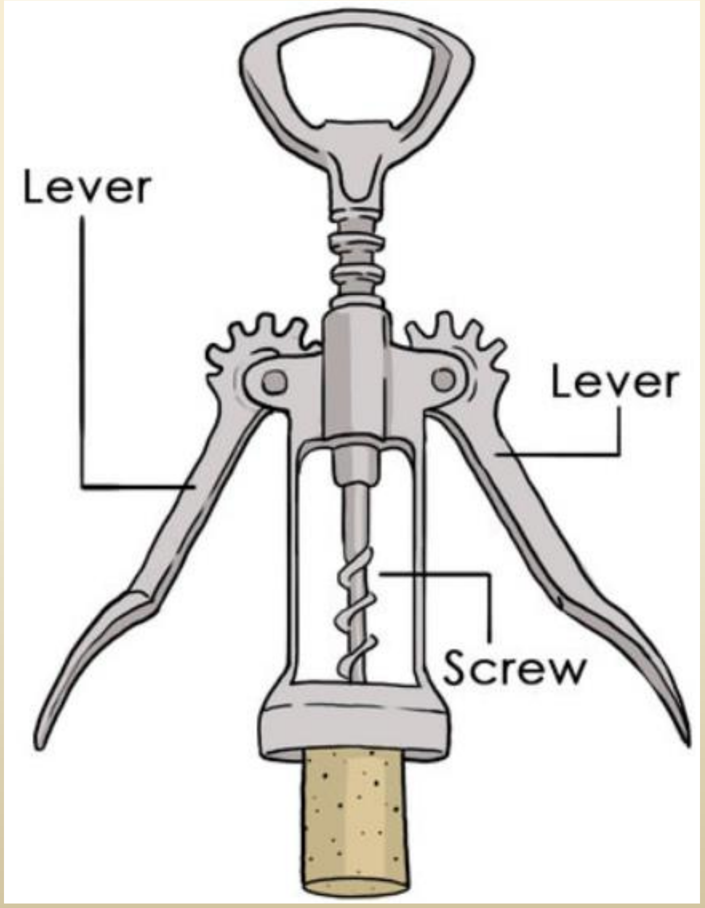
Machines



Chapter
14B

WARM-UP

A tractor exerts a force of 20,000 newtons to move a trailer 8 meters. How much work was done on the trailer?

A

G

E

S

A tractor exerts a force of 20,000 newtons to move a trailer 8 meters. How much work was done on the trailer?

A work (W)

G f = 20,000 N; d = 8 m

E W = f x d

S W = 20,000 N x 8 m = **160,000 J**

WARM-UP

A car exerts a force of 500 newtons to pull a boat 100 meters in 10 seconds. How much power does the car use?

A

G

E

S

WARM-UP

A car exerts a force of 500 newtons to pull a boat 100 meters in 10 seconds. How much power does the car use?

A Power (P in watts)

G f = 500 N; d = 100 m; t = 10 s

E **P = W / t W = f x d …. P = f x d / t**

S **P = 500 N x 100 m / 10 s = 5000 watts**

Machines make work easier to do, by changing the size of a ____ needed, the ____ of a force, or the ____ over which a force acts.

WARM-UP

Force and distance are ____ proportional, meaning as one increases, the other ____. For instance, if the force of doing the work is decreased, the distance must ____.

(e.g. wheel chair ramp is much "easier", but much "farther")

There are TWO forces involved in work:

____ **Force** – force needed to do the work on an object (effort force)

Output Force – the force of the object itself (resistance force) … usually the object's **weight**

Input distance *(the distance we apply our effort) and*

Output distance *(how far the resistance moves)*

Machines make work easier to do, by changing the size of a force needed, the direction of a force, or the distance over which a force acts.

Force and distance are inversely proportional, meaning as one increases, the other <u>de</u>creases. For instance, if the force of doing the work is decreased, the distance must increase.

(e.g. wheel chair ramp is much "easier", but much "farther")

There are TWO forces involved in work:

Input Force, f_i, force needed to do the work on an object (effort force)

Output Force, f_O, the force of the object itself (resistance force) … usually the object's **weight.**

Input distance, d_i ,*(the distance we apply our effort) and*

Output distance, d_O ,*(how far the resistance moves)*

LESSON QUESTION

Focus Questions

1. Define and calculate mechanical advantage for the six simple machines.
2. Classify levers by first, second, and third class.
3. Describe and give examples of compound machines.
4. Explain and calculate efficiency of machines.

Mechanical Advantage

Machine give the worker an advantage.

A nutcracker is a machine that **converts the input force applied to it into a larger force** capable of cracking a nut.

Because it increases force, the nutcracker has a mechanical advantage greater than 1.

Mechanical Advantage

- **Machines have actual mechanical advantage of a machine and ideal mechanical advantage.**

  The **mechanical advantage** of a machine is the number of times that the machine increases an input force.

- **Because friction is always present, the actual mechanical advantage of a machine is always less than the ideal mechanical advantage.**

Actual Mechanical Advantage

The mechanical advantage determined by measuring the actual forces acting on a machine is the actual mechanical advantage.

Actual Mechanical Advantage

$$\text{Actual mechanical advantage} = \frac{\text{Output force}}{\text{Input force}}$$

$$AMA = F_O \;/\; F_i$$

Ideal Mechanical Advantage

The **ideal mechanical advantage** (IMA) of a machine is the mechanical advantage in the **absence of friction**.

Because friction reduces mechanical advantage, engineers often design machines that use low-friction materials and lubricants.

Ideal Mechanical Advantage

$$\text{Ideal mechanical advantage} = \frac{\text{Input distance}}{\text{Output distance}}$$

$$IMA = d_i \,/\, d_O$$

Calculating Mechanical Advantage

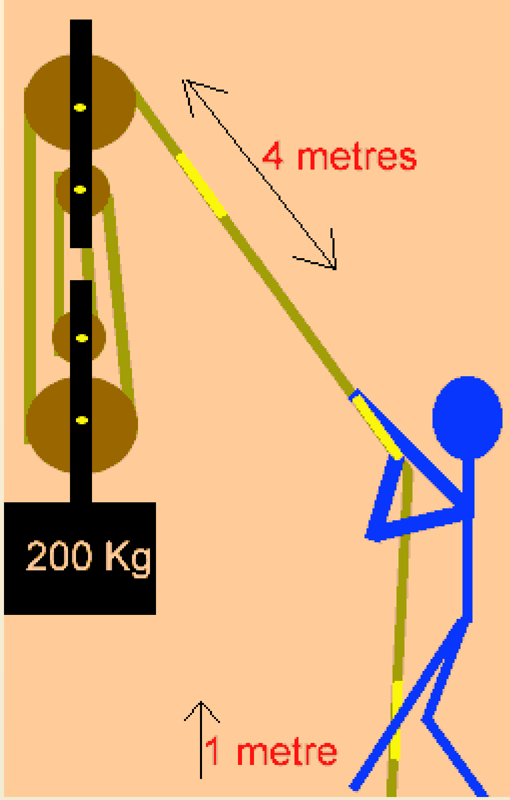
The gondola uses the inclined plane formed by its supporting cable to more easily move people uphill.

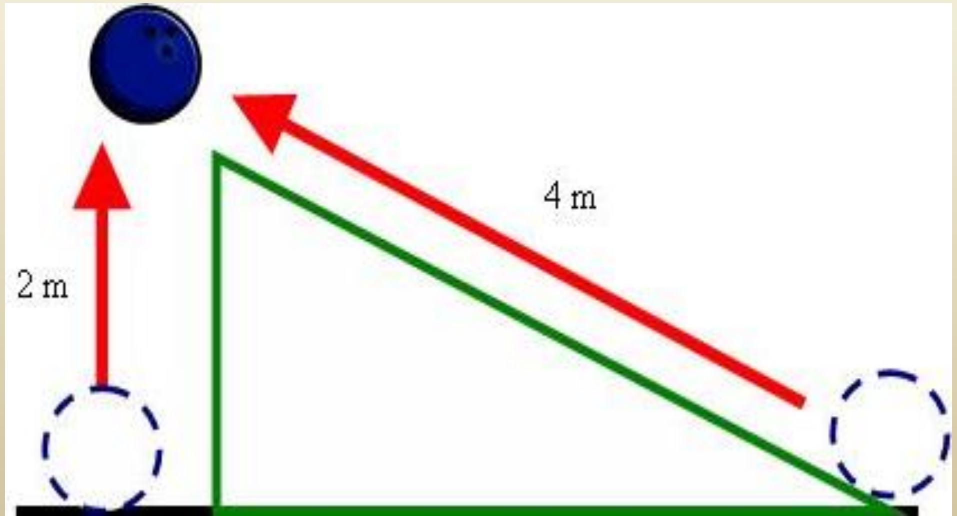
- The increased horizontal distance (input distance) is greater than the vertical gain in height (output distance).
- The inclined cable gives the gondola a mechanical advantage greater than 1.

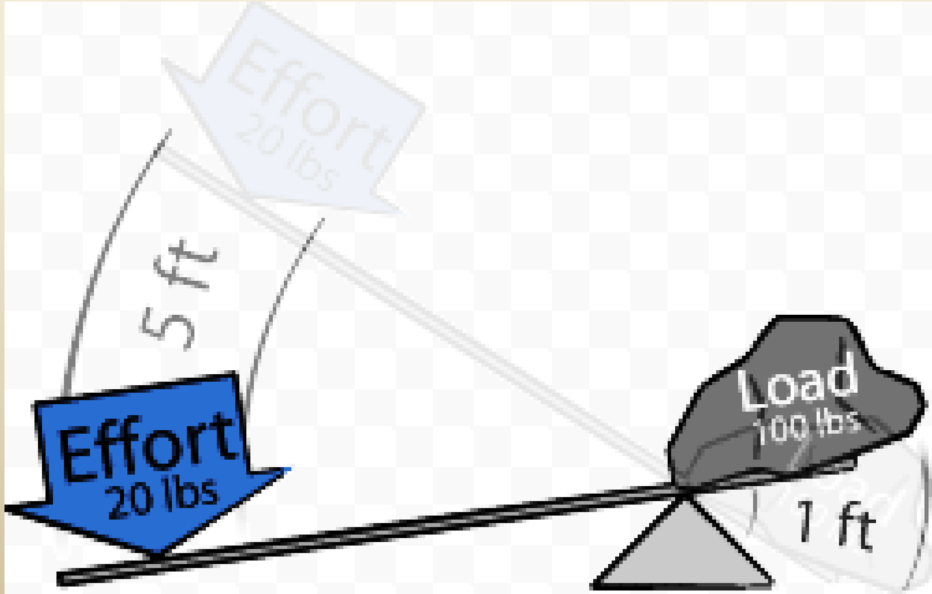
Mechanical Advantage

Why would we want to consider using machines for doing work?

Mechanical Advantage – the advantage a machine provides as we do the work.







