Name: _______________
Block: _______________

Learning Intention

- Learn how to calculate the mechanical advantage of a simple machine

Notes

1. The mathematician and physicist _______________ (287-212 BCE) studied the _______________, the _______________, and the _______________.
2. Later physicists added the _______________, the _______________ _______________, and the _______________ and _______________ to the list of simple machines.
3. The astronomer and physicist _______________ _______________ (1564-1642) described the mechanical advantage of the 6 simple machines.
4. However, there are many more than 6 simple machines. In the late 19th century, Dr. Franz Reuleaux documented hundreds of simple machines: https://digital.library.cornell.edu/collections/kmoddl
5. Mechanical advantage is a measure of _______________ _______________.
6. We will assume that no _______________ is lost - the machine's _______________ is 100%.
7. In general, mechanical advantage is calculated as:

   a. If the input effort is greater than the output effort, the mechanical advantage is _______________ than 1
   b. If the input effort is less than the output effort, the mechanical advantage is _______________ than 1

8. In a lever, the mechanical advantage is calculated as:

9. In a pair of gears (whether they are connected directly, or via a chain/belt), the mechanical advantage is calculated as:

10. In a pulley system, the mechanical advantage is calculated as:

Questions

1. A force of 55 N is applied to a lever with a mechanical advantage of 4.5. What is the magnitude of the output force?
2. A force of 120 N is applied to the 55 cm input arm of a lever. What is the magnitude of the output force at the end of the 25 cm output arm?
3. In the previous question, what is the mechanical advantage of the lever?
4. A construction worker uses a hammer to remove a nail. They apply a 250 N effort perpendicular to the end of their 33 cm long hammer. The hammer has a mechanical advantage of 5.0.
    1. What is the magnitude of the output force?
    2. How long is the output lever arm?
5. On a 12 gear bicycle, there are 2 possible front gears, and 6 rear gears. The input force is applied to the front gears, and the force is output via the rear gears. The front gears have 50 and 34 teeth. The rear gears have 11, 13, 16, 20, 25, and 32 teeth.
    1. List out the mechanical advantage for each combination of gears.
    2. When would you want to have a small mechanical advantage?
    3. When would you want to have a large mechanical advantage?
6. A 6700 N load is being lifted up by a pulley system with a mechanical advantage of 3.0.
    1. How many ropes are supporting the load?
    2. What is the magnitude of the input force needed to lift the load?
    3. What distance would you have to pull the rope to lift the load by 7.5 m?
7. A 6,200 kg elephant is being lifted by a pulley system. The rope being used has a maximum tensile strength of 12,000 N. What is the minimum number of ropes that must be supporting the pulley system to safely lift the elephant?

See over →

Answers

1. F_{out} = 250 N
2. F_{out} = 260 N
3. MA = 2.2
4. 1. F_{out} = 1200 N
   2. d_{out} = 6.6 cm
5. 1. 34 tooth gear: MA = 0.32, MA = 0.38, MA = 0.47, MA = 0.59, MA = 0.74, MA = 0.94
      50 tooth gear: MA = 0.22, MA = 0.26, MA = 0.32, MA = 0.40, MA = 0.50, MA = 0.64
   2. When going very fast (i.e. down a steep hill)
   3. When going very slow (i.e. up a steep hill)
6. 1. N = 3
   2. F_{in} = 2200 N
   3. d_{in} = 22 m
7. MA = 5.1, therefore need 6 supporting ropes