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

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

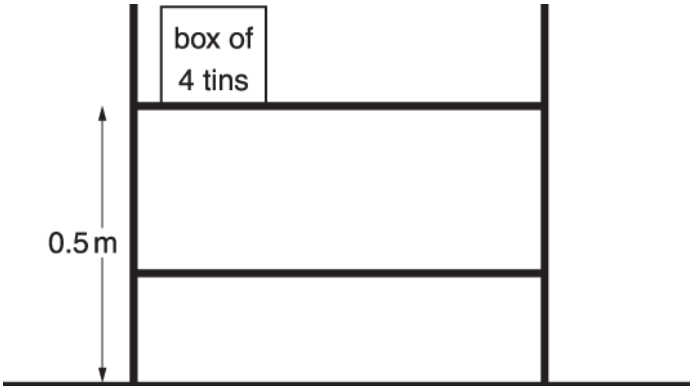
Each tin weighs 5 N.

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?

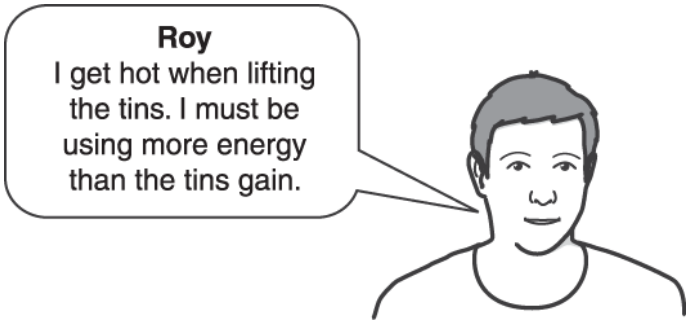
force = _____ N **[1]**

(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]

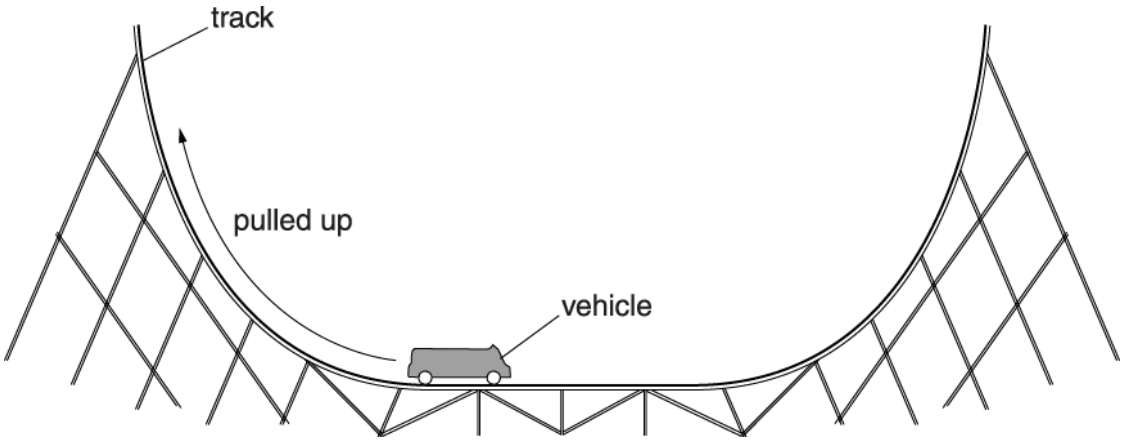
(b). A box of tins of total mass 3.2 kg, weight 32 N, falls from a shelf.

The shelf is 1.5 m above the ground.

Calculate the speed of the box just before it hits the ground. Show your working.
You may assume that the effect of air resistance is negligible.

speed = _____ m/s **[3]**

2. 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]

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

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

Hannah lifts the paper circle 1.5 m from the floor and does a total of 0.03 J of work on it.

What is the weight of the paper circle?

weight = _____ N **[1]**

(b). Hannah holds the paper circle up high.

She then drops the paper.

Describe the transfer of energy as the paper circle falls.

---

[2]

(c).

(i) Hannah then squashes the paper circle into a ball, so the mass remains the same at 0.002 kg.

