

Physics 151,
Hw #3

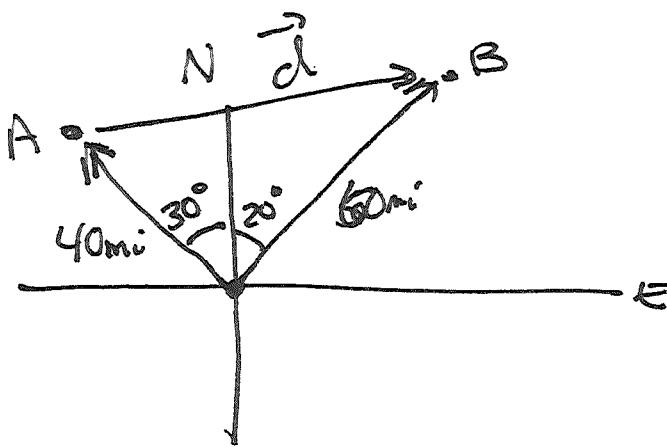
#1

Two ships : A goes 20 mph at 30° west of North
 B goes ~~30~~ mph at 20° east of North

How far apart after 2 hours?

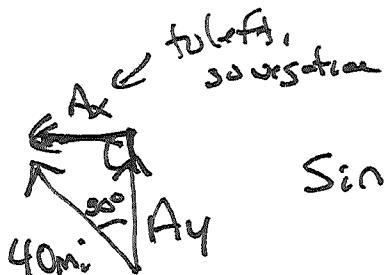
In 2 hours A travels a distance $d_A = 20 \text{ mph} (2 \text{ hours}) = 40 \text{ mi}$

B travels $d_B = \cancel{30} \text{ mph} (2 \text{ hours}) = \cancel{60} \text{ mi}$



\vec{d} 's magnitude will give us distance from A to B.

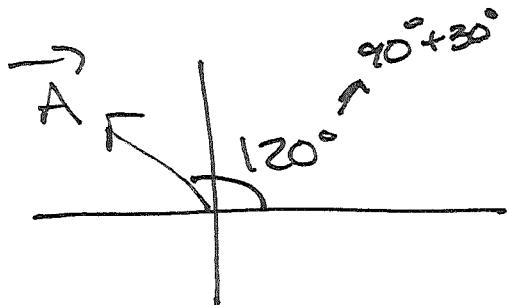
To find coordinates of A either
 Use a Non-standard Angle



$$\sin 30^\circ = \frac{Ax}{40 \text{ mi}} \Rightarrow Ax = 40 \text{ mi} \cdot \sin 30^\circ = 20 \text{ mi}$$

$$\cos 30^\circ = \frac{Ay}{40 \text{ mi}} \Rightarrow Ay = 40 \text{ mi} \cos 30^\circ = 34.64 \text{ mi}$$

You CAN ALSO just use standard Angle :

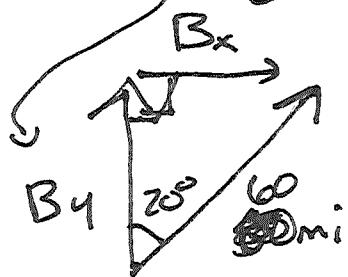


$$A = 40 \text{ mi}$$

$$Ax = 40 \text{ mi} \cos 120^\circ = -20 \text{ mi}$$

$$Ay = 40 \text{ mi} \sin 120^\circ = 34.64 \text{ mi}$$

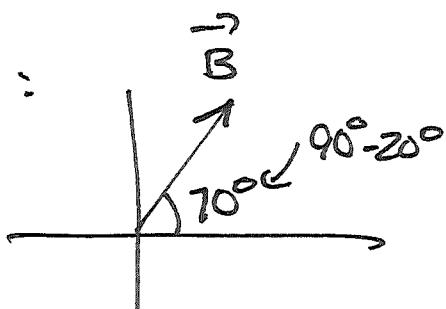
For B: Both positions



$$\sin 20^\circ = \frac{B_x}{60 \text{ mi}} \Rightarrow B_x = 60 \text{ mi} \sin 20^\circ = \cancel{+10.41 \text{ mi}} \\ 20.5 \text{ mi}$$

$$\cos 20^\circ = \frac{B_y}{60 \text{ mi}} \Rightarrow B_y = 60 \text{ mi} \cos 20^\circ = \cancel{-56.382 \text{ mi}} \\ = 56.382 \text{ mi}$$

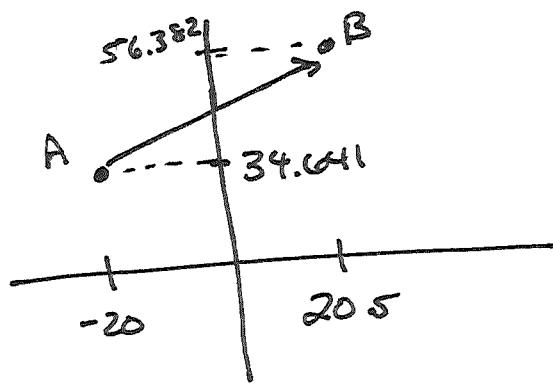
OR :



$$B_x = 60 \text{ mi} \cos 70^\circ = 20.5 \text{ mi}$$

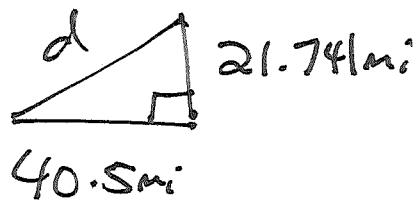
$$B_y = 60 \text{ mi} \sin 70^\circ = \cancel{56.382 \text{ mi}} \\ = 56.382 \text{ mi}$$