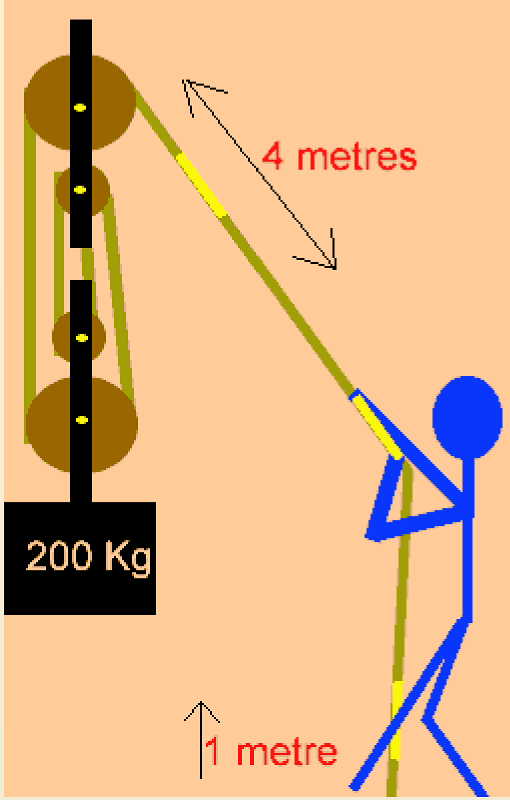
Mechanical Advantage

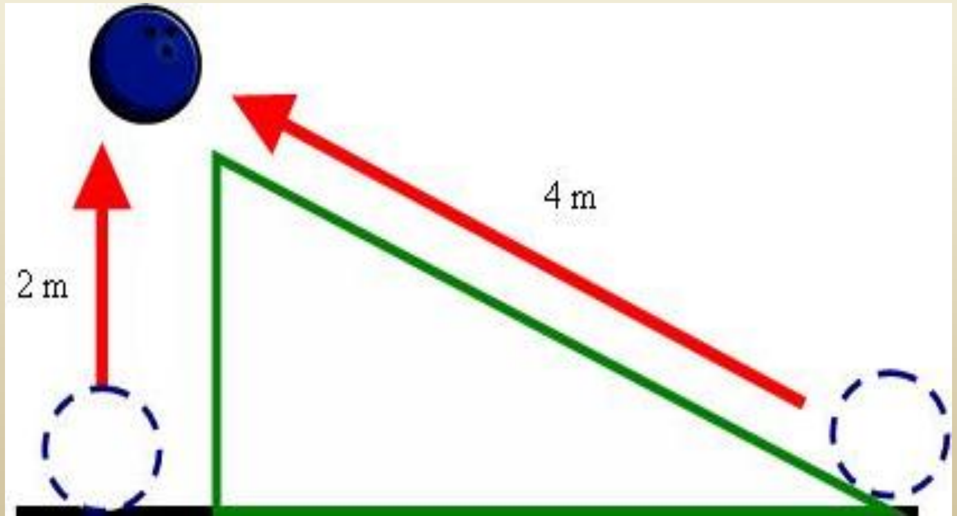
$$MA = d_i / d_O$$

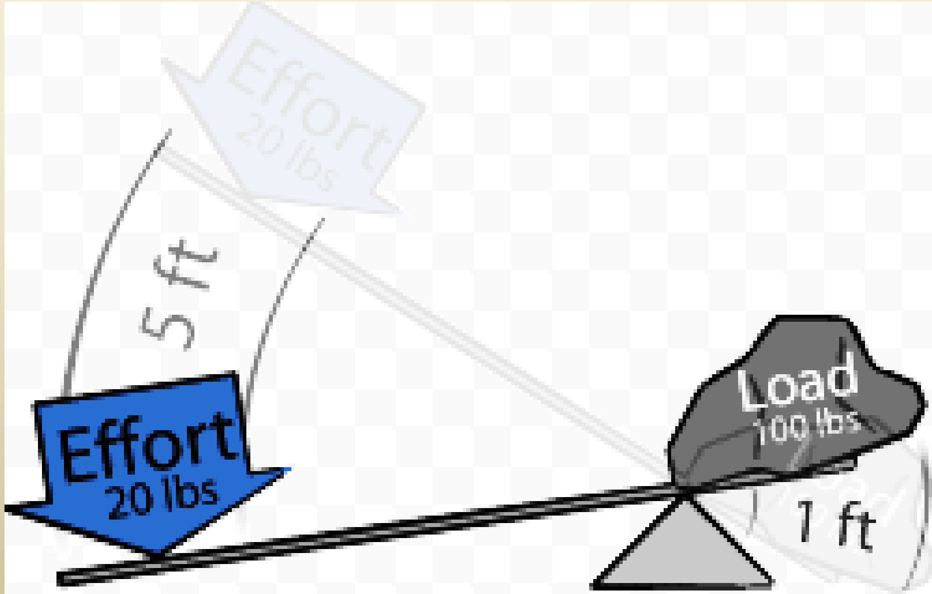
MA = input distance / output distance

MA = effort distance / resistance distance

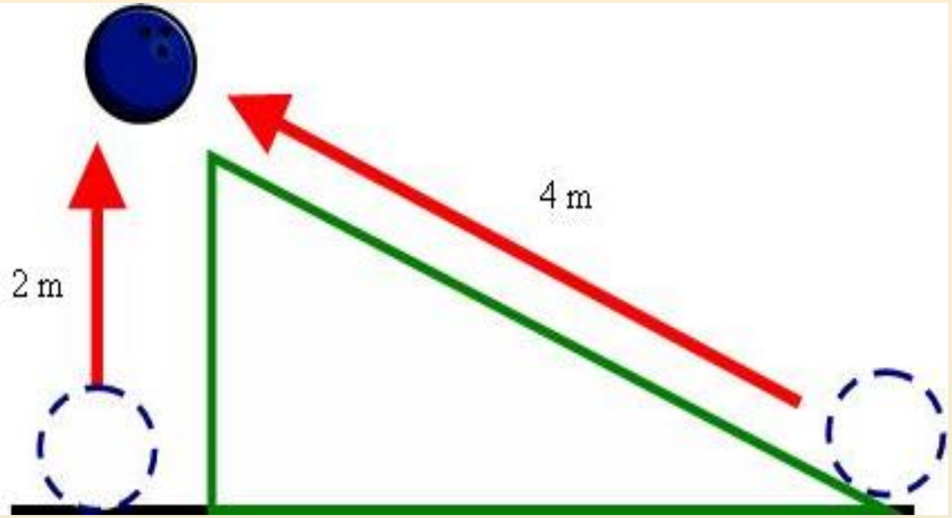
Apply effort over a longer distance, but it is easier (pulley, ramp, screw, see saw)



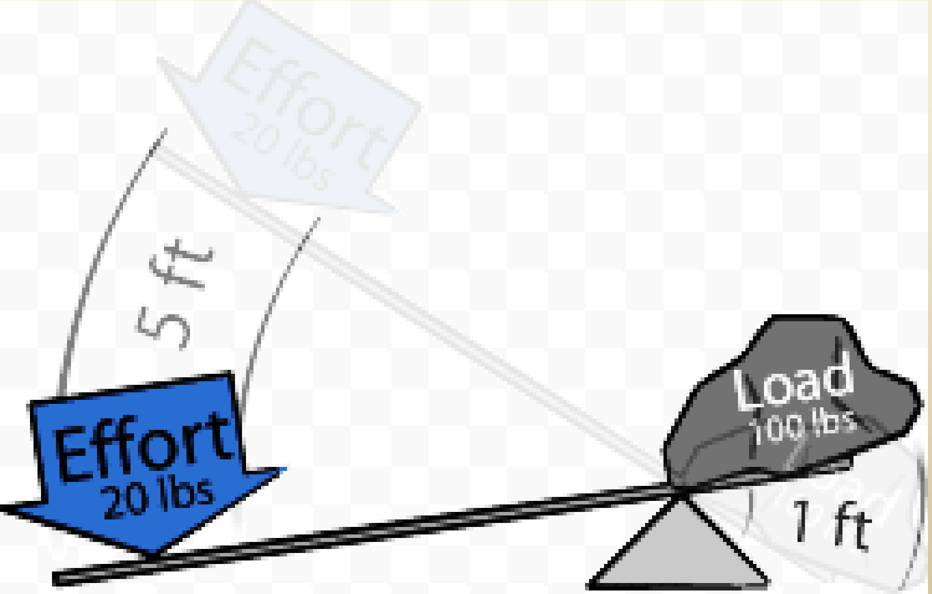


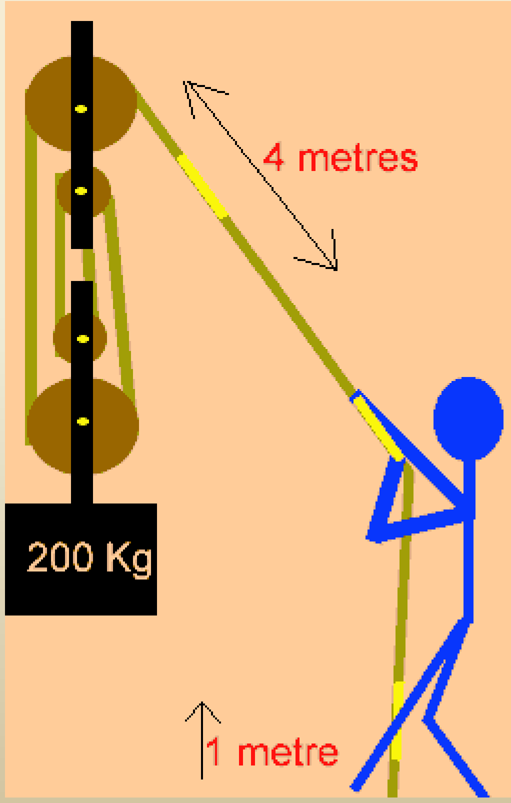


Calculate Mechanical Advantage



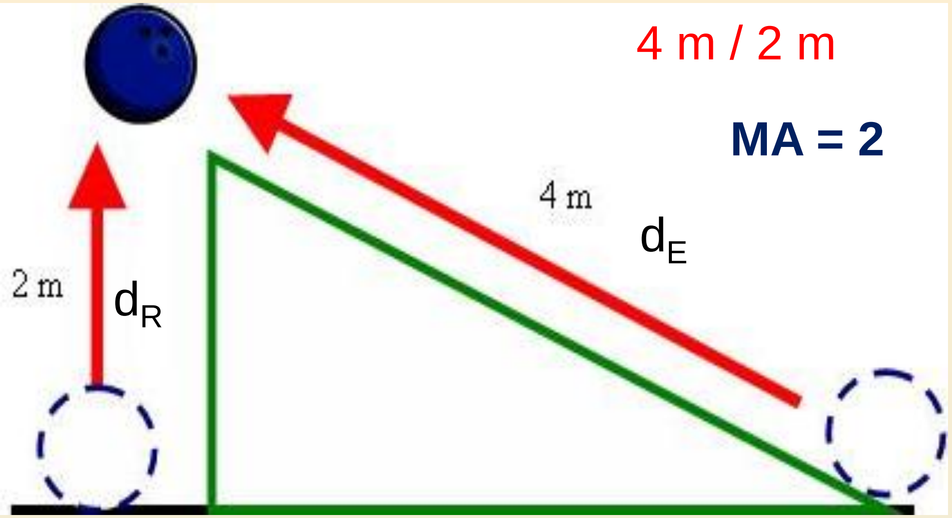
$$MA = d_E / d_R$$





Calculate Mechanical Advantage

QUICK CHECK

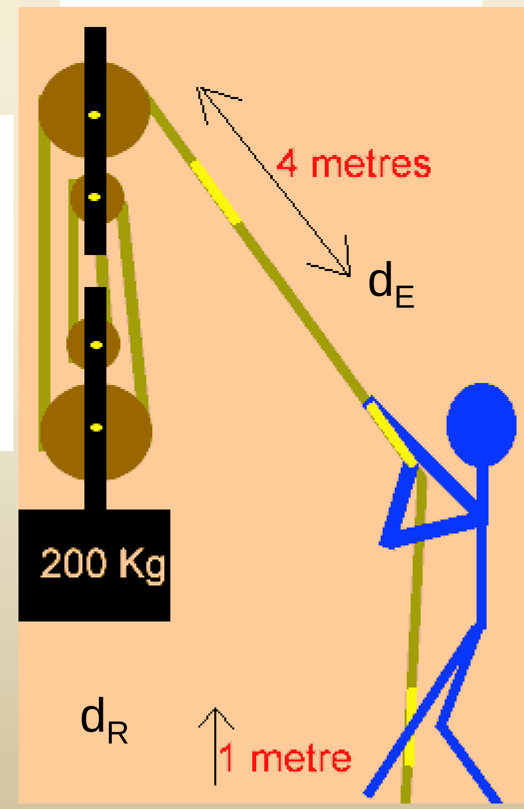


$$MA = d_i / d_O$$

MA = input distance / output distance

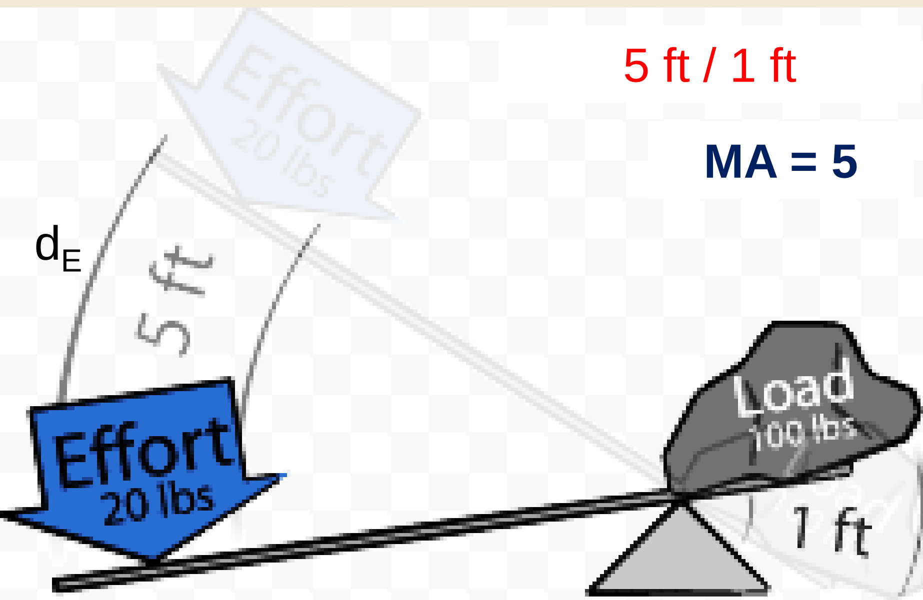
MA = effort distance/resistance distance

