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India's Number 1 Education App

PHYSICS

BOOKS - NEW JYOTHI PHYSICS (TAMIL ENGLISH)

MAGNETISM AND MATTER

Solved Problems

1. In Fig (b) , the magnetic needle has magnetic moment $6.7 \times 10^{-2} \mathrm{Am}^2$ and moment of

inertia $I = 7.5 \times 10^{-6} \mathrm{kgm}^2$. It performs 10 complete oscillations in 6.70s. 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 ?

b. What is the work done in moving it from its

most stable to most unstable position ?

c. 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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3. A magnetic needle is placed in a uniform magnetic field. It experienece

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4. What is the magnitude of the equatorial and axial fields dut to a bar magnet of length 5.0 cm at a distance of 50 cm from its mid - point ? The magnetic moment of the bar magnet is $0.40Am^2$.

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5. Which configuration is widely used in circuits ?

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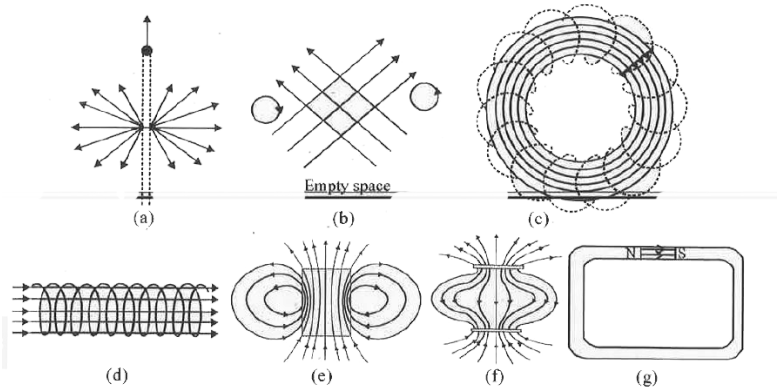
6. Many of the diagrams given in figure show magnetic field lines (thick lines in the figure) wrongly. Point out what is wrong with them . Some of them may describe electrostatic field lines correctly. Point out which ones.



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7. a. Magnetic field lines show the direction (at every point) along which a small magnetised needle aligns (at the point) Do the magnetic field also represent the lines of force one a moving charged particle at every point ?

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

c. If magnetic monopoles existed, how would the Gauss ' law of magnetism be modified ?

d. 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 ?

e.Magnetic field arises due to charges in motion . Can a system have magnetic moments eventhough its charge is zero ?

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

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

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10. A solenoid a core of a material with relative permeability 400. The windings 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) B and (c) the magnetising current I_m.

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11. A domain if ferromagnetic iron is in the form of cube of side length $1\mu m$. Estimate the number of iron atoms in the domain and the maximum possible moment and magnetisation of the domain. The molecular mass iron is 55 g/mol and its density is

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

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Solutions To Exercises From Ncert Text

1. Answer the following questions regarding earth's magnetism.

a. A vector needs three quantities conventionally used to specify the earth's magnetic field.

b. The angle of dip at a location in southern India is about 18° . Would you expect a greater or smaller dip angle in Britain ?

c. If you made a map of magnetic field lines at Melboune in Australia, would the lines seem to go into the groung or come out of the ground ?

d. In which direction would a compass free to move in the vertical plane point to , if located right on the geomagnetic north or south pole ?

e. the earth' s field, it is claimed roughly approximates the field due to a dipole of

magnetic moment $8 \times 10^{22} JT^{-1}$ located at its centre. Check the order of magnitude of this number in some way.

f. Geologists claim that besides the main magnetic N - S poles, there are several local poles on the earth's surface oriented in different directions. How is such a thing possible at all ?

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2. Answer the following questions .

a. The earth's magnetic field varies from point is space. Does it also change with time ? It so , on what time scate does it change appreciably ?

b. The earth's core is known to contain iron. Yet geologists do not regard this as a source of the earth's magnetism why ?

c. The charged currents in the outer conducting regions of the earth's core are thought to be responsible for earth's magnetism . What might be the ' battery ' (i.e.,

the source of energy) to sustain these currents ?

d. The earth may have even reversed the direction of its field several times during its history of 4 to 5 billion years. How can geologists know about the earth's field in such distant past ?

e. The earth's field departs from its dipole substantially at large distances (greater than about 30,000 km) what agencies may be responsible for this distortion ?

f. Interstellar space has an extremely weak magnetic field of the order of 10^{-12} T, Can

such a weak field be of any significant consequence ? Explain.

