# Study Guide for Much Work with Little Effort

## Questions

1. Can you name 10 sources of Potential Energy? Which are Chemical, and which are Physical?
2. Can you name 10 places where we need to have friction?
3. Can you name 10 places where we don't want friction ?
4. Can you describe 5 ways to reduce friction?
5. What is a simple machine?
6. If a simple machine makes you able to move something that you couldn't without it, what else does it do? (Think of how much rope you pull in a pulley system.)
7. If a simple machine makes it possible for you to do a job faster, what else does it do? (Think of what goes faster, a bike with a big wheel or a bike with a small one, and which goes up hill the best.)
8. What type of simple machine is each of the following:
    1. the claw on a hammer
    2. a shoelace in a sneaker
    3. stairs
    4. adjustable feet on a refrigerator
    5. a peanut butter jar lid
    6. church key can opener
    7. nutcracker
    8. a screwdriver
9. Beethoven, the huge St. Bernard, has fallen asleep in front of the TV, and you want to watch Beakman's World. If you can't wake him up, how could you move him?
10. What are the benefits of levers? What are the limitations?
11. What are the values of screws? What are the drawbacks?
12. What are the benefits of pulleys? What are their faults?
13. There's a see-saw 12 feet long from end to end. If two 50 pound girls sit four feet from the fulcrum, where should Tony, a 10 lb. boy, sit to balance them?
14. If Tony sits 3 feet from the fulcrum, is the see-saw long enough for Alice, a 50 lb. girl, to balance him? Where should she sit?
15. Jack has a 5 foot crowbar. He weighs 50 lbs., and he wants to move a 200 lb. rock. Where should he put his fulcrum?
16. What type of simple machine holds your sneakers closed? What is the mechanical advantage of your shoelace?

## Possible Answers

1. Chemical: unlit match, flashlight battery, sugar (for us), gasoline, dynamite, fire wood, car battery; Physical: water behind a dam, wound rubber band (like on a toy glider), car lifted on a jack, a blown-up balloon that isn't tied, snow waiting to slide off a roof, stretched (or compressed) spring (cocked BB gun)
2. GOOD FRICTION: tires on a road (going around a corner and accelerating or stopping), in the clutch of a car, your feet on a skateboard, your hands on a field hockey stick, between a tennis racket and tennis ball, in mountain bike brakes, between a sponge and a dirty plate, between water and a boat's rudder, between pieces of wood and the nail holding them, between air and a parachute, between a matchbook and a match to light it, between a rope and a rappellers harness, in a window that won't stay up, between the floor and the wedge holding the door open, in the snaps on your jacket...
3. UNWANTED FRICTION: Between a speedboat and water, between ice and skates, between ropes and pulleys, between a baseball and the air, between parts of an engine (pistons and cylinders), between a desk chair and the floor, in the hinges of a door, between a paint can and its lid, between a bottle and cork, between a sliding door and the door frame or an old window you're trying to close and it's frame...
4. REDUCE FRICTION WITH: Wheels, soap and water, oil (mineral or vegetable), waxed paper. plastic coating (Teflon), polishing/sanding/waxing, bearings...
5. SIMPLE MACHINES ARE : anything that changes the magnitude or direction of a force...-or, something that helps us move something more easily...-or, something that helps us do work faster...-or, A lever, inclined plane, pulley system, screw, wheel and axle.
6. If a simple machine amplifies the force you apply, it also makes you apply it over a greater distance or for a longer time than without the machine.
7. If a simple machine increases the rate at which work is done, it requires more force/power for the job.
8.
    1. lever
    2. pulley system
    3. inclined plane
    4. screw
    5. screw
    6. lever
    7. two 2nd-class levers connected (therefore considered a complex machine)
    8. 1st-class lever to open a paint can, a wheel and axle when turning a screw

9. Have fun with this! Point out what simple machines are suggested and try to get some elaborate complex systems...let their imaginations go!
10. LEVERS: low friction, high efficiency, often gravity assisted, easy to assemble....BUT very limited range i.e. only a few cm at a time, often awkward
11. SCREWS: huge theoretical mechanical advantage, often convenient...BUT very limited range, and generally very high friction
12. PULLEYS: very flexible, great range with enough rope (imagine lifting 500 lbs. 10 feet with a 12° lever)...BUT great losses in efficiency due to friction, requires special equipment
13. Tony must be four feet from the fulcrum. This can be demonstrated with a meter stick suspended by it's balance point and hanging paper clips from it. Propose some other combinations of numbers and distances--the kids get into it when they see that it works.
14. Alice has to sit 6 feet from the fulcrum. See above suggestion.
15. The rock cannot be more than 1 foot from the end: Jack has 40, the rock has 10, so that's a 4:1 advantage for Jack. However, hopefully somebody will point out that a 1st-class lever probably isn't the best option--this is a standard application for a 2nd-class lever if Jack can lift a small portion of his own body weight (with 6° of bar beneath the rock, Jack has a 10:1 advantage, and only needs to lift with 20lbs. to move the rock.
16. Answers vary.. A shoelace is a rough pulley system; the theoretical mechanical advantage is one less than the number of grommets used..good opportunity to discuss how tight shoes can be (and sometimes are) tied, but why we don't often make tourniquets of our shoes (BIG friction across the tongue).

Recommended Reading: The Way Things Work, David Macaulay, Houghton Mifflin Company, Boston, ©1988.

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*Students and teachers with questions, comments, or suggestions for other things you'd like to see can write Dr. Quark at the above address! He loves mail and will try to answer what he gets!*