Higher Mathematics

Time: 1 hour 15 minutes

NATIONAL QUALIFICATIONS

Paper I

Specimen Question Paper

Read Carefully

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FORMULAE LIST

The equation $x^2 + y^2 + 2gx + 2fy + c = 0$ represents a circle centre $(-g, -f)$ and radius $\sqrt{(g^2 + f^2 - c)}$.

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Trigonometric formulae:

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$
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$$\begin{aligned} \cos 2A &= \cos^2 A - \sin^2 A \\ &= 2\cos^2 A - 1 \\ &= 1 - 2\sin^2 A \end{aligned}$$
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$f(x)$	$\int f(x)\,dx$
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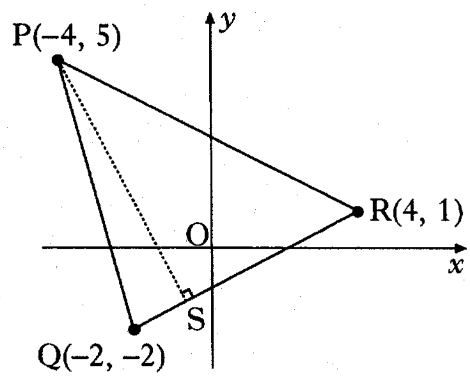
All questions should be attempted. *Marks*

1. P(−4, 5), Q(−2, −2) and R(4, 1) are the vertices of triangle PQR as shown in the diagram. Find the equation of PS, the altitude from P. **(3)**



2. A sequence is defined by the recurrence relation $u_{n+1} = 0 \cdot 3u_n + 5$ with first term u_1.

   (*a*) Explain why this sequence has a limit as n tends to infinity. **(1)**

   (*b*) Find the **exact** value of this limit. **(2)**

3. (*a*) Show that $(x - 1)$ is a factor of $f(x) = x^3 - 6x^2 + 9x - 4$ and find the other factors. **(3)**

   (*b*) Write down the coordinates of the points at which the graph of $y = f(x)$ meets the axes. **(1)**

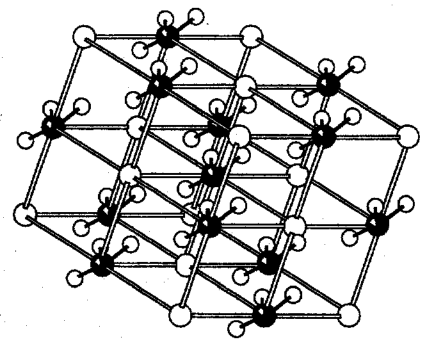
   (*c*) Find the stationary points of $y = f(x)$ and determine the nature of each. **(5)**

   (*d*) Sketch the graph of $y = f(x)$. **(1)**

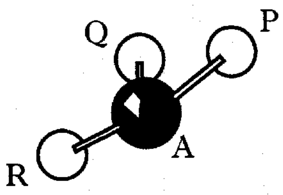
4. If $x°$ is an acute angle such that $\tan x° = \frac{4}{3}$, show that the exact value of $\sin(x + 30)°$ is $\frac{4\sqrt{3}+3}{10}$. **(3)**

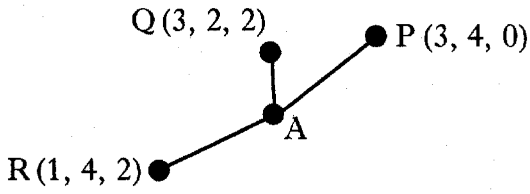
Marks

5. The diagram shows the rhombohedral crystal lattice of calcium carbonate.



The three oxygen atoms P, Q and R around the carbon atom A have coordinates as shown.





(*a*) Show that the cosine of angle PQR is $\frac{1}{2}$. **(5)**

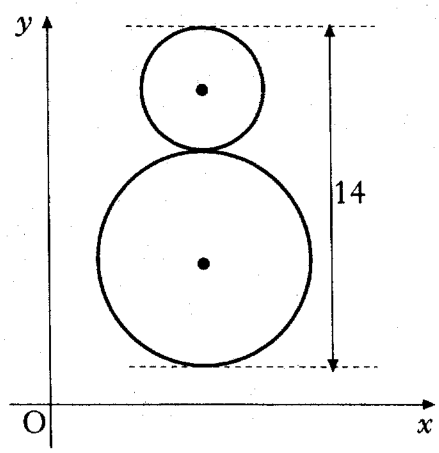
(*b*) M is the midpoint of QR and T is the point which divides PM in the ratio 2 : 1.