[Note : Exercise 2 is meant mainly to arouse your curiosity . Answers to some question above are tentative or unknown . Brief answers wherever possible are given at the end . For details , you should consult a good text on geomagnetism.]

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3. A short bar magnet placed with its axis at 30° with an external field of 0.25 T experiences a torque of magnitude to $4.5 \times 10^{-2} J$. What is the magnitude of magnetic moment of the magnet ?

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4. A short bar magnet of magnetic moment $m = 0.32 JT^{-1}$ is placed in a uniform magnetic field of 0.15 T. If the bar is free to

rotate in the place of the field , which orientation would correspond to its (a) stable , and (b) unstable equilibrium ? What is the potential energy of the magnet in each case ?

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5. A closely wound solenoid of 800 turns and area of cross section $2.5 \times 10^{-4} m^2$ carries a current of 3.0 A . Explain te sense in which the solenoid acts like a bar magnet .

What is its associated magnetic moment ?

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6. If the solenoid in is free to turn about the vertical direction and a uniform horizontal magnetic field of 0.25T is applied , what is the magnitude of torque on the solenoid when its axis makes an angle of 30° with the direction of applied field ? Given magnetic moment 0.6 JT −1 .

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7. A bar magnet of magnetic moment $1.5JT^{-1}$ lies aligned with the direction of a uniform magnetic field of 0.22 T .

a . What is the amount of work required by an external torque to turn the magnet so as to align its magnetic moment : (i) normal to the direction , (ii) opposite to the field direction ?

b. What is the torque on the magnet in cases (i) and (ii) ?

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8. A closely wound solenoid of 2000 turns and are of cross - section $1.6 \times 10^{-4} m^2$ carrying a current of 4.0 A , is suspended through its centre allowing it to turn in a horizontal plane.

a. What is the magnetic moment associated with the solenoid ?

b. What is the force and torque on the solenoid if a uniform horizontal magnetic field of $7.5 \times 10^{-2} T$ is set up at an angle of 30° with the axis of the solenoid ?

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9. A circular coil of 16 turns and radius 10 cm carrying a current of 0.75 A rests with its plane normal to an external field of magnitude $5.0 \times 10^{-2} T$. The coil is free to turn about an axis in its plane perpendicular to the field direction . When the coil is turned slightly and released , it oscillates about its stable equilibrium with a frequency of 2.0 s^{-1} . What is the moment of inertia of the coil about its axis of rotation ?

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10. A magnetic needle free to rotate in a vertical plane parallel to the magnetic meridian has its north tip pointing down at 22° with the horizontal . The horizontal component of the earth's magnetic field at the place is known to be 0.35 G . Determine the magnitude of the earth's magnetic field at the place.

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11. At a certain location in Africa, a compass 12° west of the geographic north. The northe tip of the magnetic needle of a dip circle in the plane of magnetic meridian points 60° above the horizontal . The horizontal component of the earth's field measured to be 0.16 G. Specify the direction and magnitude of the earth's field at the location.

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12. A short bar magnet has a magnetic moment of $0.48 JT^{-1}$. Give the direction and magnitude of the magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on (a) the axis, (b) the equatorial lines (normal bisector) of the magnet.

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13. A short bar magnet placed in a horizontal plane has its axis aligned along the magnetic north - south direction . Null point are found on the axis of the magnet at 14 cm from the centre of the magnet . The earth's magnetic field at the place if 0.36 G and the angle of dip is zero. What is the total magnetic field on the normal bisector of the magnet at the same distance as the null point (i.e., 14 cm) from hte centre of the magnetic ? (At null points , field due to a magnet is equal and opposite to the

horizontal component of earth's magnetic field.)

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14. If the bar magnet in exercise 13 is turned around by 180° where will the new null points be located ?

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15. A short bar magnet of magnetic moment $5.25 \times 10^{-2} JT^{-1}$ is placed with its axis perpendicular to the earth's field '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 te earth's field at the place is given to be 0.42 G, Ignore the length of the magnet in comparison to the distance involved.

