

Candidate Name

Candidate Number

Centre Name

Centre Number

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Paper 4: Mechanics 1, Mechanics 2 and Probability and Statistics 1

For Examination December 2023

Time: 2 hours

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 spaces at the top of the page
- 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.

Information

- The Total for this paper is 90
- The number of marks for each question or part question is shown in brackets.

Section A: Mechanics

Question 1

A particle P is projected vertically upwards with speed 5 m s^{-1} from a point A which is 2.8 m above horizontal ground.

- (a)** Find the greatest height above the ground reached by P . [3]

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- (b)** Find the length of time for which P is at a height of more than 3.6 m above the ground. [4]

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Question 2

- a) A particle moves in a straight line AB . The velocity $v \text{ m s}^{-1}$ of the particle $t \text{ s}$ after leaving A is given by $v = k(t^2 - 10t + 21)$, where k is a constant. The displacement of the particle from A , in the direction towards B , is 2.85 m when $t = 3$ and is 2.4 m when $t = 6$.
- i) Find the value of k . Hence find an expression, in terms of t , for the displacement of the particle from A .
- [7]

[illegible]

Question 3

The points A and B lie 50m apart on horizontal ground.

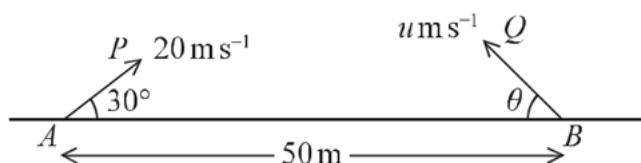
At time $t = 0$, two small balls, P and Q, are projected in the vertical plane containing AB.

Ball P is projected from A with speed 20 ms^{-1} at 30° to AB.

Ball Q is projected from B with speed $u \text{ ms}^{-1}$ at angle θ to BA, as shown in the figure below.

At $t = 2$ seconds, P and Q collide.

Until they collide, the balls are modelled as particles moving freely under gravity.



Figure

- (a) Find the velocity of P at the instant before it collides with Q.

[6]

[illegible]

(b) Find:

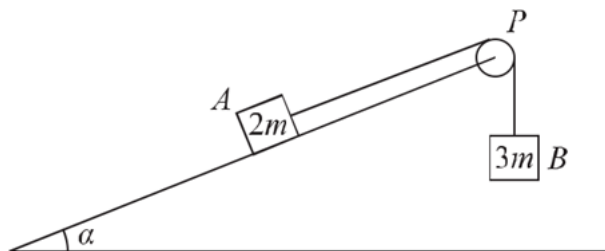
[6]

- The size of angle θ
- The value of u .

[illegible]

Question 4

Two blocks, A and B, of masses $2m$ and $3m$ respectively, are attached to the ends of a light string. Initially A is held at rest on a fixed rough plane.



The plane is inclined at angle α to the horizontal ground, where $\tan \alpha = \frac{5}{12}$

The string passes over a small smooth pulley, P, fixed at the top of the plane.

The part of the string from A to P is parallel to a line of greatest slope of the plane.

Block B hangs freely below P, as shown in the figure.

The coefficient of friction between A and the plane is $= \frac{2}{3}$.

The blocks are released from rest with the string tight and taut, leaving A to move up the plane.

The tension in the string immediately after the blocks are released is T.

(a) Show that $T = \frac{12mg}{5}$ [8]

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(b) After B reaches the ground, A continues to move up the plane until it comes to rest before reaching P.

Determine whether A will remain at rest, justify your answer. [2]

[illegible]

Section B – Statistics and Probability

Question 5

1 The score when two fair six-sided dice are thrown is the sum of the two numbers on the upper faces.

(a) Show that the probability that the score is 4 is $\frac{1}{12}$. [1]

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The two dice are thrown repeatedly until a score of 4 is obtained. The number of throws taken is denoted by the random variable X .

(b) Find the mean of X . [1]

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(c) Find the probability that a score of 4 is first obtained on the 6th throw. [1]

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(d) Find $P(X < 8)$. [2]

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Question 6

- (a) Find the number of different arrangements that can be made from the 9 letters of the word JEWELLERY in which the three Es are together and the two Ls are together. [2]

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- (b) Find the number of different arrangements that can be made from the 9 letters of the word JEWELLERY in which the two Ls are not next to each other. [4]

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Question 7

A company produces small boxes of sweets that contain 5 jellies and 3 chocolates. Jemeel chooses 3 sweets at random from a box.

- (a)** Draw up the probability distribution table for the number of jellies that Jemeel chooses. [4]

[illegible]

(b) Find the probability that no more than 7 of these boxes contain more jellies than chocolates. [3]

This image shows a full page of a blank sheet of white paper. It features approximately 20 horizontal dotted lines spaced evenly apart, providing a guide for handwriting practice. The lines extend across the entire width of the page, leaving a small margin at the top and bottom. There are no other markings, text, or illustrations on the page.

Question 8

In a music competition, there are 8 pianists, 4 guitarists and 6 violinists. 7 of these musicians will be selected to go through to the final.

