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**CRESCENT GIRLS' SCHOOL
SECONDARY FOUR 2025
PRELIMINARY EXAMINATION**

**ADDITIONAL MATHEMATICS
Paper 1**

**4049/01
29 August 2025**

Candidates answer on the Question Paper.
No Additional Materials are required.

2 hours 15 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** the questions.

Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

The use of an approved scientific calculator is expected, where appropriate.

You are reminded of the need for clear presentation in your answers.

The number of marks is given in brackets [] at the end of each question or part question.

The total number of marks for this paper is **90**.

For Examiner's Use

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Marks														

Table of Penalties		Qn. No.	Parent's/ Guardian's Signature	90
Presentation	-1			
Significant Figures / Units	-1			

This document consists of 23 printed pages and 1 blank page.

*Mathematical Formulae***1. ALGEBRA***Quadratic Equation*

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial expansion

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \dots + \binom{n}{r} a^{n-r} b^r + \dots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{r!(n-r)!} = \frac{n(n-1)\dots(n-r+1)}{r!}$

2. TRIGONOMETRY*Identities*

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

$$\sin 2A = 2 \sin A \cos A$$

$$\cos 2A = \cos^2 A - \sin^2 A = 2 \cos^2 A - 1 = 1 - 2 \sin^2 A$$

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

Formulae for $\triangle ABC$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

- 1 The curve $x^2 + xy - 6y^2 + 9 = 0$ and line $y = x + 1$ intersect at the points R and S .
Find the x -coordinate of the midpoint of RS . [3]

Sub $y = x + 1$ into $x^2 + xy - 6y^2 + 9 = 0$

$$x^2 + x(x+1) - 6(x+1)^2 + 9 = 0$$

$$x^2 + x^2 + x - 6(x^2 + 2x + 1) + 9 = 0$$

$$2x^2 + x - 6x^2 - 12x - 6 + 9 = 0$$

$$4x^2 + 11x - 3 = 0$$

$$(4x-1)(x+3) = 0$$

$$x = \frac{1}{4} \text{ or } x = -3$$

$$x\text{-coordinate of the midpoint of } RS = \frac{\frac{1}{4} + (-3)}{2} = -1\frac{3}{8}.$$

- 2 Integrate $\frac{4}{x^2} - \frac{3}{1-5x} + \sin 5x - \pi$ with respect to x . [5]

$$= \int 4x^{-2} - \frac{3}{1-5x} + \sin 5x - \pi \, dx$$

$$= \frac{4x^{-1}}{-1} - \frac{3 \ln(1-5x)}{-5} - \frac{\cos 5x}{5} - \pi x + c$$

$$= -\frac{4}{x} + \frac{3}{5} \ln(1-5x) - \frac{1}{5} \cos 5x - \pi x + c,$$

c is an arbitrary constant

- 3 A cuboid has base area $(4 + 2\sqrt{5}) \text{ cm}^2$ and a volume of $(9 + 5\sqrt{5}) \text{ cm}^3$.

Find, **without using a calculator**, the height of the cuboid, in cm, giving your answer in the form $\frac{1}{2}(a + b\sqrt{5})$, where a and b are integers. [3]

$$\begin{aligned}
 \text{Height} &= \frac{9 + 5\sqrt{5}}{4 + 2\sqrt{5}} \cdot \frac{4 - 2\sqrt{5}}{4 - 2\sqrt{5}} \\
 &= \frac{36 - 18\sqrt{5} + 20\sqrt{5} - 50}{16 - 20} \\
 &= \frac{-14 + 2\sqrt{5}}{-4} \\
 &= \frac{7}{2} - \frac{1}{2}\sqrt{5} \\
 &= \frac{1}{2}(7 - \sqrt{5}) \text{ cm}
 \end{aligned}$$

- 4 (a) Express $-4x^2 + 12x + 2$ in the form $a(x + b)^2 + c$ and state the coordinates of

the turning point of the curve $y = -4x^2 + 12x + 2$.