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16. Answer the following questions .

a. Why does a paramagnetic sample display greater magnetisation (for the same magnetising field) when cooled ?

b. Why is diamagnetism , in contrast , almost independent of temperature ?

c. If a toroid uses bismuth for its core, will the the field in the core be (slightly) greater or (slightly) less than when the core is empty ?

d. Is the permeability of a ferromagnetic material independent of the magnetic field ? If not, is it more for lower or higher fields ?

e. Magnetic field lines are always nearly normal to the surface of ferreomgnet at every point . (This fact is analogous to the static electric field lines being normal to the surface of conductor at every point). Why ?

f. Would the maximum possible magnetisation of paramagnetic sample be of the same order of magnitude as the magnetisation of ferromagnet ?

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17. Answer the following questions

a. Explain qualitatively on the basis of domain picture the irreversibility in the magnetisation curve of a ferromagnet.

b. The hysteresis loop of soft iron piece has a much smaller area than that of a carbon steel piece. If the material is to go through repeated cycles of magnetisation , which piece will dissipate greater heat energy ?

c. 'A system displaying a hysteresis loop such as a ferromagnet , is a device for storing memory ? ' Explain the meaning of this

statement.

d. What kind of ferromagnetic material is used for coating magnetic tapes in a cassette player , or for building ' memory stores ' in a modern computer ?

e. A certain region of space is to be shielded from magnetic fields . Suggest a method.

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18. A long straight horizontal cable carries a current of 2.5 A in the direction 10° north of

east . The magnetic meridian of the place happens to be 10° west of the geographic meridian The earth's magnetic field at the location is 0.33 G , ad the angle of dip is zero. Locate the line of neutral points (ignore the thickness of the cable) (At neutral points , magnetic field due to a current - carrying cable is equal and opposite to the horizontal component of earth's magnetic field).

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19. A sample of of paramagnetic salt contains 2.0×10^{24} atomic dipoles each of dipole moment $1.5 \times 10^{-23} JT^{-1}$. The sample is placed under a homogeneous magnetic field of 0.64 T , cooled to a temperature of 4.2 K . The degree of magnetic saturation achieved is equal to 15% . What is the total dipole moment of the sample for a magnetic field of 0.98 T and a temperature of 2.8 K ? (Assume Curie's law)

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20. A Rowland ring of mean radius 15 cm has 3500 turns of wire wound on a ferromagnetic core of relative permeability 800. What is the magnetic field B in the core for a magnetising current of 1.2 A ?

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21. The magnetic moment vectors μ_s and μ_i associated with the intrinsic spin angular momentum S and orbital angular momentum

l, respectively, of an electron are predicted by quantum theory (and verified experimentally to a high accuracy) to the given by

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Practice Problems For Self Assessment

1. The magnetic moment is $5Am^2$ and the pole strength is 25 A.m What is the length of the magnet ?

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2. The distance between the poles of horse shoe magnet is 10 cm and its pole strength is 10^4 A.m . Calculate the field at the point P midway between the poles.

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3. The magnetic field of a short magnetic at a distance of one metre on the axial line is $10^{-4}T$. What is the field at a distance of 2m on the same line ?

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4. A bar magnet has length 10 cm and pole strength 50 Am. Calculate the magnetic field at a point distance 20 cm from the centre of the magnet .

a. on the axial line b. on the equatorial line

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5. A thin bar magnetic is cut into two equal parts by cutting is perpendicular to ties length. What is the new magnetic moment of each part ? What is the time - period of each part as compared to that of the original magnet if if vibrated in the same field ?

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6. A magnet makes 30 oscillations per minute at a place where the field is 0.2×10^{-4} Tesla ,

At another place it takes 1.5 sec to complete one oscillation . What is the field at this place.

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7. Calculate the permeability and susceptibility of a magnetic substance of cross - sectional area $0.2cm^2$ having a magnetic flux 2.4×10^{-5} Weber. Given magnetic intensity H = 300A/m

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8. In a hydrogen atom, the $\overrightarrow{e}$ moves in an orbit of radius 0.5×10^{-10} m making 10^{16} r.p.s Calculate the magnetic moment associated with the orbital motion of $\overrightarrow{e}$.

