Access Tuition

A-Level Physics

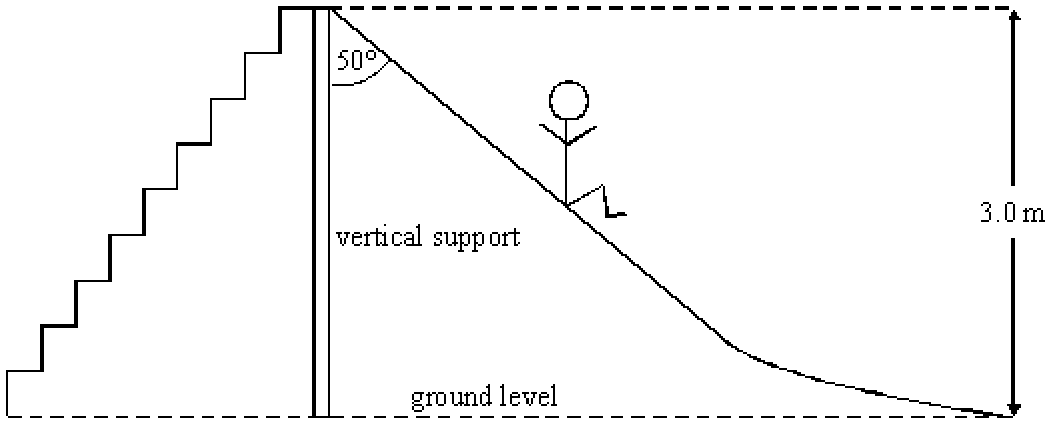
Conservation of Energy

Question Paper

Time available: 63 minutes
Marks available: 50 marks

1. The diagram below shows a child coming down a slide in a playground. The vertical height of the slide is 3.0 m. The angle between the main slope of the slide and its vertical support is 50°.

acceleration of free fall g = 9.8 m s^{-2}



(a) The child has a mass of 41 kg. Calculate the gain in gravitational potential energy as the child climbed to the top of the slide.

Gravitational potential energy gained ____________________

(2)

(b) Assume that the slide is frictionless.

(i) Use your answer to part (a) to calculate the speed of the child when reaching the bottom of the slide.

Speed ____________________

(2)

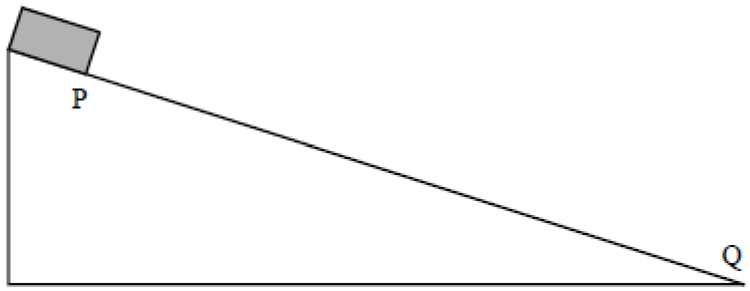
(ii) Calculate the resultant force acting on the child when in the position shown in the diagram above.

Resultant force ____________________

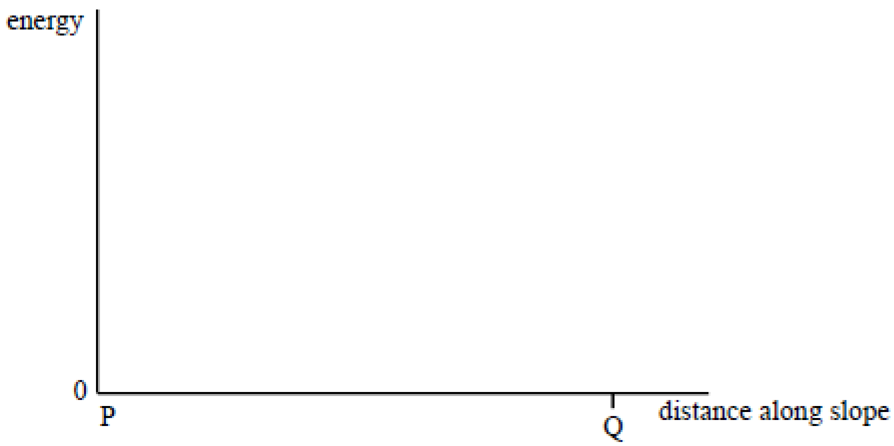
(2)

