



PHYS 2211 K

Week 5, Lecture 2

2022/02/10

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6 clicker questions today

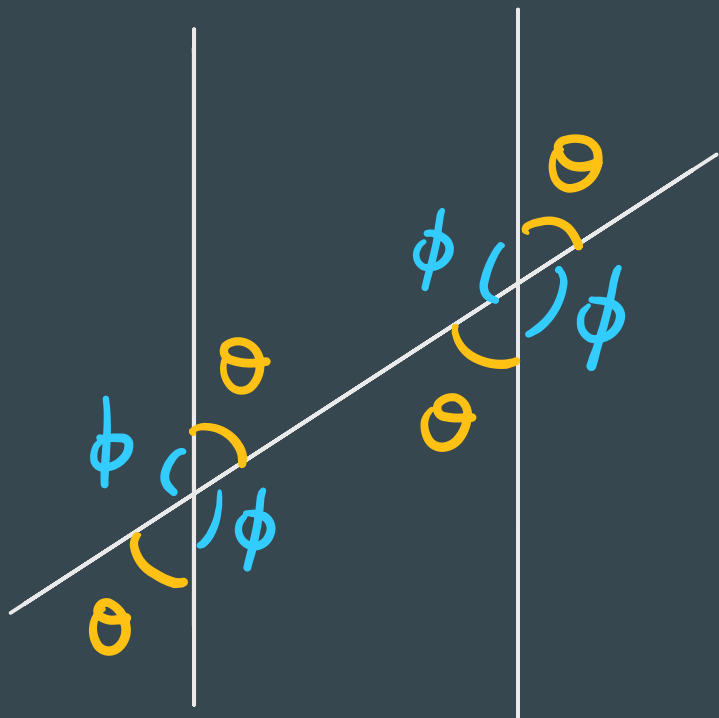
On today's class...

1. Static and Dynamic Equilibrium
2. Lots and lots of problems with static and dynamic equilibrium

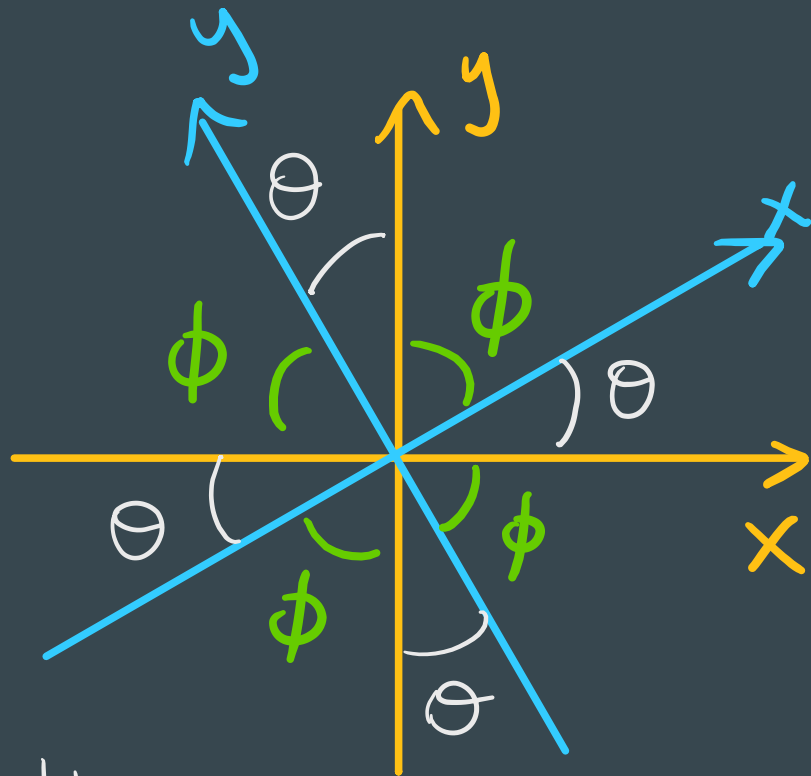
From Tuesday

- Contact forces need to be in contact with the system
- **Tension** force pulls the system along a rope/string
- Surface contact forces have a component **perpendicular** to the surface (called **normal**) and a component **parallel** to the surface (called **friction**)
- Magnitude of friction is proportional to magnitude of normal $|\vec{f}| = \mu |\vec{N}|$
- Free body diagrams show the forces acting on a system

Geometry Refresher...



alternate angles



tilted coordinates

CLICKER 1: How do you pronounce “gif”?

