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Phys 150
Hanson
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MIDTERM 1

2 Estimations and unit Analysis

① Suppose you are standing at the edge of a canyon. You clap, and hear the sound of the echo off the other side of the canyon wall about 1.5 seconds later. You estimate the canyon wall to be about 0.5 km away.

(a) what is the speed of sound in meters per second?

$$V = \frac{\Delta x}{\Delta t} = \frac{0.5\,\text{km}}{1.5\,\text{s}} \times \frac{1000\,\text{m}}{1\,\text{km}} = \frac{500\,\text{m}}{1.5\,\text{s}}$$

$$= 333.\overline{3}$$

$$\approx \boxed{333\ \text{m/s}}$$

(b) what is it in km per hour?

$$\frac{0.5\,\text{km}}{1.5\,\text{s}} \times \frac{3600\,\text{s}}{1\,\text{hr}} = \frac{1800\,\text{km}}{1.5\,\text{hr}}$$

$$= \boxed{1200\ \text{km/hr}}$$

②

a) What is $0.25\,m^3$ in cm^3?

$$\left(\frac{0.25\,m^3}{1}\right) \times \left(\frac{100\ cm}{1\ m}\right)^3 = \frac{0.25\,m^3}{1} \times \frac{1\,000\,000\,cm^3}{1\,m^3}$$

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

(b) what is 100 km/hr in m/s?

$$\frac{100\ \text{km}}{1\ \text{hr}} \cdot \frac{1000\ \text{m}}{1\ \text{km}} \cdot \frac{1\ \text{hr}}{3600\ \text{s}} = \frac{100\,000\ \text{m}}{3600\ \text{s}}$$

$$\approx 27.77$$

$$= \boxed{27.8\ \text{m/s}}$$

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

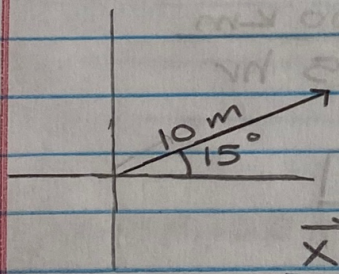
$$\frac{2\ \text{kg}}{1} \times \frac{1\ \text{m}}{1\ \text{s}^2} \times \frac{1000\ \text{gm}}{1\ \text{kg}} \times \frac{100\ \text{cm}}{1\ \text{m}} \times \frac{1\ \text{s}^2}{1{,}000{,}000\ \text{ms}^{-2}}$$

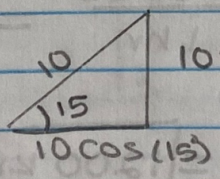
$$= \boxed{0.2\ \text{gm cm ms}^{-2}}$$

3 VECTORS

① write the following vectors in component form:

(a) $\vec{x}_1$ is a vector with a magnitude of 10 meters and that makes an angle of 15 degrees with respect to the x-axis.

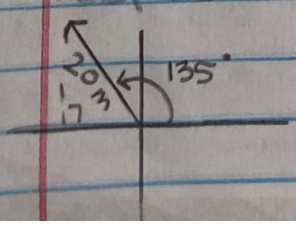


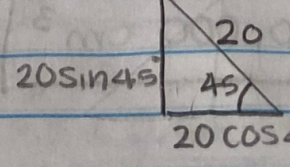


$$\vec{x}_1 = 10\cos(15^\circ)\hat{i} + 10\sin(15^\circ)\hat{j}$$

$$\boxed{\vec{x}_1 = 9.7\hat{i} + 2.6\hat{j}\ \text{m}}$$

(b) $\vec{x}_2$ is a vector with magnitude 20 meters that makes an angle of 135.0 degrees with respect to the x-axis.



