

Work Done

Stored energy can only be moved from one store to another. We say it is **transferred** from one store to another. You cannot **make** energy from nothing or **destroy** it. This is the idea of **Conservation of Energy**.

Mechanical energy transfer happens when there is a **force** that has made the object **move**. We say that force does **work** to transfer energy. The amount of **work done** by the force is given by:

$$\begin{array}{rclcl} \text{work} & = & \text{force} & \times & \text{distance} \\ W & = & F & \times & s \end{array}$$

The work done tells us **how much energy** has been taken from one **store** and moved to another. It is measured in **Joules (J)**.

If there is a **change** in energy, work has been done. The **force** is not always easy to see.

1 Which of these forces do work? How do you know?

(a) The 2 N weight of a ball on a table.

(c) A cook stirring soup.

(b) The force of friction on a box sliding across the floor.

(d) The force in an elastic band stretched around a stack of letters.

2 You pick up a ball from the floor with a force of 1 N and put it on a table 1 m high. Complete the sentences.

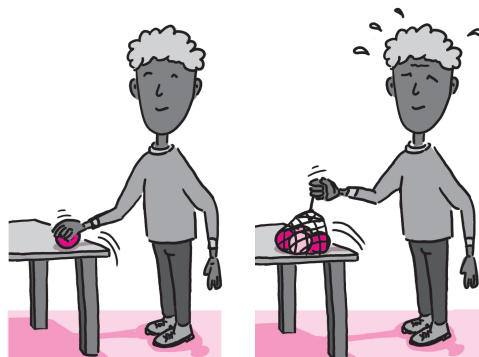
(a) You have done $1 \text{ N} \times 1 \text{ m} = \boxed{}$ J of work.

(b) You pick up a second ball and place it on a shelf 2 m high. How much work have you done?

$$\begin{array}{rclcl} \text{work (J)} & = & \text{force (N)} & \times & \text{distance (m)} \\ \boxed{} & = & \boxed{1} & \times & \boxed{2} \end{array}$$

Now you pick up 4 balls, with a force of 4 N and put them on the 1 m high table. How much work has been done?

$$\begin{array}{rclcl} \text{work (J)} & = & \text{force (N)} & \times & \text{distance (m)} \\ \boxed{} & = & \boxed{4} & \times & \boxed{1} \end{array}$$



- 3 A ball falls off a shelf onto the ground. The weight of the ball does 4 J of work. Complete the sentences using the words **increased, decreased, stayed the same, gravitational potential energy, kinetic energy, 4 J**.

(a) Just before the ball hits the ground, the ball's **kinetic energy** store has _____ compared to when it was on the shelf.

(b) Just before the ball hits the ground, the ball's **gravitational potential energy** store has _____ compared to when it was on the shelf.

(c) Just before the ball hits the ground, the ball's **elastic potential energy** store has _____ compared to when it was on the shelf.

(d) 4 J have been transferred from the _____ store to the _____ store of the ball. This last store has _____ by _____.

- 4 A lorry drives along a road at a steady 30 mph. It reaches the bottom of a hill and continues to maintain its speed as it goes up the hill. Complete the sentences using the words **decreases, increases, stays the same**.

(a) The lorry's kinetic energy store _____.

(b) The lorry's gravitational potential energy store _____.

(c) The chemical store of the engine _____.

- 5 A shopper pushes a trolley with a 4 N force for 5 m.

(a) Complete this: The distance the shopper pushes the trolley is m.

(b) Work out how much work they will have done.

$$\begin{array}{ccccc} \text{work (J)} & = & \text{force (N)} & \times & \text{distance (m)} \\ \hline \text{ } & = & 4 & \times & 5 \end{array}$$

(c) Work out how much work they will have done pushing the trolley 7 m using an equation.

$$\begin{array}{ccccc} \text{work (J)} & = & \text{force (N)} & \times & \text{distance (m)} \\ \hline \text{ } & = & 4 & \times & 7 \end{array}$$

(d) How much work will it take the shopper to push the trolley 12 m?

(e) How much work will it take the shopper to push the trolley 12 m with a force of 6 N?

- 6 Complete the word equation with the words **work, distance, force**.

$$\text{ } = \text{ } \times \text{ }$$

- 7 A submarine at the surface sinks down to 33 m below the surface of the sea. It is pulled down with a force of 10 000 N. How much work was done on the submarine?

$$\begin{array}{ccccc} \text{work (J)} & = & \text{force (N)} & \times & \text{distance (m)} \\ \boxed{} & = & \boxed{} & \times & \boxed{} \end{array}$$

- 8 Place these in order of amount of work being done:

- (a) A crane picking up 3 crates of bricks and moving them up 10 m.
- (b) A crane picking up 3 crates of bricks and moving them up 15 m.
- (c) A crane picking up 5 crates of bricks and moving them up 15 m.
- (d) A crane picking up an empty crate and moving it up 10 m.

- 9 The work done to pull 10 bricks up a certain height has been recorded and put in the following table.

Work (J)	200	1000		3000	4000
Height (m)	1	5	10	15	20

- (a) What was the amount of work done needed to reach 10 m?
- (b) How much potential energy do the bricks have at a height of 10 m?
- (c) What height was reached after doing 10 000 J of work?

- 10 Three friends try to jump start a car with a flat battery. Each friend pushes with a force of 200 N, and the car moves forwards 5 m. What is the total amount of work done on the car?

- 11 A heavy suitcase weighing 200 N (20 kg of mass) has to be lifted on to the storage rack above the seats on a train. This means raising it a height of 2 m.

- (a) How much work was done on the suitcase?
- (b) As it is so heavy, it is easier to swing it up there. How much extra work is done if you swing it an extra 0.2 m above the top of the rack?
- (c) Along a sharp bend in the railway line, the suitcase falls off the rack. How much work is done on the suitcase by gravity as it falls to the floor?