भौतिक विज्ञान (सैद्धांतिक)

PHYSICS (Theory)

निर्धारित समय : 3 घंटे
Time allowed : 3 hours

अधिकतम अंक : 70
Maximum Marks : 70

सामान्य निदेश : 

(i) सभी प्रश्न अनिवार्य हैं। इस प्रश्न-पत्र में कुल 26 प्रश्न हैं।
(ii) इस प्रश्न-पत्र के 5 भाग हैं : खण्ड-अ, खण्ड-ब, खण्ड-स, खण्ड-द और खण्ड-े।
(iii) खण्ड-अ में 5 प्रश्न हैं, प्रत्येक का 1 अंक है। खण्ड-ब में 5 प्रश्न हैं, प्रत्येक के 2 अंक हैं। खण्ड-स में 12 प्रश्न हैं, प्रत्येक के 3 अंक हैं। खण्ड-द में 4 अंक का एक मूल्याधारित प्रश्न है और खण्ड-े में 3 प्रश्न हैं, प्रत्येक के 5 अंक हैं।
(iv) प्रश्न-पत्र में समग्र पर कोई विकल्प नहीं है। तथापि, दो अंकों वाले एक प्रश्न में, तीन अंकों वाले एक प्रश्न में और पांच अंकों वाले तीनों प्रश्नों में आंतरिक चयन प्रदान किया गया है। ऐसे प्रश्नों में आपको दिए गए चयन में से केवल एक प्रश्न ही करना है।

(v) जहाँ आवश्यक हो, आप निम्नलिखित भौतिक नियतांकों के मानों का उपयोग कर सकते हैं:

- \( c = 3 \times 10^8 \text{ m/s} \)
- \( h = 6.63 \times 10^{-34} \text{ Js} \)
- \( e = 1.6 \times 10^{-19} \text{ C} \)
- \( \mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1} \)
- \( \varepsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \)
- \( \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \)

**General Instructions:**

1. **All questions are compulsory. There are 26 questions in all.**
2. **This question paper has five sections: Section A, Section B, Section C, Section D and Section E.**
3. **Section A contains five questions of one mark each, Section B contains five questions of two marks each, Section C contains twelve questions of three marks each, Section D contains one value based question of four marks and Section E contains three questions of five marks each.**
4. **There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all the three questions of five marks weighting. You have to attempt only one of the choices in such questions.**
5. **You may use the following values of physical constants wherever necessary:**

- \( c = 3 \times 10^8 \text{ m/s} \)
- \( h = 6.63 \times 10^{-34} \text{ Js} \)
- \( e = 1.6 \times 10^{-19} \text{ C} \)
- \( \mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1} \)
- \( \varepsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \)
- \( \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \)

- Mass of electron (\( m_e \)) = 9.1 \times 10^{-31} \text{ kg}
- Mass of neutron = 1.675 \times 10^{-27} \text{ kg}
- Mass of proton = 1.673 \times 10^{-27} \text{ kg}
- Avogadro’s number = 6.023 \times 10^{23} \text{ per gram mole}
- Boltzmann constant = 1.38 \times 10^{-23} \text{ JK}^{-1}
SECTION – A

1. Define the power of a lens. Write its S.I. unit.

2. Draw a graph showing the intensity distribution of fringes due to diffraction at single slit.

3. Two protons of equal kinetic energies enter a region of uniform magnetic field. The first proton enters normal to the field direction while the second enters at 30° to the field direction. Name the trajectories followed by them.

4. An electron is accelerated through a potential difference V. Write the expression for its final speed, if it was initially at rest.

5. Write the range of frequencies of electromagnetic waves which propagate through sky wave mode.
SECTION – B

6. (a) Give one use of electromagnetic radiations obtained in nuclear disintegrations.
(b) Give one example each to illustrate the situation where there is (i) displacement current but no conduction current and (ii) only conduction current but no displacement current.

7. Calculate the ratio of the frequencies of the radiation emitted due to transition of the electron in a hydrogen atom from its (i) second permitted energy level to the first level and (ii) highest permitted energy level to the second permitted level.

8. Find the frequency of light which ejects electrons from a metal surface, fully stopped by a retarding potential of 3.3 V. If photoelectric emission begins in this metal at a frequency of \(8 \times 10^{14}\) Hz, calculate the work function (in eV) for this metal.

OR

Monochromatic light of frequency \(6.0 \times 10^{14}\) Hz is produced by a laser. The power emitted is \(2.0 \times 10^{-3}\) W. Calculate the (i) energy of a photon in the light beam and (ii) number of photons emitted on an average by the source.
9. (a) Define the term magnetic susceptibility and write its relation in terms of relative magnetic permeability.

(b) Two magnetic materials A and B have relative magnetic permeabilities of 0.96 and 500. Identify the magnetic materials A and B.

