

PHYSICS



EXAM QUESTION PACK

TOPIC 8: ENERGY – FORCES DOING WORK (PACK 1)

SCORE

/133

PERCENTAGE

%

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Q1.

An athlete uses a training machine in a gym.

The display on the machine shows the time spent on the machine and the amount of energy transferred during a training session.

Figure 5 shows the displays for two different sessions by the same athlete.

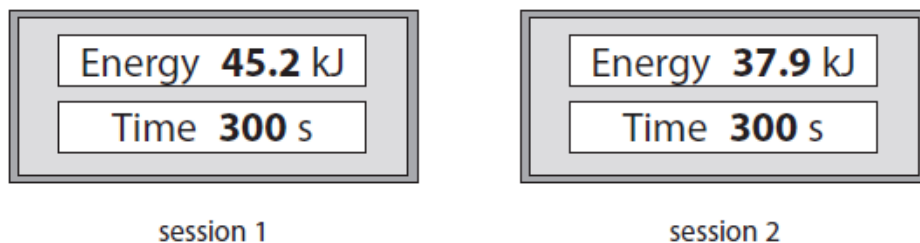


Figure 5

Explain what the displays show about the average power of the athlete in each of these two sessions.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q2.

An athlete uses a training machine in a gym.

The display on the machine shows the time spent on the machine and the amount of energy transferred during a training session.

Figure 5 shows the displays for two different sessions by the same athlete.

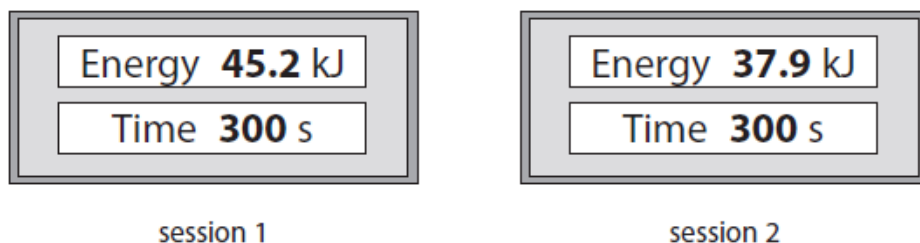


Figure 5

Explain what the displays show about the average power of the athlete in each of these two sessions.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q3.

A cyclist is riding a bicycle at a steady velocity of 12 m/s.

The cyclist and bicycle have a total mass of 68 kg.

The cyclist starts to cycle again.

The cyclist does 1600 J of useful work to travel 28 m.

Calculate the average force the cyclist exerts.

(3)

average force = ... N

(Total for question = 3 marks)

Q4.

A cyclist starts to cycle.

The cyclist does 1600 J of useful work to travel 28 m.

Calculate the average force the cyclist exerts.

(3)

average force = ... N

(Total for question = 3 marks)

Q5.

A rock falls off the top of a cliff of height h .

Figure 3 shows the rock falling.

The Earth exerts a force of 150 N on the rock.

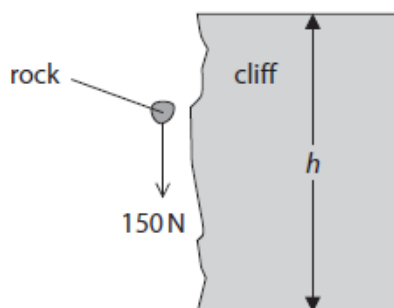


Figure 3

The work done by this force when the rock falls from the top to the bottom of the cliff is 2700 J.

(i) Calculate the height, h , of the cliff.

(2)

$h = \dots\dots\dots$ m

(ii) State the value of the kinetic energy of the rock just before it hits the ground.

(1)

kinetic energy = ... J

(iii) The mass of the rock in Figure 3 is 15 kg.

Calculate the velocity of the rock just before it reaches the bottom of the cliff.

(2)

velocity = ... m/s

(Total for question = 5 marks)

Q6.

A rock falls off the top of a cliff of height h .

Figure 1 shows the rock falling.

The Earth exerts a force of 150 N on the rock.

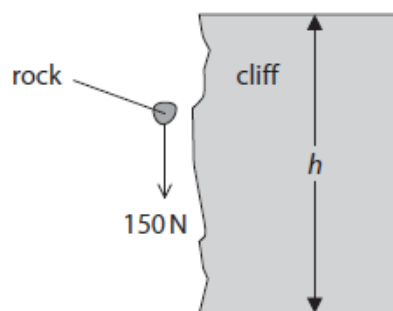


Figure 1

The work done by this force when the rock falls from the top to the bottom of the cliff is 2700 J.

(i) Calculate the height, h , of the cliff.

(2)

$h = \dots\dots\dots$ m

(ii) State the value of the kinetic energy of the rock just before it hits the ground.

(1)

kinetic energy = $\dots\dots\dots$ J

(iii) The mass of the rock in Figure 1 is 15 kg.

Calculate the velocity of the rock just before it reaches the bottom of the cliff.

(2)

velocity = $\dots\dots\dots$ m/s

(Total for question = 5 marks)

Q7.

A ball has a mass of 0.046 kg.

(i) Calculate the change in gravitational potential energy when the ball is lifted through a vertical height of 2.05 m.

Use the equation

$$\Delta GPE = m \times g \times \Delta h$$

(2)

change in gravitational potential energy = ... J

(ii) The ball is released.

Calculate the kinetic energy of the ball when the speed of the ball is 3.5 m/s.

(3)

kinetic energy of the ball = ... J

(iii) The ball bounces several times.

Figure 4 shows how the height of the ball above the floor changes with time.

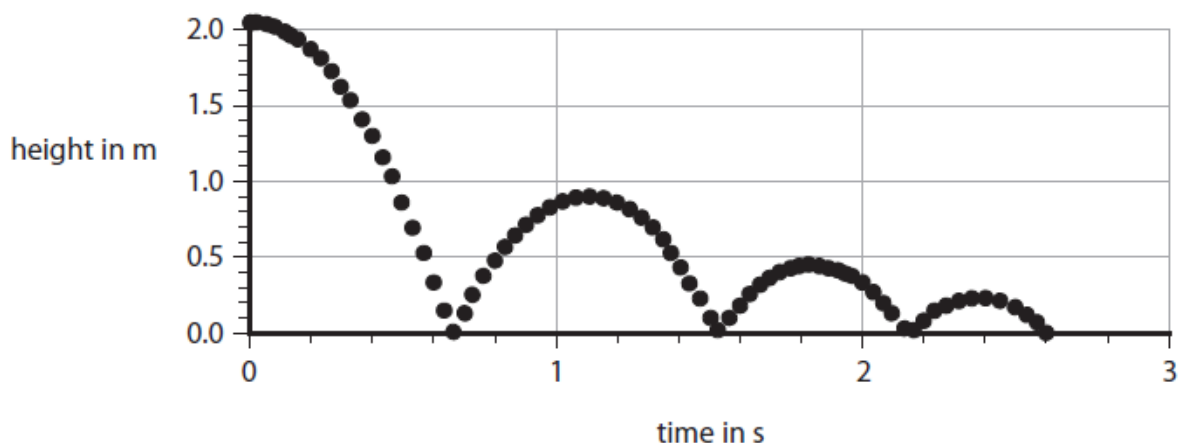


Figure 4

Use Figure 4 to estimate the maximum height that the ball reaches after the first bounce.

(1)

height after first bounce = ... m

(iv) Explain why the ball does not bounce back to its starting height of 2.05 m.

(2)

.....

.....
.....
.....

(Total for question = 8 marks)

Q8.

A ball has a mass of 0.046 kg.

(i) Calculate the change in gravitational potential energy when the ball is lifted through a vertical height of 2.05 m.

Use the equation

$$\Delta GPE = m \times g \times \Delta h$$

(2)

change in gravitational potential energy = ... J

(ii) The ball is released.

Calculate the kinetic energy of the ball when the speed of the ball is 3.5 m/s.

(3)

kinetic energy of the ball = ... J

(iii) The ball bounces several times.

Figure 1 shows how the height of the ball above the floor changes with time.