(i) Find the coordinates of T.

(ii) Show that P, Q and R are equidistant from T. **(6)**

6. A bakery firm makes ginger-bread men each 14 cm high with a circular "head" and "body". The equation of the "body" is $x^2 + y^2 - 10x - 12y + 45 = 0$ and the line of centres is parallel to the y-axis.

Find the equation of the "head".



(5)

Marks

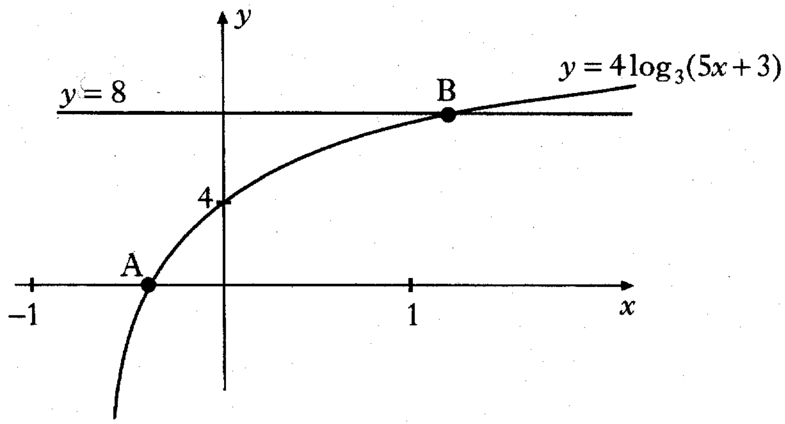
7. Find the value of $\int_1^2 \frac{u^2+2}{2u^2}\,du$. **(5)**

8. Sketch the graph of $y = 2\sin(x - 30)°$ for $0 \leq x < 360$. **(4)**

9. Find $\frac{dy}{dx}$ given that $y = \sqrt{1 + \cos x}$. **(3)**

10. Part of the graph of $y = 4\log_3(5x + 3)$ is shown in the diagram. This graph crosses the x-axis at the point A and the straight line $y = 8$ at the point B.

Find the x-coordinate of B. **(3)**



[*END OF QUESTION PAPER*]

[C056/SQP027]

Higher Mathematics

Time: 1 hour 45 minutes

NATIONAL QUALIFICATIONS

Paper II
Specimen Question Paper

Read Carefully

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SCOTTISH QUALIFICATIONS AUTHORITY

FORMULAE LIST

The equation $x^2 + y^2 + 2gx + 2fy + c = 0$ represents a circle centre $(-g, -f)$ and radius $\sqrt{(g^2 + f^2 - c)}$.

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Trigonometric formulae:

$$\sin(\mathrm{A} \pm \mathrm{B}) = \sin \mathrm{A} \cos \mathrm{B} \pm \cos \mathrm{A} \sin \mathrm{B}$$
$$\cos(\mathrm{A} \pm \mathrm{B}) = \cos \mathrm{A} \cos \mathrm{B} \mp \sin \mathrm{A} \sin \mathrm{B}$$
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$$\sin 2\mathrm{A} = 2\sin \mathrm{A} \cos \mathrm{A}$$

Table of standard derivatives:

$f(x)$	$f'(x)$
$\sin ax$	$a \cos ax$
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Table of standard integrals:

$f(x)$	$\int f(x)\,dx$
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All questions should be attempted. *Marks*

1. ABCD is a parallelogram. A, B and C have coordinates (2, 3), (4, 7) and (8, 11). Find the equation of DC. **(3)**

2. Trees are sprayed weekly with the pesticide, "Killpest", whose manufacturers claim it will destroy 60% of all pests. Between the weekly sprayings, it is estimated that 300 new pests invade the trees.

   A new pesticide, "Pestkill", comes onto the market. The manufacturers claim that it will destroy 80% of existing pests but it is estimated that 360 new pests per week will invade the trees.

