

PLUMI PRACTICE PACK

Plumi Practice Pack: A Level Mathematics (Edexcel-style, 9MA0)

Question paper | 30 questions: Pure Mathematics, Statistics and Mechanics

Name	Class	Date
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You must have:

Mathematical Formulae and Statistical Tables, calculator

Suggested time: about 6 hours, in three sittings (one per section)

Total marks

298

Instructions

- Use black ink or ball-point pen. If pencil is used for diagrams, sketches or graphs it must be dark (HB or B).
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided.
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.
- Unless otherwise indicated, whenever a value of g is required, take $g = 9.8 \text{ m s}^{-2}$ and give your answer to either 2 significant figures or 3 significant figures.

Information

- There are 30 questions in this pack, in three sections. The total mark is 298.
- The marks for **each** question are shown in brackets: use this as a guide as to how much time to spend on each question.
- Questions get harder through each section; the last three in each section are challenge questions in the style of the final questions on a paper.

Section	Questions	Marks
A: Pure Mathematics	1 to 10	106
B: Statistics	11 to 20	95
C: Mechanics	21 to 30	97

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.



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Practise questions like these on iPad: Plumi marks your handwritten answers against each question's own mark scheme.

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SECTION A: PURE MATHEMATICS

1. Using the laws of logarithms, solve the equation

$$2 \log_3 x - \log_3(x - 2) = 2$$

(5)

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(Total for Question 1 is 5 marks)

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2. Figure 1 shows a sketch of part of the curve with equation $y = (x - 1)\sqrt{x + 2}$, $x \geq -2$. The curve meets the x -axis at the points where $x = -2$ and $x = 1$

The region R , shown shaded in Figure 1, is bounded by the curve, the x -axis and the lines with equations $x = 7$ and $x = 14$

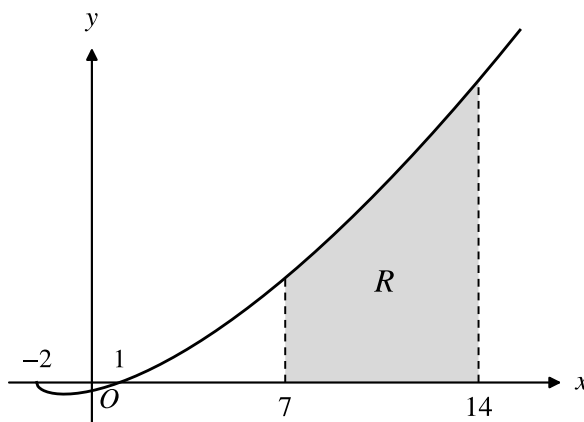


Figure 1

- (a) Use the substitution $u = \sqrt{x + 2}$ to show that

$$\int_7^{14} (x - 1)\sqrt{x + 2} \, dx = \int_3^4 (2u^4 - 6u^2) \, du \quad (4)$$

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- (b) Hence find the exact area of R .

Solutions relying entirely on calculator technology are not acceptable. (4)

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Question 2 continued

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(Total for Question 2 is 8 marks)

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3. $f(x) = x^2 - 2 \ln x - 3, \quad x > 0$

Figure 2 shows a sketch of part of the curve with equation $y = f(x)$. The equation $f(x) = 0$ has two roots. The larger root, α , is shown in Figure 2.

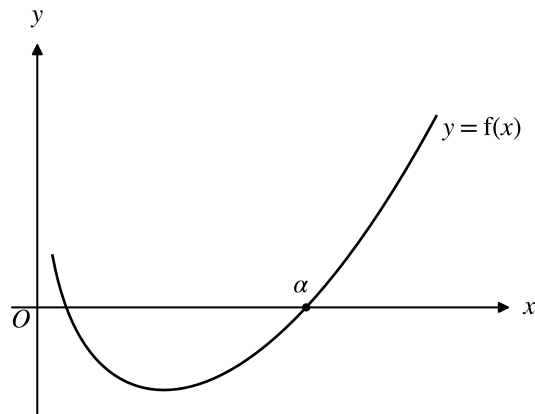


Figure 2

- (a) Show that the equation $f(x) = 0$ has a root in the interval $[2, 3]$ (2)