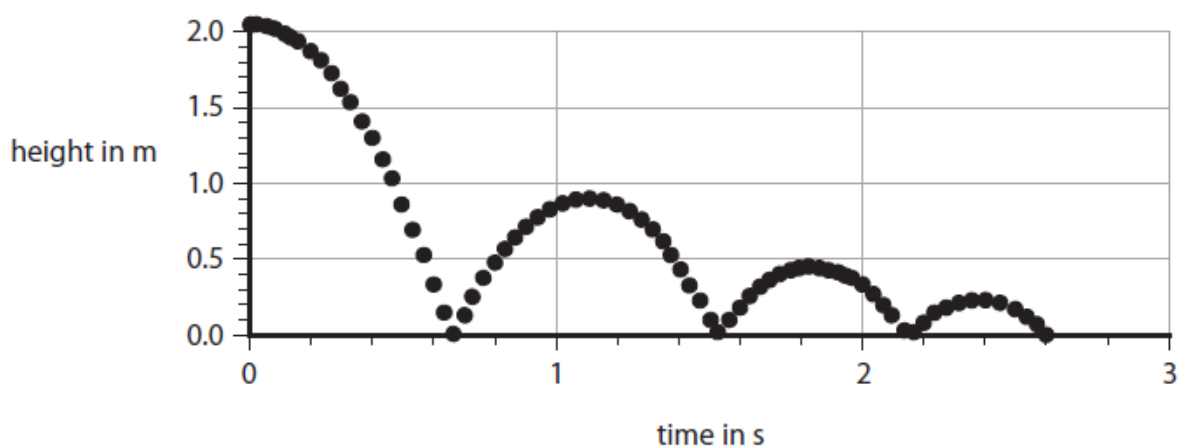


Figure 1

Use Figure 1 to estimate the maximum height that the ball reaches after the first bounce.

(1)

height after first bounce = ... m

(iv) Explain why the ball does not bounce back to its starting height of 2.05 m.

(2)

.....
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.....

(Total for question = 8 marks)

Q9.

Figure 6 shows a 'Mars rover' descending to the surface of the planet Mars.

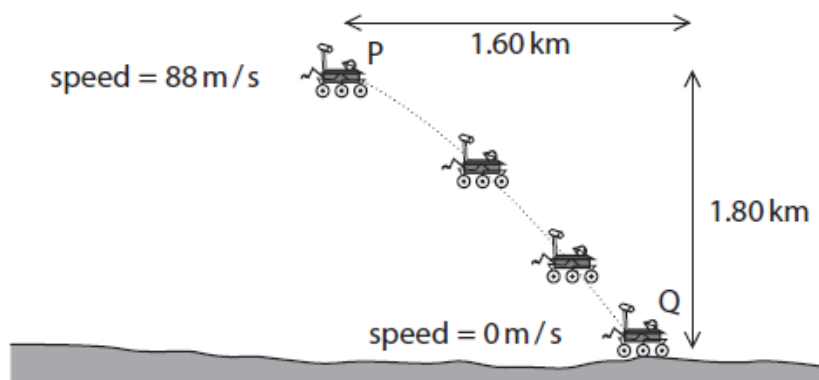


Figure 6

(i) Calculate the change in gravitational potential energy of the rover as it descends from position P to position Q.

Mass of rover = 1100 kg

Gravitational field strength on Mars = 3.7 N / kg

Give your answer to 2 significant figures.

(3)

change in gravitational potential energy = ... J

(ii) Use data from Figure 6 to calculate the change in kinetic energy of the rover as it descends from position P to position Q.

(2)

change in kinetic energy = ... J

(iii) The rover is slowed down safely using thrusters and a parachute (not shown in Figure 6).

The thrusters use jets of gas to control movements and the parachute is designed to be used in the atmosphere of Mars.

Describe the energy changes involved in terms of the work done by various forces as the rover descends.

(3)

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.....

(Total for question = 8 marks)

Q10.

A drone has a mass of 4.5 kg.

This drone rises from the ground to a height of 20 m.

(i) Calculate the change in gravitational potential energy when the drone rises through a height of 20 m.

The gravitational field strength $g = 10\text{N/kg}$.

(2)

change in gravitational potential energy = ... J

(ii) State the amount of useful work done by the blades as the drone rises through 20 m.

(1)

useful work done = ... J

(iii) It takes 4 s for the drone to rise through 20 m.

Calculate the useful power developed by the blades in this time of 4 s.

(2)

useful power developed = ... W

(Total for question = 5 marks)

Q11.

Figure 4 shows a drone.



© Liubov Kotliar/123RF

Figure 4

A different drone has a mass of 4.5 kg.

This drone rises from the ground to a height of 20 m.

(i) Calculate the change in gravitational potential energy when the drone rises through a height of 20 m.

The gravitational field strength $g = 10 \text{ N/kg}$.

(2)

change in gravitational potential energy = ... J

(ii) State the amount of useful work done by the blades as the drone rises through 20 m.

(1)

useful work done = ... J

(iii) It takes 4 s for the drone to rise through 20 m.

Calculate the useful power developed by the blades in this time of 4 s.

(2)

useful power developed = ... W

(Total for question = 5 marks)

Q12.

Figure 15 shows a 'Mars rover' descending to the surface of the planet Mars.

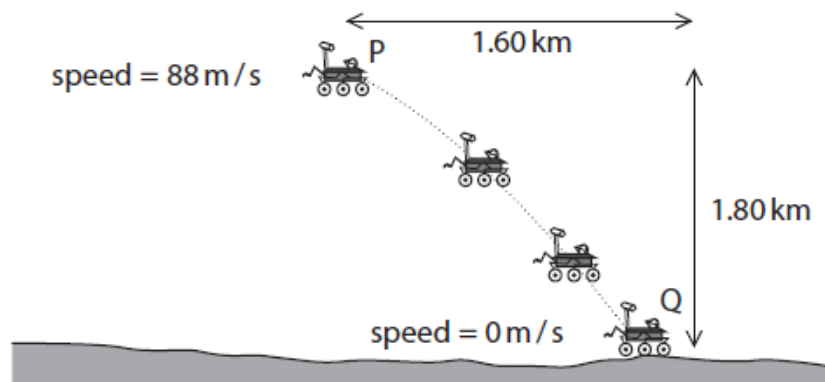


Figure 15

(i) Calculate the change in gravitational potential energy of the rover as it descends from position P to position Q.

Mass of rover = 1100 kg

Gravitational field strength on Mars = 3.7 N / kg

Give your answer to 2 significant figures.

(3)

change in gravitational potential energy = ... J

(ii) Use data from Figure 15 to calculate the change in kinetic energy of the rover as it descends from position P to position Q.

(2)

change in kinetic energy = ... J

(iii) The rover is slowed down safely using thrusters and a parachute (not shown in Figure 15).

The thrusters use jets of gas to control movements and the parachute is designed to be used in the atmosphere of Mars.

Describe the energy changes involved in terms of the work done by various forces as the rover descends.

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.....

(Total for question = 8 marks)

Q13.

Figure 8 shows a bicycle.

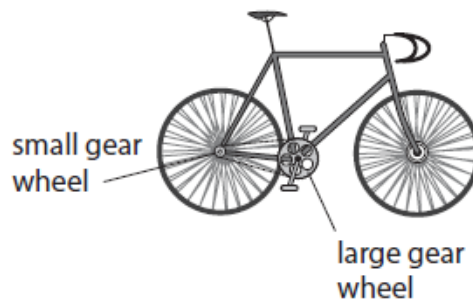


Figure 8

(i) The rider uses the pedals to make the large gear wheel turn.

The large gear wheel moves the chain.

The chain turns the small gear wheel.

The large gear wheel has 48 teeth.

The small gear wheel has 12 teeth.

The large gear wheel turns 2 times each second.

Calculate the number of times that the small gear wheel turns each second.

(2)

..... turns each second

(ii) Oil is applied to the wheel of a bicycle at the point shown in Figure 9.

