Motion in 1D

Phys109

Fall 2019

1. Particle as a function of time is given by $\overrightarrow{r} = (5t + 6t^2)\hat{i} + (7 - 3t^2)\hat{j}$, where $\overrightarrow{r}$ is in meters and t in seconds,

   (a) What is the displacement between $t_1 = 2$s and $t_2 = 3$s?
   ($\overrightarrow{\Delta r}$=35$\hat{i}-15\hat{j}$m)

   (b) Determine the particle's instantaneous velocity and acceleration as a function of time.
   ($\overrightarrow{v} = (5 + 12t)\hat{i} - 6t\hat{j}\ m/s$, $\overrightarrow{a} = 12\hat{i} - 6\hat{j}\ m/s^2$)

   (c) Evaluate $\overrightarrow{v}$ and $\overrightarrow{a}$ at $t = 3$s.
   ($\overrightarrow{v} = 41\hat{i} - 18\hat{j}\ m/s$, $\overrightarrow{a} = 12\hat{i} - 6\hat{j}\ m/s^2$)

2. An object moving with uniform acceleration has a velocity of 6 m/s in the positive x direction when its x coordinate is 3 m.If its x coordinate 2 s later is -5 m, what is its acceleration? ($\overrightarrow{a} = -10\ m/s^2$)

3. The position of a particle is given by $\overrightarrow{x} = 20t - 5t^3$, where x is in meters and t is in seconds.

   (a) when, if ever, is the particle's velocity zero? ($t = 1.33$ s)

   (b) When is its acceleration zero? ($t = 0$)

   (c) For what time range (positive or negative) is the acceleration a(t) negative or positive? (In this motion always the acceleration is negative.)

4. A plane touches the ground for landing with a speed of 100 m/s and slow down at a rate of $5m/s^2$ before it stops.

   (a) What is the time it takes the plane to stop? ($t = 20$ s)

   (b) Can this plan safely land on a small airport when the runway is only 0.8km long? (No, it can't. The plan needs a runway with 1 km long.)

5. A brick dropped from rest from the top of a building. The brick sticks the ground after 4s.

   (a) How tall, in meter is the building? ($h = 78.4$ m)

(b) What is the velocity of the brick just before it hits the ground? ($V_f = -39.2\hat{j}$ m/s)

6. A stone was thrown vertically upward from ground level with an initial speed of $v_0 = 20m/s$. The ball was caught by the thrower at a height of 5 m above the ground on its way back.

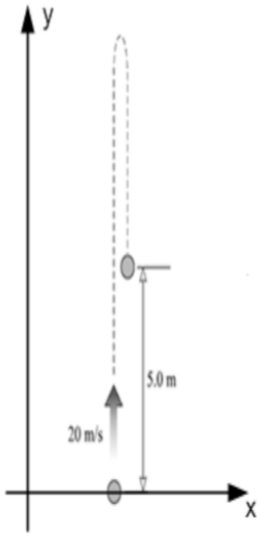

Figure 1: Problem no.6

(a) Calculate the time of flight for the stone.
($t = 3.81$s)

(b) Calculate the maximum height reached by the stone.
($t = 2$ s, $h_{max} = 20.4$ m)

(c) Calculate the velocity of the stone just before it was caught.
($\overrightarrow{V_f} = -17.33\hat{j}$ m/s)

(d) Calculate the average speed of the stone for this flight.
($V_{av} = 9.4$ m/s)

(e) Calculate the average velocity of the stone for this flight.
($\overrightarrow{V_{av}} = 1.31\hat{j}$)

7. A boy throws a ball vertically upward from a height of 3 m. Then he jumps and catches the ball on its way down where it is 1m above from its initially thrown point. If the ball's total time of flight is 10 s, find

(a) The initial speed v_0? ($49.1\ m/s$)

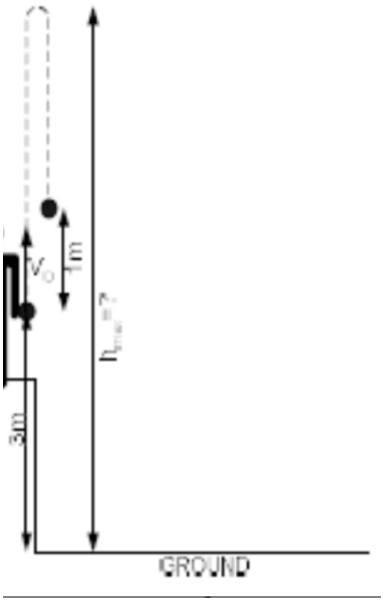

Figure 2: Problem no.7

(b) The time needed for the ball to reach its maximum height, t_{max}? (5.01 s)

(c) The ball's maximum height? (126 m)

(d) The speed of the ball just before it is caught by the boy, (48.9 m/s)

(e) The average speed and velocity of the ball? (24.5 m/s, 0.1 $\hat{j}$ m/s)

8. The position of a particle as a function of time is given by $\overrightarrow{r} = (5t^2 - 6t + 4)\hat{i} + (3t^3 - 8)\hat{j}$, where t is in seconds.

(a) Determine the particle's instantaneous velocity at $t = 3$s. ($\overrightarrow{V} = 24\hat{i} + 81\hat{j}$ m/s)

(b) Determine the particle's instantaneous speed at $t = 3$s. ($V = 84m/s$)

(c) Determine the direction of particle's velocity (θ) at $t = 3$s. ($\theta = 73°$)

(d) Determine the particle's instantaneous acceleration at $t = 3$s. ($\overrightarrow{a} = 10\hat{i} + 54\hat{j}$ m/s)

(e) Determine the particle's distance at $t = 3$s. ($|\overrightarrow{r}| = 79$ m)

9. A driver in a blue car traveling at 50 km/h sees a red car approaching in his rear-view mirror. The red car is travelling at 60 km/h and is 30 m behind the blue car when first spotted.

(a) How many seconds from the time the driver of the blue car first noticed it until the red car passes the blue car ?
($t = 1.8$ s)

(b) How much farther down the road will the blue car travel in this time?
($r = 25$ m)

10. A particle moves in the $xy - plane$ with the coordinates $x(t) = -2t + 3$ and $y(t) = -3t^2 - 4$, with x(t) and y(t) in meters and t in seconds.

(a) Write the position vector. ($\overrightarrow{r} = (-2t + 3)\hat{i} + (-3t^2 - 4)\hat{j}$ m)

(b) Find the displacement of the particle between $t = 1$s and $t = 5$s.
($\overrightarrow{\Delta r} = -8\hat{i} - 88\hat{j}$ m)

(c) Find the average velocity between $t = 1$s and $t = 5$s.
($\overrightarrow{V_{av}} = -2\hat{i} - 22\hat{j}$ m/s)

(d) Find the velocity and acceleration vector at any time t.
($\overrightarrow{V} = -2\hat{i} - 6t\hat{j}$ m/s, $\overrightarrow{a} = -6\hat{j}\ m/s^2$)