[3]

$$\begin{aligned}
 -4x^2 + 12x + 2 &= -4\left(x^2 - 3x\right) + 2 \\
 &= -4\left[x^2 - 3x + \left(\frac{3}{2}\right)^2 - \left(\frac{3}{2}\right)^2\right] + 2 \\
 &= -4\left(x - \frac{3}{2}\right)^2 + 9 + 2 \\
 &= -4\left(x - \frac{3}{2}\right)^2 + 11
 \end{aligned}$$

The turning point is $\left(1\frac{1}{2}, 11\right)$.

(b) Hence explain why the turning point is a maximum point.

[1]

For all real values of x , $\left(x - \frac{3}{2}\right)^2 \geq 0$, $-4\left(x - \frac{3}{2}\right)^2 \leq 0$, $-4\left(x - \frac{3}{2}\right)^2 + 11 \leq 11$.

Since coefficient of x^2 is negative,

$\left(1\frac{1}{2}, 11\right)$ is a maximum point.

5 Express $\frac{3x^2 + 5x - 2}{(x+1)(x^2 + 4)}$ in partial fractions.

[Turn over

[2]

$$\frac{3x^2 + 5x - 2}{(x+1)(x^2 + 4)} = \frac{A}{x+1} + \frac{Bx+C}{x^2 + 4}$$

$$3x^2 + 5x - 2 = A(x^2 + 4) + (Bx + C)(x + 1)$$

$$\text{Sub } x = -1, \quad 3 - 5 - 2 = 5A$$

$$A = -\frac{4}{5}$$

$$\text{Compare constant: } -2 = 4A + C$$

$$C = -2 - 4\left(-\frac{4}{5}\right) = \frac{6}{5}$$

$$\text{Compare coeff of } x: \quad 5 = B + C$$

$$B = 5 - \frac{6}{5} = \frac{19}{5}$$

$$\frac{3x^2 + 5x - 2}{(x+1)(x^2 + 4)} = -\frac{4}{5(x+1)} + \frac{19x+6}{5(x^2 + 4)}$$

6 It is given that $y = \frac{2x-1}{\sqrt{x+2}}$ for $x > q$.

(a) State the value of q .

[1]

$$q = -2$$

- (b) Find $\frac{dy}{dx}$. [3]

$$y = \frac{2x-1}{\sqrt{x+2}}$$

$$\begin{aligned} \frac{dy}{dx} &= \frac{2\sqrt{x+2} - (2x-1) \cdot \frac{1}{2}(x+2)^{-\frac{1}{2}}(1)}{x+2} \\ &= \frac{2\sqrt{x+2} - \frac{(2x-1)}{2\sqrt{x+2}}}{x+2} \\ &= \frac{4(x+2) - (2x-1)}{2\sqrt{(x+2)^3}} \\ &= \frac{2x+9}{2\sqrt{(x+2)^3}} \end{aligned}$$

- (c) State whether $y = \frac{2x-1}{\sqrt{x+2}}$ is an increasing or decreasing function. [2]
Explain your answer clearly.

