

Day 3: Dynamics pt. 2

SHS Physics Club Summer Camp 2026





Overview

01 HW/Quiz

Brief MCQ review quiz, go over homework questions

02 Elevators

Elevator problems, acceleration direction, and “weightlessness”

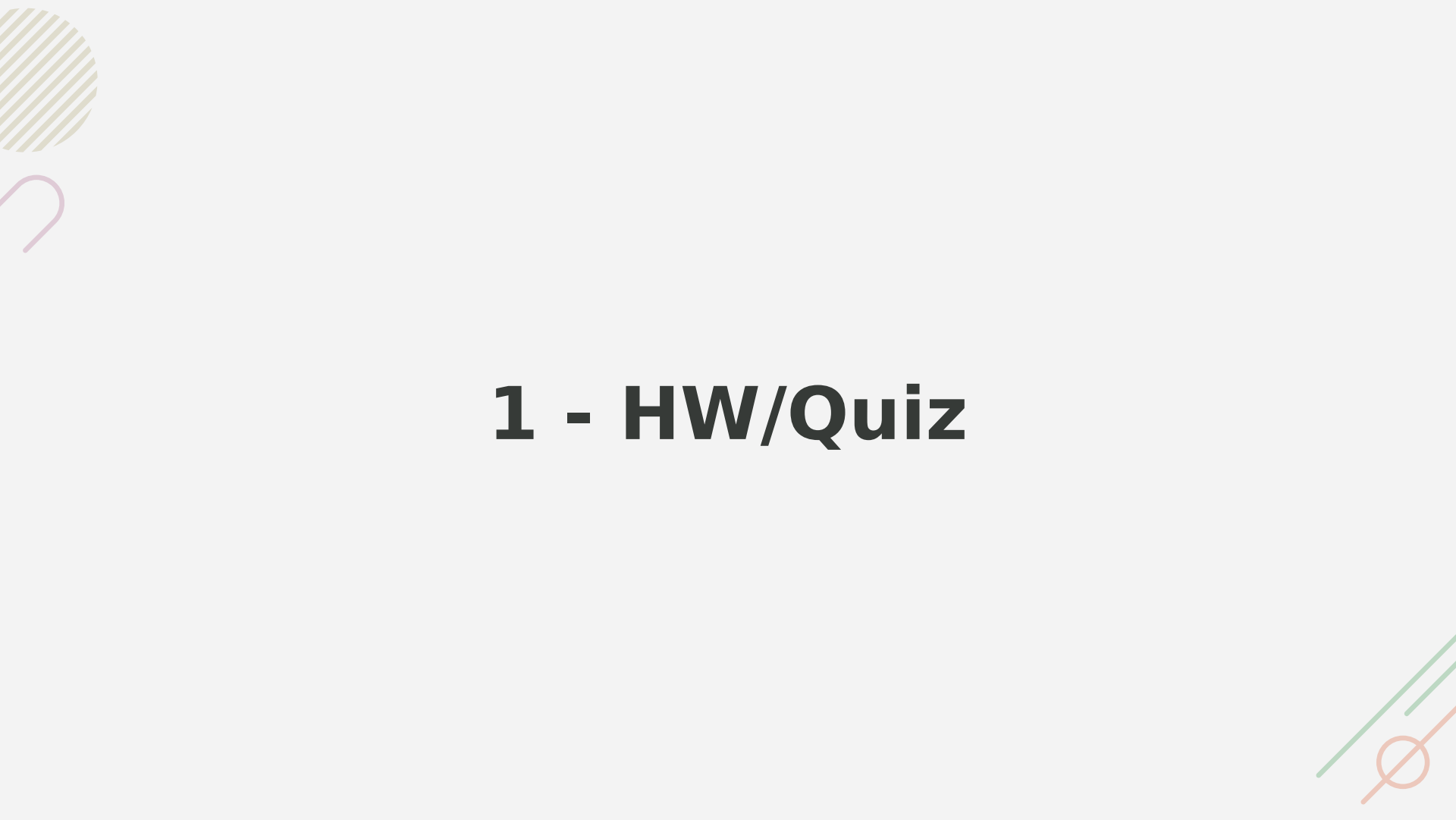
03 Friction

Advanced friction problems with a focus on normal force

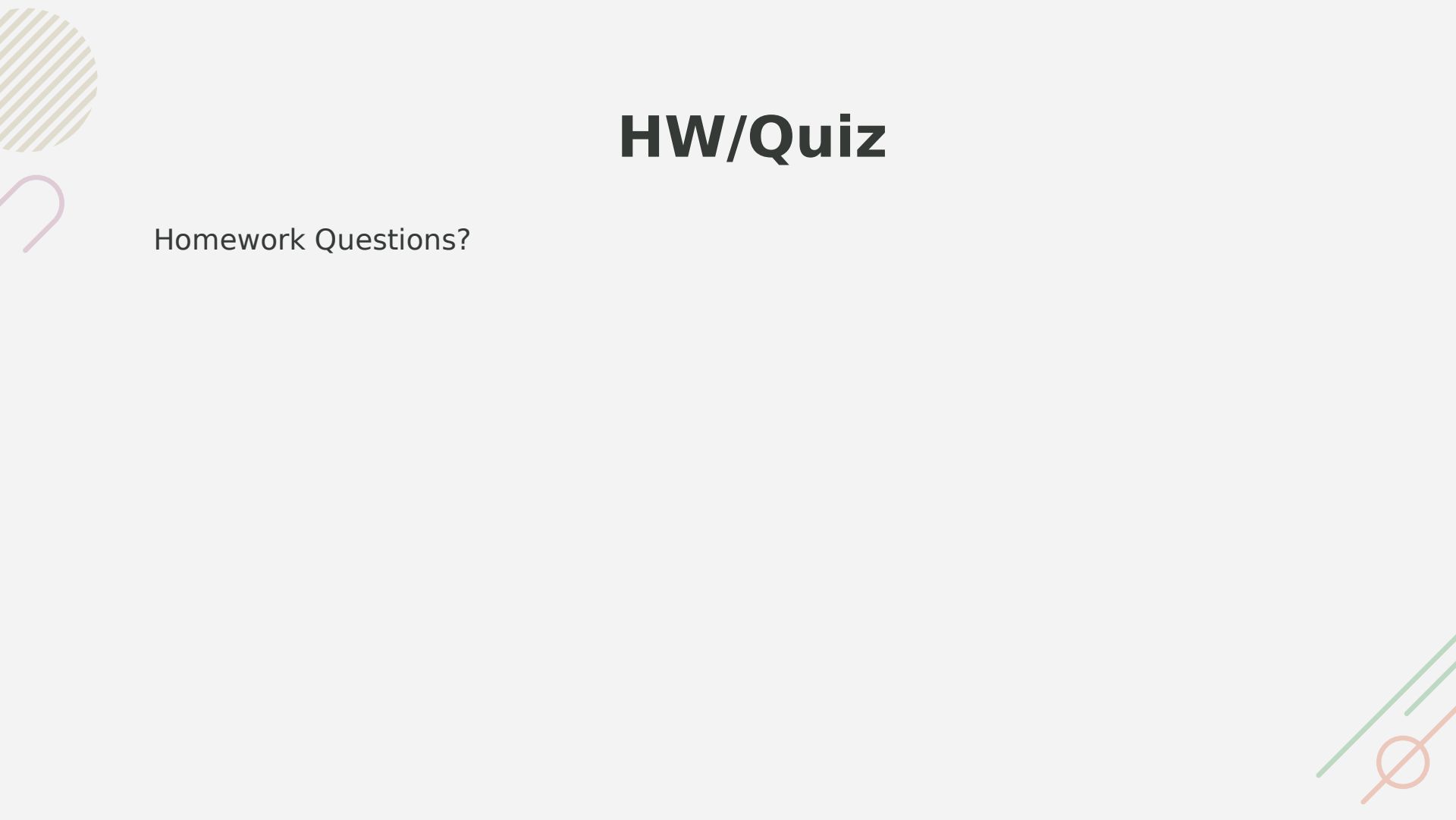
04 Pulleys

Tension, Atwood machines with pulleys, and more?