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9. A metallic wire of 10π cm and of magnetic moment M is bent into a semi circle. Calculate the new magnetic moment.

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10. A magnet vibrates 20 times in one minute. If its pole strength increased to 4 times, what the number of vibrations?

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11. A bar magnet of length 7cm breath 2cm , thickness 1 mm , is subjected to a field of 700A/m Given susceptibility is 549 ., calculate μ_r, μ flux density

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12. A cylindrical magnetic having a length of 7 cm and diameter 4 cm has a uniform magnetization of $6 \times 10^3 A/m$ Calculate the dipole moment.

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Evaluation Questions And Answers

1. Why does the magnet always align in a particular direction ?

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2. What is meant by geographic north pole ?

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3. What is meant by geographic south pole ?

Watch Video Solution

4. The north pole of a freely suspended magnet points towards geographical north. Why ?

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5. Does magnetic south pole and geographic north pole coincide ?

Watch Video Solution

6. What is meant by geographic meridian and magnetic meridian ?

Watch Video Solution

7. Do these two meridians coincide anywhere ?

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8. When a compass needle is pivoted so that it can rotate in vertical plane (dip needle) will it

align horizontally ?

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9. It it is not aligning horizontally , what does it mean ?

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10. If the above needle is taken to the pole and the magnetic equator have it will align ?

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11. How can we resolve the earth's magnetic field at a place into two rectangular components ?

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12. What are null points ?

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13. What is the magnetic field along the axis and equatorial line of a bar magnet ?

Watch Video Solution

14. Null points are obtained on the axial line , when the north pole of the bar magnet is pointing towards geographical south . Why ?

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15. Null points are obtained on equatorial line, when the north pole of the bar magnet is pointing towards geographical north. Why ?

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16. A magnetic substance is placed in magnetic fields of different intensity . Does it produce same effect ?

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17. After magnetising a substance , by measuring which quantity we can understand the extend to which it is magnetised ?

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18. When we apply an external magnetising field to a material , what will be the resultant magnetic field inside it ?

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19. It there any relation between B and H ?

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20. Is there any relation between M and H ?

Watch Video Solution

21. Do all materials have a net magnetic moment in the normal state ?

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22. What is the reason for magnetic moment of material ?

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23. Do all materials behave in the same manner in a magnetic field ?

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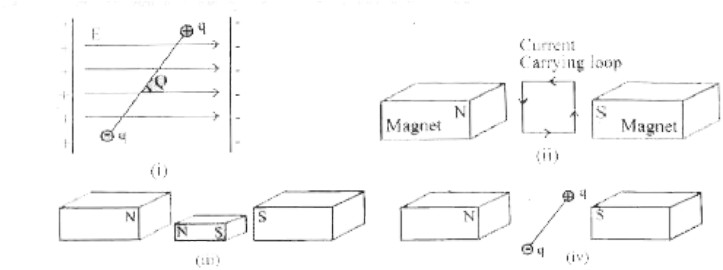
24. Pick the odd out of the following based on torque .



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25. The interaction of electric charges q_1 and q_2 separated by a distance r is

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

If p_1 and p_2 are the properties of two

magnetic poles , separated by a distance r , the force is $F = \frac{\mu_0}{4\pi}\frac{p_1 p_2}{r^2}$

a. Write two similar properties of these two forces.

b. Name the quantities p_1, p_2 and μ_0 .

c. Show that 'p' has the ampere metre^2.

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26. A single pole doesn't exist . Why ?

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27. The north pole of a freely suspended magnet points towards geographical north. Why ?

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28. When a bar magnet is dropped from the top of a building its magnetism decreases . Why ?

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29. Is there difference between magnetic lines of force and electric lines of force ? If your answer is yes. What is that difference ?

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30. Magnetic lines of force never intersect each other . What is the reason ?

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31. A bar magnet of length 21 cm and pole strength m is placed in a uniform magnetic field , B inclined at angle $'\theta'$ with the field .

a. What is the force acting on each pole ?

b. Why the magnet gets a rotating effect ?

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32. Show how a current loop acts as a magnetic dipole . Arrive at an expression for the magnetic dipole moment.

