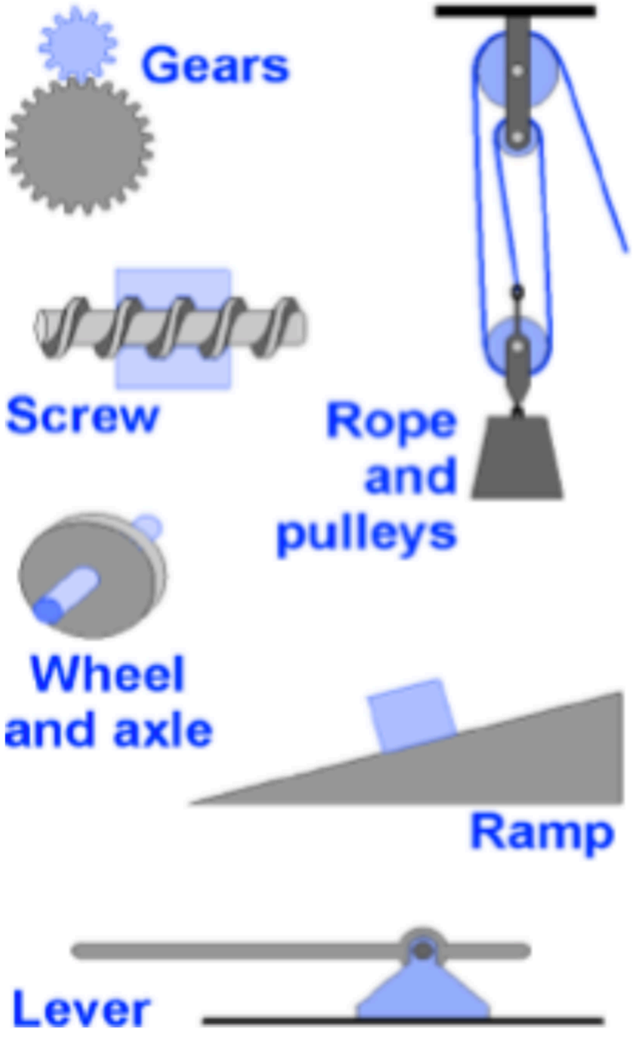
MACHINES

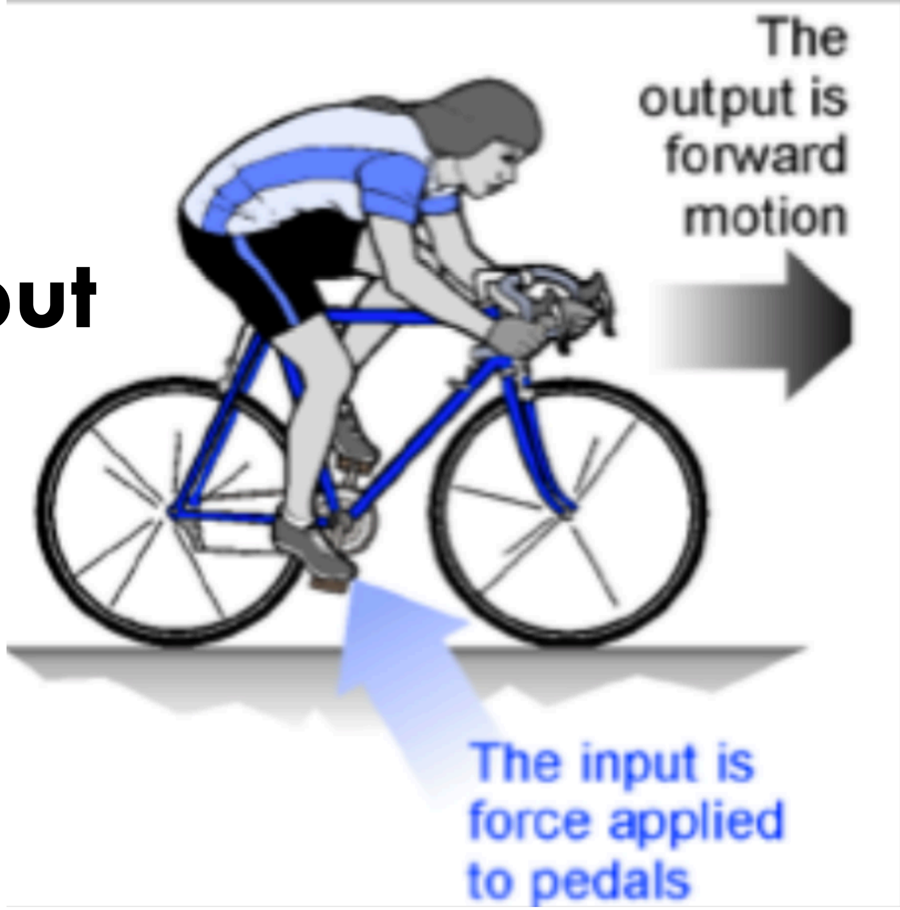
Machines are designed to take advantage of the relationship between work, force, and distance.

