Machines

A machine is a device that makes work easier.

In machines an effort (force in neuton) is applied to move the load.

The effort can be

Muscular effort from man or

Force derived from an ingine.

Principle of simple machines

The principle used in a simple machine is to produce a bi force overa small distance by using a small force over large distance.

The force which we apply to the machine is know as effort € and the load we have to overcome is is known as the load (L). both force and load are measured in neutons.

Types of machines

1. Simple machnes
2. Complex machine

Simple machines

These are devices that work with one movement and change the size and direction of force.

Examples of simple machnes include levers, pulley, hydraulic, gears, screws, and inclined planes

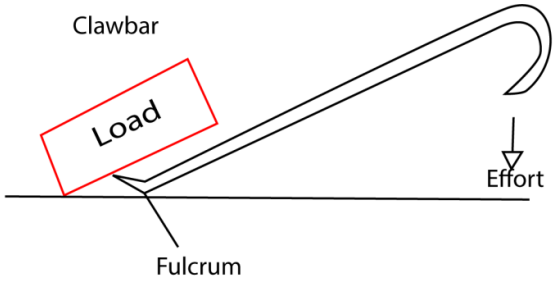
Levers

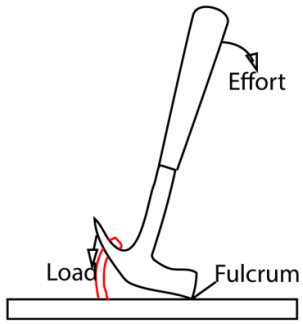
A lever is a rigid bar which is free to move about a fixed point, the Fulcrum or povot

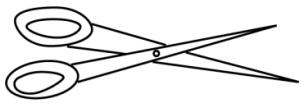
Levers are divided into three classes

(i) The first class levers
(ii) The second class lever and,
(iii) Third class levers

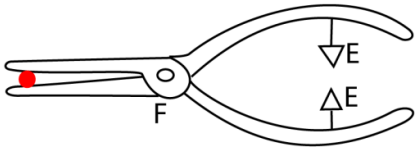
(a) First class lever
This is a type of lever in which the fulcrum is between the effort and the load.
Examples of first class lever include Craw bar, scissor, beam balance, scissor and pair of pliers,



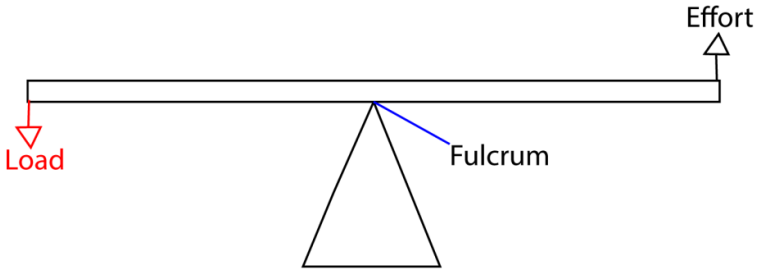




Pair of scissors

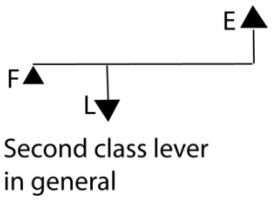


Pair of pliers

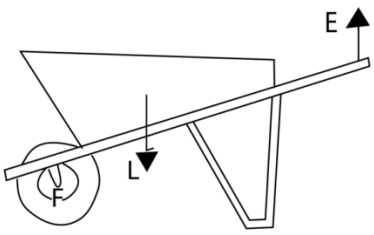


Beam balance

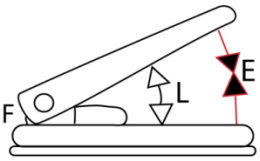
(b) Second class lever
Here the load is between the effort and fulcrum.
Examples are wheelbarrow, nut cracker and office punch



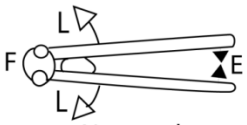
Second class lever in general



Wheelbarrow



Office punch

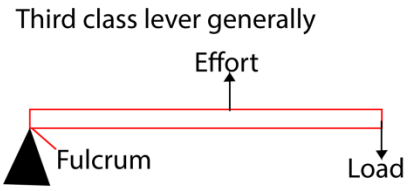


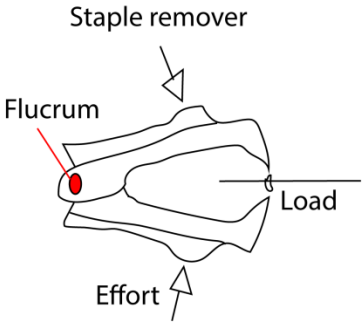
Nut cracker

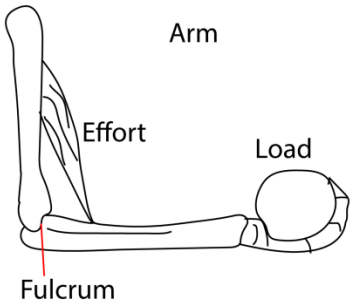
(c) Third class lever

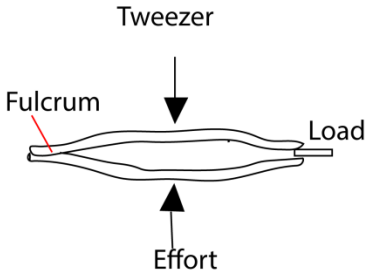
Here the effort isf between the load and fulcrum.

Examples are wheelbarrow, nut cracker and office punch









Mechanical advantage (M.A)

This is the ratio between the load and the effort applied.

i.e $M.A = \frac{Load\ (L)}{Effort\ (E)}$

Significance of mechanical advantage

The bigger the mechanical advantage the better the machine since small effort can lift a bigger load.

Factors that may lower mechanical advantage

Friction; the higher the friction the lower the mechanical advantage

Weight of moving parts: the heavier the parts the lower the mechanical advantage

Velocity ratio

This is the ratio of distance moved by effort over the distance moved by the load

i.e. Velocity ratio (V.R) = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load}$

Velocity ratio has no units

Significance of velocity ratio

The bigger the velocity ratio the less effort required to do work and the more efficient the machine. Or the machines requires less effort to overcome a big load when effort moves a bigger distance compared to the load in a uinit time.

