Algebra-Based Physics - 1 : Mechanics
PHYS 135A : MIDTERM #1

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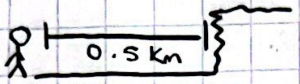
10/7/22
Hanson

Score: 23/25. Great work!

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):



$$\text{Speed} = \frac{0.5\text{ Km}}{1.5\text{ sec}} \rightarrow m = \frac{500\text{m}}{1.5\text{ sec}} = \boxed{333.3\text{ m/s}}$$

b) in km/hr:

$$\frac{333.3\ \cancel{m}}{1\ \cancel{sec}} \cdot \frac{3600\ \cancel{sec}}{1\text{ hr}} \cdot \frac{1\text{ km}}{1000\ \cancel{m}} = \boxed{1,199.88\text{ Km/hr}}$$

② a) 0.25 m^3 in cm^3 =

0.25 m $\quad \underset{(\text{cubic cm})}{x^3} = \underbrace{100000}_{6\text{ places}} \Rightarrow 0.25\text{m}$

.250000.0

$= \boxed{250,000\text{ cm}^3}$

b) 100 km/hr in m/s =

$$\frac{100\ \cancel{km}}{1\ \cancel{hr}} \cdot \frac{1000\text{m}}{1\ \cancel{km}} \cdot \frac{1\ \cancel{hr}}{3600\text{ sec}} = \boxed{27.77\text{ m/s}}$$

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

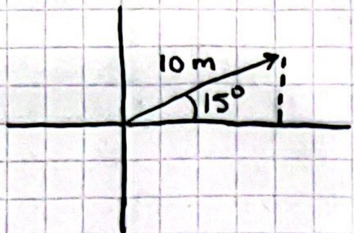
$1\text{ kg m/s}^{-2} \rightarrow \text{gm cm s}^{-2} = 10\text{ gm cm ms}^{-2}$

$$\frac{2\ \cancel{kg}\ \cancel{m}}{\cancel{s}^2} \cdot \frac{100\ \cancel{g}}{1\ \cancel{kg}} \cdot \frac{100\text{ cm}}{1\ \cancel{m}} \cdot \frac{1\ \cancel{sec}}{1000\text{ m/s}} \cdot \frac{1\text{ sec}}{1000\text{ m/s}}$$

$$= \boxed{0.2\ \frac{\text{gcm}}{\text{ms}^2}}$$

3: Vectors

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

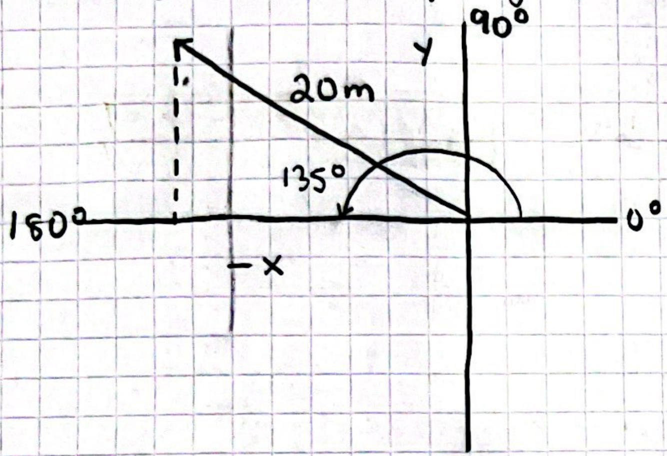


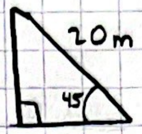
$\cos 15° \cdot 10 = x$
$9.659 = x$
≈ 9.66