To get From A to B:



$$\Delta x = 20.5 \text{ mi} - (-20 \text{ mi}) = 20.5 \text{ mi} + 20 \text{ mi} = 40.5 \text{ mi}$$

$$\Delta y = 56.382 \text{ mi} - 34.641 \text{ mi} = 21.741 \text{ mi}$$



~~21.74~~ ~~40.5~~

$$d = \sqrt{(40.5 \text{ mi})^2 + (21.74 \text{ mi})^2}$$

$$= \sqrt{2111.75 \text{ mi}^2} = 45.953 \text{ mi}$$

$$= \underline{\underline{46 \text{ mi}}}$$

PHYSICS 151

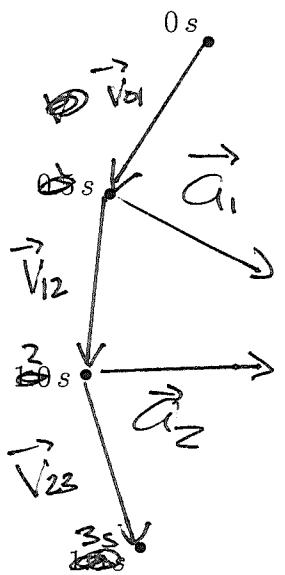
HOMEWORK ASSIGNMENT #3

DUE JUNE 20

#1 Ships *A* and *B* leave port together. For the next two hours, ship *A* travels at 20 mph in a direction 30° west of north, while ship *B* travels 20° east of north at 30 m/s. How far apart are the two ships two hours after they depart? (Assume they both have constant velocities.)

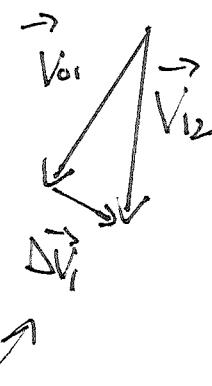
#2 Shown is the motion diagram for a car traveling along a road with constant speed.

- On the picture, draw the car's three average velocity vectors, \vec{v}_{01} , \vec{v}_{12} , \vec{v}_{23} . (\vec{v}_{01} is the average velocity between 0 s and 1 s, and so on.)
- Beside or below the picture, use your preferred method to draw the two change in velocity vectors, $\Delta\vec{v}_1 = \vec{v}_{12} - \vec{v}_{01}$ and $\Delta\vec{v}_2 = \vec{v}_{23} - \vec{v}_{12}$.
- At points 1 and 2 on your motion diagram, draw the car's average acceleration vectors.
- If the car is traveling with a constant speed, why aren't the acceleration vectors zero?

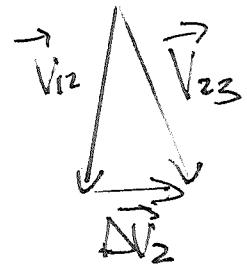


d.) Car is changing direction so is accelerating

Have to REDRAW to
find $\Delta\vec{v}$

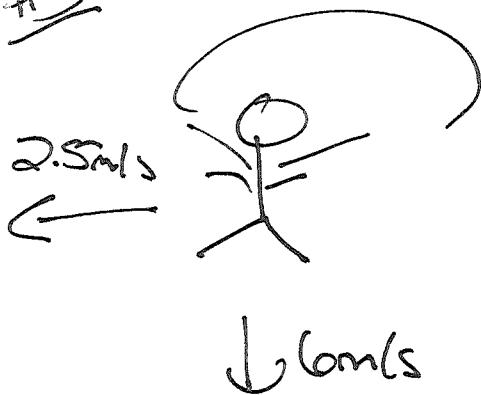


\vec{a}_1 in
same direction



\vec{a}_2 in
same direction

#3



SKYDIVER FALLING WITH
CONSTANT SPEED OF 6m/s.

WIND PUSHES HIM TO WEST
AT 2.5m/s

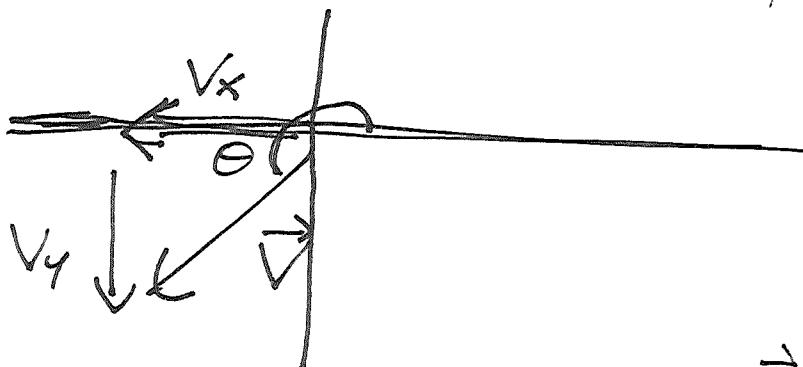
a) What ^{standard} angle does he fall at?

Parachutist has both velocities simultaneously,
since they are 90° to each other, they

become the components of his velocity.