Simple machine: devices use only the forces directly applied and accomplish their task in a single motion

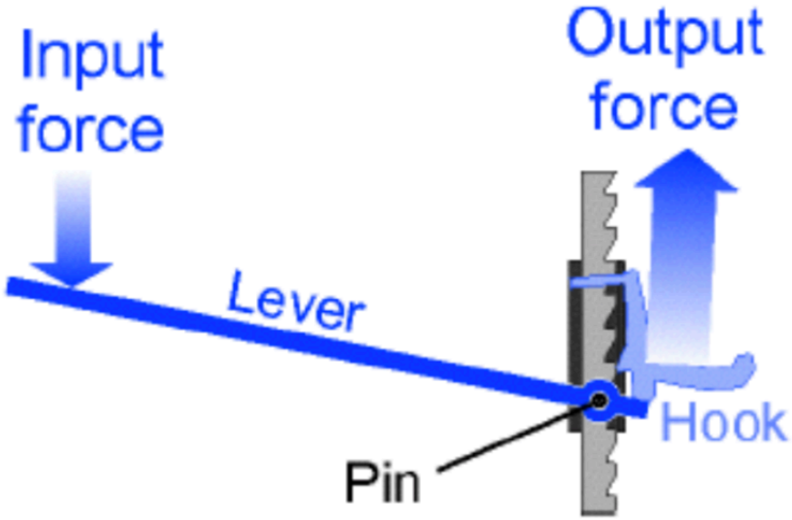


MACHINES

- Think about machine in terms of **input** and **output**
- Still constrained by conservation of energy
- At absolute best: $W_{in} = W_{out}$
- $({}_F d)_{in} = (F_d)_{out}$



