UNIVERSITY OF THE PUNJAB

Part – I A/2016
Examination:- B.A./B.Sc.

Roll No. ....

Subject: Physics-I
PAPER: A (Physics-I)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 75

NOTE: Attempt FIVE questions, selecting not more than TWO questions from each section.

Section – I

Q1. (a) Define Divergence of a vector field and show that $div\vec{V} = \nabla.\vec{V}$ (7)

(b) What do you mean by surface integral and line integral? (5)

(c) Show that if a vector is gradient of a scalar function, then its line integral around a closed path is equal to zero, (3)

Q2. (a) Define work and power. Show that work done by an arbitrary applied force is equal to the change in kinetic energy of the body. (8)

(b) Does kinetic energy depend upon the direction of motion of the body? Can it be negative? (3)

(c) A 106 Kg object is initially moving in a straight line with a speed 51.3 m/s. If it is brought to a stop with a deceleration of 1.97 m/s^2, what force is required, what distance does the object travel and how much work is done by the force? (4)

Q3. (a) What is meant by fictitious force? Explain your answer by giving examples. (8)

(b) In the conical pendulum, what happens to the period and the speed when $\theta = 90^0$. Why is this angle not achievable physically? Discuss the case for $\theta = 0^0$ (3)

(c) Give brief description of the working of the device Rotor. (4)

Q4. (a) Discuss Einstein Postulates of Special Theory of relativity. (5)

(b) Drive the Einstein mass – energy equivalence $E = mc^2$ and illustrate its importance in physics (8+2)

Section –II

Q5. (a) What do you mean by Interference of light and Coherent Sources? (7)

(b) Discuss the analytical treatment of the Young's double slit interference. (8)

P.T.O.

Q6. (a) What is a Damped Harmonic Oscillator? Drive equation of motion for damped harmonic oscillator. Find the expressions for displacement, frequency and amplitude. (15)

(b) Why are damping devices often used on machinery? Give an example.

(c)An oscillator consists of a block of mass 512 g connected to spring. When set into oscillations with an amplitude of 34.7 cm, it is observed to repeat its motion every 0.484 s. Find its frequency and maximum speed.

Q7. (a) Give construction and theory of Diffraction Grating. Also drive an expression for its resolving power. (8)

(b)Give a comparison of prism spectrum and grating spectrum (3)

(c)A grating has 315 lines/mm. For what wavelengths in the visible spectrum can fifth order diffraction be observed? (4)

Section – III

Q8. (a) Clearly differentiate between a Heat Engine and a refrigerator (5)

(b) Give two statements of Second Law of Thermodynamics and show that they are equivalent (8)

(c) Is human being a heat engine? Explain. (2)

Q9. (a) Explain the Maxwell law of distribution of molecular velocities for the molecules of a gas (8)

(b) What do you mean by Internal energy of an Ideal gas? Drive an expression for it using Maxwell Boltzmann's energy distribution. (7)

Q10. (a) What is entropy? Drive the relation for the change in entropy during a reversible process. (8)

(b) Comment on the following statement," A heat engine converts a disordered motion of heat into an organized motion of heat". (3)

(c) Give a brief description of the Thermodynamic Scale of Temperature. Define One Kelvin (4)

UNIVERSITY OF THE PUNJAB

Part-I A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: I (Mathematical Methods of Physics)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 100

NOTE: Attempt FIVE questions, at least TWO questions should be selected from each section. Clearly mention the Section, question number and part number on answer sheet. No marks will be awarded for wrong question (part) numbering on answer sheet.

Section 1

Q 1(a): State Stoke's theorem and verify it for a vector:
$\overrightarrow{F} = z\,\hat{i} + x\,\hat{j} + y\,\hat{k}$ taken over the half of the $x^2 + y^2 + z^2 = a^2$, lying above the xy-plane.
The surface "S" is enclosed by a curve "c" and the projection of "S" on xy-plane is a
circle $x^2+y^2 = a^2$. [10]

Q1(b): If a vector $\overrightarrow{B}$ is represented as $\overrightarrow{B} = \hat{\phi}\, B_\phi(\rho)$. Show that $(\overrightarrow{B}.\overrightarrow{\nabla})\overrightarrow{B} = -\hat{\rho}\,\frac{B_\phi^2}{\rho}$ [10]

