MODEL PAPER – 3

Time : 3 Hours + 15 Minutes] **[Total Marks : 70**

INSTRUCTIONS TO THE CANDIDATES :

1. Candidates are required to give their answers in their own words as far as practicable.
2. Figure in the right hand margin indicate full marks.
3. While answering the questions, candidate should adhere to the word limit as far as practicable.
4. 15 Minutes of extra time has been allotted for the candidates to read the questions carefully.
5. This question paper is divided into two sections—**SECTION – A** and **SECTION – B.**
6. In **SECTION – A** there are **70 Objective Type Question,** out of which only 35 objective questions be answered. Darken the circle with blue/black ball pen against the correct option on OMR Sheet provided to you. Do not use Whitener/Liquid/Blade/ Nail on OMR paper; otherwise the result will be invalid.
7. In **SECTION – B,** there are **20 Short Answer Type Question** (each carrying 2 marks), out of which any 10 questions are be answered.
   Apart from this, there are **6 Long Answer Type Question** (Each Carrying 5 marks), out of which 3 questions are to be answered.
8. Use of any electronic device is prohibited.

SECTION – A : Objective Type Questions

Directions : *There are 70 Objective Type Questions, out of which only 35 objectives questions to be answered. For each question, mark the correct option on the OMR answer sheet.*

$35 \times 1 = 35$

1. Which of the following physical quantities is a vector ?
(A) Electric flux (B) Electric potential
(C) Electric potential energy (D) Electric intensity

2. Van de Graff generator is an electrostatic machine which produces :
(A) Only high current
(B) Only high voltage
(C) High current and high voltage
(D) Low current and low voltage

3. What is the angle between $\vec{p}$ the electric dipole moment $\vec{p}$ and the electric field strength $\vec{E}$ when the dipole is in a stable equilibrium ?
(A) $\frac{\pi}{4}$ (B) π (C) $\frac{\pi}{2}$ (D) 0

4. Which is used to produce polarised light ?
(A) Prism of flint glass (B) NaCl prism
(C) Nicol prism (D) Biprism

5. The coefficient of reflection for total internal reflection will be :
(A) 0.5 (B) 1 (C) 0 (D) ∞

6. The final image formed by a terrestrial telescope is :
(A) virtual and inverted compared to the object
(B) virtual and erect compared to the object
(C) real and erect compared to the object
(D) none of these

7. A convex lens of focal length 40 cm and a concave lens of local length 20 cm are in contact. The power of their combination in diopter is :
(A) 2.5 (B) –2.5
(C) 7.5 (D) –7.5

8. The reason for the phenomenon of interference is :
(A) Phase difference (B) Change in amplitude
(C) Velocity change (D) Intensity change

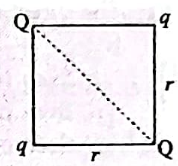
9. The function of moderation in nuclear reactor is to :
(A) Slow the speed of neutrons
(B) Fast the speed of neutrons
(C) Slow the speed of electrons
(D) Fast the speed of electrons

10. Diode is used as :
(A) An amplifier (B) An oscillator
(C) A modulator (D) A rectifier

11. If a dielectric is placed between two plates of a parallel plate capacitor, the value of capacitance :
(A) increases (B) remains constant
(C) decreases (D) none of these

12. Which of the following has unit $\frac{\text{volt}}{\text{metre}}$?
(A) Electric flux (B) Electric potential
(C) Electric capacity (D) Electric field

13. In the figure, if net force on Q is zero then value of $\frac{Q}{q}$ is :



(A) $\sqrt{2}$ (B) $2\sqrt{2}$
(C) $\frac{1}{2\sqrt{2}}$ (D) $\frac{1}{\sqrt{2}}$

14. The electric potential due to a small electric dipole at a large distance r from the center of the dipole is proportional to :
(A) r (B) $\frac{1}{r}$ (C) $\frac{1}{r^2}$ (D) $\frac{1}{r^3}$

15. Which of the following ratios is constant for an isolated conductor ?

(A) $\frac{\text{Total charge}}{\text{Potential}}$ (B) $\frac{\text{Charge added}}{\text{Potential difference}}$

(C) $\frac{(\text{Total charge})^2}{\text{Potential}}$ (D) None of these

16. The electric potential in equatorial position of an electric dipole is :

(A) $\frac{1}{4\pi \epsilon_0} \frac{p \cos \theta}{r^2}$ (B) $\frac{1}{4\pi \epsilon_0} \frac{p}{r^2}$

(C) $\frac{1}{4\pi \epsilon_0} \frac{p}{r}$ (D) Zero

17. S.I. unit of electric flux is :

(A) ohm. metre (B) ampere.metre

(C) volt-metre (D) (volt) $(\text{metre})^{-1}$

18. Surface density of charge is equal to :

(A) Total charge × Total area

(B) $\frac{\text{Total charge}}{\text{Total area}}$ (C) $\frac{\text{Total charge}}{\text{Total volume}}$

(D) Total charge × Total volume

19. Potential gradient is equal to :

(A) $\frac{dx}{dV}$ (B) $dx \cdot dV$

(C) $\frac{dV}{dx}$ (D) None of these

20. One farad is equal to :

(A) 1 CV (B) 1 CV^{-1}

(C) 1 CV^{-2} (D) 1 CV^2

21. The specific resistance of a conductor increases with :

(A) increase of temperature

(B) increase of cross-sectional area

(C) decrease in length

(D) decrease of cross-sectional area **Ans.** (A)

