is 40 Am what is the magnetic induction at the point 'P'?

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4. A bar magnet of length 10 cm and pole strength 2 A m makes an angle 60° with a uniform magnetic field of induction 50 T. The couple acting on it is

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5. When a bar magnet is placed at 90° to uniform magnetic field , it is acted upon by a couple which is maximum . For the couple to be half of the maximum value , it is to be inclined to the magnetic field at an angle is

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6. If the moment of a magnet is $0.4A - m^2$ and force acting on each pole in a uniform magnetic field of induction $3.2 \times 10^{-5} Wb/m^2$ is $5.12 \times 10^{-5} N$, then find the distance between the poles of the magnet.

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7. A small magnet of moment 4.8×10^{-2} J/T is suspended freely in the plane of a uniform

magnetic field of magnitude 3×10^{-2} T. If the magnet is slightly displaced from its stable equilibrium and released then the angular frequency of its oscillations in rad/sec. (Moment of inertia of the magnet about the axis of rotation is $2.25 \times 10^{-5} kgm^2$)

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8. A magnetic dipole is under the influence of two magnetic fields. The angle between the field direction is 60° and one of the fields has

magnitude of $1.2 \times 10^{-2} T$. If the dipole comes to stable equilibrium at an angle of 30° with this Held, then the magnitude of the field is

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9. A magnet vibrates in a magnetic field of strength 10^{-4} T. If the moment of the magnet is $10^{-1} A - m^2$ and the moment of inertia about the axis of rotation is $10^{-5} kgm^2$, then find the time period of oscillation in seconds?

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10. A magnetic needle is pivoted through its centre of mass and is free to rotate in a plane containing uniform magnetic field $200 \times 10^{-4} T$. When it is displaced slightly from the equilibrium it makes 20 oscillations per second. If the moment of inertia of the needle about the axis of oscillation is $0.75 \times 10^{-5} kgm^2$, find the magnetic moment of the needle.

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11. Two bar magnets placed together in a vibration magnetometer take 3 seconds for 1 vibration. If one magnet is reversed, the combination takes 4 seconds for 1 vibration. Find the ratio of their magnetic moments.

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12. A bar magnet makes 40 oscillations per minute in a vibration magnetometer. An identical magnet is demagnetised completely

and is placed over the magnet in the magnetometer. Calculate the time taken for 40 oscillations by this combination. Ignore induced magnetism.

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13. The time period of a thin bar magnet is T. It is cut into 'n' equal parts by cutting it normal to its length. What will be the time period of each of them in the same field?

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14. A vibration magnetometer consist of two identical bar magnets placed one over the other such that they are mutually perpendicular and bisect each other. The time period of oscillations of combination in a horizontal magnetic field is $4s$. If one of the magnets is removed, then the period of oscillations of the other in the same field is

15. The magnetic moment of a bar magnet of length 20cm is $3.6 \times 10^{-6} A - m^2$. The magnetic length is 90% of its geometric length. Then find the pole strength of the magnet.

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16. In a hydrogen atom, the electron revolves round the nucleus 6.8×10^{15} times per second in an orbit of radius 0.53Å. What is

equivalent magnetic moment ? (Given that $e = 1.6 \times 10^{-19} C$).

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17. Two identical magnets are placed perpendicular to each other with their unlike poles in contact. If each magnet has a magnetic moment 'M', what is the magnetic moment of the combination?

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18. A bar magnet of magnetic moment M_1 is suspended by a wire in a magnetic field. The tip of the wire is rotated through 180°, then the magnet rotated through 45°. Under similar conditions the magnet of magnetic moment M_2 is rotated through 30°. Then find the ratio of $M_1 \& M_2$.

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19. A bar magnet of magnetic moment M is bent into a semicircle. What is its new magnet

moment ?

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20. A magnet is suspended at an angle 60° in an external magnetic field of $5 \times 10^{-4} T$. What is the work done by the magnetic field in bringing it in its direction ? [The magnetic moment = $20A - m^2$]

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21. The magnetic moment of a bar magnet is 45 Am^2 and its length is 10 cm. Calculate the magnetic field induction at a point 10 cm away from the centre of the magnet on the axial line.

