# Science 9 Physics

## CHAPTER 13: WORK AND ENERGY

## MR. MILLER

# WORK

Work: The transfer of energy to an object by the application of a force that causes the object to move in the direction of the force.

# WORK

- Work is done ONLY when a force moves an object
- Work is a force acting over a distance
- If an object does NOT move when a force is applied to it, no work is done

# WORK

Is any work being done in the following situation?

A teacher applies a force to a wall and becomes exhausted.

# WORK

Is any work being done in the following situation?

A book falls off a table and free falls to the ground.

# WORK

Is any work being done in the following situation?

A rocket accelerates through space.

# WORK

Is any work being done in the following situation?

A waiter carries a tray full of meals above his head by one arm across the room.

# WORK

$$W = Fd$$

Measured in Joules (J)

# WORK

A crane uses an average force of 5,200 N to lift a girder 25 m.

How much work does the crane do on the girder?

# POWER

Power: A quantity that measures the rate at which work is done or energy is transformed

# POWER

- HOW FAST work is being done
- The same amount of work done faster will produce more power
- Power is the amount of work done in a certain amount of time

# POWER

$$P = \frac{W}{t}$$

Measured in Watts (W)

# POWER

While rowing across the lake during a race, John does 3,960 J of work on the oars in 60.0 seconds.

What is his power output?

# MACHINES AND MECHANICAL ADVANTAGE

- How do machines make work easier?

- Machines help do work by changing the size of an input force, the direction of the force, or both.

# MACHINES AND MECHANICAL ADVANTAGE

- Mechanical advantage is an important ratio.

- **mechanical advantage:** a quantity that expresses how much a machine multiplies force or distance

$$mechanical\ advantage = \frac{output\ force}{input\ force} = \frac{input\ distance}{output\ distance}$$

# MECHANICAL ADVANTAGE

$$mechanical\ advantage = \frac{output\ force}{input\ force} = \frac{input\ distance}{output\ distance}$$

No units for Mechanical Advantage.
It is a ratio.

# MATH SKILLS

Calculate the mechanical advantage of a ramp that is 5.0 m long and 1.5 m high.

$$\textit{mechanical advantage} = \frac{\textit{input distance}}{\textit{output distance}}$$

mechanical advantage = $\frac{5.0\ \text{m}}{1.5\ \text{m}} = 3.3$

# MATH SKILLS

Alex pulls on a handle of a claw hammer with a force of 15 N. If the hammer has a mechanical advantage of 5.2, how much force is exerted on the nail in the claw?

$$mechanical\ \ advantage = \frac{output\ \ force}{input\ \ force}$$

$$5.2 = \frac{output\ \ force}{15}$$

$$78\ \ N = output\ \ force$$

# WHAT ARE SIMPLE MACHINES?

- What are the six types of simple machines?
- The six types of simple machines are the simple lever, the pulley, the wheel and axle, the simple inclined plane, the wedge, and the screw.

# WHAT ARE SIMPLE MACHINES?, *CONTINUED*

- Simple machines are divided into two families: the *lever family* and the *inclined plane family.*