   Which pesticide will be more effective in the long term? **(5)**

3. (*a*) Show that the function $f(x) = 2x^2 + 8x - 3$ can be written in the form $f(x) = a(x + b)^2 + c$ where a, b and c are constants. **(3)**

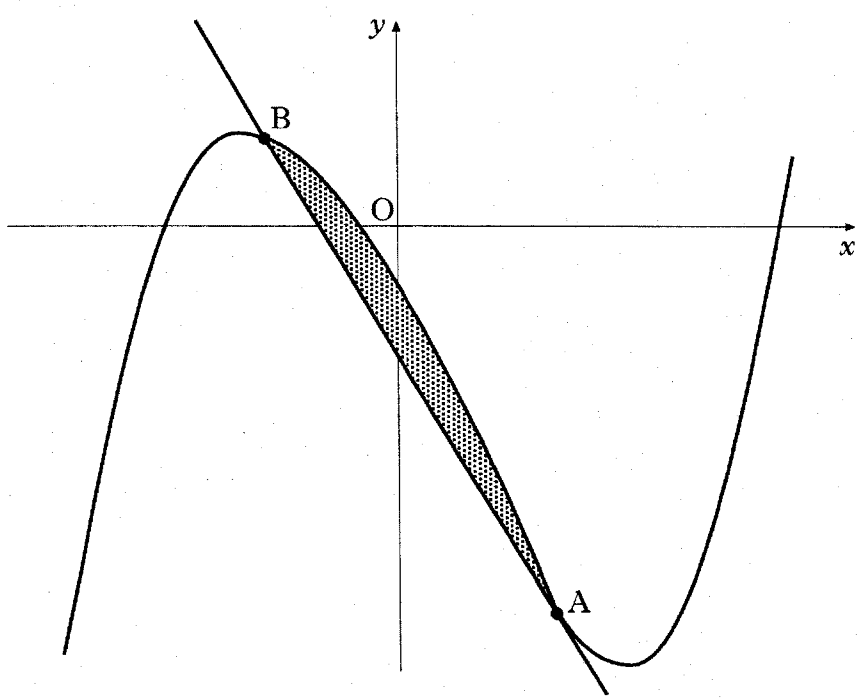
   (*b*) Hence, or otherwise, find the coordinates of the turning point of the function f. **(1)**

4. In the diagram below, a winding river has been modelled by the curve $y = x^3 - x^2 - 6x - 2$ and a road has been modelled by the straight line AB. The road is a tangent to the river at the point A(1, −8).

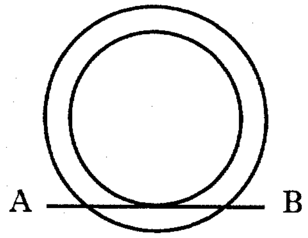
   (*a*) Find the equation of the tangent at A. **(3)**

   (*b*) Hence find the coordinates of B. **(4)**

   (*c*) Find the area of the shaded part which represents the land bounded by the river and the road. **(3)**



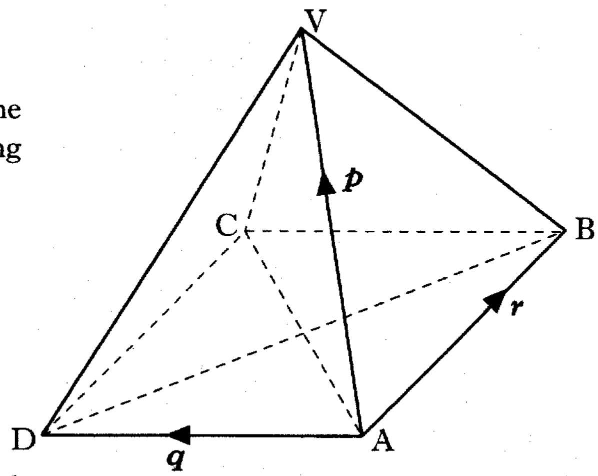
5. The diagram shows two concentric circles. The equation of the larger circle is $x^2 + y^2 - 8x + 2y - 19 = 0$. The line AB is a tangent to the smaller circle and has equation $y = -6$.



(*a*) Find the equation of the smaller circle. **(3)**

(*b*) A third concentric circle, which is to be larger than each of the first two circles, is to be added to the figure. This circle has equation $x^2 + y^2 - 8x + 2y + c = 0$. Find the range of values of c. **(3)**

6. VABCD is a square-based pyramid. The length of AD is 3 units and each sloping face is an equilateral triangle.



$\overrightarrow{AV} = \boldsymbol{p}$, $\overrightarrow{AD} = \boldsymbol{q}$ and $\overrightarrow{AB} = \boldsymbol{r}$.

