CC1-PHYSICS

MATHEMATICAL PHYSICS-I

Sample Question

Question of Mark 1:

1. (a) Calculate, $\lim_{x\to 1} \dfrac{x^2-1}{x-1}$.

(b) Find out whether $\sin(\omega t)$ and $\cos(\omega t)$ can be two solutions of a second order homogeneous ordinary differential equations.

(c) Evaluate $\iint_S \vec{\varphi}\cdot d\vec{s}$ where S is the surface enclosing a volume V.

(d) Find 'a' such that the vector $F = (4x+3y)\hat{i} + (y+2z)\hat{j} + (x+az)\hat{k}$ is solenoidal.

(e) What is the greatest rate of increase of $u = xyz^2$ at $(1, 0, 3)$?

(f) Evaluate $\int (3x^2 - 2x - 1)\delta(x-3)\,dx$

(g) For a vector field, $\oint_C A\cdot d\vec{r} = 0$. Is the vector field A solenoidal or irrotational?

(h) Let X follow the Poisson distribution such that $P(X=2) = P(X=3)$. Obtain the value of $P(X=5)$.

(i) Express $\vec{\nabla}\cdot\vec{A}$ in cylindrical co-ordinates.

(j) Calculate the probability of obtaining 4 heads in 6 tosses using an unbiased coin.

Question of Mark 5:

(a) Solve the differential equation $\dfrac{d^2y}{dx^2} - 8\dfrac{dy}{dx} + 15y = 0$

(b) Verify Gauss divergence theorem for a vector $V = r\hat{}\ r^2$, the region of integration being a sphere of radius R with centre at the origin. 5

(χ) Prove that $\vec{\nabla}\cdot(\vec{\nabla}\times A)=0$ in any orthogonal curvilinear coordinate system. 5

(d) Find the directional derivative of the divergence of $F = xy\hat{i} + xy^2\hat{j} + z^2\hat{k}$ at the point (3, 1, 4) in the direction of outwardly directed normal to the sphere $x^2 + y^2 + z^2 = 4$. 3

(e) Evaluate, $\vec{\nabla}\times(\phi\,\vec{\nabla}\phi)$. 2

(f) If A and B are two events with $P(A)=\frac{1}{4}$, $P(B)=\frac{1}{3}$, $P(A\cup B)=\frac{1}{2}$. Find $P(A\mid B)$, $P(B\mid A)$. 3

(g) Two players A and B play a game such that the player A has probability $\frac{2}{3}$ of winning whenever it plays. If A plays 4 games, find the probability that A wins exactly 2 games. 2

(h) (i) Show that the rectangular solid of maximum volume that can be inscribed in a sphere is a cube. 4

(ii) Prove that the curl of linear velocity of the particles of a rigid body rotating about an axis passing through it, is twice the angular velocity. 1

GROUP-C

Question of 10 marks

(i) (a) Evaluate $[\vec{\nabla}\cdot(r^n\vec{r})]$. Show that $r^n\vec{r}$ is solenoidal for $n=-3$.

(b) If $\phi(x, y, z) = 3x^2y - y^3z^2$, find $\nabla\phi$ at the point $(1,-3,-1)$. 6+4

(ii) (a) Show that $\int\vec{r}\cdot d\vec{s} = 3V$, where V is the volume enclosed by the closed surface S.

(b) Obtain the expression for $\nabla^2\psi$ in spherical polar coordinates. 3+7

(iii) (a) Express $z\hat{i} - 2x\hat{j} + y\hat{k}$ in cylindrical coordinates.

(b) Prove that

(i) $\delta(x) = \delta(-x)$

(ii) $f(x)\delta(x-a) = f(a)\delta(x-a)$ 5+2.5+2.5

(iv).(a) Show that the rectangular solid of maximum volume that can be inscribed in a sphere is a cube.

(b) Obtain the expression for Variance of Poisson Distribution.

(c) Using Lagrange's multiplier method, show that the rectangle of maximum area that can be inscribed in a circle is a square. 4+6

CC2-PHYSICS
Mechanics
Sample Questions

Short answer type question: (For 1 mark)

1. A particle of mass 'm' is acted upon by a force whose potential energy is given by $V=ax^2-bx^3$ .What is the value of force?
2. What remains invariant under Galilean transformation?
3. A particle is subjected to a linear restoring force F=-kx. What is the potential energy of the particle?
4. The force with components (-7, 4,-5) acts at the point (2, 4,-3) .What is the value of torque with respect to the origin exerted by this force?
5. What is the value of the coefficient of restitution 'e' for a perfectly elastic collision?
6. Three particles of masses 3g, 5g and 2g are located respectively at (1,0,-1), (-2,1,3) and (3,-1,1). What is the location of their center of mass?
7. Will the position of center of mass change in (i) inertial frame (ii) non-inertial frame?
8. Does collision necessarily mean physical contact of the colliding particles?
9. If the kinetic energy of a system of particles about the origin is equal to its kinetic energy about the centre of mass, what is the position of the centre of mass?
10. Right bank of rivers is found in both the hemispheres to be eroded more than the left bank, why?

Short answer type question: (For 5 marks)

1. Find the expression for the velocity and acceleration of a particle in plane polar co-ordinates.
2. Write down the Galilean transformation and show that Newton's 2nd law is form-invariant Under Galilean transformation.
3. (i)Define the term angular momentum. Show that the angular momentum of a single particle is invariant. (ii)What is conservative force? Show that if line integral of a vector **F** vanishes over a closed path, the vector can be written as gradient of a scalar function, called potential.
4. Show that a particle moving in conservative field of force moves such that the sum of potential and kinetic energies remain constant.

5. Prove that the total K.E of a system of particles is equal to the K.E of the centre of mass +The K.E of the particles with respect to the C.M
6. Explain the laboratory frame and the centre of mass frame. What is the relation between the recoil angle in the C.M frame and the laboratory frame?
7. Show that the K.Es of two colliding particles in the C.M frame is inversely proportional to their masses.
8. Two particles of mass m_1 and m_2 were travelling in the same line with velocities v_1 and v_2 respectively. Find out the loss in the total K.E if they collide perfectly inelastically.
9. In the case of rocket motion, show that the greater the ratio m_f/m_v , the greater is the maximum speed attained by the rocket, where m_f is the mass of the fuel at t=0 and m_v the mass of the vehicle.
10. Two rods, each of proper length l_0, move lengthwise towards each other parallel to the common axis with the same speed v relative to the laboratory frame. Show that the length of each rod in the reference frame fixed to the other rod is $l = l_o\left(\frac{1-\beta^2}{1+\beta^2}\right)$, where β=v/c.
11. Show that: $E^2 = p^2c^2 + (m_0c^2)^2$, where the symbols have their usual meaning.
12. A particle of mass 0.01 kg is subjected to a restoring force 0.5 N/m, a damping force 10^{-4} kg/s, and an external sinusoidal force of constant amplitude. For what frequency of the driving force is velocity resonance achieved? Calculate the Q-factor and the bandwidth of resonance.
13. 24) Show that the rest mass of a particle moving with the speed of light is zero. Find the mass and momentum of a photon.
14. A plane electromagnetic wave propagates in a medium which moves with velocity v relative to a reference frame S. Find the velocity of the wave in the frame S, given that the refractive index of the medium is n. What will be the result when $\ll c$?
15. Write a short note on transverse Doppler effect.
16. Derive the velocity addition formula from the Lorentz transformation equations for a frame S' moving with velocity v with respect to a frame S.
17. The equation of forced vibration of a resonant system is given as: $5\ddot{x} + 8\dot{x} + 3x = 6\sin 2t$. What is the Q-factor of the system?

Broad answer type question: (For 10 marks)

1. (a) Derive an expression for the average power supplied by the sinusoidal force driving a mechanical oscillator over a complete cycle in a steady state and show that in the steady state, the time-averaged input power equals the time averaged power dissipated through friction.

(b) A vibrator of mass 1g is acted upon by a restoring force of 10^7 dyne/cm, a retarding force of $4x10^3$ dynes/cm, and a driving force of $10^7\cos\omega t$ dyne. Find the maximum possible amplitude.

4+4+2=10

2. (a) Set up the differential equation of motion of a simple harmonic oscillator subjected to a damping force and an external simple harmonic force.

(b) Obtain expressions for the amplitude and the phase angle of the displacement in the steady state.

(c) A mass of 10g is acted on by a restoring force 5 dyne/cm and a resistance 2 dyne-sec/cm. Find out whether the motion is oscillatory or aperiodic. 3+4+3=10

3. (a) The differential equation for a one dimensional damped harmonic oscillator is

$$m\frac{d^2x}{dt^2} + k\frac{dx}{dt} + sx = 0$$

Explain the significance of each term in the equation. Solve the equation in the case of critical damping.

(b) What are half-power frequencies? How are they related to sharpness of resonance? Show that the resonance frequency is the geometric mean between the half-power frequencies.

(2+3)+(1+2+2)=10

4. (a) Using Lorentz transformation, obtain the law of velocity addition. Using this law, show that a photon moving with velocity 'c' in one frame of reference 'S_0', will appear to move with the same velocity 'c' in another frame of reference 'S', which is moving with a constant velocity relative to 'S_0'.

(b) A rigid rod of length l_0 is moving with a velocity 0.8c in a direction at 30^0 to its own length. Find the length of the rod in motion and its inclination with the x axis in the S-frame.

(c) Prove the invariance, under Lorentz transformation, of d'Alembertian $\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$

3+2+3+2=10

5. (a) Deduce the expression for the torsional rigidity of a specimen in the form of a large cylindrical shell of inner and outer radii r_1 and r_2.

(b) Derive the Poiseuille's formula for the steady flow for the incompressible viscous liquid through a horizontal capillary of uniforn cross section.

5+5=10

6. (a) Obtain the expression for the centrifugal and corioli's force experienced in a coordinate frame rotating with constant angular velocity.

(b) Show that a particle, projected vertically upward from a point on the earth's surface at a northern latitude λ strikes the ground at a point $\frac{4}{3}\omega \cos\lambda \sqrt{8h^3/g}$ to the west. Neglect air resistance and consider only small vertical heights. Under what conditions is corioli's force equals to zero or maximum? 3+5+2=10

7. (a) State the postulates of Einstein's special theory of relativity. On the basis of special theory of relativity derive the Lorentz transformation relation.

(b) Prove the invariance, under Lorentz transformation, of the differential expression $dx^2+dy^2+dz^2-c^2dt^2$.

(c) Calculate the distance traversed by a particle during one mean life if it travels with a speed of 2.22×10^{10} cm/s. (Given proper mean life $=2.5\times10^{-8}$s.) (2+3)+3+2=10

GE1/3-PHYSICS
Mechanics
Sample Questions

Short Question (1 marks each)

1. Draw the stress vs. strain curve and indicate the elastic limit.
1. A cable of length *l* is cut into two equal halves, each of length *l/2*. Will it have any effect on the maximum load the cable can support?
2. Indicate the type of electricity involved in the following (a) a gas, (b) a liquid and (c) a wire on being pulled at the end.
3. Show that the if Young's Modulus of a material is equal to the stress then the length *l* of a wire of the material increases to 2*l*.
4. Show that for a homogeneous, isotropic, deformable, elastic body $\frac{dV}{V} = \frac{dl}{l}(1 - 2\sigma)$.
5. What do you mean by axial modulus? How it differs from Young's modulus?
6. What do you mean by torsion of a cylinder?
7. Explain what you mean by couple per unit twist of a cylinder.
8. Write the relation between Y and α.
9. Can Poisson's ratio be regarded as elastic modulus?
10. Write the dimensional formula of Bulk modulus.
11. What is time integral of a force?
12. Explain what do mean by central force.
13. What do you mean by gravitational potential and intensity?
14. At which point the gravitational potential is maximum?
15. What do you mean by Coriolis force?
16. If, T be the time period of a satellite, then what is the relation between kinetic energy E and T?
17. Is escape velocity same for heavy and light objects?
18. What is the Geo-stationery/Geosynchronous satellite?
19. What is conservative force?
20. Is the central force is a conservative one?—Explain
21. Show that the angular momentum remains constant in case of central force.
22. Show that the equation of motion of rocket motion in vertically upward is $M\frac{dv}{dt} = u\frac{dM}{dt}$, where *M*= mass of rocket, *u*=emptied gas motion.
23. What is difference between periodic motion and simple harmonic motion?
24. Mention some example of simple harmonic motion.
25. A piece of wood is floating in water. It is slightly dipped in water and then released. It executes S.H.M. What is its time-period?
26. What is damped oscillation?
27. Write down the expression of damped oscillation.

28. The equation of simple harmonic motion is given by, $x = 10\sin(60\pi t - 0.4\pi)$ cm. Find the amplitude of the oscillation, time period, frequency.
29. Why Michelson and Morley performed their famous experiments?
30. What is radius of gyration?
31. What do you mean by the 'centers of mass of a system of particle?
32. Explain the concept of 'ether'
33. Explain the negative result of Michelson-Morley experiment.
34. Give the postulates of Special Theory of Relativity.
35. What was the reason behind making two postulates by Einstein?
36. Write down the 'Lorentz transformations'.
37. What do you understand by 'Simultaneity?
38. Write down the Galilean transformation formulae.
39. What are 'space-like' and 'time-like' interval?
40. Fill in the blanks
    (i) All clocks on the spaceship will run slower than stationery clock by a factor of _____, where c is the speed of light in free space.
    (ii) All objects on the spaceship have _____ in length in the direction of relative motion by a factor _____.
    (iii) The masses of spaceship and of all bodies within it are larger than when the ship is at rest by a factor _____.
    (iv) The speed of a material object can never exceed _____.
41. State length contraction equation in terms of Lorentz transformation equation.
42. What is rest mass energy?
43. State the total energy of a moving body according to the theory of relativity.
44. Can the velocity of a body be more than the velocity of light?

Descriptive Question (5 marks each)

1. Find the moment of inertia about an axis passing through the centre of gravity of the cylinder and perpendicular to its length.
2. Find the moment of inertia of a solid sphere about its diameter.
3. Find the relation between torque and angular momentum.
4. Find the acceleration of a symmetric body rolling down an inclined plane without slipping.
5. Find the value of Pseudo force of a particle on an accelerated frame of reference.
6. Three particles of masses 4 gm, 3 gm and 2 gm are at the points (2,0,-1), (1,1,3) and (3, -1, 0) respectively. Find the co-ordinate of the center of masses.
7. Explain what would be the effect of temperature on elastic moduli of a material.
8. What are the limiting values of Poisson's ratio? What will happen if σ be negative? What is the value of σ for a liquid?
9. Prove that Young's modulus Y, the bulk modulus K, the modulus of rigidity n and Poisson's ratio σ satisfy the relations-

$\frac{Y}{2\eta} = 1 + \sigma$; (ii) $\frac{Y}{2K} = 1 - 2\sigma$;

10. Show that the strain energy in case of stretching of a wire can be expressed as

$$W = \frac{1}{2} \times Stress \times Strain$$

11. Find the torsional rigidity of a cylinder or wire.
12. Deduce Newton's law of gravitation from Kepler's law.
13. Deduce an expression of gravitational potential and intensity at a point inside a solid sphere.
14. Define pseudo force in case of moving frame of reference.

15. Find the effect of Coriolis force on a particle falling freely on the surface of the earth.
16. Find the orbital velocity of Geo-stationery satellite.
17. Prove that if a number of rods of torsional rigidities $\tau_1, \tau_2, \ldots$.etc. are joined end to end, the torsional rigidity of the combination τ is given by $\frac{1}{\tau} = \sum \frac{1}{\tau_i}$.
18. A suspension thread of length $2l$ consists of a wire of length l and radius r, joined to a second wire of equal length, radius $2r$ and of similar material. The top end is clamped while the lower end is twisted. Find (i) the torsional rigidity of the complete suspension thread and (ii) the ratio of the relative angles of twist between the ends of the two parts.
19. Show that average kinetic energy and average potential energy are half of the total energy.
20. Write down the differential equation for the damped natural oscillations of a system from the energy principle and solve it. Gove the condition for over damped.
21. Determine the time average of potential and kinetic energy of a particle executing simple harmonic motion.
22. State and explain the basic postulates of the special relativity and obtain a set of transformation equations which satisfy the postulates.
23. On the basis of Lorentz transformations, discuss the following kinematical effects: (i) length contraction, (ii) time dilation.
24. Using velocity addition theorem show that it is impossible to obtain a velocity of a particle greater than that of light.
25. A body appears to be spherical to an observer at rest relative to it. Show that to a moving observer it will appear to be an oblate spheroid.
26. The half-life of a particle as measured in the lab is $4.0 \times 10^{-8} s$ when its speed is $0.80c$. Find its actual life time.
27. Establish the relation showing the variation of mass with velocity.
28. Deduce the Einstein's mass-energy equivalence relation and indicate the role it plays in the development of atomic energy.
29. Show that if T is the kinetic energy of a particle and p its momentum, its rest mass is given by $m_0 = (p^2c^2 - T^2)/2Tc^2$.
30. How fast a meter stick should be moving past us if we are to conclude that it has a length of 0.5 m? At what speed must a body travel if its mass is to be doubled?
31. Two photons approach each other. What is their relative velocity?
32. Show that $E^2 = p^2c^2 + m_0^2c^4$, when the symbols have their usual significance.
33. Describe the length contraction phenomenon in the light of special theory of relativity.
34. What is Twin Paradox?
35. Show that the expression of relativistic kinetic energy of an object reduces to the classical expression at low speed.

Descriptive Question (10 marks each)

1. (a) Show that the total energy of a particle of mass m acted upon by a central force is given by

$$E = \frac{h^2}{2m}[u^2 + \left(\frac{du}{d\theta}\right)^2] + V(r)$$

Where V(r) is the potential energy and h is the angular momentum of the body, $u = \frac{1}{r}, r \text{ and } \theta$ being the polar coordinator of the particle.

(b) Find the components of velocity and acceleration of a particle moving on a plane along radial and transverse direction. 5+5

2. (a) Prove that: $\chi = K + \frac{4}{3}\eta$

(b) Prove that : $\frac{3}{Y} + \frac{1}{K} = \frac{9}{Y}$; 5+5

3. Derive the equations of Lorentz transformation and deduce the complete relation for the addition of velocities. 10

4. (a) Establish the relation showing the variation of mass with velocity.