Example 1

A load of 100N is raised through 6m when an effort of 40N moves through 24m.

Calculate

(i) mechanical advantage

(ii) velocity ratio

Solution

(i) $M.A = \frac{Load\ (L)}{Effort\ (E)} = \frac{100}{40} = 2.5$

(ii) Velocity ratio (V.R) = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load} = \frac{24}{6} = 4$

Pulleys

A pulley is a wheel with a groove ring which passes or string .

- The effort is applied to one end of the rope and the disk of the pulley rotate as the rope moves over it
- If there are several pulleys in a frame work, it is called a block

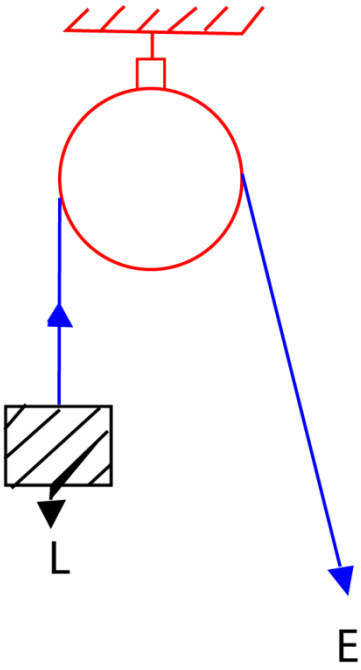
Types of pulley

Pulleys may be categorized into

- Single fixed pulley
- Single movable pulley
- Block and Tackle system

Pulleys reduce the effort to lift an object by increasing the distance and /or direction over which the effort is applied.

(a) Single fixed Pulley



A single fixed pulley is as single wheel with concave grooves fixed to a support as shown in the figure above. A rope, chain or cable passes over the groove of the pulley. One end of the rope is attached to the load and the effort is applied at the other end.

If a user pulls down on one end of the rope (Effort), the other end (Load) will raise up an equal distance in the opposite direction

The primary benefit of a single fixed pulley is to change the direction of the effort to move a load to a point (such as the top of a flagpole) that cannot be reached by the user.

Characteristics of a fixed pulley system

- It has one wheel inside the pulley

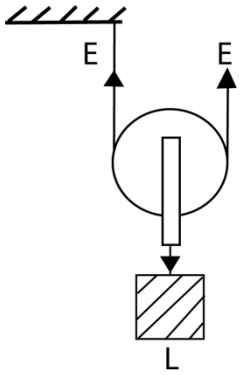
- The pulley is mounted to strong solid support
- Its mechanical advantage = 1
- Velocity ratio = 1
- It is a first class lever because the fulcrum is between the effort and the load
- Has uniform tension in the rope

Application of single pulley system

- Removing water from a well
- Lifting building material in the site

(b) A single movable Pulley

This is a pulley which moves along with the load attached to it. One end of the rope is tied to a fixed support and passes over the pulley and the other end where effort is applied makes a U-turn to the user as shown below.



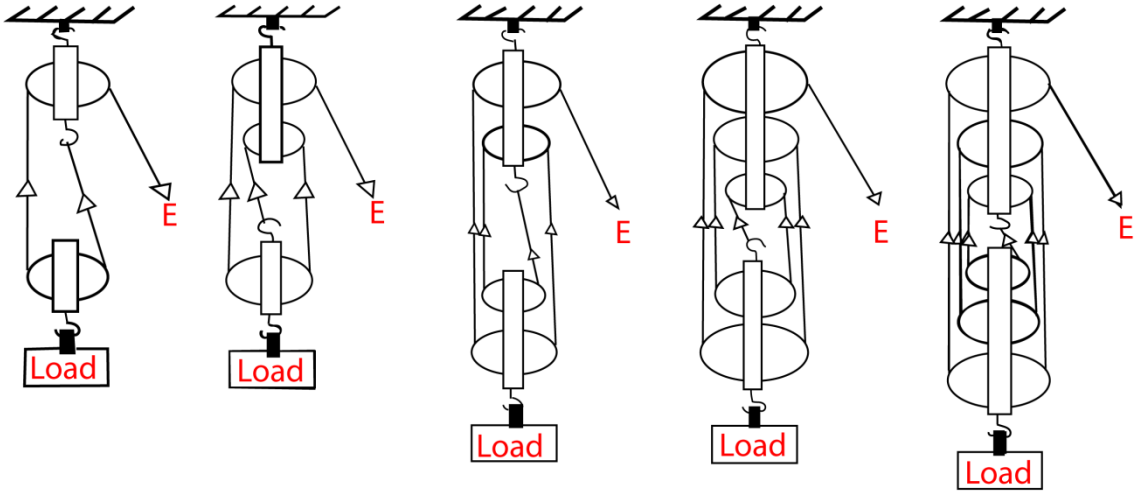
Characteristics of single fixed pulley

- Its mechanical advantage = 2, that is the effort required to lift the load is half the size of the load.
- Its velocity ration = 2, that is the effort moves twice the distance moved by the load.

(c) Block and Tackle system

This is a pulley system consisting of both fixed and movable pulleys as shown below

Drawings showing Block and tackle systems



The framework of pulleys is called block and the rope passing over each pulley is called tackle.

Characteristics of block and tackle sysytem

- Mechanical advantage (MA) = n (number of pulleys in the system
- Velocity ration (VR) = n (number of strings supporting the load or number of pulleys in the system)

Application of Block and Tackle

They are commonly used to raise or move load in

- Sailing
- Crane
- Lifts
- breakdown

Example 2

A force of 10N is required to raize a load, L, using a smooth (frictionless) and weightless block and tackle system of four pulleys. Calculate:

(a) (i) Load

(ii) M.A
(iii) Effert distance if the load rises by 2m

Soluiton

Given

E = 10N, M.A = ?, Effort dis. ? Load distance = 2m L ? No of pulleys = 4

(a)(i) in equilibrium

Downward force = upward force

$$L = 4E = 4 \times 10 = 40N$$

(ii) mechanical advantage

$$M.A = \frac{load}{effort} = \frac{40}{10} = 4$$

(iii) Neglecting friction,

Work in put = work out put

Work done by effort = work done by load

Effort x effort distance = Load x distance

$$E \times E.d = L \times L.d$$

$$10 \times E.d = 40 \times 2$$

$$E.d = 8$$

Therefore, effort distance = 8m

Efficiency of machines

The efficiency of a machine indicates how well its input energy is converted to useful output energy or work.

