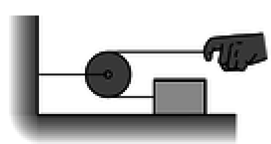
SIMPLE MACHINES

Conservation of energy provided the necessary tools for analyzing some mechanical systems, such as the seesaw on page 85 and the pulley arrangements of the homework problems on page 120, but we could only analyze those machines by computing the total energy of the system. That approach wouldn't work for systems like the biceps/forearm machine on page 85, or the one in figure t, where the energy content of the person's body is impossible to compute directly. Even though the seesaw and the biceps/forearm system were clearly just two different forms of the lever, we had no way to treat them both on the same footing. We can now successfully attack such problems using the work and kinetic energy theorems.

Constant tension around a pulley



t / The force is transmitted to the block.

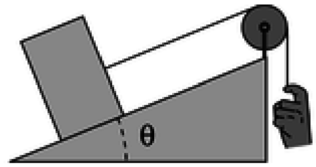
▹ In figure t, what is the relationship between the force applied by the person's hand and the force exerted on the block?

▹ If we assume the rope and the pulley are ideal, i.e., frictionless and massless, then there is no way for them to absorb or release energy, so the work done by the hand must be the same as the work done on the block. Since the hand and the block move the same distance, the work theorem tells us the two forces are the same.

Similar arguments provide an alternative justification for the statement made in section 3.2.7 that show that an idealized rope exerts the same force, the tension, anywhere it's attached to something, and the same amount of force is also exerted by each segment of the rope on the neighboring segments. Going around an ideal pulley also has no effect on the tension.

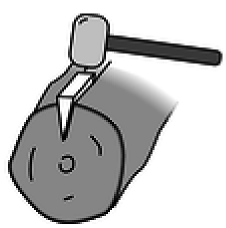
This is an example of a simple machine, which is any mechanical system that manipulates forces to do work. This particular machine reverses the direction of the motion, but doesn't change the force or the speed of motion.

Inclined plane and wedge



v / An inclined plane.

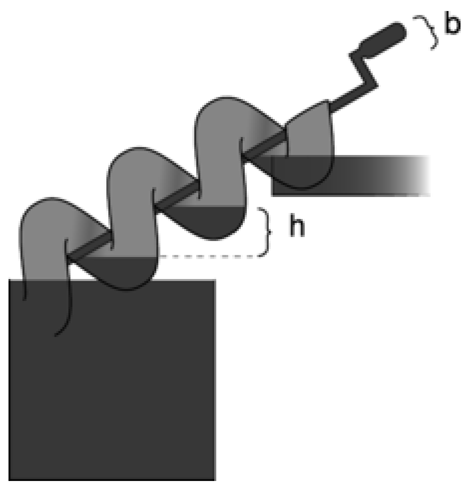
In figure v, the force applied by the hand is equal to the one applied to the load, but there is a mechanical advantage compared to the force that would have been required to lift the load straight up. The distance traveled up the inclined plane is greater by a factor of $1/\sin\theta$, so by the work theorem, the force is smaller by a factor of $\sin\theta$, and we have M.A.$=1/\sin\theta$. The wedge, w, is similar.



w / A wedge.

Example 39: Archimedes' screw

In one revolution, the crank travels a distance $2\pi b$, and the water rises by a height h. The mechanical advantage is $2\pi b/h$.



x / Archimedes' screw

Source: http://physwiki.ucdavis.edu/Fundamentals/03._Conservation_of_Momentum/3.2_Force_In_One_Dimension