SIMPLE MACHINES and MECHANICAL ADVANTAGE:

Inclined plane, Lever, Wedge, Screw, Wheel and Axle

Lever

A bar free to pivot, or rotate about a fixed point (fulcrum)

Wheel and axle
Circular lever (axle is fulcrum)

Pulley
A wheel revolving freely around an axle

Gear
Toothed wheel that fit into one another

Inclined Plane

A flat, slanted surface

Wedge
Portable/moving inclined plane

Screw
Twisted inclined plane

TYPES OF WORK

A.INPUT

work that goes into the machine

needs effort force (Effort)

B. OUTPUT

Work done by the machine

Resistance Force (Load)

Mechanical Advantage

Number of times a machine multiplies the effort force

$$\textbf{M. A.} = \frac{\text{LOAD}}{\text{EFFORT}}$$

Simple Machines

STATION 1: Inclined plane

Making the Grade

Aim: To investigate how an inclined plane makes work easier.

Problem: How does the effort required to pull an object up a ramp change with its incline?

Background: One of the simplest machines that make work easier is the inclined plane. It is much easier to push a heavy load up a ramp than it is to lift it vertically to the same height. When it is lifted vertically, a greater lifting force is required but the distance moved is less. When it is pushed up a ramp, the distance moved is greater but the force required is less. This fact illustrates the law of conservation of energy.

Summary:

As incline decreases (more distance), force decreases = High Mechanical Advantage

As incline increases (less distance), force increases = Low Mechanical Advantage

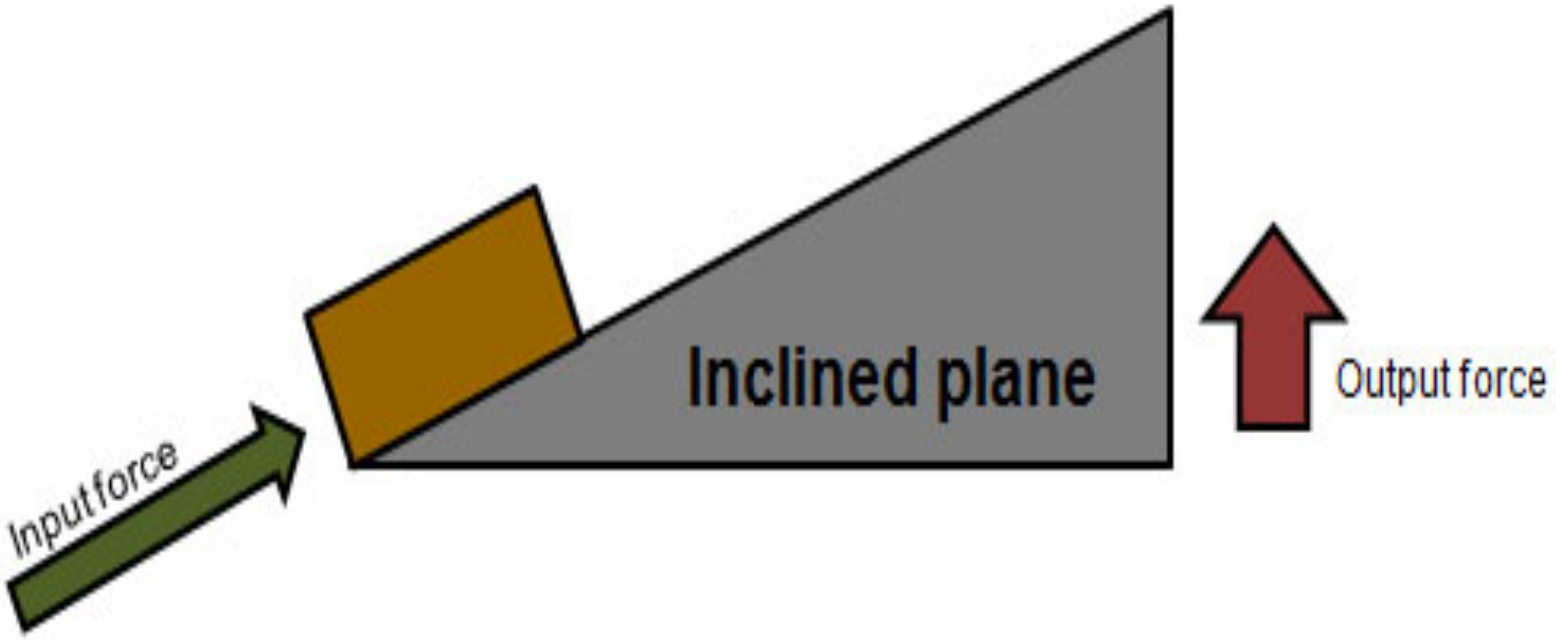
Table showing effect of a change in incline on Force