- (b) Taking $x_0 = 2$ as a first approximation to α , apply the Newton-Raphson method once to $f(x)$ to obtain a second approximation to α . Show your method and give your answer to 3 decimal places. (3)

[illegible]

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Question 3 continued

- (c) Explain why $x_0 = 1$ cannot be used as a first approximation when applying the Newton-Raphson method to $f(x)$ (2)

- (d) By choosing a suitable interval, show that $\alpha = 2.123$ correct to 3 decimal places. (2)

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(Total for Question 3 is 9 marks)

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4. The temperature, H °C, inside a greenhouse is modelled by the equation

$$H = 18 + 7 \sin(15t)^\circ - 4 \cos(15t)^\circ, \quad 0 \leq t < 24$$

where t is the time in hours after midnight.

Figure 3 shows a sketch of the graph of H against t , together with the line $H = 20$, which meets the graph at the points P and Q .

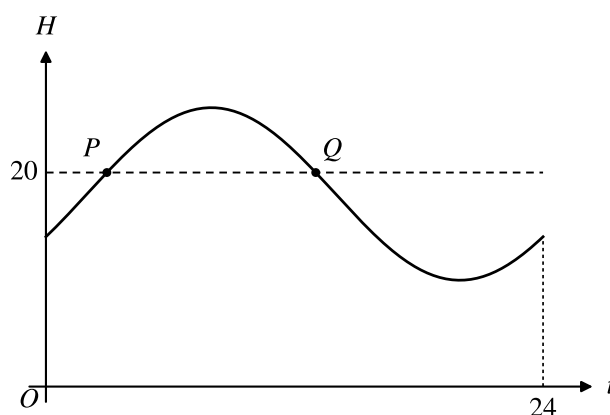


Figure 3

- (a) Express $7 \sin x - 4 \cos x$ in the form $R \sin(x - \alpha)$, where $R > 0$ and $0 < \alpha < 90^\circ$. Give the exact value of R and give the value of α , in degrees, to 2 decimal places. (3)

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- (b) Find the exact maximum temperature predicted by the model, and the value of t , to 2 decimal places, at which this maximum occurs. (4)

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Question 4 continued

- (c) The vents of the greenhouse are open whenever the temperature is at least 20°C . Using your answer to part (a), find the interval of values of t , to 2 decimal places, during which the vents are open.

Solutions relying entirely on calculator technology are not acceptable.

(4)

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(Total for Question 4 is 11 marks)

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5. A hemispherical bowl has radius 10 cm. Water is poured into the bowl at a constant rate of 50 cm^3 per second.

Figure 4 shows a vertical cross-section through the centre of the bowl when the depth of the water is h cm, where $0 < h \leq 10$

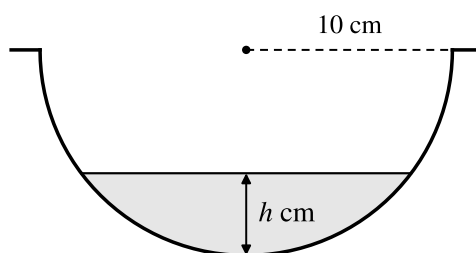


Diagram NOT accurately drawn

Figure 4

The volume, $V \text{ cm}^3$, of water in the bowl is given by

$$V = \frac{\pi}{3}h^2(30 - h)$$

- (a) Show that the area, $A \text{ cm}^2$, of the surface of the water is given by $A = \pi h(20 - h)$ (2)

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- (b) Show that $\frac{dV}{dh} = A$ (2)

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- (c) Find the rate at which the depth of the water is increasing at the instant when $h = 4$, giving your answer to 3 significant figures. (3)

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Question 5 continued

- (d) Find the exact depth of the water at the instant when the area of the surface of the water is increasing at a rate of 5 cm^2 per second.

