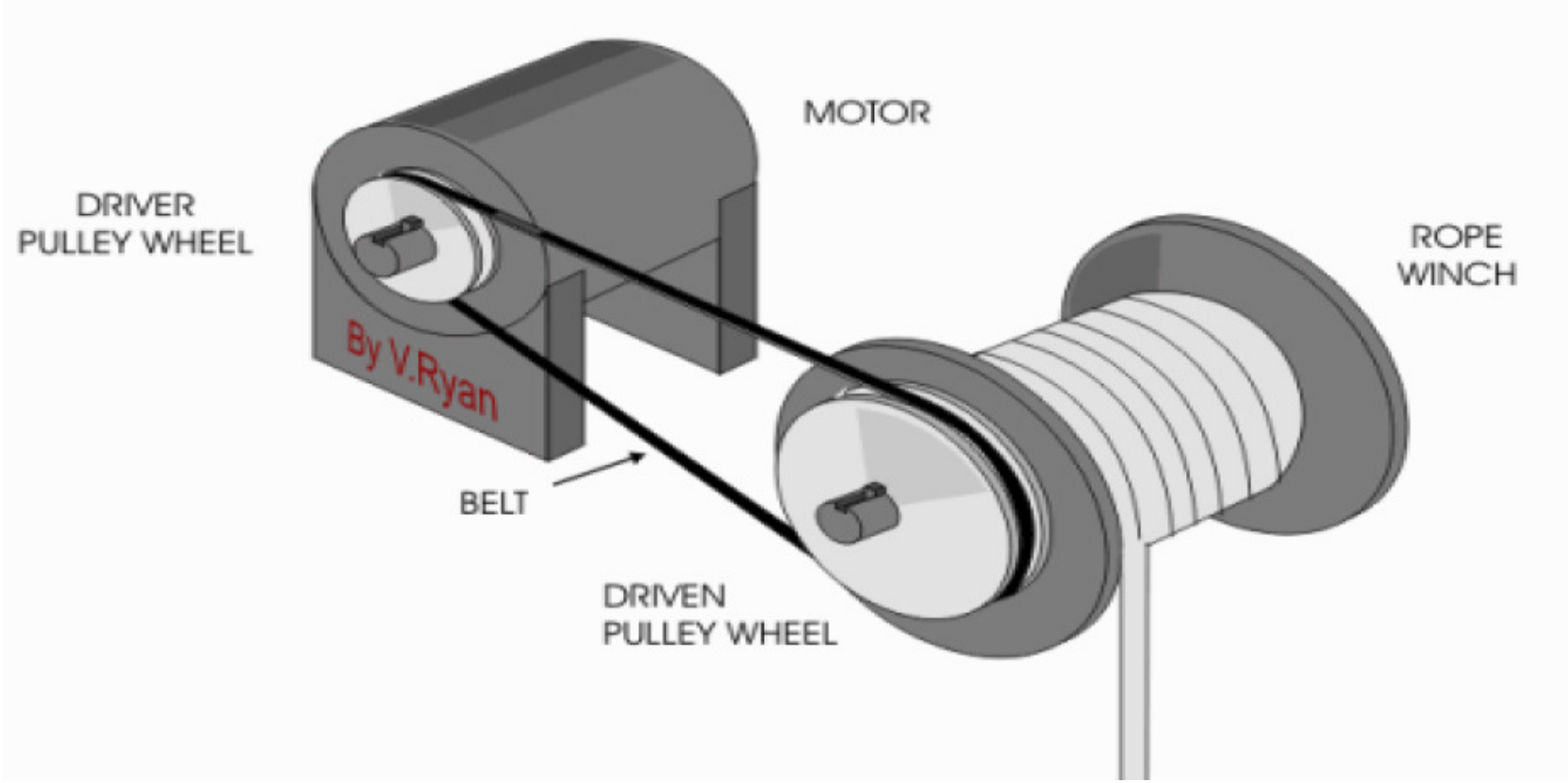
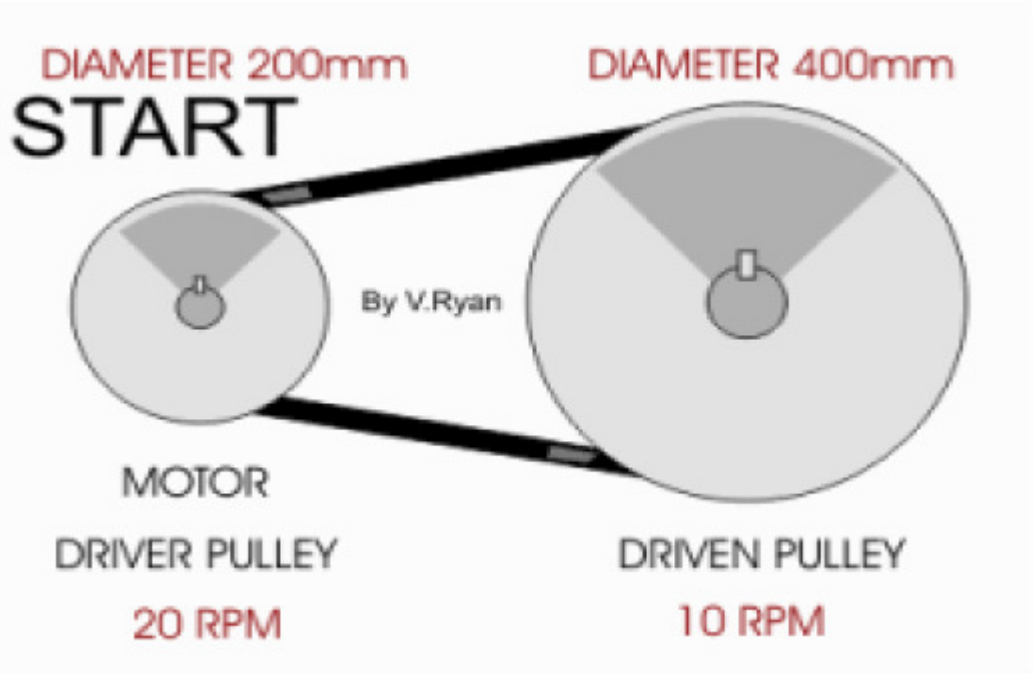
PULLEY SYSTEMS