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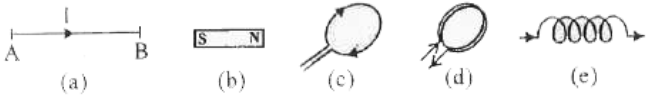
33. 

From the above collection two bodies show amost identical field parent .

a. Which are they ?

b. Draw the lines of force produced by them

c. Identify the cause producing the field in each .

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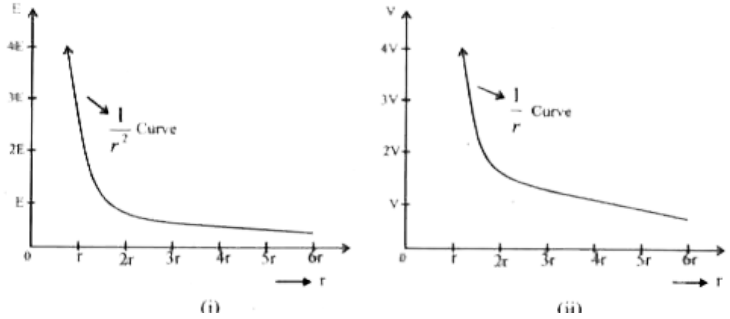
34. You are given two graphs. What conclusion do you draw from the graphs?



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35. What do you know about the following terms ?

a. Isogonic line and Agonic line

b. Isolinic line and Aclinic line

c. Isodynamic line

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36. Show that the magnetic moment of an atom is $M = \frac{1}{2}e\omega r^2$, where e the charge of an electron , ω - angular speed of electron and r - the radius of electron orbit.

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37. According to Bohr's postulate, the angular momentum of an electron , $mvr = \frac{nh}{2\pi}$ Using this formula show that magnetic moment of the atom is $M = n\mu_B$ Here what is μ_B and and what is its value ?

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38. A rod of a magnetic material move with very small velocity v as shown in Figure below , through a uniform magnetic field .

Drawn how the magnetic lines of force take shape, if the magnetic material is (i) Ferromagnetic (ii) Paramagnetic and (iii) Diamagnetic.

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39. The following terms find importance in magnetism . Explain them

a. Magnetic permeability (μ)

b. Magnetic intensity (H)

c. Intensity of magnetisation (I)

d. Magnetic susceptibility (X_m)

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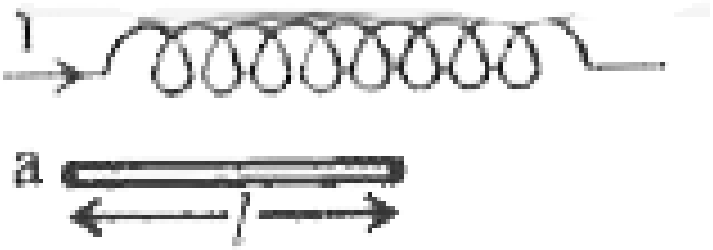
40. Figure shows a solenoid current of



I- ampere Its area is 'A' and number of turns n.

a. What is the flux density of the solenoid field

inside ?

b. If magnetic material in the form of a rod of area 'a' $(a << A)$ is inserted into the solenoid, what is the magnetising field strength ?

c. Find the total flux density inside the specimen.

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41. The relation between μ_r and X_m is $\mu_r = 1 + X_m$ How will you arrive at this

relation ? Explain.

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42. On the basis of magnetic properties the substance are classified into three

a. What are these three classifications ?

b. Explain each of them

c. Give there examples for each .

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43. Is there any importance for the curie point ? Explain .

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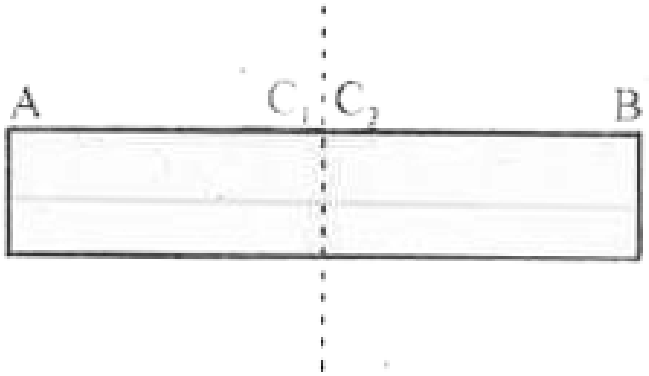
44. A (hypothetical) bar magnet (AB) is cut into two equal parts. One part is now kept over the other so that pole C_2 is above C_1 If M is the magnetic moment of thte original magnet what would be the magnetic moment

of the combination so formed ?



