

APOLLO

Geometry and trigonometry

SL

Mathematics: applications and interpretation

First assessment 2021

70 questions | mark schemes

3. (a) $\frac{1}{2} \times 4 \times \pi \times 6^2 + \pi \times 6^2$ **OR** $3 \times \pi \times 6^2$ **(M1)(A1)(M1)**

Note: Award **M1** for use of surface area of a sphere formula (or curved surface area of a hemisphere), **A1** for substituting correct values into hemisphere formula, **M1** for adding the area of the circle.

$$= 339 \text{ mm}^2 \quad (108\pi, 339.292\dots)$$

A1**[4 marks]**

(b) $\frac{339.292\dots}{240}$

(M1)

$$= 1.41 \text{ (g)} \left(\frac{9\pi}{20}, 0.45\pi, 1.41371\dots \right)$$

A1**[2 marks]****Total [6 marks]**

5. (a) every point in the shaded region is closer to tower T4

R1

Note: Specific reference must be made to the closeness of tower T4.

[1 mark]

- (b) $(-9, 1)$

A1A1

Note: Award **A1** for each correct coordinate. Award at most **A0A1** if parentheses are missing.

[2 marks]

- (c) correct use of gradient formula

(M1)

e.g. $(m =) \frac{5-3}{-9--13} \left(= \frac{1}{2} \right)$

taking negative reciprocal of **their** m (at any point)

(M1)

edge gradient $= -2$

A1

[3 marks]

Total [6 marks]

9. attempt to find any relevant maximum value
largest sides are 56.5 and 82.5
smallest possible angle is 102.5

(M1)

(A1)

(A1)

attempt to substitute into area of a triangle formula

(M1)

$$\frac{1}{2} \times 56.5 \times 82.5 \times \sin(102.5^\circ)$$

$$= 2280(\text{m}^2) \quad (2275.37\dots)$$

A1

Total [5 marks]

2. (a) attempt at substitution into 3D distance formula **(M1)**

$$AB = \sqrt{(140 - 20)^2 + (15 - 5)^2 + 250^2} \quad (= \sqrt{77\,000})$$

$$= 277 \text{ m } (10\sqrt{770}, 277.488\dots)$$

A1

[2 marks]

- (b) attempt at substitution in the midpoint formula **(M1)**

$$\left(\frac{140 + 20}{2}, \frac{15 + 5}{2}, \frac{0 + 250}{2} \right)$$

$$(80, 10, 125)$$

A1

[2 marks]

- (c) 125 m

A1

[1 mark]

Total [5 marks]

3.	$2 \times 90 \times 34$ (= 6120) AND $2 \times 42 \times 34$ (= 2856)	(A1)
	90×42 (= 3780)	(A1)
	$r = 21$	(A1)
	$\pi \times 21^2$ (= 441π , 1385.44...)	(M1)
	use of curved surface area formula	(M1)
	$21\pi \times 90$ (= 1890π , 5937.61...)	(A1)
	20100 cm^2 (20079.0...)	A1
		Total [7 marks]

4. (a) 25° **A1****[1 mark]**

$$(b) \quad AC = \frac{380}{\tan 25^\circ} \quad \text{OR} \quad AC = \sqrt{\left(\frac{380}{\sin 25^\circ}\right)^2 - 380^2} \quad \text{OR} \quad \frac{380}{\sin 25^\circ} = \frac{AC}{\sin 65^\circ}$$

(M1)

$$AC = 815 \text{ m (814.912...)}$$

A1**[2 marks]**(c) **METHOD 1**

attempt to find AB

(M1)

$$AB = \frac{380}{\tan 40^\circ}$$

$$= 453 \text{ m (452.866...)}$$

(A1)

$$BC = 814.912... - 452.866...$$

$$= 362 \text{ m (362.046...)}$$

A1**METHOD 2**

attempt to find HB

(M1)

$$HB = \frac{380}{\sin 40^\circ}$$

$$591 \text{ m (= 591.175...)}$$

(A1)

$$BC = \frac{591.175... \times \sin 15^\circ}{\sin 25^\circ}$$

$$= 362 \text{ m (362.046...)}$$

A1**[3 marks]**(d) $362.046... \times 4$

$$= 1450 \text{ m h}^{-1} \text{ (1448.18...)}$$

A1**[1 mark]****Total [7 marks]**

6. (a) gradient $AB = \frac{4}{12} \left(\frac{1}{3} \right)$ (A1)
 midpoint AB: (8, 22) (A1)

gradient of bisector $= -\frac{1}{\text{gradient AB}} = -3$ (M1)

perpendicular bisector: $22 = -3 \times 8 + b$ OR $(y - 22) = -3(x - 8)$ (M1)

perpendicular bisector: $y = -3x + 46$ A1
 [5 marks]

(b) attempt to solve simultaneous equations (M1)
 $x + 4 = -3x + 46$
 (10.5, 14.5) A1
 [2 marks]

Total [7 marks]

9. (a) $135^\circ \times \frac{12\pi}{360^\circ}$ (M1)(A1)
 14.1 (m) (14.1371...) A1

[3 marks]

(b) evidence of splitting region into two areas (M1)

$135^\circ \times \frac{\pi 6^2}{360^\circ} - \frac{6 \times 6 \times \sin 135^\circ}{2}$ (M1)(M1)

Note: Award **M1** for correctly-substituting into area of sector formula, **M1** for evidence of substituting into area of triangle formula.

42.4115... – 12.7279...
 29.7 m² (29.6835...)

A1
 [4 marks]
 Total [7 marks]

2. (a) $4 \times \frac{360^\circ}{12}$ **OR** $4 \times 30^\circ$ (M1)

120° A1
[2 marks]

(b) substitution in cosine rule (M1)

$AB^2 = 10^2 + 6^2 - 2 \times 10 \times 6 \times \cos(120^\circ)$ (A1)

$AB = 14 \text{ cm}$ A1

Note: Follow through marks in part (b) are contingent on working seen.

[3 marks]

(c) $\theta = 13 \times 6$ (M1)

$= 78^\circ$ A1
[2 marks]

(d) substitution into the formula for arc length (M1)

$l = \frac{78}{360} \times 2 \times \pi \times 10$ **OR** $l = \frac{13\pi}{30} \times 10$

$= 13.6 \text{ cm} \left(13.6135..., 4.33\pi, \frac{13\pi}{3} \right)$ A1

[2 marks]

(e) substitution into the area of a sector (M1)

$A = \frac{78}{360} \times \pi \times 10^2$ **OR** $A = \frac{1}{2} \times \frac{13\pi}{30} \times 10^2$

$= 68.1 \text{ cm}^2 \left(68.0678..., 21.7\pi, \frac{65\pi}{3} \right)$ A1

[2 marks]

(f) 23 A1

[1 mark]

continued...

Question 2 continued

- (g) correct substitution
 $h = 10 \cos(160^\circ) + 13$
 $= 3.60 \text{ cm } (3.60307\dots)$

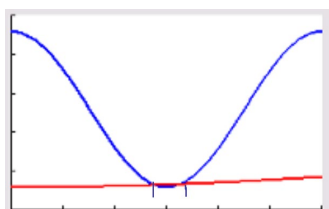
(M1)**A1****[2 marks]**

- (h) 10

A1**[1 mark]**

- (i) **EITHER**

$$10 \times \cos(\theta) + 13 = -10 \times \cos\left(\frac{\theta}{12}\right) + 13$$

(M1)**OR****(M1)**

Note: Award **M1** for equating the functions. Accept a sketch of $h(\theta)$ and $g(\theta)$ with point(s) of intersection marked.

THEN

$$k = 196^\circ (196.363\dots)$$

A1

Note: The answer $166.153\dots$ is incorrect but the correct method is implicit. Award **(M1)A0**.

[2 marks]**Total [17 marks]**

2. (a) use of cosine rule (M1)

$$\hat{A}CB = \cos^{-1} \left(\frac{1005^2 + 1225^2 - 650^2}{2 \times 1005 \times 1225} \right) \quad (A1)$$

$$= 32.0^\circ \quad (31.9980...) \quad A1$$

[3 marks]

- (b) use of sine rule (M1)

$$\frac{DE}{\sin 31.9980...^\circ} = \frac{210}{\sin 100^\circ} \quad (A1)$$

$$(DE =) 113 \text{ m} \quad (112.9937...) \quad A1$$

[3 marks]

- (c) **METHOD 1**

$$180^\circ - (100^\circ + \text{their part } (a)) \quad (M1)$$

$$= 48.0019...^\circ \quad \text{OR} \quad 0.837791... \quad (A1)$$

$$\text{substituted area of triangle formula} \quad (M1)$$

$$\frac{1}{2} \times 112.9937... \times 210 \times \sin 48.002^\circ \quad (A1)$$

$$8820 \text{ m}^2 \quad (8817.18...) \quad A1$$

METHOD 2

$$\frac{CE}{\sin(180 - 100 - \text{their part } (a))} = \frac{210}{\sin 100} \quad (M1)$$

$$(CE =) 158.472... \quad (A1)$$

$$\text{substituted area of triangle formula} \quad (M1)$$

EITHER

$$\frac{1}{2} \times 112.993... \times 158.472... \times \sin 100 \quad (A1)$$

OR

$$\frac{1}{2} \times 210... \times 158.472... \times \sin(\text{their part } (a)) \quad (A1)$$

THEN

$$8820 \text{ m}^2 \quad (8817.18...) \quad A1$$

continued...

*Question 2 continued***METHOD 3**

$$CE^2 = 210^2 + 112.993...^2 - (2 \times 210 \times 112.993... \times \cos(180 - 100 - \text{their part } (a))) \quad (M1)$$

$$(CE =) 158.472... \quad (A1)$$

$$\text{substituted area of triangle formula} \quad (M1)$$

$$\frac{1}{2} \times 112.993... \times 158.472... \times \sin 100 \quad (A1)$$

$$8820 \text{ m}^2 \quad (8817.18...) \quad A1$$

[5 marks]

$$(d) \quad 1005 - 210 \quad \text{OR} \quad 795 \quad (A1)$$

$$\text{equating answer to part (c) to area of a triangle formula} \quad (M1)$$

$$8817.18... = \frac{1}{2} \times DF \times (1005 - 210) \times \sin 48.002...^\circ \quad (A1)$$

$$(DF =) 29.8 \text{ m} \quad (29.8473...) \quad A1$$

[4 marks]**Total [15 marks]**

2. (a) attempt at substituting the cosine rule formula **(M1)**

$$\cos \theta = \frac{1660^2 + 1550^2 - 1670^2}{2(1660)(1550)} \quad \textbf{(A1)}$$

$$(\theta =) 62.6^\circ \text{ (62.5873...)} \text{ (accept 1.09 rad (1.09235...))} \quad \textbf{A1}$$

[3 marks]

- (b) correctly substituted area of triangle formula **(M1)**

$$A = \frac{1}{2}(1660)(1550)\sin(62.5873...)$$

$$(A =) 1140\,000 \text{ (1.14} \times 10^6, 1142\,043.327... \text{) km}^2 \quad \textbf{A1}$$

Note: Accept $1150\,000$ (1.15×10^6 , $1146\,279.893...$) km^2 from use of 63° .
Other angles and their corresponding sides may be used.

