proprep™

Workbook

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Kinematics

Motion in a Line (One Dimension)

Questions

1) Position and Time.

The position of a body travelling in a straight line is given by: $x(t) = 32te^{-t}$.

a. Find the time at which the body stops moving.
b. Find the distance of the body at this time from the origin.

2) Velocity as a Function of Position.

A particle is moving in the positive direction of the x-axis and its velocity is given by $v_x = c\sqrt{x}$, $c > 0$ at $t = 0$, the particle is at position $x = 0$.

a. What are the units of c?
b. Find the velocity and the acceleration as a function of time.
c. Find the average velocity in the time taken for the particle to travel a distance s.

Motion in a Straight Line

3) Position and Constant Velocity.

A car is moving at $20\,\mathrm{m/s}$.

a. What distance will it travel in $5\mathrm{s}$?
b. What will be the velocity of the car at the 5^{th} second?
c. What is the position of the car as a function of time?
d. What is the position of the car as a function of time relative to a stationary person standing $200\mathrm{m}$ from the starting point in the direction of travel?

4) From Point A to Point B.

A truck drives from A to B at $50\,\mathrm{km/h}$.

At the exact same time, a car drives from point B to point A at $80\,\mathrm{km/h}$.

a. When will the two vehicles reach their destinations?
(the distance between A and B is $100\mathrm{km}$)
b. When will the two vehicles reach point C, which is $60\mathrm{km}$ away from point B?
c. Where and when will the vehicles meet?

5) Two Race Cars.

Two racecars are located at a distance of 100m from one another.
How long will it take to the car in the second place to reach the car in first place, if we know that the first car is traveling at $40\,\text{m/s}$ and the second car is traveling at $50\,\text{m/s}$?

6) Position and Velocity – Constant Acceleration.

A car moves from rest and accelerates at an acceleration of $20\,\text{m/s}^2$.

a. What will be the displacements after 5 seconds?
b. What is the velocity of the car at 5 seconds?
c. What is the position of the car as a function of time?
d. What is the position of the car as a function of time relative to a bystander located 200m away from the origin in the direction of travel?
e. When will the car reach this bystander?

7) Two Cars Meet.

Car A is travelling at a velocity of $100\,\text{m/s}$. Car B starts moving from rest and accelerates at $10\,\text{m/s}^2$. Both cars start their motion at $t=0$ at the origin.

a. Find the velocity of both cars as a function of time.
b. Find the position of the two cars as a function of time.
c. When will the two cars meet?
d. What is the velocity of the two cars at that moment?

8) Graphs and Equations.

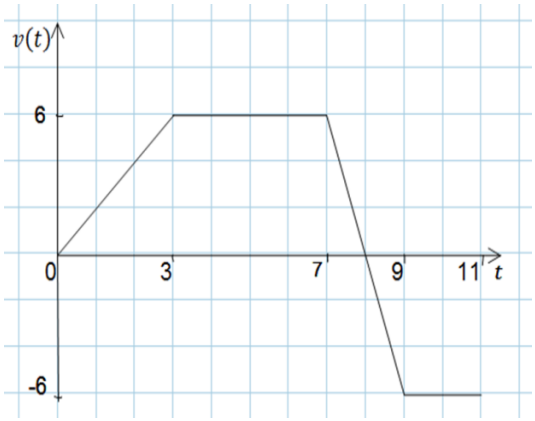
A car starts moving from rest at a constant acceleration of $5\,\text{m/s}^2$ and travels in a straight line for 4s. Then, the car travels at a constant velocity for a further 8s.
Finally, the car decelerates at a constant acceleration for 2s until coming to a stop.

a. Write the acceleration as a function of time.
b. Draw an acceleration Vs. time graph.
c. Write the velocity as a function of time.
d. Draw a velocity Vs. time graph.
e. Find the velocity of the car at $t=3$, 8, 13.
f. Write the position as a function of time.
g. Draw the position Vs. time graph.
h. What is the total displacement of the car?

9) Velocity Time Graph.

The graph describes the velocity of a car as a function of time.

a. What is the total displacement and distance travelled?
b. Find $x(t)$ and draw the position-time graph.
c. What it the average velocity between $t=0$ and $t=8$.
d. Draw an acceleration-time graph.



10) One Collision.

A car accelerates from rest at $5\,\mathrm{m/s^2}$. $10\mathrm{s}$ later a shot is fired at the car.

What needs to be the velocity of the bullet, so that the bullet and the car will collide one time only?

Vertical Shots and Free Fall

Questions

11) Two Rocks Fall from a Building.

Julie releases a rock from a height of $30\mathrm{m}$. Edna is standing at a height of $15\mathrm{m}$ and releases a rock at the same time as Julie.

a. At what velocities will the two rocks hit the ground?
b. What will be the time difference between the two rocks hitting the ground?
c. Now, Edna releases the rock only once Julie's rock passes him. What will be the time difference between the two hits now?
d. How long must Edna wait, after the release of Julie's rock, in order to release her rock if she would want both her rock and Julie's rock to hit the ground simultaneously?

12) Rock is Thrown Upwards.

