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Pearson Edexcel Level 3 GCE**Monday 18 October 2021 – Afternoon**Paper
reference**9MA0/31****Mathematics****Advanced****PAPER 31: Statistics****You must have:**

Mathematical Formulae and Statistical Tables (Green), calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Values from statistical tables should be quoted in full. If a calculator is used instead of tables the value should be given to an equivalent degree of accuracy.
- Inexact answers should be given to three significant figures unless otherwise stated.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- The total mark for this part of the examination is 50. There are 6 questions.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

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.

Turn over ►

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1. (a) State one disadvantage of using quota sampling compared with simple random sampling.

(1)

In a university 8% of students are members of the university dance club.

A random sample of 36 students is taken from the university.

The random variable X represents the number of these students who are members of the dance club.

- (b) Using a suitable model for X , find

(i) $P(X = 4)$

(ii) $P(X \geq 7)$

(3)

Only 40% of the university dance club members can dance the tango.

- (c) Find the probability that a student is a member of the university dance club and can dance the tango.

(1)

A random sample of 50 students is taken from the university.

- (d) Find the probability that fewer than 3 of these students are members of the university dance club and can dance the tango.

(2)

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2. Marc took a random sample of 16 students from a school and for each student recorded
- the number of letters, x , in their last name
 - the number of letters, y , in their first name

His results are shown in the scatter diagram on the next page.

- (a) Describe the correlation between x and y . (1)

Marc suggests that parents with long last names tend to give their children shorter first names.

- (b) Using the scatter diagram comment on Marc's suggestion, giving a reason for your answer. (1)

The results from Marc's random sample of 16 observations are given in the table below.

x	3	6	8	7	5	3	11	3	4	5	4	9	7	10	6	6
y	7	7	4	4	6	8	5	5	8	4	7	4	5	5	6	3

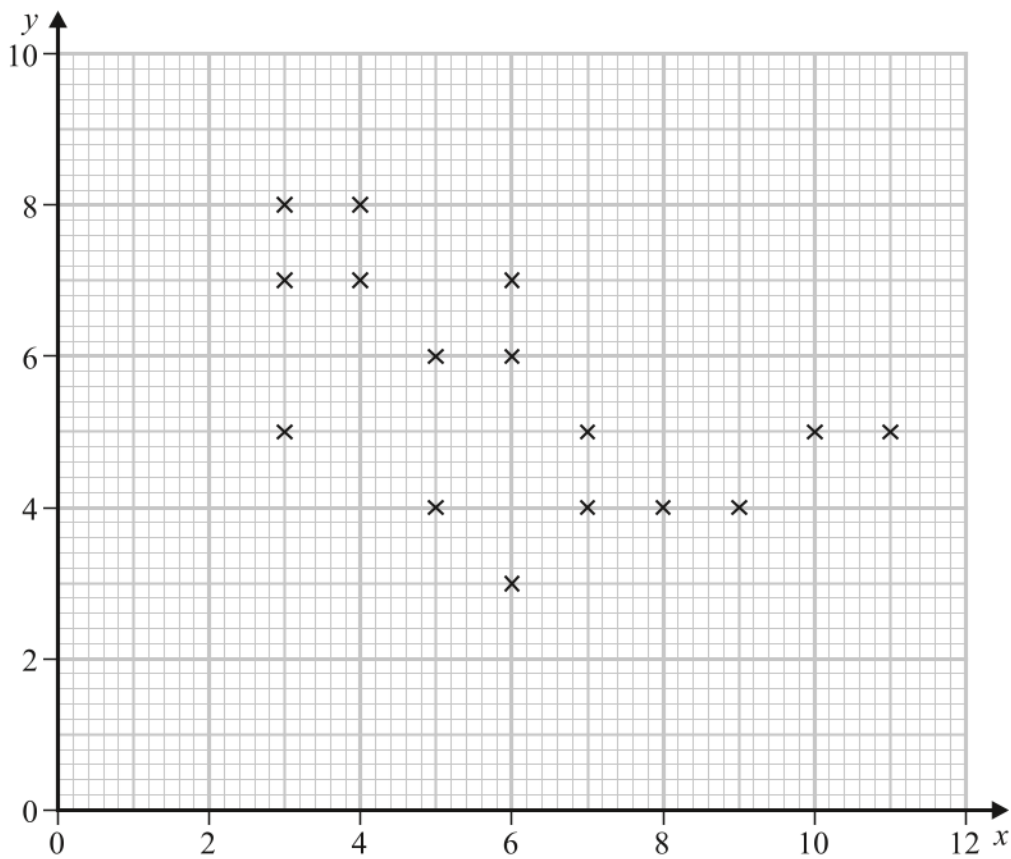
- (c) Use your calculator to find the product moment correlation coefficient between x and y for these data. (1)
- (d) Test whether or not there is evidence of a negative correlation between the number of letters in the last name and the number of letters in the first name.