Q 2(a): Prove that , [5+5]
i) curl $(\psi\,\overrightarrow{A}) = \psi$ curl $\overrightarrow{A} + \overrightarrow{\nabla}\psi \times \overrightarrow{A}$
ii) curl curl $\overrightarrow{A}$ = grad div $\overrightarrow{A} - \nabla^2\overrightarrow{A}$

Q 2(b): For the second order tensor $A_{p\,q}$, prove that $A_{p\,q}\,A_{q\,p}$ is invarient under
orthogonal transformation. [10]

Q 3(a): A triangular wave is represented by
$$f\,(x) = \left\{\begin{array}{c} x,\ 0 \prec x \prec \pi \\ -x,\ -\pi \prec x \prec 0 \end{array}\right\}$$
Show that its Fourier series is represented by
$$f\,(x) = \frac{\pi}{2} - \frac{4}{\pi}\sum_{n=1,3,5,...}\frac{Cos(nx)}{n^2}$$ [10]

Q 3(b): Find the Fourier Transformation of Gaussian probability function $f\,(x) = N\,e^{-\alpha x^2}$ where N and α are constants. [10]

Q 4(a): Derive the Rodrigue's formula for the Legender polinomials
$p_n(x) = \frac{1}{2^n\, n\,!}\frac{d^n}{d\,x^n}(x^2-1)^n$ [10]

Q 4(b): Write the formula of $Y_n^m(\theta, \phi)$ and then find
i) $Y_0^0(\theta, \phi)$ ii) $Y_1^0(\theta, \phi)$ [10]

Q 5(a): For the Bessel's function, show that
$\frac{d}{d\,x}\left[x^{-n}\,J_n(x)\right] = -x^{-n}\,J_{n+1}(x)$ [10]

Q 5(b): For Bessel's function prove that,
i) $J_{\frac{1}{2}}(x) = \sqrt{\frac{2}{\pi\, \text{n}}}\,\text{Si}\,n(x)$
ii) $J_{-\frac{1}{2}}(x) = \sqrt{\frac{2}{\pi\, \text{n}}}\,Cos(x)$ [5+5]

Section II

Q 6(a): Show that the eigen values of Strum Liouville's problem are real. [10]

Q 6(b): Show that the Green's function for
$\frac{d^2G}{dx^2} + k^2G = -\delta\,(x - x')$
with boundary conditions $G(0, x') = 0 = G(1, x')$ is
$G(x, x') = \frac{\text{Si}\,n\,K\,(1-x_>)\ \text{Si}\,n\,K\,x_<}{K\ \text{Si}\,n\,K}$ [10]

Q 7(a): If $f(z)$ is analytic inside and on the boundary "C" of a simply connected
region R, then prove that the following Cauchy's integral formula,
$$f\,(a) = \frac{1}{2\,\pi\,i}\oint_c \frac{f\,(z)}{z-a}\,dz$$ [10]

Q 7(b): Evalute $\oint_c \frac{\text{Si}\,n\,\pi\,z^2 + Cos\,\pi\,z^2}{(z-1)(z-2)}dz$; where "c" is a circle of radius 3 centered
at origin. [10]

Q 8: Evaluate the following integrals,
i) $\int_0^\infty \frac{d\,x}{x^4 + x^2 + 1}$ ii) $\int_0^{2\pi} \frac{d\,\theta}{\frac{5}{4} + \text{Si}\,n\theta}$ [10+10]

Q 9(a): State and prove Taylor's theorem in complex variable. [10]

Q 9(b): Prove that $(2n + 1)\ x\ P_n(x) = (n + 1)\ P_{n+1}(x) + n\ P_{n-1}(x)$ [10]

UNIVERSITY OF THE PUNJAB

Part-I A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: II (Classical Mechanics) **MAX. MARKS: 50**

NOTE: Attempt any FOUR questions, selecting at least ONE question from each section.

SECTION I

1(a) What are constraints? Distinguish between holonomic and nonholonomic constraints by giving examples.