4 m / 1 m



MA = 4

For a pulley, MA is equal to the # of ropes supporting the weight (resistance)



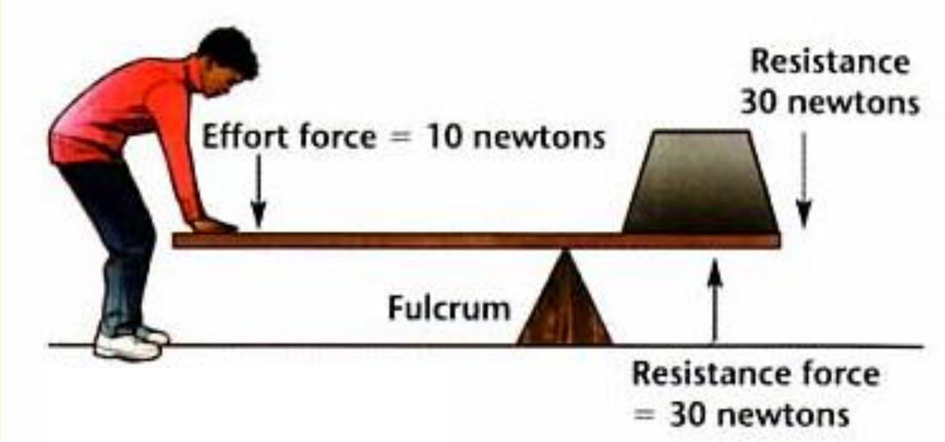
d_R

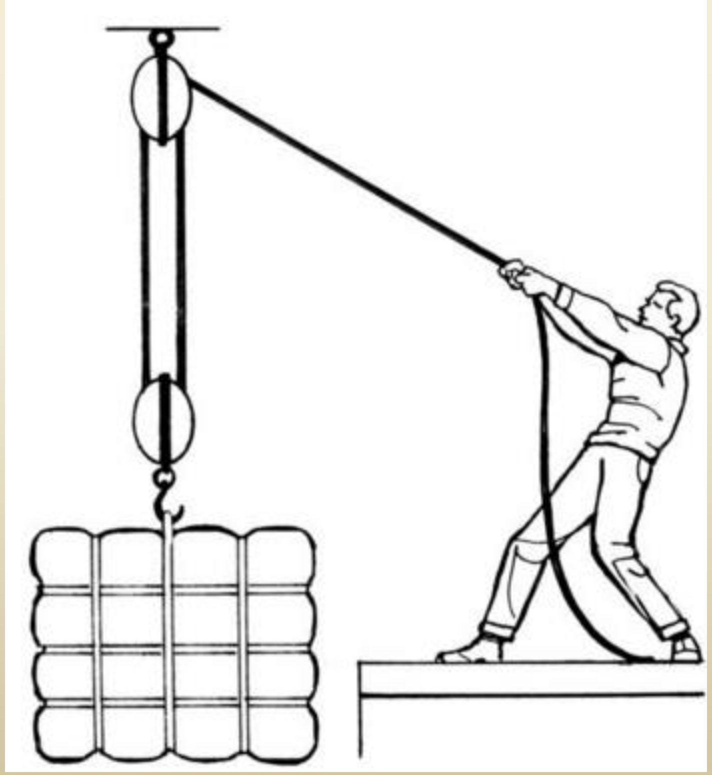
Mechanical Advantage

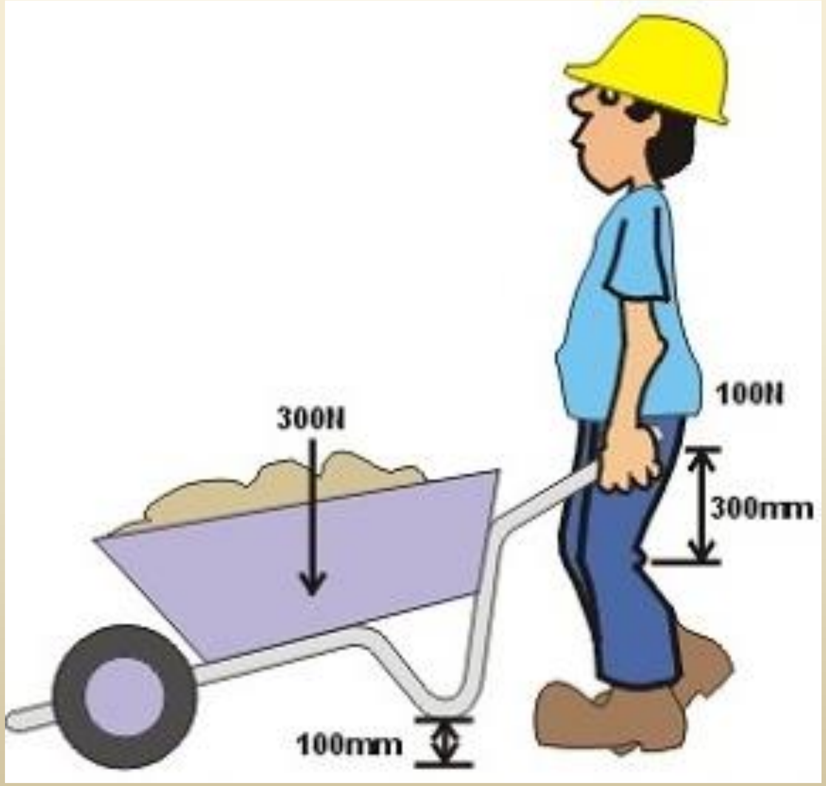
$$MA = F_o \; / \; F_i$$

MA = output force / input force

The effort force is less than the resistance force.



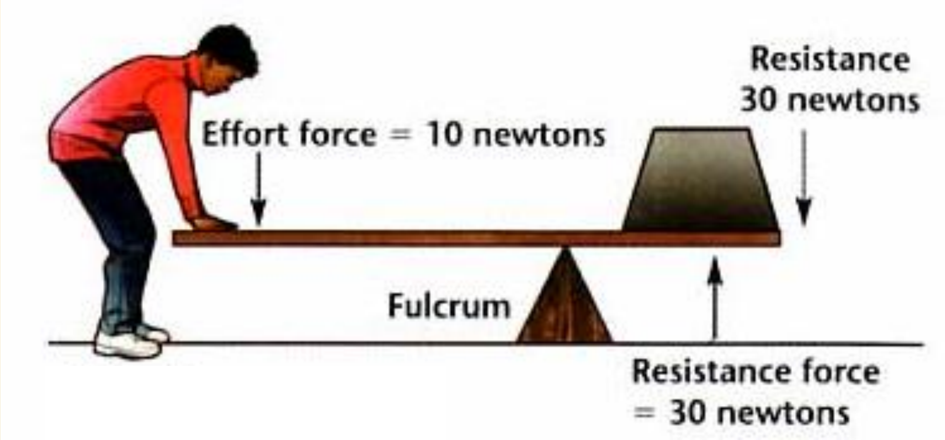


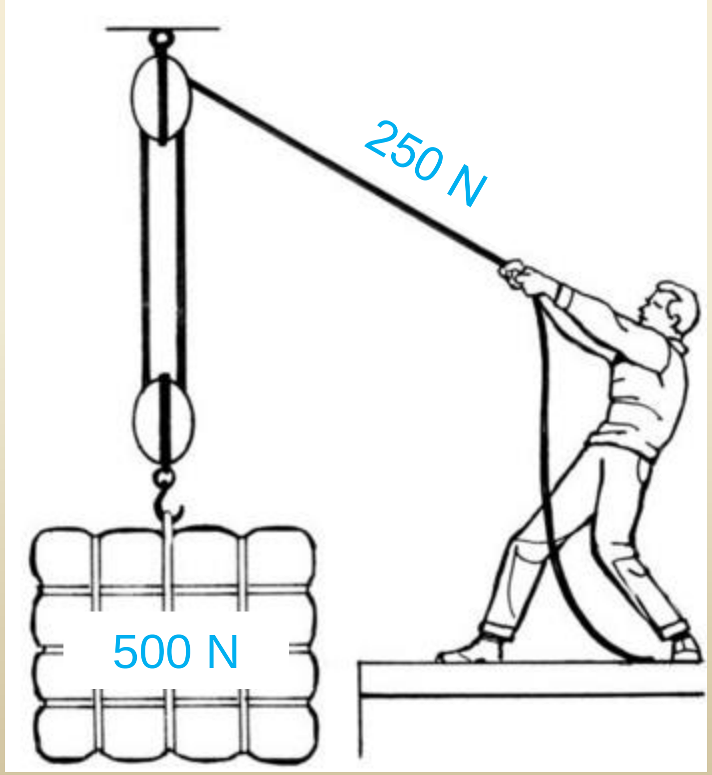


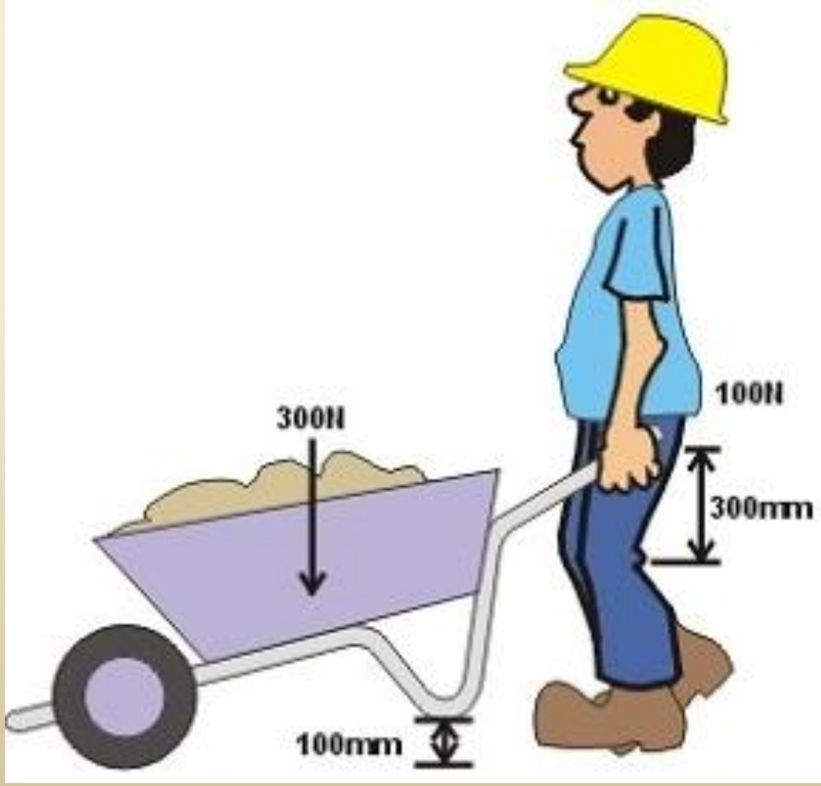
Calculate Mechanical Advantage

$$MA = F_o / F_i$$

Calculate the MA of each simple machine.