22. The algebraic sum of all currents meeting at any point in an electrical circuit is :

(A) infinite (B) positive

(C) zero (D) negative

23. The direction of the flow of current through electric circuit is :

(A) from low potential to high potential

(B) from high potential to low potential

(C) does not depend upon potential value

(D) current cannot flow through circuit

24. The resistance of ideal ammeter is :

(A) Zero (B) very small

(C) very large (D) infinite

25. One ampere is equal to :

(A) $\frac{1 \text{ coulomb}}{1 \text{ second}}$ (B) 1 coulomb × 1 second

(C) 1 volt × 1 ohm (D) $\frac{1 \text{ ohm}}{1 \text{ volt}}$

26. Voltameter measures:

(A) resistance (B) potential difference

(C) current (D) none of these

27. When magnetic moment of an oscillating magnet increases, its time period will :

(A) increase (B) decrease

(C) remain unchanged (D) become half

28. The phase difference between electric and magnetic fields in an electromagnetic wave is :

(A) 0 (B) $\frac{\pi}{2}$

(C) π (D) anything

29. The Torque $(\vec{\tau})$ experienced by a current-loop of magnetic moment $(\vec{M})$ placed in magnetic field $\vec{B}$ is

(A) $\vec{\tau} = \vec{M} \times \vec{B}$ (B) $\vec{\tau} = \vec{B} \times \vec{M}$

(C) $\vec{\tau} = \frac{\vec{M}}{\vec{B}}$ (D) $\vec{\tau} = \vec{M} \cdot \vec{B}$

30. Tesla is a unit of :

(A) electric flux (B) magnetic flux

(C) magnetic field (D) electric field

31. SI unit of magnetic pole strength is :

(A) Ampere-metre (B) Ampere-metre^2

(C) Ampere^2-metre (D) Tesla-metre

32. Instrument which converts mechanical energy into electrical energy is :

(A) Induction-coil (B) Dynamo

(C) Transformer (D) Motor

33. Impedance of L-R circuit is :

(A) $R^2 + \omega L^2$ (B) $\sqrt{R + \omega L}$

(C) $R + \omega L$ (D) $\sqrt{R^2 + \omega^2 L^2}$

34. Henry is unit of :

(A) Inductance (B) Magnetic flux

(C) Magnetic field (D) Electric field

35. The ratio of root mean square (rms) value and peak value of an alternating current is :

(A) $\sqrt{2}$ (B) $\frac{1}{\sqrt{2}}$ (C) $\frac{1}{2}$ (D) $2\sqrt{2}$

36. Hot wire ammeter measures :

(A) peak value of *ac* (B) average value of *ac*

(C) r.m.s. *ac* (D) none of these

37. Unit of $\frac{1}{Lw}$ is unit of :

(A) R (B) Lw

(C) Both 'A' and 'B' (D) None of these

38. Which of the following is not electromagnetic wave ?

(A) light waves (B) X-rays

(C) sound waves (D) infrared rays

39. Poynting vector is given as :

(A) $\vec{E} \times \vec{H}$ (B) $\vec{E} / \vec{H}$ (C) $\vec{E} . \vec{H}$ (D) $\vec{H} / \vec{E}$

40. The direction of transmission of electromagnetic wave
(A) Parallel to $\dot{E}$ (B) Parallel to $\dot{B}$
(C) Parallel to $\dot{B} \times \dot{E}$ (D) Parallel $\dot{E} \times \dot{B}$

41. When light enters from one medium into another medium, which quantity does not change ?
(A) Wavelength (B) Frequency
(C) Speed (D) Amplitude

42. Which of the relations is correct for the magnifying power of compound microscope ?
(A) $M = -\frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$ (B) $M = -\frac{f_0}{L}\left(1+\frac{D}{f_e}\right)$
(C) $M = \left(1+\frac{D}{f_e}\right)$ (D) $M = \left(1-\frac{D}{f_e}\right)$

43. The magnifying power of magnifying glass of power 12 diopter is :
(A) 4 (B) 1200 (C) 3 (D) 25

44. Mirage is a phenomenon due to :
(A) refraction of light
(B) reflection of light
(C) total internal reflection of light
(D) diffraction of light

45. Which one of the following has maximum refractive index ?
(A) glass (B) Water
(C) iron (D) diamon

46. The image formed by simple microscope is :
(A) Virtual and erect (B) Virtual and inverted
(C) Real and erect (D) Real and inverted

47. Interference of light is the redistribution of which of the following physics quantitics?
(A) Frequency (B) Intensity
(C) Wavelength (D) Speed

48. The minimum value of the refractive index is :
(A) zero (B) 1
(C) less than 1 but not zero (D) more than 1

49. The refractive index of diamond is about :
(A) 1 (B) 1.42
(C) 2.42 (D) 4.24

50. A person using a lens as a simple microscope sees an :
(A) inverted virtual image
(B) inverted real magnified image
(C) upright virtual image
(D) upright read magnified image

51. The upper half of a convex Lense is blackned, size of image formed by it :
(A) Increases
(B) Decreases
(C) Becomes of less intensity
(D) None of these

52. To remove hyper metropia lens used is :
(A) Convex (B) Concave
(C) Cylindrical (D) Plano-covex

53. Which one of the following is deflected in electric field ?
(A) Gamma rays (B) X-rays
(C) Ultraviolet rays (D) Cathode rays

