Name: ______________________ Date: ______________

PRACTICE 4.1

Power

READ

In science, work is defined as the force needed to move an object a certain distance. The amount of work done per unit of time is called power.

EXAMPLE

Suppose you and a friend are helping a neighbor to reshingle the roof of his home. You each carry 10.0 bundles of shingles weighing 300. newtons apiece up to the roof which is 7.00 meters from the ground. You are able to carry the shingles to the roof in 10.0 minutes but your friend needs 20.0 minutes.

Both of you did the same amount of work (force × distance) but you did the work in a shorter time.

$$W = F \times d$$

$$W = 10 \text{ bundles of shingles}(300 \text{ N/bundle}) \times 7.00 \text{ m} = 21{,}000 \text{ joules}$$

However, you had more power than your friend.

$$\text{Power (watts)} = \frac{\text{Work (joules)}}{\text{Time (seconds)}}$$

Let's do the math to see how this is possible.

Step one: Convert minutes to seconds.

$$10 \text{ minutes} \times \frac{60 \text{ seconds}}{\text{minute}} = 600 \text{ seconds (You)}$$

$$20 \text{ minutes} \times \frac{60 \text{ seconds}}{\text{minute}} = 1{,}200 \text{ seconds (Friend)}$$

Step two: Find power.

$$\frac{21{,}000 \text{ joules}}{600 \text{ seconds}} = 35 \text{ watts (You)}$$

$$\frac{21{,}000 \text{ joules}}{1{,}200 \text{ seconds}} = 17.5 \text{ watts (Friend)}$$

As you can see, the same amount of work that is done in less time produces more power. You are familiar with the word *watt* from a light bulb. Is it now clear to you why a 100-watt bulb is more powerful than a 40-watt bulb?

Name: ______________________ Date: ______________

PRACTICE 112m = 4 sec 4.1

Work Done against Gravity

READ

Any time you lift an object, you do work against gravity. We use the same formula for work that you already know (Work = force × distance), but it's expressed in a slightly different form:

$$\text{Work against gravity} = \text{mass} \times \text{acceleration due to gravity} \times \text{height}$$

$$W = mgh$$

Force is written in the form mg, where m is mass and g is the acceleration due to gravity, 9.8 m/sec^2. We use h for height because only the *vertical* distance an object moves matters for calculating work against gravity.

Did you know...If you have to lift a new sofa to a second-floor apartment, the work done against gravity is the same whether you haul it straight up the side of the building with ropes or take a longer path up the stairs. Only the vertical distance matters because the force of gravity is vertical.

EXAMPLE

You lift a 2-liter bottle of cola from a grocery bag on the floor to a refrigerator shelf that is 0.8 meter high. If the bottle has a mass of 2.02 kilograms, how much work did you do against gravity?

Looking for The amount of work done against gravity.	**Solution** $W = mgh$ $W = 2.02\text{ kg} \times 9.8\text{ m/sec}^2 \times 0.8\text{ m}$ $W = 15.8\text{ joules}$
Given mass of bottle = 2.02 kilograms acceleration due to gravity = 9.8 m/sec^2 height = 0.8 meter	
Relationship $W = mgh$	

PRACTICE

1. Jai-Anna, who has a mass of 45 kilograms, climbed 3 meters up a ladder to rescue her cat from a tree. How much work against gravity did she do?

2. A tram inside the Gateway Arch in Saint Louis, Missouri lifts visitors to a window-lined observation room 192 meters above the ground. How much work does the tram's motor do against gravity to carry two 55-kilogram passengers to this room? (You may ignore the work done by the motor to carry the tram itself).

3. You pick up a 10-newton book off the floor and put it on a shelf 2 meters high. How much work did you do?

4. Elijah does 44 joules of work against gravity to pull a 0.5-kilogram rope with a 1.0-kilogram bucket attached up to the floor of his tree house. How many meters high is his tree house?

5. Alejandra weighs 225 newtons. How much work does she do against gravity when she climbs to a ledge at the top of a 15-meter climbing wall?

6. A window-washer stands on a scaffolding 30 meters above the ground. If he did 23,520 joules of work to reach the scaffolding, what is his mass?