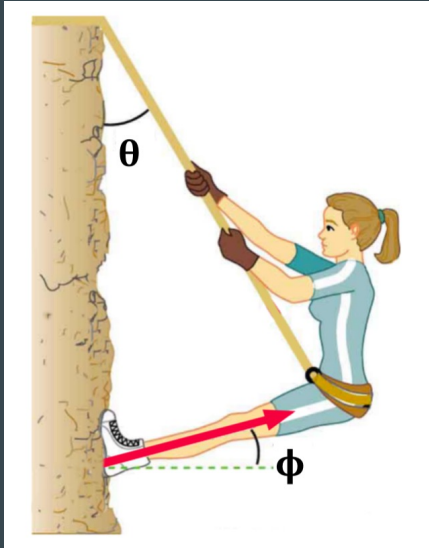
- A. With a **hard** “g” like in “get”
- B. With a **soft** “g” like in “giraffe”



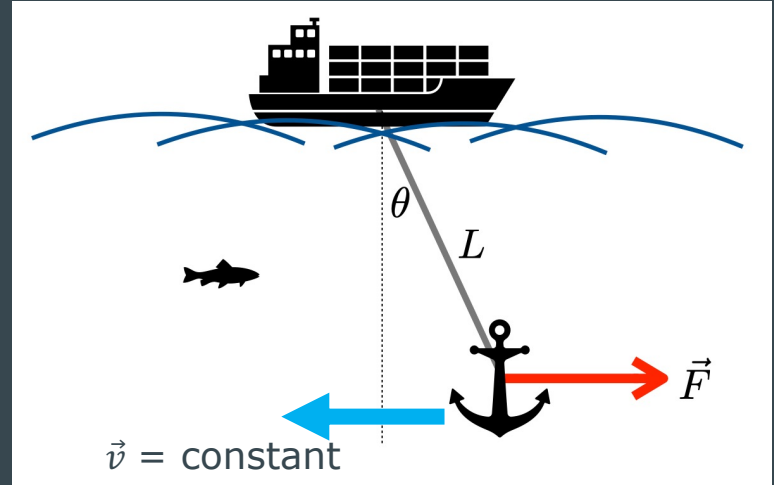
Static & Dynamic Equilibrium

A system is in **static** equilibrium when $F_{\text{net}} = 0$ and $v = 0$

Engineering students may take a class that's all about this, called "Statics"



A system is in **dynamic** equilibrium when $F_{\text{net}} = 0$ but $v = \text{constant} \neq 0$



If $F_{\text{net}} \neq 0$, then the system is **NOT** in equilibrium

Equilibrium problems

- When $\vec{F}_{\text{net}} = 0$ this means all the forces acting on the system are **balanced**
- All the x components of all the forces add up to zero
- All the y components of all the forces add up to zero
- All the z components of all the forces add up to zero

$$\vec{F}_{\text{net},x} = 0 \quad \vec{F}_{\text{net},y} = 0 \quad \vec{F}_{\text{net},z} = 0$$

Equilibrium problems

- Apply $\vec{F}_{\text{net}} = \sum_{i=1}^n \vec{F}_i = 0$ separately for x, y, z

sum of all forces along a
particular direction (e.g., "x")

- Will need **FBD** and **trigonometry** for finding x, y, z components
- Solve for **unknowns** (sometimes will end up with two equations and two unknowns)

