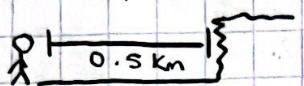


2. Estimations and Unit Analysis

① echo off a wall 1.5 sec later
canyon wall = 0.5 km away

a) speed of sound (m/s):



$$\text{speed} = \frac{0.5 \text{ km}}{1.5 \text{ sec}} \rightarrow m = \frac{500 \text{ m}}{1.5 \text{ sec}} = 333.3 \text{ m/s}$$

b) in km/hr:

$$\frac{333.3 \text{ m}}{1 \text{ sec}} \cdot \frac{3600 \text{ sec}}{1 \text{ hr}} \cdot \frac{1 \text{ km}}{1000 \text{ m}} = 1199.88 \text{ km/hr}$$

② a) 0.25 m^3 in cm^3 =

$$0.25 \text{ m} \times \frac{\text{m}^3}{(\text{cubic cm})} = \frac{100000}{6 \text{ places}} = 0.25 \text{ m} \\ = 250,000 \text{ cm}^3$$

b) 100 km/hr in m/s =

$$\frac{100 \text{ km}}{1 \text{ hr}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \frac{1 \text{ hr}}{3600 \text{ sec}} = 27.78 \text{ m/s}$$

c) 2 kg m s^{-2} in gm cm ms^{-2}

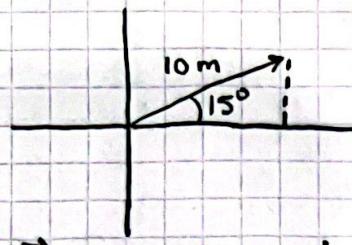
$$(1 \text{ kg m s}^{-2} \rightarrow \text{gm cm s}^{-2}) = 10 \text{ gm cm ms}^{-2}$$

$$\frac{2 \text{ kg m s}^{-2} \rightarrow \text{gm cm s}^{-2}}{1 \text{ kg}} = \frac{20 \text{ gm cm s}^{-2}}{1000 \text{ m/s} \cdot \frac{1 \text{ sec}}{1000 \text{ m/s}}} = 0.2 \frac{\text{gm}}{\text{m s}^2}$$