(Total 6 marks)

2. (a) The diagram shows an object at rest at the top of a straight slope which makes a fixed angle with the horizontal.



(i) The object is released and slides down the slope from P to Q with negligible friction. Assume that the potential energy is zero at Q. Sketch a graph showing the potential energy at different distances measured along the slope, and label it A. On the same set of axes, sketch a second graph showing the kinetic energy of the object at different distances along the slope and label it B.



(ii) Using the same axes as in part (i), sketch a third graph, labelled C, showing the kinetic energy at different distances along the slope when there is a constant frictional force between the object and the surface.

(iii) Use your knowledge of the principle of conservation of energy to explain the important features of the graphs you have drawn in part (i) and part (ii).

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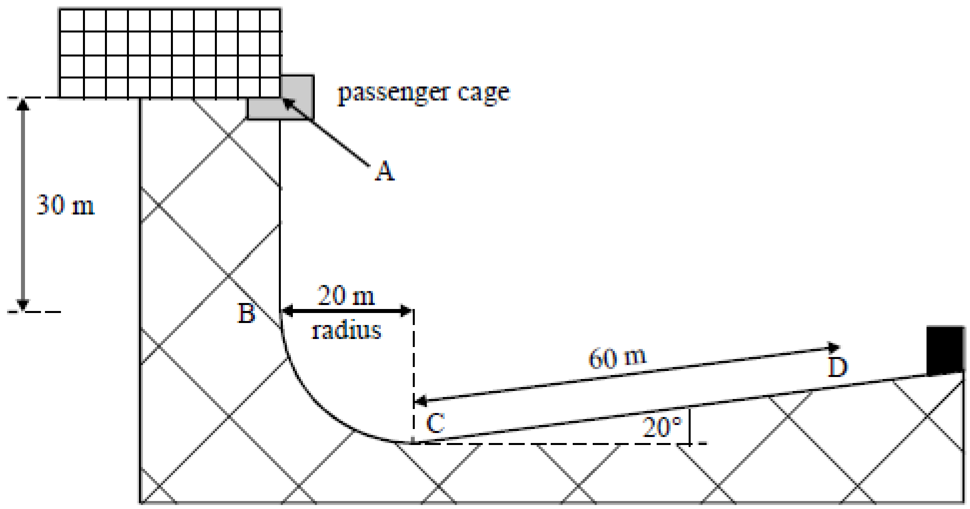
(6)

(b) In a theme park ride, a cage containing passengers falls freely a distance of 30 m from A to B and travels in a circular arc of radius 20 m from B to C. Assume that friction is negligible between A and C. Brakes are applied at C after which the cage with its passengers travels 60m along an upward sloping ramp and comes to rest at D. The track, together with relevant distances, is shown in the diagram. CD makes an angle of 20° with the horizontal



(i) Calculate the speed of the cage at C.

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(ii) Calculate the force required on a passenger of mass 80 kg for circular motion at C and state the direction of this force.

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(iii) If the mass of the cage and passengers is 620 kg, determine the gain in gravitational potential energy in travelling from C to D.