(b) Show that the magnitude R of the position vector of the centre of mass is given by the following equation

$$M^2R^2 = M\sum_i m_i x_i^2 + \frac{1}{2}\sum_{i,j} m_i m_j x_{ij}^2 .$$

(c) If L is a Lagrangian for a system of n degrees of freedom satisfying Lagrange equation of motion, show by direct substitution

$$L' = L + \frac{d}{dt}F(q_1, q_2, \ldots, q_n; t),$$

also satisfies the Lagrange's equation of motion, where F is an arbitrary differentiable function of its arguments. [4,4,4.5]

2(a) Compare Newtonian, Lagrangian and Hamiltonian formulations and discuss the advantages and disadvantages of each.

(b) What are the cyclic coordinates? Give a set of cyclic coordinates, express the Lagrange's equations of motion in terms of Routhian function.

(c) A particle of mass m glides without friction on cycloid, given by $x = a(\theta - \sin\theta)$, $y = a(1 + \cos\theta)$, $0 \le \theta \le 2\pi$. Find the Lagrange's equations of motion. [4,4,4.5]

3(a) Discuss the motion of a body of mass μ in a central force field with the Lagrangian $L = \frac{1}{2}\mu\left(\dot{r}^2 + r^2\dot{\theta}^2\right) - V(r)$. Use the angular momentum l and the total energy E (constant of motion), to derive the equations

$$\frac{d^2}{d\theta^2}\left(\frac{1}{r}\right) + \frac{1}{r} = -\frac{\mu r^2}{l^2} f\left(\frac{1}{r}\right), \text{ where } f\left(\frac{1}{r}\right) \text{ is the force law.}$$

(b) Find the force law for a central force field to move in a logarithmic spiral orbit given by $r = ke^{\alpha\theta}$, where k and α are constants. Also calculate the total energy of the orbit. [7.5, 5]

4(a) Consider a one parameter family of transformations

$$q_i(t) \to Q_i(s,t), \qquad s \in R$$

such that $Q_i(0,t) = q_i(t)$. Show that if the Lagrangian is invariant under this transformation, then there exists a conserved quantity.

(b) A particle of mass m moves in central force field with potential $V(r)$. The Lagrangian is $L = \frac{1}{2}m\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin\theta\dot{\phi}^2\right) - V(r)$.

(i) Find the momenta (p_r, p_θ, p_ϕ), (ii) Find the Hamiltonian.

(iii) Write down Hamiltons' equations of motion. [5, 7.5]

P.T.O.

SECTION II

5(a) A particle moves in an elliptical orbit in an inverse square law central force field. If the ratio of the maximum angular velocity to the minimum angular velocity of the particle in its orbit is n, then show that the eccentricity ε of the orbit is

$$\varepsilon = \frac{\sqrt{n}-1}{\sqrt{n}+1}.$$

(b) Show that the isotropy of space leads to conservation of angular momentum.

(c) Define Poisson bracket of two dynamical variables and show that the Poisson bracket obeys the Jacobi identity $\{A, \{B, C\}\} + \{B, \{C, A\}\} + \{C, \{A, B\}\} = 0$, where A, B and C are arbitrary dynamical variables. [4,4,4.5]

6(a) Define Legendre's dual transformation and use it to derive the Hamilton's canonical equations of motion.

(b) Show that the transformation on sets of coordinates $P = \frac{1}{2}\left(p^2 + q^2\right)$, $Q = \tan^{-1}\left(\frac{q}{p}\right)$ is canonical.

(c) Use Kepler's results to show that the gravitational force must be central and that the radial dependence must be $\frac{1}{r^2}$. Thus perform an inductive derivation of the gravitational law. [4,4,4.5]

7 Consider the motion of a particle of mass m in a gravitational potential $V(r) = -\frac{k}{r}$, the Hamiltonian is $H = \frac{1}{2m}\left(p_x^2 + p_y^2\right) - \frac{k}{r}$. The angular momentum vector points in z-direction and has z-component $L = L_z = xp_y - yp_x$ and the Laplace-Runge-Lenz vector lies in the x - y plane and has the components

$$K_x = p_y L - mk\frac{y}{r}, \quad K_y = -p_x L - mk\frac{y}{r}$$

(a) Show that $\{L, H\} = 0$, $\{K_x, H\} = 0$, $\{K_y, H\} = 0$

(b) Show that $\{K_x, L\} = -K_y$, $\{K_y, L\} = K_x$, $\{K_x, K_y\} = -(2mH)L$. [6, 6.5]

UNIVERSITY OF THE PUNJAB

Part-I A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: III (Quantum Mechanics) **MAX. MARKS: 100**

NOTE: Attempt any FIVE questions, At least ONE question from each section.