(b) Show that the momentum P and the kinetic energy T of a particle of rest mass m_0 are connected by the relation, $p^2c^2 = 2Tm_0c^2 + T^2$. 5+5

5. (a) Prove that under Lorentz transformation the four dimensional volume element '*dxdydzdt*' is invariant. (b) Show that under Lorentz transformation the quantity '$dx^2 + dy^2 + dz^2 - c^2dt^2$' remains invariant. (c) Deduce Einstein's velocity addition theorem using Lorentz transformation equation.

3+3+4

6. (a) Deduce equation of a simple harmonic motion from the definition. (b) Obtain expression of Potential energy, kinetic energy, and total energy. Draw curve and show that sum of P.E. and K.E. remains constant.

5+5

GE2/4-PHYSICS
Thermal Physics
Sample Questions

Short questions (Marks 1):

1. Give reasons whether an electric capacitor is a thermodynamic system or not.
2. The density of H_2 gas at N. T. P is 8×10^{-5} g/cc. Calculate the r.m.s velocity of H_2 molecules.
3. Can Carnot engine functions as a heat pump?
4. What is quasi static process? Give example.
5. What are the units of reduce volume and reduce pressure?
6. Prove that $\left(\frac{\partial P}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial P}{\partial T}\right)_V$.
7. State how viscosity of gas and thermal conductivity arerelated.
8. How does viscosity of gas very with temperature.
9. Give Kelvin-Planck's statement of second law of thermodynamics and explain the law with example.
10. What is isothermal process? Derive expression of work done for such process.

Medium questions (Marks 5):

1. From the four thermodynamics potentials, establish the Maxwell's four thermodynamical relations.
2. What is Brownian motion? Give the essential features of the motion. Write down the Einstein's equation for Brownian motion.
3. What do you mean by collision probability? Show that the probability of a gas molecule traversing a distance x, without collision is $e^{-x/\lambda}$ where λ is the mean free path of the gas molecule.
4. Write down the relation between entropy and unavailable energy in an irreversible process.
5. Find the increase of entropy when 1 kg of water at 273K is mixed with 1 kg of water at 373K. Given that the specific heat of water is 4.2×10^3 J/kg/°C.
6. Prove that maximum number of phases that can co-exist in equilibrium is 3 for an one component pVT system.
7. Explain the principle of refrigerator. How does it differ from a heat engine?
8. What is adiabatic process? Derive expression of work done for such process.
9. What do mean internal energy of an ideal gas and a real gas? Does it depend upon volume and temperature of a gas?
10. Calculate the work done, when 1 mole of a perfect gas is compressed adiabatically. The initial pressure and volume of the gas are 10^5 N/m^2 and 6 liters respectively. The final volume of the gas is 2 liters. Molar specific heat of the gas at constant volume is 3R/2.

Broad questions (Marks 10):

1. Represent the Carnot cycle on (i) P-V diagram, (ii) S-T diagram and hence find the efficiency of a Carnot Cycle.
2. Show that for an irreversible process, the net change of entropy will be positive.

3. A reversible engine converts $\frac{1}{6}$ th of the heat inputinto the work. If the temperature of the sink is reduced by 62˚C, its efficiency is doubled. Find the temperature of the source and the sink.

4. Why $C_p > C_v$? Explain it physically.

5. Show that for a Carnot engine, efficiency $\eta = 1 - \frac{T_2}{T_1}$, where $T_2 < T_1$. Where T_1 is the temperature of the source and T_2 is the temperature of the sink.

6. What is Joule-Thompson effect? Explain.

7. What is Clausius-Clapeyron equation? Explain.

8. What is Rayleigh-Jeans law for radiation? Explain.

9. What are Stefan-Boltzmann law and Wien's displacement law?

CC3-PHYSICS

ELECTRICITY AND MAGNETISM
Sample Questions

1. Short Answer type questions (of 1 marks)

(a) What happens when an electric dipole is placed in a (i) uniform, (ii) non-uniform electric field?

(b) What is the physical significance of $\nabla \cdot B = 0$?

(c) Draw the hysteresis curves for materials suitable to use (i) in a transformer, (ii) as a permanent magnet.

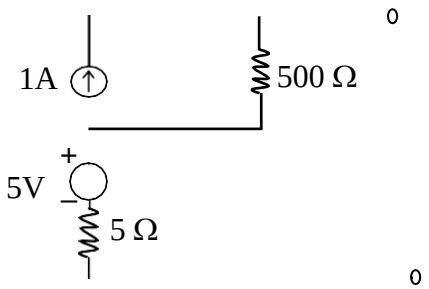
(d) If the resistance of a series L-C-R circuit is doubled, what is the effect on the Q-factor and band-width of the circuit?

(e) Is the equation $\vec{\nabla} \cdot D = \rho_{free}$ sufficient to determine D in a dielectric medium?

(f) Express Faraday's law of electromagnetic induction in its differential form.

(g) The electric main in a house is marked 220 Volt - 50 Hz. Write down the equation for the instantaneous voltage.

(h) Find out the nature of the resultant energy source for the following combination and determine the corresponding value(s):



Medium Answer type questions (of marks 5)

2. Consider a spherical charge distribution of radius '*a*' with a volume charge density:

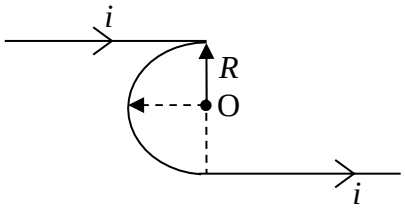
$$\rho(r) = \rho_0 \frac{a}{r} \quad \text{for} \quad 0 \le r \le a$$
$$= 0 \quad \text{for} \quad r > a$$

(a) Find out the electric field at any point outside and inside the charge distribution. 2

(b) Show that the total electrostatic energy of the system is $\frac{Q^2}{6\pi\varepsilon_0 a}$, where Q is the total charge of the distribution. 3

3. (a) Using the concept of magnetic vector potential, obtain the Biot-Savart's law. 3

(b) Find out the magnetic field at the point O due to the flow of electric current '*I*' in the wire having straight and semicircular portion as shown in the figure. 2



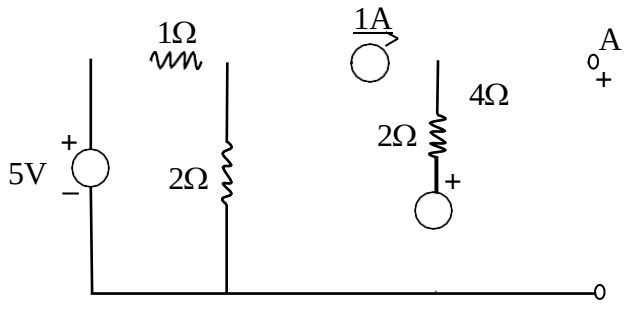
4. (a) Distinguish between free and bound current. 2

(b) A circular loop described by $x^2 + y^2 = 1$ is located in the X-Y plane with its centre at the origin. If a magnetic field $\vec{B} = z\sqrt{x^2 + y^2}\cos(\omega t)$ is applied, what would be the e.m.f. induced in the loop? 3

5. Write down the Maxwell's equations in connection with electromagnetism and explain their physical significances. 2+3

6. (a) State Thevenin's theorem. 1

(b) What load resistance should be connected accross the terminal A, B of the following network to obtain maximum power? 4




10V
B

GROUP-C

Broad Answer type questions (10 marks)

7. (a) A point charge 'q' is placed in front of an earthed conducting sphere of radius 'R'. Determine, using the method of images, the electric potential at a point outside the sphere. 5

   (b) Calculate the total charge enclosed in a sphere of radius 'R' placed in a region of space where the electric field is given by $E = kr^3\hat{r}$, where k is a constant and r is measured from the origin that coincides with the centre of the sphere. 3

   (c) Find out the electric field very close to a charged conducting plane with local surface charge density σ. 2

8. (a) Show that the field due to a dipole of moment p at a distance r (from charge $-q$) is given by, 5

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\left[\frac{3(\vec{p}.\vec{r})\vec{r}}{r^5} - \frac{p}{r^3}\right]$$

   (b) What is Lorentz force? Can a magnetic field, alone, do any work on a moving charge? 1+1=2

   (c) A proton at a distance 10 cm from a long straight wire carrying current 1A, is moving parallel to the direction of current flow with speed 0.6c. Calculate the force on the proton (c is the velocity of light in free space). 3

9. (a) What is meant by electrical resonance and how it can be explained in a series L-C-R circuit? 1+3

   (b) Explain the meaning of "acceptor circuit" and "rejector circuit". Under which condition a series LCR circuit can be used as a rejector circuit? — Explain. 2+2

   (c) What is quality factor for an A.C. circuit? Explain its physical significances. 1+1

10. (a) Prove that the torque acting on a current loop placed in a uniform magnetic field is independent of the shape of the loop. 5

    (b) Show that the self inductance per unit length for a straight wire is given by $L = \frac{\mu_0}{8\pi}$. 5

CC4-PHYSICS

WAVES AND OPTICS
Sample Questions

1. Short Answer type questions (of 1 marks)

(a) Does the function $\psi(x, t) = A(x - vt)$ represent a wave? A is constant. Explain your answer.

(b) What will be the effect on the interference fringes if one half of a biprism is covered?

(c) What will be the frequency ratio of the Lissajous figure on an oscilloscope with a pattern similar to "8"?

(d) A progressive harmonic wave is represented by $y(x, t) = a\sin(0.5x - 10t)$, obtain the wave velocity.

(e) Two wires of same material and same diameter have lengths in the ratio 2:3, and tensions in the ratio 16:9. What will be the ratio of the frequency of the emitted fundamental tones?

(f) How does the amplitude of a spherical wave fall off with distance 'r' from the centre of the sphere?

(g) What will be the intensity of light at maxima when the light from two Coherent sources of the same intensity I interfere?

(h) How would the intensity of the central maxima change in a single slit diffraction experiment if the slit width is made double?

GROUP-B

Medium Answer type questions (of marks 5)

2. (a) A wave is represented by $\psi_1 = 10\cos(5x + 25t)$. A second wave $\psi_2 = 20\cos(5x + 25t + \frac{\pi}{3})$ interferes with the first wave. Deduce the amplitude and phase of the resultant wave. 3

(b) Calculate the velocity of sound in a gas in which the waves of wavelength 0.50 m and 0.505 m produce 6 beats per second. 2

3. (a) How will you test the flatness of a surface by interference? 2

(b) What is meant by group velocity? 1

(c) Two sinusoidal waves $y_1 = 0.03 \sin(7t - 10x)$ m, $y_2 = 0.03 \sin(5t - 8x)$ m are superimposed on each other. Calculate the phase velocity of the resultant wave. 2

4. (a) What is a wavefront? What are the nature of sources that produce spherical and cylindrical wave fronts? Write down the expression for the wave function for the cylindrical waves. 1+1+1=3

(b) Distinguish between Fraunhöfer and Fresnel diffraction. 2

5. (a) What do you understand by "temporal-coherence" and "spatial coherence"? 2

(b) Explain the following terms: 3

(i) Fringes of equal inclination

(ii) Fringes of equal thickness.

6. (a) Explain why the central fringe is black in a Lloyd's mirror experiment? 2

(b) A diffraction grating 2 cm wide is just able to resolve the sodium D-lines in second order. Find out the number of rullings per mm. 3

GROUP-C

Broad Answer type questions (10 marks)

7. (a) Obtain an expression for the velocity of a plane longitudinal wave in a fluid medium. Hence show that the velocity of sound in air is given by $\sqrt{\frac{\gamma P}{\rho}}$. Where P is the pressure and the density of the fluid. 4+2=6

(b) Express the intensity of sound in dB. What is the absolute intensity of a 60 dB sound if the standard intensity is 10^{-12} W/m^2 ? 2+2=4

8. (a) For a struck string, the displacement at a point 'x' and at time t can be represented by a superposition of harmonics, denoted by "s", as follows: 5

$$y(x, t) = A \sum_{s=1, 2, \ldots} \frac{1}{s} \sin \frac{s\pi a}{l} \sin \frac{s\pi x}{l} \sin \frac{s\pi ct}{l}$$

Where l is the length of the string, a is the point of striking, A is a constant and c the velocity of the transverse wave through the string. Find out the nodal points of the s-th harmonic. Show that if the point of striking coincides with any of the nodal points of the s-th harmonic, it will be absent from the vibration.

(b) Show that the energy of vibration of a stretched string for a given mode is proportional to the square of the eigen-frequency and the square of the amplitude 3

of the mode.

(c) What do you mean by Ripple and Gravity wave? 2

9. (a) What is Huygens's principle? 2

(b) Find out an expression for the fringe-width in case of Young's double slit experiment. 3

(c) Why are the fringes in Newton's ring arrangement circular and in an air-wedge straight and parallel? 2

(d) Suppose that in a Newton's rings arrangement, the incident light consists of two closely spaced wavelengths ($\lambda_1 = 5890$ Å; $\lambda_2 = 5896$ Å). The radius of curvature of the curved surface is 100 cm. Calculate the distance (from the point of contact of the plano-convex lens and the plane glass plate) at which rings will disappear. 3

10.(a) Explain the rectilinear propagation of light on the basis of Fresnel's half-period zones. 3

(b) Explain how circular fringes are produced in a Michelson's interferometer. 4

(c) The radius of the 8th circular zone in a zone plate is 4.5 mm. Find out its focal length to a light of wavelength 650 nm. Also, find the position of the image for a point source 7.788 m from the plate. 3

GE2A & GE2B-PHYSICS

GE2A

Electricity and Magnetism

Sample Questions

Short Answer type questions (of 1 marks)

1. Find a vector perpendicular to the surface $x^2 + y^2 - z^2 = 11$ at the point (4, 2, 3). 1

2. If the electric field at a point is zero, should the potential at the point be zero? 1

3. What do you mean by electric flux through a surface placed in the electric field? 1

4. What is equation of continuity of current? 1

5. What is the difference between polarisation vector and displacement vector? 1

6. What is magnetic shell? 1

7. Write the Maxwell equation which indicates the absence of magnetic monopole. 1

8. What does Poynting vector represent? 1

GROUP-B

Medium Answer type questions (of 5 marks)

9. (a) Prove that $\nabla r^n = n r^{n-2} \vec{r}$ where, $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$. 3

   (b) What is conservative field? Give an example of such a field. 1+1

10.(a) State Gauss' theorem in electrostatics and deduce its differential form. 1+2

(b) Using Gauss' theorem find electric field at a point outside the surface of a uniformly charged spherical shell. 2

11.(a) State and explain Ampere's circuital law. 2

(b) Electric potential function in a field is given by $V = 2x + 4y$ volt in free space. Find the energy density of the field at the origin. 3

12.(a) State and explain Faraday's laws of electromagnetic induction. 2

(b) Show that the energy required to build up a current I in a circuit of self inductance L is $\frac{1}{2}LI^2$. 3

13.(a) Write down Maxwell's equations in electromagnetic theory. 2

(b) If a 500 watt LASER beam is concentrated by a lens into a cross-sectional area of 10^{-10}m^2, find the magnitude of Poynting vector and the amplitude of electric field. Given $\varepsilon_0 = 9\times10^{-12}$ SI unit. 3

GROUP-C

Broad Answer type questions (of 10 marks)

14.(a) Prove that $\nabla\cdot(\phi A) = \phi\,\nabla\cdot A + A\cdot(\nabla\phi)$, where ϕ is a scalar function. 3

(b) Evaluate $\iint \vec{r}\cdot\hat{n}\,ds$ over the unit cube defined by $x=0,\ y=0,\ z=0$ and $x=1,\ y=1,\ z=1$. 4

(c) Prove that the divergence of a curl of a vector is always zero. 3

15.(a) Define E, D and P. Establish the relation $D = \varepsilon_0 E + P$, where the symbols have their usual meaning. 3+2

(b) Find the expression for the capacity of a spherical condenser where the inner sphere of radius r_1 is charged and the outer sphere of radius r_2 is earth-connected. 5

16.(a) State and explain Biot-Savart law. Apply the law to find the magnetic field due to a circular current carrying loop at an axial point. 2+4

(b) An infinitely long solenoid of radius '*a*' having *n* number of turns per unit length carries a current *I*. Find the magnetic vector potential at a distance *r* ($r > a$) from the axis of the solenoid. 4

17.(a) A magnetic field of $1.6\times10^{-3}\,\text{Am}^{-1}$ produces a flux of 2.4×10^{-5} Wb in a bar of 3

iron of cross-section 0.2 cm^2. Find the permeability and susceptibility of the specimen.

(b) Obtain an expression for energy stored in a magnetic field. 3

(c) Show from Maxwell's equation that velocity of a plane electromagnetic wave in an isotropic dielectric medium is, $v = \frac{c}{\sqrt{K}}$ where is dielectric constant of the medium. 4

GE2B

Waves and Optics

GROUP-A

Short Answer type questions (of 1 marks)

1. What do you mean by sharpness of resonance? 1

2. Can our eye distinguish between polarised and unpolarised lights? 1

3. If path difference between two waves be $\frac{3\lambda}{2}$. What will be their phase difference? 1

4. What is the intensity of 60 dB sound? 1

5. What are beats? 1

6. Give the difference between interference and diffraction. 1

7. The angular frequency of deep water waves varies as the inverse square root of wavelength λ. What is the relation between group velocity v_g and phase velocity v_p? 1

8. State the factors on which speed of transverse wave in a string depends? 1

GROUP-B

Medium Answer type questions (of 5 marks)

9. (a) A particle is subjected simultaneously to two Harmonic oscillations of the same period but of different amplitudes and phases in perpendicular directions. Find the expression for the resultant motion. 3

   (b) For what condition the path may be a straight line? 2

10. (a) Is it possible to observe interference fringes with light emanating from two independent sources? If not why? 2

    (b) Two coherent sources are 0.18 mm apart and the fringes are observed on a screen 80 cm away. It is found that, with a certain monochromatic source of light, the fourth bright fringe is situated at a distance of 10.8 mm from the central fringe. Calculate the wavelength of light. 3

11. (a) What are Lissajous figures? 1

    (b) Define bel and phon. 2

    (c) Calculate the number of beats heard per second produced by two waves 2

$y_1 = 2\sin 1000\pi t$ and $y_2 = 2\sin 988\pi t$.