(4)

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(Total for Question 5 is 11 marks)

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6. The curve C has parametric equations

$$x = t^2, \quad y = 9t - t^3, \quad 0 \leq t \leq 3$$

The curve meets the x -axis at the points where $t = 0$ and $t = 3$. The point P on C has parameter $t = 2$. The line l is the tangent to C at P and l meets the x -axis at the point Q .

The finite region S , shown shaded in Figure 5, is bounded by C , l and the x -axis.

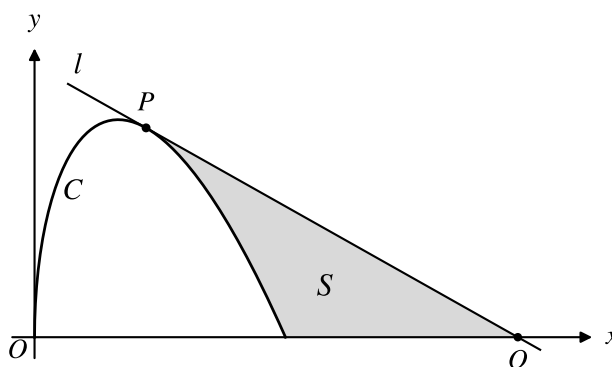


Figure 5

- (a) Show that l has equation $3x + 4y - 52 = 0$ (3)

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- (b) Show that a Cartesian equation of C is $y = \sqrt{x}(9 - x)$, $0 \leq x \leq 9$ (2)

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Question 6 continued

- (c) Use calculus to find the exact area of S .

Solutions relying entirely on calculator technology are not acceptable.

(6)

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(Total for Question 6 is 11 marks)

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where k is a positive constant.

(a) Express $\frac{1}{x(6-x)}$ in partial fractions. (2)

(a) Express $\frac{1}{x(6-x)}$ in partial fractions. (2)

- $$x = \frac{6}{1 + 5 \left(\frac{2}{5}\right)^t} \quad (6)$$

$$x = \frac{6}{1 + 5 \left(\frac{2}{5}\right)^t} \quad (6)$$

Question 7 continued

- (c) Find, according to the model, the time after the launch at which the number of people playing the game is increasing most rapidly. Give your answer to the nearest day. (4)

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(Total for Question 7 is 12 marks)

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8. Figure 6 shows a sketch of part of the curve C with equation

$$y = x^2 e^{-kx}, \quad x \geq 0$$

where k is a positive constant.

The straight line l passes through the origin O and touches C at the point A , where $x > 0$

The finite region R , shown shaded in Figure 6, is bounded by C and l . The area of R is $\frac{11 - 4e}{16e}$

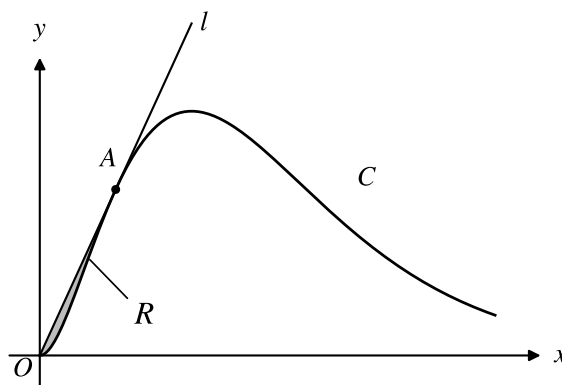


Figure 6

In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.

Find the value of k .

(13)

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Question 8 continued

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(Total for Question 8 is 13 marks)

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9. A container is in the shape of a right circular cone of height 40 cm and base radius 20 cm. The container is held with its axis vertical and its vertex V at the bottom, as shown in Figure 7.

