PHYS 2211 K

Week 5, Lecture 1
2022/02/08
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4 clicker questions today

On today's class...

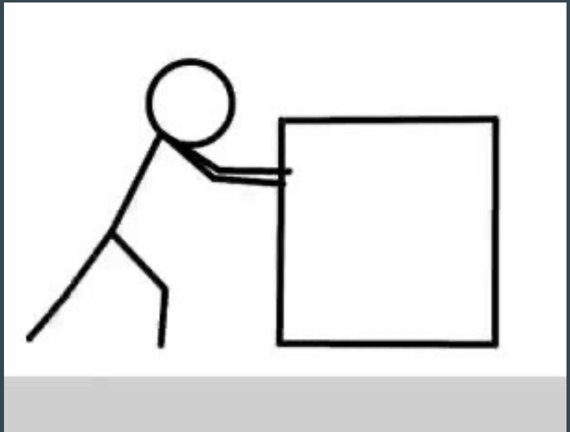
1. Contact and non-contact forces
2. Tension, normal, friction
3. Free body diagrams
4. Static and Dynamic Equilibrium (continued Thursday)

CLICKER 1: How was the test?

A B C D E

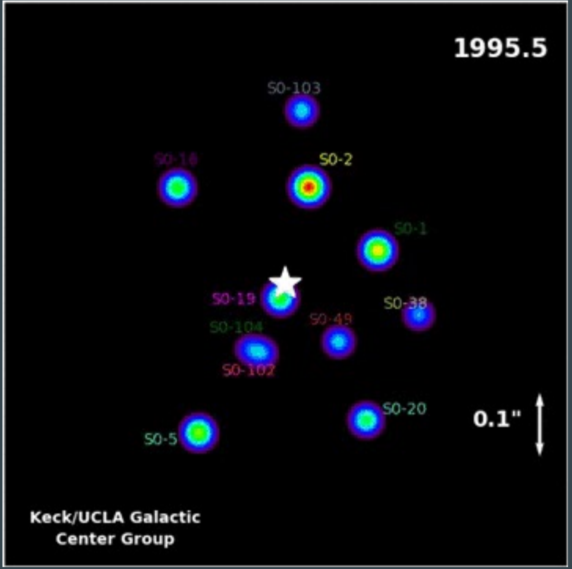
Contact and Non-Contact Forces

Contact forces need the system to be in physical contact with the objects in the surroundings causing the forces



(examples: spring force, tension, friction, normal force, pushing something, pulling something)

Non-contact forces cause their effects at a distance



(examples: gravity, electric force)

Tension Force ($\vec{F}_T$ or $\vec{T}$)

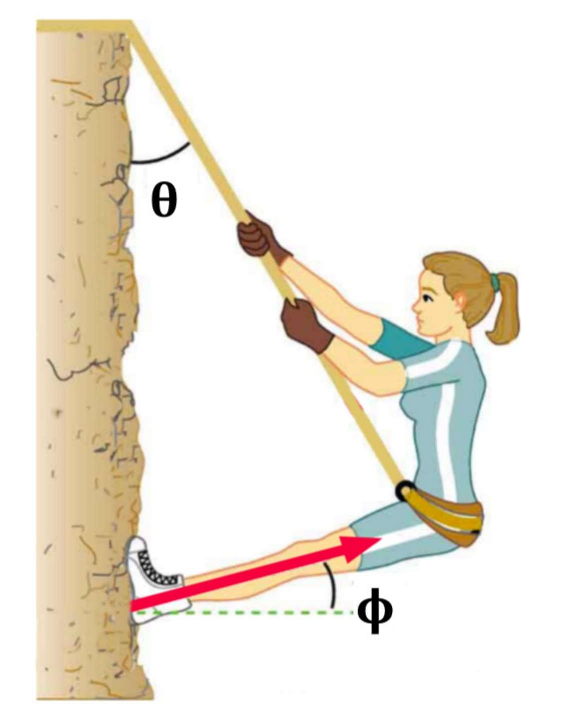
- Always pulls on the system directly along the length of the rope/string

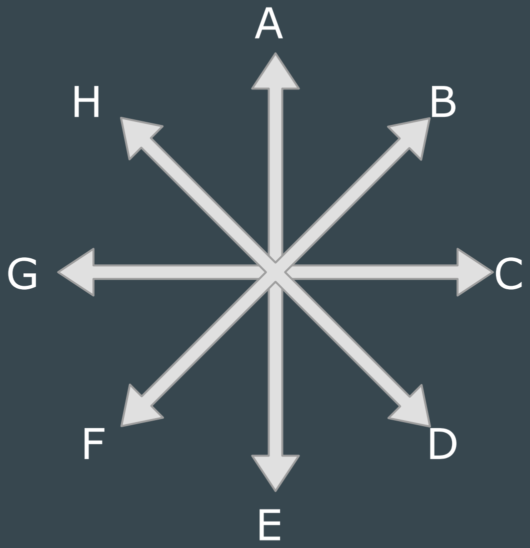
- Constant in magnitude throughout the entire length of the rope

- You can't push using a rope!

- Microscopically caused by spring-like interactions between atoms (the "ball-and-spring model" of solids)

CLICKER 2: What is the (**best approximate**) direction of the **tension** force on the rock climber due to the rope?





I - zero magnitude

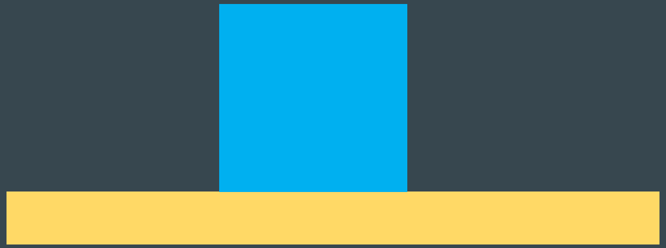
Surface Contact Forces $\vec{F}_C$

- When the system is in contact with a surface, there is a contact force acting on the system

- This contact force has a component perpendicular to the surface, which we call the **normal force**, and a component parallel to the surface, which we call the **friction force**

Normal Force ($\vec{F}_N$ or $\vec{N}$)

- Always pushes on the system, perpendicular to the surface exerting the force
- Prevents things from sinking into surfaces
- Microscopically caused by electric repulsion between electrons in the system and the surface

