CLASS – 12

WORKSHEET- MAGNETISM AND MATTER

A. BAR MAGNET & MAGNETIC FIELD LINES

(1 Mark Questions)

1. What is source of magnetic field?

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2. Write S.I. unit of (i) Pole strength and (ii) Magnetic dipole moment.

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(2 Marks Questions)

3. How does the (i) pole strength and (ii) magnetic moment of each part of bar magnet change if it is cut into two equal pieces transverse to its length?

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4. A magnetized 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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5. A short bar magnet placed with its axis at 30º with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5×10^{-2} J. What is the magnitude of magnetic moment of the magnet? [Ans. 0.36 JT^{-1}]

6. A short bar magnet of magnetic moment m = 0.32 J T^{-1} is placed in a uniform magnetic field of 0.15 T. If the bar is free to rotate in the plane 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? [Ans. -4.8×10^{-2}J,+ 4.8×10^{-2}J]

7. A closely wound solenoid of 800 turns and area of cross section 2.5×10^{-4} m^2 carries a current of 3.0 A. Explain the sense in which the solenoid acts like a bar magnet. What is its associated magnetic moment? [Ans. 0.60 JT^{-1}]

8. If the solenoid in previous Question is free to turn about the vertical direction and a uniform horizontal magnetic field of 0.25 T 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? [Ans. 7.5×10^{-2}J]

9. How 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 transverse to its length?

10. A mangetised 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?

11. A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25T experiences a torque of magnitude equal to 4.5×10^{-2} J. What is the magnetic moment of the magnet? [Ans. 0.36 JT^{-1}]

12. A short bar magnet of magnetic moment m = 0.32 JT^{-1} is placed in a uniform external magnetic field of 0.15T. If the bar is free to rotate in the plane of the field, which orientations would correspond to its (i) stable and (ii) unstable equilibrium? What is the potential energy of the magnet in each case? [Ans. -4.8×10^{-2}J, $+4.8\times10^{-2}$J]

13. A closely wound solenoid of 800 turns and area of cross section 2.5×10^{-4} m^2 carries a current of 3.0A. Explain in what sense does the solenoid act like a bar magnet. What is its associated magnetic moment? [Ans. 0.60 JT^{-1}]

14. If the solenoid in previous question is free to turn about the vertical direction and a uniform horizontal magnetic field of 0.25T is applied, what is the magnitude of the

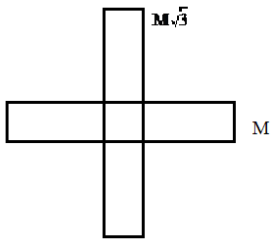
torque on the solenoid when its axis makes an angle of 30° with the direction of the magnetic field? [Ans. 7.5×10^{-2} J]

(3 Marks Questions)

15. State Gauss's law for magnetism. Explain its significance.

16. Two identical bar magnets P and Q are placed in two identical uniform magnetic fields. Justify that both the magnets are in equilibrium. Which one of these is in stable equilibrium? Give reasons for your answer.

17. Two magnets of magnetic moments M and $M\sqrt{3}$ are joined to form a cross. The combination is suspended in a uniform magnetic field B. The magnetic moment M now makes and angle θ with the field direction. Find the value of angle θ.



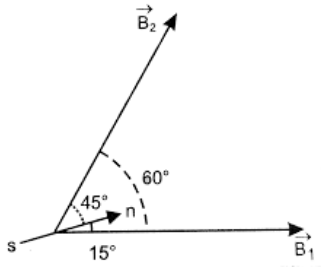
18. A bar magnet of magnetic moment 1.5 J T^{-1} lies aligned with the direction of a uniform magnetic field of 0.22 T.
(a) What is the amount of work required by an external torque to turn the magnet so as to align its magnetic moment: (i) normal to the field direction, (ii) opposite to the field direction?
(b) What is the torque on the magnet in cases (i) and (ii)?
[Ans. (a) (i)0.33Nm, (ii) 0.66J (b) 0]

19. A short bar magnet has a magnetic moment of 0.48 J T^{-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. [Ans. 0.48G]

20. A magnetic dipole is under the influence of two magnetic fields. The angle between the field directions is 60º, and one of the fields has a magnitude of 1.2×10^{-2} T. If the dipole comes to stable equilibrium at an angle of 15º with this field, what is the magnitude of the other field? [Ans. 4.4×10^{-3}T]

21. A bar magnet of magnetic moment 1.5 JT^{-1} lies aligned with the direction of a uniform magnetic field of 0.22T. (a) What is the amount of work required to turn the magnet so as to align its magnetic moment (i) normal to the field direction (ii) opposite to the field direction? (b) What is the torque on the magnet in case (i) and (ii)?