For $x > -2$

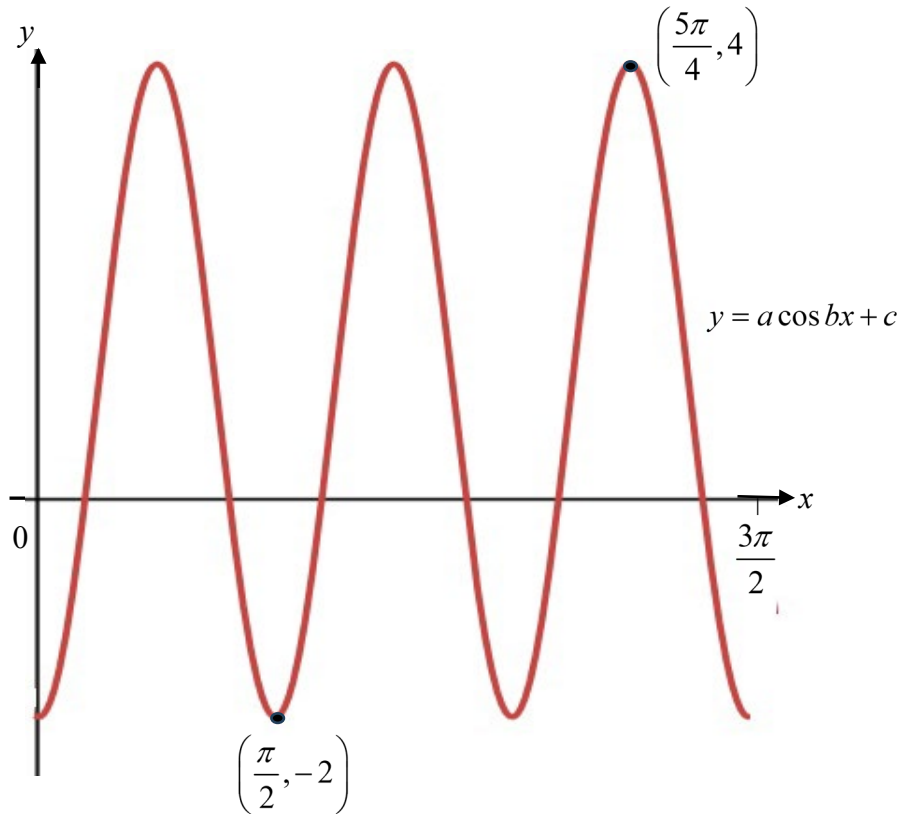
$$\sqrt{(x+2)^3} > 0, 2\sqrt{(x+2)^3} > 0 \text{ and } 2x+9 > 0$$

$$\Rightarrow \frac{dy}{dx} > 0$$

$$y = \frac{2x-1}{\sqrt{x+2}} \text{ is an increasing function.}$$

[Turn over

7



The diagram shows the curve $y = a \cos bx + c$ for $0 \leq x \leq \frac{3\pi}{2}$ radians.

A minimum point $\left(\frac{\pi}{2}, -2\right)$ and a maximum point $\left(\frac{5\pi}{4}, 4\right)$ are indicated on the diagram.

(a) Explain why $b = 4$.

[2]

$$\text{Period} = \frac{\pi}{2}$$

$$\text{Period, } \frac{2\pi}{b} = \frac{\pi}{2}$$

$$b = 2\pi \div \frac{\pi}{2} = 4$$

- (b) Explain why $c = 1$.

[2]

$y = c$ is the axis of curve

$$c = \frac{\text{maximum} + \text{minimum}}{2}$$

$$= \frac{4 + (-2)}{2}$$

$$c = 1$$

- (c) Hence find the equation of the curve.

[2]

By observation, $a < 0$.

$$a = -(4 - 1)$$

OR

$$a = -[1 - (-2)]$$

OR

$$a = -\left(\frac{\text{maximum} - \text{minimum}}{2}\right)$$

$$= -\left(\frac{4 - (-2)}{2}\right)$$

$$= -3$$

Equation of curve is $y = -3 \cos 4x + 1$.

- 8 (a) Prove the identity $\frac{\sin \theta}{1 + \cos \theta} = \tan \frac{\theta}{2}$. [3]

$$\begin{aligned} \frac{\sin \theta}{1 + \cos \theta} &= \tan \frac{\theta}{2} \\ \text{LHS} &= \frac{2 \sin \frac{\theta}{2} \cos \frac{\theta}{2}}{1 + (2 \cos^2 \frac{\theta}{2} - 1)} \\ &= \frac{\sin \frac{\theta}{2} \cos \frac{\theta}{2}}{\cos^2 \frac{\theta}{2}} \\ &= \frac{\sin \frac{\theta}{2}}{\cos \frac{\theta}{2}} \\ &= \tan \frac{\theta}{2} \end{aligned}$$