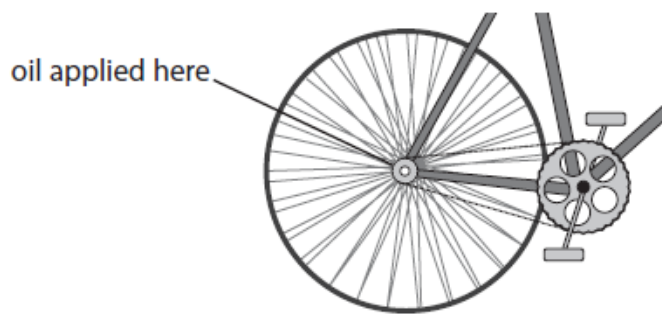


Figure 9

Explain how the oil improves the efficiency of the bicycle.

(3)

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(Total for question = 5 marks)

Q14.

Figure 14 shows an athlete using a fitness device.

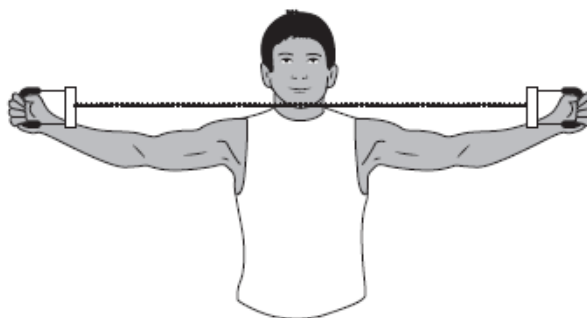


Figure 14

The athlete stretches the spring in the device by pulling the handles apart.

The spring constant of the spring is 140 N/m.

The athlete does 45 J of work to extend the spring.

The athlete takes 0.6 s to expand the spring.

(i) Calculate the useful power output of the athlete when stretching the spring.

(2)

useful power output of the athlete = ... W

(ii) Calculate the extension of the spring.

Use an equation selected from the list of equations at the end of this paper.

(3)

extension of the spring = ... m

(Total for question = 5 marks)

Q15.

Figure 7 shows an athlete using a fitness device.

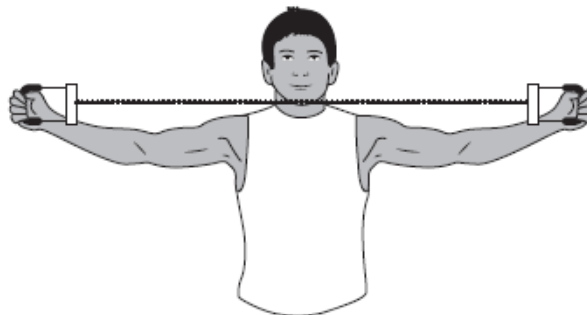


Figure 7

The athlete stretches the spring in the device by pulling the handles apart.

The spring constant of the spring is 140 N/m.

The athlete does 45 J of work to extend the spring.

The athlete takes 0.6 s to expand the spring.

(i) Calculate the useful power output of the athlete when stretching the spring.

(2)

useful power output of the athlete = ... W

(ii) Calculate the extension of the spring.

Use an equation selected from the list of equations from the relevant equation sheet.

(3)

extension of the spring = ... m

(Total for question = 5 marks)

Q16.

The kinetic energy of another cyclist is 2800 J.

The mass of the cyclist is 85 kg.

Calculate the velocity of this cyclist.

Use the equation

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

(3)

velocity = ... m / s

(Total for question = 3 marks)

Q17.

The kinetic energy of another cyclist is 2800 J.

The mass of the cyclist is 85 kg.

Calculate the velocity of this cyclist.

Use the equation

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

(3)

velocity = ... m/s

(Total for question = 3 marks)

Q18.

Fuel weighing 230 000 N is pumped into an aircraft.
This fuel moves upwards through a vertical height of 4.7 m.
The power developed by the pump is 1600 W.
Calculate the time needed to refuel the aircraft.

(3)

time = ... s

(Total for question = 3 marks)

Q19.

Figure 1 shows part of a roller coaster ride seen from the side.

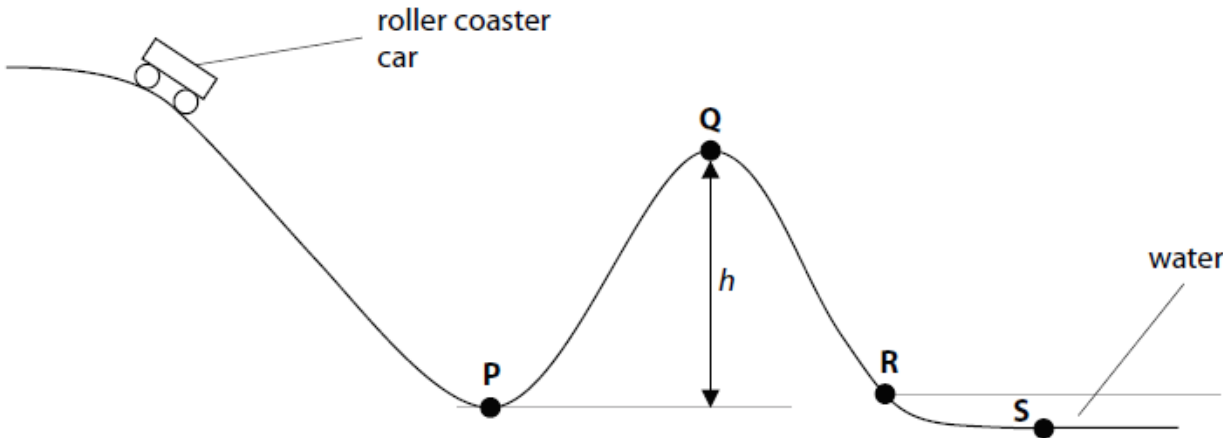


Figure 1

(a) The roller coaster car rolls down towards **P**. The car has mass, m kg and velocity v m/s.

Which of these is the correct equation for calculating the kinetic energy of the car?

(1)

☐ **A** $KE = mv$

☐ **B** $KE = mv^2$

☐ **C** $KE = \frac{1}{2}mv^2$

☐ **D** $KE = 2mv^2$

(b) The mass of the car is 580 kg.

The car gains 39 000 J of gravitational potential energy as it climbs from **P** to **Q**.

(i) State the equation relating change in gravitational potential energy, mass, gravitational field strength and change in vertical height.

(1)

(ii) Calculate the height h , shown in Figure 1.

(gravitational field strength, $g = 10$ N/kg)

(3)

$h = \dots\dots\dots$ m

(Total for question = 5 marks)

Q20.

A cyclist is riding a bicycle at a steady velocity of 12 m/s.

The cyclist and bicycle have a total mass of 68 kg.

Calculate the kinetic energy of the cyclist and bicycle.

Use the equation

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

(2)

kinetic energy = $\dots\dots\dots$ J

(Total for question = 2 marks)

Q21.

A cyclist is riding a bicycle at a steady velocity of 12 m/s.

The cyclist and bicycle have a total mass of 68 kg.

Calculate the kinetic energy of the cyclist and bicycle.

Use the equation

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

(2)

kinetic energy = ... J

(Total for question = 2 marks)

Q22.

The espresso machine shown in Figure 27 is an electrical appliance.



(Source: © tanawaty/123RF)

Figure 27

The espresso machine has a steam pipe that can be used to heat milk in a jug, as shown in Figure 28.



(Source: © Wavebreak Media Ltd/123RF)

Figure 28

Steam from the pipe enters the milk, where steam condenses to water.

The steam and hot water heat the milk.

(i) Describe, in terms of energy, how the arrangement and movement of particles in the steam changes as the steam enters the milk, condenses and cools.

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.....

.....

.....

(ii) The specific heat capacity of milk is 3840 J/kg K.

The specific heat capacity of water is 4200 J/kg K.

The specific latent heat of condensation of steam is 2260 kJ/kg.

The temperature of the steam is 100°C

The mass of steam that condenses is 25 g.

The temperature of the milk rises from 5°C to 65°C.

By considering the transfer of energy from the steam to the milk, calculate the mass of milk that is heated by the steam and hot water.

Use equations from the formula sheet.

(4)

mass of milk = ... kg

(iii) Give **two** reasons why the actual mass of steam needed to heat the milk from 5°C to 65°C is greater than 25 g.