Pulley wheels are grooved so that the belt cannot slip off. Also, the belt is pulled tight between the two pulley wheels (in tension). The friction caused by this means that when the driver rotates the driven follows.

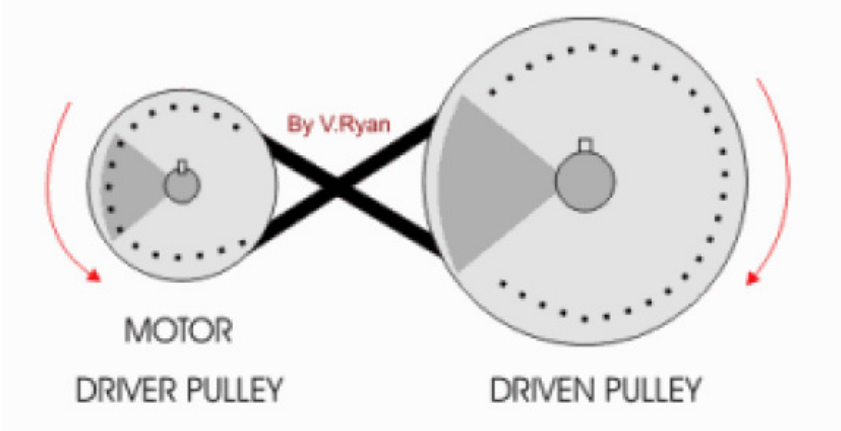
VELOCITY RATIO

