

ENGINEERING ADMISSIONS ASSESSMENT D564/12
Wednesday 2 November 2016
40 minutes
SECTION 2

* 9 8 0 7 6 7 9 2 7 1 *	Candidate number		J						Centre number						
	Date of birth		d	d				m	m			y	y	y	y
	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 15 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 attempt all 15 questions. The number of marks each question is worth is indicated. In total 29 marks are available.

Please complete this section in **pencil**. For each question **circle** the **one** option you consider correct. 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.

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	
------------------	--

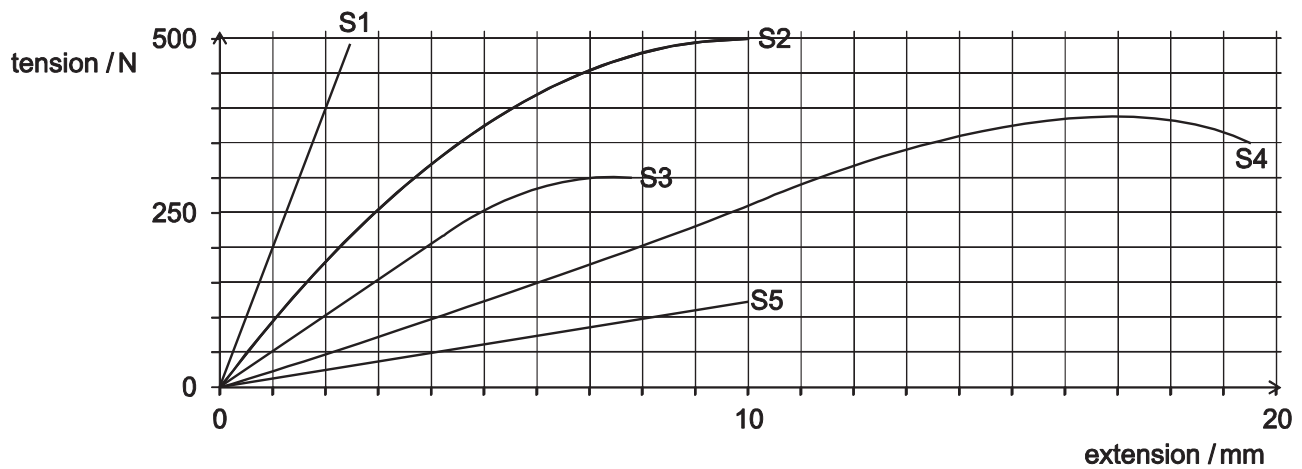
Please wait to be told you may begin before turning this page.

This question paper consists of 16 printed pages and 4 blank pages.

PV2

This page is intentionally left blank for your rough working or notes.

- 1 A series of 100 mm long samples have a square cross-section of 5 mm $\times$ 5 mm. Each sample is tested in an apparatus which applies increasing tension to the ends of the sample until it breaks. The length of the sample is measured and a plot of tension vs extension obtained. The results for five samples S1-S5 are shown in the figure below.



- a) Which of the samples is the stiffest compared to the other samples?

[1 mark]

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

- A S1
- B S2
- C S3
- D S4
- E S5

Answer:

.....

.....

.....

.....

.....

- b) Which sample does not obey Hooke's Law up to 2% strain?

[1 mark]

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

- A S1
- B S2
- C S3
- D S4
- E S5

Answer:

.....

.....

.....

.....

.....

- c) What is the value of the Young's Modulus of sample S3, assuming that changes in its cross-section are negligible?

[2 marks]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

- A 200 MPa
- B 20 MPa
- C 100 MPa
- D 10 MPa

Answer:

.....

.....

.....

.....

.....

.....