12.(a) What is a quarter waveplate? 1

(b) What is the nature of emergent polarised light when circularly polarised light is passed through 1+1

(i) a quarter waveplate,

(ii) a half waveplate.

(c) Plane polarised light is converted into circularly polarised light after passing through a slice of crystal. What is the minimum thickness of the crystal if the difference in refractive index of the two rays in the crystal is 0.005 and wavelength of light is 6000Å? 2

13.(a) Define grating element. 1

(b) What are ghost line in grating spectra? 1

(c) A grating 4000 slits per cm is illuminated with a monochromatic light and produces the second order bright line at a 30° angle. What is the wavelength of light used? 3

GROUP-C

Broad Answer type questions (of 10 marks)

14.(a) What is a forced oscillator? Derive differential equation of a forced oscillator. State the condition for resonance. 1+3+2

(b) Find the energy density of progressive wave and intensity of the wave from it. 4

15.(a) What is a zone-plate? Derive an expression for its focal length. 1+5

(b) Show that a zone-plate has multiple foci. 4

16.(a) Prove that in Newton's rings experiment, diameter of dark rings are proportional to square root of natural integral numbers. 2

(b) What will happen in Newton's ring experiment if the glass plate is replaced by plane mirror? 2

(c) In a Newton's ring experiment the diameter of the 15^{th} ring was found to be 0.59 cm and that of the 5^{th} ring was 0.336 cm. If the radius of the plane convex lens is 100 cm, calculate the wavelength of light used. 4

(d) The central fringe of Newton's ring is dark. In the case of white light, the fringes are coloured. Why? 2

17.(a) Define 'reverberation' and 'standard time of reverberation'. What are the conditions to be satisfied for an acoustically acceptable auditorium? 2+3

(b) The stationary waves on a string is represented by 5

$$y(x, t) = 0.15 \sin 5x \cos 300t \text{ m}$$

Find the amplitude of vibration at the antinode, distance between consecutive nodes, wavelength, frequency and the speed of the wave.

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CC5-PHYSICS
Mathematical Physics-II

Short Answer type questions (of 1 marks)

1. Answer any ***five*** questions from the following:

   (a) If the Fourier series expansion of a function $f(x)$, contains only sine terms, what kind of function is $f(x)$?

   (b) Illustrate orthogonality of sine and cosine functions.

   (c) What do you mean by cyclic co-ordinates?

   (d) Evaluate $\Gamma(1)$.

   (e) Is the differential equation $x\frac{\partial f(x,y)}{\partial x} + y\frac{\partial f(x,y)}{\partial y} = 0$; linear or non-linear?

   (f) Write down the orthogonal condition of Bessel's Polynomials.

   (g) Write down the general form of second order linear homogeneous differential equation.

   (h) For what value of n, $\int_{-1}^{+1} P_n(x)\,dx = 2$.

GROUP-B

Medium Answer type questions (of 5 marks)

2. (a) Show that the relation between Beta and Gamma function is $\beta(x,y) = \frac{\Gamma(x)\,\Gamma(y)}{\Gamma(x+y)}$. 3

   (b) Evaluate, $\int_0^{\infty} x^4 e^{-x^2}\,dx$. 2

3. Using Euler-Lagrange equation, prove that the shortest distance between two points is a straight line. 5

4. (a) Express the function $f(x) = 4x^3 + 6x^2 + 7x + 2$ in terms of Legendre's Polynomials. 3

(b) Show that, $P_n(-x) = (-1)^n P_n(x)$. 2

5. Show that, $J_{1/2}(x) = \left(\frac{2}{x\pi}\right)^{1/2} \sin(x)$. 5

6. Find the solution to the following differential equation using separation of variables method. 5

$$\frac{\partial}{\partial r}\left(r^2 \frac{\partial U}{\partial r}\right) + \frac{1}{\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial U}{\partial \theta}\right) = 0$$

GROUP-C

Broad Answer type questions (of 10 marks)

7. (a) What do you mean by non-periodic function? Give an example. 2

(b) Write down the Dirichlet conditions in connection with Fourier Series. 2

(c) Sketch the function $f(x) = |x|$ between –1 to +1 and find the Fourier Series of the function in the same interval. 2+4

8. (a) Examine the singularities for the following differential equation 3

$$\frac{d^2y}{dx^2} + \frac{1}{x}\frac{dy}{dx} - \frac{1}{x^2}y = 0$$

(b) Solve the differential equation by power series method, $x\frac{d^2y}{dx^2} + 3\frac{dy}{dx} + 4x^3 y = 0$. 7

9. (a) A bead slides without friction on a wire which is rotating with angular velocity ω, in the force free space. Write down the Lagrange's equation of motion and explain the results. 3

(b) Starting from the generating function prove the recurrence relation $J_{n+1}(x) = \frac{2n}{x} J_n(x) - J_{n-1}(x)$. 5

(c) Show that $H_n(0) = \frac{(-1)^{n/2} n!}{(n/2)!}$. 2

10. (a) Obtain the Rodrigues formula for Legendre's Polynomial $P_n(x)$. 6

(b) Using Rodrigues formula prove that integers and $m < n$. 4

$\int_{-1} x^m P_n(x)\,dx = 0$, where m, n are positive

CC6-PHYSICS

Thermal Physics and Statistical Mechanics

1. **Short Answer type questions (of 1 marks)**

(a) What is extensive and intensive thermodynamic variables? Give examples. 1

(b) A volume of a gas expands isothermally to four times its initial volume. Find the change in entropy in terms of gas constant (R). 1

(c) Explain clearly the meaning of a 'quasistatic' process. 1

(d) Calculate the specific heat of saturated steam, given that the specific heat of water at 100°C = 1.01 and latent heat of vaporization decreases with increase in temperature at the rate of 0.64 cal/K. Latent heat of evaporation is 540 cal/gm. 1

(e) Prove that maximum number of phases that can co-exist in equilibrium is 3 for a one-component pVT-system. 1

(f) At what temperature will the r.m.s. velocity of a gas be half its value at 0°C? 1

(g) Are the van der Waals' constants really constant? 1

(h) What do you mean by 'mean free path'? 1

GROUP-B

Medium Answer type questions (of 5 marks)

1. (a) Explain what do you mean by 'reversible' and 'irreversible' process? 2

(b) Find an expression for Work done in an adiabatic process. 3

2. (a) Discuss physical significance of entropy. 2

(b) Calculate the change in entropy when 10 gm of water at 60°C is mixed with 30 gm of water at 20°C. 3

3. (a) Show that at critical temperature the departure of the van der Waals gas law from that of the perfect gas $\frac{P_c V_c}{T_c} = R$ measures 62.5%. 2

(b) The velocity distribution function of a group of N particles is given by 3

$dN_v = Kv\,dv$ for $0 \le v \le V$

$= 0$ for $v > N$

Calculate

(i) the constant K in terms of N and V

(ii) mean velocity of the particles

(iii) r.m.s. velocity of the particles.

4. (a) From thermodynamic consideration deduce the relation $\frac{dL}{dT} = \frac{L}{T^2} + C_2 - C_1$, where C_2 is the specific heat of saturated vapour and C_1 is the specific heat of liquid. 3

(b) Hence show that specific heat of saturated steam is negative. 2

5. (a) What are transport phenomena? 2

(b) Explain in brief the viscosity, conductivity and self-diffusion on the basis of kinetic theory of gases. 3

GROUP-C

Broad Answer type questions (of 10 marks)

6. (a) Prove that no engine can be more efficient than a reversible engine working between the same temperatures and all reversible engines working between the same two temperatures have the same efficiency. 3+1=4

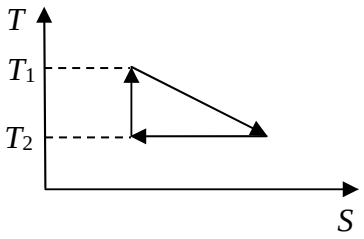
(b) Show that for van der Waals gas, $C_p - C_v = R\left(1 + \frac{2a}{RTV}\right)$. 3

(c) A Carnot's engine absorps 10^4 calories of heat from a reservoir at 627°C and rejects heat to a sink at 27°C. What is its efficiency? How much work does it perform? 1+2=3

7. (a) State Principle of equipartition of energy. 2

(b) Show that the average kinetic energy per molecule of a perfect gas per degrees of freedom is $\frac{1}{2}KT$. 4

(c) Compare the efficiency of the cycle of the figure below 4



8. (a) Assuming Maxwell's velocity distribution of molecules of a gas derive Maxwell's energy distribution law. 3

(b) Derive an expression for mean free path for a Maxwellian gas. 4

(c) If the mean free path of the molecules of a certain gas is 10^{-6} cm and the mean speed is 500 m/sec, estimate the average number of collisions made by a molecule per second. 3

10.(a) With necessary diagram explain the principle of cooling of a paramagnetic substance by adiabatic demagnetisation. Derive an expression for the amount of cooling. 3+3=6

(b) Show that $U = F - T\left(\frac{\partial F}{\partial T}\right)_V = -T^2\left[\frac{\partial}{\partial T}\left(\frac{F}{T}\right)\right]_V$. 3

(c) What is temperature of inversion? 1

CC7-PHYSICS

Sample questions

1. **Short Answer type questions (1 marks)**

(a) Convert the binary number $(11011100.101010)_2$ to hexadecimal equivalent number. 1

(b) Subtract $(1011)_2$ from $(11001)_2$ using 2's Complement Method. 1

(c) What are Maxterm and Minterm? 1

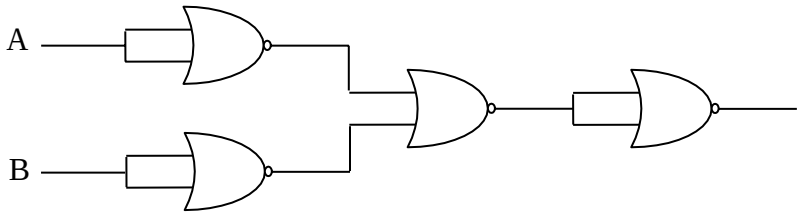
(d) What is the basic difference between combinational and sequential logic circuits? 1

(e) Find the number of bits required to encode 56 elements of information. 1

(f) Prove the Boolean identity $AB + \overline{A}\,\overline{B} = \overline{(A\overline{B} + \overline{A}B)}$. 1

(g) What is the minimum number of flip-flops required for a synchronous decade counter? 1

(h) Which logic gate does the following circuit represent? 1



GROUP-B

Medium Answer type questions (5 marks)

2. (a) What are the advantages of integrated circuits over discrete circuits? 3

(b) Why ASCII code is a 7 bit code? 2

3. (a) What is full adder? How does it differ from half adder? 2

(b) Design full adder using only NAND- gate. 3

4. What is a multiplexer? Design a 4:1 multiplexer using basic gate. 1+4

5. What is a parity checker? Discuss how XOR gate can be employed as parity checker. 1+4

6. (a) What is a Karnaugh-map and what for it is used? 1+1
   (b) Why Gray code is used in labelling the cells of K-map? 1
   (c) Simplify the Boolean expression $\overline{AB} + \overline{A} + AB$. 2

GROUP-C

Short Answer type questions (10 marks)

7. (a) Explain the operation of a JK flip flop having preset and clear input facilities with the help of a truth table. 4
   (b) What is meant by race around condition in JK flip flop? How can it be removed by using edge triggered clocking arrangements? 2+2
   (c) How do you convert JK flip flop into D- flip flop? 2

8. (a) Given the logic equation $f = ABC + B\overline{C}D + \overline{A}BC$ 2+2+2
   (i) Make a truth table
   (ii) Simplify using K-map
   (iii) Realize f using NAND gates only.
   (b) Explain the operation of a 4 bit serial-in, serial-out shift register. 4

9. (a) Draw the circuit diagram of an astable multivibrator and explain its principle of action. Hence find an expression for the frequency of oscillation. 2+2+2
   (b) Explain with a neat diagram the working of timer IC 555. 4

10. (a) What is a counter? Differentiate between synchronous and asynchronous counters. 1+2
   (b) Explain with the help of a neat circuit diagram the operation of a decade counter. 4
   (c) What is RAM? What are the advantages of dynamic RAM over static RAM? 1+2

GE-PHYSICS

The question paper contains GE3A and GE3B.
The candidates are required to answer any *one* from *two* courses.

Candidates should mention it clearly on the Answer Book.

GE3A

MECHANICS

GROUP-A

1. Short Answer type questions (of marks 1)

(a) What is Geosynchronous orbit? 1

(b) Define shearing stress. 1

(c) What is solenoidal vector? 1

(d) Explain the term 'Ether' in Michelson-Morley Experiment. 1

(e) Define the term Resonance. 1

(f) What is the difference between impulse of force and impulsive force? 1

(g) Write the dimension of torque. 1

(h) Write down the most general form of a homogeneous first order differential equation. 1

GROUP-B

Medium Answer type questions (of marks 5)

2. (a) A linear harmonic oscillator is characterized by $y = a\cos\omega t$. Calculate the displacement at which K.E. is equal to its P.E. 2

(b) What is damped vibration? How does it differ from free vibration? 1+2 = 3

3. (a) Show that the vectors $\vec{a} = \hat{i} - 2\hat{j} + 3\hat{k}$, $b = -2\hat{i} + 3\hat{j} - 4\hat{k}$ and $\vec{c} = -\hat{j} + 2\hat{k}$ are coplanar. 2

(b) Find the gradient of the scalar function $\phi(x, y, z) = 4e^{(2x-y+z)}$ at the point (1, 1, –1). 3

4. (a) State Kepler's laws in connection with planetary motion. 3

(b) A disc of mass 50 g and radius 2 cm is rolling down with linear velocity 5 cm/s. Find out its linear and rotational kinetic energy. 2

5. (a) Find the general solution of differential equation $\frac{d^2y}{dx^2} - 5\frac{dy}{dx} + 6y = 0$. 3

(b) Establish the relation between total energy and momentum of a relativistically moving body. 2

6. (a) Derive an expression for the energy stored in an elastic body in the case of longitudinal strain. 2

(b) The compressibility of water is 44×10^{-6} / atm, if 125 atm pressure is applied to 200 cc of water, then find the volume compressed. 3

GROUP-C

Broad Answer type questions (of marks 10)

7. (a) Write down Lorentz transformation equations. 2

(b) On the basis of Lorentz transformation, discuss 'Time dilation'. 4

(c) A spaceship of rest length 120 m passes an observer on earth in 4.5 μs. Find the velocity of the spaceship with respect to the earth. 4

8. (a) A force $F = 3\hat{i} + 2\hat{j} - 4\hat{k}$ is applied at the point (1, –1, 2). Find the moment of the force about the point (2, –1, 3). 3

(b) Determine the height of the Geosynchronous Satellite from the earth surface. 4

(c) Prove Newton's 3rd law of motion from the conservation principle of linear momentum. 3

9. (a) If the distance between the Sun and Earth is reduced to half of their present distance. What will be the length of the year? 3

(b) If the length of a simple pendulum is increased by 75%. Find the percentage increase in its time period. 3

(c) Prove that the resultant motion of two Simple Harmonic Motion's having same period and amplitude but a phase difference of π |2 is circular. 4

symbols are their usual meanings.

10.(a) Show that the torsional couple per unit twist of a wire is

$\frac{\pi\eta r^4}{2l}$, where the 4 ____

(b) A wire of 50 cm length and 1 mm^2 cross-sectional area has Young's modulus of 1.24×10^{12} dyne/cm^2. Find out workdone to increase its length by 1 mm. 3

(c) Show that Poisson's ratio σ lies between –1 to $\frac{1}{2}$. 3

GE3B

THERMAL PHYSICS AND STATISTICAL MECHANICS

GROUP-A

1. **Short Answer type questions (of marks 1)**

(a) State the principle of equipartition of energy. 1

(b) What is the change of internal energy in a reversible cycle? 1

(c) State Wien's displacement law. 1

(d) What is the dimension of the entropy? 1

(e) State the Carnot theorem. 1

(f) What is the reflective power of a perfect black body? 1

(g) Write down the expression for "pressure of radiation". 1

(h) What is the value of ln10! according to the Stirling's formula? 1

GROUP-B

Medium Answer type questions (of marks 5)

2. (a) What is free expansion? Is it an adiabatic process? 1+1

(b) Show that for an ideal gas, the internal energy depends only on the temperature not on pressure and/or volume. 3

3. (a) What is the meaning of mean free path of the molecules of a gas? Show that it is equal to $\frac{1}{\pi nd^2}$, where n is the number of molecules per unit volume and d is the diameter of each molecules. 1+3

(b) Write down the relation between the coefficient of viscosity and thermal conductivity of a gas? 1

4. (a) What are bosons? Give examples. 1+1

(b) Discuss the difference between the Fermi-Dirac and the Bose-Einstein statistics. 3

5. (a) Mention the physical significance of the Gibb's potential. 2

(b) Show that the ratio of the adiabatic to isothermal elasticity is γ. 2

(c) Write down the Clausius-Clapeyron equation of state. 1

6. (a) State Kirchhoff's law of radiation. 1

(b) Using dimensional analysis establish the Stefan-Boltzmann law. 3

(c) What is the limitation of Newton's law of cooling? 1

GROUP-C

Broad Answer type questions (of marks 10)

7. (a) Distinguish between extensive and intensive variables. Give examples. 2

(b) Represent (i) an isobaric process and (ii) an isochoric process on a P-V diagram. 2

(c) Show that for an adiabatic process $TV^{\gamma-1}$ = constant, where the symbols have their usual meaning. 3

(d) Find the work done in compressing 1 gm of air adiabatically at NTP (initially) to half of its original volume. The density of air at NTP = 0.000129 gm/cc and $\gamma = 1.4$. 3

8. (a) If 'αdt' be the probability of a gas molecule making a collision in the time interval 'dt', then find the probability of a molecule experiencing no collision during the interval 't'. 3

(b) At what temperature will average speed of molecules of hydrogen gas be double the average speed of oxygen at 300 K. 3

(c) Calculate the degrees of freedom of a linear triatomic molecule. 2

(d) Show that $\gamma = 1 + \frac{2}{f}$, where the symbols have their usual meaning. 2

9. (a) Calculate the change in entropy when 2 gm of ice melt's into water at the same temperature. The latent heat of ice 80 cal/gm. 3

(b) Using Maxwell's thermodynamical relation, prove that for a Van der Waals gas 4

$$C_P - C_V = R\left(1 + \frac{2a}{RTV}\right)$$

(c) Give two statements of second law of thermodynamics and show that they are equivalent. 3

10. (a) Discuss on the conditions for the application of Maxwell-Boltzmann statistics. 2

(b) The Fermi velocity of the electron in a metal is 0.7×10^6 m/s. Calculate the Fermi velocity. 3

(c) Show that adiabatic curves are steeper than the isothermal ones. 2

(d) Using Maxwell's thermodynamic relations show that the ratio of adiabatic to isobaric volume expansivity is $\frac{1}{1 - \gamma}$ 3

PHYSICS

The question paper contains Section-IA and Section-IB. Candidates are required to answer any *one* from the *two* sections and they should mention it clearly on the Answer Book.