n= MA / VR

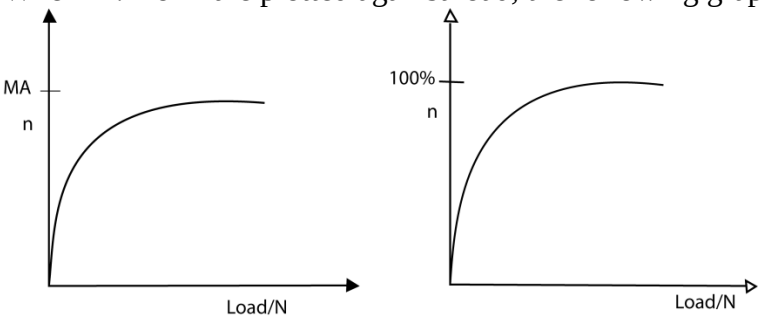
Efficiency = Mechanical Advantage / Velocity ratio.
In an ideal machine (with no friction), the efficiency = 1, also known as 100%.

How can efficiency be increased

(a) Machines can be made more efficient by reducing friction. This usually is done by adding a lubricant, such as oil or grease, to surfaces that rub together
(b) For the case of pulleys, by making the string and the block plus the pulleys as light as possible.

Graphical relatonship between M.A and Load

When M.A or n are plotted against load, the following graphs are obtained



raph

Explanation of the shape of the graph

In both, a small increase in load cause high increase in M.A and efficiency, n. on further increase on the load, graphs begin to level as M.A and efficiency reach their maximum values and the remain constant.

The efficiency of the pulley sysytem increase with the load because when the load is small, the weight of the lower moving pulley block and friction is significant.

The weight of the lower movable pulley block and friction become negligible to the load as the size of the lad increases.

NB. For figure (a), the graph levels at the value of M.A. while (b), the graph levels below 100% for imperfect machine and levels at 100% for perfect machines

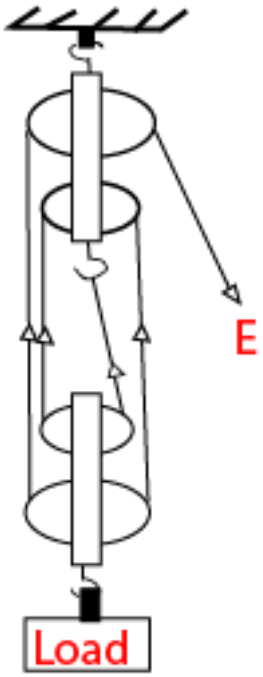
Example 3

(a) Define the following terms

(a) (i)Mechanical advantage

(ii) Velocity ration

(b) The diagram in the figure shows a pulley system used to raise the load



(i) What is the velocity ratio of the system
(ii) Find how far the load is raised if the effort moves down by 4m
(iii) Calculate the effort required to raise a load of 800N, if MA = 4

(c) Explain what happen to efficiency of the system in (b) above if the load is much

(i) Less than 800N
(ii) More than 800N

(d) Draw a sketch graph to show how mechanical advantage of the system in (b) varies with the load
(e) Give two practical applications where the pulleys are used.

Solution

(a) (i) mechanical advantage is the ratio of load to effort

(ii) Velocity ration is the ratio of effort distance to load distance

(b) (i) VR = number of pulleys = 5

(ii) Effort distance = 4m, load distance = ?, V.R = 5

$$\text{V.R} = \frac{Effort\ distance}{Load\ distance} = 5 = \frac{4}{load\ distance}$$

Load distance = 0.8m

(iii) E = ?, L = 800N, M.A = 4

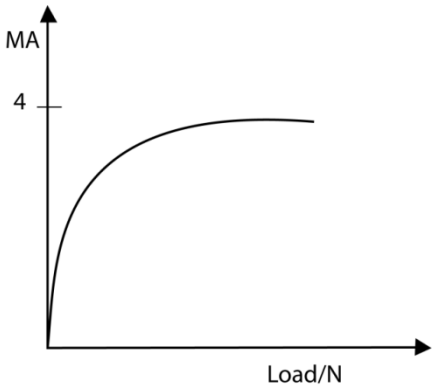
M.A = $\frac{Load}{Effort} = 4 = \frac{800}{E}$

E = 200N

(iv) n = ?, MA = 4, V.R

n = $\frac{M.A}{VR} x100\% = \frac{4}{5} x\ 100 = 80\%$

(d)

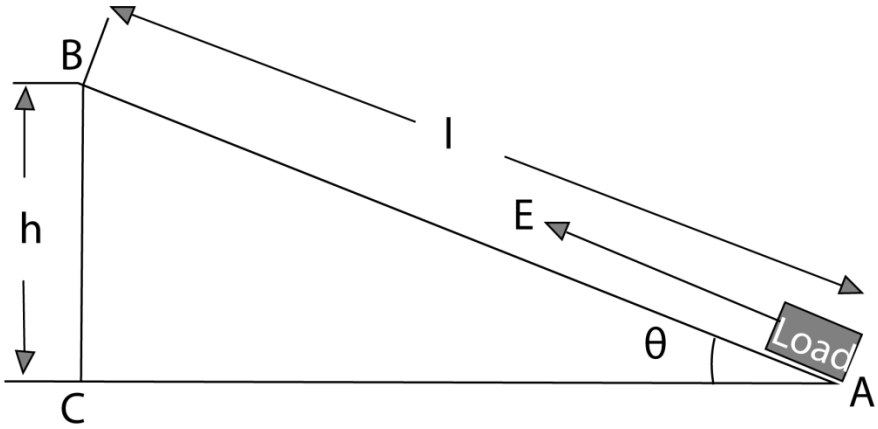


(a)

(f) they are used in cranes, breakdown, ships, for lifting

Inclined Plane

This refers to a type of a machine in which a plane is inclined to an angle to the horizontal such that one end is higher than the other by angle, Θ.



- it used to lift heavy load by pulling/pushing it along the sloping surface.

- It is easier to carry the load along the slope than lifting it through the vertical height, h, since the weight of the load acts vertically downwards (and only a component of weight acts along the plane)
- In order to raise the load through a vertical height, h, th effort, E is applied through a longer distance, l, equal to the length of the plane.

