UNIVERSITY OF CAMBRIDGE

ENGINEERING ADMISSIONS ASSESSMENT D564/12

Thursday 2 November 2017 40 minutes

SECTION 2

4764933560

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 17 multiple choice questions arranged into 4 groups. Some questions are connected to other questions.

Please complete this section in **pencil**. Your working or reasoning must be written in the spaces provided in this question paper and may be taken into account in the assessment of your work.

Your final choice of answer option must be recorded by shading a circle in the spaces provided on the inside front cover. For each question shade the **one** option you consider correct. If you make a mistake, erase thoroughly and try again.

There are no penalties for incorrect responses, only marks for correct answers, so you should attempt all 17 questions. The number of marks each question is worth is indicated. In total 38 marks are available.

You can use the blank pages 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 20 printed pages and 4 blank pages.

PV1

INSTRUCTIONS TO CANDIDATES

Your working or reasoning must be written in the spaces provided in this question paper, and your final choice of answer recorded by shading a circle in the spaces below, e.g.

Use a soft pencil. If you make a mistake, erase thoroughly and try again.

Question 1	
1a	A B C D E
1b	A B C D E
1c	A B C D E
1d	A B C D E
1e	A B C D E

Question 2	
2a	A B C D
2b	A B C D
2c	A B C D E
2d	A B C D E
2e	A B C D E

Question 3	
3a	A B C D E
3b	A B C D E
3c	A B C D E
3d	A B C D E

Question 4	
4a	A B C D E
4b	A B C D E
4c	A B C D E

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

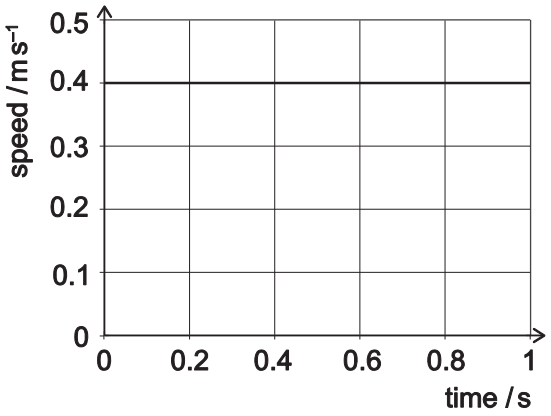
1 A ball of mass $m = 0.5\,\text{kg}$ is at rest a distance d above the flat floor of a spacecraft.

Installed in the floor is an artificial gravity generator which produces a field at right angles to the floor, directed towards the floor. There is no air in the spacecraft.

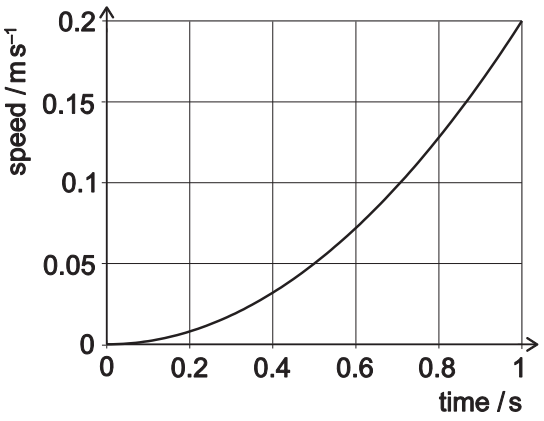
The generator is switched on at time $t = 0\,\text{s}$ and produces a field g that increases linearly with time, such that $g = 0.4\,t\ \text{m s}^{-2}$. The artificial gravity is the only force experienced by the ball.

a) Assuming that the ball does not hit the floor within the first second of motion, which of these graphs represents the speed of the ball plotted against time? **[2 marks]**

A



B



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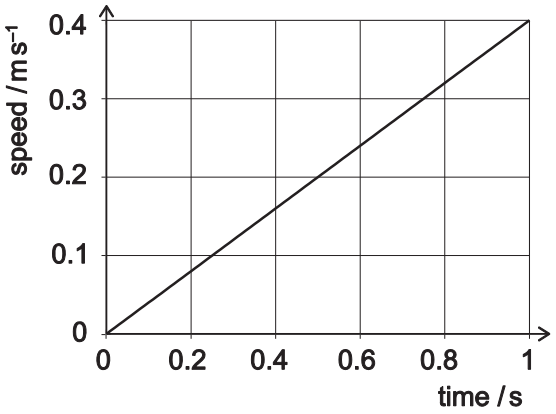