SECTION-IA

COMPUTATIONAL PHYSICS

GROUP-A

Questions of 3 marks

1. (a) Briefly discuss the importance of computers in physics. 2
   (b) Write a FORMAT statement to print an integer value 5454 using FORTRAN Language. 1

2. Write commands to plot sin(x) in Gnuplot. How to label the axes and make the title of the plot? 3

3. What are the advantages of LaTex word processor over the others word processor? 3

4. (a) What is the significance of Unconditional GOTO and Computed GOTO statement? 2
   (b) Find the error in the following statement : 1

DO I = M,

$456 \cdot 4$, I

5. Write an algorithm to compute the sum of all natural numbers between given limits. 3

6. Write LaTex Commands to express the following equation. 3

$$\frac{d^2y}{dx^2} + w^2 y = 0 .$$

GROUP-B

Question of 6 marks

7. (a) Write down the flowchart to find roots of quadratic equations. 3
   (b) What is the basic reason for the usage of Linux over the other operating systems? 2
   (c) Expand the term FORTRAN. 1

8. Write down the rules of the 'Do' Loops for FORTRAN Language with examples. 6

9. (a) Briefly describe different types of document classes in LaTex. 3
   (b) Show how sectioning is done in article type document class? 3

10.(a) Write a LaTex file to draw a horizontal line. 2

(b) What are the different font sizes available in article type document class? Show them with LaTex file and output file with the word 'Examination'. 4

11.(a) Write a LaTex file to type the following special symbols – 5

#, $, %, { , }, &, _ , ©, ®, ™

(b) Write the LaTex command for bold font. 1

12.(a) How can you change the default plot range in plot cos(x) command in Gnuplot? 2

(b) What are the commands in Gnuplot to plot the following – 2

$\sin(2x)$, $\cos(x)$

(c) Show the commands to plot with lines and with points in Gnuplot. 2

GROUP-C

Questions of 12 marks

13. Write a Fortran program to find 6+6

(i) the smallest number from a given set of data.

(ii) a set of prime numbers.

14. Write a LaTex code which will produce the following text as pdf file: 12

Charge Relaxation in Conductors. We discuss the issue of charge relaxation in good conductors. Ohm's law reads in line domain:

$$\bar{J}(\bar{r},\, t) = \omega_p^2 \int_{-\infty}^{t} e^{-r(t-t')} \varepsilon_0 \bar{E}(\bar{r},t')\, dt' \ldots\ldots(1)$$

Taking the divergence of both sides and using charge conservation, $\bar{\nabla} \cdot \bar{J} + \rho = c$, and Gauss's law $\varepsilon_0 \nabla \cdot \bar{E} = \rho$, we obtain the following equation for charge density $\rho(\bar{r}, t)$:

$$-\dot{\rho}(\bar{r},\, t) = \nabla \cdot \bar{J}(\bar{r},\, t) = \omega_p^2 \int_{-\infty}^{t} e^{-r(t-t')} \varepsilon_0 \nabla \cdot \bar{E}(\bar{r},\, t')\, dt'$$

$$= \omega_p^2 \int_{-\infty}^{t} e^{-r(t-t')} \rho(\bar{r},\, t')\, dt' \ldots\ldots\ldots\ldots (2)$$

Differentiating both sides of equation (2) with respect to *'t'*, we find that ρ satisfies the second order differential equation:

$$\ddot{\rho}(\bar{r},\, t) + r\dot{\rho}(\bar{r},\, t) + \omega_p^2\, \rho(\bar{r},\, t) = 0 \ \ldots\ldots.(3)$$

15.(a) Write the algorithm and Fortran Code to find the Fibonacci series upto a given maximum limit. 4

(b) A projectile is fixed at an angel θ with the horizontal. Write a Fortran Code that will input θ and output the trajectory in a data file. 5

(c) Also write a Gnuplot input file to visualize the trajectory. 3

16.(a) Write a program in Gnuplot for the following functions: 3+3

(i) Gaussian distributions: $\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\pi}{\sigma}\right)^2}$

(ii) $f(x) = 4x^2 - 3x - 1.$

(ii) $f(x) = 4x^2 - 3x - 1.$

(ii) $f(x) = 4x^2 - 3x - 1.$

(b) Write a FORTRAN program to find the sum of even numbers between 2 to 200. 4

(c) Write the LaTex command of the equation: 2

$$y = \frac{ax+b}{ax-b}$$

SECTION-IB

ELECTRICAL CIRCUITS AND NETWORK SKILLS

GROUP-A

Questions of 3 marks

1.	What do you mean by reluctance? How reluctance effects the working of D.C generator?	3
2.	A coil consists of 2000 turns of copper wire having a cross-sectional area of 0.8 mm^2. The mean length per turn is 80 cm and the resistivity of the copper is 0.02 $\mu\Omega$-m. Find the resistance of the coil and power absorbed by the coil when connected across 110V d.c. supply.	3
3.	Give examples of electrical components which obey or disobey Ohm's law.	3

4.		Define speed of a motor. What does the speed depends on?	3
5.		Write key differences between single phase and three phase motors.	3
6.		What is relay? How does a relay work?	3

GROUP-B

Questions of 6 marks

7.		List and explain the essential qualities of a protective relay.	6
8.		Describe the construction and working of a DC generator.	6
9.	(a)	Draw a symbol for p-n diode.	1
	(b)	How can a multimeter be used to test a diode?	3
	(c)	What is the basic differences between analog and digital multimeter?	2
10.		Write short notes of the following (i) Bridge Rectifier (ii) Transformer Losses	3+3
11.	(a)	Explain briefly the principle of resistance measurement with a multimeter.	4

(b) What is the necessity of Zero adjust control? 2

12.(a) Describe how an ammeter can be converted into a voltmeter. 4

(b) Write the difference between dc motor and ac motor. 2

GROUP-C

Questions of 12 marks

13.(a) What do you mean by an ideal voltage and ideal current source? 3

(b) Give examples of practical current and voltage sources.

(b) 2

(C) Define mesh or loop of an electric circuit.

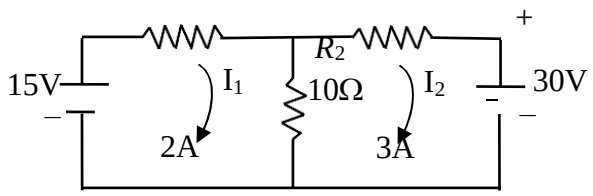
(c) 2

Why are capacitors and not inductors preferred in modern electronic circuit design?

(d) 5

14.(a) Derive the formulae for delta to star transformation. 6

(b) Using Mesh analysis find the value of R_1 and R_2 shown in the figure. 4



(c) Mention different kind of losses that occur in a DC generator. 2

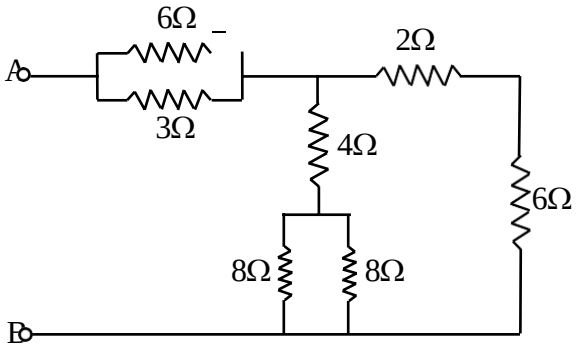
15.(a) A sinusoidal emf is applied to a circuit containing a capacitor and a resistor in series. Derive an expression for the instantaneous current and power factor. 5

(b) Draw the phasor diagram. Show that the power is dissipated only in the resistance. 2+3
Phasor diagram

(c) Explain the term wattless current. 2

16.(a) In an ac circuit the complex impedance is $Z_1 = (1+2j)\Omega$ and complex voltage is $(-4+7j)$V . Find the complex current in the circuit. 3

(b) Compute the total circuit resistance of the given network. 3



(c) With a neat diagram, explain the construction and working principle of a reverse power or directional relay. 6

CC8 PHYSICS
Mathematical Physics III (4th Semester)
Sample Questions

Short questions (Marks 1)

(a) Which of the following is analytic function of the complex variable $z = x + iy$:

(i) $|z|$ (ii) $\mathrm{Re}(z)$ (iii) $\sin z$ (iv) $\log z$

(b) What kind of singularity exists for the function $f(z) = \frac{\sin z}{z}$ at $z = 0$?

(c) Solve: $x^5 = 1$

(d) If A is an orthogonal matrix then show that , $|A| = \pm 1$.

(e) Is it possible to have Fourier transformation of a function $f(x)$ having infinite periodicity? Justify your answer.

(f) Write down the polar form of Cauchy-Riemann conditions.

(g) Find the transpose of the following matrix:

$$\begin{bmatrix} 1 & i & 3 \\ -i & 2i-4 & 0 \\ 0 & -i & 1 \end{bmatrix}$$

(h) Find the residue of $e^{-\frac{1}{z}}$ at the singularity.

Medium questions (Marks 5)

2. (a) Find the Fourier transform of the function 3

$$f(x) = \begin{cases} 1 & \text{if } |x| \le a \\ 0 & \text{if } |x| > a \end{cases}$$

(b) Hence show that, $\int_0^{\infty} \left(\frac{\sin u}{u} \right)^2 du = \frac{\pi}{2}$. 2

3. Given $A = \begin{bmatrix} 2 & -2 & -4 \\ -1 & 3 & 4 \\ 1 & -2 & -3 \end{bmatrix}$ then find the matrix, 5

$$A^{100} + A^{99} + A^{98} + \cdots\cdots + A^2 + A$$

4. (a) Evaluate the following integral using Cauchy's integral formula: 3

$$\oint_C \frac{e^{2z}}{(z+1)^4} dz$$

where C is the circle $|z| = 3$.

(b) Find the Laurent series of $f(z) = \frac{z - \sin z}{z^3}$ about the singularity $z = 0$. 2

5. For the given matrix 5

$$M = \begin{bmatrix} 3 & -1 & 1 \\ 7 & -5 & 1 \\ 6 & -6 & 2 \end{bmatrix}$$

Find the eigen vector associated with each eigen values.

6. (a) Find the principal value of i^i. 2

(b) Show that, the function $x^2 + iy^3$ is not analytic anywhere. 3

Broad questions (Marks 10)

8. (a) Define essential singularity, removable singularity and simple pole of order n with proper examples. 3

(b) Evaluate the following integral 6

$$I = \int_0^{\infty} \frac{dx}{x^6 + 1}$$ using the residue theorem.

(c) What kind of singularity exist for the function $f(z) = \frac{1}{\sqrt{z}}$? 1

9. (a) Find the Fourier transformation of the function $f(x) = e^{-|x|}$ and its inverse transformation. 6

(b) From the previous function, prove that $\int_0^{\infty} \frac{\cos \alpha x}{\alpha^2 + 1} d\alpha = \frac{\pi}{2} e^{-|x|}$. 4

10.(a) Let $f(z) = u + iv$ be an analytic complex function, then show that u and v are harmonic function. 2

(b) Find the poles and the residues at the poles of the function $f(z) = \left(\frac{z+1}{z-1}\right)^2$. 4

(c) Evaluate the integral, $\int_0^{2\pi} \frac{d\theta}{5 + 4\sin\theta}$. 4

CC9 Physics

Elements of Modern Physics, Semester: 4th

Short Questions (Marks 1)

1) Write the value of Planck's constant with proper unit.

2) What is moderator in nuclear reactor?

3) What do you mean by stationary state of a quantum mechanical system?

4) What is specific activity of a radioactive element?

5) Write the full form of LASER.

6) Define half life of a radioactive substance.

7) What do you mean by slow neutron?

8) What do you mean by wave-particle duality?

9) What are magic numbers?

10) What do you mean by canonical pair of variables?

Medium Questions (Marks 5)

1) a) Classical electromagnetic theory cannot explain the basic features of photoelectric effect'-Explain.

b) Write down Einstein's photoelectric equation and explain the basic features of photo electric effect with the help of this equation. 2+3

2) a) Describe the construction of a He-Ne laser in brief .

b) With the help of a simple energy diagram show how population inversion is achieved in He-Ne laser. 2+3

3) a) State and explain Heisenberg's uncertainty principle .

b) Using Heisenberg's uncertainty principle,explain why free electrons cannot exist in atomic nuclei . 2+3

4) Describe Davisson and Germer experiment to demonstrate the wavelike behavior of moving electrons. 5

4) Describe the thought experiment with gamma-ray-microscope and show that the measurement of position of the particle and its momentum with a gamma-ray microscope takes place in accordance with Heisenberg's uncertainty principle. 5

5) a) Give a physical interpretation of the wave function of a quantum mechanical system.

b) Write down the properties of the wave function associated with a quantum mechanical system.

c) State and explain the normalization of the wave function. 1.5+1.5+ 2

6) a) Define the expectation value of a dynamical quantity.

b) Write down the expectation values of energy and momentum of a particle.

c) Write down the time-independent Schrodinger equation and show that this equation is linear. 1+1+3

7) a) Define probability current density and relate it to the position probability density.

b) For the wave function ψ = A exp i(kx-wt),find the probability current density, where A is a constant and i=$\sqrt{-1}$,k=wave vector and w= cyclic frequency. 2+3

8) a) Define binding energy of a nucleus.

b) Draw the pattern of graph between binding energy per nucleon and mass number of the nucleus and explain the significances of the peaks for very small values of mass number in this graph. 1+(2+2)

9) a) Differentiate between nuclear fission and nuclear fusion.

b) Write the properties of nuclear force. 3+2

10) Draw a neat and clean diagram of a nuclear reactor ,label different parts of it and explain the functions of them. 2+3

Broad questions (Marks 10)

1) a) Describe with energy level diagrams the phenomena of spontaneous emission, stimulated emission and stimulated absorption in a two level system.

b) What are Einstein's A,B coefficient? Derive a relation between them. 3+(2+5)

2) a) What is Compton effect?

b) Derive an expression for shift of wavelength in Compton effect.

c) What is Compton wavelength?

d) Explain why unmodified line is always present with the modified lines in Compton effect.

e) What is the significance of Compton effect with regard to the nature of light. 2+4+1+2+1

3) a) What is the hypothesis of de Broglie?

b) Why is the wave nature of matter not apparent for macroscopic particles?

c) Derive the de Broglie relation for a photon from the principle of mass-energy equivalence.

d) Show that the group velocity of the de Broglie wave is equal to the velocity of the particle.

e) Show that for de Broglie waves representing a relativistic particle , the product of phase velocity and the group velocity is equal to c^2, where c is the velocity of light in vacuum. 2+2+2+2+2

4) a) A particle of mass m is free to move in a force-free region in one dimension between two rigid walls situated at x= -L/2 and x = +L/2.

i) Find the eigenfunctions and eigenvalues of the Hamiltonian.

ii) Sketch the wave function of the ground state and first excited state.

iii) Find the ratio of the energy eigenvalues corresponding to the first excited state and ground state.

d) The wave function of a particle is $\psi(x)= A \exp(- \beta x^2)$, where $(-\infty< x < +\infty)$,where A and β are constants.

Normalize the wave function and calculate the probability of finding the particle in the region

$0< x < +\infty$. (4+2+2)+2

5) a) What is quantum mechanical tunneling?

b) An electron of mass m and total energy E is incident on a rectangular potential barrier of height V_0 and width a , where $V_0 > E$.

Derive the expression for the transmission coefficient and discuss qualitatively how alpha-decay is explained in the light of this derivation.

c) A proton of energy 3Mev is incident on a rectangular potential barrier of height 10 Mev and thickness 10^{-14}m. Calculate the value of transmission coefficient of the proton. Given, the mass of prpton = 1.67 x 10^{-27}kg. 2+(4+2)+2

6) a) A particle of mass m and total energy E moves from a region of constant potential V_1 to a region of constant potential V_2.

Derive the expression for the reflection and transmission coefficient when

i) $E > V_1$ or V_2 and ii) $V_1< E < V_2$.

b) Calculate the value of the height of potential barrier in eV for alpha-particles emitted from an element with atomic number ,Z = 86. Assume that the effective nuclear radius $r_0 = 10^{-12}$cm.

c) A spherical dust particle of radius $r = 10^{-5}$m, density $p=10^4$kg/m^3 and moving with velocity $v = 10^{-2}$ m/s, encounters a potential step of height equal to twice the kinetic energy of the particle. Estimate the penetration distance of the particle inside the step. (3+3)+2+2

7) a) Draw the pattern of NZ graph and explain the significance of this graph, where N= Neutron number of a nucleus and Z = Proton number of a nucleus.

b) Show that the activity of a radioactive sample is A = (0.693/T) N, Where the symbols have their usual meanings.

c) A piece of an ancient wooden boat shows an activity of ^{14}C of 3.9 dpm/g of carbon. Estimate the age of the boat if the half life of ^{14}C is 5568 years. Assume that the activity of fresh ^{14}C is 15.6 dpm/g. (2+3)+2+3

8) a) How beta-decay differs from alpha decay?

b) Discuss the apparent non-conservation of energy in beta-decay process.

c) Explain qualitatively how did the neutrino hypothesis restore the energy conservation laws in beta-decay.

d) Differentiate between electron and beta particle. 2+3+3+2

9) a) How do the gamma rays originate?

b) How does pair production take place by a high energy gamma ray photon?

c) Can pair production occur in free space? Answer with proper explanation.

d) What do you mean by the mean life of a radioactive substance? Show that the mean life of a radioactive element is equal to the reciprocal of the decay constant. 2+2+3+(1+2)

10) a) Explain the basic similarities between a liquid drop and an atomic nucleus.

b) Obtain Bethe-Wiezsacker semi-empirical mass formula clearly explaining the significances of the terms involved in it.

c) Mention the failures of liquid drop model of nucleus. 2+6+2

CC10 Physics

Analog System and Applications (4th Semester)

Short Questions (Marks 1)

1.

