Exercise 3.3 Power and efficiency

The questions in this section will help you improve solving problems involving power and efficiency.

1 In a water well, a motor lifts a 40 kg bucket 30 m in 12 s. Calculate the

a work done by the motor.

b output power of the motor.

2 A small car, whose engine is rated at 15 kW, travels at a constant speed of 20 ms^{-1}. Calculate the effective driving force of the engine.

3 Three boys are arguing about who is the most powerful. They each time themselves to do some work. Their results are given in Table 3.1.

Boy's name	Work done / J	Time taken
Anton	3.25×10^3	15 minutes
Ravi	90	25 s
Joshua	11.5×10^3	1 hour

Table 3.1

Which boy is the most powerful?

4 An athlete trains by running up a set of steps. The athlete, of mass 65 kg, runs up 5 m of steps in a time of 6 s.

a Calculate the power of the athlete.

b If the athlete's efficiency is 20%, how much energy has the athlete used?

5 Mount Snowdon in North Wales is 1085 m high. A popular way of reaching the summit is to walk along the Pyg Track, which is about 5 km long and takes a typical climber about 5 hours to complete.

If a chocolate bar contains 1.1 MJ of chemical energy and the human body is 25% efficient,

a calculate how many chocolate bars a typical climber of mass 75 kg would have to eat in order to be able to climb Mount Snowdon. (g = 10 Nkg^{-1})

b suggest why, in practice, it might require more than this.

c calculate the average power that a typical climber must develop during his ascent.

6 Garry and Anatoly are two boys using the gym. They both have a mass of 70 kg. Garry does 20 step-ups in 45 s, raising his centre of mass by 25 cm each time, whilst Anatoly does 12 pull-ups in 20 s, raising his centre of mass by 35 cm each time.

a Calculate

i Garry's power output.

ii Anatoly's power output.

b Which of the boys is likely to be out of breath after their exercise?

7 In a healthy human heart, blood is pumped into arteries 72 times per minute. 20 g of blood is accelerated from a speed of 0.20 ms^{-1} to a speed of 0.34 ms^{-1} in every heart beat. Calculate the power generated by a healthy human heart.

8 A crane on a construction site operates at an output power of 2.2 kW and has an operating efficiency of 0.35. If a steel girder of mass 400 kg is to be lifted to a height of 45 m, show that it would take the crane about 4 minutes to lift the girder. (g = 10 Nkg^{-1})

9 In 79 CE, Mount Vesuvius erupted, destroying the Roman towns of Pompeii and Herculaneum. Historical and scientific records have suggested that 1.36 Gkg of hot ash and rock were ejected per second to a height of 33.0 km—well into the stratosphere.

a Ignoring any effects due to air friction, at what speed must the ejected material have left the volcano?

b Calculate the power output of Mount Vesuvius.

c The Koeberg nuclear power station in South Africa has an output power of 1.86 GW.

i How many times more powerful was the volcanic eruption of Vesuvius in 79 CE than the Koeberg power station?

ii According to the *Washington Post*, there are about 62 500 power stations around the world. If the output of the Koeberg power station is considered to be typical of other power stations, how many times more powerful was the Vesuvius eruption than the total power output of the world's power stations?