54. Who established that electric charge is quantised ?
(A) J.J. Thomson (B) William Crookes
(C) R.A. Millikan (D) Wilhelm Rontgen

55. The energy of a photon of wavelength λ is :
(A) $hc\lambda$ (B) hc/λ
(C) $h\lambda/c$. (D) λ/hc

56. Transverse nature of light is shown by :
(A) Interference (B) Reflection
(C) Polarisation (D) Dispersion

57. Cathode rays are :
(A) electrons (B) neutrons
(C) protons (D) photons

58. The specific charge of electron is :
(A) 1.8×10^{11} c/kg (B) 1.8×10^{-19} c/kg
(C) 1.9×10^{-19} c/kg (D) None of these

59. The energy of a photon of wavelength λ is :
(A) $hc\lambda$ (B) $\frac{hc}{\lambda}$ (C) $\frac{h\lambda}{c}$ (D) $\frac{\dot{\lambda}}{hc}$

60. Full wave reftifier uses :
(A) two diodes (B) three diodes
(C) four diodes (D) five diodes

61. Density of nucleus is about :
(A) 2.29×10^{7} kg m^{-3} (B) 2.29×10^{-7} kg m^{-3}
(C) 2.29×10^{17} kg m^{-3} (D) 2.29×10^{-17} kg m^{-3}

62. The impurity doped in germanium to obtain *n*-type germanium is :
(A) Tetravalent (B) Trivalent
(C) Pentavalent (D) None of these

63. Main gate (Basic gate) is :
(A) AND, OR (B) NAND, NOR
(C) OR, NOT (D) AND, OR, NOT

64. Donor impurity atom has valency:
(A) 3 (B) 4
(C) 5 (D) 6

65. For Binary number 10101, the number in decimal representation will be :
(A) 31 (B) 21
(C) 11 (D) 3

66. Diode is used as :
(A) An amplifier (B) An oscillator
(C) A modulator (D) A rectifier

67. Which frequency range is used for TV transmission ?
(A) 30 HZ – 300 Hz (B) 30 kHZ – 300 kHZ
(C) 30 MHz – 300 MHz (D) 30 GHz – 300 GHz

68. The most suitable metal for making permanent magnets is :
(A) iron (B) steel
(C) copper (D) aluminium

69. The magnetic flux linked with a coil is inversely proportional to the
(A) magnetic field (B) area of cross section
(C) number of turns (D) none of the above

70. Faraday constant :
(A) depends on the amount of the electrolyte
(B) depends on the current in the electrolyte
(C) is a universal constant
(D) depends on the amount of charge passed through the electrolyte

SECTION – B : Non-Objective Type Questions

SHORT ANSWER TYPE QUESTIONS

Directions : *Questions Nos. 1 to 20 are of short answer type. Each question carries 2 marks. Answer any ten question on your copy.* $10 \times 2 = 20$

1. **Under that condition will the magnifying power of a microscope be maximum ?**
2. **What are eddy currents ? Give their one use.**
3. **What is the frequency of domestic alternating current supply ? How many times does it become zero in one second ?**
4. **Explain huygen's principle for propagation of a wave front.**
5. **State the postulates of huygen's wave theory and draw wavefront for parallel and converging or diverging beams.**
6. **Explain the following terms :**
   (i) Ground waves (ii) Space waves (iii) Sky waves
7. **State two factors by which the range of transmission of signals by a T.V. tower can be increased.**
8. **State some applications of γ-rays.**
9. **Calculate the electric field intensity required to just support a water drop of mass 10^{-7} kg and having a charge 1.6×10^{-19} C.**
10. **Define mutual induction.**
11. **Why the inductance coils are made of copper ?**
12. **The lense of focal length 10 cm placed 5 cm away from a concave lense of focal length 20 cm. Find the equivalent focal length.**
13. **Explain Copper-loss in a transformer.**
14. **Explain Electrical Resonance.**
15. **Define electric dipole and Dipole moment.**
16. **Show that a charge 'q' be divided equally into two parts to have maximum force of repulsion between them.**
17. **Define equipotential Surface. Draw it for a point charge and represent electric field.**
18. **Can the potential difference across a battery be greater than its e.m.f. ?**
19. **Why is the terminal voltage across a battery more than the e.m.f. during recharging ?**
20. **What is the difference between an electromagnet and a permanent magnet ? How is an electromagnet designed ? State any two factors on which the strength of an electromagnet depends.**

LONG ANSWER TYPE QUESTIONS

Directions : *Questions Nos. 21 to 26 are Long Answer Type Questions. Answer any 3 out of them.* $3 \times 5 = 15$

21. **Define self inductance and mutual inductance. Find an expression for mutual inductance of two Co-axial solenoid.**
22. **What do you understand by terms 'average value', 'r.m.s. value', 'virtual value' and maximum value of an alternating current. Find expression for them.**
23. **Derive expression for current in L-C-R series or parallel circuit. What is the condition of resonance? What is impedence of resonant frequency?**
24. **State Kirchoff's law and use it to obtain condition of balance of a wheatstone bridge.**
25. **What do you mean by joule's heating effect ? Give the laws of Joule's heating and how can you verify it ?**
26. **State Biot-Savart's law. Using this law, derive the expression for the magnetic field due to a current carrying circular loop of radius 'R', at a point which is at a distance 'x' from its centre along the axis of the loop.**

