1(a). Roy is stacking shelves at the supermarket.

He lifts boxes of tins from the floor to the shelves.

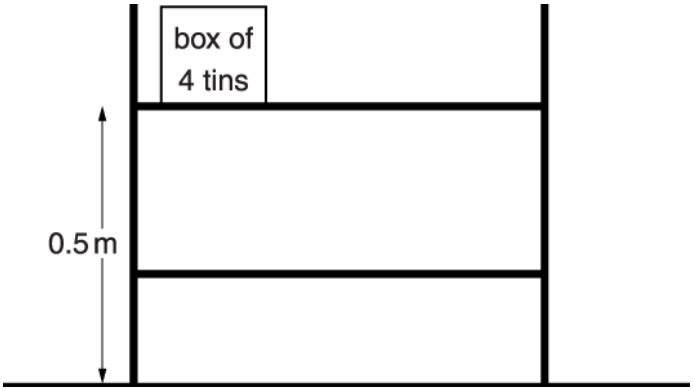
Each tin weighs 5 N.

An empty box weighs 2 N.

(i) What is the smallest force that Roy has to pull on a **box of 4 tins** when lifting it?

force = _____ N **[1]**

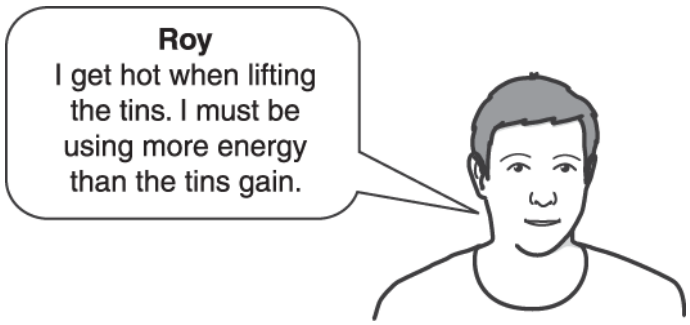
(ii) Roy lifts a box of 4 tins from the floor to a shelf 0.5 m above the floor.



Calculate how much gravitational potential energy the box gains.
Include the correct unit in your answer.

gain in gravitational potential energy = _____ unit _____ **[2]**

(iii)



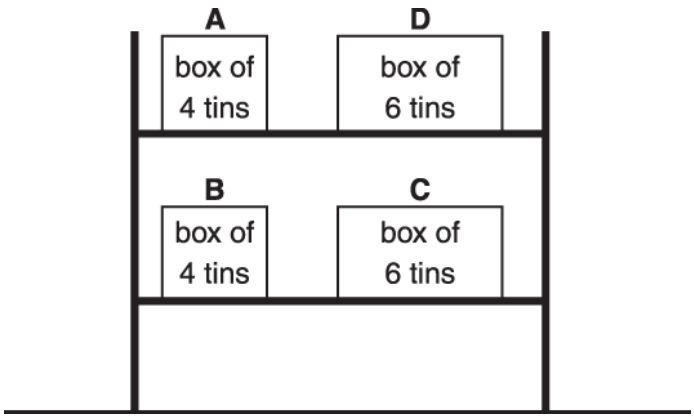
State what is meant by **conservation of energy** and explain how it applies to Roy.

---

[2]

(b). Roy lifts boxes of 4 tins and boxes of 6 tins from the floor onto the shelves.

He puts a box of 4 tins and a box of 6 tins on each shelf, as shown in the diagram.