Section I

Q1. (a) State any two postulates of Quantum Mechanics.
(b). Prove that if two Hermitian operators have common set of eigenfunctions, they commute.

(6+14)

Q2. (a). Derive the expression for time rate of change of expectation value of an operator $\hat{A}$. Use the expression to find the time rate of change of $<\hat{P}>$

(20)

Q3. (a) If Ψ_1, Ψ_2, Ψ_3 are normalized states then which of the following is an acceptable wavefunction. Give reason

$$\begin{aligned}\Psi(x,t) &= \frac{1}{3}\Psi_1 + \frac{1}{3}\Psi_2 + \frac{\sqrt{7}}{3}\Psi_3,\\ \Psi(x,t) &= \frac{1}{2}\Psi_1 + \frac{2}{3}\Psi_2 + \frac{\sqrt{7}}{3}\Psi_3.\end{aligned}$$

(b) If $\Psi(x) = A\exp(-2x)$ is a normalized wavefunction, find the value of normalization constant A. Also find the expectation value of $<x>$, where $0 \le x \le 10$.

(6+14)

Section II

Q4. A particle of mass m and total energy $E > V_o$ strikes a potential step from left. Where

$$\left.\begin{aligned}V(x) &= 0, \text{ for } -\infty < x < 0,\\ &= V_o \text{ for } 0 < x < \infty.\end{aligned}\right\}$$

Calculate the reflection and transmission coefficients. Also show that sum of reflection and transmission coefficients is equal to one. $(R+T=1)$

(20)

Q5. (a). Define angular momentum in Quantum Mechanics. Write down the expression for $\hat{L}_z$ and $\hat{L}^2$ in spherical polar coordinates.
(b). Obtain the eigenfunctions and eigenvalues of $\hat{L}_z$.

(12+8)

Q6. (a). Write down the expression for the operators for spin angular momentum in Quantum Mechanics in matrix form.
(b). What is exchange degeneracy? Also define Exchange operator. Show that exchange operator commutes with Hamiltonian.

(9+11)

Section III

Q7. What is perturbation theory? What is the difference between time independent and time dependent perturbation theory? By using time independent perturbation theory for nondegenerate states, obtain the first order correction in energy.

(20)

Q8. Use Variational method to find the ground state energy of a simple harmonic oscillator. Where

$$\begin{aligned}\hat{H} &= \frac{p^2}{2m} + \frac{1}{2}m\omega^2x^2,\\ \Psi &= A\exp\left(-ax^2\right),\end{aligned}$$

and A and a are constants.

(20)

Q9. State and prove Generalized uncertainty principle. (20)

UNIVERSITY OF THE PUNJAB

Part-I A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics
PAPER: IV (Solid State Physics-1)

TIME ALLOWED: 3 hrs.
MAX. MARKS: 50

NOTE: Attempt any FOUR questions selecting at least ONE question from each section.

Section I

Q. 1. Explain the heat capacity of solids on the basis of the Debye model. Define Debye temperature; also make a comparison of this model and the actual results in very low and very high temperature limits. (12.5)

Q. 2. Considering solid as a discrete periodic medium,

i) Find the dispersion relation for diatomic crystal. (6.5)

ii) Sketch the dispersion relation in the first Brillouin Zone, and explain the physical nature of optical and acoustic branches. (3+3)

Q. 3. What do you mean by interplaner distance in crystals? Derive an expression for the orthogonal crystal system and find its values for the (110) planes of three Bravais lattice of cubic system. (8)

(b) Define packing fraction of crystals and find its value for the FCC crystal. (4.5)

Q. 4. (a) Derive the Laue equation and explain how their graphical representation is related to the diffraction condition. (8)

(b) Prove that the reciprocal of BCC lattice is FCC lattice. (4.5)

Section II

Q. 5. Explain the formation of the crystals of inert gases and find the expression of its equilibrium distance and cohesive energy. (12.5)

Q. 6. Differentiate between the followings: (4+4.5+4)

i) Schottky and Frenkel defects.

ii) Edge and screw dislocations.

iii) F-centers and V-centers.

Q. 7. Write notes on the followings: (6+6.5)

i) Crystal structure of sodium chloride.

ii) Bragg`s law in direct and reciprocal lattice.