To Left AND Down \Rightarrow Both Negative

$$\Rightarrow V_x = -2.5 \text{ m/s}, V_y = -6 \text{ m/s} \Rightarrow 3^{\text{RD}} \text{ Quadrant}$$



3^{RD} QUADRANT gets
angle wrong by 180°

$$\Rightarrow \theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) + 180^\circ$$

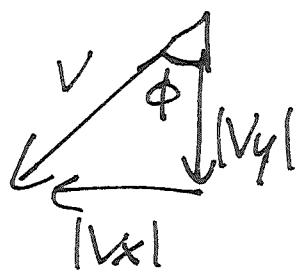
$$= \tan^{-1}\left(\frac{-6}{-2.5}\right) + (80^\circ)$$

$$= 67.38^\circ + 180^\circ = 247.38^\circ \\ = 250^\circ$$

b) What Angle from Vertical?

Now, we just DRAW A triangle AND make everything positive

From vertical \Rightarrow Angle from V_y

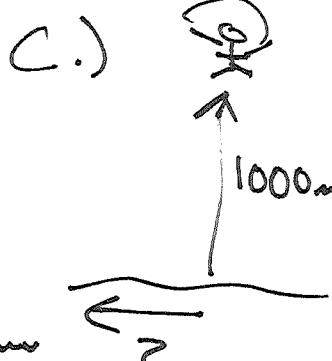


$$\tan \phi = \frac{\text{opp}}{\text{adj}} = \frac{|V_x|}{|V_y|}$$

$$\Rightarrow \tan \phi = \frac{2.5}{6} \Rightarrow \phi = \tan^{-1}\left(\frac{2.5}{6}\right)$$

$$= 22.62^\circ$$

$$= \underline{\underline{23^\circ}}$$



How far does he travel to west?

No Acceleration in x or y (we're told the speeds are constant.)

$$\Rightarrow X = X_0 + (V_0)_x t \quad y = y_0 + (V_0)_y t$$

$$(V_0)_x = -2.5 \text{ m/s}, (V_0)_y = -6 \text{ m/s}$$

$$X_0 = 0, \quad \cancel{x}$$

$$y_0 = 1000 \text{ m}, y = 0$$

$\left. \begin{array}{l} \text{we're just being more} \\ \text{careful with our labeling} \\ \text{since there's no acceleration} \\ V_x = (V_0)_x \text{ and } (V_0)_y = (V_0)_y \end{array} \right\}$

Unknown: $\Delta t = ?$, $x = ?$ \swarrow FINAL ANSWER

It's Fairly straightforward here, we'll use $y = y_0 + (v_0)y \Delta t$ to find Δt and then solve for x .

$$y = y_0 + (v_0)y \Delta t \Rightarrow 0 = 1000m - 6m/s \Delta t$$

$$\Rightarrow \Delta t = \frac{1000m}{6m/s} = 166.66\dots s$$

$$x = x_0 + (v_0)x \Delta t \Rightarrow x = 0 - 2.5m/s (166.66\dots s)$$

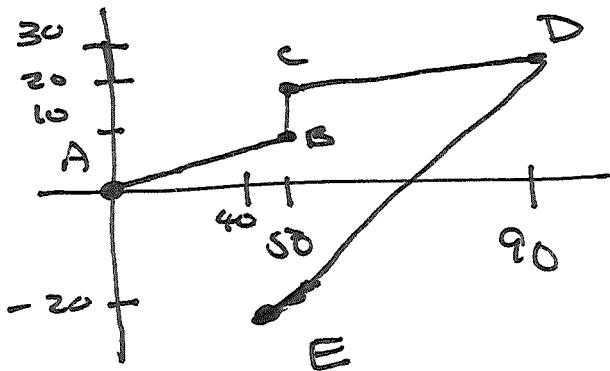
$$\Rightarrow x = -416.66\dots m$$

$$\Rightarrow x = -417m \text{ or } 417m \text{ to west.}$$

#4

E Coli with Constant Speed of 25 $\mu\text{m/s}$

Follows Path :



For each segment
Find x -any y -Components
of displacement and its
velocity.

Displacement: \vec{dr} has Components Δx and Δy

Since speed is constant Components of velocity are

$$V_x = \frac{\Delta x}{\Delta t} \quad \text{and} \quad V_y = \frac{\Delta y}{\Delta t}$$

For AB: $\Delta x = 50 \mu\text{m}$, $\Delta y = 10 \mu\text{m}$

To find Δt , use $V = \frac{\text{distance}}{\Delta t} \Rightarrow \Delta t = \frac{\text{distance}}{V} = \frac{d}{V}$

\uparrow
Speed

distance is straight-line from A to B (or magnitude of \vec{dr} if you prefer) $\Rightarrow d_{AB} = \sqrt{(50 \mu\text{m})^2 + (10 \mu\text{m})^2} = \sqrt{2600 \mu\text{m}^2} = 50.99 \mu\text{m}$

$$\text{So } \Delta t_{AB} = \frac{50.99\mu\text{m}}{25\mu\text{m/s}} = 2.0396\text{s}$$

$$\therefore V_x = \frac{50\mu\text{m}}{2.0396\text{s}} = 24.5\mu\text{m/s} \quad V_y = \frac{10\mu\text{m}}{2.0396\text{s}} = 4.9\mu\text{m/s}$$