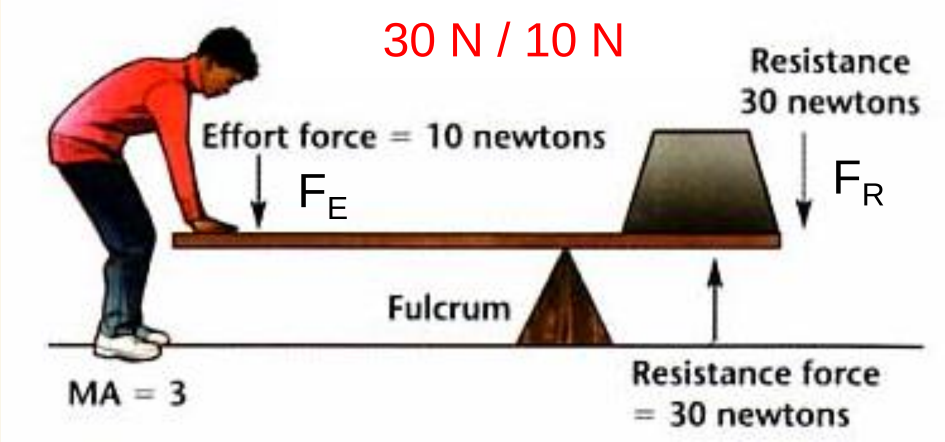


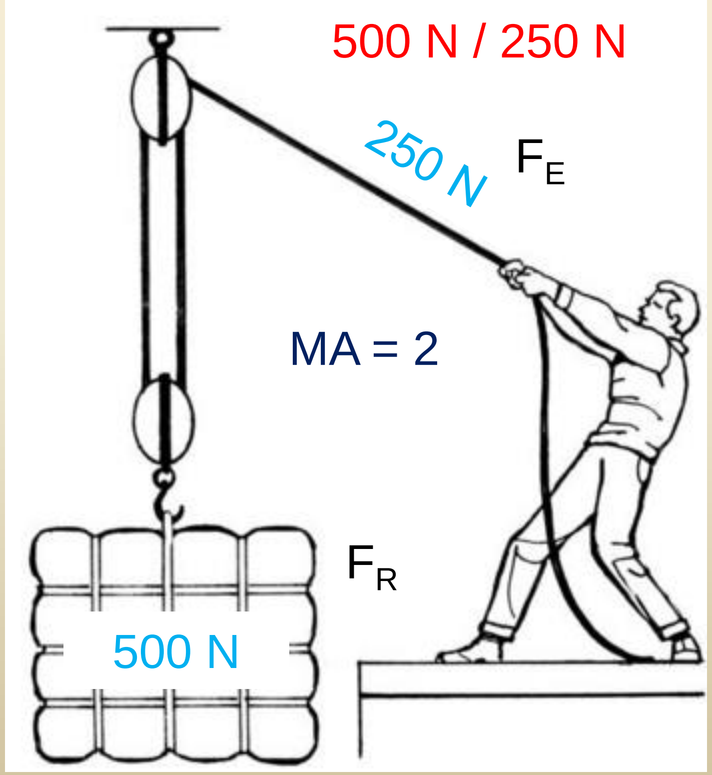


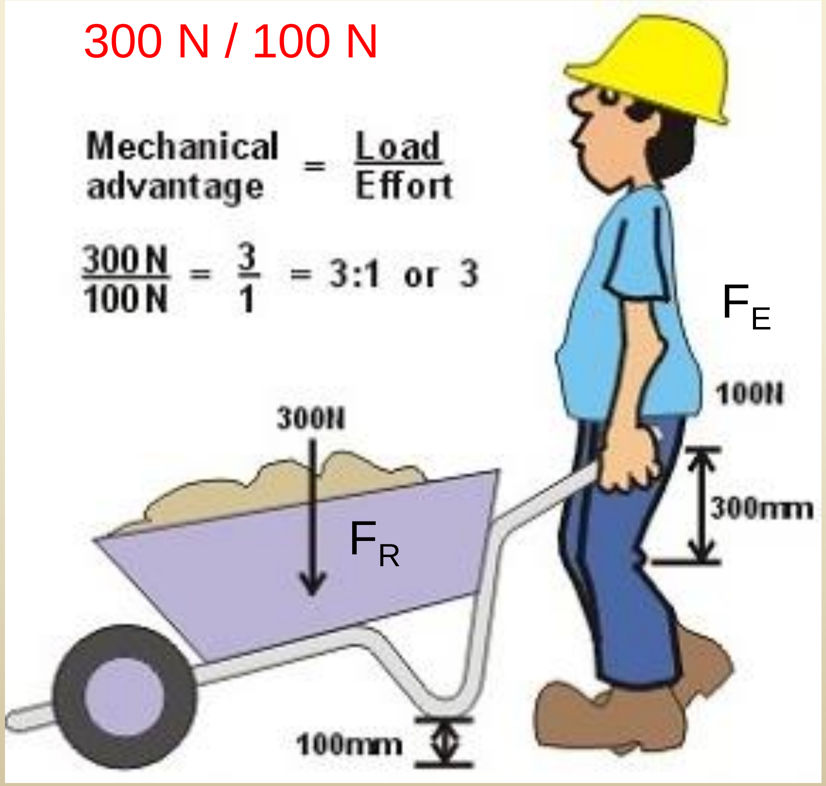


Calculate Mechanical Advantage

$$MA = F_O / F_i$$

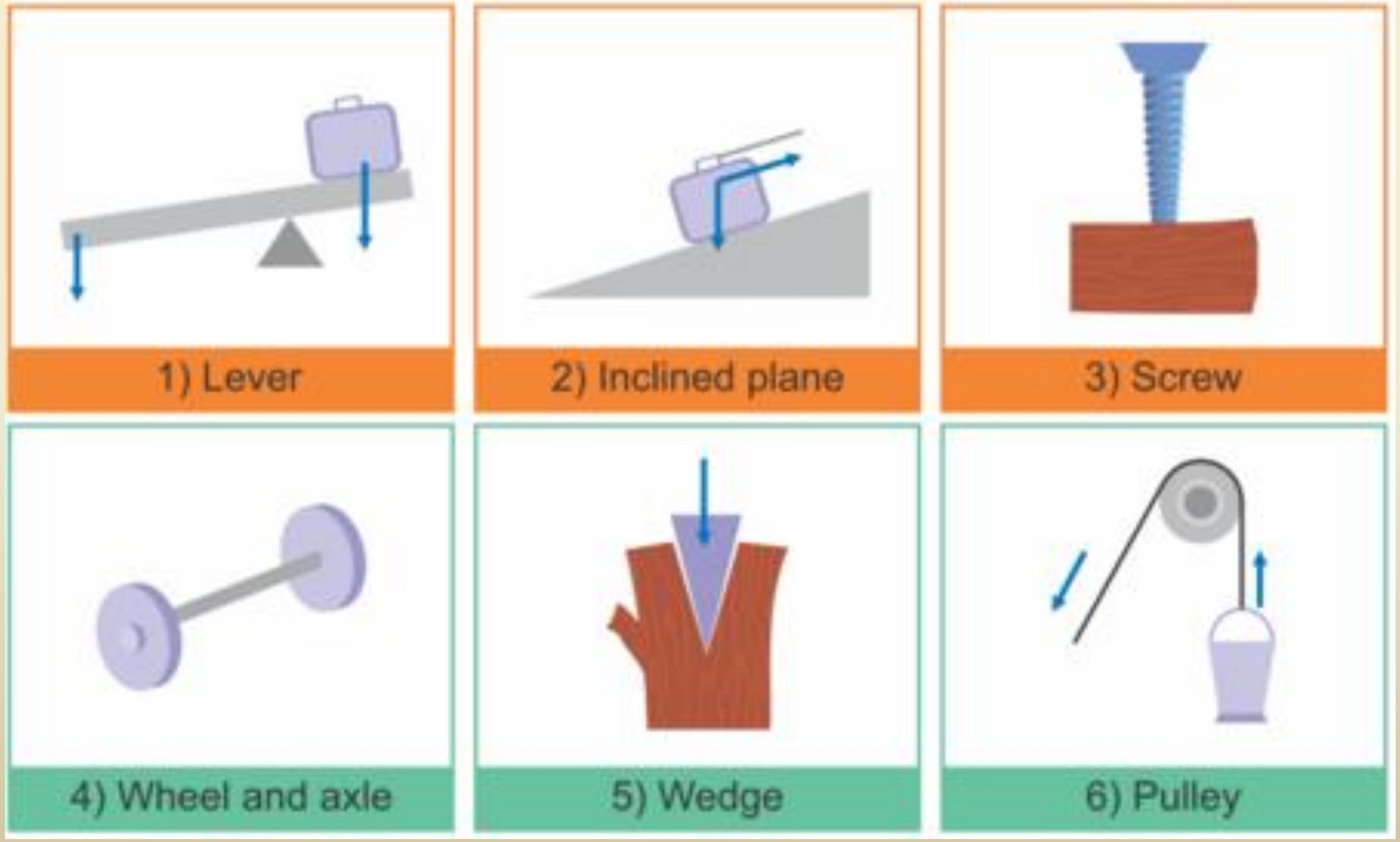






Types of Simple Machines

Simple Machines normally DECREASE the effort force or angle … Therefore, they INCREASE the effort distance. But the actual **work DONE or work OUTPUT does NOT change**.



Types of Simple Machines

INCLINED PLANES

– a slanted surface which decreases the effort force

Inclined planes are the most used simple machines.

Examples?

Specialized Planes:

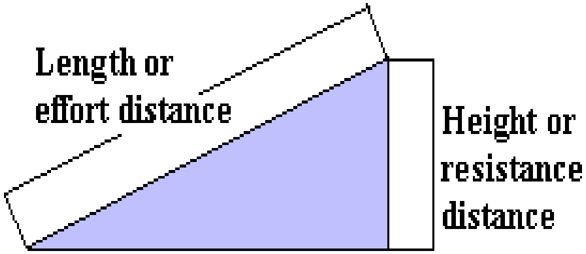
WEDGE – ***an inclined plane that moves … the longer the wedge the less effort force***

SCREWS – ***an inclined plane wrapped around a cylinder***

Types of Simple Machines

INCLINED PLANES

– a slanted surface which decreases the effort force



Wheelchair Ramp

Exit Ramp

Slanted Roof

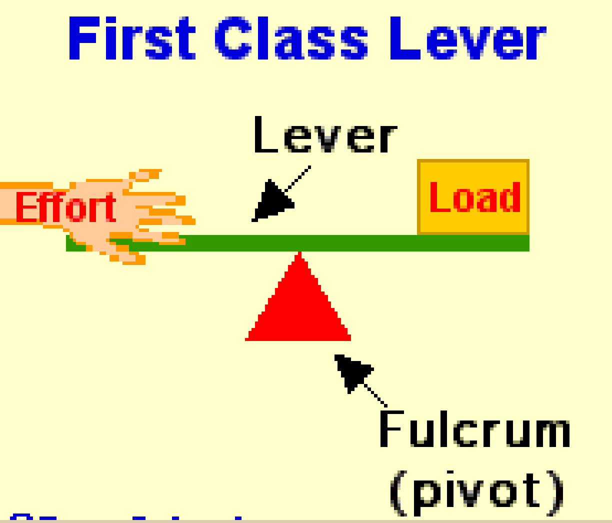
Skateboard Ramp

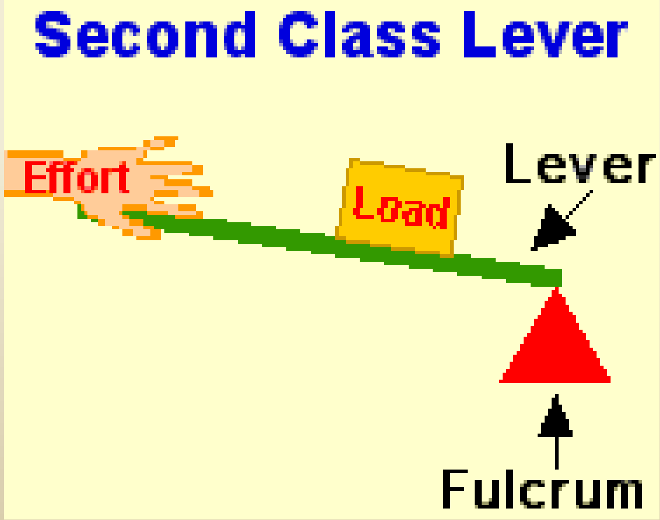
Board

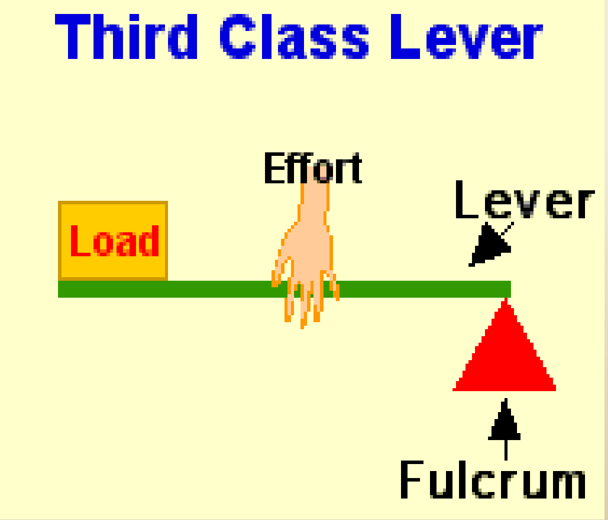
LEVERS

– a rigid bar that is free to pivot, or move about, a fixed point (fulcrum). Second most used simple machine.