[2 marks]
Total: [5 marks]

7. (a) (the best placement is either point P or point Q)
attempt at using the distance formula

(M1)

$$AP = \sqrt{(10-6)^2 + (6-2)^2} \quad \text{OR}$$

$$BP = \sqrt{(10-14)^2 + (6-2)^2} \quad \text{OR}$$

$$DP = \sqrt{(10-10.8)^2 + (6-11.6)^2} \quad \text{OR}$$

$$BQ = \sqrt{(13-14)^2 + (7-2)^2} \quad \text{OR}$$

$$CQ = \sqrt{(13-18)^2 + (7-6)^2} \quad \text{OR}$$

$$DQ = \sqrt{(13-10.8)^2 + (7-11.6)^2}$$

$$(AP \text{ or } BP \text{ or } DP \Rightarrow) \sqrt{32} = 5.66 \text{ (5.65685...)} \quad \text{AND}$$

$$(BQ \text{ or } CQ \text{ or } DQ \Rightarrow) \sqrt{26} = 5.10 \text{ (5.09901...)} \quad \text{A1}$$

$$\sqrt{32} > \sqrt{26} \quad \text{OR} \quad AP \text{ (or } BP \text{ or } DP) \text{ is greater than } BQ \text{ (or } CQ \text{ or } DQ) \quad \text{A1}$$

point P is the furthest away

AG

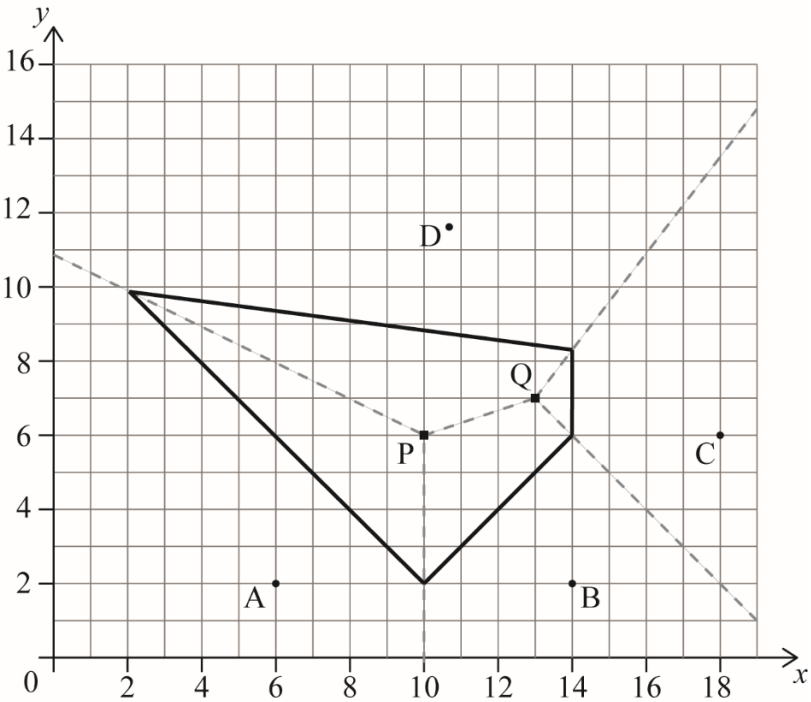
Note: Follow through from their values provided their AP (or BP or DP) is greater than their BQ (or CQ or DQ).

[3 marks]

(b) (i) $x = 14$

A1

(ii)



A1A1

Note: Award **A1** for each correct straight line. Do not **FT** from their part (b)(i).

[3 marks]
Total: [6 marks]

8. (a) (i) 13π cm**A1****Note:** Answer must be in terms of π .(ii) **METHOD 1**

$$\frac{\theta}{360} \times 2\pi(18) = 13\pi \quad \text{OR} \quad \frac{\theta}{360} \times 2\pi(18) = 40.8407\dots$$

(M1)**Note:** Award **(M1)** for correct substitution into length of an arc formula.

$$(\theta =) 130^\circ$$

A1**METHOD 2**

$$\frac{\theta}{360} \times \pi \times 18^2 = \pi \times 6.5 \times 18$$

(M1)

$$(\theta =) 130^\circ$$

A1**[3 marks]**(b) **EITHER**

$$\frac{130}{360} \times \pi(18)^2$$

(M1)**Note:** Award **(M1)** for correct substitution into area of a sector formula.**OR**

$$\pi(6.5)(18)$$

(M1)**Note:** Award **(M1)** for correct substitution into curved area of a cone formula.**THEN**

$$(\text{Area} =) 368 \text{ cm}^2 \quad (367.566\dots, 117\pi)$$

A1**Note:** Allow **FT** from their part (a)(ii) even if their angle is not obtuse.**[2 marks]****Total: [5 marks]**

4. (a) $\tan(\theta) = \frac{6}{10}$ **(M1)**

$(\theta =) 31.0^\circ (30.9637\dots^\circ)$ **OR** $0.540 (0.540419\dots)$ **A1**

[2 marks]

(b) (i) $(CV =) 40 \tan(\theta)$ **OR** $(CV =) 4 \times 6$ **(M1)**

Note: Award **(M1)** for an attempt at trigonometry or similar triangles (e.g. ratios).

$(CV =) 24 \text{ m}$ **A1**

(ii) $(V =) \frac{1}{3} 80^2 \times 24 - \frac{1}{3} 60^2 \times 18$ **M1A1A1**

Note: Award **M1** for finding the difference between the volumes of two pyramids, **A1** for each correct volume expression. The final **A1** is contingent on correct working leading to the given answer.
If the correct final answer is not seen, award at most **M1A1A0**. Award **M0A0A0** for any height derived from $V = 29600$, including 18.875 or 13.875.

$(V =) 29600 \text{ m}^3$ **AG**

[5 marks]

(c) **METHOD 1**

$\left(\frac{29600}{80} = \right) 370 \text{ (days)}$ **A1**

$(370 > 366)$ Joshua is correct **A1**

Note: Award **A0A0** for unsupported answer of "Joshua is correct". Accept $1.01\dots > 1$ for the first **A1** mark.

METHOD 2

$80 \times 366 = 29280 \text{ m}^3$ **OR** $80 \times 365 = 29200 \text{ m}^3$ **A1**

$(29280 < 29600)$ Joshua is correct **A1**

Note: The second **A1** can be awarded for an answer consistent with their result.

[2 marks]

continued...

Question 4 continued

(d) height of trapezium is $\sqrt{10^2 + 6^2}$ ($= 11.6619\dots$) **(M1)**

area of trapezium is $\frac{80+60}{2} \times \sqrt{10^2 + 6^2}$ ($= 816.333\dots$) **(M1)(A1)**

(SA =) $4 \times \left(\frac{80+60}{2} \times \sqrt{10^2 + 6^2} \right) + 60^2$ **(M1)**

Note: Award **M1** for adding 4 times their (MNOP) trapezium area to the area of the (60×60) base.

(SA =) 6870 m^2 (6865.33 m^2) **A1**

Note: No marks are awarded if the correct shape is not identified.

[5 marks]
Total: [14 marks]

7. (a) $\frac{3-1}{7-3}$ (M1)

$= 0.5$ A1
[2 marks]

(b) $y-2 = -2(x-5)$ (A1)(M1)

Note: Award (A1) for their -2 seen, award (M1) for the correct substitution of (5, 2) and their normal gradient in equation of a line.

$2x + y - 12 = 0$ A1
[3 marks]

(c) every point in the cell is closer to E than any other snow shelter A1
[1 mark]

Total [6 marks]

$$11. \quad \text{volume} = 240 \left(\pi \times 8.4^2 - \frac{1}{2} \times 8.4^2 \times 0.872664 \dots \right) \quad \textbf{M1M1M1}$$

Note: Award **M1** $240 \times \text{area}$, award **M1** for correctly substituting area sector formula, award **M1** for subtraction of their area of the sector from area of circle.

$$= 45800 \quad (= 45811.96071)$$

A1
Total [4 marks]

14. (a) $\frac{\sin \hat{CAB}}{6} = \frac{\sin 15^\circ}{4.5}$ (M1)(A1)

$\hat{CAB} = 20.2^\circ$ (20.187415...) A1

Note: Award (M1) for substituted sine rule formula and award (A1) for correct substitutions.

[3 marks]

(b) $\hat{CBD} = 20.2 + 15 = 35.2^\circ$ A1
(let X be the point on BD where Ollie activates the sensor)

$\tan 35.18741\dots^\circ = \frac{1.8}{BX}$ (M1)

Note: Award A1 for their correct angle $\hat{CBD}$. Award M1 for correctly substituted trigonometric formula.

$BX = 2.55285\dots$ A1

$5 - 2.55285\dots$ (M1)

$= 2.45 \text{ (m)} \text{ (2.44714\dots)}$ A1

[5 marks]

Total [8 marks]

1. height of triangle at roof $= 1.35 - 0.9 = 0.45$ **(A1)**

Note: Award **A1** for 0.45 (height of triangle) seen on the diagram.

slant height $= \sqrt{0.45^2 + 0.45^2}$ **OR** $\sin(45^\circ) = \frac{0.45}{\text{slant height}}$ **(M1)**

$= \sqrt{0.405}$ (0.636396..., $0.45\sqrt{2}$) **A1**

Note: If using $\sin(45^\circ) = \frac{0.45}{\text{slant height}}$ then **(A1)** for angle of 45° , **(M1)** for a correct trig statement.

area of one rectangle on roof $= \sqrt{0.405} \times 0.9$ ($= 0.572756...$) **M1**

area painted $= (2 \times \sqrt{0.405} \times 0.9 = 2 \times 0.572756...)$

1.15 m^2 ($1.14551... \text{ m}^2$, $0.81\sqrt{2} \text{ m}^2$) **A1**

[Total 5 marks]

2. (a) $\sqrt{3.2^2 + 4.5^2 + 5.8^2}$ (M1)
 $= 8.01 \text{ (8.00812...)} \text{ m}$ A1
[2 marks]
- (b) $\hat{FAO} = \sin^{-1}\left(\frac{5.8}{8.00812...}\right)$ OR $\cos^{-1}\left(\frac{5.52177...}{8.00812...}\right)$ OR $\tan^{-1}\left(\frac{5.8}{5.52177...}\right)$ (M1)
 $46.4^\circ \text{ (46.4077...}^\circ\text{)}$ A1
[2 marks]
[Total 4 marks]

4. (a) midpoint (1, 2.5)

$$m_{AB} = \frac{6 - (-1)}{8 - (-6)} = \frac{1}{2}$$

A1

(M1)A1

Note: Accept equivalent gradient statements including using midpoint.

$$m_{\perp} = -2$$

M1

Note: Award **M1** for finding the negative reciprocal of their gradient.

$$y - 2.5 = -2(x - 1) \quad \text{OR} \quad y = -2x + \frac{9}{2} \quad \text{OR} \quad 4x + 2y - 9 = 0$$

A1

[5 marks]

- (b) substituting $x = -6$ into their equation from part (a)

$$y = -2(-6) + \frac{9}{2}$$

(M1)

$$y = 16.5$$

A1

Note: Award **M1A0** for $(-6, 16.5)$ as their final answer.

