

Kinetic Energy

Mark Scheme



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1. Kinetic energy is the energy stored in moving objects, and its size depends on just **two** factors: the mass of the object and the square of its velocity.

- a) A snowboarder hikes to the top of a mountain run and gains 15,000 J of gravitational potential energy. He rides down the mountain. Upon reaching the bottom of the run, his kinetic energy is 3,500 J.

How much energy was lost to friction and air resistance as the snowboarder travelled down the slope?

B – is the only correct answer.	1 mark
	Total: 1 mark

- b) A cyclist and their bike have a total mass of **80 kg**. They are travelling at a speed of **6 m/s**. What is the kinetic energy of the cyclist?

B – is the only correct answer.	1 mark
	Total: 1 mark

- c) A drone with a mass of 500 g is flying at a speed of 12 m/s. Calculate the kinetic energy of the drone.

A – is the only correct answer.	1 mark
	Total: 1 mark

- d) A car with a mass of 1000 kg has 20 000 J of kinetic energy. What is the speed of the car?

A – is the only correct answer.	1 mark
	Total: 1 mark

- e) A bullet with a mass of 20 g is fired. It has a kinetic energy of 900 J. Calculate the speed of the bullet.

C – is the only correct answer.	1 mark
	Total: 1 mark

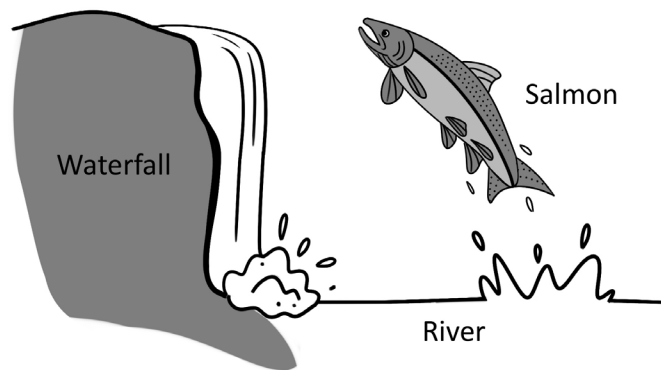
- f) A truck with a mass of 4 tonnes is travelling at a speed of 54 km/h. Calculate the kinetic energy of the truck.

C – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 6 marks)

2. While migrating upstream to spawn, salmon must often leap up waterfalls.

The diagram below shows a salmon launching itself out of the water. On this jump, the salmon fails to reach the top and falls back down into the river.



- a) The salmon has a mass of 2 kg, it launches vertically from the water with a kinetic energy of 20.4 J. Calculate the speed of the salmon as it jumps from the water.

$20.4 = 0.5 \times 2 \times v^2$	1 mark
$v = 4.5 \text{ m/s}$	1 mark
	Total: 2 marks

- b) Determine the maximum height reached by the salmon.

$20.4 = 2 \times 9.8 \times h$	1 mark
$h = 20.4 \div 19.6$	1 mark
$h = 1.04 \text{ m}$	1 mark
	Total: 3 marks

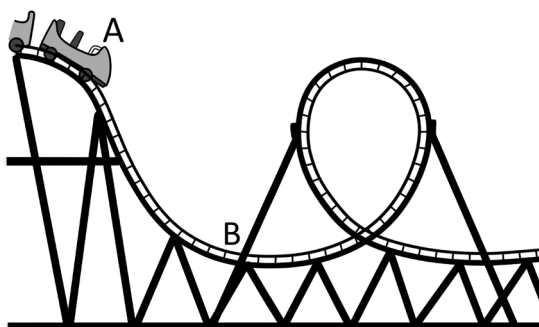
- c) When the salmon splashes back down into the river, it loses almost all of its kinetic energy. Describe what has happened to this energy.