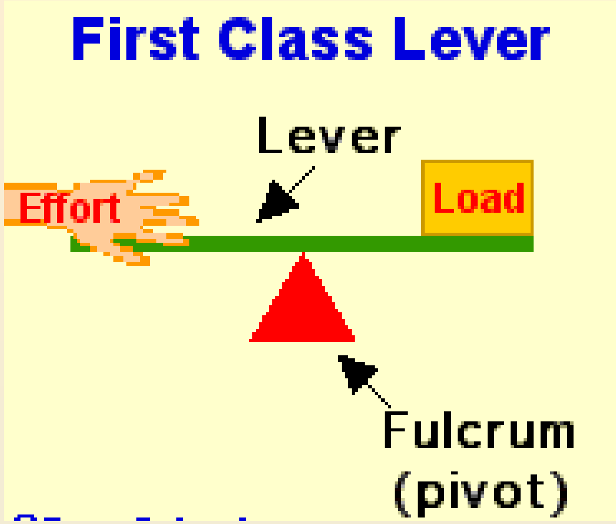
There are THREE classes of Levers:







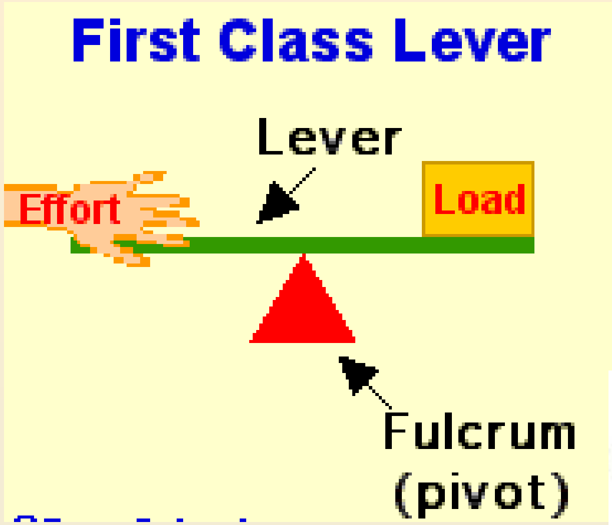
Types of Simple Machines

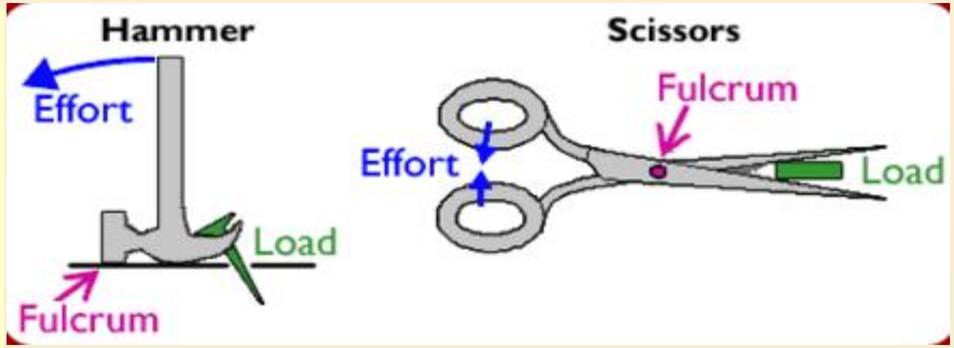


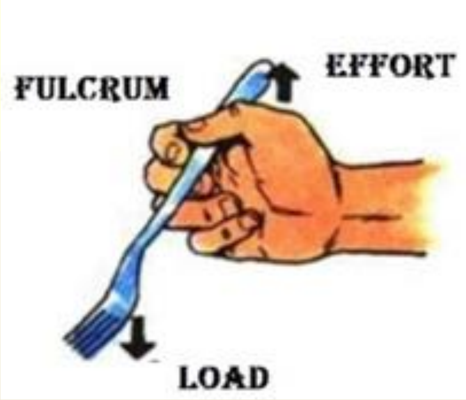
Examples?

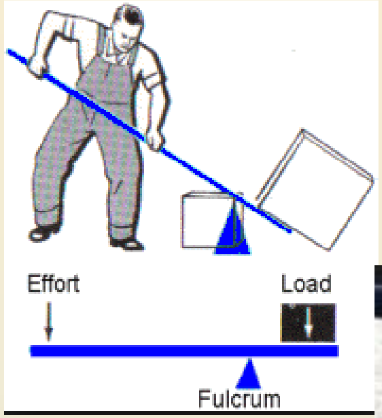
The MA of a 1st class lever can be greater than, less than or equal to 1.

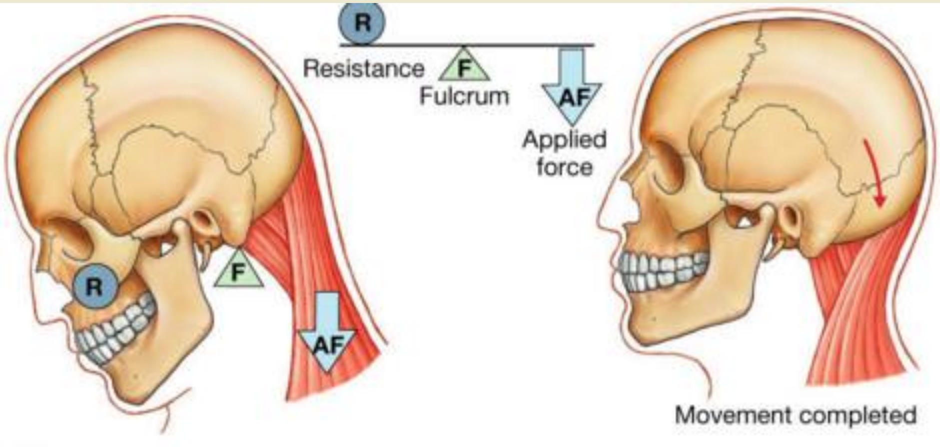
Types of Simple Machines

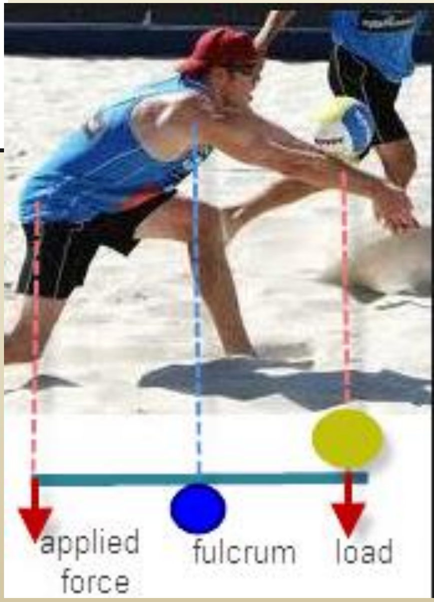




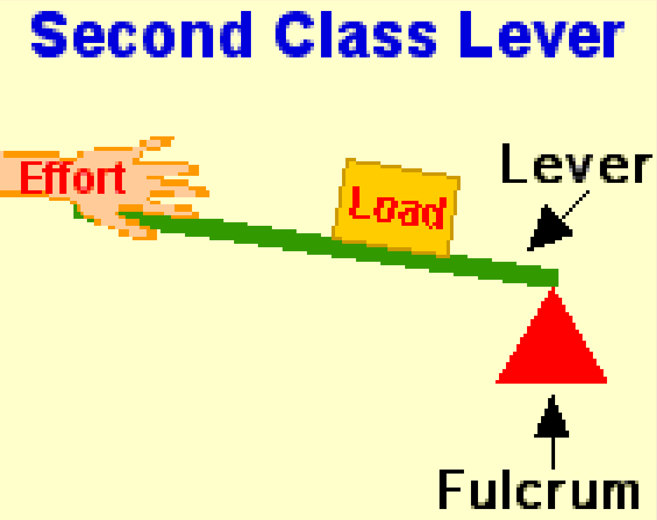






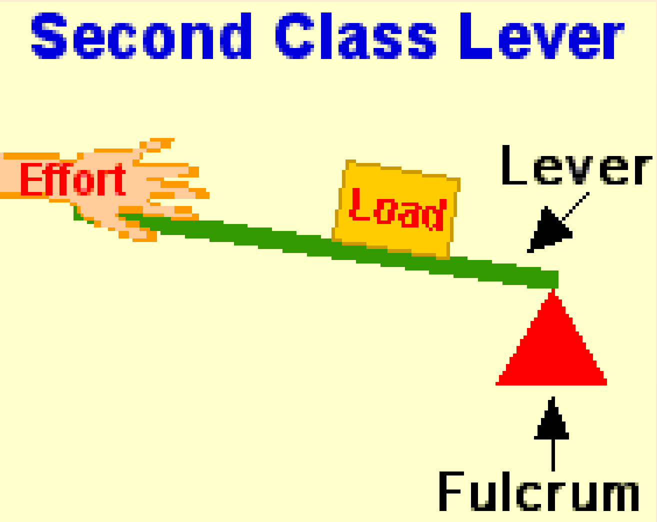


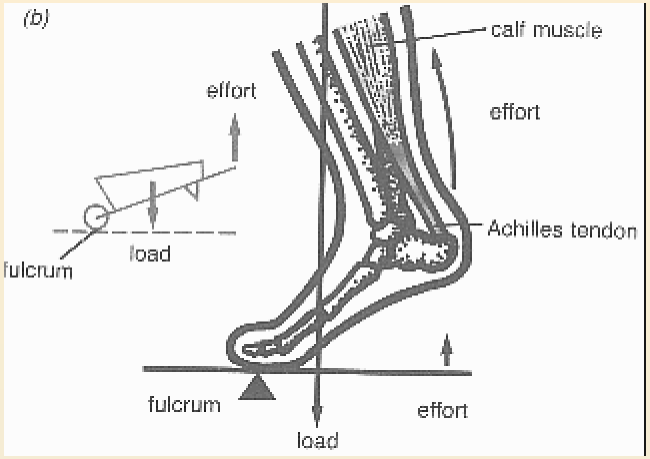
Types of Simple Machines

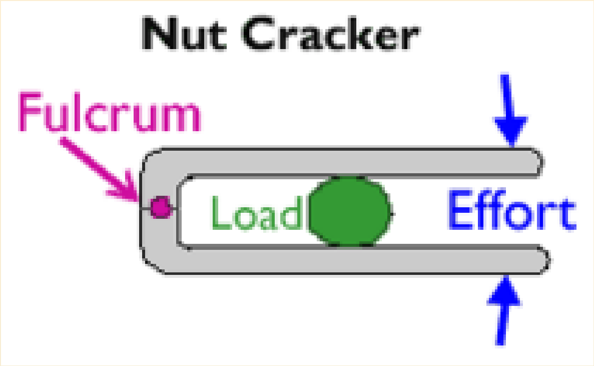


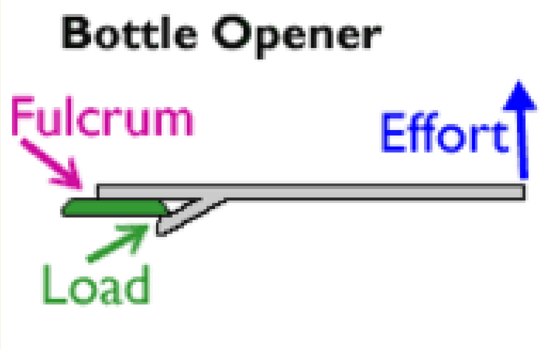
Examples?