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45. Define the S.I unit of magnetic field " A charge moving at right angles to uniform magnetic field does not undergo change in kinetic energy " Why ?

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46. Hoe does the (i) pole strength and (ii) magnetic moment of each part of a bar magnet change if it is cut into two equal pieces along its length ?

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47. a. Where on the earth's surface is the value of vertical component of the earth's magnetic field zero ?

b. The horizontal component of the earth's magnetic field at a given place is $0.4 \times 10^{-4} Wb/m^2$ and angle of dip is 30° Calculate the value of (i) vertical component (ii) the total intensity of the earth's magnetic field.

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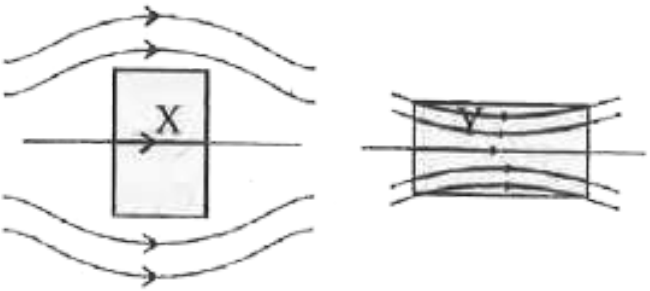
48. A uniform magnetic field gets modified as shown, when two spectimens X and Y are placed in it.

i. Identify the two specimens X and Y .

ii. State the reason for the behaviour f the field lines in X and Y.



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49. How will a dia , para ferro magnetic material behave when kept in a non uniform

external magnetic field ? Give one example of each of these materials.

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50. Answer the following questions .

a. Why does a paramagnetic sample display greater magnetisation (for the same magnetising field) when cooled ?

b. Why is diamagnetism , in contrast , almost independent of temperature ?

c. If a toroid uses bismuth for its core, will the

the field in the core be (slightly) greater or (slightly) less than when the core is empty ?

d. Is the permeability of a ferromagnetic material independent of the magnetic field ? If not, is it more for lower or higher fields ?

e. Magnetic field lines are always nearly normal to the surface of ferreomgnet at every point . (This fact is analogous to the static electric field lines being normal to the surface of conductor at every point). Why ?

f. Would the maximum possible magnetisation of paramagnetic sample be of the same order

of magnitude as the magnetisation of ferromagnet ?

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Continuous Evaluation Project

1. Construction of a buzzer, using electromagnet.

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Continuous Evaluation Assignment

1. Discuss the various types of magnets .

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2. Discuss the basic properties or bar magnets.

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3. Mention the classification of magnetic materials

Watch Video Solution

4. Mention the uses of electromagnets.

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5. Explain the ways to demagnetise a magnet .

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6. Explaing the source of earth magnetism.

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7. Discuss any one of the magnetic instruments.

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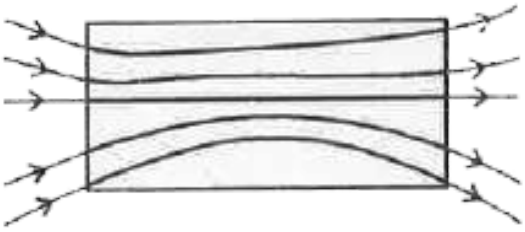
Previous Year Questions

1. Depending on the magnetic property, the materials are classified into diamagnetic , paramagnetic and ferromagnetic.

a. The behaviour of magnetic field lines near a magnetic substance is shown in thte figure . Which material corresponds to the figure.



b. State and explain Curie's law.

c. Compare paramagnetism and Ferro magnetism . Give examples of each .

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2. Permanent magnets should have

A. high retentivity and low coercivity

B. low retenitivity and high coercivity

C. high retentivity and high coerecivity

D. low retentivity and low coercivity

Answer:

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3. Distinguish between Para, Ferro and Diamagnetism.