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22. A bar magnet of length 0.1m has pole strength of 50A-m. Calculate the magnetic field at distance of 0.2m from tis centre on

(i) its axial line and (ii) it equatorial line.

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23. A short bar magnet of magnetic movement $5.25 \times 10^{-2} JT^{-1}$ is placed with its axis perpendicular to the earth's field direction. At what distance from the centre of the magnet,

the resultant field is inclined at 45° with earth's field on (a) its normal bisector and (b) its axis. Magnitude of the earth's field at the place is given to be 0.42 G. Ignore the length of the magnet in comparison to the distances involved.

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24. Two like poles of strength $49 \times 10^{-3} Am$ and $9 \times 10^{-3} Am$ are separated by a distance of 10 cm . Find the

distance of the neutral point from the stronger pole where the magnetic induction due to the two poles will be zero .

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25. A bar magnet is kept in the earth's magnetic field with its north pole pointing earth's north. The distance between the null point is 20 cm. If earth's horizontal magnetic field is $4 \times 10^{-5} T$, then find the magnetic moment of the magnet.

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26. A bar magnet of magnetic moment $0.4Am^2$ is placed in the magnetic meridian with its north pole pointing north. A neutral point is obtained at a distance of 10 cm from the centre of the magnet. If the length of the magnet is also 10 cm, what is the value of horizontal component of earth's field at the place?

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27. A bar magnet of length $8cm$ and having a pole strengh of $1.0Am$ is placed vertically on a horizontal table with its south pole on the table. A neutral point is found on the table at a distance of 6.0 cm north of the magnet. Calculate the earth's horizontal magnetic field.

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28. A very small magnet is placed in the magnetic meridian with its S-pole pointing north. The null point is obtained 20 cm away

from the centre of the magnet. What is the magnetic moment of the magnet if earth's field is $0.3 \times 10^{-4} T$?

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29. A magnetising field of $1500 Am^{-1}$ produces flux of 2.4×10^{-5} weber in a iron bar of the cross-sectional area of $0.5 cm^2$. The permeability of the iron bar is

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30. An iron bar of length 10 cm and diameter 2cm is placed in a magnetic field of intensity $1000Am^{-1}$ with its length parallel to the direction of the field. Determine the magnetic moment produced in the bar if permeability of its material is $6.3 \times 10^{-4}TmA^{-1}$.

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31. A compass needle whose magnetic moment is $60Am^2$ pointing geographical north at a certain place where the horizontal component

of earth's magnetic field is $40 \times 10^{-6} Wbm^{-2}$ experiences a torque of $1.2 \times 10^{-3} Nm$. The declination of the place is

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32. The value of horizontal component of earth's magnetic field at a place is $0.35 \times 10^{-4} T$. If the angle of dip is 60°, the value of vertical component of earth's magnetic field is nearly

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33. A magnet is suspended in such a way that it oscillates in the horizontal plane. It makes 20 oscillation per minute at a place where dip angle is 30° and 15 oscillation per minute at a place where dip angle is 60°. The ratio of earth's magnetic fields at two places is

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34. A magnetic needle suspended in a vertical plane at 30° from the magnetic meridian

makes an angle of 45° with the horizontal. Find the true angle of dip.

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35. Considering the earth as a short magnet with its centre coinciding with the centre of earth, show that the angle of dip$\phi$is related to magnetic latitude λ by the relation $\tan\phi = 2\tan\lambda$.

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Exercise Long Answer Questions

1. State inverse square law and explain how can it be verified by Gauss method.

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2. Describe the principle of working of deflection magnetometer. Explain how the magnetic moments of two short bar magnets can be compared in tan A position by Null method.

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3. Describe the principle of working of deflection magnetometer. Explain how the magnetic moments of two short bar magnets can be compared in tan A position by Equal distance method

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4. Define Magnetic moment of a bar magnet. Explain the method of comparing the magnetic moments of two short bar magnets in tan B position in Null method.

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5. Define Magnetic moment of a bar magnet. Explain the method of comparing the magnetic moments of two short bar magnets in tan B position in Equal distance method,

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6. Describe the principle of working of deflection magnetometer. Explain how the magnetic moments of two short bar magnets can be compared in tan A position by Null method.