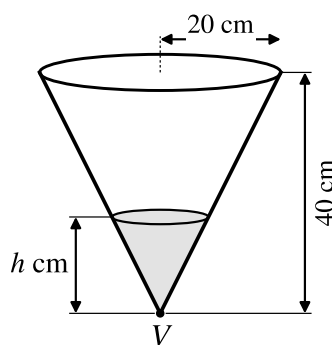


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Figure 7

Water leaks out through a small hole at V . At time t minutes the depth of the water is h cm and the volume of the water is decreasing at a rate proportional to $\sqrt{h}$

[The volume of a cone of base radius r and height H is $\frac{1}{3}\pi r^2 H$]

- (a) Show that

$$\frac{dh}{dt} = -\lambda h^n$$

where λ is a positive constant and n is a constant to be found.

(5)

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Question 9 continued

Initially the depth of the water is 16 cm. After 10 minutes the depth of the water is 9 cm.

- (b) Find, according to the model, the total time taken for the container to empty, from the start. Give your answer in minutes and seconds, to the nearest second. **(6)**

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- (c) With reference to the differential equation, give one criticism of the model as h approaches 0 **(1)**

(Total for Question 9 is 12 marks)

Turn over ►



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10. (a) Prove that

$$\cos 3\theta \equiv 4 \cos^3 \theta - 3 \cos \theta \quad (3)$$

(b) Hence, using the substitution $x = 2 \cos \theta$, where $0 \leq \theta \leq 180^\circ$, solve the equation

$$x^3 - 3x - 1 = 0$$

giving each answer to 3 decimal places. Explain why the equation has no other solutions.

Solutions relying entirely on calculator technology are not acceptable. (5)

Turn over ►



Question 10 continued

(c) Hence prove that

$$\cos 20^\circ \cos 40^\circ \cos 80^\circ = \frac{1}{8} \quad (3)$$

(d) Find the exact value of

$$\cos^2 20^\circ + \cos^2 40^\circ + \cos^2 80^\circ \quad (3)$$

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(Total for Question 10 is 14 marks)

TOTAL FOR SECTION A IS 106 MARKS

Turn over ►



12. The lengths, L cm, of fish of one species in a lake are modelled by a normal distribution with mean μ cm and standard deviation σ cm.

It is found that $P(L < 30) = 0.15$ and $P(L > 48) = 0.1$, as shown by the two shaded regions in Figure 8.

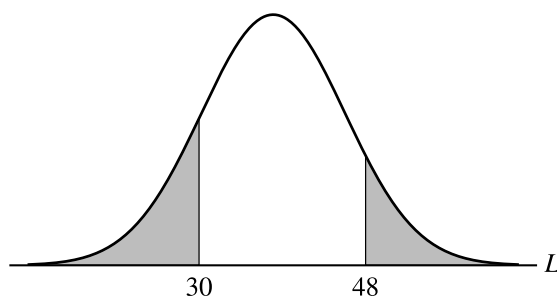


Figure 8

- (a) Find the value of μ and the value of σ . (5)

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- (b) Find $P(35 < L < 45)$ (2)

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Question 12 continued

- (c) Two fish are chosen at random, independently. Find the probability that both have lengths between 35 cm and 45 cm. (2)

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(Total for Question 12 is 9 marks)**Turn over ►**

Question 13 continued

In Lucy's sample, 25 of the 40 players complete the first level at their first attempt.

- (e) With reference to your critical region, state, giving a reason, whether or not there is evidence to reject the designer's claim. (2)

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(Total for Question 13 is 9 marks)

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14. A biologist grows a culture of bacteria. She records the number of bacteria, N , in the culture at time t hours, over a period of 12 hours.

She codes the data using $y = \log_{10} N$ and finds that the equation of the regression line of y on t is

$$y = 2.15 + 0.0792t$$

- (a) Show that this relationship can be written in the form $N = ab^t$ and find the value of a and the value of b , giving each to 3 significant figures. (3)

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- (b) Interpret the value of b in this context. (1)

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The biologist believes that an antibiotic makes the number of these bacteria decrease over time. She treats a second culture with the antibiotic and measures N on 9 occasions. For these 9 occasions, the product moment correlation coefficient between t and $\log_{10} N$ is -0.6013

- (c) Test, at the 5% level of significance, whether there is evidence to support the biologist's belief. State your hypotheses clearly and the critical value used. (3)

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(Total for Question 14 is 7 marks)

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15. The Venn diagram in Figure 9 shows the probabilities associated with three events A , B and C . The events A and C are mutually exclusive. The values p , q and r are probabilities.