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Competitive Exam Corner

1. Choose the correct statement .

A. a) A paramagnetic tends to move from a strong magnetic field to weak magnetic

field

B. b) A magnetic material is in the paramagnetic phase below its Curie temperature

C. c) The resultant magnetic moment in an atom of a diamagnetic subtance is zero

D. d) Typical domain size of a ferromagnetic material is 1 nm.

Answer: C

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2. A domain in a ferromagnetic substance is in the form of a cube of side length $1\mu m$. If it contains 8×10^{10} atoms and each atomic dipole has a dipole moment of $9 \times 10^{-24} Am^2$, then the magnetization of the domain is

A. A) $7.2 \times 10^5 Am^{-1}$

B. B)$7.2 \times 10^3 Am^{-1}$

C. C) $7.2 \times 10^9 Am^{-1}$

D. D) $7.2 \times 10^{12} Am^{-1}$

Answer: A

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3. An electron moving around the nucleus with the an angular momentum l has a magnetic moment

A. a) $\frac{e}{m}l$

B. b) $\frac{e}{2m}l$

C. c) $\frac{2e}{m}l$

D. d) $\frac{e}{2\pi m}l$

Answer: B

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4. A magnetic needle lying parallel to a magnetic field requires W units of work to turn it through 60° The torque required to keep the needle in this position will be

A. a) $2W$

B. b) W

C. c) $\frac{W}{\sqrt{2}}$

D. d) $\sqrt{3}W$

Answer: D

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5. Two identical magnetic magnetic dipoles of magnetic moment $2Am^2$ are placed at a separation of 2 m with their axis perpendicular to each other in air. The resultant magnetic field at a midpoint between the dipoles is

A. $4\sqrt{5} \times 10^{-5}T$

B. $2\sqrt{5} \times 10^{-5} T$

C. $4\sqrt{5} \times 10^{-7} T$

D. $2\sqrt{5} \times 10^{-7} T$

Answer: D

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6. A straight wire carrying current I is made into a circular loop . If M is the magnetic moment associated with the loop , then length of the wire is

A. $\sqrt{\frac{4\pi M}{I}}$

B. $\sqrt{\frac{2\pi M}{I}}$

C. $\sqrt{\frac{\pi M}{I}}$

D. $\sqrt{\frac{\pi M}{2I}}$

Answer: A

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7. A magnet takes a minute to make 30 oscillations in a magnetic field. If the strength

is doubled, then the time period of oscillation (in S) is

A. $\sqrt{2}$

B. $2\sqrt{2}$

C. $\frac{\sqrt{3}}{2}$

D. $\sqrt{3}$

Answer: A

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8. The ferromagnetic core of electromagnets should have

A. a broad hysteresis loop

B. high permeability and high retentivity

C. low permeability and low retentivity

D. high permeability and low retentivity

Answer: D

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9. If the susceptibility of dia, para , and ferro magnetic materials are X_d, X_p, X_f respectively , then

A. $X_d < X_p < X_f$

B. $X_d < X_f < X_d$

C. $X_f < X_d < X_p$

D. $X_f < X_p < X_d$

Answer: A

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10. The angle of dip at a place where horizontal and vertical components of earth's magnetic field a equal is

A. 45°

B. 30°

C. 0°

D. 60°

Answer: A

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11. A bar magnet of moment of inertia $9 \times 10^{-5} \mathrm{kg\,m^2}$ placed in a vibration magnetometer and oscillating in a uniform magnetic field $16\pi^2 \times 10^{-5} T$ make 20 oscillations is 15 s . The magnetic moment of the magnet is

A. a) $3Am^2$

B. b) $2Am^2$

C. c) $5Am^2$

D. d) $4Am^2$

Answer: D

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12. Identify the correctly matched pair

A. a)

Material	Example
Diamagnetic	Gadolinium

B. b)

Material	Example
Soft ferromagnetic	Alnico

C. c)

Material	Example
Hard ferromagnetic	Copper

D. d)

Material	Example
Paramagnetic	Sodium

Answer: D

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13. If a magnetic dipole of moment M situated in the direction of a magnetic field B is rotated by 180° then the amount of work done is

A. a) MB

B. b) $2MB$

C. c) $\frac{MB}{\sqrt{2}}$

D. d) 0

Answer: B

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