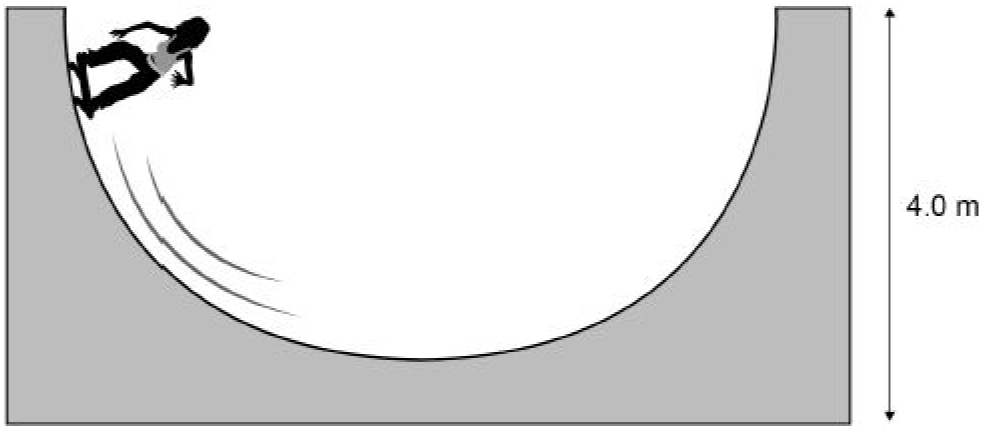
1 The diagram below shows a girl skateboarding on a semi-circular ramp.



The girl has a mass of 50 kg

(a) Calculate the gravitational potential energy (g.p.e.) of the girl at the top of the ramp.

Use the equation:

g.p.e. = mass × gravitational field strength × height

gravitational field strength = 9.8 N/kg

____

____

g.p.e. = ________________________ J

(2)

(b) The girl has a speed of 7 m/s at the bottom of the ramp.

Calculate the kinetic energy of the girl at the bottom of the ramp.

Use the equation:

kinetic energy = 0.5 × mass × $(\text{speed})^2$

____

____

Kinetic energy = ________________________ J

(2)

(c) Not all of the g.p.e. has been transferred to kinetic energy.

Which **two** statements explain why?

Tick **two** boxes.

Some energy is wasted.	☐
The mass of the girl is too low.	☐
The ramp is not high enough.	☐
The g.p.e. of the girl is not zero.	☐
The speed of the girl is too great.	☐

(2)

(d) Explain how lubricating the wheels of the skateboard can increase the speed of the girl.

Use ideas about energy in your explanation.

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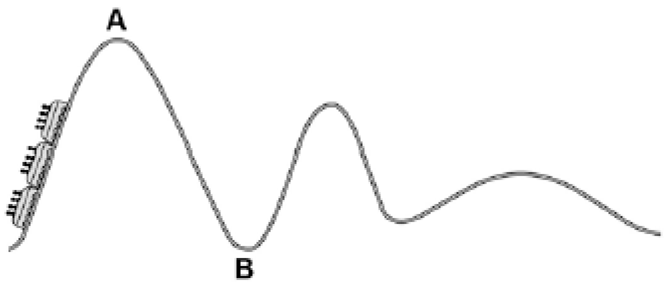
(3)

(Total 9 marks)

2 The figure below shows a rollercoaster.



The rollercoaster car is raised a vertical distance of 35 m to point **A** by a motor in 45 seconds.

The mass of the rollercoaster is 600 kg.

The motor has a power rating of 8 000 W.

(a) Calculate the percentage efficiency of the motor.

Gravitational field strength = 9.8 N / kg.

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____

Efficiency = ___________________ %

(5)

(b) The rollercoaster rolls from point **A** to point **B**, a drop of 35 m.

Calculate the speed of the roller coaster at point **B**.

Assume that the decrease in potential energy store is equal to the increase in kinetic energy store.

