CPP

KINEMATICS - SHEET: 1 (LECTURE–1&2)

LEVEL - I

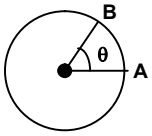
1. In x-y plane a particle is displaced from a point A (1, 2, 3)m to a point B(-1, 0, 1)m in 2 sec. Find the displacement of the particle and its average velocity in vector form in the given time interval.

2. A motor car is going due north at a speed of 50 km/h. It makes a 90° left turn without changing the speed. Calculate the change in the velocity of the car

3. A person travelling on a straight line moves with a uniform velocity v_1 for a distance x and with a uniform velocity v_2 for the next equal distance. Find the average velocity v

4. A car moves with a speed of 60 km/hr form point A to point B and then with speed of 30 km/hr from point B to point C. Further it moves to a point D with a speed equal to its average speed between A and C. Points A, B, C and D are collinear equidistant. Find the average speed of the car between A and D

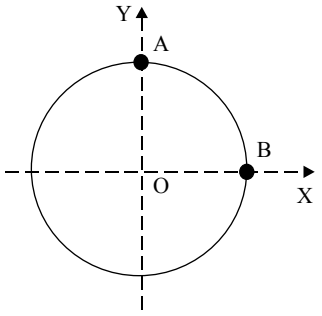
5. A particle moves at a constant speed v from point A to point B along a circle of radius r. If points A and B have an angular separation of θ, determine the magnitude of change in velocity in moving from A to B.



6. A particle moving along a straight line travels one third of the total distance with a speed of 3.0 m/s. the remaining distance is covered with a speed of 4.0 m/s for half the time and 5.0 m/s for the other half of the time. Find the average speed during the motion.

7. A person travelling on a straight line moves with a uniform velocity v_1 for some time and with uniform velocity v_2 for the next equal time. Find the average velocity v

8. In the figure shown , a particle is moving in x-y plane in a circle (centre at O) with a constant speed of 6.28 m/s in clockwise sense. At time t = 0 it is at the point A (0, 20)m and at time t = 5 s it reaches the point B (20, 0)m. Over the time interval from 0-5 s, calculate (a) the change in velocity of the particle (b) the average acceleration of the particle. First express your answer in terms of $\hat{i}$ and $\hat{j}$ and thereafter calculate their magnitudes.



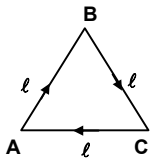
9. A bike moving with speed of 10 m/s takes a 90° turn in 10 sec maintaining it's constant speed. Find the magnitude of average acceleration in the interval of 10 seconds is

10. A bird starts flying from a tree and flies along a horizontal straight line. It is observed that velocity v of the bird varies with time according to the equation v = t – 2 m/s. With respect to starting point calculate
    (a) the displacement and (b) the distance travelled by the bird in 4s.

11. During an accelerated motion of a particle (initial velocity of particle is zero)
(A) average velocity of the particle is always less than its final velocity
(B) average velocity of the particle is always greater than its final velocity
(C) average velocity of the particle may be zero also
(D) average velocity of the particle is half its final velocity

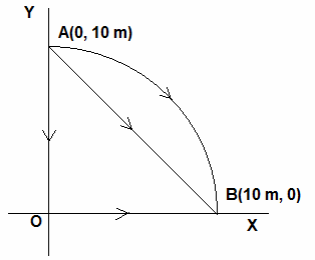
LEVEL - II

1. A particle starts from the origin of a co-ordinate system. First it moves along positive y-axis with a constant speed of 2 m/s for 3 sec. Without any delay, it takes a right turn and moves parallel to positive x-axis with a constant speed of 4 m/s for 2 sec and stops. Over first 5 sec of its motion calculate;
(a) the displacement and distance travelled by the particle (b) average velocity (both magnitude and direction) and average speed of the particle.
2. A train moves from station A to station B as follows. It covers half of the total distance with the constant speed of 10 m/s. For second half of the distance, it moves with the constant speed of 5 m/s for half of the time and with the constant speed of 15 m/s for remaining half of the time. Find the average speed of the train over total journey.
3. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/hr. Finding the market closed he instantly turns and walks back home with a speed of 7.5 km/hr. What is the magnitude of his average velocity and his average speed over the time interval from (a) 0 - 30 min (b) 0 – 50 min and (c) 0 – 40 min.
4. In carrom board game, you can assume that velocities of a coin makes equal angle with the edge of the board before and after its collision with the edge. Under this assumption solve the given question.
A carom board (4 ft× 4 ft square) has the queen at the centre. The queen, hit by the striker moves to the front edge, rebounds and goes in the hole behind the striking line. Find the magnitude of displacement of the queen (a) from the centre to the front edge (b) from the front edge to the hole and (c) from the centre to the hole.
5. A baller throws a ball which reaches the batsman with a constant speed of 25 m/s. The batsman deflects the ball at an angle of 60^o with its initial direction of motion with same speed. The ball remains in contact with the bat for 0.1 s. With the help of vector diagram calculate (a) the change in velocity of the ball due to impact with the bat (b) the average acceleration of the ball during the time of impact.
6. A particle moves over the sides of an equilateral triangle of side ℓ with constant speed v as shown in figure. Find the magnitude of average acceleration as it moves from A to C through B.



