Jharkhand University of Technology, Ranchi

B.Tech. 1st Semester Examination, 2018

Subject : Physics-I (Introduction to Mechanics) **Subject Code : IM-18102**

Time Allowed : 3 Hours **Full Marks : 70**

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

Answer any five questions.

1. Choose the correct answer: 2×7=14

(i) A block of mass M_1 rests on a block of mass M_2 which lies on a frictionless table. The coefficient of friction between the block is μ. The maximum horizontal force which can be applied to the lower block M_2 to accelerate without slipping on one another is

(a) $\mu M_1 g$

(b) $\mu (M_1 + M_2) g$

(c) $\mu M_2 g$

(d) $\mu (M_1 + M_2)$

(ii) A maximum of a potential energy curve is a point of

(a) stable equilibrium.

(b) unstable equilibrium.

(c) neutral equilibrium.

(d) None of the above

(iii) The Coriolis force acting on a particle of mass m in rotating frame is

(a) $m\vec{\omega} \times (\vec{\omega} \times \vec{r})$

(b) $-mv^2 r$

(c) $-m\vec{\omega} \times \overrightarrow{v_{rot}}$

(d) $-2m\vec{\omega} \times \overrightarrow{v_{rot}}$

(iv) Consider a simple harmonic motion of time period T. The time taken for the displacement to change value from half the amplitude to the amplitude is

(a) $T/4$

(b) $T/6$

(c) $T/2$

(d) $T/12$

(v) The moment of inertia of uniform ring of mass M and radius R about a diameter is

(a) MR^2

(b) $\frac{1}{2}MR^2$

(c) $\frac{1}{4}MR^2$

(d) $\frac{3}{2}MR^2$

(vi) The position vector of a particle is $\vec{r}$. The torque of the force $\vec{F}$ acting on the particle about the origin is $\vec{\tau}$. Then

(a) $\vec{F}.\vec{\tau} = 0, \vec{r}.\vec{\tau} \neq 0$

(b) $\vec{F}.\vec{\tau} \neq 0, \vec{r}.\vec{\tau} = 0$

(c) $\vec{F}.\vec{\tau} \neq 0, \vec{r}.\vec{\tau} \neq 0$

(d) $\vec{F}.\vec{\tau} = 0, \vec{r}.\vec{\tau} = 0$

(vii) A small weight of mass m hangs from a string in an automobile which accelerates at rate A. The static angle of the string from the vertical is

(a) $\tan^{-1}\frac{A}{g}$

(b) $\tan^{-1}\frac{g}{A}$

(c) $\sin^{-1}\frac{A}{g}$

(d) $\sin^{-1}\frac{g}{A}$

Or,

(i) Show that the gravitational field inside a uniform thin spherical shell is zero.

(ii) For a conservative force, show that $\vec{F} = -\vec{\nabla}\,U$, where symbols have usual meaning. 10+4=14

2. (a) Obtain the transformation law for the components of a vector under rotation of the co-ordinate system.

(b) Show that the components of the vector product $C = A \times B$ must obey the transformation law.

(c) An automobile enters a turn whose radius is R. The road is banked at angle θ and the coefficient of friction between wheels is μ. Find the maximum speed for the car to stay on the road without skidding sideways. 6+4+4=14

3. (a) Define curl of a vector field and obtain its expression.

(b) Show that gravitational field is a conservative field. Also obtain the potential energy function. 8+6=14

4. (a) What are inertial and non inertial frames? Derive the expression for the force in a uniformly rotating frame of reference. Discuss centrifugal force and coriolis force.

(b) Discuss the effect of centrifugal force on the value of g due to rotation of Earth. Show that the effect is maximum at the equator and minimum at the poles. 10+4=14

5. (a) Write down the equation of motion of a damped simple harmonic system. What are the different solutions of this equation?

(b) The equation of motion of a particle started at $t = 0$ is given by $x = (5.0\ cm) \sin (20t + \frac{\pi}{3})$ where x in centimeter and t in second. When does the particle

(i) first come to rest,

(ii) first have zero acceleration,

(iii) first have maximum speed? 10+4=14

6. (a) State and prove theorems of moment of inertia.

(b) Define angular momentum of a particle. Establish a relation between angular momentum and moment of inertia for a rigid body rotating about a fixed axis. 6+8=14

7. (a) What is tensor of inertia? A rod executing conical motion with centre of mass fixed. Show that this motion looks two dimensional but is threedimensional.

(b) A cylinder is released from rest from the top of an incline of inclination θ and length L. If the cylinder rolls without slipping, what will be its speed when it reaches the bottom? 10+4=14