Types of Simple Machines

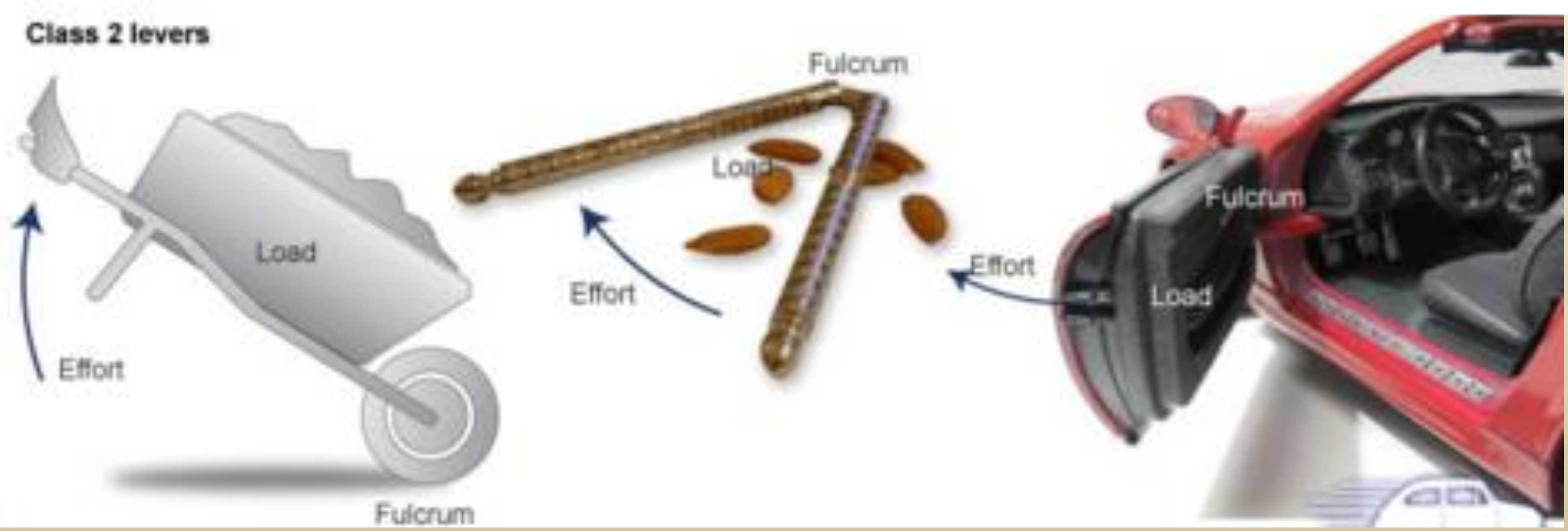




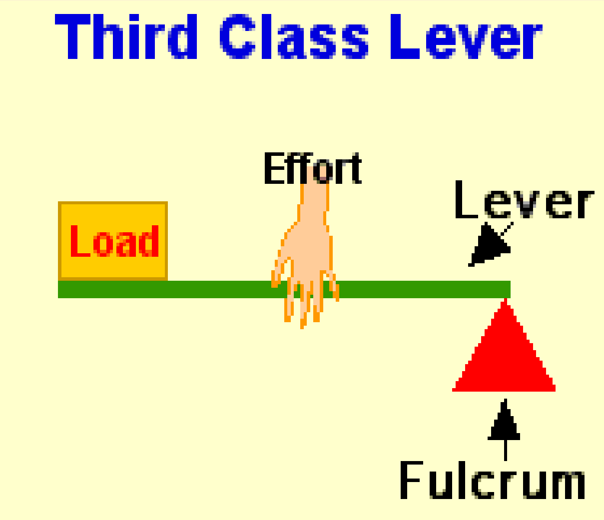




The MA of a 2nd class lever is always GREATER than 1.

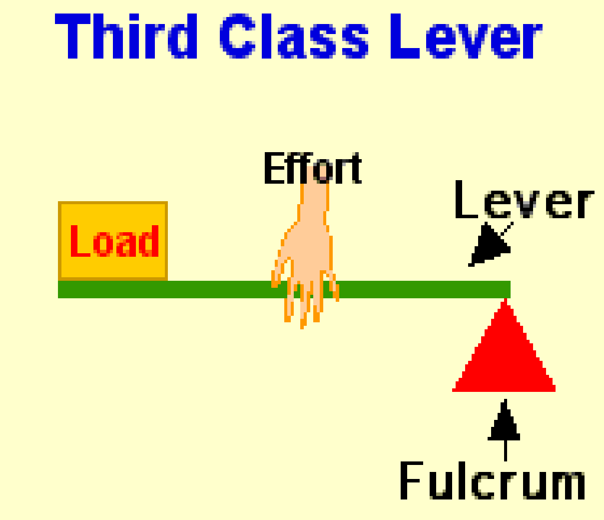


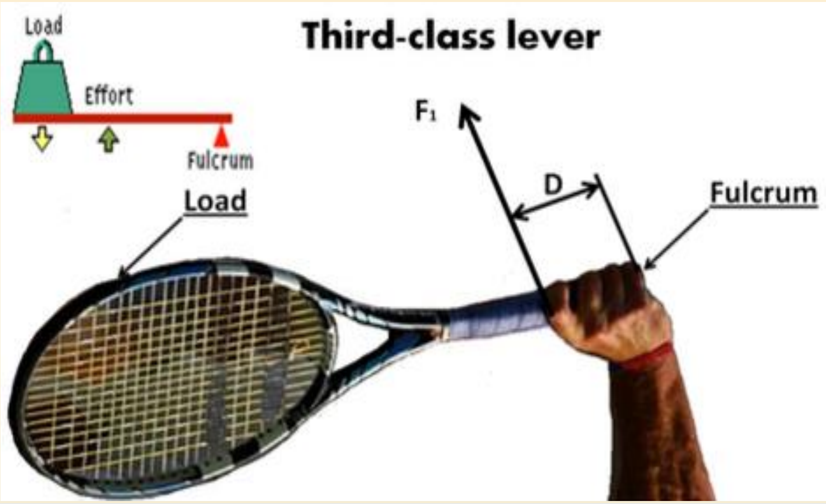
Types of Simple Machines

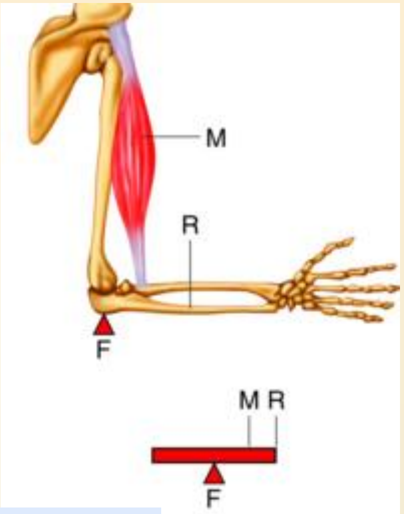


Examples?

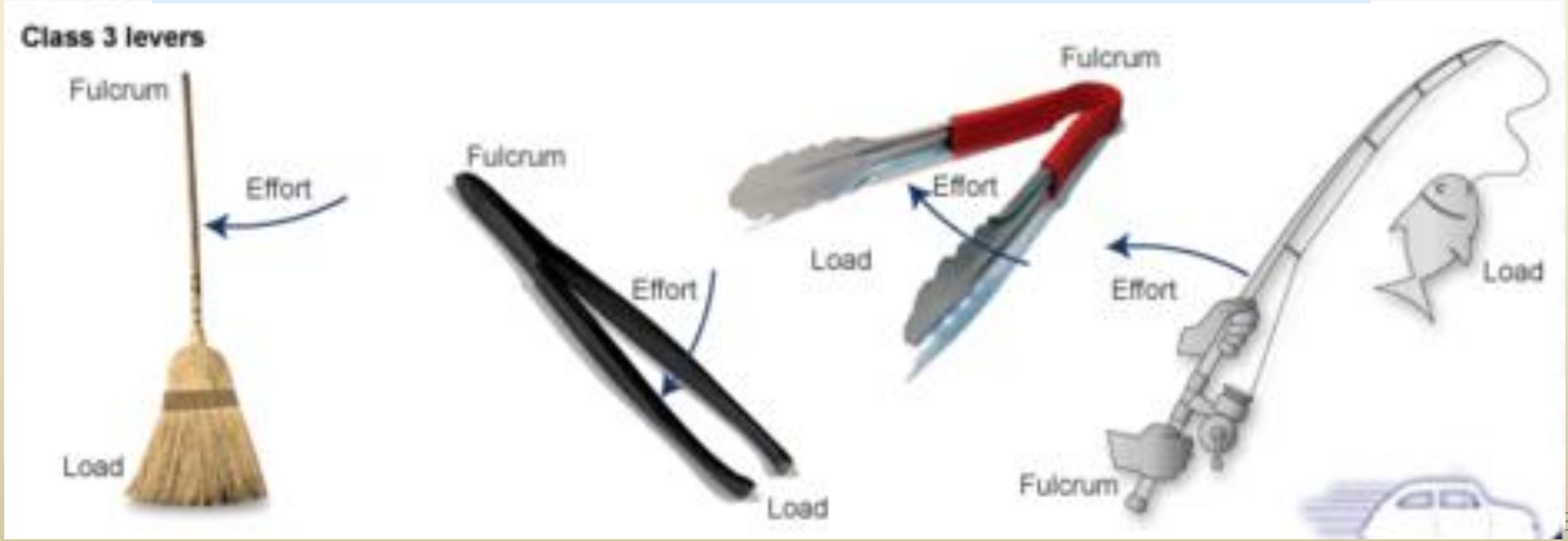
Types of Simple Machines







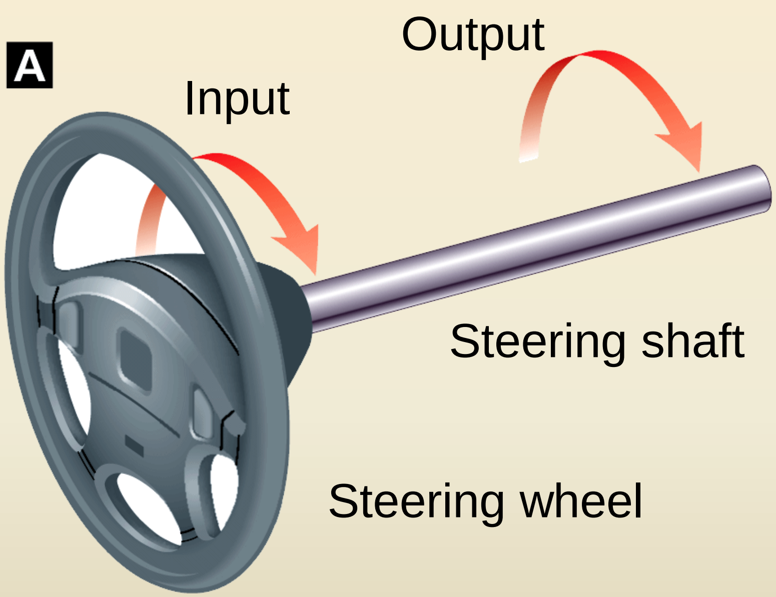
The MA of a third-class lever is always LESS than 1.