(a) At a high temperature an extrinsic semiconductor behaves like an intrinsic semiconductor. — Explain.

(b) For a certain transistor with $\alpha_{dc} = 0.98$ and emitter current $I_E = 2$ mA, calculate the base current.

(c) What is the virtual ground of an operational amplifier?

(d) What is the open loop gain of an operational amplifier?

(e) What do you mean by the term 'avalanche breakdown' of a p-n junction diode?

(f) What do you mean by the term Q-point of a transistor?

(g) In a half wave rectifier, the peak value of the ac voltage across the secondary of the transformer is $20\sqrt{2}$ volt. If, no filter circuit is used, calculate the maximum dc voltage across the load.

(h) Draw the voltage transfer characteristics (VTC) of a Schmidt trigger circuit.

Medium Questions (Marks 5)

2. (a) Explain the use of Zener diode as a voltage regulator with suitable circuit diagram. 4

(b) Write down the voltage-current relation in a p-n junction diode in forward bias condition. 1

3. (a) Draw the energy-band diagram of a p-n junction diode and indicate the locations of donor level, acceptor level and fermi energy level in this diagram. 3

(b) Calculate the values of dc resistance and ac resistance of a germanium p-n junction diode at temperature 27°C for applied voltage 0.1 volt, reverse saturation current I_0 = 20 μA and ratio of Boltzmann constant to electric charge of an electron $= \frac{k_B}{e} = \frac{1}{11600}$. 2

4. (a) Draw the diagram of the voltage divider biasing circuit in transistor and derive the expression of the base current I_B. 3

(b) Show that the value of stability factor for the voltage divider biasing method approaches to unity. 2

5. (a) Show that negative feedback in amplifiers can improve the stability of an amplifier. $1\frac{1}{2}$

(b) Show that negative feedback can change the input impedance of an amplifier. $1\frac{1}{2}$

(c) Explain why common emitter configuration is preferred for amplifier design. 2

6. (a) Draw a net diagram of a RC-phase shift oscillator. 2

(b) Write down the expression for frequency of oscillation in RC-phase shift oscillator. (Derivation is not needed). 1

(c) Why three identical R-C sections are used in R-C phase shift oscillator? 2

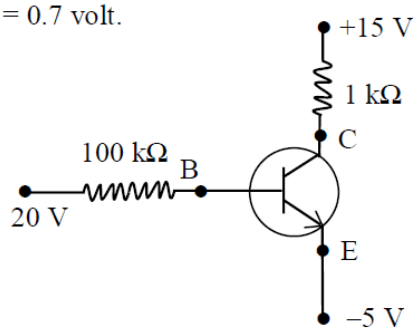
Broad Questions (10 Marks)

7. (a) Draw and label the circuit diagram of a small signal single stage low frequency transistor amplifier in the CE mode. 2+1+1+1+2

Using the h parameters, obtain the expressions of current gain, input impedance, voltage gain and output impedance of this transistor amplifier.

(b) Calculate the values of I_B, I_C, I_E and V_{OE} for the transistor circuit given below. 3

Assume, $\beta = 50$, $V_{BE} = 0.7$ volt.



8. (a) Derive the expression of output voltage for inverting amplifier with proper circuit diagram. 4

(b) Why inverting amplifier circuit is also known as 180° phase shifter circuit? 1

(c) Show that the electrical mobility of the electrons in a semiconductor is $\mu = \frac{e\tau}{m^*}$, where the symbols have their usual meanings. 3

(d) What are the differences between Field Effect Transistor (FET) and Bipolar Junction Transistor (BJT)? 2

9. (a) Draw the circuit diagram of a full wave bridge rectifier using semiconductor diodes. 2+4

Find out the expressions of Ripple factor and Rectification efficiency of this full wave bridge rectifier.

(b) The band gap of a specimen of gallium arsenide phosphide is 1.98 eV. 2

Determine the wavelength of the electromagnetic radiation that is emitted upon direct recombination.

What is the colour of the emitted radiation?

(c) State and explain the Barkhausen criterion for an oscillator. 2

10.(a) Explain the operation of an OPAMP as a 3+3

(i) Differentiator

(ii) Integrator.

(b) What should be the input resistance, output resistance, voltage gain and band width of an ideal OPAMP? 2

(c) At the temperature 300 K, the intrinsic carrier concentration of silicon is 1.5×10^{16} m^{-3}. 2

If the electron and the hole mobilities are 0.13 $m^2v^{-1}s^{-1}$ and 0.05 $m^2v^{-1}s^{-1}$ respectively, determine the value of intrinsic resistivity of the silicon at temperature 300 K.

GE 2A/4A Physics

Electricity and Magnetism (2nd Sem or 4th Sem)

Short Questions (Mark 1)

1.

(a) Find the value of x for which $\vec{A} = \hat{i} + x\hat{j} + \hat{k}$ and $\vec{B} = 2\hat{i} - 2\hat{j} - 2\hat{k}$ are perpendicular.

(b) Write the differential form of Gauss's law of electrostatic.

(c) Define the unit of capacitance.

(d) Why the equipotential surfaces do not intersect each other?

(e) Define electric flux.

(f) What do you mean by intensity of magnetism?

(g) Write down the equation of continuity of current.

(h) Write the Maxwell equation which indicates the absence of magnetic monopole.

Medium Questions (Marks 5)

2. (a) Find the unit normal to the surface $x^2y + 2xz = 4$ at the point $(2, -2, 3)$. 2

   (b) If $\vec{r}$ be the position vector then find the value of grad$\left(\frac{1}{r}\right)$. 3

3. (a) Find the capacitance of a parallel plate capacitor when a dielectric of breadth 't' is placed between the plates of the capacitor. 4

   (b) Write the integral form of Ampere's circuital law. 1

4. (a) Define electric dipole. Give unit of electric dipole moment. 1+1

   (b) Find the electric potential at a point due to electric dipole. 3

5. (a) State and explain Lenz's law. Also show that it supports the conservation of energy. 4

   (b) Write down the Maxwell equation, which can be derived from Faraday and Lenz law. 1

6. State and explain Biot-Savart law in magnetostatic and hence calculate the magnetic induction at a point due to a straight infinitely long current carrying wire. (Assume steady current flow) 2+3

Broad Questions (Marks 10)

7. (a) Find the value of $\text{div}(r^n \vec{r})$, where $\vec{r} = x\hat{i} + y\hat{i} + z\hat{k}$. Find the value of n for which $(r^n \vec{r})$ is solenoidal. 4+2

(b) If $\vec{v} = \vec{w} \times \vec{r}$, show that $\frac{1}{2}\text{curl}\vec{v} = \vec{w}$, where $\vec{w}$ is a constant vector and $\vec{r}$ is the position vector. 4

8. (a) Find the electric field for a plane charged sheet using Gauss's theorem. 5

(b) Prove that, 3

$$\nabla^2 \phi = -\frac{\rho}{\varepsilon_0}$$

where ϕ, ρ and ε_0 have their usual meaning.

(c) Find the electric field at point (2, 1, 2) where electric potential is given by $\phi = -x^2 y + 2z$. 2

9. (a) Distinguish between dia, para and ferromagnetic substances. 5

(b) A steady current I flows down a long cylindrical conductor of radius a. The current density at a distance r from the axis of the conductor is proportional to r. Calculate the magnetic field both inside and outside of the wire as a function of r. 5

10.(a) Show from Maxwell's equation that velocity of a plane electromagnet wave in an isotropic dielectric medium is, $v = c/\sqrt{k}$, where k is dielectric constant of that medium. 5

(b) What is poynting vector? Find its relationship with electric and magnetic field. 2+3

GE2B/GE4B Physics

Waves and Optics, Semester: 2nd/4th

Short Questions (Mark 1)

1) Write the principle of superposition of two waves.

2) What do you mean by formation of beats?

3) Write the units of Intensity and Loudness of sound wave.

4) Define time of reverberation.

5) What will be the shape of the source of light emitting cylindrical waves?

6) Define wave front.

7) What is the actual shape of interference fringes in Young's double slits experiment?

8) What is the difference in the appearance of Newton's rings between those obtained by interference between the reflected waves and those obtained by interference between transmitted waves?

9) What do you mean by diffraction of light?

10) Calculate the magnitude of velocity of an electromagnetic wave propagating through vacuum.

Medium Questions (Marks 5)

1) a) What do you mean by phase velocity and group velocity of a wave?

b) Find the relation between phase velocity and group velocity in a dispersive medium. 2+3

2) A particle is simultaneously subjected to two simple harmonic motions at right angle to each other. Their frequencies are in the ratio 1:2. Obtain the locus of that particle when the simple harmonic motions are in phase difference i) 0 degree and ii)90 degree. 5

3) a) If w_1 and w_2 are the half-power frequencies and w_0 is the resonance frequency of a particle under forced vibration , then show that $w_0^2 = w_1 w_2$.

b) The sound pressure levels of two sources are 20 dB and 40 dB respectively. What is the sound pressure level when the two sources emit sound simultaneously? 3+2

4) Deduce Sabine's formula for reverberation time. 5

5) Discuss the propagation of spherical waves using Huygens'principle. 5

6) a) Draw a neat diagram to show the formation of fringes in Llyod's single mirror and explain why the central fringe is dark.

b) A diffraction grating of 2 cm wide is just able to resolve sodium D-lines in second order. Find the number of rulings per mm in the grating. 3+2

7) What do you mean by fringes of equal thickness and fringes of equal inclination? Explain the formation of these two types of fringes with suitable ray diagram. 5

8) Discus how can you measure i)the unknown wavelength of a monochromatic light, ii) the difference of wave lengths of a compound light containing two different wave lengths by using Michelson's interferometer. 2+3

9) a) Differentiate between Fraunhofer diffraction and Fresnel diffraction of light wave.

b) What do you mean by zone plate? 3+2

10) a) What do you mean by plane polarized light?

b) Describe and explain a method of production of plane polarized light. 2+3

Broad Questions (Marks 10)

1) Set up the differential equation of motion of a simple harmonic oscillator subjected to a damping force and a simple harmonic force.

Obtain an expression for the amplitude and the phase angle of the displacement in the steady state.

Show that in the steady state, the time averaged input power equals the time averaged power dissipated through friction. (2+4)+4

2) a) Distinguish between amplitude resonance and velocity resonance in the motion of a simple harmonic oscillator subjected to a damping force and a harmonic force.

b) Prove that the velocity of sound waves in a solid bar is given by $\sqrt{(Y/p)}$, where Y is the Young's modulus and p is the density of the material of the bar, mentioning clearly the assumptions made in the derivation. 4+6

3) Obtain the differential equation of vibration of a uniform string of length L, stretched between the fixed ends x=0 and x= L.

Hence find an expression for the transverse displacement 'y(x,t)' at any point of the string excited by striking. 4+6

4) a) Prove that for a forced vibration ,

Average Potential Energy/Average Kinetic Energy = w_0^2/w^2, where $w_0 = \sqrt{(s/m)}$, s = Proportionality constant of restoring force, m = mass of the particle in forced vibration and w = cyclic frequency of periodic force.

b) An increase of pressure of 100 kPa causes a certain volume of water to decrease by

5×10^{-3} percent of its original volume. Calculate the value of speed of sound in water.

c) Explain 'Sharpness of resonance' and 'Quality factor' for forced vibration. 3+3+4

5) a) Derive the expression for the velocity of a simple harmonic wave in a stretched string and also find the expression for the fundamental frequency of the vibration.

b) A flexible string of length 0.99 m and mass 1 g is stretched by a tension of T Newton. The string vibrates in three segments with a frequency of 500 Hz. Calculate the value of the tension. (6+2)+2

6) a) Find the expression for the fringe width of interference patterns in Young's double slits experiment.

b) State Stokes' law of phase change in reflection of wave and prove it mathematically.

c) Differentiate between division of amplitude and the division of wave front in the phenomena of interference of light. 3+(2+3)+2

7) a) By drawing ray diagram explain the formation of Newton's rings by interference between reflected waves.

b) Find the expression for the diameter of the n th dark Newton's ring produced by interference between reflected waves.

c) How can you determine the value of refractive index of a transparent liquid by formation of Newton's rings? 3+5+2

8) a) Find the expression for the Intensity of the diffraction patterns obtained in diffraction of light through a single slit.

b) How the diffraction patterns of light by a single slit differ from the diffraction patterns of light by double slits?

c) What do you mean by 'missing order'? 6+3+1

9) a) What do you mean by Half period zones? –Explain with proper ray diagram.

b) Using the concept of half period zones how can you explain the rectilinear propagation of light ?

c) Consider a diffraction grating of width 5 cm with slits width 0.001 mm, separated by a distance of 0.002 mm. How many orders would be visible when the wave length of the used monochromatic light is 550 nm? 3+5+2

10) a) 'Light is a transverse wave.'- Explain it properly.

b) Describe a method for analysis of a plane polarized light.

c) What do you mean by Circularly polarized light and Elliptically polarized light? 3+3+(2+2)

SEC 2A Physics

Basic Instrumentation Skills (4th Semester)

Short Questions (Marks 3)

1

(a) Define the terms accuracy and precision in any experiment.

(b) What is a Shunt? What is the purpose of use of it?

(c) State the advantages of digital instruments over analog instruments.

(d) How can you construct a square wave signal generator?

(e) What are the differences between a moving coil and a moving magnet galvanometer?

(f) State the advantages of an ac R-L-C bridge over a dc R-L-C bridge.

Medium Questions (Marks 6)

2. Describe the principle of measurement of resistance by a multimeter. What may be the sources of error in such a measurement? 4+2

3. (a) Explain how frequency can be measured by a CRO. 3

   (b) The pattern on a CRO is stationary and has 5 horizontal and 2 vertical tangencies. If the frequency of the horizontal input is 1000 Hz, find the frequency of the vertical input. 3

4. Describe the operation of a full wave rectifier circuit and hence calculate its ripple factor. 4+2

5. With the help of a block diagram explain the operation of a function generator. 2+4

6. (a) Derive the general equation of balance for an ac bridge. 4

   (b) Why is it preferable in bridge circuits, that the equations of balance should be independent of frequency? 2

7. (a) What do you mean by sensitivity of an electrical instrument? Explain the advantages of electronic voltmeter over conventional type voltmeter with respect to sensitivity. 1+3

   (b) Explain, how can one construct a voltmeter using an ammeter? 2

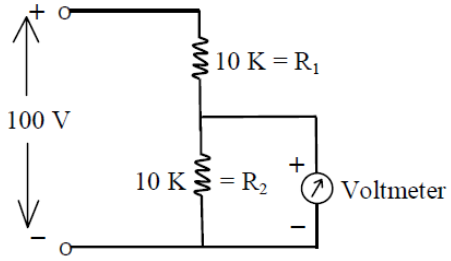
Broad Questions (Marks 10)

8. (a) Describe with a diagram the operation of a multirange voltmeter. State its limitations. 6+2

   (b) Briefly characterize different types of analog voltmeter. 4

9. (a) Explain the term 'loading effect'. 3

   (b) Referring to the following figure if the voltage across R_2 is to be measured by voltmeters having a sensitivity of (i) 1000 Ω/V and (ii) 20,000 Ω/V, which will give accurate reading and why, assuming both the meters are used on 50 V range. 5



(c) What do you mean by a filter circuit? What is the difference between a high and a low pass filter? 4

10.(a) A four arm ac bridge a-b-c-d has the impedances as: 4

ab , $z_1 = 200\angle 60^\circ\ \Omega$; ad , $z_2 = 400\angle -60^\circ\ \Omega$;

bc , $z_3 = 300\angle 0^\circ\ \Omega$ and cd , $z_4 = 600\angle 30^\circ\ \Omega$

Determine whether it is possible to balance the bridge or not.