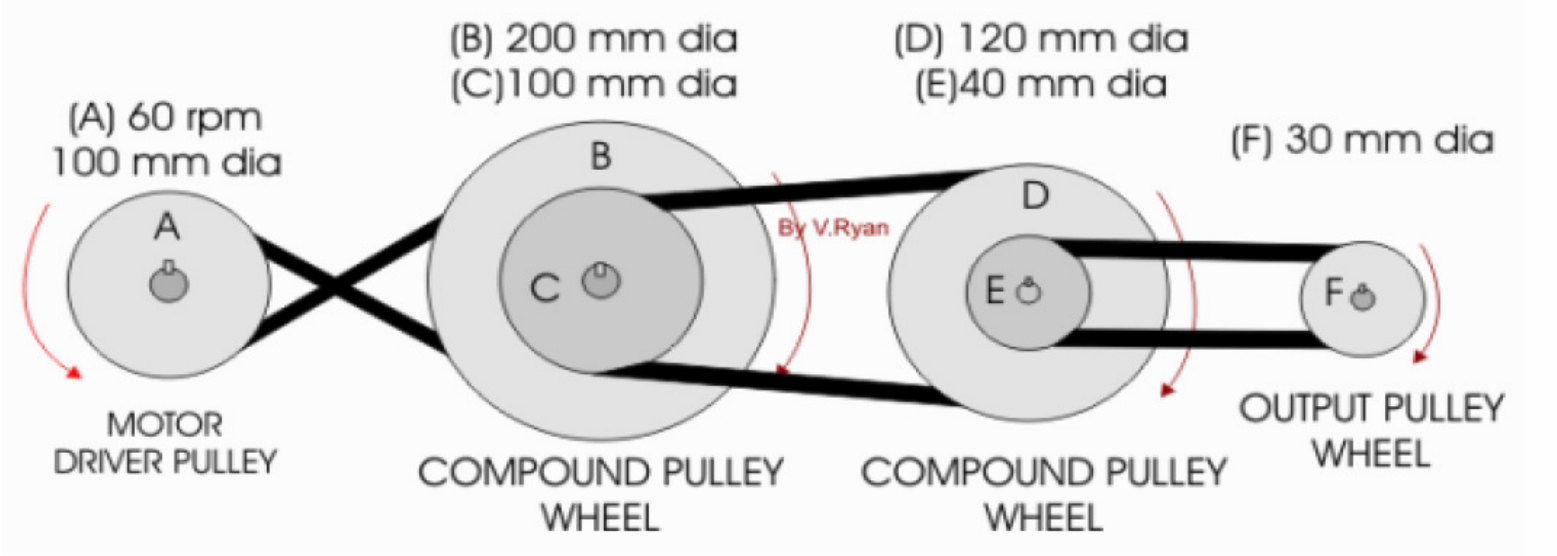


$$\text{VELOCITY RATIO} = \frac{\text{DRIVER PULLEY MOVES 2 REVOLUTIONS}}{\text{DRIVEN PULLEY MOVES 1 REVOLUTIONS}} = \frac{2}{1} \quad \text{OR} \quad 1:2$$

DRIVEN : DRIVER

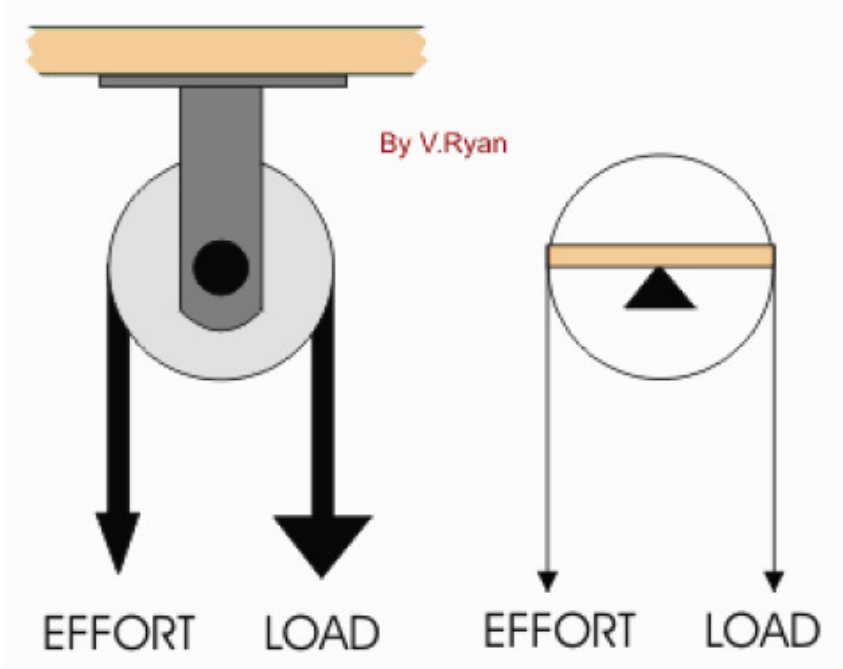
Changing the direction of Rotation:

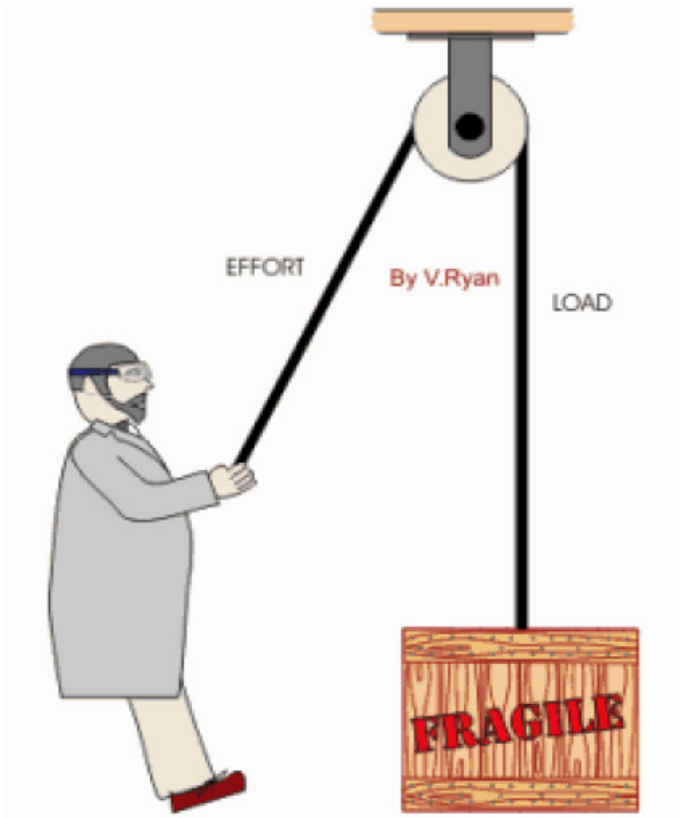




PULLEYS AND LIFTING

'Mechanical advantage' is defined as the ratio of load to effort.





$$\text{FORMULA FOR MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{1}{1} = 1$$

'Velocity Ratio' (sometimes called movement ratio) is defined as the ratio of the distance moved by the effort to the distance moved by the load. The formula seen below is best understood by writing it within a triangle. This helps when it is necessary to change the formula to find either; velocity ratio or the distance moved by the load or the distance moved by effort. In this way three formulas can be generated from the single formula inside the triangle.

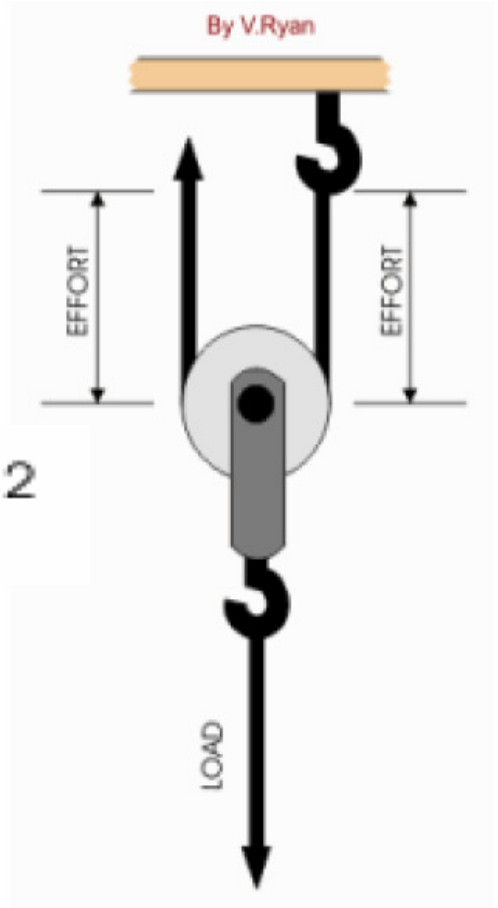
$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}}$$

$$\text{DISTANCE MOVED BY LOAD} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{VELOCITY RATIO}}$$

$$\text{DISTANCE MOVED BY EFFORT} = \text{DISTANCE MOVED BY LOAD} \times \text{VELOCITY RATIO}$$

With a single pulley, the pulley must be able to move so that mechanical advantage can be increased.