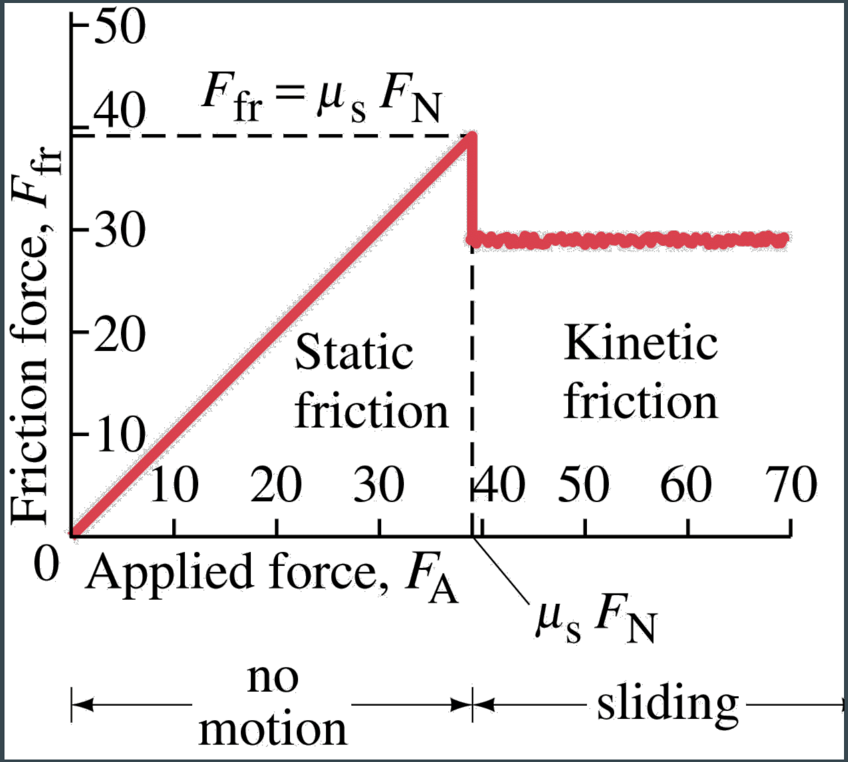


Friction Force $\vec{f}$

- Tries to prevent sliding between surfaces

- Can be static (system not moving relative to the surface exerting the force) or kinetic (system sliding across the surface exerting the force)

- Microscopically caused by little 'hooks' (roughness) in the surfaces that get caught on each other as they slide



Friction Force $\vec{f}$

- The magnitude of the friction force is proportional to the magnitude of the normal force

- The proportionality constant is called the coefficient of friction; its value depends on the surfaces, and it will be different for static friction and for kinetic friction

$$|\vec{f}_s| \leq \mu_s |\vec{N}|$$

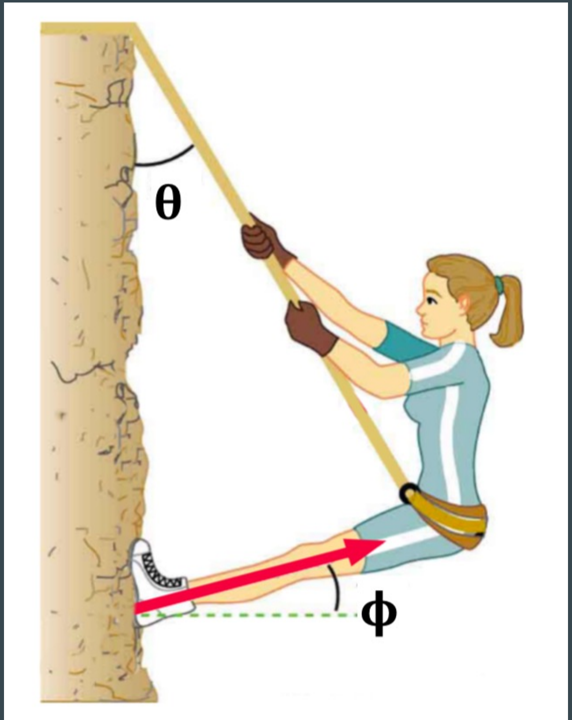
Static friction

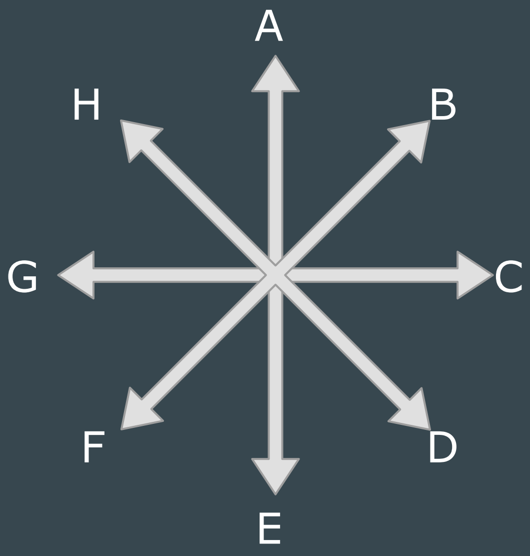
$$|\vec{f}_k| = \mu_k |\vec{N}|$$

Kinetic friction

Maximum static friction $$|\vec{f}_{\mathrm{s,max}}| = \mu_s |\vec{N}|$$

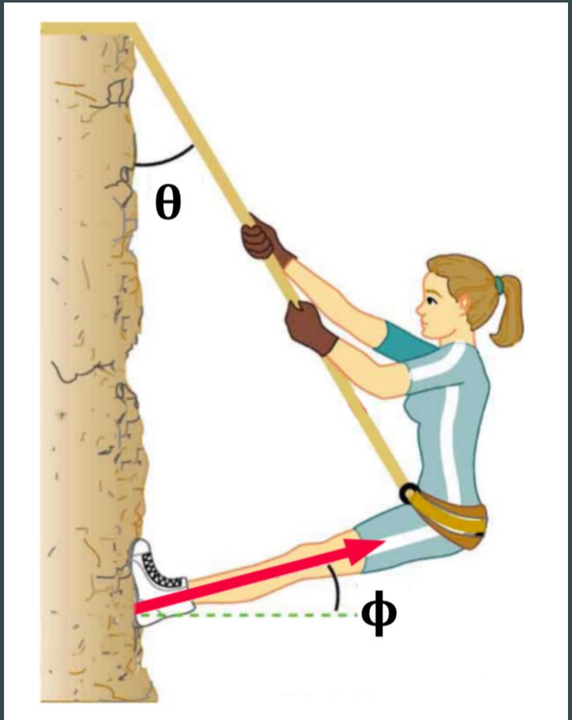
CLICKER 3: The red arrow is the contact force on the climber's feet due to the rock wall. If the climber's feet are motionless, what is the direction of the normal force?

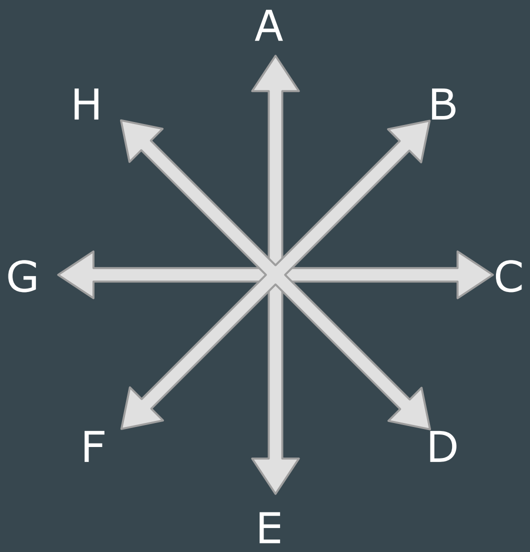




I - zero magnitude

CLICKER 4: The red arrow is the contact force on the climber's feet due to the rock wall. If the climber's feet are motionless, what is the direction of the friction force?