10. A rectangular frame of wire is placed in a uniform magnetic field directed outwards, normal to the paper. AB is connected to a spring which is stretched to A'B' and then released at time t = 0. Explain qualitatively how induced e.m.f. in the coil would vary with time. (Neglect damping of oscillations of spring)
SECTION – C

11. उभयनिष्ठ उत्सर्जक विन्यास में n-p-n जमेनियम ट्रांजिस्टर का नामांकित परिपथ आरेख खींचिए। संक्षेप में व्याख्या कीजिए कि यह ट्रांजिस्टर बोल्ट्टा प्रवर्धक के रूप में किस प्रकार उपयोग किया जाता है।

Draw a labelled circuit diagram of n-p-n germanium transistor in common emitter configuration. Explain briefly, how this transistor is used as a voltage amplifier.

12. (a) चित्र में दर्शाए गेटों के द्वारा गए संयोजन के लिए सत्यमान सारणी लिखिए।

(b) किसी फोटो-डायोड के प्रचालन की संख्या में व्याख्या कीजिए।

(a) Write the truth table for the combination of the gates shown in the figure.

(b) Explain briefly how a photo diode operates.

13. (a) किसी न्यूक्लियों के समूल की स्थितिज ऊर्जा का, इनके बीच पृथक के फलन के रूप में,

   विचरण ग्राफ खींचकर दर्शाइए। उन क्षेत्रों को अंकित कीजिए जहाँ नाभिकीय बल (i) आकर्ष, तथा

(ii) प्रतिकर्ष है।

(b) दी गयी नाभिकीय अभिक्रिया –

   \[ n + \frac{235}{92} U \rightarrow a \overset{54}{Xe} + \frac{94}{b} Sr + 2n \]

   में a और b के मान निर्धारित कीजिए।
(a) Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions where the nuclear force is (i) attractive and (ii) repulsive.

(b) In the nuclear reaction

\[ n + _{92}^{235}U \rightarrow _{54}^{a}Xe + _{88}^{b}Sr + 2n \]

determine the values of \( a \) and \( b \).

14. उपयोग किए गए पदों की व्याख्या करते हुए आइस्टीन के प्रकाश बिचुत समीकरण का उल्लेख कीजिए।

State Einstein’s photoelectric equation explaining the symbols used.

Light of frequency \( v \) incident is on a photosensitive surface. A graph of the square of the maximum speed of the electrons \( v^2_{\text{max}} \) vs. \( v \) is obtained as shown in the figure.

Using Einstein’s photoelectric equation, obtain expressions for (i) Planck’s constant (ii) work function of the given photosensitive material in terms of parameters \( l \), \( n \) and mass of the electron \( m \).
15. (i) व्यतिकरण और विरंचन से उत्पन्न फ्रिंजेज के बीच दो भेद लिखें।

(ii) यदि पद्धति के किसी दिशा में द्वितीय परिमार्जन में द्वितीय पद्धति के कुछ स्थित पद्धति पर फ्रिंज प्राप्त होती है। यदि पद्धति के किसी दिशा, पद्धति के कुछ स्थित पद्धति के क्रियाकलाप विरंचन हो जाता है। दिया है कि द्वितीय पद्धति के बीच की दूरी 1 mm है। उपयोग किए गए प्रकाश की तारंगदैर्ध्य परिकलित कीजिए।

(i) Write two points to distinguish between interference and diffraction fringes.

(ii) In a Young’s double slit experiment, fringes are obtained on a screen placed a certain distance away from the slits. If the screen is moved by 5 cm towards the slits, the fringe width changes by 30 μm. Given that the slits are 1 mm apart, calculate the wavelength of the light used.

16. किर्चहोफ के नियमों का प्रयोग करते हुए, दिए गए परिपथ आरेख में B और D के बीच विभवान्तर परिकलित कीजिए।

![Circuit Diagram]

Using Kirchhoff’s rules, calculate the potential difference between B and D in the circuit diagram as shown in the figure.

![Updated Circuit Diagram]
17. (a) State Biot–Savart law and express it in the vector form.
(b) Using Biot–Savart law, obtain the expression for the magnetic field due to a circular coil of radius \( r \), carrying a current \( I \) at a point on its axis distant \( x \) from the centre of the coil.

18. (a) With the help of a ray diagram, show how a concave mirror is used to obtain an erect and magnified image of an object.
(b) Using the above ray diagram, obtain the mirror formula and the expression for linear magnification.

19. (a) When an unpolarized light of intensity \( I_o \) is passed through a polaroid, what is the intensity of the linearly polarized light ? Does it depend on the orientation of the polaroid ? Explain your answer.
(b) A plane polarized beam of light is passed through a polaroid. Show graphically the variation of the intensity of the transmitted light with angle of rotation of the polaroid in complete one rotation.
20. (a) दो समान्तर विद्युत धारावाही चालकों के बीच लगने वाले बल के पदों में विद्युत धारा के SI मात्रक की परिभाषा दीजिए।

(b) एक दूसरे से पृथक दूर के दो लम्बे सीधे समान्तर चालकों से समान दिशा में $I_a$ और $I_b$ स्थिर धाराएँ प्रवाहित हो रही हैं। इन चालकों के बीच आकर्षण की व्याख्या किस प्रकार की जा सकती है? यदि इन दोनों चालकों के ठीक मध्य में किसी तीसरे चालक को, जिससे धारा $I_c$ विपरीत दिशा में प्रवाहित हो रही है, रख दिया जाए तो तीसरे चालक पर कार्यरत परिणामी बल ज्ञात कीजिए।

(a) Define SI unit of current in terms of the force between two parallel current carrying conductors.

