Torque and Simple Machines

7.4

Objectives

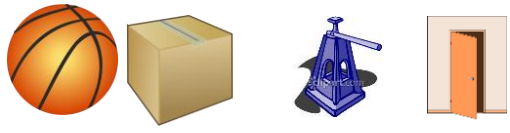
- **Distinguish** between torque and force.
- **Calculate** the magnitude of a torque on an object.
- **Identify** the six types of simple machines.
- **Calculate** the mechanical advantage of a simple machine.

Rotational Motion

- This is the motion of an object that is rotating about its center of mass
  - The center of mass does not always have to be in the center of the object
    - Examples…
    - Football
    - Bowling pin

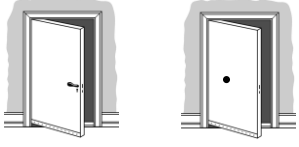
The magnitude of Torque

- **Torque** is a quantity that measures the ability of a force to rotate an object around some axis.
- The axis of rotation is the axis the objects rotates around
  - Identify the axis of rotation for…



The Magnitude of Torque

- How easy, or hard, it is to make an object rotate depends on 2 things…
  - Force applied
  - Distance from axis of rotation
- Think about opening a door



The Magnitude of Torque

- The **lever arm** is the distance along the "lever"
  - How far away the force is from the axis of rotation

Torque Equation

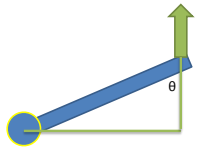
$$\tau = Fd\sin\theta$$

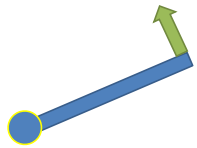
$$Torque\ (N*m) = Force(N) * perp\ dist.(m)$$

- How much torque is applied to a door if you apply 100 N of force at a distance of 150 cm from the axis?

Torque

- Torque does not always have to be applied perpendicular to an object to make it rotate





the direction of the lever arm ($d \sin \theta$) is always **perpendicular** to the direction of the applied force, as shown here.

Think about removing lug nuts

The Sign of Torque

- Torque is a **vector** quantity. We will assign each torque a positive or negative sign, depending on the direction the force tends to rotate an object.
- Torque is **positive** if the rotation is **counterclockwise** and **negative** if the rotation is **clockwise.**

Multiple forces

- To determine the sign of a torque, imagine that the torque is the only one acting on the object and that the object is free to rotate. Visualize the direction that the object would rotate. If more than one force is acting, treat each force separately.

$$\tau_{net} = \tau_1 + \tau_2 + \text{etc.}$$

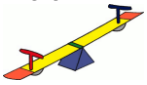
Make sure to watch the Torque Math Help Video

Simple Machines

- A **machine** is anything that modifies <u>force</u> produced
  - Usually by changing the force required
- There are 6 simple machines
  1. Lever
  2. Pulley
  3. Incline Plane
  4. Wheel and Axle
  5. Wedge
  6. Screw

Simple Machines

Lever



Pulley

Incline Plane

Wheel and Axle

Wedge

Screw

Simple Machines

- A simple machine will change the direction or force or the magnitude of force
- We use the **mechanical advantage** to determine a machines advantage
- If friction is disregarded…

$$MA = \frac{F_{out}}{F_{in}} = \frac{d_{in}}{d_{out}}$$

Machines can alter F and d

Efficiency

- The **efficiency** of a machine is the ratio of useful work output to work input

$$eff = \frac{W_{out}}{W_{in}} x100$$

- Because of friction, all machines in the "real world" have an efficiency less than 100%

Make sure to watch the Mechanical Advantage and Efficiency Math Help Video