Examples of inclined plane include

(i) Slopping roads

(ii) Stair case

Properties of inclined planes

M. A = V.R = $\frac{l}{h}$

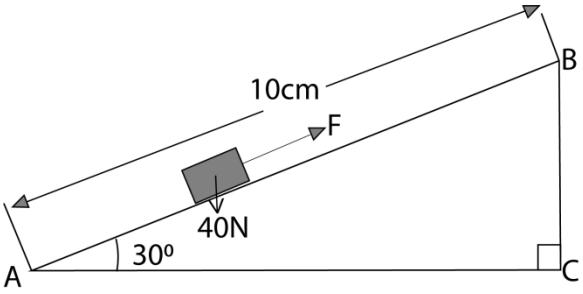
But h = lsinθ

MA = $\frac{l}{lsin\,\theta} = \frac{1}{sin\theta}$

Example 3

A load of 40N ispulled steadily from A to B along inclined plane by a force F as shown in the figure. Find the velocity ratio of the system.

A. 1.0 B. 1.2 C. 2.0 D. 4



AC = 10 cm, Bc = ? θ = 30^0

BC = AC x sin30 = 10 x 0.5 = 5cm

VR = $\frac{AC}{BC} = \frac{10cm}{5cm}$ = 2

Alternatively

VR = $\frac{1}{\sin 30} = 2$

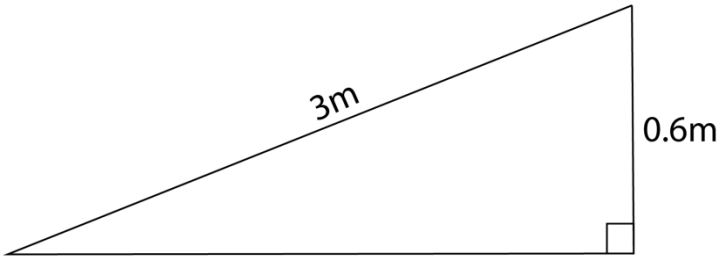
Answer is C

Example 4

A wooden plank 3m long is used to raise a load of 1200N through a vertical height of 60 cm. if the frictional force between the load and the plane is 40N. calculate

(a) The effort required
(b) The mechanical advantage

Solution



Given: L = 1200N, E = ? l = 3m, h = 60cm = 0.6m, friction force = 40N

(a) Work input = work out put + useless work done
Work done by effort = work done by load + work by frictional force
Effort x effort distance = Load x load distance + friction force x Effort distance
E X 3 = 1200 x 0.6 + 40 x 3
E = 280N

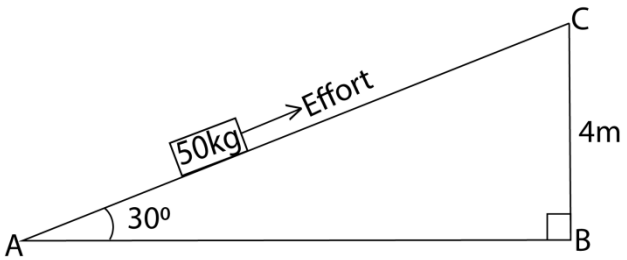
(b) MA = $\frac{L}{E} = \frac{1200}{280} = 4.3$

Example 5

A man uses the incline plane to lift a 50 kg load through a vertical height of 4.0m. the inclined the incline plane makes an angle of 300 with the horizontal. If the efficiency of the plane is 72%, calculate

(a) The effort needed to move the load up the inclined plane at a constant velocity
(b) The work done against friction in raising the load through the height of 4.0m (take g = 10Nkg^{-1})

Solution



Given

MA = $\frac{L}{E}$ = $\frac{1}{sin30} = 2 = \frac{50\ x\ 10}{E}$

E = 250N

Let the actual effort used = x

Efficiency = $\frac{250}{x}\ x\ 100 = 72$

X = 347.6N

Therefore effort = 347.2N

(b) work against friction = friction x Effort distance

= (347.2 – 250) x AC N

= 97.6 x $\frac{4}{sin30}$

=777.8N

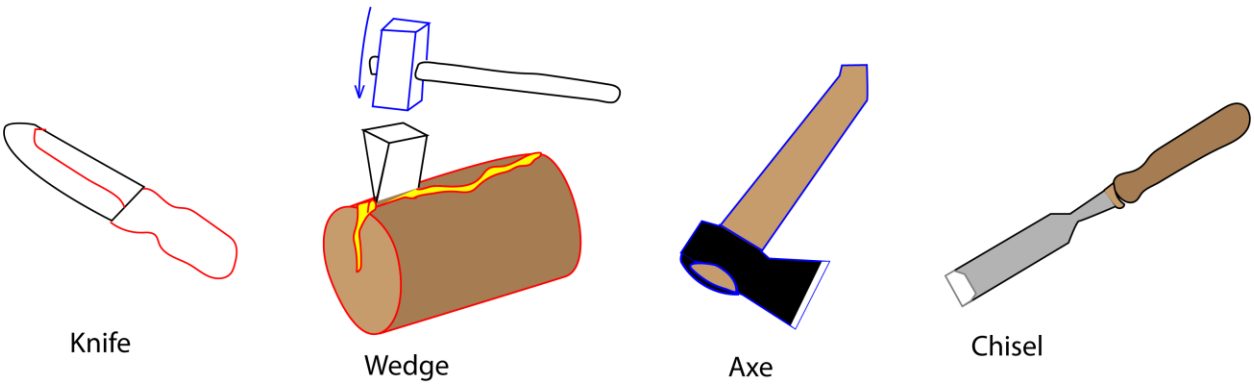
The Wedges

The wedge is a kind of simple machine which is an inclined plane having one or two sloping sides. With a wedge, the sloping surface is pushed through the material which is held still.