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____

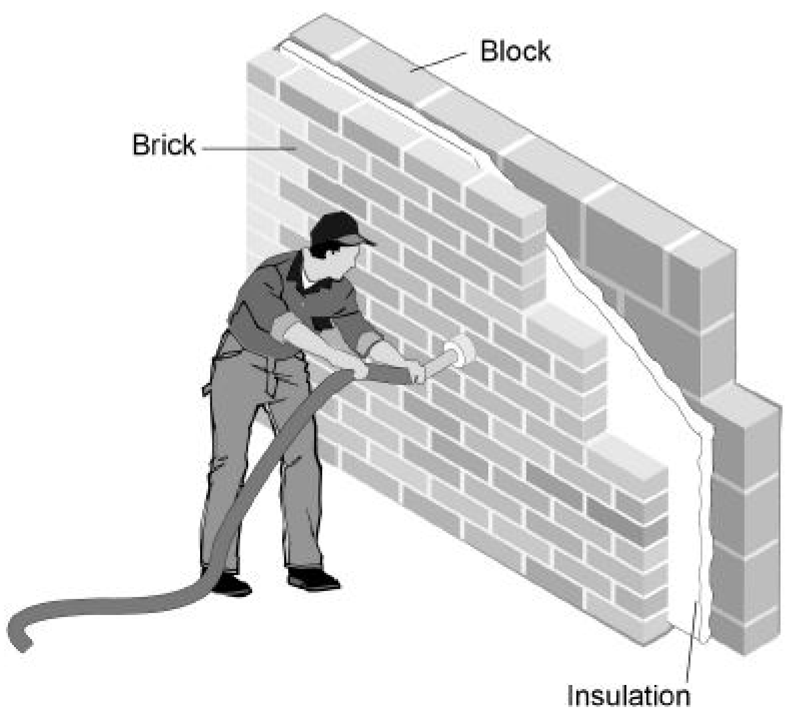
Speed at point **B** = ____________________ m / s

(6)

(Total 11 marks)

3 **Figure 1** shows cavity wall insulation being installed in the wall of a house.

Figure 1



(a) Explain how the wall reduces unwanted energy transfers.

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____

____

____

____

(3)

(b) The cavity insulation was tested.

- The heating inside the house was switched off.
- The temperature inside the house was measured every 20 minutes for 2 hours.

The table below shows the results.

Time in minutes	**Temperature in °C**
0	25.0
20	20.8
40	17.4
60	14.5
80	12.1
100	10.0
120	8.4

Determine the temperature inside the house after 30 minutes.

____

____

____

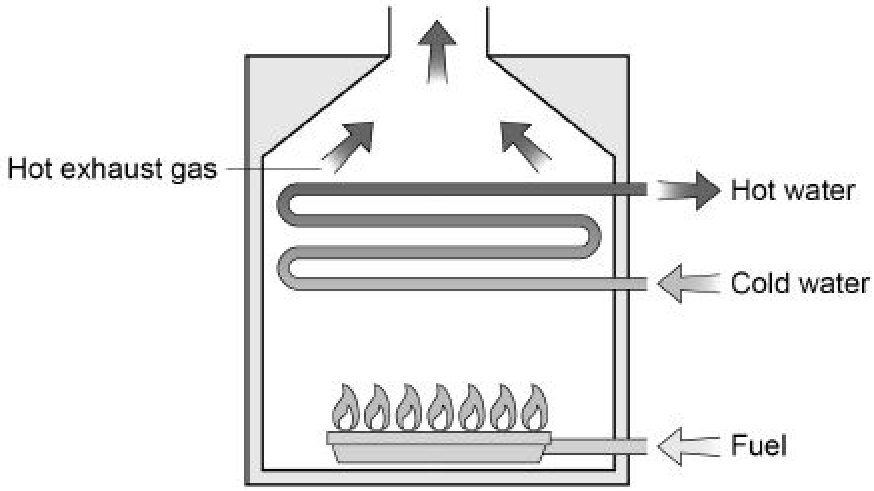
____

Temperature = ______________________ °C

(2)

(c) **Figure 2** shows the gas boiler used to heat the house.

