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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 Input > Output (multiplies force)

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

Calculating Mechanical Advantage — 2 Ways

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

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

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

$MA = \frac{F_{output}}{F_{input}}$

MA = 50N/10N = 5

Notice that newtons cancel – *there are no units for mechanical advantage*

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

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

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

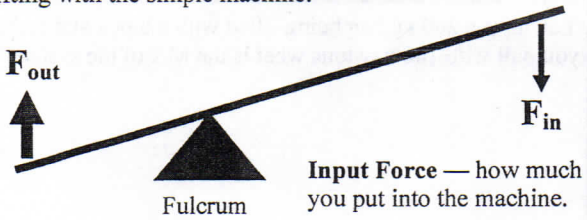
$MA = \frac{D_{effort}}{D_{resistance}}$

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.

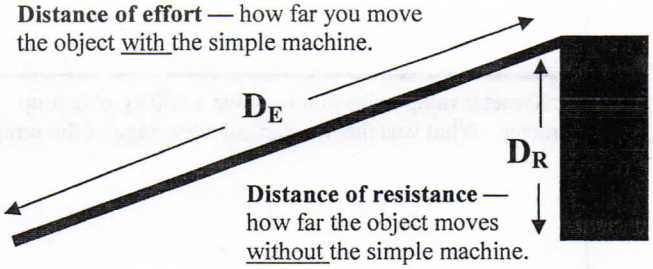


Input Force — how much you put into the machine.

F_{out} and F_{in} of a lever.

Distance of Effort vs. Distance of Resistance

Distance of effort — how far you move the object with the simple machine.



Distance of resistance — how far the object moves without the simple machine.

D_E and D_R of an incline plane.

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Identify these simple machines:

A. _____

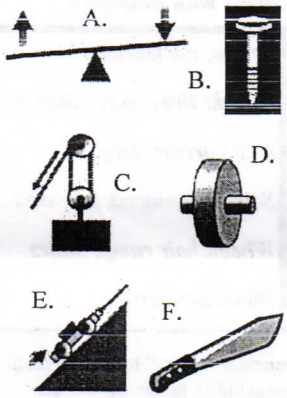
B. _____

C. _____

D. _____

E. _____

F. _____



1. Mechanical Advantage	A. How much a machine amplifies or reduces your force.
2. None	B. The units for mechanical advantage.
3. D_E	C. How far the object would move without the simple machine.
4. D_R	D. How far the object moves with the simple machine.

1. Machine	A. The force you put into a machine.
2. F_{in}	B. A device that has moving parts and can do work.
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})?

_____ You lift a 200 N object.

_____ A wedge applies 400 N of force to a piece of wood.

_____ You push 240 N on a lever.

_____ You turn a screw with 30 N of force.

_____ A pulley applies 48 N of force up.

Distance of Effort (D_E) or Distance of Resistance (D_R)?

_____ You use an incline plane to lift a car up 4 meters.

_____ You use a 10 meter ramp to raise up a car.

_____ You lift a 200 kg object up 2 meters.

_____ The distance you push down on a lever.

_____ 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?