

Vectors

1. A car travels 6 km due east and then 4 km in a direction 60° north of east. Find the magnitude and direction of the car's displacement vector by using the analytical method.
2. Find the volume of the parallelepiped with edges $a = 3i + 2j + k$, $b = 2i + j + k$ and $c = i + 2j + 4k$.
3. Find a unit vector that is perpendicular to both $a = i + 2j - 3k$ and $b = 2i + 3j + k$
4. (a) What is the sum in unit-vector notation of the two vectors $a = 4i + 3j$ and $b = -13i + 7j$? (b) What are the magnitude and direction of $a + b$?
5. If $a - b = 2c$, $a + b = 4c$ and $c = 3i + 4j$, then what are a and b
6. If $A = 6i - 8.0j$ units, $B = -8.0i + 3j$ units, and $C = 26i + 19j$ units, determine a and b so that $aA + bB + C = 0$
7. Check whether the following vectors are coplanar or not. $u = i + 5j - 2k$, $v = 3i - j$, and $w = 5i + 9j - 4k$

Kinematics and Dynamics

1. Which of the following is true for displacement?
 - (a) It cannot be zero.
 - (b) Its magnitude is greater than the distance the object travels.
 - (c) displacement may or may not be equal to the distance
2. If the displacement of the body is zero, the distance covered by it may not be zero
3. In which of the following cases of motions the distance moved, and the magnitude of displacement is equal?
 - (a) If the object is moving along the straight road
 - (b) If the object is moving along the straight path
 - (c) The pendulum is moving back and fro
 - (d) The earth revolving around the sun
4. A particle moves along the x-axis according to the equation given below.

$$\vec{x}(t) = (4 + 2t - t^2) \hat{m} \hat{i}$$

where t is in second.

- a) Determine the displacement of this particle between the time interval $t = 0$ and $t = 1\text{s}$
- b) Determine the average velocity during those two-time intervals
- c) Derive a general expression for the instantaneous velocity as a function of time.
- d) calculate the instantaneous velocity at $t = 2\text{s}$.

5. A boy walk from his home to school at constant speed of 5m/s along straight line and then back along the same line (road) from school to his home at constant speed of 6m/s.

6. A particle moves along the x-axis component varies with time according to the equation given below.

$$\vec{x}(t) = (20 - 2t + t^3) \hat{m} \hat{i}$$

Where t is in second.

- a) Determine the initial position of the particle.
- b) Determine the displacement of this particle between the time interval $t = 0$ and $t = 1\text{s}$; $t = 1$ and $t = 4\text{s}$
- c) Determine the average velocity during those two-time intervals
- d) Derive a general expression for the instantaneous velocity as a function of time.
- e) calculate the instantaneous velocity at $t = 3\text{s}$.
- f) average acceleration between $t = 2\text{s}$ to $t = 3\text{s}$.
- g) Derive a general expression for the instantaneous acceleration as a function of time.
- h) calculate instantaneous acceleration at $t = 2\text{s}$.

7. An electron in a cathode ray tube accelerates uniformly from $2.0 \times 10^4 \text{ m/s}$ to $6.0 \times 10^6 \text{ m/s}$ over 1.5cm.

a) How long does the electron travel this 1.5cm?

b) What is its acceleration?

8. A track covers 40m in 8.5s while smoothly slowing down to a final speed of 2.8m/s.

Find

a) its original velocity

b) its acceleration

9. A jet lands on an aircraft at 140mi/hr and stops in 2s due to an arresting cable that snags the airplane.

a) What is its acceleration?

b) If the plane touches down at position $x_i = 0$, what is the final position of the plane?

10. A car traveling at a constant speed of 45m/s passes a trapper hidden behind a billboard.

One second after the speeding car passes the billboard, the trapper sets out from the billboard to catch it, accelerating at a constant rate of 3.0m/s^2 . How long does it take her to overtake the car?