1 - HW/Quiz



HW/Quiz

Homework Questions?

HW/Quiz

- **Quiz**

- ☐ 10 min
- ☐ 5 MCQ

<https://forms.gle/Nh3T7144E6mbwntk9>





2 - Elevator Problems



F=ma review

- **F=ma and normal force**

- Net force and acceleration have the same direction
- Normal force is perpendicular to the surface and acts as a support force for the object

- **Elevator problems:**

- Focuses on the relationship between gravity and normal force
- Focus on the direction of acceleration!

- **Example problem:**

- A box of 5 kg is placed inside an elevator. Gravity is 10 m/s^2 for ease of calculation
- a) if this elevator is traveling upward at a constant velocity what normal force does the box experience?
50N - Constant velocity means no acceleration, so gravity and normal force will balance
- b) if this elevator is traveling downward and slowing down at 5 m/s^2 , what normal force does the box experience?

75N - downward + slowing down means acceleration is 5 m/s^2 upward.
 $F_N - mg = ma$, $F_N = 5 (10 + 5) = 75\text{N}$

Free fall

- **What is free fall?**

- When an object only experiences the force of gravity, it is in free fall
- Kinematics!
- All objects accelerate at the same rate, ignoring air resistance!

- **More Elevator problems:**

- A box of 10 kg is placed in another elevator, this time on top of a scale.
- If the scale reads 200 N, what is the acceleration of elevator? Let $g = 10\text{m/s}^2$

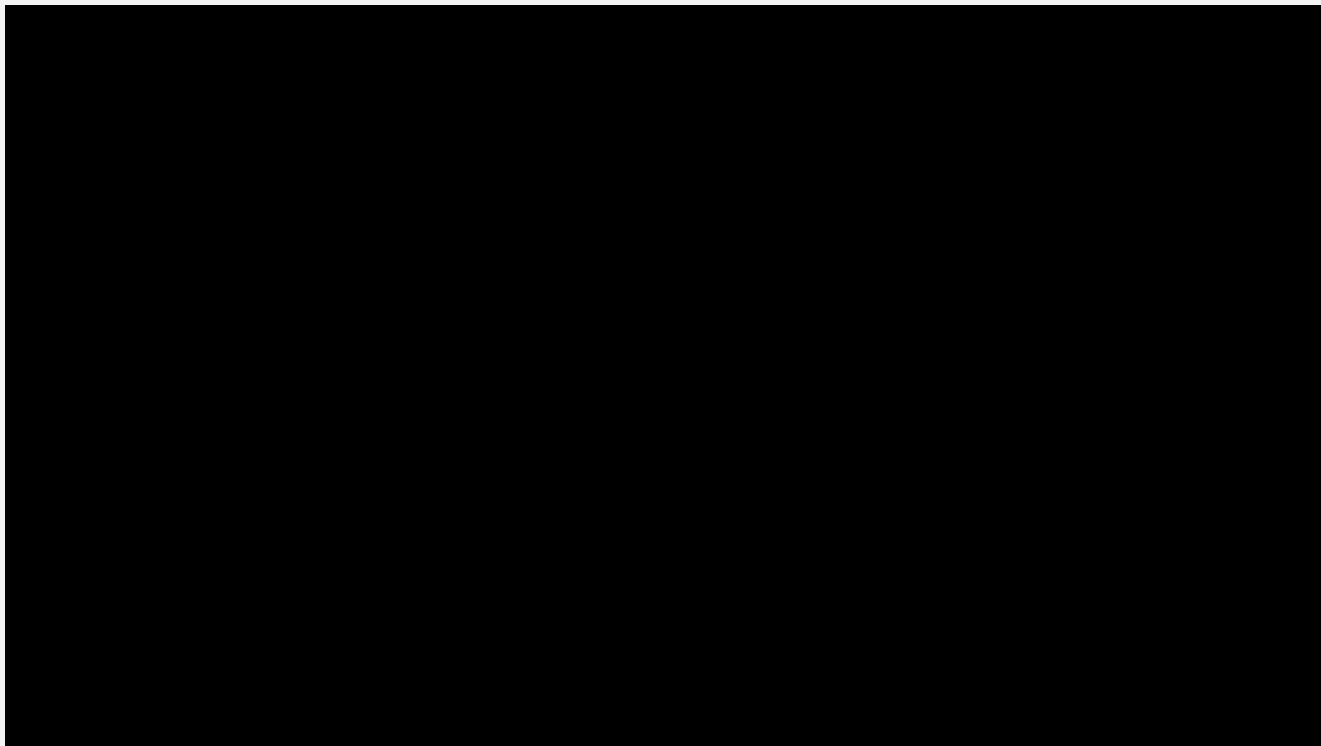
10 m/s² upward. The normal force is 100 N greater than gravity, giving a 100 N