- (b) Hence solve the equation $\frac{1 + \cos \theta}{\sin \theta} = -3$ for $0^\circ \leq \theta \leq 360^\circ$. [4]

$$\frac{1 + \cos \theta}{\sin \theta} = -3$$

$$0^\circ \leq \theta \leq 360^\circ$$

$$\frac{\sin \theta}{1 + \cos \theta} = -\frac{1}{3}$$

$$0^\circ \leq \frac{\theta}{2} \leq 180^\circ$$

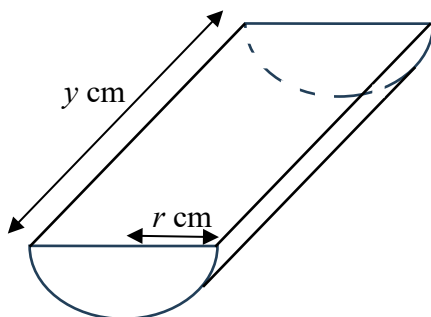
$$\tan \frac{\theta}{2} = -\frac{1}{3}$$

Reference angle = 18.435° (to 3 d.p.)

$$\frac{\theta}{2} = 180^\circ - 18.435^\circ$$

$$\theta = 323.1^\circ \text{ (to 1 d.p.)}$$

- 9 The diagram shows a container, made of a thin sheet of plastic, in the shape of a hollow cylinder. The length of the container is y cm and each of the semicircular ends has radius r cm. The total external area of the plastic used is 8500 cm^2 .



- (a) Show that the volume, $V \text{ cm}^3$, of the container is given by $4250r - \frac{1}{2}\pi r^3$. [3]

$$\begin{aligned}\text{External surface area, } \pi r^2 + \frac{1}{2}(2\pi r y) &= 8500 \\ \pi r^2 + \pi r y &= 8500 \\ y &= \frac{8500 - \pi r^2}{\pi r}\end{aligned}$$

$$\begin{aligned}\text{Volume of the container, } V &= \frac{1}{2}\pi r^2 y \\ &= \frac{1}{2}\pi r^2 \left(\frac{8500 - \pi r^2}{\pi r} \right) \\ &= 4250r - \frac{1}{2}\pi r^3 \quad (\text{shown})\end{aligned}$$

- (b) Given that r can vary, find the stationary value of V and determine its nature. [4]

$$V = 4250r - \frac{1}{2}\pi r^3$$

$$\frac{dV}{dr} = 4250 - \frac{3}{2}\pi r^2$$

For stationary value of V , $\frac{dV}{dr} = 0$

$$4250 - \frac{3}{2}\pi r^2 = 0$$

$$\frac{3}{2}\pi r^2 = 4250$$

$$r = \sqrt{\frac{8500}{3\pi}} \quad (r > 0)$$

$$= 30.031 \text{ cm (to 5 s.f.)}$$

$$\frac{d^2V}{dr^2} = -3\pi r$$

When $r = 30.031$, $\frac{d^2V}{dr^2} = -3\pi(30.031) < 0$

When $r = 30.031$, V is maximum.

$$\begin{aligned} \text{Maximum } V &= 4250(30.031) - \frac{1}{2}\pi(30.031)^3 \\ &= 85\,100 \text{ cm}^3 \quad (\text{to 3 s.f.}) \end{aligned}$$

10 The solution of the equation $3^{2x-1} = 4(3^x)$ can be expressed as $\frac{\ln p}{\ln q}$.

(a) Find the value of p and of q .

