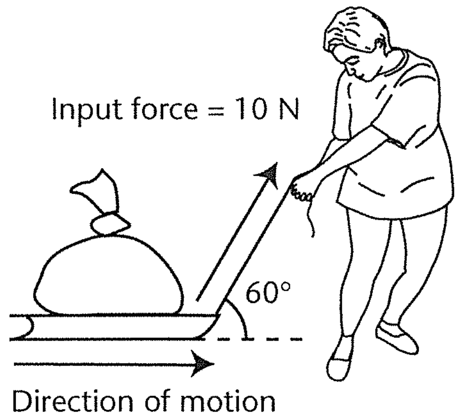
Name ______________________ Date __________ Class __________

Enrich

Work and Power

Read the passage below. Then complete the table and use a separate sheet of paper to answer the questions that follow the table.

Exploring Work, Direction, and Weight



In cases where the force is applied in exactly the same direction as the motion of the thing being worked upon, it is easy to calculate the amount of work performed. As the drawing shows, sometimes the force is applied at an angle to the movement of the object. When this happens, not all of the force contributes to the work being done. How do you calculate the amount of work when this happens?

The fraction of the applied force that actually contributes to the work depends upon the angle formed by the direction of the force and the direction of the object's motion. For example, in the drawing the force of the person pulling the sled is at a 60° angle to the sled's movement. Only part (0.5) of that force contributes to the work, as the table shows. Knowing this, it is easy to calculate the total work:

10 N (the force exerted) × 0.5 (the fraction of the force doing work) × 5 m (the distance moved) = 25 J

Each row of this table gives information about a situation where force is applied to an object to cause movement, including the fraction of the force that contributes to the movement. Calculate the amount of work performed and complete the last column.

Angle Between Direction of Force and Movement	Total Force (N)	Fraction of Force Doing Work	Distance Moved (m)	Total Work (J)
0°	10	1.0	5	**1.**
30°	10	0.87	5	**2.**
45°	10	0.71	5	**3.**
60°	10	0.5	5	**4.**
90°	10	0	5	**5.**

6. As the angle between the direction of the input force and the direction of movement increases from 0° to 90°, what happens to the fraction of the force that contributes to the work?
7. Why was no work done in the situation on line five of the table?
8. Did you need to know the mass of the moving objects to calculate the amount of work?

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Enrich

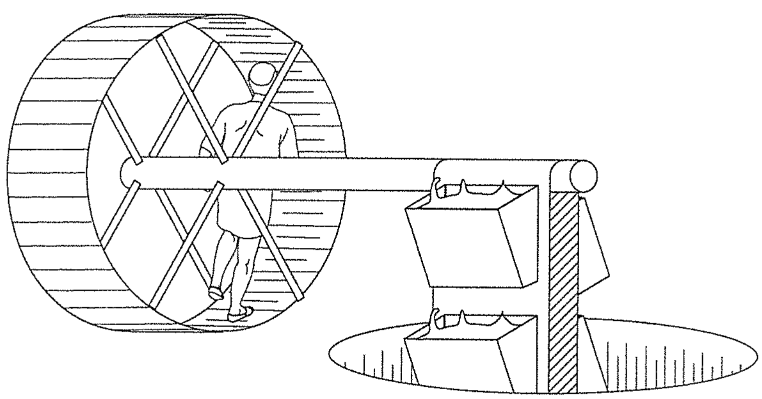
Understanding Machines

Read the passage below. Then use a separate sheet of paper to answer the questions that follow. Show your calculations.

An Ancient Machine

Ancient societies did not have machines that ran on electric current, coal, or gasoline. Ancient engineers needed to use the energy generated from human and animal muscles as efficiently as possible. One ancient machine is the treadmill, 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, the force of gravity pulls his body back to the bottom and turns the wheel. The work performed by the man in the wheel turns an axle that drives a belt to move buckets down into a well, where they fill with water, and then come back up. The man turning the wheel supplies the input force, and water is pulled up from the well by output force. In this example, the man weighs 740 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 7400 N of water a distance of 0.05 m.



