Name Key

Simple Machines

1. A person wants to lift a 150 kg barrel onto the back of his pickup (height 1.3 meters). He has access to a 5.3 meter board from which he makes an inclined plane. If he pushes the barrel up the ramp and gets it onto his truck in 7.8 seconds, find the following.
   a. What is the output force?
   $F_{OUT} = m \cdot g = (150 kg)(10 m/s^2) = 1500 N$
   b. What force does he need to exert to push the barrel up the incline?
   $F_{IN} = \frac{F_{OUT} D_{OUT}}{D_{IN}} = \frac{(1500 N)(1.3 m)}{5.3 m} = 368 N$
   c. How much work did he do?
   $W = F_{OUT} D_{OUT}$ or $F_{IN} \cdot D_{IN} = 1950 J$
   d. What is the mechanical advantage of the incline?
   $MA = \frac{F_{OUT}}{F_{IN}} = \frac{1500 N}{368 N} = 4.08$
   e. What power did he exert?
   $P = W/t = 1950 J / 7.8 s = 250 W$
2. Harry uses a lever to move a rock in his yard. The rock has a mass of 75 kg and his lever is 1.4 meters long. If he places a fulcrum .25 meters from the rock and it takes .5 seconds for him to lift the rock. Find
   a. What is the output force?
   $F_{OUT} = m \cdot g = (75 kg)(10 m/s^2) = 750 N$
   b. What force does he need to exert to push the rock up with the lever?
   $F_{IN} = \frac{F_{OUT} D_{OUT}}{D_{IN}} = \frac{(750 N)(.25 m)}{1.15 m} = 163 N$
   c. How much work did he do?
   $W = F_{IN} D_{IN}$ or $F_{OUT} D_{OUT} = 188 N$
   d. What is the mechanical advantage of the lever?
   $MA = \frac{F_{OUT}}{F_{IN}} = \frac{750 N}{188 N} = 4$
   e. What power did he exert?
   $P = W/t = 188 N / .5 s = 376 W$
3. Through a pulley system, Jill decides to move a 180 kg dresser. If she pulls 110 meters of rope to move the dresser 3.7 meters in 2.3 minutes, find
   a. What is the output force?
   $F_{OUT} = M \cdot g = 1800 N$
   b. What force does she need to exert to lift the dresser?
   $F_{IN} = \frac{F_{OUT} D_{OUT}}{D_{IN}} = \frac{(1800)(3.7 m)}{110 m} = 60.5$
   c. How much work did she do?
   $W = F_{OUT} D_{OUT}$ or $F_{IN} D_{IN} = 6660 J$

d. What is the mechanical advantage of the pulley system?

$MA = \frac{110}{3.7}$ or $\frac{1800}{60.5} = 29.7$

e. What power did she exert?

$P = W/t = \frac{6660}{2.3 \times 60} = 48.3\,W$

4. Gerry tries to use a lever system to pick up a heavy weight. The lever is 1 meter long. He places a fulcrum .25 meters from the end where he exerts the force. He places the weight at the long end of the lever. It takes 1.3 seconds to lift the weight. 150kg = M

a. What is the output force?

$F_{OUT} = m \cdot g = 1500\,N$

b. What force does he need to exert lift the weight?

$F_{IN} = \frac{F_{OUT} D_{OUT}}{D_{IN}} = \frac{(1500)(.75)}{.125} = 4500\,N$

c. How much work did he do?

$W = F_{IN} D_{IN}$ or $F_{OUT} D_{OUT} = 1125\,J$

d. What is the mechanical advantage of the lever?

$MA = \frac{1}{4} = .25$

e. What power did he exert?

$P = W/t = 1125J/1.3 = 865\,W$

5. In which of the 4 examples is the use of a simple machine most advantageous? Why?

Pulley #3 – highest MA

6. In which of the 4 examples is the use of the simple machine actually a disadvantage? Why? How could this person (people) fix their simple machine so that it would work better?

lever #4 – MA < 1 - use more force than if you simply lifted it yourself.

7. How do simple machines help people lift heavy objects? How can it be said that they obey the law of conservation of energy?

trade Force for distance (Increasing Distance decreases Input Force)

8. What is efficiency? Which of the 4 simple machines would have the highest efficiency? Which would have the lowest? Why?

Efficiency = % of work that is useful. levers would be highest, Inclined Plane lowest. Efficiency is proportional to the amount of friction.