[4]

$$\frac{3^{2x-1}}{3^x} = 4$$

$$3^{2x-1-x} = 4$$

$$3^{x-1} = 4$$

$$(x-1)\ln 3 = \ln 4$$

$$x-1 = \frac{\ln 4}{\ln 3}$$

$$x = \frac{\ln 4}{\ln 3} + 1$$

$$= \frac{\ln 4 + \ln 3}{\ln 3}$$

$$= \frac{\ln 12}{\ln 3}$$

Hence $p = 12$, $q = 3$

- (b) Express the solution of $\log_{16}(3y-1) + \frac{1}{2} = \log_4(3y)$ as a rational number. [4]

$$\log_{16}(3y-1) - \log_4(3y) = -\frac{1}{2}$$

$$\frac{\log_4(3y-1)}{\log_4 4^2} - \log_4(3y) = -\frac{1}{2}$$

$$\frac{\log_4(3y-1)}{2} - \log_4(3y) = -\frac{1}{2}$$

$$\log_4(3y-1) - 2\log_4(3y) = -1$$

$$\log_4\left(\frac{3y-1}{9y^2}\right) = -1$$

$$\frac{3y-1}{9y^2} = 4^{-1}$$

$$9y^2 - 12y + 4 = 0$$

$$(3y-2)^2 = 0 \Rightarrow y = \frac{2}{3}$$

- 11(a)** Cement is poured into an empty right circular cone mould at a constant rate of $36\pi \text{ cm}^3/\text{s}$. The height of the cone is always twice its radius.

- (i) Show that the radius of the cone after 1.5 minutes is approximately 16.94 cm. [2]

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

$$\frac{dV}{dt} = 36\pi \text{ cm}^3/\text{s}$$

$$36\pi(90) = \frac{1}{3}\pi r^2(2r)$$

$$r = \sqrt[3]{\frac{3240(3)}{2}} \approx 16.94 \text{ cm (shown)}$$

- (ii) Find the rate of change of the radius of the cone after 1.5 minutes. [3]

$$V = \frac{1}{3}\pi r^2(2r)$$

$$= \frac{2}{3}\pi r^3$$

$$\frac{dV}{dr} = 2\pi r^2$$

$$\begin{aligned} \text{When } r = 16.94, \frac{dV}{dr} &= 2\pi(16.94)^2 \\ &= 1803.0 \text{ (to 5 s.f.)} \end{aligned}$$

$$\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$$

$$\frac{dr}{dt} = \frac{36\pi}{1803.0}$$

$$= 0.0627 \text{ cm/s (to 3 s.f.)}$$

The radius is increasing at a rate of 0.0627 cm/s after 1.5 minutes.

- (b) The intensity of light, I candelas, at a certain distance, x metres, from a light source is given by the formula $I = \frac{k}{x^2}$, where k is a constant.

Given that the intensity of light is 12 candelas at a distance of 4 metres from the source, find the rate at which the intensity of light is changing with respect to the distance when $x = 8$.

[3]