1. Gravity pulls objects downward. How much work is performed when gravity pulls the man down 0.5 m after each step?
2. How much work is done to lift 7400 N of water in the well 0.05 m? Compare this to the work done by the man in the treadmill.
3. What is the input force exerted by the man inside the wheel? What is the output force exerted upon the water rising from the well? What is the mechanical advantage of this machine?
4. Calculate the efficiency of this treadmill. Is this likely? What factor might cause a real treadmill to be less efficient?

Name ____________________ Date __________ Class __________

Enrich

Inclined Planes and Levers

Read the passage below. Then answer the questions that follow in the spaces provided.

Archimedes Screw

An Archimedes screw is a machine that can be used to raise water from a lower level to a higher level. For example, water can be taken out of a river, even when the water is low, and moved to irrigation ditches so that farm crops can be watered.

The device is a screw inside a cylinder. The screw is able to turn within the cylinder. The top and bottom of the cylinder are open. The bottom of the screw is submerged in the water and the screw is turned. The turning screw scoops up water and raises it along the surface of the screw thread. When the water reaches the top of the screw, it spills out of the cylinder into a duct or channel and is carried to where it will be used.

In some forms of the Archimedes screw, the screw and the cylinder turn together. In other forms, instead of a screw, the device is a coiled tube.

A small Archimedes screw can be turned by hand. Larger screws, such as those used for irrigation, are turned by other machines. In the Netherlands, windmills provide the power to turn Archimedes screws that remove water from low-lying farmland.

1. Why does the screw have to be inside a cylinder?

____

____

2. What information would you need in order to calculate the mechanical advantage of an Archimedes screw?

____

3. The height to which an Archimedes screw can raise water is limited because the device must be used at a low angle, no higher than 45° above the surface of the water. Why can't the device be used in a vertical position?

____

____

4. What other materials might an Archimedes screw be able to move?

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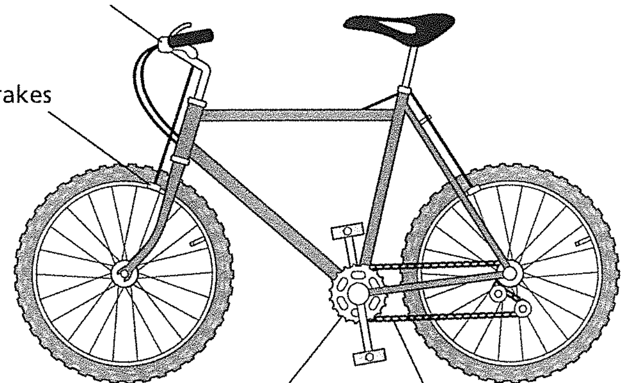
Enrich

Putting Machines Together

Read the passage and look at the diagram below it. Then use a separate sheet of paper to answer the questions that follow the diagram.

A Compound Machine

Mountain bike



A bicycle is made up of many simple machines. The brakes on a bicycle are levers that apply pressure to the wheel rims. Friction between the brake pad and the wheel rim slows the rate at which the wheels turn until you stop. You engage the brake levers by pulling on the levers attached to the handlebar. The levers on the handlebar are attached to a cable that pulls on the levers, which press on the wheel rim.

If a bicycle has quick-release wheels, the release mechanism is a lever. When you lift the lever, it disconnects the wheel so that you can remove it and fix a flat tire easily. When you put the wheel back on the bicycle, the lever securely locks the wheel in place.

A bicycle has more wheels than those it rides on. Your feet make circles as they turn the pedals and the axle to which the pedal crank is attached. You exert force over a wheel to turn the axle. The axle of the pedals turns the front gear. Another wheel that is attached to a chain turns the rear gear. The rear gear turns an axle. This axle turns the rear wheel of the bicycle. The force to the pedals is transmitted through all these machines to the rear wheel, which turns and pushes the bicycle forward.

1. Why are the brake and shift levers on the handlebar even though they control functions not located near the handlebars?
2. Why is the mechanical advantage provided by a lever important in a quick-release bicycle wheel?
3. Is the bicycle a machine to increase force or distance? Explain your answer. (Hint: Compare the size of the pedal "wheel" to the size of the bicycle wheel.)