$\sin 15° = y/10$
$2.588 = y$
≈ 2.59

$\boxed{\vec{x}_1 = 9.66\hat{\imath} + 2.59\hat{\jmath}\ m}$

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





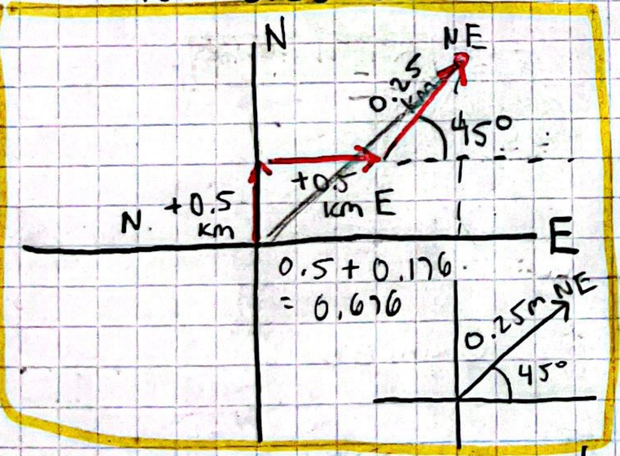
$\cos(135°) \cdot 3 = x$
$-14.14 = x$

$\sin(135°) = y/20$
$14.14 = y$

$\boxed{\vec{x}_2 = -14.14 + 14.14\hat{\jmath}\ m}$

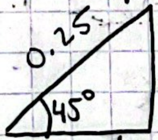
② 0.5 km to N, 0.5 km to E, NE ∡ = 45° w/ respect to x-axis for 0.25 km

ⓐ

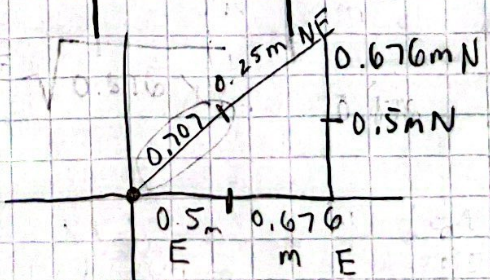


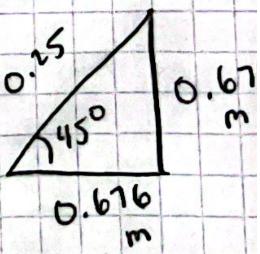
ⓑ final location

Leg	horiz	vert
1	0m	0.5m
2	0.5m	0m
3	0.176m	0.176m
Total	0.676m x	0.676m y



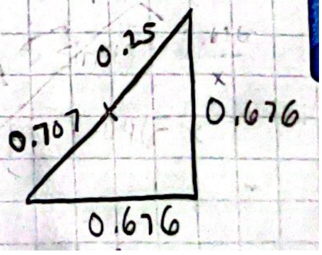
0.25 sin 45° = 0.176 m (horiz)
0.25 cos 45° = 0.176m (vert)



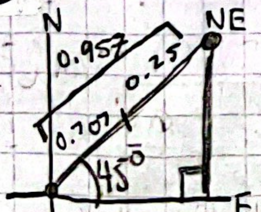


$\sin 45 = y/.25$
$0.176 = y$

$\cos 45 = x/.25$
$0.176 = x$



ⓒ distance from origin



displacement = $\boxed{0.957m}$

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

$\Delta x = 0.676\hat{\imath}m + 0.676\hat{\jmath}m$

$\boxed{\Delta x = 0.68\hat{\imath}m + 0.68\hat{\jmath}m}$

4: Motion Along a Straight Line

① $x(t) = -1.0 - 4.0t$ m

a) displacement between $t = -2$ sec and $t = 2$ sec

$t = -2$ sec

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

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

$\boxed{x(-2) = 7}$

$t = 2$ sec

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

$= -1 - 8$

$\boxed{x(2) = -9}$

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

$= -9 - 7$

$\boxed{\Delta x = -16 \text{ m}}$ (displacement)

