Activity 2: Energy and work

Learning intentions

This activity will get students thinking more deeply about the concept of energy and work and how we quantify it. Students are introduced to the measurement of energy and work through the relationship, Work = force × distance/displacement.

Materials

- A box filled with something to add appropriate weight to it. A student needs to be able to push it across a floor but expend a bit of energy doing it.

Teacher Notes	Teaching Notes: Running the activity
Remember energy is the capacity for something to do work or cause change in a system. A key part of this definition is the concept of work. For example, work is apparent when parents tell their child to clean up their room and move their box of toys or sport gear from the floor. When they (eventually) push that box across the floor to under their bed, work has been done. Your muscles have done work by exerting a force (pushing) on a box to move it across the floor. The box has done work as it moved across the floor. There is mechanical movement over a distance – muscles moved your arms and legs a distance to push the box, and the box moved from the floor to under the bed. Energy was required to enable this movement (work) to happen. But where does the energy come from? Your muscles get their energy from the food you eat; the box gets its energy from your muscles pushing on it. How much work something can do depends on how much energy it has. But the food itself is not the energy; it is just the source of energy. For the box, its source of energy is the force applied on it by your muscles. Regarding energy to clean up your room versus the energy a car uses – ie the petrol/diesel/gas. It is essentially the same form of energy in that it is energy released by the breaking of chemical bonds in either your food or the fuel. This will become clearer later in this unit as we start to examine the different forms of kinetic and potential energy.	**Method** **Activity 1**. Get students to take the box and push it three metres across the floor. Get students to consider the following questions: Describe what had to occur to make the box move that three metres? For a box to move it needs energy. Where does the box get its energy from? What have students noticed so far about energy? For example, is the energy you (the human) uses to move the box the same as what a car engine will use to move a car? **Activity 2**: Calculate the amount of work done to move your box 3 metres. The relationship is Work = force × distance/displacement We will assume you used 50 Newtons of force to push the box. The distance we know is three metres. **Brain teaser:** Does a stationary object – such as your box in the middle of the floor – have any forces acting on it?

Bit of math
Math can help explain the relationship between energy and work and we can calculate the amount of energy needed or used and how much work is done. We will keep it simple here.

Energy is measured in Joules. One joule is equal to the work done by a one-newton force acting over a one-metre distance.

A Newton (N) is the force necessary to accelerate a mass of one kilogram at one metre per second per second. Think about the force it took to move that box of toys/sport gear. The heavier the box, the more force would have been required to move it.

One Calorie (C) is the amount of energy required to raise the temperature of one kilogram of water by 1˚ Celsius.

(Sources: https://www.britannica.com/science/energy and https://www.physics.uci.edu/~silverma/units.html)

Work is done when a force (N) is applied to an object to make it move a certain distance. Thus, work is related to the force applied to something and the distance it moves or is displaced. This relationship can be expressed mathematically as
Work = Force × distance/displacement

As noted above, force is measured in Newtons and a force is essentially a push or pull applied to an object such as the box of toys or sport gear as it is pushed under the bed. Distance or displacement is measured in metres. How far did you push that box?

Therefore, work is measured in Newton Metres (NM). And 1 NM (or one newton of force causing a displacement or movement in one direction of 1 metre) = 1 joule.

Or 1 joule (1 unit of energy) = 1 Newton of force moving an object 1 metre.

Activity 2. Pushing that box 3 metres: We used 50 Newtons of force to push the box 3 metres across the room. Work (W) = 50N × 3 metres. Therefore, the work done would be 150NM. Or you would have used 150 Joules of energy to move your toy box. Time for a chocolate bar. In Activity 8 we work out how much work you have to do to use up the energy in that chocolate bar. **Brain teaser**: Does a stationary object – such as your box in the middle of the floor – have any forces acting on it? Answer: Yes. Gravitational force pulls the box toward the floor and there is an opposite and equal force of the floor pushing back on the box. We know that gravitational force exists because things fall if you drop them from a height. But without the force from the floor opposing the gravitational force, your toy box would keep falling toward the centre of the Earth. In this case, the forces are balanced and the box does not move. When one force (a push or pull) is greater, you will get movement over a certain distance. When something exerts a force (an action) in one direction there will be an equal action in the opposite direction. This is Newton's 3rd law of motion, which is applied in FLEET's Balloon Rocket activity	