ANSWER WITH EXPLANATION

SECTION – A

OMR ANSWER-SHEET

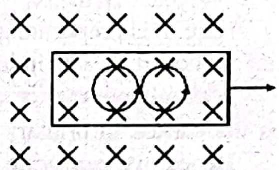
1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	36.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	37.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	38.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	39.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	40.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	41.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	42.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	43.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	44.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	45.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	46.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	47.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	48.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	49.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	50.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	51.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	52.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	53.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	54.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	55.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	56.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	57.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	58.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	59.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	60.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	61.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	62.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	63.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	64.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	65.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
31.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	66.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
32.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	67.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
33.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	68.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
34.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	69.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
35.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	70.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

ANSWER

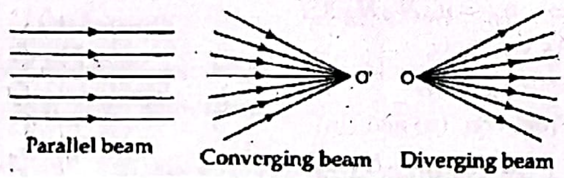
1. (D)	2. (B)	3. (D)	4. (C)	5. (B)
6. (B)	7. (B)	8. (A)	9. (A)	10. (D)
11. (A)	12. (D)	13. (B)	14. (C)	15. (A)
16. (D)	17. (C)	18. (B)	19. (C)	20. (B)
21. (A)	22. (C)	23. (B)	24. (A)	25. (A)
26. (B)	27. (B)	28. (B)	29. (A)	30. (C)
31. (B)	32. (B)	33. (D)	34. (A)	35. (B)
36. (C)	37. (D)	38. (C)	39. (A)	40. (D)
41. (B)	42. (A)	43. (D)	44. (C)	45. (D)
46. (A)	47. (B)	48. (C)	49. (C)	50. (C)
51. (C)	52. (A)	53. (D)	54. (C)	55. (B)
56. (C)	57. (A)	58. (A)	59. (B)	60. (A)
61. (C)	62. (C)	63. (D)	64. (C)	65. (B)
66. (D)	67. (C)	68. (B)	69. (A)	70. (C)

SECTION – B

1. The magnifying power of a simple microscope depends on the ratio $\frac{D}{f}$ for a farsighted person. Here, D for a farsighted person is greater than that for a normal person, but the value of f remains the same. Therefore, the magnifying power of a simple microscope is greater for a farsighted person compared to that for a person with normal vision.
2. **Eddy Currents** : Whenever a metallic piece is placed in time varying magnetic field, the magnetic flux linked with it changes, so the induced currents are produced; these currents are called eddy currents. These currents may be so strong that they heat the metal piece to red but.



3. The frequency of domestic ac supply is 50 Hz. It becomes zero twice in each cycle and so it becomes zero 100 times per second.
4. According to Huygen's principle for propagation of wavefront will be along all directions. All the points where wave reach at same time is called wavefronts, Propogation of wavefront stablished on the following two assumptions :
   (i) Each point on a wavefront acts as a fresh source of disturbance.
   (ii) The new wavefront of any later time is obtained by taking the forward envelope of the secondary wavelets at that time.
5. (i) Each point on a wavefront acts as a fresh source of disturbance.
   (ii) The new wavefront at any later time is obtained by taking the forward envelope of the secondary wavelets at that time.



6. (i) **Ground waves :** A radiowave that travels directly from one point to another following the surface of the earth is called ground wave or surface wave.
   (ii) **Space waves :** A radiowave that travels directly from a high trnasmitting antenna to the receiving station is called a space wave.
   (iii) **Sky waves :** A radiowave transmitted towards the sky and reflected by the ionosphere towards the desired location of the earth is called a sky wave.
7. (i) By increasing the height of the tower.
   (ii) By increasing the height of the receiving antenna, so that it may directly intercept the signal from the transmitting antenna.
8. (i) They are used in radiotherapy to treat tumours and cancer.
   (ii) They (soft g-rays) are used to kill micro organisms in food industry so as to preserve food stuffs for a longer time.
   (iii) They are used to produce nuclear reactions.
9. Here $m = 10^{-7}$ kg; $q = 1.6 \times 10^{-19}$ c
   Let E be the strength of the electric field required to just support the water drop.
   Then, $F = mg$ [$\because$ $F = qe$ and $q = e$]
   $Ee = \text{mg}$
   $$E = \frac{mg}{e} = \frac{10^{-7} \times 9.8}{1.6 \times 10^{-19}}$$
   $$\boxed{E = 6.125 \times 10^{12}\ \text{NC}^{-1}}$$
10. It is defined as the process of producing induced em.f. in a coil by changing the current or magnetic flux linked with the neighbouring coil.
11. The inductance coils made of copper have very small ohmic resistance. Due to change in magnetic flux, a large induced current will be produced in such an inductance and it offers appreciable opposition to the flow of current due to the applied e.m.f.
12. Here $f_1 = 10$ cm, $f_2 = -20$ cm, $d = 5$ cm
    focal length of eq. lense = F = ?
    By using formula
    $$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$
    $$= \frac{1}{10} + \frac{1}{-20} - \frac{5}{10 \times (-20)}$$
    $$= \frac{1}{10} - \frac{1}{20} + \frac{1}{40} = \frac{4-2+1}{40} = \frac{3}{40}$$
    $$\therefore\ F = \frac{40}{3}\ \text{cm} = 13.33\ \text{cm}$$
13. **Copper-loss**—As the alternative current flows through the primary and the secondary coil, heat is developed inside the copper turns. This waste of energy is known as 'Copper-loss'.

