Code : 101101

B.Tech 1st Semester Special Exam., 2020

(New Course)

PHYSICS

(Mechanics)

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

(v) Symbols used (if any) have their usual meanings.

1. Answer any *seven* questions : 2×7=14

(a) The position of a particle of mass m under the influence of a free particle is given by $\vec{r} = A\sin\omega t\,\hat{i} + B\cos\omega t\,\hat{j}$. Find the expression for its momentum.

(b) Express $\vec{r}$ of spherical coordinate system into unit vectors of Cartesian coordinate system.

(c) Give two examples of non-conservative forces.

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(d) Define Euler angles.

(e) Consider a cloud of point particles interacting through gravitational forces and having a distribution of kinetic energy. What is the conditioner potential energy under which this cloud will contract?

(f) How long will it take the plane of oscillation of a Foucault pendulum to make one complete revolution if the pendulum is rotated at north pole?

(g) The natural frequency of a mass vibrating on a spring is 20 Hz while its frequency with damping is 16 Hz. Find logarithmic decrement.

(h) If in an electric circuit $L = 10^{-2}$ H and $C = 20\times10^{-6}$ F, deduce its frequency of oscillations.

(i) Write down the expression for moment of inertia of a ring, axis passing through the centre and perpendicular to its plane.

(j) Define angular velocity vector.

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2. *(a)* A particle moves in a circle of radius b with angular velocity $\dot{\theta} = \alpha t$, where α (rad / sec^2) is a constant. Describe the particle's velocity in polar coordinates. 8

(b) Three freight cars of mass M are pulled with force F by a locomotive. Friction is negligible. Find the forces on each car. 6

3. *(a)* Derive length, area and volume elements in spherical coordinate system. 7

(b) The motion of a particle is observed for 10 seconds and is found to be in accordance with the following equation :

$$r = R \text{ (constant)}, \ \theta = \left(\frac{\pi}{12}\right)t \text{ and } \phi = \pi t$$

What will be its velocity? 7

4. *(a)* A force is said to be conservative if $\oint \vec{F} \cdot d\vec{r} = 0$. Show that this condition can also be written as curl $F = 0$. 7

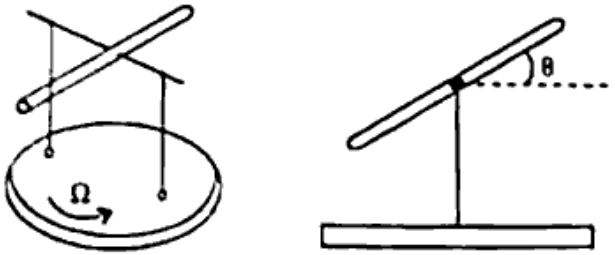
(b) Prove that the electrostatic forces between two charges are conservative. 7

5. *(a)* What do you mean by equipotential surfaces? Find out the gravitational potential due to a thin spherical shell. 8

(b) Find the spherical surface of zero potential due to $+2q$ and $-3q$ charges fixed at (4, 0, 0) and (9, 0, 0) respectively. 6

6. Write and solve equation of motion of a mass executing simple harmonic oscillator in the presence of a damping force. Also, discuss the cases of overdamping, critically-damping and underdamping oscillations. 8+6=14

7. Derive Euler's equations of rigid body motion. Consider a uniform rod mounted on a horizontal frictionless axle through its centre. The axle is carried on a turntable revolving with constant angular velocity Ω with the centre of the rod over the axis of the turntable. Let θ be the angle shown in the sketch below. Using Euler's equations, show that the motion of the rod is simple harmonic. 8+6=14



8. Write short notes on any two of the following : 7·2·14

   (a) Angular velocity vector and its rate of change

   (b) Moment of inertia tensor

   (c) Foucault pendulum

9. Write short notes on any two of the following : 7·2·14

   (a) Harmonic oscillator

   (b) Satellite manoeuvres

   (c) Motion of a rod executing canonical motion with centre of mass fixed

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