- d) The equation of the force-extension curve for sample S2 is given by $T = ax - bx^2$ where T is the tension in N, x the extension in m and a and b are constants. Sample S2 breaks when its extension is 10 mm. How much work does the apparatus do on sample S2 in breaking it?
- [2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\frac{a}{2} \times 10^{-4} - \frac{b}{3} \times 10^{-6} \text{ Nm}$

B $\frac{a}{2} \times 10^{-2} - \frac{b}{3} \times 10^{-3} \text{ Nm}$

C $\frac{a}{2} \times 10^2 - \frac{b}{3} \times 10^3 \text{ Nm}$

D $\frac{a^2}{2} \times 10^2 - \frac{b^2}{3} \times 10^3 \text{ Nm}$

E $\frac{a}{2} \times 10^{-2} - \frac{b}{2} \times 10^{-3} \text{ Nm}$

Answer:

.....

.....

.....

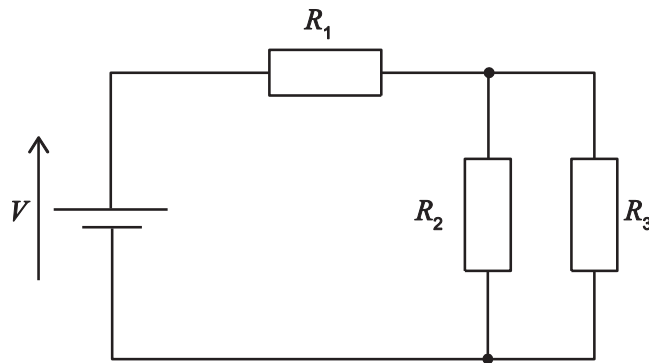
.....

.....

.....

.....

- 2 The figure below shows a network of three non-zero resistances R_1 , R_2 , R_3 connected to a voltage source V with zero internal resistance.



- a) Which of the following statements must be correct?

[1 mark]

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

- A** The currents through resistances R_1 and R_2 are the same.
- B** The currents through resistances R_1 and R_3 are the same.
- C** The currents through resistances R_2 and R_3 are the same.
- D** The voltages across resistances R_1 and R_2 are the same.
- E** The voltages across resistances R_1 and R_3 are the same.
- F** The voltages across resistances R_2 and R_3 are the same.

- b) Which of the following expressions gives the current through the voltage source? [2 marks]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\frac{V(R_2 + R_3)}{R_1R_2 + R_1R_3 + R_2R_3}$

B $\frac{V(R_1R_2 + R_1R_3 + R_2R_3)}{R_2 + R_3}$

C $\frac{VR_2R_3}{R_2 + R_3 + R_1R_2R_3}$

D $\frac{V}{R_1 + R_2 + R_3}$

E $\frac{V(R_1R_2 + R_1R_3 + R_2R_3)}{R_1R_2R_3}$

Answer:

.....

.....

.....

.....

.....

.....

.....

- c) R_1 and R_2 are now fixed such that $R_1 = R_2$. Which of the following expressions gives the power P that is dissipated by resistance R_3 ? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\frac{V^2 R_3}{(R_1 + 2R_3)^2}$

B $\frac{V^2}{2R_1 + R_3}$

C $\frac{V^2 (R_1 + 2R_3)^2}{R_3^3}$

D $\frac{V^2 R_3}{(R_1 + 2R_3)^2}$

E $\frac{V^2 (R_1 + R_3)^2}{(R_1 + 2R_3)^2 R_3}$

Answer:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

- d) For the case where $R_1 = R_2$, which of the following values of R_3 maximises its power dissipation? You may find it helpful to use the fact that any value of R_3 that maximises P also minimises $1/P$. **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $R_3 = \frac{1}{4}R_1^2$

B $R_3 = \frac{1}{2}R_1$

C $R_3 = \exp\left(-\frac{4}{R_1^2}\right)$

D $R_3 = \frac{1}{\sqrt{2}}R_1$

E $R_3 = \frac{1}{4}R_1$

F Either $R_3 = \frac{1}{2}R_1$ or $R_3 = -\frac{1}{2}R_1$ would result in maximum power dissipation in R_3 .

