Grade 8 Science
Unit 4: Systems in Action

Systems

Last class we discussed a variety of systems and we looked at five features that may be used to define any system.

What was the definition of system?

A system is a structure (physical or organizational) that has parts that are connected and influence each other in some way.

What were the five features we used to define a system?

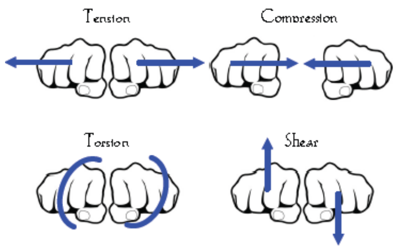
Purpose	What the system is to accomplish.
Input	The things put into the system.
Output	What is obtained from the system.
Components	The parts of the system.
Processes	The actions performed by the system.

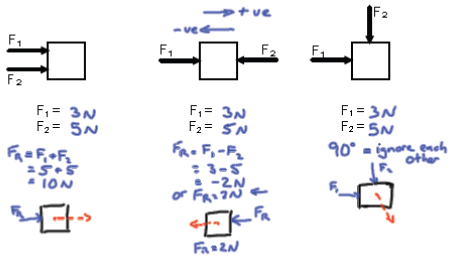
Force

We will be looking mainly at *mechanical systems* in this unit. Mechanical systems are things that use forces to create movement.

Movement	A change in location of all or part of the system. Can be linear or rotational. Mechanical systems often repeat the same movements continuously.
Force	A push or a pull that can cause movement.

We discussed forces in detail last year, and so we will not dwell on it this year. If you need a review, please see **lesson 9** and **lesson 11** from the grade 7 unit on structures.





Work

When you hear the word "work," what does it mean to you?

Often times we confuse the words "work" and "effort." Let's look at a situation:

A very common sight on a cold Canadian winter day is to see a car stuck in the snow. Sometimes, no matter how hard you try, you cannot push that car out of the snow. Below is a question with two possible answers. Both answers are colloquially correct, but only one is scientifically correct.

"Did you get the car out?"

1. "No, I put in a lot of work, but it did not move."
2. "No, I gave it my best effort, but it did not move."

Work

The word work, by its scientific definition, does not mean "to try." It is directly related to movement, so simply trying does not guarantee work has been done.

Work	The transfer of energy through motion.
Effort	"To try," does not <u>necessarily</u> result in movement.

So, by this definition, you do zero work if you do not accomplish movement of the object to which you are applying your force.

Work is something that can be calculated. It requires knowledge of two variables, force and distance.

Work = Force x Distance

What units would we use to measure work?

Force is measured in newtons (N), and distance is measured in meters (m). Therefore work is measured in newton-meters (N·m). However, scientists replace this unit with a new unit called a joule (J).

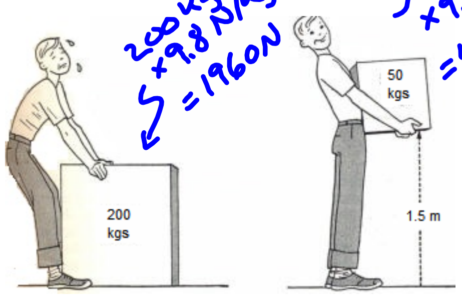
Work

Look at these two situations. In which one is the man doing more work?

How much work is being done in each scenario?

200 kgs × 9.8 N/kgs = 1960N

50 kgs × 9.8 N/kg = 490N



F = 1960N
d = 0 m
W = ?

W = Fd
W = 1960 × 0
W = 0 J

∴ No work is done

F = 490N
d = 1.5m
W = ?

W = Fd
W = 490 × 1.5
W = 735 J

∴ In the second scenario you do more work, 735 J

We need to note, when we are calculating work, the force and the distance need to be in the same direction (high school trigonometry will explain what to do when they are not.)

Energy

Energy is another topic we have looked at already in our previous studies. We most recently discussed energy when referring to cells. Energy is a word that everyone knows, and the we have all used.

What does the word energy mean to you?

In science, energy has a vague definition:

Energy — The ability to do work.

Based on our new knowledge of what work truly means, we can therefore define energy as follows:

Energy — The ability to apply a force to move an object a certain distance.

Energy, like work, is measured in joules. By knowing how much energy is available, you can determine how much work can be done.