Figure 2



Describe how different energy stores are changed by the boiler.

____

____

____

____

(3)

(d) To heat the house, the boiler transfers 15 MJ of energy in 10 minutes.

Calculate the power of the boiler.

Write any equation that you use.

____

____

____

Power = ______________________ W

(4)

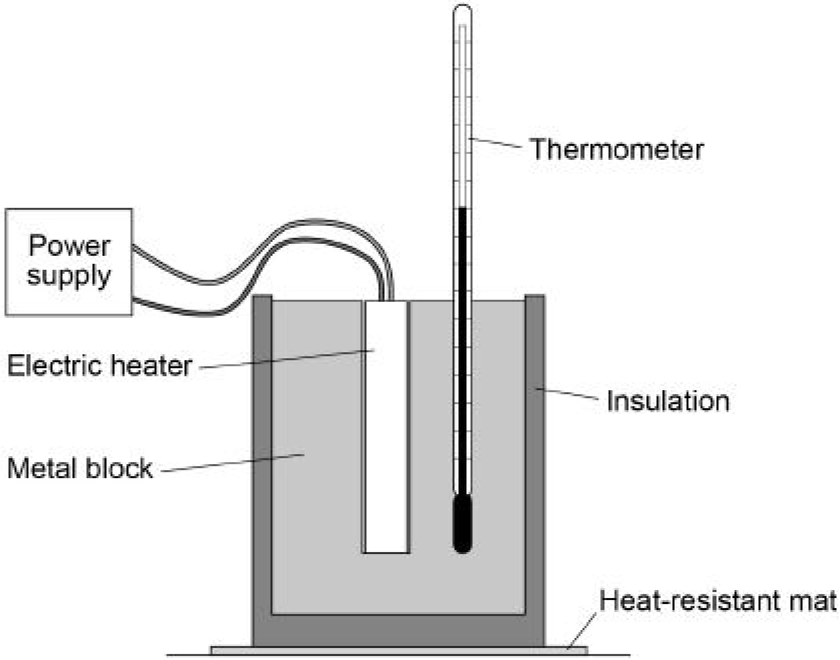
(Total 12 marks)

4 A student investigated how the temperature of a metal block changed with time.

An electric heater was used to increase the temperature of the block.

The heater was placed in a hole drilled in the block as shown in **Figure 1**.