A description to include:	
It is transferred to the thermal energy store of the water / salmon / surroundings.	1 mark
Allow: heat for thermal Allow: dissipated to surroundings.	
It is transferred to the kinetic energy store of the water / splashes or transferred as sound	1 mark
	Total: 2 marks

(Total for Question 2 is 7 marks)

3. A theme park has a new rollercoaster called 'The Drop'.

The figure below shows the new rollercoaster.



A rollercoaster carriage with a total mass of 600 kg is travelling along a horizontal section of the track.

- a) Write down the equation that links kinetic energy (E_k), mass (m) and speed (v).

kinetic energy = $0.5(\text{mass}) \times \text{velocity squared}$	1 mark
Accept any correct version of this equation.	
	Total: 1 mark

- b) At point A, the carriage is travelling at a speed of 12 m/s.
Calculate the kinetic energy of the carriage at point A.

$E_k = 0.5 \times 600 \times 12$	1 mark
$E_k = 43200 \text{ J}$	1 mark
	Total: 2 marks

- c) The carriage descends a steep drop and reaches its maximum speed at point B.

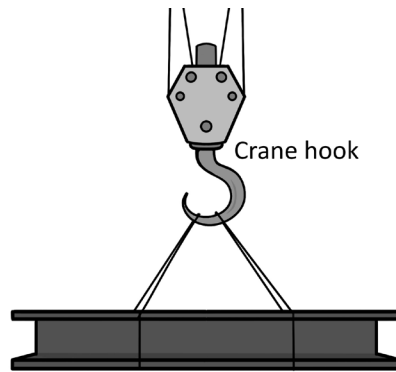
At point B, the carriage has a kinetic energy of 147 000 J.

Calculate the speed of the carriage at point B. Show your working.

$147\,000 = 0.5 \times 600 \times v^2$	1 mark
$v^2 = 490$	1 mark
$v = 22.1$	1 mark
	Total: 3 marks

(Total for Question 3 is 6 marks)

4. A construction worker is using a crane to lift a steel beam on a building site.
The steel beam has a mass of 800 kg.



- a) The crane is using energy to lift the steel beam.
State the law of conservation of energy.

Energy cannot be created or destroyed	1 mark
it can only be transferred (from one store to another), stored, or dissipated.	1 mark
	Total: 2 marks

- b) The crane lifts the beam vertically to a height of 25 m.
Calculate the gravitational potential energy gained by the beam.

$E_p = 800 \times 9.8 \times 25$	1 mark
$E_p = 196\,000\text{ J}$	1 mark
	Total: 2 marks

- c) It takes the crane 50 seconds to lift the beam to this height.
Calculate the useful power output of the crane's motor.

Power = $(196000 \div 50)$	1 mark
Power = 3920 W	1 mark
	Total: 2 marks

- d) While the beam is suspended at a height of 25 m, the cable snaps and the beam falls to the ground.
There is an air resistance of 1500 N acting on the beam as it falls.

Calculate the speed of the beam just before it hits the ground.

Work done = $1500 \times 25 = 37500\text{ J}$	1 mark
Final Ek = $196000 - 37500 = 158500\text{ (J)}$	1 mark
$158500 = 0.5 \times 800 \times v^2$	1 mark
$v^2 = 396.25$	1 mark
$v = 19.9\text{ m/s}$	1 mark
	Total: 5 marks

(Total for Question 4 is 11 marks)

5. A student wants to investigate how the height of a ramp affects the final kinetic energy of a toy car when it reaches the bottom.