Furthermore, the pulley is turned upside-down.



the rope on the left and right
of the pulley are both lifting the LOAD

$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{2}{1} = 2$$

the effort can be seen to move twice
as far as the load.

$$\text{VELOCITY RATIO (MOVEMENT RATIO)} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}} = \frac{2}{1} = 2$$

PULLEYS AND LIFTING

(i) what is the mechanical advantage of this pulley system?

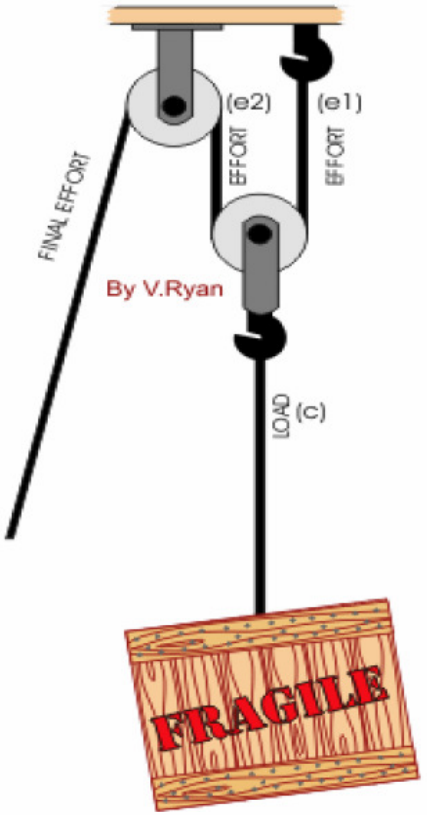
$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{2}{1} = 2$$

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

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}} = \frac{2}{1} = 2$$

(iii)What effort is required to lift the load?

$$\text{EFFORT} = \frac{\text{LOAD}}{\text{MECHANICAL ADVANTAGE}} = \frac{200\text{N}}{2} = 100\text{N}$$



(iv) if the system moves the load 5metes upwards, how far must the effort move?

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCED MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}}$$

$$\text{DISTANCED MOVED BY EFFORT} = \text{VELOCITY RATIO} \times \text{DISTANCE MOVED BY LOAD}$$

$$= 2 \times 5 = 10\text{M} \quad \text{(DISTANCE MOVED BY EFFORT)}$$

Examples:

A simple pulley system is shown
A 40N effort is used to move a 80N load.
The final effort moves 2 meters and at the same time the load moves 1 meter.

$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{2}{1} = 2$$

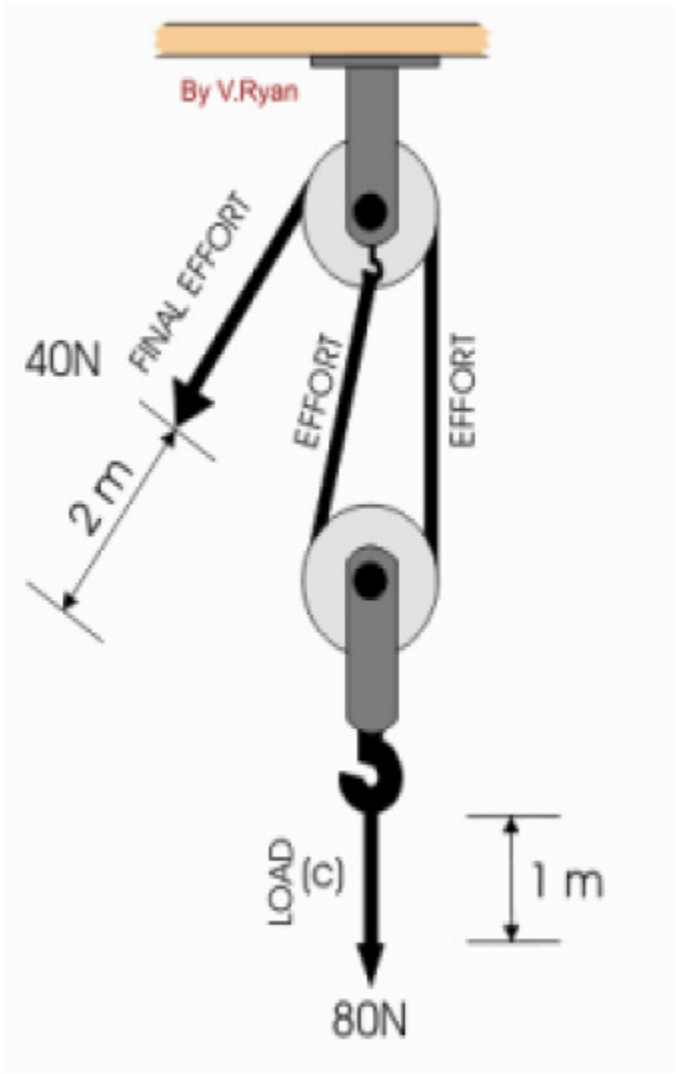
$$\text{OR} \quad \frac{80\text{N}}{40\text{N}} = 2$$