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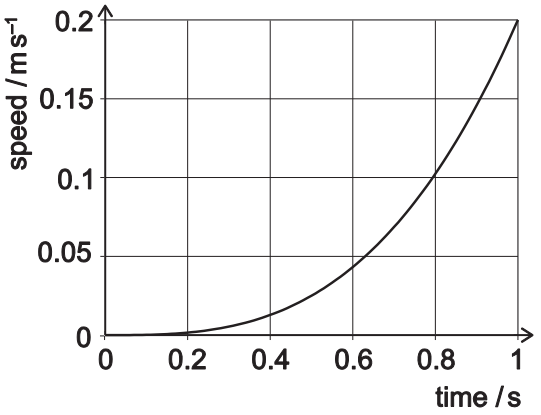

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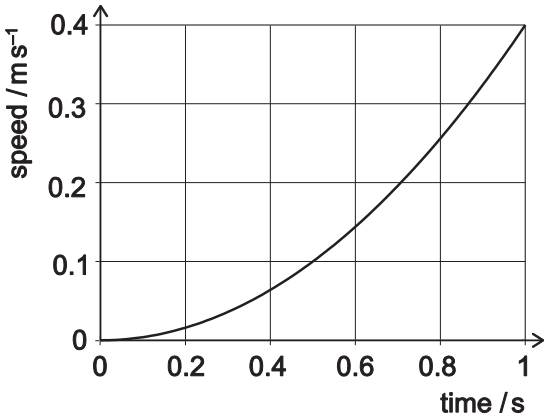

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Answer: ……

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b) Which of these expressions gives the time taken for the ball to first hit the floor? **[2 marks]**

A $(15d)^{\frac{1}{3}}$

B $(5d)^{\frac{1}{3}}$

C $(5d)^{\frac{1}{2}}$

D $\left(\frac{15d}{2}\right)^{\frac{1}{3}}$

E $\left(\frac{5d}{2}\right)^{\frac{1}{3}}$

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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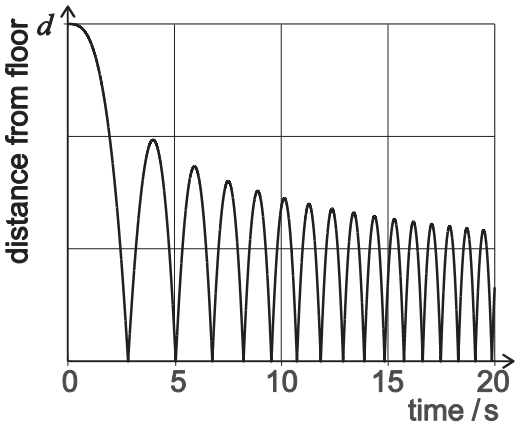
c) The ball bounces and hits the floor repeatedly. Which of these graphs might represent the position of the ball plotted against time? **[3 marks]**

P



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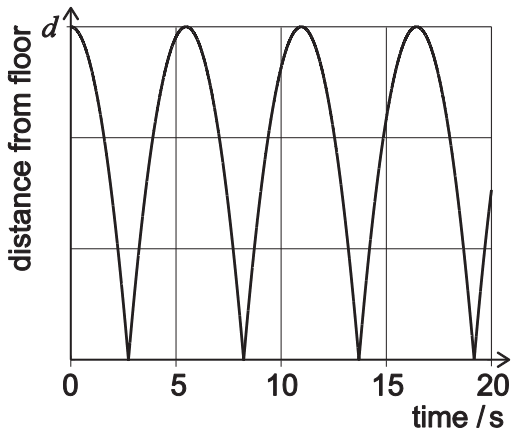

