P-I (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : I-A

[New Syllabus]

Full Marks : 15 Time : Thirty Minutes

Important Instructions for OMR Sheet

1. Write / Fill your correct Subject Name, Subject Code & Paper Code in the space provided on the top of the OMR sheet (Subject Codes are given on the back of the OMR sheet & Paper Code in the Question Paper.) -
2. Write / Fill your Name, Roll number, Registration number, Regn. Session, Exam Date and Exam Session in the space provided on the OMR Sheet.
3. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
4. Your responses to the items are to be indicated in the **OMR Sheet given inside the Paper Booklet only.** If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
5. If you write your Phone Number in the OMR Sheet or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
6. You have to return the OMR Sheet to the invigilators at the end of the examination compulsorily and must not carry it with you outside the Examination Hall.
7. **Use only Blue/Black Ball point pen. Use of any mobile phone, calculator or log table etc. in examination hall, is prohibited.**

OMR Sheet-এর জন্য জরুরী নির্দেশাবলী

১। OMR Sheet এর নির্দেশিত স্থানে সঠিক Subject Name, Subject Code এবং Paper Code লিখতে/পূরণ করতে হবে। OMR Sheet এর পিছনের পাতায় Subject Code গুলি দেওয়া আছে এবং Paper Code টি প্রশ্নপত্রে উল্লেখ আছে।

২। OMR Sheet এর নির্দেশিত স্থানে Name, Roll number, Registration number, Regn. Session, Exam date এবং Exam Session লিখতে/পূরণ করতে হবে।

৩। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে সঠিক উত্তরের গোল ঘরটি নীল/কালো কালিতে পূরণ করতে হবে।

৪। সঠিক উত্তর কেবলমাত্র উত্তর পত্র অর্থাৎ OMR Sheet-এর নির্দিষ্ট স্থানে গোল ঘর পূরণ করেই দিতে হবে। অন্য কোনো উপায়ে দেওয়া উত্তরের মূল্যায়ন হবে না।

৫। পরীক্ষার্থীর ফোন নম্বর OMR Sheet এর কোনো অংশে লেখা যাবে না। কোনোরূপ অবাঞ্ছিত শব্দ লেখা বা দুর্নীতির আশ্রয় নিলে পরীক্ষার্থী নিজেই তার জন্য দায়ী থাকবে।

৬। পরীক্ষা শেষে উত্তর পত্র (OMR Sheet) সংশ্লিষ্ট তত্ত্বাবধায়কের নিকট জমা দিয়ে পরীক্ষা কেন্দ্রের বাইরে যেতে হবে এবং কোনোভাবেই পরীক্ষা কেন্দ্রের বাইরে OMR Sheet টি আনা যাবে না।

৭। শুধুমাত্র নীল/কালো বল পয়েন্ট কলম ব্যবহার করতে হবে। পরীক্ষাকক্ষে মোবাইল ফোন, ক্যালকুলেটর অথবা লগ-টেবিল ইত্যাদি ব্যবহার নিষিদ্ধ।

Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries $1\frac{1}{2}$ marks.

1. Two vectors $\vec{A}$ and $\vec{B}$ satisfy the relation $\left|\vec{A}+\vec{B}\right|=\left|\vec{A}-\vec{B}\right|$. Neither of them is a null vector. The angle between them is —

   (A) 0°

   (B) 90°

   (C) 135°

   (D) 180°

2. If the linear momentum of a particle moving in a force field at time t is $\vec{p}=2t\hat{i}+\left(t^2+1\right)\hat{j}+4t^2\hat{k}$, the force acting on the particle at $t=0$ is —

   (A) zero

   (B) $\hat{j}$

   (C) $2\hat{i}$

   (D) $2\hat{i}+2\hat{j}+4\hat{k}$

Turn Over

3. The angle between the body diagonals of a unit cube is —

   (A) 45°

   (B) 90°

   (C) $\cos^{-1}\left(\frac{2}{3}\right)\simeq 48.7°$

   (D) $\cos^{-1}\left(\frac{1}{3}\right)\simeq 70.53°$

4. C is a closed curve enclosing an area S in the x-y plane. $\vec{A}$ is a vector given by $\vec{A}=-\hat{i}y+\hat{j}x$. The line integral $\oint_c \vec{A}.d\vec{r}$ will have a value —

   (A) $2S$

   (B) S

   (C) $3S$

   (D) zero

5. A solid sphere of radius 'R' rolls down an inclined plane from rest. If the vertical height of the incline be 'h', the velocity of the sphere at the bottom of the incline will be —