[2 marks]

[Total 7 marks]

1. (a) attempt to substitute into length of arc formula **(M1)**

$$\frac{140^\circ}{360^\circ} \times 2\pi \times 56$$

$$137 \text{ cm} \left(136.833\dots, \frac{392\pi}{9} \text{ cm} \right)$$

A1

[2 marks]

- (b) subtracting two substituted area of sectors formulae **(M1)**

$$\left(\frac{140^\circ}{360^\circ} \times \pi \times 56^2 \right) - \left(\frac{140^\circ}{360^\circ} \times \pi \times 10^2 \right) \quad \text{OR} \quad \frac{140^\circ}{360^\circ} \times \pi \times (56^2 - 10^2) \quad \textbf{(A1)}$$

$$3710 \text{ cm}^2 \quad (3709.17\dots \text{ cm}^2)$$

A1

[3 marks]

Total [5 marks]

3. (a) $\sin \theta = \frac{2.1}{2.8}$ **OR** $\tan \theta = \frac{2.1}{1.85202\dots}$ (M1)

$(\theta =) 48.6^\circ$ (48.5903...°) A1
[2 marks]

(b) **METHOD 1**

$\sqrt{2.8^2 - 2.1^2}$ **OR** $2.8 \cos(48.5903\dots)$ **OR** $\frac{2.1}{\tan(48.5903\dots)}$ (M1)

Note: Award **M1** for attempt to use Pythagorean Theorem with 2.1 seen or for attempt to use cosine or tangent ratio.

1.85 (m) (1.85202...) (A1)

Note: Award the **M1A1** if 1.85 is seen in part (a).

$(6.4 - 1.85202\dots)$
4.55 m (4.54797...) (A1)

Note: Award **A1** for 4.55 or equivalent seen, either as a separate calculation or in Pythagorean Theorem.

$\sqrt{(4.54797\dots)^2 + 2.1^2}$
5.01 m (5.00939...m) A1

METHOD 2

attempt to use cosine rule (M1)

$(c^2 =) 2.8^2 + 6.4^2 - 2(2.8)(6.4)\cos(48.5903\dots)$ (A1)(A1)

Note: Award **A1** for 48.5903...° substituted into cosine rule formula, **A1** for correct substitution.

$(c =) 5.01$ m (5.00939...m) A1

[4 marks]

(c) camera 1 is closer to the cash register (than camera 2 and both cameras are at the same height on the wall) R1

the larger angle of depression is from camera 1 A1

Note: Do not award **R0A1**. Award **R0A0** if additional calculations are completed and used in their justification, as per the question. Accept "1.85 < 4.55" or "2.8 < 5.01" as evidence for the **R1**.

[2 marks]

Total [8 marks]

4. (a) (i) $\left(\frac{1}{2}A\hat{O}B = \right) \arccos\left(\frac{4}{4.5}\right) = 27.266\dots$ **(M1)(A1)**

$A\hat{O}B = 54.532\dots \approx 54.5^\circ$ ($0.951764\dots \approx 0.952$ radians) **A1**

Note: Other methods may be seen; award **(M1)(A1)** for use of a correct trigonometric method to find an appropriate angle and then **A1** for the correct answer.

(ii) finding area of triangle

EITHER

area of triangle = $\frac{1}{2} \times 4.5^2 \times \sin(54.532\dots)$ **(M1)**

Note: Award **M1** for correct substitution into formula.

$= 8.24621\dots \approx 8.25 \text{ m}^2$ **(A1)**

OR

$AB = 2 \times \sqrt{4.5^2 - 4^2} = 4.1231\dots$

area triangle = $\frac{4.1231\dots \times 4}{2}$ **(M1)**

$= 8.24621\dots \approx 8.25 \text{ m}^2$ **(A1)**

finding area of sector

EITHER

area of sector = $\frac{54.532\dots}{360} \times \pi \times 4.5^2$ **(M1)**

$= 9.63661\dots \approx 9.64 \text{ m}^2$ **(A1)**

OR

area of sector = $\frac{1}{2} \times 0.951764\dots \times 4.5^2$ **(M1)**

$= 9.63661\dots \approx 9.64 \text{ m}^2$ **(A1)**

THEN

area of segment = $9.63661\dots - 8.24621\dots$

$= 1.39 \text{ m}^2$ (1.39040...) **A1**

[8 marks]

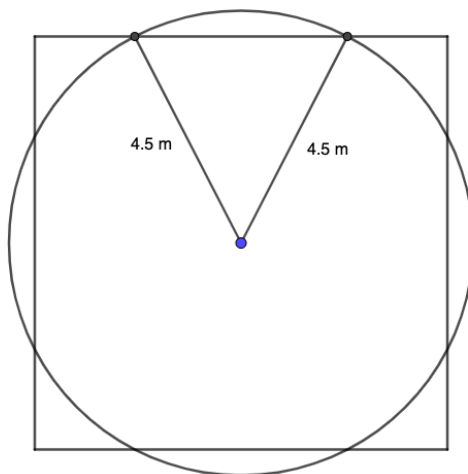
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Question 4 continued

(b) (i) $\pi \times 4.5^2$
 63.6 m^2 (63.6172... m^2)

(M1)**A1**

(ii) **METHOD 1**



$$4 \times 1.39040... \text{ (5.56160)}$$

(A1)

subtraction of four segments from area of circle

(M1)

$$= 58.1 \text{ m}^2 \text{ (58.055...)}$$

A1**METHOD 2**

$$4(0.5 \times 4.5^2 \times \sin 54.532...) + 4 \left(\frac{35.4679}{360} \times \pi \times 4.5^2 \right)$$

(M1)

$$= 32.9845... + 25.0707$$

(A1)

$$= 58.1 \text{ m}^2 \text{ (58.055...)}$$

A1**[5 marks]**

(c) sketch of $\frac{dV}{dt}$ **OR** $\frac{dV}{dt} = 0.110363...$ **OR** attempt to find where $\frac{d^2V}{dt^2} = 0$
 $t = 1$ hour

(M1)**A1****[2 marks]****[Total 15 marks]**

3. (a) $\left(\frac{2+6}{2}, \frac{2+0}{2}\right)$ (M1)
 (4, 1) A1

Note: Award **A0** if parentheses are omitted in the final answer.

[2 marks]

- (b) attempt to substitute values into gradient formula (M1)
 $\left(\frac{0-2}{6-2}\right) = -\frac{1}{2}$ (A1)
 therefore the gradient of perpendicular bisector is 2 (M1)
 so $y-1 = 2(x-4)$ ($y = 2x-7$) A1

[4 marks]

- (c) identifying the correct equations to use: (M1)
 $y = 2-x$ and $y = 2x-7$
 evidence of solving their correct equations or of finding intersection point graphically (M1)
 (3, -1) A1

Note: Accept an answer expressed as " $x = 3, y = -1$ ".

[3 marks]

- (d) attempt to use distance formula (M1)
 $YZ = \sqrt{(7-(-1))^2 + (7-3)^2}$
 $= \sqrt{80}$ ($4\sqrt{5}$) A1

[2 marks]

- (e) **METHOD 1 (cosine rule)**
 length of XZ is $\sqrt{80}$ ($4\sqrt{5}, 8.94427\dots$) (A1)

Note: Accept 8.94 and 8.9.

- attempt to substitute into cosine rule (M1)
 $\cos \hat{XYZ} = \frac{80+32-80}{2 \times \sqrt{80} \sqrt{32}}$ ($= 0.316227\dots$) (A1)

Note: Award **A1** for correct substitution of XZ, YZ, $\sqrt{32}$ values in the cos rule.
 Exact values do not need to be used in the substitution.

- ($\hat{XYZ} =$) 71.6° ($71.5650\dots^\circ$) A1

Note: Last **A1** mark may be lost if prematurely rounded values of XZ, YZ and/or XY are used.

continued...

Question 3 continued

METHOD 2 (splitting isosceles triangle in half)length of XZ is $\sqrt{80}$ ($4\sqrt{5}$, 8.94427...) **(A1)****Note:** Accept 8.94 and 8.9.required angle is $\cos^{-1}\left(\frac{\sqrt{32}}{2\sqrt{80}}\right)$ **(M1)(A1)****Note:** Award **A1** for correct substitution of XZ (or YZ), $\frac{\sqrt{32}}{2}$ values in the cos rule.
Exact values do not need to be used in the substitution. $(\hat{X}\hat{Y}\hat{Z} =) 71.6^\circ$ (71.5650°) **A1****Note:** Last **A1** mark may be lost if prematurely rounded values of XZ, YZ and/or XY are used.**[4 marks]**(f) (area =) $\frac{1}{2}\sqrt{80}\sqrt{32}\sin 71.5650\dots$ **OR** (area =) $\frac{1}{2}\sqrt{32}\sqrt{72}$ **(M1)** $= 24 \text{ km}^2$ **A1****[2 marks]**(g) *Any sensible answer such as:*

There might be factors other than proximity which influence shopping choices.

A larger area does not necessarily result in an increase in population.

The supermarkets might be specialized / have a particular clientele who visit even if other shops are closer.

Transport links might not be represented by Euclidean distances.

etc.

R1**[1 mark]****Total [18 marks]**

1. (a) $\sin(\hat{B}\hat{S}\hat{K}) = \frac{218}{1200}$ **OR** $\frac{\sin(\hat{B}\hat{S}\hat{K})}{218} = \frac{\sin(90^\circ)}{1200}$ **(M1)**

Note: Award **M1** for a correct trig formula. Accept other variables representing $\hat{B}\hat{S}\hat{K}$.

$(\hat{B}\hat{S}\hat{K} =) 10.5^\circ$ (10.4668...) **A1**

Note: Award **A1** for the radian answer, 0.182681.... Award **M1A0** if the candidate finds the correct angle of elevation but then uses it to find a complementary angle as their final answer.

[2 marks]

(b) $SB^2 + 218^2 = 1200^2$ **OR** $\cos(10.4668...) = \frac{SB}{1200}$ **OR** $\tan(10.4668...) = \frac{218}{SB}$ **OR**
 $\frac{BS}{\sin(79.5331...^\circ)} = \frac{1200}{\sin(90^\circ)}$ **(M1)**

1180 (m) ($\sqrt{1392476}$, 1180.03...) **A1**

[2 marks]

(c) 1.18×10^3 **A1A1**

Note: Award **A1** for 1.18
 Award **A1** for 10^3
 Accept their rounded answer to part (b).
 Award **A0A0** for answers of the type: 11.8×10^2 .

[2 marks]**Total [6 marks]**

2. (a) (i) 19° **A1**

(ii) $\frac{BD}{\sin 120^\circ} = \frac{40}{\sin 19^\circ}$ **(M1)(A1)**

Note: Award **M1** for substituted sine rule for BCD, **A1** for their correct substitution.