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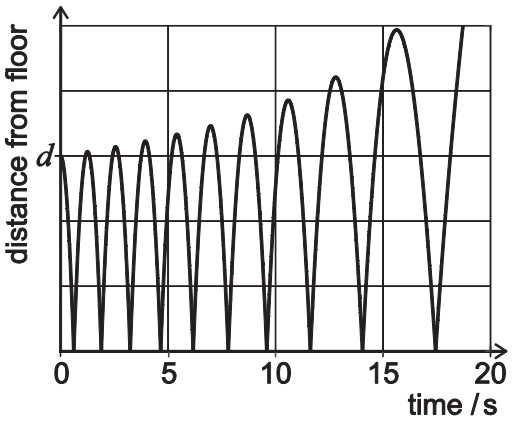

A P only

B Q only

C R only

D P and Q only

E Q and R only

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d) Force is usually measured in Newtons (N). Given that $F = ma$, which of the following is an alternative unit for force? **[1 mark]**

A $\mathrm{kg\,s\,m^{-2}}$

B $\mathrm{kg^{-1}\,m^{-1}\,s^{2}}$

C $\mathrm{kg\,m\,s^{-2}}$

D $\mathrm{N\,kg^{-1}\,m^{-1}\,s^{2}}$

E $\mathrm{N^{-1}\,kg\,m\,s^{-2}}$

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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e) Air is now injected into the spacecraft, creating air resistance. The drag force D on the ball is given by

$$D = \frac{1}{2} X \rho v^2 A$$

where ρ is the air density, v is the ball's speed, A is its cross-sectional area and X is an unknown parameter.

What are the units of X? **[2 marks]**

A $\mathrm{m\,s^{-2}}$

B $\mathrm{m\,s^{-1}}$

C $\mathrm{kg^{-1}\,m^{-1}\,s^{2}}$

D $\mathrm{kg\,m\,s^{-2}}$

E X has no units

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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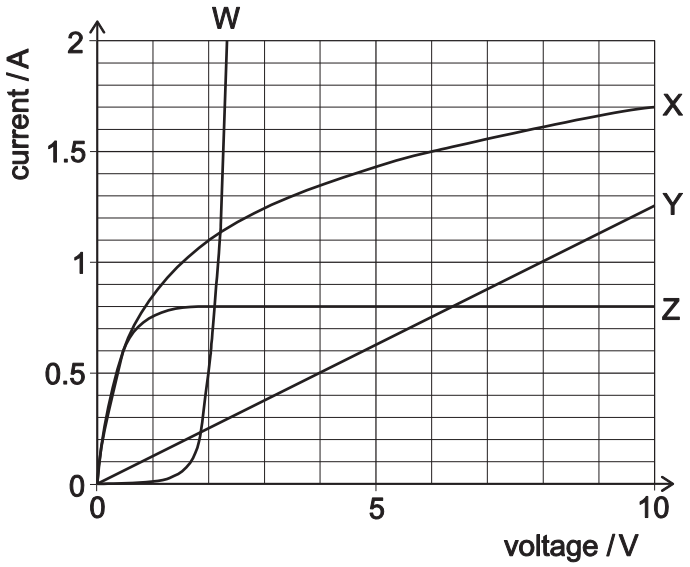
2 The graph shows the current against voltage characteristics of four different electronic devices W, X, Y and Z. One of the devices is an 8 Ω resistor and one is a filament lamp rated 9 W at 6 V. You may assume that the filament lamp does not 'blow' in the context of this question.



a) Which of the devices is the resistor? **[1 mark]**

A device W

B device X

C device Y

D device Z

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b) Which of the devices is the filament lamp? **[2 marks]**

A device W

B device X

C device Y

D device Z

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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c) The filament lamp and the resistor are connected in parallel to a 6.0 V power supply with negligible internal resistance.

Approximately what current is drawn from the supply? **[3 marks]**

A 0.75 A

B 1.5 A

C 1.83 A

D 2.25 A

E 2.42 A

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d) The previous circuit is disconnected, and then devices W and Y are connected in series to the same 6.0 V power supply.

Which one of the following statements about the new circuit must be correct? **[1 mark]**

A Devices W and Y dissipate equal power.

B Devices W and Y have equal voltages across them.

C Equal currents flow through devices W and Y.

D The power supply delivers more power than it would if device W or device Y were connected alone.

E The power supply delivers more power than it would if devices W and Y were connected in parallel.

