Topic P1 — Energy

Page 71 — Energy Transfers

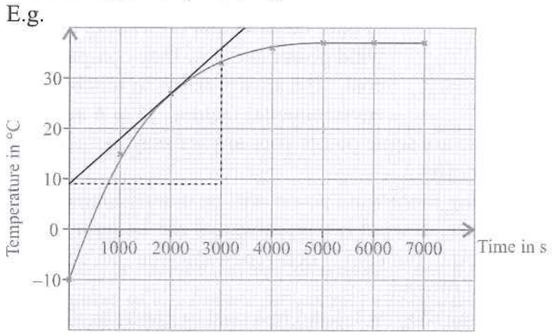
1.1 mass of stone, m_s = 20 g = 20 ÷ 1000 = 0.02 kg
mass of box = 100 g = 100 ÷ 1000 = 0.1 kg
total mass of box and stone, m_T = 0.1 + 0.02 = 0.12 kg
height of swing = 20 cm = 20 ÷ 100 = 0.2 m
$E_p = m_T gh = 0.12 \times 9.8 \times 0.2 = 0.2352$ J
energy transferred to g.p.e. stores of box and stone = energy transferred from kinetic energy store of the stone, $E_p = E_k$
$E_k = \frac{1}{2} m_s v^2$
$v = \sqrt{\frac{2E_k}{m_s}} = \sqrt{\frac{2 \times 0.2352}{0.02}}$
= 4.8497... m/s
= **4.8 m/s (to 2 s.f.)**
[6 marks for correct answer, otherwise 1 mark for correct substitution into equation for gravitational potential energy, 1 mark for correct calculation of energy in gravitational potential energy store, 1 mark for correct rearrangement of the kinetic energy equation, 1 mark for correct substitution into the kinetic energy equation and 1 mark for correct unrounded answer]

1.2 The energy transferred is nine times larger than the first time. ***[1 mark]***

The initial extension was one times the original length, and the new extension is three times the original length. Because the extension has been tripled, and the energy in the elastic potential energy store is proportional to the square of the extension, the energy transferred is nine times larger.

Pages 72-75 — Specific Heat Capacity, Power and Efficiency

1.1 Draw a tangent at (2000, 27)
E.g.



rate of temperature change = gradient of tangent = $\frac{36 - 9}{3000 - 0}$
= **0.009 °C/s**
(Accept any answer between 0.0085 °C/s and 0.0095 °C/s)
[3 marks for correct answer, otherwise 1 mark for correctly drawn tangent and 1 mark for attempt to calculate gradient]

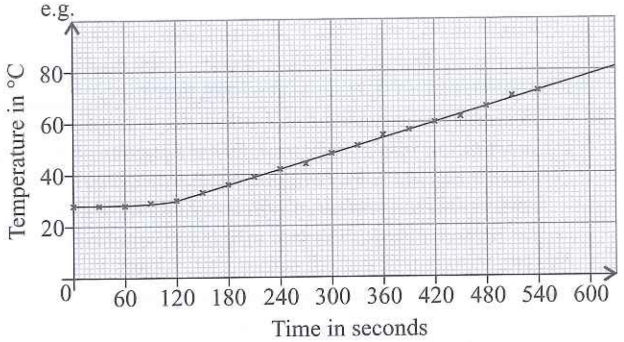
1.2 $\Delta E = mc\Delta\theta$
Replace change in temperature with rate of temperature change to find rate of energy transfer.
So, rate of energy transfer = mass × specific heat capacity × rate of temperature change
= 2.0 × 1800 × 0.009
= **32.4 J/s**
[2 marks for correct answer, otherwise 1 mark for correct substitution]

Even if you got the answer to 1.1 wrong, you get full marks for 1.2 if you did the calculations correctly using your answer for 1.1.

1.3 Find the total input energy transferred to the freezer:
power = energy transferred ÷ time, so:
energy transferred = power × time
20.0 minutes = 20.0 × 60 = 1200 s
so total input energy transfer = 250 × 1200 = 300 000 J
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$
efficiency = 95% = 0.95
useful output energy transfer = efficiency × total input energy transfer
= 0.95 × 300 000
= **285 000 J**
[5 marks for correct answer, otherwise 1 mark for correct substitution into energy transferred equation, 1 mark for correct calculation of total input energy transfer, 1 mark for correct rearrangement of efficiency equation and 1 mark for correct substitution into efficiency equation]
OR:
Find the useful power output of the freezer:
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$
efficiency = 95% = 0.95
useful power output = efficiency × total power input
= 0.95 × 250
= 237.5 W
Then find the useful output energy transferred in 20.0 minutes:
energy transferred = power × time
20.0 minutes = 20.0 × 60 = 1200 s
so energy transferred = 237.5 × 1200 = **285 000 J**
[5 marks for correct answer, otherwise 1 mark for correct rearrangement of the efficiency equation, 1 mark for correct substitution into efficiency equation, 1 mark for correct calculation of useful power output and 1 mark for correct substitution into energy transferred equation]