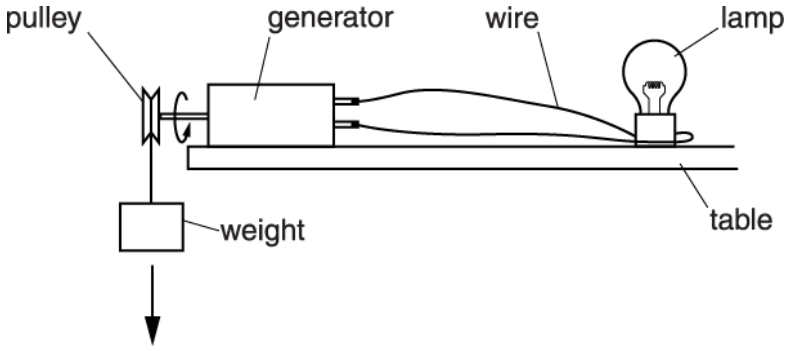
Which box gains the most gravitational potential energy?

Put a (ring) around the correct answer.

A B C D

[1]

2. Rai sets up an experiment.



When Rai lets the weight fall, the generator spins and the lamp lights up.

Describe the energy transfers that allow the falling weight to light up the lamp.

The quality of written communication will be assessed in your answer.

[6]

3(a). John hits a hard ball with a bat.
The ball has a mass 0.3 kg and is travelling at a speed of 4 m/s.

Calculate the momentum of the ball.

momentum = _____ kg m/s **[2]**

(b). The 0.3 kg ball hits a glass window with a speed of 4 m/s. The glass will not break if the ball has a kinetic energy of less than 10 J.

Will the glass window break?
Use a calculation to help justify your answer.

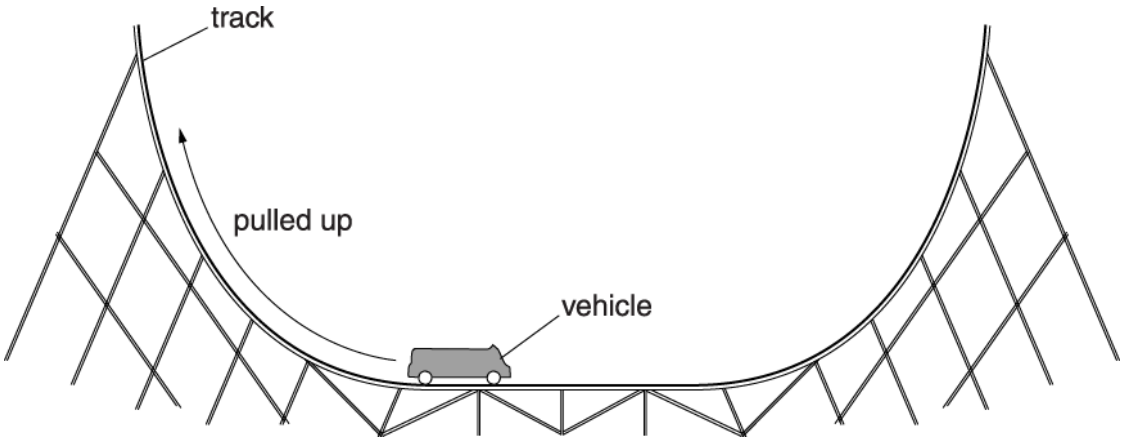
[3]

(c). How can the kinetic energy of a moving object be increased?
Put ticks (?) in the **two** boxes next to the correct answers.

increase the speed of the object	☐
increase the mass of the object	☐
increase the friction on the object	☐
increase the time it takes to stop the object	☐
increase the gravitational potential energy of the object	☐

[2]

4. A simple roller coaster has one line of track on which a vehicle travels backwards and forwards.



- The vehicle is pulled up the left side of the track, and is then released.
- It travels down the track, speeding up as it moves.
- It rises up the right side of the track, slowing down as it moves upwards.
- It rolls back down.
- It moves backwards and forwards on the track several times, with each move becoming lower and lower and the top speed becoming slower and slower.

Use ideas of energy to explain the motion of the vehicle.

The quality of written communication will be assessed in your answer.

[6]

5(a). Hannah is doing an experiment with falling paper shapes.

When Hannah lifts a paper circle, she does work on the paper.

(i) Calculate the work done on the paper when it is lifted up 2 m.