MECHANICAL ADVANTAGE



Ratio of output force to input force

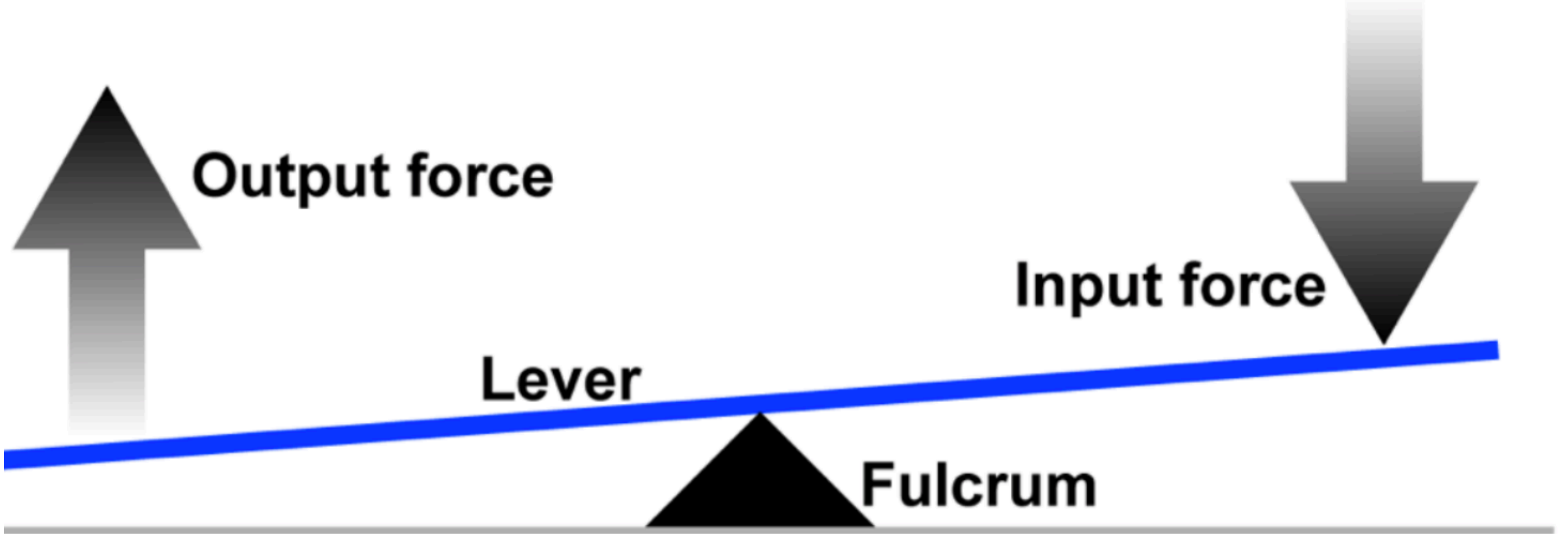
$MA = F_{out}/F_{in}$

Typical automotive jack has mechanical advantage of 30 or more

I.e. Force of 100N (22.5 lb) input → output force of 3000N (675 lb) – enough to lift a corner of the car

LEVER

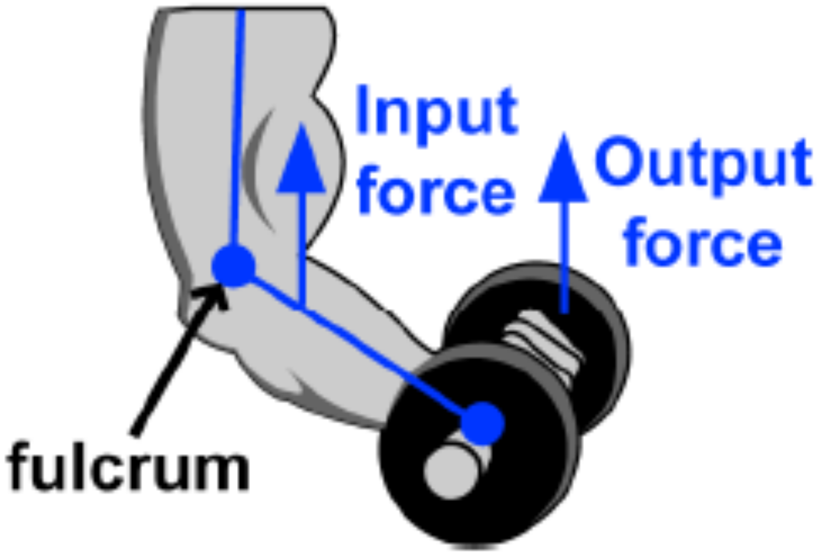
Lever includes stiff structure (**lever**) that rotates around a fixed point called a **fulcrum**