Answer:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

- 3 The speed of light in vacuum and air can be taken to be $c = 3.0 \times 10^8 \text{ m s}^{-1}$. The refractive index n of a material is the ratio of the speed of light c in vacuum to the speed of light in the material.

- a) A lighthouse emits a beam of light. How far does this beam of light travel in 1.0 ns? [1 mark]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

- A 0.30 mm
- B 300 m
- C 0.30 m
- D $3.0 \times 10^{-12} \text{ m}$

Answer:

.....

.....

.....

.....

- b) The propagation time T is the time taken for a pulse of light to travel directly along an optical fibre. A straight optical fibre has a length of 9 km. Its refractive index is 1.5. What is T for this fibre? [1 mark]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

- A 20 ms
- B 20 μs
- C 30 ms
- D 30 μs
- E 45 ms
- F 45 μs

Answer:

.....

.....

.....

.....

- c) An engineer has used a refractive index of $n = 1.5$ to estimate the nominal propagation time T_{nom} for an optical fibre. The actual refractive index of the fibre depends on the wavelength of the light. For red and blue light the refractive indices obey the inequality $n_{\text{red}} < n_{\text{blue}} < 1.5$. If T_{red} and T_{blue} are the propagation times for red and blue light, respectively, which of the following inequalities is correct? **[2 marks]**

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

A $T_{\text{red}} < T_{\text{blue}} < T_{\text{nom}}$

B $T_{\text{blue}} < T_{\text{red}} < T_{\text{nom}}$

C $T_{\text{red}} < T_{\text{nom}} < T_{\text{blue}}$

D $T_{\text{blue}} < T_{\text{nom}} < T_{\text{red}}$

E $T_{\text{nom}} < T_{\text{red}} < T_{\text{blue}}$

F $T_{\text{nom}} < T_{\text{blue}} < T_{\text{red}}$

Answer:

.....

.....

.....

.....

.....

.....

.....

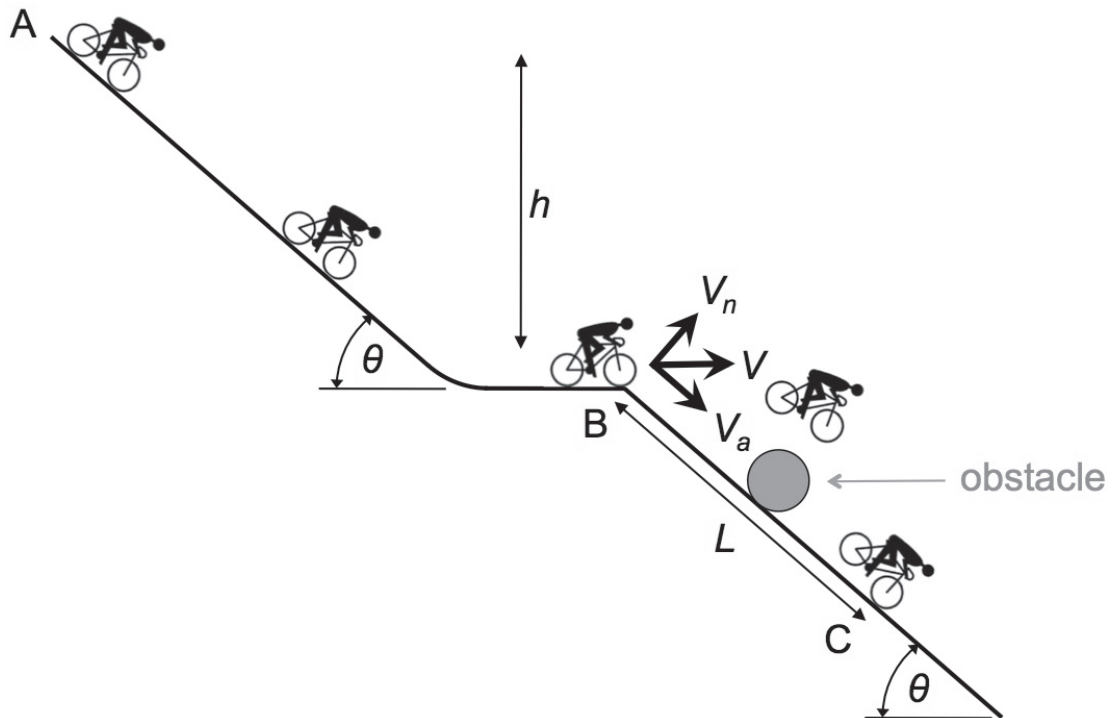
.....