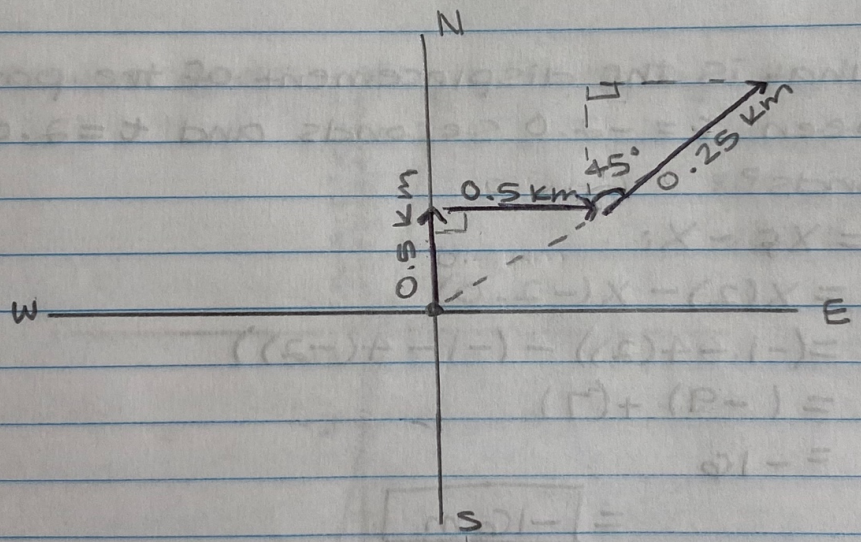


$\vec{X}_2 = 20\cos 45°\hat{i} + 20\sin 45°\hat{j}$

$\boxed{\vec{X}_2 = -14.1\hat{i} + 14.1\hat{j}\ m}$

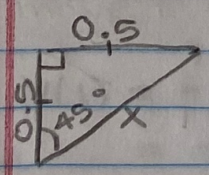
③ A person goes for a walk. They head 0.5 km to the North, and then 0.5 km to the East. Finally, they head North-East at an angle of 45 degrees with respect to the x-axis for 0.25 km.

(a) Draw a diagram of their trajectory. (East is x-axis, North is y-axis).



(b) What is the final location in x-y coordinates?

move 1



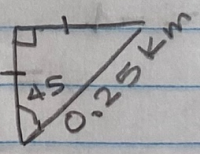
$x\sin 45° = 0.5$

$x = 0.71$

$\Delta X_1 = 0.5\hat{j}\ km$

$\Delta X_2 = 0.5\hat{i}\ km$

move 2



$0.25\cos 45$

≈ 0.18

$0.25\sin 45$

≈ 0.18

$\Delta X_3 = 0.18\hat{i} + 0.18\hat{j}\ km$

$\boxed{\vec{X}_f = 0.68\hat{i} + 0.68\hat{j}\ km}$

(c) what is the distance from the origin?

$\vec{x}_f = 0.68\hat{i} + 0.68\hat{j}$ km

$|\vec{x}_f| = \sqrt{(0.68)^2 + (0.68)^2}$

$\boxed{|\vec{x}_f| = 0.96 \text{ km}}$

4 MOTion Along a Straight line

① The position of a particle moving along the x-axis is given by $x(t) = -1.0 - 4.0t$ m.

(a) what is the displacement of the particle between $t = -2.0$ seconds and $t = 2.0$ seconds?

$\Delta x = x_f - x_i$

$= x(2) - x(-2.0)$

$= (-1 - 4(2)) - (-1 - 4(-2))$

$= (-9) + (7)$

$= -16$

$= \boxed{-16 \text{ m}}$

(b) what is the velocity?

$x(t) = -1.0 - 4.0t$ m * find the derivative.

$= -4$

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

(2) A particle moves along the x-axis according to $x(t) = -2t + 7t^2$.

(a) what is the average velocity between $t=0$ and $t=2$ seconds?

$t = 2$

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

$= -4 + 28$

$= 24$

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

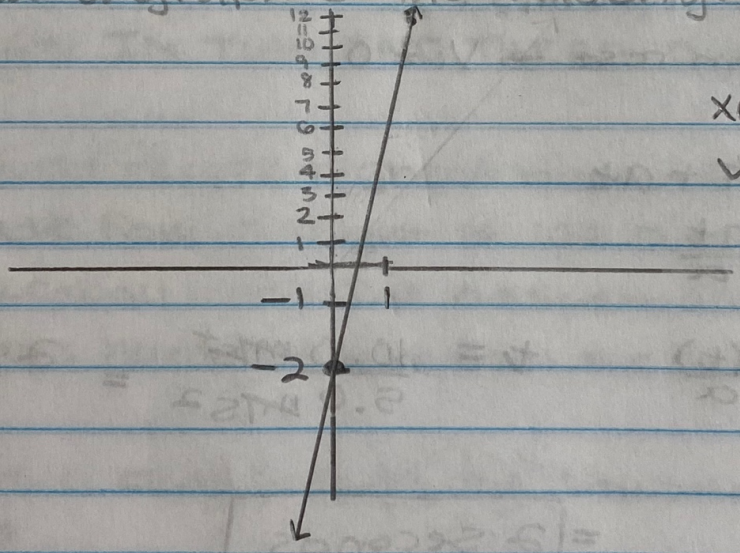
$= 0 + 0$

$= 0$

$24 - 0$

$= \boxed{24 \text{ m/s}}$

(b) Draw a graph of the velocity.



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

$v(t) = -2 + 14t$

(c) what is the instantaneous velocity at $t=1$ second?

$v(1) = -2 + 14(1)$

$= -2 + 14$

$= 12$

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

(d) What is the acceleration?

from the equation $v(t) = -2 + 14t$ ← velocity function, acceleration is the derivative.

The derivative of the function is 14.

acceleration = $14\ m/s^2$

(3) A sprinter has a constant acceleration of $5.0\ m/s^2$. Suppose she starts from rest.