(2)

1

.....

2

.....

(Total for question = 8 marks)

Q23.

Figure 14 shows a demolition ball of mass 400 kg.

The ball is used to demolish a wall.

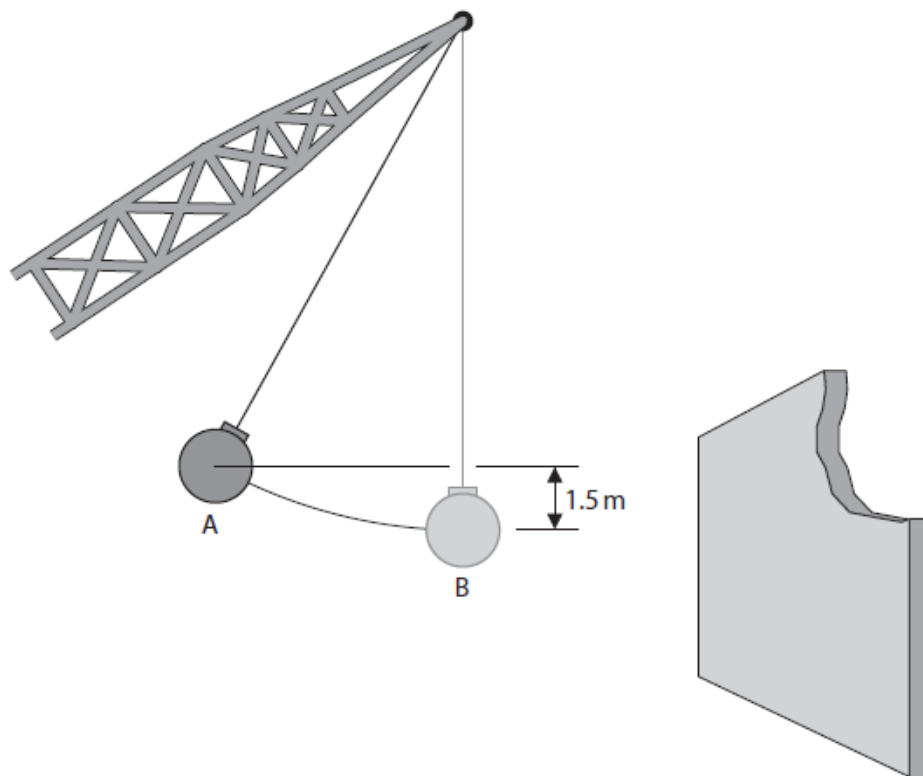


Figure 14

As the ball swings from A to B, it moves through a vertical height of 1.5 m.

(i) Calculate the change in gravitational potential energy.

Take gravitational field strength, g , to be 10 N/kg.

(3)

(ii) The heavy ball comes to rest soon after smashing into the wall. In doing this, the temperatures of the ball, wall and surroundings all increase slightly.

Explain this observation.

(2)

.....

.....

.....

.....

(iii) Which of these quantities of the ball changes in **both** magnitude and direction while the ball is swinging?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** gravitational potential energy

☐ **B** velocity

- ☐ **C** the gravitational force acting
- ☐ **D** kinetic energy

(Total for question = 6 marks)

Q24.

Figure 8 shows a demolition ball of mass 400 kg.

The ball is used to demolish a wall.

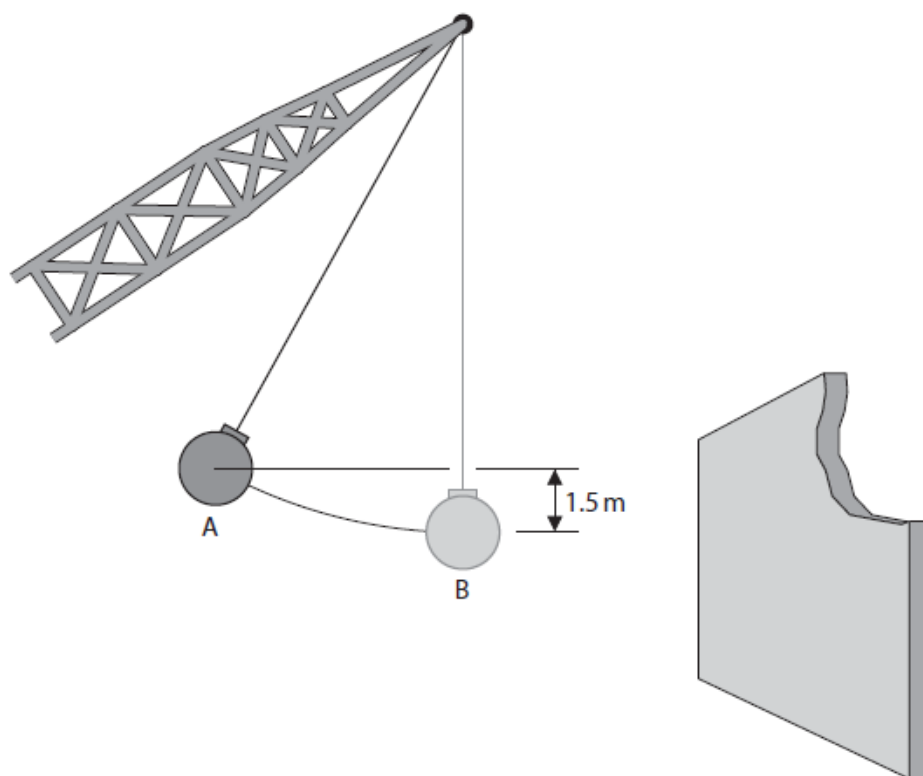


Figure 8

As the ball swings from A to B, it moves through a vertical height of 1.5 m.

(i) Calculate the change in gravitational potential energy.

Take gravitational field strength, g , to be 10 N/kg.

(3)

(ii) The heavy ball comes to rest soon after smashing into the wall. In doing this, the temperatures of the ball, wall and surroundings all increase slightly.

Explain this observation.

(2)

.....

.....

.....

.....

(iii) Which of these quantities of the ball changes in **both** magnitude and direction while the ball is swinging?

Put a cross ☐ in the box next to your answer.

(1)

- ☐ **A** gravitational potential energy
- ☐ **B** velocity
- ☐ **C** the gravitational force acting
- ☐ **D** kinetic energy

(Total for question = 6 marks)

Q25.

Figure 17 shows information about the pressures in the ocean and in the atmosphere of a distant planet.

Graph A shows the variation of pressure as the depth in the ocean increases.

Graph B shows the variation of pressure as the height in the atmosphere increases.



Figure 17

(i) Use information from Graph A to obtain a value for the density of the ocean water.

Use an equation selected from the list of equations at the end of this paper.

(4)

density = ... kg/m³

* (ii) Explain the similarities and differences in the pressure variations shown in graphs A and B.

Your answer should refer to both the particle model (kinetic theory) and to density.

