PUMDET-2018 **82250001**
Subject: Physics **(Booklet Number)**

Duration: 90 minutes **Full Marks: 100**

Instructions

1. All questions are of objective type having four answer options for each. Only one option is correct. Correct answer will carry full marks 2. In case of incorrect answer or any combination of more than one answer, ½ marks will be deducted.
2. Questions must be answered on OMR sheet by darkening the appropriate bubble marked A, B, C, or D.
3. Use only Black/Blue ball point pen to mark the answer by complete filling up of the respective bubbles.
4. Do not make any stray mark on the OMR.
5. Write question booklet number and your roll number carefully in the specified locations of the OMR. Also fill appropriate bubbles.
6. Write your name (in block letter), name of the examination centre and put your full signature in appropriate boxes in the OMR.
7. The OMRs will be processed by electronic means. Hence it is liable to become invalid if there is any mistake in the question booklet number or roll number entered or if there is any mistake in filling corresponding bubbles. Also it may become invalid if there is any discrepancy in the name of the candidate, name of the examination centre or signature of the candidate vis-a-vis what is given in the candidate's admit card. The OMR may also become invalid due to folding or putting stray marks on it or any damage to it. The consequence of such invalidation due to incorrect marking or careless handling by the candidate will be sole responsibility of candidate.
8. Candidates are not allowed to carry any written or printed material, calculator, pen, docu-pen, log table, any communication device like mobile phones etc. inside the examination hall. Any candidate found with such items will be reported against & his/her candidature will be summarily cancelled.
9. Rough work must be done on the question paper itself. Additional blank pages are given in the question paper for rough work.
10. Hand over the OMR to the invigilator before leaving the Examination Hall.

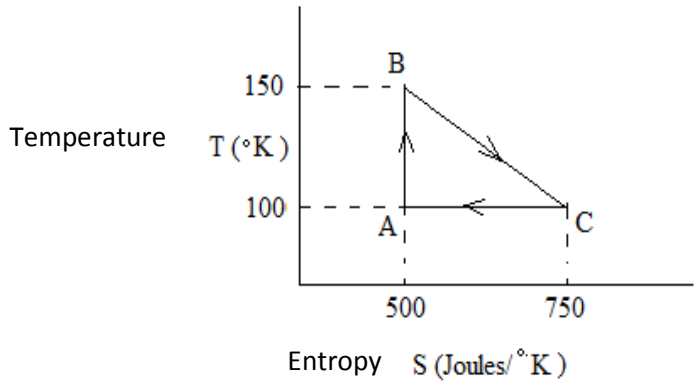
ROUGH WORK ONLY

1.	The equation, $2x^2+3xy+y^2+3x+2y+1 = 0$, represents (A) An ellipse (B) A hyperbola (C) A parabola (D) A pair of straight lines
2.	The independent solutions of the equation $\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = 0$ are (A) x^2 and x (B) e^{2x} and e^{-x} (C) e^{2x} and e^{x} (D) $sin2x$ and $cosx$
3.	As p goes to ∞, the integral $\int_0^\infty \frac{dx}{(1+x^p)}$ goes to (A) 0 (B) 1 (C) 2 (D) ∞
4.	If $\vec{r}$ is the position vector of any point on the surface of a cube, each side of which has length L, then the surface integral $\oiint \vec{r} \cdot \overrightarrow{dS}$ has the value (A) 0 (B) $3L^2$ (C) L^3 (D) $3L^3$
5.	Which one of the following matrices is hermitian? (A) $\begin{bmatrix} i & 0 \\ 0 & -i \end{bmatrix}$ (B) $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ (C) $\begin{bmatrix} 0 & i \\ i & 0 \end{bmatrix}$ (D) $\begin{bmatrix} 1 & 0 \\ 0 & i \end{bmatrix}$
6.	The value of the integral $I = \oint \frac{dz}{(z-2)}$, where the contour is the circle given by $\lvert z \rvert = 4$, is (A)$2\pi i$ (B) 0 (C) $1/2\pi i$ (D) 1
7.	A non-trivial (i.e. x≠ 0) solution of the equation $\tanh(x) = kx$ is possible for (A) $k = 0$ (B) $0 < k < 1$ (C) $k > 1$ (D) $k < 0$
8.	Let $f(t) = 0$ for $t < 0$ and $f(t) = e^{-i\omega_0 t - \frac{t}{\tau}}$ for $t \geq 0$. Denote the Fourier transform of $f(t)$ by $F(\omega)$. Then $\lvert F(\omega) \rvert^2$ is proportional to (A) $\exp(-\frac{(\omega-\omega_0)^2}{2\tau^2})$ (B) $\exp(-\frac{(\omega-\omega_0)^2\tau^2}{2})$ (C) $\frac{1}{(\omega-\omega_0)^2+\frac{1}{\tau^2}}$ (D) $\frac{1}{(\omega-\omega_0)^2+\frac{1}{4\tau^2}}$
9.	A uniform thin rod of length d, mass m, is lying on a smooth horizontal table. A horizontal impulse I is suddenly applied perpendicularly to the rod at one end. How far does the rod travel during the time it takes to make one complete revolution? (A) $\frac{md^2}{I}$ (B) $2\pi d/3$ (C) $\pi d/3$ (D) I/d