(b) Two long straight parallel conductors carrying steady currents $I_a$ and $I_b$ along the same direction are separated by a distance $d$. How does one explain the force of attraction between them? If a third conductor carrying a current $I_c$ in the opposite direction is placed just in the middle of these conductors, find the resultant force acting on the third conductor.

21. $\varepsilon_1$ और $\varepsilon_2$ emf के दो सेल जिनके आन्तरिक प्रतिरोध क्रमशः $r_1$ और $r_2$ हैं, समान्तर क्रम में संयोजित हैं।

(i) संयोजन के तुल्य प्रतिरोध, तथा

(ii) संयोजन के तुल्य emf के लिए व्यंजक प्राप्त कीजिए।

Two cells of emfs $\varepsilon_1$ & $\varepsilon_2$ and internal resistances $r_1$ & $r_2$ respectively are connected in parallel. Obtain expressions for the equivalent.

(i) resistance and

(ii) emf of the combination
Define electric flux and write its SI unit. The electric field components in the figure shown are: \( E_x = \alpha x, E_y = 0, E_z = 0 \) where \( \alpha = \frac{100 \text{ N}}{\text{Cm}} \). Calculate the charge within the cube, assuming \( a = 0.1 \text{m} \).
An electron falls through a distance of 1.5 cm in a uniform electric field of magnitude $2.0 \times 10^4$ N/C (Fig. a)

![Diagram of electron falling through an electric field](image)

Calculate the time it takes to fall through this distance starting from rest.

![Diagram of proton falling through an electric field](image)

If the direction of the field is reversed (fig. b) keeping its magnitude unchanged, calculate the time taken by a proton to fall through this distance starting from rest.

Mrs. Rajlakshmi had a sudden fall and was thereafter unable to stand straight. She was in great pain. Her daughter Rita took her to the doctor. The doctor took a photograph of Mrs. Rajlakshmi’s bones and found that she had suffered a fracture. He advised her to rest and take the required treatment.

(a) Write two values displayed by Rita.

(b) Name the electromagnetic radiation used to take the photograph of the bones.

(c) How is this radiation produced?

(d) Mention the range of the wavelength of this electromagnetic radiation.
24. (a) An alternating A-C source of the amplitude of the source is applied to a device, which has a resistance of 220 V. The current through the device is 0.25 A. If the same voltage is applied to another device, which has the same current but leads the applied voltage by \( \pi/2 \) radians, name the two devices.

(b) Define the concept of inductive reactance and capacitive reactance with frequency of the applied ac source.

(c) Draw the phasor diagram for a series RC circuit connected to an ac source.

(d) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

OR

(a) State the principle of working of a transformer.
(b) Define the concept of efficiency of a transformer.
(c) State any two factors that reduce the efficiency of a transformer.
(d) Calculate the current drawn by the primary of a 90% efficient transformer which steps down 220 V to 22 V, if the output resistance is 440 \( \Omega \).
25. (a) Explain with the help of suitable diagram, the two processes which occur during the formations of a p-n junction diode. Hence define the terms (i) depletion region and (ii) potential barrier.

(b) Draw a circuit diagram of a p-n junction diode under forward bias and explain its working.

OR

(a) Describe briefly three factors which justify the need for modulation of audio frequency signals over long distances in communication.

(b) Draw the waveforms of (i) carrier wave, (ii) a modulating signal and (iii) amplitude modulated wave.

26. दो बिन्दु आवेश q और – q क्रमश: (0, 0, –a) और (0, 0, a) बिन्दुओं पर स्थित हैं |

(a) (0, 0, z) और (x, y, 0) पर स्थिर विद्युत विभव परिकलित कीजिए |

(b) किसी लघू परीक्षण आवेश को X-अक्ष के अनुदिश (5, 0, 0) से (–7, 0, 0) तक ले जाने में कितना कार्य किया जाता है ?
Two point charges \( q \) and \(-q\) are located at points \((0, 0, -a)\) and \((0, 0, a)\) respectively.

(a) Find the electrostatic potential at \((0, 0, z)\) and \((x, y, 0)\)

(b) How much work is done in moving a small test charge from the point \((5, 0, 0)\) to \((-7, 0, 0)\) along the x-axis ?

(c) How would your answer change if the path of the test charge between the same points is not along the x-axis but along any other random path ?

(d) If the above point charges are now placed in the same positions in a uniform external electric field \( \vec{E} \), what would be the potential energy of the charge system in its orientation of unstable equilibrium ?

Justify your answer in each case.

OR
A capacitor of capacitance $C_1$ is charged to a potential $V_1$ while another capacitor of capacitance $C_2$ is charged to a potential difference $V_2$. The capacitors are now disconnected from their respective charging batteries and connected in parallel to each other.

(a) Find the total energy stored in the two capacitors before they are connected.

(b) Find the total energy stored in the parallel combination of the two capacitors.

(c) Explain the reason for the difference of energy in parallel combination in comparison to the total energy before they are connected.