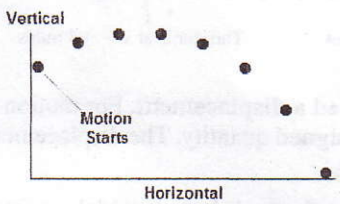
Questions and Example Problems from Chapter 1

Question 1

For each motion diagram, write a short description of the motion of an object that will match the diagram. Your descriptions should name specific objects.

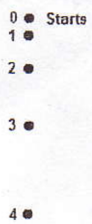
A car breaks to a stop from a speed of 20 m/s.

(Any linear motion of an object slowing down to a stop).



Sally launches a water balloon from her second floor window in an attempt to hit her boyfriend.

(projectile motion)

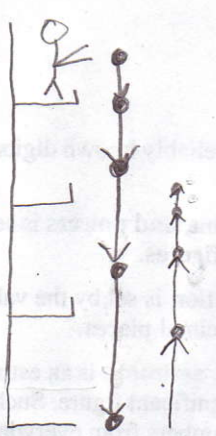


Mikey drops a rock off a cliff.

(Any downward acceleration from rest).

Question 2

Your roommate drops a tennis ball from a third-story balcony. It hits the sidewalk and bounces as high as the second story. Draw a motion diagram, using the particle model, showing the ball's velocity vectors from the time it is released until it reaches the maximum height on its bounce.



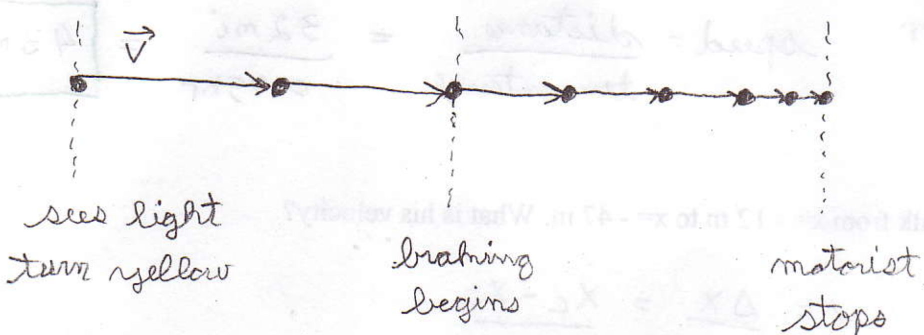
upward motion

downward motion

Problem 1

Interpret the following problem by drawing a motion diagram showing the object's position and its velocity vectors. Do *not* solve this problem or do any mathematics.

A motorist is traveling at 20 *m/s*. He is 60 m from a stop light when he sees it turn yellow. His reaction time, before stepping on the brake, is 0.50 s. What steady deceleration while braking will bring him to a stop right at the light?



Problem 2

A car travels along a straight east-west road. A coordinate system is established on the road, with *x* increasing to the east. The car ends up 14 mi west of the intersection with Mulberry Road. If its displacement was -23 mi, how far from and on which side of Mulberry Road did it start?

$X_f = -14\,mi$

$\Delta X = -23\,mi$

$X_i = ?$

$\Delta X = X_f - X_i$

$X_i = X_f - \Delta X$

$X_i = -14\,mi - (-23\,mi) = 9\,mi$

$\boxed{X_i = 9\,mi \text{ east of Mulberry Road}}$

Problem 3

Keira starts at position $x = 23$ m along a coordinate axis. She then undergoes a displacement of -45 m. What is her final position?

$X_i = 23\,m$

$\Delta X = -45\,m$

$X_f = ?$

$\Delta X = X_f - X_i$

$X_f = X_i + \Delta X$

$= 23\,m + (-45\,m)$

$\boxed{X_f = -22\,m}$

↗49

Problem 4

Alberta is going to have dinner at her grandmother's house, but she is running a bit behind schedule. As she gets onto the highway, she knows that she must exit the highway within 45 min if she is not going to arrive late. Her exit is 32 mi away. What is the slowest speed at which she could drive and still arrive in time? Express your answer in miles per hour.

⇒ Alberta must drive 32 mi in 45 min

$45\,\text{min} = 0.75\,\text{hr}$

$$\text{speed} = \frac{\text{distance}}{\text{time interval}} = \frac{32\,\text{mi}}{0.75\,\text{hr}} = \boxed{43\,\text{mi/hr}}$$

Problem 5

It takes Harry 35 s to walk from x= - 12 m to x= - 47 m. What is his velocity?