(A) $\sqrt{2gh}$

(B) $\left(\frac{4}{3}gh\right)^{1/2}$

(C) $\left(\frac{10}{7}gh\right)^{1/2}$

(D) $\left(\frac{2}{5}gh\right)^{1/2}$

6. Three particles of masses 4 gm, 3 gm and 2 gm are at the points (2,0,–1), (1, 1, 3) and (3, –1, 0) respectively. The co-ordinates of their centre of mass (c.m.) are —

(A) $\left(\frac{1}{9}, \frac{5}{9}, \frac{17}{9}\right)$

(B) $\left(\frac{17}{9}, \frac{1}{9}, \frac{5}{9}\right)$

(C) $\left(\frac{1}{9}, \frac{17}{9}, \frac{5}{9}\right)$

(D) $\left(\frac{5}{9}, \frac{1}{9}, \frac{17}{9}\right)$

Turn Over

7. The diameter of the orbit of the planet Neptune round the sun is 30 times that of the earth's orbit, both orbits being assumed to be circular. The time period of revolution of Neptune round the sun is —

(A) 164.3 earth years (approx.)

(B) 52 earth years (approx.)

(C) 90 earth years (approx.)

(D) 150 earth years (approx.)

8. The excess pressure inside a soap bubble of radius 8.0 mm balances 2.0 mm column of oil of specific gravity 0.8. The surface tension of soap solution is —

(A) 12.54×10^{-2} Nm^{-1}

(B) 62.72×10^{-3} Nm^{-1}

(C) 12.54×10^{-3} Nm^{-1}

(D) 31.36×10^{-3} Nm^{-1}

9. A flat plate of area 2×10^{-3} m^2 is separated by a layer of glycerine 2.0 mm thick from a large stationary plate. If the coefficient of viscosity of glycerine be 2.0 decapoise, the force required to pull the first plate with a uniform velocity of 1.5×10^{-2} ms^{-1} on the oil surface is —

(A) 0.3 N

(B) 3.0 N

(C) 0.03 N

(D) 30.0 N

10. A cube of a metal of side 10.0 cm is subjected to a shearing stress of $10^4\ Nm^{-2}$. The top surface of the cube is displaced by 0.01 cm with respect to the bottom. The modulus of rigidity of the metal is —

(A) $10^7\ Nm^{-2}$

(B) $10^6\ Nm^{-2}$

(C) $10^5\ Nm^{-2}$

(D) $10^4\ Nm^{-2}$

Turn Over

2018

PHYSICS (Honours)

Paper Code : I-B

[New Syllabus]

Full Marks : 55 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions taking at least *one* from each group.

Group - A

[Mathematical Methods]

1. (a) The scalar triple product of three vectors is a pseudoscalar. Justify. 2

(b) If $\vec{A}$ has a constant magnitude and $\left|\frac{d\vec{A}}{dt}\right| \neq 0$, show that $\vec{A}$ and $\frac{d\vec{A}}{dt}$ are mutually perpendicular. 2

(c) A vector $\vec{r}$ satisfies the equations :

$\vec{r} \times \vec{b} = \vec{c} \times \vec{d}$ and $\vec{r} \cdot \vec{a} = 0$, but $\vec{a} \cdot \vec{b} \neq 0$.

Prove that $\vec{r} = \frac{(\vec{b} \times \vec{c}) \times \vec{a}}{\vec{a} \cdot \vec{b}}$ 3

(d) Evaluate the integral $\oint_C \left[(xy - x^2)dx + x^2 y\, dy\right]$ over the triangle bounded by the lines $y = 0$, $x = 1$ and $y = x$ and hence verify Green's theorem in the plane. 4

2. (a) Find $\oint \vec{A} \cdot d\vec{l}$ over a circular path of radius R, centred at the origin in the xy-plane, where $\vec{A} = ay\,\hat{x} + bx\,\hat{y}$ (a and b being constants). 3

(b) A periodic function $f(x)$ is given by

$$f(x) = \begin{cases} 0, & \text{for } -\pi < x < 0 \\ x, & \text{for } 0 < x < \pi \end{cases}$$

It is also given that $f(x + 2\pi) = f(x)$. Expand $f(x)$ in a Fourier series. Hence, show that $1 + \frac{1}{3^2} + \frac{1}{5^2} + \ldots = \frac{\pi^2}{8}$ 4+1

(c) Two cards are selected at random from 10 cards, numbered 1 to 10. If the two cards are drawn together, find the probability that the sum is odd. 3

3. (a) The following recurrence relation for a Legendre polynomial $P_n(x)$ is true :

$nP_n(x) = (2n-1)xP_{n-1}(x) - (n-1)P_{n-2}(x)$. Using the above relation, prove that $P_n' - xP_{n-1}' = nP_{n-1}$. 4