(Notice that $\sqrt{V_x^2 + V_y^2} = 25\mu\text{m/s}$ as it should)

$$\text{For BC: } \Delta X = 0, \Delta Y = 20\mu\text{m} - 10\mu\text{m} = 10\mu\text{m}$$

$$\text{We'll Need it later on: } \Delta t_{BC} = \frac{10\mu\text{m}}{25\mu\text{m/s}} = 0.4\text{s}$$

Not really necessary to find Δt_{BC} to get V_x AND V_y

$$\text{Since } \Delta X = 0 \Rightarrow V_x = 0 \text{ so } V_y = 25\mu\text{m/s}$$

~~to find~~

A vector with NO
x-Component Must
have ~~an~~ y-Component
EQUAL to its magnitude.

$$CD: \Delta X = 90\mu\text{m} - 50\mu\text{m} = 40\mu\text{m}$$

$$\Delta Y = 30\mu\text{m} - 20\mu\text{m} = 10\mu\text{m}$$

$$d_{CD} = \sqrt{(40\mu m)^2 + (10\mu m)^2} = \sqrt{1700\mu m^2} = 41.23\mu m$$

$$\text{so } \Delta t_{CD} = \frac{41.23\mu m}{25\mu m/s} = 1.649 s$$

$$V_x = \frac{40\mu m}{1.649 s} = 24.3\mu m/s \quad V_y = \frac{10\mu m}{1.649 s} = 6.1\mu m/s$$

~~DE~~: $\Delta x = 40\mu m - 90\mu m = -50\mu m, \Delta y = -20\mu m - 30\mu m$

\uparrow
goes left

$= -50\mu m$
 \uparrow
goes downward

$$d_{DE} = \sqrt{(-50\mu m)^2 + (-50\mu m)^2} = \sqrt{2500\mu m^2 + 2500\mu m^2} = \sqrt{5000\mu m^2} = 70.71\mu m$$

$$\Delta t_{DE} = \frac{70.71\mu m}{25\mu m/s} = 2.828 s$$

$$V_x = \frac{-50\mu m}{2.828 s} = -17.7\mu m/s \quad V_y = \frac{-50\mu m}{2.828 s} = -17.7\mu m/s$$

In Summary:

	$\Delta x^{(\mu m)}$	$\Delta y^{(\mu m)}$	$V_x^{(\mu m/s)}$	$V_y^{(\mu m/s)}$
AB	50	10	24.5	4.9
BC	0	10	0	25
CD	40	10	24.3	6.1
DE	-50	-50	-17.7	-17.7

b. Calculate total distance and magnitude of net displacement.

Total distance is the sum of individual distances \Rightarrow

$$d_{\text{TOTAL}} = d_{AB} + d_{BC} + d_{CD} + d_{DE} = 50.99 \mu\text{m} + 16 \mu\text{m} + 41.23 \mu\text{m} + 70.71 \mu\text{m}$$

$$\Rightarrow d_{\text{TOTAL}} = \underline{\underline{172.93 \mu\text{m}}} = 173 \mu\text{m}$$

Displacement doesn't care about what happens in between.

$$\text{For E: } X = 40 \mu\text{m}, Y = -20 \mu\text{m} \quad \text{For A: } X = 0, Y = 0$$

$$\text{So } \Delta X_{\text{TOTAL}} = 40 \mu\text{m} - 0 = 40 \mu\text{m} \quad \Delta Y_{\text{TOTAL}} = -20 \mu\text{m} - 0 = -20 \mu\text{m}$$

$$\text{So } \Delta r_{\text{TOTAL}} = \sqrt{(40 \mu\text{m})^2 + (-20 \mu\text{m})^2} = \sqrt{1600 \mu\text{m}^2 + 400 \mu\text{m}^2} = \sqrt{2000 \mu\text{m}^2}$$

$$\underline{\underline{\Delta r_{\text{TOTAL}} = 44.7 \mu\text{m}}}$$

c) Magnitude and direction of \vec{V}_{AV} for entire trip.

$$\vec{V}_{AV} = \frac{\vec{D}_{\text{TOTAL}}}{D_{\text{total}}} \quad \text{We already know } D_{\text{TOTAL}} = 44.7 \mu\text{m}$$

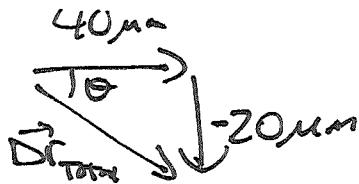
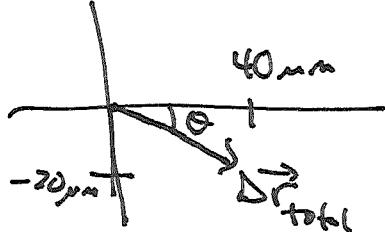
$D_{\text{total}} = D_{AB} + D_{BC} + D_{CD} + D_{DE}$ which we've already calculated!

$$D_{\text{total}} = 2.0396s + 0.4s + 1.649s + 2.828s = 6.9166s \\ = 6.92s$$

$$(\text{You could also use } D_{\text{total}} = \frac{d_{\text{TOTAL}}}{v} = \frac{173 \mu\text{m}}{25 \mu\text{m/s}})$$

$$\text{So } V_{AV} = \frac{44.7 \mu\text{m}}{6.92s} = \underline{\underline{6.46 \mu\text{m/s}}} \quad \leftarrow V_{AV} \text{ is smaller than } 25 \mu\text{m/s because when going left or downward, } V_x \text{ and } V_y \text{ are negative.}$$

