



**FEDERAL PUBLIC SERVICE COMMISSION
COMPETITIVE EXAMINATION - 2016
FOR RECRUITMENT TO POSTS IN BS-17
UNDER THE FEDERAL GOVERNMENT**

Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Candidate must write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the attempted question will not be considered. (vii) Use of Calculator is allowed.		

PART-II

- Q. No. 2.** (a) State and prove Stoke's theorem. (8)
(b) Prove that if the vector is the gradient of a scalar function then its line integral around a closed curve is zero. (4)
(c) A particle moves along the curve $x = 2t^2$, $y = t^2 - 4t$, $z = 3t - 5$ where t is the time. Find the components of its velocity and acceleration at time $t=1$ in the direction $2i-3j+2k$ (8)
- Q. No. 3.** (a) What is moment of inertia? State and prove parallel axis theorem. (12)
(b) Calculate rotational inertia of a hollow cylinder about cylindrical axis. (8)
- Q. No. 4.** (a) State and prove the Kepler's law of areas and Kepler's law of periods of planetary motion. (8)
(b) A satellite orbits at a height of 230km above the Earth surface. What is the period of satellite? (6)
(c) At what altitude above the earth surface the value of 'g' is three quarters of its value at the surface of the earth. (6)
- Q. No. 5.** (a) What is diffraction grating? Explain how grating diffracts light. Derive relation for resolving power of grating. (12)
(b) What is meant by polarization of light? How can we get a plane polarized light by a polarizing sheet? (8)
- Q. No. 6.** (a) Derive equation of Lorentz velocity transformations and show that speed of light is independent of the relative motion between the frames of reference. (12)
(b) The siren of a police car emits a source tone at a frequency of 1125 Hz. Find the frequency that would you receive in your car under the following circumstances. (8)
(i) Your car at rest, police car moving towards you at 29 m/s.
(ii) Police car at rest, your car moving towards it at 29 m/s.
(iii) Your and police car are moving towards one another at 14.5 m/s.
(iv) Your car moving at 9 m/s, police car chasing behind you at 38 m/s.
- Q. No. 7.** (a) Define Entropy. State Second law of thermodynamics in terms of Entropy. (8)
(b) Discuss applications of First Law of thermodynamics. (6)
(c) Discuss briefly the Lissajous patterns. (6)
- Q. No. 8.** Explain any FOUR of the following terms. (05 each) (20)
(a) Doppler's Effect
(b) Bernoulli's theorem
(c) Newton's rings
(d) He-Ne Gas LASER
(e) Brownian motion



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PHYSICS, PAPER-II

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PART-II

- Q. No. 2.** (a) Define electric field intensity $\vec{E}$. State its value for a point charge and give its units. (8)
(b) State differential form of Gauss's law and from there develops the poisson's & Laplace's equations. (8)
(c) A charge of $10\sqrt{2}$ Coulomb is located at $(3\hat{i} + 4\hat{j} + 5\hat{k})m$. Calculate the electric field intensity at a point having position vector $(5\hat{i} + 4\hat{j} + 3\hat{k})m$. (4)
- Q. No. 3.** (a) Differentiate between a series and parallel resonant circuits. (6)
(b) Explain the construction and operation of a transformer. What are energy losses in a transformer and how are they reduced to a minimum. (10)
(c) A series LCR circuit contains a coil with $L=2.25H$, a capacitor having $C=16\mu F$ and a resistor with $R=50\Omega$. Calculate the impedance and the phase difference between current and voltage. (Take frequency $f = 50Hz$) (4)
- Q. No. 4.** (a) State and explain the basic postulates of Quantum Physics. (5)
(b) Briefly explain with examples what do you mean by Eigen function and Eigen values. (5)
(c) Derive the time-dependent Schrodinger Wave Equation for a free particle. (10)
- Q. No. 5.** (a) Why the resistivity of metals increases with temperature but that of semiconductor decreases? (6)
(b) In the process of making semiconductor devices, why silicon is preferred over Germanium? (4)
(c) Briefly explain the construction and operation of a Bipolar Junction Transistor (BJT). How it can be used as an Amplifier? (10)
- Q. No. 6.** (a) What do $\langle 111 \rangle$, $[010]$, (111) , and $\{100\}$ represents for a cubic crystal lattice. (5)
(b) What is packing factor? Determine the Atomic Packing factor of FCC lattice. (5)
(c) With neat diagram showing X-ray diffraction, derive an expression for Bragg's Law. (10)
- Q. No. 7.** Define Curie and Becquerel. Establish the relation between them. (6)
Calculate the Decay Constant for ^{14}C which has half-life of 5730 years. (4)
State and explain Half-life and Mean life of a radioactive element. Show that $\langle T \rangle$ is greater than $T_{1/2}$. (10)



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PART-II

- Q. No. 2.** (a) What is the cross product of two vectors? Why the cross product is called pseudo vector? (5)
(b) What is divergence of vector field? What is its physical significance? (5)
(c) What is line integral? Under what condition it is used to calculate the work done. (5)
(d) Consider three vectors: (5) (20)
 $\vec{A} = -3\hat{i} + 3\hat{j} + 2\hat{k}$ $\vec{B} = -2\hat{i} - 4\hat{j} + 2\hat{k}$ and $\vec{C} = 2\hat{i} + 3\hat{j} + 1\hat{k}$
(i) Find $\vec{A} \cdot (\vec{B} \times \vec{C})$ (ii) Find $\vec{A} \times (\vec{B} \times \vec{C})$
- Q. No. 3.** (a) What do you mean by circular motion? What is centrifugal force? Explain your answer by taking an example from daily life. (5)
(b) What is projectile motion? Why a cricket player lowers his hand while catching a ball? (7)
(c) What do you mean by work done by the system and work done on the system? Explain by taking an example of each. (5)
(d) A batsman hits a cricket ball at an angle with respect to the horizontal. The ball would strike the ground at 60m from the batsman if it is not stopped. But a fielder at a distance 55 m catches the ball at a height of 1.5 m. Calculate the angle of projection and the velocity of projection. (3) (20)
- Q. No. 4.** (a) What do you mean by phase and group velocity? Derive a relation between a group and phase velocity. (7)
(b) What is superposition of waves? Show that the standing waves are produced by the superposition of two waves of equal amplitudes moving in opposite direction. (7)
(c) A medium is disturbed by an oscillation described by, (3)
 $Y = 3.0\text{cm} \sin(\pi x/10\text{cm}) \cos(50\pi t)$
Determine the amplitude, frequency, wavelength, speed and direction of the component waves whose superposition produces this result.
(d) If light of $\lambda = 660\text{nm}$ has wave train 20λ , what is its coherence length and coherence time? (3) (20)
- Q. No. 5.** (a) What is unique about light from a laser source, and why should you never look directly into a laser beam? Explain briefly. (5)
(b) What is plasma? What do you mean by plasma frequency? Briefly discuss. (5)
(c) How the blue laser is useful in storing large amount of data on a CD as compared to red laser? (5)
(d) For the He-Ne laser at 2m and 4m distances from the laser, the output beam spot diameters are 2 mm and 3 mm. Calculate the angle of divergence. (5) (20)

PHYSICS, PAPER-I

- Q. No. 6.** (a) What is viscosity? Discuss effect of temperature on the viscosity of liquids and gases. (6)
- (b) Differentiate between streamline and turbulent flow and establish equation of continuity. (4)
- (c) Explain why the level of mercury is down in capillary when placed in container of mercury, while it is up in the capillary in case of water? (6)
- (d) A garden hose has an inside diameter of 2 cm and water flows through it is at 3 m/s. (4) (20)
- (i) What nozzle diameter is required for the water to emerge at 10 m/s?
- (ii) At what rate does the water leave the nozzle?
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- Q. No. 7.** (a) What do you understand by classical statistical mechanics and quantum statistical mechanics? (6)
- (b) Differentiate between Fermi-Dirac, Bose-Einstein and Maxwell-Boltzman's statistics. (6)
- (c) What is equipartition of energy? Explain. (5)
- (d) A 0.5m³ vessal is filled with air at atmospheric pressure. The air is churned by a paddel wheel attached to a shaft 0.1m in diameter, rotating at a speed of 1800 rpm. A force of 5.0N acts on the rim of the shaft. What would be the pressure in the vessel after 10 sec of operation (3) (20)
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- Q. No. 8.** Write notes on any **FOUR** of the following: (5 each) (20)
- (a) Polarization of light and its application in determining specific rotation of a liquid.
- (b) Wave equation on a string.
- (c) Normal and anomalous dispersion of light.
- (d) Kinetic theory of gases.
- (e) Scalar Triple product.



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PHYSICS, PAPER-II

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PART-II

- Q. No. 2.** (a) What is dipole moment? Obtain the expression for the potential and field due to an electric dipole. (10)
(b) Calculate the potential at a point on the axis of circular plastic disk of radius R, one surface of which carries a uniform charge density σ . (8)
(c) Why do we use unit “electron volts”? (2) (20)
- Q. No. 3.** (a) State and explain the Biot Savart law. (4)
(b) State and prove Ampere’s law. Apply it to calculate the magnetic field due to a solenoid. (10)
(c) A long straight wire carries a current of 20 Amperes. An electron at 2.0 cm from the wire is travelling at a speed of 10^7 m/sec. What force acts on the electron if its motion is directed (1) towards the wire, (2) parallel to the wire and (3) at right angles to the direction given in (1) and (2). (6) (20)
- Q. No. 4.** (a) Write the Maxwell’s equations and explain the significance of each equation. (6)
(b) Deduce the Maxwell equations for free space and also prove that electromagnetic waves are transverse. (12)
(c) What is index of refraction? (2) (20)
- Q. No. 5.** (a) Describe the Stern Gerlach experiment that provided experimental evidence of the space quantization of atomic magnetic moments. (10)
(b) What is the physical significance of the three quantum numbers n, l, and m in the labelling of the hydrogenic wave functions? (6)
(c) What do you understand by strange particles? (4) (20)
- Q. No. 6.** (a) What is liquid drop model of nucleus and write down its essential features? (8)
(b) What are magic numbers? How can they be generated on the basis of shell model? (8)
(c) What is nuclear fusion? (4) (20)
- Q. No. 7.** (a) Differentiate the Metals, Semiconductors and Insulators on the basis of Energy Band Theory. (6)
(b) What is a rectifier? How we can use diode as a rectifier? Explain half-wave rectification in detail with diagrams. (14) (20)
- Q. No. 8.** Write short notes on any TWO of the following: (10 each) (20)
(a) Schrodinger equation
(b) Linear accelerator
(c) Cyclotron



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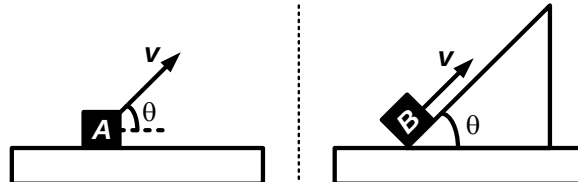
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PHYSICS, PAPER-I

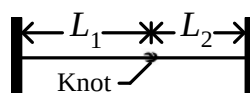
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PART-II