Figure 1



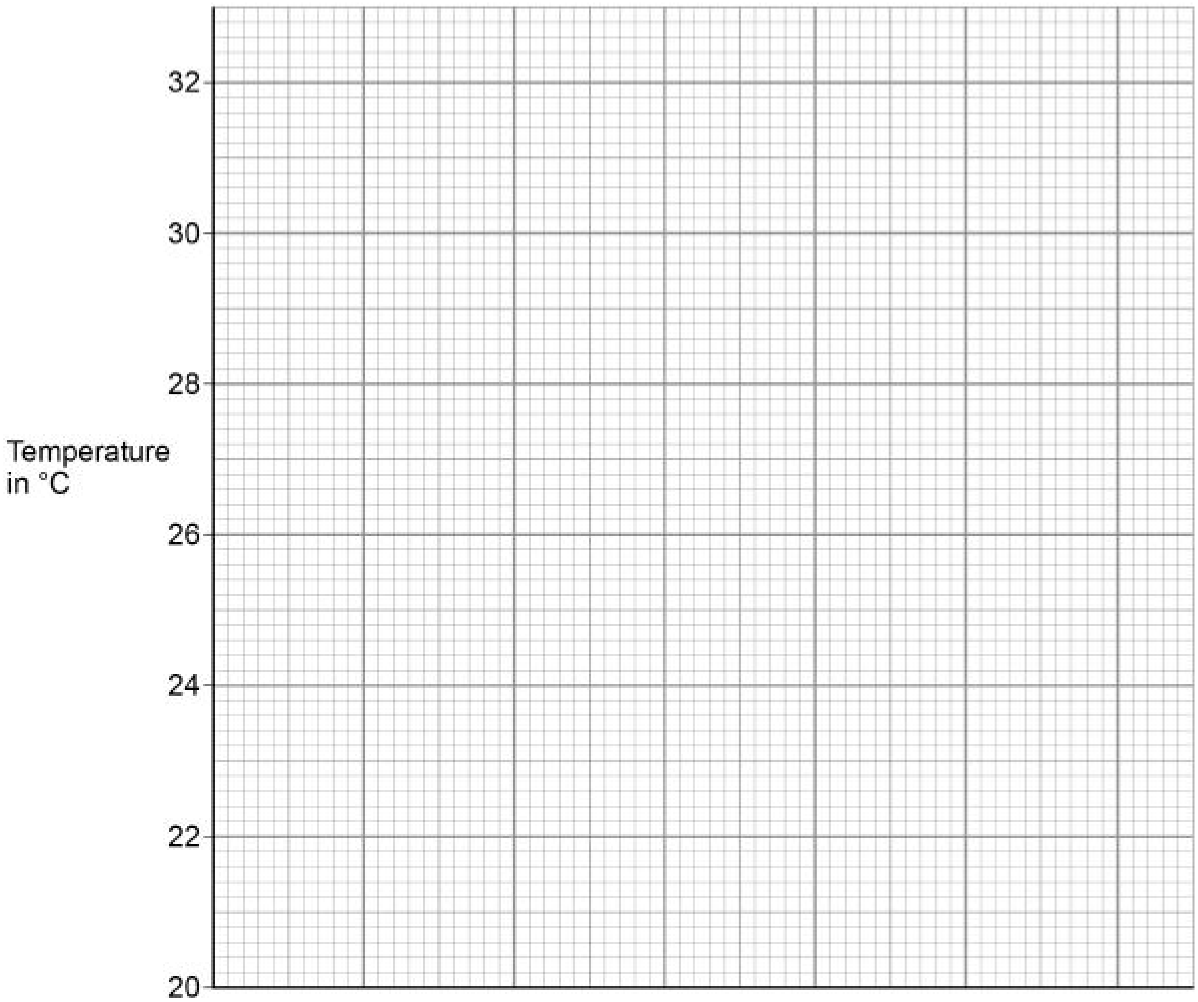
The student measured the temperature of the metal block every 60 seconds.
The table below shows the student's results.

Time in s	**Temperature in °C**
0	20.0
60	24.5
120	29.0
180	31.0
240	31.5

(a) Complete the graph of the data from the table above on the graph below.

- Choose a suitable scale for the x-axis.
- Label the x-axis.
- Plot the student's results.
- Draw a line of best fit.

Figure 2



(4)

(b) The rate of change of temperature of the block is given by the gradient of the graph.

Determine the gradient of the graph over the first 60 seconds.

____

____

____

____

Gradient = ______________________

(2)

(c) The metal block had a mass of 1.50 kg

The specific heat capacity of the metal was 900 J/kg °C

Calculate the change in thermal energy of the metal during 240 seconds.

Use the Physics Equations Sheet.

Give your answer in kilojoules.

____

____

____

____

____

____

____

____

Change in thermal energy = ____________________ kJ

(4)

(d) Another student repeated the investigation.

Give **two** variables this student would need to control to be able to compare their results with the results in the table above.

1. ____

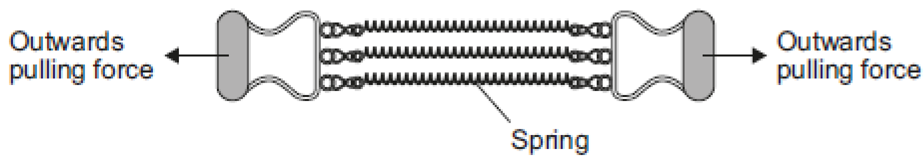
2. ____

(2)

(Total 12 marks)

5 **Figure 1** shows an exercise device called a chest expander. The three springs are identical.

