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Chapter 1: Variable Motion

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P1. The rectilinear motion of a particle has its position defined by the relation $x = t^3 - 7t^2 + 20t - 10$ m. Determine, a) position, velocity and acceleration at t = 2 sec. (b) Minimum velocity and the corresponding time.

P2. A particle starts from rest at t = 0 and travels in one particular direction. Its rectilinear motion is given by the relation $x = 3t^3 - 9t^2 + 12$ m. Determine the time at which the particle reverses its sense of motion.

P3. The acceleration of a particle is given by $a = -kx^{-3}$ m/s². Knowing at x = 2 m, v = 0 and at x = 0.5 m, v = 3 m/s. Determine a) the value of k b) the particle's velocity at x = 1 m.

P4. The acceleration of an oscillating particle is defined by the relation $a = -kx$ m/s². Determine a) the value of k such that v = 12 m/s at x = 2 m and v = 0 at x = 6 m b) velocity at x = 4 m c) maximum velocity.

P5. A particle performing rectilinear motion starts from rest and has its acceleration defined by $a = 25 - v^2$ m/s². Determine the time interval and the particle's displacement as it acquires a speed of 4 m/s.

P6. The motion of a particle is defined by the relation $a = 0.8t$ m/s². It is found that at x = 5 m, v = 12 m/s when t = 2 sec. Find position and velocity at t = 6 sec.

P7. The velocity relation of a rectilinear moving particle is defined as $v = 4t^2 - 3t - 1$ m/s. At t = 0, x = – 4m. Determine
a) the time at which the particle reverses its sense of motion
b) At t = 3 sec. i) acceleration ii) position iii) displacement iv) distance traveled.

P8. A bullet fired with a velocity of 200 m/s into a soft wooden block, penetrates 0.4 m inside and comes to rest. If the velocity of the bullet during its penetration is defined by the relation $v = 200 - kx$ m/s, Determine
a) acceleration of the bullet at t = 0
b) the time taken by the bullet to penetrate 0.35 m into the wood.

P9. A particle performing rectilinear motion has its acceleration given by $a = (2 - 5t)$ m/s². At t = 4 sec its velocity is 15 m/s and at t = 8 sec its position is 60 m. Find at t = 0, the particles position, velocity and acceleration. Also find the time when its velocity becomes zero.

P10. A stone is projected from the ground vertically up with an initial velocity of 20 m/s. Knowing that the air resistance causes an additional deceleration of $0.01v^2$ m/s², determine the maximum height reached by stone above the ground.

Answers

P1. a) 10 m, 4 m/s, – 2 m/s²
b) 3.66 m/s, 2.33 sec

P2. 2 sec.

P3. a) 2.4 b) 1.342 m/s

P4. a) 4.5 b) 9.487 m/s c) 12.72 m/s

P5. 0.2197 sec, 0.5108 m

P6. 74.33 m, 24.8 m/s.

P7. a) 1 sec b) 21 m/s², 15.5 m, 19.5 m, 21.82 m

P8. -1×10^5 m/s², 0.00416 sec

P9. 46.5 m, 47 m/s, 2 m/s², 4.75 sec

P10. 17.1 m

P1. A curvilinear motion is defined by $y = 8t^3 - 6t$ m and $a_x = 4t$ m/s². At t = 1 sec, $v_x = 6$ m/s. Calculate magnitude of velocity and acceleration at t = 3 sec.

P2. A particle starts from rest from the position (- 5, - 2, 4) m. Its acceleration is defined by $\bar{a} = 3t\ i + 12t^2\ j + 5\ k$ m/s². Find the particle's position, displacement, velocity and acceleration at t =2 sec.

P3. For a particle in motion, at t = 0, position $\bar{r} = -16\ i - 20\ j + 5\ k$ m and velocity $\bar{v} = 4\ i - 3\ j + 2\ k$ m/s. Also acceleration $\bar{a} = 12t^2\ i - 16t\ j + 8\ k$ m/s². Determine at t = 5 sec. a) position, displacement, velocity and acceleration b) N and T components of acceleration.

P4. A particle performing curvilinear motion has velocity components given as $v_x = 32\ t - 4$ m/s and $v_y = 4$ m/s. At t = 3 sec it occupied the position (5, 12) m Determine the equation of the path traced by the particle.

P5. A particle P moves in a circular path of 4 m radius. At an instant the speed is increasing at a rate of 8 m/s² and its total acceleration is 10 m/s². Determine the particle's speed at this instant.

P6. A racing car traveling on a circular curve ABC of 400 m radius increases its speed uniformly from 72 kmph at A to 108 kmph at C over a distance of 300 m along the curve. What was the total acceleration of the car when it was at B, 250 m from A.

P7. A particle travels along a parabolic shaped track $y = 10 + 0.4\ x^2$ with a constant speed of 6 m/s. At x = 3 m, find
a) components of velocity b) acceleration

P8. An airplane travels along a path such that its acceleration is given by $\bar{a} = 10\ i + 6t\ j$ m/s². If the plane starts from rest from the origin, determine at t = 4 sec.
a) speed of the airplane b) radius of curvature of the path c) position of the airplane.

P9. A particle moves in the x–y plane with acceleration components $a_x = -5$ m/s² and $a_y = 2$ m/s². If at t = 0, its velocity is 10 m/s directed at 36.87° with the + ve x-axis, find the radius of curvature at t = 8 sec.

P10. A particle moves along a curved path defined by $y = {}^1/_8\ x^2$. At any instant its x coordinate is given by $x = 2t^2 - 4t$. Determine its velocity and acceleration at x = 8 m.

P11. A particle travels on a circular path whose arc distance traveled is defined by $s = 0.5\ t^3 + 3\ t$ m. If the total acceleration is 10 m/s² at t = 2 sec, find the radius of the circular path.

P12. A particle starts from rest at t = 0 and travels on a circular path of 10 m radius. Its arc distance traveled is defined by $s = 0.2\ t^3$ m. Find the acceleration of the particle at t = 3 sec.

Answers

P1. 211.15 m/s, 144.5 m/s^2

P2. $\bar{r} = -i + 14j + 14k$ m, $\Delta\bar{r} = 4i + 16j + 10k$ m, $\bar{v} = 6i + 32j + 10k$ m/s, $\bar{a} = 6i + 48j + 5k$ m/s^2

P3. $\bar{r} = 629i - 368.36j + 115k$ m, $\Delta\bar{r} = 645i - 348.3j + 110k$ m
$\bar{v} = 504i - 203j + 42k$ m/s, $\bar{a} = 300i - 80j + 8k$ m/s^2,
$a_n = 41.02$ m/s^2, $a_t = 307.8$ m/s^2

P4. $x = y^2 - y - 127$

P5. 4.9 m/s

P6. 2.205 m/s^2

P7. $v_x = 2.308$ m/s,
$v_y = 5.538$ m/s, 1.638 m/s^2

P8. 62.48 m/s, 508.14 m,
$\bar{r} = 80i + 64j$ m

P9. 1273 m

P10. 20 m/s, 28.28 m/s^2

P11. 10.125 m

P12. 4.63 m/s^2

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