14. Electric Resonance—The phenomenon of resonance occurs in those systems which have a tendency to oscillate at a particular frequency known as natural frequency of oscillation of the system. When such type of a system is driven by such a periodic energy source whose frequency is equal to the natural frequency of the system, then the amplitude of oscillation becomes maximum and resonance is said to occur. For example, a swinging child has a natural frequency of oscillation. If another child pushes the swinging child at regular intervals such that frequency of the pushes is nearly the same as the natural frequency of oscillation, then the amplitude of oscillation of the child becomes maximum. Thus resonance has occurred.

15. Electric dipole : An electric dipole is a pair of equal and opposite point charges q and $-q$, separated by a distance $2a$.

Dipole moment : The dipole moment vector p of an electric dipole is defined by

$$p = q \times 2a\,\hat{p}$$

16. Let q' and $(q - q')$ be separated by a distance r.

Now, the force of repulsion

$$F = \frac{1}{4\pi\epsilon_0}\frac{q'(q-q')}{r^2}$$

For F to be maximum $\frac{dF}{dq'} = 0$

$$\frac{d}{dq'}\left[\frac{1}{4\pi\epsilon_0}\left(\frac{q'(q-q')}{r^2}\right)\right] = 0$$

or, $$\frac{1}{4\pi\epsilon_0 r^2}[q - 2q] = 0$$

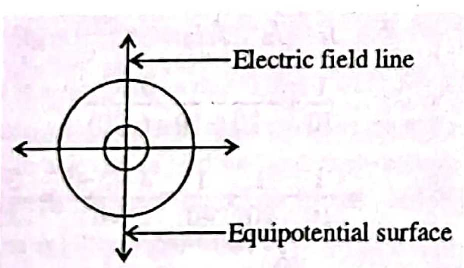
$$q - 2q' = 0$$

$$q = 2q$$

$$\boxed{q' = \frac{q}{2}}$$

Hence, charge q must be divided equally for maximum force of repulsion.

17. That surface on which potential be same at every point.



Equipotential surface for a point charge be spherical.

18. Normally not, But during the charging when the battery is connected to the external source, the terminal potential difference V is greater than E i.e.,

$$V_{applied} = E + IR$$

19. During recharging of the battery, the voltage across the internal resistance (= Ir) and the e.m.f. are in the same direction, hence they get added up to give terminal voltage. So the terminal voltage is greater than the e.m.f.

20. A **permanent magnet** is an object made from a material that is magnetized and creates its own persistent magnetic field. An everyday example is a refrigerator magnet used to hold notes on a refrigerator door.

An **electromagnet** is a type of magnet whose magnetic field is produced by the flow of electric current. The magnetic field disappears when the current passes.

Design of electromagnet : An electromagnet is made from a coil of wire wrapped on a soft iron core which acts as a magnet when an electric current passes through it, but stops being a magnet when the current stops.

Following factors affecting the strength of Electro-magnet :

(i) the number of windings in the electromagnet.

(ii) the amount of current supplied.

21. Self inductance : As we know rate of change of magnetic flux through a coil be directly proportional to induced emf in that coil as

$$\varepsilon \propto \frac{d\phi_B}{dt}$$

$$\varepsilon = -\frac{Ld\phi_B}{dt}$$

Here, L is proportionality constant and is called coefficient of self induction or self inductance.

Mutual inductance : Since flux in secondary coil depends on the current in primary coil.

Hence, we can write

$$\phi \propto I$$

$$\Rightarrow \quad \phi = MI \qquad \text{... (1)}$$

where M is called coefficient of mutual induction or mutual inductance.

Coefficient of mutual induction due to co-axial solenoid.

Consider two co-axial solenoid having radius r_P and r_S placed such that there is no linkage of flux.

Consider N_P and N_S be the number of terms in primary and secondary solenoid respectively & let I be the current flow through the primary solenoid. Hence magnetic field at the centre of primary solenoid be given as

$$B = \mu_0 N_P I \qquad \text{... (i)}$$

Hence, the magnetic flux through the secondary solenoid be given as

$$\phi_B = N_S B A_S$$

$$\Rightarrow \quad \phi_B = N_S(\mu_0 N_P I) A_S$$

$$\Rightarrow \quad \phi_B = \mu_0 N_P N_S A_s I \qquad \text{... (ii)}$$

As we know,

$$\phi_B = MI \qquad \text{... (iii)}$$

From eqn. (ii) and (iii)

$$M = \mu_0 N_P N_S A_S$$

If l_P & l_S be the length of primary & secondary solenoid & n_P & n_S be the numbers of turns of primary & secondary solenoid.

$\therefore \quad N_P = n_p l_p$

& $\quad N_S = n_S l_S$

$A_S = \pi r_S^2$

$\therefore \quad \boxed{M = \mu_0 n_p n_s l_p l_s \pi r_s^2}$

22. Average value : It is an steady current which gives the same amount of charge in time $\frac{T}{2}$ as it is given by alternating current to that circuit in time $\frac{T}{2}$.