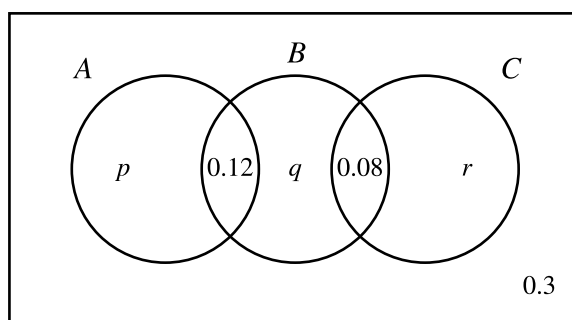


Figure 9

The events A and B are independent, $P(B | C) = 0.5$ and $P(A) < P(B)$

- (a) Find the value of r .

(2)

- (b) Find the value of p and the value of q .

(5)

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Question 15 continued

(c) Find $P(A \mid B \cup C)$

(2)

(d) Determine, giving a reason, whether or not the events B and C are independent.

(2)

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(Total for Question 15 is 11 marks)

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16. The time, X minutes, taken by adults to complete a particular puzzle is normally distributed with mean 24 minutes. 2.5% of adults take more than 32.82 minutes to complete the puzzle.

A new set of instructions is written for the puzzle. The designer believes that the new instructions will reduce the mean time taken. A random sample of 20 adults using the new instructions is taken and their times, y minutes, give $\sum y = 442$

You may assume that the times taken using the new instructions are normally distributed with the same standard deviation as X .

- (a) Using a 5% level of significance, test whether there is evidence to support the designer's belief. State your hypotheses clearly.

(7)

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Question 16 continued

The test is to be repeated at the 1% level of significance using a larger random sample. Assume that the sample mean is again 22.1 minutes.

- (b) Find the smallest sample size for which the null hypothesis would be rejected. **(3)**

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(Total for Question 16 is 10 marks)

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17. The lifetime, L hours, of a particular type of battery is modelled by a normal distribution with mean μ hours and standard deviation σ hours.

The interquartile range of L is 12 hours, and 10% of these batteries have a lifetime of less than 32 hours.

- (a) Find the value of σ and the value of μ . (5)

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The batteries are sold in packs of 8. A pack may be regarded as a random sample of 8 batteries. The manufacturer wants to state a whole number of hours, h , as large as possible, such that the probability that all 8 batteries in a pack have a lifetime of at least h hours is at least 0.9

- (b) Find the value of h . (5)

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(Total for Question 17 is 10 marks)

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18. The lengths, L mm, of bolts made by a machine are normally distributed with standard deviation 0.8 mm. The mean length, μ mm, of bolts made t hours after the machine is switched on is modelled by

$$\mu = 50 + 0.2t - 0.02t^2, \quad 0 \leq t \leq 8$$

A bolt is rejected if its length is more than 51.5 mm.

- (a) Find, according to the model, the greatest proportion of bolts that are rejected during the 8 hours. (3)

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A random sample of 50 bolts made 5 hours after the machine is switched on contains 10 rejected bolts.

- (b) Test, at the 5% level of significance, whether there is evidence that the proportion of bolts rejected at this time is greater than the model predicts. State your hypotheses clearly. (4)

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Question 18 continued

- (c) Find, according to the model, the total time during the 8 hours for which more than 5% of the bolts made are rejected.

(5)

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(Total for Question 18 is 12 marks)

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19. A factory has two machines, A and B , which make metal rods. Machine A makes a proportion q of the rods and machine B makes the rest.

