UNIVERSITY OF CAMBRIDGE

Admissions Testing Service

ENGINEERING ADMISSIONS ASSESSMENT

SPECIMEN PAPER and ANSWER BOOKLET

40 minutes

SECTION 2

Candidate number	J						Centre number					

	d d	m m	y y y y
Date of Birth		–	–

First name(s)	

Surname / Family Name	

INSTRUCTIONS TO CANDIDATES

Please read these instructions carefully, but do not open the question paper until you are told that you may do so. This paper is Section 2 of 2.

This question paper contains 17 multiple choice questions arranged into 4 groups. Some questions are connected to other questions.

There are no penalties for incorrect responses, only marks for correct answers, so you should try to attempt all 17 questions. The number of marks each question is worth is indicated. In total 32 marks are available.

Please complete this section in **pencil**. For each question **circle** the **one** option you consider correct (**A – E**). If you make a mistake, erase thoroughly and try again.

Unless otherwise indicated, marks will only be awarded for correct answers if these are accompanied by working or reasoning justifying the answer chosen. Such working or reasoning must be written in the spaces provided on the question paper. No additional answer sheets may be used.

You can use the blank inside front and back covers for rough working or notes, but no extra paper is allowed. Only answers in the spaces indicated in the paper will be marked.

Calculators may be used in this section. Please record your calculator model in the box below:

Calculator model	

Please wait to be told you may begin before turning this page

This question paper consists of 11 printed pages and 5 blank pages

PV5

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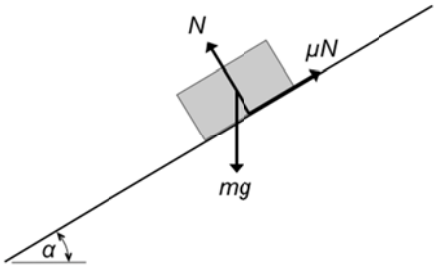
1 Consider a block of mass m moving with velocity v down a slope of angle α to the horizontal. The coefficient of friction between the block and the slope is μ. You may assume that α is sufficiently large to ensure that the block accelerates down the slope and does not topple. Take the gravitational field strength to be g.

a. Which of the following diagrams best represents the forces acting on the block? **[1 mark]**

NO WORKING NEEDS TO BE GIVEN FOR THIS PART OF THIS QUESTION.

A



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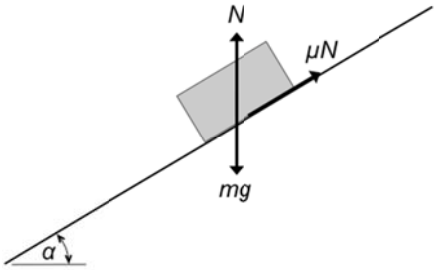

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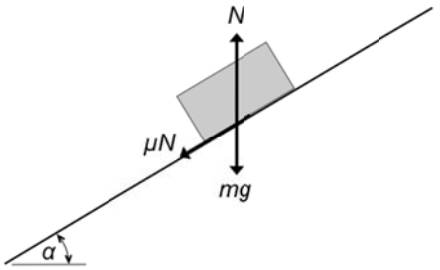

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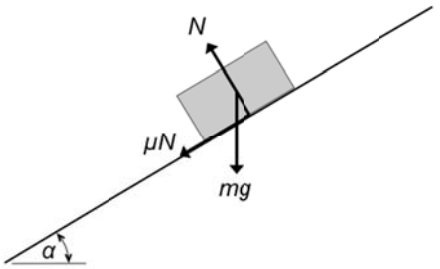
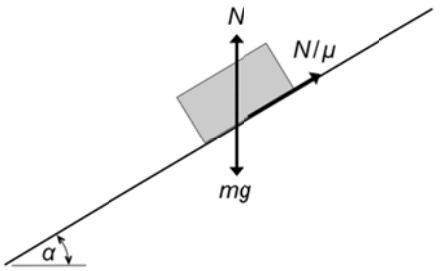


E



b. Which of the following statements is correct? **[1 mark]**

NO WORKING NEEDS TO BE GIVEN FOR THIS PART OF THIS QUESTION.

A The forces balance when resolved horizontally.

B The forces balance when resolved vertically.

C The forces balance when resolved parallel to the slope.

D The forces balance when resolved perpendicular to the slope.