(b) Describe how one can convert a square wave signal to a triangular wave signal. 4

(c) Explain the special features of a dual trace CRO. 4

11.(a) Describe with a diagram the operation of a half wave rectifier type ac voltmeter. 6

(b) Briefly explain instrumental error, random error and probable error. 6

SEC2B Physics

Renewable Energy and Energy Harvesting, Semester: 4th

Short Questions (Marks 3)

1) What do you mean by fossil fuels? Mention the names of some fossil fuels. 2+1

2) State and explain the main principle for generation of nuclear energy. 1+2

3) What do you mean by renewable energy? Mention the names of some renewable energies.2+1

4) Define bio-mass. Mention the sources of Ocean bio-mass. 2+1

5) Discuss in brief the main hurdles in the development of tidal energy. 3

6) What do you mean by a linearly cycle power plant? How does it generate electricity? 1+2

7) What is the basic principle of carbon-capture technology? Mention its importance. 1+2

8) Discuss the hurdles in development of nuclear power in our country? 3

9) Discuss the environmental hazards produced by a hydroelectric power plant. 3

10) What do you mean by global warming. Mention the effect of global warming on ocean. 1+2

Medium Questions (Marks 6)

1) a) What do you mean by greenhouse effect?

b) Write down the impacts of green house gas on environment? 3+3

2) a) Derive an expression of power output from a wind mill.

b) What are the most favourable sites for installing wind turbines? 4+2

3) a)Draw a neat diagram of a solar water heater and label different parts of it.

b) On what parameters the efficiency of a solar water heater depends? 4+2

4)a) Write down the salient characteristics of an ocean wave.

b) Write a short note on Tidal current. 3+3

5) a)What is a solar pond?

b) What are the advantages of using of a solar pond in modern power production technologies?

c) What do you mean by thermoelectric modules? 2+2+2

6) a) Explain the basic principle of an electromagnetic energy harvesting generator.

b) Write a short note on Geothermal energy. 3+3

7) a) Draw a neat and clean diagram of a Nuclear reactor and label different parts of it.

b) A nuclear reactor produces nuclear energy at a rate of 32 MW. How many atoms of Urenium-23 are required for this purpose? Given that the energy released by a Urenium-235 nucleus is 200 Mev and 1 Mev = 1.6×10^{-13} Joule. 4+2

8) a) What do you mean by one-axis sun tracking? Mention the names of two collectors required for one-axis sun tracking.

b) What do you mean by Tidal barrage. (2+2)+2

9) Draw a neat diagram of a hydroelectric power plant and explain its working. 6

10) a)What do you mean by the term ‘piezoelectricity’?

b) Write down the characteristics of piezoelectric materials.

c) What do you mean by piezoelectric energy harvesting? 2+2+2

Broad Question (Marks 10)

1) a) What do you mean by bio gas? Write down the names of components of a bio gas.

b) Draw a neat and clean diagram of a bio gas plant and label different parts of it.

c) Explain the working principle of bio gas plant. (2+2)+3+5

2) a) What is a solar cell?

b) Write the basic construction and the working principle of a solar cell.

c) A single solar cell of area 100 cm^2 produces a voltage of 0.5 V and a current of 2.5 A. If the amount of solar radiation on a unit horizontal surface of the cell cover over a specified time is 800W/m^2, calculate the efficiency of the solar cell. 2+(2+5)+3

3) a) What do you mean by the term wind energy?

b) What is wind turbine?

c) Draw a neat and clean diagram of a wind turbine and label different parts of it.

d) Write the names of different electrical machines in wind turbines and mention the functions of these machines. 2+2+3+5

4) a) Write the characteristics of ocean wave.

b) Write the names of three wave energy devices and explain the working principle of them.

c) Write down the characteristics of a photovoltaic (PV) system. 3+6+3

5) a) Write down the characteristics of tidal energy.

b) Write down the names of tidal energy technologies and describe the functions of them.

c) What do you mean by ocean thermal energy? 4+6+2

6) a) Write down the names of Geothermal technologies and describe the functions of them.

b) What do you mean by sustainable development?

c) Explain the contributions of renewable energies for sustainable development. 6+2+4

c) Mention the failures of liquid drop model of nucleus. 2+6+2

7) a) What do you mean by the term 'fossil fuels'?

b) Write down the merits and demerits of fossil fuels.

c) Describe different types of wind mills. 2+4+6

8) a) Mention the names of different carbon capture technologies and describe the functions of them.

b) Describe two applications of piezoelectric energy harvesting. 6+6

9) a) Draw a neat and clean diagram of a solar cooker and label different parts of it.

b) Describe the working principle of a solar cooker.

c) Define Osmotic power. Mention two practical methods for generation of osmotic power. (2+2)+4+(2+2)

10) a) Describe different types of sun tracking system and mention the merits and demerits of them.

b) Describe the process of solar distillation by drawing a neat and clean diagram of a solar distillation plant. (4+2)+(4+2)

CC11 Physics
Quantum Mechanics and Applications
Sample Questions

Short answer type questions (each question carrying marks 1)

1.

(a) Find out the value of A if the wave function $\psi(x) = Ae^{ikx}$ is normalized over the region $-a \le x \le a$.

(b) Employing the uncertainty principle estimate the maximum kinetic energy of an election confined within a region whose size is $l = 0.2\,\text{nm}$.

(c) Let f_1 and f_2 be two orthonormalized states of two electrons. Construct the two-electron state keeping Pauli's exclusion principle in mind.

(d) Tick out the correct answer(s) and explain it.

Potential of a free particle is

(i) maximum
(ii) minimum
(iii) zero
(iv) infinity
(v) uniform

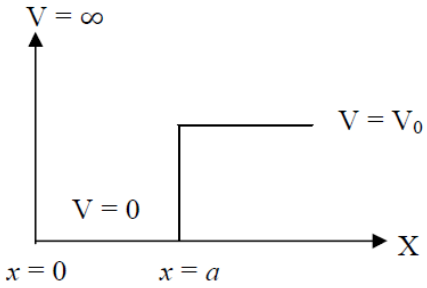
(e) Operators $\hat{A}$ and $\hat{B}$ are the quantum operators representing two observables A and B of a physical system. Then what must be true of the eigen values of the commutator $[\hat{A}, \hat{B}]$ so that the system can have definite values of both A and B simultaneously.

(f) If $\frac{1}{\sqrt{V}} e^{i\vec{k}\cdot\vec{r}}$ represents the state of a particle in the co-ordinate space, what will be the state in the momentum space?

(g) What is the origin of fine structures in the hydrogen atom spectrum?

Medium Questions (Marks: 5)

2. A particle is located in a one dimensional well with an infinite potential wall on one side and a finite potential wall on the other side as shown in the figure below 3+2



(a) For $E < V_0$, write down and solve the Schrodinger equation for (i) the region inside the well and (ii) the region outside the well.

(b) Apply the boundary conditions at $x = 0$ and $x = a$ to obtain an equation that defines the allowed values of the energy E.

3. (a) Develop the Schrodinger equation of a system consisting of two identical bosons confined in a one dimensional box. 3+2

(b) What is the ground state energy of a one dimensional box containing three electrons?

4. For a large, value of the external magnetic field B (applied in z directions) the Zeeman Splitting is given by 3+2

$$\Delta E = -\langle \mu_2 \rangle B$$

when $\langle \mu_2 \rangle$ is the expectation value of electron's dipole moment in the z-direction.

(a) Show that

$$\langle \mu_2 \rangle = \frac{e\hbar}{\partial m_e}[m_l + \partial m_s]$$

where does the factor of ∂ come from?

(b) Into how many states does the 3D state of hydrogen split in a strong external magnetic field?

5. Determine the expectation value of the potential energy of a linear harmonic oscillator with respect to its n^{th} eigen-state. Comment on the result that you get. 5

6. Consider a particle of mass M moving on a ring of radius R with the centre at the origin. The ring lies in the x-y plane. Find out the allowed energy values of the particle. 5

Broad answer type questions (Marks: 10)

7. A particle of mass m is confined within an infinite potential well. Find out the energy eigenvalue and normalize the wave function. Derive the expectation value of position in the ground state of the system. Show that the eigenfunctions corresponding to different states are mutually orthogonal. 3+2+2+3

8. (a) What do you understand by L-S and J-J coupling? 2+2+3+3

(b) What are the values of total angular momentum J and orbital angular momentum L for the atomic state $^2D_{5/2}$?

(c) Suppose the Hamiltonian for a single particle is given by,

$$H = A + B\vec{L}\cdot\vec{S} + C\,\vec{L}\cdot\vec{L}$$

where A, B and C are constants. A spin-$\frac{1}{2}$ particle is in the D-state. What will be the possible values of J ? Show that the eigenstates of $\hat{J}$ are also eigenstates of the above Hamiltonian.

(d) Find out the Lande's g-factor for an s-electron.

9. (a) Distinguish between the normal and anomalous Zeeman effect. 1+4+3+2

(b) Obtain the energy splitting formula for the anomalous Zeeman effect and show that the same can be applied to the normal Zeeman effect.

(c) Explain how many spectral lines are observed for the $(1s^2 3p)\ ^2P_{1/2} \rightarrow (1s^2 2s)\ ^2s_{1/2}$ transition in Lithium. Is this a normal or an anomalous Zeeman effect? Justify your answer.

Draw an energy level diagram showing the splitting of levels and the allowed transitions.

(d) What is the significance of π and σ lines?

10.(a) Solve the eigenvalue problem for a simple harmonic oscillator. 5+2+1+2

(b) Draw a sketch of $\psi_4(x)$ against x superposed on the $V(x)$ vs. x plot for the above problem.

(c) What is the significance of zero point energy?

(d) Find out the zero point energy of a quantum simple pendulum of length 1 mt and a bob of mass 0.1 kg.

CC12 Physics
Solid State Physics, Semester: 5th
Sample Questions

Short answer type questions (Mark: 1)

1) What is a single crystal?

2) Define the term 'Packing fraction' in crystal structure.

3) Find the Miller indices of a plane having intercepts of 6a,4b and 2c on the x-, y- and z-axes, respectively.

4) X-rays of wavelength 1.54 Å is incident on a single cubic crystal of lattice constant 4Å.Calculate the angle for the first order(n=1)reflection.

5) The energy versus wave vector relationship for a conduction electron in a semiconductor is $E = 5h^2k^2/4\pi^2m_0$.Determine the electron effective mass.

6) What do you mean by Meissner effect?

7) What is ferromagnetic domain?

8) What is the Curie temperature in ferromagnetic material?

9) What is an electric dipole?

10) What is type I superconductor?

Medium questions (Marks: 5)

1) a) What is Wigner-Seitz cell? How would you construct such a cell?

b) Why X-rays are used in crystal structure analysis? (1+2)+2

2) How does the potential energy of an electron vary in an infinite one-dimensional crystal? How is this potential represented in Kronig-Penney model? 2+3

3) a) Distinguish among metals, insulators and semiconductors on the basis of band structure of electronic energy levels in crystals.

b) Why does a completely filled band contribute nothing to an electric current in the presence of an electric field in a crystal? 3+2

4) a) Why does the electric field seen by the dipoles in a solid differ from the applied electric field?

b) Derive the Clausious –Mossotti equation in a dielectric material with cubic structure. 1+4

5) Find the expression of magnetic susceptibility of a diamagnetic material on the basis of Langevin's classical theory. 5

6) Find the expression of magnetic susceptibility of a paramagnetic material on the basis of quantum theory. 5

7) Explain the Weiss's theory of ferromagnetism and find the expression of ferromagnetic susceptibility of a ferromagnetic material on the basis of this theory. 5

8) a) What do you mean by ferroelectricity?

b) Explain the origin of ferroelectricity.

c) Draw the pattern of P-E hysteresis loop in a ferroelectric material and describe different parts of it. 1+1+(1+2)

9) a) Differentiate between Piezoelectric effect and pyroelectric effect.

b) What do you mean by isotope effect in a superconductor? 3+2

10) Derive London equations of superconductivity and solve them.5

Broad Questions (Marks: 10)

1) a) What is the difference between a crystal and an amorphous solid?

b) Calculate the value of packing of a f.c.c crystal.

c) Describe the crystal structure of KCl.

d) Show that for a cubic lattice the direction indices[hkl]is normal to the (hkl)planes of the cubic lattice. 2+3+3+2

2) a) Define Miller indices of a plane in a crystal. What is the utility of Miller indices.

b) What do mean by the term co-ordination number of a lattice? Calculate the value of co-ordination number of a b.c.c lattice.

c) State Bragg's law of diffraction and discuss the importance of it in crystal structure analysis.(1+2)+(1+2)+(2+2)

3) a) What is Reciprocal lattice?

b) State the advantage of using reciprocal lattice over direct space lattice in crystal structure analysis.

c) Prove that any reciprocal lattice vector is normal to a lattice plane of the crystal lattice.

d) Show that the spacing 'd' of (hkl)planesof a crystal lattice is equal to $2\pi n/k$, where $k = |h\mathbf{a}^{*}+k\mathbf{b}^{*}+l\mathbf{c}^{*}|$, n is an integer and $\mathbf{a}^{*}$, $\mathbf{b}^{*}$and $\mathbf{c}^{*}$ are the primitive translation vectors of the reciprocal lattice. 2+2+3+3

4) a) Discuss briefly the Kronig-Penny model for the motion of an electron in a periodic potential.
b)Draw schematically the energy-wave vector diagram for a crystal.

c) What do you mean by reduced zone representation? 5+3+2

5) a) What do you mean by the dispersion relation in a linear lattice?

b) Obtain the dispersion relation for a linear diatomic lattice and show that its vibration spectrum consists of two branches.

c) What is the first Brillouin zone? 2+6+2

6) a) Define the term 'effective mass of electron' .Is it different from the free electron mass?

b) Plot the energy E against the wave vector k for the first allowed energy band in a crystalline solid. How do you account for the negative effective mass of an electron from this E-k curve?

c) Show that the effective mass of a hole is more than that of a free electron. (1+1)+(3+3)+2

7) a) State the assumptions made by Einstein's theory of specific heat of solids.

b) Deduce an expression for specific heat capacity at constant volume of a solid according to Einstein's theory.

c) Discuss how this expression of specific heat agrees with experiment?

d) What isEinstein's temperature? 3+5+1+1

8) a) Why is Debye's theory of specific heat is more acceptable than the Einstein's theory.

b) Obtain the expression of specific heat capacity of solids at constant volume at low temperature on the basis of Debye's theory.

c) What is Debye temperature?

d) What is the weakness of Debye's theory of specific heat of solids? 3+5+1+1

9) a) Explain the term electronic polarization and electronic polarisibility.

b) Find an expression for electronic polarisibility of a gas with atomic radius R.

c) Does the electronic polarisibility vary with temperature?

d) Differentiate among the electronic, ionic and orientational polarization. 2+3+2+3

10) a) Explain the phenomenon of Hall effect.

b) Find the expression of Hall coefficient.

c) Write the importance of Hall Coefficient.

d) How can the value of Hall coefficient are measured by experiment. 2+2+2+4

DSE-1A Physics
ADVANCED MATHEMATICL PHYSICS-I
Sample question

Short answer type questions (Marks: 1)

1.

(a) What do you mean by a piecewise continuous function?

(b) If $A = \lambda_i x^i$ for all values of the independent variables x^i 's and λ_i 's are const $\frac{\partial}{\partial x^j}(\lambda_i x^i)$.

(c) Write down the Christoffel 3 index symbol of second kind denoted by $\begin{Bmatrix} m \\ p\ q \end{Bmatrix}$.

(d) Define inner product of two vectors.

(e) What is the Laplace transform $L[\delta(t)]$, $\delta(t)$being Dirac Delta function?

(f) Convert the function$f(t) = \begin{cases} 6, t < 2 \\ 4, t \geq 2 \end{cases}$, in terms of unit step function.

(i) Under what condition a set of vectors can be called linearly independent?

(j) Define a linear functional.

Medium Questions (Marks: 5)

2. Show that the set of vectors $\{(1,-1,0),(1,1,0),(0,1,1)\}$ forms a basis in the real space R^3. Hence express the vector $(5,3,4)$ in terms of given basis. 3+2

3. (a) Write down the Quotient law of tensors.

   (b) For the line element $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$, argue that is a covariant tensor of rank two. 2+3

4. Find out the Laplace transform of a periodic function $f(t)$ with period T. Using the result obtained find the Laplace transform of the waveform $f(t) = \frac{2t}{3}, 0 \le t \le 3$. 3+2

5. Using the properties of Levi-Civita tensor show that

   (a) $\vec{A}.\left(\vec{A}x\vec{B}\right) = 0$

   (b) $\vec{\nabla}.\left(\vec{\nabla}x\vec{B}\right) = \vec{\nabla}\left(\vec{\nabla}.\vec{A}\right) - \nabla^2\vec{A}$ 2+3

6. Consider the transformation $T: R^3 \to R^3$ such that $T\begin{pmatrix}x\\y\end{pmatrix} = \begin{pmatrix}x-y\\2x+y\end{pmatrix}$. Prove that T is linear. Also find the matrix which represents T relative to the basis $\left\{\begin{pmatrix}1\\0\end{pmatrix}, \begin{pmatrix}0\\1\end{pmatrix}\right\}$. 2+3

7. Write down the Cauchy-Schwarz inequality. Hence show that, if $a_1, a_2, a_3, \ldots, a_n$ are positive numbers, then $(a_1 + a_2 + a_3 + \cdots + a_4)\left(\frac{1}{a_1} + \frac{1}{a_2} + \frac{1}{a_3} + \cdots + \frac{1}{a_n}\right) \ge n^2$. 1+4

8. Use Laplace transform to solve the Newton's second law $m\frac{d^2x}{dt^2} + kx = 0$ for a mass m hanging from a spring with spring constant k with proper initial conditions $x(t=0) = A$ and $\frac{dx}{dt}(t=0) = 0$.

9. Write down the Moment of Inertia tensor explaining each term. Hence construct the inertia matrix for a system of three point masses of 1 unit, 2 units and 1 unit placed at $(1,1,-2), (-1,-1,0)$ and $(1,1,2)$ respectively. 2+3

Broad Questions (Marks: 10)

10. (a) When do two linear vector spaces are said to be homomorphic and isomorphic?

    (b) What do you mean by kernel and nullity of a linear transformation?

    (c) Using Gram-Schmidt process, obtain an orthogonal basis for the subspace of spanned by the vectors $\{(1,0,1,0), (1,1,1,1), (-1,2,0,1)\}$. 2+2+6

11. (a) Show that a second rank contravariant symmetric tensor remains symmetric under a general coordinate transformation.

    (b) Show that the familiar Kronecker delta δ_{kl} is a mixed tensor of rank two. Why is called an isotropic tensor?

    (d) Find g^{ij} and $g = \det(g^{ij})$ corresponding to the metric tensor

    $$ds^2 = 5(dx^1)^2 + 3(dx^2)^2 + 4(dx^3)^2 - 6dx^1dx^2 + 4dx^2dx^3.$$ 2+(2+1)+5

12. (a) Find the inverse Laplace transform $L^{-1}[F(s)]$, where $F(s) = \frac{s+1}{s^2-6s+25}$.

(b) If the Laplace transform of a function $L[f(t)] = F(s)$, then show that $L[\int_0^t f(t)dt] = \frac{F(s)}{s}$.

(c) Solve the following initial value problem by Laplace transform

$$\frac{d^2y}{dt^2} - y = t,\ y(t=0) = \frac{dy}{dt}(t=0) = 0.$$ 3+2+5

13. (a) Define pure strain tensor ε_{ij} . Prove that it is a symmetric tensor of rank 2. Also give the physical significance of its components ε_{11} and ε_{12}.

(b) A covariant rank one tensor has components $xy, 2y - z^2, xz$ in rectangular Cartesian coordinates. Find its covariant components in spherical polar coordinates. (1+2+2)+5

14. (a) What do you mean by dimension of a linear vector space? Justify whether every subspace of a finite dimensional vector space is finite dimensional or not.

(b) Solve the differential equation

$$\frac{d}{dt}\vec{X} = A\vec{X}$$

where, $\vec{X} = \begin{pmatrix} x(t) \\ y(t) \end{pmatrix}$ and $A = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$, given the initial conditions $x(t=0) = x_0$ and $y(t=0) = y_0$. (2+2)+6

15. (a) Show that in general coordinates, the quantities $\frac{\partial v^i}{\partial u^j}$ do not form the components of a tensor.