You should

- state your hypotheses clearly
 - use a 5% level of significance
- (3)



Question 2 continued.



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3. Stav is studying the large data set for September 2015

He codes the variable Daily Mean Pressure, x , using the formula $y = x - 1010$

The data for all 30 days from Hurn are summarised by

$$\sum y = 214 \quad \sum y^2 = 5912$$

- (a) State the units of the variable x (1)
- (b) Find the mean Daily Mean Pressure for these 30 days. (2)
- (c) Find the standard deviation of Daily Mean Pressure for these 30 days. (3)

Stav knows that, in the UK, winds circulate

- in a **clockwise** direction around a region of **high** pressure
- in an **anticlockwise** direction around a region of **low** pressure

The table gives the Daily Mean Pressure for 3 locations from the large data set on 26/09/2015

Location	Heathrow	Hurn	Leuchars
Daily Mean Pressure	1029	1028	1028
Cardinal Wind Direction			

The Cardinal Wind Directions for these 3 locations on 26/09/2015 were, in random order,

W NE E

You may assume that these 3 locations were under a single region of pressure.

- (d) Using your knowledge of the large data set, place each of these Cardinal Wind Directions in the correct location in the table.
Give a reason for your answer. (2)



Question 3 continued.

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(Total for Question 3 is 8 marks)



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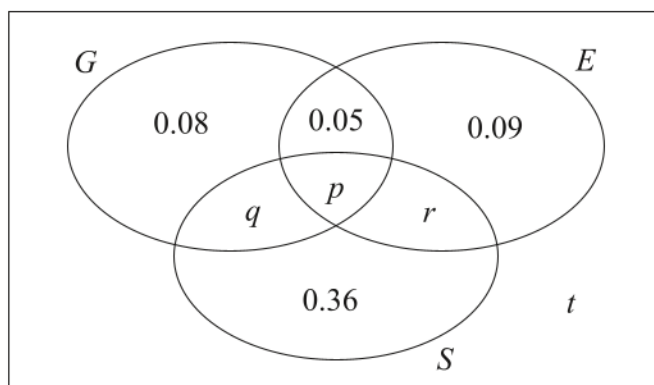
4. A large college produces three magazines. One magazine is about green issues, one is about equality and one is about sports. A student at the college is selected at random and the events G , E and S are defined as follows

G is the event that the student reads the magazine about green issues

E is the event that the student reads the magazine about equality

S is the event that the student reads the magazine about sports

The Venn diagram, where p , q , r and t are probabilities, gives the probability for each subset.



- (a) Find the proportion of students in the college who read exactly one of these magazines. (1)

No students read all three magazines and $P(G) = 0.25$

- (b) Find (3)
- (i) the value of p
 - (ii) the value of q

Given that $P(S | E) = \frac{5}{12}$

- (c) find (4)
- (i) the value of r
 - (ii) the value of t
- (d) Determine whether or not the events $(S \cap E')$ and G are independent. Show your working clearly. (3)



Question 4 continued.