Height of Ramp (in cm) **45 CM**

Load (weight of car in N) **4.5N**

Incline/ distance in m	Force of Car F/N	M. A. = Load / Effort
0.5	4.3	1.1
0.6	3.6	1.3
0.7	3.1	1.5
0.8	2.6	1.7
0.9	2.1	2.1
1.0	1.8	2.5

An inclined plane decreases the effort force but increases the distance over which the force is exerted.

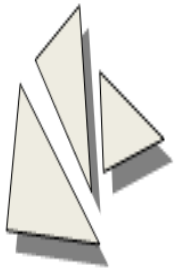


Credits: http://www.ontrack-media.net

It is important to remember that machines do not save or lessen the amount of work; they only change the size, distance or direction of a force you have to exert.

STATION 2. Wedge

Wedge Wise

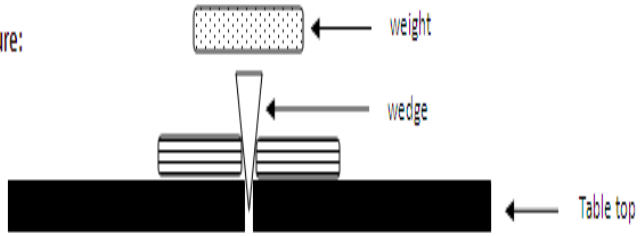


Problem: How does the length of a wedge affect how easily it pushes through something?

Background:

The wedge is an example of two back-to-back inclined planes. Examples of wedges include knives, axes, chisels, or anything with a sharp edge used for cutting or splitting. The ideal mechanical advantage of a wedge is *determined by dividing the length of one of the inclined planes by the thickness at the wedge's widest point.*

Procedure:



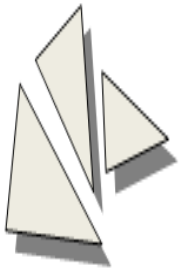
1. Place 2 tables beside each other with about 6 cm of space between them.
2. Place one book on one desk and the other book on the second desk. Each book should have a thickness of about 5 cm. Slide the books together until the bindings are touching and are centered over the space between the tables.
3. Lightly hold a wedge vertically above the place where the books touch. Add weights until the wedge is forced between the books and until the top of the wedge is even with the top of the books.
4. Record how much weight was placed on the wedge to get it to force the books apart.
5. Repeat Steps 3 and 4 for each wedge.

Type	I.M.A.= Length/ Thickness	Amount of Weights (g)
A	3.3	1,000
B	4.4	700
C	2	1,100

A wedge _____ the effort force but _____ the distance over which the force is exerted.

STATION 2. Wedge

Wedge Wise



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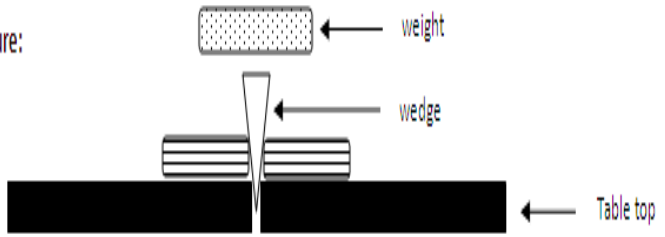