2.1 Find the rate at which energy is wasted, i.e. the wasted power, in order to find total power input:
power = energy transferred ÷ time
wasted power = energy wasted ÷ time
time = 9 × 60 = 540 s
wasted power = 300 ÷ 540 = 0.555... W
useful power output = 0.1 × 1000 = 100 W
total power input = useful power output + wasted power
= 100 + 0.555... = 100.555... W
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$
= $\frac{100}{100.555...}$
= 0.994475...
= **0.99 (= 99%) (to 2 s.f.)**
[6 marks for correct answer, otherwise 1 mark for correct substitution into power equation, 1 mark for correct calculation of wasted power, 1 mark for correct calculation of total power input, 1 mark for correct substitution into efficiency equation and 1 mark for correct unrounded answer]
OR:
Find the useful output energy transferred:
power = energy transferred ÷ time, so:
energy transferred = power × time
time = 9 × 60 = 540 s
power = 0.1 × 1000 = 100 W
useful output energy transferred = 100 × 540 = 54 000 J
total input energy transfer = useful output energy transfer + wasted energy
= 54 000 + 300 = 54 300 J
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$
= $\frac{54\ 000}{54\ 300}$
= 0.994475...
= **0.99 (= 99%) (to 2 s.f.)**
[6 marks for correct answer, otherwise 1 mark for correct substitution into power equation, 1 mark for correct calculation of useful output energy transfer in 9 mins, 1 mark for correct calculation of total input energy transfer, 1 mark for correct substitution into efficiency equation and 1 mark for correct unrounded answer]

2.2 Draw a line of best fit,
e.g.



10 mins in seconds = 10 × 60 = 600 s
Evaluate temperature at 600 s,
Temperature = **78 °C (Accept between 76 °C and 80 °C)**
[2 marks for correct answer, otherwise 1 mark for suitably drawn line of best fit with a constant positive gradient between 120 s and 600 s]

2.3 From line of best fit:
Change in temperature between 180 s and 540 s = 72 – 36
= 36 °C
Time taken for temperature change = 540 – 180 = 360 s
Useful power of heater = 0.1 kW = 0.1 × 1000 = 100 W
Energy transferred = power × time, so:
Energy transferred in 360 s = 100 × 360 = 36 000 J
$\Delta E = mc\Delta\theta$, so $c = \frac{\Delta E}{m\Delta\theta}$
$c = \frac{36\,000}{6 \times 36}$
= 166.666... J/kg°C
= **167 J/kg°C (to 3 s.f.)**
(Accept between 162 J/kg°C and 171 J/kg°C)
[6 marks for correct answer, otherwise 1 mark for evaluating two temperatures from your line of best fit at least 240 s apart, 1 mark for correct substitution into energy transferred equation, 1 mark for correct calculation of the energy transferred, 1 mark for correct substitution into specific heat capacity equation and 1 mark for correct unrounded answer]

Even if you got the gradient in 2.2 wrong, you get full marks for 2.3 if you did the calculations correctly using your gradient from 2.2.

2.4 A higher thermal conductivity would mean energy would be transferred at a higher rate from the lead to the surroundings ***[1 mark]***. This means the temperature of the lead would increase at a lower rate, which would give a higher value of specific heat capacity ***[1 mark]*** as more energy is transferred for a given increase in temperature / specific heat capacity is inversely proportional to temperature change ***[1 mark]***.

3.1 47.5 MJ = 4.75×10^7 J
$\Delta E = mc\Delta\theta$, so $c = \frac{\Delta E}{m\Delta\theta}$
$c = \frac{4.75 \times 10^7}{3000 \times 4.0}$
= 3958.333... J/kg°C
= **3960 J/kg°C (to 3 s.f.)**
[4 marks for correct answer, otherwise 1 mark for correct rearrangement, 1 mark for correct substitution and 1 mark for correct unrounded answer]

3.2 Find the total input energy transferred to the solar panel by the Sun:
power = energy transferred ÷ time, so:
energy transferred = power × time
time = 12 hours = 12 × 60 × 60 = 43 200 s
power = 5 kW = 5 × 1000 = 5000 W
energy transferred = 5000 × 43 200 = 2.16×10^8 J
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$
$= \frac{4.75 \times 10^7}{2.16 \times 10^8}$
= 0.21990...
= **0.22 (= 22%) (to 2 s.f.)**
[5 marks for correct answer, otherwise 1 mark for correct substitution into energy transferred equation, 1 mark for correct calculation of energy transferred, 1 mark for correct substitution into efficiency equation and 1 mark for correct unrounded answer]

Page 76 — Energy Resources

1.1 How to grade your answer:
Level 0: There is no relevant information. ***[No marks]***
Level 1: There are some relevant points but they are basic or unclear. Mentions a benefit and a drawback for using more wind power, or makes a comparison of wind and coal in at least one area. ***[1 to 2 marks]***
Level 2: There is a description referring to at least one benefit and one drawback of using more wind power and how this compares to using coal. The points made have some detail, but may not be linked. ***[3 to 4 marks]***
Level 3: There is a clear and detailed description referring to both benefits and drawbacks of using more wind power and how they compare to using coal. The answer refers to reliability and environmental factors. ***[5 to 6 marks]***

Here are some points your answer may include:
Benefits:
Using more wind power will be more sustainable for the future, as wind is renewable and can be replenished/will not run out, but coal is non-renewable and can't be replenished/will run out.
Using more wind and less coal to generate electricity will reduce the harm done to the environment, such as the amount of pollutants released into the atmosphere.
Using wind to generate electricity does not produce carbon dioxide but burning coal does.
Carbon dioxide contributes to the greenhouse effect/climate change/global warming.
Using wind to generate electricity does not release sulfur dioxide but burning coal does.
Sulfur dioxide contributes to acid rain, which can be harmful to trees and soils and can have far-reaching effects in ecosystems.
Wind does not need to be mined, but coal does, which can destroy habitats and changes the landscape.
Drawbacks:
Using more wind than coal to generate electricity may cause electricity supply issues.
Wind is less reliable than coal as power cannot be generated when it isn't windy / it is too windy, whereas coal is currently always in stock, and can be burnt at any time to produce energy.
Wind power cannot be increased to meet demand, whereas a coal-fuelled power station can be made to increase its power by burning coal at a greater rate.
Using more wind than coal to generate electricity may also raise economic and social issues.