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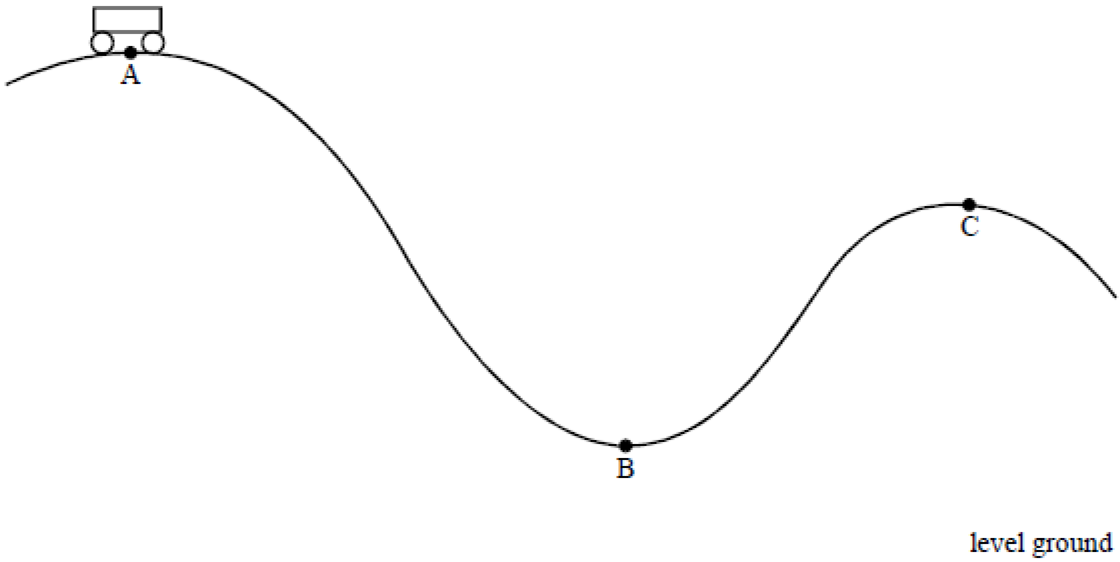
(iv) Calculate the average resistive force exerted by the brakes between C and D.

(9)
(Total 15 marks)

3. The figure shows the track of a funfair ride.



Carriages are pulled up to the highest point, A, of the ride and then released so that they follow the path ABC.

(a) Point A is 18 m above the ground and point C is 12 m above the ground. Show that the maximum possible speed of the carriage at C is 11 m s^{-1}.

(b) The actual speed at C is less than 11 m s^{-1}. Describe the energy changes that take place as the carriage moves from A to B to C.

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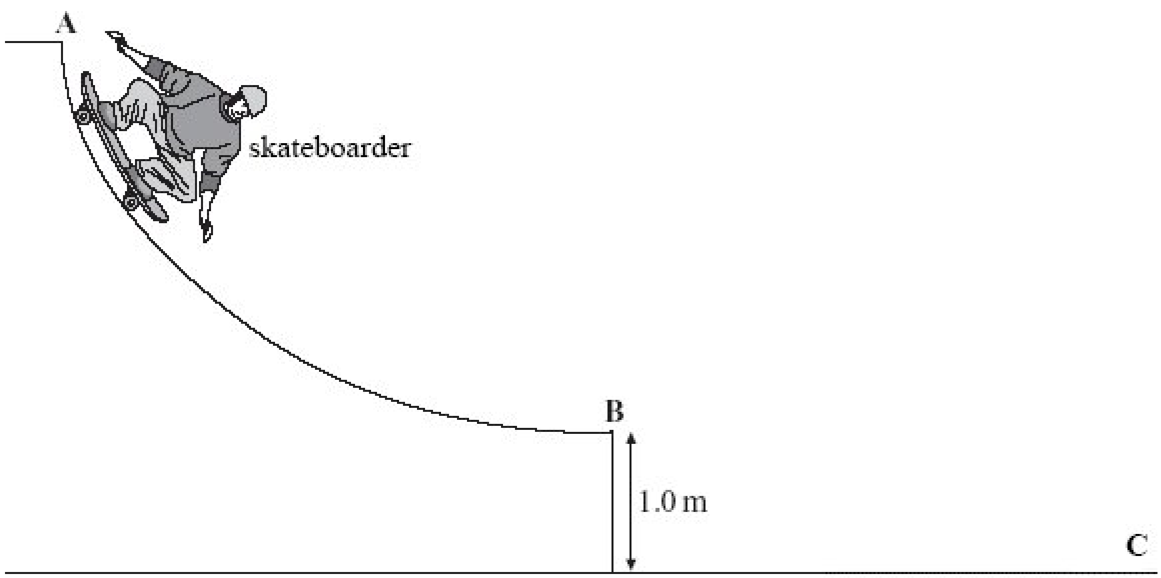
(4)