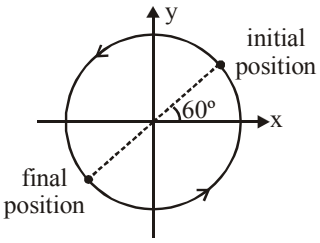
7. A particle is moving in x-y plane in such a way that its x- and y- coordinates change with time as $x(t) = at$ and $y(t) = bt^2$. Here 'a' and 'b' are positive constants and 't' is time in second. Calculate, (i) the position vectors of the particle at t = 2 s and at t = 7s, in terms of $\hat{i}$ and $\hat{j}$, where these symbols have their usual meanings. (ii) The displacement of the particle in 7s (iii) The magnitude and direction (angle either with x-axis or with y-axis) of its average velocity over first 7 s. Take a = 2m/s and b = 4 m/s^2.

8. In the adjacent figure a particle moves from point A to point B through three different paths, named 1, 2, and 3. The path 1 is a quarter of a circle with centre at 'O', the path 2 is a straight line and for path 3, first particle moves from A to O and then from O to B. If the particle takes 5 sec to complete its journey along any of the given paths, then calculate its average velocity along all three paths over the time interval from start to the end of the motion.



9. A person is standing on the roof of a 20 m tall building. On the roof first he moves towards north with a speed of 2 m/s for 5 sec, he then suddenly turned towards east and moves for 10 sec with a speed of 2 m/s and reaches the edge of the roof. Without any delay he takes a coin from his pocket and drops it. After 2 sec since dropping the coin lands on the ground. Express the displacement vector of the coin in terms of rectangular components with the origin at the starting point. Take positive x-axis towards east, positive y-axis towards north and upward as positive z-axis. Calculate (a) the average velocity of the coin over the period of 17sec of its motion in vector form and find its magnitude. (b) the average speed of the coin over the same time period. Neglect the height of the person.

10. A particle moves with a speed v in a circle of radius R. Find the x-component of the average velocity of the particle in a half-revolution, as shown in figure



11. Magnitude of the displacement of a particle in a given time interval
   (A) must be equal to the distance travelled by particle if motion is linear and direction of velocity of the particle does not change in that time interval
   (B) must be equal to the distance travelled by particle if motion is linear and direction of velocity of the particle changes in that time interval
   (C) must be equal the magnitude of change in initial position vector and final position vector in that time interval
   (D) must be less than the distance travelled by the particle in that time interval

12. The position vector of a particle is given by the relation $\vec{r} = \vec{\alpha}\left(1 - \gamma t + \beta t^2\right)$, where $\vec{\alpha}$ is a constant vector while, β and γ are positive constants. Which of the following statement is true?
   (A) Displacement in first two seconds is $\vec{\alpha}\left(1 - 2\gamma + 4\beta\right)$
   (B) Velocity at t = 0 is $-\vec{\alpha}\gamma$.
   (C) Acceleration at t = 0 is $2\beta\vec{\alpha}$.
   (D) Speed is decreasing with time at t = 0.

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ANSWERS

LEVEL – I

1. $-2(\hat{i}+\hat{j}+\hat{k})$ m, $-(\hat{i}+\hat{j}+\hat{k})$ m/s
2. $50\sqrt{2}$ km/h towards south west
3. $\frac{2}{v}=\frac{1}{v_1}+\frac{1}{v_2}$
4. 40 km/hr
5. 2 v sin (θ/2)
6. 3.8 m/s
7. $v=\frac{v_1+v_2}{2}$
8. (a) $-\left(6.28\hat{i}+6.28\hat{j}\right)$m/s , 8.9 m/s (b) $\frac{-\left(6.28\hat{i}+6.28\hat{j}\right)\text{m/s}^2}{5}$, 1.8 m/s^2
9. $\sqrt{2}$ m/s^2
10. (a) 0 (b) 4 m
11. C

LEVEL - II

1. (a) 10 m, 14 m(b) 2 m/s, 37^0 with positive x-axis
2. 10 m/s
3. (a) 5 km/hr, 5 km/hr (b) 0, 6 km/hr (c) $\frac{15}{8}km/hr$, $\frac{45}{8}km/hr$
4. (a) $\frac{2}{3}\sqrt{10}$ft (b) $\frac{4}{3}\sqrt{10}$ ft (c) 2$\sqrt{2}$ ft
5. (a) 25 m/s (b) 250 m/s^2
6. $\frac{\sqrt{3}}{2}\frac{v^2}{\ell}$
6. $<\vec{a}>=\frac{\vec{v}_f-\vec{v}_i}{\Delta t}=\frac{\left(-v\hat{i}\right)-\left(v\cos 60^\circ\hat{i}+v\sin 60^\circ\hat{j}\right)}{(2\ell/v)}=\frac{(v)\left(-\frac{3}{2}\hat{i}+\frac{\sqrt{3}}{2}\hat{j}\right)}{(2\ell/v)}=\frac{v^2\left(-3\hat{i}+\sqrt{3}\hat{j}\right)}{4\ell}$

   $|<\vec{a}>|=\frac{\sqrt{3}v^2}{2\ell}$
7. (i) $4\hat{i}+16\hat{j}$ (t = 2 sec), $14\hat{i}+196\hat{j}$ (t = 7 sec). (ii) $14\hat{i}+196\hat{j}$
   (iii) 28.07, θ = tan^{-1}(14) with positive x-axis
8. 2$\sqrt{2}$ m/s
9. (a) $20\hat{i}+10\hat{j}$-$20\hat{k}$, 30/17 m/s (b) 50/17 m/s
10. $\frac{-v}{\pi}$
10. $\upsilon_x=\frac{\Delta x}{T/2}$, where $T=\frac{2\pi R}{\upsilon}$
11. A, C
12. B, C, D