$m \rightarrow \text{cm}$

3: Vectors

① a) \vec{x}_1 = vector w/ magnit. 10m, \angle of 15° to x-axis



$$\cos 15^\circ \cdot 10 = x \\ \approx 9.66$$

$$9.659 = x$$

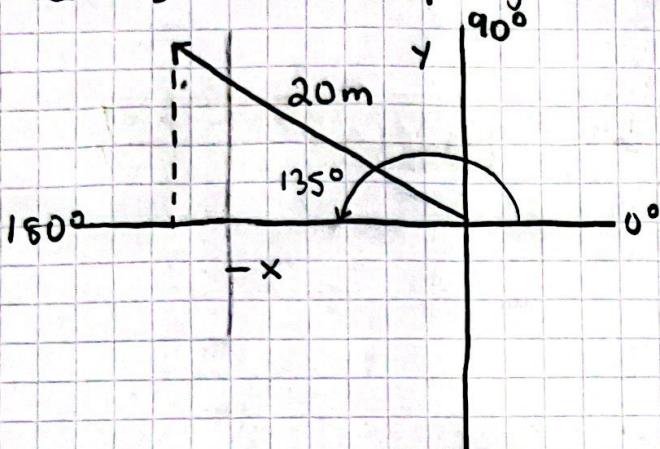
$$\sin 15^\circ = y/10$$

$$2.588 = y$$

$$y = 2.59$$

$$\vec{x}_1 = 9.66 \hat{i} + 2.59 \hat{j} \text{ m}$$

b) \vec{x}_2 = vector w/ magnit. 20m, \angle of 135° to x-axis



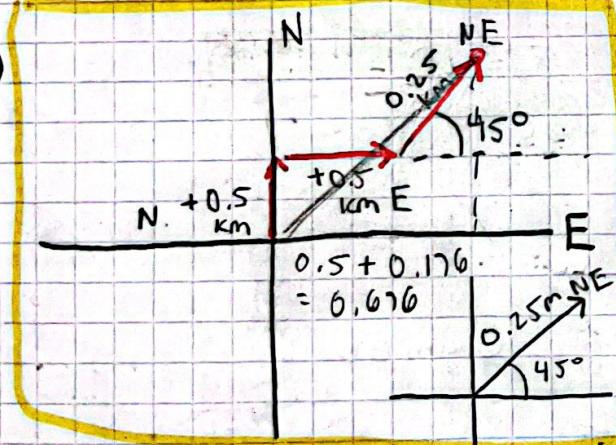
$$\cos(135^\circ) \cdot 3 = x \\ -14.14 = x$$

$$\sin(135^\circ) = y/20 \\ 14.14 = y$$

$$\vec{x}_2 = -14.14 \hat{i} + 14.14 \hat{j} \text{ m}$$

② 0.5 km to N, 0.5 km to E, NE $\angle = 45^\circ$ w/ respect to x-axis
for 0.25 km

a)



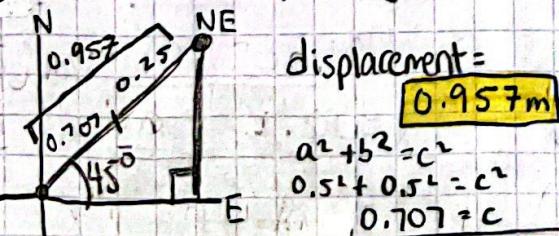
b) final location

| Leg | horiz | vert |
|-------|---------|---------|
| 1 | 0 m | 0.5 m |
| 2 | 0.5 m | 0 m |
| 3 | 0.176 m | 0.176 m |
| Total | 0.676 m | 0.676 m |

$$0.25 \sin 45^\circ = 0.176 \text{ m} \quad (\text{horiz})$$

$$0.25 \cos 45^\circ = 0.676 \text{ m} \quad (\text{vert})$$

c) distance from origin



$$\text{displacement} = 0.25 \text{ m}$$

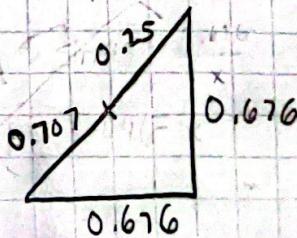
$$a^2 + b^2 = c^2 \\ 0.5^2 + 0.5^2 = c^2 \\ 0.707 = c$$

$$\Delta x = 0.676 \hat{i} \text{ m} + 0.676 \hat{j} \text{ m}$$

$$\Delta x = 0.68 \hat{i} \text{ m} + 0.68 \hat{j} \text{ m}$$

$$\sin 45^\circ = y/0.25 \\ 0.176 = y$$

$$\cos 45^\circ = x/0.25 \\ 0.176 = x$$



4: Motion Along a Straight Line

$$\textcircled{1} \quad x(t) = -1.0 - 4.0t \text{ m}$$

a) displacement between $t = -2 \text{ sec}$ and $t = 2 \text{ sec}$

$$t = -2 \text{ sec}$$

$$x(-2) = -1.0 - 4.0(-2)$$

$$x(-2) = -1 + (8)$$

$$x(-2) = 7$$

$$t = 2 \text{ sec}$$

$$x(2) = -1.0 - 4.0(2)$$

$$= -1 - 8$$

$$x(2) = -9$$

$$\Delta x = x(-2) - x(2)$$

$$= -9 - 7$$

$$\Delta x = -16 \text{ m}$$

(displacement)

b) find veloc. $x(t)$

$$x(4) =$$

$$x(-1) =$$

$$\bar{v} = \frac{\Delta \bar{x}}{\Delta t} = \frac{\bar{x}_f - \bar{x}_i}{t_f - t_i}$$