The paper has a weight of 0.1 N.

work done = _____ J **[1]**

(ii) After the circle of paper is lifted up, what type of energy has increased?

Put a (ring) around the correct answer.

electrical **kinetic** **nuclear**

gravitational

potential

[1]

(b). Hannah then drops the paper circle.

(i) What forces act on the paper circle as it falls?

---

[2]

(ii) When Hannah first drops the paper circle, it speeds up.

Which type of energy increases?

Put a (ring) around the correct answer.

electrical kinetic nuclear

gravitational

potential

[1]

(c). Hannah then squashes the paper circle into a ball.

She then repeats her experiment dropping the paper ball from the same height.

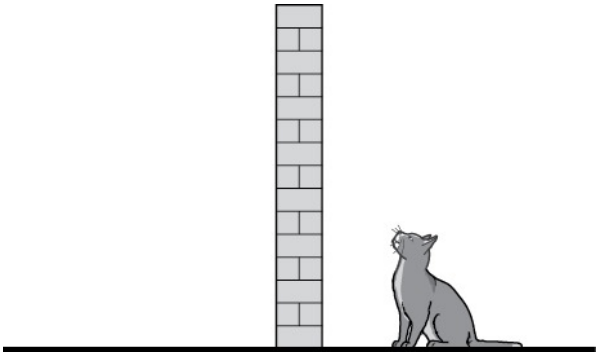
She finds that the paper ball now drops **faster**.

Explain why.

---

[3]

6(a). Iggy the cat is sitting next to the bottom of a wall.



He jumps from the ground onto the wall.
Iggy has mass 5 kg and weighs 50 N. The wall is 1.2 m high.

What is the correct way to calculate the gravitational potential energy gained by Iggy?

Put a (ring) around the correct answer.

$\frac{5\,\text{kg}}{1.2\,\text{m}}$ $5\,\text{kg} \times 1.2\,\text{m}$ $\frac{50\,\text{N}}{1.2\,\text{m}}$ $50\,\text{N} \times 1.2\,\text{m}$

[1]

(b). As Iggy walks along the wall he knocks a plant pot off the wall.
The pot falls to the ground.

(i) What force pulls the pot to the ground?

---

[1]

(ii) What type of energy does the pot gain as it falls?

---

[1]

(c). The pot hits the ground and breaks.

Complete the sentence, using **one** of the phrases below:

less than **more than** **the same as**

The total energy of the broken pot and its surroundings when it is on the ground is _____ the total energy of the pot and its surroundings when it is on the wall.

[1]

(d). George and Kate are doing an experiment with falling objects.

They use two balls of the same shape and size, but **different masses**.
They release the balls from the same height above the floor.

The balls take the same time to drop to the floor.

Explain why the balls have the **same speed** but **different kinetic energy**.

---

[2]

7. Alex is investigating the forces acting on a trolley to slow it down on different surfaces.

Fig. 6.1 shows his apparatus. Each time, he starts the trolley at the same marked point and measures how far it goes along the test surface before it stops. The centre of the trolley is marked with a dot.

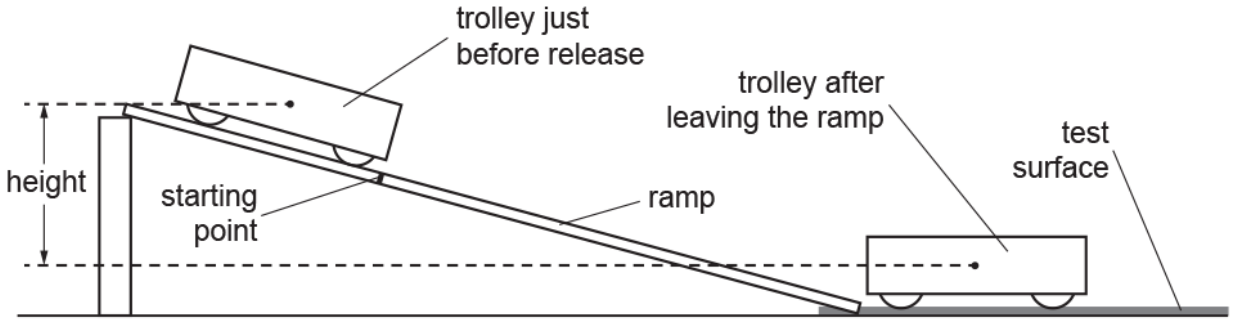


Fig. 6.1

(i) Here are measurements that Alex takes.