(b) Construct a scalar from the tensor A^{ij}_{kl}.

(c) Write down the metric tensor of the Minkowski space in spherical polar coordinates. Why is Minkowski space not an Euclidean one?

(d) Show that the process of contraction of a tensor of rank N produces another tensor of rank $N-2$. 2+2+(2+1)+3

DSE-1B Physics
Nano Physics and Applications
Sample question

Short answer type questions (Marks: 1)

1.

(a) What is the size range of nanomaterials?

(b) What do you mean by quasi-particles?

(c) What is thermionic emission?

(d) How many dimensions do the nanotubes have on the nanoscale?

(e) Filters used in XRD may eliminate which line?

(f) Selection of deposition process depends on which factor?

(g) Which deposition process is used when a film needs to be deposited on both sides of the wafer?

(h) What is double quantum dot?

Medium answer type questions (Marks: 5)

2. Explain with suitable examples specific surface area of Nanoparticles and their special applications. 5

3. (a) Distinguish between top-down approach and bottom-up approach for the fabrication of nanomaterials. 2

(b) Explain chemical vapour deposition (CVD) technique. 3

4. Write on the specific features of quantum dot lasers. 5

5. If a quantum box is very small such that there are not any confined levels in the box, then under what condition there will be at least one bound level? 5

6. Explain the conditions for blockade. 5

Broad answer type questions (Marks: 10)

7. (a) What is NEMS? 3
   (b) Explain the application of nanostructured thin films for photonic device. 5
   (c) Define magnetic quantum well. 2

8. What is XRD? Discuss its instrumentation and application briefly. 2+8

9. (a) Solve the Schrödinger equation in order to describe the wave function and energy levels for two dimensional quantum wells. 8
   (b) What are the properties of CNTs? 2

10. Make short notes on: 5+5
   (a) Scanning Tunneling Microscopy
   (b) Atomic Force Microscopy.

DSE 2A Physics
Applied Dynamics
Sample question

Short answer type questions (Marks: 3)

1. What is Reynold's number?

2. State Lyapunov stability theorem.

3. What do you mean by normal modes of oscillation?

4. Write down the Navier-Stokes equations explaining the term involved?

5. For the differential equation $\dot{x} = \frac{1}{2r}x^2 - \frac{x}{r} - 1$, r is a non zero positive constant. Find the fixed points.

6. Find the stable equilibrium point of a particle of mass m moving in a potential $V(x) = \frac{1}{2}ax^2 + \frac{b}{4}x^4$, where a and b are positive constants.

7. Give an example of an autonomous system.

8. What is fractal? Define fractal dimension.

9. What is Chaos? What do you mean by bound motion?

10. What are the routes of the Chaos? Explain.

11. What is recursion relation?

12. What do you mean by a Hamiltonian system in two dimensions?
13. Distinguish between irrotational and rotational motion of fluid.

Medium answer type questions (Marks: 5)

1. Consider the differential equation $\dot{x} = -x^2 + x(1 - r) + r, r > 0,$ for this equation

(i) Find the fixed points and their stability,
(ii) Determine the potential function $V(x, r)$.

2. For the system of differential equations $\dot{x} = -x^3 + y,\ \dot{y} = -ax - by$, $a, b > 0$, show that (0,0) is a fixed point. Also find the Jacobin and calculate eigen values of the fixed point as a function of a and b.

3. Use Euler's equation to show that the equation for the free surface of the liquid rotating with constant angular velocity, is a paraboloid of revolution.

4. Solve the equations $\dot{x} = -x - 3y,\ \dot{y} = 2x$ and sketch the phase portrait.

5. What do you mean by a logistic map? Characterize the logistic map $x_{n+1} = rx_n(1 - x_n)$ for $0 \leq x_n \leq 1$ and $0 \leq r \leq 4$.

6. What do you mean by orbit of dynamical systems? What is it's important to find stability of the system?

7. What do you mean by Feigenbaum constant? What is it's important to set chaos. Estimate its value to set chaos for logistic map.

8. What is Lotka Voltera model of Predator and prey? Explain the dynamical system $\dot{x} = x(y - 1)$, $\dot{y} = y(2 - x)$.

Broad answer type questions (Marks: 10):

1. What do you Cobweb analysis of stability? Consider the map $x_{n+1} = Sinx_n$, show that stability of the fixed point $x^* = 0$ is not determined by the linearization. Then use Cobweb to show that $x^* = 0$ is a stable in fact globally stable.

2. What do you mean by characterizing of chaotic behaviour by power spectra?

3. What do you mean by critical points of a dynamical system? Obtain the critical points of the system $\dot{x} = Siny,\ \dot{y} = Cosx$. What is the meaning of linearization of the system? Linearized the above system of equation.

4. Consider the Predator-prey syatem $\dot{x} = x(x(1 - x) - y),\ \dot{y} = y(x - a), 0 < a < 1$. Find the fixed points and hence justify the statement that a state exists where the predator goes extinct and the prey is still alive.

5. What are the routes of chaos? Explain the following route of chaos: Periodic doubling route of chaos, Method of quasi-periodicity, Intermittency.

6. Consider the dynamical system of the form $\dot{x} = 25x - y - x(x^2 + y^2),\ \dot{y} = x + 25y - y(x^2 + y^2)$. Change the variable of the system in polar co ordinates (r, θ). From the equation of $\dot{\theta}$, show that the origin is the only fixed point of the system.

7. Define fractal dimension. Obtain the fractal dimension of the Sierpinski triangle. What is the application of the fractal geometry in dynamical system? and also fin the area of the Sierpinski triangle?

8. What do you mean by Cantor set? Find its dimension.

9. Derive the expression of the equation of continuity of a fluid. What is Venturimeter? What is Pilot-tube? A vessel of rectangular cross section containing water is moving with constant acceleration f horizontally and water is coming out from the hole which at depth h from the free surface of water. Find the velocity of efflux of water when the height of the water column is h above the hole.

10. Consider the following set of differential equations: $\dot{x} = -x + y + xy,\ \dot{y} = x - y - x^2 - y^3$. Show that the system has one fixed point. Hence prove that this fixed point is stable by applying a Lyapunov functional of the form $V(x, y) = ax^2 + 2y^2, a > 0$.

11. Deduce the eigen value equation for small oscillation. Find the frequency of small oscillation for parallel pendulum.

DSE-2B

ATMOSPHERIC PHYSICS

Sample question

Short answer type questions (Marks: 1)

1. (a) What are aerosols?

   (b) Mention the fundamental forces that govern atmospheric motion.

   (c) How does the atmosphere maintain Earth's average surface temperature?

   (d) What is the basic principle of radiometry?

   (e) What do you mean by Mesoscale Convective System (MCS)?

   (f) What is Hadley scale?

   (g) State the difference between geostropic flow and gradient flow.

   (h) What do you mean by Easterly Jet Stream (EJS)?

   (i) Give a reason for why weather pattern differs between the northern hemisphere and southern hemisphere.

   (j) Assuming dry air, state the difference between a stable and an unstable atmosphere.

Medium answer type questions (Marks: 5)

2. Briefly explain the working principle of atmospheric RADAR. How can it forecast cyclonic storm? 3+2

3. What do you mean by adiabatic lapse rate? Show that the adiabatic lapse rate of dry air is given by $\frac{g}{c_p}$, where c_p is the specific heat at costant pressure of dry air and g is the acceleration due to gravity. 1+4

4. On what factors scattering of light depend? Differentiate between Rayleigh scattering and Mie scattering. 2+3

5. Briefly discuss about different types of clouds with their identifying features. 5

6. Write down the working principle and applications of an atmospheric LIDAR. 3+2

7. Assuming an ideal gas model, deduce the expression of atmospheric pressure at an altitude measured vertically upwards from the surface of the Earth. 5

8. What are the different types of atmospheric waves? Briefly explain their characteristics. 1+4

9. What is Brunt-Vaisala frequency in an isothermal atmosphere? Explain its importance in determining atmospheric stability. 2+3

Broad answer type questions (Marks: 10)

10. What is Radiosonde measurement? Describe the process of vertical atmospheric profiling using a Radiosonde instrument. 2+8

11. Deduce the Euler's equation of motion of a non viscous fluid. Express this equation in vectorial form and explain the physical meaning of each term present in the expression. 6+4

12. Define absorption and scattering cross-section of a radiation. Discuss spectral distribution of solar radiation. 3+7

13. Starting from the principle of conservation of absolute vorticity deduce the Rossby wave equation. Also find the expressions for the phase and group velocities of Rossby waves. 5+5

14. With a schematic diagram explain the heat balance process of the Earth's atmosphere. What is Greenhouse effect? 8+2

15. Assuming the air to behave like an ideal gas, derive the equation of state for dry air. How this equation is modified for moist air? 8+2

CC13
Electromagnetic Theory
Sample Questions

Short questions (Marks: 1)

1.
(a) Find out the dimension of the quantity $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$.

(b) What is the value of impedance of free space?

(c) Why it is not possible for sound waves to be polarized?

(d) What is the essential difference between a step-index and a graded-index optical fibre?

(e) What is an evanescent wave?

(f) Define optic axis of a crystal.

(g) What is the value of the magnetic field in air at a distance 250 cm from a radiating source of power 1 kW?

(i) Why any initial charge density in a conductor dissipates in a characteristic time?

(j) Why for a plane electromagnetic wave propagating through a good conducting medium, the field energy is almost entirely magnetic in character?

Medium Questions (Marks: 5)

2. (a) Determine the electric field at the surface of an infinitely long solenoid with N turns per unit length, radius R and a carrying a time dependent current $I(t) = I_0 \cos \omega t$.

   (b) In free space the electric field associated with an electromagnetic wave is given by $\vec{E} = \vec{E}_0 \sin(\omega t - kz)\hat{j}$. Find the corresponding magnetic field $\vec{B}$. Graphically represent both the fields at time $t = 0$. 2+ (2+1)

3. (a) A beam of light of frequency ω is reflected from a dielectric-metal interface at normal incidence. The refractive index of the dielectric medium is η and that of the metal is $\eta(1 +$

$i\rho$). If the beam is polarized parallel to the interface, calculate the phase change experience by the light upon reflection.

(b) What is displacement current? How it differs from normal conduction current? 3+ (1+1)

4. Show that the electromagnetic potentials $(\phi, \vec{A})$ in uniform electric and magnetic field can be expressed as $\phi = -\vec{E}.\vec{r}$ and $\vec{A} = \frac{1}{2}(\vec{B}x\vec{r})$. Assume now, there exists another set of potentials $(\phi', \vec{A}')$. By how much the two sets of potentials differ so that the electric field $\vec{E}$ and the magnetic field $\vec{B}$ remain invariant? Justify your answer. 2+3

5. Consider two electromagnetic waves propagating in vacuum with their electric field vectors

$$\vec{E} = \vec{E}_0 \cos(kz - \omega t)\hat{\imath} + \vec{E}_0 \cos(kz - \omega t)\hat{\jmath}.$$

(a) Calculate the magnetic field $\vec{B}$ corresponding to the superposition of these two waves.

(b) Calculate the time-averaged energy density $\langle u \rangle$.

(c) Calculate the Poynting vector $\vec{S}$. 2+2+1

6. (a) Explain the phenomenon of double refraction in a uniaxial crystal on the basis of Huygen's theory.

(b) Explain why, if we hold a glass plate horizontally at the level of our eye, the plat acts like a mirror. 3+2

7. What do you mean by plasma oscillation in a dilute ionized gas which is subjected to an externally applied electromagnetic field? Define electron plasma frequency (ω_p). Show that the applied field cannot propagate through the given medium if its frequency is shorter that ω_p. 2+1+2

8. (a) What do you mean by an optically active substance? State Biot's law of rotatory polarization.

(b) A certain solution of concentration 6.0 $g/100\ cc$ used in a tube of length 33 cm causes $14^0 30'$ rotation in the plane of polarization of an incident light beam of wavelength 550 nm. Estimate the rotation that would be caused by the some solution to a light beam of wavelength 450 nm. (1+1)+3

9. (a) Stating the boundary conditions explicitly, find all the field components corresponding to the lowest transverse magnetic (TM) mode for a rectangular wave guide.

(b) What do you mean by Numerical Aperture of an optical fibre? 4+1

Broad Questions (Marks: 10)

10. (a) Show that the electric field $\vec{E}$, the magnetic field $\overrightarrow{B}$ and the propagation unit vector $\hat{n}$ are related by $c\overrightarrow{B} = \hat{n}x\vec{E}$.

    (b) Assuming a charge free condition, develop the electromagnetic wave equations for a conducting medium. Hence derive the expression for 'skin depth' in a conductor.

    (c) An electromagnetically shielded room is designed so that at a frequency $10^7\ rad/s$, the intensity of the external radiation that penetrates the room is 1% of the incident radiation. If the conductivity of the shielding material of the room is $\frac{1}{2\pi}10^6\ \Omega m^{-1}$, calculate its minimum thickness. 3+(3+1)+3

11. Give the construction details of Laurent's half-shade polarimeter. Explain how this device can be used to find the concentration of a given sugar solution. 5+5

12. Starting from Maxwell's equations obtain the wave equations for the propagation of an electromagnetic wave in a symmetric planar waveguide. What is the dimensionless wave guide parameter 'V'? Show that there exists only one symmetric transverse electric (TE) mode for the given situation for $0 < V < \pi$. 4+2+4

13. (a) In what respect does an electrically anisotropic medium differ from an isotropic one? Write down the expression for the permittivity tensor in an electrically anisotropic medium and show that it is symmetric in nature. 2+1+1

    (b) Derive Fresnel's relations for reflection and reflection of plane electromagnetic waves at an interface between two dielectric media assuming that the electric field vector of the incident wave is normal to the plane of incidence. 6

14. (a) Show that the superposition of a left-handed and a left-handed circularly polarized light produces a plane polarized light.

(b) A ray of yellow light ($\lambda = 5893A^0$) incident on a doubly refracting plate at an angle 50^0. The plate is cut so that the optic axis is perpendicular to the plane of incidence and parallel to the front face. Find the angular separation between the emerging O-ray and E-ray. The refractive indices of the two rays are given by, $n_0 = 1.662, n_e = 1.474$ respectively.

(c) What should be the angle of the Sun at the horizon, so that sunlight reflected from a still lake is plane polarized? Take the refractive index of water as 1.33. 4+4+2

15. (a) Stating the required conditions, derive the inhomogeneous wave equations satisfied by the electromagnetic potentials $(\phi, \vec{A})$.

(b) Obtain Kirchoff's voltage law for series LCR circuit using Maxwell's equations. (3+4)+3

CC14
Statistical Mechanics
Sample Questions

Short questions (Marks: 1)

1.

(a) Write down the Additive law of probability.

(b) Which statistics is obeyed by an atomic nucleus?

(c) What is meant by 'Thermodynamic limit'?

(d) Sketch a plot of C_V vs. T for an ideal Bose gas highlighting the important features.

(e) An energy level is 3 fold degenerate. In how many ways can two Maxwell-Boltzmann particles be distributed over them?

(f) Identical particles can be considered as distinguishable if

(i) $n\lambda^3 >> 1$, (ii) $n\lambda^3 \approx 1$, (iii) $n\lambda^3 << 1$, (iv) None of these

(g) Chemical potential of a bosonic system cannot be negative. — Explain.

(h) (3, 1, 1) and (2, 3, 0) are the two macrostates of a system of five particles corresponding to energy $9E$. Which of the above two corresponds to most probable distribution?

Medium questions (Marks: 5)

2. (a) Derive Wien's displacement law of black body radiation from Planck's law. 3

   (b) A body at 1500 K emits maximum energy of radiation at a wavelength of 2000 nm. If the sun emits maximum energy of radiation at 550 nm, what is the temperature of the sun? 2

3. (a) What do you mean by electron gas in a metal? Why is it called a 'highly degenerate Fermi system'? $1\frac{1}{2}+1\frac{1}{2}$

   (b) The number of conduction electrons per c.c. in Beryllium is 24.2×10^{22} and in Cesium it is 0.91×10^{22}. If the Fermi energy of conduction electrons in Beryllium is 14.44 eV, calculate the Fermi energy in Cesium. 2

4. (a) Explain the concept of phase space and phase trajectory. 2

   (b) Find the phase space trajectory of a one dimensional oscillator having energy E, mass m and frequency ν. 2

   (c) Calculate the number of phase cells available. 1

9

5. Show that, under MB statistics the number of molecules of an ideal gas in equilibrium at temperature T having momentum in the range from p to $p+dp$ is given by, $h(p)\,dp = \dfrac{4\pi N}{(2\pi mkT)^{3/2}} \cdot p^2 e^{-\frac{p^2}{2mkT}}\,dp$. $3\frac{1}{2}+1\frac{1}{2}$

   Hence find the expression of most probable momentum.

6. Show that, for a two dimensional free electron gas, the number of electrons per unit area is given by, $n = \dfrac{4\pi mkT}{h^2}\ln(E^{E_F/kT}+1)$. 5

Broad Questions (Marks: 10)

7. (a) Establish Gibbs paradox for mixing of two ideal gases, assuming appropriate expression for entropy. 3

(b) Discuss Gibbs' solution of the paradox. 4

(c) Deduce the correct expressions for Gibbs free energy and Helmholtz free energy. 3

8. (a) In a two dimensional gas, the molecules can move freely on a plane, but are constrained within an area A. Show that, 3+2+2

(i) The density of states is given by, $g(E)\,dE = \dfrac{2\pi mA}{h^2}dE$.

(ii) The single particle partition function is given by, $Z_1 = \left(\dfrac{2\pi mA}{h^2}\right)kT$.

(iii) The equation of state is given by, $p = \dfrac{NkT}{A}$.

