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End Semester Examination of Semester–III, 2015
Subject : PHYSICS (HONS) (UG)
Paper : IIIA (Theory)
Full Marks : 40
Time : 2 Hrs

The figures in the margin indicate the marks corresponding to the question.

Candidates are requested to give their answers in their own word as far as practicable.

Illustrate the answers wherever necessary.

Group A

Answer **any two** out of four questions : 10X2=20

1. a) A rigid body rotates about a fixed axis with angular velocity $\vec{\omega}$. Calculate the angular momentum of the rigid body and define moment of inertia. 3+1

   b) Set up the Euler's dynamical equations for rotation for a rigid body about a point. 3

   c) Calculate the moment of inertia of a uniform solid cube about an axis passing through the centre of mass and perpendicular to two opposite faces. 3

2. a) What is non-inertial frame? Give one example of it. 1+1

b) A particle describes a curve with angular velocity $\frac{\omega}{r^2}$ about a fixed point as pole. Show that transverse velocity at any point on the path is proportional $\left(\propto \frac{1}{r}\right)$ to $\frac{1}{r}$. 3

c) A particle of mass m moves under the action of a central force $\vec{F}=f(r)\hat{r}$. Show that the equation for the path of the particle is

$$\frac{d^2u}{d\theta^2}+u=-\frac{f\left(\frac{1}{u}\right)}{mL^2u^2}$$

L = Constant of motion, $u = \frac{1}{r}$. 5

3. a) Find unit vectors in cylindrical co-ordinate system. 2

b) A bullet is fired towards east horizontally with a velocity 1600 m/s from a tank gun at a place of latitude 45^0S on the earth surface. Calculate magnitudes and directions of vertical and horizontal components of its Corioli's deflection after 2s. 4

c) A heat engine operates between two identical finite heat reservoirs as source and sink, each having total heat capacity C. If they have initial temperature T_1 and T_2

respectively and final temperature T_f then show that i) $T_f \geq \sqrt{T_1 T_2}$, ii) the maximum obtainable work from the engine is $W_{max} = C\left(\sqrt{T_1} - \sqrt{T_2}\right)^2$. 2+2

4. a) If the state functions x, y, z are related by an equation of state f(x, y, z) = 0 show that

$$\left(\frac{\delta x}{\delta y}\right)_z \left(\frac{\delta y}{\delta z}\right)_x \left(\frac{\delta z}{\delta x}\right)_y = -1.$$ 3

b) Draw T–S diagram of Carnot's cycle and calculate its efficiency. 2

c) Prove $\mu = \frac{1}{C_p}\left[T\left(\frac{\delta V}{\delta T}\right)_P - V\right]$ where μ is Joule-Thomson coefficient. Show that inversion temperature of Van der Waal's gas is given by $T \approx \frac{2a}{Rb}$. 3+2

Group B

Answer **any two** out of four questions : 5X2=10

5. A force field is defined as $\vec{F} = \frac{-y\hat{i} + x\hat{j}}{x^2 + y^2}$. Find the work done around any circular path with origin of the force at (i) the centre of the circle and (ii) outside the circular path. 3+2

6. A frame S′ moves with velocity 3C/5 with respect to a rest frame S along a the common X′ or X axis. The clocks of both frames are set to 0 second when their origins coincide. The distance from origin along common axis and time of an event in frame S′ are 60 m and 8×10^{-8} s. Find the space time co-ordinates of the event in the S frame. 3

   Find the condition when two events will be simultaneous in all inertial frames irrespective of their velocities. 2

7. a) What is quasitatic process? Give example of it. 2

   b) Prove that $C_p - C_v = -T\left(\frac{\partial P}{\partial V}\right)_T\left(\frac{\partial V}{\partial T}\right)_P^2$. 3

8. Write down the criteria for first and second order phase transition with examples. Establish Ehrenfest's equation for the second order phase transition. 2+3

Group C

Answer **any five** out of 10 questions : 2×5=10

9. A particle moves on the x-axis in a force field having potential $V = x^2(6 - x)$. Find the points of equilibrium and investigate their stability.

10. Distinguish between a spherical top, symmetric top, asymmetric top and rotor.

11. What is Gravitational self energy?

12. What is Fresnel's lrag co-efficient?

13. Find the position of the centre of mass of a uniform solid hemisphere.

14. Prove that the radius vector drawn from the centre of force to the particle sweeps out equal area in equal time.

15. The life time of a μ-messon at rest is $2{\cdot}3\times10^{-6}$ s and its rest mass is 207 m_e. In a laboratory measurement the life time of a moving μ-messon becomes $6{\cdot}9\times10^{-6}$ s. What was the moving mass of the μ-messon.

16. For $P=\frac{RT}{V-6}e^{-\frac{a}{RTV}}$ show that $\left(\frac{\partial U}{\partial V}\right)_T=\frac{ap}{RTV}$.

17. Give the differences between free expansion of J–T expansion.

18. Calculate the change in the boiling point of water when the pressure is increased from 1 atmosphere to 2 atmospheres. Given : boiling point of water at 1 atmosphere is 100^0C, specific volume of steam = $1{\cdot}671$ m^3/kg and latent heat of steam = $2{\cdot}268\times10^6$J/Kg.