$(BD \Rightarrow) 106 \text{ m } (106.401\dots)$ **A1**

[4 marks]

(b) **METHOD 1 (cosine rule)**

$\cos BAD = \frac{85^2 + 85^2 - 106.401\dots^2}{2 \times 85 \times 85}$ **(M1)(A1)**

Note: Award **M1** for substituted cosine rule, **A1** for their correct substitution.

77.495 **A1**

Note: Accept an answer of 77.149 from use of 3 sf answer from part (a). The final answer must be correct to five significant figures.

METHOD 2 (right angled trig/isosceles triangles)

$\sin\left(\frac{BAD}{2}\right) = \frac{53.2008\dots}{85}$ **(A1)(M1)**

Note: Award **A1** for 53.2008... seen. Award **M1** for correctly substituted trig ratio. Follow through from part (a).

$77.495\dots$ **A1**

Note: Use of 3 sf answer from part (a), results in 77.149 .

[3 marks]

(c) **EITHER**

$(\text{Area} =) \frac{1}{2} \times 85 \times 85 \times \sin(77^\circ)$ **(M1)(A1)**

Note: Award **M1** for substituted area formula, **A1** for correct substitution.
Award at most **(M1)(A1)A0** if an angle other than 77° is used.

OR

$(\text{Area} =) \frac{1}{2} \times (2 \times 85 \times \sin(38.5^\circ)) \times (85 \times \cos(38.5^\circ))$ **(M1)(A1)**

Note: Award **M1** for substituted area formula $A = \frac{1}{2}bh$, **A1** for correct substitution.

$3520 \text{ m}^2 (3519.91\dots)$ **A1**

[3 marks]

continued...

Question 2 continued

(d) 85 m

A1**[1 mark]**(e) $85 + 85 + \frac{77}{360} \times 2\pi \times 85$ **(M1)(M1)**

Note: Award **M1** for correctly substituted into $\frac{\theta}{360} \times 2\pi \times r$, **M1** for addition of AB and AD.

284 m (284.231...)

A1**[3 marks]**(f) $\frac{77}{360} \times \pi \times (85)^2 - 3519.91...$ **(M1)(M1)**

Note: Award **M1** for correctly substituted area of sector formula, **M1** for subtraction of their area from part (c).

1330 m² (1334.93...)**A1****[3 marks]****Total [17 marks]**

3. (a) (i) B

A1

(ii) F

A1

[2 marks]

(b) correct substitution into the midpoint formula

(M1)

$$\frac{8+5}{2}$$

$$y = 6.5$$

A1

Note: Answer must be an equation for the **A1** to be awarded.

[2 marks]

(c) midpoint = (5, 7)

(A1)

correct use of gradient formula

(M1)

$$\frac{8-6}{7-3}$$

gradient of BC = 0.5

(A1)

negative reciprocal of gradient

(M1)

perpendicular gradient = -2

$$y - 7 = -2(x - 5) \quad (\text{or } y = -2x + 17)$$

A1

[5 marks]

(d) (i) attempt to find the intersection of two perpendicular bisectors (BC & CD) (M1)

Note: This may be seen graphically or algebraically.

$$6.5 - 7 = -2(x - 5) \quad \text{OR} \quad 6.5 = -2x + 17$$

Note: Accept equivalent methods using the perpendicular bisector of BD, $y - 5.5 = 4(x - 5)$ OR $y = 4x - 14.5$

$$x = 5.25, y = 6.5 \quad \text{OR} \quad (5.25, 6.5)$$

A1

Note: The x -coordinate must be exact or expressed to at least 3 sf.

(ii) their correct substitution into distance formula

(M1)

$$\sqrt{(5.25 - 7)^2 + (6.5 - 5)^2}$$

$$= 2.30 \text{ km} \left(2.30488..., \frac{\sqrt{85}}{4} \right)$$

A1

[4 marks]

Total [13 marks]

2. (a) attempt to calculate $\hat{A}HB$ using 33 **OR** use of alternate angles **(M1)**
 e.g., $180 - (33 + 130)$ **OR** $90 - (33 + 40)$ **OR** $57 - 40$
 17 ($^{\circ}$) **A1**

[2 marks]

- (b) attempt to use sine rule **(M1)**

$$\frac{BH}{\sin(130^{\circ})} = \frac{156}{\sin(17^{\circ})}$$
 (A1)
 (BH =) 409 (m) (408.736...) **A1**

Note: If radians are used, answer is 151 (150.922...); award at most (M1)(A1)A0 .

[3 marks]

- (c) (the angle of depression from the hot air balloon) gets smaller **A1**
 (as the horizontal distance increases)

[1 mark]

[Total: 6 marks]

11. (a) 14.55 (cm) to 14.65 (cm)

A1A1

Note: Award **A1** for each value. Accept $14.55 \leq AC < 14.65$.

[2 marks]

- (b) attempt to use Pythagorean theorem **OR** trig ratio to find slant height
a correct expression for either the **upper** or **lower** bound

(M1)

(A1)

$$\sqrt{14.55^2 - 10^2} \quad \text{OR} \quad \sqrt{14.65^2 - 10^2} \quad \text{OR}$$

$$\sin(46.5844\dots^\circ) = \frac{AH}{14.55} \quad \text{OR} \quad \sin(46.9533\dots^\circ) = \frac{AH}{14.65}$$

(lower bound =) 10.6 (cm) (10.5689...) **AND**

(upper bound =) 10.7 (cm) (10.7061...)

A1

[3 marks]

continued...

Question 11 continued

(c) **METHOD 1**

attempt to find the maximum angle measure of the post using trigonometry **(M1)**

$$\text{e.g. } \cos \theta = \frac{10}{10.7061...} \quad \text{OR} \quad \frac{\sin \theta}{3.82393...} = \frac{\sin(90^\circ)}{10.7061...}$$

Note: Accept an inequality.

$(\theta =) 20.9^\circ$ $(20.9265...^\circ)$ **A1**

and hence the post is safe **AG**

Note: Use of radians gives an answer of 0.365 (0.365237...); award at most **(M1)A0** since this value cannot be directly compared to 22° .
Award at most **(M1)A0** for an angle calculated using their lower bound from part (b).

METHOD 2

attempt to find the longest slant height for angle to be a maximum of 22° **(M1)**

$$\text{e.g. } \cos(22^\circ) = \frac{10}{x}$$

$$(x = 10.7853...)$$

$$10.7061... < 10.7853... \quad \text{A1}$$

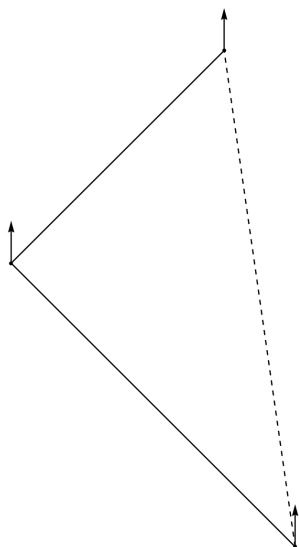
and hence the post is safe **AG**

Note: A comparison to their upper bound from part (b) is required for **A1** to be awarded. Use of radians gives an unreasonable answer of $-10.0003...$; award at most **(M1)A0**.

[2 marks]

Total [7 marks]

13. diagram showing (approximately) correct directions (and order) for the 315° and 045° **(A1)**



Note: Values do not need to be seen on the diagram to award the **A1**.

recognizing right angle triangle

(M1)

correct expression to find second angle in triangle

(A1)

e.g. $\arctan\left(\frac{6}{8}\right)$ **OR** $\arctan\left(\frac{8}{6}\right)$

correct expression to find bearing

(A1)

e.g. $\arctan\left(\frac{6}{8}\right) + 135^\circ$ **OR** $360^\circ - \left(\arctan\left(\frac{8}{6}\right) + 135^\circ\right)$

$= 172^\circ$ (171.869...°)

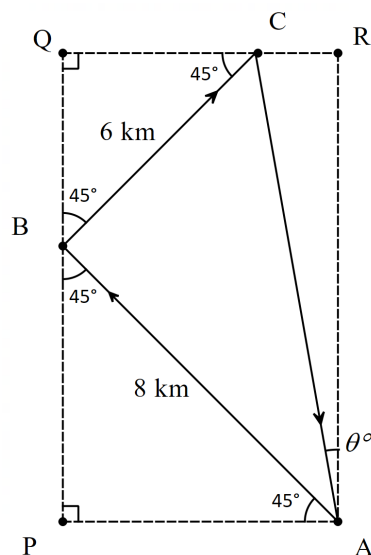
A1

continued...

Question 13 continued

METHOD 2

diagram showing (approximately) correct directions (and order) for the 315° and 045° (these may be shown in reverse as the return journey)

(A1)

finding the lengths marked AP, BP, CQ and BQ in the diagram

(M1)

$$AP = BP = 8 \frac{\sqrt{2}}{2} = 5.6568\dots$$

$$CQ = BQ = 6 \frac{\sqrt{2}}{2} = 4.2426\dots$$

Note: This may be done using a vector approach.

using $\tan \theta^\circ = \frac{AP - CQ}{PB + BQ}$ or equivalent to find the direction of AC

(A1)

correct expression to find bearing

(A1)

$$180^\circ - \arctan \left(\frac{8 \frac{\sqrt{2}}{2} + 6 \frac{\sqrt{2}}{2}}{8 \frac{\sqrt{2}}{2} - 6 \frac{\sqrt{2}}{2}} \right)$$

$$= 172^\circ \quad (171.869\dots^\circ)$$

A1**[Total: 5 marks]**

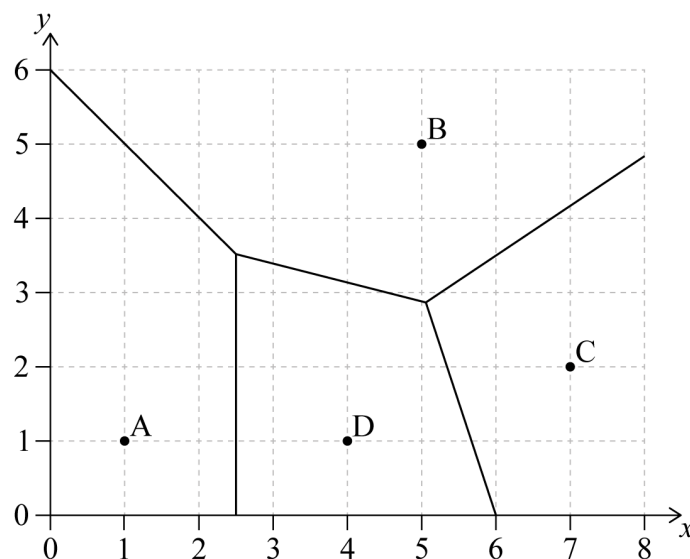
7. (a) attempt to find gradient of CD **(M1)**
 gradient of CD = $\frac{1}{3}$ therefore perpendicular gradient CD = -3 **A1**
 $y - 1.5 = -3(x - 5.5)$ **OR** $1.5 = -3(5.5) + c$ **M1**

Note: Award **M1** for substituting the gradient and midpoint into equation of line, provided further work is seen leading to a correct answer.

$$y = -3x + 18$$

AG**[3 marks]**

(b)

perpendicular bisector AD: a vertical line with x intercept 2.5**A1**

Note: The perpendicular bisector should not go beyond the intersection point (should not enter site B).