$$I = \frac{k}{x^2}, k \text{ is a constant}$$

$$\text{When } I = 12, x = 4,$$

$$k = 12(4)^2$$

$$= 192$$

$$I = 192x^{-2}$$

$$\frac{dI}{dx} = 192(-2)x^{-3}$$

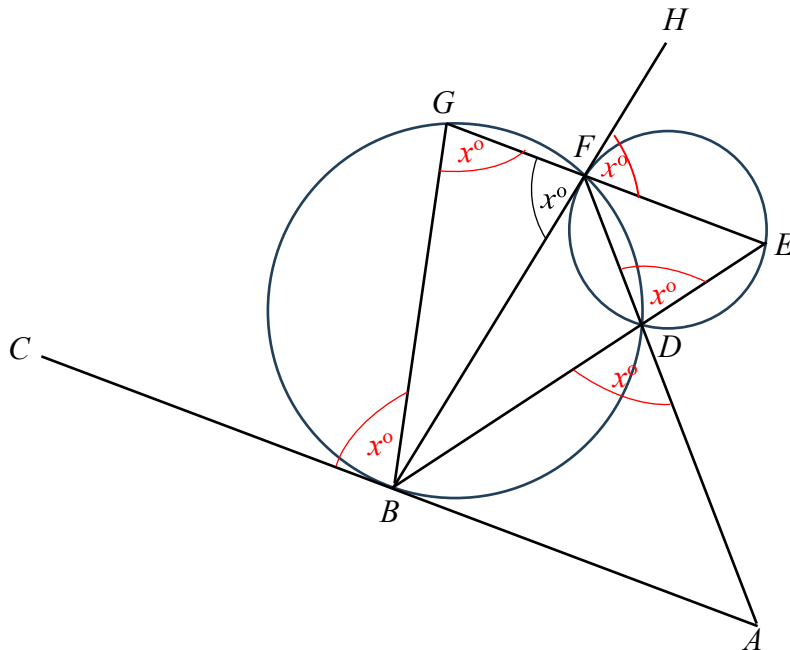
$$= -\frac{384}{x^3}$$

When $x = 8$, the rate at which the intensity of light is changing with respect to the distance is $-\frac{384}{8^3} = -0.75$ candelas per metre.

ABC is a tangent to the bigger circle at B and BFH is a tangent to the smaller circle at F .

ADF , BDE and GFE are straight lines.

It is given that angle $BFG = x^\circ$.



- (a) Prove that triangle BGF is an isosceles triangle.

[4]

$$\angle BFG = \angle EFH = x^\circ \text{ (vert. opp. angles)}$$

$$\angle EFH = \angle EDF = x^\circ \text{ (Alternate Segment Theorem)}$$

$$\angle BDF = 180^\circ - \angle EDF$$

$$= 180^\circ - x^\circ \text{ (adj. angles on a straight line)}$$

$$\angle BGF = 180^\circ - \angle BDF$$

$$= 180^\circ - (180^\circ - x^\circ)$$

$$= x^\circ \text{ (angles in opp. segment)}$$

Alternatively,

$$\angle EDF = \angle ADB = x^\circ \text{ (vert. opp. angles)}$$

$$\angle BGF = \angle EDF = x^\circ \text{ (ext. angle of cyclic quad.)}$$

Since $\angle BFG = \angle BGF = x^\circ$, $BG = BF$.

Triangle BGF is an isosceles triangle.

- (b) Show that CBA is parallel to GFE . [2]

$$\angle BGF = \angle ABF$$

$$= x^\circ \quad (\text{Alternate Segment Theorem})$$

$$\angle ABF = \angle BFG = x^\circ$$

$\therefore CBA$ is parallel to GFE (Converse of alternate angles)

- (c) Show that triangle ABD is similar to triangle BEG . [2]

In $\triangle ABD$ and $\triangle BEG$,

$$\angle ABD = \angle BEG \quad (\text{alternate angles, } CBA \parallel GFE)$$

$$\angle ADB = \angle EDF \quad (\text{vert. opp. angles})$$

$$= \angle BGE \quad (\text{ext. angle of cyclic quad})$$

$$= x^\circ$$

Alternatively,

$$\angle ADB = 180^\circ - \angle BDF \quad (\text{adj. angles on a str. line})$$

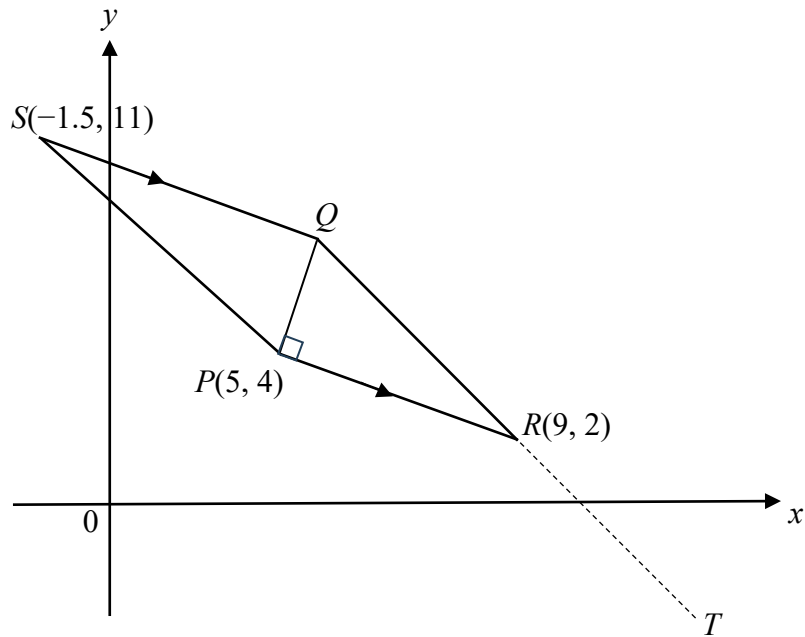
$$= 180^\circ - (180^\circ - \angle BGF) \quad (\text{angles in opp. segment})$$