(a) How long does it take her to reach her top speed of $10.0\ m/s$?

starts from rest → $V_i = 0$

$$V(t) = \cancel{V_i} + at$$

$$\frac{V(t)}{a} = \frac{at}{a}$$

$$t = \frac{V(t)}{a} \qquad t = \frac{10.0\ \cancel{m/s}}{5.0\ \cancel{m/s^2}} = 2s$$

$$= \boxed{2 \text{ seconds}}$$

(b) What is her displacement at that time?

$$X(t) = \frac{1}{2}at^2 + V_i t + \cancel{X_i}$$ ← initial position = 0 because she starts at rest

$$= \frac{1}{2}(5.0\ m/s^2)(2s)^2 + (10)(2)$$

$$= \frac{1}{2}(5.0\ m/\cancel{s^2})(4\cancel{s^2})$$

$$= \frac{1}{2}(20.0m)$$

$$= \boxed{10.0m}$$

(c) Suppose she is running the 100 meter sprint. If she continues at 10.0 m/s for the remainder of the race, what will be her total time?

$V = 10.0\ m/s$

$t = ?$

$X = 100m$

$X(t) = X_i + Vt$

$100 = 0 + (10.0)(t)$

$\frac{100}{10.0t} = \frac{10.0t}{10.0t}$

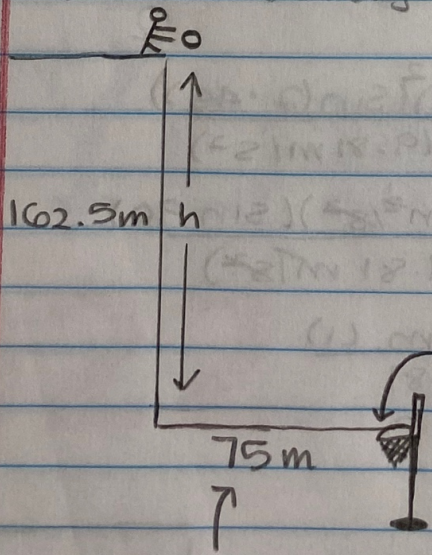
$t = 10$ seconds

$= \boxed{10 \text{ seconds}}$

5 MOTION IN TWO AND THREE DIMENSIONS

① The world record highest basketball shot was made from a height of 162.5 meters above the basketball hoop. The basketball hoop was placed 75 meters horizontally from the shooter.

(a) Draw a diagram of the situation.



(b) What is the horizontal velocity required to make the shot? That is, assume the shooter shoots the ball with no vertical velocity, only horizontal.

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

$y_i = 162.5\text{ m}$

distance $(x) = 75\text{ m}$

Y	X
$a_y = -9.8\text{ m/s}^2$	$a_x = 0$
$v_{iy} = 0$	$v_x = ?$
$d_y = -162.5\text{ m}$	$d_x = 75\text{ m}$

$t = ?$

horizontal velocity =

$$v_x = \frac{\Delta x}{\Delta t} = \frac{75\text{ m}}{5.76\text{ sec}} = 12.5$$

horizontal velocity = 12.5 m/s

solving for y time =

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

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

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

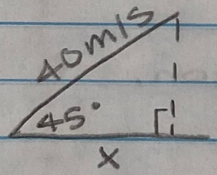
$$t = \sqrt{\frac{2d_y}{a_y}}$$

$$t = \sqrt{\frac{2(-162.5\text{ m})}{-9.8\text{ m/s}^2}}$$

≈ 5.76 or 6 sec

(2) A basketball is hit at a 45 degree angle with respect to the horizontal at 40 m/s.

(a) How far away does it land?



$$R = \frac{v_0^2 \sin(2\theta_0)}{g}$$

$$= \frac{(40\text{ m/s})^2 (\sin(2 \cdot 45))}{(9.81\text{ m/s}^2)}$$

$$= \frac{(1600\text{ m}^2/\cancel{\text{s}^2})(\sin 90)}{(9.81\text{ m}^1/\cancel{\text{s}^2})}$$

$$= \frac{1600\text{ m}\ (1)}{9.81}$$

$$\approx \boxed{163.1\text{ m}}$$

(b) How long is it in the air

$$T = \frac{2 v_0 \sin\theta}{g} = \frac{2 \cdot 40 \cdot \sin(45)}{9.81} \approx \boxed{5.77\text{ seconds}}$$

6 Forces

① Two children pull a third child on a snow saucer sled exerting forces $\vec{F_1}$ and $\vec{F_2}$. Find the acceleration of the system if the mass of the child and sled together is 49.0 kg. Note the direction of the frictional force is unspecified; it will be in the opposite direction of the sum of $\vec{F_1}$ and $\vec{F_2}$.

Total mass = 49.0kg

Sum of $\vec{F_1}$ and $\vec{F_2}$

push − friction

(10 N + 8N) − (7.5 N)

= 10.5 Net external force.

$$\vec{a} = \frac{10.5\,N}{49.0\,kg} = \boxed{0.21\ m/s^2}$$