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# AS FURTHER MATHEMATICS

Paper 2 Mechanics

Thursday 14 May 2020

Afternoon

Time allowed: 1 hour 30 minutes

#### **Materials**

- You must have the AQA formulae and statistical tables booklet for A-level Mathematics and A-level Further Mathematics.
- You should have a scientific calculator that meets the requirements of the specification. (You may use a graphical calculator.)
- You must ensure you have the other optional Question Paper/Answer Book for which you are entered (either Discrete or Statistics). You will have 1 hour 30 minutes to complete both papers.

#### **Instructions**

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer each question in the space provided for that question.
   If you require extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do **not** write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 40.

#### Advice

- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

For Examiner's Use	
Question	Mark
1	
2	
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7	
8	
TOTAL	



Answer all questions in the spaces provided.

## 1 In this question use $g = 10 \,\mathrm{m\,s^{-2}}$

A particle of mass  $2 \, \text{kg}$  is attached to one end of a light elastic string of natural length 0.5 metres and modulus of elasticity  $100 \, \text{N}$ . The other end of the string is attached to the point O.

Find the extension of the elastic string when the particle hangs in equilibrium vertically below *O*.

Circle your answer.

[1 mark]

0.01 m

 $0.1 \, \text{m}$ 

 $0.2 \, \text{m}$ 

0.4 m

**2** An object moves under the action of a single force F newtons.

It is given that  $F = 6x^2$ , where x represents the displacement in metres from the initial position of the object.

Find the work done by F in moving the object from x = 1 to x = 2

Circle your answer.

[1 mark]

12 J

14 J

18 J

42 J



3	The time taken for the moon to make one complete orbit around Earth is approximately 27.3 days.
	Model this orbit as circular, with a radius of $3.84\times10^8$ metres.
	Find the approximate speed of the moon relative to Earth, in metres per second.  [3 marks]

Turn over for the next question

4	A particle $P$ , of mass $m$ kg, collides with a particle $Q$ , of mass $2 \text{ kg}$
	Immediately before the collision the velocity of $P$ is $\begin{bmatrix} 4 \\ -2 \end{bmatrix}$ m s <sup>-1</sup> and the velocity of $Q$ is $\begin{bmatrix} -3 \\ 5 \end{bmatrix}$ m s <sup>-1</sup>
	As a result of the collision the particles coalesce into a single particle which moves with velocity $\begin{bmatrix} k \\ 0 \end{bmatrix}$ m s <sup>-1</sup> , where $k$ is a constant.
	Find the value of $k$ . [4 marks]



A train consisting of an engine and eight carriages moves on a straight horizontal track.	
A constant resistive force of 2400 N acts on the engine.	
A constant resistive force of 300 N acts on each of the eight carriages.	
The maximum speed of the train on the track is $120\mathrm{km}\mathrm{h}^{-1}$	
Find the maximum power output of the engine.	
Fully justify your answer.	re
	[5 marks]
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6	The magnitude of the gravitational force $F$ between two planets of masses $m_1$ and $m_2$ with centres at a distance $d$ apart is given by
	$F = \frac{Gm_1m_2}{d^2}$
	where $G$ is a constant.
6 (a)	Show that $G$ must have dimensions $L^3M^{-1}T^{-2}$ , where $L$ represents length, $M$ represents mass and $T$ represents time. [2 marks]



6 (b)	The lifetime $t$ of a planet is thought to depend on its mass $m$ , its radius $r$ , the constant $G$ and a dimensionless constant $k$ such that
	$t = km^a r^b G^c$
	where $a$ , $b$ and $c$ are constants.
	Determine the values of $a,b$ and $c.$ [3 marks]