.....

.....

.....

- 4 A stunt cyclist is preparing a new trick. The track on which he will perform the trick is shown schematically in the figure below. As shown, most of the track is sloped at an angle θ to the horizontal.



The cyclist starts riding from rest at A. In riding down the slope from A to B he transfers an amount of energy E from his muscles to provide kinetic energy to the rider-bicycle system and descends through a vertical distance h . The cyclist leaves the track at B, travelling horizontally initially. He lands on the track at C, a distance L down the slope.

Assume that the rider-bicycle system can be modeled as a point mass of mass M , that frictional forces and air resistance can be neglected, and that the gravitational field strength is g .

- a) What is V_a , the component of the velocity of the rider-bicycle system along (parallel to) the slope, immediately after the cyclist has left the track at B? **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\sqrt{\left[\frac{E}{M} + 2gh\right]} \cos \theta$

B $\sqrt{\frac{2}{M}[E + Mgh]} \sin \theta$

C $\sqrt{\frac{2}{M}[E + Mgh]} \frac{1}{\cos \theta}$

D $\sqrt{\left[\frac{E}{M} + 2gh\right]} \sin \theta$

E $\sqrt{2 \left[\frac{E}{M} + gh\right]} \cos \theta$

Answer:

.....

.....

.....

.....

.....

.....

- b) The cyclist leaves the track at B at time $t = 0$ with an initial speed V . By considering motion parallel and/or perpendicular to the slope, or otherwise, find an expression for the time taken to land at C. **[2 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $2\frac{V}{g}$

B $2\frac{V}{g}\tan\theta$

C $\frac{V}{g}\sin\theta$

D $\frac{V}{g}\tan\theta$

E $2\frac{V}{g}\sin\theta$

Answer:

.....

.....

.....

.....

.....

.....

.....

.....

c) How far along the slope will the cyclist land, i.e. what is the value of L ?

[3 marks]

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $2\frac{V^2}{g}\sin\theta$

B $\frac{V^2}{2g}$

C $2\frac{V^2}{g}\frac{\sin\theta}{\cos^2\theta}$

D $2\frac{V^2}{g}\frac{\cos\theta}{\sin^2\theta}$

E $2\frac{V^2}{g}[\sin\theta + \tan^2\theta]$

Answer:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

- d) As part of the trick, the cyclist wants to clear an obstacle placed on the slope between B and C. To give the cyclist the greatest chance of clearing the obstacle it should be placed at the point at which the cyclist's perpendicular distance from the track is greatest. At what distance from B should the obstacle be placed? **[3 marks]**

SHOW YOUR WORKING IN THE SPACE PROVIDED BELOW.

A $\frac{1}{2}L$

B $\frac{v^2 \sin^2 \theta}{2g \cos \theta}$

C $\frac{1}{2}h$

D $\frac{v^2}{g} \sin \theta \left[1 + \frac{1}{2} \tan^2 \theta \right]$

E $\frac{v^2}{2g}$

Answer:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

This page is intentionally left blank for your rough working or notes.

This page is intentionally left blank for your rough working or notes.

This page is intentionally left blank for your rough working or notes.

J