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}}$$

$$= \frac{2}{1} = 2$$

$$\text{EFFICIENCY} = \frac{\text{MECHANICAL ADVANTAGE}}{\text{VELOCITY RATIO}} \times 100\%$$

$$= \frac{2}{2} \times 100\% = 100\%$$



Examples:

$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{2}{1} = 2$$

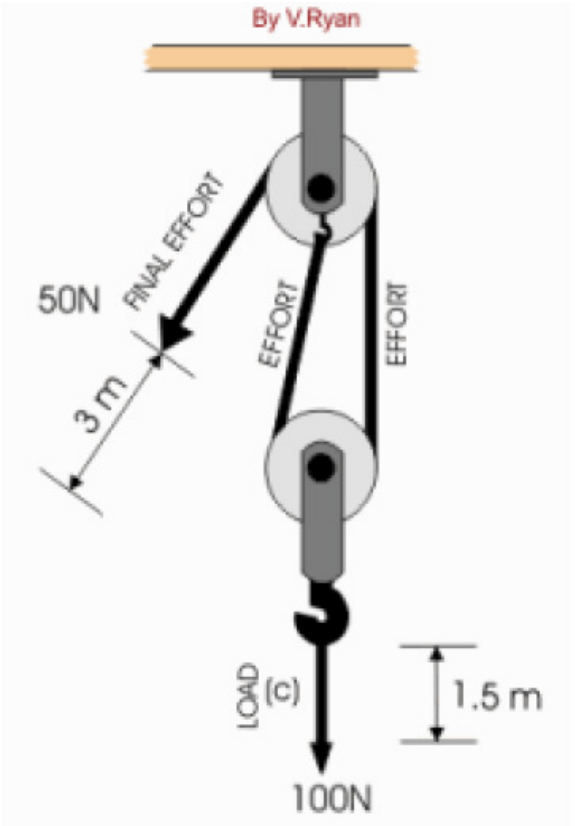
$$\text{OR} \quad \frac{100\text{N}}{50\text{N}} = 2$$

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCE MOVED BY LOAD}}$$

$$= \frac{3}{1.5} = 2$$

$$\text{EFFICIENCY} = \frac{\text{MECHANICAL ADVANTAGE}}{\text{VELOCITY RATIO}} \times 100\%$$