She then repeats her experiment, lifting the paper ball to the same height of 1.5 m above the floor, so the work done on the paper ball is still 0.03 J.

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

Using ideas about energy, show that the maximum speed the paper ball could reach as it falls to the floor is 5.5 m/s.

Show your working clearly.

[2]

(ii) John suggests that the speed of the paper ball can be calculated using:

$$\text{speed (m/s)} = \frac{\text{1.5 metres}}{\text{time taken to fall (seconds)}}$$

The value calculated in part **(c)(i)** is too large.

John's calculated value is too small.

Explain why.

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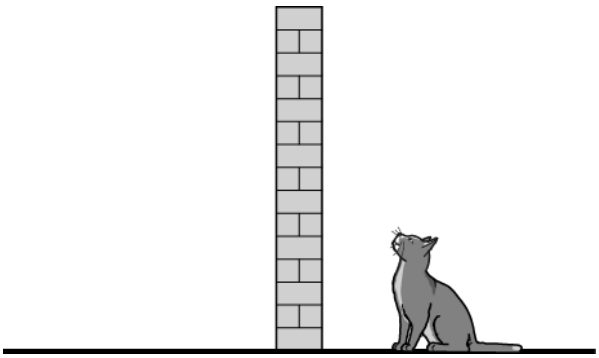
[2]

4. Iggy the cat is sitting next to the bottom of a wall.



He jumps from the ground onto the wall.
The wall is 1.5 m high.

Iggy gains 66 J of gravitational potential energy. What is Iggy's weight?

Put a (ring) ring around the correct answer.

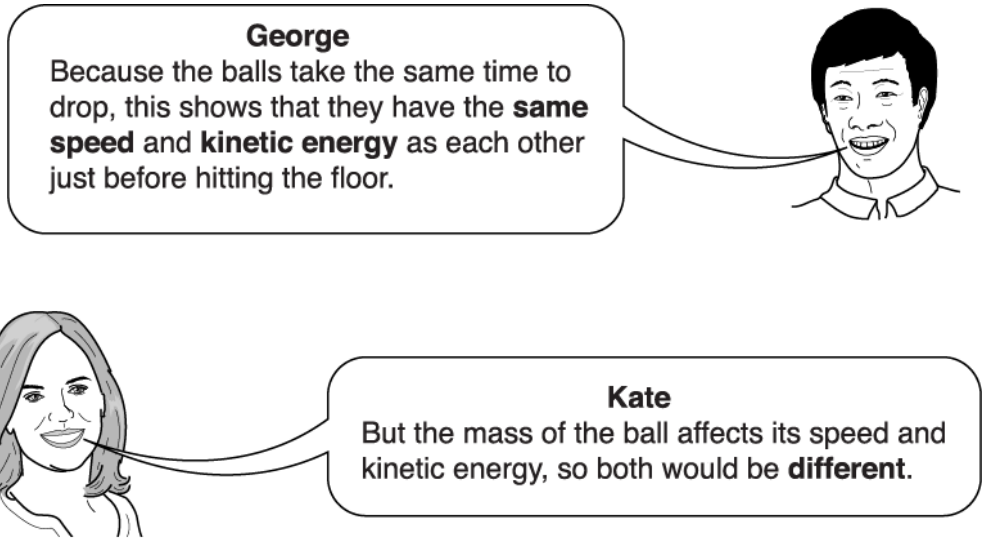
4.4 N **9.9 N** **44 N** **99 N**

[1]

5. George and Kate do 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 and find that they take the same time to drop to the floor.



Comment on their conclusions.

Use equations to justify your answer.

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[3]

6(a). Tamsin hits two balls with a bat.

The hard ball has a mass of 0.3 kg.

The soft ball has a mass of 0.2 kg.

Each ball gains the same momentum.

(i) The hard ball will have the smaller velocity.

Explain why.

---

[1]

(ii) The soft ball changes shape when hit so it is in contact with the bat for longer.

What effect will this have on the force acting on the soft ball?

Explain your answer.

---

[2]

(b). The 0.3 kg hard ball hits a glass window with a speed of 4 m/s.

