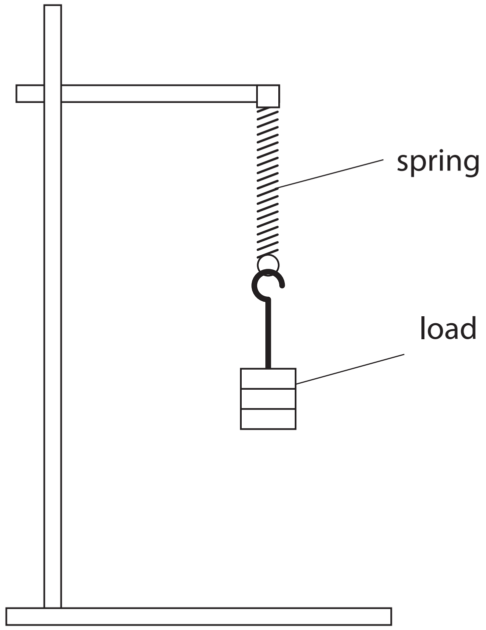
1 A student investigates how the extension of a spring varies when he hangs different loads from it.



(a) Write a plan for the student's investigation.

Your plan should include details of how the student can make accurate measurements.

You may add to the diagram to help your answer.

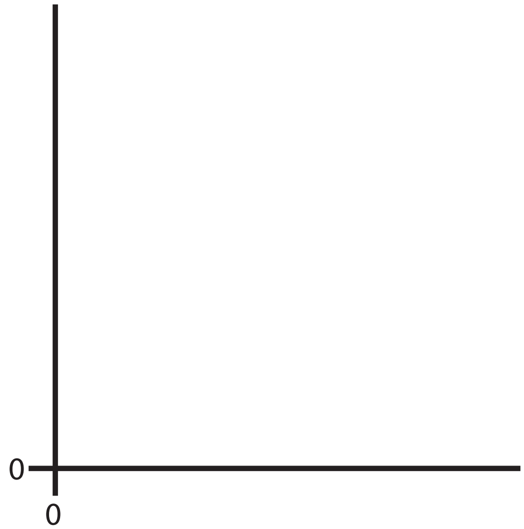
(5)

(b) The student finds that the spring obeys Hooke's law.

Draw a graph on the axes to show the Hooke's law relationship.

Label the axes.

(3)



(c) The student concludes that the spring shows elastic behaviour.

Explain what is meant by the term **elastic behaviour**.

(2)

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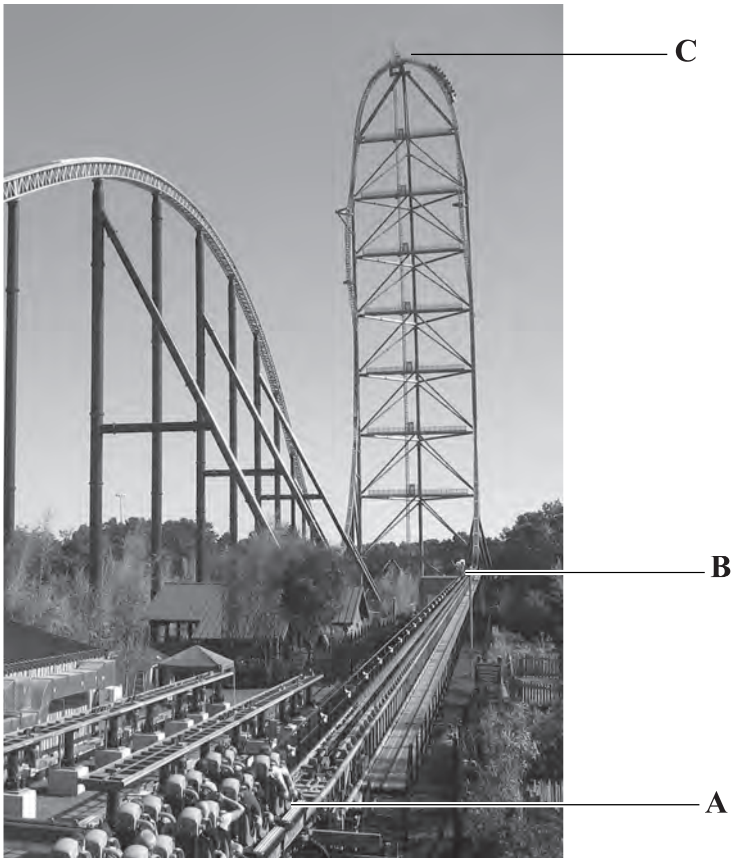
(Total for Question 1 = 10 marks)

2 The photograph shows a type of rollercoaster.

The car is launched from point **A** in the photograph, accelerates to point **B** and then rises over point **C**.



(a) Each loaded car has a mass of 2000 kg.

C is 128 m above **B**.

(i) State the equation linking gravitational potential energy, mass, height and gravitational field strength.

(1)

(ii) Show that the gravitational potential energy gained by the car when it rises from **B** to **C** is about 2.6 MJ.