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Type	I.M.A.= Length/ Thickness	Amount of Weights (g)
A	3.3	1,000
B	4.4	700
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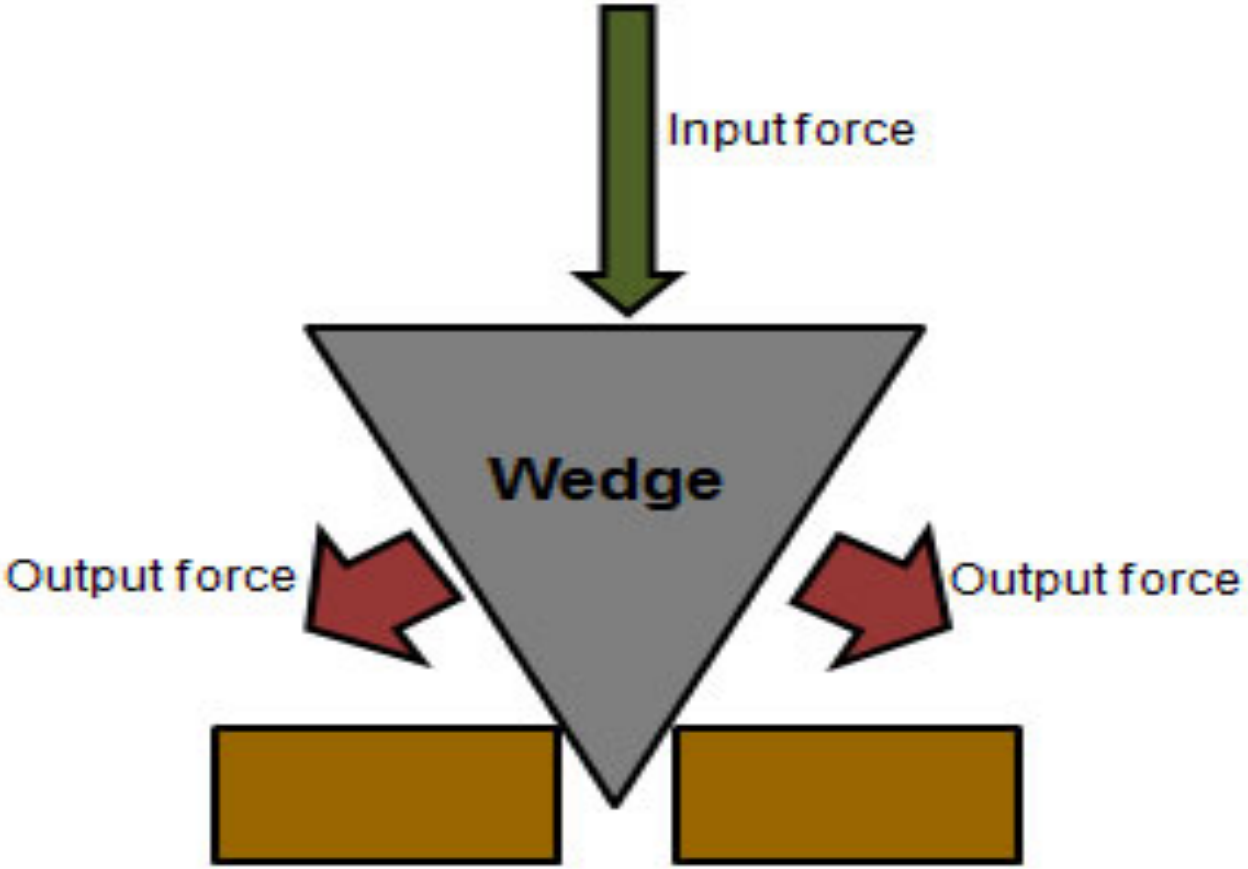
The longer the wedge (more distance), the lesser the effort force= High Mechanical Advantage.

The shorter the wedge (less distance), the greater the effort force= Low Mechanical Advantage.



It is important to remember that machines do not save or lessen the amount of work; they only change the size, distance or direction of a force you have to exert.

Table showing effect of change distance of effort arm on Force and Distance

Load (weight in N) **10N** Resistance Arm **0.2 m**

Distance in m (Effort Arm)	Effort Force (N)	Actual M.A. = Load / Effort	Ideal M.A. = Effort Arm / Resistance Arm
0.2	4.5	2.2	1.0
0.3	3.5	2.9	1.5
0.4	2.5	4.0	2.0
0.5	2.0	5.0	2.5
0.6	1.7	5.9	3.0
0.7	1.5	6.7	3.5

The longer the _____ arm, the _____ the effort force.

The _____ the effort arm, the _____ the effort force.

A lever _____ the effort force but _____ the distance over which the force is exerted.