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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e) In the new circuit, approximately what power is dissipated by device W? **[3 marks]**

A 0.5W

B 1.0W

C 1.5W

D 2.0W

E 2.5W

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3 Fig. 3(a) shows the results of an experiment in which a 0.5 m length of elastic cord has been extended by a force with a corresponding extension. The cord fails at point Q by fracture.

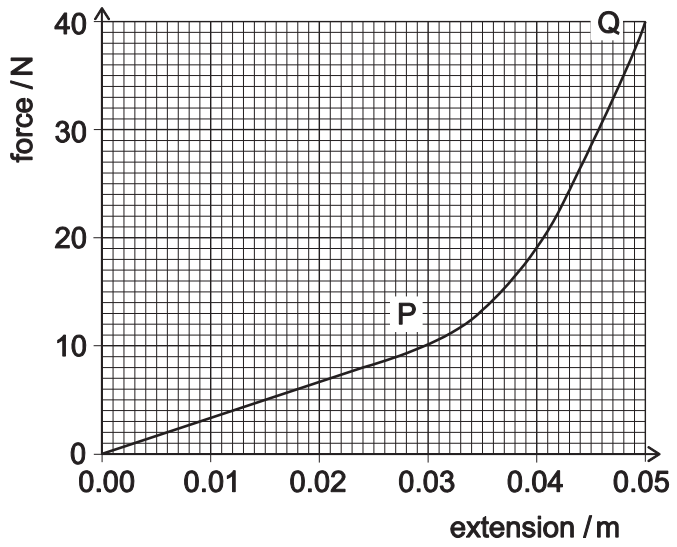

Fig. 3(a)

a) The elastic behaviour of a material can often be described by Hooke's law, which is given by the equation $F = kx$, where x is extension, F is force and k is an elastic constant which depends on the material studied.

Which of the following statements correctly describes the behaviour of the cord? **[2 marks]**

A no Hooke's law behaviour and fracture at a strain of 0.05

B Hooke's law behaviour up to P and fracture at a strain of 0.05

C Hooke's law behaviour up to Q and fracture at a strain of 0.05

D Hooke's law behaviour up to P and fracture at a strain of 0.1

E Hooke's law behaviour up to Q and fracture at a strain of 0.1

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b) What is the work done *U* in stretching this 0.5 m length of elastic cord by 0.05 m (to 2 significant figures)? **[3 marks]**

A 0.15 J

B 0.30 J

C 0.60 J

D 2.0 J

E 6.0 J

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c) An unstretched 0.25 m length of the same type of cord is used in a catapult to propel a mass m, as illustrated in Fig. 3(b).

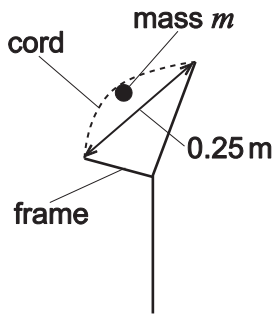

Fig. 3(b)

What is the maximum speed V_{max} at which the mass can be propelled (where U is the work done calculated in part **b)**)? **[3 marks]**

A $\sqrt{mU}$

B $\sqrt{\frac{U}{m}}$

C $\sqrt{\frac{2U}{m}}$

D $\sqrt{2mU}$

E $\sqrt{\frac{U}{2m}}$

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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d) Two parallel 0.25 m lengths of the elastic cord are used in the catapult as shown in Fig. 3(c).

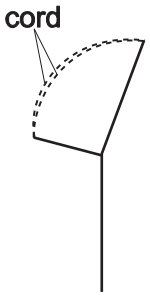

Fig. 3(c)