- Q. No. 2.** (a) Show that the work done by a constant force is equal to the difference of initial and final kinetic energies of the body. **(8)**
- (b) A 25 kg bear slides, from rest, 12 m down a pine tree, moving with a speed of 5.6 m/s just before hitting the ground. **(8)**
- (i) What change occurs in the gravitational potential energy of the bear-Earth system during the slide?
- (ii) What is the kinetic energy of the bear just before hitting the ground?
- (c) Object A is launched as projectile with initial speed v at an angle θ above the horizontal. Object B has exactly the same initial speed at exactly the same angle as object A but object B is sliding up a frictionless incline as shown in the figure. Object A has mass M and object B has mass $2M$. During the subsequent motion, each object will reach a maximum height above the starting location. **(4)**

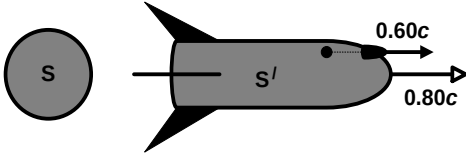


- (i) At its maximum height, which object has the larger kinetic energy? Explain.
- (ii) Which object has the larger maximum height? Explain.
- Q. No. 3.** (a) Derive the expression for the total mechanical energy in simple harmonic motion. Draw and discuss the graphs of Energy versus Time and Energy versus Position. **(8)**
- (b) In the figure shown below, two strings have been tied together with a knot and then stretched between two rigid supports. The strings have linear densities $\mu_1 = 1.4 \times 10^{-4}$ kg/m and $\mu_2 = 2.8 \times 10^{-4}$ kg/m. Their lengths are $L_1 = 3$ m and $L_2 = 2$ m, and string 1 is under a tension of 400 N. Simultaneously, on each string a pulse is sent from the rigid support end, toward the knot. Which pulse reaches the knot first? **(8)**



- (c) A mass-spring system is oscillating with amplitude A . What will be the displacement at which kinetic energy is equal to the potential energy? **(4)**

PHYSICS, PAPER-I

- Q. No. 4.** (a) What is polarization? Discuss polarization by reflection. (8)
- (b) Light of wavelength 624 nm is incident perpendicularly on a soap film ($n = 1.33$) suspended in air. What are the (8)
- (i) least and
- (ii) second least thicknesses of the film for which the reflections from the film undergo fully constructive interference?
- (c) A maintenance crew is working on a section of a three lane highway, leaving only one lane open to traffic. The result is much slower traffic flow (a traffic jam). Do cars on a highway behave like (4)
- (i) the molecules of an incompressible fluid or
- (ii) the molecules of a compressible fluid? Explain.
- Q. No. 5.** (a) Show that mass and energy are interconvertible. (8)
- (b) A spaceship is moving away from the earth at a speed of $0.80c$ when it fires a missile parallel to the direction of motion of ship. The missile moves at a speed of $0.60c$ relative to the ship (see figure). What would be the speed of the missile as measured by an observer on the earth? Compare with the prediction of Galilean kinematics. (8)
- 
- (c) If $\vec{A}$ and $\vec{B}$ are nonzero vectors, is it possible for $\vec{A} \cdot \vec{B}$ and $\vec{A} \times \vec{B}$ to be zero? Explain. (4)
- Q. No. 6.** (a) Distinguish between Linear and Angular momentum. Derive expression for the angular momentum of a rigid body rotating about a fixed axis. Explain the Law of Conservation of Angular Momentum. (8)
- (b) A girl of mass M stands on the rim of a frictionless merry-go-round of radius R and rotational inertia I that is not moving. She throws a rock of mass m horizontally in a direction that is tangent to the outer edge of the merry-go-round. The speed of the rock, relative to the ground, is v . Afterward, what are (8)
- (i) the angular speed of the merry-go-round and
- (ii) the linear speed of the girl?
- (c) A planet is moving at constant speed in a circular orbit around a star. In one complete orbit, what is the net amount of work done on the planet by the star's gravitational force? What if the planet's orbit is an ellipse, so that the speed is not constant? Explain. (4)
- Q. No. 7.** (a) Differentiate between Fermi-Dirac, Bose-Einstein and Maxwell-Boltzman statistics. (6)
- (b) Show that the entropy remains constant in a reversible process but increases in an irreversible one. (6)
- (c) When 20.9 J was added as heat to a particular ideal gas, the volume of the gas changed from 50 cm^3 to 100 cm^3 while the pressure remained at 1 atm. (8)
- (i) By how much did the internal energy of the gas change?
- (ii) If the quantity of gas present was $2 \times 10^{-3} \text{ mol}$, find C_p .
- Q. No. 8.** Explain the following: (05 each) (20)
- (a) Scalar triple product (b) Surface tension
- (c) He-Ne Gas LASER (d) Gravitational potential energy



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PART-II

- Q. No. 2.** (a) Define and explain Gauss' Law. Deduce Coulomb's Law from Gauss' Law. (8)
(b) Find the Electric Field Intensity due to an infinite sheet of charge. (8)
(c) The electric field near an infinite sheet of charge is $3.84 \times 10^5 \text{ N/C}$. What is the surface charge density on the sheet? ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N. m}^2$) (4)
- Q. No. 3.** (a) Derive an expression for capacitance of cylindrical and spherical capacitor. (8)
(b) Show that the energy consumed in charging a capacitor to charge Q and voltage V can be considered as potential energy stored in the field between the plates. Find expression for energy stored in the field. (8)
(c) An isolated conducting sphere whose radius R is 6.85 cm has a charge $q = 1.25 \text{ nC}$. How much potential energy is stored in the electric field of this charged conductor? ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N. m}^2$) (4)
- Q. No. 4.** (a) Derive an expression for time dependent Schrodinger's wave equation. (8)
(b) Explain de Broglie's hypothesis of matter wave. (8)
(c) Determine the de Broglie's wavelength of an electron that has been accelerated through a potential difference of 100V. ($h = 6.63 \times 10^{-34} \text{ J.s}$) (4)
- Q. No. 5.** (a) What is Transistor? Briefly explain three types of Transistor Circuit Configurations. (8)
(b) Draw a neat diagram of Transistor Characteristics in Common Emitter Configuration for P-N-P and N-P-N transistor. Also discuss types of characteristic curves for a transistor in Common Emitter Configuration. (8)
(c) Write a short note on Load line. (4)
- Q. No. 6.** (a) What do you understand by nuclear fission? How was it explained theoretically on the basis of liquid drop model? (8)
(b) Briefly describe important uses of radioisotopes. (8)
(c) A 5.30 MeV alpha particle happens, by chance, to be headed directly towards the nucleus of an atom of gold, which contains 79 protons. How close does the alpha particle get to the centre of the nucleus before coming momentarily to rest and reversing the relatively massive nucleus? (4)
- Q. No. 7.** (a) Explain construction and working of a Geiger Muller Counter. (8)
(b) Draw the characteristic of Geiger Muller Counter and also explain it. (8)
(c) What are the properties of Gamma Rays? (4)
- Q. No. 8.** Write short notes on any **TWO** of the following: (10 each) (20)
(a) Poynting Vector
(b) Heisenberg's Uncertainty Principle
(c) Mass Defect and Binding Energy



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PART – II

- Q. 2.** (a) Explain the Divergence of a Vector field with its physical significance? (10)
(b) A rural mail carrier leaves the post office and drives 22.0 km in a northerly direction. He then drives in a direction 60.0° south of east for 47.0 km. What is his displacement from the post office? (5)
(c) Vectors $\vec{C}$ and $\vec{D}$ have magnitudes of 3 units and 4 units, respectively. What is the angle between the directions of $\vec{C}$ and $\vec{D}$ if $\vec{C} \cdot \vec{D}$ equals (a) zero, (b) 12 units and (c) -12 units? (5) **(20)**
- Q. 3.** (a) Distinguish between Linear and Angular momentum. Explain the laws of conservation of Angular momentum. (10)
(b) Estimate the net force needed to accelerate (i) a 1000kg car at $\frac{1}{2} g$; (ii) a 200g apple at the same rate. (5)
(c) A vertical force is applied to a block of mass m that lies on a floor. What happens to the magnitude of the normal force on the block from the floor as magnitude F is increased from zero if force is (a) downward and (b) upward? (5) **(20)**
- Q. 4.** (a) Describe the Michelson - Morley Experiment and show how negative results obtained from this experiment were interpreted? (10)
(b) Derive equation of Lorentz velocity transformations and show that speed of light is independent of the relative motion between the frames of reference. (10) **(20)**
- Q. 5.** (a) What is surface tension? How surface tension is responsible for rising of liquid in capillaries? (10)
(b) Water circulates throughout a house in a hot-water heating system. If the water is pumped at a speed of 0.50 m/s through a 4.0cm diameter pipe in the basement under a pressure of 3.0 atm, what will be the flow speed and pressure in a 2.6cm diameter pipe on the second floor 5.0 m above? Assume the pipes do not divide into branches. (5)
(c) When blood pressure is measured, why must the cuff be held at the level of the heart? (5) **(20)**
- Q. 6.** (a) What is polarization of waves? How plane polarized light can be obtained by a polarization sheet. (10)
(b) Two flat mirrors are perpendicular to each other. An incoming beam of light makes an angle of 15° with the first mirror. What angle will the outgoing beam make with the second mirror? (5)
(c) Since the density of air decreases with an increase in temperature, but the bulk modulus B is nearly independent of temperature. How would you expect the speed of sound waves in air to vary with temperature? (5) **(20)**
- Q. 7.** (a) State and explain Equipartition Theorem. (10)
(b) Define laws of thermodynamics. Explain 3rd law of thermodynamics in detail. (10) **(20)**
- Q. 8.** Write the short notes on any TWO of the following: (10 each) **(20)**
(a) Gyrocope (b) Classical Maxwell-Boltzmann Statistics
(c) Spin and Precession



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NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) Derive an expression for the torque and potential energy of an electric dipole (10) in an electric field.
(b) Show that the energy density of a parallel plate capacitor with dielectric (6) medium between them is directly proportional to the square of electric field intensity.
(c) In a microwave oven torque acting on an electric dipole is responsible for the (4) (20) production of heat. Comment.
- Q. 3.** (a) Discuss origin of magnetism by considering processes that creates magnetic field (8) in an atom.
(b) What are ferromagnetic domains? How does a typical ferromagnetic (8) material is investigated by Hysteresis loop for technological applications?
(c) How does effect of nuclear magnetism becomes important in nuclear (4) (20) magnetic resonance?
- Q. 4.** (a) Derive an expression for the time-independent Schrodinger wave equation (10) in one dimension for a single particle. Define Hamiltonian operator.
(b) Discuss various quantum numbers to describe the complete behavior of an (6) electron in an orbital.
(c) How slowly must an electron be moving for its deBroglie wave-length equal to (4) (20) 1mm?
- Q. 5.** (a) Discuss the behavior of particle trapped in infinitely deep well and show that the (10) energy of particle inside the well is quantized.
(b) Explain the terms wave function, probability density and normalization (6) condition associated with quantum mechanics.
(c) Find the expectation value of the momentum. (4) (20)
- Q. 6.** (a) What is an oscillator? How an LC oscillator works? Discuss Barkhaaussian (10) criteria for oscillations.
(b) What is a feedback transistor? Differentiate negative feedback and positive (6) feedback.
(c) what are RC filters (4) (20)
- Q. 7.** (a) Discuss principle, construction and working of Nuclear Reactor. Define (8) Breeder Reactor.
(b) What is nuclear fusion? Describe Proton-Proton cycles for energy release in the (8) Sun and Stars.
(c) What is Q-Value of a nuclear reaction? (4) (20)
- Q. 8.** Write comprehensive notes on any TWO of the following (10 each) (20)
(a) The Biot and Savart law (b) Cyclotron
(c) Electromagnetic waves