**Lever family:**

- **simple lever**
- **pulley**
- **wheel and axle**

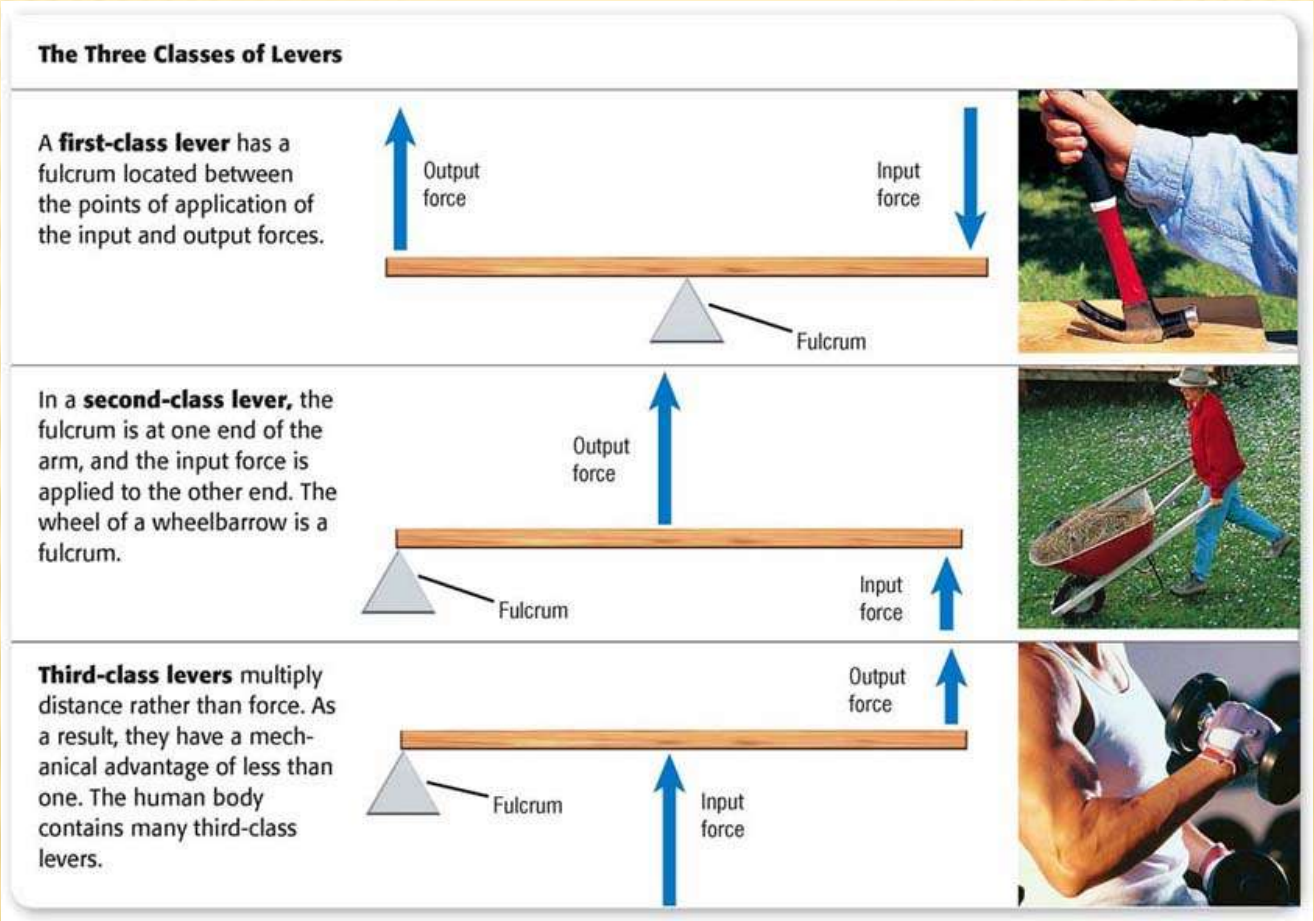
**Inclined plane family:**

- **simple inclined plane**
- **wedge**
- **screw**

# THE LEVER FAMILY

- What are the two principal parts of all levers?
- All levers have a rigid arm that turns around a point called the fulcrum.
- Levers are divided into three classes.