E The forces do not balance in any direction.

c. Assuming $v = 0$ at time $t = 0$, what is the equation for the velocity v of the block as a function of time? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $v = g(\sin\alpha + \mu\cos\alpha)t$

B $v = g(\cos\alpha + \mu\sin\alpha)t$

C $v = g(\cos\alpha - \mu\sin\alpha)t$

D $v = g(\sin\alpha - \mu\cos\alpha)t$

E $v = g(\sin\alpha - \mu\cos\alpha - \cos\alpha)t$

Answer: ……

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d. Now suppose there is also air resistance acting on the block, and that the resultant drag force is kv. What happens as $t \to \infty$? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A The block approaches a constant non-zero acceleration.

B The block comes to a halt.

C The block approaches a terminal velocity of $mg(\cos\alpha - \mu\sin\alpha)/k$.

D The block approaches a terminal velocity of $mg(\sin\alpha - \mu\cos\alpha)/k$.

E The block approaches a terminal velocity of $mg(\cos\alpha + \mu\sin\alpha)/k$

Answer: ……

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2 A power station generates 1 GW of electricity and supplies it to a city 100 km away over a pair of aluminium cables, each of diameter 30 mm. The voltage between the cables at the power station is 400 kV. The resistivity of aluminium is 2.6×10^{-8} Ωm.

a. What is the approximate resistance of each of the cables that connect the power station to the city? **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A 37 mΩ **B** 37 μΩkm^{-1} **C** 37 μΩ **D** 37 mΩkm^{-1} **E** 3.7 Ωkm^{-1}

Answer: ……

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b. Which of the following is approximately the total power lost in the cables? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A 18.4 kW **B** 135 kW **C** 11.5 MW **D** 23 MW **E** 46 MW

Answer: ……

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c. Some statistics concerning electricity are quoted in GWh (gigawatt hours). Which of the following statements is correct? **[1 mark]**

GIVE YOUR REASONING IN THE SPACE PROVIDED BELOW.

A 1 GWh is an amount of power, equivalent to 3.6×10^{12} W.

B 1 GWh is an amount of energy, equivalent to 3.6×10^{12} J.

C 1 GWh is an amount of energy, equivalent to 6.0×10^{10} J.

D 1 GWh is an amount of energy, equivalent to 3.6×10^{9} J.

E 1 GWh is neither an amount of energy nor of power, because energy is measured in joules (J), and power in watts (W).

Answer: ……

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d. The *Digest of UK Energy Statistics (2015)* states that in the UK in 2014 the total amount of electricity generated was 3.4×10^{5} GWh, and it also states that total electricity consumption was 3.0×10^{5} GWh. Which of the following is the main reason for the difference between the figures quoted for generation and consumption? **[1 mark]**

GIVE YOUR REASONING IN THE SPACE PROVIDED BELOW.

A Power stations in the UK are on average only about 88% efficient.

B Electrical appliances in the UK are on average only about 88% efficient.

C About 12% of the electricity generated is lost in the distribution network.

D The data on consumption are incomplete (the law of conservation of energy means that generation and consumption must actually be equal).

E It is difficult to measure large amounts of electricity accurately (the law of conservation of energy means that generation and consumption must actually be equal).

Answer: ……

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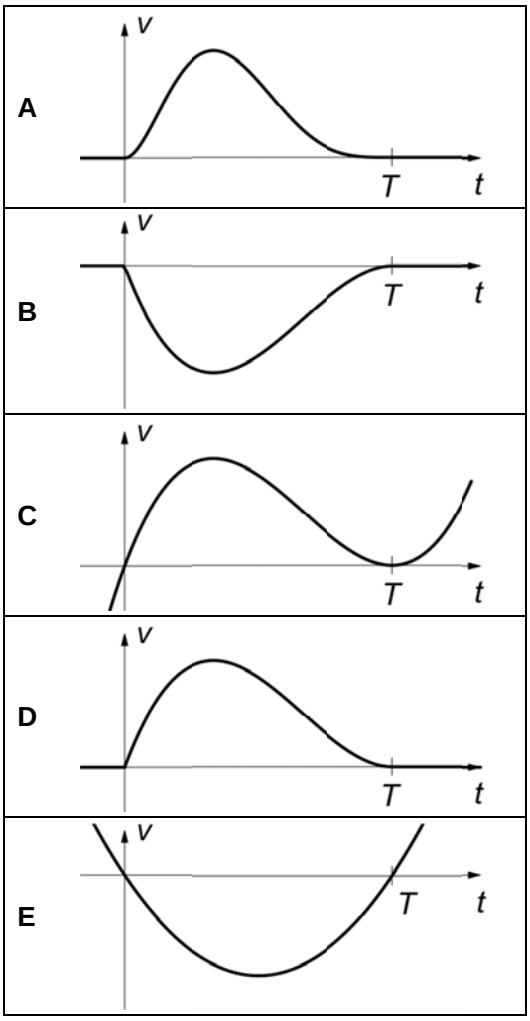
3 An object moves in a straight line with its velocity v for time $0 \leq t \leq T$ modelled by $v(t) = at(t - T)^2$, where a and T are positive constants. Outside this interval the object is at rest.

a. Which of the following sketch graphs most accurately represents the variation of velocity with time? **[1 mark]**

GIVE YOUR REASONING IN THE SPACE PROVIDED BELOW.