- net force upward. $100/10 = 10\text{ m/s}^2$
What about if it read 50N? 0N?

5 m/s² downward. The normal force is 50 N less than gravity. Same solve as before.

- **Bowling ball vs feather!**

10 m/s² downward. There is no normal force. The elevator and box are in free fall!



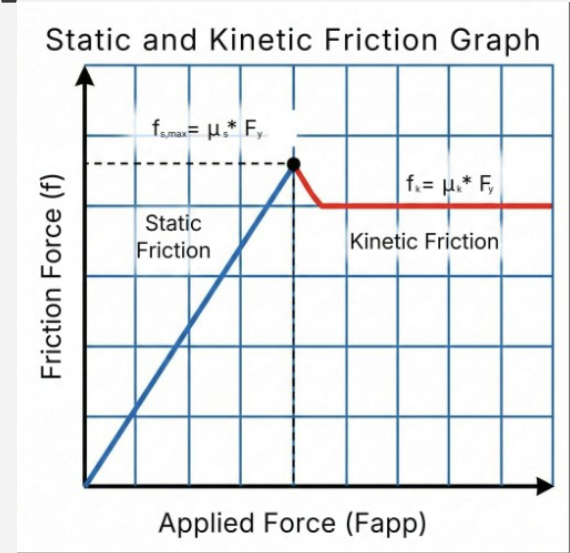


3 - Advanced Friction Problems

Friction Review

● Friction

- Two kinds of friction:
- Kinetic friction
 - $F_k = \mu_k F_N$
 - Opposes sliding movement
- Static friction
 - $F_s \leq \mu_s F_N$
 - Opposes net external force up until its max value
- $\mu_{s/f}$ is the coefficient of friction and depends only on the materials
- Must be multiplied with the normal force
- ex. When you push a piano, its harder to get it to start moving than it is to keep it moving, because the coefficient kinetic friction is typically lower



Friction problems

- Quick Quiz

- Cyrus and Aaron are trying to slide crates on a rough warehouse floor. Aaron pushes down on a crate at a 30 degree angle to move it while Cyrus uses a rope to pull a crate at 30 degree angle above the horizontal to move it. Who made the right choice?

Cyrus made the better choice. Pulling at an upward angle reduces normal force, in turn reducing friction. Aaron's downward push does the opposite.

- Truck Problem:

- A tailgate of a pickup truck is down, there is an unsecured crate of 15 kg sitting on the pickup truck. The coeff. of static friction between the crate and the truck is 0.7. If the truck accelerates at 7 m/s^2 , will the crate fall off? Why?

The crate will fall off. Max static friction is $mg\mu$, which is $0.7 * 15 * 9.8$, which is 102.9 N. The force needed to accelerate the crate with the truck is $F = ma = 15 * 7$, which is 105 N. That means static friction is not enough!



