# Worksheet - Simple Machines

1.) You apply a force of $18\ N$ on to the end of a lever to open a paint can lid. The length of the fulcrum to the paint can is $0.25\ m$, and from the paint can to the lid is $0.020\ m$. The resistance of the lid is $9.0\ N$. Calculate the MA.

Answers - $MA = \frac{LE}{LR}$ $MA = \frac{0.25}{0.020}$ $MA = 12.5$

2.) You apply a force on a crowbar to open a stuck door. The effort length of the crowbar is $26\ cm$ long and the resistance length is $4.0\ cm$. Find the MA of the crowbar.

Answers - $MA = \frac{LE}{LR}$ $MA = \frac{26}{4.0}$ $MA = 6.5$

3.) A worker uses a board that is $4.0\ m$ long to pry up a boulder. A small rock is used for a fulcrum and is placed $0.50\ m$ from the resistance end of the lever. Calculate the MA of the board.

Answers - $MA = \frac{LE}{LR}$ $MA = \frac{4.0}{0.50}$ $MA = 8.0$

4.) a.) Three of your friends are all sitting on one end of a seesaw. The combined weight is $275\ N$. The length from the fulcrum to your friends is $2.5\ m$. The rest of the seesaw (from the fulcrum to you) is $4.5\ m$. What is the MA? What effort force is needed to lift your friends?

Answers - $MA = \frac{LE}{LR}$ $MA = \frac{4.5}{2.5}$ $MA = 1.8$

Answers - $\frac{d_{in}}{d_{out}} = \frac{\vec{F}_{out}}{\vec{F}_{in}}$ $\frac{4.5}{2.5} = \frac{275}{\vec{F}_{in}}$ $\vec{F}_{in} = 152.7778\ N$ $\vec{F}_{in} = 150\ N$

b.) You want to see if you can lift your three friends when each side of the seesaw is equal in length ($3.5\ m$). What is the MA? What effort force is needed to lift them?

Answers - $MA = \frac{LE}{LR}$ $MA = \frac{3.5}{3.5}$ $MA = 1.0$

$\frac{\vec{F}_{out}}{\vec{F}_{in}} = \frac{d_{in}}{d_{out}}$ $\frac{275}{\vec{F}_{in}} = \frac{3.5}{3.5}$ $\vec{F}_{in} = -275\ N$ $\vec{F}_{in} = -280\ N$

5.) A person weighing $800.\ N$ moves an object with a simple machine using all his weight. The mechanical advantage of the machine is MA = $5.0$. Determine the mass of the object.

Answers - $MA = \frac{\vec{F}_{out}}{\vec{F}_{in}}$ $5.0 = \frac{\vec{F}_{out}}{800.}$ $\vec{F}_{out} = +4000\ N$

$\vec{F}_g = mg$ $4000 = m(9.81)$ $m = 407.747\ kg$ $m = 410\ kg$

6.) The force arm of a lever is $4.0\ m$ long and the length of the load arm is $1.0\ m$. Calculate the force $\vec{F}$ needed to lift a $1000.\ N$ load, and find out the mechanical advantage of the lever.

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = \frac{d_{in}}{d_{out}}$ $\frac{1000.}{\vec{F}_{in}} = \frac{4.0}{1.0}$ $\vec{F}_{in} = +250\ N$

7.) The force arm of a lever is $2.0\ m$ long and the length of the load arm is $80.\ cm$. Work out the weight we can lift making a $200.\ N$ force and calculate the mechanical advantage of the lever.

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = \frac{d_{in}}{d_{out}}$ $\frac{\vec{F}_{out}}{200.} = \frac{2.0}{0.80}$ $\vec{F}_{out} = +5.0 \times 10^{2} N$

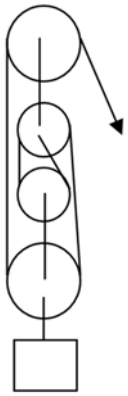
8.) The force arm of a lever is $1.5\ m$ long. We want to lift a $2500.\ N$ weight applying a $1200.\ N$ force. Find out the length of the load arm needed and work out the mechanical advantage of the lever.

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = \frac{d_{in}}{d_{out}}$ $\frac{2500.}{1200.} = \frac{1.5}{d_{out}}$ $d_{out} = 0.72\ m$

9.) We want to lift a $8200.\ N$ weight applying a $+820.\ N$ force. Find out the mechanical advantage needed. How many movable pulleys will we need?