$$= x^\circ$$

$$= \angle BGE$$

Triangle ABD is similar to triangle BEG (AA Similarity Test).

- 13 The diagram (not drawn to scale) shows a right-angled triangle PQR in which point P is $(5, 4)$ and point R is $(9, 2)$.
Point S is $(-1.5, 11)$ and PR is parallel to SQ .



- (a) Find the equation of PQ . [2]

$$\text{Gradient of } PR \text{ is } \frac{4-2}{5-9} = -\frac{1}{2}$$

$$\text{Gradient of } PQ = 2$$

$$\text{Equation of } PQ \text{ is } y - 4 = 2(x - 5)$$

$$y = 2x - 6 \quad \text{----- (1)}$$

- (b) Find the coordinates of Q . [3]

$$\text{Gradient of } SQ \text{ is } -\frac{1}{2}$$

$$\text{Equation of } SQ \text{ is } y - 11 = -\frac{1}{2}(x + 1.5)$$

$$y = -\frac{1}{2}x + \frac{41}{4} \quad \text{----- (2)}$$

$$(1) = (2): \quad 2x - 6 = -\frac{1}{2}x + \frac{41}{4}$$

$$\frac{5}{2}x = \frac{65}{4} \Rightarrow x = 6.5$$

$$\text{Sub } x = 6.5 \text{ into (1): } y = 2(6.5) - 6 = 7$$

Coordinates of Q are $(6.5, 7)$.

- (c) Given that T is a point on QR extended such that $QT = 10\sqrt{5}$ units, find the coordinates of T .

[5]

$$\text{Gradient of } QR \text{ is } \frac{7-2}{6.5-9} = -2$$

$$\text{Equation of } QR \text{ is } y - 2 = -2(x - 9)$$

$$y = -2x + 20$$

Let the coordinates of T be $(a, -2a + 20)$.

$$QT = \sqrt{500} \text{ units}$$

$$(a - 6.5)^2 + (-2a + 20 - 7)^2 = 500$$

$$(a - 6.5)^2 + (13 - 2a)^2 = 500$$

$$a^2 - 13a + \frac{169}{4} + 169 - 52a + 4a^2 - 500 = 0$$

$$20a^2 - 260a - 1155 = 0$$

$$4a^2 - 52a - 231 = 0$$

$$(2a - 33)(2a + 7) = 0$$

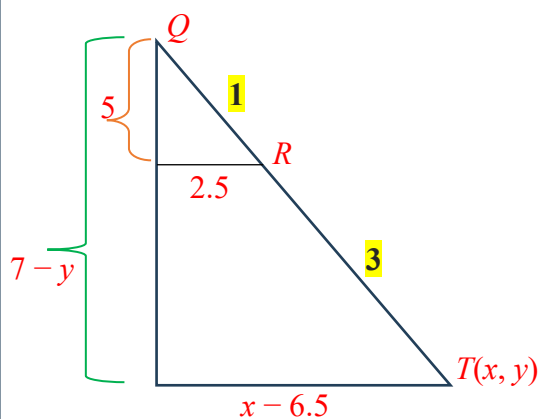
$$a = 16.5 \text{ or } a = -3.5 \text{ (rejected as } a > 0)$$

$$y\text{-coordinate of } T \text{ is } -2(16.5) + 20 = -13.$$

Coordinates of T are $(16.5, -13)$.