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Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2. (a)** What is the curl of a vector field? Explain its physical significance. (10)
(b) What is vector triple product? Show that (6)
$$\vec{A} \times (\vec{B} \times \vec{C}) = (\vec{A} \cdot \vec{C})\vec{B} - (\vec{A} \cdot \vec{B})\vec{C}$$
 (4) (20)
(c) If $\phi = 2x^3y^2z^4$ then find the $\text{div grad } \phi$.
- Q. 3. (a)** State and explain Kepler's law of areas. (8)
(b) A spaceship of mass $m = 4.50 \times 10^3$ kg is in a circular Earth orbit of radius $r = 8.00 \times 10^6$ m and period $T_0 = 118.6$ min $= 7.119 \times 10^3$ s when a thruster is fired in the forward direction to decrease the speed to 96.0% of the original speed. What is the period T of the resulting elliptical orbit? (6)
(c) Which has greater magnitude, the angular momentum of the Earth (relative to its center) associated with its rotation on its axis or the angular momentum of the Earth (relative to the center of its orbit) associated with its orbital motion around the Sun? (6) (20)
- Q. 4. (a)** Explain the equivalence of mass and energy. (6)
(b) Explain two tests of time dilation i.e microscopic and macroscopic clocks. (8)
(c) The mean lifetime of stationary muons is measured to be 2.2000 ms. The mean lifetime of high-speed muons in a burst of cosmic rays observed from Earth is measured to be 16.000 μ s. To five significant figures, what is the speed parameter b of these cosmic-rays muons relative to Earth? (6) (20)
- Q. 5. (a)** What is viscosity? Explain in detail. What is the effect of temperature on viscosity? (8)
(b) Castor oil, which has a density of 0.96×10^3 kg/m³ at room temperature, is forced through a pipe of circular cross section by a pump that maintains a gauge pressure of 950 Pa. The pipe has a diameter of 2.6 cm and a length of 65 cm. The castor oil emerging from the free end of the pipe at atmospheric pressure is collected. After 90 s, a total of 1.23 kg has been collected. What is the coefficient of viscosity of the castor oil at this temperature? (5)
(c) A liquid flows through a horizontal pipe whose inner radius is 2.52 cm. The pipe bends upward through a height of 11.5 m where it widens and joins another horizontal pipe of inner radius 6.14 cm. What must the volume flux be if the pressure in the two horizontal pipes is the same? (7) (20)
- Q. 6. (a)** What is damped harmonic oscillator? Write its equation of motion and find its solution. (10)
(b) The amplitude of a lightly damped oscillator decreases by 3.0% during each cycle. What percentage of the mechanical energy of the oscillator is lost in each cycle? (4)
(c) An insulating vessel containing 1.8 kg of water is placed on a hot plate, both the water and hot plate being initially at 20°C. The temperature of the hot plate is raised very slowly to 100°C, at which point the water begins to boil. What is the entropy change of the water during this process? (6) (20)

PHYSICS, PAPER-I

- Q. 7.** (a) What are travelling waves? Find the rate at which energy is transported by a wave travelling along a string. (5)
- (b) A string has linear density $\mu = 525 \text{ g/m}$ and is under tension $T = 45 \text{ N}$. We send a sinusoidal wave with frequency $f = 120 \text{ Hz}$ and amplitude $y_m = 8.5 \text{ mm}$ along the string. At what average rate does the wave transport energy? (5)
- (c) Two sinusoidal waves with the identical wavelengths and amplitudes travel in opposite directions along a string with a speed of 10 cm/s . If the time interval between instants when the string is flat is 0.50 s , what is the wavelength of the waves? (10) **(20)**
- Q. 8.** (a) Explain the volume and pressure corrections in ideal gas law as suggested by van der Waals. (10)
- (b) For oxygen the van der Waals coefficients have been measured to be $a = 0.138 \text{ J} \cdot \text{m}^3/\text{mol}^2$ and $b = 3.18 \times 10^{-5} \text{ m}^3/\text{mol}$. Assume that 1.00 mol of oxygen at $T = 50 \text{ K}$ is confined to a box of volume 0.0224 m^3 . What pressure does the gas exert according to (a) the ideal gas law and (b) the van der Waals equation? (5)
- (c) State and explain the zeroth law of thermodynamics. (5) **(20)**



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Roll Number

PHYSICS, PAPER-II

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) Discuss electric field of point charges, keeping in view the magnitude of force acting on test charge according to Coulomb's Law. (8)
(b) Derive Poisson's equation from Gauss's Law. Also write the expression for Laplace's equation. (8)
(c) Find out the electric field due to charge of $2e$ at a distance of 26.5×10^{-12} m. (4) **(20)**
($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N.m}^2$ and $e = 1.60 \times 10^{-19} \text{ C}$)
- Q. 3.** (a) Discuss in details the Energy Transport and the Poynting Vector. (8)
(b) Write the four Maxwell's Equations both in integral and differential forms. (8)
(c) Explain vector potential. (4) **(20)**
- Q. 4.** (a) State and explain Heisenberg's Uncertainty Principle. (8)
(b) Discuss the phenomenon Barrier Tunneling. (8)
(c) Find the momentum of an electron moving with a speed of 1.88×10^6 m/s. where mass of electron is 9.11×10^{-31} kg. (4) **(20)**
- Q. 5.** (a) What do you understand by the term Dopping? How we can make semiconductors as n-type or p-type with the dopping? (8)
(b) Discuss in details the N-P-N and P-N-P transistors. (8)
(c) Explain MOFET. (4) **(20)**
- Q. 6.** (a) Discuss in detail the process of Natural Radioactivity. (8)
(b) Discuss in detail the radioactive decay. (8)
(c) Find the energy released during the alpha-decay of ^{238}U . Where the needed atomic masses are ^{238}U 238.050785 u, ^{234}Th 234.043539 u and ^4He 4.002603 u. (4) **(20)**
- Q. 7.** (a) Discuss in detail the phenomenon of Fission. (8)
(b) Explain the basic principles of Nuclear Reactors. (8)
(c) Briefly write about the methods of detection of nuclear radiation. (4) **(20)**
- Q. 8.** Write notes on any **TWO** of the following: **(10 each)** **(20)**
(a) Dielectric medium and Electric Polarization
(b) Ampere's Law
(c) Accelerators



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Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) Describe Einstein postulates of special theory of Relativity. Express the difference between the special and the general theories of Relativity. (10)
(b) Establish the energy-mass relationship and give its significance. (10) **(20)**
- Q. 3.** (a) Differentiate between Fermi-Dirac, Bose-Einstein and Maxwell Statistics. Give application of each. (10)
(b) Draw a labelled diagram of a nuclear reactor and give significance of each part. (10) **(20)**
- Q. 4.** (a) Distinguish between the linear and angular momentum. Express Newton's second law in terms of the linear and angular motion. (10)
(b) Discuss the acceptor and rejecter electronic circuits. (10) **(20)**
- Q. 5.** (a) Describe and explain the Miller indices. Recognize the symbols $\langle 111 \rangle$, $[010]$, (111) . (10)
(b) Discuss the closest packed crystal structures. (10) **(20)**
- Q. 6.** (a) Can you imagine a three dimensional diffraction grating? Describe in detail. (10)
(b) Justify the dual nature of light with elaborative examples. (10) **(20)**
- Q. 7.** (a) State and explain the three laws of Thermodynamics. (10)
(b) What is a heat engine? Determine the efficiency of the engine if it takes 10,000 J of heat and delivers 2000 J of work per cycle. (10) **(20)**
- Q. 8.** Write notes on any **TWO** of the following: **(10 each)** **(20)**
(a) Mickelson-Morley experiment and its latest usage in a recent Nobel award.
(b) Unification of forces and Abdus Salam contribution.
(c) An essay on Large Hadron Partical Accelerator.



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FOR RECRUITMENT TO POSTS IN BS-17
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Roll Number

PHYSICS, PAPER-II

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) Consider an infinitely long cylindrical insulating shell of inner radius a , and outer radius b , and has a uniform volume charge density ρ . If a line of charge density λ is placed along the axis of the shell then determine the electric field intensity at a point r such that (i) $a < r < b$ and (ii) $r > b$. (8)
- (b) Determine the energy density for a capacitor. (6)
- (c) Discuss the Lorentz force. (6) (20)
- Q. 3.** (a) Find the magnetic energy density for the magnetic field of the inductor. (10)
- (b) State and explain the Lenz's law. (6)
- (c) Why is the work done by a magnetic field on a charged particle always zero? (4) (20)
- Q. 4.** (a) Describe the properties of each of, an electron and the light, that show their dual nature. (8)
- (b) State and explain the de Broglie hypothesis? (6)
- (c) Metals A, B and C have work functions 2.2eV, 3.6eV and 4.8eV. If a light of wavelength 320nm is incident on these, then find (6) (20)
- (i) Which metals exhibit photoelectric effect?
- (ii) Maximum kinetic energy of photoelectron in each case?
- Q. 5.** (a) Determine the transmission co-efficient for a particle having energy E incident on a rectangular barrier, so that $E < V_0$, the barrier is given by (14)

$$V(x) = \begin{cases} +V_0 & \text{for } -a < x < a \\ 0 & \text{for } |x| > a \end{cases}$$

- (b) For an operator $\hat{A}$, we know $[\hat{H}, \hat{A}] = 0$, where $\hat{H}$ is the Hamiltonian operator, what can we conclude about the eigen states of $\hat{A}$ and the $\langle \hat{A} \rangle$? (4)
- (c) Give two examples for the operator $\hat{A}$, given in part (b) above. (2) (20)

PHYSICS, PAPER-II

- Q. 6.** (a) Describe the electrical conduction in different types of solids in terms of band theory. (8)
- (b) Explain the crystal structure of diamond. (6)
- (c) Find the carrier concentration of electrons in Silicon at a temperature of 25°C. (6) **(20)**
- Q. 7.** (a) What factors contribute to the stability of a nucleus? Draw and explain the plot of neutron number N versus atomic number Z for stable nuclei. (10)
- (b) Explain the use of chain reaction in relation to a nuclear reactor. (6)
- (c) The stable isotope of potassium is ^{39}K , what kind of radioactivity do you expect from ^{40}K ? Give reasons. (4) **(20)**
- Q. 8.** Write notes on any **TWO** of the following: **(10 marks each)** **(20)**
- (a) Poynting Vector
- (b) Fusion in stars
- (c) MOSFET