Examples of wedges are: Knife, axe, chisel, needle, nail, razor blade

Uses of wedges include: Cutting, pitching

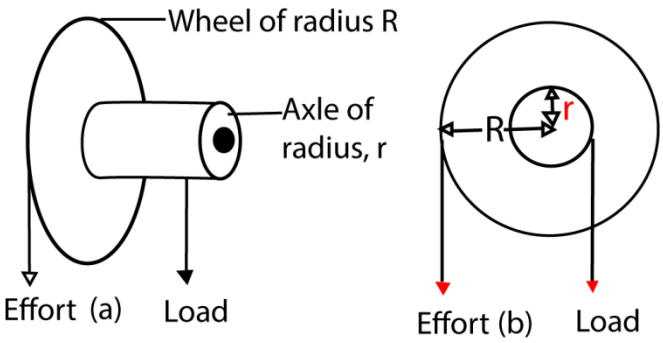
Examples of wedges



Wheel and axle

A wheel and axle is a type of simple machine made up of a wheel and axles rigidly attached to each other so that they turn together about an axis.

The effort is applied to the larger wheel and the load is raised by string attached to the axle of small diameter as show below:



For one complete turn, the load and effort move through distances equal to the circumference of the wheel and axle respectively.

Characteristic of Wheel and axle

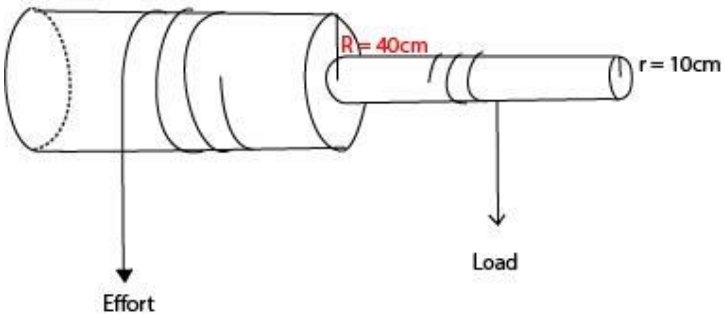
MA = VR = $\frac{R}{r}$

Uses of wheel and axle

(i) The car steering wheel
(ii) Screw driver
(iii) Windlass (used to raise a heavy bucket of water in a well.

Example 6

The figure below shows a wheel and axle system. When an effort of 300N is applied, a load of 900N is raised through a distance of 1.0m.



Calculate

(a) Velocity ratio
(b) The efficiency of the machine

Solution

VR = $\frac{R}{r} = \frac{40}{10} = 4$

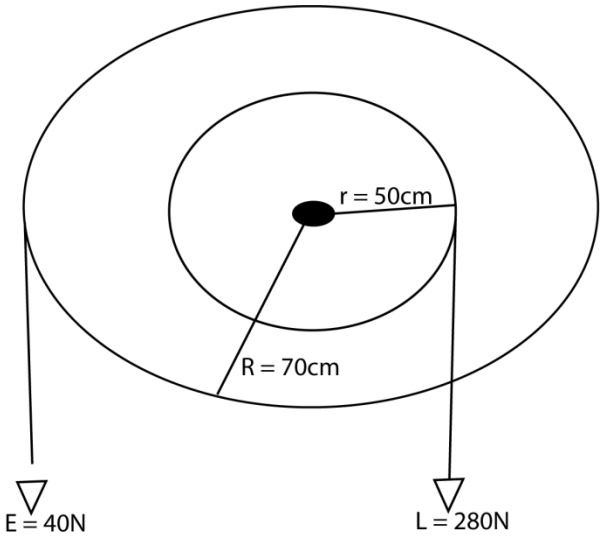
(b) efficiency = $\frac{M.A}{V.R}\ x\ 100$

$= \frac{L}{X}\ x\ \frac{1}{V.R}\ x\ 100\ = \frac{900}{300}\ x\ \frac{1}{4}\ x100 = 75\%$

Example 7

A wheel and axle is used to raise a load of 280N by a force of 40N applied to the rim of the wheel. If the radii of the wheel and axle are 70cm and 5cm respectively, calculate the M.A, V.R and the efficiency.

Solution



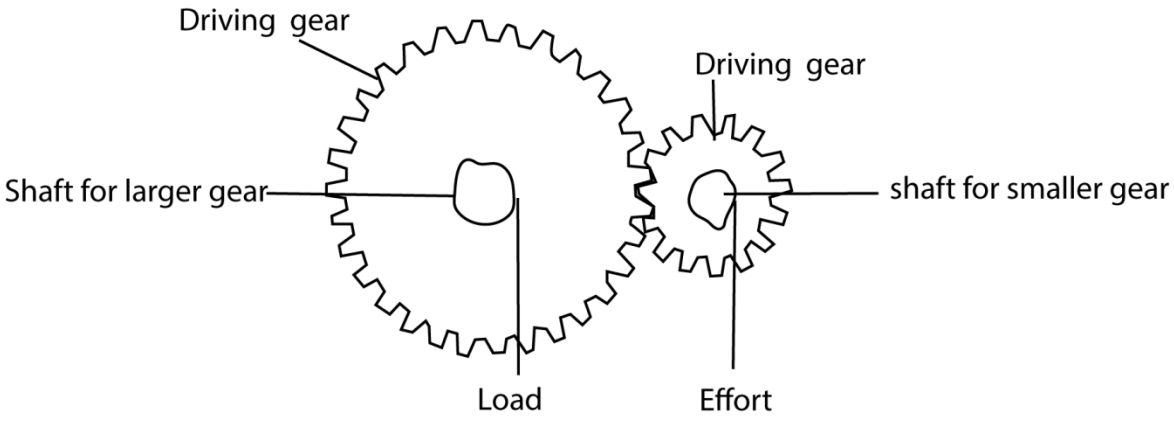
M.A = $\frac{load}{effort} = \frac{280}{40} = 7$

V.R = $\frac{R}{r} = \frac{70}{5} = 14$

Efficiency = $\frac{M.A}{V.R} x\ 100 = \frac{7}{14}\ x\ 100 = 50\%$

Gears

A gear is a device which consists of a set of toothed wheels. Gears change the direction and speed of rotation. They are similar to wheel and axle. In gear wheel, the effort and the load are applied to the shafts connected to gear.



Velocity ratio = $\frac{Number\ of\ teeth\ in\ the\ driven\ wheel}{Number\ of\ teeth\ in\ the\ driving\ wheel}$

The velocity ratio of gears depends on which gear wheel is the effort applied.

Torque may be applied to the smaller gear in order to increase the torque and decrease the rate of rotation of the larger gear.

Or

Torque may be applied to the larger gear in order to decrease torque and increase the rate of rotation in the smaller gear.