b) find veloc. $x(t)$

$x(4) =$

$x(-1) =$

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

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

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

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

② $x(t) = -2t + 7t^2$

a) avg. veloc between $t = 0$ and $t = 2$ sec

$t = 0$ sec

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

$= 0 + 0$

$x(t) = 0$m

$t = 2$ sec

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

$= -4 + 28$

$x(t) = 24$ m

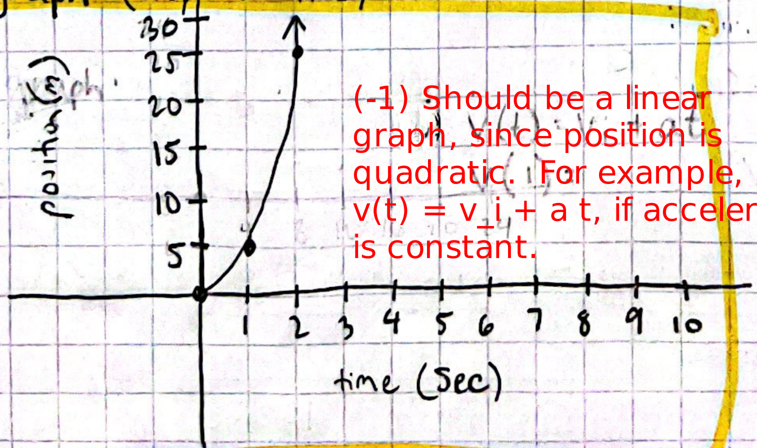
$V_{avg} = \dfrac{\Delta x}{\Delta t}$

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

$V_{avg} = \dfrac{24}{2}$

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

b) veloc. graph (displ. vs time)



(-1) Should be a linear graph, since position is quadratic. For example, $v(t) = v_i + a\,t$, if acceleration is constant.

c) instantaneous veloc at $t = 1$ sec

displacement (distance)

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

initial veloc $= u = v - at$ or $u^2 = v^2 - 2as$ or $u = \frac{s}{t} - \frac{1}{2}at$

final veloc

~~$v(1) = v_i + 6 m/s^2 (1)$~~

$-v_i = 6 m/s^2$

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

(-1) The acceleration turns out to be 14 m/s^2

d) acceleration

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

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

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

(vi) initial veloc $= 0 m/s$
accel $= 5.0 m/s^2$
time $= 0$

$v = v_i + at$

$10 m/s = 0 + 5 m/s^2 (t)$

$\frac{10 m/s}{5} = \frac{5 m/s^2 (t)}{5}$

$\boxed{2 sec = t}$

b) displacement at that time?

$x = \frac{1}{2}(v + u) t$ (initial veloc: u; final veloc: v)

x

final veloc $= u + at$
$= 0 m/s + 5.0 m/s^2 (2)$

$10 m/s = v$ (final veloc, top speed)

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

$= 5(2)$

$\boxed{x = 10 m}$

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

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

Well done!

$100m - 10m = 90m$

$\Rightarrow$ time $= \frac{90 m}{10 m/s}$

$10 m/s = \frac{90 m}{x}$

$10x = 90$

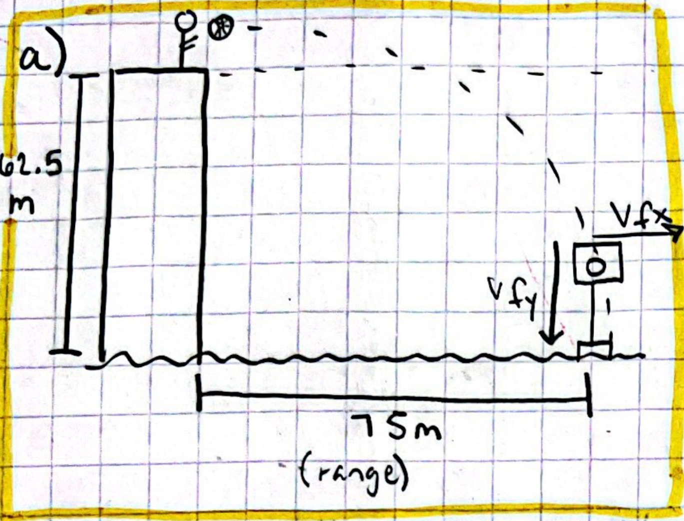
$x = 9$

$9s + 2 = 11$

$\boxed{\text{total time} = 11 sec}$

5: Motion in 2 and 3 Dimensions

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



Δvertical veloc = 0

$V_{ox} = 0$ m/s

$h = 162.5$ m

$V_x = V_i \cos\theta$

$\measuredangle$ of projectile lanch $= 0°$

b) horizontal veloc. required to make the shot

$V_x = 75\text{m} \cdot \frac{x}{t}$

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

$x = a_x = 0$

$V_0 = 0$ m/s

$\boxed{Y}$ $d_y = -162.5$m

$d_y = \cancel{V_{iy} t} + \frac{1}{2} a_y t^2$

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

$\sqrt{\frac{2d_y}{a_y}} = t$

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

$t = 5.75$ sec

$V_{iy} = 0$

$V_x = ?$

$d_x = 75$m

$V_x = \frac{d_x}{t}$

$= \frac{75 \text{ m}}{5.75 \text{ sec}}$

$V_x = 13.04$ m/s

Yes! Nice work.