# THE LEVER FAMILY, *CONTINUED*



# VISUAL CONCEPT: LEVER

Lever Movie

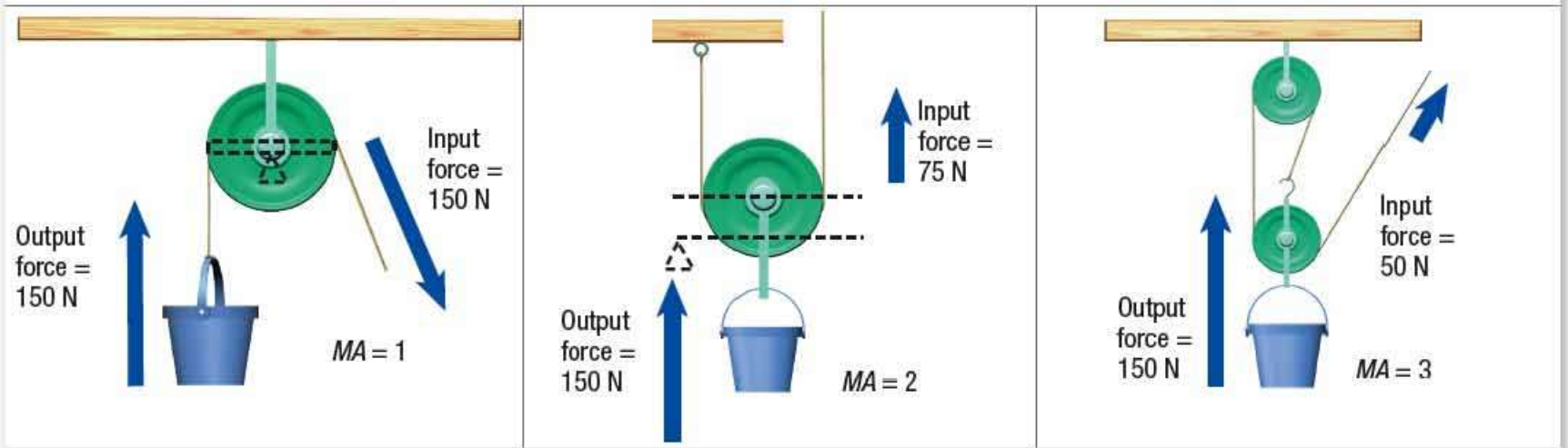
# THE LEVER FAMILY, *CONTINUED*

- Pulleys are modified levers.
  - The point in the middle of a pulley is like the fulcrum of a lever.
  - The rest of the pulley behaves like the rigid arm of a first-class lever.

- A wheel and axle is a lever or pulley connected to a shaft.
  - Screwdrivers and cranks are common wheel-and-axel machines.

# THE MECHANICAL ADVANTAGE OF PULLEYS

**The Mechanical Advantage of Pulleys**




When a 150 N weight is lifted by using a single, fixed pulley, the weight must be fully supported by the rope on each side of the pulley. This kind of pulley has a mechanical advantage of one.

When a moving pulley is used, the load is shared by two sections of rope pulling upward. The input force supports only half of the weight. This pulley system has a mechanical advantage of two.

In this arrangement of multiple pulleys, all of the sections of rope are pulling up against the downward force of the weight. This arrangement gives an even higher mechanical advantage.

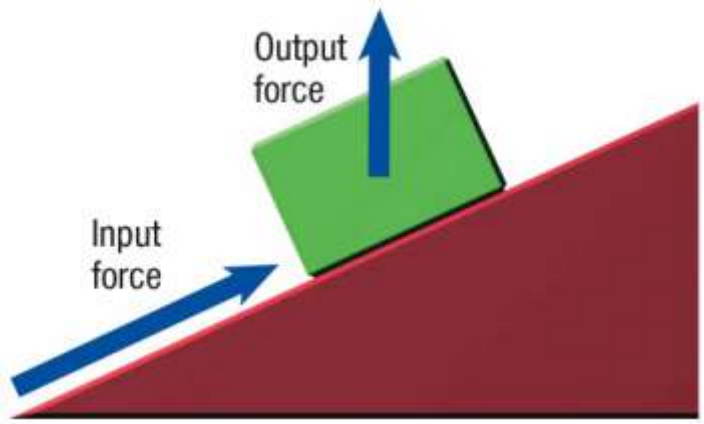
# VISUAL CONCEPT: PULLEY

Pulley Movie

# THE INCLINED PLANE FAMILY

- How does using an inclined plane change the force required to do work?

- Pushing an object up an inclined plane requires less input force than lifting the same object does.