Example 7

Two gear wheels A and B with 20 and 10 teeth respectively lock into each other. They are fastened on axles of equal diameter such that a weight of 100N attached to a string wound around one axle raises a load of 160N attached to a string wound around the other axles.

Calculate

(a) (i) the velocity ratio

(ii) The efficiency of the system when a small gear wheel is the driven gear

(b) (i) the velocity ratio

(iii) The efficiency of the system when a big gear wheel is the driven gear

Solution

(a) i) V.R = $\frac{Number\ of\ teeth\ in\ the\ driven\ \ wheel}{number\ of\ teeth\ in\ the\ driving\ wheel} = \frac{10}{20} = 0.5$

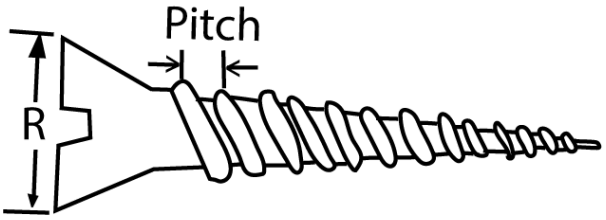
(ii) Efficiency, n = $\frac{M.A}{V.R}\ x\ 100 = \frac{L}{E}\ x\ \frac{1}{V.R}\ x\ 100 = \frac{160}{100}\ x\ \frac{1}{0.5}\ x\ 100 = 320\%$

(b) (i) V.R = $\frac{Number\ of\ teeth\ in\ the\ driven\ \ wheel}{number\ of\ teeth\ in\ the\ driving\ wheel} = \frac{20}{10} = 2$

(ii) Efficiency, n = $\frac{M.A}{V.R}\ x\ 100 = \frac{L}{E}\ x\ \frac{1}{V.R}\ x\ 100 = \frac{160}{100}\ x\ \frac{1}{2}\ x\ 100 = 80\%$

The screw

A screw may be considered as continuous inclined plane wound round a cylindrical threaded rod.



- The distance between two successive threads is called a pitch
- In one revolution, the screw moves forward (or backward) through a distance of equal to one pitch.
- Effort distance equals the circumference of the screw head (2πR)
- Load distance equals the length of the pitch.
- When a screw is combined with lever can be uses as a jack for lifting heavy loads such cars

The velocity ration of screws

The V.R of the screw is given by the formula = $\frac{Distance\ moved\ by\ the\ effort}{distance\ move\ by\ the\ load}$

$$V.R = \frac{2\pi R}{screw\ pitch}$$

M.A of screw = $\frac{2\pi R}{screw\ pitch}$ (ignoring friction)

Example 8

(a) In a screw jack the length of the handle is 24cm and the screw pitch is 2mm.if it is used to raise a car of mass 2000kg, calculate
   (i) The effort required
   (ii) The V.R
   (iii) The M.A

(b) Comment the value of M.A obtained in (a)(iii) above
   (Take g= 10ms^{-2}, π = 3.14)

Solution

L = 24 cm = $\frac{24}{100} = 0.24m$, pitch =2mm = $\frac{2}{1000} = 0.002m$, L = 2000 kg = 2000 x 10 = 20000N, E = ?

(i) Effort x 2πl = Load x screw pitch

$$Effort = \frac{\text{Load x screw pitch}}{2\pi l}$$

$$= \frac{20000\ x\ 0.002}{2\ x\ 3.14\ x\ 0.24} = 26.54N$$

(ii) and (ii) V.R = M.A = $\frac{2\pi l}{screw\ pith} = \frac{2\ x\ 3.14\ x\ 0.24}{0.002} = 753.6$

(b) MA = VR because the screw jack is assumed to be perfect, i.e. frictionless

NB in practice the effort must be higher than 26.54N in order to overcome friction

Example 9

A car weighing 1600 kg is lifted with a jack-screw of 11mm pitch. If the handle is 28cm from the screw, find the force applied.

Solution

V.R of the screw = $\frac{circumference\ of\ the\ handle}{Pitch}$

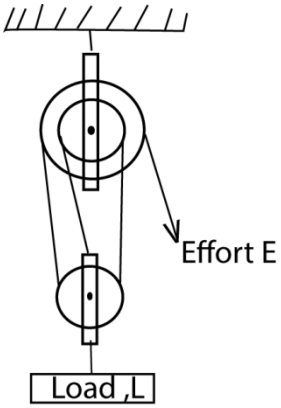
Neglecting friction, MA = VR = $\frac{L}{E}$

$$\frac{1600}{E} = \frac{2\pi R}{pitch} = \frac{2\ x\ 3.14\ x\ 0.28}{0.011}$$

E = 10N

Exercise

1. (a) Define the statement efficiency of a machine



(b) The diagram above represents a pulley system in which an effort, E, applied to raise the load, L.

(i) Copy the diagram and indicate the force acting on the string.

(ii) What is the velocity ratio of the system?

(iii) How far will the load move if the effort move by 3m?

(iv) Using the effort will, just raise a load of 1000N, if mechanical advantage is 2.

(v) Using the result above, calculate the efficiency of the system.

(c) (i) Draw a sketch graph to show the mechanical advantage of the pulley system in (b) varies with the load.

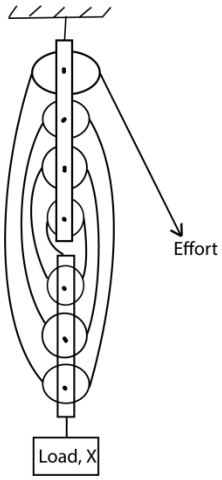
(ii) Explain the features of the sketch in (c)(i) above.

(d) Give two practical examples where pulley system is used.

2. (a) define the following terms

(i) mechanical advantage

(ii) velocity ratio



(b) The diagram above shows a pulley system, where effort E is applied to raise the load , X.

(i) What is the velocity ratio of the system?

(ii) If the effort moves a distance of 5 meters, find the distance the load moves.

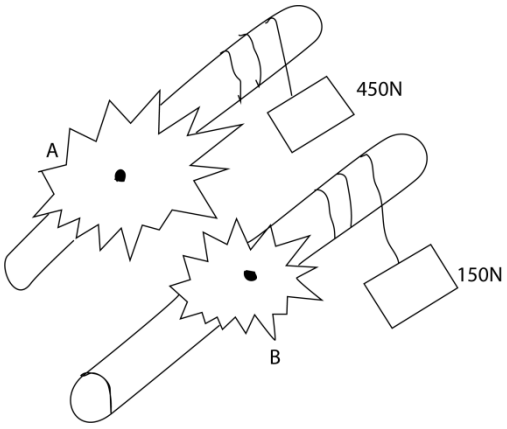
(iii) Calculate the effort needed to lift a load of 1000N, if mechanical advantage is 6.