(i) 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]**

(ii) The 0.2 kg soft ball hits the window at a speed of 6 m/s. It bounces back from the window at a speed of 4 m/s.
What is the change in momentum of the soft ball?

change in momentum = _____ kg m/s **[1]**

[Total: 7]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a	i	22 (N)	1	Examiner's Comments This question required candidates to use forces and transfer of energy. The majority of candidates scored at least 2 marks, usually in parts (i) and (ii). Only a small minority of candidates scored any marks in parts (iii). The most common wrong answer was 20, due to forgetting to add the weight of the box.
		ii	11 (1); J (1)	2	**allow**: ECF from ai **allow**: j / Nm / joules **do not allow**: n (for N)/ mN Examiner's Comments This question required candidates to use forces and transfer of energy. The majority of candidates scored at least 2 marks, usually in parts (i) and (ii). Only a small minority of candidates scored any marks in parts (iii). Error carried forward was applied from part (a)(i) but many candidates failed to see the relationship between the two parts. The unit was often wrong or omitted. Most common wrong unit was N, N/m or gpe.
		iii	Total energy stays the same / energy is not lost (or gained) (1);	2	**allow**: energy cannot be created or destroyed **allow**: energy is **only** transferred (into other forms)

Question			Answer/Indicative content	Marks	Guidance
		iii	(work done by Roy =) heat (wasted) **and** GPE/energy gained by tins (1)		**ignore** sound / KE of Roy **Examiner's Comments** This question required candidates to use forces and transfer of energy. The majority of candidates scored at least 2 marks, usually in parts (i) and (ii). Only a small minority of candidates scored any marks in parts (iii). The majority of candidates did not know the principle of conservation of energy. Many answers gave the meaning of conservation as retention or saving in reserve. Those candidates that did state the principle were often not able to relate it to Roy's situation. Heat was mentioned as wasted energy but not linked to the GPE of the tins and the total work done by Roy. A number of answers assumed the GPE of the tins became heat.
	b		GPE = KE / Wh = ½ mv^2 (1); Correct substitution (1); 5.5 (1)	3	**allow**: mgh for Wh **allow**: gh = ½ v^2 Correct substitution also gains first marking point. E.g. 32 x 1.5 = 0.5 x 3.2 x v^2 3.2 x 10 x 1.5 = 0.5 x 3.2 x v^2 10 x 1.5 = 0.5 x v^2 48 = 0.5 x 3.2 x v^2 / 48 = 1.6 v^2 5.5 without working gains 3 marks **allow**: an answer with more than 2 s.f. provided that it rounds to 5.5 **Examiner's Comments** Only a small minority of candidates scored any marks in this part. Most candidates did not see that the question was about transferring GPE to KE. Some calculated the GPE as 48 J but did not link it to KE. A few candidates gave well-explained answers showing their working. Some tried using the equations for average speed or momentum.

Question			Answer/Indicative content	Marks	Guidance
			Total	8	

Question			Answer/Indicative content	Marks	Guidance
2			**(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 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 **ignore** significant confusion in scientific ideas for Level 1 **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** In this six-mark extended writing question the majority of candidates produced creditworthy answers involving appropriate identification of gravitational potential energy and kinetic energy. Most candidates were able to extend their answers by appropriate discussion of energy transfer, although some candidates 'muddied the water' by trying too hard to force a discussion of momentum into their response. The best answers clearly accounted for the reduction in maximum height reached over time to the dissipation of energy due to the action of resistive forces, such as friction between the vehicle and the track. Weaker responses often only discussed one cycle, and stated that a combination of 'friction and gravity' stopped the vehicle from rising any further on the

Question			Answer/Indicative content	Marks	Guidance
					other side. Only a minority of candidates made correct reference to work done by the resistive forces.
			Total	6	