$\Delta t = 35\,\text{s}$

$x_i = -12\,\text{m}$

$x_f = -47\,\text{m}$

$v = ?$

$$v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}$$

$$v = \frac{-47\,\text{m} - (-12\,\text{m})}{35\,\text{s}} = \frac{-35\,\text{m}}{35\,\text{s}} \longrightarrow \boxed{v = -1.0\,\text{m/s}}$$

Problem 6

In the United States, we often use miles per hour (mi/h) when discussing speed, while the SI unit of speed is m/s. What is the conversion factor for changing m/s to mi/h? If you want to make a quick approximation of the speed in mi/h given the speed in m/s, what might be the easiest conversion factor to use?

$$1\,\text{m/s} = 1\,\cancel{\text{m}}/\cancel{\text{s}}\left(\frac{1\,\text{mi}}{1609\,\cancel{\text{m}}}\right)\left(\frac{3600\,\cancel{\text{s}}}{1\,\text{hr}}\right)$$

$$\boxed{1\,\text{m/s} = 2.24\,\text{mi/hr}}$$

easy conversion factor $1\,\text{m/s} \approx 2\,\text{mi/hr}$

Problem 7

Convert the following to SI units: a) 8.0 in b) 66 ft/s

(a) $$8.0\,\text{in} = 8.0\,\cancel{\text{in}}\left(\frac{2.54\,\cancel{\text{cm}}}{1\,\cancel{\text{in}}}\right)\left(\frac{1\,\text{m}}{10^2\,\cancel{\text{cm}}}\right)$$

$$\boxed{8.0\,\text{in} = 0.20\,\text{m}}$$

(b) $$66\,\text{ft/s} = 66\,\cancel{\text{ft}}/\text{s}\left(\frac{1\,\text{m}}{3.28\,\cancel{\text{ft}}}\right)$$

$$\boxed{66\,\text{ft/s} = 2.0 \times 10^1\,\text{m/s}}$$

→ 17

Problem 8

List the following three speeds in order, from smallest to largest: 1 mm per /μs, 1 km per ks, 1 cm per ms.

$\mu = 10^{-6}$

$m = 10^{-3}$

$c = 10^{-2}$

$K = 10^{3}$

$$\frac{1\,mm}{\mu s} = \frac{1\,mm}{\mu s}\left(\frac{10^{-3}m}{1\,mm}\right)\left(\frac{1\,\mu s}{10^{-6}s}\right) = 1\times10^{3}\ m/s$$

$$1\,Km/Ks = 1\,Km/Ks\left(\frac{10^{3}m}{1\,Km}\right)\left(\frac{1\,Ks}{10^{3}s}\right) = 1\ m/s$$

$$1\ cm/ms = 1\,cm/ms\left(\frac{1\,m}{10^{2}cm}\right)\left(\frac{1\,ms}{10^{-3}s}\right) = 1\times10^{1}\ m/s$$

$$\boxed{1\,Km/Ks,\ 1\,cm/ms,\ 1\,mm/\mu s}$$

Problem 9

Estimate the average speed at which your fingernails grow, in both m/s and um/h. Briefly describe how you arrived at this estimate.

Suppose you clip your nails about every 10 days. You might clip off about 1 mm of nail every 10 days.

$$V = \frac{\Delta x}{\Delta t} = \frac{1\,mm}{10\,days}\left(\frac{1\,m}{10^{3}mm}\right)\left(\frac{1\,day}{24\,hrs}\right)\left(\frac{1\,hr}{3600\,s}\right) \approx \boxed{1\times10^{-9}\ m/s}$$

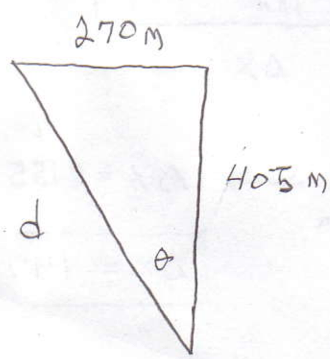
$$V = \frac{1\,mm}{10\,days}\left(\frac{10^{3}\mu m}{1\,mm}\right)\left(\frac{1\,day}{24\,hrs}\right) \approx \boxed{4\ \mu m/hr}$$

Problem 10 → 28

A city has streets laid out in a square grid, with each block 135 m long. If you drive north for three blocks, then west for two blocks, how far are you from your starting point?