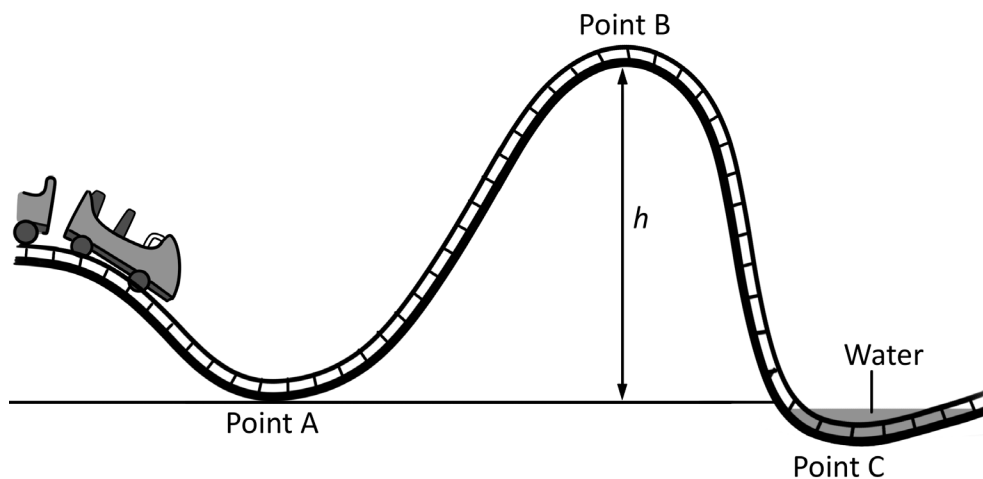
Describe a laboratory experiment the student could perform to investigate this relationship.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Fragmented points regarding the experiment. The student may list some correct equipment (e.g., ruler, toy car) or state the kinetic energy equation, but does not formulate a coherent method to link the ramp height to the final kinetic energy.
Level 2	3 - 4	A partially complete method. It identifies most of the necessary equipment and measurements but may lack clarity on how exactly speed is determined (e.g., mentions measuring speed but forgets equipment like a stopwatch or light gate). The calculation for kinetic energy is mentioned.
Level 3	5 - 6	A clear, logically sequenced, and comprehensive method is described. It details the correct equipment needed to measure all necessary variables (mass, distance/time or speed, and height). It clearly explains how to calculate kinetic energy from these measurements <u>and</u> states that the experiment should be repeated at varying heights.

Indicative content:	
Equipment: • Ramp or block of wood (to create incline) • Metre ruler or tape measure • Balance or scales • Light gate(s) and data logger OR stopwatch (to find speed). Measurements to be taken: • Measure the mass of the toy car using the balance. • Measure the vertical height of the ramp using the metre ruler. Measure the velocity of the car at the bottom of the ramp: • <u>If using light gates:</u> place a light gate at the bottom of the ramp to measure speed directly. • <u>If using stopwatch:</u> measure a set distance along the floor from the bottom of the ramp with a ruler, and use the stopwatch to time how long the car takes to travel that distance. Calculate speed = distance ÷ time. Determining Kinetic Energy: • Use the equation: Kinetic energy = $0.5 \times \text{mass} \times \text{velocity}^2$ • Substitute the measured mass and calculated/measured speed into the equation. Investigation steps: • Change the vertical height of the ramp (e.g., by adding more blocks) • Repeat the measurements and calculation for several different heights to see the relationship.	
	Total: 6 marks

(Total for Question 5 is 6 marks)

6. The figure below shows a cart on a roller coaster at a fair ground.



- a) The mass of the cart is 500 kg. The kinetic energy of cart at point A = 180.5 kJ
Calculate the speed of the cart.

$180500 = 0.5 \times 500 \times v^2$	1 mark
$v^2 = 180500 \div 250$	1 mark
$v = 26.9$	1 mark
Total: 3 marks	

- b) As the car travels from A to B, it loses 40 kJ of energy due to friction.
The car just manages to roll over the crest of the hill at B. Calculate the height h .

$180\,500 - 40\,000 = 140\,500 \text{ (J)}$	1 mark
$140500 = 500 \times 9.8 \times h$	
$h = 28.7$	1 mark
Total: 2 marks	

- c) At point C, the cart travels through a shallow pool of water and the kinetic energy of the car is reduced to zero. Make **three** suggestions for what happens to this kinetic energy.

Transferred to the thermal energy store of the water / cart / surroundings.	1 mark
Transferred to the kinetic energy store of the water (splashing / waves).	1 mark
Transferred as sound.	1 mark
Total: 3 marks	

(Total for Question 6 is 8 marks)