4 - Springs and Pulleys

Springs

- **Springs**

- Springs are coils of metal that can both compress and stretch
- Each spring has a unique spring constant that depends on the properties of the spring

- **Spring force**

- All springs have a resting length, and so always resist changes in length, wanting to return to the resting length
- This resistive force is called the restoring force, and is always proportional to the amount of stretch or compression
- $F_s = -kx$
- k is the spring constant and the negative sign is because the spring force is a resistive force

- A spring has a spring constant of 100 N/m and is stretched by 5 cm. What is the direction and magnitude of the restoring force?

$$5 \text{ cm} = 0.05 \text{ m} \quad 0.05 * 100 = 5\text{N}$$

Spring Problems

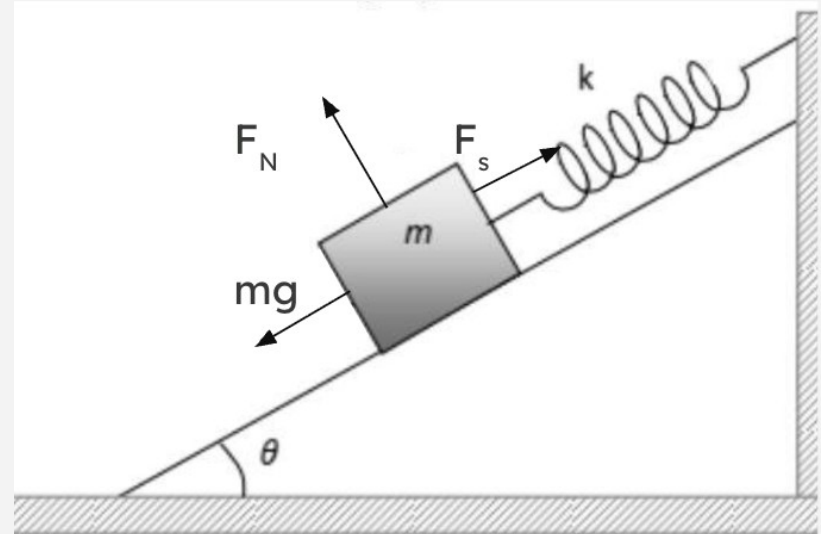
● Example Problem

- A block of mass 30 kg is on a frictionless slope 45 degrees above the horizon and attached to a spring of constant 250 N/m. If block is at rest, how far is the spring stretched by? Draw a free body diagram first.

$$x = 0.83\text{m}$$

$$F_s - F_g = ma = 0 \Rightarrow F_s = F_g$$

$$30 \cdot 9.8 \cdot \sin 45 = 250 \cdot x$$
$$x = 0.83\text{m}$$





Pulleys

- **Tension**

- Tension is the force transmitted through a string, rope, or cable
- Along the rope and always away from the object it's pulling
- It can only be in *tension* and holds no compressive resistance

- **Pulleys**

- Pulleys only change the direction of force, they don't influence it
- Direction of force becomes CW and CCW
- Frictionless and massless wheel with a frictionless and massless rope/string that cannot stretch

- **Spring Scales**

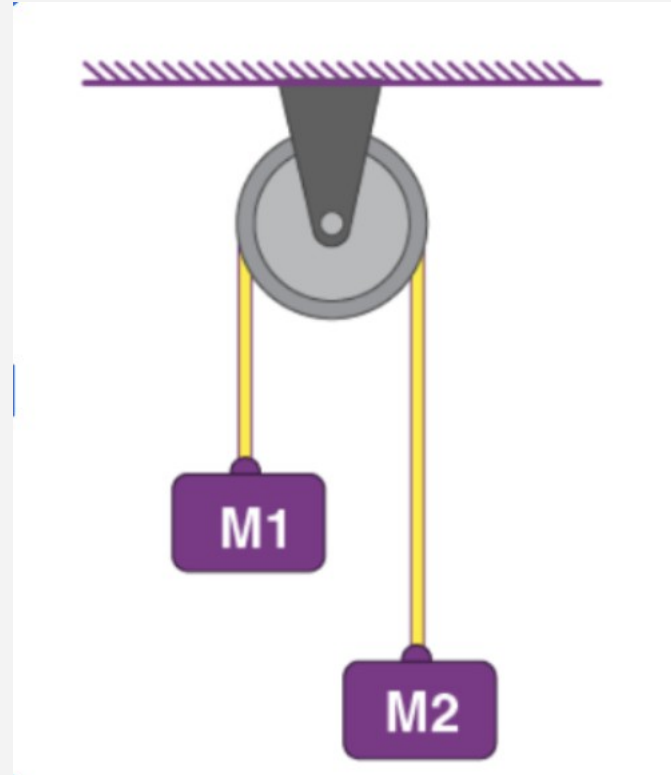
- Uses an internal spring to measure tension
- Has nothing to do with spring calculations

