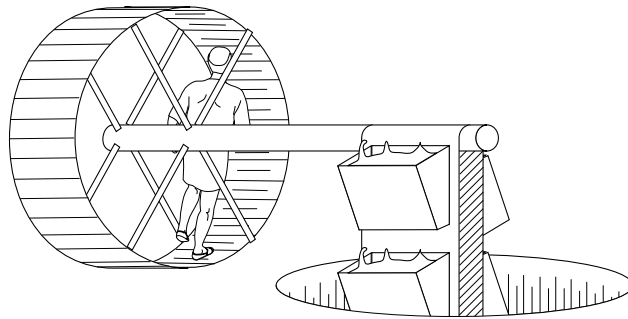


Bones and Muscles ▪ 13.4 *Enrich***An Ancient Machine**

Ancient societies did not have machines that ran on electric current, coal, or gasoline. For this reason, ancient engineers needed to use the energy generated from human and animal muscles as efficiently as possible. One example of an ancient machine is the *treadmill*. This was a hollow wheel, large enough for someone to stand inside.

In the example below, a treadmill is used to lift water from a well. As the man tries to walk up the curved inner surface of the wheel, his weight turns the wheel. His weight is caused by the force of gravity, which pulls his body back to the bottom. The work performed by the man in the wheel turns an axle that drives a belt to move buckets down into a well. There, the buckets fill with water, and then they come back up. The man walking in the wheel supplies the effort force, and water is pulled up from the well by the resistance force. In this example, the man has a weight of 735 N. With each step, he raises his body 0.5 m, and is pulled back down by the force of gravity. Each step that he takes causes the conveyor to lift 7350 N of water a distance of 0.05 m.



Use what you learned in Section 13.4 of your textbook and the information above to answer the following questions. Write your answers on a separate sheet of paper. Show your calculations.

1. When the man inside the treadmill steps up, what force pulls him back? In what direction does this force move him?
2. How much downward force does the man generate with each step he takes? How much work is performed when gravity pulls him down 0.5 m after each step?
3. How much force is exerted to lift the 7350 N of water in the well against the force of gravity? How much work is done to lift this water 0.05 m? How does this compare to the work done by the man in the treadmill?
4. Remember, like a lever, the treadmill is a machine. What is the effort force exerted by the man inside the wheel? What is the resistance force exerted upon the water rising from the well? What is the mechanical advantage of this machine?