[Ans. (i) +0.33J, 0.33Nm (ii) 0.66J, 0]



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

(5 Marks Questions)

23. A closely wound solenoid of 2000 turns and area of cross section 1.6×10^{-4} m^2, carrying a current of 4.0A, 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 are the force and torque on the solenoid if a uniform horizontal magnetic field of 7.5×10^{-2}T is set up at an angle of 30° with the axis of the solenoid?

[Ans. 1.28 Am^2, 0.0048Nm]

24. A circular coil of 16 turns and radius 10cm carrying a current of 0.75A rests with its plane normal to an external field of magnitude 5.0×10^{-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? [Ans. 1.2×10^{-4} kg m^2]

25. 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 a magnitude of 1.2×10^{-2} T. If the dipole comes to stable equilibrium at an angle of 15° with this field, what is the magnitude of the other field?

B. EARTH'S MAGNETISM

(1 Mark Questions)

1. Where on the surface of Earth is the vertical component of Earth's magnetic field zero?

2. The material which is not suitable for making a permanent magnet is
(a) Steel (b) Ticonal (c) Lead (d) Alnico

3. If the horizontal and vertical components of the Earth's magnetic field are equal at a certain place, what would be the angle of dip at that place?

4. Answer the following questions regarding earth's magnetism: (1 mark each)
(a) A vector needs three quantities for its specification. Name the three independent quantities conventionally used to specify the earth's magnetic field.

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

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

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(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?

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(e) The earth's field, it is claimed, roughly approximates the field due to a dipole of magnetic moment 8×10^{22} J T^{-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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5. How does the angle of dip vary from equator to poles?

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6. Answer the following: (1 mark each)

(a) The earth's magnetic field varies from point to point in space. Does it also change with time? If so, on what time scale does it change appreciably?

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

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(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?

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(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?

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

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(f) Interstellar space has an extremely work magnetic field of the order of 10^{-12} T. Can such a weak field be of any significant consequence? Explain.

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7. Name the elements of parameters of earth's magnetic field.

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8. Define angle of dip (or magnetic inclination) at a place.

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9. Define declination at a place.

10. Horizontal components of Earth's magnetic field at a place is $\sqrt{3}$ times the vertical component. What is the value of angle of dip at this place?

11. Where on the surface of the earth is the angle of dip (i) 0° and (ii) 90°?

(2 Marks Questions)

12. At a certain location in Africa, a compass points 12º west of the geographic north. The north tip of the magnetic needle of a dip circle placed in the plane of magnetic meridian points 60º above the horizontal. The horizontal component of the earth's field is measured to be 0.16 G. Specify the direction and magnitude of the earth's field at the location. [Ans. 0.32G]

(3 Marks Questions)

13. A bar magnet of magnetic moment 6 JT^{-1} is aligned at 60° with a uniform external magnetic field of 0.44T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final, orientation in case (ii)

14. A magnetic needle free to rotate in a vertical plane parallel to the magnetic meridian has its north tip pointing down at 22º 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. [Ans. 0.38G]

15. A short bar magnet placed in a horizontal plane has its axis aligned along the magnetic north-south direction. Null points 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 is 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 the centre of the magnet? (At *null points*, field due to a magnet is equal and opposite to the horizontal component of earth's magnetic field.) [Ans. 0.54G]

16. If the bar magnet in previous question is turned around by 180º, where will the new null points be located? [Ans. 11.1 cm]

17. A short bar magnet of magnetic moment 5.25×10^{-2} J T^{-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 45º 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. [Ans. -5cm , 6.3cm]

18. A long straight horizontal cable carries a current of 2.5 A in the direction 10º south of west to 10° north of east. The magnetic meridian of the place happens to be 10º west of the geographic meridian. The earth's magnetic field at the location is 0.33 G, and 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.) [Ans. 1.5 cm]

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 earth in this location? [Ans. 0.52G]

(5 Marks Questions)

20. A compass needle free to turn in a horizontal plane is placed at the centre of circular coil of 30 turns and radius 12 cm. The coil is in a vertical plane making an angle of 45º with the magnetic meridian. When the current in the coil is 0.35 A, the needle points west to east.
(a) Determine the horizontal component of the earth's magnetic field at the location.

(b) The current in the coil is reversed, and the coil is rotated about its vertical axis by an angle of 90º in the anticlockwise sense looking from above. Predict the direction of the needle. Take the magnetic declination at the places to be zero. [Ans. 0.39G, east to west]

21. A telephone cable at a place has four long straight horizontal wires carrying a current of 1.0A in the same direction east to west. The earth's magnetic field at the place is 0.39G and the angle of dip is 35°. The magnetic declination is nearly zero. What are the resultant magnetic fields at points 4.0cm below, and above the cable?