(6)

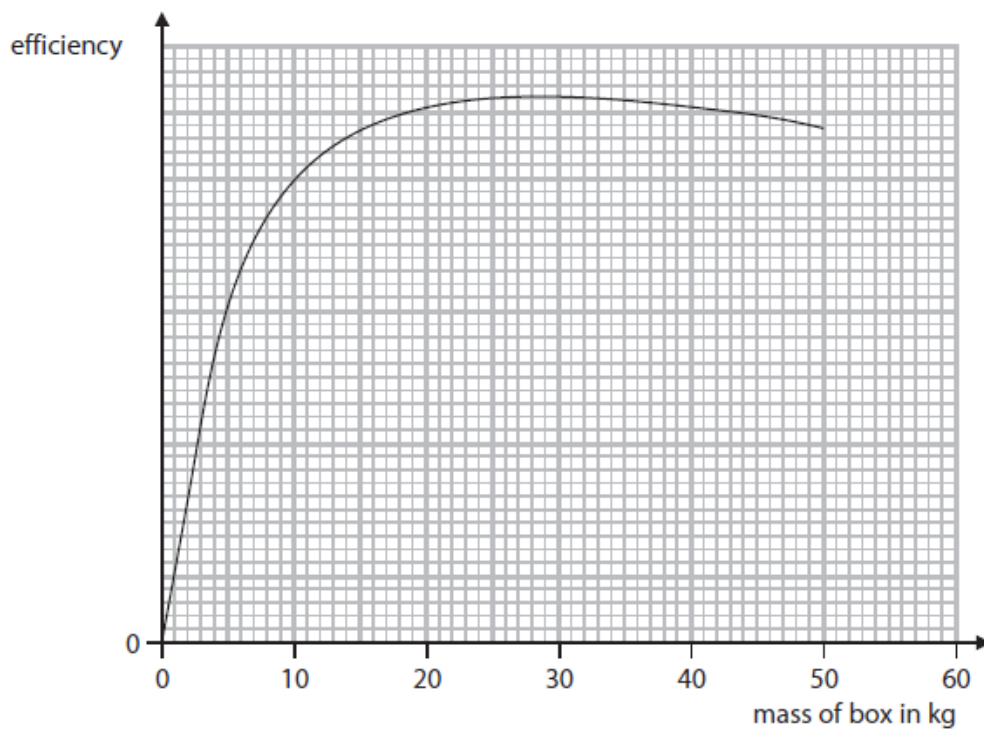
This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

(Total for question = 10 marks)

Q26.

An electric motor is used to lift a box.

Figure 4 shows how the efficiency of the electric motor changes as the mass of the box increases.



Describe how the efficiency of the electric motor depends on the mass of the box lifted.

(2)

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.....

(Total for question = 2 marks)

Q27.

An electric motor is used to lift a box.

Figure 2 shows how the efficiency of the electric motor changes as the mass of the box increases.

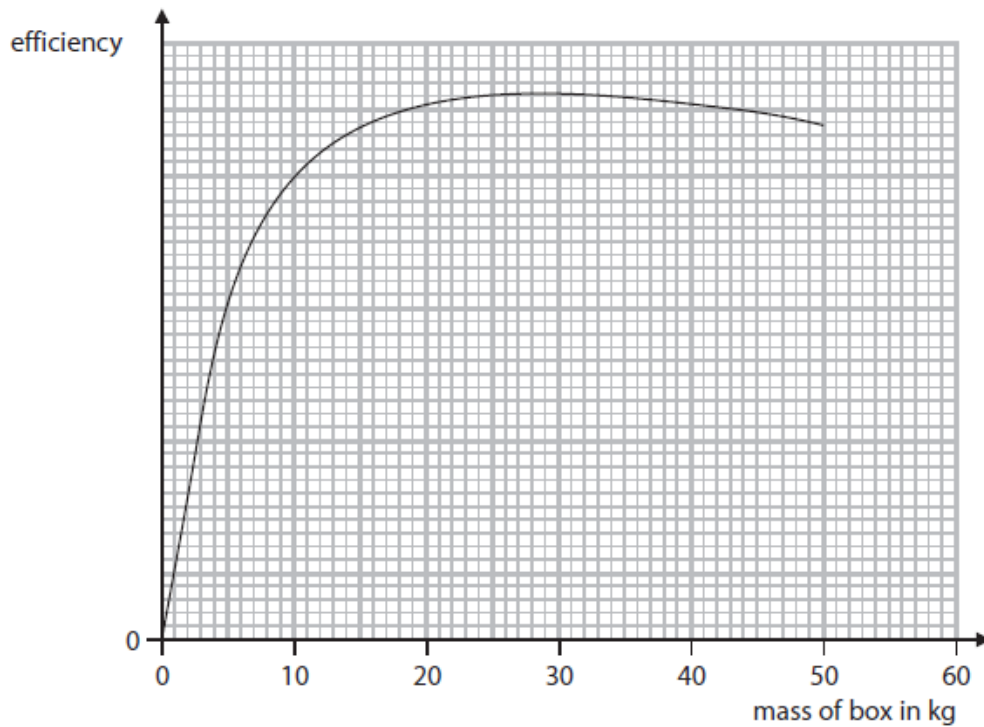


Figure 2

Describe how the efficiency of the electric motor depends on the mass of the box lifted.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Q28.

Figure 1 shows part of a roller coaster ride seen from the side.

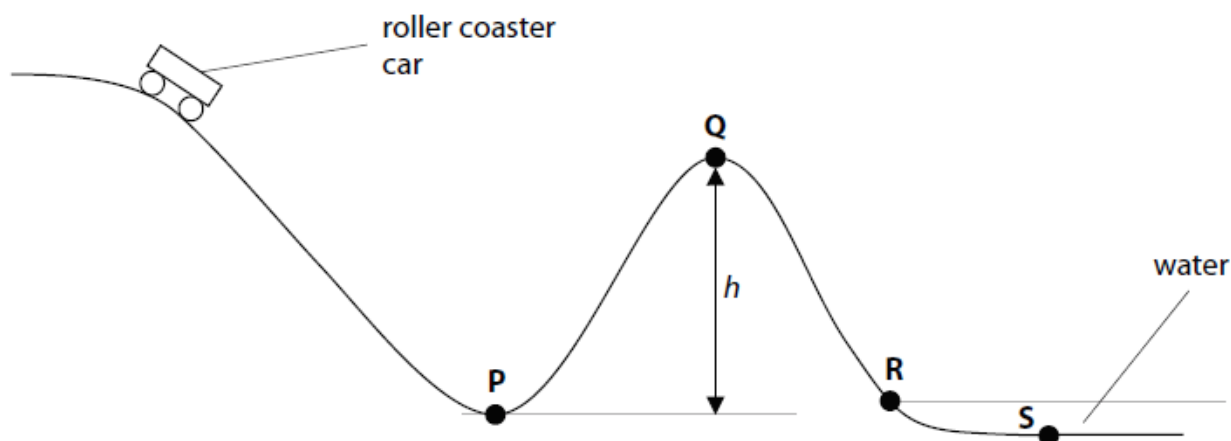


Figure 1

The car enters a pool of water at **R**. It slows down and stops at **S**.

Describe how the total energy of the system is conserved as the car travels between **R** and **S**.

(2)

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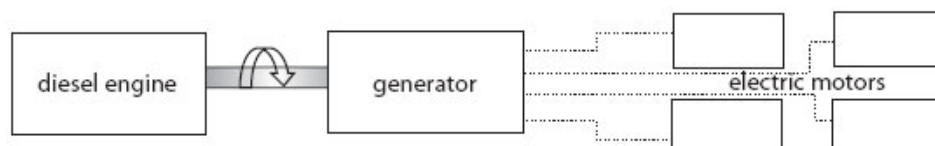
(Total for question = 2 marks)

Q29.

(a) A train is powered by a diesel engine.

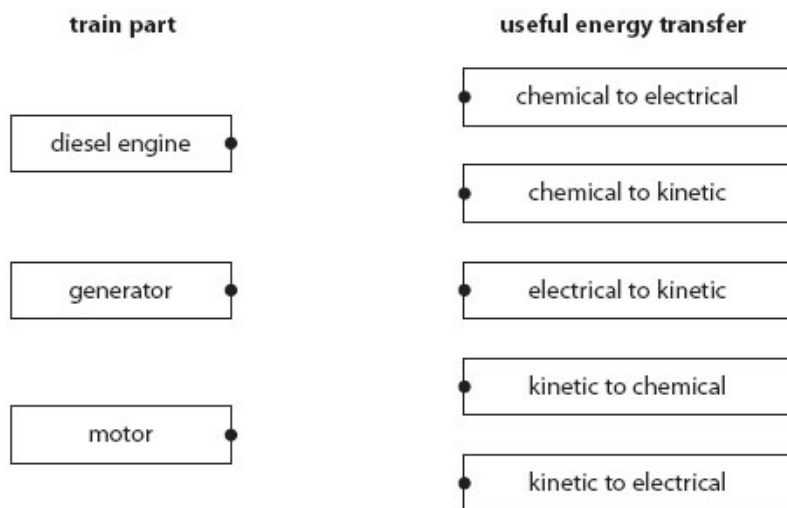
The diesel engine is used to turn a generator.

