NATIONAL INSTITUTE OF TECHNOLOGY SILCHAR
ENGINEERING MECHANICS (ME 1101)
Second Semester (All Branch)
ASSIGNMENT – 14

1. A rocket car moves along a track according to the equation $x = 3t^3 + t + 2$, where x is in meters and t is in seconds. Determine the displacement, velocity, and acceleration when $t = 4$ s. What is the average acceleration during the fifth second? Ans. $x = 198$ m, $v = 145$ m/s, $a = 72$ m/s^2, $a_{av} = 81$ m/s^2.

2. A ball is tossed with a velocity of 10 m/s directed vertically upward from a window located 20 m above the ground. Knowing that the acceleration of the ball is constant and equal to 9.81 m/s^2 downward, determine (a) the velocity v and elevation y of the ball above the ground at any time t, (b) the highest elevation reached by the ball and the corresponding value of t, (c) the time when the ball will hit the ground and the corresponding velocity. Draw the v-t and y-t curves. *Ans.* (a) $v = 10 - 9.81t$, $y = 20 + 10t - 4.90t^2$ (b) $t = 1.019\ s, y = 25.1\ m$, (c) $t = 3.28\ s, v = 22.2\ m/s$.

3. If the crank of the engine shown in Fig. A rotates $\omega = 4\pi\ rad/sec$ and crank radius $r = 10\ m$, find the maximum velocity and maximum acceleration of the piston. *Ans.* $|\dot{x}|_{max} = 40\pi\ m/s$; $|\ddot{x}|_{max} = 160\,\pi^2\ m/sec^2$.

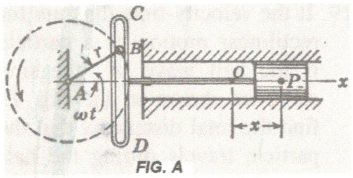

FIG. A

4. A balloon is rising with a velocity of 2 m/s when a bag of sand is released. If the height at the time of release is 120 m, how long does it take the bag of sand to reach the ground? *Ans.* $t = 5.16$ s

5. A ball is projected vertically upward with a velocity of 40 m/s. Three seconds later a second ball is projected vertically upward with a velocity of 30 m/s. At what point above the surface of the earth will they meet? *Ans.* $s = 42.4$ m.

[Turn over]

6. A ball is thrown at an angle of 40^0 to the horizontal. What height will the ball reach if it lands 100 m away? Neglect air resistance. *Ans.* $y_{max} = 20.9\ m$.

7. A stone is dropped from a balloon that is ascending at a uniform rate of 10 m/s. If it takes the stone of 10 s to reach the ground, how high was the balloon at the instant the stone was dropped? *Ans.* 390 m

8. A rope AB is attached at B to a small block of negligible dimensions and passes over a pulley C so that its free end A hangs 5 m above the ground when the block rests on the floor as shown in Fig. B. The end A of the rope is moved horizontally in a straight line by a man walking with a uniform velocity $v_0 = 10$ m/s. (a) Plot the velocity-diagram for the motion of the block B. (b) Find the time t required for the block to reach the pulley if $h = 15$ m and the pulley is negligibly small. *Ans.* (a) $v = v_0^2 t/\sqrt{h^2 + v_0^2 t^2}$; (b) $t = 3.16\ sec$.

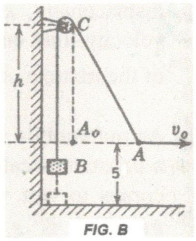

FIG. B

9. A particle starts from rest and moves along a straight line with constant acceleration a. If it acquires a velocity $v = 10$ m/s after having travelled a distance $s = 25$ m, find the magnitude of the acceleration. *Ans.* $a = 2\ m/s^2$.