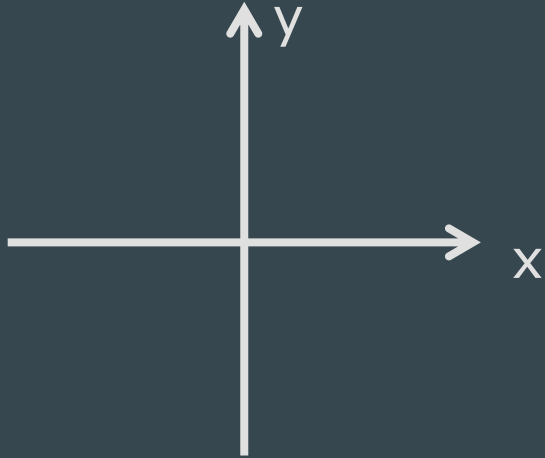
Non-Equilibrium problems

- When $\vec{F}_{\text{net}} \neq 0$ this means the forces acting on the system are **unbalanced**, and therefore the system is **accelerating**
- In this case,

$$\vec{F}_{\text{net},x} = m\vec{a}_x \quad \vec{F}_{\text{net},y} = m\vec{a}_y \quad \vec{F}_{\text{net},z} = m\vec{a}_z$$

- But we'll worry more about that next week 😊

Example: A block of mass m sits motionless on a table. Find the magnitude of the **normal force** exerted by the table on the block.



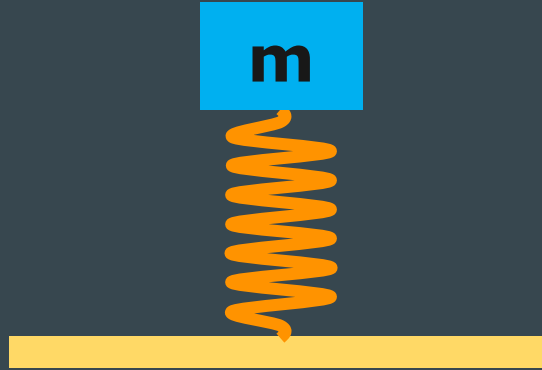
CLICKER 2: A block of mass $m = 3 \text{ kg}$ sits **motionless** on a spring that is compressed by an amount $s = 12 \text{ cm}$. What is the **stiffness** of the spring, k ?