[1 mark]

- (c) attempt to solve simultaneous equations: $3y = 2x - 1.5$ and $y = -3x + 18$ **(M1)**
 $(5.05, 2.86)$ $((5.04545..., 2.86363...))$ **A1**

Note: Accept $x = 5.05$ (5.04545...), $y = 2.86$ (2.86363...) in place of coordinates.
 Accept (5.05, 2.87) and (5.05, 2.85) for using their 3 sf or 4 sf x -value to find y from any of the two equations.

[2 marks]**Total [6 marks]**

8. (a) **EITHER**

$$\frac{4}{3}\pi(3.4)^3 \quad (\text{A1})$$

multiplying their volume by $\frac{4}{5}$ (M1)

OR

$$\frac{4}{3}\pi(3.4)^3 \quad (\text{A1})$$

Subtracting $\frac{1}{5}$ of their volume (M1)

$$\left(\frac{4}{3}\pi(3.4)^3 - \frac{1}{5} \times \frac{4}{3}\pi(3.4)^3 \right)$$

Note: The **M1** can be awarded for a final answer of 32.9272... seen without working.

THEN

$$132 \text{ cm}^3 \text{ (131.708... cm}^3\text{)} \quad \text{A1}$$

[3 marks]

(b) $\pi \times 3 \times 11$ (A1)

$$103.672... (\text{cm}^2) \quad \text{OR} \quad 33\pi(\text{cm}^2)$$

$$104 (\text{cm}^2) \quad \text{A1}$$

[2 marks]**Total [5 marks]**

1. (a) attempt to use sine rule (M1)

$$\frac{\sin \hat{A}BO}{25.9} = \frac{\sin 10^\circ}{6.36} \quad (A1)$$

$$45.0^\circ \text{ (45.0036...}^\circ\text{)} \quad A1$$

Note: Accept an answer of 45° for full marks.

[3 marks]

- (b) ($\hat{O}AB =$) $124.996...^\circ$ (A1)

attempt to use area of triangle formula (M1)

$$\frac{1}{2} \times 25.9 \times 6.36 \times \sin(124.996...^\circ) \quad (A1)$$

$$67.5 \text{ m}^2 \text{ (67.4700... m}^2\text{)} \quad A1$$

Note: Units are required. The final **A1** is only awarded if the correct units are seen in their answer; hence award **(A1)(M1)(A1)A0** for an unsupported answer of 67.5. Accept $67.4670...m^2$ from use of 3 sf values.

Full follow through marks can be awarded for this part even if their $\hat{O}AB$ is not obtuse, provided that all working is shown.

[4 marks]

- (c) attempt to use cosine rule (M1)

$$(BK =) \sqrt{12^2 + 6.36^2 - 2 \times 12 \times 6.36 \times \cos 45^\circ} \quad (A1)$$

$$8.75 \text{ (m) (8.74738...(m))} \quad A1$$

Note: Award **(M1)(A1)(A0)** for radian answer of 10.2 (m) (10.2109...(m)) with or without working shown.

[3 marks]

continued...

Question 1 continued**(d) METHOD 1**

attempt to use sine rule with measurements from triangle OKX

(M1)

$$\frac{OX}{\sin 51.1^\circ} = \frac{22.2}{\sin 53.8^\circ}$$

(A1)

(OX =) 21.4 (m) (21.4099...)(m)

A1

(21.4 (m) < 22.2 (m))

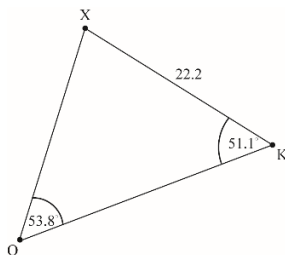
Odette is closer to the football / Khemil is further from the football

A1

Note: For the final **A1** to be given, 21.4 (21.4099...) must be seen. Follow through within question part for final **A1** for a consistent comparison with their OX.

METHOD 2

sketch of triangle OXK with vertices, angles and lengths

(A1)

51.1° is smallest angle in triangle OXK

R1

opposite side (OX) is smallest length

R1

therefore Odette is closest

A1**[4 marks]****(e)** attempt to use length of arc formula**(M1)**

$$\frac{135}{360} \times 2\pi \times 12$$

(A1)28.3(m) (9π , 28.2743...) (m)**A1****[3 marks]****Total [17 marks]**

2. (a) (upper bound =) 0.525 (m) A1
 (lower bound =) 0.515 (m) A1

Note: Accept an answer in interval notation or written as an inequality.

[2 marks]

- (b) **METHOD 1 Convert REC to linear metres**
 attempt to convert REC to metres using their lower bound (M1)
 440×0.515 (= 226.6) **OR** 280×0.515 (= 144.2) seen

attempt to use the formula for the volume of a right pyramid (M1)

$$(V =) \frac{1}{3} (440 \times 0.515)^2 (280 \times 0.515) \quad \text{(A1)}$$

$$2470000 \text{ (m}^3\text{)} \quad (2468106.051\dots, 2.47 \times 10^6) \quad \text{A1}$$

METHOD 2 Convert REC to cubic metres
 attempt to use the formula for the volume of a right pyramid (M1)

$$(V =) \frac{1}{3} (440)^2 (280) \quad (= 18069333.33\dots)$$

attempt to convert 1 cubic REC to cubic metres using their lower bound (M1)
 (1 cubic REC =) 0.515^3

$$(V =) \frac{1}{3} (440)^2 (280) \times (0.515)^3 \quad \text{(A1)}$$

$$2470000 \text{ (m}^3\text{)} \quad (2468106.051\dots, 2.47 \times 10^6) \quad \text{A1}$$

[4 marks]

[Total 6 marks]

4. (a) (4, 8) **A1**
[1 mark]
- (b) attempt to find the gradient of AC **(M1)**
 $\frac{13-3}{8-0}, \frac{10}{8}, \left(\frac{5}{4}\right), (1.25)$
 attempt to substitute **their** coordinates and the negative reciprocal of **their** gradient into the equation of a straight line **(M1)**
 $y-8 = -\frac{4}{5}(x-4)$ **OR** $8 = -\frac{4}{5}(4) + c$ **OR** $c = 11.2$
 $y-8 = -\frac{4}{5}(x-4)$ ($y = -0.8x + 11.2, 4x + 5y - 56 = 0$) **A1**
[3 marks]
- (c) (i) attempt to find one distance from a farm to any closest vertex **M1**
 finding a correct distance from at least two distinct vertices **A1**
 $7.58968\dots, 4.472135\dots \left(\sqrt{20}\right), 5.830951\dots \left(\sqrt{34}\right)$
 $\left(\frac{9}{11}, \frac{116}{11}\right)$ (is furthest) **A1**
- (ii) 7.59 (km) (= 7.58968...) **A1**
[4 marks]
[Total 8 marks]

5. (a) recognizing supplementary angles or acute angles in right-triangles (M1)
 $(\hat{R}\hat{S}T =) 38^\circ + (180^\circ - 120^\circ), 38^\circ + (90^\circ - 30^\circ)$

$$\hat{R}\hat{S}T = 98^\circ$$

A1

[2 marks]

- (b) $\hat{R}\hat{T}\hat{S} = 52^\circ$ (may be seen in part (a)) (A1)
 attempt to substitute into the sine rule (or equivalent) (M1)

$$\frac{RT}{\sin 98^\circ} = \frac{150}{\sin 52^\circ}$$

(A1)

$$RT = 189 \text{ (km)} (=188.500\dots)$$

A1

[4 marks]

[Total 6 marks]

2. (a) (upper bound =) 0.525 (m) A1
 (lower bound =) 0.515 (m) A1

Note: Accept an answer in interval notation or written as an inequality.

[2 marks]

- (b) **METHOD 1 Convert REC to linear metres**
 attempt to convert REC to metres using their lower bound (M1)
 440×0.515 (= 226.6) **OR** 280×0.515 (= 144.2) seen

attempt to use the formula for the volume of a right pyramid (M1)

$$(V =) \frac{1}{3} (440 \times 0.515)^2 (280 \times 0.515) \quad \text{(A1)}$$

$$2470000 \text{ (m}^3\text{)} \quad (2468106.051\dots, 2.47 \times 10^6) \quad \text{A1}$$

METHOD 2 Convert REC to cubic metres
 attempt to use the formula for the volume of a right pyramid (M1)

$$(V =) \frac{1}{3} (440)^2 (280) \quad (= 18069333.33\dots)$$

attempt to convert 1 cubic REC to cubic metres using their lower bound (M1)
 (1 cubic REC =) 0.515^3

$$(V =) \frac{1}{3} (440)^2 (280) \times (0.515)^3 \quad \text{(A1)}$$

$$2470000 \text{ (m}^3\text{)} \quad (2468106.051\dots, 2.47 \times 10^6) \quad \text{A1}$$

[4 marks]

[Total 6 marks]

4. (a) (4, 8) **A1**
[1 mark]
- (b) attempt to find the gradient of AC **(M1)**
 $\frac{13-3}{8-0}, \frac{10}{8}, \left(\frac{5}{4}\right), (1.25)$
 attempt to substitute **their** coordinates and the negative reciprocal of **their** gradient into the equation of a straight line **(M1)**
 $y-8 = -\frac{4}{5}(x-4)$ **OR** $8 = -\frac{4}{5}(4) + c$ **OR** $c = 11.2$
 $y-8 = -\frac{4}{5}(x-4)$ ($y = -0.8x + 11.2$, $4x + 5y - 56 = 0$) **A1**
[3 marks]
- (c) (i) attempt to find one distance from a farm to any closest vertex **M1**
 finding a correct distance from at least two distinct vertices **A1**
 $7.58968\dots, 4.472135\dots \left(\sqrt{20}\right), 5.830951\dots \left(\sqrt{34}\right)$
 $\left(\frac{9}{11}, \frac{116}{11}\right)$ (is furthest) **A1**
- (ii) 7.59 (km) (= 7.58968...) **A1**
[4 marks]
[Total 8 marks]

5. (a) recognizing supplementary angles or acute angles in right-triangles (M1)
 $(\hat{A}BC =) 41^\circ + (180^\circ - 112^\circ), 41^\circ + (90^\circ - 22^\circ)$

$$\hat{A}BC = 109^\circ$$

A1

[2 marks]

- (b) $\hat{A}CB = 49^\circ$ (may be seen in part (a)) (A1)
 attempt to substitute into the sine rule (or equivalent) (M1)

$$\frac{AC}{\sin 109^\circ} = \frac{100}{\sin 49^\circ}$$

(A1)

$$AC = 125 \text{ (km)} (= 125.282\dots)$$

A1

[4 marks]

[Total 6 marks]