7	In this question use $g=9.8\mathrm{ms^{-2}}$
	As part of a competition, Jo-Jo makes a small pop-up rocket.
	It is operated by pressing the rocket vertically downwards to compress a light spring, which is positioned underneath the rocket.
	The rocket is released from rest and moves vertically upwards.
	The mass of the rocket is 18 grams and the stiffness constant of the spring is $60\mathrm{N}\mathrm{m}^{-1}$
	Initially the spring is compressed by 3 cm
7 (a)	Find the speed of the rocket when the spring first reaches its natural length.  [4 marks]
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7 (b)	By considering energy find the distance that the rocket rises.  [2 marks]
7 (c)	In order to win a prize in the competition, the rocket must reach a point which is 15 cm vertically above its starting position.
	With reference to the assumptions you have made, determine if Jo-Jo wins a prize or not.
	Fully justify your answer.  [3 marks]



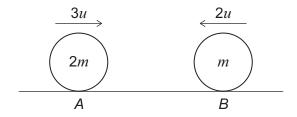
**8** Two smooth spheres *A* and *B* have the same radius and are free to move on a smooth horizontal surface.

The masses of A and B are 2m and m respectively.

Both A and B are initially at rest.

The sphere A is set in motion directly towards B with speed 3u and at the same time B is set in motion directly towards A with speed 2u.

Subsequently A and B collide directly.



The coefficient of restitution between the spheres is e.

**8 (a)** Show that the speed of *B* after the collision is given by

$$\frac{2u(2+5e)}{3}$$

[4 marks]

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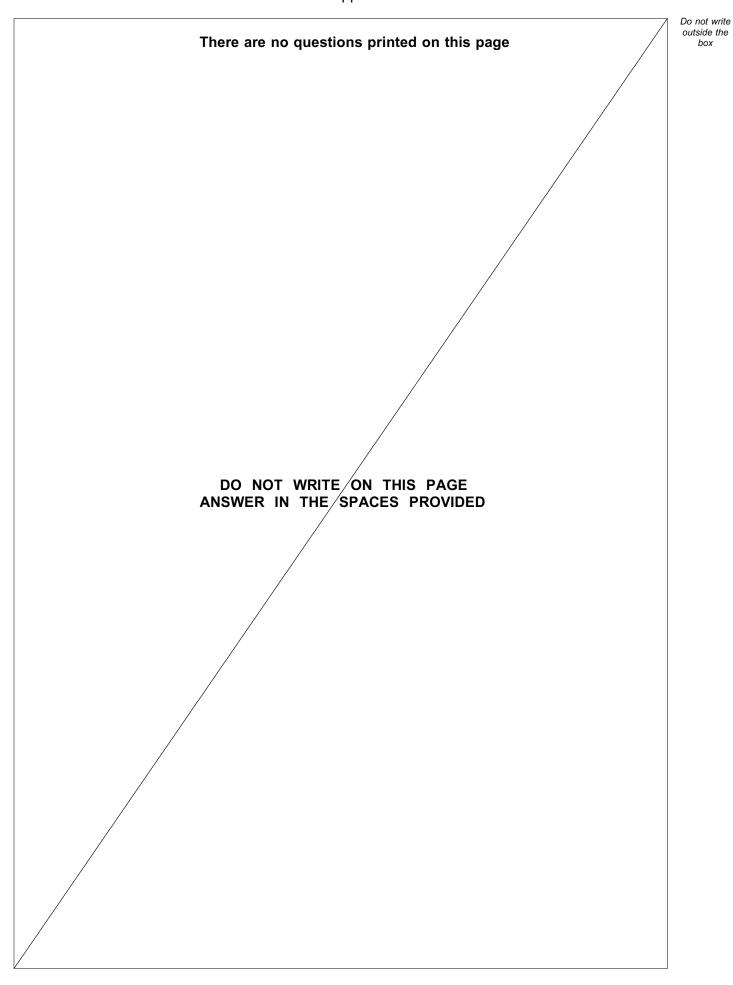


Fully justify your answer.	_
	[4



8 (c)	Given that the magnitude of the impulse that $A$ exerts on $B$ is $\frac{19mu}{3}$ , find value of $e$ .	the
	value of c.	[4 marks]
	END OF QUESTIONS	







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