A. $k = -2.45 \text{ N/m}$

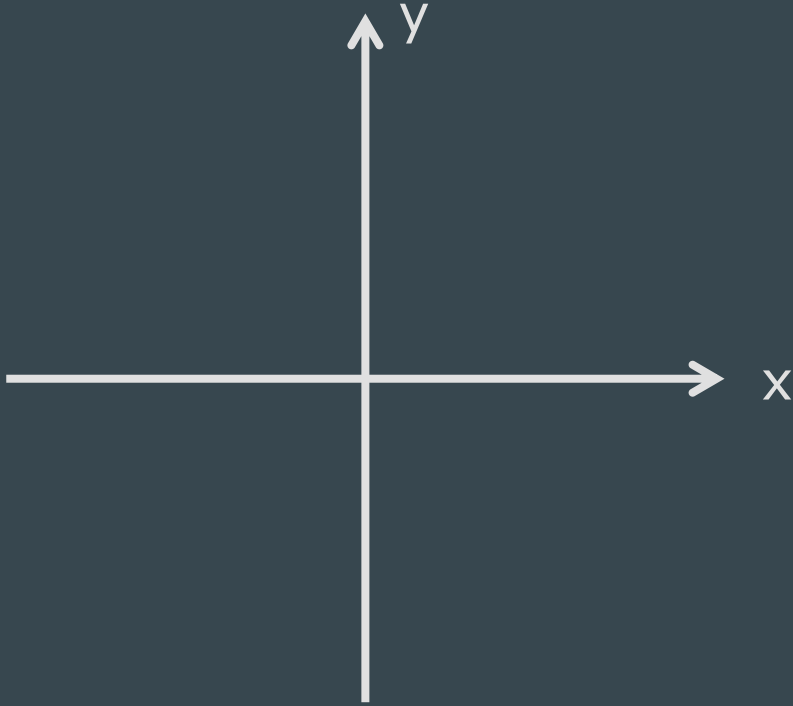
B. $k = 245 \text{ N/m}$

C. $k = -245 \text{ N/m}$

D. $k = -2.45 \text{ N/m}$

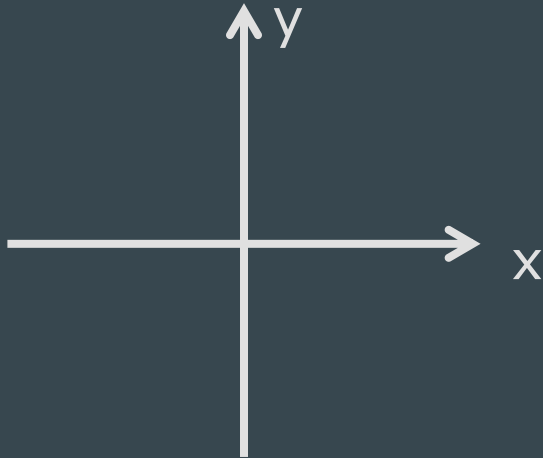
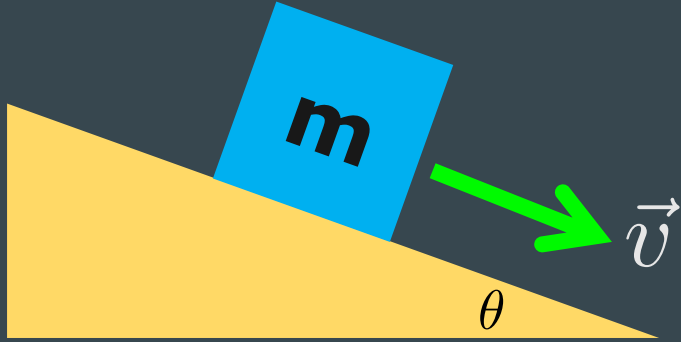


Solution: A block of mass $m = 3 \text{ kg}$ sits motionless on a spring that is compressed by an amount $s = 12 \text{ cm}$. What is the stiffness of the spring, k ?



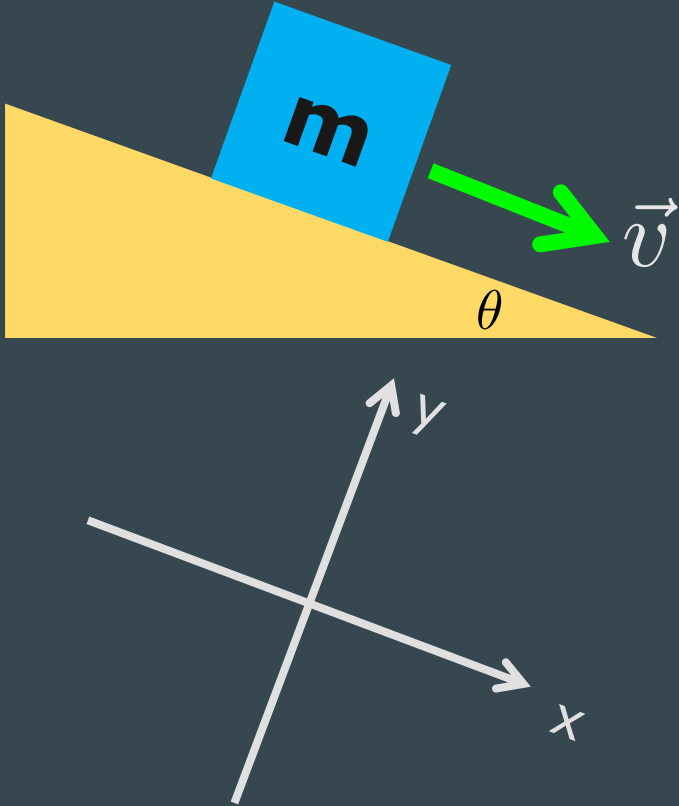
Example: A block of **mass m** slides down a ramp inclined at an angle θ at **constant velocity**. What is the **magnitude of the friction force** acting on the block?

Method 1: xy coordinates as usual



Example: A block of **mass m** slides down a ramp inclined at an angle θ at **constant velocity**. What is the **magnitude of the friction force** acting on the block?

Method 2: Tilted xy coordinates



CLICKER 3: A block of mass $m = 3 \text{ kg}$ sits **motionless** (but just on the verge of sliding) on a ramp that is inclined by an angle $\theta = 35^\circ$. What is the **coefficient of friction** between the ramp and the block?