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FOR RECRUITMENT TO POSTS IN BS-17
UNDER THE FEDERAL GOVERNMENT

Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) A particle of unit mass moves in potential $V(x) = ax^2 + b/x^2$ where a & b are positive constants. Find the angular frequency of small oscillations? (08)
- (b) A hollow spherical shell carries charge density $\rho = k/r^2$ in region $a \leq r \leq b$. Find the electric field in three regions (i) $r < a$ (ii) $a < r < b$ (iii) $r > b$. (07)
- (c) A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. Determine its angle of projection. (05) **(20)**
- Q. 3.** (a) Assume that a star has uniform density. Show that the gravitational pressure P is proportional to $V^{-3/4}$ where V is volume. (08)
- (b) Derive expressions for potential and electric field associated with point charge q located near an infinite grounded conducting plane. (07)
- (c) Determine equation of motion of masses attached to the string of Atwood machine by Lagrangian methods. (05) **(20)**
- Q. 4.** (a) $Q \text{ cm}^3$ of water flows per second through a horizontal tube of uniform bore of radius r & of length L . Another tube of half the length but radius $2r$ is connected in parallel to same pressure head. What will be the total quantity of water flowing / sec through these two tubes? (08)
- (b) A linear quadrupole is an arrangement of a system of charges which consist of $-2Q$ at the origin and $+Q$ at the two points $(\pm d, 0, 0)$. Show that at distances much greater than (*i.e.* $r \gg d$), the potential may be written in the approximate form
- $$V = \frac{Qd^2}{4\pi\epsilon_0 r^3} (3 \cos^2 \theta - 1), r \gg d$$
- (c) Two soap bubbles with radii r_1 and r_2 coalesce to form a bigger bubble of radius r . Show that $r = (r_1^3 + r_2^3)^{1/3}$. (05) **(20)**

PHYSICS, PAPER-I

- Q. 5.** (a) Explain wave function. Derive wave formula and explain phase and group velocity. (08)
- (b) Two semi-infinite grounded metal plates parallel to each other and to the xz -plane are located at $y = 0$ and $y = a$ planes, respectively. The left ends of these two plates at $x = 0$, are closed off by a strip of width a and extend to infinity in the z -direction. The strip is insulated from both the plates and is maintained at a specific potential $V_0(y)$. Find the potential distribution in the slot. (07)
- (c) A two level system has energies 0 & E . The level with zero energy is non-degenerate while the level with energy E is triply degenerate. Find the mean energy of a classical particle in this system at temperature T . (05) **(20)**
- Q. 6.** (a) Explain the particle in finite potential well with all possible cases and solutions and make a comparison with infinite potential well. (08)
- (b) The potential $V_0(\theta)$ is specified on the surface of a hollow sphere, of radius R . Find potential inside the sphere. (07)
- (c) A particle is confined to region $x > 0$ by a potential which increases linearly as $u(x) = u_0 x$. Find the mean position of particle at temperature T . (05) **(20)**
- Q. 7.** (a) When a gas expands adiabatically its volume is doubled while its absolute temperature is decreased by a factor 1.32. Compute number of degree of freedom of gas molecule? (08)
- (b) State and prove Ampere's Law. (07)
- (c) Find the rms speed of oxygen molecules at 0°C ? (05) **(20)**
- Q. 8.** (a) An ensemble of non-interacting spin $-1/2$ particles is in contact with a heat bath at temperature T & is subjected to an external magnetic field. Each particle can be in one of the two quantum states of energies ϵ_0 . If the mean energy per particle is $-\epsilon_0/2$, then find free energy per particle? (08)
- (b) Derive the electromagnetic wave equation in vacuum and also describe the properties of monochromatic electromagnetic waves. (07)
- (c) Discuss adiabatic demagnetization using TDS equations mathematically in detail? (05) **(20)**



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PHYSICS, PAPER-II

Roll Number

TIME ALLOWED: THREE HOURS
PART-I(MCQS): MAXIMUM 30 MINUTES

PART-I (MCQS)
PART-II

MAXIMUM MARKS = 20
MAXIMUM MARKS = 80

- NOTE: (i)** Part-II is to be attempted on the separate **Answer Book**.
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(vii) **Use of Calculator is allowed.**

PART – II

- Q. 2. (a)** An electric dipole, comprising a positive charge q and a negative charge $-q$, is placed on the x -axis. Each charge is at the same distance from the origin. The total separation between the charges is $2a$. Calculate the electric field E due to these charges along the y -axis at the point P, which is at a distance y from the origin. Assume $y \gg a$ ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$). (10)
- (b)** Write down a mathematical expression to evaluate electric field E at a distance r from the source charge Q in vector form. Sketch the graph of E as a function of r . (6)
- (c)** Define electric field and a dipole. (4) **(20)**
- Q. 3. (a)** Discuss photoelectric effect and establish Einstein's equation for the photoelectric effect. (10)
- (b)** Describe the inadequacy of the wave theory of light to explain the effect. (6)
- (c)** A photon of energy 12 eV falls on a certain metal plate whose work function is 4.15 eV. Find the stopping potential. The mass and charge of electron are $9.11 \times 10^{-31} \text{ kg}$ and $1.6 \times 10^{-18} \text{ C}$ respectively and the value of Planck's constant is $6.64 \times 10^{-34} \text{ J} \times \text{s}$. (4) **(20)**
- Q. 4. (a)** Discuss intrinsic and extrinsic semiconductors. (10)
- (b)** Describe the properties of diamagnetic, paramagnetic and ferromagnetic materials. (6)
- (c)** Briefly discuss the Landé g factor. (4) **(20)**
- Q. 5. (a)** Four charged particles of charge q , $2q$, $3q$ and $4p$ are at the corners of a square of side ' a ' arranged in counter clockwise direction. Determine **(i)** the electric field at the location of charge q and **(ii)** the total electric force exerted on q . (8)
- (b)** A parallel plate capacitor has a plate separation of 1 mm. Calculate the surface area of each plate of the capacitor to obtain a capacitance of 1F. Is it possible to produce such a capacitor in the lab? Comment. ($\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$). (6)
- (c)** Define (6) **(20)**
- (i)** Capacitance **(ii)** The unit of capacitance **(iii)** Surface charge density

PHYSICS, PAPER-II

- Q. 6.** (a) Set up the Schrodinger wave equation for a particle of mass m confined in a one-dimensional box which has perfectly rigid walls at $x = 0$ and $x = L$. Solve the differential equation to find the expressions for energy and the eigen wave functions of the particle. (10)
- (b) Sketch the graphs for the first three eigen wave functions ψ_1 , ψ_2 and ψ_3 . (5)
- (c) Plot the graphs for the probability densities corresponding to ψ_1 , ψ_2 and ψ_3 . (5) **(20)**
- Q. 7.** (a) Discuss the motion of a charged particle of mass m , charge q and velocity v in a magnetic field B which is directed into the plane of paper. (8)
- (b) Discuss atomic description of dielectrics. (6)
- (c) Let x be the separation between the parallel plates of a capacitor of capacitance C in the absence of a dielectric material. A slab of a material of dielectric constant γ and thickness $\frac{1}{3}x$ is placed between the plates. Calculate the capacitance in the presence of the dielectric material. (6) **(20)**
- Q. 8.** (a) Discuss the properties of three subatomic particles and their corresponding antiparticles. (10)
- (b) Explain in detail, how γ - radiation can be detected? (5)
- (c) How can we prove that an electron does not exist in the nucleus of an atom? (5) **(20)**



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PHYSICS, PAPER-I

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PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

- Q. 2.** (a) What is Gradient of a scalar function? Give its physical significance and show that $\overrightarrow{\text{Grad}}\phi = \vec{\nabla}.\phi$ (10)
(b) Define the term ‘acceleration’ and find its Cartesian components. (06)
(c) If $\vec{A} = xz^3\hat{i} - 2x^2z\hat{j} + 2yz^4\hat{k}$, then find curl of A at the point (1,-1,1) (04) **(20)**
- Q. 3.** (a) Explain the rotational kinetic energy and determine its formula for a disc, hoop and sphere. (10)
(b) What do you mean by the term ‘inertia’ in physics? Calculate respectively the rotational inertia of a solid cylinder and a hollow cylinder about an axis of symmetry. (06)
(c) Calculate the angular speed of the second’s hand, minutes hand and hour’s hand of a watch. (04) **(20)**
- Q. 4.** (a) What was Physics like before relativity and how did Einstein come up with his theory? Mathematically explain how mass and energy is interchangeable? (10)
(b) Discuss in detail the relativity of length using Einstein’s special theory of relativity. (06)
(c) Calculate the mass equivalent of energy from an antenna radiating 10KW for 24 hours. (04) **(20)**
- Q. 5.** (a) Define capillarity and derive an expression for the rise of liquid in a capillary tube to show that the height of the liquid column supported is inversely proportional to the radius of the tube. (10)
(b) What are fluids? Write their important characteristics. (06)
(c) A cylindrical swimming pool has radius 2m and depth 1.3m. It is filled completely with salt water. (04) **(20)**
Given, density of salt water = $1.03 \times 10^3 \text{ kg m}^{-3}$, volume of water = 16.34 m^3 , and the atmospheric pressure = $1.013 \times 10^5 \text{ Pa}$. Calculate the pressure at the bottom of the pool.

PHYSICS, PAPER-I

- Q. 6.** (a) For a wave travelling through a medium, demonstrate that the total energy per unit volume is always equal to one half the kinetic and one half the potential energy. (10)
- (b) The longitudinal waves can pass through solids. How it is possible and on what parameters the velocity of such waves will depend? (06)
- (c) The angular Vibrational frequency of CO molecule is $0.6 \times 10^{15} \text{ s}^{-1}$. Calculate the amount of work required for stretching it by $0.5 \text{ \AA}$ from the equilibrium position. (04) **(20)**
- Q. 7.** (a) An ideal gas is enclosed in a cylinder with movable piston. Calculate the work done on such gas and show that pressure force is non-conservative. (10)
- (b) State and briefly explain the intermolecular forces. (06)
- (c) Oxygen gas having a volume of 1130 cm^3 at 42°C and a pressure of 101 kPa expanded until its volume is 1530 cm^3 and its pressure is 106 kPa . Find the number of moles of oxygen in the system and its final temperature. (04) **(20)**
- Q. 8.** Write short notes on any TWO of the following. **(10 each)** **(20)**
- a. Kepler's Law of Periods
 - b. Michelson interferometer
 - c. Young's double slit experiment



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PHYSICS, PAPER-II

TIME ALLOWED: THREE HOURS	PART-I (MCQS)	MAXIMUM MARKS = 20
PART-I(MCQS): MAXIMUM 30 MINUTES	PART-II	MAXIMUM MARKS = 80
NOTE: (i) Part-II is to be attempted on the separate Answer Book. (ii) Attempt ONLY FOUR questions from PART-II. ALL questions carry EQUAL marks. (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places. (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper. (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed. (vi) Extra attempt of any question or any part of the question will not be considered. (vii) Use of Calculator is allowed.		