(b) Prove that the eigenvalues of a Hermitian matrix are real. 3

(c) If A is a non-singular matrix, show that the eigenvalues of A^{-1} are reciprocals of those of A and every eigenvector of A is also an eigenvector of A^{-1}. 4

Turn Over

Group - B

[Mechanics]

4. (a) For a planar motion of a particle in the xy-plane, $x = r\cos\theta$ and $y = r\sin\theta$, where the terms bear usual significance. Prove that

$$\dot{r} = \frac{x\dot{x} + y\dot{y}}{r} \quad \text{and} \quad r\dot{\theta} = \frac{x\dot{y} - y\dot{x}}{r} \qquad 4$$

(b) A frame S' is moving with a velocity $5\hat{i} + 7\hat{j}$ ms^{-1} relative to an inertial frame S. A particle is moving with a velocity $(t+5)\hat{i} + 9\hat{j}$ ms^{-1} with respect to S. Find the magnitude and direction of the acceleration of the particle in the frame S'. 3

(c) Define a central force.

The path of a particle of mass 'm', moving under the influence of a central force, in plane polar co-ordinates, is given by $r = r_0 e^{k\theta}$, where r_0 and k are positive constants of appropriate dimensions. The angular momentum of the particle is $\vec{L}$ and its total energy (E) is zero. Prove that the potential energy $V(r)$ of the particle is given by $V(r) = -\dfrac{(k^2+1)L^2}{2mr^2}$. 1+3

5. (a) Define radius of gyration of a rotating body about the axis of rotation.

Using spherical polar co-ordinates, find the moment of inertia of a solid sphere about a diameter. 1+4

(b) A uniform chain of length 'a' rests on a frictionless table so that a length 'b' dangles over the table. Prove that the time taken by the chain to slide off the table is $t_0 = \sqrt{\dfrac{a}{g}}\ln\left(\dfrac{a+\sqrt{a^2-b^2}}{b}\right)$. 6

6. (a) The total force on a system of particles is zero while the net torque is non-zero. Show that the net torque has the same value in any co-ordinate system. 4

(b) For a general vector $\vec{G}$, show that

$$\left(\frac{d\vec{G}}{dt}\right)_{fixed} = \left(\frac{d\vec{G}}{dt}\right)_{rotation} + \vec{W}\times\vec{G}\Big|_{rotation}$$, terms being usual.

Hence, obtain expressions for centrifugal and coriolis accelerations. 5+2

Group - C

[General Properties of Matter]

7. (a) Define torsional rigidity of a cylinder. Deduce an expression for the torsional rigidity of a hollow cylinder of length 'l' and internal and external radii R_1 and R_2 respectively. The modules of rigidity of the material is 'n'. 1+5

(b) A sessile drop of thickness H rests on a horizontal surface. Show that the surface tension of the liquid is given by $S = \dfrac{\rho g H^2}{2(1-\cos\theta)}$, where '$\theta$' is the angle of contact and other terms are usual. 5

8. (a) Derive an expression for the excess pressure acting inside a curved liquid membrane. 4

(b) If the rate of change of surface energy E of a liquid with temperature is proportional to the absolute temperature T, show that $\left(\dfrac{dE}{dT} + \dfrac{dS}{dT}\right)$ is a constant and S is a quadratic function of temperature, where S is the surface tension of the liquid. 4

Turn Over

(c) Water flows steadily through a composite system consisting of two narrow tubes '*A*' and '*B*' joint end to end. '*A*' has a length 25 cm and radius 0.03 cm, while '*B*' tube has a length 10 cm and radius 0.04 cm. If the total pressure difference between the extreme ends be 16 cm of water, calculate the pressure difference between ends of tube '*A*'. 3

P-1 (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : II-A

[New Syllabus]

Full Marks : 15 Time : Thirty Minutes

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OMR Sheet-এর জন্য জরুরী নির্দেশাবলী

১। OMR Sheet এর নির্দেশিত স্থানে সঠিক Subject Name, Subject Code এবং Paper Code লিখতে/পূরণ করতে হবে। OMR Sheet এর পিছনের পাতায় Subject Code গুলি দেওয়া আছে এবং Paper Code টি প্রশ্নপত্রে উল্লেখ আছে।

২। OMR Sheet এর নির্দেশিত স্থানে Name, Roll number, Registration number, Regn. Session, Exam date এবং Exam Session লিখতে/পূরণ করতে হবে।

৩। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে সঠিক উত্তরের গোল ঘরটি নীল/কালো কলিতে পূরণ করতে হবে।