Figure 1



A person pulls outwards on the handles and does work to stretch the springs.

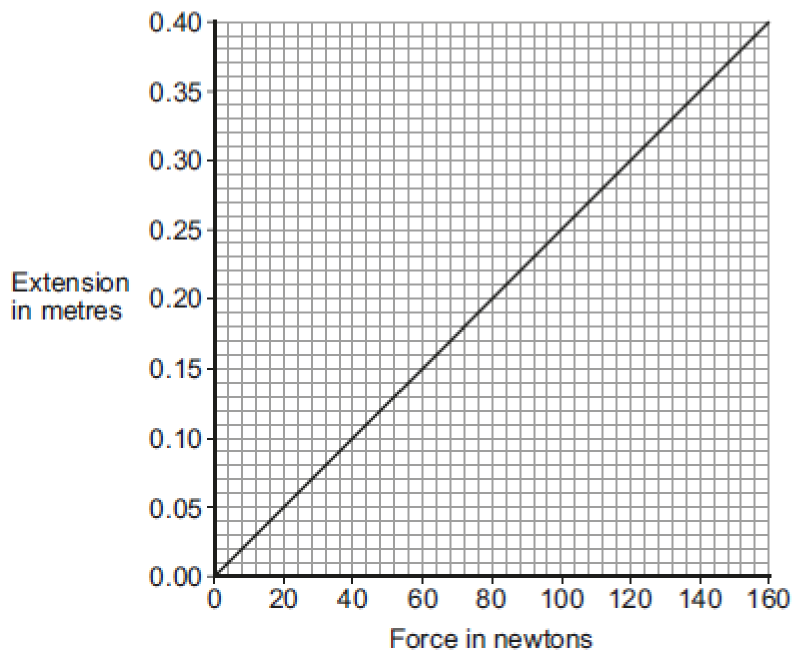
(a) Complete the following sentence.

When the springs are stretched ____________ ____________ energy is stored in the springs.

(1)

(b) **Figure 2** shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

Figure 2



(i) How can you tell, from **Figure 2**, that the limit of proportionality of the spring has not been exceeded?

____

____

(1)

(ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

____

____

____

Spring constant = ____________ Unit ____________

(3)

(iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

____

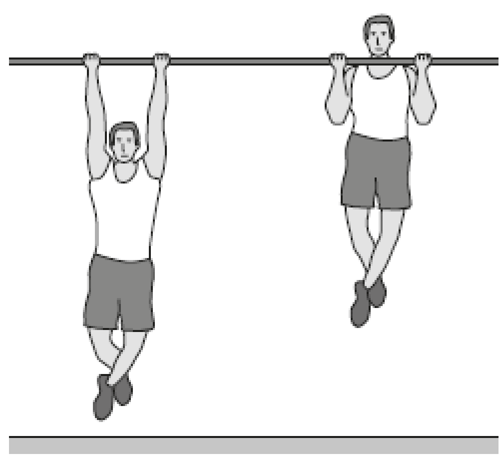
____

Total force = ____________ N

(2)

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

____

____

____

____

____

Power = ___________ W

(3)

(Total 10 marks)

Mark schemes

1 (a) $E_p = 50 \times 9.8 \times 4.0$ **1**

$E_p = 1960$ (J)

allow an answer rounded to 2000 (J) **1**

*allow a maximum of **1** mark if g = 10 N/kg is used*

*an answer of 1960 scores **2** marks*

(b) $E_k = 0.5 \times 50 \times 7^2$ **1**

$E_k = 1225$ (J)

allow 1200 or 1230 (J) **1**

*an answer of 1225 scores **2** marks*

(c) some energy is wasted **1**

the g.p.e of the girl is not zero **1**

(d) reduces the amount of friction

*do **not** accept reference to friction between the wheels and the ramp* **1**

so more energy is usefully transferred

*allow less energy is wasted **or** less heating* **1**

greater kinetic energy **1**

[9]