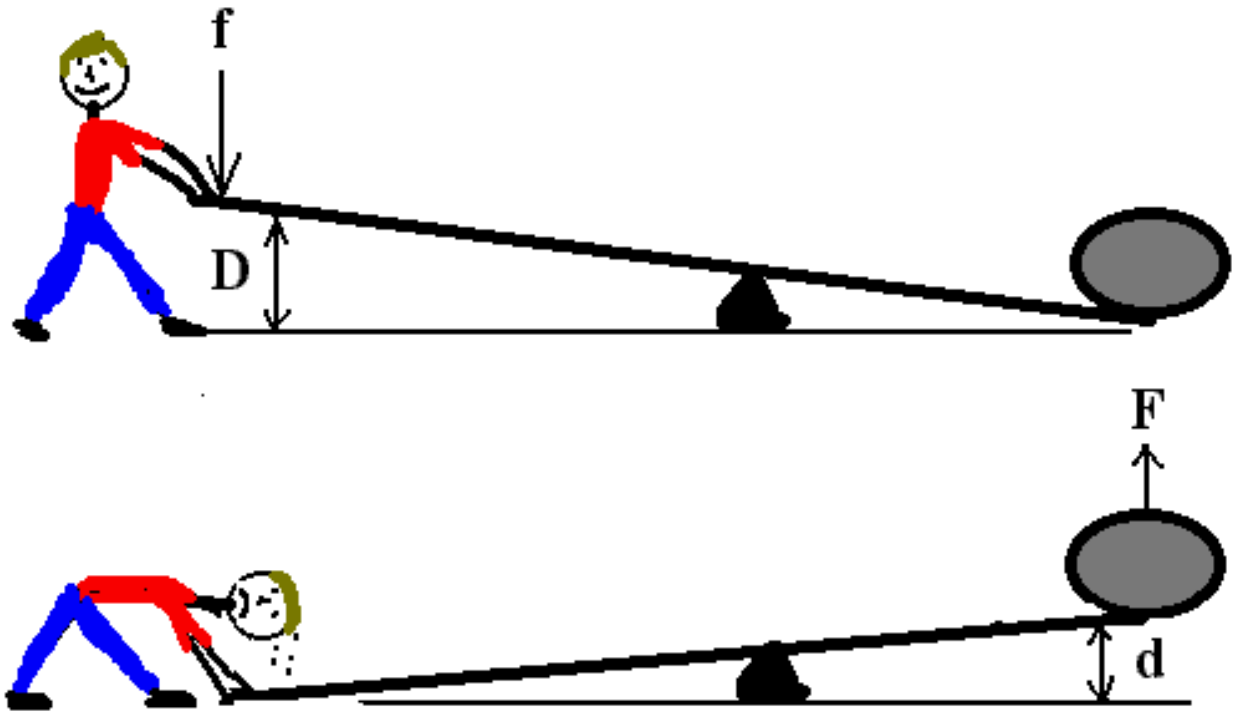
Table showing effect of change distance of effort arm on Force and Distance			
Load (weight in N) **10N**		Resistance Arm **0.2 m**	
Distance in m (Effort Arm)	Effort Force (N)	Actual M.A. = Load / Effort	Ideal M.A. = Effort Arm / Resistance Arm
0.2	4.5	2.2	1.0
0.3	3.5	2.9	1.5
0.4	2.5	4.0	2.0
0.5	2.0	5.0	2.5
0.6	1.7	5.9	3.0
0.7	1.5	6.7	3.5

The longer the effort arm, the lesser the effort force.

The shorter the effort arm, the higher the effort force.

A lever decreases the effort force but increases the distance over which the force is exerted.

Work in = f D



Work out = F d

Image credit: http://phys100.ccbcscience.org/lectures

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Screw (Interactive lab)

Click on this link: http://sunshine.chpc.utah.edu/Labs/Machines/act3a/lab1.html

1. **Go to Lesson 3. The Screw**
2. **Read the background information (click NEXT)**
3. **Perform activity. Collect data and record in the the data table below.**

   a. **Changing thread density.** (Radius of wheel at 100 cm)

      1. Start with a thread density of 3. Press lift. Record results.
      2. Repeat Step 1 by changing thread density from 3 to 4,5,6, and 7. Record all results.

Table showing effect of a change in thread density on Force and Distance			
Thread Density	**Force (N)**	**Distance in m**	**Radius in cm**
3			100
4			100
5			100
6			100
7			100

Analysis questions:

1. As the number of threads increases what happens to the distance the wheel is turned to lift the gate?

2. As the number of threads increases what happens to the amount of force needed to turn the wheel?

Table showing effect of change in thread density on Force and Distance			
Thread Density	Force (N)	Distance in m	Radius in cm
3	398.09	18.84	100
4	298.57	25.12	100
5	238.85	31.4	100
6	199.04	37.68	100
7	170.61	43.96	100

As thread density increases, the force _____ and the distance _____.