Alternative method

[Turn over



$$QR = \sqrt{(6.5-9)^2 + (7-2)^2}$$

$$= \sqrt{\frac{125}{4}} \text{ units}$$

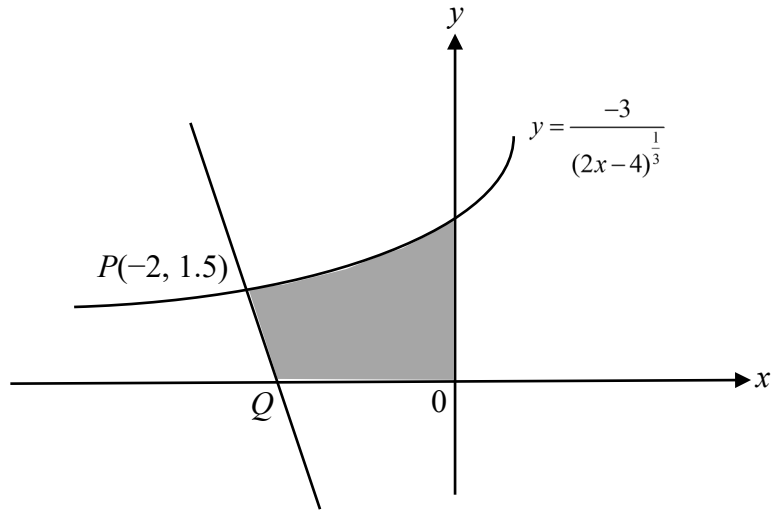
$$\frac{QR}{QT} = \frac{\frac{1}{2}\sqrt{125}}{2\sqrt{125}} = \frac{1}{4}$$

$$\frac{x-6.5}{2.5} = 4 \Rightarrow x = 16.5$$

$$\frac{7-y}{5} = 4 \Rightarrow y = -13$$

Therefore, $T(16.5, -13)$.

- 14 The graph shows part of the curve $y = \frac{-3}{(2x-4)^{\frac{1}{3}}}$. The point $P(-2, 1.5)$ lies on the curve and the normal to the curve at P meets the x -axis at Q .



- (a) Find the coordinates of Q .

[5]

$$y = -3(2x-4)^{-\frac{1}{3}}$$

$$\frac{dy}{dx} = -3\left(-\frac{1}{3}\right)(2x-4)^{-\frac{4}{3}}(2)$$

$$= \frac{2}{(2x-4)^{\frac{4}{3}}}$$

$$\text{When } x = -2, \frac{dy}{dx} = \frac{2}{[2(-2)-4]^{\frac{4}{3}}} = \frac{1}{8}$$

Gradient of normal at $P = -8$.

Equation of normal at P is $y - 1.5 = -8(x + 2)$

$$y = -8x - \frac{29}{2}$$

At Q , $y = 0$.

$$0 = -8x - \frac{29}{2} \Rightarrow x = -\frac{29}{16}$$

$$Q\left(-\frac{29}{16}, 0\right)$$

- (b) Find the area of the shaded region bounded by the curve, the normal PQ and the coordinate axes.
Give your answer correct to 3 decimal places.

[5]

Area of shaded region

$$= \int_{-2}^0 -3(2x-4)^{-\frac{1}{3}} dx - \frac{1}{2}(2-1.8125)(1.5)$$

$$= \left[\frac{-3(2x-4)^{\frac{2}{3}}}{\frac{2}{3}(2)} \right]_{-2}^0 - \frac{9}{64}$$

$$= \left[-\frac{9}{4}(2x-4)^{\frac{2}{3}} \right]_{-2}^0 - \frac{9}{64}$$

$$= -\frac{9}{4} \left[(-4)^{\frac{2}{3}} - (-8)^{\frac{2}{3}} \right] - \frac{9}{64}$$

$$= 3.190 \text{ units}^2 \text{ (to 3 d.p.)}$$