- **Atwood Machine**

- A simple rope-pulley system with blocks connected by ropes
 - The motion of an Atwood machine is typically induced by gravity
- 

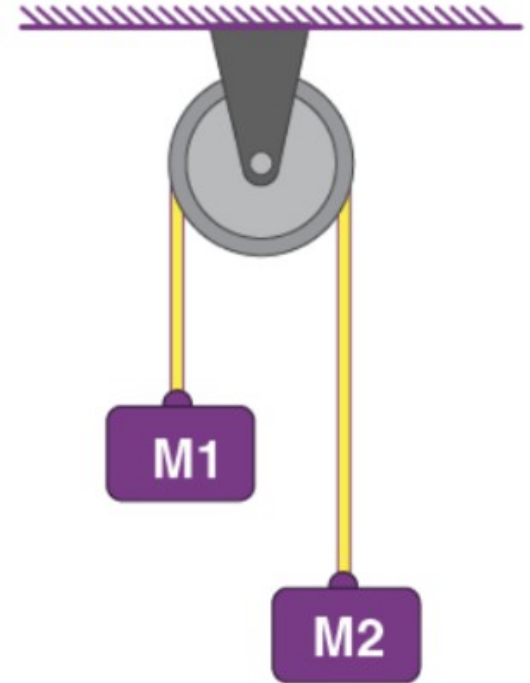
Basic Atwood machine

- 180 degree change in force direction
- Internal vs external force
 - Depends on system
 - Internal forces are forces within the system that exert itself between objects within the system
 - Newton's 3rd law
 - External forces are forces exerted from outside the system
 - If system is rope blocks and pulley, then rope is an internal force and gravity is an external force



Basic Atwood machine

- Assume M_1 is 5 kg and M_2 is 3kg
- Atwood machine Questions
 - Solve for acceleration (same for both blocks)
 - 2 methods:
 - System of equations
 - Internal forces



Pulley Problems

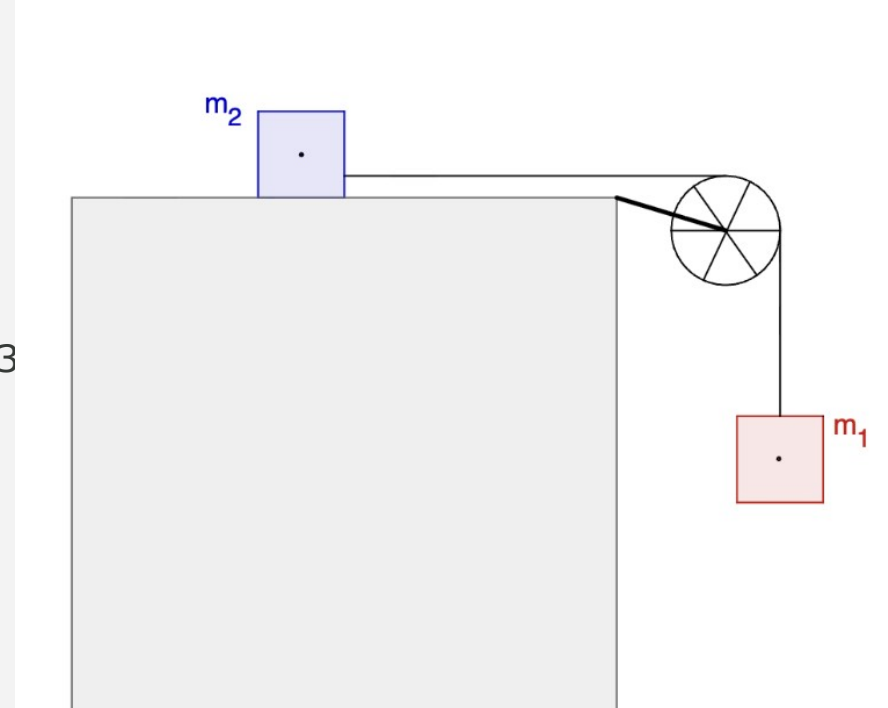
- Two blocks are connected with an ideal string pulley system. Mass 2 of 5kg is on a frictionless plane, and mass 1 of 10 kg is hanging in the air. What is the acceleration of the system?