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Exercise Short Answer Questions

1. Derive the equation for the couple acting on a bar magnet in a uniform magnetic field and hence deduce the definition of "magnetic moment".

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2. Derive an expression for the magnetic induction at a point on the axial line of a bar magnet.

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3. State Tangent Law in magnetism.

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4. A defiection magnetometer works on

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5. Derive an expression for the period of a geostationary satellite.

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6. Write three points of differences between para, dia-and ferro- mangetic materials, giving one example for each.

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Exercise Very Short Answer Questions

1. The force between two magnetic poles separated by a distance 'd' in air is F. At what

distance between them the force becomes doubled.

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2. Can the force on unit N - pole between two isolated equal like poles be zero at any point?

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3. Can the force on unit N- pole between two isolated unlike poles be zero at any point?

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4. Why don't two magnetic lines of force intersect each other?

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5. Distinguish between uniform and non-uniform motions, giving an example of each.

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6. When is the couple acting on a bar magnet in a uniform magnetic field (i) maximum (ii) minimum.

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7. Define the magnetic moment of a bar magnet. What is its direction?

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8. What are the units of the following physical quantities?

i) magnetic moment ii) magnetic permeability

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9. A bar magnet of magnetic moment M is bent into a semicircle. What is its new magnet

moment ?

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10. A bar magnetic dipole moment M is cut into two equal pieces as shown, magnetic moment of each piece is

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11. The magnetic moment of a bar magnet is M. If it is cut into two pieces in the ratio 1:2 perpendicular to its length, what is the ratio of their magnetic moments.

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12. Define magnetic flux density (magnetic induction) . The magnetic induction of a point is B. What is the magnetic flux through an area A ?

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13. Derive an expression for the magnetic induction at a point on the axial line of a bar magnet.

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14. Derive an expression for the magnetic induction at a point on the axial line of a bar magnet.

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15. A magnet is placed horizontally on ground with its north pole towards the geographic north pole of the earth. The natural point obtained

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16. When the Npole of a bar magnet points towards uniform the South and Spole towards the North, the null period points are at the

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17. What is the magnetic induction at the mid-point of the straight line joining the two poles of a horse shoe magnet , separated by a distance '2d' ? (The pole strength of each pole is 'm'.)

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18. Two magnets of magnetic moments M_1 and M_2 are joined at their centres to

form a cross (perpendicular to each other). The combination is suspended in a uniform magnetic field directed vertically upwards. It stands in equilibrium when either of them. makes an angle of 45° with the vertical field. What is the ratio of their magnetic moments?

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19. On what factors does the period of oscillation of a bar magnet in a uniform magnetic field depend.

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20. How do you determine the magnetic nature of a material, given in the form of a rod?

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21. Classify the following substances into Dia, Para and Ferro magnetic materials: (i) Manganese, (ii) Bismuth, (iii) Cobalt, (iv) Oxygen, (v) Copper and (vi) Aluminium.

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22. The relative permeability of silicon is 0.999837 and that of palladium is 1.000692. What do you infer about the magnetic nature of silicon and palladium?

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23. What happens to the length of a ferromagnetic rod when it is magnetised?

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24. What happens to the magnetism of an iron bar magnet when it is melted?

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25. A red hot steel needle is suspended along the North South direction and cooled. What happens

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Problems Level I

1. The distance between a north pole of strength 6×10^{-3}Am and a south pole of strength 8×10^{-3} Am is 10 cm. The poles are separated in air. Find the force between them.

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2. Two poles separated by 10 cm experiences a force of 5 mN. Find the force between them

when the distance is doubled and pole strengths are doubled.

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3. What is the magnetic induction due to a magnet of pole strength 20A-m and length 20 cm at a distance of 0.5m from its centre on the axial line?

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4. Find the force experienced by a pole of strength 100 Am at a distance of 20 cm from a short bar magnet of length 5 cm and pole strength of 200 Am on its axial line.

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5. Find the magnetic induction at a distance of 20 cm on the equatorial line of a short bar magnet with a magnetic moment $60Am^2$.