(c) (i) Draw a sketch to show how mechanical advantage of the above system would vary with the load.

(ii) Give two uses of the pulley system.

(iii) Explain what happens to the efficiency of the pulley, if the load is less than 1000N and more than 1000N

3.



Two gear-wheels A and B with 80 and 20 teeth respectively lock each other. They are fastened on axles of equal diameter such that a weight of 150N attached to a string wound around one axles raises a load of 450N attached to a sting wound around the other axle as shown in figure above

Calculate

(i) The velocity ratio (2marks)

(ii) Efficiency of the system (2marks)

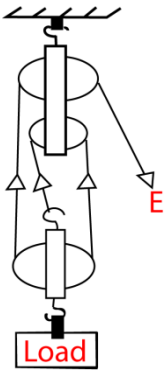
4. In a pulley system, the distance moved by the effort is 5 times the distance moved by the load. Calculate the efficiency of the system if an effort required to move a load of 60N is 20N.

5. (a) What is meant by efficiency of a machine? (1mark)

(b) Draw a single pulley system of velocity ratio 3. (2marks)

(c) state one reason why the efficiency of a machine is less than 100%

6.



(a) What is the velocity ratio of the pulley system above?

(b) Calculate the efficiency of the pulley system when the minimum effort required to raise a load of 210N is 90N

7. (a) what is meant by

(i) Velocity ratio of a machine

(ii) Pitch of a screw?

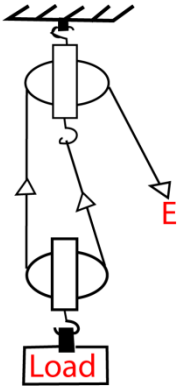
(b) A screw jack with a lever arm of 56cm and a pitch of 2.5mm is used to raise a load of 200N if its efficiency is 25%, find

(i) Velocity ratio

(ii) Mechanical advantage

(c) Describe an experiment to show how the mechanical advantage of a block and tackle pulley system with velocity ratio 4 varies with the load.

8. The figure below shows a pulley system supporting load of 600N



Find the

(i) Tension in the string (02marks)

(ii) Value of E if the mechanical advantage is 3 (o2marks)

9. (a) define velocity ratio and efficiency as applied to a machine

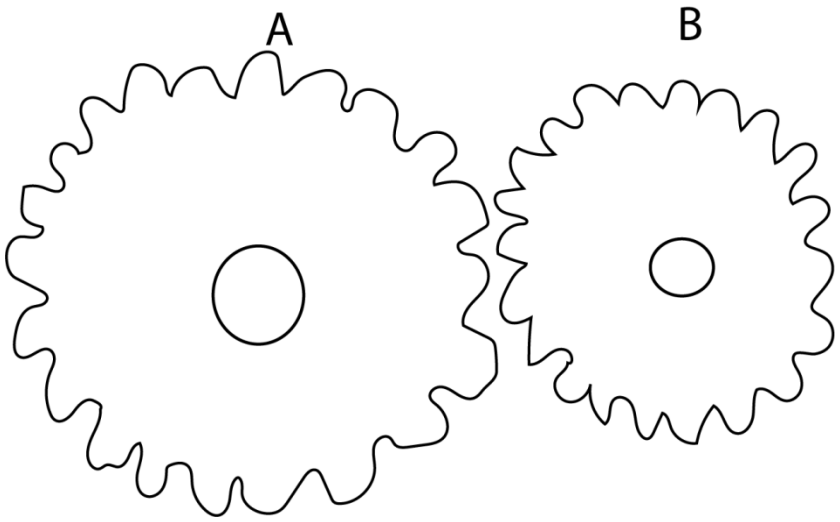
(b)(i) Drawn a diagram of a pulley system with velocity ratio = 6

(ii) Calculate the efficiency of the pulley system in (b)(i) above if effort of 1000N is required to raise a load of 4500N

(iii) Find the energy wasted when a load of 1500N is lifted through 2m by the pulley in (b)(i).

(c) Explain why the fulcrum must be near to the load than effort in the first class lever.

(d) The figure shows gear wheel



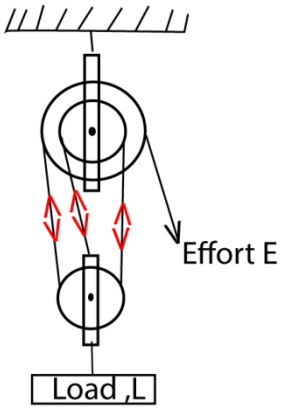
Explain how A and B should engage to give turning force of low mechanical advantage.

Responses to exercise

1. (a) Efficiency is the percentage work out put over work in put,

   i.e. efficiency = $\frac{work\ out\ put}{work\ in\ put}\ x\ 100\%$

   (b) (i)



   (ii) V.R = 3 (number of strings supporting the lower pulley)

   (iii) V.R = $\frac{Effort\ distance}{Load\ distance}$

   Load distance = 3/3 = 1m

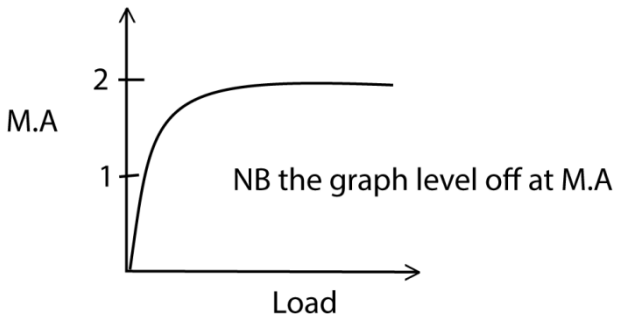
   (iv) M.A = $\frac{Load}{Effort}$

   2 = $\frac{1000}{E}$

   E = 1000/2 = 500N

   (v) Efficiency = $\frac{MA}{VR}\ x\ 100\% = \frac{2}{3}\ x\ 100\% = 66.7\%$

   (c)(i)



   (ii) for small load, friction and weight of the moving parts and string is comparable to the load, but for large loads, they are negligible.