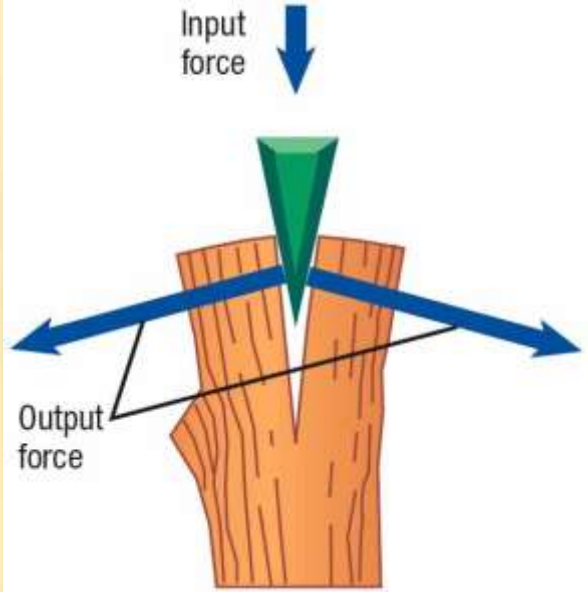
# VISUAL CONCEPT: INCLINED PLANE

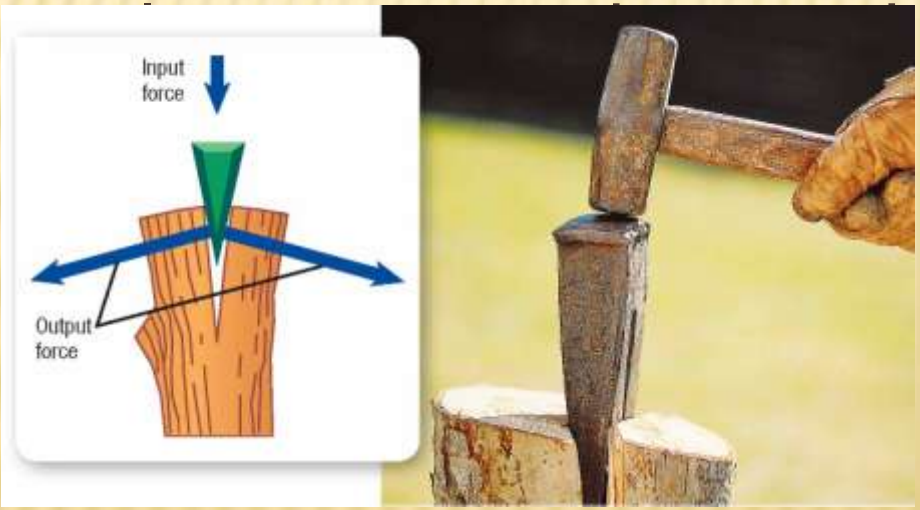
Inclined Plane Movie

# THE INCLINED PLANE FAMILY

- A wedge is a modified inclined plane.