(*a*) (i) Evaluate $\boldsymbol{p}.\boldsymbol{q}$.

(ii) Hence evaluate $\boldsymbol{p}.(\boldsymbol{q} + \boldsymbol{r})$. **(3)**

(*b*) (i) Express $\overrightarrow{CV}$ in terms of $\boldsymbol{p}$, $\boldsymbol{q}$ and $\boldsymbol{r}$.

(ii) Hence show that angle CVA is 90°. **(4)**

7. $f(x) = 2\cos x° + 3\sin x°$.

(*a*) Express $f(x)$ in the form $k\cos(x - \alpha)°$ where $k > 0$ and $0 \leq \alpha < 360$. **(4)**

(*b*) Hence solve $f(x) = 0{\cdot}5$ for $0 \leq x < 360$. **(3)**

(*c*) Find the x-coordinate of the point nearest to the origin where the graph of $f(x) = 2\cos x° + 3\sin x°$ cuts the x-axis for $0 \leq x < 360$. **(2)**

Marks

8. (*a*) Show that $2\cos 2x° - \cos^2 x° = 1 - 3\sin^2 x°$. **(2)**

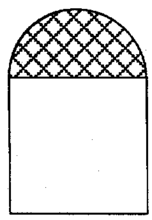
(*b*) **Hence**

(i) write the equation $2\cos 2x° - \cos^2 x° = 2\sin x°$ in terms of $\sin x°$

(ii) solve this equation in the interval $0 \leq x < 90$. **(3)**

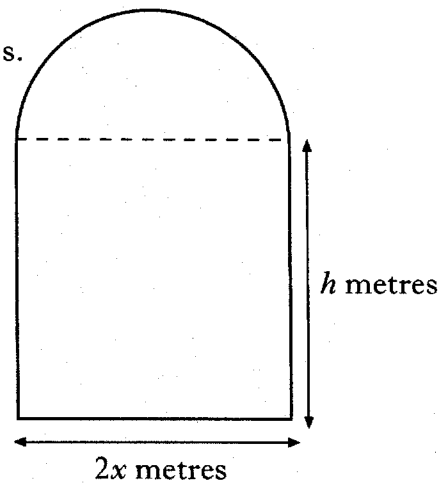
9. The roots of the equation $(x - 1)(x + k) = -4$ are equal.
Find the values of k. **(5)**

10. A window in the shape of a rectangle surmounted by a semicircle is being designed to let in the maximum amount of light.



The glass to be used for the semicircular part is stained glass which lets in one unit of light per square metre; the rectangular part uses clear glass which lets in 2 units of light per square metre.

The rectangle measures $2x$ metres by h metres.



(*a*) (i) If the perimeter of the whole window is 10 metres, express h in terms of x. **(2)**

(ii) Hence show that the amount of light, L, let in by the window is given by $L = 20x - 4x^2 - \frac{3}{2}\pi x^2$. **(2)**

(*b*) Find the values of x and h that must be used to allow this design to let in the maximum amount of light. **(5)**

Marks

11. Six spherical sponges were dipped in water and weighed to see how much water each could absorb. The diameter (x millimetres) and the gain in weight (y grams) were measured and recorded for each sponge. It is thought that x and y are connected by a relationship of the form $y = ax^b$.

By taking logarithms of the values of x and y, the table below was constructed.

