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Oxford Cambridge and RSA

# Level 3 Cambridge Technical in Engineering

## 05822/05823/05824/05825 /05873

### Unit 23: Applied mathematics for engineering

## Wednesday 18 January 2017 – Afternoon

### Time allowed: 2 hours

**You must have:**

- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

<b>First Name</b>					<b>Last Name</b>				
<b>Centre Number</b>					<b>Candidate Number</b>				
<b>Date of Birth</b>									

**INSTRUCTIONS**

- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number centre number and question number(s).
- The acceleration due to gravity is denoted by  $g \text{ m s}^{-2}$ . Unless otherwise instructed, when a numerical value is needed, use  $g = 9.8$ .

**INFORMATION**

- The total mark for this paper is **80**.
- The marks for each question are shown in brackets [ ].
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **16** pages.

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Question No	Mark
1	/11
2	/11
3	/14
4	/12
5	/11
6	/12
7	/9
<b>Total</b>	<b>/80</b>

Answer **all** questions.

- 1** For this question you may refer to the constant acceleration formulae in section 6.4 of the formula booklet provided.

A new car is being tested for braking distance on a test track. The car is travelling at a speed of  $v \text{ m s}^{-1}$  when the brakes are applied and the car comes to rest after 3 s. The distance,  $s \text{ m}$ , that the car travels in  $t \text{ s}$  after the brakes are applied is recorded. Recordings are made at 0.5 s intervals and the results are shown in Table 1.

Time $t$ (s)	Distance travelled $s$ (m)
0	0
0.5	13.75
1	25
1.5	33.75
2	40
2.5	43.75
3	45

**Table 1**

- (a) On the grid below, draw a graph of  $s$  against  $t$  for  $0 \leq t \leq 3$ .



[3]

- (b) The car decelerates uniformly. The distance the car travels may be modelled by the following equation.

$$s = At^2 + Bt \quad \text{for } 0 \leq t \leq 3$$

- (i) Use information from Table 1 to calculate the values of  $A$  and  $B$ .

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- (ii) Calculate the time taken for the car to travel the first 30 m after the brakes are applied.

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- (iii) Calculate the speed of the car when  $t = 0$ .

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- (iv) Calculate the deceleration of the car.

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- 3 Fig. 3 shows a concrete block of mass  $m$  kg supported at rest in equilibrium by two ropes, A and B. Rope A has tension  $T_1$  N and Rope B has tension  $T_2$  N. The angle between the two ropes is  $\alpha^\circ$  and the angle between Rope B and the horizontal is  $\alpha^\circ$  where  $0 < \alpha < 90$ .

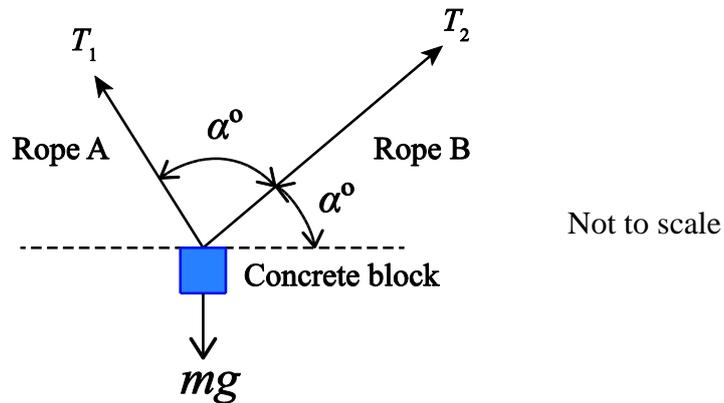


Fig. 3

- (a) Express the tensions  $T_1$  and  $T_2$  as vectors  $\vec{T}_1$  and  $\vec{T}_2$  in component form, expressing each component in terms of  $\alpha$  and  $T_1$  or  $T_2$  as appropriate.

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- (b) Sketch a vector diagram showing the relationship between the resultant vector  $\vec{R} = \vec{T}_1 + \vec{T}_2$  and the vectors  $\vec{T}_1$  and  $\vec{T}_2$ .







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- 5 A domestic storage heater produces heat over a 10-hour period. During this time the instantaneous power,  $P$  kW, produced is modelled by the equation

$$P = 4he^{-\frac{h}{2}},$$

where  $h$  is the time, measured in hours, from when the heating system is turned on.

- (a) Calculate the time at which the instantaneous power produced is a maximum.

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- (b) Calculate  $\frac{1}{10} \int_0^{10} 4he^{-\frac{h}{2}} dh$  to find the average power produced during the 10-hour period.

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(b) You are given following values.

$$\omega = 10^4 \quad R = 1 \quad L = 10^{-2} \quad C = 10^{-5}$$

(i) Express  $Z_t$  in the form  $a + jb$  where  $a$  and  $b$  are real values.

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(ii) Express  $Z_t$  in the form  $r(\cos \theta + j\sin \theta)$  where  $r$  is a real value and  $\theta$  is an angle in degrees.

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(c) Comment on whether or not the model appears to provide a realistic description of the speed of the flywheel as it is slowing down.

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**END OF QUESTION PAPER**

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