Consider on A.C.

$$I = I_0 \sin \omega t$$

Let, dq be the charge given by the current in time 'dt' to that circuit.

$$I = \frac{dq}{dt}$$

$$dq = Idt$$

$$dq = I_0 \sin \omega t \, dt$$

$$q = I_0 \int_0^{\frac{T}{2}} \sin \omega t \, dt = I_0 \left| \frac{-\cos \omega t}{\omega} \right|_0^{\frac{T}{2}}$$

$$= \frac{-I_0}{\omega} \left| \cos \frac{2\pi}{T} \times \frac{T}{2} - \cos \frac{2\pi}{T} \times 0 \right|$$

$$= \frac{-I_0}{\omega}(-1-1) = \frac{2\pi}{\omega}$$

$$q = \frac{2I_0}{\omega}$$

$$q = \frac{2I_0}{\omega} = I_m = 0.637\, I_0$$

$$I_m / I_{avg} = \frac{q}{T/2} = \frac{2I_0}{\omega} \times \frac{2}{T} = \frac{2I_0}{2\Pi / T} \times \frac{2}{T}$$

$$= \frac{2I_0}{2\Pi} \times \frac{2T}{T}$$

$$I_m = \frac{2I_0}{\pi}$$

Root mean square values (rms value) or virtual value :

It is that steady current which produce the some heat in given resistance in a given as is done by the alternating current when passed through the same resistance for the same time.

Let the A.C. be represented by

$$I = I_0 \sin \omega t$$

Let, $d\theta$, be the amount of heat produced by this current is resistance R in an infinitesimally small time dt.

Then, $d\theta = I^2 R dt$

The total quantity of heat produced over one complete cycle of A.C. is given by

$$\theta = \int_0^T I^2 R dt$$

where T is the period of alternating current.

Now, $$\theta = \int_0^T (I_0 \sin \omega t)^2 R\, dt$$

$$= \int_0^T I_0^2 R \sin^2 \omega t \, dt$$

$$= I_0^2 R \int_0^T \sin^2 \omega t \, dt$$

But $$\int_0^T \sin^2 \omega t \, dt = \int_0^T \frac{1 - \cos q\omega t}{2} dt$$

$$= \int_0^T \frac{1}{2} . dt - \int_0^T \frac{\cos 2\omega t}{2} dt$$

$$dt = \frac{1}{2}[t]_0^T - \frac{1}{2}\left[\frac{\sin 2\omega t}{2\omega}\right]_0^T$$

$$= \frac{1}{2}(T - 0) - \frac{1}{4\omega}(\sin 4\pi - \sin 0)$$

$$= \frac{T}{2} - \frac{1}{4\omega}(0 - 0) = \frac{T}{2}$$

$$\theta = I_0^2 R \times \frac{T}{2} \qquad \text{... (1)}$$

If I_v be the virtual value of A.C. then,

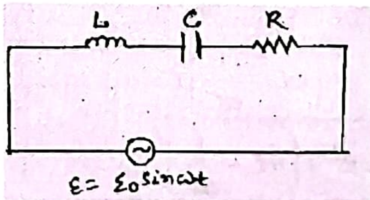
$$\theta = I_v^2 RT \qquad \text{... (2)}$$

Eqn. (2) and (1)

$$I_v^2 RT = I_0^2 R \times \frac{T}{2}$$

$$I_v = \frac{I_0}{\sqrt{2}} = 0.707\, I_0 \qquad \Rightarrow \boxed{I_v = 0.707\, I_0}$$

23. Consider a circuit having a resistance R, a coil of inductance L & a capacitor of capacitance C are connection series as shown in fig.



Let emf through the circuit

$$\varepsilon = \varepsilon_0 \sin \omega t$$

Here $\varepsilon = IR + L\frac{dI}{dt} + \frac{Q}{C}$ ... (i)

$\Rightarrow$ $\varepsilon_0 \sin\omega t = IR + \frac{LdT}{dt} + \frac{Q}{C}$ ... (ii)

Let $I = A\sin\omega t + B\cos\omega t$ ... (iii)

Here, A & B are constant

Differentiating eqn. (iii)

$$\frac{dI}{dt} = A\omega\cos\omega t - B\sin\omega t$$

$\because$ $I = \frac{d\theta}{dt} \Rightarrow d\theta = Idt$

From eqn. (iii)

$$d\theta = (A\sin\omega t + B\cos\omega t)\,dt$$

Integrating both side :

$$\int dQ = \int A\sin\omega t dt + \int B\cos\omega t\, dt$$

$$Q = A\left(-\frac{\cos\omega t}{\omega}\right) + B\left(\frac{\sin\omega t}{\omega}\right)$$

Putting the value of I, $\frac{dT}{dt}$ & Q in eqn. (ii)

$$R(A\sin\omega t + B\cos\omega t) + L(A\omega\cos\omega t - B\omega\sin\omega t) + \frac{1}{C}\left\{\left(-\frac{A\cos\omega t}{\omega}\right) + \left(\frac{B}{\omega}\sin\omega t\right)\right\}$$

$$= \varepsilon_0 \sin\omega t$$

Initially let $\omega t = 0$

$\sin\omega t = 0$ & $\cos\omega t = 1$

$$\boxed{RB + LA\omega + \frac{1}{L}\left(-\frac{A}{\omega}\right) = 0} \quad \text{... (iv)}$$

when $\omega t = \frac{\pi}{2}$

$\sin\omega t = 1$ & $\cos\omega t = 0$

$$\boxed{RA - LB\omega + \frac{B}{\omega C} = \varepsilon_0} \quad \text{... (v)}$$

On solving eqn. (iv) & (v)

$$A = \frac{R\varepsilon_0}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\& \quad B = \frac{-\left(\omega L - \frac{1}{\omega C}\right)\varepsilon}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