Answer: ……

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b. Which of the following expressions gives the acceleration of the object for $0 \leq t \leq T$?

[2 marks]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $2at(t-T)$ **B** $3at^2 - 4aTt - aT^2$ **C** $3a(t^2 - 4Tt + T^2)$

D $a(3t-T)(t-T)$ **E** $a(3t+T)(t-T)$

Answer: ……

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c. What is the most negative acceleration experienced by the object? **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $-\frac{7aT^2}{4}$ **B** $-a$ **C** $-4aT$ **D** $-\frac{4aT^3}{27}$ **E** $-\frac{aT^2}{3}$

Answer: ……

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d. What is the most positive acceleration experienced by the object? **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A aT^2 **B** $\frac{aT^2}{3}$ **C** ∞ **D** $\frac{4aT^3}{27}$

E The object never experiences positive acceleration.

Answer: ……

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e. Assuming the object is at the origin at $t = 0$, what is its displacement at $t = 2T$? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $2aT^2$ **B** $\frac{10aT^4}{3}$ **C** $\frac{aT^4}{12}$ **D** $-\frac{aT^4}{12}$ **E** 0

Answer: ……

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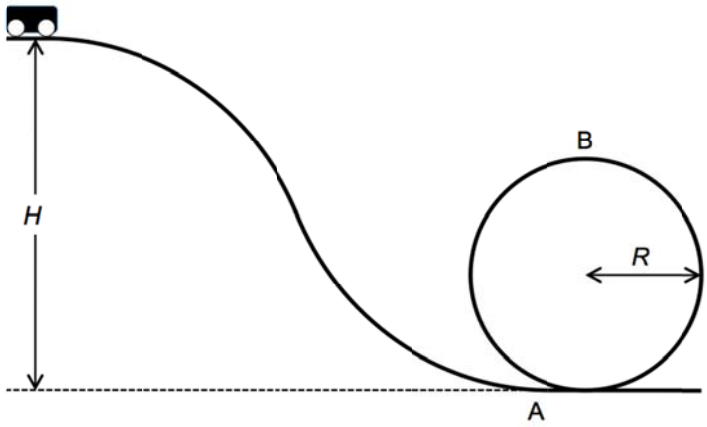
4 This question is about rollercoaster safety. The fundamental question it seeks to answer is:

'From what height *H* must a rollercoaster car be released if it is to travel successfully around a loop of radius *R* without falling off at the top of the loop?'

The rollercoaster in question is shown schematically in the figure below.



a. The rollercoaster car has mass *M*. Assuming frictional forces can be neglected, if the car is released from rest at height *H*, what is its speed when it reaches point A, the entrance to the loop? The acceleration due to gravity is *g*. **[1 mark]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\sqrt{gH}$ **B** gH **C** $2gH$ **D** $\sqrt{2gH}$ **E** $2\sqrt{gH}$

Answer: .....

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b. If the car follows the circular path to the top of the loop at B, what is its speed there? **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\sqrt{2gH}$ **B** $2g(H-2R)$ **C** $\sqrt{2g(H-R)}$ **D** $\sqrt{2gH}-2\sqrt{gR}$

E $\sqrt{2g(H-2R)}$

Answer: .....

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c. The instantaneous centripetal acceleration, a_c, of an object moving in a circular path of radius *R* at speed *V* is given by $a_c = \frac{V^2}{R}$. In what direction does this acceleration act?

[1 mark]

NO WORKING NEEDS TO BE GIVEN FOR THIS PART OF THIS QUESTION.

A In the direction of travel

B Towards the centre of the circle

C Radially away from the centre of the circle

D In the opposite direction to the instantaneous velocity

E None of these

d. Consider the forces acting on the car when it is at B and its acceleration there. What is the minimum height *H* from which the car must be released if it is not to lose contact with the track at B? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $H > 5R$ **B** $H > 3.5R$ **C** $H > 3R$ **D** $H > 2.5R$ **E** $H > 2R$

Answer: ……

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END OF TEST

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