C19 – Force, work and power

In science, the word 'work' refers specifically to the action of a force making an object move.

WORK

Work is done when a force makes an object move.

The amount of work done is defined by:

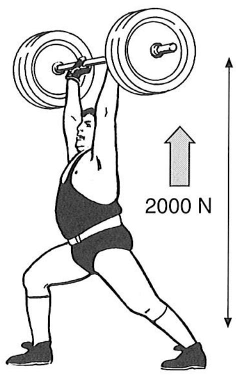
work done = force × distance moved

(The distance must be measured in the direction of the force.)

1 J of work is done when a force of 1 N moves through a distance of 1 m.

Notice that the unit of work is the same as the unit of energy. This is because energy must be transferred when work is done.

Example 1



The athlete uses a force of 2000 N to lift the weights.

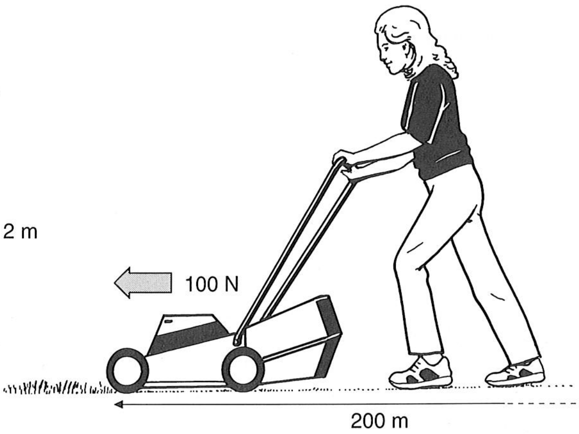
He raises the bar through 2 m.

work done = force × distance

work done = 2000 N × 2 m

work done = **4000 J**

Example 2



A force of 100 N is being used to push the lawnmower.

She pushes it a total of 200 m.

work done = force × distance

work done = 100 N × 200 m

work done = **2000 J**

POWER

Power tells us how quickly work is being done (and how rapidly energy is being transferred).

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

The unit of power is the **watt** (**W**). A power of 1 W means that 1 J of work is being done in 1 second.

1 kilowatt (kW) = 1000 W

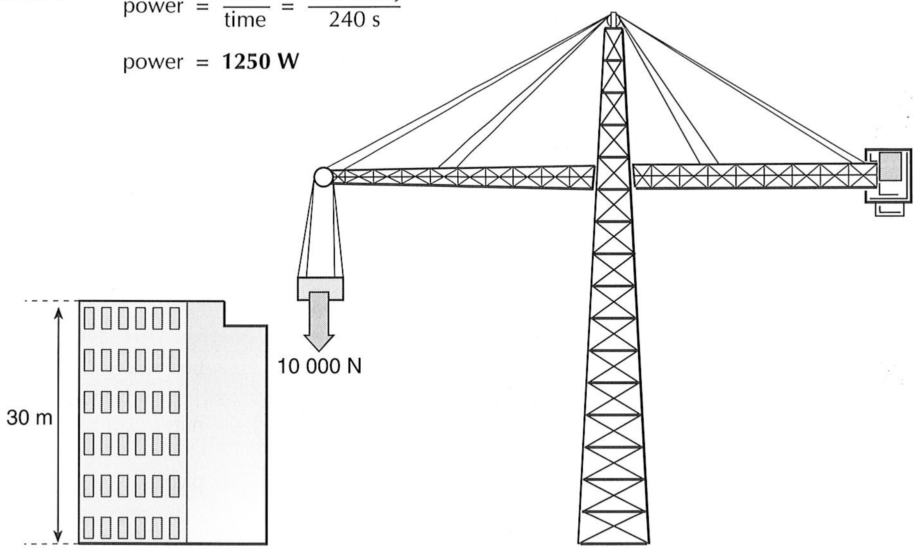
Example

A crane takes 240 s to lift a concrete block which weighs 10 000 N from the ground to the top of a 30 m building.