(Total 7 marks)

4. The figure below shows a skateboarder descending a ramp.



The skateboarder starts from rest at the top of the ramp at **A** and leaves the ramp at **B** horizontally with a velocity *v*.

(a) State the energy changes that take place as the skateboarder moves from **A** to **B**.

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(2)

(b) In going from **A** to **B** the skateboarder's centre of gravity descends a vertical height of 1.5 m. Calculate the horizontal velocity, *v*, stating an assumption that you make.

(3)

(c) Explain why the acceleration decreases as the skateboarder moves from **A** to **B**.

(2)

(d) After leaving the ramp at **B** the skateboarder lands on the ground at **C** 0.42 s later.

Calculate for the skateboarder

(i) the horizontal distance travelled between **B** and **C**,

(ii) the vertical component of the velocity immediately before impact at **C**,

(iii) the magnitude of the resultant velocity immediately before impact at **C**.

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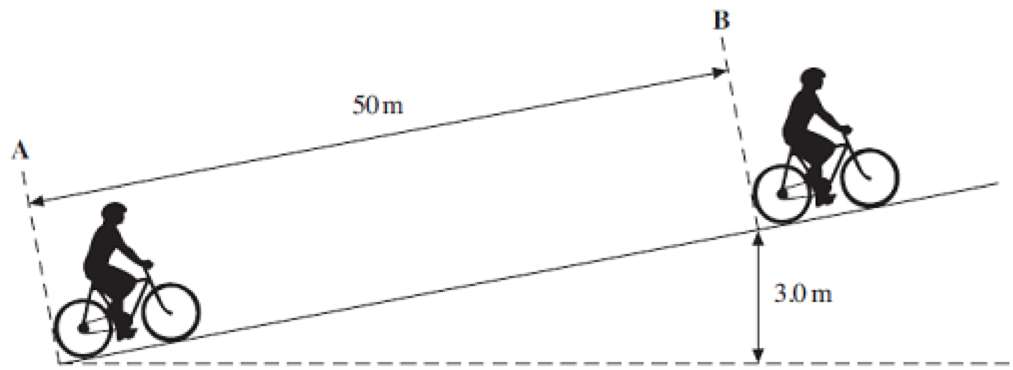
(5)

(Total 12 marks)

5. An 'E-bike' is a bicycle that is assisted by an electric motor. The figure below shows an E-bike and rider with a total mass of 83 kg moving up an incline.



(a) (i) The cyclist begins at rest at **A** and accelerates uniformly to a speed of 6.7 m s^{-1} at **B**. The distance between **A** and **B** is 50 m.
Calculate the time taken for the cyclist to travel this distance.

______________________ s

(2)

(ii) Calculate the kinetic energy of the E-bike and rider when at **B**. Give your answer to an appropriate number of significant figures.

______________________ J

(2)

(iii) Calculate the gravitational potential energy gained by the E-bike and rider between **A** and **B**.

______________________ J

(2)

(b) Between **A** and **B**, the work done by the electric motor is 3700 J, and the work done by the cyclist pedalling is 5300 J.

(i) Calculate the wasted energy as the cyclist travels from **A** to **B**.

______________________ J

(2)

(ii) State **two** causes of this wasted energy.

Cause 1 ____

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Cause 2 ____

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(2)

(Total 10 marks)