

Chapter 1: Variable Motion

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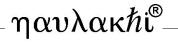
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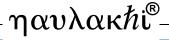
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- The rectilinear motion of a particle has its position defined by the relation $x = t^3 7 t^2 + 20 t 10 m$. Determine, a) position, velocity and acceleration at t = 2 sec.

 (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 = 3 $t^3 9$ $t^2 + 12$ m. Determine the time at which the particle reverses its sense of motion.
 - **P3.** The acceleration of a particle is given by $a = -kx^{-3} m/s^2$. 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 $a = -kx \text{ m/s}^2$. 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 $a = 25 v^2 \text{ m/s}^2$. 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 $a = 0.8 \text{ t m/s}^2$. 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 $v = 4 t^2 3t 1$ 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 waveled.
- 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.
- A particle performing rectilinear motion has its acceleration given by $a = (2-5t) \text{ m/s}^2$. 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.





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Answers

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

2 sec. P2.

a) 2.4 b) 1.342 m/s P3.

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

0.2197 sec, 0.5108 m P5.

P9.

74.33 m, 24.8 m/s. P6.

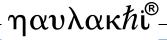
b) 21 m/s^2 , 15.5 m, a) 1 sec P7. 19.5 m, 21.82 m

 $-1 \times 10^5 \text{ m/s}^2$, 0.00416 sec P8.

 $46.5 \text{ m}, 47 \text{ m/s}, 2 \text{ m/s}^2, 4.75 \text{ sec}$

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 $a = 3t i + 12t^2 j + 5 k m/s^2$. 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/s. 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 $a = 10 i + 6t j m/s^2$. 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 $a_x = -5 \text{ m/s}^2$ and $a_y = 2 \text{ m/s}^2$. 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 $x = 2 t^2 4 t$. 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 $10 m/s^2$ 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.





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Answers

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/s²

P3.
$$\vec{r} = 629 \text{ i} - 368.36 \text{ j} + 115 \text{ k}$$
 m, $\Delta \vec{r} = 645 \text{ i} - 348.3 \text{ j} + 110 \text{ k}$ m $\vec{v} = 504 \text{ i} - 203 \text{ j} + 42 \text{ k}$ m/s, $\vec{a} = 300 \text{ i} - 80 \text{ j} + 8 \text{ k}$ m/s², $a_n = 41.02 \text{ m/s}^2$, $a_t = 307.8 \text{ m/s}^2$

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

P7.
$$v_x = 2.308 \text{ m/s},$$
 $v_y = 5.538 \text{ m/s}, 1.638 \text{ m/s}^2$

P6.
$$2.205 \text{ m/s}^2$$

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

P10. 20 m/s,
$$28.28 \text{ m/s}^2$$

P12.
$$4.63 \text{ m/s}^2$$

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