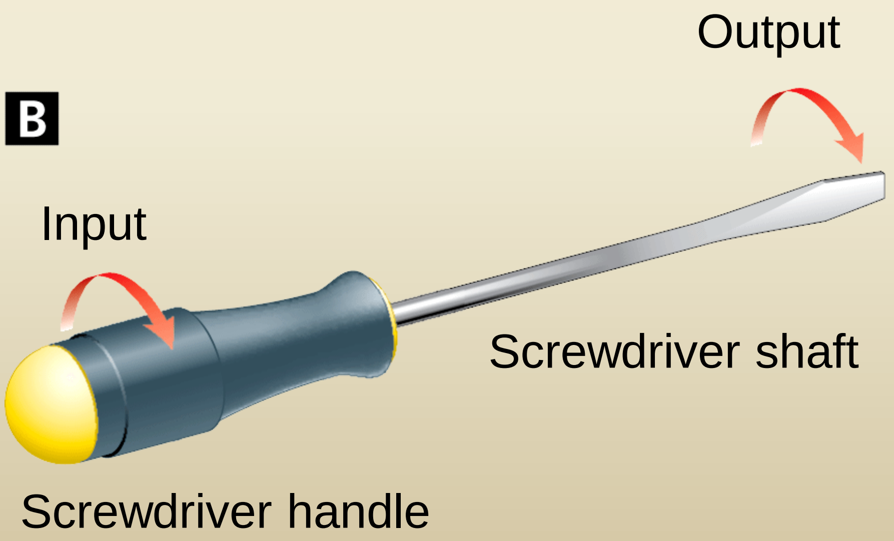
Types of Simple Machines

WHEEL AND AXLE

– two circular objects of different sizes (wheel = the largest object; axle = the smaller object)



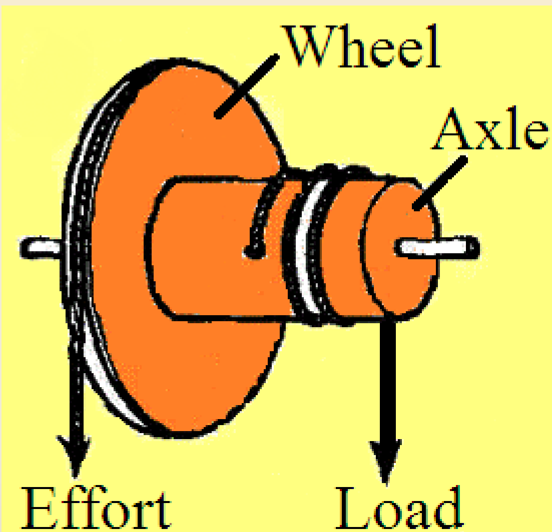
Examples?



Types of Simple Machines

WHEEL AND AXLE

– two circular objects of different sizes (wheel = the largest object; axle = the smaller object)

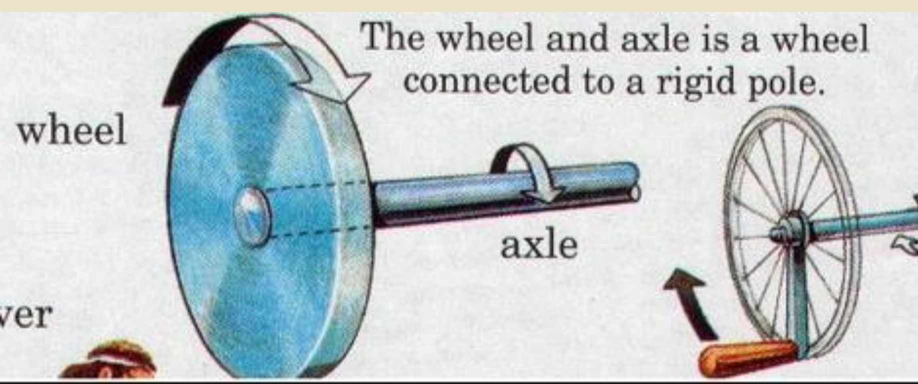


Screwdriver

Ferris wheel

Adjustable wrenches

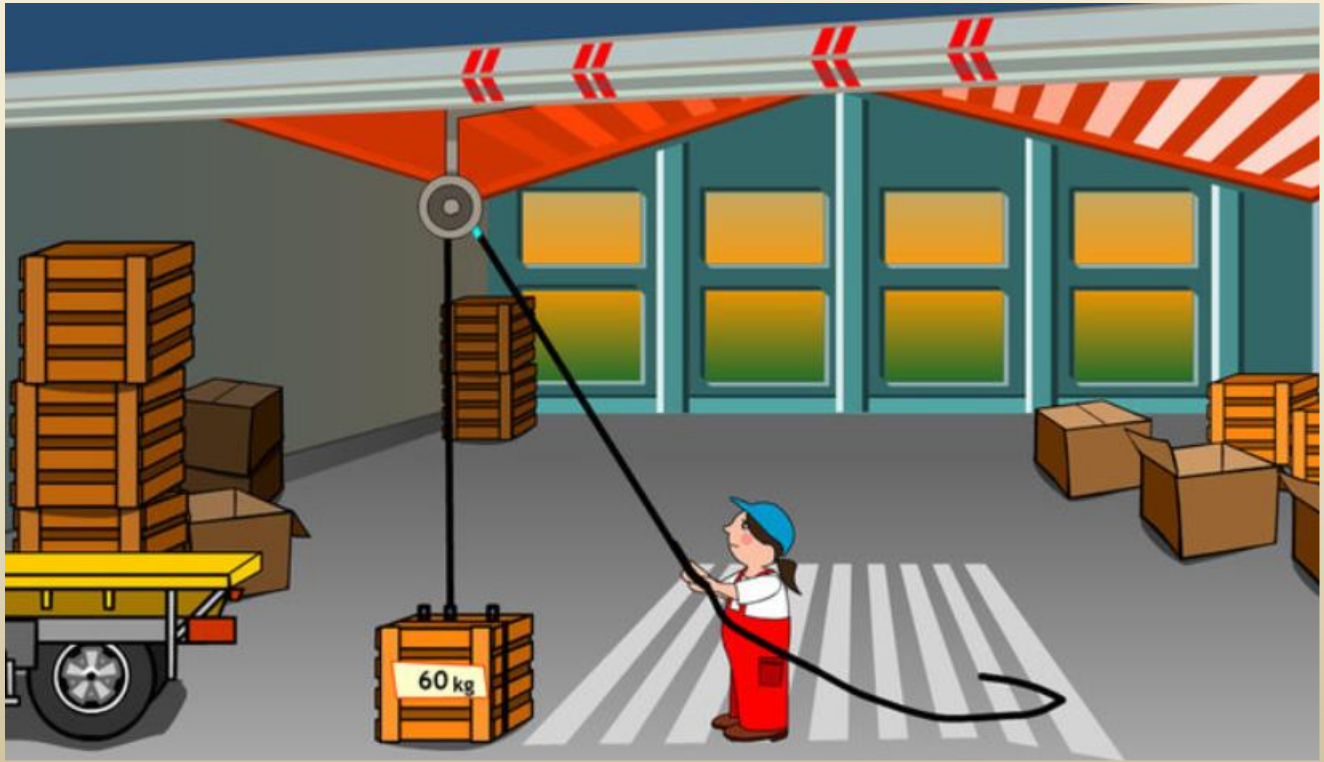
Steering wheels



Pulleys

A rope, belt, or chain wrapped around a grooved wheel which can change the direction of a force or the amount of effort force.

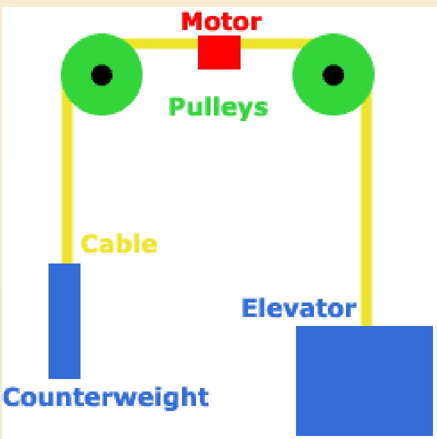
The example below shows a pulley with MA = 1. Why use it?

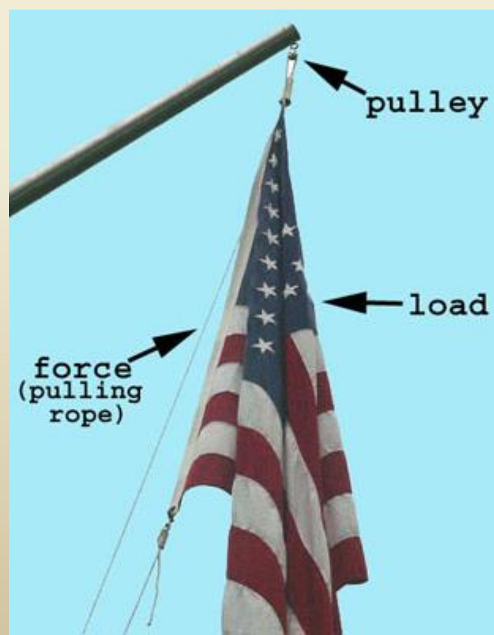


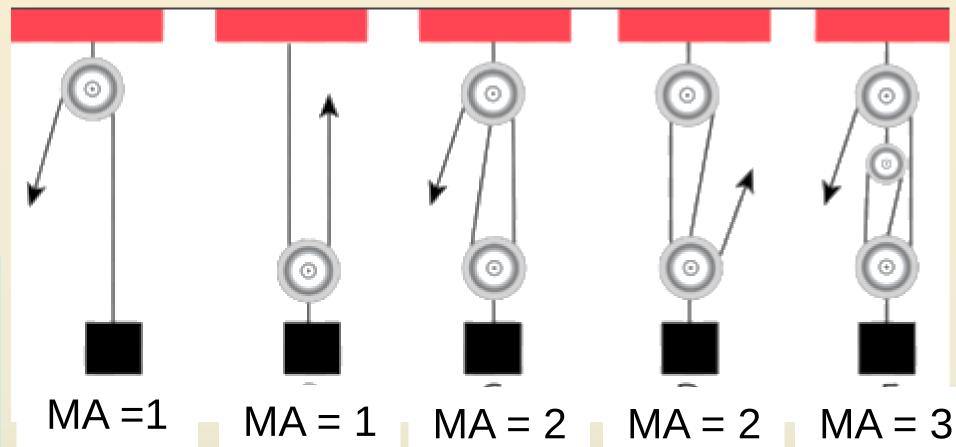
Types of Simple Machines

Pulleys

Mechanical Advantage is defined by # of ropes supporting the resistance.







Wheel & Axle & Pulleys (2:16)

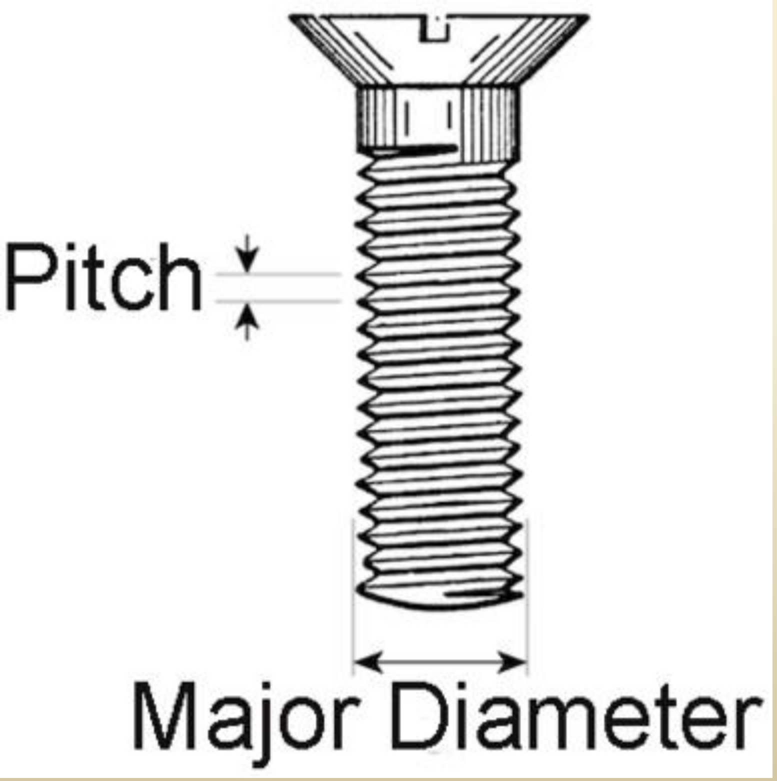
http://somup.com/cFX2qRniWs

Types of Simple Machines

Screw

– an inclined plane wrapped around a cylinder

Examples?