The lengths of rods made by machine A are normally distributed with mean 20.0 cm and standard deviation 0.15 cm. The lengths of rods made by machine B are normally distributed with mean 20.1 cm and standard deviation 0.2 cm.

A rod is defective if its length is more than 20.3 cm. Of all the defective rods made by the factory, 80% are made by machine B .

- (a) Find the value of q . (5)

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The mean length of rods made by machine B is adjusted. Its standard deviation is unchanged, machine A is not changed and the value of q is unchanged. After the adjustment, the proportion of all the factory's rods that are defective is half of its previous value.

- (b) Find the new mean length of rods made by machine B . (6)

Turn over ►



Question 19 continued

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(Total for Question 19 is 11 marks)

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20. The score, X , on a spinner has the probability distribution shown in the table, where k is a constant.

x	1	2	3	6
$P(X = x)$	k	$\frac{k}{2}$	$\frac{k}{3}$	$\frac{k}{6}$

In a game, a player spins the spinner twice and adds the two scores. The player wins the game if the total is more than 6

Sam believes that he wins the game more often than this model predicts. He plays the game n times and wins 11 times.

- (a) Find the largest value of n for which Sam's results would provide evidence, at the 5% level of significance, to support his belief. State your hypotheses clearly. (9)

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Question 20 continued

- (b) Sam's friend also wins 11 games but plays fewer games than the value of n found in part (a). Without further calculation, explain whether or not her results provide evidence, at the 5% level of significance, that she wins more often than the model predicts. (2)

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(Total for Question 20 is 11 marks)

TOTAL FOR SECTION B IS 95 MARKS

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22. A small stone is projected vertically upwards with speed 7 m s^{-1} from a point A , just beyond the edge of a bridge. The point A is 23.1 m vertically above the surface of the water in a river.

The stone moves freely under gravity and falls into the water without hitting the bridge. The stone is modelled as a particle.

- (a) Find the greatest height above the water reached by the stone. (3)

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- (b) Find the time taken for the stone to travel from A to the water. (3)

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- (c) Find the speed of the stone at the instant it reaches the water. (2)

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(Total for Question 22 is 8 marks)

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23. Figure 10 shows a van of mass 2400 kg towing a trailer of mass 600 kg along a straight horizontal road. The van is joined to the trailer by a tow bar, which is horizontal and parallel to the direction of motion.

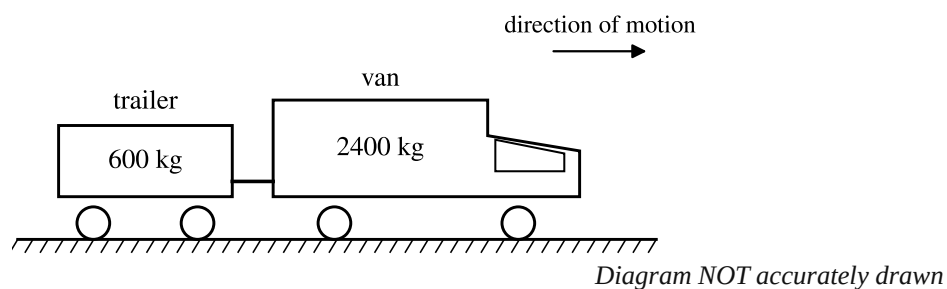


Figure 10

The van and the trailer are modelled as particles and the tow bar is modelled as a light rigid rod. While the van is moving, the driver applies the brakes and the engine produces no driving force. The van is then subject to a braking force of constant magnitude 8200 N. The resistances to the motion of the van and the trailer are modelled as constant forces of magnitude 600 N and 200 N respectively. The trailer has no brakes.

- (a) Find the deceleration of the van and the trailer while the van is braking. (2)

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- (b) Find the force in the tow bar while the van is braking, stating whether it is a tension or a thrust. (4)

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Question 23 continued

- (c) State the magnitude and the direction of the force exerted on the van by the tow bar while the van is braking. (1)

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(Total for Question 23 is 7 marks)

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Question 24 continued

- (c) State how you have used the modelling assumption that the man is a particle. (1)

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(Total for Question 24 is 7 marks)

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25. In this question take $g = 9.8 \text{ m s}^{-2}$. Give each answer to 2 or 3 significant figures.