PART – II

Q. 2. A particle of mass m is in the state

$$\psi(x, t) = A e^{-a[(\frac{mx^2}{h}) + it]}$$

Where A and a are positive constants.

- (a) Find A . (5)
- (b) For what potential energy function $V(x)$ does $\psi(x, t)$ satisfy the Schrodinger equation? (5)
- (c) Calculate the expectation values of x , x^2 , p , and p^2 (5)
- (d) Find σ_x and σ_y . Is their product consistent with the uncertainty principle? (5) **(20)**

Q. 3. (a) Consider a pair of copper wires 1 mm in diameter and 5 cm apart. In copper the number of conduction electrons per cubic meter is 8.45×10^{28} . Suppose their mean drift velocity v is 0.3 cm / s, calculate current in each wire. (8)

- (b) If the wires are 20 cm apart, calculate the magnetic force on the wires. (8)
- (c) Define electric current in a wire with respect to number of charges and their drift velocity. (4) **(20)**

Q. 4. Give expressions for the following quantities in terms of e , h , c , k , m_e and m_p .

- (a) The energy needed to ionize a hydrogen atom. (5)
- (b) The difference in frequency of the Lyman alpha line in hydrogen and deuterium atoms. (5)
- (c) The magnetic moment of the electron. (5)
- (d) The spread in measurement of the π^0 mass, given that the π^0 lifetime is τ . (5) **(20)**

Q. 5. (a) An atom is capable of existing in two states: a ground state of mass M and an excited state of mass $M + \Delta$. If the transition from ground to excited state proceeds by the absorption of a photon, what must be the photon frequency in the laboratory where the atom is initially at rest? (7)

- (b) Derive the energy levels of the hydrogen atom, from Coulomb's law and the simple quantization of angular momentum. (7)
- (c) In radio astronomy, hydrogen atoms are observed in which, for example, radiative transitions from $n = 109$ to $n = 108$ occur. What are the frequency and wavelength of the radiation emitted in this transition? (6) **(20)**

Q. 6. (a) Consider the elastic vibrations of a crystal with one atom in the primitive cell and calculate the frequency of an elastic wave in terms of the wavevector that describes the wave and in terms of the elastic constants. (12)

- (b) Describe vibrations of crystal. (8) **(20)**

Q. 7. (a) Discuss density of states in Three Dimension (8)

- (b) Describe Debye Model for Density of States (8)
- (c) Define phonon heat capacity. (4) **(20)**

Q. 8. Write Notes on any TWO of the following: **(10 each) (20)**

- (a) Maxwell's Equations
- (b) Magnetic Materials: (Ferro-Dia-Para)
- (c) Black Body Radiation



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PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	(PART-I MCQs) MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II) MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes. (ii) Overwriting/cutting of the options/answers will not be given credit. (iii) There is no negative marking. All MCQs must be attempted.	

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the **OMR Answer Sheet.(20x1=20)**
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

- What is the magnitude of the vector, $12\mathbf{i} - 8\mathbf{j} - 24\mathbf{k}$?**
(A) 18 (B) 28 (C) 38 (D) 48
- Moment of inertia of solid sphere is:**
(A) $\frac{2}{3} Mr^2$ (B) $\frac{1}{2} Mr^2$ (C) $\frac{2}{5} Mr^2$ (D) None of these
- Radial component of velocity for a particle moving in a circular path is:**
(A) Constant (B) Radius itself (C) Variable (D) Zero
- The linear thermal coefficient of a solid is less than its volume thermal expansion coefficient by a factor of:**
(A) $\frac{3}{2}$ (B) 3 (C) 9 (D) 6
- A body is thrown vertically upwards from the ground with a speed of 980 cm/sec. It will rise to a height of:**
(A) 980 cm (B) 490 cm (C) 49 cm (D) None of these
- Optically active crystals rotate the:**
(A) Vibrating plane (B) Interference plane (C) Polarization plane (D) Diffraction plane
- A sound source of frequency 600 Hz is moving towards an observer with velocity 20 m/s. The speed of sound is 340 m/s. The frequency heard by observer will be :**
(A) 30 Hz (B) 63.5 Hz (C) 637.5 Hz (D) None of these
- A system consisting of two particles moves on a plane. Then the degree of freedom is:**
(A) 2 (B) 3 (C) 4 (D) 6
- Projection of vector A in the direction of x-axis is represented by the angle of:**
(A) Cos (B) Sin (C) Tan (D) None of these
- When the movable mirror of a Michaelson Interferometer is shifted through 0.0589 mm, 200 fringes cross the field. What is the wavelength of the light?**
(A) 5890 Å (B) 5245 Å (C) 4965 Å (D) None of these
- The frequency of 2nd pendulum is:**
(A) 1.5 Hz (B) 2 Hz (C) 0.5 Hz (D) 1 Hz
- A skater moves with a constant velocity of 12km/s. If her momentum is 600kgm/s, what is its mass?**
(A) 72kg (B) 0.05kg (C) 50kg (D) 46kg
- The escape velocity from the surface of the earth is approximately equal to:**
(A) 9.81 km/sec (B) 11.2 km/sec (C) 14 km/sec (D) None of these
- The value of relative permittivity for all the dielectrics is:**
(A) Less than unity (B) Zero (C) Equal to unity (D) Greater than unity
- When travelling wave is a sin or cos function of $(x+Vt)$ is called:**
(A) Plane progressive wave (B) Non-harmonic wave (C) Wave function (D) None of these
- A particle on the trough of a wave at any instant will come to the mean position after a time:**
(A) $T/2$ (B) $T/4$ (C) T (D) 2T
- The efficiency of a heat engine working between the freezing point and boiling point of water is:**
(A) 6.25% (B) 0% (C) 26.8% (D) 100%
- Wavelength of an incident light when it is incident normally on a diffraction grating, having 3000 lines per centimeter and angular separation of 10° is:**
(A) 500 nm (B) 650 nm (C) 580 nm (D) 600 nm
- Which of the following have highest value of surface tension?**
(A) Water (B) Mercury (C) Milk (D) Oil
- The dimensions of work are:**
(A) MT^{-1} (B) MLT^{-1} (C) M^2L^2T (D) ML^2T^{-2}

PART-II

- NOTE:** (i) **Part-II** is to be attempted on the separate **Answer Book**.
 (ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
 (iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.
 (iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
 (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
 (vi) Extra attempt of any question or any part of the question will not be considered.
 (vii) **Use of Calculator is allowed.**

- Q.2.** (a) State and prove Stoke's Theorem. Also explain its significance. (6, 4)
 (b) A particle moves in xy plane so that its x and y coordinates vary with time according to $x(t)=At^3 + Bt$ and $y(t)=Ct^2+D$. where $A=1.00 \text{ m/s}^3$ $B= -32 \text{ m/s}$ $C= 5 \text{ m/s}^2$ and $D=12\text{m}$. Find the position, velocity and acceleration of the particle when $t=3 \text{ s}$. (10) (20)
- Q.3.** (a) What is relativity of length according to Einstien? Also discuss consequences of lorentz transformation for relativity. (5, 5)
 (b) Prove $E^2= m^2c^4+P^2c^2$. (5)
 (c) Derive formula for work and kinetic energy in rotational motion. (5) (20)
- Q.4.** (a) What is conservative field? Prove that gravitational force is negative derivative of potential energy. (10)
 (b) Find the direction cosines of Cartesian coordinates (2,-1, 2). (4)
 (c) Calculate which is greater, angular momentum of earth associated with its rotation about its own axis or angular momentum of earth associated with its orbital motion around sun. Radius of the earth= 6400 km and radius of the orbit of the earth about the sun is equal to $1.5 \times 10^8 \text{ km}$. (6) (20)
- Q.5.** (a) Write in detail about the variation of pressure in a fluid at rest and in the atmosphere with relevant mathematical formulas. (7, 7)
 (b) The siren of a police car emits a pure tone at frequency 1125 Hz find the frequency that you perceive in your car when you moving at 9 m/s , police car chasing behind you at 38 m/s . (6) (20)
- Q.6.** (a) If two waves having same amplitude and are propagating in opposite directions through a string, will they produce standing waves? Is energy transported, and are there any nodes? (10)
 (b) How dispersion and resolving power of a grating can be calculated in terms of wavelength? (10) (20)
- Q.7.** (a) Differentiate between real and ideal gas. Describe about work done on ideal gas in thermal isolation. (10)
 (b) A heat pump acting as a refrigerator is used to heat a house. The temperature outside the house is -9°C and inside is kept at 21°C . Find the maximum coefficient of performance of the heat pump? (6)
 (c) What do you know about fermi-Dirac statistics? (4) (20)
- Q.8.** Write Comprehensive note on any two of the followings: (10 each) (20)
 (a) Damped harmonic motion
 (b) Young Double Slit Experiment
 (c) Longitudinal and transverse coherence



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Roll Number

PHYSICS, PAPER-II

TIME ALLOWED: THREE HOURS	(PART-I MCQs)	MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II)	MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes. (ii) Overwriting/cutting of the options/answers will not be given credit. (iii) There is no negative marking. All MCQs must be attempted.		

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the OMR Answer Sheet.(20x1=20)