11. A jet plane lands at a speed of 100m/s and slows down at the rate of 5m/s^2 as it comes to rest.

a) What is the time interval needed by the jet to come to rest?

b) Can this jet land at an airport where the runway is 0.8km long?

12. A girl throws a ball upwards, moving it at an initial speed of $u = 15\text{m/s}$. Neglect air resistance

a) How long does the ball return to the girl's hand?

b) What will be its velocity then?

13. A ball is thrown upward. While the ball is in free fall, does its acceleration (a) increase

(b) decrease (c) increase and then decrease (d) decrease and then increase (e) remain constant?

14. After a ball is thrown upward and is in the air, its speed (a) increases, (b) decreases, (c)

increases and then decreases (d) decreases and then increases (e) remains the same.

15. A ball is kicked with an initial velocity of 40m/s from the ground at an angle of 30° to the horizontal. (Use $g = 10\text{m/s}^2$) Calculate

- a) the Horizontal and vertical component of initial velocity
- b) The vertical velocity after $t = 1s, 2s, 3s,$ and $4s$
- c) Position $\vec{r} = (\hat{x} + \hat{y})$ after $t = 1s, 2s, 3s,$ and $4s$
- d) Time of flight (total time)
- e) maximum height
- f) Range of projectile

16. An airplane moving horizontally with a velocity of 500km/hr at 2km above the ground drops a bomb when it is directly above the target. By how much distance will the bomb miss the target?

17. An astronaut on a strange planet finds that she can jump at a maximum horizontal distance of 15.0m if her initial speed is 3.00m/s. What is the free-fall acceleration on the planet?

18. The angular position of a y wheel of a car engine is given by

$$\theta = (2 \text{ rad/s}^3)t^3$$

The diameter of the y wheel is 0.36m.

- a) Find the angle θ in radian, degree and revolution at time $t_1=2,$ second $t_2 = 5\text{sec}$:
- b) Find the distance that the particle of the rim moves during that time interval.
- c) Find the average angular velocity in rad/s and rev./m
- d) Find the general expression for the angular velocity at any time t .
- e) Find the general expression for the angular acceleration at any time t .

19. A wheel rotates with an angular acceleration of 3.5 rad/s^2 . If the angular speed of the wheel is 2.0m/s at $t=0$.

- a) through what angle does the wheel rotate in 2.0s
- b) what is the angular speed at $t = 2.0s$

20. The position vector of a particle of mass 2kg is given as a function of time by $\vec{r} = (6\hat{i} + 5t\hat{j})$. Determine the angular momentum of the particle about the origin as a function of time.

21. A large circular disk of mass 2kg and radius 0.2m initially rotating at 50rad/s is coupled with a smaller circular disk of mass 4kg and radius 0.1m initially rotating at 20rad/s in the same direction as a large disk.

- a) Find the common angular velocity after the disk is coupled.
 b) Calculate the loss of kinetic energy during this collision.

22. Object of mass 10kg is exerted on by a force of

$$\vec{F}_1 = (2\hat{i} + 3\hat{j})\text{N}, \vec{F}_2 = (4\hat{i} - 3\hat{j})\text{N} \wedge \vec{F}_3 = (-\hat{i} + 3\hat{j})\text{N}, \text{Calculate}$$

- a) net force on this object
 b) its acceleration

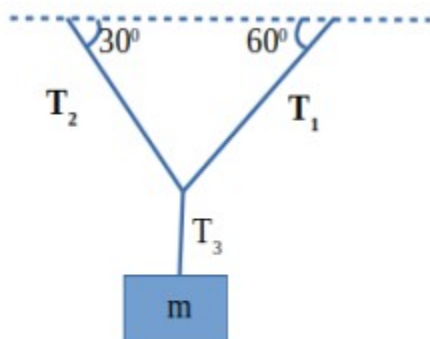
23. A 2kg object undergoes an acceleration of given by $\vec{a} = (3\hat{i} + 4\hat{j})\text{m/s}^2$. Find the magnitude resultant of force.