Figure 12 shows a box of mass 12 kg being pulled up a rough slope by a rope. The slope is a plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$

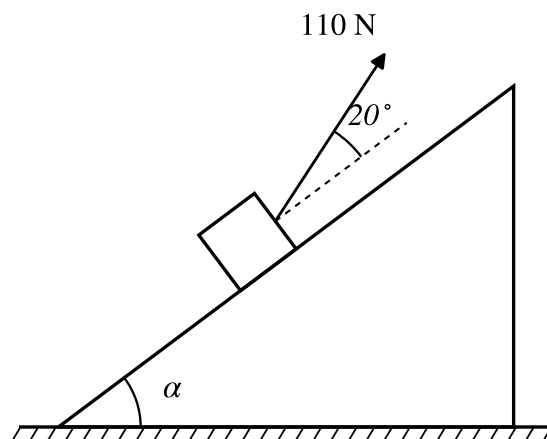


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Figure 12

The rope is inclined at 20° to a line of greatest slope, as shown in Figure 12, and lies in the vertical plane containing that line of greatest slope.

The coefficient of friction between the box and the slope is 0.3 . The box is modelled as a particle and the rope is modelled as light.

The tension in the rope is 110 N and the box moves up the slope.

- (a) Find the magnitude of the normal reaction between the box and the slope. (3)

- (b) Find the acceleration of the box. (4)

Turn over ►

Question 25 continued

- (c) Later, while the box is moving up the slope, the tension in the rope is reduced to P newtons, with the rope at the same angle to the slope. The box then moves up the slope at constant speed.
Find the value of P .

(3)

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(Total for Question 25 is 10 marks)

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26. Figure 13 shows a particle A , of mass km , on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$

Particle A is attached to one end of a light inextensible string which passes over a small smooth pulley P fixed at the top of the plane. The other end of the string is attached to a particle B , of mass m , which hangs freely below P . The part of the string between A and P lies along a line of greatest slope of the plane.

The coefficient of friction between A and the plane is μ .

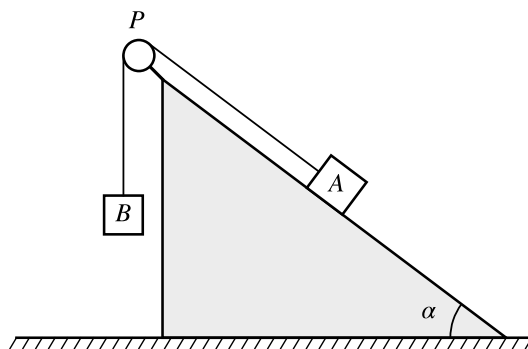


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Figure 13

- (a) Given that A is in equilibrium and on the point of moving up the plane, show that

$$\mu = \frac{5 - 3k}{4k} \quad (4)$$

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Question 26 continued

- (b) Given now that $\mu = \frac{1}{2}$ and that the system is in equilibrium, find the set of possible values of k . (4)

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- (c) Given instead that $\mu = \frac{1}{2}$ and $k = 6$, and that the system is released from rest with the string taut, find, in terms of g , the magnitude of the acceleration of B . (3)

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(Total for Question 26 is 11 marks)

Turn over ►



27. In this question take $g = 9.8 \text{ m s}^{-2}$.

A ball is projected from a point O on horizontal ground with speed $U \text{ m s}^{-1}$ at an angle α above the horizontal, where $\tan \alpha = \frac{4}{3}$

The ball moves freely under gravity in a vertical plane perpendicular to a vertical wall. The wall has height 8.4 m and its base is 21 m from O . The ball must pass over the wall and then land on the ground between the wall and the point C , where $OC = 33 \text{ m}$, as shown in Figure 14.

The ball is modelled as a particle and the wall is modelled as having negligible thickness.