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6. What is the magnetic induction due to a magnet of pole strength 20A-m and length 20 cm at a distance of 0.5m from its centre on the axial line?

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7. What is the magnetic moment of a semi circular magnet of radius 'r' and pole strength 'm'?

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8. The magnetic moment of a bar magnet of length 0.2m is $1Am^2$. If it is cut into two equal pieces along its axis, what is the magnetic moment of each piece.

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9. Two magnets have their lengths in the ratio 2:3 and their pole strengths in the ratio 3:4. Find the ratio of their magnetic moments.

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10. If the maximum couple acting on a magnet in a field of induction 0.2T is 10Nm, what is its magnetic s moment?

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11. The maximum torque on the magnet of length $2 \times 10^{-1} m$ in a uniform magnetic field having induction $2 \times 10^{-1} T$ is 10Nm. Calculate its pole strength.

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12. At what angle with the magnetic meridian will a magnetic needle rest if it is subjected to a magnetic field of induction $0.6 \times 10^{-4} T$ perpendicular to the magnetic meridian? ($B_H = 0.2 \times 10^{-4} T$)

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13. A bar magnet of moment of inertia $1 \times 10^{-2} Kgm^2$ vibrates in a magnetic field of induction 0.36×10^{-4} Tesla. The time period of vibration is 10 s. Find the magnetic moment of the bar magnet.

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14. Along bar magnet of time period T, used in vibration magnetometer is cut into four equal parts cutting it perpendicular to both length

and breadth. Find the time period of one small part.

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15. Two bar magnets of the same mass, length and breath having magnetic moment M and 2M are joined together pole to pole and suspended in na vibration magnetomer. The time period of oscillation is 3s. If the polarity of one of the magnets is reversed, the time period of oscillation will be

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16. The permeability of substance is 6.28×10^{-4} wb/A-m. Find its relative permeability and susceptibility?

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17. A bar magnet made of steel has a magnetic moment of $2.5Am^2$ and mass of $6.6 \times 10^{-5}kg$. If the density of steel is

$7.9 \times 10^3 kgm^{-3}$, find the intensity of magnetization of the magnet.

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18. A magnetic field strength (H) $3 \times 10^3 Am^{-1}$ produces a magnetic field of induction (B) of $12\pi T$ in an iron rod. Find the relative permeability of iron?

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19. A ship is sailing due east according to Mariner's compass. If the declination of that place is 18° east of north, what is the actual direction of the ship?

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20. A bar magnet of magnetic moment $10Am^2$ has a cross sectional area of $2.5 \times 10^{-4}m^2$. If the intensity of magnetisation of the magnet is $10^6 Am^{-1}$, find the length of the magnet?

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21. A rod of cross sectional area $10cm^2$ is placed with its length parallel to a magnetic field of intensity 1000 Am^{-1}. The flux through the rod is $10^4 Wb$. Find the permeability of the material of the rod.

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Problems Level Ii

1. The force between two poles is reduced to P newton, when their original separation is increased to x times, it is increased to Q newton, when their separation is made 1/xth of their original value. Then the relation between P and Q is

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2. The field intensities of two points on the axial line of a bar magnet at distances of

$10 \times 10^{-2} m$ and $15 \times 10^{-2} m$ are in the ratio 5.8:1. Find the distance between the two poles of the magnet.

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3. The magnetic induction on the equatorial line of a short magnet at distance d from the centre of the magnet is B. At what distance on the equatorial line of the magnet the magnetic induction would become 4B?

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4. A short bar magnet produces magnetic fields of equal induction at two points one on the axial line and the other on the equatorial line. What is the ratio of their distances.

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5. Calculate the moment of couple required to keep a bar magnet of magnetic moment $2 \times 10^2 Am^2$ a uniform field of induction 0.36

T at an angle of 30° with the direction of the field.

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6. A bar magnet of length 0.2m placed in a uniform magnetic field of induction $15Wbm^{-2}$, with its axis at 30° to the field experience a couple of 7.5 N-m. Find the pole strength of the bar magnet.

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7. A bar magnet of magnetic moment $2.0Am^2$ is free to rotate about a vertical axis through its centre. The magnet is released from rest from the east-west position. Find the kinetic energy of the magnet as it takes the north-south position. The horizontal component of the earth's magnetic field is $B = 25\mu T$.

