

**B.Sc. 5th Semester (Honours) Examination, 2024 (CBCS)****Subject : Physics****Course : DSE-2 (1)****(Nano Materials and Applications)****Time: 2 Hours****Full Marks: 40***The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words  
as far as practicable.***1. Answer any five of the following questions: 2×5=10**

- (a) Why are nano materials more reactive than their bulk counterpart?
- (b) Compare the specific surface area of spherical nanoparticles of size 80 nm and 4 nm.
- (c) What is meant by top-down approach in the synthesis of nanoparticles?
- (d) What information can we obtain by analyzing XRD pattern of a crystal?
- (e) What do you mean by a quasi-particle?
- (f) Distinguish between defects and impurities.
- (g) Define grain boundary of a nanoparticle.
- (h) What is a Quantum dot laser?

**2. Answer any two of the following questions: 5×2=10**

- (a) What do you mean by 'length scale' in Physics? Explain briefly. State the range of dimensions of nano materials. 4+1
- (b) What is a quantum wire? How many dimensions are confined in this case? For a quantum wire, sketch the density of states (DOS) as function of energy,  $E$ . 2+1+2
- (c) What is a sol-gel process? What are the basic steps in a lithography sequence? 2+3
- (d) What do you mean by Magnetic Dots? Explain the mechanism of Magnetic Data Storage. 2+3

**3. Answer any two of the following questions: 10×2=20**

- (a) (i) Show that the accuracy of a measurement will increase with the increase in angle of diffraction. Monochromatic X-rays of wavelength 1.4 nm are incident on a crystal having a lattice constant  $d = 1.5$  nm. Find the maximum order in which the diffraction take place.
- (ii) Describe the process of spray pyrolysis for the synthesis of nanoparticles. (2+3)+5

- (b) (i) Why are optical microscopes not suitable for resolving objects at atomic level? Compare the features of scanning electron microscopy and scanning tunneling microscopy.
- (ii) Discuss briefly about the accuracy of the average particle size determined by XRD and TEM. (2+4)+4
- (c) (i) Briefly outline the few important characteristics of excitons. In which way Mott-Wannier excitons are different from Frenkel excitons?
- (ii) Where can you observe both Mott-Wannier as well as Frenkel excitons and why? What is the physical significance of exciton Bohr radius? (3+2)+(3+2)
- (d) (i) Explain briefly Coulomb blockade effect in connection to quantum dot. What is the origin of the presence of line defects in a crystal?
- (ii) Discuss briefly the applications of quantum dots in LED. Indicate some of the major commercial applications of MEMS. (3+2)+(3+2)
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**B.Sc. 5th Semester (Honours) Examination, 2024 (CBCS)****Subject : Physics****Paper : DSE-2(2)****(Communication Systems)****Time: 2 Hours****Full Marks: 40***The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words  
as far as practicable.***1. Answer any five of the following questions: 2x5=10**

- (a) What is the function of a carrier signal in a modulation system?
- (b) Differentiate phase modulation and frequency modulation.
- (c) What is meant by diagonal clipping and negative peak clipping?
- (d) Define signal-to-noise ratio (S/N) and noise figure.
- (e) What is aliasing? How is it reduced?
- (f) Define bit rate and baud rate.
- (g) What are the advantages of satellite communication system?
- (h) What is the minimum bandwidth needed to transmit a 4kHz voice signal using AM?

**2. Answer any two questions from the following: 5x2=10**

(a) State sampling theorem of a continuous signal. Find the Nyquist rate and Nyquist interval for the given signal:  $x(t) = \frac{1}{2\pi} \cos(4000\pi t) \cos(1000\pi t)$ . 2+3

(b) The output of an AM transmitter is given by:

$U_m(t) = 600(1 + 0.5 \sin 3140t) \sin 6.28 \times 10^7 t$  volt. Calculate carrier frequency, modulating frequency, modulation index, carrier power if the load is  $600\Omega$  and also find the total power. 5

(c) With suitable signal diagrams explain the principle of Binary Phase Shift Keying (BPSK). 5

(d) A frequency modulated wave is represented by  $v(t) = V_0 \cos(\omega_c t + m_f \sin \omega_m t)$ , where the symbols have their usual meaning. Show that if the modulation index  $m_f \ll 1$  then the bandwidth of the FM is approximately  $2\omega_m$ . 5

3. Answer *any two* questions from the following:

$10 \times 2 = 20$

(a) Describe the role of transponders in satellite communication systems. Why is uplink frequency generally higher than downlink frequency in satellite communication?

Using Kepler's law, estimate the orbital velocity of a Geosynchronous satellite and hence estimate round trip propagation delay between a satellite and an earth station located just below it.

2+2+6

(b) Define the following terms for FSK modulation— frequency deviation, modulation index and deviation ratio. What is Binary Phase Shift Keying? FSK and PSK signals preferred over ASK signals.—Why?

2+2+2+2+2

(c) What is a discriminator? In the context of FM demodulation, explain with necessary diagrams the working of a slope detector.

2+8

(d) Draw the block diagram of a superheterodyne receiver and explain the function of each block.