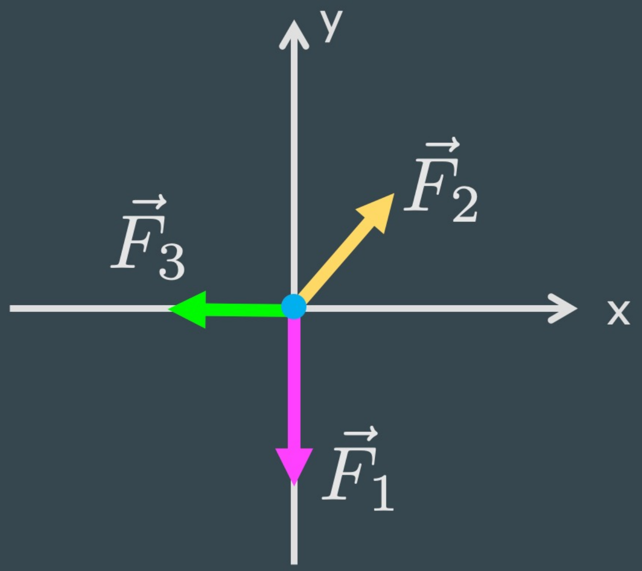


Free Body Diagrams (FBD)

- Also known as "force diagrams" – see this slide from January 18:

Force Diagrams

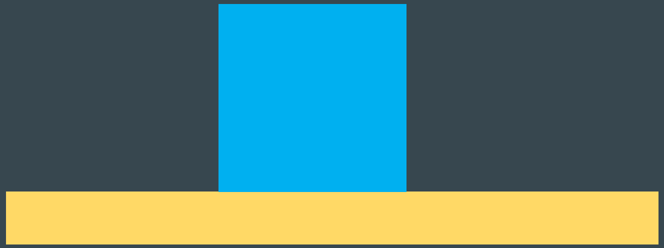
- Represent system as a point, and put it at the origin of the coordinate system
- Represent each force with an arrow, pointing in the direction of the force (angles are important!
- The relative lengths of the arrows represent the relative strengths of the forces



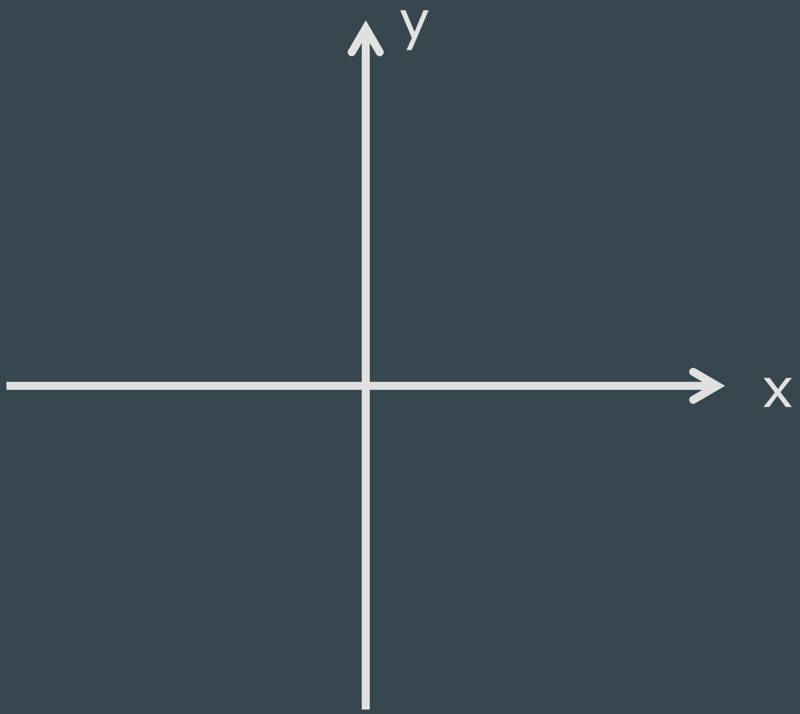
Free Body Diagrams – Example 1

System:

A block of mass m sitting motionless on a table

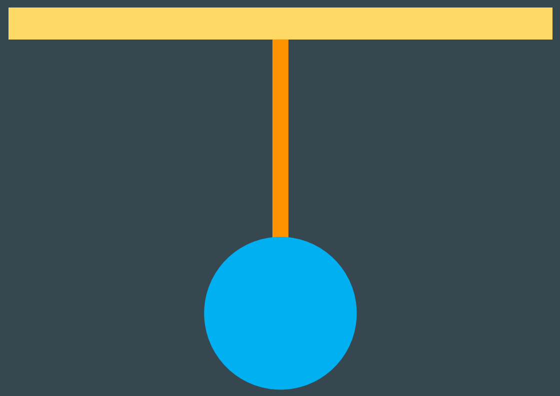


Forces acting on the system:

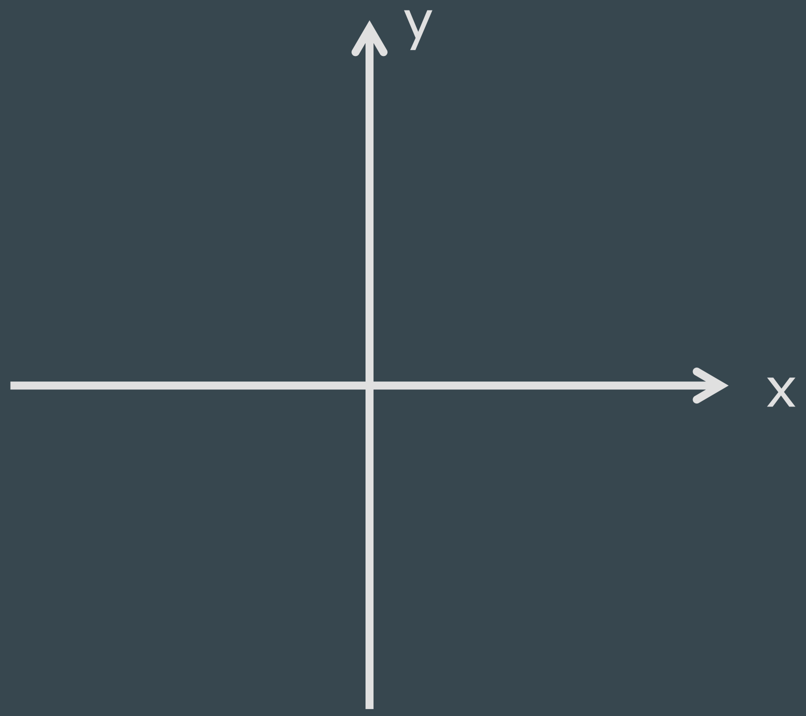


Free Body Diagrams – Example 2

System:
A ball of mass m hanging motionless from a string

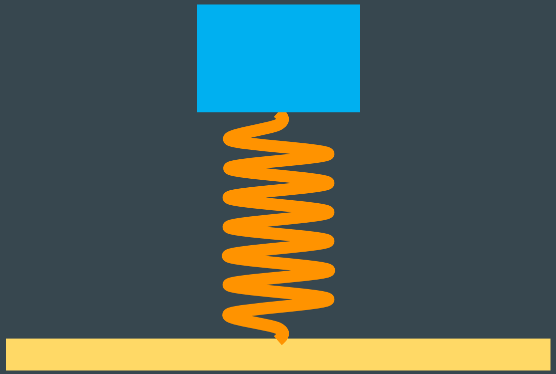


Forces acting on the system:

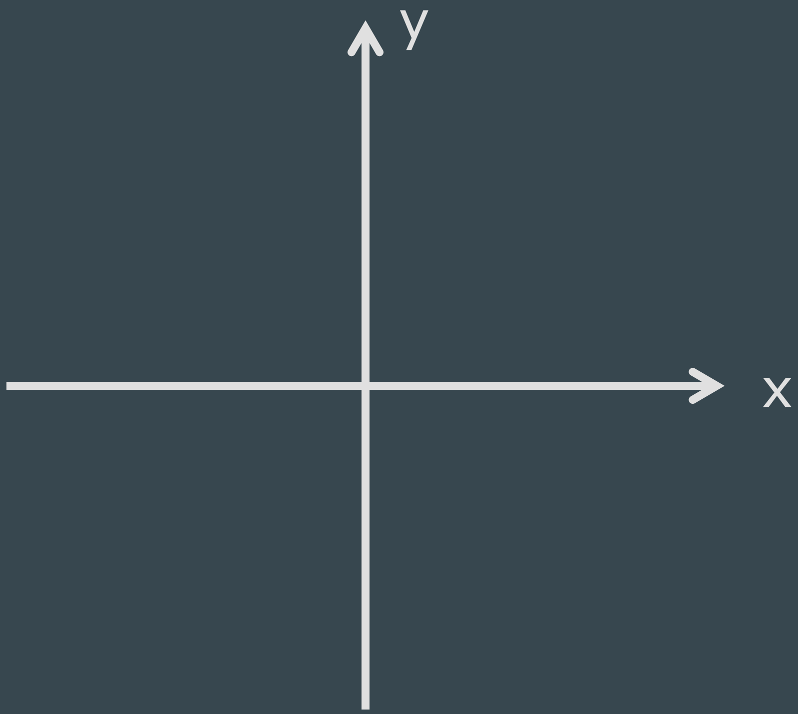


Free Body Diagrams – Example 3

System:
A block of mass m sits motionless on a compressed spring

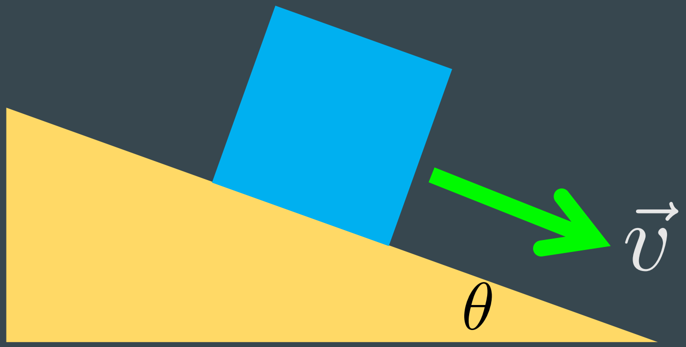


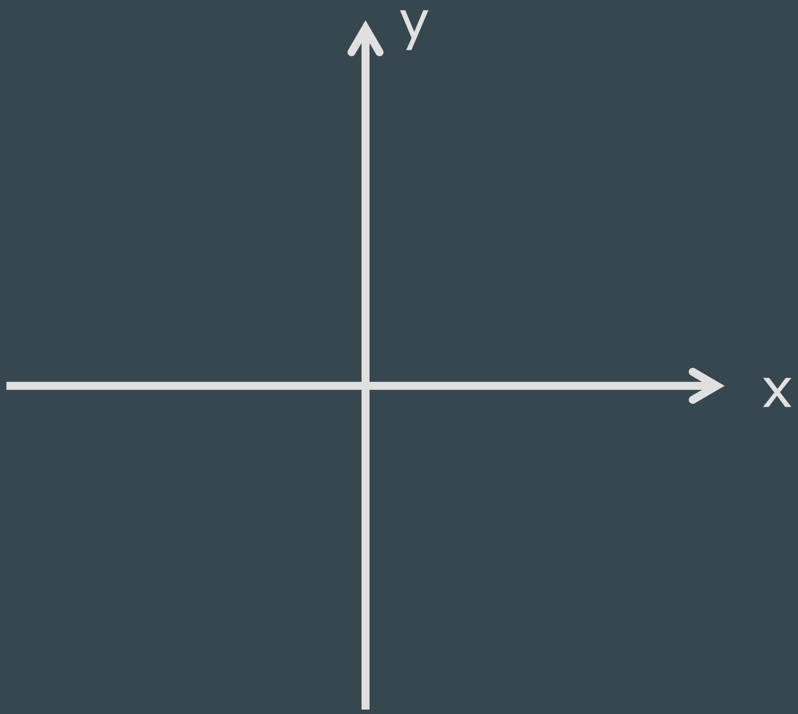
Forces acting on the system:



Free Body Diagrams – Example 4

System:
A block of mass m slides down a rough inclined plane



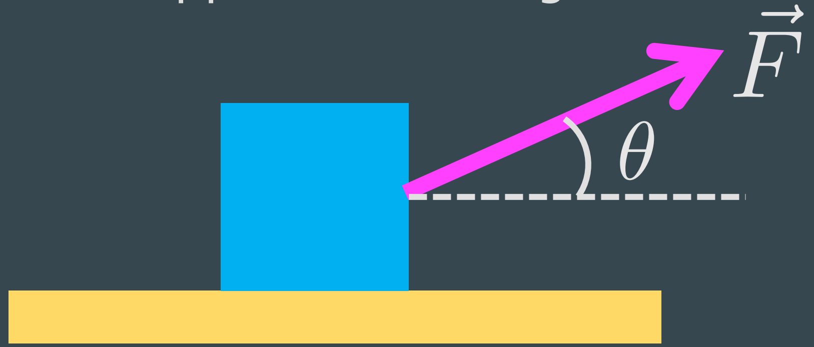


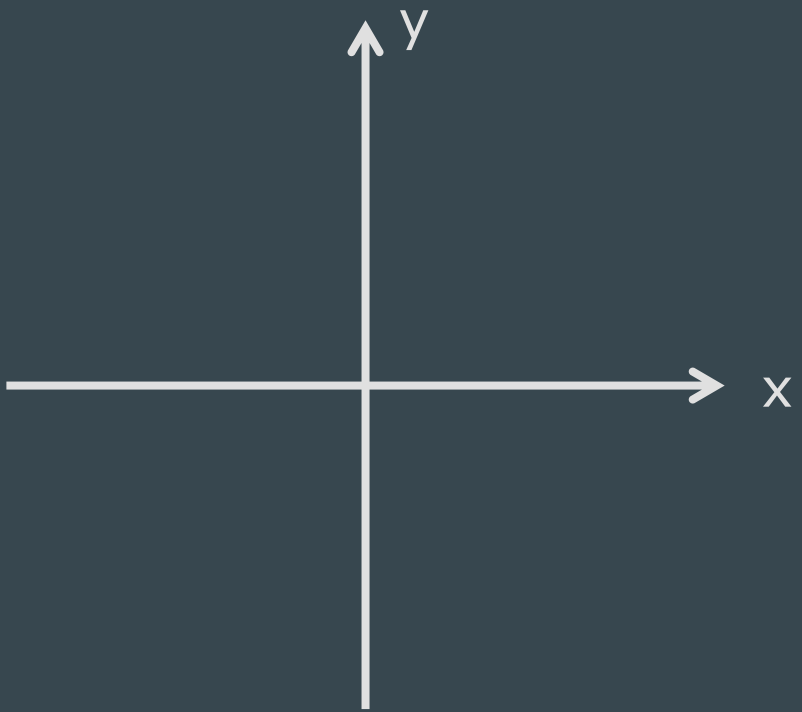
Forces acting on the system:

Free Body Diagrams – Example 5

System:

A block of mass m being pulled along a frictionless table with a force applied at an angle



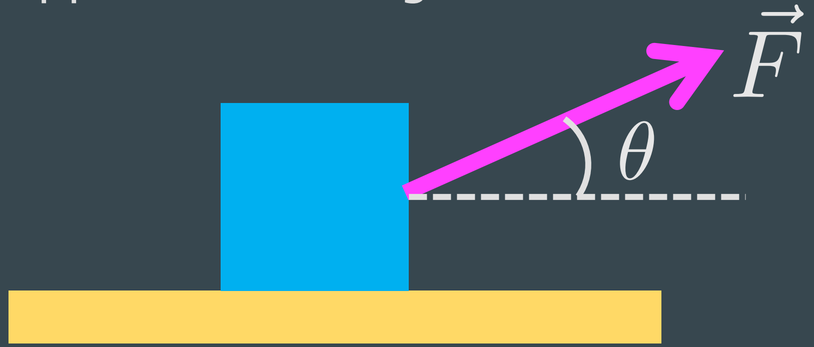


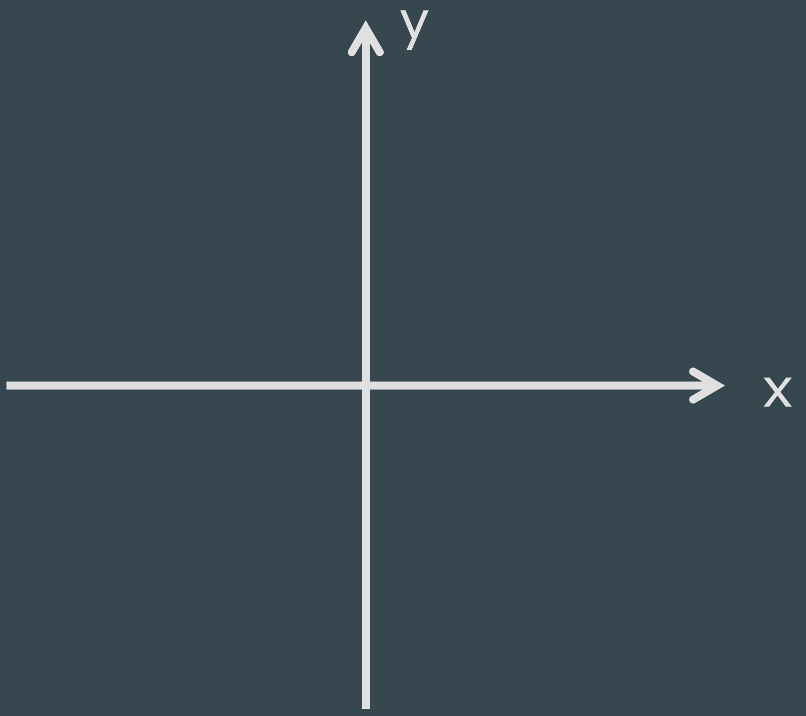
Forces acting on the system:

Free Body Diagrams – Example 6

System:

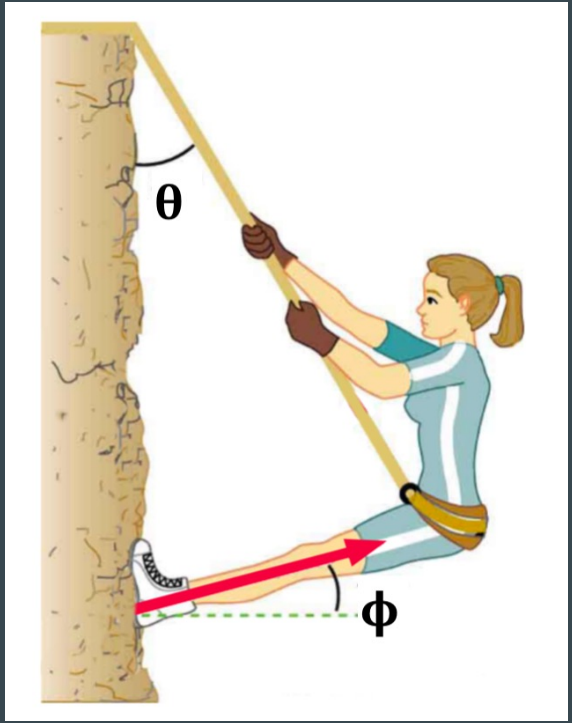
A block of mass m being pulled along a carpeted floor with a force applied at an angle

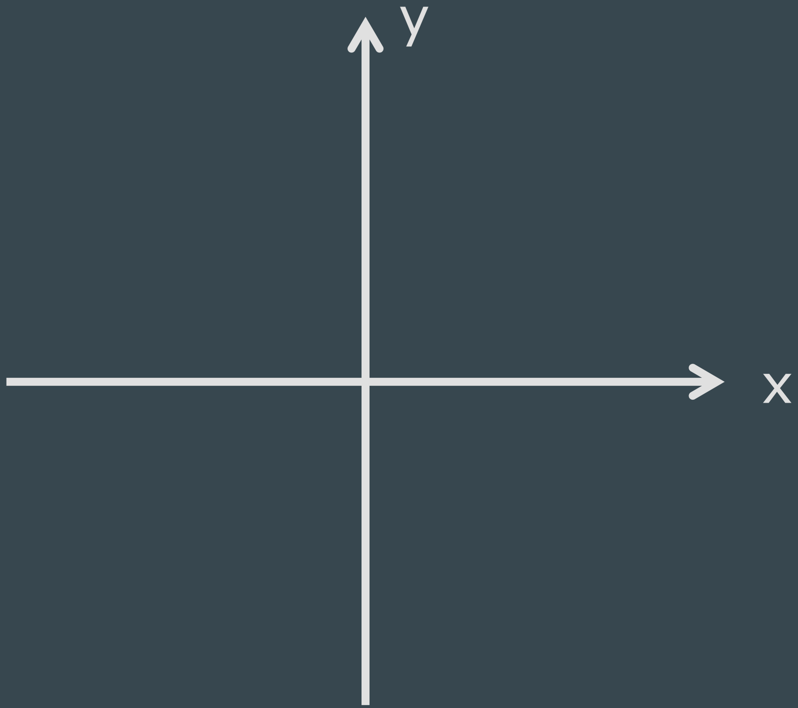




Forces acting on the system:

Free Body Diagrams – Example 7

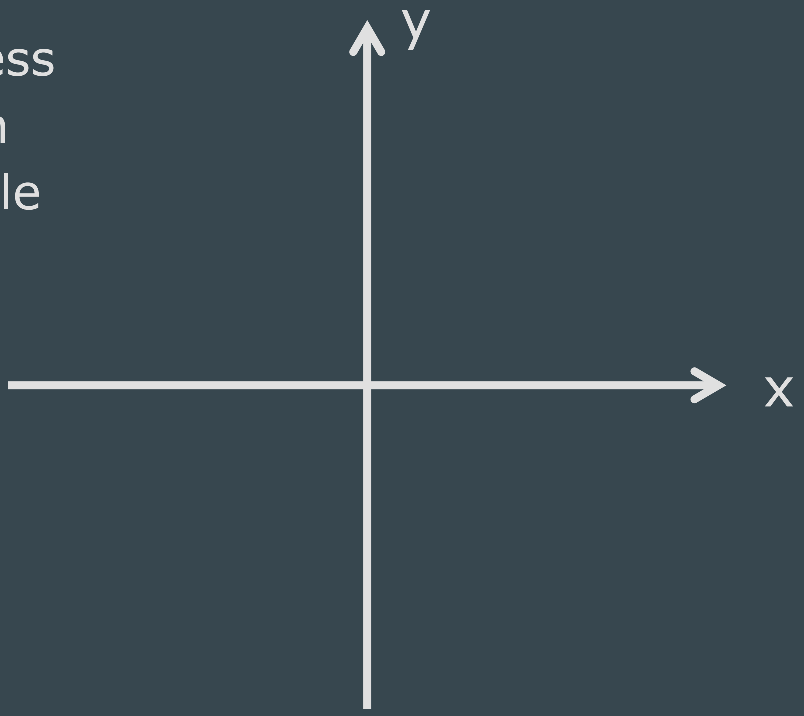




Free Body Diagrams – Example 8

System:

A block of mass m sitting motionless on top of a block of mass M, which itself is sitting motionless on a table



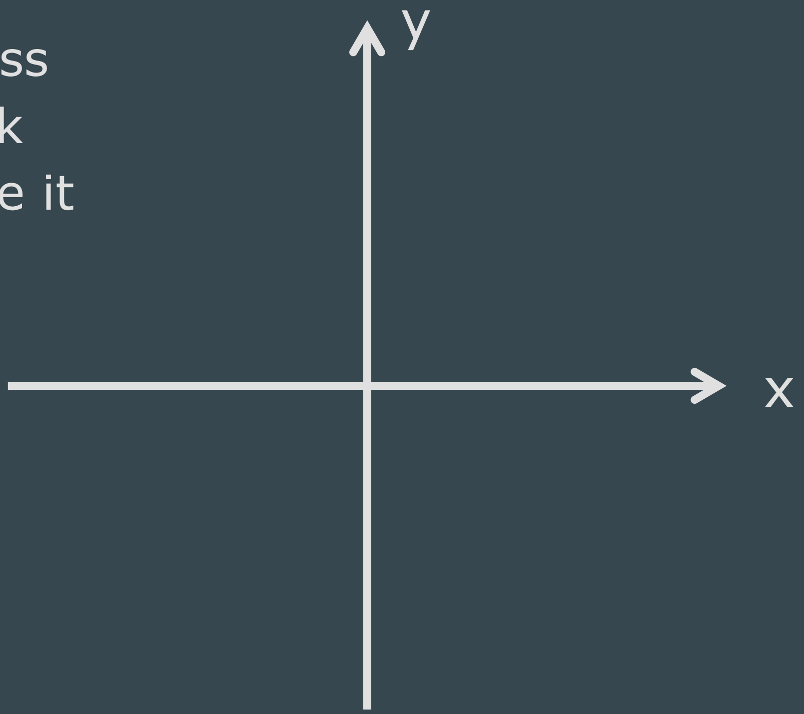
Forces acting on the system:

Free Body Diagrams – Example 9

System:

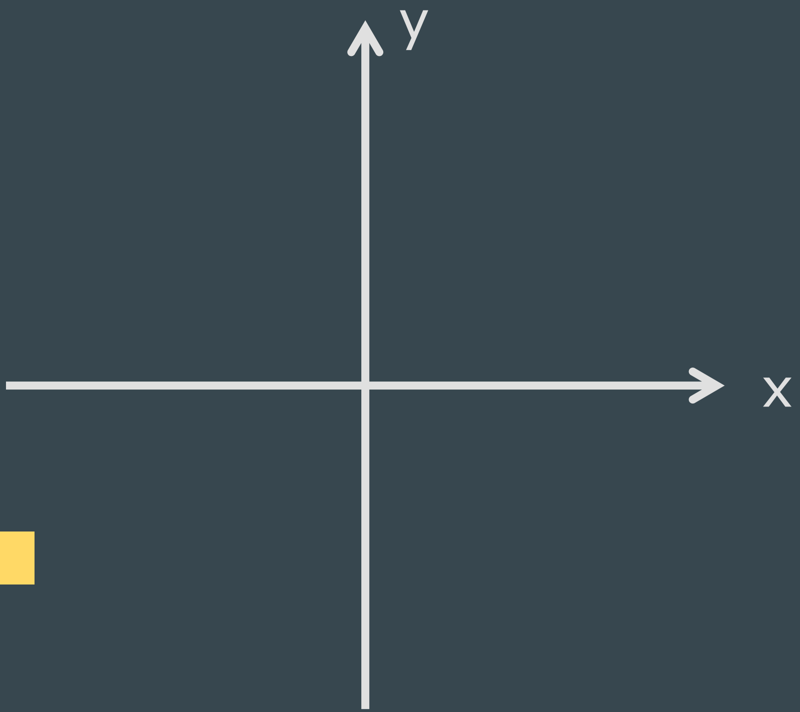
A block of mass M sitting motionless on a table, that has a smaller block of mass m sitting motionless above it

Forces acting on the system:



Free Body Diagrams – Example 10

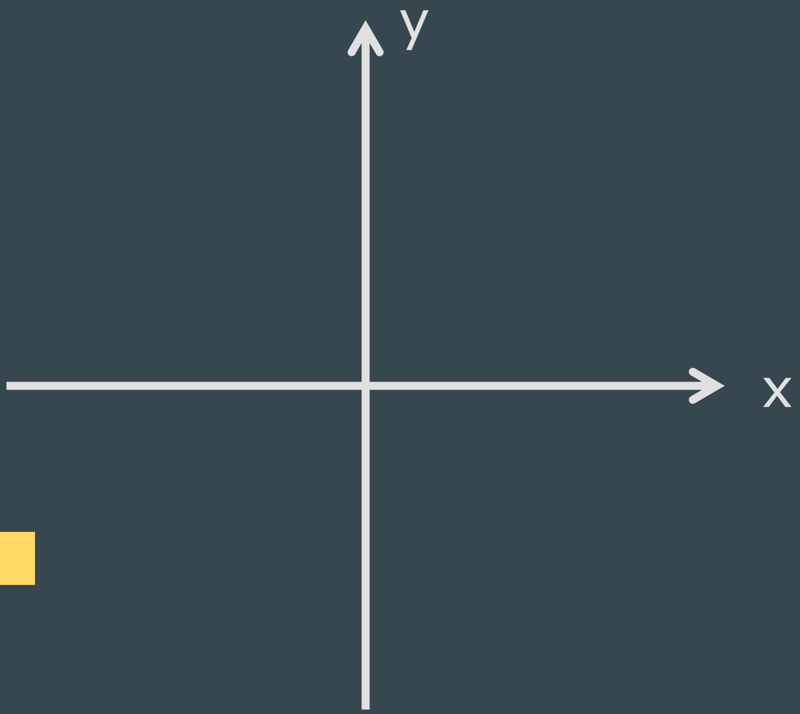
System: A block of mass M sits on a rough surface and is being pushed to the right, making it touch another block that has mass m



Forces acting on the system:

Free Body Diagrams – Example 11

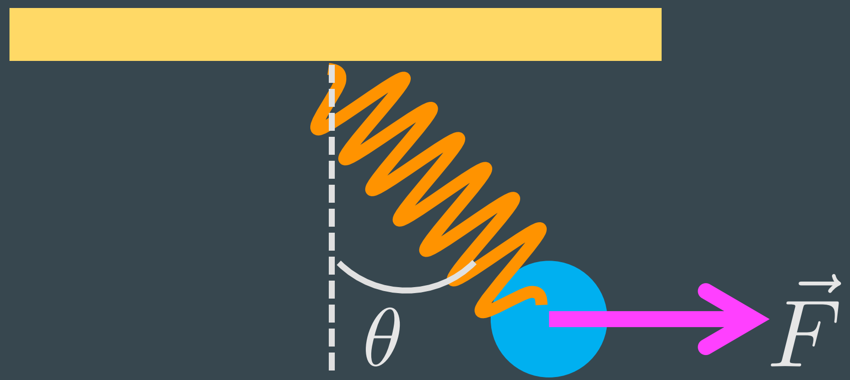
System: A block of mass m sits on a rough surface and is being pushed to the right by a block of mass M, which is itself being pushed to the right

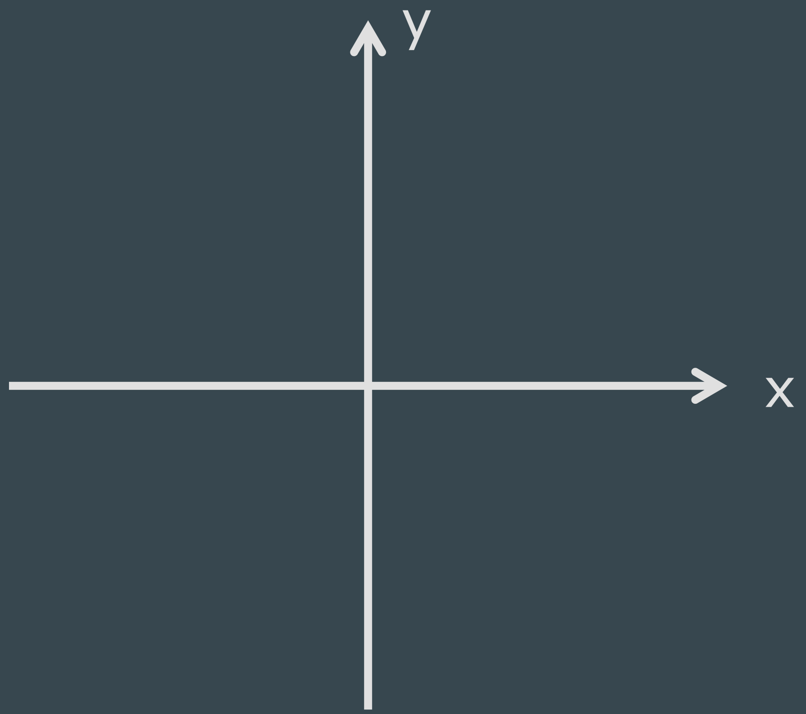


Forces acting on the system:

Free Body Diagrams – Example 12

System: A ball of mass m attached to a stretched spring and to a rope pulling it to the right

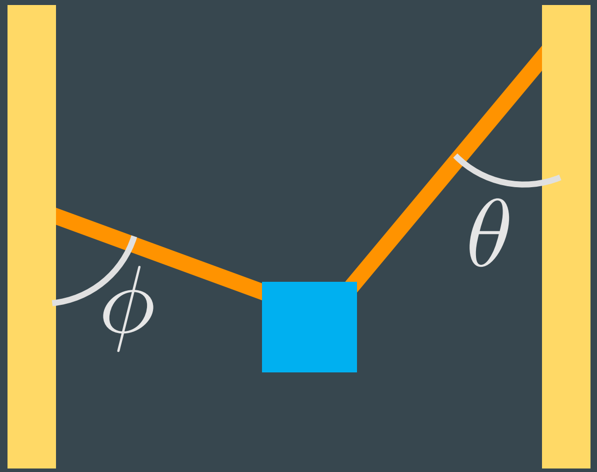




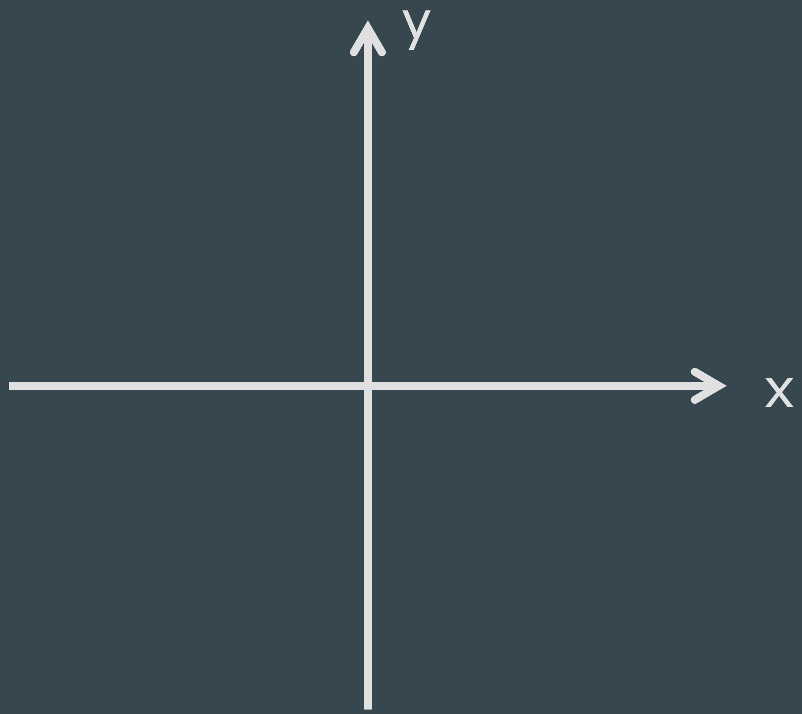
Forces acting on the system:

Free Body Diagrams – Example 13

System: A block of mass m attached to two ropes that make different angles on two parallel walls