3 blocks north = 3(135 m) = 405 m north

2 block west = 2(135 m) = 270 m west



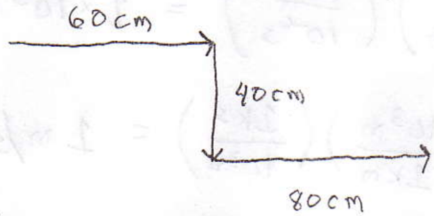
$$d^2 = (270\,m)^2 + (405\,m)^2$$

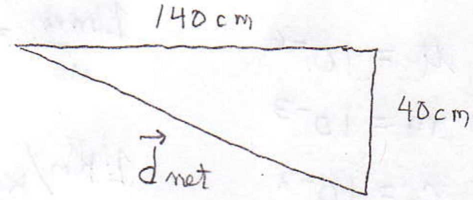
$$d = \sqrt{(270\,m)^2 + (405\,m)^2} = \boxed{487\,m}$$

$$\theta = \tan^{-1}\left(\frac{270\,m}{405\,m}\right) = 33.7^\circ$$

Problem 11

A ball on a porch rolls 60 cm to the porch' s edge, drops 40 cm, continues rolling on the grass, and eventually stops 80 cm from the porch's edge. What is the magnitude of the ball 's net displacement, in centimeters?





$\Delta X_{total} = 60\,cm + 80\,cm = 140\,cm$

$\Delta Y_{total} = 40\,cm$

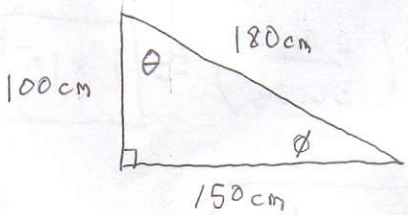
$d_{net} = \sqrt{(140\,cm)^2 + (40\,cm)^2}$

$= 146\,cm$

$\boxed{d_{net} = 1.5 \times 10^2\,cm}$ (answer w/ 2 sig figs)

Problem 12

What is the value of each of the angles of a right triangle whose sides are 100, 150, and 180 cm in length?



$\sin\phi = \left(\frac{100\,cm}{180\,cm}\right)$

$\phi = \sin^{-1}\left(\frac{100\,cm}{180\,cm}\right) = 33.7°$

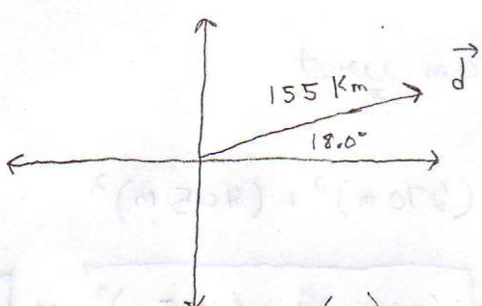
$\cos\theta = \left(\frac{100\,cm}{180\,cm}\right)$

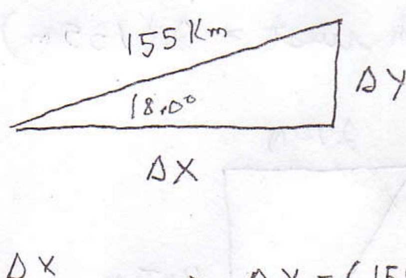
$\theta = \cos^{-1}\left(\frac{100\,cm}{180\,cm}\right) = 56.3°$

$\boxed{33.7°, 56.3°, 90°}$

Problem 13

An ocean liner leaves New York City and travels 18.0° north of east for 155 km. How far east and how far north has it gone. In other words, what are the magnitudes of the components of the ships displacement vector in the directions (a) due east and (b) due north?





(a) $\cos 18.0° = \frac{\Delta X}{155\,Km} \longrightarrow \Delta X = (155\,Km)\cos 18.0°$

$\boxed{\Delta X = 147\,Km}$

(b) $\sin 18.0° = \frac{\Delta Y}{155\,Km}$

$\Delta Y = (155\,Km)\sin 18.0° \longrightarrow \boxed{\Delta Y = 48\,Km}$