What is the maximum speed at which the mass can now be propelled? **[2 marks]**

A $\frac{1}{2} V_{max}$

B $\frac{1}{\sqrt{2}} V_{max}$

C V_{max}

D $\sqrt{2} V_{max}$

E $2V_{max}$

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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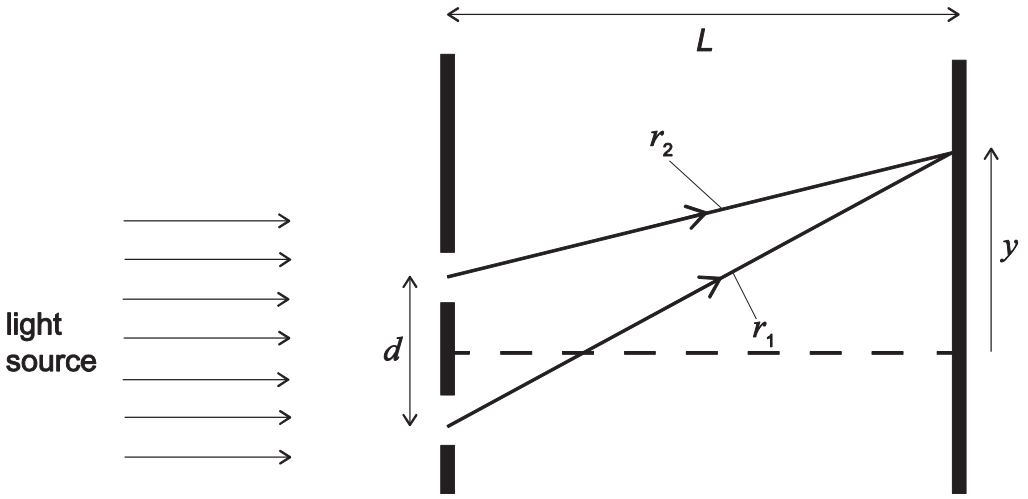
4 The diagram shows the geometry for two slit diffraction of light, with the slits on the left and the viewing screen on the right; $d = 800\,\text{nm}$, $L = 1\,\text{m}$ and the speed of light is $3 \times 10^8\ \text{m s}^{-1}$.



a) The pair of slits is illuminated by laser light of wavelength $\lambda = 600\,\text{nm}$.

Which of the following statements are correct (where n is an integer)? **[2 marks]**

1 Points of maximum brightness on the screen occur where the distances r_1 and r_2 differ by $n\lambda$.

2 Points of maximum brightness on the screen occur where the distances r_1 and r_2 differ by $\left(n + \frac{1}{2}\right)\lambda$.

3 Points of minimum brightness on the screen occur where the distances r_1 and r_2 differ by $\left(n + \frac{1}{2}\right)\lambda$.

4 For a diffraction pattern to appear, the light from the two slits must be coherent.

5 The maxima are all of equal brightness.

A 1 and 4 only

B 1, 3 and 4 only

C 1, 3 and 5 only

D 1, 4 and 5 only

E 2 and 4 only

SHOW YOUR REASONING IN THE SPACE PROVIDED ON THE NEXT PAGE.

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b) A thin piece of transparent material, thickness 300 nm and in which the speed of light is half that in air, is now placed immediately behind one of the two slits.

Which one of the following statements is correct? **[3 marks]**

A The diffraction pattern is unchanged.

B The diffraction pattern disappears because the light from the two slits is no longer coherent.

C The diffraction pattern disappears because the light from the two slits is no longer in phase.

D The complete diffraction pattern shifts in the y direction.

E Each maximum is replaced by two because the material alters the wavelength of the light coming from it.

SHOW YOUR REASONING IN THE SPACE PROVIDED BELOW.

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c) A radio transmitter transmits a signal at 600 MHz to a receiver 1 km away. In an attempt to double the strength of the signal at the receiver, a second antenna is added at the transmitter, 1 m away alongside the original one, and fed by the same signal. It is suggested that, instead of improving reception, diffraction effects might actually make reception much worse.

Which of the following statements is correct? **[3 marks]**

A Diffraction effects would not be a problem because light and radio are different types of wave.

B Diffraction effects would not be a problem because the waves are too low frequency to produce diffraction effects.

C Diffraction effects would not be a problem as the transmitting antennas are too far apart to produce diffraction effects.

D Diffraction effects will occur, but the maxima would be sufficiently close together that this would not be a problem.

E Diffraction effects could be a problem because the distance between the transmitting antennas is comparable to the wavelength.

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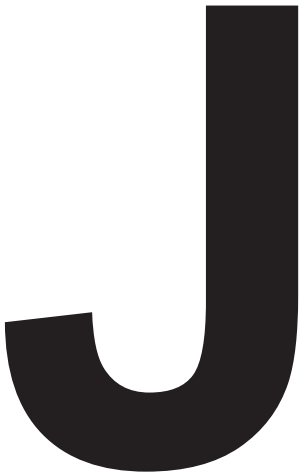

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