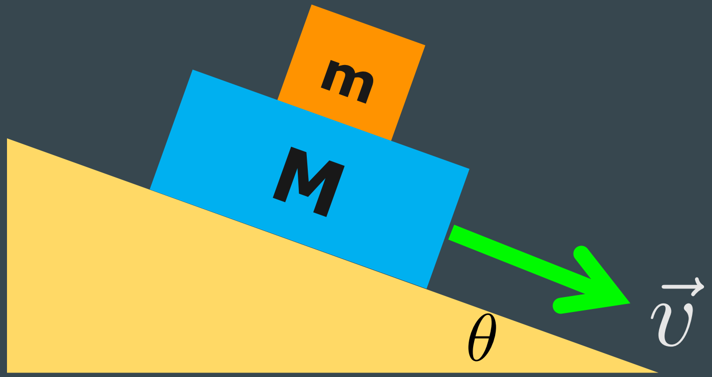


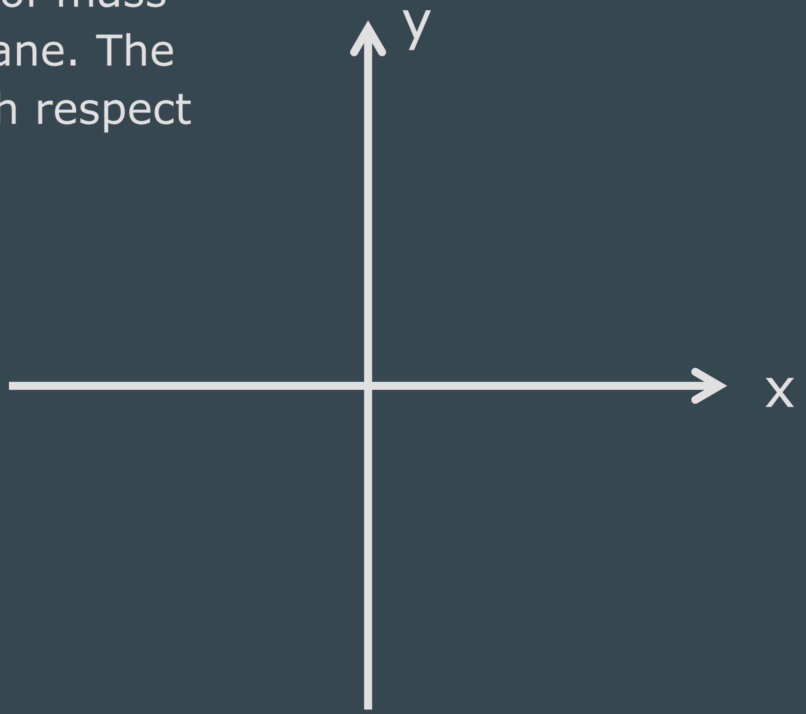
Forces acting on the system:



Free Body Diagrams – Example 14

System: A block of mass m sits on a block of mass M which is sliding down a rough inclined plane. The position of block m remains unchanged with respect to the inclined plane

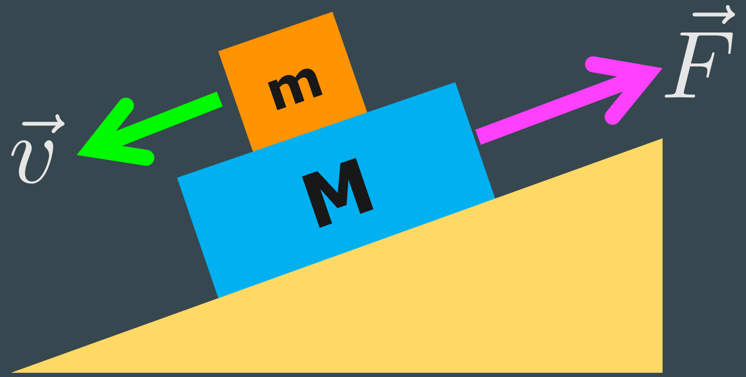


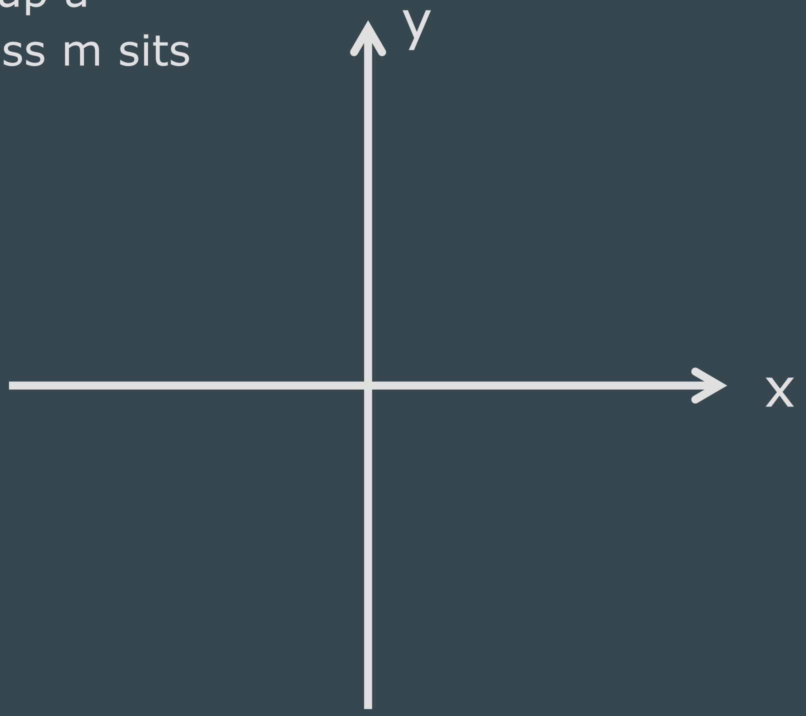


Forces acting on the system:

Free Body Diagrams – Example 15

System: A block of mass M is being pulled up a rough inclined plane. A smaller block of mass m sits on top of the block M and slides backwards



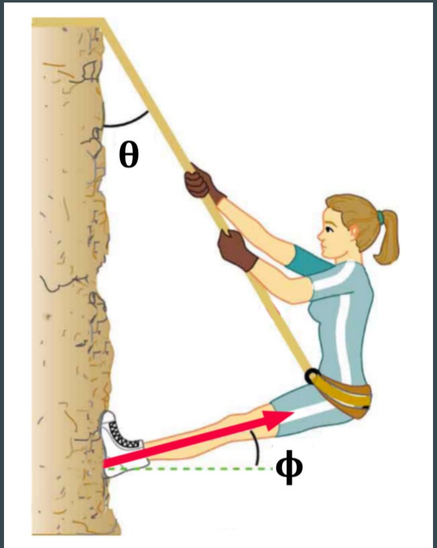


Forces acting on the system:

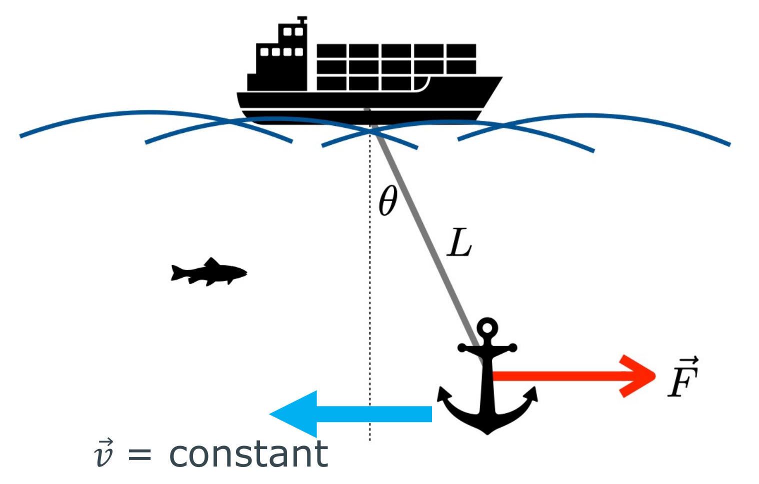
Static & Dynamic Equilibrium

A system is in static equilibrium when Fnet = 0 and v = 0

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



A system is in dynamic equilibrium when Fnet = 0 but v = constant ≠ 0



If Fnet ≠ 0, then the system is **NOT** in equilibrium

We'll do lots of equilibrium problems on Thursday!