2 (a) 600 kg = 5880 N **1**

power = $\frac{5880 \times 35}{45}$ **1**

= 4573.3 (W)

*this step without the previous steps stated gains **3** marks* **1**

% Eff. = $\frac{4573.3}{8000} \times 100$ **1**

= 57.17 (%)

*allow 57.17 with no working shown for **5** marks*

1

(b) gpe = 600 × 9.8 × 35

1

= 205 800

1

gpe = KE = ½ m v^2

1

$$v = \sqrt{\frac{2 \times kE}{m}}$$

1

$$= \sqrt{\frac{411\ 600}{600}}$$

1

= 26.2 (m / s)

*allow 26.2 with no working shown for **6** marks*

1

[11]

3 (a) the wall has two / three layers

allow the wall is thick

1

cavity wall insulation / brick / block has a low thermal conductivity

1

so less energy is transferred by conduction

allow rate of energy transfer is lower

ignore any reference to convection and / or radiation

1

(b)

$$T = 17.4 + \left(\frac{(20.8 - 17.4)}{2}\right)$$

or

$$T = 20.8 + \left(\frac{(20.8 - 17.4)}{2}\right)$$

1

T = 19.1 (°C)

1

an answer in the range 18.5−19.1 scores **2** marks

(c) chemical energy store of the fuel decreases

1

thermal energy store of the water increases

allow kinetic energy store of the water particles increases

1

thermal energy store of the air / atmosphere increases

allow kinetic energy store of the air particles increases

1

(d) E = 15 000 000 (J)

1

t = 600 (s)

1

$$p = \frac{15000000}{600}$$

allow a correct substitution of incorrectly / not converted values of E and / or t

1

P = 25 000 (W)

allow a correct calculation using incorrectly / not converted values of E and / or t

1

[12]

4 (a) *x*-axis labelled **and** suitable scale

1

points plotted correctly

*allow 5 correctly plotted for **2** marks, 3−4 correctly plotted for **1** mark*
allow ± ½ square

2

line of best fit

1

(b) $\frac{4.5}{60}$

*allow ecf from line of best fit in part **(a)***

1

0.075 (°C/s)

1

*an answer of 0.075 (°C/s) scores **2** marks*

(c) $\Delta\theta = 11.5$ (°C)

a calculation using an incorrect temperature scores max 3 marks

1

$\Delta E = 1.50 \times 900 \times 11.5$

1

$\Delta E = 15\ 525$ (J)

1

$\Delta E = 15.525$ (kJ)

1

an answer of 15.525 (kJ) ***or*** *15.53 (kJ)* ***or*** *15.5 (kJ) scores* ***4*** *marks*

an answer of 15 525 (kJ) scores ***3*** *marks*

(d) any **two** from:

- mass of block*
- size / dimensions of block*
- material of block*

allow same block for* ***1* *mark*

- current through heater

allow power of heater

- thickness of insulation*
- material of insulation*

allow same insulation for* ***1* *mark*

- time interval
- starting temperature (of block / heater)

2

[12]

5 (a) elastic potential

1

(b) (i) line is straight

accept line does not curve

1

(ii) 400

allow ***1*** *mark for correct substitution of any pair of numbers correctly taken from the graph e.g.160 = k × 0.40*

2

newtons per metre **or** N/m

if symbols are used they must be correct

1

(iii) 300

*allow **1** mark for correctly obtaining force on 1 spring = 100N*

2

(c) 52

*allow **2** marks for calculating change in gpe for 1 chin-up as 260 (J) or for 12 chin-ups as 3120 (J)*

*an answer 4.3 gains **2** marks*

*allow **1** mark for correct substitution into gpe equation ie gpe = 65 × 10 × 0.4 (× 12)*

or

correct use of power equation with an incorrect value for energy transferred

3

[10]