- A screw is an inclined



# VISUAL CONCEPT: SCREWS

Screws Movie

# COMPOUND MACHINES

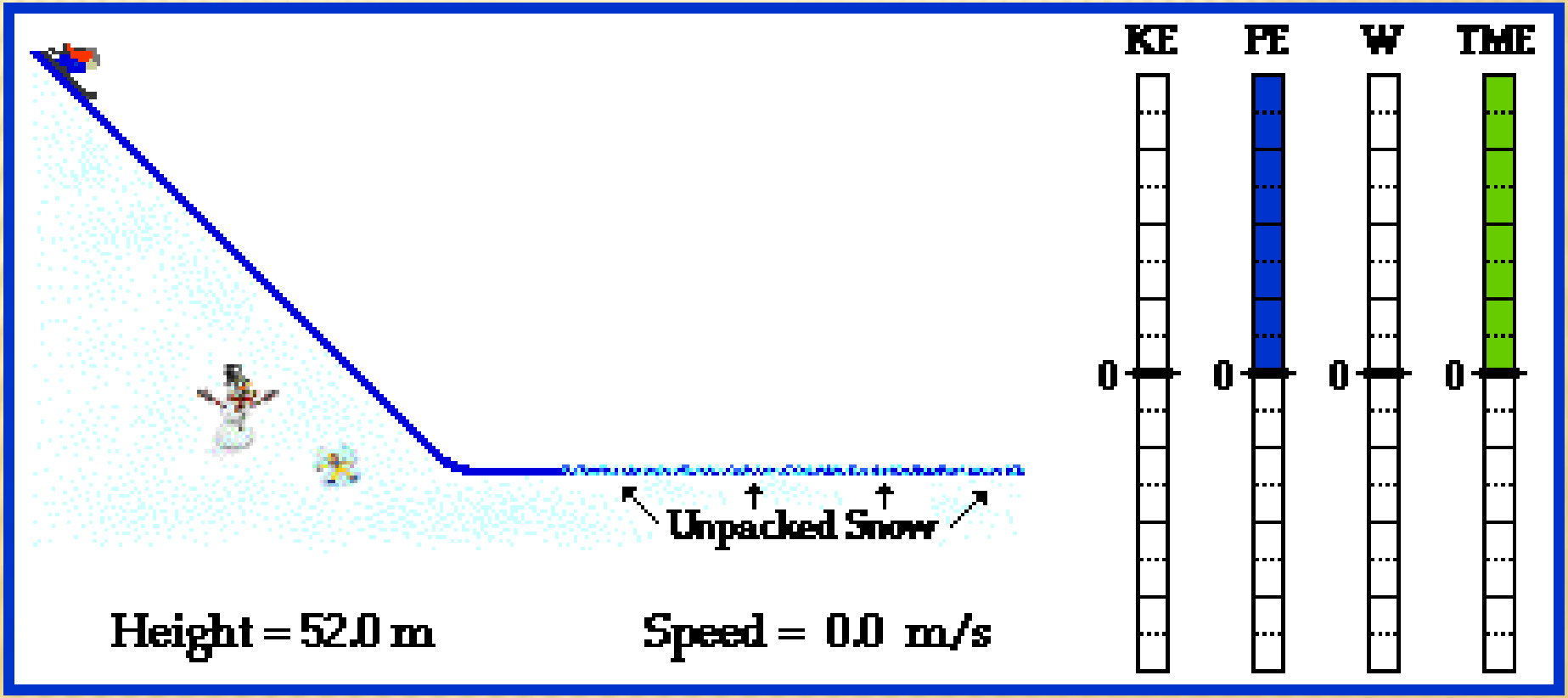
- What simple machines make up a pair of scissors?
- A pair of scissors uses two first-class levers joined at a common fulcrum; each lever arm has a wedge that cuts into the paper.

- **compound machine:** a machine made of more than one simple machine

# CONSERVATION OF ENERGY

Energy cannot be created not destroyed. It can be transformed from one form into another, but the total amount of energy never changes.