LEVERS AND THE HUMAN BODY

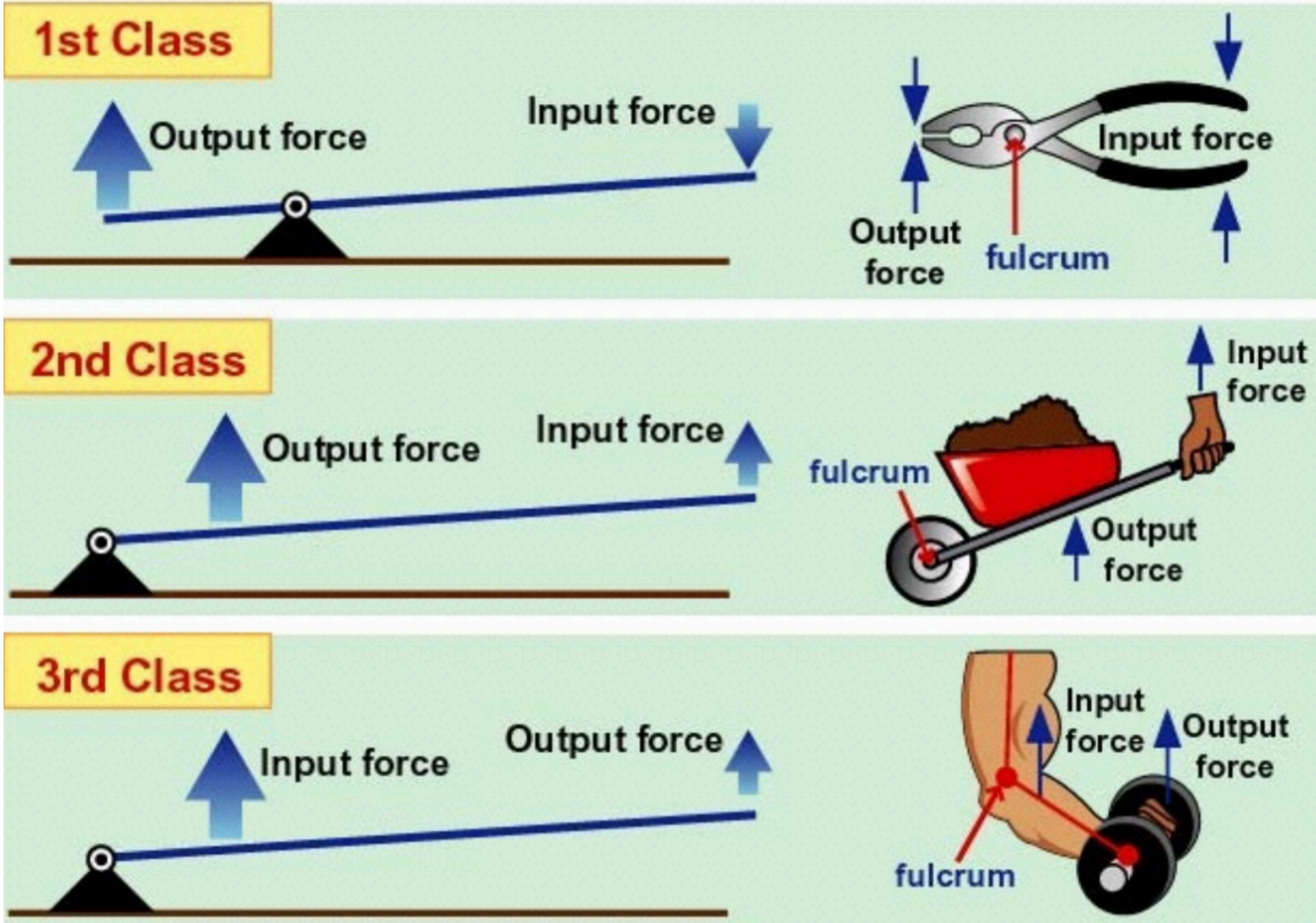
Your body contains muscles attached to bones in ways that act as levers.

Here the bicep muscle attached in front of the elbow opposes the muscles in the forearm.



Can you think of other muscle levers in your body?

