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1 SEM TDC PHYH (CBCS) C 2

2019

(December)

PHYSICS

(Core)

Paper : C–2

(Mechanics)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : 1×4=4

(a) Which of the following quantities is/are not invariant under Galilean transformation?

(i) Space and velocity

(ii) Acceleration

(iii) Force

(iv) Velocity and acceleration

(b) A particle moves under the effect of force $F = cx$; from $x = 0$ to $x = x_1$. The work done in the motion of the particle is

(i) zero

(ii) cx_1^2

(iii) $\frac{(cx_1)^2}{2}$

(iv) cx_1^4

(c) The time period of an earth satellite in circular orbit is independent of

(i) both the mass and radius of the orbit

(ii) the radius of the orbit

(iii) the mass of the satellite

(iv) neither the mass of the satellite nor the radius of its orbit

(d) A body of mass m is placed on the earth's surface. It is taken from the earth's surface to a height $h = 3R$ (where R is the radius of the earth). The change in gravitational PE of the body is

(i) $\frac{2}{3}mgR$ (ii) $\frac{3}{4}mgR$

(iii) $\frac{1}{2}mgR$ (iv) $\frac{1}{4}mgR$

2. *(a)* "An inertial frame is one in which law of inertia or Newton's first law is valid." Prove the above statement. 2

(b) Write the Poiseuille's equation. Draw and explain the profile or the velocity distribution curve of the advancing liquid through a tube. 2

Or

The acceleration due to gravity on the surface of moon is $1{\cdot}7\ m\ s^{-2}$. What is the time period of a simple pendulum on the surface of moon, if its time period on the surface of earth is 3·5s?

3. *(a)* Show that the basic laws of physics are invariant under Galilean transformation. 3

Or

Derive the equation of motion of a rocket

$$v = u \log e \frac{M_0}{M} - gt$$

where v is the velocity of the rocket relative to earth.

u is the exhaust velocity of gases relative to rocket.

M_0 is the initial mass of rocket-fuel system.

M is the mass of the rocket after time t.

g is the acceleration due to gravity.

(b) State work-energy theorem. Also draw energy diagram for PE, KE and total energy for the case of a spring. 1+2=3

Or

Prove the principle of conservation of energy for the freely falling bodies under the action of gravity. 3

4. (a) Show that the rate of change of angular momentum vector of a particle is equal to torque acting on it. What kind of motion is expected for $\vec{L} = 0$? 3+2=5

(b) For rotational motion of rigid body, derive an expression for kinetic energy in terms of moment of inertia and angular velocity. Also obtain an expression for the moment of inertia of a circular ring about an axis passing through its centre and perpendicular to the plane of the ring. 3+2=5

(Continued)

(c) Show that for a satellite moving in a circular orbit, the square of the period of revolution is proportional to the cube of its distance from the centre of the earth ($T^2 \propto r^3$). What is geosynchronous or geostationary orbit? 4+1=5

Or

State Kepler's three laws of planetary motion. Prove any one of Kepler's laws. 3+2=5

5. (a) Find out the expression of potential energy ($w = \frac{1}{2} c\phi^2$) of a twisted cylinder, when it has a twist ϕ. 3

(b) What is damped vibration? What will happen when—

(i) damping is large;

(ii) damping is critical;

(iii) damping is small? 1+1+1+1=4

Or

What is forced vibration? Discuss the condition for resonance in forced vibration. 1+3=4

(c) Derive an expression for the (i) gravitational potential and (ii) gravitational field due to a spherical shell of radius R and mass M at any distance r from its centre, where $r > R$. 3+2=5

Or

What is a geosynchronous satellite? A rocket is launched vertically upward from the surface of the earth with an initial velocity of v_0. Show that its velocity v at a height h is given by

$$v_0^2 - v^2 = \frac{2gh}{1+\frac{h}{R}}$$

where R is the radius of the earth and g is the acceleration due to gravity at earth's surface. 1+4=5

(d) A frame of reference rotates with angular velocity $\vec{\omega}$. For this frame, establish the identity (operator)

$$\frac{d}{dt} = \frac{d'}{dt} + \vec{\omega} x$$

3

Or

Calculate the magnitude and direction of Coriolis acceleration of a rocket moving with a velocity of 2 km/s at 60° south latitude.

(e) At what speed a particle will move if the mass is equal to three times its rest mass? 3

Or

Calculate the wavelength of gamma ray photon produced in two-quarter annihilation of an electron and positron. ($h = 6 \cdot 6 \times 10^{-34}$ J-sec; $c = 3 \times 10^{8}$ m/s; $m_e = m_p = 9 \times 10^{-31}$ kg)

6. *(a)* Deduce the expression for relativistic variation of mass with velocity. 4

Or

Deduce the mathematical expression for the law of addition of velocity.

(b) A rocket is moving with a speed of 0·9 c with respect to the earth in a certain direction. With what speed must another rocket move with respect to earth so that it overtakes the first rocket by 0·4c? 2

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