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5. The heights of females from a country are normally distributed with

- a mean of 166.5 cm
- a standard deviation of 6.1 cm

Given that 1% of females from this country are shorter than k cm,

(a) find the value of k (2)

(b) Find the proportion of females from this country with heights between 150 cm and 175 cm (1)

A female, from this country, is chosen at random from those with heights between 150 cm and 175 cm

(c) Find the probability that her height is more than 160 cm (4)

The heights of females from a different country are normally distributed with a standard deviation of 7.4 cm

Mia believes that the mean height of females from this country is less than 166.5 cm

Mia takes a random sample of 50 females from this country and finds the mean of her sample is 164.6 cm

(d) Carry out a suitable test to assess Mia's belief.
 You should

- state your hypotheses clearly
- use a 5% level of significance

(4)

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Question 5 continued.

Lined area for student response.

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Question 5 continued.

Lined area for writing the answer to Question 5.

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(Total for Question 5 is 11 marks)



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6. The discrete random variable X has the following probability distribution

x	a	b	c
$P(X=x)$	$\log_{36} a$	$\log_{36} b$	$\log_{36} c$

where

- a, b and c are distinct integers ($a < b < c$)
- all the probabilities are greater than zero

(a) Find

- the value of a
- the value of b
- the value of c

Show your working clearly.

(5)

The independent random variables X_1 and X_2 each have the same distribution as X

(b) Find $P(X_1 = X_2)$

(2)

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Question 6 continued.

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Question 6 continued.

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(Total for Question 6 is 7 marks)

TOTAL FOR STATISTICS IS 50 MARKS



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- 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

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
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1. A particle P moves with constant acceleration $(2\mathbf{i} - 3\mathbf{j})\text{ms}^{-2}$

At time $t = 0$, P is moving with velocity $4\mathbf{i}\text{ms}^{-1}$

(a) Find the velocity of P at time $t = 2$ seconds.

(2)

At time $t = 0$, the position vector of P relative to a fixed origin O is $(\mathbf{i} + \mathbf{j})\text{m}$.

(b) Find the position vector of P relative to O at time $t = 3$ seconds.

(2)



Question 1 continued

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(Total for Question 1 is 4 marks)



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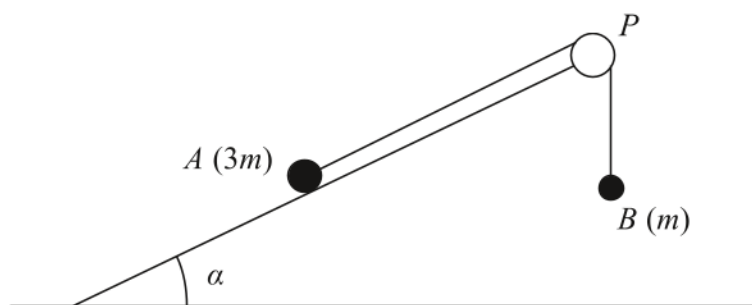


Figure 1

A small stone A of mass $3m$ is attached to one end of a string.

A small stone B of mass m is attached to the other end of the string.

Initially A is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$

The string passes over a pulley P that is 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.

Stone B hangs freely below P , as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{1}{6}$

Stone A is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before B reaches the pulley,

(a) write down an equation of motion for A (2)

(b) show that the acceleration of A is $\frac{1}{10}g$ (7)

(c) sketch a velocity-time graph for the motion of B , from the instant when A is released from rest to the instant just before B reaches the pulley, explaining your answer. (2)

In reality, the string is not light.

(d) State how this would affect the working in part (b). (1)



Question 2 continued

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Question 2 continued

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(Total for Question 2 is 12 marks)