From eqn. (iii)

$I = A\sin\omega t + B\cos\omega t$

$$I = \frac{R\varepsilon_0}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}\sin\omega t - \frac{\left(\omega L - \frac{1}{\omega C}\right)\cos\omega t}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$\Rightarrow I = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}\left\{\frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}\sin\omega t - \frac{\left(\omega L - \frac{1}{\omega C}\right)\cos\omega t}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}\right\}$$

Let $\frac{R}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = \cos\phi$

and $\frac{\left(\omega L - \frac{1}{\omega C}\right)}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} = \sin\phi$

$$I = I_0 \cos\phi\sin\omega t - \sin\phi\cos\omega t$$

$$\Rightarrow \boxed{I = I_0 \sin(\omega t - \phi)}$$

$$I_0 = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

At resonant frequency

ω_0, $X_C = X_C$ & impedence is minimum

$$Z = \sqrt{R^2 + 0} = R$$

This impedence is called impedence of resonant frequency.

24. Kirchoff's law : To solve the complicated circuit Kirchoff suggested two rules that are :

(i) Kirchoff's 1st law/junction rule/current law :

In his 1st law Kirchoff tells that the algebraic sum of current at a junction of circuit be always equal to 0

$$\sum_{i=1}^{n} I_1 = 0$$

(a) Current going toward the junction is taken as + ve whereas current going away the junction taken as – ve.

Current towards the junction

= Current away the junction.

· **(ii) Kirchoff's second law / Loop rule voltage law :**

In his 2nd law Kirchoff state that the sum of potential drop & total emf of a close loop of a circuit always be 0 i.e.,

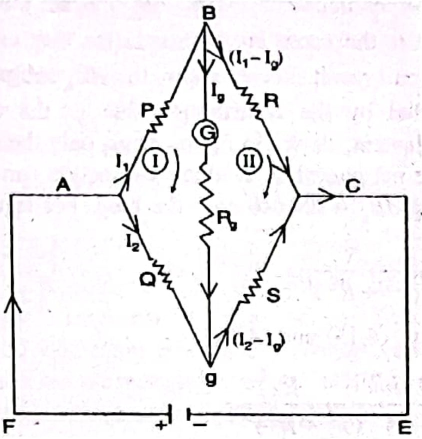
$$\sum_{i=1}^{n} I_i R_i + \sum_{i=1}^{n} \varepsilon_i$$

Applying Kirchoff's second law for the loops (*ABDA*)

$$-I_1 P - I_g R_g + I_2 Q = 0 \quad \text{... (i)}$$

For the second loop :

$$-(I_1 - I_g)R + (I_2 + I_g)S + I_g R_g = 0 \quad \text{... (ii)}$$



Now we adjust the resistance such that deflection of galvanometer is 0.

i.e., $I_g = 0$

From equation (i)

$$-I_1 P + I_2 Q = 0$$

$$\Rightarrow \quad I_1 P = I_2 Q$$

$$\Rightarrow \quad \frac{I_1}{I_2} = \frac{Q}{P}$$

From eqn. (ii)

$$-(I_1 - I_g)R + (I_2 + I_g)S + I_g R_g = 0$$

$$\Rightarrow \quad -(I_1 - 0)R + (I_2 + 0)S + 0 \times R_g = 0$$

$$\Rightarrow \quad -I_1 R + I_2 S + 0 = 0$$

$$\Rightarrow \quad I_2 S = I_1 R$$

$$\Rightarrow \quad I_1 R = I_2 S$$

$$\boxed{\frac{I_1}{I_2} = \frac{S}{R}} \quad \text{... (iv)}$$

Now, eqn. (iii) & (iv)

$$\frac{Q}{P} = \frac{S}{R}$$

$$\frac{P}{Q} = \frac{R}{S}$$

$$\frac{P}{R} = \frac{Q}{S}$$

$$\frac{S}{Q} = \frac{R}{P}$$

This condition is called balance condition for wheatstone bridge. It obtain when current through galvanometer is 0.

25. When an electric current passes through a conductor the electrical resistance of the conductor opposes the current. In the conductor electrons move from lower Potential end to higher potential end. While moving from one end to the other inside a conductor work is done either on the charge or by the charge. In the external circuit if a charge of Q coul. moves through a potential difference of V volt, energy gained or lost by the charge is $Q.V.$ joule.

This energy appears in the form of heat inside the conductor.

Hence heat energy produced is

$$H = Q.\ V = I.t.V$$

or, $\quad H = I.t.\ I.R \quad$ or, $\quad H = I^2 R.t \quad$ ... (i)

Where I is the current passing through the conductor of resistance R ohm for t sec.

Joule's laws—According to Joule, when a steady current of I amp. passes through a conductor of fixed resistance and for a fixed time, then heat energy produced is proportional to square of the current

i.e. $H \alpha I^2$ ... (ii)

If the current through the resistor remains constant and it passes through different resistors for same time then the quantity of heat produced is proportional to the resistance of the conductor

i.e. $H \alpha R$ ... (iii)

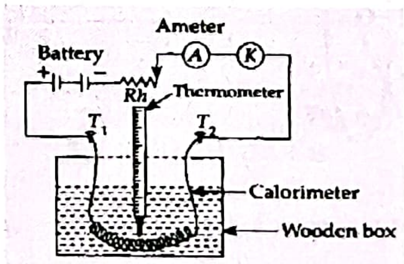
If same current is passed through a given conductor but for different time then the quantity of heat produced is proportional to time for which the current passes.

i.e. $H \alpha t$ ... (iv)

Verification of Joule's laws.

