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AQA

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I declare this is my own work.

AS

FURTHER MATHEMATICS

Paper 2 Mechanics

7366/2M

Thursday 14 May 2020 Afternoon

Time allowed: 1 hour 30 minutes

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

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For this paper 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.**
- **Answer ALL questions.**
- **You must answer each question in the space provided for that question.**
- **Do NOT write on blank pages.**
- **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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

Answer ALL questions in the spaces provided.

1 **IN THIS QUESTION USE $g = 10\,\text{m s}^{-2}$**

A particle of mass 2 kg is attached to one end of a light elastic string of natural length 0.5 metres and modulus of elasticity 100 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 m** **0.2 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 3.84×10^8 metres.

Find the approximate speed of the moon relative to Earth, in metres per second.
[3 marks]

[Turn over]

4 A particle P, of mass m kg, collides with a particle Q, of mass 2 kg

Immediately before the collision the velocity of P is $\begin{bmatrix} 4 \\ -2 \end{bmatrix}$ m s^{-1} and the velocity of Q is $\begin{bmatrix} -3 \\ 5 \end{bmatrix}$ m s^{-1}

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^{-1}, where k is a constant.

Find the value of k. [4 marks]

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5 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 km h^{-1}

Find the maximum power output of the engine.

Fully justify your answer. [5 marks]

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]

[Turn over]

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 $g = 9.8\,\text{m s}^{-2}$**

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 $60\,\text{N m}^{-1}$

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]**

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]

[Turn over]

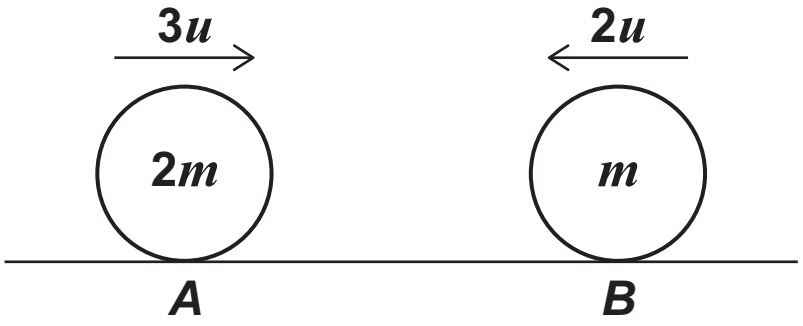
8 Two smooth spheres *A* and *B* have the same radius and are free to move on a smooth horizontal surface.

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]

[Turn over]

8 (b) **Given that the direction of the velocity of *A* is reversed during the collision, find the range of possible values of e.**

Fully justify your answer. [4 marks]

8 (c) Given that the magnitude of the impulse that *A* exerts on *B* is $\frac{19mu}{3}$, find the value of e.

[4 marks]

END OF QUESTIONS

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For Examiner's Use	
Question	Mark
1	
2	
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TOTAL	