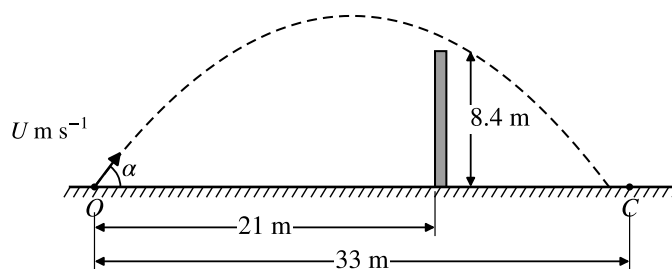


Diagram NOT accurately drawn

Figure 14

(a) Find the set of possible values of U .

(8)

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Turn over ►

Question 27 continued

(b) Given that $U = 18$, find the speed of the ball as it passes over the wall. (3)

(c) State one limitation of the model that could affect your answer to part (a). (1)

(Total for Question 27 is 12 marks)

Turn over ►



28. A ladder AB , of length 4 m and weight W , rests with its end A on rough horizontal ground and its end B against a rough vertical wall. The ladder makes an angle θ with the ground, where $\tan \theta = \frac{4}{3}$, and lies in a vertical plane perpendicular to the wall, as shown in Figure 15.

The coefficient of friction between the ladder and the ground is $\frac{1}{2}$ and the coefficient of friction between the ladder and the wall is $\frac{1}{3}$

A man of weight $3W$ climbs up the ladder from A . The ladder is modelled as a uniform rod and the man is modelled as a particle. (The man is not shown in Figure 15.)

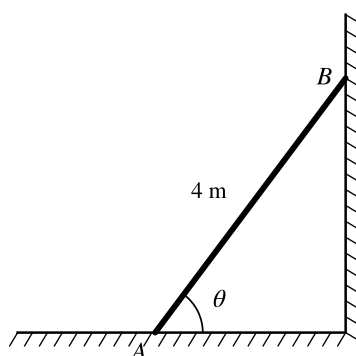


Diagram NOT accurately drawn

Figure 15

- (a) Find the greatest distance from A , measured along the ladder, that the man can climb before the ladder slips.

(9)

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Question 28 continued

- (b) The ground is now covered with a different material, so that the coefficient of friction between the ladder and the ground is μ . The wall is unchanged. Find the least value of μ for which the man can climb to the top of the ladder without it slipping. (4)

(Total for Question 28 is 13 marks)

Turn over ►



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(b) Find the total distance travelled by the robot during the 8 seconds. (4)

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Question 29 continued

- (c) The robot's battery can power at most 35 m of travel. Comment, with a reason, on whether, according to the model, the battery is sufficient for the 8 seconds of motion.

(1)**(Total for Question 29 is 11 marks)**

Turn over ►



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The system is released from rest with the string taut and A moves up the plane. B hits the floor 1 second after release and does not rebound. A then moves a further 0.4 m up the plane before coming to instantaneous rest. A does not reach the pulley.

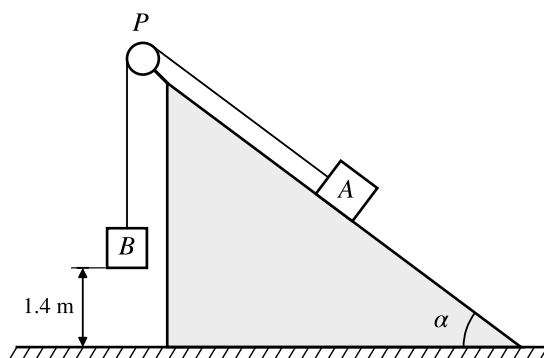


Figure 16

- (b) Find the value of M . (4)

Question 30 continued

- (c) Determine whether A remains at rest. If it does not, find the speed of A at the instant the string becomes taut again. (5)

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(Total for Question 30 is 13 marks)

TOTAL FOR SECTION C IS 97 MARKS

TOTAL FOR PAPER IS 298 MARKS

END





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