10.	What is the number of quantities that remain invariant when a particle moves around a centre under an attractive inverse-square (i. e. $F \propto 1/r^2$) type central force? (A) 1 (B) 2 (C) 4 (D) 7
11.	A moving proton collides with another proton which is initially at rest. If M_p be the mass of a proton, what is the minimum kinetic energy that the moving proton must have in order to make possible the reaction $p + p \rightarrow p + p + p + \bar{p}$? (A)$2M_pc^2$ (B) $4M_pc^2$ (C) $6M_pc^2$ (D) None of these
12.	According to the Newtonian theory of gravitation, the gravitational potential due to the Sun is given by $\phi = -\frac{GM_{sun}}{r}$, symbols having their usual significance. On introducing general relativistic corrections, the expression for ϕ becomes $\phi = -\frac{GM_{sun}}{r} + \frac{K}{r^2}$. From dimensional arguments K must be proportional to (A) $\frac{GM^2_{sun}}{c^2}$ (B) $\frac{G^2M^2_{sun}}{c^2}$ (C) $GM_{sun}c^2$ (D) $\frac{(M_{sun}c^2)^2}{G^2}$ (c = Velocity of light)
13.	The Hamiltonian for a particle is given by $H = \frac{1}{2m}{p_x}^2 + kx^4$, symbols having their usual meanings. What is the formula for $\ddot{x}$? (A)$-kx^3$ (B) $-4kx$ (C) $-\frac{4kx}{m}$ (D) $-\frac{4kx^3}{m}$
14.	A particle moves in a medium which offers a resistance proportional to the cube of the velocity of the particle. During a time t the velocity diminishes from v_1 to v_2. If no other force is acting on the particle, the distance traversed by it in this time t is (A) $\frac{(v_1+v_2)t}{2}$ (B)$\frac{2v_1v_2t}{v_1+v_2}$ (C) $\frac{(v_1^3-v_2^3)t}{(v_1+v_2)^2}$ (D) $\frac{(v_1^2-v_2^2)t}{(v_1+v_2)}$
15.	The point of suspension of a simple pendulum of length l is not fixed but is attached to a moving lift which falls with acceleration f. How many degrees of freedom does the system have? (A) 1 (B) 2 (C) 0 (D) 3
16.	Two equal inductors (each of inductance L), two equal capacitors (each of capacitance C) and a resistor (resistance R) are connected in series and placed across an A. C. source whose frequency can be varied. The resonance frequency of the circuit is (A)$\frac{1}{2\pi\sqrt{LC}}$ (B) $\frac{1}{4\pi\sqrt{LC}}$ (C) $\frac{1}{\pi\sqrt{LC}}$ (D) $\frac{1}{2\pi\sqrt{LC-\frac{L^2}{2R^2}}}$