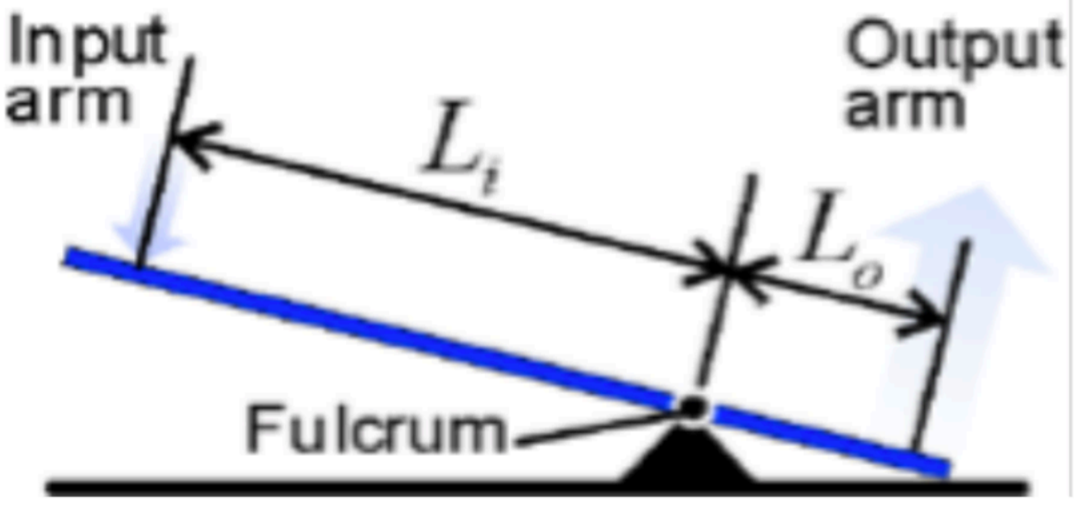
The 3 Classes of Levers



LEVER MECHANICAL ADVANTAGE (MA)

$MA_{lever} = L_{in}/L_{out}$ ($=F_{out}/F_{in}$)

What force must be applied to the end of a 2.0 m long crowbar in order to lift a 500N rock if the fulcrum of the bar is 0.5 m from the rock?



$MA = 1.5/0.5 = 3$

$3 = 500N\ /F_{in}$

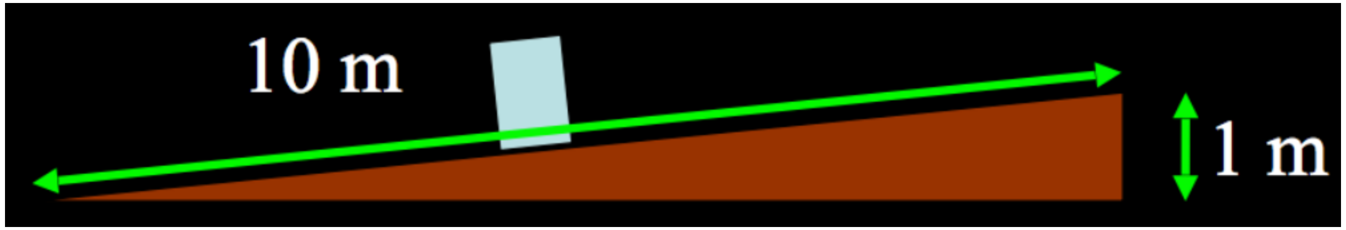
$F_{in} = 167N$

RAMP

You need to get a 100 kg couch into a moving van 1.0m off the ground

If you lifted it, how much work would you need to do? How much force would you apply?

W = mgh = 981 J, F = mg = 981 N



RAMP

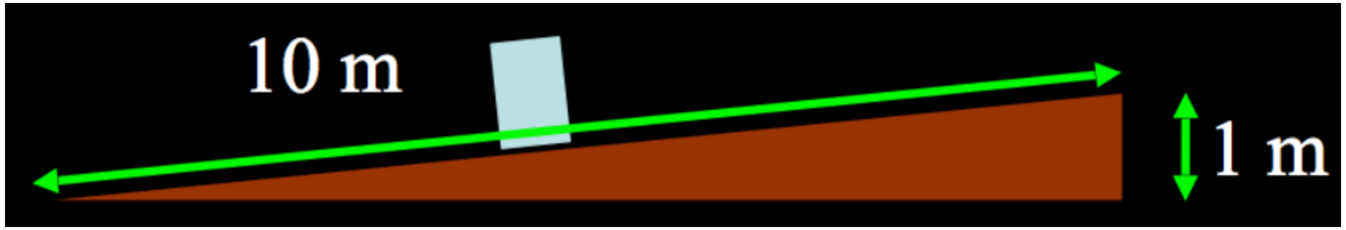
W = mgh = 981 J, F = mg = 981 N

Instead you use a ramp 10 m long and 1 m high

How much force would you need to apply?