A. $\mu = 0.70$

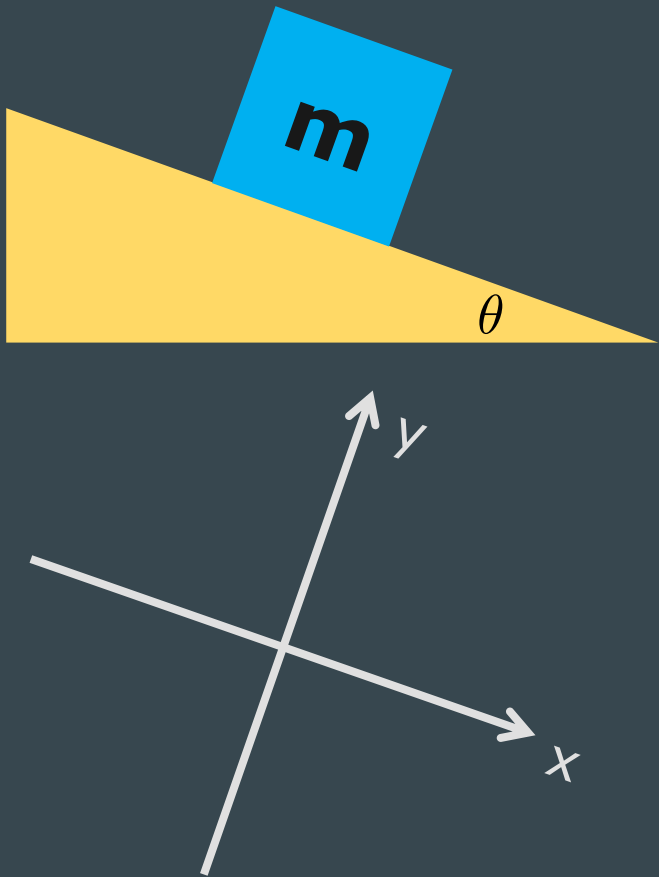
B. $\mu = 1.43$

C. $\mu = 0.57$

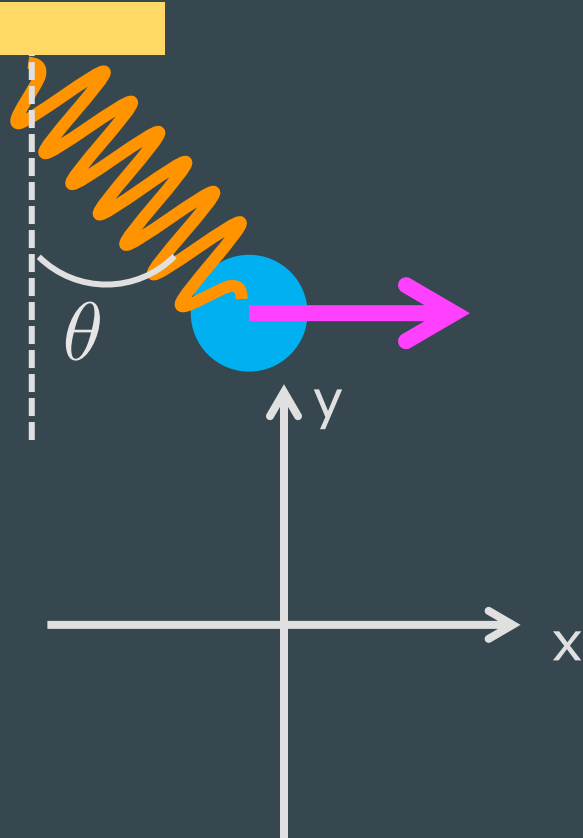
D. $\mu = 0.82$



Solution: A block of mass $m = 3\text{ kg}$ sits motionless (but just on the verge of sliding) on a ramp that is inclined by an angle $\theta = 35^\circ$. What is the coefficient of friction between the ramp and the block?