$$= \frac{-9 - 7}{2 - (-2)} \text{ m}$$

$$\bar{v} = \frac{-16}{4} \text{ m}$$

$$\bar{v} = -4 \text{ m/s}$$

$$\textcircled{2} \quad x(t) = -2t + 7t^2$$

a) avg. veloc between $t = 0 \text{ sec}$ and $t = 2 \text{ sec}$

$$t = 0 \text{ sec}$$

$$t = 2 \text{ sec}$$

$$x(t) = -2(0) + 7(0)^2$$

$$= 0 + 0$$

$$x(t) = 0 \text{ m}$$

$$x(2) = -2(2) + 7(2)^2$$

$$= -4 + 28$$

$$x(t) = 24 \text{ m}$$

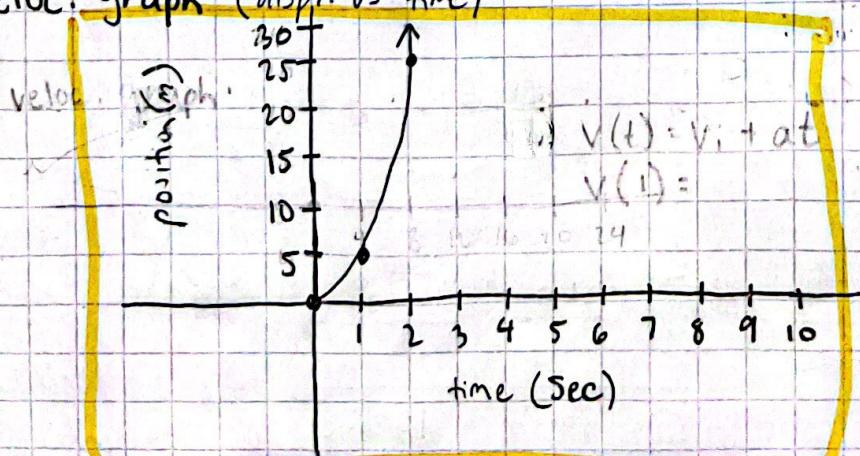
$$V_{\text{avg}} = \frac{\Delta x}{\Delta t}$$

$$= \frac{24 \text{ m} - 0 \text{ m}}{2 \text{ sec} - 0 \text{ sec}}$$

$$V_{\text{avg}} = \frac{24}{2}$$

$$V_{\text{avg}} = 12 \text{ m/s}$$

b) veloc. graph (displ. vs time)



$$V(t) = V_i + at$$

$$V(1) =$$

c) instantaneous veloc. at $t = 1$ sec

$$v(t) = v_i + at$$

~~C initial veloc. = $v = v_i - at$ or $v^2 = v_i^2 - 2as$ or $v = \frac{s}{t} - \frac{1}{2}at$~~

$v(1) = v_i + 6 \text{ m/s} \cdot (1)$

$-v_i = 6 \text{ m/s}^2$

$\frac{-2(1) + 7(1)^2 \text{ m}}{1 \text{ sec}} = 5 \text{ m/s}$

displacement (distance)

d) acceleration

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{12 \text{ m/s}}{2 \text{ s} - 0 \text{ s}} = \frac{12 \text{ m/s}}{2 \text{ s}} = 6 \text{ m/s}^2$$

③ constant accel. of 5.0 m/s^2 , starts from rest

a) time to reach top speed 10.0 m/s ?

$$(v_i) \text{ initial veloc.} = 0 \text{ m/s} \quad v = v_i + at$$
$$\text{accel.} = 5.0 \text{ m/s}^2 \quad 10 \text{ m/s} = 0 + 5 \text{ m/s}^2 (t)$$
$$\text{time} = 0 \quad \frac{10 \text{ m/s}}{5} = \frac{5 \text{ m/s}^2 (t)}{5}$$
$$2 \text{ sec} = t$$

b) displacement at that time?

$$x = \frac{1}{2} (v_i + v_f) t$$

v_i initial veloc.
 v_f final veloc.