24. A particle of mass 2unit moves along space curve defined by $\vec{r}(t) = (4t^2 - t^3)\hat{i} - 5t\hat{j} + (t^4 - 2)\hat{k}$. Find the force acting on it at any time t.

25. Find the force needed to accelerate a mass of 400kg from velocity $\vec{V}_0 = (4\hat{i} - 5\hat{j} + 3\hat{k})\frac{\text{m}}{\text{s}}$ to $\vec{V}_f = (8\hat{i} + 3\hat{j} - 5\hat{k})\text{m/s}$ in 10s.

24. A 20kg block is initially at rest on a horizontal surface. A horizontal force of 75N is a required to set the block in motion. After it is in motion a horizontal force of 60N is required to keep the block moving with constant speed. Find the coefficient of static and kinetic friction.

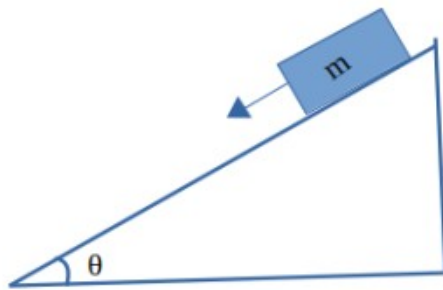
25. A block of mass 10kg hangs from three cords as shown below



What are the tension in the cords?
 (Assume the cords has negligible mass)

Figure: 10kg hungs from three cords

26. A block of mass m slides down an inclined plane as shown in the figure below.

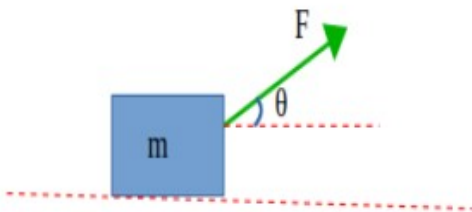


Find the expression for the acceleration of the block if the inclined plane

- a) is friction less
- b) has coefficient of friction μ_k

Figure: mass m slides down an inclined plane

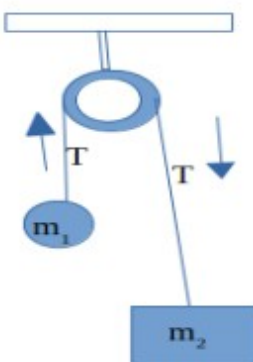
27. The block of mass m sliding horizontally as shown in figure below.



Find the expression for the acceleration of the block, if the coefficient of friction between the block and the surface is μ_k

Figure: block of mass m sliding horizontally

28. Two objects of unequal mass are hung vertically over a frictionless pulley of negligible mass as in the figure below



Determine the expression for magnitude of acceleration of the two object and tension in the cord

Figure: unequal mass is hung vertically over a frictionless pulley

29. A ball of mass 2 kg is moving with a velocity of 12m/s collides with a stationary ball of mass 6 kg and comes to rest. Calculate the velocity of the ball of mass 6kg after the collision.
30. A 10.0g bullet is fired into a stationary wood block ($m = 5.00\text{kg}$). The bullet sticks the block, and the speed of the bullet-plus combination immediately after a collision is 0.600m/s. What was the original speed of the bullet?
31. A block of mass $m_1 = 1.6\text{kg}$, initially moving to the right with a speed of 4m/s on a horizontal frictionless track, collides with a block of mass $m_2 = 2.1\text{kg}$, initially moving to the left with a speed of 2.5m/s. If the collision is elastic, find the velocities of the two blocks after the collision.
32. A particle of mass 4kg, initially moving with a velocity of 2m/s, collides with a particle of mass 6.0kg, initially moving velocity of -4m/s. What is the velocity of the two particles after collision?
33. A 4kg block moving right at 6m/s collides elastically with a 2kg moving at 3m/s left, find the final velocities the blocks.
34. A 4 kg object moves in a circle of radius 8 m at a constant speed of 2 m/s. What is the angular momentum of the object with respect to an axis perpendicular to the circle and through its center?