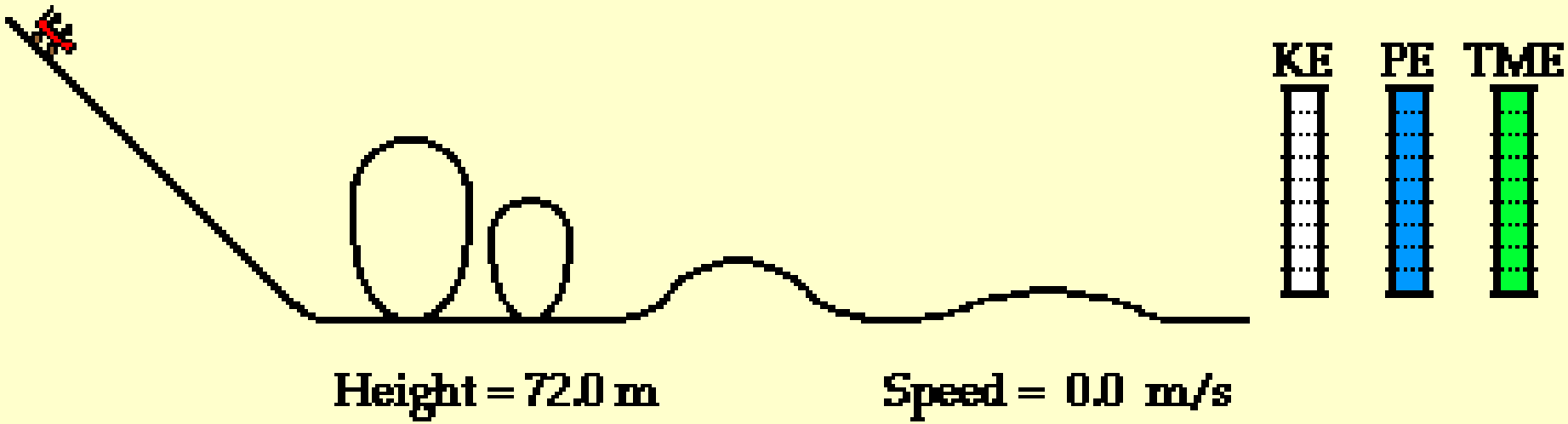
# CONSERVATION OF ENERGY



# Conservation of Energy

Time for a Gizmo!

# CONSERVATION OF ENERGY



# Conservation of Energy

Time for a Gizmo!

# CONSERVATION OF ENERGY

Open System

- A system in which energy and matter are exchanged with it's surroundings.

- Example: Boiling water, Running an engine,

# CONSERVATION OF ENERGY

Closed System

- A system in which energy, not matter, is exchanged with it's surroundings.

- Example: fluid being compressed by a piston in a cylinder

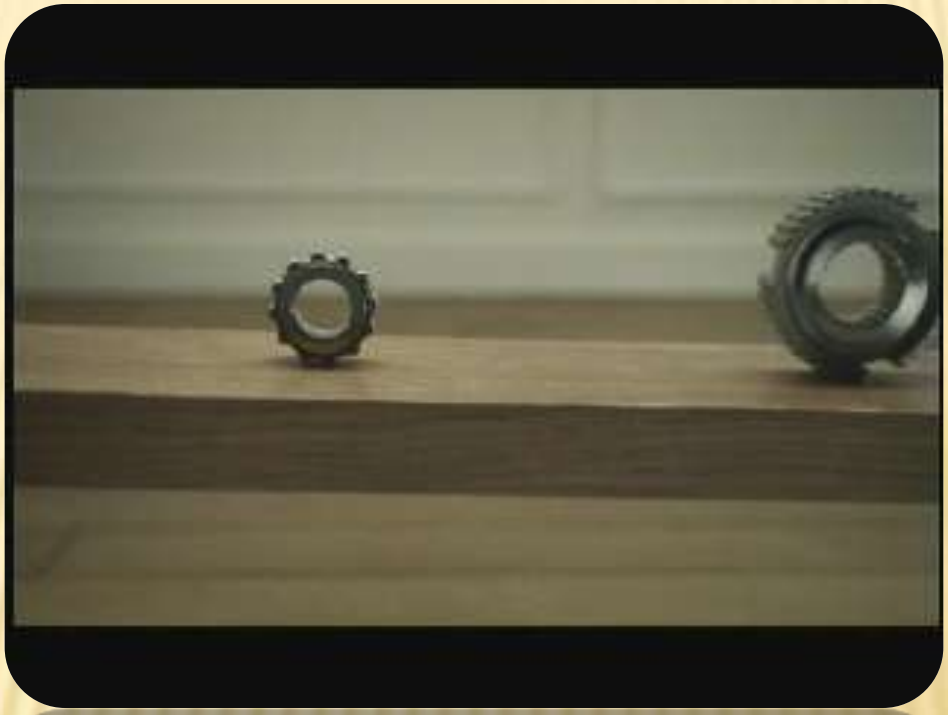
# CONSERVATION OF ENERGY

Isolated System

- A system in which no energy or matter is exchanged with it's surroundings.