৪। সঠিক উত্তর কেবলমাত্র উত্তর পত্র অর্থাৎ OMR Sheet-এর নির্দিষ্ট স্থানে গোল ঘর পূরণ করেই দিতে হবে। অন্য কোনো উপায়ে দেওয়া উত্তরের মূল্যায়ন হবে না।

৫। পরীক্ষার্থীর ফোন নম্বর OMR Sheet এর কোনো অংশে লেখা যাবে না। কোনোরূপ অবাঞ্ছিত শব্দ লেখা বা দুর্নীতির আশ্রয় নিলে পরীক্ষার্থী নিজেই তার জন্য দায়ী থাকবে।

৬। পরীক্ষা শেষে উত্তর পত্র (OMR Sheet) সংশ্লিষ্ট তত্ত্বাবধায়কের নিকট জমা দিয়ে পরীক্ষা কেন্দ্রের বাইরে বেরোতে হবে এবং কোনোভাবেই পরীক্ষা কেন্দ্রের বাইরে OMR Sheet টি আনা যাবে না।

৭। **শুধুমাত্র নীল/কালো বল পয়েন্ট কলম ব্যবহার করতে হবে। পরীক্ষাকক্ষে মোবাইল ফোন, ক্যালকুলেটর অথবা লগ-টেবিল ইত্যাদি ব্যবহার নিষিদ্ধ।**

Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries $1\frac{1}{2}$ marks.

1. For an ideal gas, $\gamma\left(=\frac{C_p}{C_v}\right)$ has a value 1.40. The number of degrees of freedom of each molecule of the gas is —

   (A) Three

   (B) Four

   (C) Five

   (D) Six

2. The temperature at which oxygen molecules will have the same r.m.s. speed as that of hydrogen molecules at $-100°C$ is —

   (A) 2495 °C

   (B) 2768 °C

   (C) – 6.25°C

   (D) – 100°C

3. Given : Boltzmann's constant $k = 1.38 \times 10^{-23}\ JK^{-1}$. The number of molecules per m^3 of a gas at a temperature of 27°C and pressure $10^5\ N/m^2$ is —

   (A) 2.42×10^{18}

   (B) 2.42×10^{24}

   (C) 2.42×10^{23}

   (D) None of the above

4. Two closed pipes of lengths 1.1m and 1.175m are sounded together at the fundamental modes. If the speed of sound in air is 340 ms^{-1}, the number of beats produced per second is nearly —

   (A) 8

   (B) 7

   (C) 6

   (D) 5

5. A tension of 245 N is applied to a uniform rope having mass 0.05 $kg.m^{-1}$. Its length is 30m. A transverse pulse is created at the free end. The time it will take to reach the other end is nearly —

   (A) 0.43 second

   (B) 0.85 second

   (C) 0.61 second

   (D) 1.28 second

6. The electric field in a certain region of space is given by $\vec{E} = by\,\hat{j}$, where b is a constant and $\vec{E}$ and y have been expressed in SI units. A cube of side 'a' m is placed in the field with one corner at the origin. Then the charge (q) inside the cube is —

(A) $\epsilon_0 ab^3$ coulomb

(B) $\epsilon_0 a^2b^2$ coulomb

(C) $\epsilon_0 b^4$ coulomb

(D) $\epsilon_0 ba^3$ coulomb

7. Why is a resistance coil (as used in a resistance box) doubled on itself before winding ?

(A) To eliminate any error due to non-uniformity in diameter

(B) To make it non-inductive

(C) To make Joule heating a minimum

(D) To make it an equivalent capacitor

8. In the region $r > 1$, the dielectric displacement $\vec{D} = \left(\frac{10}{r^2}\right)\hat{r}$ in spherical co-ordinates. The corresponding volume density (ρ) of free charge is —

(A) $\rho < 10$ coulomb/m^3

(B) $\rho > 10$ coulomb/m^3

(C) $\rho = 0$

(D) $\rho < 0$ coulomb/m^3

Turn Over

9. The electric potential at a point is given by $\phi = x^2y + 2z$. The magnitude of the electric field intensity at the point (2, 1, 2) is —

(A) 4 units

(B) 6 units

(C) 8 units

(D) 10 units

10. A long thin wire carries a current of 15 amp. Taking $\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$, the magnitude of the magnetic field at a distance of 1.0 cm would be —

(A) 3×10^{-4} tesla

(B) 3×10^{-6} tesla

(C) 6×10^{-4} tesla

(D) 3×10^{-7} tesla

P-I (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : H-B

[New Syllabus]

Full Marks : 55 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions taking at least *one* from each group.