A rock is thrown upwards at a velocity of $40\,\mathrm{m/s^2}$.

a. Where will the rock be after $3\mathrm{s}$?
b. What will be its velocity after $4\mathrm{s}$?
c. How long will the rock be moving in an upwards direction?
d. What is the maximum height that the rock will reach?
e. What will be the rock's velocity when it return to its starting position?
f. How long will it take for the rock to reach $5\mathrm{m}$ below its start point?

Answer Key

1) a. $t=1$ b. $x(t=1)=\frac{32}{e}$

2) a. $c=[\text{m}]^{\frac{1}{2}}\cdot[\text{s}]^{-1}$ b. Velocity: $v_x=\frac{c^2}{2}t$, acceleration: $a_x=\frac{c^2}{2}$. c. $\bar{v}=s^{\frac{1}{2}}\cdot\frac{c}{2}$

3) a. $x(t=5)=100\text{m}$ b. $v(t=5)=20\,\text{m\s}$ c. $x(t)=20t$

d. $x'(t)=-200+20t$

4) a. $t_{Truck}=-2\text{hr},\quad t_{Car}=\frac{5}{4}\text{hr}$ b. $t_T=\frac{4}{5}\text{hr},\quad t_C=\frac{3}{4}\text{hr}$

c. $t=\frac{10}{13}\text{hrs},\quad x\left(t=\frac{10}{13}\right)=\frac{800}{13}\text{km}$

5) $t=10\text{s}$

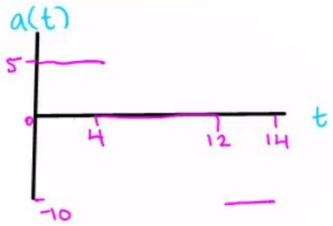
6) a. 250m b. 100m/s c. $10t^2$ d. $x'(t)=-200+10t^2$ e. $t=\sqrt{20}\text{s}$

7)

Part	Car A	Car B
a.	$v(t)=100$	$v(t)=10t$
b.	$x(t)=100t$	$x(t)=5t^2$
c.	$t=20$	
d.	$v(t=0)=100$ $v(t=20)=100$	$v(t=0)=0$ $v(t=20)=200$

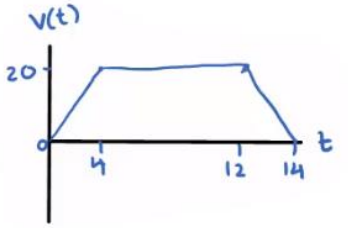
8) a. $a(t)=\begin{cases}0\le t\le 4 & 5\\ 4\le t\le 12 & 0\\ 12\le t\le 14 & ?\end{cases}$

b.



c. $v(t)=\begin{cases}0\le t\le 4 & 5t\\ 4\le t\le 12 & 20\\ 12\le t\le 14 & 20-10t\end{cases}$

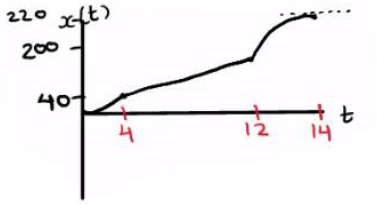
d.



e. $v(t=3)=15\text{m/s},\quad v(t=8)=20\text{m/s},\quad v(t=13)=10\text{m/s}$

f. $x(t)=\begin{cases}0\le t\le 4 & \frac{5}{2}t^2\\ 4\le t\le 12 & 40+20(t-4)\\ 12\le t\le 14 & 20-10t\end{cases}$

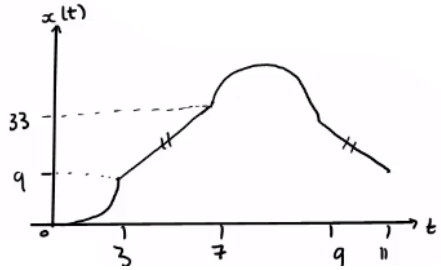
g.



h. $x_{Total}(t=14)=200\text{m}$

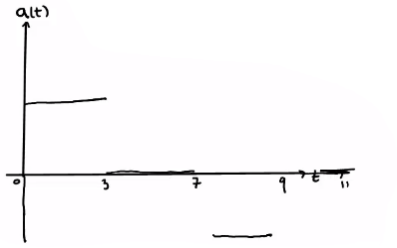
9) a. Distance: $S_1+S_2=51\text{m}$, displacement: $S_1-S_2=21\text{m}$.

b. $x(t)=\begin{cases}t^2 & 0\le t\le 3\\ 9+6(t-3) & 3\le t\le 7\\ 33+6(t-7)-3(t-7)^2 & 7\le t\le 9\\ 33-6(t-9) & 9\le t\le 11\end{cases}$



c. $\frac{9}{2}\text{m/s}$

d.



10) $v=100$ at $t=20$.

11) a. $t_J=\sqrt{6},\quad t_E=\sqrt{3}$ b. $t_d=\sqrt{6}-\sqrt{3}$ c. $t_{d'}=\sqrt{6}-2\sqrt{3}$ d. $t_w=\sqrt{6}$

12) a. $y(t=3)=75\text{m}$ b. $v(t=4)=0$ c. $t=4\text{sec}$ d. $h_{\max}=80\text{m}$

e. $v_f(t=8)=-40\text{m/s}$ f. $t=4+\frac{\sqrt{1700}}{10}$