\vec{V}_{AV} is same direction as \vec{D}_{TOTAL}

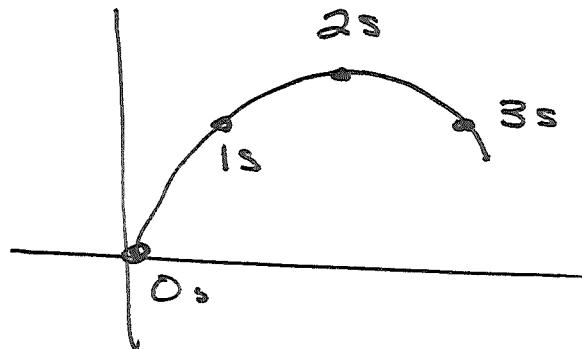


4th Quadrant so calc. ok

$$\Theta = \tan^{-1}\left(\frac{-20 \mu\text{m}}{40 \mu\text{m}}\right) = \tan^{-1}(0.5) \\ \Rightarrow \Theta = \underline{\underline{-26.6^\circ}}$$

HS

Planet Exidor



At $t = 1s$, $V_x = 2.8 \text{ m/s}$, $V_y = 3 \text{ m/s}$

a) Determine x and y-components of velocity
at $0s, 2s, 3s$

V_x is easy. On any planet, projectiles have
no acceleration in x-direction \Rightarrow no change in V_x
 $\Rightarrow V_x = 2.8 \text{ m/s}$

To get V_y , we use $V_y = (V_0)_y - g \Delta t \Rightarrow$ same
change in V_y for $\Delta t = 1s$ (i.e. $\Delta V_y = -g \Delta t$)

Notice that ~~at~~ $2s$, is the top ~~of~~ of the trajectory
 $\Rightarrow V_y = 0$ so for $\Delta t = 2s - 1s = 1s$ $\Delta V_y = 0 - 3 \text{ m/s} = -3 \text{ m/s}$

Here $\Delta V_y = (V_y)_{2s} - (V_y)_{1s}$

\uparrow
at 2s

$$\text{so } \Delta V_y = (V_y)_{1s} - (V_y)_{0s} = -3 \text{ m/s too}$$

$$\therefore -3 \text{ m/s} = 3 \text{ m/s} - (V_y)_{0s} \Rightarrow (V_y)_{0s} = 3 \text{ m/s} + 3 \text{ m/s} \\ = 6 \text{ m/s}$$

in the same way $(V_y)_{3s} = -3 \text{ m/s}$ since ~~0~~
~~(V_y)~~ $(V_y)_{2s} = 0$

	t	V_x	V_y
0	2.8 m/s	6 m/s	
1s	2.8 m/s	3 m/s	
2s	2.8 m/s	0	
3s	2.8 m/s	$\frac{8}{8} - 3 \text{ m/s}$	

b) what is g ?

We kind of already found this ~~but~~. Since $\Delta y = g \Delta t$

$$\Rightarrow g = -\frac{\Delta y}{\Delta t} = \underline{\underline{-\frac{(-3m/s)}{1s} + 3m/s^2}}$$

c) At what angle was it launched? \Rightarrow use $t = 0$ values

$$(V_0)_x = 2.8m/s, \quad (V_0)_y = 6m/s$$

$$\theta = \tan^{-1}\left(\frac{(V_0)_y}{(V_0)_x}\right) \cancel{=} = \tan^{-1}\left(\frac{6m/s}{2.8m/s}\right)$$

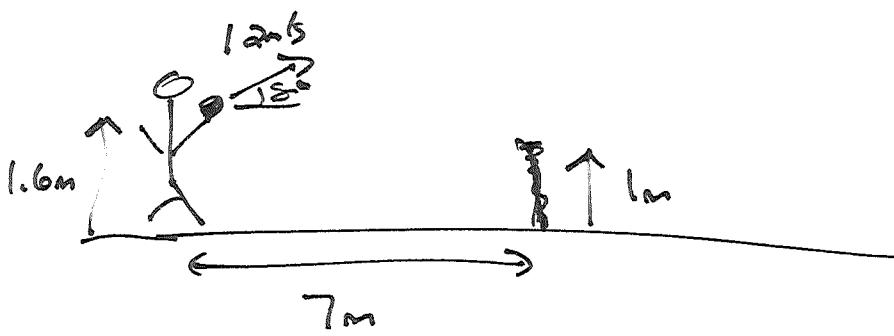
$$\cancel{\Rightarrow \theta = 38^\circ}$$

$$\theta = \tan^{-1}(2.142857) = 64.98^\circ$$

$$= 65^\circ$$

#6

Tennis player hits ball 1.6m above ground with speed of 12m/s at 8° . Net is 1m horizontal and 1m high. Does ball clear net?



$$\text{Known: } x_0 = 0$$

$$y_0 = 1.6\text{m}$$

$$\vec{V}_0 = 12\text{m/s at } 8^\circ$$

$$\Rightarrow (V_0)_x = 12\text{m/s} \cos 8^\circ = 11.883\text{m/s}$$

$$(V_0)_y = 12\text{m/s} \sin 8^\circ = 1.67\text{m/s}$$

Probably the easiest way to do this problem is to let $X = 7\text{m}$ and solve for y . If y is greater than 1m the ball clears the net.

