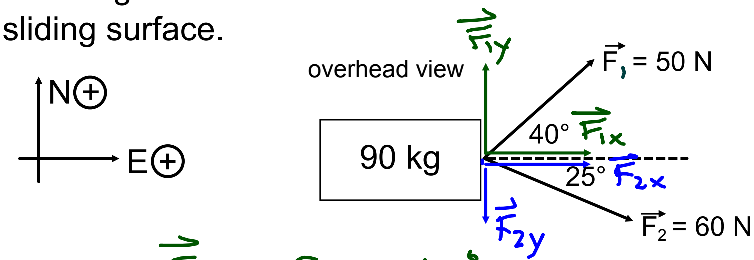
3.4 FBDs in 2-D with Component Vectors

ex. A 70 kg person sits on a 20 kg sled. Two people pull the sled with the following forces. Determine the acceleration of the sled assuming a frictionless sliding surface.



$\vec{F}_{2x} = 60\cos(25°)$
$= 54.4$ N

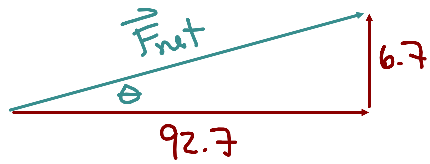
$\vec{F}_{2y} = 60\sin(-25°)$
$= -25.4$ N

$\vec{F}_{1x} = 50\cos 40°$
$= 38.3$ N

$\vec{F}_{1y} = 50\sin 40°$
$= 32.1$ N

$\vec{F}_{net\,y} = \vec{F}_{1y} + \vec{F}_{2y}$
$= 32.1 + (-25.4)$
$= 6.7$ N [N]

$\vec{F}_{net\,x} = \vec{F}_{1x} + \vec{F}_{2x}$
$= 38.3 + 54.4$
$= 92.7$ N [E]



Acceleration requires magnitude AND direction!!

$\tan\theta = \frac{6.7}{92.7}$

$\theta \doteq 4°$

$|\vec{F}_{net}|^2 = 6.7^2 + 92.7^2$ ← pythagoras

$|\vec{F}_{net}| = 93$ N

$\therefore \vec{F}_{net} = 93$ N [E 4° N]

total mass = 70 kg + 20 kg
= 90 kg

$\therefore \vec{a} = \frac{\vec{F}_{net}}{m}$

$= \frac{93 \text{ N}}{90 \text{ kg}}$

$\vec{a} = 1$ m/s² [E 4° N]

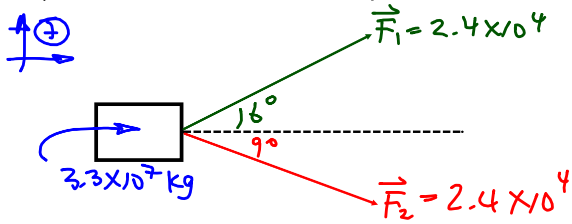
ex. Two tugboats are towing a tanker of mass 3.30×10^7 kg. If one is pulling at 2.40×10^4 N [E 16° N] and the other is pulling at 2.40×10^4 N [E 9° S],

a) calculate the acceleration of the tanker assuming no resistance

b) If the tanker has a resistive force of 5.60×10^3 N, find the acceleration

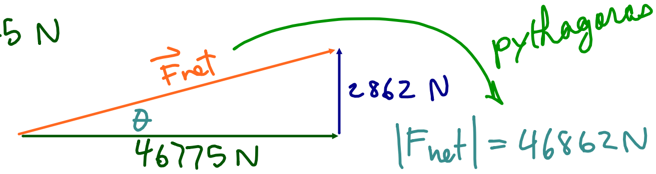
c) find the speed reached in part b) after 2 minutes in km/h

d) Calculate the distance required to reach a speed of 5k/h



X: $\vec{F}_{1x} = 2.4 \times 10^4 \cos 16$
$= 2.307 \times 10^4$ N
$\vec{F}_{2x} = 2.4 \times 10^4 \cos(9°)$
$= 2.370 \times 10^4$ N
$\vec{F}_{netx} = \vec{F}_{1x} + \vec{F}_{2x}$
$= 46775$ N

Y: $F_{1y} = 2.4 \times 10^4 \sin 16°$
$= 0.6615 \times 10^4$ N
$F_{2y} = 2.4 \times 10^4 \sin(-9°)$
$= -0.3754 \times 10^4$ N
$\vec{F}_{net_y} = 2862$ N



$\tan\theta = \frac{2862}{46775}$

$\theta = 3.5°$

$|F_{net}| = 46862$ N

$\vec{F}_{net} = 46862$ N [E 3.5° N] $\Rightarrow \vec{a} = \frac{F}{m} = \frac{46862}{3.3 \times 10^7}$

$\vec{a} = 0.00142$ m/s² [E 3.5° N]

b) $\vec{F}_{resistance}$ ← • → $\vec{F}_{tug}$

$\vec{F}_{net} = 46862$ N $- 5600$ N
$= 41262$ N [E 3.5° N] $\Rightarrow \vec{a} = 0.00125$ m/s² [E 3.5° N]

practice: photocopy #48, 49, 50

c) 2 min = 120 s

$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$ (starts from rest)

$\vec{V}_2 = \vec{a}\Delta t$
$= (0.00125\ m/s^2)(120\ s)$
$= 0.15$ m/s × 3.6

$\vec{V}_2 = 0.54$ km/h [E 3.5° N]

d) $\vec{V}_2^{\,2} = \vec{V}_1^{\,2} + 2\vec{a}\Delta d$ ($\vec{V}_1 = 0$)

but $\vec{V}_2 = 5$ km/h
$= 1.389$ m/s

$\Delta d = \frac{\vec{V}_2^{\,2}}{2a}$
$= \frac{(1.389)^2}{2(0.00125)}$

$\Delta d = 772$ m