$$= \frac{2}{2} \times 100\% = 100\%$$



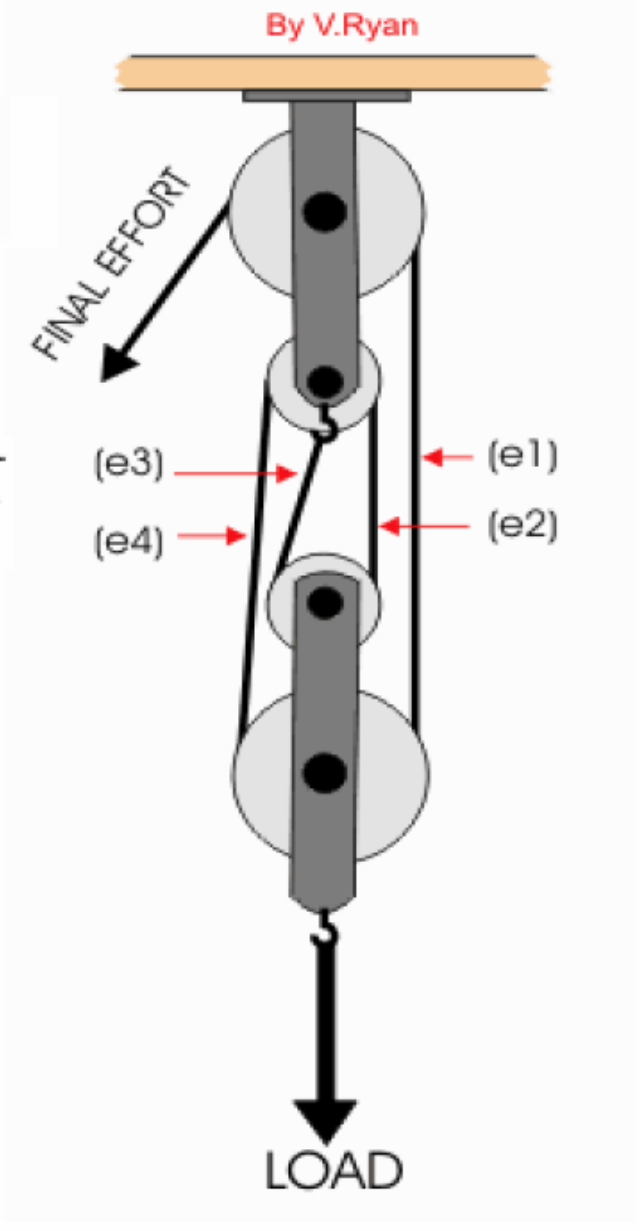
It is important to remember that NO pulley system is 100% efficient. This is due to friction of the ropes against the pulley wheels and the friction of the bearings of the pulley wheels

Examples:

$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{4}{1} = 4$$

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCED MOVED BY LOAD}}$$

$$= \frac{4}{1} = 4$$



Examples:

The example in the right figure shows a pulley system used to lift a 100N load. Work out the mechanical advantage and velocity ratio.

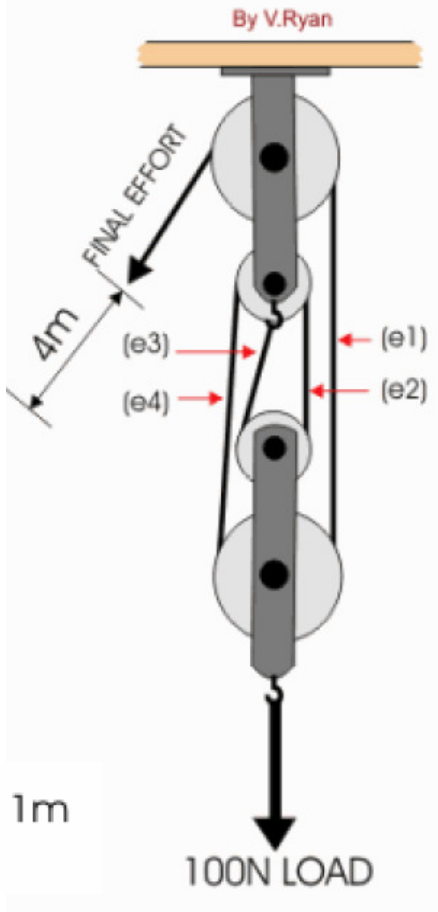
$$\text{MECHANICAL ADVANTAGE} = \frac{\text{LOAD}}{\text{EFFORT}} = \frac{4}{1} = 4$$

$$\text{VELOCITY RATIO} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{DISTANCED MOVED BY LOAD}} = \frac{4}{1} = 4$$

What effort is required to lift the 100N load?

$$\text{EFFORT} = \frac{\text{LOAD}}{\text{MECHANICAL ADVANTAGE}} = \frac{100\text{N}}{4} = 25\text{N}$$

$$\frac{\text{DISTANCED MOVED}}{\text{BY LOAD}} = \frac{\text{DISTANCE MOVED BY EFFORT}}{\text{VELOCITY RATIO}} = \frac{4\text{m}}{4} = 1\text{m}$$



Examples:

The pulley system shown below (left) has 1:4 ratio (effort: load) and an effort of 25N can lift a load of 100N

The other pulley system shown below (right) is capable of lifting 150N.