$X\ (= \log_e x)$	2·10	2·31	2·40	2·65	2·90	3·10
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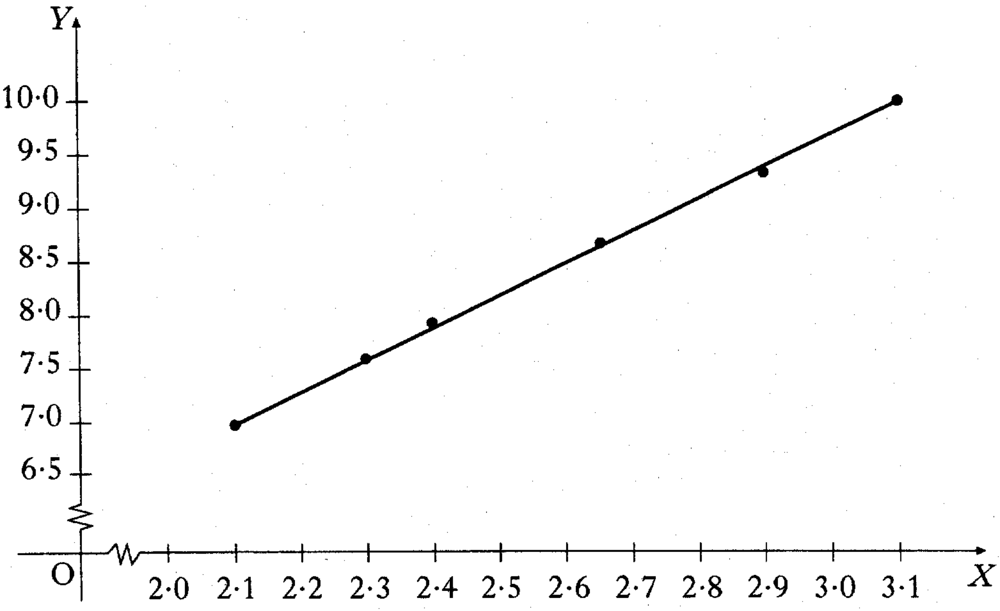

(*a*) Find the equation of the line in the form $Y = mX + c$. **(3)**

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[CO56/SQP027]

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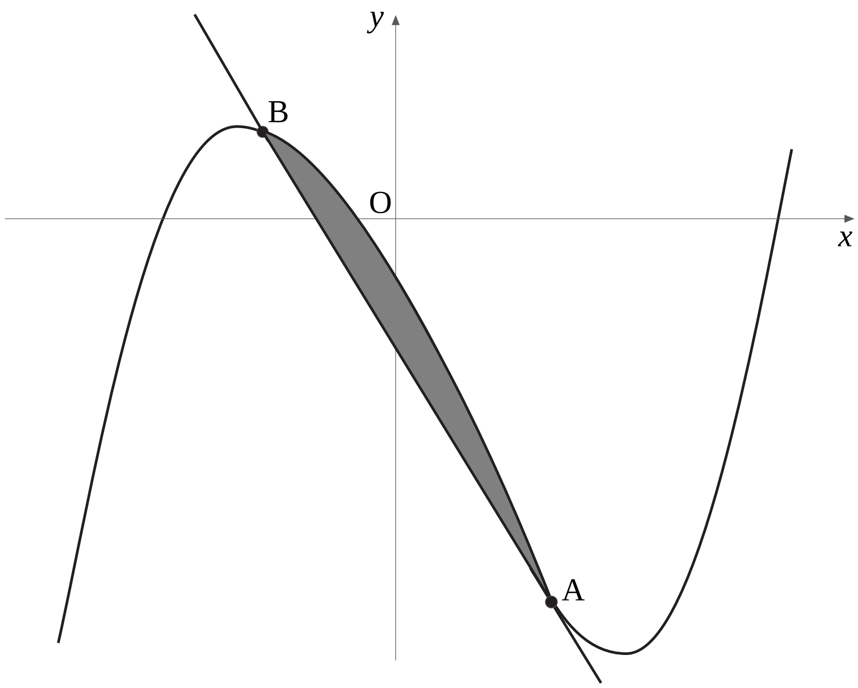

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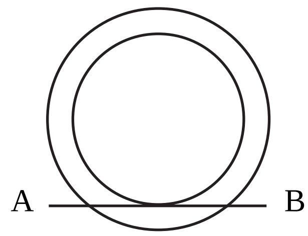

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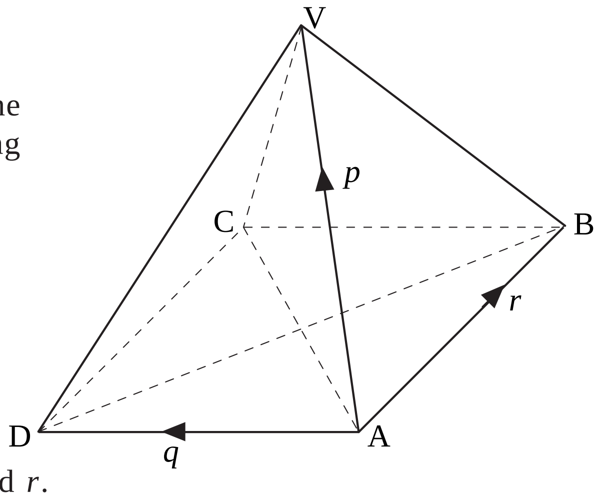