(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

- A Gaussian surface in the form of a cylinder of radius R immersed in a uniform electric field with the cylinder axis parallel to the field. What is the flux of the electric field through this closed surface?**
(A) Zero (B) EA (C) $2EA$ (D) None of these
- Differential form of Gauss's law in magneto statics is:**
(A) $\text{div } B = \mu_0 J$ (B) $\text{div } B = 0$ (C) $\text{div } B = -dB/dT$ (D) None of these
- Which of the following is the correct expression for the group velocity?**
(A) $\frac{d\omega}{dv}$ (B) $\frac{dE}{dK}$ (C) $\frac{dE}{dK}$ (D) None of these
- The Eigen value of a particle in a box is**
(A) $L/2$ (B) $\sqrt{2/L}$ (C) $\sqrt{L/2}$ (D) None of these
- The probability of finding an electron is uniform in every direction is in which orbital?**
(A) s (B) p (C) d (D) None of these
- The degeneracy of the state having energy $\frac{27h^2}{8mL^2}$ for a particle in a three-dimensional cubic box of length L is:**
(A) 4 (B) 3 (C) 2 (D) None of these
- In an electromagnetic wave in free space, the root mean square value of the electric field is 6 V/m. The peak value of the magnetic field is:**
(A) $2.83 \times 10^{-8} \text{ T}$ (B) $1.51 \times 10^{-8} \text{ T}$ (C) $0.80 \times 10^{-8} \text{ T}$ (D) None of these
- An alpha particle having energy 5MeV entering the proportional counter with capacity of 25 pf. The ionization potential will be $\sim 15 \text{ eV}$. The resultant pulse height will be close to:**
(A) 2.1 mV (B) 4.3 mV (C) 6.3 mV (D) None of these
- A parallel plate capacitor is charged by connection to a battery. If the battery is disconnected and the separation between the plates is increased, what will happen to the charge on the capacitor and the voltage across it?**
(A) Both increase (B) The charge increases and the voltage decreases
(C) The charge remains fixed and the voltage increases (D) None of these
- A hollow metal sphere of radius R is positively charged. Of the following distances from the centre of the sphere, which location will have the greatest electric field strength?**
(A) 0 (centre of the sphere) (B) $3R/2$ (C) $2R$ (D) None of these
- Two parallel conducting plates are connected to a constant voltage source. The magnitude of the electric field between the plates is 2,000 N/C. If the voltage is doubled and the distance between the plates is reduced to 1/5 the original distance, the magnitude of the new electric field is:**
(A) 1,600 N/C (B) 2,400 N/C (C) 20,000 N/C (D) None of these
- An isolated capacitor with air between its plates has a potential difference V_0 and a charge Q_0 . After the space between the plates is filled with oil, the difference in potential is V and the charge is Q . Which of the following pairs of relationships is correct?**
(A) $Q = Q_0$ and $V > V_0$ (B) $Q = Q_0$ and $V < V_0$ (C) $Q > Q_0$ and $V = V_0$ (D) None of these
- A positive charge of $3.0 \times 10^{-8} \text{ C}$ is placed in an upward directed uniform electric field of $4.0 \times 10^4 \text{ N/C}$. When the charge is moved 0.5 meter upward, the work done by the electric force on the charge is:**
(A) $6 \times 10^{-4} \text{ J}$ (B) $12 \times 10^{-4} \text{ J}$ (C) $2 \times 10^4 \text{ J}$ (D) None of these
- A conducting sphere of radius R carries a charge Q . Another conducting sphere has a radius $R/2$ but carries the same charge. The spheres are far apart. The ratio of the electric field near the surface of the smaller sphere to the field near the surface of the larger sphere is most nearly to:**
(A) 1/2 (B) 2 (C) 4 (D) None of these
- If the only force acting on an electron is due to a uniform electric field, the electron moves with constant:**
(A) Acceleration in the direction opposite to that of the field (B) Acceleration in the direction of the field
(C) Speed in a direction opposite to that of the field (D) Speed in the direction of the field
- An ion with charge q , mass m , and speed v enters a magnetic field B and is deflected into a path with a radius of curvature R . If a second ion has speed $2v$, while m , q , and B are unchanged, what will be the radius of the second ion's path?**
(A) $4R$ (B) $2R$ (C) $R/2$ (D) None of these
- The Ampere law is based on which theorem?**
(A) Green's theorem (B) Gauss divergence theorem (C) Stoke's theorem (D) None of these

PHYSICS, PAPER-II

18. A nucleus of ${}^{235}_{92}\text{U}$ disintegrates to ${}^{207}_{82}\text{Pb}$ in about a billion years by emitting 7 alpha particles and x beta particles, where x is:
(A) 3 (B) 4 (C) 5 (D) None of these
19. Two identical coaxial coils P and Q carrying equal amount of current in the same direction are brought nearer. The current in:
(A) P increases while in Q decreases (B) Q increases while in P decreases
(C) Both P and Q increases (D) Both P and Q decreases
20. In an electromagnetic wave, the electric field of amplitude 6.2 V/m oscillates with a frequency of 2.4×10^{10} Hz. The Energy density of the wave is:
(A) $1.4 \times 10^{-10} \text{ J/m}^3$ (B) $2.4 \times 10^{-10} \text{ J/m}^3$ (C) $3.4 \times 10^{-10} \text{ J/m}^3$ (D) None of these

PART-II

- NOTE:** (i) **Part-II** is to be attempted on the separate **Answer Book**.
(ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
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(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
(vi) Extra attempt of any question or any part of the question will not be considered.
(vii) **Use of calculator is allowed.**

- Q. 2.** (a) Derive the work-energy theorem of electrodynamics (Poynting theorem) and discuss the Poynting vector. (10)
(b) What is magnetic vector potential? Also compare magnetic vector potential and electric scalar potential. (05)
(c) Find the magnetic field a distance **z** above the center of a circular loop of radius **R**, which carries a steady current **I**. (05) (20)
- Q. 3.** (a) What are the limitations of Gauss's Law? How it can be applied on a material with bound charges(dielectrics)? (10)
(b) The long solenoid has 220 turns/cm and carries a current $i = 1.5 \text{ A}$; its diameter **D** is 3.2 cm. At its center we place a 130-turn closely packed coil **C** of diameter $d = 2.1 \text{ cm}$. The current in the solenoid is reduced to zero at a steady rate in 25 ms. What is the magnitude of the emf that is induced in coil **C** while the current in the solenoid is changing? (05)
(c) Calculate the Curl of electric field **E**. (20)
- Q. 4.** (a) Briefly discuss the phenomenon of Photoelectric effect. Deduce the value of Planck's constant using concepts of stopping potential and work function. (10)
(b) X rays of wavelength $\lambda = 22 \text{ pm}$ (photon energy = 56 keV) are scattered from a carbon target, and the scattered rays are detected at 85° to the incident beam. What is the Compton shift of the scattered rays? (05)
(c) Describe the significance of a nearby nucleus in the process of pair production. Why is it necessary for the phenomenon to take place? (05) (20)
- Q. 5.** (a) Explain the splitting of energy levels of atoms in external magnetic field based on the quantum theory by considering the spectral lines of sodium. (10)
(b) Discuss the momentum and energy operators in quantum mechanics and write down the significance of these operators. (05)
(c) Show that the particle in one dimensional box can only have discrete energy values. (05) (20)
- Q. 6.** (a) How the energy levels in the crystalline solids form the energy bands? Differentiate between metals and semiconductors bases on the band gap pattern and electrical properties of the solids. (10)
(b) How many conduction electrons are in a cube of sodium ${}^{23}_{11}\text{Na}$ of volume $2 \times 10^{-6} \text{ m}^3$. Sodium atoms are monovalent. Density and molar mass of sodium are 0.968 g/cm^3 and 22.98 g/mol respectively. (05)
(c) What is a Bravais lattice? Write down types of Bravais lattice in three-dimensional space. (05) (20)

PHYSICS, PAPER-II

- Q. 7.** (a) How radiations are detected? Discuss any two radiation detectors in detail. (10)
(b) Explain working principle of the cyclotrons and synchrotrons. (05)
(c) Suppose a cyclotron is operated at an oscillator frequency of 12 MHz and has a dee radius $R = 53$ cm. What is the magnitude of the magnetic field needed for deuterons to be accelerated in the cyclotron? The deuteron mass is $m = 3.34 \times 10^{-27}$ kg (twice the proton mass). What is the resulting kinetic energy of the deuterons? (05) (20)
- Q. 8.** (a) Discuss the working principle and applications of MOSFET. (10)
(b) What is the probability that a quantum state whose energy is 0.10 eV above the Fermi energy will be occupied? Assume a sample temperature of 800 K. (05)
(c) Graphically show the occupancy probability and density of states as a function of energy. (05) (20)



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PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	(PART-I MCQs) MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II) MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes.	
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(iii) There is no negative marking. All MCQs must be attempted.	

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the OMR Answer Sheet.(20x1=20)
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

1. **The energy of a simple harmonic motion depends upon:**
(A) Mass (B) Frequency (C) Both (A) & (B) (D) None of these
2. **The zeroth law of thermodynamics helps to define the term:**
(A) Temperature (B) Pressure (C) Volume (D) Density
3. **What is the change in the phase if a wave is reflected from a denser medium?**
(A) 3π (B) 0 (C) π (D) 2π
4. **The light can totally pass through the polaroid only if the electric field vector vibrates _____ to the polarizing vector.**
(A) Antiparallel (B) Parallel (C) Opposite (D) None of these
5. **When the net wave intensity is greater than the individual intensities the interference of the waves is said to be.**
(A) Constructive (B) Destructive (C) Both (A) & (B) (D) None of these
6. **The angle of incidence for which polarization is maximum is called:**
(A) Scattering angle (B) Angle of reflection (C) Polarization angle (D) None of these
7. **X-rays are electromagnetic waves of wavelengths of the order of:**
(A) 1nm (B) 0.1 nm (C) 2nm (D) 100 nm
8. **The viscous force the relative motion between the adjacent layers of a fluid in motion. Which one of the flowing fits best in the sentence?**
(A) Opposes (B) Never affects (C) Facilitates (D) May effect under certain conditions
9. **The viscosity of a fluid in motion is 1 Poise. What will be it's viscosity (in Poise) when the fluid is at rest?** (A) 0 (B) 0.5 (C) 1 (D) 2
10. **For the successful operation of heat engine, which condition should be met?**
(A) Cyclic process (B) Operated at certain temperature difference
(C) Both (A) & (B) (D) None of these
11. **Which quantity is not a state function?**
(A) Internal energy (B) Pressure (C) Heat (D) Volume
12. **Fermi-Dirac statistics cannot be applied to:**
(A) Electrons (B) Photons (C) Fermions (D) Proton
13. **In which process all the heat supplied is converted into work done?**
(A) Isothermal (B) Isochoric (C) Isobaric (D) Isentropic
14. **At constant pressure and Volume, exact relation between C_p and C_v is:**
(A) $C_p > C_v$ (B) $C_p / C_v > 1$ (C) $C_p - C_v = R$ (D) All of these
15. **The internal energy of an ideal gas is _____ dependent.**
(A) Pressure (B) Temperature (C) Volume (D) All of these
16. **What is not the condition for the equilibrium in three dimensional system of axis?**
(A) $F_x = 0$ (B) $F_y = 0$ (C) $\sum F_z = 0$ (D) $\sum F \neq 0$
17. **The tendency of rotation of the body along any axis is also called:**
(A) Moment of inertia (B) Moment of couple (C) Torque (D) Force
18. **A simple pendulum is set into oscillations. The bob of the pendulum comes to rest after some time due to:**
(A) Friction of air (B) Its mass (C) Tension in the string (D) Gravity
19. **The energy of a damped oscillator:**
(A) Decreases linearly with time (B) Increases linearly with time
(C) Decreases exponentially with time (D) Increases exponentially with time
20. **The product of mass and velocity is known as:**
(A) Work (B) Moment (C) Impulse (D) Momentum

PART-II

- NOTE:** (i) **Part-II** is to be attempted on the separate **Answer Book**.
 (ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
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 (v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
 (vi) Extra attempt of any question or any part of the question will not be considered.
 (vii) **Use of Calculator is allowed.**