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**B.Sc. 5th Semester (Honours) Examination, 2024 (CBCS)****Subject : Physics****Paper : DSE-2(3)****(Classical Dynamics)****Time: 3 Hours****Full Marks: 60***The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words  
as far as practicable.*

1. Answer *any ten* questions from the following:  $2 \times 10 = 20$
- (a) What is action in Lagrangian dynamics? Write down its dimension.
  - (b) The Lagrangian of a system is  $L = \frac{\dot{q}^2}{2} + q\dot{q} - \frac{q^2}{2}$ . Show that it describes the motion of harmonic oscillator.
  - (c) Mention the conserved quantities of a system with Lagrangian  $L = \frac{m}{2}(\dot{r}^2 + r^2\dot{\theta}^2) - V(r)$ . Explain in favour of your answer.
  - (d) If the Lagrangian of a particle moving in one dimension is given by  $L = \frac{\dot{x}^2}{2x} - V(x)$ , find the Hamiltonian of the particle.
  - (e) If the Lagrangian of a system does not depend upon time explicitly, show that the Hamiltonian of the system is a constant of motion.
  - (f) Define laminar flow and turbulent flow of fluid.
  - (g) The speed of an electron in a uniform electric field changes from  $0.95c$  to  $0.98c$ . Calculate the change in mass of the electron (rest mass of an electron is  $9.1 \times 10^{-31}$  Kg).
  - (h) What is proper time interval between the occurrence of two events if in one inertial frame events are separated by  $7.5 \times 10^8$  m and occur 6.5 s apart?
  - (i) A squared disc of length 1m is moving with velocity  $0.8c$  along one of its edge in S-frame. Find the area of the disc in that frame.
  - (j) In 4-vector representation show that the Lorentz transformation is equivalent to a rigid rotation through an imaginary angle of Cartesian axes.
  - (k) What is proper time? Obtain the expression of four-velocity.
  - (l) Prove that the wavelength of a photon is  $\lambda = \frac{h}{p}$ , where  $p$  is the momentum of the photon.
  - (m) If an electron entering at a uniform magnetic field  $2 \times 10^{-2}$  T with velocity  $3 \times 10^7$  m/sec describes a circle of radius  $8 \times 10^{-3}$  m, then find the value of e/m of the electron.
  - (n) Derive the equation of continuity for fluid in the absence of source or sink.
  - (o) What is Reynold's number? Mention one of its uses.

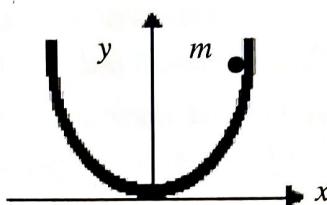
2. Answer *any four* questions from the following:

5×4=20

- (a) (i) Show that the conjugate momentum corresponding to cyclic coordinate is conserved.  
 (ii) A particle of mass  $m$  slides under the gravity without friction along the parabolic path

$y = ax^2$ , where  $a$  is constant. Find the Lagrangian and Lagrange's equation of motion of the particle.

2+(2+1)



- (b) (i) Define stable and unstable equilibrium in one-dimensional motion of a dynamical system.  
 (ii) A particle of unit mass moves in a potential  $(x) = ax^2 + \frac{b}{x^2}$ , where  $a$  and  $b$  are positive constants. Find the angular frequency of small oscillations about the minimum of the potential.

2+3

- (c) A charge particle starts moving from origin with an initial velocity in a plane perpendicular to a uniform magnetic field. Show that the path of the particle is helix. 5  
 (d) Write down the Lorentz transformations in Minkowski representation  $(x, y, z, ct)$ . Explain the time-dilation in this representation. 2+3  
 (e) Show that the norm of space-time interval between two events is a Lorentz invariant quantity. Explain the terms space-like interval and time-like interval. 3+2  
 (f) According to Navier-Stokes law for cylindrical steady flow of incompressible fluid the pressure gradient along the axis of the cylinder can be expressed as  $\frac{\partial P}{\partial z} = \frac{\eta}{r} \frac{\partial}{\partial r} \left( r \frac{\partial V}{\partial r} \right)$ , where  $\eta$  is coefficient of viscosity of the fluid and  $V$  is the velocity of fluid within the cylinder. Derive the Poiseuille's equation for the cylindrical flow of fluid. 5

3. Answer *any two* questions from the following:

10×2=20

- (a) (i) If two Lagrangians differ by the total time-derivative of a function, show that both of them give rise to the same equation of motion.  
 (ii) If the Lagrangian of a closed system remains translational invariant, prove that the linear momentum is conserved.

- (iii) A particle of mass  $m$  is connected by a spring of unstretched length  $r_0$  and spring constant  $k$ . The other end of the spring is connected to a point in the roof and the particle is swinging in a vertical plane like simple pendulum. Write down the Lagrangian and Lagrange's equations of motion. 2+3+(2+3)
- (b) (i) What is Hamiltonian of a system? Derive Hamilton's equations of motion. For a conservative system show that the Hamiltonian of the system is equals the total energy.
- (ii) The Lagrangian of a particle in cylindrical coordinate is
- $$L = \frac{m}{2} (\rho^2 \dot{\phi}^2 + \dot{z}^2) - \frac{k}{2} (\rho^2 + z^2).$$
- Obtain the Hamiltonian of the system and hence find the canonical equations of motion of the particle. (1+3+2)+(2+2)
- (c) (i) From the definition of four-momentum vector show that  $E^2 = p^2 c^2 + m_0^2 c^4$ .
- (ii) Prove that the spontaneous two-body decay is possible if the sum of the rest masses of product particles is smaller than the rest mass of a decaying particle. Obtain the expressions of total energies of product particles in terms of their rest masses. Hence, show that the total kinetic energy of the product particles is the energy due to difference in mass of decaying particle and that of the product particles. 2+(3+3+2)
- (d) (i) Define normal coordinates and normal frequencies in coupled vibration.
- (ii) The Lagrangian of an oscillating system is  $L = \frac{m}{2} (\dot{x}^2 + \dot{y}^2) - \frac{1}{2k} (x^2 + y^2) + \alpha xy$ .
- Obtain the secular equation. Hence, find the normal frequencies and the eigenvectors. 2+(2+2+4)
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