UNIVERSITY OF THE PUNJAB

Part-I A/2016
Examination:- M.A./M.Sc.

Roll No. ....

Subject: Physics **TIME ALLOWED: 3 hrs.**
PAPER: V (Electronics) **MAX. MARKS: 100**

NOTE: Attempt any FIVE questions selecting at least ONE from each Section.

Section I

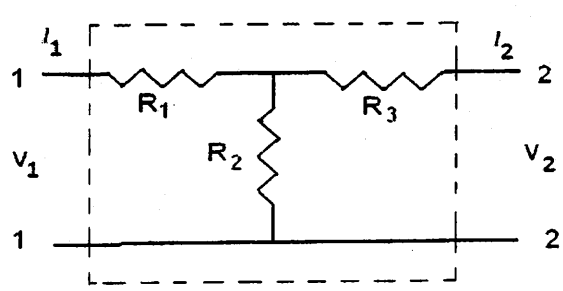
Q.1 **(a)** Draw the circuit of full wave (center tapped transformer) rectifier with π filter and find the expression for ripple factor and V_{dc} in it. 10

(b) Determine the ripple factor for full wave rectifier with π-filter at 50 Hz frequency having $C_1 = C_2 = 50\ \mu F$, L= 5 H, I_{dc} = 300 mA and V_{dc} = 30 V. 7

(c) How does a Zener diode regulate dc voltage. 3

Q.2 **(a)** Why the h-parameters are called hybrid parameters? How would you convert an active one port network into its equivalent **(i)** Voltage source and **(ii)** Current source. 10

(b) Calculate the h-parameters for the two port circuit given below with $R_1 = 5\ \Omega$, $R_2 = 15\ \Omega$ and $R_3 = 12\ \Omega$. Draw the equivalent circuit. 8



(c) What is meant by matching a load? 2

Q.3 **(a)** Draw the g_m-model equivalent circuit of Common-emitter amplifier and derive expression for A_{ve}, A_{ie}, R_{ie} and R_{oe}. 10

(b) In a Common emitter amplifier we use R = 2 KΩ with a transistor having h_{fe} = 25, h_{ie} = 900 Ω, $h_{re} = 1\times10^{-4}$ and $h_{oe} = 16 \times 10^{-6}$ mho. Calculate g_m, A_{ve}, A_{ie}, R_{ie}, R_{oe} and power gain in dB. 10

Section II

Q.4 **(a)** Why the gain of RC coupled amplifier reduces at low and high frequencies. 4

(b) Discuss the low frequency response of RC coupled amplifier and find the expression for $A_{v(low)}$ and phase angle θ. 10

(c) A transistor has C_{be} = 36 pF, C_{bc} = 4.0 pF, h_{ie} = 950 Ω, h_{fe} = 190 and R_c = 1.2 KΩ, then find out its Miller input capacitance C_{ie}. 6

Q.5 **(a)** Explain the construction, draw the symbol and working of n-channel JFET with the help of its characteristics. 10

(b) Describe how to draw a dc load line on the characteristics of an n-channel JFET. 8

(c) Why JFET cannot work in enhancement mode. 2

Q.6 **(a)** Draw the circuit of current series feedback and find the relation for feedback factor β, voltage gain with feedback and input and output resistances. 10

(b) For the current series feedback circuit R_E = 1.5 KΩ, R = 10 KΩ, h_{ie} = 2 KΩ, h_{fe} = 50 and $h_{oe} = 10^{-4}$ mho. Find the β, gain, input and output resistances, without and with feedback. 10

Section III

Q.7 **(a)** Write the conditions of sustained oscillation. 5

(b) Draw the circuit and explain the working of practical Colpitt oscillator. 10

(c) In a Colpitt oscillator $C_1 = C_2 = C$, and L = 150 μH. Find C when f = 1.5 MHz. 5

Q.8 **(a)** Explain the working of class B push-pull amplifier and find its maximum efficiency. 10

(b) What is cross over distortion and how it is eliminated? 5

(c) A transformer is mounted on an 8 Ω speaker. The turns ratio is 12:1. What ac primary resistance will be present. 5

Q.9 Write a note on any **two** of the following. 10 + 10

(i) The operational amplifier.

(ii) Darlington compound transistor.

(iii) Monostable multivibrator.