The generator provides electricity for electric motors which drive the wheels.



(i) Draw one straight line from each train part to its useful energy transfer.

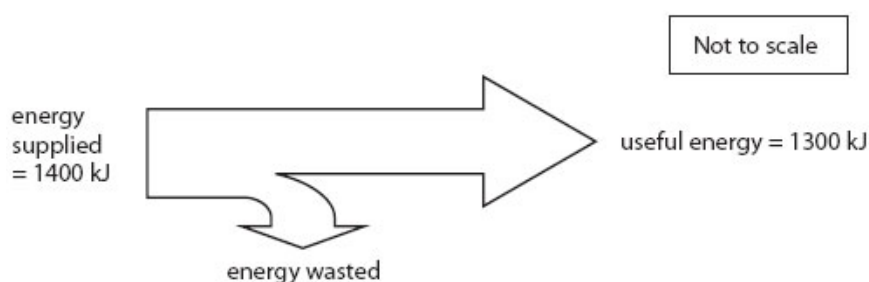
(3)



(ii) State **one** example of a non-useful energy transfer in the motor.

(1)

(b) The diagram represents the energy transfer in one second in the generator.



(i) Calculate the amount of energy wasted in one second in the generator.

(1)

energy wasted = ...kJ

(ii) Calculate the efficiency of the generator.

(2)

efficiency of generator = ...

(c) The electric motors which drive the wheels are painted black.

Suggest why the motors are painted black.

(1)

.....

.....

(Total for Question is 8 marks)

Q30.

A cyclist is riding a bicycle at a steady velocity of 12 m/s.

The cyclist and bicycle have a total mass of 68 kg.

Describe the energy transfers that happen when the cyclist uses the brakes to stop.

(2)

.....

.....

.....

.....

(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number:	Answer	Additional Guidance	Mark
	an explanation linking: over the same time / in 300s, more work done / energy transferred in session 1 than in session 2 (1) (therefore) more power (developed) in session 1 (1)	allow reverse argument power in session 1 = $\frac{45.2}{300} = 0.15 \text{ (kW) or } 150 \text{ (W)}$ allow statement that power = $\frac{\text{work}}{\text{time}}$ or power = $\frac{\text{energy}(\text{transferred})}{\text{time}}$ for MP1 power in session 2 = $\frac{37.9}{300} = 0.13 \text{ (kW) or } 126 \text{ (W)}$	(2) AO 3 2a AO 3 2b

Q2.

Question Number:	Answer	Additional Guidance	Mark
	an explanation linking: over the same time / in 300s, more work done / energy transferred in session 1 than in session 2 (1) (therefore) more power (developed) in session 1 (1)	allow reverse argument power in session 1 = $\frac{45.2}{300} = 0.15 \text{ (kW) or } 150 \text{ (W)}$ allow statement that power = $\frac{\text{work}}{\text{time}}$ or power = $\frac{\text{energy}(\text{transferred})}{\text{time}}$ for MP1 power in session 2 = $\frac{37.9}{300} = 0.13 \text{ (kW) or } 126 \text{ (W)}$	(2) AO 3 2a AO 3 2b

Q3.

Question Number:	Answer	Additional Guidance	Mark
	recall and substitution (1) $1600 = \text{force} \times 28$ rearrangement (1) $(\text{force}) = \frac{1600}{28}$ evaluation (1) 57 (N)	substitution and rearrangement in either order accept f, F or ? for force accept values that round down to 57 e.g. 57.14 award full marks for correct answer without working award 1 mark for answers of 44800 or 0.0175 and a correct expression relating work, force and distance	(3) AO 2 1

Q4.

Question Number:	Answer	Additional Guidance	Mark
	recall and substitution (1) $1600 = \text{force} \times 28$ rearrangement (1) $(\text{force}) = \frac{1600}{28}$ evaluation (1) 57 (N)	substitution and rearrangement in either order accept f, F or ? for force accept values that round down to 57 e.g. 57.14 award full marks for correct answer without working award 1 mark for answers of 44800 or 0.0175 and a correct expression relating work, force and distance	(3) AO 2 1

Q5.

Question number	Answer	Additional guidance	Mark
(i)	rearrangement of work = force $\times$ distance to give distance = work $\div$ force (1) substitution and evaluation (1) 18 (m)	seeing $2700 \div 150$ Award full marks for correct answer without working	(2)

Question number	Answer	Mark
(ii)	2700 (J)	(1)

Question number	Answer	Additional guidance	Mark
(iii)	rearrangement of $KE = \frac{1}{2}mv^2$ $v = \sqrt{2 \times KE \div m}$ (1) substitution and evaluation (1) 19 (m/s)	 $v = \sqrt{2 \times 2700 \div 15}$ $v^2 = (2 \times 2700 \div 15)$ allow answers that round to 19 award full marks for correct answer without working allow alternative route using $v^2 - u^2 = 2ax$ for full marks	(2)

Q6.

Question number	Answer	Additional guidance	Mark
(i)	rearrangement of work = force $\times$ distance to give distance = work $\div$ force (1) substitution and evaluation (1) 18 (m)	seeing $2700 \div 150$ Award full marks for correct answer without working	(2)

Question number	Answer	Mark
(ii)	2700 (J)	(1)

Question number	Answer	Additional guidance	Mark
(iii)	rearrangement of $KE = \frac{1}{2}mv^2$ $v = \sqrt{2 \times KE \div m}$ (1) substitution and evaluation (1) 19 (m/s)	$v = \sqrt{2 \times 2700 \div 15}$ $v^2 = (2 \times 2700 \div 15)$ allow answers that round to 19 award full marks for correct answer without working allow alternative route using $v^2 - u^2 = 2ax$ for full marks	(2)

Q7.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $(\Delta GPE =) (0.0)46 \times 10 \times 2.05$ evaluation (1) 0.94(3) (J)	allow $g=9.8(1) \text{ m/s}^2$ 0.9 (J) values that round to 0.92 or 0.93 (from using $g = 9.8$ or 9.81) do not award for 1(J) no POT error in evaluation award full marks for the correct answer without working.	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	recall (1) $(KE =) \frac{1}{2} \times m \times v^2$ substitution (1) $(KE =) \frac{1}{2} \times (0.046 \times 3.5^2$ evaluation (1) 0.28 (J)	allow answers that round to 0.28 e.g. 0.28175 (J) allow max 2 marks for POT error e.g. 0.00028 award full marks for the correct answer without working	(3)

Question Number	Answer	Additional guidance	Mark
(iii)	Any value between 0.8 (m) and 0.95 (m) inclusive		(1)

Question Number	Answer	Additional guidance	Mark
(iv)	An explanation linking (the ball) has lost energy (1) identification of what has happened to that energy (1)	accept (energy) dissipated or (transferred to) surroundings / ground or thermal energy or heat / sound or system is not 100% efficient or bounce is not (100%) elastic or squashing (the ball or the ground)	(2)

Q8.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $(\Delta GPE =) (0.0)46 \times 10 \times 2.05$ evaluation (1) 0.94(3) (J)	allow $g = 9.8(1) \text{ m/s}^2$ 0.9 (J) values that round to 0.92 or 0.93 (from using $g = 9.8$ or 9.81) do not award for 1(J) no POT error in evaluation award full marks for the correct answer without working.	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	recall (1) $(KE =) \frac{1}{2} \times m \times v^2$ substitution (1) $(KE =) \frac{1}{2} \times (0.0)46 \times 3.5^2$ evaluation (1) 0.28 (J)	allow answers that round to 0.28 e.g. 0.28175 (J) allow max 2 marks for POT error e.g. 0.00028 award full marks for the correct answer without working	(3)

Question Number	Answer	Additional guidance	Mark
(iii)	Any value between 0.8 (m) and 0.95 (m) inclusive		(1)

Question Number	Answer	Additional guidance	Mark
(iv)	An explanation linking (the ball) has lost energy (1) identification of what has happened to that energy (1)	accept (energy) dissipated or (transferred to) surroundings / ground or thermal energy or heat / sound or system is not 100% efficient or bounce is not (100%) elastic or squashing (the ball or the ground)	(2)

Q9.