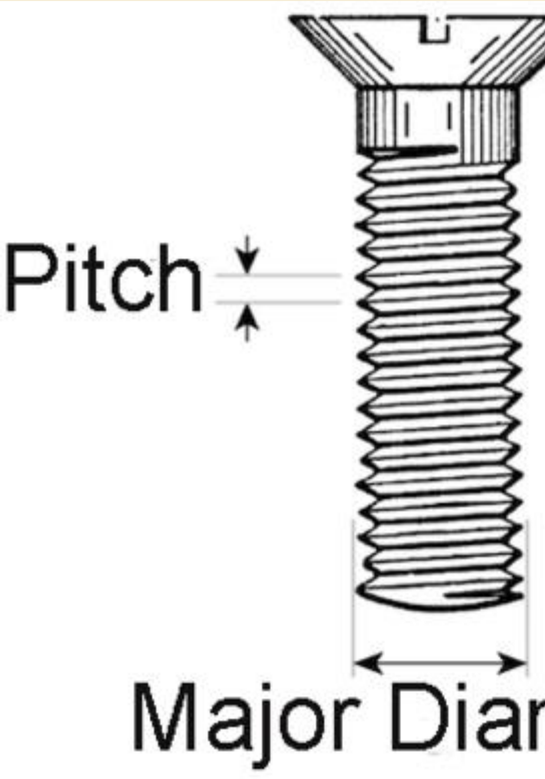
Mechanical Advantage of a screw:

Major Diameter / Pitch

Types of Simple Machines

Screw

– an inclined plane wrapped around a cylinder



Mechanical Advantage of a screw:

Major Diameter / Pitch

Types of Simple Machines

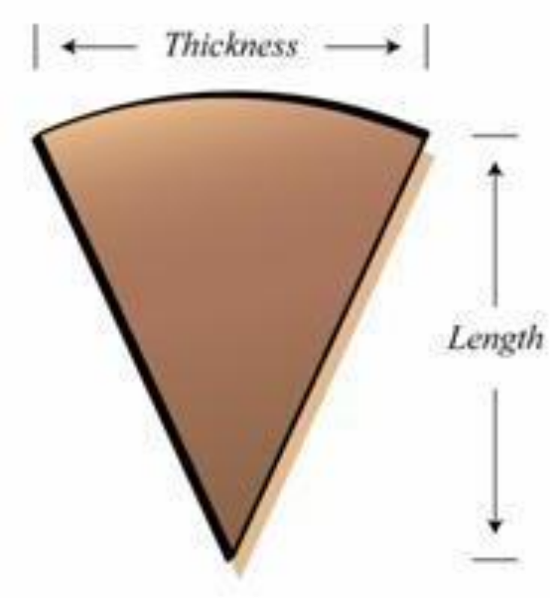
Wedge

A double inclined plane that moves … the longer the wedge the less effort force

Examples?

Mechanical Advantage of a wedge:

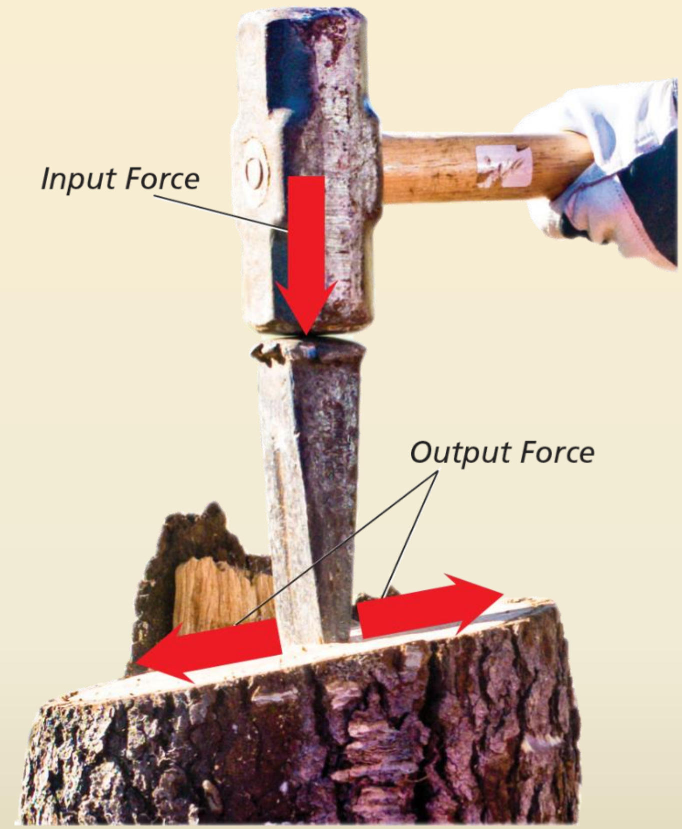
Length / thickness



Types of Simple Machines

Wedge

A double inclined plane that moves … the longer the wedge the less effort force



Compound Machines

Compound Machines are a combination of simple machines.

"This Too Shall Pass"

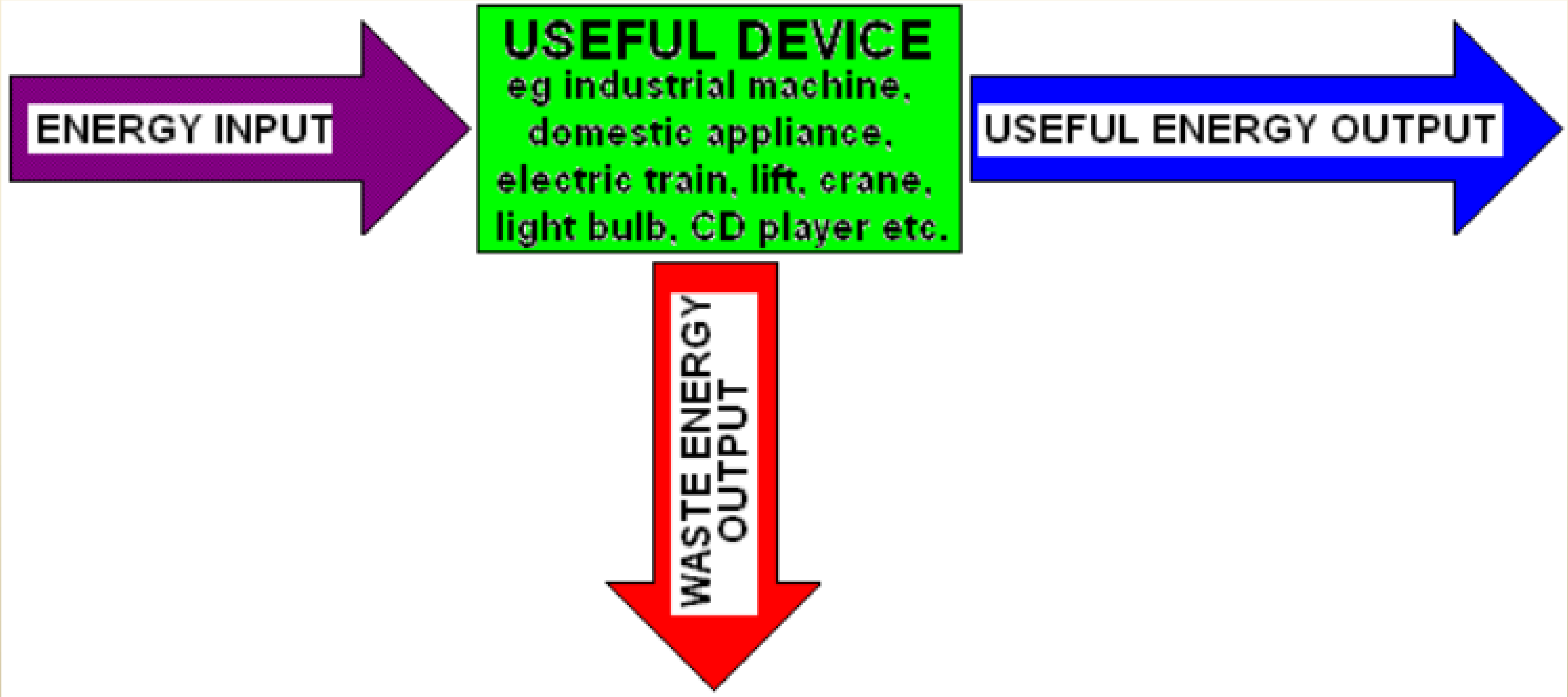
http://somup.com/cFX2YfniWP

(3:47)

Efficiency

An ideal machine puts out 100% efficiency … meaning that it does all of the useful work intended.

This NEVER happens in reality because **energy is transferred** and therefore, lost as **heat (friction)**.



Efficiency

Energy is transferred in all machines

Car wheels (*mechanical energy, friction of brake pads turns energy into heat*)

Ropes on the pulleys have friction and therefore, lose energy as heat

Electricity (energy) is converted into heat (for our homes) and lighting

Dishwasher uses heat energy to produce steam, plus mechanical energy of the moving water to clean dishes.

Throwing, hitting, kicking a ball faces air resistance (fluid friction).

Efficiency

Efficiency

$$\text{Efficiency} = \frac{\text{Work output}}{\text{Work input}} \times 100\%$$

For example, if the efficiency of a machine is 75 percent, then you know that 75 percent of the work input becomes work output.

e.g. If a machine requires 10.0 J of work input to operate, then the work output is 75% of 10.0 J.

Efficiency

$$\frac{\text{Work Output}}{\text{Work Input}} = \frac{\text{Work Done}}{\text{Energy Used}}$$

Most complex machines give off a lot of waste

- human body is ~55% efficient
- automobiles are ~20% (gas) to 40% (diesel) efficient

This means that of all the fuel used to supply the body or a machine, much or most of it is “lost” (transformed into) heat / friction and other by-products (soot, smoke, ash, etc.)

Efficiency

Reducing friction increases the efficiency of a machine. What are ways to reduce friction?

Efficiency

THINK ABOUT IT

Reducing friction increases the efficiency of a machine. What are ways to reduce friction?

- Lubrication (sliding & rubbing friction)
- Stream-line (fluid friction)
- Ball bearing (rolling friction)

QUICK CHECK

Which statement about the actual mechanical advantage of a machine is true?

a. The actual mechanical advantage is greater than one if the input force is greater than the output force.

b. The actual mechanical advantage of a machine is greater than its ideal mechanical advantage when the output force is greater than the input force.

c. The actual mechanical advantage of a machine is always less than its ideal mechanical advantage.

d. The actual mechanical advantage of a machine is never affected by friction.

The efficiency of any machine is less than ___% because of losses due to ___.

Which statement about the actual mechanical advantage of a machine is true?

a. The actual mechanical advantage is greater than one if the input force is greater than the output force.

b. The actual mechanical advantage of a machine is greater than its ideal mechanical advantage when the output force is greater than the input force.

c. **The actual mechanical advantage of a machine is always less than its ideal mechanical advantage.**

d. The actual mechanical advantage of a machine is never affected by friction.

QUICK CHECK

The efficiency of any machine is less than **100**% because of losses due to **friction**.

A bar that rotates about a fixed point is called a

Fulcrum ... Lever … wedge … compound machine

A 3-meter-long ramp is used to lift a piano to a moving truck, which is 1 meter off the ground. What is the ideal mechanical advantage of the ramp?

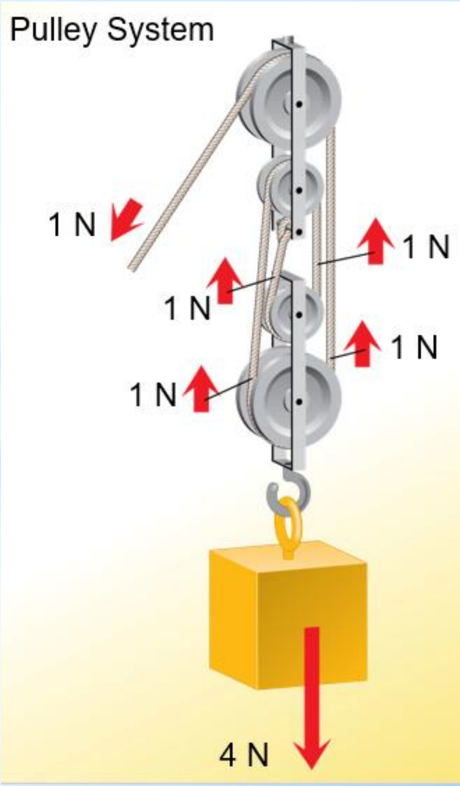
A

G

E

S

What is the mechanical advantage of the pulley to the right?



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Fulcrum … **Lever** … wedge … compound machine

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A MA

G $d_i = 3$ m; $d_O = 1$ m

E $MA = d_i / d_O$

S $MA = 3$ m / 1 m = **3**

What is the mechanical advantage of the pulley?

A MA

G $f_i = 1$ N; $f_O = 4$ N (block)

E $MA = / f_O / f_i$

S $MA = 4$ N / 1 N = **4 (also 4 supporting ropes)**