Joule's laws are verified by the following experimental arrangement.

Law of current—A Joule's calorimeter is taken. It is cleaned, dried and weighed. Some koil is taken into the calorimeter and its mass is obtained. The initial temperature of the colorimeter + kerosin oil is noted with the help or a sensitive thermometer. The electrical connection is completed as in the fig. When a steady current is passed through the coil, heat is produced. The temperature of the k, oil and the calorimeter, coil increases. The increase in temperature of the system is recorded by the thermometer in a fixed interval of time. The rise in temperature of the system is proportional to the heat energy produced.



Now, the system is allowed to come to its original condition, by switching off the circuit. Again a different current is passed through the system for same time interval and the rise in temperature is again recorded. If I_1 & I_2 be the current in two cases and θ_1 and θ_2 be the rise in temperature then it is found that $\frac{I_1^2}{I_2^2}\frac{\theta_1}{\theta_2}$.

This shows that $\theta \alpha I$ but $\theta \alpha H$ and hence.

$$\boxed{H \alpha I^2}$$

Similarly by taking two different coils, a constant current of I amp is passed through the two different coils for same time. The rise in temperature of the system is recorded. Let R_1 and R_2 be the resistance of the two coils and θ_1 and θ_2 be the rise in temperature, then it is observed that

$$\frac{R_1}{R_2} = \frac{\theta_1}{\theta_2} \quad \text{or,} \quad \theta \alpha R$$

But $\theta \alpha H$ and hence $\boxed{H \alpha R}$

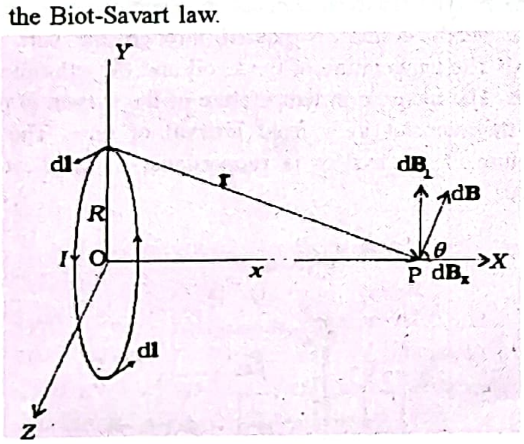
The same current of I amp. is passed through the same coil but for different time intervals. The rise in temperature of the system is recorded. Let I amp of current is passed through a coil of resistance R ohm for t_1 sec and t_2 see respectively. Let the rise in temperature of the system in two different cases be $\theta_1{}^\circ C$ and $\theta_2{}^\circ C$ respectively. Then it is found that $\frac{\theta_1}{\theta_2} = \frac{t_1}{t_2}$

or, $\boxed{\theta \alpha t}$

But θ is proportional to H, hence $\boxed{H \alpha t}$

26. Consider a circular loop carrying a steady current I. The loop is placed in the y-z plane with its centre at the origin O and has a radius R. The x-axis is the axis of the loop. We wish to calculate the magnetic field at the point P on this axis. Let x be the distance of P from the centre O of the loop.

Consider a conducting element dl of the loop. This is shown in Figure. The magnitude dB of the magnetic field due to dl is given by the Biot-Savart law.



$$dB = \frac{\mu_0}{4\pi}\frac{I|dl \times r|}{r^3} \qquad \text{(i)}$$

Now, $r^2 = x^2 + R^2$. Further, any element of the loop will be perpendicular to the displacement vector from the element to the axial point. For example, the element dl in Figure is in the y-z plane whereas the displacement vector r from dl to the axial point P is in the x-y plane. Hence $|dl \times r| = rdl$. Thus,

$$dB = \frac{\mu_0}{4\pi}\frac{Idl}{(x^2 + R^2)} \qquad \text{(ii)}$$

The direction of dB is shown in figure. It is perpendicular to the plane formed by dl and r. It has an x-component dB_x and a component perpendicular to x-axis, $dB_\perp$. When the components perpendicular to the x-axis are summed over, they cancel out and we obtain a null result. For example, the $dB_\perp$ component due to dl is cancelled by the contribution due to the diametrically opposite dl element, shown in figure. Thus, only the x-component survives. The net contribution along x-direction can be obtained by integrating $dB_x = dB\cos\theta$ over the loop. For figure,

$$\cos\theta = \frac{R}{(x^2 + R^2)^{1/2}} \qquad \text{(iii)}$$

From Eqs. (4.13) and (4.1),

$$dB_x = \frac{\mu_0 Idl}{4\pi}\frac{R}{(x^2 + R^2)^{3/2}}$$

The summation of elements dl over the loop yields $2\pi R$, circumference of the loop. Thus, the magnetic field at P due to entire circular loop is

$$B = B_x\hat{i} = \frac{\mu_0 IR^2}{2(x^2 + R^2)^{3/2}}\hat{i} \qquad \text{(iv)}$$

As a special case of the above result, we may obtain the field at the centre of the loop. Here $x = 0$, and we obtain,

$$B_0 = \frac{\mu_0 I}{2R}\hat{i} \qquad \text{(v)}$$

The magnetic field lines due to a circular wire from closed loops and are shown in figure. The direction of the magnetic field is given by (another) stated below :