② baseball hit at 45°$\measuredangle$, 40 m/s

a) distance to landing?

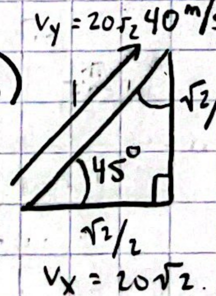
horizontal veloc.

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

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

distance traveled = 163m

b)



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

$\Delta t = \frac{V_f - V_i}{g}$

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

$\Delta t = 2.886$ s

at top of arc time = 2.8 sec x 2

total time (up + down)

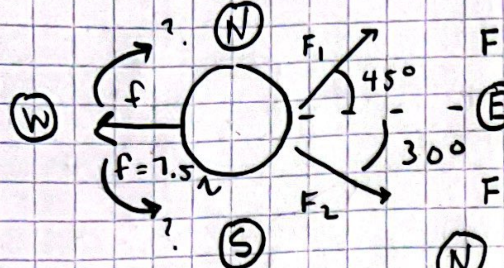
total air time = 5.77 seconds

Scanned with CamScanner

6: Forces

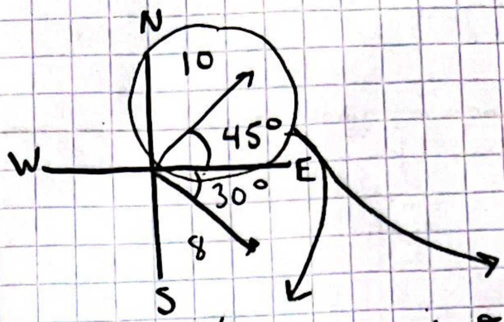
① Fig. 1 (snow saucer)

mass of child + sled = 49.0 kg



$F_1 = 10\ N$

$F_2 = 8\ N$



$\cos\theta = a/h$

$\cos 45 = x/10$

$x = 7.1\ N$

$\sin\theta = o/h$

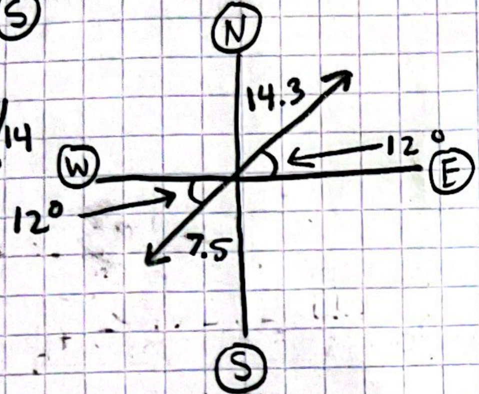
$\sin 45 = y/10$

$y = 7.1\ N$

$\tan\theta = y/x$

$\tan\theta = 3.1/14$

$\theta = 12°$



$\cos\theta = a/h$

$\cos 30 = x/8$

$x = 6.9\ N$

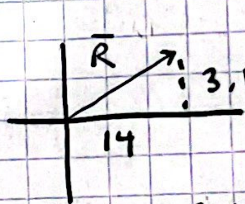
$\sin\theta = o/h$

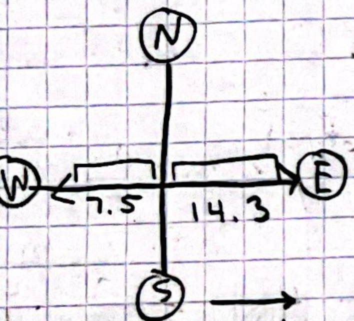
$\sin 30 = -y/8$

$-y = 4.0$

$y = -4.0\ N$

$$\begin{array}{r} 7.1 \\ +\ 6.9 \\ \hline 14.0 \end{array} \qquad \begin{array}{r} 7.1 \\ +(-)\ 4.0 \\ \hline 3.1 \end{array}$$





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

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

$14.3 = c$

N

(net force)

$\xrightarrow{\hspace{2em}}$ acceleration

$\sum F = m \cdot a_x$

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

Nice job.

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

↳ direction not mentioned = at 12° North of East