- Q.2.** (a) State and prove Stoke's theorem. (10)
 (b) Prove that if the vector is the gradient of a scalar function then its line integral around a closed curve is zero. (6)
 (c) A particle moves along the curve $x = 2t^2$, $y = t^2 - 4t$, $z = 3t - 5$ where t is the time. Find the components of its velocity and acceleration at time $t=1$ in the direction $2i-3j+2k$ (4) (20)
- Q.3.** (a) Differentiate between Fermi-Dirac, Bose-Einstein and Maxwell-Boltzman's statistics. (10)
 (b) What do you understand by classical statistical mechanics and quantum statistical mechanics? (6)
 (c) A $0.5m^3$ vessel is filled with air at atmospheric pressure. The air is churned by a paddel wheel attached to a shaft 0.1m in diameter, rotating at a speed of 1800 rpm. A force of 5.0N acts on the rim of the shaft. What would be the pressure in the vessel after 10 sec of operation? (4) (20)
- Q.4.** (a) What is viscosity? Discuss effect of temperature on the viscosity of liquids and gases. (10)
 (b) Explain why the level of mercury is down in capillary when placed in container of mercury, while it is up in the capillary in case of water? (6)
 (c) A garden hose has an inside diameter of 2 cm and water flows through it is at 3 m/s. (i) What nozzle diameter is required for the water to emerge at 10 m/s? (ii) At what rate does the water leave the nozzle? (4) (20)
- Q.5.** (a) Discuss analytical treatment of interference of light to calculate intensity in double slit interference. Describe the conditions of maximum and minimum intensity and also draw the intensity pattern for double slit interference. (10)
 (b) What is resolving power of a grating? Show that it increases with the order of image. (6)
 (c) A body having SHM has an amplitude of 5cm, and a period of 0.2s. When the displacement is 5cm, find the acceleration and velocity. (4) (20)
- Q.6.** (a) What is Carnot Cycle? Draw and explain it for a reversible process. (10)
 (b) What does Gibbs function describe? Prove that Gibbs function for a reversible isothermal and isobaric process is constant. (6)
 (c) A heat engine absorbs 52.4 kJ of heat and exhausts 36.2 kJ of heat in each cycle. Calculate efficiency of heat engine and work done by engine per cycle. (4) (20)
- Q.7.** (a) Derive Clausius – Claypron equation and also write its two conclusions. (10)
 (b) Prove that $TV^{\gamma-1} = \text{constant}$ (6)
 (c) Air occupying $0.142 m^3$ at 2.04×10^5 is expanded isothermally to 1 atm and then cooled at constant pressure until it reaches its initial volume. Find work done on the gas. (4) (20)
- Q.8.** Write Comprehensive notes on any two of the following: (10 each) (20)
 (a) Newton's ring (b) Polarization by reflection (c) Doppler effect



FEDERAL PUBLIC SERVICE COMMISSION
COMPETITIVE EXAMINATION-2025 FOR RECRUITMENT
TO POSTS IN BS-17 UNDER THE FEDERAL GOVERNMENT
PHYSICS, PAPER-II

Roll Number

TIME ALLOWED: THREE HOURS	(PART-I MCQs)	MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II)	MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes. (ii) Overwriting/cutting of the options/answers will not be given credit. (iii) There is no negative marking. All MCQs must be attempted.		

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the OMR Answer Sheet.(20x1=20)
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

1. **A charge moving in a uniform static magnetic field experiences:**
(A) A force perpendicular to magnetic field and velocity (B) Increase in momentum
(C) Decrease in momentum (D) Decrease in velocity
2. **The same energy alpha particles and electrons associated De Broglie wave lengths are:**
(A) Equal (B) Longer than electrons (C) Smaller electrons (D) None of these
3. **The mass deficit defines:**
(A) Nuclear binding energy (B) Nuclear Quadrapole moment (C) Shape of the nucleus (D) None of these
4. **In nuclear physics the magic number defines:**
(A) Nuclear binding energy (B) Relatively exceptionally stable nuclei (C) Radioactivity (D) None of these
5. **The Zeeman effect is due to the interaction of:**
(A) External magnetic field and total magnetic field of the specimen
(B) External electric field and magnetic field of specimen (C) L, S coupling (D) None of these
6. **A photon having the same energy as an electron has wavelength _____ as electron's De Broglie wavelength.**
(A) Shorter (B) Longer (C) Same (D) None of these
7. **In Laurens transformation motion along _____axis's remains zero.**
(A) One axis (B) Two axis (C) Three axis (D) None of these
8. **Gausses law is applicable on the charges which are:**
(A) Closely distributed in space (B) Sparsely distributed in space
(C) Enclose by a broken surface (D) Enclose by a close surface
9. **The ratio between the angular momentum and orbital magnetic moment vector of the first orbital electron of Hydrogen Atoms is known as:**
(A) Total Magnetic Moment (B) Bohr Magnetron (C) Magnetic Moment (D) None of these
10. **The cyclotron is a device which primarily used to:**
(A) Accelerate sub atomic particles (B) To generate electrons
(C) To generate neutrons (D) To generate protons
11. **The rate of change of current in a coil is proportional to:**
(A) V (B) - emf (C) R (D) None of these
12. **The charging and discharging behavior of an ideal RLC circuit is:**
(A) Simple harmonic (B) Linear (C) Elliptical (D) Un predictable
13. **The Lorentz force is given by:**
(A) $F_q = q(\mathbf{v} \times \mathbf{B})$ (B) $\Phi = \oint \mathbf{A} \cdot \mathbf{d}\mathbf{l} = \oint \mathbf{A} \cdot \mathbf{d}\mathbf{l}_x + \oint \mathbf{A} \cdot \mathbf{d}\mathbf{l}_y + \oint \mathbf{A} \cdot \mathbf{d}\mathbf{l}_z$ (C) $\mathbf{qF} = q(\mathbf{v}_d \times \mathbf{B})$ (D) None of these
14. **The poynting vector represents:**
(A) The rate and direction of electromagnetic energy transferred in space.
(B) The amount of electromagnetic energy transferred in different forms of energy.
(C) Loss of electromagnetic energy in a medium. (D) The flow of thermal energy in a certain direction.
15. **The De Broglie wave particle duality is said to be foundation of uncertainty principle because:**
(A) The velocities of the particles were very high. (B) The mass could not attain the velocity of light.
(C) The mass increases at velocities comparable to the velocity of light increases.
(D) The uncertainty in position of the moving mass.
16. **The relation between half-life and mean life are:**
(A) Inversely proportional (B) Directly proportional (C) Equal (D) Half
17. **The concept of mutual frame of reference was used in:**
(A) Reduced mass correction in spectroscopy (B) Radioactivity
(C) Relative nuclear stability. (D) None of these

PHYSICS, PAPER-II

18. **The Ultraviolet catastrophe means:**
(A) The spectral energy concentration towards longer wave length.
(B) The spectral energy concentration at the middle of the spectrum.
(C) The spectral energy concentration towards shorter wave side. (D) None of these
19. **As per quantum physics, the observables 'E' and _____ can not be simultaneously measured with hundred percent accuracy.**
(A) p_x (B) t (C) x (D) None of these
20. **The theory of relativity predicts that at velocities comparable to the velocity of light, the moving mass appears to:**
(A) Increase (B) Decrease (C) Remains the same (D) None of these

PART-II

NOTE: (i) **Part-II** is to be attempted on the separate **Answer Book**.
(ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.
(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
(vi) Extra attempt of any question or any part of the question will not be considered.
(vii) **Use of calculator is allowed.**

- Q. 2.** (a) Discuss the spectral properties of perfect black body radiation. Explain the ultra violet catastrophe. (10)
(b) Find the fifth & seventh member of Balmer spectral series. If the third member is 1200 Å. (10) (20)
- Q. 3.** (a) In quantum mechanics explain the term commutation between the observables. (10)
(b) Explain how De Broglie wave particle duality laid down the fundamentals of uncertainty principle. (10) (20)
- Q. 4.** (a) In the context of nuclear physics explain the magic numbers. (10)
(b) Explain nuclear Quadruple moment and explain its significance. (10) (20)
- Q. 5.** (a) Derive the expression for electric dipole moment. Discuss two uses in modern science. (10)
(b) Discuss Biot and Savart law and derive its expression, using suitable schematic figure. (10) (20)
- Q. 6.** (a) Explain how Hall's effect could be used to find the sign of charge carriers. (10)
(b) Explain the Hall's effect. How it could calculate the number of charge carriers in material. (10) (20)
- Q. 7.** (a) Explain the construction and working of photo multiplier tube (PMT). (10)
(b) Compare the energies of a proton and electron having same De Broglie wave length of 1Å. (10) (20)
- Q. 8.** Write short notes any TWO of the following: (10 each) (20)
(a) Reduced mass correction in spectroscopy
(b) Electron microscope
(c) Heisenberg uncertainty principal



FEDERAL PUBLIC SERVICE COMMISSION
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Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	(PART-I MCQs) MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II) MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes. (ii) Overwriting/cutting of the options/answers will not be given credit. (iii) There is no negative marking. All MCQs must be attempted.	

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the OMR Answer Sheet.(20x1=20)
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

- If $A=6i-8j$, then $4A$ has magnitude:
(A) 10 (B) 40 (C) 20 (D) -28
- Which of the following is not a vector quantity?
(A) Momentum (B) Force (C) Work (D) Displacement
- Let $A=2i+6j-2k$ and $B=i+4k$, then $A.B$ is equal to:
(A) -6 (B) 6 (C) 0 (D) None of these
- When the velocity of a body is constant, its acceleration is:
(A) Non-zero (B) Maximum (C) Minimum (D) zero
- What does a wave transmit from one place to another?
(A) Energy (B) Mass (C) Wavelength (D) Amplitude
- The rate of change of momentum of a particle is equal to:
(A) Energy (B) Force (C) Acceleration (D) Speed
- The waves in which particles of the medium vibrate in the direction of the wave motion are called:
(A) Stationary (B) Longitudinal (C) Transverse (D) Mechanical
- What is the SI unit of angular acceleration?
(A) ms^{-1} (B) $rad s^{-1}$ (C) rad (D) None of these
- Which of the following statements is correct for particles obeying Fermi–Dirac statistics?
(A) Any number of particles can occupy the same quantum state,
(B) The occupation probability becomes infinite at low energy
(C) Each quantum state can be occupied by at most one particle (D) The chemical potential is always zero
- An isothermal process is carried out at constant:
(A) Volume (B) Temperature (C) Pressure (D) Energy
- What is the total work done in moving a body along a closed path in gravitational field?
(A) Zero (B) Maximum (C) Minimum (D) None of these
- Shock absorbers in cars are example of oscillations:
(A) Damped (B) Forced (C) Undamped (D) Simple
- Bernoulli's Principle is based on the conservation of:
(A) Mass (B) Momentum (C) Energy (D) Force
- When the pressure of the system remains constant, it is called _____ process.
(A) Isochoric (B) Isobaric (C) Isothermal (D) Adiabatic
- What happens to the volume of most gases when their temperature is increased at constant pressure?
(A) Decreases (B) Increases (C) Remains the same (D) No change
- Entropy is defined by $dS =$ _____.
(A) dQ/T (B) TdQ (C) dU/dW (D) dQ/U
- In the absence of net external force, _____ remains constant.
(A) Mass (B) Momentum (C) Work (D) None of these
- A motor lifts a weight of 3000 N through a height of 20 m in 30 seconds. Calculate the power developed by the motor.
(A) 200W (B) 18000W (C) 2000W (D) 1500W
- Divergence and Curl of a vector field are:
(A) Scalar and Scalar (B) Scalar and vector (C) Vector and Scalar (D) Vector and Vector
- The gradient of a vector is:
(A) Curl (B) Scalar (C) Divergence (D) None of these

PART-II

- NOTE:** (i) **Part-II** is to be attempted on the separate **Answer Book**.
(ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.
(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
(vi) Extra attempt of any question or any part of the question will not be considered.
(vii) **Use of Calculator is allowed.**