- Example: The Universe, no true isolated system

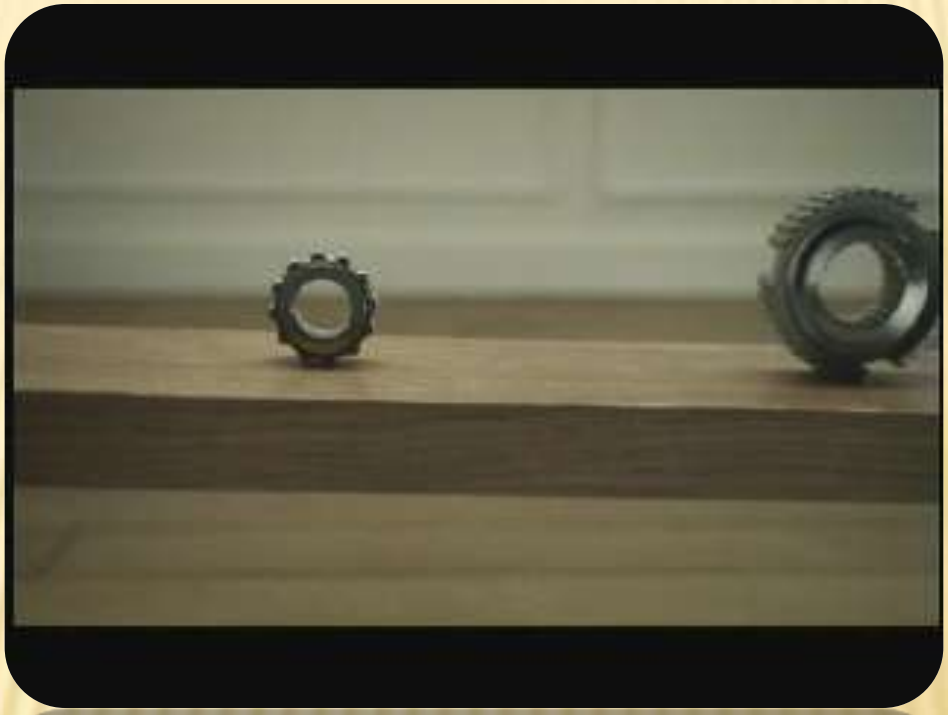
# CONSERVATION OF ENERGY



Honda COG Commercial

The commercial took 606 different takes to complete

# CONSERVATION OF ENERGY



Making of the Honda COG Commercial

# EFFICIENCY OF MACHINES

- Only a portion of the work done by any machine is *useful work*

- *Useful work*- work that the machine is designed or intended to do

# EFFICIENCY OF MACHINES

Efficiency of a machine is a measure of how much useful work a machine can do

$$efficiency = \frac{useful\ work\ output}{work\ input}$$

# EFFICIENCY OF MACHINES

To change an answer found by using the efficiency equation into a percentage, multiply the answer by 100 and then add the percent sign (%).

$$efficiency = 0.67$$

$$0.67 \times 100 = 67\%$$

# MATH SKILLS

Alice and Jim caluclate that they must do 1,800 J of work to push a piano up a ramp. However, because they must overcome friction, they actually must do 2,400J of work. What is the efficiency of the ramp?

$$efficiency = \frac{useful\ work\ output}{work\ input}$$

$$efficiency = \frac{1800\ \text{J}}{2400\ \text{J}}$$

$$efficiency = .75$$

$$.75 \times 100 = 75\%$$

# EFFICIENCY OF MACHINES

*Perpetual Motion Machine* is a machine designed to keep going forever without any input of energy.

*Perpetual Motion Machine* will only work in absence of friction and air resistance, a condition not found in this world.

# EFFICIENCY OF MACHINES

*Perpetual Motion Machine* will only work in absence of friction and air resistance, a condition not found in this world.

# EFFICIENCY OF MACHINES

*Perpetual Motion Machine Movie*