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MATHEMATICS

9709/04

Paper 4 Mechanics

For examination from 2020

SPECIMEN PAPER

1 hour 15 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- Where a numerical value for the acceleration due to gravity (g) is needed, use 10 ms^{-2} .

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [].

This document has **14** pages. Blank pages are indicated.

1 A particle P is projected vertically upwards with speed 20 m s^{-1} from a point on the ground.

(a) Find the greatest height above the ground reached by P . [2]

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(b) Find the total time from projection until P returns to the ground. [2]

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2 A constant resistance of magnitude 1350 N acts on a car of mass 1200 kg.

(a) The car is moving along a straight level road at a constant speed of 32 m s^{-1} .

Find, in kW, the rate at which the engine of the car is working. [2]

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(b) The car travels at a constant speed down a hill inclined at an angle of θ° to the horizontal, where $\sin \theta^\circ = \frac{1}{20}$, with the engine working at 31.5 kW.

Find the speed of the car. [3]

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- 3 Three small smooth spheres A , B and C of equal radii and of masses 4 kg, 2 kg and 3 kg respectively, lie in that order in a straight line on a smooth horizontal plane. Initially, B and C are at rest and A is moving towards B with speed 6 m s^{-1} . After the collision with B , sphere A continues to move in the same direction but with speed 2 m s^{-1} .

(a) Find the speed of B after this collision.

[2]

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Sphere B collides with C . In this collision these two spheres coalesce to form an object D .

(b) Find the speed of D after this collision.

[2]

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(c) Show that the total loss of kinetic energy in the system due to the two collisions is 38.4J. [2]

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A series of horizontal dotted lines for writing.

5 A car of mass 1200 kg is pulling a trailer of mass 800 kg up a hill inclined at an angle of $\sin^{-1}(0.1)$ to the horizontal. The car and the trailer are connected by a light rigid tow-bar which is parallel to the road. The driving force of the car's engine is 2500 N and the resistances to the car and trailer are 300 N and 100 N respectively.

(a) Find the acceleration of the system and the tension in the tow-bar. [4]

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- 6 A particle P moves in a straight line. The velocity $v \text{ m s}^{-1}$ at time $t \text{ s}$ is given by

$$\begin{aligned} v &= 5t(t-2) && \text{for } 0 \leq t \leq 4, \\ v &= k && \text{for } 4 \leq t \leq 14, \\ v &= 68 - 2t && \text{for } 14 \leq t \leq 20, \end{aligned}$$

where k is a constant.

- (a) Find k . [1]

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- (b) Sketch the velocity–time graph for $0 \leq t \leq 20$. [3]

- (c) Find the set of values of t for which the acceleration of P is positive. [2]

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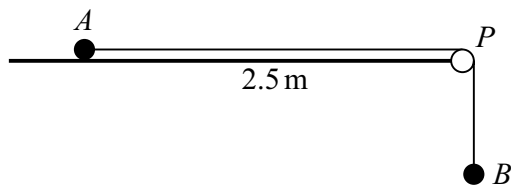
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(d) Find the total distance travelled by P in the interval $0 \leq t \leq 20$. [5]

A series of horizontal dotted lines for writing the solution to the problem.

7



Two particles A and B , of masses 0.8 kg and 0.2 kg respectively, are connected by a light inextensible string. Particle A is placed on a horizontal surface. The string passes over a small smooth pulley P fixed at the edge of the surface, and B hangs freely. The horizontal section of the string, AP , is of length 2.5 m (see diagram). The particles are released from rest with both sections of the string taut.

- (a) Given that the surface is smooth, find the time taken for A to reach the pulley. [5]

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- (b) It is given instead that the surface is rough and that the speed of A immediately before it reaches the pulley is $v \text{ m s}^{-1}$. The work done against friction as A moves from rest to the pulley is 2 J .

Use an energy method to find v .

[4]

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Additional page

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