Energy

A battery in a ride on toy car has 3000 J of energy left. It takes a force of 6 N, once started, on average, to keep the car moving? If a park is 400 m away, should the parents let the kid ride his car there?

Let's see how far it goes.

$F = 6N$
$d = ?$
$W = 3000J$

$W = Fd$
$3000 = 6d$
$d = \frac{3000}{6}$
$d = 500m$

$\therefore$ It can go 500m ... but the park is 400m away, so 800m round trip.

Efficiency

In the previous question we looked at some specific numbers, and based our answer on those. Having 3000 J of energy, taking 6 N of force to work, the car should move 500 m. However, this is most likely not the case in real life. In real life, assuming the numbers are correct, the car would not make it 500 m. Why is that?

Efficiency is a ratio of the work obtained from a system to the work that is put into the system. If something was 100% efficient, you could put a set value of work into it, and achieve that exact amount of work from it. However, this is never truly the case.

For example, if the car in our previous question was only able to travel 480 m, we could define its efficiency as follows:

$$\text{Efficiency} = \frac{\text{Work Obtained}}{\text{Work Put In}} = \frac{F \times d}{3000} = \frac{6 \times 480}{3000} = \frac{2880}{3000} = 0.96 = 96\%$$

This tells us that the car is only 96% efficient which means work is being wasted.

Work

We will use the remaining time to do some practise problems involving work. The answers to these will be posted online.

1. Who does more work lifting a 100 lb dumbbell,...
   a) ... a male or a female?
   b) ... a weak person or a strong person?
   c) ... a tall person or a short person?

2. How much work does it take to pick up, from the ground, and raise a 20 kg rock above your head to a total height of 2.3 m?

3. How much work does it take, once lifted, to hold the rock, from question 2, above your head for 36 minutes?

4. How much work would it take to lift the rock if you were on the moon?

5. If you built a machine to lift the rock for you, and it took 500 J of energy to do it, what would be the efficiency of your machine?

Work

1. Who does more work lifting a 100 lb dumbbell,...
    a) ... a male or a female?

    Assuming they are the same height, they both do the same amount of work. Work is force times distance, the force required to lift the dumbbell does not change, nor does the distance. Therefore the work is the same.

    b) ... a weak person or a strong person?

    Assuming they are both capable of lifting it... see answer above.

    c) ... a tall person or a short person?

    In this case, the tall person would presumable lift the dumbbell higher, meaning a greater distance, so therefore the taller person would have to do more work.

Work

2. How much work does it take to pick up, from the ground, and raise a 20 kg rock above your head to a total height of 2.3 m?

    Force = 20 kg x 9.8 N/kg
    = 196 N
    Distance = 2.3 m
    Work = ?

    Work = Force x Distance
    Work = 196 N x 2.3 m
    Work = 450.8 N·m
    Work = 450.8 J

    Therefore it would take 450.8 J of work to lift the rock.

3. How much work does it take, once lifted to hold the rock, from question 2, above your head for 36 minutes?

    Force = 20 kg x 9.8 N/kg
    = 196 N
    Distance = 0 m
    Work = ?

    Work = Force x Distance
    Work = 196 N x 0 m
    Work = 0 N·m
    Work = 0 J

    Since the rock is no longer moving once you are holding it above your head, therefore it would take no work to hold the rock.

Work

4. How much work would it take to lift the rock if you were on the moon?

   On the moon gravity is much lower, meaning the force required to lift the rock would be lower. That means that it will take less work to perform the same task.

   Force = 20 kg x 1.6 N/kg
   = 32 N
   Distance = 2.3 m
   Work = ?

   Work = Force x Distance
   Work = 32 N x 2.3 m
   Work = 73.6 N·m
   Work = 73.6 J

   Therefore it would take 73.6 J of work to lift the rock.

Work

5. If you built a machine to lift the rock for you, and it took 500 J of energy to do it, what would be the efficiency of your machine?

   Work obtained from the machine = 450.8 J
   Work input to the machine = 500 J
   Efficiency = ?

   $$\text{Efficiency} = \frac{\text{Work Obtained}}{\text{Work Put in}}$$

   $$\text{Efficiency} = \frac{450.8\ \text{J}}{500\ \text{J}}$$

   Efficiency = 0.9016
   Efficiency = 90.16%

   Therefore the machine was approximately 90% efficient.