Mass of trolley = 0.80 kg

Height = 0.20 m

Assume gravitational field strength = 10 N/kg

Calculate the gravitational potential energy transferred when the trolley leaves the ramp.

Gravitational potential energy transferred = ---------- J **[3]**

(ii) Alex says that the kinetic energy of the trolley when it leaves the ramp is the same as the gravitational potential energy transferred.

Which of the following statements must be true if Alex is to assume this?

Tick (✓) **two** boxes.

Air resistance is very small. ☐

Gravity acts downwards on the trolley. ☐

The ramp is very flat. ☐

The trolley is very light. ☐

There is not much friction acting on the trolley. ☐

[2]

(iii) Alex repeats the experiment five times. He measures the distance the trolley travels along the test surface each time.

Table 6.1 shows his results.

Reading	1	2	3	4	5
Distance travelled (m)	1.2	1.4	1.2	0.6	1.4

Table 6.1

Calculate the mean distance the trolley travelled along the test surface.

Tick (✓) **one** box.

1.1 m ☐

1.2 m ☐

1.3 m ☐

1.4 m ☐

[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a	i	22 (N)	1	**Examiner's Comments** Candidates found this more difficult than expected with many answering 20N by missing the weight of the box.
		ii	11 (1) J (1)	2	**allow**: ECF from ai **allow**: j / Nm / joule **do not allow**: n (for N) / mN **Examiner's Comments** Many candidates did get the error carried forward from the previous part of this question. Hardly any candidates managed to give the correct unit of energy.
		iii	Total energy stays the same / energy is not lost (or gained) (1); (work done by Roy =) heat (wasted) **and** GPE / energy gained by tins (1)	2	**allow**: energy cannot be created or destroyed **allow**: energy is **only** transferred (into other forms) **Reject** Similar **ignore** sound / KE of Roy **Examiner's Comments** Hardly any candidates could state anything creditworthy about conservation of energy, and even fewer could apply this to Roy.
	b		D (4th answer)	1	**Examiner's Comments** The vast majority of candidates scored this mark with the answer D.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
2			**(Level 3)** Correctly describes an energy transfer in part of the apparatus. Quality of written communication does not impede communication of the science at this level. (5–6 marks) **(Level 2)** Correctly identifies type of energy in parts of the apparatus. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) **(Level 1)** Adds some scientific detail to the description provided in the question. Quality of written communication impedes communication of the science at this level. (1–2 marks) **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to E Indicative scientific points may include: • weight transfers gpe to ke as it falls • generator transfers ke to electrical energy as shaft spins • current in wires transfers energy from generator to lamp • lamp transfers electrical energy to light (and heat) energy. Use the L1, L2, L3 annotations in Scoris; do not use ticks. **accept** electricity as current **accept** potential / gravitational energy as gpe **accept** light as light energy **note that** "energy tranfers … weight falls … generator spins … lamp lights up" is given in the question stem, so earns no credit. <u>Examiner's Comments</u> Most candidates struggled with this question about energy transfers in a demonstration using apparatus that the majority must have seen during their course. Despite the instruction to describe energy transfers, a concerning number of candidates managed to avoid mentioning energy completely in their answer, simply describing what happened in general terms when the weight was released. Many managed to name a type of energy in one part of the apparatus, but only a minority were able to state the type of energy going into a part as well as the type of energy coming out of it.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
3	a		(momentum = mass × speed) = 0.3 × 4 1.2	1 1	look for correct substitution correct numerical response gains 2 marks Examiner's Comments The vast majority of candidates were able to calculate the correct value for the momentum of the ball.