2. (a) 45 (m) **A1**
[1 mark]
- (b) (i) recognition of need to use Pythagoras theorem **(M1)**
 $BE^2 = 32^2 + 45^2$
 (BE =) 55.2 (55.2177..., $\sqrt{3049}$) (m) **A1**
- (ii) correct use of trig ratio for $\hat{BEM}$ **(M1)**
 ($\hat{BEM}$ =) $\tan^{-1}\left(\frac{45}{32}\right)$ or equivalent
 ($\hat{BEM}$ =) 54.6 (54.5829...) **A1**
[4 marks]
- (c) attempt to use arc length formula **(M1)**
 (arc length =) $\frac{2 \times 54.5829...}{360} \times 2\pi(55.2177...)$ **(A1)**
 (arc length =) 105 (105.206...) (m) **A1**
[3 marks]
- (d) 59.2177... (seen anywhere) **(A1)**
 use of area of sector formula **(M1)**
 recognition of subtracting areas of two sectors **(M1)**
 (area =) $\frac{109.165...}{360} \times \pi((59.2177...)^2 - (55.2177...)^2)$
 (area =) 436 (m²) (436.068...) **A1**
[4 marks]

– 9 –

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- (e) multiplying their area from part (d) by 0.15 or 15
 0.15 (m) seen **OR** 4360688 (cm²) seen
 436.068... $\times$ 0.15 **OR** 4360688 $\times$ 15
 65.4 (65.4103...) m³ **OR** 65400000 (65410332) cm³

(M1)**(A1)****A1****[3 marks]****[Total 15 marks]**

2. (a) 25 (m) A1
[1 mark]

(b) (i) recognition of need to use Pythagoras theorem (M1)
 $BF^2 = 20^2 + 25^2$

(BF =) 32.0 (32.0156..., $\sqrt{1025}$, $5\sqrt{41}$) (m) A1

(ii) correct use of trig ratio for $\hat{BFM}$ (M1)

($\hat{BFM}$ =) $\tan^{-1}\left(\frac{25}{20}\right)$ or equivalent

($\hat{BFM}$ =) 51.3 (51.3401...) A1

Note: Accept an answer of 51.4 from use of 3sf answer to part (b)(i) and then either cosine rule or inverse sine.

[4 marks]

(c) attempt to use arc length formula (M1)

(arc length =) $\frac{2 \times 51.3401...}{360} \times 2\pi(32.0156...)$ (A1)

(arc length =) 57.4 (57.3755...) (m) A1

Note: Accept 57.3 from use of 3 sf. values of their answers from parts (b)(i) and (b)(ii).

[3 marks]

(d) 34.0156... (seen anywhere) (A1)

use of area of sector formula (M1)

recognition of subtracting areas of two sectors (M1)

(area =) $\frac{102.680...}{360} \times \pi((34.0156...)^2 - (32.0156...)^2)$

(area =) 118 (m²) (118.335...) A1

[4 marks]

– 9 –

8823–7215M

- (e) multiplying their area from part (d) by 0.12 or 12
 0.12 (m) seen **OR** 1183350 (cm²) seen
 118.335... $\times$ 0.12 **OR** 1183350 $\times$ 12
 14.2 (14.2002...) m³ **OR** 14200000 (14200236) cm³

(M1)**(A1)****A1****[3 marks]****[Total 15 marks]**

6. (a) $y = 0.5x - 1$ A1A1

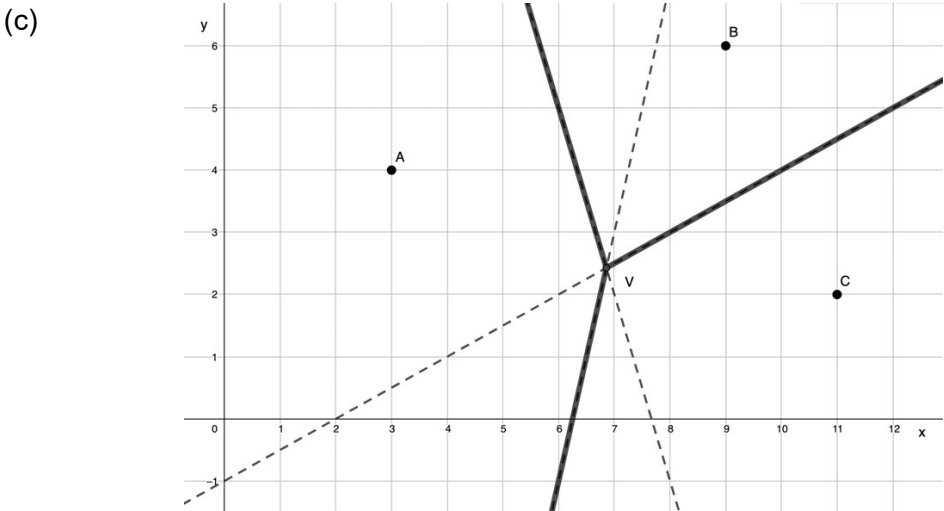
Note: Award **A1** for $0.5x$ and **A1** for -1 (or equivalent equation). Award at most **A1A0** if answer is not presented as an equation.

[2 marks]

(b) $(6.857, 2.429)$ A1A1

Note: If both answers are not correct to 4 sig figs, award at most **A1A0**.
Accept $x = 6.857$, $y = 2.429$.
Award **A1A0** for $\left(\frac{48}{7}, \frac{17}{7}\right)$. Award **A0A1** for $(2.429, 6.857)$.

[2 marks]



A2

Note: Award marks as shown in the table below. Condone edges that do not extend to the sides of the graph or beyond the x -axis.

Correct edges	Incorrect edges	Marks
3	0	A2
3	1	A1A0
3	2 or more	A0A0
2	0	A1A0
2	1	A1A0
2	2 or more	A0A0
1	0	A1A0
1	1 or more	A0A0

[2 marks]
[Total 6 marks]

11. (recognition that OB is a radius)

$$(\text{radius} =) \sqrt{5^2 + 8^2} (= \sqrt{89}) \quad (\text{A1})$$

EITHER (finding angle BOQ)

correct calculation for finding $\hat{BOA}$ (A1)

$$\hat{BOA} = \arctan\left(\frac{8}{5}\right) \quad \text{OR} \quad \tan \hat{BOA} = \frac{8}{5}$$

expressing $\hat{BOQ}$ as $90 + \hat{BOA}$ (M1)

$$\hat{BOQ} = 90 + \arctan\left(\frac{8}{5}\right) \quad \text{OR} \quad \hat{BOQ} = \frac{\pi}{2} + \arctan\left(\frac{8}{5}\right)$$

$$(\hat{BOQ} =) 147.994^\circ \dots \quad \text{OR} \quad 2.58299 \dots$$

substituting *their* radius and angle $\hat{BOQ}$ correctly into arc length formula (M1)

$$(\text{arc BQ} =) \frac{90 + \arctan\left(\frac{8}{5}\right)}{360} \times 2\pi(\sqrt{5^2 + 8^2}) \quad \text{OR} \quad \left(\frac{\pi}{2} + \arctan\left(\frac{8}{5}\right)\right) \times (\sqrt{5^2 + 8^2})$$

$$24.4 \text{ (m)} \quad (24.3679 \dots) \quad \text{A1}$$

OR (finding angle BOP)

correct calculation for finding angle $\hat{BOP}$ (A1)

$$\hat{BOP} = \arctan\left(\frac{5}{8}\right) \quad \text{OR} \quad \tan \hat{BOP} = \frac{5}{8}$$

substituting *their* radius and $\hat{BOP}$ correctly into arc length formula (M1)

$$(\text{arc BP} =) \frac{\arctan\left(\frac{5}{8}\right)}{360} \times 2\pi(\sqrt{5^2 + 8^2})$$

subtracting *their* arc BP from arc PQ (M1)

$$(\text{arc BQ} =) \pi\sqrt{5^2 + 8^2} - \frac{\arctan\left(\frac{5}{8}\right)}{360} \times 2\pi(\sqrt{5^2 + 8^2})$$

$$24.4 \text{ (m)} \quad (24.3679 \dots) \quad \text{A1}$$

[Total: 5 marks]

2. (a) attempt to substitute into cosine rule formula (M1)
 $(BC^2 =) 15^2 + 25^2 - 2 \times 15 \times 25 \times \cos(22)$ (A1)
 $(BC =) 12.4 \text{ (cm)} \text{ (12.4343...)} \quad \text{A1}$

[3 marks]

- (b) selecting sine rule formula **OR** cosine rule formula (M1)
 $\frac{12.4343...}{\sin 22} = \frac{15}{\sin \hat{A}BC} \quad \text{OR} \quad (\cos \hat{A}BC =) \frac{25^2 + 12.4343...^2 - 15^2}{2 \times 25 \times 12.4343...}$ (A1)

Note: Award **M1A1** for correct cosine rule formula to find $\hat{A}BC$.

$(\hat{A}BC =) 26.9^\circ \text{ (26.8658...}^\circ) \quad \text{A1}$

Note: Accept 26.9461... from use of 12.4 in the sine rule formula and 26.7267... in the cosine rule formula.

[3 marks]

[Total: 6 marks]

11. attempt to substitute into area of triangle formula (M1)
 (sheep's field area =) $0.5 \times 15 \times 21 \times \sin(78^\circ)$
 $=154.058... \text{ (m}^2\text{)}$ A1

EITHER

(goat's field area =) $\frac{282}{360} \times \pi \times 8^2$ (A1)(A1)

Note: Award **A1** for 282, **A1** for correct entries in formula (including their 282).

OR

$\pi \times 8^2 - \frac{78}{360} \times \pi \times 8^2$ (M1)(A1)

Note: Award **A1** for minor sector area, **M1** for subtracting their sector area from circle area.

THEN

$=157.498... \left(\frac{752\pi}{15} \right) \text{ (m}^2\text{)}$ A1

the goat has most area by 3.44 (m²) (3.44026...) A1

Note: Accept 154 and 157 for the intermediate **A1** marks, but do NOT follow through within the question; a final answer of 3 m² is awarded **A0**.

[Total: 6 marks]

2. (a) $BC = 20$ (m) A1

[1 mark]

(b) use of Pythagoras (M1)

$$AB = \sqrt{12^2 + 4^2}$$

$$= 12.6 \text{ (m)} \quad (12.6491\dots, \sqrt{160}) \quad \text{A1}$$

[2 marks]

(c) **METHOD 1 – finding angle ABC**

correct use of a trig ratio to find $\hat{ABC}$ (or finding the bearing of B from A)

(A1)

$$\text{e.g. } \tan(\hat{ABC}) = \frac{12}{4}, \cos \hat{ABC} = \frac{20^2 + 12.649^2 - 20^2}{2 \times 20 \times 12.649}, \cos \hat{ABC} = \frac{6.3245}{20}$$

$$\hat{ABC} = 71.6 \text{ (71.5650\dots)} \quad \text{(A1)}$$

Note: Angle $\hat{ABC}$ can be 71.5 or 72.2 depending on their working out. Bearings should be given in degrees.

$$180 + 71.5650\dots = 252^\circ \text{ (251.565\dots)} \quad \text{A1}$$

Note: The final **A1** can be awarded for 180 plus their 71.6. If radians used, award **A1A1** for 1.24904... or 4.39063... seen, and then **A0** for the radian answer.

