Work Done and Power

I'm sure you're no stranger to doing work, but in physics it's all to do with forces and energy.

If A Force Moves An Object, Work is Done

1) To make something move, some sort of force needs to act on it. The thing applying the force needs a source of energy (like fuel or food).

When a force moves an object through a distance, WORK IS DONE on the object and ENERGY IS TRANSFERRED.

2) The force does 'work' to move the object and energy is transferred mechanically from one store to another (p.157).

3) Whether energy is transferred 'usefully' (e.g. lifting a load) or is 'wasted' (p.158) you can still say that 'work is done'. Just like Batman and Bruce Wayne, 'work done' and 'energy transferred' are indeed 'one and the same'.

4) You can find out how much work has been done using:

5) One joule of work is done when a force of one newton causes an object to move a distance of one metre. You can also write this as 1 J = 1 Nm (newton metre).

$$E = F \times d$$

Work done (J) — Force (N) — Distance moved in the direction of the force (m)

EXAMPLE: Find the energy transferred when a tyre weighing 70 N is lifted 1.2 m into the air.

work done = force × distance = 70 × 1.2 = 84 J

Here, work is being done against gravity. Energy is being transferred to the tyre's gravitational potential energy store.

6) A force doing work often causes a rise in temperature as energy is dissipated to the thermal energy stores of the moving object and its surroundings. This means that the process is wasteful and the efficiency of the process is reduced. Remember, efficiency = $\frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}$ (p.158-159).

When you push something along a rough surface you are doing work against frictional forces. Energy is being transferred to the kinetic energy store of the object because it starts moving, but some is also being transferred to thermal energy stores due to the friction. This causes the overall temperature of the object to increase. (Like rubbing your hands together to warm them up.)

Lubrication (p.159) reduces friction and unwanted energy transfers.

Power is How Much Work is Done per Second

1) Power is the RATE OF ENERGY TRANSFER. The unit of power is the watt (W). 1 W = 1 J/s. Another way of describing power is how much work is being done every second.

2) This is the very easy formula for power:

3) The larger the power of an object, the more work it does per second. E.g. if an electric heater has a power of 600 W this means it transfers 600 J of energy every second. A 1200 W heater would transfer twice as much energy per second and so would heat a room quicker than the 600 W heater.

$$\text{power (W)} = \frac{\text{work done (J)}}{\text{time taken (s)}} \quad \text{or} \quad P = \frac{E}{t}$$

EXAMPLE: A motor does 4.8 kJ of work in 2 minutes. Find its power output.

1) Convert the values to the correct units first (see p.8). 4.8 kJ = 4800 J and 2 mins = 120 s

2) Substitute the values into the power equation. $P = E \div t = 4800 \div 120 = 40$ W

Watt's power? Power's watts...

Make sure you're happy using the equations on this page before you move on.

Q1 A constant force of 20 N pushes an object 20 cm. Calculate the work done on the object. [2 marks]

Q2 An appliance transfers 6000 J of energy in 30 seconds. Calculate its power. [2 marks]

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Warm-Up

Complete the sentences below using the words or phrases from the box.
You can only use each option once and you do not need to use every option.

As a rubber ball falls, it experiences a ..... due to .....

..... is done on the ball and ..... is transferred from the ball's

..... energy store to its ..... energy store.

force work chemical potential kinetic gravity
elastic potential energy gravitational potential heating

1 Which of these is the definition of power? Grade 4–6

- ☐ **A** Power is the total work done by an object.
- ☐ **B** Power is the rate of energy transfer.
- ☐ **C** Power is the total energy transferred to an object.
- ☐ **D** Power is the minimum work done to an object to cause it to move.

[Total 1 mark]

2 A student is investigating the work done by different washing machines during a standard washing cycle. **Figure 1** shows the manufacturer's data about three machines. Grade 6–7

Figure 1

Machine	Power	Time needed
A	600 W	125 minutes
B	400 W	160 minutes
C	.....	125 minutes

a) Calculate the work done by machine A during its standard washing cycle.
Give your answer in kJ.

Work done = ... kJ
[4]

b) Machine C's standard cycle lasts for 125 minutes. It does 3 930 000 J of work in that time.
Complete the table in **Figure 1** by calculating the power of machine C.

[2]

[Total 6 marks]

3 A woman pushes a 20 kg wheelbarrow 15 m along a flat path using a horizontal force of 50 N.

Grade 6-7

a) i) State the equation that links work done, force applied and distance moved in the direction of the force.

.....

[1]

ii) Calculate the work done by the woman.

Work done = ... J

[2]

b) Work has to be done against the frictional forces acting on the wheel of the wheelbarrow. Explain the effect this has on the temperature of the wheel.

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.....

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[2]

[Total 5 marks]

4 A mechanic replaces a worn out engine of a car with a new, more efficient one. The old engine had a useful output power of 52 kW and an efficiency of 25%. The new engine has an efficiency of 30%.

Grade 7-9

a) Calculate the useful output power of the new engine.
You can assume that the input power of both engines is the same.

Output power = ... W

[5]

b) Explain the effect replacing the engine will have on the time taken for the car to accelerate from rest to 20 m/s.

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.....

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[3]

[Total 8 marks]