F_{app} = mgsinθ=(100 kg)(9.8 m/s^2)(1/10) = 98.1N

MA = 981N/98.1N = 10

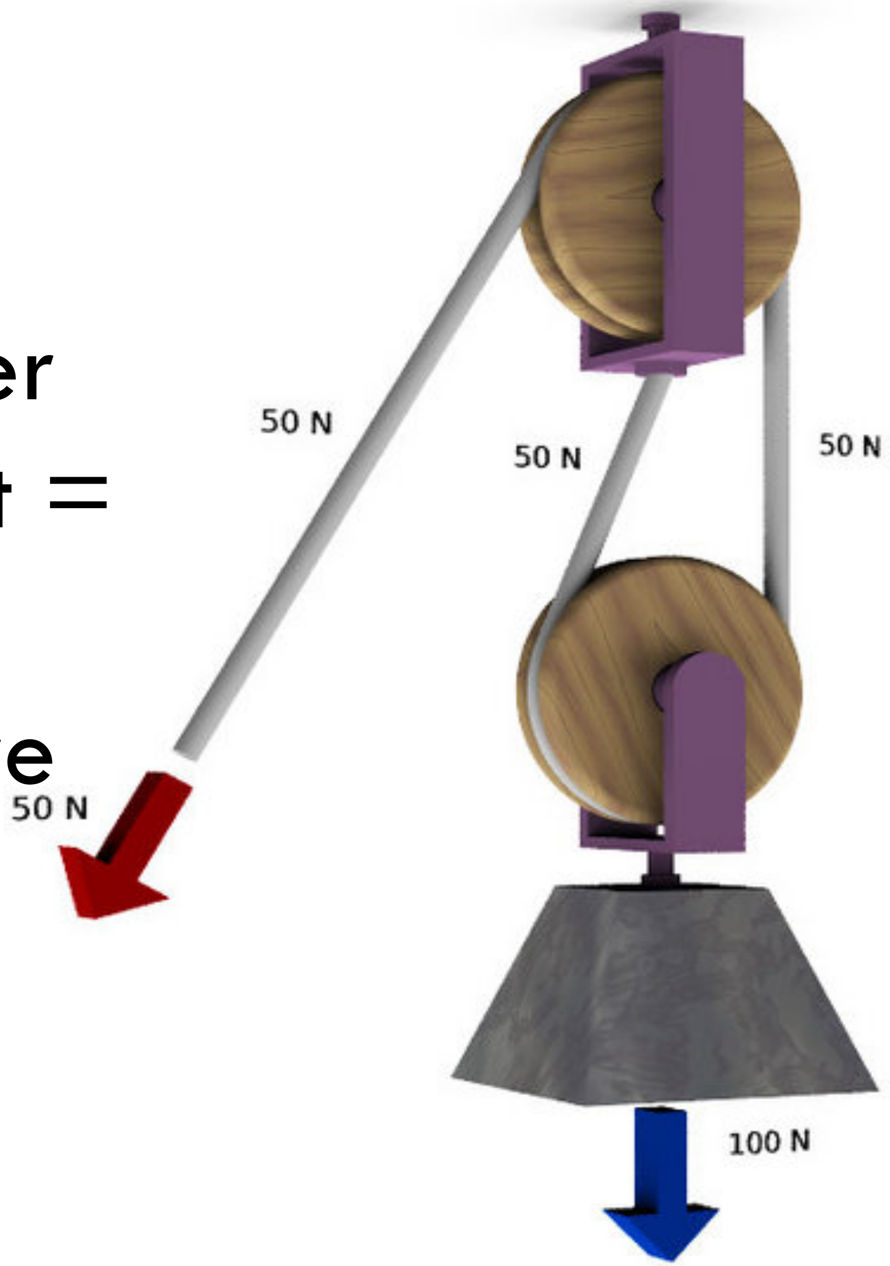


(excludes frictional losses)