   (e) Used in cranes and lifts.

2. (a)(i) mechanical advantage

   (ii) velocity ration = $\frac{distance\ moved\ by\ effort}{distance\ moved\ by\ the\ load}$

   (b) (i) VR = 7 (= number of pulleys)

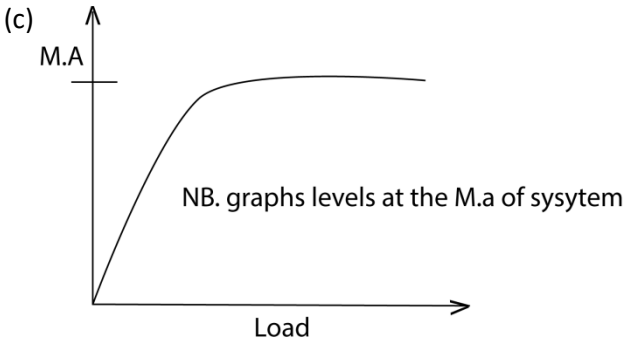
   (ii) 7 = $\frac{5}{x}$; => x = 0.71m

   (iii) M.A = $\frac{load}{effort}$;

6 = $\frac{1000}{effort}$; E = 166.7N

(iv) Efficiency = $\frac{M.A}{V.R}\ x\ 100 = \frac{6}{7}\ x\ 100 = 85.7\%$

(c)



(ii) uses: lifts, cranes

(iii) - if the load is less than 1000N is attached, the efficiency of the pulley system is less because the weight of the lower pulley is significant

- If the load is more than 1000N is attached, the efficiency of the pulley system increase because the weight of the lower pulley and friction are not significant.

3. (i) V.R = $\frac{No.of\ teeth\ of\ driven\ gear}{N0.of\ teeth\ of\ driving\ gear} = \frac{80}{20} = 4$

M.A = $\frac{Load}{Effort} = \frac{450}{150} = 3$

Efficiency = $\frac{M.A}{V.R}\ x\ 100 = \frac{3}{4}\ x\ 100 = 75\%$

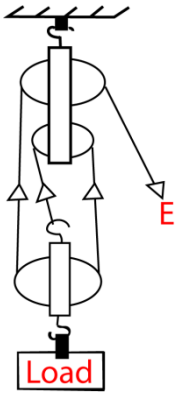
4. V.R = 5

MA = $\frac{Load}{effort} = \frac{60}{20} = 3$

Efficiency = $\frac{M.A}{V.R}\ x\ 100 = \frac{3}{5}\ x\ 100 = 60\%$

5. (a) what is the ratio of work out put to work input of a machine

(b)



(c) energy is wasted to lift part of the machine and to overcome friction.

6. (a) 3(= number of the strings supporting the load)

   (b) M.A = $\frac{Load}{Effort} = \frac{210}{90} = 2.3$

   Efficiency = $\frac{M.A}{VR}\ x\ 100\% = \frac{2.3}{3}\ x\ 100 = 77.8\%$

7. (a) (i) is the ration of the distance moved by the effort to that moved by the load.

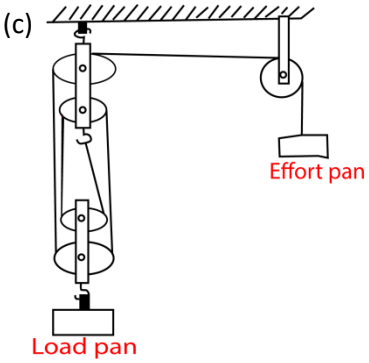
   (ii) the distance between two successive thread of a screw

   (b) (i) velocity ratio = $\frac{Distance\ moved\ by\ efffort}{distance\ moved\ by\ the\ load} = \frac{2\pi R}{pitch} = \frac{2\ x\ 3.14\ x\ 0.56}{0.0025} = 1407$

   (ii) Efficiency = $\frac{M.A}{VR}\ x\ 100\% = \frac{M.A}{1407}\ x\ 100 = 25\%$

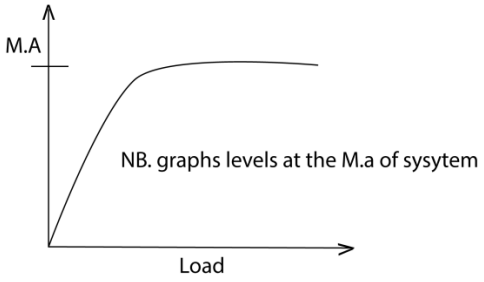
   ⇨ M.A = 352

   (c)



Procedure

- Known weights are put on the weightless load pan
- The effort required to move the load at constant velocity are determined
- Mechanical advantages of varying weights are determined by dividing load weight over effort weights and recorded in a table
- A graph of MA against the load are plotted.



8. (i)T = $\frac{600}{2}\ 300N$ (because there 2 strings supporting the load)

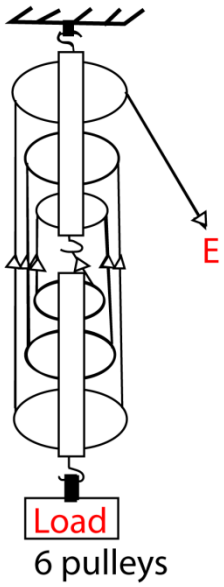
   (ii) M.A = $\frac{Effort}{Load} = 3 = \frac{600}{E}$

   E = 200N

9. (a) velocity ratio is the ratio of distance moved by the effort to the distance moved by the load at the same time

   Efficiency is the ratio of useful work out put over the work input

(b)(i)



(ii) MA = $\frac{Load}{Effort} = \frac{4500}{1000} = 4.5$

Efficiency = $\frac{M.A}{V.R}\ x\ 100 = \frac{4.5}{6}\ x\ 100 = 75\%$

(iii) Work out put = load x distance = 1500 x 2 = 3000

Efficiency = $\frac{work\ output}{work\ input}\ x\ 100 = 75 = \frac{3000}{work\ input}\ x\ 100$

Work in put = 4000

Energy wasted = work input – work output = 4000 – 3000 = 1000J

(c) In order to use less effort to lift the load

(d) **A** should be the driver and **B** the driven. This makes the system move with a higher speed when a small force is applied to A