Question			Answer/Indicative content	Marks	Guidance
3	a		0.02 (N)	1	**Examiner's Comments** This question involved ideas of energy transfer. It posed few problems for most candidates. A significant number of weaker candidates incorrectly multiplied the values for height and work done in an attempt to calculate the weight.
	b		GPE to KE (1) idea that some energy is dissipated as heat / heating to the air (1)	2	**allow** PE or gravitational for GPE **Examiner's Comments** Almost all candidates knew that gravitational potential energy was transferred to kinetic energy as the paper fell, but surprisingly few mentioned that some of the gravitational potential energy would also be transferred to heat energy during the fall.
	c	i	rearranges correctly so v = 5.5 (5.48)(m / s)	2	$v = \sqrt{(0.03 \times 2 / 0.002)}$ or v = ?(KE × 2 / mass) 2nd marking point is consequential on 1st **allow** reverse working i.e. calc of KE using v = 5.5 evaluated as 0.03 (0.03025) J Answer of v = 5.48 (m/s) scores 2 marks **Examiner's Comments** This question defeated all but the most able. In (i) the rearrangement of the kinetic energy formula was rarely seen, although some candidates could correctly state that they were to assume that initial gravitational potential energy equalled the final kinetic energy.

Question			Answer/Indicative content	Marks	Guidance
		ii	c(i) assumes no energy loss / no air resistance (1) John has calculated the average speed / no account of acceleration (1)	2	**allow** energy lost due to heating **ignore** references to incorrect measurements **Examiner's Comments** Most candidates misinterpreted the instruction for (ii) and only discussed issues with one experiment rather than both separately.
			Total	**7**	
4			44N (3rd answer)	1	**Examiner's Comments** Most candidates chose the correct option.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
5			speed is same / George is correct about speed / Kate is wrong about speed (1) KE is different / George is wrong about KE / Kate is correct about KE (1) justification for speed or KE (1)	3	e.g. appropriate use of average speed equation travels same distance in same time they have the same acceleration (g) appropriate use of KE formula KE formula has mass in it speed formula has no mass in it heavier ball has more GPE at beginning so KE is greater at end **N.B.** just stating a formula is insufficient for the justification mark. **Examiner's Comments** This question was poorly answered by most candidates. A significant number of candidates thought they had to choose between George and Kate, or that both were correct. Many contradictions were seen in answers. Common misconceptions were: that gravitational potential energy was the same for both balls at the start; that they reached terminal velocity; that heavier objects fall faster. Some candidates discussed momentum rather than kinetic energy and speed. The best answers were supported by referring to the relationships at the front of the paper. Some candidates quoted the relationship/s but made no reference to it/them in their answer; others misquoted the relationship/s.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
6	a	i	greater mass / momentum = mass x velocity	1	ignore heavier Examiner's Comments Many responses did not clearly differentiate between mass and weight. 'Heavier' was the most common answer and this only gained the mark if it was made clear that the ball had more mass. Those candidates who correctly selected and quoted the equation for momentum were awarded the mark.
		ii	smaller force (1) change in momentum = force x time (1)	2	change in momentum is constant and (when dividing by) a longer time gives a smaller force = 2 marks Examiner's Comments This question was an overlap with the Foundation tier. There were many well set out answers with the correct numerical solution and a statement that the ball would not break the glass. However, candidates needed to justify their answer with the help of the calculation eg. '2.4J<10J' or 'ball only has 2.4J'. Those candidates who obtained an incorrect numerical answer either transformed the mass into weight or failed to square the velocity.
	b	i	K.E = $0.5 \times 0.3 \times 4^2$	1	
		i	= 2.4 (J)	1	correct numerical response = 2 marks

Question			Answer/Indicative content	Marks	Guidance
		i	(The window does NOT break) **because** the balls ke (2.4J) is less than the windows breaking energy (10J)	1	**allow ecf** from incorrect value for KE **accept** doesn't break because 2.4 is less than 10 **Examiner's Comments** This question was an overlap with the Foundation tier. There were many well set out answers with the correct numerical solution and a statement that the ball would not break the glass. However, candidates needed to justify their answer with the help of the calculation eg. '2.4J<10J' or 'ball only has 2.4J'. Those candidates who obtained an incorrect numerical answer either transformed the mass into weight or failed to square the velocity.
		ii	2	1	**allow** ?2 **Examiner's Comments** Few candidates knew that the momenta should be added because velocity is a vector. The most common incorrect answer was 0.4 (kgm/s) as candidates had subtracted the momenta. A few candidates wrongly tried to apply the change in momentum equation.
			Total	**7**	