$$y = y_0 + (V_0)_y t - \frac{1}{2} g t^2 \Rightarrow \text{Need } \Delta t$$

Use $X = x_0 + (V_0)_x \Delta t$ to find it

$$7\text{m} = 0 + 11.883\text{m/s} \Delta t \Rightarrow \Delta t = \frac{7\text{m}}{11.883\text{m/s}} = 0.589\text{s}$$

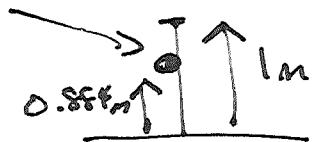
$$y = y_0 + (V_0 y) \Delta t - \frac{1}{2} g \Delta t^2$$

$$\Rightarrow y = 1.6m + (1.67m/s)(0.589s) - \frac{1}{2} (9.8m/s^2)(0.589s)^2$$

$$\Rightarrow y = 1.6m + 0.98363m = 1.6999m$$

$$\Rightarrow y = 0.884m \quad \leftarrow \text{Does not clear net}$$

Ball
hits
here



So it misses the top by

$$1m - 0.884m = 0.116m$$

$$= 0.12m = \underline{\underline{12cm}}$$

#79

Car Accelerating to Right.

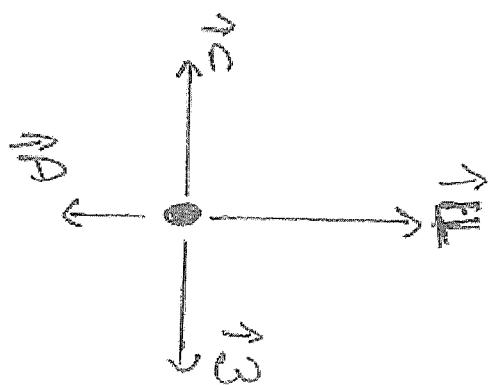


↑
Ground \Rightarrow Normal Force
And Forward Push.
→

Long-Range = Weight of Car

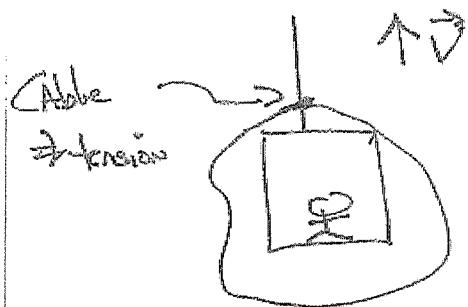
This is a frictional force. ~~since~~ When the wheels turn due to the motor, they push back on the ground.
↳ This can't happen without friction

Car Accelerating to Right \Rightarrow Forward Frictional Push longer than Drag. No Motion/Acceleration in $y \Rightarrow$ Normal & Weight have Equal Length.



#7b

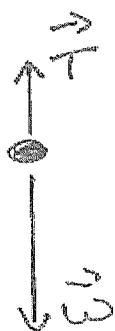
Ascending ELEVATOR



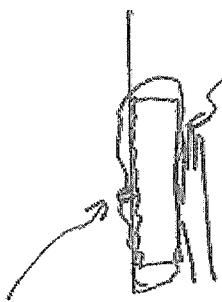
Tension is the only Contact Force
(Since Drag wasn't given as a choice on masking)

Long-range: Weight

Elevator is slowing down \Rightarrow Acceleration is opposite to velocity \Rightarrow Downward \vec{a} \Rightarrow Downward net force.
So \vec{w} must be longer than \vec{T} .



24



Hand Touches

Picture \Rightarrow Force to left, \vec{P} ← "Push"
Makelis calls this a pressure
force

Wall
touches

Picture

\Rightarrow Normal force

and friction (see
Discussion Below)

Long-Range: \vec{G} Down

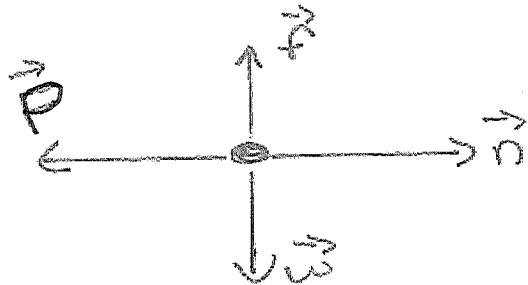
Normal force: The wall is VERTICAL \Rightarrow so NORMAL force is HORIZONTAL, i.e., to the Right.

Friction: With No friction, the picture would slide Downwards.

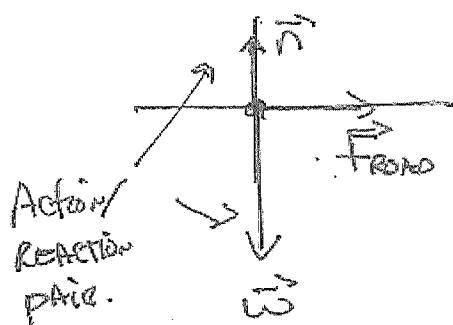
Friction Prevents this by pointing Upwards.

Picture not Accelerating $\Rightarrow \sum \vec{F} = 0 \Rightarrow \vec{P} + \vec{n}$ are same size

\vec{f} AND \vec{w} are SAME size.



HS



Student f.b.d. for
Car traveling at Constant
Speed on a level ROAD.

What are mistakes?