A screw makes the work easier by _____ the _____ force but increases the _____ over which the force is exerted.

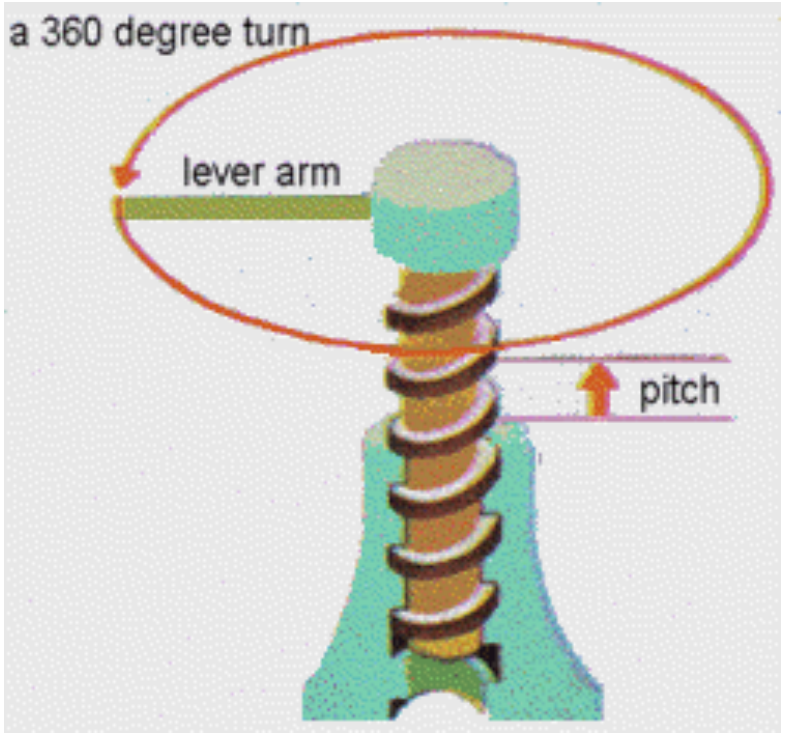

Image credit: www.robinsonlibrary.com/technology/mechanical/machines/screw

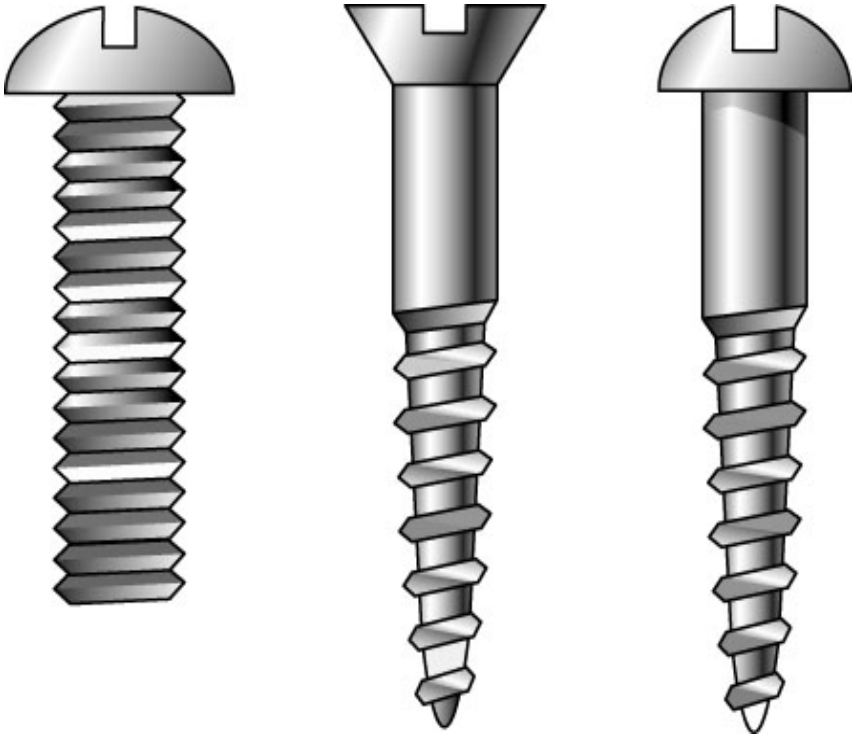

Image credit: http://ed101.bu.edu/

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b. **Changing the radius of the wheel** (Thread density at 3)

1. Start with a radius of 100. Press lift. Record results.
2. Repeat Step 1 by changing the radius of the wheel from 100 to 90, 8, 70, 60, and 50 cm. Record all results.