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{8200.}{820.} = MA$ $MA = 10$ 9 Pulleys

10.) A block and tackle has three movable pulleys. Find out the load we can lift applying a $+600.\ N$ force and work out the mechanical advantage of the machine.



Answers - $MA = \#\ of\ ropes$ $MA = 4$

$\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{\vec{F}_{out}}{600.} = 4$ $\vec{F}_{out} = 2400\ N$

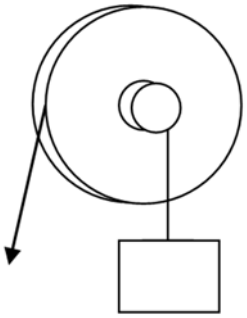
11.) What is the mechanical advantage of the system pictured on the right?

Answers - $MA = \#\ of\ ropes$ $MA = 4$

12.) If the load is $100.\ kg$, how much effort is required to pick up the load for the pulley in the previous question?

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{981}{\vec{F}_{in}} = 4$ $\vec{F}_{out} = 245.25\ N$ $\vec{F}_{out} = 245\ N$

13.) What is the mechanical advantage of the system pictured below if the diameter of the wheel is $3.0\ m$ and the diameter of the axle is $1.0\ m$?



Answers - $MA = \frac{LE}{LR}$ $MA = \frac{3.0}{1.0}$ $MA = 3.0$

14.) If Mr. Wilkison can only pull with $+25\ N$ of force, how much weight can he lift using the wheel and axle system from question 13?

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{\vec{F}_{out}}{25} = 3.0$ $\vec{F}_{out} = +75\ N$

15.) If we build a ramp that is $2.0\ m$ high and the length of the ramp is $30.\ m$, what is the mechanical advantage?

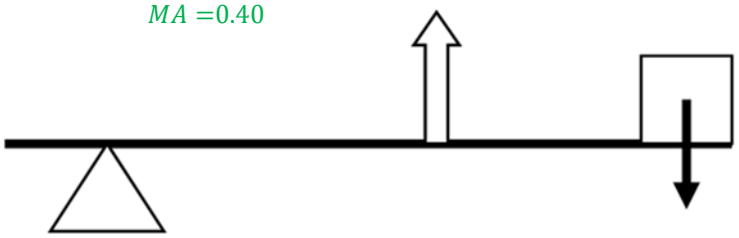
Answers - $MA = \frac{L}{H}$ $MA = \frac{30.}{2.0}$ $MA = 15$

16.) How much effort force would someone need to push a $45\ kg$ box up the ramp from question 15?

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{(45\times9.81)}{\vec{F}_{in}} = 15$ $\vec{F}_{in} = +29.43\ N$ $\vec{F}_{in} = +29\ N$

17.) Jose and Suzette construct an arm where the effort is located $10.\,cm$ from the fulcrum and the load is $25\ cm$ from the fulcrum, what is the mechanical advantage of the arm?

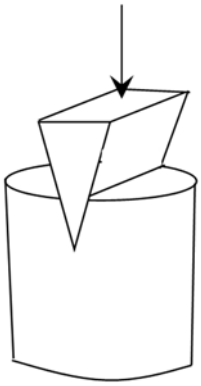
Answers - $\frac{LE}{LR} = MA$ $\frac{10.}{25} = A$ $MA = 0.40$



18.) Find the mechanical advantage and the maximum separation load for a wedge used to split the object shown. The wedge has an incline length of $8.0\ cm$, an overall height of $2.0\ cm$. The effort load applied is $60.\,N$.

Answers - $MA = \frac{L}{H}$ $MA = \frac{8.0}{2.0}$ $MA = 4$

$\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{\vec{F}_{out}}{60.} = 4$ $\vec{F}_{out} = +240\ N$



19.) A wheel and axle is used to raise a weight of $+720\ N$ with an effort of $200\ N$. If the radii of the wheel and axle are $40\ .cm$ and $10.\,cm$ respectively; What is the efficiency of the machine?

Answers - $\frac{\vec{F}_{out}}{\vec{F}_{in}} = MA$ $\frac{720}{200} = MA$ $MA = 3.6$

$MA = \frac{LE}{LR}$ $MA = \frac{40.}{10.}$ $MA = 4.0$

$eff = \frac{real}{theoretical}$ $eff = \frac{3.6}{4.0} \times 100$ $eff = 90\%$