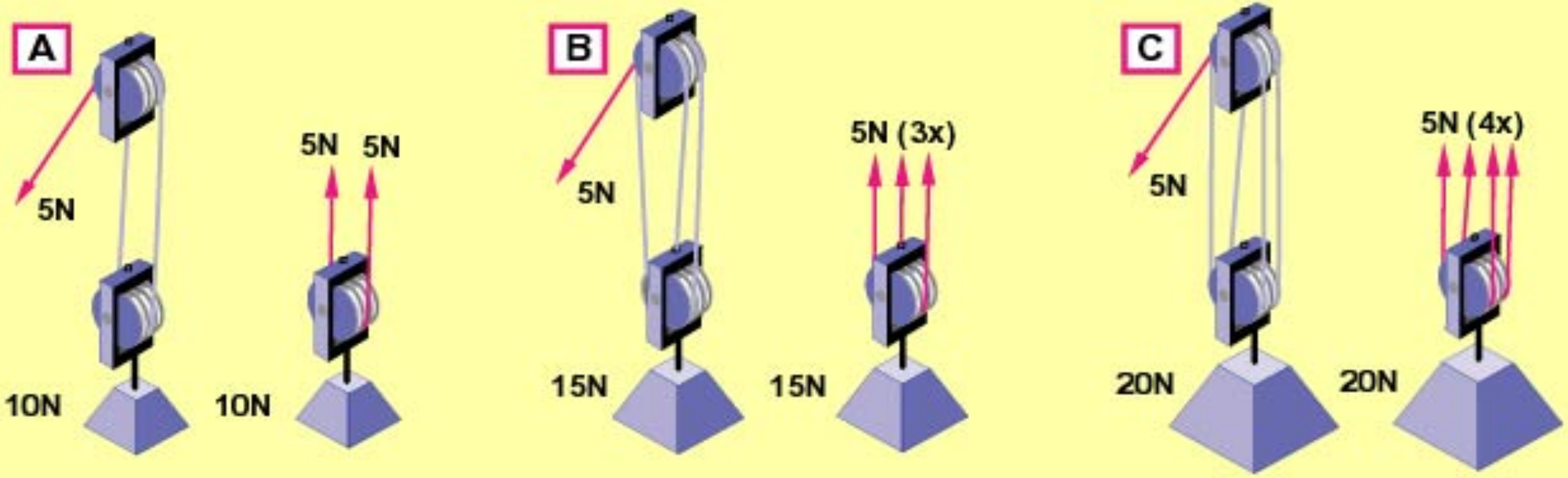
PULLEYS

Like levers and ramps, **pulleys** sacrifice displacement for greater forces: pull greater displacement = apply less forces

MA is shown by how many ropes are supporting the "load"