17.	Consider a cylinder of radius a and length L filled uniformly with a completely ionized gas of charge density ρ moving parallel to the axis of the cylinder with velocity v. What is the magnetic field at a distance r ($<a$) from the axis? (Neglect end effects). (A) $B = 0$ (B) $B = \frac{\mu_0 \rho v a}{2}$ (C) $B = \frac{\mu_0 \rho v a^2}{2r}$ (D) $B = \frac{\mu_0 \rho v r}{2}$
18.	The two rails of a railway line are insulated from each other and from ground and are connected by a microvoltmeter. What is its reading when a train travels with a velocity of 90 km/hr along the line, assuming that the vertical component of the geomagnetic field is 0.1 gauss and that the rails are separated by 1 metre? (A) $1V$ (B) $250\ mV$ (C) $250\ \mu V$ (D) $100\ \mu V$
19.	An infinite long, thin wire carrying a current I ampere is placed at a distance d metres from a semi-infinite slab of soft iron. The wire is parallel to the surface of the iron slab. If we assume that iron has infinite permeability ($\mu = \infty$)what is the force per unit length of the wire? (A) $F = \frac{I^2}{d} \times 10^{-7}$ Newtons/metre (B) $F = \frac{I^2}{2d} \times 10^{-7}$ Newtons/metre (C) 0 (D) $F = \frac{I^2}{2d} \times 10^{-7}$ dynes/cm
20.	An isolated metallic object is charged in vacuum to a potential V_0, its electrostatic energy becoming E_0. It is then disconnected from the source of the potential, its charge (Q) being left unchanged. It is then placed inside a large volume of a dielectric with dielectric constant K. What is its new electrostatic energy? (A) KE_0 (B) $\frac{QV_0}{K}$ (C) $\frac{E_0}{K}$ (D) KQV_0
21.	What is the lowest-frequency of normal-mode electromagnetic oscillation in a rectangular cavity resonator of sides a, b, d along X, Y and Z direction with $a<b<d$? Assume that the cavity has perfectly conducting walls. (c = Velocity of light). (A) $\nu = \sqrt{\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{d^2}} \cdot \frac{c}{2}$ (B) $\nu = \frac{c}{2\pi a}$ (C) $\nu = \sqrt{\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{d^2}} \cdot \pi c$ (D) $\nu = \frac{c}{2d}$
22.	For all metals, the relation between thermal conductivity (K),electrical conductivity (σ) and temperature (T) is (A) $\frac{K}{\sigma} = \text{Constant}$ (B) $\frac{K}{\sigma T} = \text{Constant}$ (C) $\frac{K}{\sigma T^2} = \text{Constant}$ (D) $\sigma \propto KT$
23.	The ruby laser produces a radiation with wavelength 6943Å and line-width 5×10^{-4}Å. What is the coherence length for this system? (A) 3 cm (B) 271.8 cm (C) 964.1 cm (D) 153.4 cm

24.	Suppose two events occur at x_1 and x_2 at the same time t according to a frame of reference S. According to the frame of reference S' which is moving with a velocity v along the common X-axis of the two frames these events occur at x_1' and x_2' at times t_1' and t_2'. The origins of the frames S and S' coincided at $t = t' = 0$. Then (A) $t_2' = t_1'$ (B) $x_2' = x_1'$ (C) $t_2' - t_1' = \frac{(x_1 - x_2)\cdot\frac{v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$ (D) $x_2' - x_1' = \frac{(x_1 - x_2)\cdot\frac{v^2}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$
25.	Assume that a source of light S is moving towards an observer O with velocity v. In the rest frame of the source, the frequency of the emitted radiation is ν_S. What is the value of the frequency recorded by the observer? (A) $\nu_O = \nu_S\left(1 + \frac{v}{c}\right)$ (B) $\nu_0 = \frac{\nu_s}{\sqrt{\left(1-\frac{\nu^2}{c^2}\right)}}$ (C) $\nu_0 = \frac{\nu_s}{1-\frac{\nu}{c}}$ (D) $\nu_0 = \nu_s \cdot \sqrt{\frac{1+\frac{\nu}{c}}{1-\frac{\nu}{c}}}$
26.	The reciprocal lattice of a simple cubic structure is another simple cubic structure. If the lattice constant of the direct lattice be a, what is the lattice constant of the reciprocal lattice? (A) a (B) $\frac{1}{2\pi a}$ (C) $\frac{1}{a}$ (D) $\frac{2\pi}{a}$
27.	A thin-walled vessel of volume V is kept at constant temperature T. An ideal gas slowly leaks out of the vessel through a hole of area A into surrounding vacuum. The mean velocity of the gas molecules is $\bar{v}$. Find the time required for the pressure in the vessel to drop to $1/e$ of its original value. (A) $\frac{2V}{\bar{v}A}$ (B) $\frac{V}{\bar{v}A}$ (C) $\frac{V}{2\bar{v}A}$ (D) $\frac{4V}{\bar{v}A}$
28.	A sphere, having moment of inertia (I) is suspended from a thin massless filament of torsional rigidity c in a gas at temperature T. Let θ be the angle through which the sphere is found to be rotated at some instant of time. What is the mean value of $\overline{\theta^2}$? (A) $\overline{\theta^2} = kT/2c$ (B) $\overline{\theta^2} = kT/c$ (C) $\overline{\theta^2} = kT/I$ (D) $\overline{\theta^2} = kT/\sqrt{cI}$
29.	Blackbody radiation at temperature T_i fills a cavity of volume V. The system expands adiabatically and reversibly to a volume equal to $8V$. The final temperature of the system is given by (A) $T_f = \frac{1}{8}T_i$ (B) $T_f = \frac{1}{2}T_i$ (C)$T_f = T_i ln8$ (D) $T_f = 2T_i$