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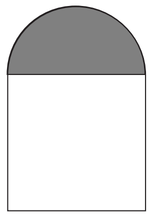

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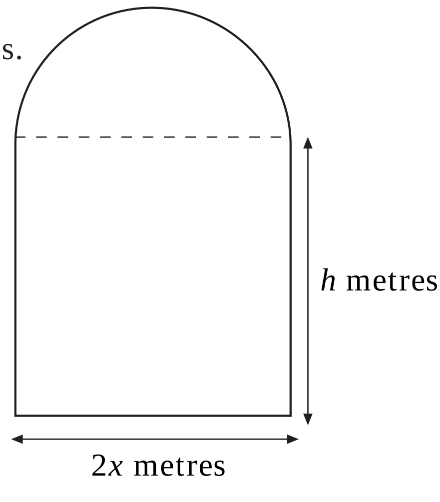

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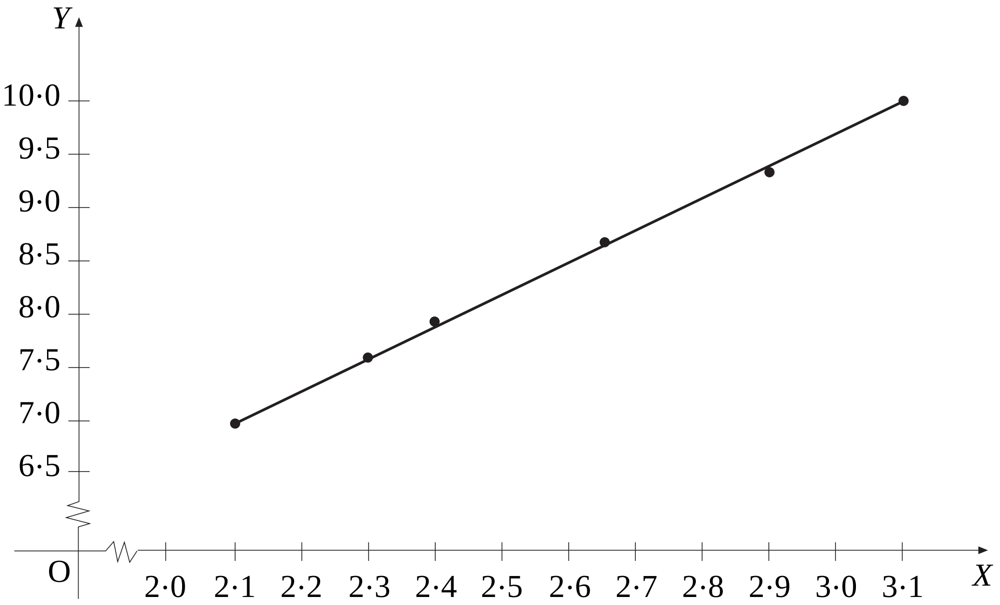

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[*END OF QUESTION PAPER*]

[C056/SQP027]

Higher Mathematics

NATIONAL QUALIFICATIONS

Higher I

Specimen Question Paper

(Statistics questions; see note below)

Higher Mathematics—Commentary to accompany Specimen Question Paper I

The attached questions constitute the statistics option for Higher level Mathematics. A Specimen Question Paper for component units Higher Mathematics 1, Higher Mathematics 2 and Higher Mathematics 3 was issued to centres in November 1998. When the statistics option is followed then the attached statistics questions would be used in place of the Mathematics 3 questions 5, 9 and 10.

When the Higher level Mathematics examinations become operational in the year 2000, two separate versions of the papers will be printed for each of Higher I and Higher II. One of these versions will contain questions pertaining to the component units Higher Mathematics 1, Higher Mathematics 2 and Higher Mathematics 3; the second will contain questions pertaining to the component units Higher Mathematics 1, Higher Mathematics 2 and Higher Statistics.