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8. A magnet of magnetic moment $5Am^2$ is freely suspended in a uniform magnetic field

of strength 2T. Find the work done in rotating the magnet through an angle of 60°.

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9. A very long magnet of pole strength 4A-m is placed vertically with its one pole on the table. At what distance from the pole, will there be a neutral point on the table? [$B_H = 4 \times 10^{-5} Wbm^{-2}$]

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10. A short bar magnet is placed with its north pole pointing north. The neutral point is $10cm$ away from the centre of the magnet. If $H = 0.4G$, calculate the magnetic moment of the magnet.

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11. A magnet is suspended in such a way that it oscillates in the horizontal plane. It makes 20 oscillation per minute at a place where dip angle is 30° and 15 oscillation per minute at

a place where dip angle is 60°. The ratio of earth's magnetic fields at two places is

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12. A magnet makes 10 oscillations per minute at a place where the angle of dip is 45° and the resultant earth's field is 0.4 gauss. Calculate the number of oscillations made per second by the same magnet at another place where the angle of dip is 60° and the resultant earth's field is 0.5 gauss.

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13. A magnetic needle is free to rotate in a vertical plane which makes an angle of 60° with the magnetic meridian. If the needle stays in a direction making an angle of $\tan^{-1}\left(\frac{2}{\sqrt{3}}\right)$ with the horizontal, what would be the dip at that place?

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14. The work done in rotating a magnet from the direction of uniform field to the opposite direction of the field is W. Find work done in rotating the magnet from the field direction to half the maximum couple position

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15. A freely suspended short magnet makes 20 oscillations per minute in the earth's horizontal magnetic field of $40\mu T$. Another

short magnet of moment $1.6Am^2$ is now placed at 20 cm east pointing its north pole towards north. Find the new number of oscillations per minute.

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16. In an uniform field the magnetic needle completes 10 oscillations in 92 seconds. When a small magnet is placed in the magnetic meridian 10cm due north of needle with north pole towards south completes 15 oscillations

in 69seconds. The magnetic moment of magnet ($B_H = 0.3G$) is

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Additional Exercise

1. In Fg. 5.4 (b). The magnetic needle has magnetic moment $6.7 \times 10^{-2} Am^2$ and moment of inertia $= 7.5 \times 10^{-6} kgm^2$. It performs 10 complete oscillations is 6.70 s. what is the magnitude of the magnetic field?

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2. A short bar magnet placed with its axis at 30° with an external field of 800 G experiences a torque of 0.016 Nm.

(a)What is the magnetic moment of the magnet ?

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3. A short bar magnet placed with its axis at 30° with an external field of 800 G experiences

a torque of 0.016 Nm.

(a)What is the magnetic moment of the magnet ?

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4. A short bar magnet placed with its axis at 30° with an external field of 800 G experiences a torque of 0.016 Nm.

The bar magnet is replaced by a solenoid of cross sectional area $2 \times 10^{-4} m^2$ and 1000 turns, but of the same magnetic moment.

Determine the current flowing through the solenoid.

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5. (a) What happens if a bar magnet is cut into two pieces : (i) transverse to its length. (ii) along its length?

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6. A magnetised needle in a uniform magnetic field experiences a torque but no net force. An iron nail near a bar magnet, however, experiences a force of attraction in addition to a torque. Why?

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7. Must every magnetic configuration have a north pole and a south pole? What about the field due to a toroid?

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8. (b) A magnetised needle in a uniform magnetic field experiences a torque but not net force. An iron nail near a bar magnet, however, experiences a force of attraction in addition to a torque. Why?

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9. What is the magnitude of the equatorial and axial fields due to a bar magnet of length

5 cm at a distnce of 50 cm from its mid point? The magnetic moment of the the bar magnet is $0.4Am^2$.

