RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

FIRST YEAR [BATCH 2018-21]
B.A./B.Sc. SECOND SEMESTER (January – June) 2019
Mid-Semester Examination, March 2019

Date : 25/03/2019 — **PHYSICS (Honours)**

Time : 11 am – 1 pm — Paper : II — Full Marks : 50

Group – A

(Answer any *three questions* from question no. 1 to 5)

1. a) What do you mean by a linear transformation? Explain with an example. [1+1]

   b) Three linear transformations are defined as

   $T_1(x,y)=(x,0), T_2(x,y)=(0,y)$ and $T_3(x,y)=(y,x)$

   Are these transformations commutative? [3]

2. a) Determine the matrix which produces a rotation about z-axis by an angle θ together with a reflection through the (x,y) plane. Show that the determinant of your matrix is -1. [2+1]

   b) Determine the Hermition conjugate of the matrix A,

   where $A=\begin{pmatrix} 2+3i & 1-i & 5i & -3 \\ 1+i & 6-i & 1+3i & -1-2i \\ 5-6i & 3 & 0 & -4 \end{pmatrix}$ [2]

3. a) Given $\vec{A}=(3i,1-i,2+3i,1+2i)$ and $\vec{B}=(-1,1+2i,3-i,i)$. Find the norms of $\vec{A}$ and $\vec{B}$ and also the inner product between them. Show that the Schwartz inequality is satisfied. [3]

   b) For what values of λ does the following set of equations have nontrivial solutions for x and y?

   $(4-\lambda)x-2y=0,\ -2x+(7-\lambda)y=0$ [2]

4. a) Show that $T_{ijk}V_k$ is a tensor of rank 2. [2]

   b) Write the triple scalar product $\vec{A}.(\vec{B}\times\vec{C})$ in tensor form and show that it is equal to the determinant. [2]

   c) Find whether $\vec{A}\times(\vec{B}\times\vec{C})$ is a vector or a pseudo vector assuming $\vec{A}$ is a vector and $\vec{B}$ and $\vec{C}$ are pseudo vectors. [1]

5. a) Evaluate the integral $I=\int_0^{10}\frac{x^{5/2}dx}{(10-x)^{3/2}}$ [1]

   b) Determine erf(0.1). [2]

   c) Prove that $\delta(x^2-a^2)=\frac{1}{2|a|}\left[\delta(x-a)+\delta(x+a)\right]$ [2]

Group – B

(Answer any *two questions* from question no. 6 to 9)

6. Prove that the angular momentum of a system of particles is equal to the sum of the angular momentum of a particle of mass $M=\sum m_i$, placed at the CM of the system, and the angular momentum of the system relative to the CM.

   Hence show the time rate of change of the angular momentum relative to the CM is equal to the total torque of the external forces about the CM. [3+2]

7. Show that when two particles of mass and velocity, given respectively by $(m_1, \vec{u}_1)$ and $(m_2, \vec{u}_2)$ undergo a direct collision, the change in total kinetic energy before and after collision is given by $\Delta T = \frac{1}{2}\mu(1-e^2)(\vec{u}_1 - \vec{u}_2)^2$, when μ is the reduced mass of the system and e is the coefficient of restitution. Obtain an expression for perfectly inelastic collision, when m_2 is at rest. [4+1]

8. Obtain an expression for the moment of inertia of a rigid body about an axis $\hat{n}$ passing through a given point, O, of the body, in terms of the inertia coefficient I_{ij}. Hence find the equation of the ellipsoid of inertia about O. [3+2]

9. Define the principal axes of a rigid body at a given point O, of the body. If I_1,I_2, I_3 are the principle moments of inertia, and if $I_1>I_2>I_3$, show that the M. I. $I_{\hat{n}}$ about an axis $\hat{n}$ through O, satisfy the inequality $I_1 < I_{\hat{n}} < I_3$. [5]

Group – C

(Answer any *two questions* from question no. 10 to 13)

10. Derive the formula of relativistic kinetic energy of a particle. [5]

11. a) If the kinetic energy of particle is equal to its rest mass energy then calculate its velocity.

    b) Write down the two fundamental postulates of Special Theory of Relativity. [3+2]

12. Derive the equations of Lorentz transformation. [5]

13. a) Calculate the percentage contraction of a rod moving with a velocity 0.8 times the velocity of light in a direction inclined at 60^o to its own length.

    b) What do you mean by proper length and proper time? [3+2]

Group – D

(Answer any *three questions* from question no. 14 to 18)

14. Explain Fermat's principle for propagation of light. From Fermat's principle derive the following relation for spherical refracting surface $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ where the symbols have their conventional meaning. [2+3]

15. Explain what is meant by spherical aberration. If f_1 and f_2 are the local lengths of two thin lenses separated by a distance d, show that the spherical aberration for such a combination is minimum if $d = f_1 - f_2$. [2+3]

16. a) Prove that the axial chromatic aberration is equal to ωf, where ω is the dispersive power of the material of lens for blue and red rays and f is the mean focal length of light. [3]

    b) The object of a telescope is an achromat of focal length 90 cm. If the magnitude of the dispersive powers of the two lenses are 0.024 and 0.036, calculate the focal lengths. [2]

17. a) Obtain the expression for the intensity distribution in Young's double slit experiment.

    b) Show that an abrupt phase change of π occurs when light gets reflected by a denser medium. [3+2]

18. a) Define 'fringes of equal Thickness'.

    b) What will be the fringe pattern for white light is Newton's ring experiment?

    c) For a sodium lamp, the distance travelled by the mirror between two successive disappearance is 0.289 mm. Calculate the difference in the wavelengths of the D_1 and D_2 lines. Assume $\lambda \approx 5890Å$ [2+1+2]

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