work done = 10000 N × 30 m
= 300 000 J

$$\text{power} = \frac{\text{work}}{\text{time}} = \frac{300\ 000\ \text{J}}{240\ \text{s}}$$

power = **1250 W**



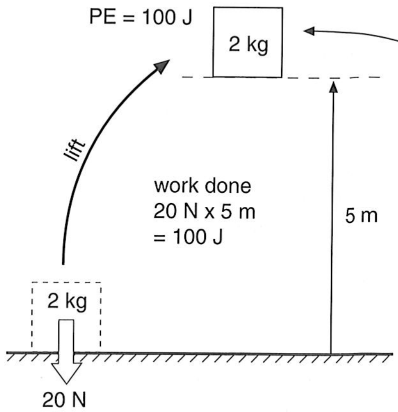
C20 – Work, potential energy and kinetic energy

When objects are lifted they gain potential energy: when they fall they gain kinetic energy.

WORK AND POTENTIAL ENERGY

To lift an object we need to do work against gravity. We can calculate the work done using the equation:

work done = force × vertical distance object is raised



Now that the object has been lifted from the ground it has gravitational potential energy (PE). The amount of PE is exactly the same as the amount of work done in lifting it.

PE = *m g h*

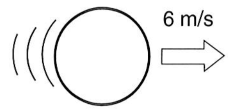
m = mass
g = gravitational strength (10 N/kg)
h = vertical height

KINETIC ENERGY

A moving object possesses kinetic energy (KE). The amount of KE depends on the mass of the object and its velocity.

KE = $\frac{1}{2} m v^2$

m = mass
v = velocity
(v^2 = velocity × velocity)



$m = 0.5$ kg

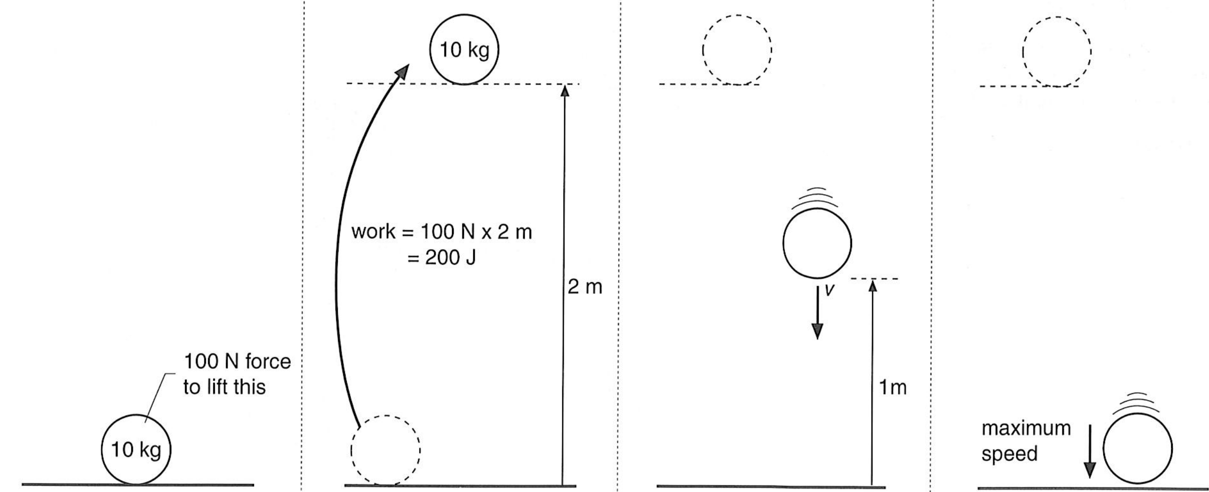
$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.5 \times 6 \times 6$ J

KE = 9 J

WORK, POTENTIAL ENERGY AND KINETIC ENERGY

- Work is needed to increase the PE of an object.
- As the object falls, its PE is converted into KE.
- Just as it hits the ground, all the PE has been converted into KE.
- The total energy (PE + KE) remains the same.

Object on ground	Someone lifts the object	Object falling *(halfway down)*	Object just about to hit ground



Object on ground	Someone lifts the object	Object falling (halfway down)	Object just about to hit ground
PE = 0	PE = 200 J	PE = 100 J	PE = 0 (almost)
KE = 0	KE = 0	KE = 100 J	KE = 200 J (almost)
	Total energy = 200 J	**Total energy = 200 J**	**Total energy = 200 J**