$$x = \frac{1}{2} (10 \text{ m/s} + 0 \text{ m/s}) 2 \text{ sec}$$
$$= 5(2)$$
$$x = 10 \text{ m}$$

$$\text{final veloc.} = v + at$$
$$= 0 \text{ m/s} + 5.0 \text{ m/s}^2 (2)$$

$$10 \text{ m/s} = v \text{ (final veloc., top speed)}$$

c) running the 100m, cont. at 10.0 m/s , total time?

$$\text{Speed} = \frac{\text{distance}}{\text{time}} \Rightarrow \text{time} = \frac{\text{distance}}{\text{speed}}$$

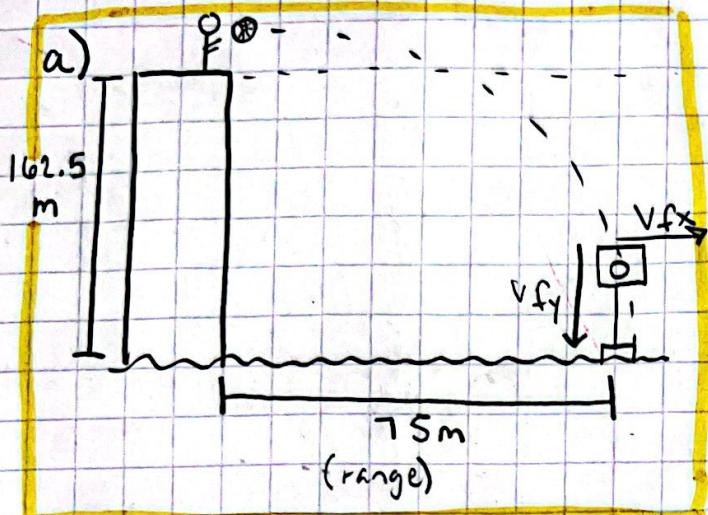
$$100 \text{ m} = \frac{10 \text{ m/s}}{\text{time}} \cdot \text{time}$$
$$100 \text{ m} = 10 \text{ m/s} \cdot \text{time}$$
$$100 \text{ m} = 10 \text{ m/s} \cdot \frac{90 \text{ m}}{10 \text{ m/s}} = \frac{900 \text{ m}}{10 \text{ m/s}} = \frac{90 \text{ m}}{X}$$
$$10 \times = 90$$

$$\text{total time} = 9 \text{ s}$$

$$9s + 2 = 11$$

5: Motion in 2 and 3 Dimensions

- ① basketball shot 162.5 m above hoop
75m horizontally from shooter



$$\text{vertical velocity} = 0$$

$$v_{ox} = 0 \text{ m/s}$$

$$h = 162.5 \text{ m}$$

$$v_x = v_i \cos \theta_x$$

horizontal velocity of projectile = 0°

b) horizontal veloci required to make the shot

$$v_x = 75 \text{ m} \times \frac{x}{t}$$

$$v_x = \frac{\Delta x}{t} \quad y = a_y = -9.81 \text{ m/s}^2$$

$$x = a_x = 0$$

$$v_0 = 0 \text{ m/s}$$

$$a_y = -9.81 \text{ m/s}^2 \quad v_{iy} = 0 \text{ m/s}$$

$$v_x = ? \quad v_{dx} = 75 \text{ m/s}$$

$$y = -162.5 \text{ m}$$

$$dy = v_{iy} t + \frac{1}{2} a_y t^2$$

$$dy = 0 + \frac{1}{2} a_y t^2$$

$$\sqrt{\frac{2dy}{a_y}} = t = \sqrt{\frac{2(-162.5 \text{ m})}{-9.81 \text{ m/s}^2}}$$

$$t = 5.75 \text{ sec}$$

$$v_x = \frac{dx}{t} = \frac{75 \text{ m}}{5.75 \text{ sec}} = 13.04 \text{ m/s}$$

- ② baseball hit at 45° , 40 m/s

a) distance to landing?

$$\text{horizontal velocity, } \sin 45^\circ$$

$$= 20\sqrt{2} \text{ m/s}$$

$$= 20\sqrt{2} (5.77)$$

$$\text{distance traveled} = 163 \text{ m}$$

b)