METHOD 2 – finding angle that AB makes with the horizontal (angle H)

correct use of a trig ratio to find H , the angle AB makes with horizontal (A1)

$$\text{e.g. } \tan \hat{H} = \frac{4}{12}, \cos \hat{H} = \frac{12^2 + 12.649^2 - 4^2}{2 \times 12 \times 12.649}$$

$$\hat{H} = 18.4 \text{ (18.4349\dots)} \quad \text{(A1)}$$

Note: Accept 18.5 (18.5078...) from use of 3sf answer from part (b). Bearings should be given in degrees.

$$270 - 18.4348\dots = 252^\circ \text{ (251.565\dots)} \quad \text{A1}$$

Note: The final **A1** can be awarded for 270 minus their 18.4. If radians used, award **A1A1** for 0.321750... or 4.39063... seen, and then **A0** for the radian answer.

[3 marks]

– 10 –

2224 – 7210M

(d) (i) $-\frac{4}{3} \left(-\frac{16}{12} \right)$ **A1**

(ii) $(6, 8)$ **A1A1**

Note: Award **A1A0** if parentheses are missing.

(iii) gradient of (their) perp line = $\frac{3}{4}$ **(M1)**

equation of perpendicular bisector of AC **(A1)**

e.g. $(y-8) = \frac{3}{4}(x-6)$ **OR** $y = \frac{3}{4}x + 3.5$

EITHER

equation of perpendicular bisector of BC is $y = 10$ **(A1)**

OR

equation of perpendicular bisector of AB is $y = -3x + 36$ **(A1)**

Note: The **A1** is for either equation of perpendicular bisector of BC or AB.

point of intersection $\left(8\frac{2}{3}, 10 \right)$ **OR** $(8.67, 10)$ $[(8.666..., 10)]$ **(M1)A1**

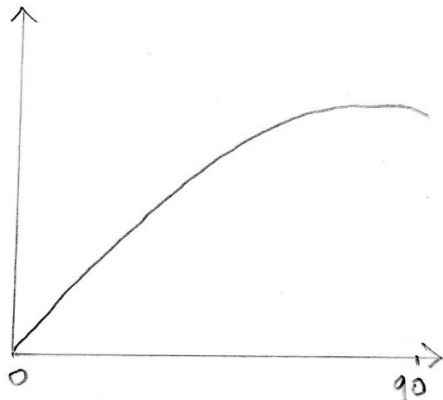
Note: Award **M1** for an attempt to equate their perpendicular bisectors
Award the final **A1** for the correct coordinate pair – parentheses omitted or not.

[8 marks]

[Total: 14 marks]

5. (a) (i) correct approach to find missing length **(A1)**
 $\sqrt{4^2 - 1^2} (= \sqrt{15})$
 attempt to find cross-section **(M1)**
 e.g. use of area of trapezoid formula or rectangle+triangle or rectangle – triangle
 use of volume of prism formula **(M1)**
 (their cross-section multiplied by 3)
 $3 \left[\frac{1}{2} (10 + 11) (\sqrt{4^2 - 1^2}) \right]$
 $= 122 (\text{m}^3) (121.998\dots)$ **A1**
- (ii) correct approach to find missing height **(A1)**
 $\sqrt{4^2 - 3.2^2} (= 2.4)$
 attempt to find volume **(M1)**
 (multiplication by 3.2 and 3 seen)
 $3 \left[\frac{1}{2} (10 + 10 + \sqrt{4^2 - 3.2^2}) (3.2) \right]$
 $= 108 (\text{m}^3) (107.52\dots)$ **A1**
- (iii) correct approach to find missing lengths **(A1)**
 $\sin(60^\circ)$ and $\cos(60^\circ)$ **OR** $\sin(60^\circ)$ and Pythagoras etc seen in work
 $3 \left[\frac{1}{2} (10 + 10 + 4 \cos(60^\circ)) 4 \sin(60^\circ) \right]$
 $= 114 (\text{m}^3) (114.315\dots)$ **A1**
- [9 marks]**
- (b) $V = 3 \left[\frac{1}{2} (10 + 10 + 4 \cos(\theta)) 4 \sin(\theta) \right]$ **A1**
 all correct intermediate working leading to given answer **A1**
 e.g. $V = 6 \sin(\theta) (20 + 4 \cos(\theta))$
 $V = 24 \sin(\theta) (5 + \cos(\theta))$ **AG**
- Note:** The **AG** line must be seen for the final **A1** to be awarded.
- [2 marks]**
- (c) *accept any reasoning along the lines:* “skip would have zero volume” or
 “if the angle is zero, then the contents would fall out” **R1**
[1 mark]

(d) (i)



A1A1

Note: Award **A1** for the correct shape and **A1** for the graph on the correct, labelled, domain. Condone omission of θ/V labels (or x/y).

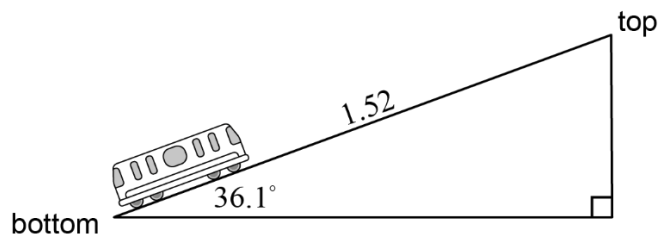
(ii) $\theta = 79.3^\circ$ (79.2723... $^\circ$) (1.38 (1.38356...)), $V_{\max} = 122$ (122.292...) **A1A1**

Note: Award **A0A1** if values are reversed and **A0A0** for a coordinate pair.

[4 marks]

[Total: 16 marks]

1. (a)



A1A1

A1 for correct angle of elevation labelled as 36.1

A1 for hypotenuse labelled as 1.52 (km)

[2 marks]

- (b) $1.52 \times \sin 36.1^\circ$
 0.896 (km) ($0.895578\dots$ (km), 896 m)

(A1)

A1

[2 marks]

[Total 4 marks]

4. (a) attempt to use the cosine rule to find $\hat{TRS}$ **(M1)**

$$(\hat{TRS} =) \cos^{-1} \left(\frac{46^2 + 39^2 - 40^2}{2 \times 46 \times 39} \right) \quad \textbf{(A1)}$$

$$(\hat{TRS} =) 55.4^\circ \text{ (55.4082...}^\circ) \textbf{ OR } 0.967 \text{ (0.967055...)} \quad \textbf{A1}$$

[3 marks]

(b) (Area =) $\frac{1}{2} \times 46 \times 39 \times \sin 55.4082...^\circ$ **(A1)**

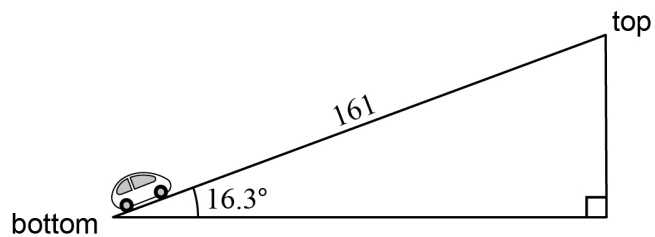
$$(\text{Area} =) 738 \text{ (738.426...)} \text{ cm}^2 \quad \textbf{A1}$$

Note: Correct units must be seen for the final **A1** to be awarded.

[2marks]

[Total 5 marks]

1. (a)



A1A1

A1 for correct angle of elevation labelled as 16.3

A1 for hypotenuse labelled as 161 (m)

[2 marks]

- (b) $161 \times \sin 16.3^\circ$
45.2 (45.1873....) (m)

(A1)

A1

[2 marks]

[Total 4 marks]

4. (a) attempt to use the cosine rule to find $\hat{CAB}$ **(M1)**

$$(\hat{CAB} =) \cos^{-1} \left(\frac{42^2 + 35^2 - 36^2}{2 \times 42 \times 35} \right) \quad \textbf{(A1)}$$

$$(\hat{CAB} =) 54.8^\circ \text{ (54.8407...}^\circ) \textbf{ OR } 0.957 \text{ (0.957152...)} \quad \textbf{A1}$$

[3 marks]

(b) (Area =) $\frac{1}{2} \times 42 \times 35 \times \sin 54.8407...^\circ$ **(A1)**

$$(\text{Area} =) 601 \text{ (600.903) cm}^2 \quad \textbf{A1}$$

Note: Correct units must be seen for the final **A1** to be awarded.

[2 marks]
[Total 5 marks]

1. (a) (2, 6)

A1

Note: Award **A0** if parentheses are omitted.

[1 mark]

(b) (i) attempt to use midpoint formula (at least one correct)

(M1)

$$\left(\frac{11+12}{2}, \frac{0+6}{2} \right)$$

$$(11.5, 3)$$

A1

$$(ii) \quad \left(m = \frac{6-0}{12-11} = \right) 6$$

(A1)

finding negative reciprocal of their gradient

(M1)

$$m_{\perp} = -\frac{1}{6}$$

attempt to substitute their midpoint and their gradient into equation of straight line

(M1)

$$\text{eg. } y-3 = -\frac{1}{6}\left(x-\frac{23}{2}\right) \quad \text{OR} \quad 3 = -\frac{1}{6}(11.5) + c$$

$$y = -0.167x + 4.92 \quad \left(y = -0.166666\dots x + 4.91666\dots, y = -\frac{1}{6}x + \frac{59}{12} \right)$$

A1

Note: Substituting $m = 6$ (no negative reciprocal) and their point into the equation of straight line would receive at most **A1M0M1A0**.

[6 marks]

(c) (closest to Q so) 4

A1

[1 mark]

(d) EITHER

$$(H_1 :) \mu_1 < \mu_2.$$

A1

OR

mean amount of money spent by all customers on weekdays is less than the
mean amount of money spent by all customers on weekends

A1

Note: Award **A0** for 'sample mean' or if 'mean' is omitted. For example, 'money spent on weekdays is less than the money spent on weekends'.

[1 mark]

continue...

Question 1 continued.

- (e) (i) convenience **A1**
- (ii) not representative of the whole population **A1**

Do not accept the following reasons

- disadvantages of other sampling methods
- there are five days during the week, only two on a weekend
- anything based on speculation/information not presented in the question
- people spend different amounts of money
- this is a sample (doesn't collect every data point) more data should have been collected

[2 marks]

- (f) $p > 0.05$ (α) **OR** $0.0897\dots > 0.05$ **R1**
- There is insufficient evidence to reject H_0 **A1**

Note: Do not award **R0A1**.

[2 marks]

[Total 13 marks]

5. (a) attempt to use Pythagoras' theorem (M1)
- $$\sqrt{4.2^2 - 3^2}$$
- $$= 2.94 \text{ (2.93938...)} \text{ (m)}$$

A1
[2 marks]

- (b) (i) **METHOD 1** (Use of $\frac{1}{2} \times a \times b \times \sin(\theta)$)
- 60° (A1)
- attempt to find area of one triangle using $\frac{1}{2} \times a \times b \times \sin(\theta)$ (M1)
- $$\frac{1}{2} \times 3 \times 3 \times \sin(60^\circ)$$
- $$\left(6 \times \frac{1}{2} \times 3 \times 3 \times \sin(60^\circ) \right) = 23.4 \text{ (23.3826..., } \frac{27\sqrt{3}}{2} \text{)} \text{ (m}^2\text{)}$$
- A1

Note: Award **A0M0A0** for $\frac{1}{2} \times 3 \times 3$ or equivalent.