C. MAGNETIC MATERIAL

(1 Mark Questions)

1. The magnetic field lines are _____ by a diamagnetic substance.

2. Answer the following questions: (1 mark each)

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

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

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

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

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

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(f) Would the maximum possible magnetisation of a paramagnetic sample be of the same order of magnitude as the magnetization of a ferromagnet?

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3. Answer the following questions: (1 mark each)

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

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(b) The hysteresis loop of a 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?

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

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(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?

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

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4. In a permanent magnet at room temperature
(a) magnetic moment of each molecule is zero.
(b) the individual molecules have non-zero magnetic moment which are all perfectly aligned.
(c) domains are partially aligned. (d) domains are all perfectly aligned.

5. A paramagnetic sample shows a net magnetisation of 8 Am^{-1} when placed in an external magnetic field of 0.6T at a temperature of 4K. When the same sample is placed in an external magnetic field of 0.2 T at a temperature of 16K, the magnetisation will be
(a) 32/3 Am^{-1} (b) 2/3 Am^{-1} (c) 6 Am^{-1} (d) 2.4 Am^{-1} .

6. A proton has spin and magnetic moment just like an electron. Why then its effect is neglected in magnetism of materials?

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7. If a toroid uses Bismuth at its core, will the field in the core be lesser or greater than when it is empty?

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8. Define magnetic susceptibility?

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9. The susceptibility of a magnetic material is 1.9×10^{-5}. Name the type fo magnetic materials it represents.

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10. What does the area of hysteresis loop indicate?

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(2 Marks Questions)

11. If χ stands for the magnetic susceptibility of a given material, identify the class of material for which (i) $-1 \le \chi < 0$ (ii) $0 < \chi < \varepsilon$ (ε stands for a small positive number)

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12. Write two properties of a material suitable for making (a) a permanent magnet, and (b) an electromagnet.

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13. State and Explain Curie's law of magnetism for paramagnetic material.

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14. What is hysteresis loop? Explain with its help the terms related to it.

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(3 Marks Questions)

15. Show diagrammatically the behavior of magnetic field lines in the presence of (i) paramagnetic, and (ii) diamagnetic substances. How does one explain this distinguishing feature.

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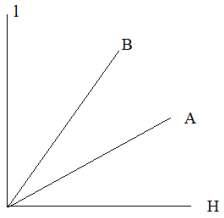
16. The following figure show the variation of intensity of magnetization versus the applied magnetic field intensity, H, for two magnetic materials A and B.



(a) Identify the materials A and B
(b) For the materials A, plot the variation of intensity of magnetization versus temperature.

17. Explain the phenomenon of hysteresis in magnetic materials. Draw a hysteresis loop showing remanence and coercive force.

18. 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? [Ans. 4.48T]

19. What is relative permeability of a magnetic material? How is it related to the magnetic susceptibility?

20. What is hysteresis loop? Explain with its help the terms related to it.

(5 Marks Questions)

21. Define the terms (i) magnetic intensity (ii) magnetization (iii) magnetic induction (iv) magnetic permeability (v) relative permeability and (vi) magnetic susceptibility. Give their SI units, if any. Derive a relation between relative permeability and susceptibility.

22. Distinguish the magnetic properties of a dia-, para- and ferromagnetic substances in terms of (i) magnetic permeability and (ii) correctivity. Give one example of each of these materials.
Draw the field lines due to an external magnetic field near a (i) diamagnetic (ii) paramagnetic substance.

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D. CHALLENGING PROBLEMS

1. Answer the following questions:

(a) The earth's magnetic field varies from point to point in space.
Does it also change with time? If so, on what time scale does it change appreciably?

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(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?

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(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?

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(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?

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

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(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.

2. A sample of paramagnetic salt contains 2.0×10^{24} atomic dipoles each of dipole moment 1.5×10^{-23} J T^{-1}. The sample is placed under a homogeneous magnetic field of 0.64 T, and 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) [Ans. 7.9 JT^{-1}]

3. (i) A small compass needle of magnetic moment M is free to turn about an axis perpendicular to the direction of uniform magnetic field B. The moment of inertia of the needle about the axis is I. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence, deduce, the expression for its time period, (ii) A compass needle free to turn in a vertical plane orients itself with its axis vertical at a certain place on the earth. Find out the values of (a) horizontal component of the earth's magnetic field and (b) angle of dip at the place.

4. If δ_1 and δ_2 be the angles of dip observed in two vertical planes at right angles to each other and δ is the true angle of dip, prove that: $\cot^2 \delta_1 + \cot^2 \delta_2 = \cot^2 \delta$.

SPACE FOR ROUGH WORK

SPACE FOR NOTES