Mechanical Advantage



$$\text{Mechanical advantage} = \frac{\text{Output force}}{\text{Input force}}$$

	A	B	C
Input force	5N	5N	5N
Output force	10N	15N	20N
Mechanical advantage	2	3	4

PULLEYS

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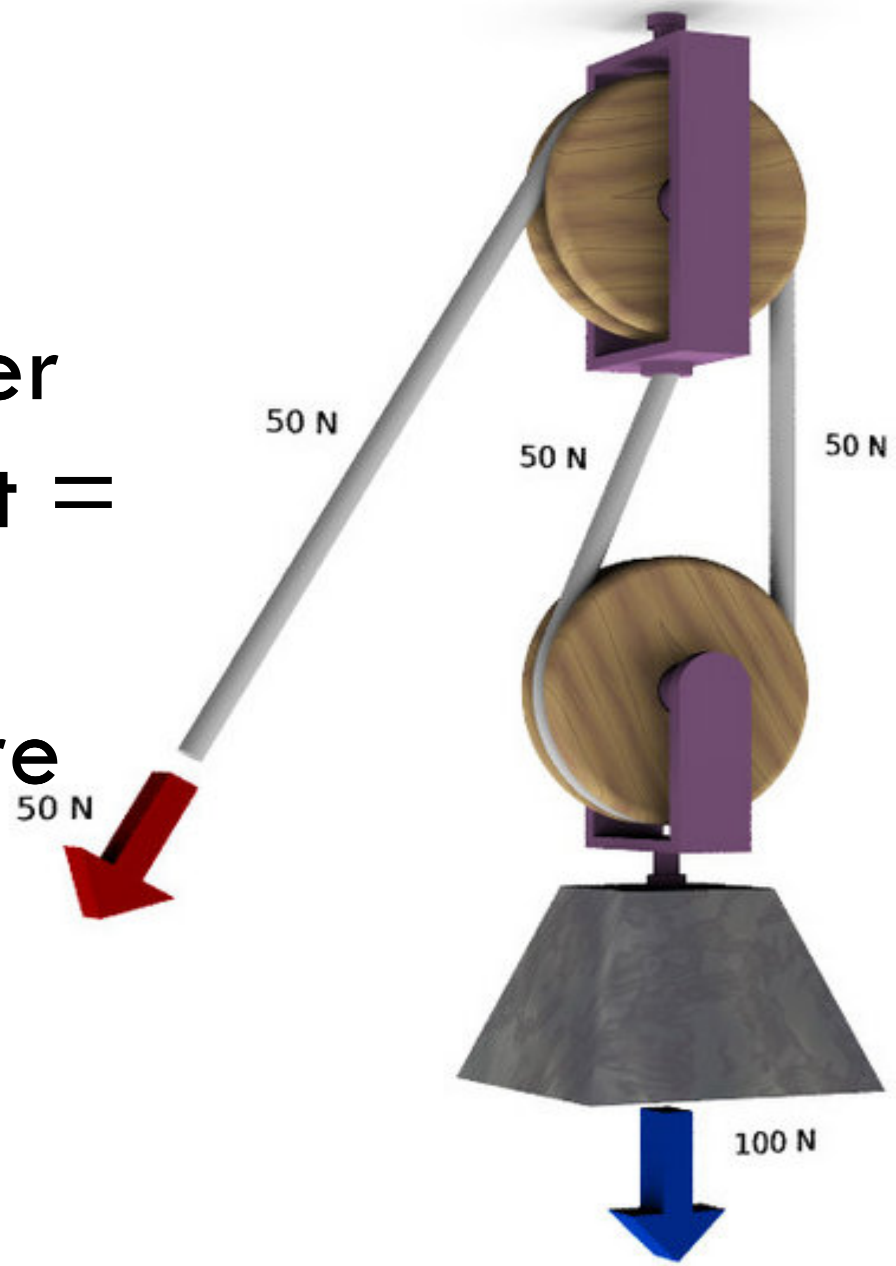
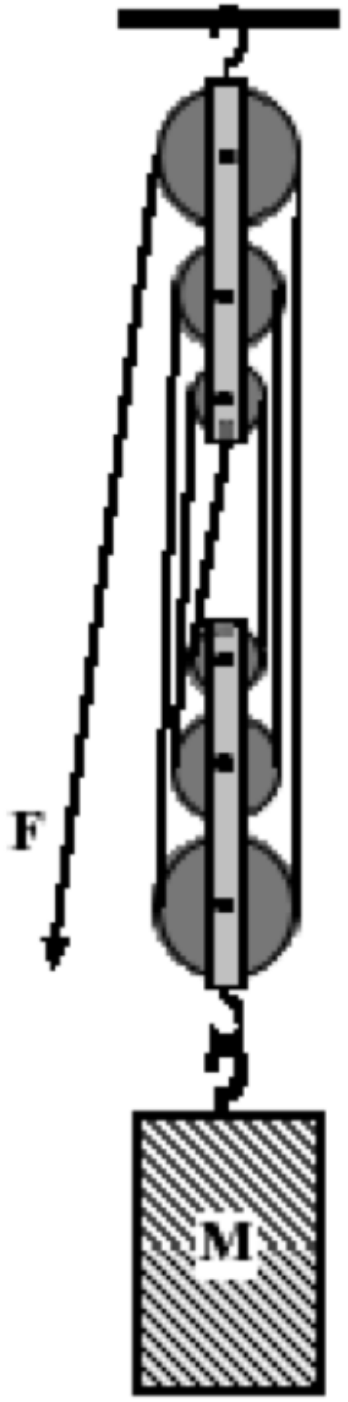


PULLEYS

The pulley system to the right has an input force of 220 N applied to it. As a result of this input force the mass M is lifted a distance of 25.0 cm.

a. How much work was done on M?

W_{out} = Fd = (220Nx6) x .25 m = 330J



PULLEYS

a. How much work was done on M?

W_{out} = Fd = (220Nx6) x .25 m = 330J

b. Through what distance was the input force applied (how much rope is pulled out)?

$W_{in} = W_{out}$ = 330J = 220N x d_{in}

d_{in}=1.5m