Question number	Answer	Additional guidance	Mark
(i)	select and substitute (1) $(\Delta GPE = m \times g \times \Delta h)$ $= 1100 \times 3.7 \times 1.8 (\times 10^3)$ evaluation (1) 7 326 000 (J) evaluation to 2 s.f. (1) 7 300 000 (J)	any number rounding to 7 300 000 7326 scores 1 mark independent mark -any final answer stated to 2 s.f.	(3) A02.1

Question number	Answer	Additional guidance	Mark
(ii)	select and substitute (1) $(\Delta KE = \frac{1}{2} m \times v^2)$ $= \frac{1}{2} 1100 \times 88^2$ evaluation (1) 4 300 000 (J)	ignore minus signs accept numbers that round to 4 300 000 (J) e.g. 4 259 200 (J) award full marks for the correct answer without working	(2) A02.1

Question number	Answer	Additional guidance	Mark
iii	A description linking three from: 1. work is done against / by gravity (1) 2. idea of work done by the thrusters / jets (on the rover) (1) 3. (work done) by air/atmospheric resistance on the parachute (and rover) (1) 4. this reduces the kinetic energy (store) (1) 5. (there is a) decrease in the gravitational potential energy (store) of the rover (1) 6. (there is a) transfer of chemical energy from the thrusters (1) 7. energy transferred to thermal energy (store) (1) 8. (transfer) mechanically (to the thermal store) (1)	KEY: attempt to explain <u>how work done</u> contributes towards the energy changes / conservation of energy if no other mark scored allow one mark for work = force x distance	(3) AO2.1

Q10.

Question number	Answer	Additional guidance	Mark
(i)	recall and substitution into (1) $\text{gpe} = m \times g \times h$ $(\text{gpe}) = 4.5 \times 10 \times 20$ evaluation (1) 900(J)	allow 90(J) for 1 mark award full marks for the correct answer without working	(2)

Question number	Answer	Additional guidance	Mark
ii	900(J)	allow ecf from i	(1)

Question number	Answer	Additional guidance	Mark
iii	recall and substitution (1) power = work done / time taken (power =) 900 / 4 evaluation (1) 200 (W)	allow ecf from i or ii accept 230(W), 225(W) award full marks for the correct answer without working	(2)

Q11.

Question number	Answer	Additional guidance	Mark
(i)	recall and substitution into (1) $\text{gpe} = m \times g \times h$ $(\text{gpe}) = 4.5 \times 10 \times 20$ evaluation (1) 900(J)	allow 90(J) for 1 mark award full marks for the correct answer without working	(2)

Question number	Answer	Additional guidance	Mark
ii	900(J)	allow ecf from bi	(1)

Question number	Answer	Additional guidance	Mark
iii	recall and substitution (1) power = work done / time taken (power =) 900 / 4 evaluation (1) 200 (W)	allow ecf from bi or bii accept 230(W), 225(W) award full marks for the correct answer without working	(2)

Q12.

Question number	Answer	Additional guidance	Mark
(i)	select and substitute (1) ($\Delta GPE = m \times g \times \Delta h$) $= 1100 \times 3.7 \times 1.8 \times 10^3$) evaluation (1) 7 326 000 (J) evaluation to 2 s.f. (1) 7 300 000 (J)	 any number rounding to 7 300 000 7326 scores 1 mark independent mark - any final answer stated to 2 s.f.	(3) A02.1

Question number	Answer	Additional guidance	Mark
(ii)	select and substitute (1) $(\Delta KE = \frac{1}{2} m \times v^2)$ $= \frac{1}{2} 1100 \times 88^2$ evaluation (1) 4 300 000 (J)	ignore minus signs accept numbers that round to 4 300 000 (J) e.g. 4 259 200 (J) award full marks for the correct answer without working	(2) A02.1

Question number	Answer	Additional guidance	Mark
iii	A description linking three from: 1. work is done against / by gravity (1) 2. idea of work done by the thrusters / jets (on the rover) (1) 3. (work done) by air/atmospheric resistance on the parachute (and rover) (1) 4. this reduces the kinetic energy (store) (1) 5. (there is a) decrease in the gravitational potential energy (store) of the rover (1) 6. (there is a) transfer of chemical energy from the thrusters (1) 7. energy transferred to thermal energy (store) (1) 8. (transfer) mechanically (to the thermal store) (1)	KEY: attempt to explain how work done contributes towards the energy changes / conservation of energy if no other mark scored allow one mark for work = force x distance	(3) A02.1

Question Number	Answer	Additional guidance	Mark
(i)	(In every second), distance moved by chain around large gear = distance moved by chain around small gear (1) $2 \times 48 = \text{turns} \times 12$ rearrangement and evaluation (1) 8 (turns each second)	accept use of gear ratio seen or implied e.g. 4:1 or 4/1 or 48:12 or 48/12 or converse e.g. 1:4 award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking reduces friction/amount of thermal energy transferred (1) extra useful energy is available/less input energy is required (1) efficiency = useful energy transferred (by the bicycle) $\div$ total energy supplied (to the bicycle) (1)	(oil provides) lubrication less energy wasted allow for the last two mark points; either less input energy is required to produce the same output for 2 marks or more output energy is available for the same input energy for 2 marks	(3)

Q14.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) $(P =) \frac{E}{t}$ substitution and evaluation (1) $(P =) 75 \text{ (W)}$	P = work done ÷ time $P = \frac{45}{0.6}$ award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $E = \frac{1}{2} \times k \times x^2$ (1) $45 = \frac{1}{2} \times 140 \times x^2$ rearrangement (1) $(x =) \sqrt{\frac{2 \times 45}{140}}$ evaluation (1) $0.8(0) \text{ (m)}$	allow substitution and rearrangement in either order $x^2 = \left(\frac{E}{0.5k} \right) = \frac{2 \times 45}{140}$ $x^2 = 0.64(28571)$ accept values that round to 0.80 e.g. 0.80178 award full marks for the correct answer without working	(3)

Q15.

Question Number	Answer	Additional guidance	Mark
(i)	recall (1) $(P =) \frac{E}{t}$ substitution and evaluation (1) $(P =) 75 \text{ (W)}$	$P = \text{work done} \div \text{time}$ $P = \frac{45}{0.6}$ award full marks for the correct answer without working	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $E = \frac{1}{2} \times k \times x^2$ (1) $45 = \frac{1}{2} \times 140 \times x^2$ rearrangement (1) $(x =) \sqrt{\frac{2 \times 45}{140}}$ evaluation (1) $0.8(0) \text{ (m)}$	allow substitution and rearrangement in either order $x^2 = \left(\frac{E}{0.5k} = \right) \frac{2 \times 45}{140}$ $x^2 = 0.64(28571)$ accept values that round to 0.80 e.g. 0.80178 award full marks for the correct answer without working	(3)

Q16.

Question number	Answer	Additional guidance	Mark
	substitution (1) $2,800 = \frac{1}{2} \times 85 \times v^2$ rearrangement (1) $(v^2 =) \frac{2800 \times 2}{85}$ evaluation (1) $v = 8.1 \text{ (m/s)}$	allow substitution and rearrangement in either order 66 or 65.88 seen allow values that round to 8.1 e.g 8.1168 award full marks for the correct answer without working	(3) AO2

Q17.

Question number	Answer	Additional guidance	Mark
	substitution (1) $2,800 = \frac{1}{2} \times 85 \times v^2$ rearrangement (1) $(v^2 =) \frac{2800 \times 2}{85}$ evaluation (1) $v = 8.1 \text{ (m/s)}$	allow substitution and rearrangement in either order 66 or 65.88 seen allow values that round to 8.1 e.g 8.1168 award full marks for the correct answer without working	(3) AO2

Q18.

Question number	Answer	Additional guidance	Mark
	Equating energy in both equations (1) $E = \text{weight} \times \text{height} = \text{power} \times \text{time}$ Rearrangement (1) $\text{time} = \frac{(\text{weight} \times \text{height})}{\text{power}}$ Substitution and evaluation (1) $\text{time} = 230\,000 \times \frac{4.7}{1600}$ $\text{time} = 680(\text{s})$	allow answers which round to 680, e.g. 675.6	(3)

Q19.