$$(m_1 + m_2)a = m_1g \quad a = (m_1)g/(m_1+m_2) = 6.53$$

- What is the acceleration of the system if the coefficient of kinetic friction between mass 2 and the surface is 0.4?

$$F_f = \mu_k mg = 0.4 * 5 * 9.8 = 19.6\text{N}$$

$$m_1g - F_f = (m_1 + m_2) a \quad a = 5.23 \text{ m/s}^2$$



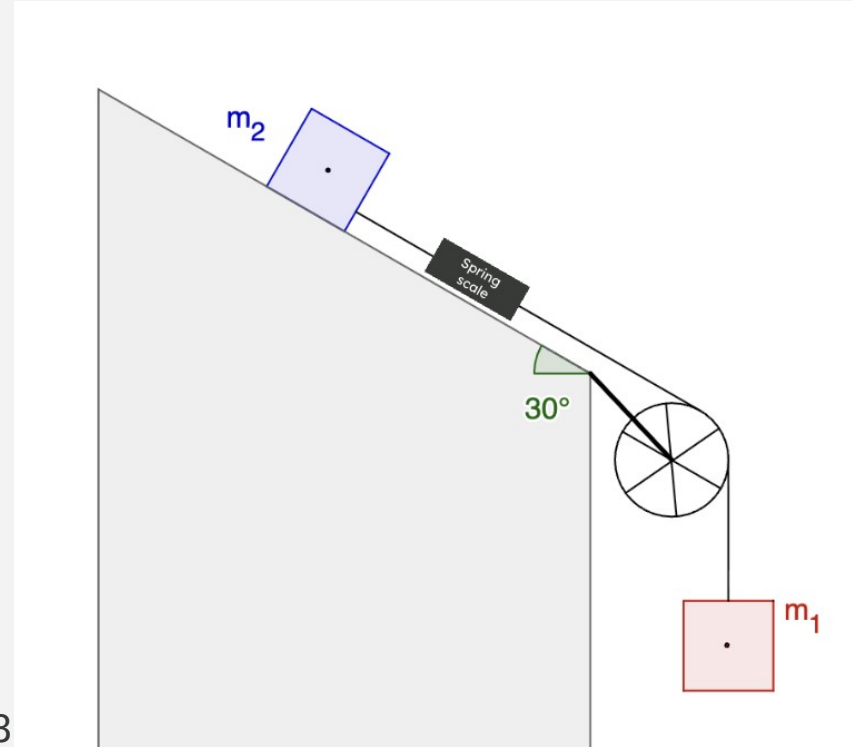
Pulley Problems P2

- Two blocks are connected with an ideal string pulley system. Mass 2 of 6 kg is on a frictionless slope 30 degrees above the horizontal, and mass 1 of 12 kg is hanging in the air. What is the acceleration of the system?

$$m_1g + m_2g\sin 30 = ma \quad a = 4.9 \text{ m/s}^2$$

- What is the reading on the spring scale that is on the string connecting the blocks?

$$m_1g - T = m_1a \quad T = m_1(g - a) = 4.9 * 12 = 58.8$$



**See you next
class!**