How many different selections of 7 finalists can be made if there must be at least 2 pianists, at least 1 guitarist and more violinists than guitarists? [4]

This image shows a single page of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Question 9

On Mondays, Rani cooks her evening meal. She has a pizza, a burger or a curry with probabilities 0.35, 0.44, 0.21 respectively. When she cooks a pizza, Rani has some fruit with probability 0.3. When she cooks a burger, she has some fruit with probability 0.8. When she cooks a curry, she never has any fruit.

(a) Draw a fully labelled tree diagram to represent this information.

[2]

(b) Find the probability that Rani has some fruit.

[2]

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(c) Find the probability that Rani does not have a burger given that she does not have any fruit. [4]

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Question 10

The lengths of female snakes of a particular species are normally distributed with mean 54 cm and standard deviation 6.1 cm.

- (a) Find the probability that a randomly chosen female snake of this species has length between 50 cm and 60 cm. [4]

[illegible]

The lengths of male snakes of this species also have a normal distribution. A scientist measures the lengths of a random sample of 200 male snakes of this species. He finds that 32 have lengths less than 45 cm and 17 have lengths more than 56 cm.

(b) Find estimates for the mean and standard deviation of the lengths of male snakes of this species. [5]

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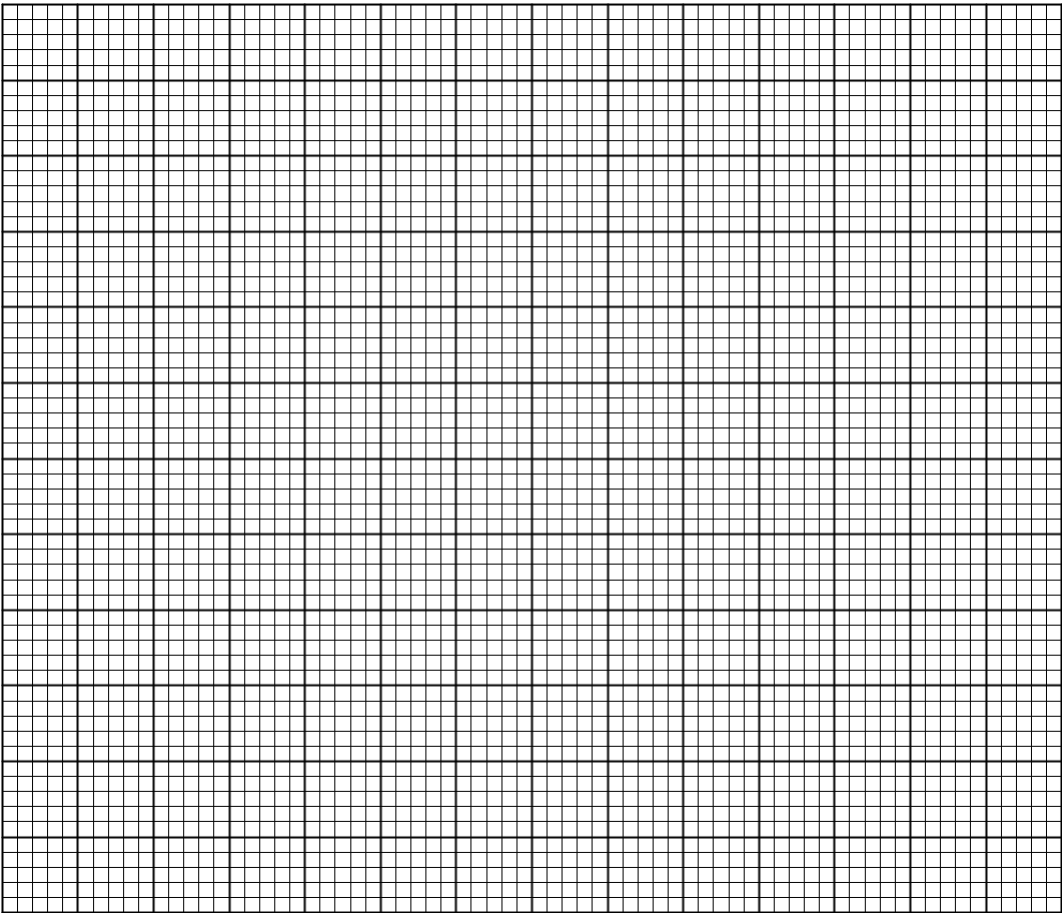
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Question 11

The numbers of chocolate bars sold per day in a cinema over a period of 100 days are summarised in the following table.

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|-------------------------------|------|-------|-------|-------|-------|
| Number of chocolate bars sold | 1–10 | 11–15 | 16–30 | 31–50 | 51–60 |
| Number of days | 18 | 24 | 30 | 20 | 8 |

(a) Draw a histogram to represent this information. [5]



(b) What is the greatest possible value of the interquartile range for the data? [2]

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(c) Calculate estimates of the mean and standard deviation of the number of chocolate bars sold. [4]

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End of Paper