Table showing effect of a change in radius of wheel on Force and Distance				
Radius of wheel (in cm)	**Force (N)**	**Distance in m**	**Thread density**	**MA= radius of wheel / radius of axle**
100			3	
90			3	
80			3	
70			3	
60			3	

MECHANICAL ADVANTAGE of the Wheel and Axle:

Calculate the **mechanical advantage** if the **axle is 10 cm.**

Table showing effect of change in radius of the wheel on Force and Distance

Radius of wheel in cm	Force (N)	Distance in m	Thread Density	Mechanical Advantage
100	398.09	18.84	3	10
90	441.36	16.99	3	9
80	485.18	15.15	3	8
70	567.90	13.21	3	7
60	660.25	11.36	3	6

As radius of wheel increases, the force _____ and the distance _____.

A wheel makes the work easier by _____ the _____ force but increases the _____ over which the force is exerted.

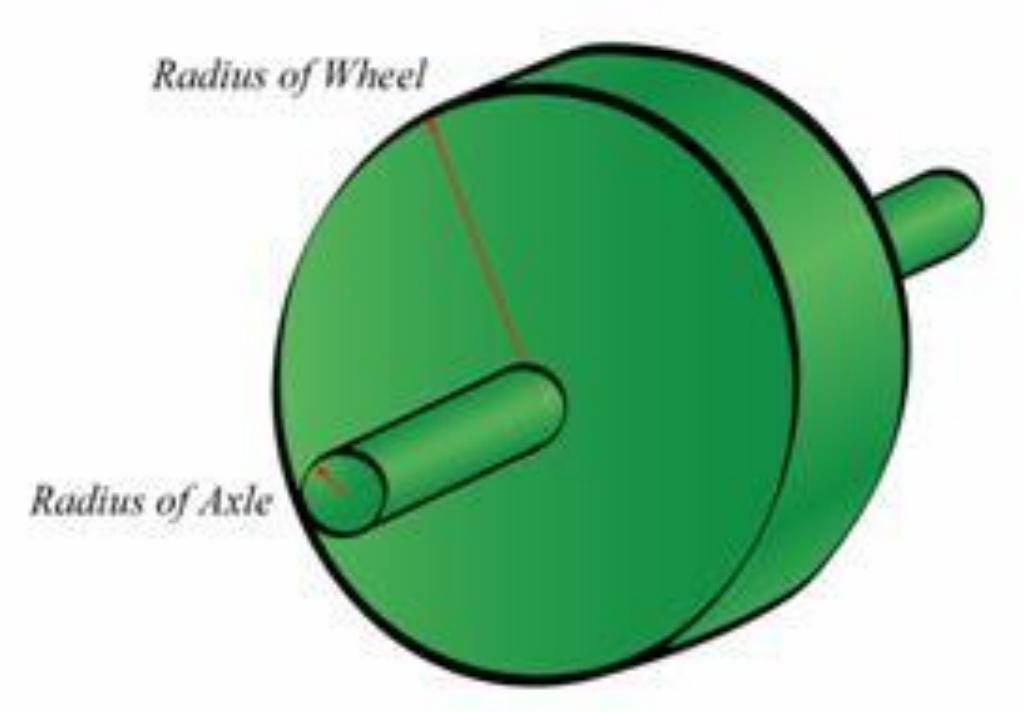

Image credit: www.teachengineering.org

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Mechanical Advantage of a Wheel & Axle

The mechanical advantage of a wheel and axle is the ratio of the radius of the wheel to the radius of the axle.

Wheel and Axle

Input Information

wheel radius	30 cm (centimeters)
axle radius	5 cm (centimeters)

The radius is equal to 1/2 the diameter of a circle.