Group - A

[Heat]

1. (a) Derive an expression for the pressure of an ideal gas in terms of its density and mean squarred speed of its molecules. From the above expression obtain Dalton's law of partial pressure. 4+2

(b) Define mean free path of gas molecules. Deduce the survival equation : $N_x = Ne^{-x/\lambda}$, where the terms are usual. 1+2

(c) A shower of 1000 gas molecules, each originally moving with the same velocity, traverses a distance equal to the mean free path. Calculate the number of molecules which will remain undeflected. 2

2. (a) What is Brownian motion ? From Einstein's theory of the translational Brownian motion, find an expression for the coefficient of diffusion for the irregular motion of the suspended particles. 1+3

(b) From the standpoint of kinetic theory of gases, deduce the relation : $\eta = \frac{1}{3}\rho\bar{c}\bar{\lambda}$, terms being usual. Discuss the effect of temperature of the gas on 'η'. 5+2

Turn Over

3. (a) State and deduce Dulong-Petit's law. 1+2

(b) Deduce expressions for the critical constants of a gas obeying van der Waals' equation of state. 5

(c) Calculate the van der Waals' constants for dry air, given $T_C = 132k$, $P_C = 37.2$ atm, $R = 82.07\ \text{cm}^3\ \text{atm mole}^{-1}\ K^{-1}$. 3

Group - B

[Sound]

4. (a) Show that the function $f(vt - x)$ represents a plane progressive wave propagating in the positive x-direction. 3

(b) Show that the fractional change in the natural frequency of a damped simple harmonic oscillator is $\frac{1}{8Q^2}$, where Q is the quality factor. 3

(c) The second harmonic of the note emitted from a bar, free at both ends, coincides with the third harmonic of the note emitted from another bar, clamped at one end and free at the other. Find the ratio of the lengths of the two bars, assuming that both the bars execute longitudinal vibrations. 2

(d) What are the requirements of a good auditorium ? Define optimum reverberation time in a 'live' room. 2+1

5. (a) A string of length 'l' is stretched along x-axis. It is struck at a point at a distance 'a' from one end with a light hammer of width Δx. Deduce an expression for the general displacement $y(x,t)$ of the string by Fourier method.

Why is the note emitted from a struck-string instrument more melodious than that emitted from a plucked-string instrument ? 5+1

(b) Define phase velocity and group velocity of a group of waves travelling in a dispersive medium and obtain a relation between those two velocities. 2+3

Group - C

[Electricity - I]

6. (a) State Gauss's theorem in electrostatics and obtain its differential form. 1+2

(b) Show that the force experienced by an electric dipole of moment $\vec{p}$ kept in a non-uniform electric field $\vec{E}$ is given by $\vec{F} = \left(\vec{p}\cdot\vec{\nabla}\right)\vec{E}$. 4

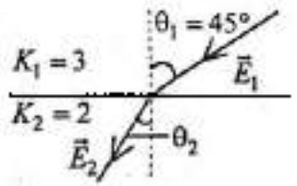
(c) A long charged cylinder of radius 'a' has a volume charge density $\rho = \gamma r$, where γ is a constant and r is the distance from the axis of the cylinder. Show that the electric field is given by

$$\vec{E}(r) = \frac{\gamma r^2}{3\epsilon_0}\hat{r} \text{ for } r < a, \text{ and}$$

$$= \frac{\gamma a^3}{3\epsilon_0 r}\hat{r} \text{ for } r < a \qquad 4$$

7. (a) A point charge 'q' is placed at a distance 'f' from the centre of a grounded conducting sphere of radius 'a' $(a < f)$. Calculate the magnitude and location of the image charge. Find also the potential and field at an external point. Hence calculate the surface density of induced charge on the sphere. 3+2+3

(b) At the plane interface between two dielectrics with $K_1 = 3$ and $K_2 = 2$, electric field $E_1 = 1200\ Vm^{-1}$ in the upper medium makes an angle $\theta_1 = 45°$ with the normal to the interface (see figure). Find E_2 and θ_2. 3



Turn Over

8. (a) Using Biot-Savart law, find an expression for the magnetic field at an axial point of a circular coil carrying a steady current. 4

(b) Deduce the equation of continuity : $\vec{\nabla}\cdot\vec{J} = -\partial\rho/\partial t$, terms being usual. 3

(c) State Ampere's circuital theorem and obtain its differential form. 1+1

(d) A copper wire is carrying a current of 2.0 amp and has a cross-sectional area of $10^{-6}\ m^2$. If the number of free electrons per m^3 be 8×10^{28}, calculate the current density and the average drift velocity. Take $e = 1.6\times10^{-19}$ coulomb. 2