Question number	Answer	Mark
(a)	C	(1)

Question number	Answer	Mark
(b)(i)	change in GPE = mass $\times$ gravitational field strength $\times$ change in vertical height	(1)

Question number	Answer	Additional guidance	Mark
(b)(ii)	transformation (1) $h = \Delta E \div mg$ substitution (1) $h = 39\,000 \div (580 \times 10)$ evaluation (1) 6.7(m)	accept use of $g = 9.81$ accept 6.72 accept 6.85 (from $g = 9.81$)	(3)

Q20.

Question Number:	Answer	Additional Guidance	Mark
	substitution (1) (KE =) $\frac{1}{2} \times 68 \times 12^2$ evaluation (1) 4900 (J)	$\frac{1}{2} \times 68000 \times 12^2$ scores 1 mark accept values that round to 4900(J) e.g. 4896(J) award full marks for correct answer without working	(2) AO 2 1

Q21.

Question Number:	Answer	Additional Guidance	Mark
	substitution (1) (KE =) $\frac{1}{2} \times 68 \times 12^2$ evaluation (1) 4900 (J)	$\frac{1}{2} \times 68000 \times 12^2$ scores 1 mark accept values that round to 4900(J) e.g. 4896(J) award full marks for correct answer without working	(2) AO 2 1

Q22.

Question number	Answer	Mark
(i)	An answer that combines the following points of understanding to provide a logical description: - when steam condenses, its molecules move closer together, so the internal energy decreases (1) - when the water from the condensed steam cools, its molecules move more slowly, therefore storing less kinetic energy (1)	allow as water cools, the distance between the particles decreases which increases the intermolecular forces (2)

Question number	Answer	Additional guidance	Mark
(ii)	equating the variables in the three equations/principle of conservation of energy (1) $(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w) = (m_m \times c_m \times \Delta\theta_m)$ rearrangement (1) $m_m = \frac{(m_w \times l_w) + (m_w \times c_w \times \Delta\theta_w)}{(c_m \times \Delta\theta_m)}$ substitution of correctly calculated quantities (1) $= \left(\frac{\left(\left(\frac{25}{1000} \right) \times 2260000 \right) + \left(\left(\frac{25}{1000} \right) \times 4200 \times 35 \right)}{3840 \times 60} \right)$ evaluation (1) 0.26 (kg)	allow in words or with suitable alternative subscripts temperature changes and l_w must be correct allow maximum of 3 marks for calculations that omit the energy from cooling of water	(4)

Question number	Answer	Mark
(iii)	Any two of the following reasons: - more steam must condense and transfer the energy that is dissipated to the jug during the process (1) - more steam must condense and transfer the energy that is dissipated to the surroundings during the process (1) - more steam must condense and transfer the energy needed to cause the milk to froth (1) - more steam must condense to replace any steam that might leave the milk without condensing (1)	(2)

Q23.

Question number	Answer	Additional guidance	Mark
(i)	Recall $GPE = m \times g \times \Delta h$ (1) Substitution = $400 \times 9.8 \times 1.5$ (1) Evaluation = 5900 (J) (1) (which is nearly 6000 J)	accept 5880 (J)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning (1 mark) - energy is dissipated/scattered (1) - into the surroundings (1)	energy from a loss of ball's PE / its gain in KE ends up as (kinetic) energy of molecules (of ball / wall / air)	(2)

Question number	Answer	Mark
(iii)	B velocity	(1)

Q24.

Question number	Answer	Additional guidance	Mark
(i)	Recall $GPE = m \times g \times \Delta h$ (1) Substitution = $400 \times 9.8 \times 1.5$ (1) Evaluation = 5900 (J) (1) (which is nearly 6000 J)	accept 5880 (J)	(3)

Question number	Answer	Additional guidance	Mark
(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning (1 mark) - energy is dissipated/scattered (1) - into the surroundings (1)	energy from a loss of ball's PE / its gain in KE ends up as (kinetic) energy of molecules (of ball / wall / air)	(2)

Question number	Answer	Mark
(iii)	B velocity	(1)

Q25.

Question number	Answer	Additional guidance	Mark
(i)	rearrange $p = \rho g h$ to give $\rho = p / (g h)$ (1) substitution using any point from graph (1) e.g. depth = 50km and pressure = 1.5 GPa $\rho = p / (g h)$ $= 1.5 \times 10^9 / (10 \times 50 \times 10^3)$ Evaluation (2) $= 3000 \text{ (kg/m}^3\text{)}$	rearrangement and substitution in any order allow any combination from the graph and ignore 'pot' error here 'pot' error scores 2 marks maximum	(4)

Question number	Indicative content	Mark
(ii)	Answers will be credited according to the candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all of the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A02 (3 marks) A03 (3 marks) A03 Interpretation and evaluation from the graph Similarities: • both show increasing pressure with depth • both show a range of pressures over kilometre depths / heights Differences: • ocean water shows a linear relationship (straight line) but atmosphere gives a non-linear (curved) relationship • density of ocean water not changing with depth but density of atmosphere changes as you go higher • The pressures in the ocean recorded are much bigger (GPa compared with kPa) The depth of the ocean shown is up to 100km whereas the height of the atmosphere involved is only up to 10km A02 Link between graph shapes and underlying physics Similarities: • pressure is due to (increasing) weight of fluid (liquid / gas) above • more molecules above Differences: • atmosphere becomes thinner the higher you go molecules in the ocean stay (on average) the same distance apart but in the atmosphere they get further apart (on average) as you go higher up	(6)

Level	Mark	Descriptor
	0	No awardable content
Level 1	1–2	- Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) - The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	- Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) - The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	- Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) - The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q26.

Question number	Answer	Additional guidance	Mark
	An answer that combines points of interpretation/evaluation to provide a logical description: efficiency increases (at first) (1) to maximum efficiency (for mass of about 25 kg) (1)	e.g. decreases for larger masses	(2)

Q27.

Question number	Answer	Additional guidance	Mark
	An answer that combines points of interpretation/evaluation to provide a logical description: efficiency increases (at first) (1) to maximum efficiency (for mass of about 25 kg) (1)	e.g. decreases for larger masses	(2)

Q28.

Question number	Answer	Additional guidance	Mark
	An answer that combines the following points of application of knowledge and understanding to provide a logical description: • work is done against friction (1) • energy is stored in another specified way (1)	ignore references to friction as energy store acceptable stores are: • KE of water • thermal energy of water • thermal energy of air • (G)PE of water	(2)

Q29.

	Answer	Acceptable answers	Mark
(ai)	A line connecting a train part with a useful energy transfer as shown below (1)	Lines need not be straight Ignore any arrow heads drawn Note: if more than one line is drawn from a train part then zero mark for that train part.	(3)

	Train part transfer <pre> graph LR subgraph "Train part transfer" DE[diesel engine] G[generator] M[motor] end subgraph "useful energy" CE[chemical to electrical] CK[chemical to kinetic] EK[electrical to kinetic] KC[kinetic to chemical] KE[kinetic to electrical] end DE --> CE DE --> CK G --> EK M --> KC M --> KE </pre>		
(aii)	(transfer of energy to) thermal (1)	heat/sound	(1)
(bi)	1400 - 1300 (= 100) (kJ) (1)		(1)
(bii)	Substitution (1) $1300 / 1400 \times 100$ Evaluation (1) 93(%) or 0.93	A value which rounds to 93(%) or 0.93 Correct answer with no working scores 2 marks	(2)
(c)	Any one from black is a good thermal radiator (1) (helps to) prevent motors overheating (1)	(good) emitter (helps to) remove wasted energy/ heat (from the motor)	(1)

Q30.

Question Number:	Answer	Additional Guidance	Mark
	a description to include: kinetic energy (store) (of cyclist and /or bicycle) decreases / is transferred into(1) thermal energy (store) (of brakes / surroundings) increases (1)	KE for kinetic energy allow heat for thermal allow brakes get hotter ignore sound energy accept kinetic (energy) to heat (energy) for 2 marks in this context	(2) AO 1 1