	b		K.E = $0.5 \times 0.3 \times 4^2$ = 2.4 (J) (The window does NOT break) **because** the balls ke (2.4J) is less than the windows breaking energy (10J)	1 1 1	 correct numerical response gains 2 marks **allow ecf** from incorrect value for ke **accept** doesn't break because 2.4 is less than 10 Examiner's Comments The need to square the speed when calculating the kinetic energy defeated many candidates. Too many candidates lost a mark by not explicitly comparing the kinetic energy of the ball with the energy needed to break the glass; simply stating that the ball did not have enough energy was not enough to earn the mark.
	c		increase the speed of the object ? increase the mass of the object ? increase the friction on the object increase the time it takes to stop the object increase the gravitational potential energy of the object	2	Examiner's Comments The majority of candidates knew that increasing the speed of an object increased its kinetic energy, but only half knew that increasing mass also had the same effect.
			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
4			**Level 3** Correctly links changes in speed or height to changes in KE or GPE or describes the energy transfer from GPE to KE **and** explains why the vehicle has lost speed or KE or height or GPE during the ride. Quality of written communication does not impede communication of the science at this level. (5–6 marks) **Level 2** Links changes in speed or height to changes in KE or GPE at correct points in the ride **or** describes the energy transfer from GPE to KE **or** explains why the vehicle has lost speed or KE or height or GPE during the ride. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) **Level 1** Correctly links GPE with height **or** Correctly links KE with speed **or** limited discussion of energy or forces. Quality of written communication impedes communication of the science at this level. (1–2 marks) **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to C** **Indicative scientific points:** • gains GPE as raised • this turns to KE as falls • KE increase means speed increases • on other side, KE drops, so speed decreases • GPE increases again • energy lost on each move • due to friction • heat • surroundings / structure / wheels etc • so lower speed / lower rise • no more energy needed after initial input • total energy is conserved. **accept** correct discussion of forces use of diagrams to explain **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This six-mark extended writing question looked for an explanation of the motion of a roller coaster using ideas of energy. Candidates were expected to make links between height changes and GPE and/or make links between speed changes and KE. Candidates could also describe the transfer of energy GPE to KE to work done against friction to explain why the roller coaster eventually stops. This question proved to be very challenging to Foundation candidates. Many responses simply repeated the information about the movement given in the stem of the question. For the candidates who gained marks in this question, most did so for making a link between friction and the loss of speed. Very few candidates described the transfer of GPE to KE and fewer still explained the transfer to heat.

Question			Answer/Indicative content	Marks	Guidance
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
5	a	i	0.2	1	**ignore** wrong unit **Examiner's Comments** Part (i) was answered correctly by many candidates. The most common incorrect answer was '20'.
		ii	gravitational potential	1	**Examiner's Comments** In part (ii) many candidates correctly identified the correct answer, but there was a sizeable number who chose 'kinetic'.
	b	i	gravity / weight (1) air resistance / drag (force) / air friction	2	**ignore** references to sideways forces / wind **accept** a diagram with clearly labelled forces **ignore** upthrust **Examiner's Comments** Most candidates achieved at least 1 mark in part (i) usually by mentioning either gravity or weight. Unfortunately in this part some candidates confused forces and energy giving gravitational potential as an incorrect answer. Others gave lists in the hope some were correct and included both gravity and weight. Air resistance or drag was not often given in addition to weight for the second mark. Some candidates gave 'reaction' which did not gain a mark.
		ii	kinetic	1	**Examiner's Comments** Part (ii) was not answered as well.

