123/Phs/II/II

UG/1st Sem/PHSH/CC-T-II/18

U.G. 1st Semester Examination - 2018

PHYSICS

(HONOURS)

Course Code : PHSH/CC-T-II

Mechanics

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.

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

1. Answer any **five** questions: $2\times5=10$

a) Sometimes centre of mass frame is called zero frame of reference. Justify it.

b) For a non-conservative force show that the sum of K.E. and Potential Energy is not constant.

c) What is the physical significance of Reynold's No.?

d) Discuss briefly global positioning system (GPS).

e) Why the kinetic energy of a moving body is not completely transferred to other colliding body, when it collides?

[Turn over]

f) Prove that the three dimensional volume element is not invariant under Lorentz transformation, while the four dimension volume element is invariant.

g) Consider an air-plane moving in a circle of radius 'b' with a constant speed $v = b\omega$, where ω is the angular velocity. Show that the velocity of plane is tangential, while the acceleration is completely radial.

h) Define amplitude resonance and velocity resonance in forced vibration.

2. Answer any **two** questions: $5\times2=10$

a) Prove the angular momentum theorem for a system of particles mentioning the condition for its validity. $4\frac{1}{2}+\frac{1}{2}$

b) i) A mass 'M' is suspended at the end of a spring of length 'l' and stiffness constant k. If the mass of spring is 'm' and the velocity of an element 'dy' of its length is proportional to its distance 'y' from the fixed end of the spring, show that the period for small verticle oscillation is given by

$$T = 2\pi\sqrt{\frac{M+\frac{m}{3}}{R}}.$$ 3

ii) In a damped harmonic oscillator the amplitude of vibration decreases from 10cm to 1 cm after 100 complete cycle of oscillation. The time-period of oscillation is 23 seconds. Estimate the first undamped amplitude. 2

c) i) Estimate the height of geo-stationary satellite, taking the radius of earth 6400 km and g=10 m/s². 2

ii) The potential energy of a particle is given by the expression $v(x) = k(x^3 - 2x^2 + x)$. Find the point of stable and unstable equilibrium. 2

iii) Explain how Einestein's postulate explain the null-result of Michelson-Morley experiment. 1

d) i) Show that the momentum 'p' and kinetic energy T of a particle are related $p^2c^2 = T(T + 2m_0c^2)$. 2

ii) A space-ship travels as related to a stationary observer with velocity $v = 0.99c$. What time has elapsed by the observers clock, if by the clock on board the ship one year has passed? For the stationary observer, how will the linear dimension of the bodies on the ship changed? For the same observer how density of bodies will change?

1+1+1

3. Answer any **two** questions: 10×2=20

a) i) Prove that Newton's second law remains invariant under Galilean transformation.

1

ii) Derive the equation for the Rocket propulsion.

2

iii) Suppose that a Rocket, which starts from rest, falls in a constant gravitational field. At the instant it starts to fall its ejects a gas at a constant rate α in the direction of the gravitational field and at speed v_0 with respect to the Rocket. Find its speed after any time 't'.

3

iv) Show that the work done by a force on a particle is equal to the difference in the kinetic energy between two positions of the particles and also for conservative system the above work done is equal to the changing potential energy between the two position of the particle. Hence prove that the total energy is conserved in a conservative system. 4

b) i) A particle of mass 'm_1' and kinetic energy 'T_1' collides elastically with a particle of mass 'm_2' which is at rest. The particle of mass 'm_2' leaves the collision at an angle 'θ' with the original direction of motion of the particle of mass 'm_1'. Find out the kinetic energy of the particle of 'm_2' with which it leaves the collision and show that for a given value of 'T_1', this energy is maximum for a head-on collision. 4

ii) Show that the Kinetic Energy for pure rotation of a body is $\frac{1}{2}I\omega^2$ where 'I' and 'ω' are the moment of intertia and angular velocity of the body respectively. 3

iii) A sphere of mass 'm' and radius 'r' rolls without slipping down a plane inclined at an angle 'α' with angular velocity 'ω'. Show that acceleration of centre of mass is $\left(\frac{5}{7}g\sin\alpha\right)$. [The moment of inertia of sphere about its diameter is $\frac{2}{5}mr^2$] 3

c) i) Writing the interval between two events in four vector space express different components of it. 2

ii) Simultaneity is not absolute, but relative – Justify it. 1

iii) Derive the expression for the moment of shearing couple of a cylindrical wire. 3

iv) Using the principle of dimensional homogeneity. Deduce Poiseulle's equation for the laminar flow of liquid through a capillary tube. 4

d) i) Prove that the path of a particle under a central force lies in a plane. 2

ii) Write down the differential equation of an orbit in a central force.

A particle moving in a central field describe the orbit $r = a(1 + \cos\theta)$. Sketch the nature of the orbit and also find out the nature of force law. 3

iii) Considering a frame of reference rotating with an angular velocity $\vec{\omega}$ relative to a fixed frame, write down operator equation and also the expression for a force on a particle in the rotating frame and define various terms of the expression. $2\frac{1}{2}$

iv) Prove that due to the rotation of earth, the value of 'g' at latitude 'λ' decreases by a value of $\omega^2 R \cos^2 \lambda$, where R is the radius of earth and 'ω' is the angular velocity of earth around its axis.

$2\frac{1}{2}$
