U.G. 1st Semester Examination - 2020

PHYSICS

[HONOURS]

Course Code : PHYS-H-CC-T-2

(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 from the following: $2\times5=10$

a) A volume element '*dV*' is expressed as '*dxdydz*' in Cartesian co-ordinate. What will be its expression in spherical polar co-ordinate?

b) Show that the total linear momentum is zero in the centre of mass frame.

c) A particle of mass 'm' executes a simple harmonic motion. Its total energy is given by $E=E_K+E_P=\frac{1}{2}mv^2+\frac{1}{2}sx^2$, the terms being as usual. If there is no dissipation of energy i.e the energy remains constant, hence obtain the equation of motion of the system.

d) A cylinder of mass *M* and cross section area *A* floats vertically in a liquid of density *p*. If it is depressed slightly and then released, find the frequency of vertical oscillations.

e) Find the force field associated with the potential energy $V=Ae^{k(x+y+z)}$, where A and k are constants.

f) Two wires X and Y are of the same material. While X has a length *l* and diameter *d*, Y has a length twice that of X and a diameter half that of X. The two wires are stretched by the same force. Then what will be the ratio of the elongations of X and Y?

g) Consider a rod of circular cross-section of radius *a* and length *l*. The volume of the rod is not changed when the rod is stretched. Show the Poisson's ratio has the value $\frac{1}{2}$ in this case.

h) Prove that a shearing strain is equivalent to two equal linear strains of half the magnitude is mutually perpendicular directions.

i) Show that Newton's 2nd law remains invariant under Galilean transformation.

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

a) 'Beat frequency is equal to the difference between the frequencies of the component oscillations'. Prove it.

A string of length 'L' is stretched horizontally with a tension 'T' between two rigid supports. A mass 'm' is attached at a distance 'a' from one end. Find the frequency of small vertical oscillation of the mass. Assume that the tension in the string remains constant. $2\frac{1}{2}+2\frac{1}{2}$

b) Show that due to Coriolis force the deviation of a vertically free falling body at time is given that $x=\frac{1}{3}\omega g t^3\cos\lambda$, symbols are their usual meanings. Neglecting Coriolis force and considering the rotating motion of earth prove that the acceleration due to gravity reduce to $g'=g-\omega^2 R\cos^2\lambda$ in magnitude. Hence calculate g' at the poles. $3+1\frac{1}{2}+\frac{1}{2}$

c) A ball is released from ground level with a given initial speed. At what inclination angle should a ball be thrown so that it travels the maximum horizontal distance by the time it returns to the ground? Assume that the ground is horizontal. Prove that four dimensional volume elements 'dxdydzdt' is invariant under Lorentz transformation. $3+2$

d) Find the distance which an object moves in time t if it starts from rest and has an acceleration $\frac{d^2x}{dt^2}=ge^{-kt}$, where k is a constant. Show that for small t the result is $x=\frac{1}{2}gt^2$ and for very large t the velocity $\frac{dx}{dt}$ is approximately constant. Find the amount of work done in twisting a steel wire of radius 1 mm and length 25 cm through an angle of 45°, modulas of rigidity of steel being 8×10^{11} cgs units. $3+2$

3. Answer any **two** questions from the following: $10\times2=20$

a) A particle of mass '**m**' subject to a restoring forces proportional to displacement and a frictional force proportional to its velocity and also an external simple harmonic force. Obtain expression for the amplitude and the phase angle of the displacement in the steady state. Prove that at resonance the phase difference between

the driver and the driven system is $\frac{\pi}{2}$. Show that "In the steady state the average power supplied by the driver is equal to the average power dissipated against damping by the driven system". 4+2+4

b) Show that in centre of mass system the magnitude of the velocities of the particles remains unaltered in 'elastic' collision. A 6.0kg rock with speed 3.50 m/s collides with another motionless 6.0kg rock. What are the velocities of the rocks after the collision if it is (a) elastic or (b) totally inelastic? (c) How much energy was lost in the inelastic collision? Ignore friction and assume all motion is in a straight line. 4+4+2

c) If the displacement equation of simple harmonic motion be $x = a\sin(wt+\phi)$, show that the velocity (v) and the acceleration (f) satisfy $w^2 + f^2 = a^2w^4$. The differential equation for an one dimensional damped harmonic oscillator is given by $m\frac{d^2x}{dt^2} + k\frac{dx}{dt} + sx = 0$.

i) Explain the significance of each term in the equation.

ii) Solve the equation in case of critical damping. 2+2+6

d) A rigid rod is fixed along x axis in an inertial frame (S') which is moving with uniform relative velocity v $(v \to c)$ with respect to a fixed frame (S) in X- direction. An observer is fixed in the rest frame (S). Show that the rigid rod appears to have its maximum length in the moving frame in which it is at rest.

"A free electron cannot absorb a photon" – Explain using relativity. Give the basic concept of global positioning system (GPS). Why an astronaut in a satellite feels weightlessness? 3+3+2+2

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