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QUALIFICATIONS
AUTHORITY

Statistics formulae list for Higher level Mathematics (for internal unit assessment and for external course assessment)

Sample standard deviation $s = \sqrt{\dfrac{\sum(x_i - \bar{x})^2}{n-1}} = \sqrt{\dfrac{\sum x_i^2 - \dfrac{(\sum x_i)^2}{n}}{n-1}}$ where n is the sample size.

Sums of squares and products:

$$S_{xx} = \sum(x_i - \bar{x})^2 = \sum x_i^2 - \frac{(\sum x_i)^2}{n}$$

$$S_{yy} = \sum(y_i - \bar{y})^2 = \sum y_i^2 - \frac{(\sum y_i)^2}{n}$$

$$S_{xy} = \sum(x_i - \bar{x})(y_i - \bar{y}) = \sum x_i y_i - \frac{\sum x_i \sum y_i}{n}$$

Linear regression:

The equation of the least squares regression line of y on x is given by $y = \alpha + \beta x$, where estimates for α and β, a and b, are given by:

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2} = \frac{S_{xy}}{S_{xx}}$$

Product moment correlation coefficient r:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

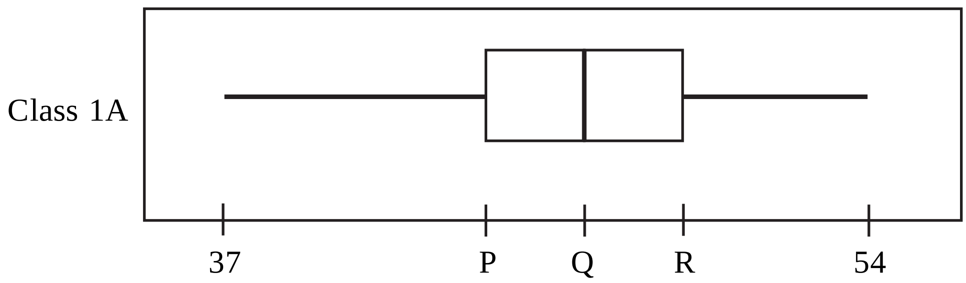
Marks

5. Class 1A sat a test out of 60. The marks are shown in the stem-and-leaf diagram below.

3	7											
4	0	1	2	2	4	4						
4	5	5	6	7	7	7	8	8	8	9	9	9
5	0	1	1	2	3	4						

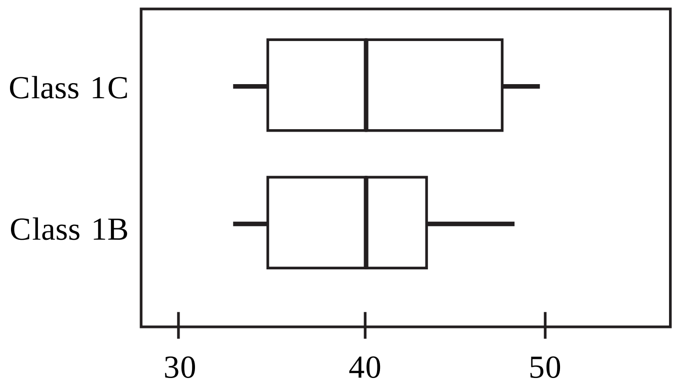
$n = 25$ 3 | 7 represents 37

The diagram below shows an incomplete boxplot for this data.



(*a*) Find the values associated with the points P, Q and R. (2)

(*b*) The boxplot below shows the data for classes 1B and 1C.



Compare the results of these two classes. (2)

Marks

9. A random device moves one unit to the right with probability 0·3, one unit to the left with probability 0·3 or remains in the same position after each trial.

(*a*) Tabulate the probability distribution of X, the position of the device, after one trial. (2)

(*b*) A calculator produces the following random numbers.