Question			Answer/Indicative content	Marks	Guidance
	c		**any three from:** less area (so) less air resistance same weight net / resultant / overall force down greater / gravity has greater effect (so) acceleration greater	3	**accept** smaller size **do not accept** smaller object **accept** more aerodynamic / streamlined **accept** hits less air particles **do not accept** increased weight (max 2 for rest of answer) **accept** energy arguments i.e.: same work done on paper / same gravitational potential energy less work done against air resistance more GPE transferred to KE energy dissipated by the air / heating the air **Examiner's Comments** The two most common correct answers given were ‘less surface area’ and ‘less air resistance’. However, most candidates only gave one of these and so those achieving 2 or 3 marks were very few in numbers. A third point regarding either same weight or resultant force was rarely made. The majority of candidates wrongly thought that the weight of the paper increased when it was squashed into a ball.
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
6	a		50 N × 1.2 m (4th answer)	1	Examiner's Comments Less than half of the candidates correctly identified the way to calculate gravitational potential energy for this part, many confusing mass with weight.
	b	i	weight	1	**allow** gravity Examiner's Comments The vast majority of candidates knew that gravity provided the downwards force on the cat for this part of the question.
		ii	kinetic	1	**allow** thermal Examiner's Comments Only half the candidates correctly stated kinetic energy as the answer, with gravitational potential energy being a very popular incorrect answer.
	c		the same as (3rd answer)	1	**allow** correct answer ringed Examiner's Comments Only a minority of candidates realised that energy was conserved as the pot fell to the floor in this part.
	d		same speed because: EITHER same distance fallen in same time OR objects have the same size and/or shape OR same acceleration (in same time)	1	**accept** same surface area

Question			Answer/Indicative content	Marks	Guidance
			different KE because EITHER they have different masses OR because mass is part of formula for calculating KE	1	accept weight for mass, heavier/lighter for different mass not smaller mass has larger KE Examiner's Comments Most candidates knew that the balls had different kinetic energy because of their different masses, only a minority were able to satisfactorily explain why they had the same speed.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
7		i	FIRST CHECK THE ANSWER ON THE ANSWER LINE. If answer = 1.6 (J) award 3 marks Δg.p.e. = *mgh* ✓ = 0.80 (kg) × 10 (N/kg) × 0.20 (m) ✓ = 1.6 (J) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	Examiner's Comments Candidates generally did very well on this question. There were a few across the ability range who could not remember the equation correctly and divided by the height. Lower ability candidates were more likely not show their working and unfortunately if they had not calculated the answer correctly they could not be credited for their prior working. The mark distribution for this question was extreme, there was a 50:50 split between full marks and no marks, with only a few candidates receiving intermediate marks for their workings. Misconception Candidates know that if they get a calculation correct in a physics examination they will usually get full marks and so choose to 'save time' by not showing their workings. This is a high risk strategy as most marks can still be credited for correct working even if the final calculation wrong.
		ii	Air resistance is very small.✓ There is not much friction acting on the trolley. ✓	2 (AO 3.1a) (AO 2.1)	1st and 5th box Examiner's Comments Many candidates did not identify that this question was about efficiency, and chose answers that may have been true but were not relevant. The most common incorrect answer given was 'Gravity acts downwards on the trolley.'

Question			Answer/Indicative content	Marks	Guidance
		iii	1.3 m ✓	1 (AO 2.2)	3rd box Examiner's Comments Candidates were expected to evaluate the data in terms of precision and repeatability and then consider whether the anomalous observation should have been discarded. Although variance of reading 4 was 7 × larger than the variance of the other observations most chose to retain this anomalous reading and calculated a mean value of 1.16. Many then correctly rounded to give 1.2 m. while others truncated the answer to 1.1 m. OCR support Candidates should be aware that they are expected to evaluate whether to retain or discard anomalous readings in data sets. In this instance the reading was an extreme outlier outside the expected variation and should have been discarded when calculating the mean. Further guidance is available in the Mathematical Skills Handbook http://www.ocr.org.uk/Images/310651-mathematical-skills-handbook.pdf
			Total	6	