PH 571.1

Reg. No.

St Aloysius College (Autonomous)

Mangaluru

Semester I – P.G. Examination – M.Sc. Physics

February - 2022

MATHEMATICAL PHYSICS - I

Time: 3 hrs. Max Marks: 70

Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) Express $\vec{\nabla}\emptyset$ in curvilinear coordinate system and hence express it in cylindrical coordinate system. (9)

   b) State Stoke's theorem. Verify the Stoke's theorem for $\vec{v} = (2xz + 3y^2)\hat{j} + (4yz^2)\hat{k}$ along the square surface of unit side. (6)

OR

2. a) Verify the divergence theorem for $\vec{A} = 4xz\hat{\imath} - y^2\hat{j} + yz\hat{k}$ taken over a region bounded by a cube x=0, x=1; y=0, y=1; z=0, z=1. (8)

   b) Compute $\oint(xy - x^2) + x^2ydy$ over a triangle bounded by the lines y=0, x=1 and y=x and hence verify the Green's theorem in a plane (7)

UNIT-II

3. a) Express following matrix in terms of Hermitian and Anti-Hermitian matrix: (6)

$$\begin{pmatrix} 1 & -2 \\ 2 & 0 \end{pmatrix}$$

   b) Show that multiplication of two tensors is also a tensor whose rank is equal to the sum of the rank of the two tensors. (4)

   c) 1 and -1 are the eigen values of Matrix A and the corresponding eigen vectors are $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$. Construct the matrix A. (5)

OR

4. a) Write down the transformation laws for the following tensors. (6)
   (i) A^{pq} (ii) B_t^s (iii) A_t^{mn}

   b) Show that eigen values of the unitary matrix have unit magnitude. (3)

   c) Obtain the metric tensor for two dimensional plane in Cartesian and polar Coordinates (6)

UNIT III

5. a) Give an account of classification of second order partial differential equations into elliptic, parabolic and hyperbolic types. Provide an example for each type. (9)

   b) Obtain the general solution of the equation $\frac{\partial^2\phi(x,y)}{\partial x^2} + \frac{\partial^2\phi(x,y)}{\partial y^2} = 0$ in Cartesian coordinate system. (6)

Contd...2

6. a) The time dependent Schrodinger equation is given by $i\hbar\frac{\partial\psi(\vec{r},t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi(\vec{r},t) + V\psi(\vec{r},t)$ separate it into space and time part. (7)

b) Separate the three dimensional Helmholtz equation $(\nabla^2 + k^2)(\vec{r}) = 0$, in spherical polar coordinate system and identify the three ordinary differential equations. (8)

UNIT IV

7. a) Obtain the series solution of the following Legendre differential equation by power series method: (8)

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

b) Given (4)

$$J_n(x) = \sum_{r=0}^{\infty}(-1)^r\frac{1}{r!\,T(n+r+1)}\left(\frac{x}{2}\right)^{n+2r},$$

Show that $J_{\frac{1}{2}}(x) = \sqrt{\frac{2}{\pi x}}\sin x.$

c) Show that Hermite polynomials satisfy the following recurrence relation $H_{n+1}(x) = 2(n+1)H_n(x)$. (3)

OR

8. a) Prove the recurrence relation $\frac{d}{dx}[x^nJ_n(x)] = x^nJ_{n-1}(x)$ for Bessel function (7)

b) Prove the ortho normality relation for the Legendre polynomials (8)

$$\int_{-1}^{+1}P_n(x)P_m(x) = \left(\frac{2}{2n+1}\right)\delta_{mn}$$

PART-B

Answer any <u>TWO</u> questions **(5x2=10)**

9. a) If $V=5r^2\cos(\theta)\cos(\emptyset)$, find ∇^2V in spherical coordinates.

b) For any three matrices A, B and C, prove that Trace (ABC) = Trace(CAB)

c) Show that for the following differential equation x=0, is an irregular singular point.

$$x^4\frac{d^2y}{dx^2} + 2x^2(x+1)\frac{dy}{dx} + y = 0$$

d) For Legendre polynomials, show that $nP_n(x) = xP_n'(x) - P_{n-1}'(x)$

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CLASSICAL MECHANICS

Time: 3 hrs. Max Marks: 70

PART - A

Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) For a system of particles in a closed system show that the linear momentum is conserved. (9)

   b) Masses 1,2 and 3 kg are located positions $\hat{i}+\hat{j}+\hat{k}$, $4\hat{j}+3\hat{k}$ and $2\hat{i}+2\hat{k}$ respectively. If their velocities are $7\hat{i}$, $-6\hat{j}$ and $-3\hat{i}$, find the position and velocities of the centre of mass. Also, find the angular momentum of the system with respect to the origin. (6)

OR

2. a) Obtain the Euler-Lagrange equation by using the variational principle. (10)

   b) Write the equation of phase space trajectory of one dimensional simple harmonic oscillator and draw it also. (5)

UNIT- II

3. a) What are action-angle variables? Explain how they can be used to obtain the frequencies of periodic motion. (8)

   b) Apply the Hamilton-Jacobi method to determine the motion of a body falling vertically in a uniform gravitational field. (7)

OR

4. a) State and derive the principle of least action. (10)

   b) Show that the shortest distance between two points is a straight line. (5)