- Q.2.** (a) What is the difference between Divergence, Gradient, and Curl. Give one example of each. (10)
- (b) A particle moves in the xy plane, starting from the origin at $t=0$ with an initial velocity having an x component of 20 m/s and a y component of -15 m/s. The particle experiences an acceleration in the x direction, given by $a_x = 4 \text{ m/s}^2$. Determine the total velocity vector at any time. (10) (20)
- Q.3.** (a) What is law of conservation of angular momentum? Give at least one example. (8)
- (b) A 6 kg block initially at rest is pulled to the right along a horizontal surface by a constant horizontal force of 12N. Find the speed of the block after it has moved 3m if the surfaces in contact have a coefficient of kinetic friction of 0.15. (10)
- (c) Can a normal force do work? If not, why not? If so, give an example. (2) (20)
- Q.4.** (a) What is Kepler's third law? Prove that the square of the period is proportional to the cube of the semimajor axis. (12)
- (b) Consider a satellite of mass m moving in a circular orbit around the Earth at a constant speed v and at an altitude h above the Earth's surface. Determine the speed of satellite in terms of G (Universal Gravitational Constant), h , R (the radius of the Earth), and M (the mass of the Earth). (8) (20)
- Q.5.** (a) What is Bernoulli's Theorem? Show that (10)
- $$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$$
- Where P is pressure of the fluid, ρ is density of the fluid, v is velocity of the fluid, g is acceleration due to gravity, and h is height above a reference level.
- (b) In a car lift used in a service station, compressed air exerts a force on a small piston that has a circular cross section of radius 5 cm. This pressure is transmitted by a liquid to a piston that has a radius of 15 cm. What force must the compressed air exert to lift a car weighing 1000 N? (10) (20)
- Q.6.** (a) What is Young's double-slit experiment? Derive the mathematical formula for constructive and destructive interference of light. (12)
- (b) A 200g block connected to a light spring for which the force constant is 5 N/m is free to oscillate on a frictionless, horizontal surface. The block is displaced 5cm from equilibrium and released from rest. Find the period of its motion. (8) (20)
- Q.7.** (a) What is diffraction of light? Explain diffraction of X-rays by crystals. (10)
- (b) Monochromatic light from a helium-neon laser ($\lambda = 632 \text{ nm}$) is incident normally on a diffraction grating containing 4000 grooves per centimeter. Find the angles at which the second-order maximum is observed. (10) (20)
- Q.8.** (a) What is first-law of thermodynamics? Show that work done on the gas during isothermal expansion of an ideal gas is $W = nRT \ln \left(\frac{V_i}{V_f} \right)$, where R is universal gas constant, T is temperature, n is number of moles. V_i and V_f is the initial and final volume, respectively. (12)
- (b) A 1 mole sample of an ideal gas is kept at 0°C during an expansion from 3 L to 10 L. How much work is done on the gas during the expansion? (8) (20)



FEDERAL PUBLIC SERVICE COMMISSION
COMPETITIVE EXAMINATION-2026 FOR RECRUITMENT
TO POSTS IN BS-17 UNDER THE FEDERAL GOVERNMENT
PHYSICS, PAPER-II

Roll Number

TIME ALLOWED: THREE HOURS	(PART-I MCQs)	MAXIMUM MARKS: 20
PART-I (MCQs) : MAXIMUM 30 MINUTES	(PART-II)	MAXIMUM MARKS: 80
NOTE: (i) First attempt PART-I (MCQs) on separate OMR Answer Sheet which shall be taken back after 30 minutes . (ii) Overwriting/cutting of the options/answers will not be given credit. (iii) There is no negative marking. All MCQs must be attempted.		

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ☐ on the **OMR Answer Sheet.(20x1=20)**
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

1. **The angle between two vectors $\vec{A} = \hat{x} + \hat{z}$ and $\vec{B} = \hat{y} + \hat{z}$ is:**
(A) 0° (B) 20° (C) 30° (D) 60°
2. **The curl of a gradient of a scalar field T , $\nabla \times (\nabla T)$, is zero. This statement is:**
(A) Always true (B) Depends on the value of T
(C) In contradiction to the fundamental theorem of Gradient
(D) In contradiction to the fundamental theorem of Curl
3. **The electric field of a sphere falls off like $1/r^2$; the electric field of an infinite line falls off like $1/r$; and the electric field of an infinite plane falls off as:**
(A) $1/r^3$ (B) $1/r^2$ (C) $1/r$ (D) None of these
4. **The dimension of $(\vec{p} \cdot \vec{\nabla})\vec{E}$ represents which of the following physical quantity?**
(A) Dipole moment (B) Force (C) Magnetic field (D) None of these
5. **When the continuity equation is such that $\vec{\nabla} \cdot \vec{J} = 0$; which of the following statements is true?**
(A) Steady current flows (B) Charge is not piling up (C) $\frac{\partial \rho}{\partial t} = 0$ as well (D) All of these
6. **The correction term used by Maxwell to the Ampere's law $\vec{J}_d = \epsilon_0 \frac{\partial \vec{E}}{\partial t}$ called the displacement current is a misleading term and has nothing to do with the:**
(A) Current (B) Charge (C) Electric field (D) Magnetic field
7. **What is meant by specific surface?**
(A) Surface area per unit volume (B) Surface area per unit weight
(C) Surface weight per unit area (D) None of these
8. **Quartz crystal, normally used in quartz clocks etc. is chemically:**
(A) Silicon dioxide (B) Germanium dioxide
(C) A mixture of germanium oxide and silicon dioxide (D) Sodium silicate
9. **Bohr's Atomic Model is based upon:**
(A) Einstein's relativistic theory (B) Classical theory (C) Planks quantum theory (D) Both (B) & (C)
10. **With increasing quantum number n , the energy difference between adjacent levels in atoms is:**
(A) Decreases (B) Increases (C) Remain constant (D) Zero
11. **The relationship between energy of a photon of light and its frequency is given by:**
(A) De-Broglie dual nature of matter (B) Bohr's model
(C) Planck's Quantum theory (D) Rutherford's atomic model
12. **Rutherford's Model of atom failed because:**
(A) The atom did not have a nucleus and electrons
(B) It did not account for the attraction between protons and neutrons
(C) It did not account for the stability of the atom (D) There is no space between the nucleus and the electron
13. **The spectral lines of Lyman series are emitted when electron jumps from higher orbit to:**
(A) 1st orbit (B) 2nd orbit (C) 3rd orbit (D) 4th orbit
14. **The factor that indicates attenuation taking place per centimeter is known as the:**
(A) Mass attenuation coefficient (B) Linear attenuation coefficient (C) Decay rate (D) Atomic number
15. **If ϕ_m and ϕ_n are two wavefunctions, such that $\int_{-\infty}^{\infty} \phi_m^* \phi_n = 1$, then ϕ_m and ϕ_n must be:**
(A) Orthogonal (B) Perpendicular (C) Normalized (D) Orthonormal
16. **In the case of infinite square-well potential, if width of the well is halved, the energy of the ground state will:** (A) Be halved (B) Remain the same (C) Become doubled (D) Become four times
17. **Beta minus (β^-) decay involves:**
(A) Proton $\rightarrow$ neutron + positron + neutrino (B) Neutron $\rightarrow$ proton + electron + antineutrino
(C) Proton $\rightarrow$ neutron + electron + neutrino (D) Neutron $\rightarrow$ proton + positron + neutrino
18. **The strong nuclear force acts between:**
(A) Protons only (B) Neutrons only (C) Protons and neutrons (D) Electrons and protons

PHYSICS, PAPER-II (2026)

19. **The binding energy of a nucleus is:**
(A) Energy required to remove a nucleon (B) Energy released when the nucleus is formed from nucleons
(C) Both (A) & (B) (D) Energy of the electrons
20. **Which of the following is not a naturally occurring radioactive element?**
(A) Uranium (B) Plutonium (C) Thorium (D) Radium

PART-II

NOTE: (i) Part-II is to be attempted on the separate **Answer Book**.
(ii) Attempt **ONLY FOUR** questions from **PART-II**. **ALL** questions carry **EQUAL** marks.
(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.
(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
(vi) Extra attempt of any question or any part of the question will not be considered.
(vii) **Use of calculator is allowed.**

- Q. 2.** (a) State and explain Gauss' law in dielectrics. Also give its significance. (5)
(b) Derive a mathematical expression for an electric field at a point lying outside of a uniformly charged spherical shell. (5)
(c) A spherical shell has a total charge $q = 4\mu C$ and radius 0.3 m . Calculate the electric field at a distance of $.5\text{ m}$ from the center of the shell. (10) (20)
- Q. 3.** (a) What is meant by induced emf? Why is it called induced? (10)
(b) Derive an expression for induced emf in a coil with N turns due to changing magnetic flux. (5)
(c) Magnetic flux through a 20 turn coil changes from 0.5 to 0.1 Wb in 0.2 s . How much emf would be induced in the coil? (5) (20)
- Q. 4.** (a) Discuss the time-independent Schrodinger wave equation. Why is it called time independent? (5)
(b) Solve the time-independent Schrodinger wave equation for a particle in a one-dimensional potential well of width of L . (5)
(c) Find the ground-state energy of electron in a 1-D potential well with $L = 1\text{ nm}$. Mass of electron $= m = 9.11 \times 10^{-31}\text{ kg}$. (10) (20)
- Q. 5.** (a) What is meant by Bravais lattice? (5)
(b) Calculate the volume of the base-centered cubic structure of side length 0.4 nm . The volume needs to be in $\text{\AA}^3$. (5)
(c) Clearly elaborate the difference between base-centered and face-centered cubic lattices. Also discuss types of base-centered cubic cell. (10) (20)
- Q. 6.** (a) Define Fermi sphere. Is this an energy state? Explain. (10)
(b) Deduce the Fermi-Dirac distribution function (5)
$$f(E, T) = \frac{1}{e^{(E-E_F)/K_B T} + 1}$$
for Fermi energy level ($E = E_F$)
(c) Calculate the Fermi energy for Cu in eV with number density (n) of $8.49 \times 10^{28}\text{ atoms}/\text{m}^3$ (5) (20)
$$\left[E_F = \frac{h^2}{2m} \left(\frac{3n}{8\pi} \right)^{2/3}, m = 9.11 \times 10^{-31}\text{ Kg}, h = 6.62 \times 10^{-34}\text{ J.s} \right]$$
- Q. 7.** (a) Explain on scientific grounds the difference between alpha, beta and gamma decay. (5)
(b) Write the decay equation for the alpha decay of U_{92}^{38} . (5)
(c) The charge number and mass number of two nuclei A & B are the same. But their binding energies are such that $(B.E)_A > (B.E)_B$. Which nucleus will have more mass and why? (10) (20)

PHYSICS, PAPER-II (2026)

- Q. 8.** (a) Explain nuclear fission with the help of one practical application. (5)
- (b) What are elementary and composite particles? Give two examples from each family of elementary particles. (5)
- (c) What is controlled fusion? Why is it hard to achieve on earth? (10) (20)