30.	What is the efficiency of a reversible engine operating around the cycle illustrated?  (A) 20% (B) 33.3% (C) 17.5% (D) 15%
31.	A solid body of density 5 $gm.cm^{-3}$ melts at the pressure $5 \times 10^6 dynes\ cm^{-2}$ and the absolute temperature 300 K to form a liquid of density $2gm.cm^{-3}$. The latent heat of melting per gram of the solid is10 *Joules*. What is the change of internal energy resulting from the melting of a gram of the solid? (A) 0.985 *Joules* (B) 0 (C) 9.85*Joules* (D) 2.355*Joules*
32.	Consider an isothermal column of air near the earth. If T be the absolute temperature, and $n(z)$ be the density of molecules at the height z above the earth, then (A) $n(z) = n(0)$ (B) $n(z) = n(0)(1 - \frac{mgz}{kT})$ (C) $n(z) = \frac{n(0)}{1+\frac{mgz}{kT}}$ (D) $n(z) = n(0)e^{-\frac{mgz}{kT}}$ [m, g (assumed constant)and k have their usual meanings]
33.	For what value of energy (ε) is the occupation number of a state equal to ½ for a system comprising of identical bosons? Assume chemical potential $\mu > -kT$. (A) $\varepsilon = \lvert\mu\rvert$ (B) $\varepsilon = 0$ (C) $\varepsilon = \mu + kTln2$ (D) $\varepsilon = \mu + kTln3$ [T = Temperature of the system]
34.	Estimate the minimum lens diameter required to resolve objects 1*cm* apart at a distance of 1000 *metres*? Assume that the wavelength of light is 550 *nm*. (A) 10 cm (B) 2.54 cm (C) 6.71 cm (D) 3.36 cm
35.	A projector makes the image of a slide on a screen 5 *m* from the lens. If the 2.5 *cm* dimension of the slide is magnified to 1.2 *m*, what is the focal length of the lens? (A) 5/49 m (B) 5/94 m (C) 1/10 m (D) 1/5 m