(2)

(b) The car gains kinetic energy when work is done on it by the launching system between **A** and **B**.

Assume there are no energy losses.

(i) State the minimum kinetic energy that the car must have at **B** for it to reach **C**.

(1)

....

(ii) How is the kinetic energy gained related to the work done?

(1)

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(iii) Write down the equation linking work done, force and distance.

(1)

(iv) The launching system provides a force of 32 kN.

Calculate the minimum length of track needed between **A** and **B** for the car to reach **C**.

(2)

Length of track .... m

(c) Sometimes the car does not reach **C**, but rolls backwards to the start.

This can happen when it becomes windy or the track becomes wet.

Explain why these conditions could cause the car to stop before it reaches **C**.

(2)

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(Total for Question 2 10 marks)

3 A flying squirrel is an animal that can glide through the air.

It spreads out its limbs to stretch a membrane that helps it to glide.

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(a) The mass of a flying squirrel is 0.19 kg.

It climbs 17 m up a tree.

(i) State the equation linking gravitational potential energy (GPE), mass, g and height.

(1)

(ii) Calculate the GPE gained by the squirrel during this climb.

(2)

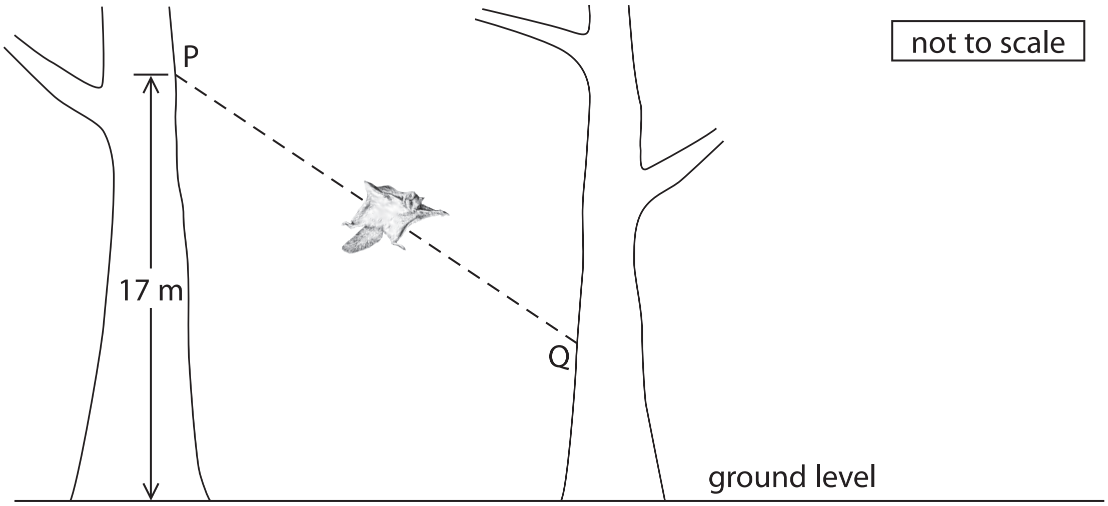
GPE = ... J

(iii) State the amount of work done against the force of gravity by the squirrel during this climb.

(1)

work done = ... J

(b) The flying squirrel glides from P to Q with a constant velocity of 13 m/s.



(i) Add labelled arrows to the diagram to show the directions of the forces of weight and drag acting on the squirrel.

(2)

(ii) State the equation linking kinetic energy (KE), mass and velocity.

(1)

(iii) Calculate the KE of the squirrel as it glides.

(2)

KE = ... J

(iv) The velocity of the squirrel decreases to zero when it reaches the second tree because

(1)

☒ **A** an unbalanced force acts on the squirrel

☒ **B** no force acts on the squirrel

☒ **C** the GPE of the squirrel increases

☒ **D** the KE of the squirrel increases

(Total for Question 3 = 10 marks)

4 The Moon orbits the Earth.

(a) State a difference between the orbit of a moon and the orbit of a planet.

(2)

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(b) The radius of the Moon's orbit is 385 000 km.

It takes 27 days for the Moon to complete one orbit.

Calculate the orbital speed of the Moon.

Give a suitable unit.

(3)

orbital speed = ... unit ....

(c) In 1971, astronaut Alan Shepard hit a golf ball on the surface of the Moon.

The golf ball had a mass of 50 g and he transferred 56 J of energy to it.

(i) State the equation linking kinetic energy, mass and velocity.

(1)

(ii) Calculate the initial velocity of the ball.

(3)

initial velocity = ... m/s

(d) At its highest point the ball had gained 12 J of gravitational potential energy.

(i) State the kinetic energy of the ball at its highest point.

(1)

kinetic energy = ... J

(ii) State the equation linking gravitational potential energy, mass, g and height.

(1)

(iii) Calculate the maximum height that the ball reached.
(gravitational field strength on the Moon, g = 1.6 N/kg)

(2)

maximum height = ... m

(e) Suggest why the ball travelled further on the Moon than it would have done on Earth.

(2)

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(Total for Question 4 = 15 marks)