UNIT- III

5.a) Show that a two particle equation of motion can be reduced to a one particle problem. (8)

   b) A particle moves in a circular circumstance of the circle. Find the law of force. (7)

OR

6.a) Obtain the scattering cross-section formula for scattering of charged particles by a coulomb field. (10)

   b) Derive differential equation of orbit of a particle moving under central force. (5)

Contd...2

7.a) Obtain the expression of angular momentum of a rigid body rotating with angular velocity $\vec{\omega}$ about an axis passing through the centre of mass (8)

b) Obtain Euler's equation of motion for a rigid body. (7)

OR

8.a) Explain the meaning of normal coordinates and normal frequencies. Show that when kinetic energy and potential energy are expressed in terms of normal coordinates, both potential energy and kinetic are homogeneous quadratic functions. (9)

b) Discuss the torque-free motion of a rigid body. (6)

PART – B

Answer any <u>TWO</u> questions: **(5x2=10)**

9.a) Write a note on degrees of freedom.

b) State and prove virial theorem.

c) What are Poisson Brackets?

d) Write a note on moment of inertia tensor.

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PH 573.1 Reg. No.

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Semester I – P.G. Examination – M.Sc. Physics

February - 2022

CLASSICAL ELECTRODYNAMICS

Time: 3 hrs. Max Marks: 70

PART - A

Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) Calculate the potential inside a uniformly charged solid sphere of Radius R and total charge 'q'. (5)

   b) Using the method of images, find the total charge induced on an infinite grounded conducting plane when a point charge Q is held at a distance 'd' above it. (10)

OR

2. a) A current I is uniformly distributed over a wire of circular cross section, with radius 'a'. Find the volume current density $\vec{J}$. (5)

   b) Explain Diamagnets, Paramagnets and Ferromagnets. (5)

   c) Define Ampere's Law in magnetostatics. (5)

UNIT- II

3. a) What are gauge transformations? Show that electric and magnetic fields are invariant under a gauge transformation. (7)

   b) State and prove Poynting's theorem. (8)

OR

4. a) Obtain the expression for Lienard-Wiechert potentials for a moving point charge. (10)

   b) Compare magnetic and electric dipole Radiations. (5)

UNIT- III

5.a) Obtain Fresnel's equations for the case of polarization in the plane of incidence. (10)

   b) What is Brewster's angle? Explain. (5)

OR

6.a) Discuss the propagation of plane electromagnetic waves in conducting media. (10)

   b) Write a note on Resonant Cavities. (5)

Contd...2

UNIT- IV

7.a) What are Lorentz transformations? Explain. (5)

b) Obtain the Lorentz transformation equations for electric and magnetic fields. (10)

OR

8.a) Explain the terms 'Proper time' and 'Proper Velocity'. (7)

b) Construct the field tensor ($F^{\mu\nu}$) using 4-Vector transformation rule. (8)

PART – B

(2x5=10)

Answer any <u>TWO</u> questions:

9.a) An infinite plane carries Uniform surface charge 'σ' Find its electric field.

b) Write Larmour formula and Explain its significance.

c) Prove that Radiation Pressure $P = \frac{1}{2}\epsilon_0 E^2$.

d) Write a note on 4-vector notation.

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ELECTRONICS

Time: 3 hrs. Max Marks: 70

PART - A

Answer all questions choosing ONE from each unit. (15x4=60)

UNIT- I

1. a) What is an order of a filter? With circuit diagram explain the working of first order active Butterworth high-pass filter. Derive the expression for gain. **(8)**

b) What is Schmitt-trigger? With circuit diagram explain the working of Schmitt trigger and draw the hysteresis loop. **(7)**

OR

2. a) Explain the working of integrator and differentiator using op-amp. Derive the expressions for output voltage. **(9)**

b) With necessary diagrams explain the working of summing and averaging amplifiers using op-amp. **(6)**

UNIT- II

3. a) Explain the construction and working of UJT. Draw its V-I characteristics. **(7)**

b) Explain the working of square and triangular wave generators with suitable circuit diagrams. **(8)**

OR

4. a) With relevant block diagram explain the working of astable multivibrator using 555 timer **(6)**

b) Write a note on phase detector. **(5)**

c) Explain the Barkhansen criteria for oscillation. **(4)**

UNIT- III

5.a) With necessary diagrams explain the working of Class B push-pull power amplifier. Obtain its efficiency. **(10)**

b) Explain the construction and working of solar cell. **(5)**

OR

6.a) What is impedance matching? Explain how the impedance matching is achieved in power amplifier. **(6)**

b) What is Boxcar averager? With circuit diagram explain its operation in static gate mode and in waveform recovery mode. **(9)**

Contd...2

UNIT- IV

7.a) With block diagram explain the working of successive approximation ADC. **(9)**

b) With necessary block diagram explain the working of JK master-slave flip flop **(6)**

OR

8.a) Write a note on semiconductor memory **(5)**

b) Explain the working of 4-bit synchronous up counter. **(5)**

c) Write a note on shift register. **(5)**

PART – B

(5x2=10)

Answer any <u>TWO</u> questions:

9.a) Explain the working of inverting and non-inverting comparator with – 1 Volt as reference voltage.

b) Explain the characteristics of PLL.

c) What is cross-over distortion? How to overcome this condition?

d) Explain the synchronous and asynchronous inputs of a flip-flop.

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