36.	Circularly polarized light is passed through a quarter-wave-plate. What is the general polarization state of the outgoing light? (A) Elliptically polarized light (B) Linearly polarized light (C) Circularly polarized light (D) None of these
37.	Suppose right-handed circularly polarized light (for which the electric field is seen to rotate in the clockwise direction when the observer looks back towards the source) falls normally on the bottom surface of a horizontal absorbing slab. The slab is suspended by a vertical thread. If the circularly polarized light beam has a power of 1 *watt* and the wavelength of light is 6200Å, and if all of this light is absorbed by the slab, what is the torque exerted on the slab? (A) 1×10^{-9} *Newton.m.* (B) 1.645×10^{-9} *dyne.cm.* (C) 3.29×10^{-9} *dyne.cm.* (D)1.645×10^{-9} *Newton.m.*
38.	Interference fringes are produced by a thin, wedge-shaped film of plastic of refractive index 1.4. If the angle of the wedge (α) is 20 seconds of arc and the distance between the fringes is 2.5*mm*, what is the wavelength of the incident light? [Assume that the light falls normally on one face of the plastic.] (A) 5460 Å (B) 6787 Å (C) 5893 Å (D) 6943 Å
39.	For maximum polarization of light by reflection from a transparent dielectric medium having refractive index 1.5, what is the angle between the reflected and the refracted rays? (A) 56.3° (B) 90° (C) 41.8° (D) 60°
40.	What type of aberration is present in lenses but absent from plane mirrors? (A) Spherical aberration (B) Astigmatism (C) Coma (D) Chromatic aberration
41.	Consider a potential well for which $V = V(x) = 0$ if $-1 < x < 1$ and $V = \infty$ outside this range. The wave function of a particle trapped in this well is given by $\psi = \begin{cases} A\cos\frac{\pi x}{2} + \frac{1}{4}\cos\frac{3\pi x}{2} + \sin 3\pi x, & \text{inside the well} \\ 0, & \text{outside the well} \end{cases}$ What is the value of *A*? [You may assume that *A* is a real number]. (A) $A = 4\sqrt{\frac{1}{33}}$ (B) $A = \frac{1}{4}\sqrt{15}$ (C) $A = \sqrt{\frac{47}{32}}$ (D) $A = \sqrt{\frac{17}{32}}$
42.	What is the classical radius of an electron? (A) $4.8 \times 10^{-15}\ metres$ (B) $1 \times 10^{-15}\ metres$ (C) $1.6 \times 10^{-15}\ metres$ (D) $1.4 \times 10^{-15}\ metres$

43.	A positron has the same mass as an electron but opposite charge and spin magnetic moment. If the proton in a hydrogen atom is replaced by a positron, one gets a positronium atom. What is its binding energy in the ground state? (A) 13.6 eV (B) 6.8 eV (C) 27.2 eV (D) 0.0074 eV
44.	The formula for the energy levels of a particle of mass m moving in one-dimensional potential $V = V(x) = \begin{cases} \frac{1}{2} m\omega^2 x^2, & x > 0 \\ \infty, & x \le 0 \end{cases}$ is given by (A) $E_m = \left(m + \frac{1}{2}\right)\hbar\omega \quad (m = 0, 2, 4 \ldots\ldots)$ (B) $E_m = \left(2m + \frac{3}{2}\right)\hbar\omega \quad (m = 1, 3, 5 \ldots\ldots)$ (C) $E_m = \left(2m + \frac{3}{2}\right)\hbar\omega \quad (m = 0, 1, 2, 3, 4 \ldots\ldots)$ (D) None of these
45.	Let ψ_{lm} be an eigenstate of L^2 and L_z with eigenvalues $l(l+1)\hbar^2$ and $m\hbar$ respectively. If $\phi = (L_x + iL_y)\psi_{lm}$ is also an eigenstate of L^2 and L_z, then the eigenvalue of L_z for ϕ is (A) $m\hbar$ (B) $(m-1)\hbar$ (C) $(m+1)\hbar$ (D) ϕ is not an eigenstate of L_z
46.	What is the probability of decay during the 101st year of a radioactive atom having a mean life of 10^3 years? (A) 10^{-3} (B) 10^{-1} (C) $10^{-3.1}$ (D) $10^{-2.9}$
47.	What accounts for the stability of bound neutrons in some nuclei, e. g. in $^{14}_{7}N$? (A) For these nuclei, the number of neutrons equals a magic number (B) The principle of conservation of energy (C) The Pauli exclusion principle (D) The principle of conservation of angular momentum
48.	If a beam of photons is passed through a Stern-Gerlach apparatus, into how many component beams will it split? (A) 2 (B) 1 (C) 3 (D) 1 or 2, depending on the state of polarization of the beam

49.	The number $(1001.0101)_2$ is the same as (A) $(9.3125)_{10}$ (B) $(9.\ 5)_{10}$ (C) $(1001.0101)_{10}$ (D) None of these
50.	If A, B and C are Boolean numbers, then $(A+B)(\bar{A}+C)$ equals (A) BC (B) $\bar{A}B+BC$ (C) $\bar{A}B+AC$ (D) 1