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Simple Machines and Mechanical Advantage

A **Machine** is anything that has moving parts and can perform a task (can do work).

Machines make work easier.

A **Simple Machine** is a device that accomplishes a task with one simple motion and without an engine.

Most devices you know are combinations of the six simple machines.

The Six Simple Machines with examples	
Screw	*Screw; corkscrew*
Wheel and **A**xle	*Crank; tires; screwdrivers*
Wedge	*Nail; arrow; knife*
Lever	*Scissors; nutcracker; arm*
Ramp or **I**ncline Plane	*Wheelchair ramp; stairs*
Pulley	*Block and tackle*

Just to know: some people consider "gears" to be a seventh simple machine. Gears are actually levers on wheels.

Mechanical Advantage tells us how much advantage is given OR how much a machine multiplies your force (or time).

If MA = 1, then Input = Output

If MA > 1, then Output > Input (multiplies force)

If MA < 1, then Output < Input (reduces force)

Calculating Mechanical Advantage — 2 Ways

Mechanical advantage (no units) →
$$MA = \frac{F_{out}}{F_{in}}$$
Output force (in N)
Input force (in N)

Mechanical Advantage equals the output force divided by the input force.

Mechanical advantage (no units) →
$$MA = \frac{D_E}{D_R}$$
Distance of Effort (in m)
Distance of Resistance (in m)

Mechanical Advantage equals the distance of effort divided by the distance of resistance.

Ex. Using a block and tackle a boy pulls on a rope with 10 newtons of force and raises a 50 newton weight. Find the mechanical advantage of the block and tackle.

F_{input} = 10 N F_{output} = 50 N $MA = \dfrac{F_{output}}{F_{input}}$	MA = 50N/10N = 5 Notice that newtons cancel – *there are no units for mechanical advantage*

Ex. Using a block and tackle (pulleys) a boy pulls the rope 10 meters to move the weight up 2 meters. Find mechanical advantage.

D_{effort} = 10 m $D_{resistance}$ = 2 m $MA = \dfrac{D_{effort}}{D_{resistance}}$	MA = 10m/2m = 5 Just as before – no units for mechanical advantage.

Output Force vs. Input Force

**Output Force —** what you are lifting with the simple machine.

F_{out}

F_{in}

Fulcrum

Input Force — how much you put into the machine.
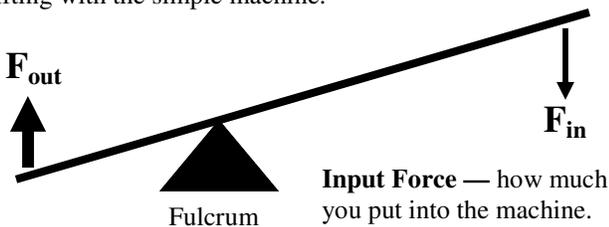
Distance of Effort vs. Distance of Resistance

Distance of effort — how far you move the object <u>with</u> the simple machine.

D_E

D_R

Distance of resistance — how far the object moves <u>without</u> the simple machine.

F_{out} and F_{in} of a lever.
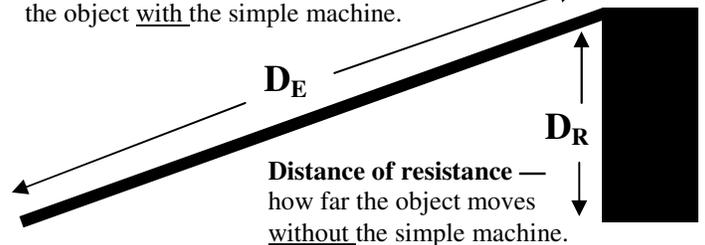
D_E and D_R of an incline plane.

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Identify these simple machines:		1. Mechanical Advantage	A. How much a machine amplifies or reduces your force.
A. _____	A. ↑ ↓	2. None	B. The units for mechanical advantage.
B. _____	B. (screw)	3. D_E	C. How far the object would move without the simple machine.
C. _____	C. (pulley) D. (wheel and axle)	4. D_R	D. How far the object moves with the simple machine.
D. _____		1. Machine	A. The force you put into a machine.
E. _____	E. (incline) F. (knife)	2. F_{in}	B. A device that has moving parts and can do work.
F. _____		3. F_{out}	C. A block and tackle is another name for this.
		4. Pulley	D. The force you get out of a machine.
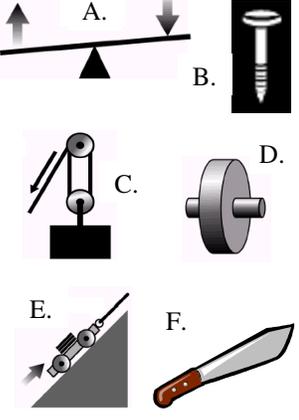
Input Force (F_{in}) or Output Force (F_{out})?	Distance of Effort (D_E) or Distance of Resistance (D_R)?
_____ You lift a 200 N object.	_____ You use an incline plane to lift a car up 4 meters.
_____ A wedge applies 400 N of force to a piece of wood.	_____ You use a 10 meter ramp to raise up a car.
_____ You push 240 N on a lever.	_____ You lift a 200 kg object up 2 meters.
_____ You turn a screw with 30 N of force.	_____ The distance you push down on a lever.
_____ A pulley applies 48 N of force up.	_____ The distance the object moves with a lever.

A kid pulls on a rope with 20 newtons of force. The block and tackle system pulls up a 160 newton box. What is the mechanical advantage of the pulley system?	A pulley system has an MA of 4. How much force would be necessary to pull up a 200 newton box?
If it takes 100 N to push a 300 N object up an incline plane, what was the mechanical advantage of the ramp?	A 10 N force pulls to the right and friction opposes 2 N. If the object is 20 kg, find the acceleration.
A 10 meter ramp helps you to move a 500 kg object up 1 meter. What was the mechanical advantage of the ramp?	You have a 200 kg bag being lifted with a block and tackle. If you pull with 100 newtons what is the MA of the system?