Result

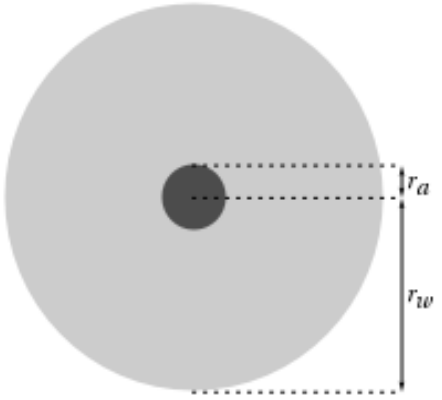
mechanical advantage	6

http://iqa.evergreenps.org/science/phy_science/ma.html

Equation

$$MA = \frac{r_w}{r_a}$$

MA	mechanical advantage
r_w	wheel radius
r_a	axle radius

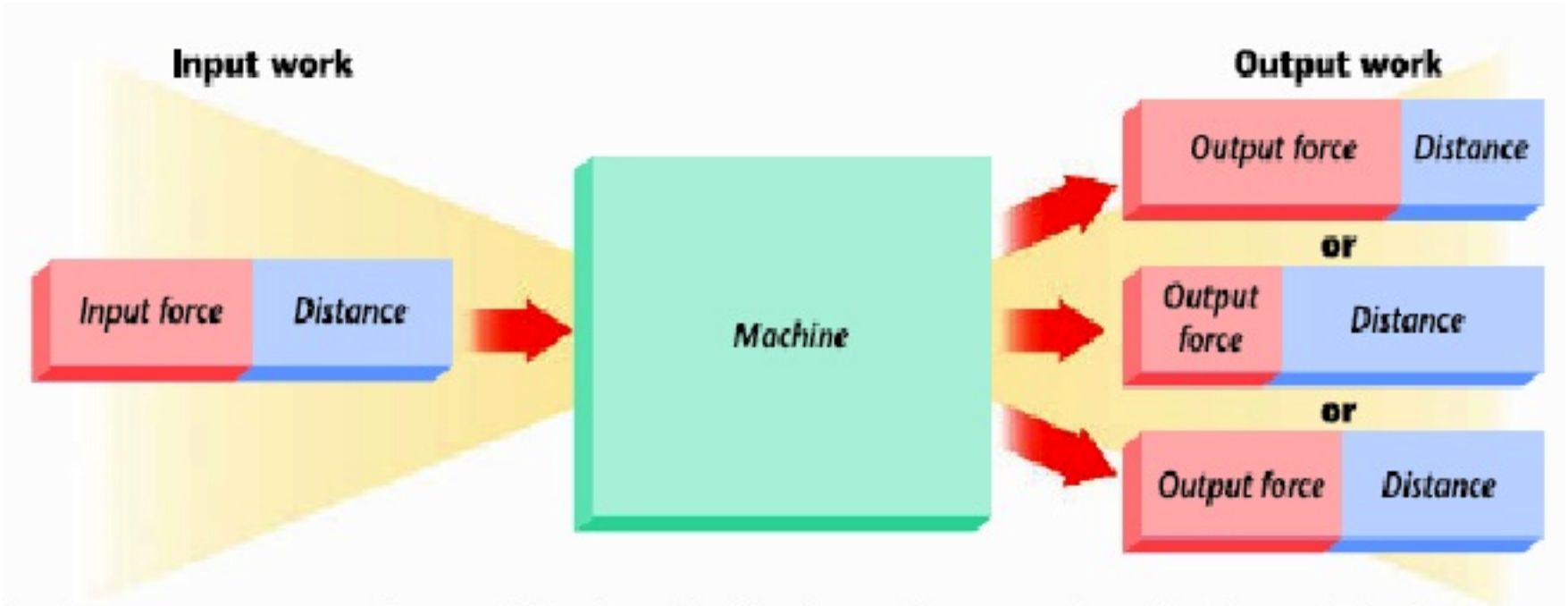


The radius of the wheel is six times larger than the radius of the axle.

Therefore, the mechanical advantage is 6:1 or 6.

21 Machines

A machine makes work easier by changing the amount of force you exert, the distance over which you exert your force, or the direction in which you exert your force.



•The force you exert on the machine is called the **input force** or the effort force. The force exerted by the machine is called the **output force** or the resistance force.

•If you compare the input force to the output force, you can determine the advantage of using a machine. **A machine's mechanical advantage is the number of times a force exerted on a machine is multiplied by the machine.**