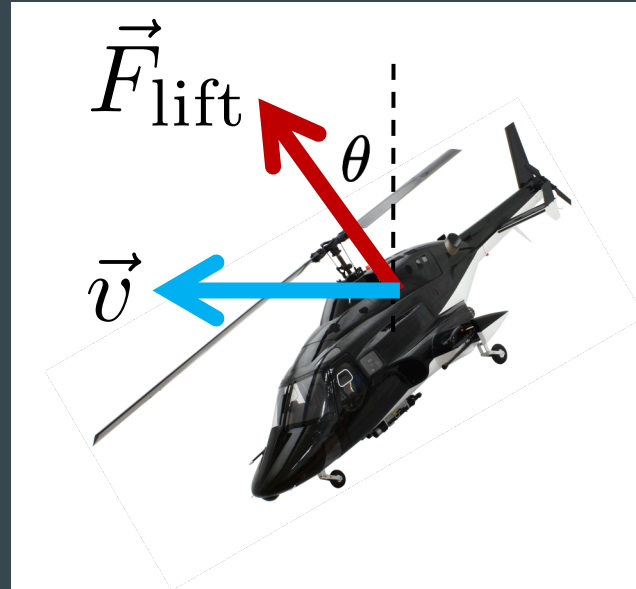


Example: A ball of mass m is attached to stretched spring. You pull the ball with a rope exerting on it a force of unknown magnitude. This causes the ball to hang motionless at an angle θ from the vertical. What is the magnitude of the unknown force?

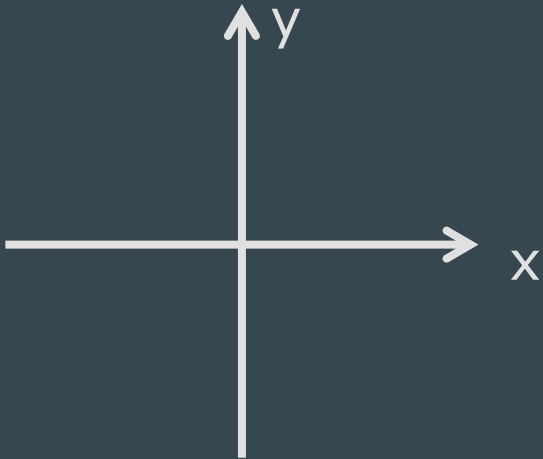


CLICKER 4: A helicopter ($m = 5500 \text{ kg}$) moves to the left at **constant velocity**. The lift force generated by the blades makes an angle of 30 degrees with respect to the vertical. What is the **magnitude of the air resistance** that opposes the helicopter's motion?

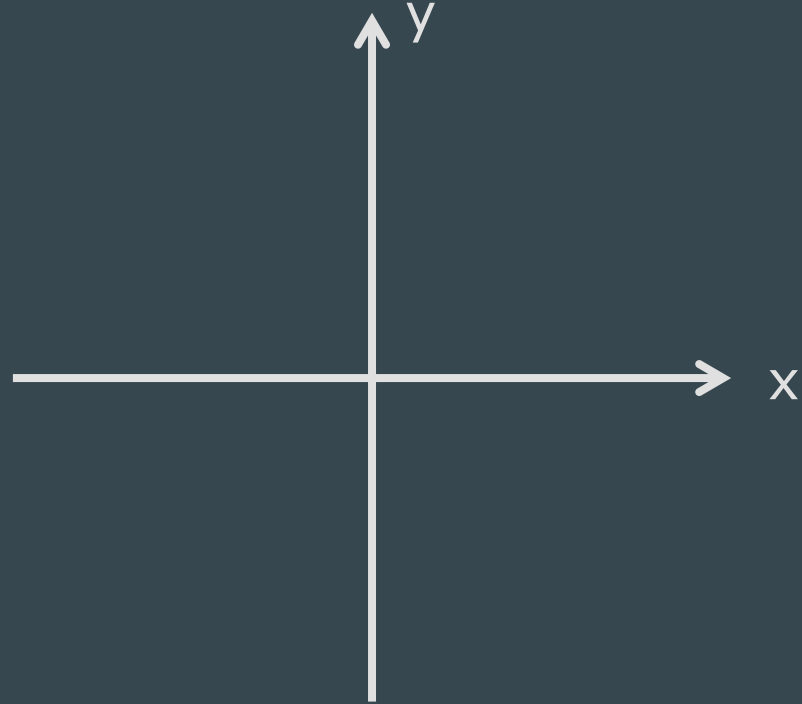
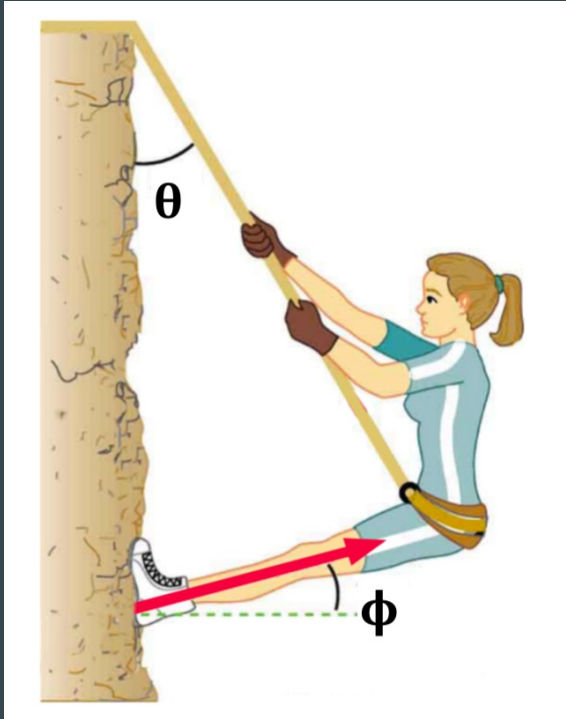
- A. $F_{\text{air}} = 3175 \text{ N}$
- B. $F_{\text{air}} = 53900 \text{ N}$
- C. $F_{\text{air}} = 93358 \text{ N}$
- D. $F_{\text{air}} = 31119 \text{ N}$
- E. $F_{\text{air}} = 46679 \text{ N}$