10. A bullet leaves the muzzle of a gun with velocity $v = 2500$ m/s. Assuming constant acceleration from breech to muzzle, find the time t occupied by the bullet in travelling through the gun barrel, which is 1 m long. *Ans.* $t = 0.0008\ sec$

11. A ship while being launched slips down the skids with uniform acceleration. If 10 sec is required to traverse the first 16 m, what time will be required to slide the total distance of 400 m? With what velocity v will the ship strike the water? *Ans.* $t = 50\ sec, v = 16\ m/sec$

12. A stone is dropped with zero initial velocity into a well. The sound of the splash is heard 3.63 s later. How far below the ground surface is the surface of the water? Assume that the velocity of sound is 330 m/s. *Ans.* $s = 58.4\ m$

13. The rectilinear motion of a particle is defined by the displacement-time equation $x = x_0(2e^{-kt} - e^{-2kt})$, in which x_0 is the initial displacement, k is a constant. Sketch the displacement-time and velocity-time curves for this motion and find the maximum velocity of the particle. *Ans.* $\dot{x}_{max} = -\frac{kx_0}{2}, when\ t = \frac{\ln 2}{k}$.

14. An automobile starting from rest increases its speed from 0 to v with a constant acceleration a_1, runs at this speed for a time, and finally comes to rest with constant deceleration a_2. If the total distance travelled is s, find the total time t required. *Ans.* $t = \frac{s}{v} + \left(\frac{v}{2}\right)\left(\frac{1}{a_1} + \frac{1}{a_2}\right)$.

15. The greatest possible acceleration or deceleration that a train may have is a and its maximum speed is v. Find the minimum time in which the train can get from one station to the next if the total distance is s. *Ans.* $t_{min} = \frac{s}{v} + \frac{v}{a}$.

16. Point A', starting from A_0 moves with constant speed around the circumference of a circle of radius r, as shown in Fig. C. Develop expressions for the displacement, velocity, and acceleration of its projection A on the x-axis, that is, on the diameter OA_0 of the circle. *Ans.* $x = r\cos\omega t,\ \dot{x} = -r\omega\sin\omega t,\ \ddot{x} = -r\omega^2\cos\omega t$

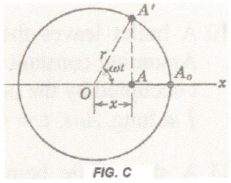

FIG. C

17. A slender bar AB of length l which remains always in the same vertical plane has its ends A and B constrained to remain in contact with a horizontal floor and a vertical wall, respectively, as shown in Fig. D. The bar starts from a vertical position, and the end A is moved along the floor with constant velocity v_0 so that its displacement $OA = v_0t$. Write the displacement-time, velocity-time, and acceleration-time equations for the vertical motion of the end B of the bar. *Ans.* $x = \sqrt{l^2 - (v_0t)^2},\ \dot{x} = -\frac{v_0^2t}{\sqrt{l^2 - v_0^2t^2}},\ \ddot{x} = -\frac{v_0^2l^2}{(l^2 - v_0^2t^2)^{3/2}}$

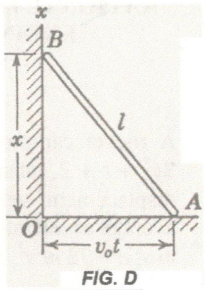

FIG. D

18. Water drips from a faucet at the uniform rate of n drops per second. Find the distance x between any two adjacent drops as a function of time t that the trailing drop has been in motion. Neglect air resistance and assume constant acceleration $g = 9.8\ m/s^2$. *Ans.* $x = \frac{gt}{n} + \frac{g}{2n^2}$

19. If the velocity-time diagram for rectilinear motion of a particle is the half wave of the sine curve as shown in the Fig. E, find the total distance x that the particle travels during the half period time interval $\tau/2$. Ans. $x = \frac{\tau v_{max}}{\pi}$

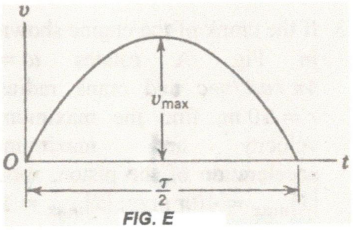

FIG. E

20. If the velocity-time curve shown in the Fig. E is a parabola with vertical axis, find the distance travelled by the particle during the time interval $\tau/2$. Ans. $x = \frac{\tau v_{max}}{3}$

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