Car moving at constant speed \Rightarrow No Acceleration $\Rightarrow \sum F = 0$

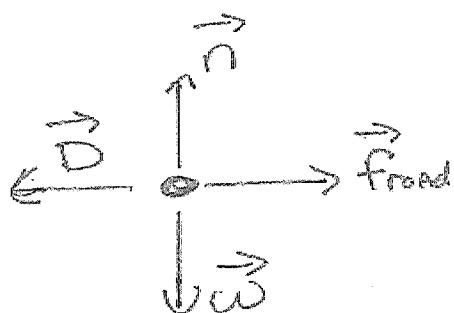
so ① \vec{n} and \vec{w} must have same size

then there must be a force opposite to f_{road} to cancel it, so ② Must be a drag force to left, $-f_{drag}$

Finally \vec{n} and \vec{w} applied to same object, so

③ \vec{n} and \vec{w} are not Action/Reaction PAIR

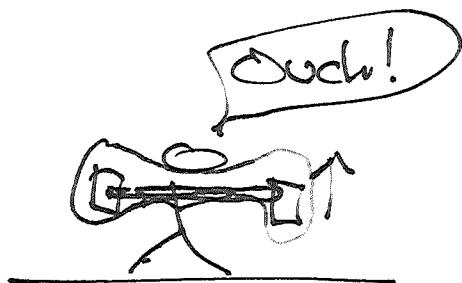
Correct fbd



#9

WEIGHTLIFTER

a.)



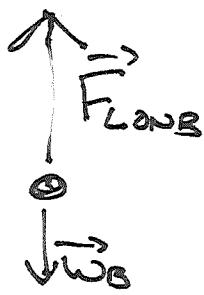
Forces on Barbell:

Upward force on Barbell

From weightlifter that accelerates it upwards,
call that \vec{F}_{LNB}
 \downarrow
Lifter \rightarrow Barbell

The only other force is the long-range gravity

\vec{W}_B Down



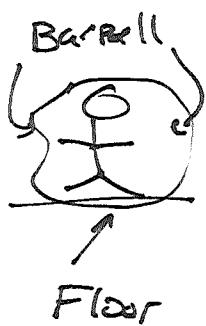
F_{long} is larger than W_B since it's accelerating up.

b.) REACTIONS? If weightlifter pushes up on Barbell, it pushes down on him $\Rightarrow \vec{F}_{\text{BarL}}$

Earth pulls down on Barbell \Rightarrow Barbell pulls up on Earth.

C) Weightlifter is NOT Accelerating. His center stays at rest. (when replaced by a particle that particle is stationary)

d.)

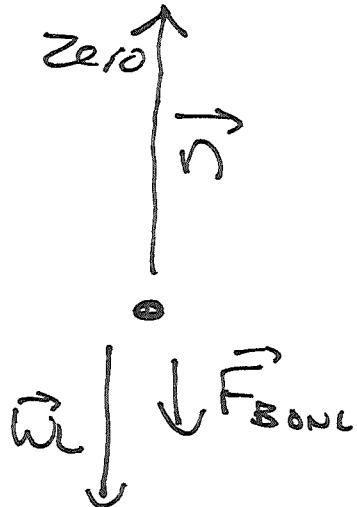


Forces on weightlifter : $\vec{F}_{\text{Barbell Down}}$

• Normal force from floor. \vec{n} up

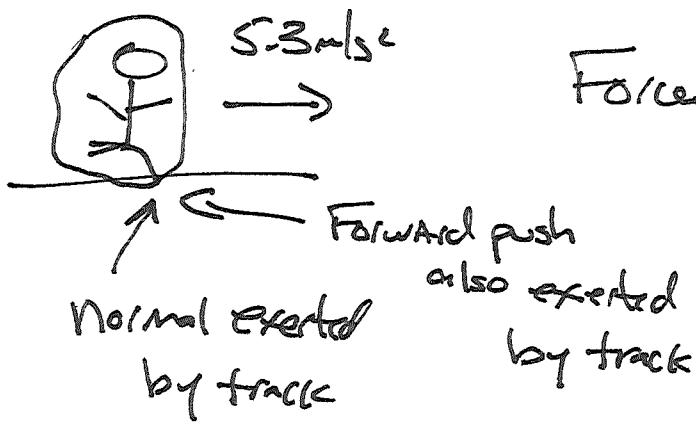
Long-range: Weight of weightlifter
 \vec{W}_L Down.

Since not accelerating these forces must add to zero

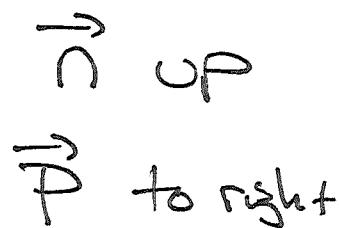


$$n = W_L + F_{\text{Barbell}}$$

#10 $M = 85\text{kg}$



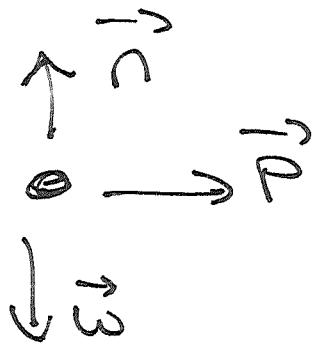
Forces on Sprinter:



we could also call this
 \vec{f}_t since it's a frictional
force

Also have gravity \vec{w} Down

$$w = Mg = (85\text{kg})(9.8\text{m/s}^2) = 833\text{N}$$



What part (a.) is telling us to do is to consider \vec{N} and \vec{P} to be the components of a Total "track" force, \vec{F}_t