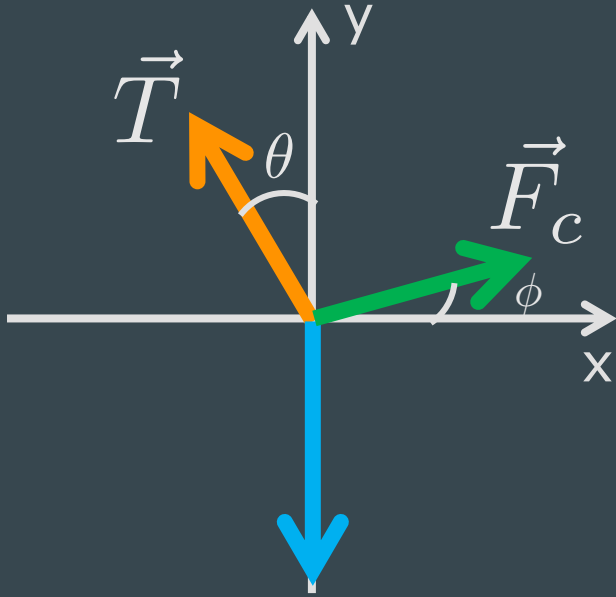
Solution: A helicopter ($m = 5500 \text{ kg}$) moves to the left at **constant velocity**. The lift force generated by the blades makes an angle of 30 degrees with respect to the vertical. What is the **magnitude of the air resistance** that opposes the helicopter's motion?



Example: A rock climber ($m = 60 \text{ kg}$) is leaning back from a rock wall, **motionless**, as shown in the diagram. The rope has some **unknown tension T** and makes an angle $\theta = 31^\circ$ with the vertical. In this position, the wall exerts a contact force on the climber of unknown magnitude at an angle $\phi = 15^\circ$ above the horizontal. **What is the magnitude of the tension force?**



Solution: A rock climber ($m = 60 \text{ kg}$) is leaning back from a rock wall, **motionless**, as shown in the diagram. The rope has some **unknown tension T** and makes an angle $\theta = 31^\circ$ with the vertical. In this position, the wall exerts a contact force on the climber of unknown magnitude at an angle $\phi = 15^\circ$ above the horizontal. **What is the magnitude of the tension force?**



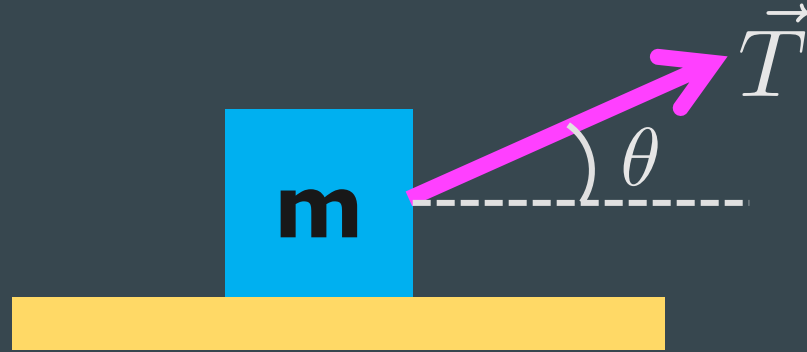
CLICKER 5: A block of mass **m** is dragged along a table by a string so it moves to the right at **constant speed v**. The string makes an angle θ with the table, and the coefficient of kinetic friction between table and block is μ . **What is the magnitude of the tension force?**