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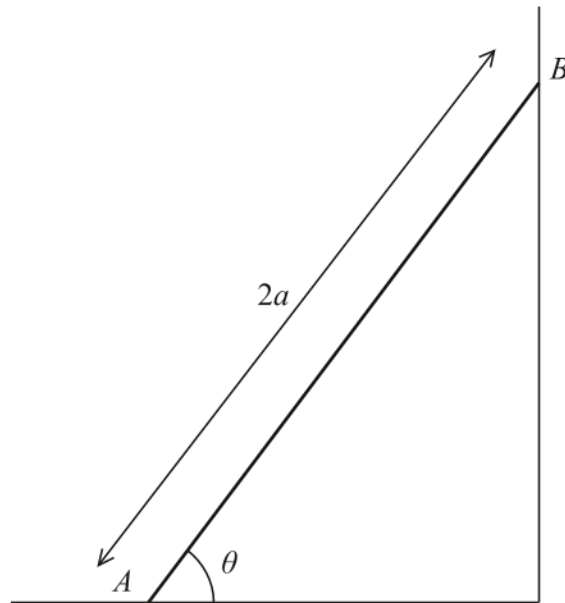


Figure 2

A beam AB has mass m and length $2a$.

The beam rests in equilibrium with A on rough horizontal ground and with B against a smooth vertical wall.

The beam is inclined to the horizontal at an angle θ , as shown in Figure 2.

The coefficient of friction between the beam and the ground is μ

The beam is modelled as a uniform rod resting in a vertical plane that is perpendicular to the wall.

Using the model,

(a) show that $\mu \geq \frac{1}{2} \cot \theta$ (5)

A horizontal force of magnitude kmg , where k is a constant, is now applied to the beam at A .

This force acts in a direction that is perpendicular to the wall and towards the wall.

Given that $\tan \theta = \frac{5}{4}$, $\mu = \frac{1}{2}$ and the beam is now in limiting equilibrium,

(b) use the model to find the value of k . (5)



Question 3 continued

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Lined writing area for the answer.



Question 3 continued

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Lined writing area for the answer to Question 3.

(Total for Question 3 is 10 marks)



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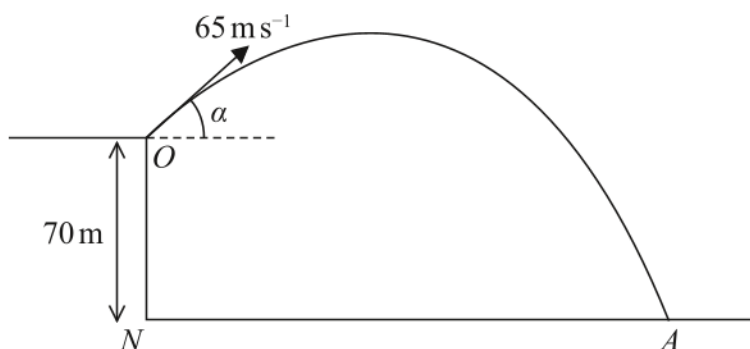


Figure 3

A small stone is projected with speed 65 m s^{-1} from a point O at the top of a vertical cliff.

Point O is 70 m vertically above the point N .

Point N is on horizontal ground.

The stone is projected at an angle α above the horizontal, where $\tan \alpha = \frac{5}{12}$

The stone hits the ground at the point A , as shown in Figure 3.

The stone is modelled as a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude 10 m s^{-2}

Using the model,

(a) find the time taken for the stone to travel from O to A , (4)

(b) find the speed of the stone at the instant just before it hits the ground at A . (5)

One limitation of the model is that it ignores air resistance.

(c) State one other limitation of the model that could affect the reliability of your answers. (1)

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Question 4 continued

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5. At time t seconds, a particle P has velocity \mathbf{v} m s^{-1} , where

$$\mathbf{v} = 3t^{\frac{1}{2}} \mathbf{i} - 2t \mathbf{j} \quad t > 0$$

- (a) Find the acceleration of P at time t seconds, where $t > 0$ (2)

- (b) Find the value of t at the instant when P is moving in the direction of $\mathbf{i} - \mathbf{j}$ (3)

At time t seconds, where $t > 0$, the position vector of P , relative to a fixed origin O , is \mathbf{r} metres.

When $t = 1$, $\mathbf{r} = -\mathbf{j}$

- (c) Find an expression for \mathbf{r} in terms of t . (3)

- (d) Find the exact distance of P from O at the instant when P is moving with speed 10 m s^{-1} (6)

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Question 5 continued

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Question 5 continued

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Question 5 continued

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