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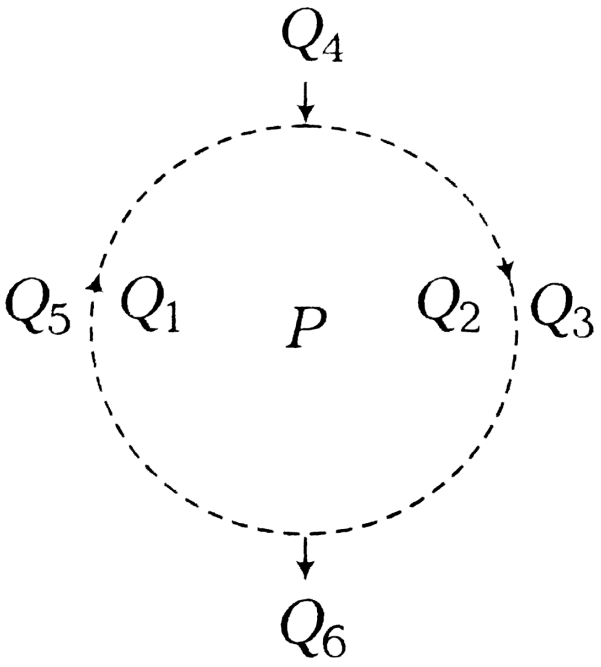
10. The figure shows the various p[osiotions (labelled by subscripts) of small magnetised needles P and Q. The arrows ashopw the directio of their magnetic moment. Which configuration corresponds to the lowest potential energy of all the configuration

shown?



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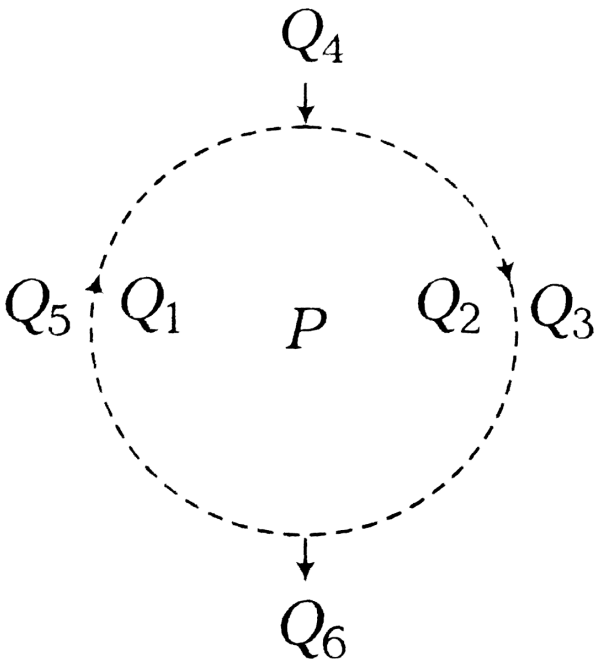

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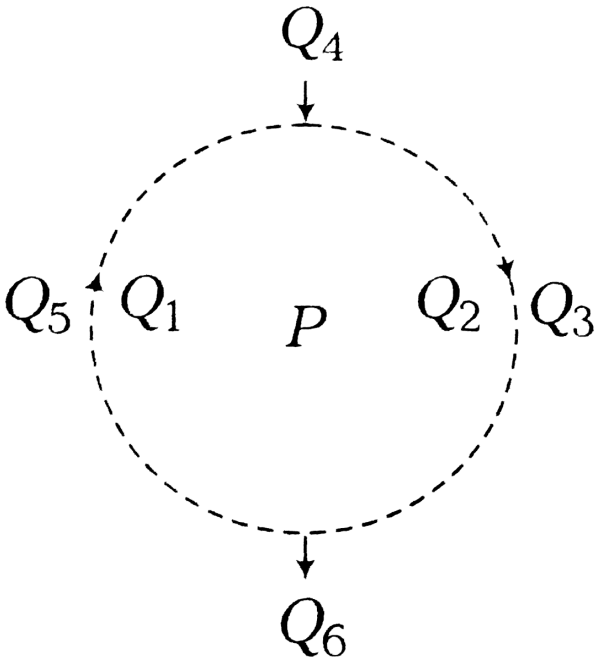

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13. Magnetic field lines show the direction (at every point) along which a small magnetised

needle aligns (at the point). Do the magnetic field lines also represent the lines of force on a moving charged particle at every point?