We need to find the magnitude and direction of \vec{F}_t

The only Acceleration is to the right \Rightarrow

~~a_x~~ $a_x = 5.3\text{m/s}^2, a_y = 0$

$$\sum F_x = m a_x \Rightarrow \cancel{A_x} + P_x + \cancel{W_x} = m a_x$$

$$\Rightarrow 0 + P + 0 = m a_x$$

↑
a force to the
Right only has an
x-Component

$$\Rightarrow P = (85 \text{ kg})(5.3 \text{ m/s}^2) = 450.5 \text{ N}$$

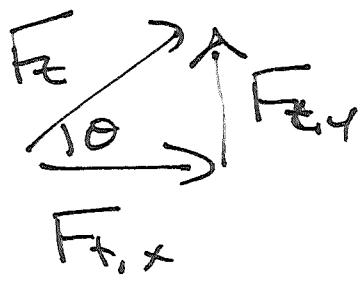
$$\sum F_y = m a_y \Rightarrow N_y + \cancel{P_y} + \cancel{W_y} = 0$$

$$+n + 0 - w = 0$$

↑ T
a force A downward force
up only only has -
has + y-component

$$\Rightarrow n = w \Rightarrow n = 833 \text{ N}$$

$$\text{So } F_{t,x} = 450.5N \quad F_{t,y} = 833N$$



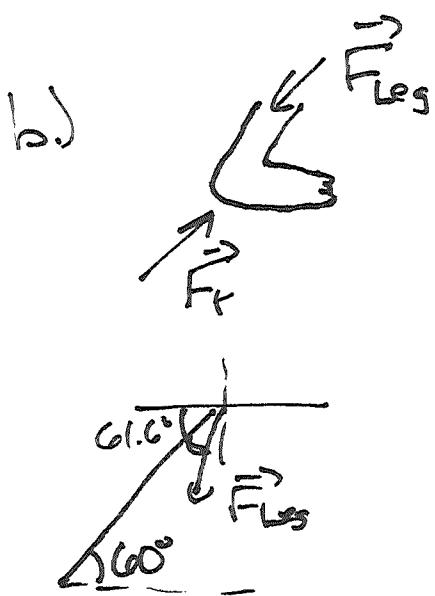
$$\text{so } F_t = \sqrt{F_{t,x}^2 + F_{t,y}^2}$$

$$= \sqrt{(450.5N)^2 + (833N)^2}$$

$$\therefore F_t = \underline{\underline{947N}}$$

1st QUADRANT so } $\theta = \tan^{-1} \left(\frac{F_{t,y}}{F_{t,x}} \right)$
 Calculator find:

$$= \tan^{-1} \left(\frac{833N}{450.5N} \right) = 61.6^\circ$$

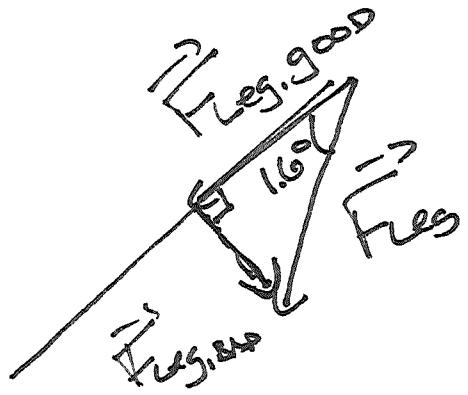


$$F_{\text{leg}} = 947N \text{ at } \underline{\underline{61.6^\circ}}$$

FIND Components of \vec{F}_{leg} parallel & perpendicular to leg at 60°

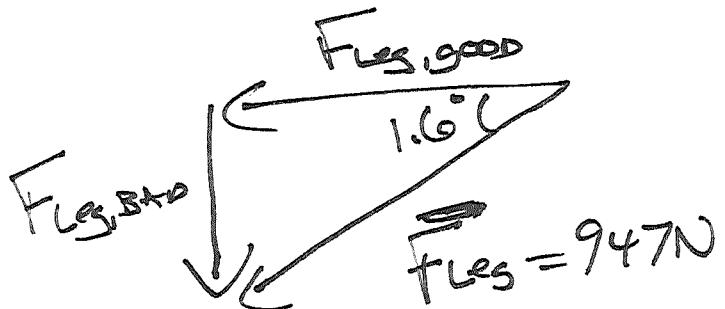
$$\text{so } \vec{F}_{\text{leg}} \text{ is } 61.6^\circ - 60^\circ = 1.6^\circ$$

From Leg Bone



Component at
 90° to Bone
 CAN cause
 Dislocation

turn Side way's



$$\text{so } \sin 1.6^\circ = \frac{F_{\text{leg}, \text{BAD}}}{F_{\text{leg}}} = \frac{F_{\text{leg}, \text{BAD}}}{947\text{N}}$$

$$\Rightarrow F_{\text{leg}, \text{BAD}} = 947\text{N} \sin 1.6^\circ = 26.4\text{N}$$

$$\cos 1.6^\circ = \frac{F_{\text{leg}, \text{good}}}{F_{\text{leg}}} = \frac{F_{\text{leg}, \text{good}}}{947\text{N}}$$

$$F_{\text{leg}, \text{good}} = 947\text{N} \cos 1.6^\circ = 946.63\text{N}$$

g

So mostly good