(b) N distinguishable particles are distributed in three states having energy 0, kT and 3 kT. If the total equilibrium energy of the system is 2000 kT, then find N. 3

9. (a) Draw the FD distribution function for temperatures $T = 0\,\text{K}$ and $T \neq 0\,\text{K}$. 2

(b) Show that for a completely degenerate Fermi system, the Fermi energy is given by, $E_{\text{F}} = \dfrac{h^2}{8m}\left(\dfrac{3n}{\pi}\right)^{2/3}$, where n is the number density of the fermions. 3

(c) Explain Bose-Einstein condensation. Derive an expression for the critical temperature at which this phenomenon sets in. 5

10.(a) What is thermodynamic probability? 1

(b) Find the expression of thermodynamic probability for a macro-state. 3

(c) Calculate the percentage error introduced in using Stirling's approximation when n = 5, 10 and 20. Hence comment on the result. What would be the case for $n \to \infty$? 3+1+1

(d) What is Boson? 1

DSE 3A Physics
Advance Mathematical Physics II
Sample questions

Short questions (Marks: 3)

(a) Show that the inverse of each group element of a group is unique. 3

(b) Prove that for all $x, y \in G$, $(xy)^{-1} = y^{-1}x^{-1}$. 3

(c) Define Hamiltonian H. Give its physical significance. 1+2

(d) Discuss the limit at which binomial distribution becomes Poisson distribution. 3

(e) Show $[J_z, J_x] = J_y$ where [ ] stands for Poisson bracket and J_x, J_y and J_z are the x, y and z-component of angular momentum. 3

(f) The mean and variance of a Binomial distribution are 3 and 2. Find the probability that the variate takes values less than or equal to 2. 3

Medium questions (Marks: 6)

2. Show that homogeneity and isotropy of space leads to conservation of linear and angular momentum respectively. 3+3

3. (a) Show that a function whose Poisson bracket with Hamiltonian vanishes is a constant of motion. 3

(b) What do you mean by Legendre dual transformation? How one can obtain Hamilton's function from Lagrange's function. 1+2

4. (a) What do you mean by representation of a group? Distinguish between reducible and irreducible representation. 2+2

(b) Define a cyclic group. 2

5. (a) Derive the expression for mean and standard deviation of the Binomial distribution. $1\frac{1}{2}+2\frac{1}{2}$

(b) Four bad apples are mixed accidentally with 20 good apples. Obtain the probability distribution of the number of bad apples in a draw of 2 apples at random. 2

6. (a) What do you mean by canonical transformation? Show that the transformations $P = \log(\sin p)$ and $Q = q \tan p$ are canonical. 4

(b) State and explain Hamilton's least action principle. 2

7. A point P is chosen at random on the circumference of the circle $x^2 + y^2 = 1$. The random variable X denotes the distance of P from the point (1, 0). Find the mean and variance of X. 6

Broad Questions (Marks 12)

8. (a) What is Abelian group? 2

(b) Show that four matrices $A=\begin{pmatrix}1 & 0\\ 0 & 1\end{pmatrix}$, $B=\begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix}$, $C=\begin{pmatrix}-1 & 0\\ 0 & -1\end{pmatrix}$ and $D=\begin{pmatrix}0 & -1\\ 1 & 0\end{pmatrix}$ form an Abelian group of order four under multiplication. 4

(c) Show that the identity element of a group is unique. 2

(d) Write short notes on: 2+2=4

(i) Homomorphism

(ii) Isomorphism.

9. (a) Define the character of a representation. 2

(b) Prove that all conjugate elements of a group have the same character. 4

(c) State and explain Schur's lemma. 3

(d) What do you mean by order of a group? Prove that an element of a group and its inverse have the same order. 1+2

10.(a) Discuss the motion of a force free symmetrical top. 4

(b) Obtain the Euler Lagrange differential equation by variational method. 4

(c) The Hamiltonian of a one dimensional harmonic oscillator is given by 4

$$H(q,\ p)=\frac{p^2}{2m}+\frac{1}{2}m\omega^2q^2$$

where all the symbols have their usual meanings. A canonical transformation from (q, p) to (Q, P) is performed using the following generating function:

$$F_1(q, Q)=\frac{1}{2}m\omega q^2\cot Q$$

Find $H(Q, P)$.

11.(a) Define the Poisson distribution. 1

(b) Work out the Moment Generating Function (MGF) for the distribution. 4

(c) A biased die has probabilities $p/2$, p, p, p, p, $2p$ of showing 1, 2, 3, 4, 5, 6 respectively. Find the variance of this probability distribution. 4

(d) Calculate the mean of the probability distribution 3

$$f(x)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{(x-\mu)^2}{2\sigma^2}}$$

σ, μ are positive constants.

Physics 6th Semester
DSE 3B
Astronomy and Astrophysics
Sample questions

Short questions (Marks: 3):
1. What is Hubble law related to velocity distance of galaxies?
2. What do you mean by optical depth?
3. What are the sources of solar energy?
4. What is reflecting telescope?
5. What is refractive telescope?
6. What is parsec?
7. What is astronomical unit?
8. What is light year?
9. What do you mean by S0 galaxy?
10. What do you mean by galactic plane?
11. The radio sun is the solar corona – Establish the statement.
12. How are the various forms of solar activity related to the sun's magnetic field?

Medium questions (Marks: 6):
1. State Hubble law. Given H0 = 70 km/s/MPc, estimate the age of the universe.
2. What do you mean by thermodynamical equilibrium both globally and locally?
3. Determine the size of the earth must shrink so that the use of Einstein's theory of gravity become necessary.
4. What do you mean main sequence star? Explain briefly.
5. Estimate the time for which a 10 $M_\odot$ main sequence star will continue to burn hydrogen. (where $M_\odot$ is the solar mass & the burning time of hydrogen for sun is 10^{10} years).
6. What do you mean by galaxy morphology?
7. Make a sketch of the Milky Way galaxy. Show the position of Sun in it.
8. Describe the difference between Newtonian theory of gravity and Einstein's theory of gravity.
9. Compare advantages and disadvantages of reflecting and refractive telescope.
10. Why short waves are used for radio transmission at far off places?
11. Two source emitting 21 cm radiation are situated at an angular distance of 5 degree from each other. Obtain the minimum diameter of a parabolic dish that will just separate the two sources.
12. The parallax of the star Proxima Centuri is 0.785". Find its distance in parsec, light year, astronomical unit, mile and kilometer.
13. What do you mean by face on and edge on picture of galaxy? What do you mean by galactic plane?
14. What are population-I and population-II stars? Which types of stars are older?
15. What do you mean by microwave background radiation?
16. Why gravitational interaction is the most relevant interaction in cosmology?
17. Why Newtonian framework is not suitable for the theory of gravitation in cosmology?

18. List the different nuclear reactions which may be present in the stars. Discuss the solar neutrino puzzle.

Broad questions (Marks 12):

1. a) What is binary star system? Explain. 6
b) Using the appropriate diagram, explain the horizontal coordinates of a star and determine these for the pole star. 6
2. a) Derive the expression for Jean's mass for stellar object. What is the physical significance of Jean's mass? 5
b) What is luminosity of a star? What is apparent and absolute luminosity of a star? Find therelation between them. If the apparent luminosity of Sirius A star is -1.47 and its distance from us is 2.67 Pc. Calculate the absolute luminosity. 7
3. a) What are the different types of telescopes? Explain briefly working principal of anyone type telescope. 6
b) What do you mean by galaxy? Describe Hubble's classification of galaxies. 6
4. a) Describe the basic structure and properties of the Milky Way. 6
b) Describe the nature of rotation and rotational curve of the Milky Way. 6
5. a) Describe the properties of the Galactic Nuclei and the properties around the Galactic Nuclei. 5
b) What are the sources of solar energy? Describe it by nuclear reactions? Describe different layers of Sun. 7
6. a) Describe Virial theorem in astrophysics. 6
b) Describe Hertzsprung Russel's diagram to classification of stars. 6
13. Explain the equivalence of Colour magnitude (C-M) and Hertzsprung-Russel (H-R) diagrams. Why C-M diagram is used more often than the H-R diagram in the stellar photometer?
7. a) What is the age of the universe? With this age calculate the upper limit of the present size of the universe. And also calculate total mass in the universe. Given Hubble constant H=75 km/s/MPc, density of the universe 10^{-29} g/cc. 6
b) Describe galactic nuclei having different degree of activity. Discuss the effect of nuclear activity on the structure and evolution of the galaxy. 6
8. a) Derive the formula for the radial velocity (v_r) and the tangential velocity (v_T) for the rotation of the galaxy in terms of the Oort's constants A and B. Interpret physically A and B. 6
b) Write down the basic equilibrium conditions (mechanical & thermal) that must be satisfied by a stable stellar structure. Explain. 6

Physics 6th Semester
DSE 4A
Classical Dynamics
Sample questions

Short questions (Marks 3):

1. Prove that a possible Lagrangian for a free particle is $L = \dot{q}^2 - q\dot{q}$?
2. What are the Lagrange's equations for a non conservative system?
3. What do you mean by stable and unstable equilibrium? Give example.
4. Discuss the importance of invariant interval in special theory of relativity.

5. What are space-like, time-like and light like intervals?
6. What is the meaning of critical velocity and turbulent motion?
7. What do you mean by generalized coordinates? What is the advantage of using generalized coordinates?
8. The potential energy of a particle is given by $V(x) = x^4 - 4x^3 - 8x^2 + 48x$. Find the points of stable and unstable equilibrium?
9. Explain the meaning of normal modes and principal oscillations.
10. State the fundamental postulate of special theory of relativity. What is the significance of the postulate?
11. Explain the meaning of pressure and density at a point inside the fluid.
12. What is Reynold's number? What is its important in the study of fluid motion?
13. Find the centre of mass of a rigid circular solid cone having a base radius *R* and a height *H*.
14. Establish the relation showing the variation of mass with velocity. Define the momentum and the force of relativistically.

Medium questions (Marks 6) :
1. What is Hamilton's principle? Derive Lagrange's equation of motion from it?
2. Derive Poiseuille's equation in case of flow of liquid through a capillary tube.
3. Write down Navier Stoke's equation for the motion of viscous fluid and explain the trems?
4. Discuss the four momentum and the energy-momentum dispersion relation.
5. Show that $E^2 = p^2c^2 + m_0^2c^4$ (the symbols have their usual meaning) for a relativistic particle of rest mass m_0.
6. Determine the length and the orientation of a rod of length 10m in a frame of reference which is moving with $0.6c$ velocity in a direction making 30° angel with the rod.
7. For a symmetric top, the Lagrangian is expressed as $L = \frac{1}{2}I_0\left(\dot{\theta}^2 + \dot{\varphi}^2 \sin^2\theta\right) + \frac{1}{2}I_3\left(\dot{\vartheta}^2 + \dot{\varphi}\cos^2\theta\right) - Mgl\,cos\theta$, where $\theta, \varphi, \vartheta$ are the variables. Obtain the Hamiltonian. What are the integral of motion in this case?
8. Obtain the equation of continuity for a fluid flow.
9. What do you mean by light cone? Explain in 3-dimensional space. Explain longitudinal Doppler effect using 4-vector perspective.
10. A particle moving under a central force describes a spiral orbit given by $r = ae^{b\theta}$, where a and b are constants. Obtain the force law.
11. Obtain the normal corordinates of a system of which the Lagrangian is given by $L = \frac{1}{2}(m_1\dot{x}^2 + m_2\dot{y}^2) + \beta\dot{x}\dot{y} - \frac{1}{2}(x^2 + y^2)$. Where m_1, m_2 and $\beta$are constants.
12. Show that the motion of a particle under central force is planar.
13. Define center of mass of a rigid body or of a system of particles. Show that it is a unique point.
14. Derive the equations of Lorentz transformation. Hence explain the length contraction, time dilation and the relativity of simultaneity.

Broad questions (Marks 12):
1. a) Explain the meaning of conjugation space. Show that symmetry in the Lagrangian leads to different constants of motion.
b) What do you mean by Minkowski space and define what are world lines? 6+6

2. a) Explain the geometric interpretation of length contraction and time dilution using space time diagrams? 6
b) A central attractive force varies as r^m. The velocity of a particle in a circular orbit of radius r is twice the escape velocity from the same radius. Find m. 6
3. a) Show that ordinary 3-vector momentum is not conserved under Lorentz transformation whereas the 4-vector momentum is conserved under the Lorentz transformation. 6
b) Obtain the Lagrangian, Hamiltonian and equations of motion for a projectile near the surface of earth. 6
4. a) Water is flowing with a speed of 50 cm/s through a pipe of diameter 3 mm. Calculate Reynold's number. Is it streamline? Given η = 1centripoise. 6
b) Explain the meaning of steady state and stationary state in the context of fluid dynamics. 6
5. a) Discuss the time-derivatives that usually appear in the discussion of the motion of any fluid dynamics. 6
b) Prove that three dimensional volume element $dxdydz$ is not invariant under Lorentz transformation while the four dimensional volume element $dxdydzdt$ in invariant. 6
6. a) Obtain the relativistic energy momentum transformation relation. 6
b) What do you mean by holonomic and scleronpmic systems? Give examples.
7. a) Determine the Lagrangian of a free particle in (i) Cartesian, (ii) Cylindrical, (iii) Spherical polar coordinates. Also find the expressions for the Hamiltonian of the corresponding systems. 7
b) Establish the relation $T\ddot{\eta} + V\eta = 0$, for small oscillations of a system, the symbols having their usual meaning. 5
8. a) Explain the terms: normal frequencies, normal modes of vibrations and normal coordinates of a coupled system. 6
b) A particle of mass *m* moves in potential energy given by $V(x) = bx^2 + \frac{a}{x^2}; a > 0, b > 0.$ Show that its frequency of oscillation is $\sqrt{8b/m}$. 6

Physics Honours

Paper: DSE4B Nuclear and Particle Physics, Semester: 6th

Short questions (Question of 3 marks each):

1) What are mirror nuclei? Mention examples of mirror nuclei. 2+1

2) Differentiate between inverse beta decay and electron k-capture. 3

3) What are magic numbers? Explain the significances of magic numbers. 1+2

4) State the Geiger-Nuttall law in alpha-decay. What is the importance of this law. 1+2

5) Write the properties of lepton. Mention names of two leptons. 2+1

6) Explain the term atomic mass unit. Compute the energy equivalent to 1amu of mass in Mev unit. 1+2

7) Find out the ratio of nuclear magnetic moment to Bohr magneton. Find out the value of magnetic moment of proton and neutron. 1+2

8) Discuss the role of using electronic circuits in conjunction with nuclear detectors. 3

9) Both neutrino and anti-neutrino have the same properties-zero rest mass, zero electric charge and a spin ½. Then how are they distinguished? 3

10) Write the differences between electron and β^- particle. 3

Medium question (Question of 6 marks each):

1)a)Define binding energy of a nucleus.

b)Draw the pattern of graph between binding energy per nucleon and mass number of the nucleus and explain the significances of the peaks for very small values of mass number in this graph. 2+(2+2)

2) a) ${}_2He^4$ nucleus has no magnetic moment.-explain why?

b) Write the properties of nuclear force. 2+4

3) a)Neutron is an electrically neutral particle , still experiments show that it is associated with a negative magnetic moment.-why?

b) Explain the concept of parity of a nucleus. 2+4

4) Find an expression of alpha disintegration energy in terms of kinetic energy of alpha particle and show that most of the disintegration energy is carried by the alpha particle. 4+2

5) a)Discuss the origin of fine structure of alpha-ray spectra.

b) If the alpha particles are emitted from states other than ground state , then how the probability of alpha-emission will be affected? 3+3

6) a) What is Cherenkov radiation?

b) What do you mean by quenching of a GM-counter? 3+3

7) a)Discuss the principle of working of the van de Graff generator.

b) Mention some of the uses of the van de Graff generator. 4+2

8) a)Explain the principle of operation of a cyclotron?

b) Why electrons can not be accelerated by cyclotron? 4+2

9) Explain the phase stability and phase oscillations in a synchrotron. 6

10) a)How does a muon differ from a meson?-Explain.

b) How do the quarks combine to form baryons and mesons?

c) What are antiparticles? Mention the names of a pair of particle and antiparticle. 2+2+2

Broad Questions (Question of 12 marks each):

1) a) What is quantum mechanical tunneling?

b) Write the Gamow's theory of alpha-decay .

c) Explain qualitatively how did the neutrino hypothesis restore the energy and angular momentum conservation laws in beta-decay. 2+6+4

2) a) How do the gamma rays originate?

b) What do you understand by internal conversion? How does it take place?

c) Show that β^- decay occurs if the mass of the parent atom is greater than the daughter atom.

d) Show that electron capture is possible, if and only if the mass of the parent atom is greater than that of the daughter atom by at least the binding energy of the electron. 3+(2+3)+2+2

3) a) Define Q-value of a nuclear reaction and write down its expression.

b) What do you mean by exoergic and endoergic nuclear reactions? Mention one examples of each type of these two types of nuclear reaction.

c) Define threshold energy of a nuclear reaction and write its expression.

d) In the reaction $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n + Q$, the energy released is 3.26 Mev. If the masses of the atoms of deuterium and helium are 2.014102 u and 3.016049 u respectively, find the mass of neutron. 3+5+2+2

4) a) Define and explain the term nuclear reaction cross section. What is its unit?

b) If a beam of N_0-particles is incident on a slab of thickness x of the material , how many particles will emerge out of the slab? Given that the slab contains n atoms per unit volume and δ is the cross section of the reaction.

c) Define and explain the term differential cross section of the reaction. (3+1)+5+3

5) a) Explain the basic similarities between a liquid drop and an atomic nucleus.

b) Obtain Bethe-Wiezsacker semi-empirical mass formula clearly explaining the significances of the terms involved in it.

c) Mention the failures of liquid drop model of nucleus. 4+6+2

6) a) Point out the basic assumptions of shell model of the nucleus. Write down the evidences in favour of shell model.

b) Write down the basic assumptions behind Fermi gas model of nucleus. (4+4)+4

7) a) Describe the construction, principle and working of an ionization chamber.

b) Explain the difference between ionization chamber and GM counter.

c) What are the three properties of nuclear radiation used in detection instruments. 6+3+3

8) a) Describe the construction and working of a semiconductor detector. What are its advantages?

b) What is scintillation? 7+3+2

9) a) Explain the working principle of a linear accelerator?

b) Find out the expression of drift tube length of a linear accelerator.

c) Can an electron be accelerated by it?-Explain. 7+3+2

10) a) Discuss the broad categories into which elementary particles are classified.

b) Write the names of the conservation laws which govern the elementary particle reaction and decay.

c) What are strange particles? How are the strangeness, quantum number, the baryon number and the third component of isotopic spin related to the charge of an elementary particle? 3+4+(1+4)