$v_y = 20\sqrt{2} 40 \text{ m/s}$

$\theta = 45^\circ$

$\frac{v^2}{2}$

$$g = \frac{\Delta v}{\Delta t} =$$

$$\Delta t = \frac{v_f - v_i}{g}$$

$$v_x = 20\sqrt{2}$$

$$\Delta t = \frac{0 - 20\sqrt{2}}{-9.81}$$

$$\Delta t = 2.886 \text{ s}$$

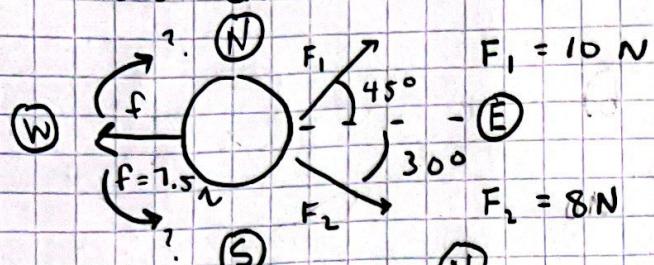
at top of arc time = 2.8 sec $\times 2$
total time (up + down) seconds

$$\text{total air time} = 5.77 \text{ seconds}$$

6: Forces

① Fig. 1 (Snow saucer)

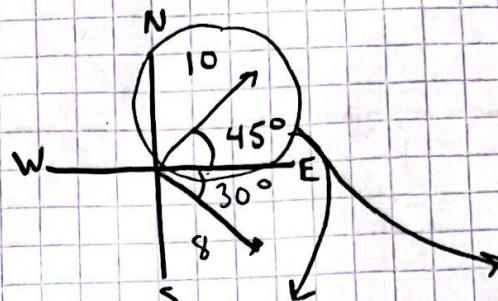
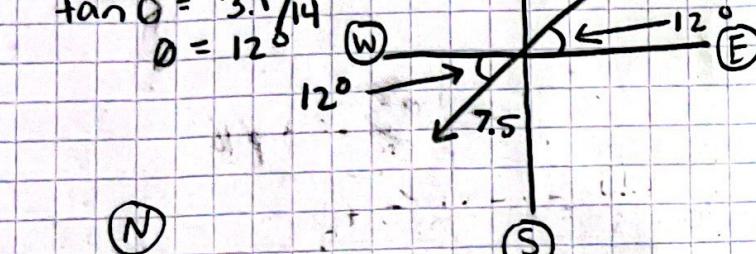
mass of child + sled = 49.0 kg



$$\tan \theta = y/x$$

$$\tan \theta = 3.1/14$$

$$\theta = 12^\circ$$



$$\cos \theta = a/h$$

$$\cos 45 = x/10$$

$$x = 7.1 \text{ N}$$

$$\cos \theta = a/h$$

$$\cos 30 = x/8$$

$$x = 6.9 \text{ N}$$

$$\sin \theta = o/h$$

$$\sin 45 = y/10$$

$$y = 7.1 \text{ N}$$

$$\sin \theta = o/h$$

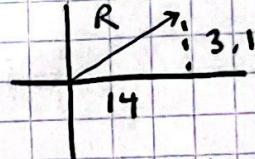
$$\sin 30 = y/8$$

$$-y = 4.0$$

$$y = -4.0$$

$$\begin{array}{r} 7.1 \\ + 6.9 \\ \hline 14.0 \end{array}$$

$$\begin{array}{r} 7.1 \\ + (-) 4.0 \\ \hline 3.1 \end{array}$$



$$a^2 + b^2 = c^2$$

$$14^2 + 3.1^2 = c^2$$

$$14.3 = c$$

\vec{N}
(net force)

$$\sum F = m \cdot a_x$$

$$\frac{14.3 - 7.5}{49} = \frac{49 \cdot a}{49}$$

$$0.14 \text{ m/s}^2 = \text{acceleration}$$

↳ direction not mentioned = at 12° North of East