A. $T = \frac{mg}{\mu \cos \theta + \sin \theta}$

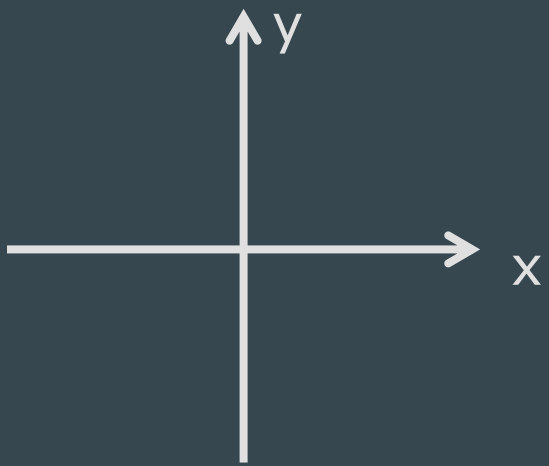
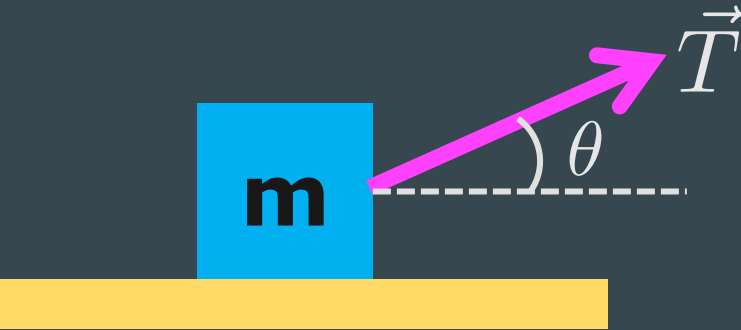
B. $T = \frac{\mu N}{\cos \theta}$

C. $T = N - mg \sin \theta$

D. $T = \frac{\mu mg}{\cos \theta + \mu \sin \theta}$



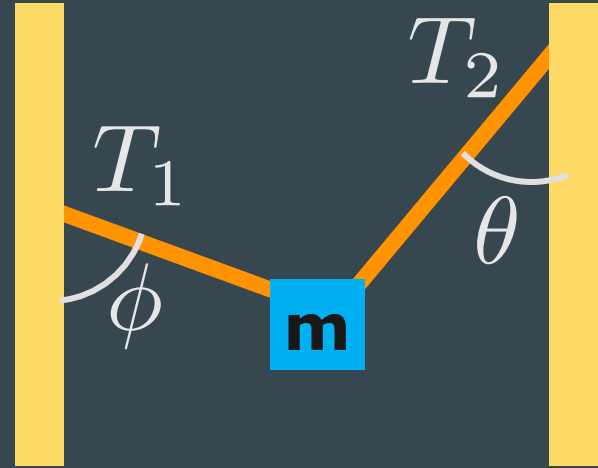
Solution: A block of mass m is dragged along a table by a string so it moves to the right at constant speed v . The string makes an angle θ with the table, and the coefficient of kinetic friction between table and block is μ . What is the magnitude of the tension force?



CLICKER 6: A block of mass **m** hangs motionless tied to **two ropes** which make different angles on two parallel walls. What is the **magnitude of Tension 2**?

A. $T_2 = \frac{mg \sin \phi}{\sin \theta \cos \phi + \cos \theta \sin \phi}$

B. $T_2 = \frac{mg \sin \theta}{\sin \phi \cos \theta + \cos \phi \sin \theta}$



Solution: A block of mass m hangs motionless tied to two ropes which make different angles on two parallel walls. What is the magnitude of Tension 2?