0·764	0·380	0·410	0·175	0·458
0·552	0·709	0·935	0·451	0·854

(i) Explain how you would use these numbers to simulate ten trials of this random experiment. (2)

(ii) List the results of your simulation. (1)

10. The total lifetime (in years) of 5 year old washing machines of a certain make is a random variable whose cumulative distribution function F is given by

$$F(x) = \begin{cases} 0 & \text{for } x \leq 5 \\ 1 - \dfrac{25}{x^2} & \text{for } x > 5 \end{cases}$$

(*a*) Find the probability that such a washing machine will be in service for:

(i) less than 8 years; (1)

(ii) more than 10 years. (2)

(*b*) Find the probability density function $f(x)$. (2)

(*c*) Calculate the exact value of the median lifetime of these washing machines. (3)

[C056/SQP027]

Higher Mathematics

NATIONAL QUALIFICATIONS

Higher II

Specimen Question Paper

(Statistics questions; see note below)

Higher Mathematics—Commentary to accompany Specimen Question Paper II

The attached questions constitute the statistics option for Higher level Mathematics. A Specimen Question Paper for component units Higher Mathematics 1, Higher Mathematics 2 and Higher Mathematics 3 was issued to centres in November 1998. When the statistics option is followed then the attached statistics questions would be used in place of the Mathematics 3 questions 6, 7 and 11.

When the Higher level Mathematics examinations become operational in the year 2000, two separate versions of the papers will be printed for each of Higher I and Higher II. One of these versions will contain questions pertaining to the component units Higher Mathematics 1, Higher Mathematics 2 and Higher Mathematics 3; the second will contain questions pertaining to the component units Higher Mathematics 1, Higher Mathematics 2 and Higher Statistics.

SCOTTISH QUALIFICATIONS AUTHORITY

Statistics formulae list for Higher level Mathematics (for internal unit assessment and for external course assessment)

Sample standard deviation $s = \sqrt{\dfrac{\Sigma\left(x_i - \bar{x}\right)^2}{n-1}} = \sqrt{\dfrac{\Sigma x_i^2 - \dfrac{\left(\Sigma x_i\right)^2}{n}}{n-1}}$ where n is the sample size.

Sums of squares and products:

$$S_{xx} = \Sigma\left(x_i - \bar{x}\right)^2 = \Sigma x_i^2 - \frac{\left(\Sigma x_i\right)^2}{n}$$

$$S_{yy} = \Sigma\left(y_i - \bar{y}\right)^2 = \Sigma y_i^2 - \frac{\left(\Sigma y_i\right)^2}{n}$$

$$S_{xy} = \Sigma\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right) = \Sigma x_i y_i - \frac{\Sigma x_i \Sigma y_i}{n}$$

Linear regression:

The equation of the least squares regression line of y on x is given by $y = \alpha + \beta x$, where estimates for α and β, a and b, are given by:

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{\Sigma\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{\Sigma\left(x_i - \bar{x}\right)^2} = \frac{S_{xy}}{S_{xx}}$$

Product moment correlation coefficient r:

$$r = \frac{\Sigma\left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right)}{\sqrt{\Sigma\left(x_i - \bar{x}\right)^2 \Sigma\left(y_i - \bar{y}\right)^2}} = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}$$

Marks

6. In an archery competition, the probability that a particular competitor hits the target with any shot is $\frac{3}{4}$. In the competition, she is allowed three shots.

(*a*) Find the probability that she hits the target:

(i) exactly twice; (2)

(ii) at least once. (2)

(*b*) State a statistical assumption that you have made. (1)

7. A market gardener wishes to investigate the relationship between the total weight of tomatoes produced by a tomato plant and the amount of fertiliser used. An experiment was carried out where known amounts of fertiliser were applied to 8 similar plants. The results are shown in the table.

Weight of fertiliser (g)	x	0	2	4	6	8	10	12	14
Tomato yield (kg)	y	4·44	5·13	5·45	5·27	5·81	6·04	5·90	6.23

A scattergraph shows that a linear model is appropriate.

You may assume that $\sum y = 44\cdot27$, $\sum y^2 = 247\cdot3665$ and $\sum xy = 328\cdot58$.

(*a*) (i) Determine the equation of the least squares regression line of y on x. (6)

(ii) Use the regression equation to predict the tomato yield for 9 g of fertiliser. (1)

(*b*) Calculate the product moment correlation coefficient and comment on your answer. (3)

11. The random variable X has a probability density function

$$f(x) = \begin{cases} kx^2(1-x) & \text{for } 0 \leq x \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

(*a*) Find the value of k. (2)

(*b*) Find the probability that X lies in the range $0 \leq X \leq \frac{2}{3}$. (2)

(*c*) Calculate the mean and variance of X. (4)