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14. Magnetic field liness can be entirely confined within the core of a toroid, but not within a straight solenoid Why ?

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15. If magnetic monpole existed, how would Gauss law of magnetism be modified?

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16. Does a bar magnet exert a torque on itself due to its own field? Does one element of a current-carrying wire exert a force on another element of the same wire?

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17. Magnetic field arises due to charges in motion. Can a system have magnetic moments even though its net charge is zero?

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18. The earth's magnetic field at the equator is approximately 0.4 G. Estimate the earth's dipole moment.

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19. In the magnetic meridian of a certain place, the horizontal component of the earth's magnetic field is 0.26G and the dip angle is 60°. What is the magnetic field of the arth at this location?

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20. A solenoid has a core of a material with relative permeability 400. The wtndings of the solenoid are insulated from the core and carry a current of 2A. If the number of turns is 1000

per metre. Calculate (a) H, (b)M,(c) B and (d) the magnetising current I_m.

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21. A domain in ferromagnetic iron is in the form of a cube of side length 1μm. Estimate the number of iron atoms in the domain and the maximum possible dipole moment and magnetisation of the domain. The molecular mass of iron is 55 g/mole and its density is

$7.9g/cm^3$. Assume that each iron atom has a dipoe moment of $9.27 \times 10^{-24} Am^2$.

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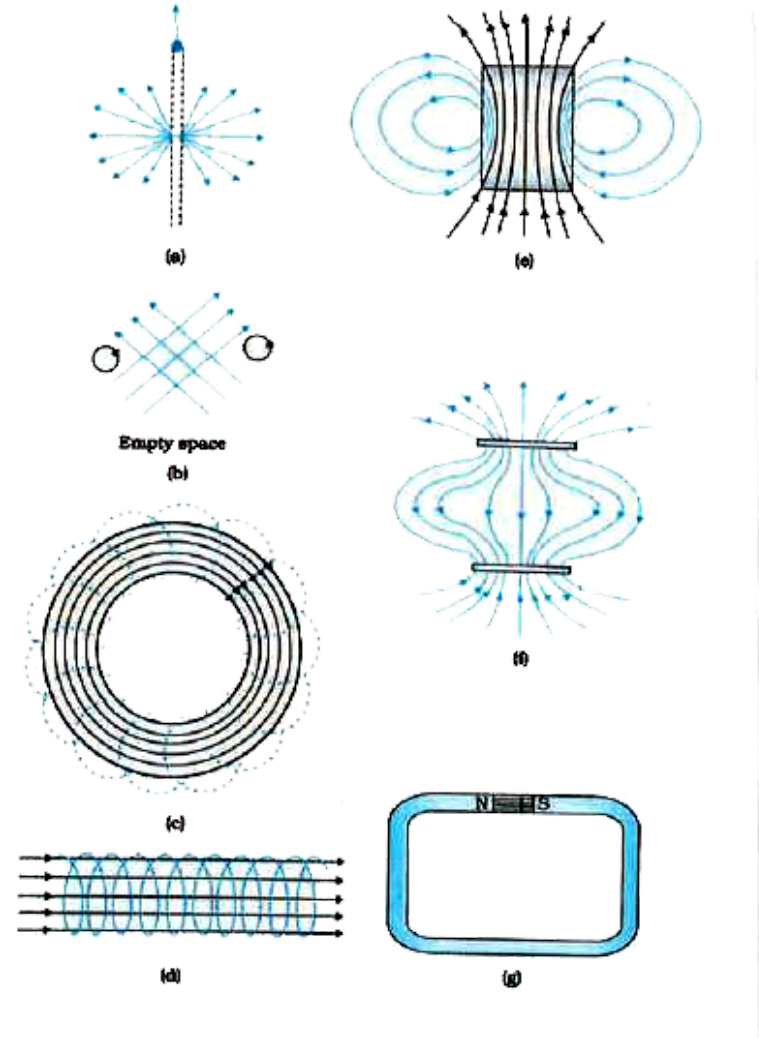
22. Many of the diagrams given in Fig. show magnetic field lines (thick lines in the figure) wrongly. Point out what is wrong with them. Some of them may describe electrostatic field

lines correctly. Point out which ones.



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