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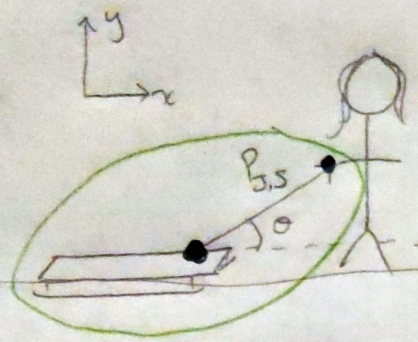
FORCES WORKSHEET:

written explicitly in prob. statement

(1) Start with sketch



Given:

$m = 15\,kg$ $P_{J,S} = 55N$

$\theta = 35°$

$\mu = 0.3$

Unknown: $\vec{a}$?

IMPLIED:

told sled moves horizontally

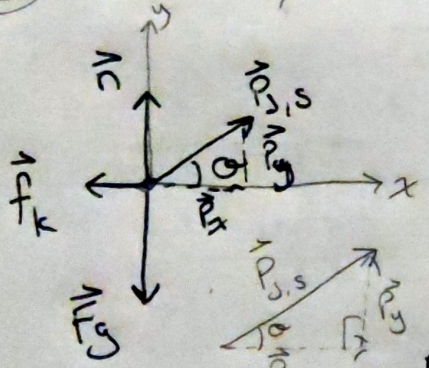
- $g = -9.8\ m/s^2$ (constant, on Earth) → $a_y = 0\ m/s^2$

TIPS FOR SKETCHES!

- make them big!
- label your coordinate system
- circle the system we're focusing on for the problem
  - mark points of contact
- write down given information
  - note variable to find, unknown to solve

ASSESS! think about situation of system, what to expect, what makes sense

(2) FREE BODY DIAGRAM (FBD)



what else will we need to know to find unknown..?

ΣF_x	ΣF_y
$-\vec{f}_k = -\mu\vec{n}$	$-\vec{F}_g = -m \cdot g$
$\vec{P}_x = \vec{P}_{J,S}\cos\theta$	$\vec{n} = \ldots ?$
	$\vec{P}_y = \vec{P}_{J,S}\sin\theta$
net: $\vec{P}_x - \vec{f}_k$	$\vec{P}_y + \vec{n} - \vec{F}_g$

Σ: Sigma, means to sum (kinda like ... net)

FBD tips:

- draw force vectors appox. to scale... if you don't know magnitude, think before drawing!
- make force table

(3) MATH ⇒ ALGEBRA FIRST, ALWAYS! (trust me, it'll be much easier!)

$\vec{F}_{net} = m\vec{a}$ in component form...

$F_{net,x} = m a_x$

$\vec{P}_x - \vec{f}_k = m a_x$

$\rightarrow \vec{a}_x = \dfrac{\vec{P}_x - \vec{f}_k}{m} \Rightarrow \boxed{\vec{a}_x = \dfrac{\vec{P}\cos\theta - \mu\vec{n}}{m}}$

$F_{net,y} = m a_y$

Use that $a_y = 0$ to find $\vec{n}$

$\vec{P}_y + \vec{n} - \vec{F}_g = 0$ (m) 0

$\rightarrow \boxed{\vec{n} = \vec{F}_g - \vec{P}_y}$ ← last piece of puzzle, now we can find $\vec{a}_x$

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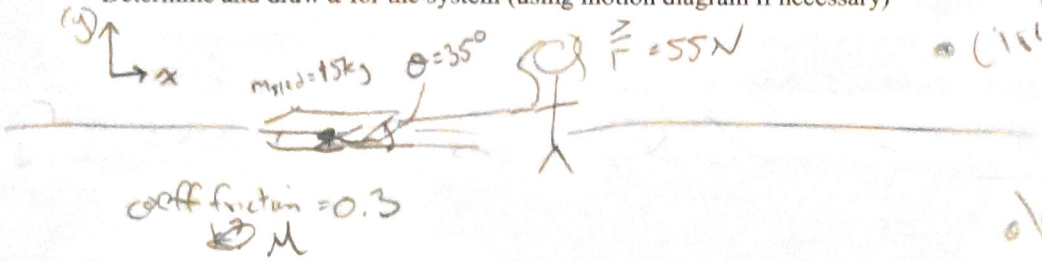
Forces Worksheet

Problem Statement

Jane is pulling a 15 kg sled along a horizontal snow-covered sidewalk by a rope at an angle above the horizontal of 35° with a force of 55 N. The coefficient of kinetic friction between the sled and the snow is 0.3. What is the acceleration of the sled?

Sketch

- Identify "the system" in your sketch by circling the object(s) of interest
- Establish a coordinate system
- Determine and draw $\vec{a}$ for the system (using motion diagram if necessary)

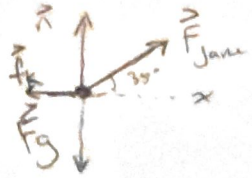


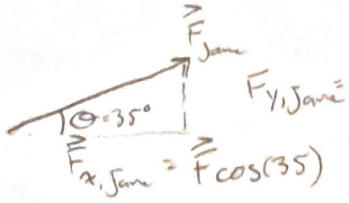
• Circle around system
• identify pts of contact
• label forces by source/part

$f_k = \mu N$

Free Body Diagram (FBD)

- Should show all the forces acting on "the system"
- For torques (extended FBD), draw pivot and lever arms
- Define symbols for all forces and other quantities
- List knowns and desired unknowns





$mg = 147.15N$

$f_k = mg\mu$

$m = 15\,kg$ $\quad \vec{F}_{Jane} = 55\,N$ $\quad \mu = 0.3$ $\quad g = 9.81\,m/s^2$ $\quad \vec{n} = -\vec{F}_g$

$\vec{F}_g = (-9.81\,m/s^2)(15\,kg)$

Mathematical Representation

- Write down Newton's second law in component form
- Use the FBD to obtain force components for Newton's laws
- Solve equation(s) for the desired unknown
- Substitute in the known values, including units, and calculate the target value
- Check units and assess if your answer is reasonable

$F_{net} = ma = \vec{F}_1 + \vec{F}_2 + \ldots$ $\quad \vec{F} = m\vec{a}$

$\vec{n} = (15\,kg)(9.81\,m/s^2)$

$\vec{n} = mg - \vec{F}_{y,Jane}$

$= (15\,kg)(9.81\,m/s^2) - 55\,N\sin(35)$

$n = 115.6\,N$ up

$a = \frac{\vec{F}}{m}$ $\quad a_x = \sum F_x = 0.69\,m/s^2$ right

$= 0.908$

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$

$\vec{F}_{net,x} \approx 90N$ right $\leftarrow \vec{F}_{net,x} = \vec{f}_k + \vec{F}_{x,Jane} \Rightarrow 55N\cos(35) - (0.3)(15\,kg)(9.81\,m/s^2)$

90N

a_x

$a_x = \frac{90N}{15kg} \approx 6\,m/s^2$ right $= 0.06\,m/s^2$

$\vec{F}_{net,y} = \vec{F}_g + \vec{n} + \vec{F}_{y,Jane}$

$31.5N \approx \vec{F}_{y,Jane} = \vec{F}\sin(\theta) = 55N\sin(35)$

$a_y = \frac{31.5N}{15kg} \approx 2\,m/s^2$ up

$\vec{a}_{net} \approx 6.4\,m/s^2$ (35° from horizontal)