- METHOD 2** (Use of altitude)
- (altitude is) $\frac{3}{2}\sqrt{3}$ (2.59807...) (A1)
- attempt to find area of one triangle using $\frac{1}{2} \times b \times h$ with their altitude (M1)
- $$\frac{1}{2} \times 3 \times \frac{3}{2}\sqrt{3}$$
- $$\left(6 \times \frac{1}{2} \times 3 \times \frac{3}{2}\sqrt{3} \right) = 23.4 \left(23.3826..., \frac{27\sqrt{3}}{2} \right) \text{ (m}^2\text{)}$$
- A1

Note: Award **A0M0A0** for $\frac{1}{2} \times 2 \times 2$ or equivalent.

- METHOD 3** (Finding the area of a trapezoid)
- (altitude of one trapezoid is) $\frac{3}{2}\sqrt{3}$ (2.59807...) (A1)
- attempt to find area of one trapezoid using $\frac{1}{2} \times (a+b)h$ (M1)
- $$\frac{1}{2}(3+6)\left(\frac{3}{2}\sqrt{3}\right) \text{ OR } \frac{27}{4}\sqrt{3}$$
- $$\left(2 \times \frac{1}{2}(3+6)\left(\frac{3}{2}\sqrt{3}\right) \right) = 23.4 \left(23.3826..., \frac{27\sqrt{3}}{2} \right) \text{ (m}^2\text{)}$$
- A1

continue...

Question 5 continued.

$$(ii) \quad \frac{1}{3} \times 23.3826... \times 2.93938... \quad (A1)$$

$$= 22.9 \text{ m}^3 \text{ (22.9102...)} \quad A1$$

Note: Units must be seen.

[5 marks]

$$(c) \quad \cos(\hat{OAT}) = \frac{3}{4.2} \text{ or correct equivalent} \quad (A1)$$

$$(\hat{OAT} =) 44.4^\circ \text{ (44.4153..., 0.775193... radians)} \quad A1$$

[2 marks]

$$(d) \quad \text{Angle QAP} = 180 - 44.4... = 135.584...^\circ \quad (A1)$$

$$\text{Angle QPA} = 180 - 30 - 135.584... = 14.4153...^\circ \quad (A1)$$

Note: These angles may be seen in the sine rule.

Attempt to substitute into sine rule

(M1)

$$\frac{AQ}{\sin(14.4153...)} = \frac{3.5}{\sin(135.584...)}$$

$$AQ = 1.25 \text{ (1.24500...) (m)}$$

A1

Note: Accept 1.24, from use of a 3sf value for $\hat{QAP}$ and $\hat{QPA}$.

[4 marks]

$$(e) \quad \text{attempt to substitute into cosine rule to form a quadratic for QR} \quad (M1)$$

$$0.8^2 = QR^2 + 1.24500...^2 - 2 \times 1.24500... \times QR \times \cos(30) \quad (A1)$$

$$QR = 0.576 \text{ (0.575717...) (m) , } 1.58 \text{ (1.58068...) (m)} \quad A1A1$$

[4 marks]

[Total: 17 marks]

1. (a) (2, 2)

A1

Note: Award **A0** if parentheses are omitted.

[1 mark]

(b) (i) attempt to use midpoint formula (at least one correct)

(M1)

$$\left(\frac{9+10}{2}, \frac{0+6}{2} \right)$$

$$(9.5, 3)$$

A1

$$(ii) \quad \left(m = \frac{6-0}{10-9} = 6 \right)$$

(A1)

finding negative reciprocal of their gradient

(M1)

$$m_{\perp} = -\frac{1}{6}$$

attempt to substitute their midpoint and their gradient into equation of straight line (M1)

$$\text{eg. } y-3 = -\frac{1}{6}\left(x-\frac{19}{2}\right) \quad \text{OR} \quad 3 = -\frac{1}{6}(9.5) + c$$

$$y = -\frac{1}{6}x + \frac{55}{12} \quad \text{OR} \quad y = -0.167x + 4.58 \quad (y = -0.166666...x + 4.58333...)$$

A1

Note: Substituting $m = 6$ (no negative reciprocal) and their point into the equation of straight line would receive at most **A1M0M1A0**.

[6 marks]

(c) (closest to B so) 5

A1

[1 mark]

(d) **EITHER**

$$(H_1 :) \mu_1 < \mu_2$$

A1

OR

mean amount of money spent by all customers on weekdays, is less than the
mean amount of money spent by all customers on weekends

A1

Note: Award **A0** for “sample mean” or if ‘mean’ is omitted. Eg “money spent on weekdays, is less than the money spent on weekends”.

[1 mark]

continue...

Question 1 continued.

- (e) (i) convenience **A1**
- (ii) not representative of the whole population **A1**

Do not accept the following reasons

- disadvantages of other sampling methods
- there are five days during the week, only two on a weekend
- anything based on speculation/information not presented in the question
- people spend different amounts of money
- this is a sample (doesn't collect every data point) more data should have been collected

[2 marks]

- (f) $p > 0.05$ (α) **OR** $0.0897\dots > 0.05$ **R1**
- There is insufficient evidence to reject H_0 . **A1**

Note: Do not award **R0A1**.

[2 marks]

[Total 13 marks]

5. (a) attempt to use Pythagoras' theorem (M1)
- $$\sqrt{3.4^2 - 2^2}$$
- $$= 2.75 \text{ (2.74954...) (m)}$$

A1
[2 marks]

- (b) (i) **METHOD 1** (Use of $\frac{1}{2} \times a \times b \times \sin(\theta)$)
- 60° (A1)
- attempt to find area of one triangle using $\frac{1}{2} \times a \times b \times \sin(\theta)$ (M1)
- $$\frac{1}{2} \times 2 \times 2 \times \sin(60^\circ)$$

$$\left(6 \times \frac{1}{2} \times 2 \times 2 \times \sin(60^\circ) \right) = 10.4 \text{ (10.3923..., } 6\sqrt{3}) \text{ (m}^2\text{)} \quad \text{A1}$$

Note: Award **A0M0A0** for $\frac{1}{2} \times 2 \times 2$ or equivalent.

- METHOD 2** (Use of altitude)
- (altitude is) $\sqrt{3}$ (A1)
- attempt to find the area of one triangle using $\frac{1}{2} \times b \times h$ with their altitude. (M1)

$$\frac{1}{2} \times 2 \times \sqrt{3}$$

$$\left(6 \times \frac{1}{2} \times 2 \times \sqrt{3} \right) = 10.4 \text{ (10.3923..., } 6\sqrt{3}) \text{ (m}^2\text{)} \quad \text{A1}$$

Note: Award **A0M0A0** for $\frac{1}{2} \times 2 \times 2$ or equivalent.

- METHOD 3** (Finding the area of a trapezoid)
- (altitude of one trapezoid is) $\sqrt{3}$ (A1)
- attempt to find area of one trapezoid using $\frac{1}{2} \times (a + b) h$ (M1)

$$\frac{1}{2} \times (2 + 4) \sqrt{3} \quad (3\sqrt{3})$$

$$\left(2 \times \frac{1}{2} \times (2 + 4) \sqrt{3} \right) = 10.4 \text{ (10.3923..., } 6\sqrt{3}) \text{ (m}^2\text{)} \quad \text{A1}$$

continue...

Question 5 continued.

$$(ii) \quad \frac{1}{3} \times 10.3923... \times 2.74954... \quad (A1)$$

$$= 9.52 \text{ m}^3 \text{ (9.52470...)} \quad A1$$

Note: Units must be seen.

[5 marks]

$$(c) \quad \cos(\hat{MAT}) = \frac{2}{3.4} \text{ or correct equivalent} \quad (A1)$$

$$(\hat{MAT} =) 54.0^\circ \text{ (53.9681...)} \quad A1$$

[2 marks]

$$(d) \quad \text{Angle YAX} = 180 - 53.9681... = 126.031...^\circ \quad (A1)$$

$$\text{Angle YXA} = 180 - 35 - 126.031... = 18.9681...^\circ \quad (A1)$$

Note: These angles may be seen in the sine rule.

Attempt to substitute into sine rule (M1)

$$\frac{AY}{\sin(18.9681...)} = \frac{2.6}{\sin(126.031)}$$

$$AY = 1.05 \text{ (1.04503...)} \text{ (m)}$$

A1
[4 marks]

$$(e) \quad \text{attempt to substitute into cosine rule to form a quadratic for YZ} \quad (M1)$$

$$0.9^2 = YZ^2 + 1.04503...^2 - 2 \times 1.04503... \times YZ \times \cos(35) \quad (A1)$$

$$YZ = 0.185 \text{ (0.184692...)} \text{ (m)}, 1.53 \text{ (1.52739...)} \text{ (m)} \quad A1A1$$

[4 marks]

[Total: 17 marks]

6. (a) attempt to calculate area of a circle using 4 or 2.8

M1

recognition of multiplication by $\frac{1}{5}$ or $\frac{72}{360}$

M1

$$A = \frac{1}{5}(\pi(4)^2 - \pi(2.8)^2)$$

$$5.13 \text{ (m}^2\text{)} \text{ (5.12707... (m}^2\text{), } \frac{204\pi}{125} \text{ (m}^2\text{), } 1.632\pi \text{ (m}^2\text{))}$$

A1

$$5.12707... < 6 \quad \text{OR} \quad \text{Maureen has enough}$$

AG

Note: Do not award the final **A1** for the area unless a comparison to 6 is shown OR a statement of having enough is seen.

[3 marks]

- (b) $(C =) 2\pi(4) \text{ (25.1327...)}$

(A1)

recognition to multiply by $\frac{3}{5}$ or $\frac{216}{360}$

(M1)

$$\frac{3}{5} \times 2\pi(4) + 2 \times 4$$

$$23.1 \text{ (m)} \text{ (23.0796...(m), } \frac{24\pi}{5} + 8)$$

A1**[3 marks]****[Total: 6 marks]**

13. (a) (i) 170° (A1)
- (ii) attempt to substitute into the cosine rule formula (M1)
- $$(DC^2) = 2^2 + 13^2 - 2(2)(13)\cos(170^\circ)$$
- (A1)
- $$(DC \Rightarrow) 15.0 \text{ (14.9736...)} \text{ (km)}$$
- A1

Note: Do not accept a 2sf answer of 15. Award **M0A0A0** for a 2sf answer of 15 with no working shown OR $2+13=15$.

- (iii) correct substitution into sine rule or cosine rule (A1)
- $$\frac{\sin \hat{BDC}}{13} = \frac{\sin 170^\circ}{14.9736...} \quad \text{OR} \quad \cos(\hat{BDC}) = \frac{14.9736...^2 + 2^2 - 13^2}{2 \times 14.9736... \times 2}$$
- ($\hat{BDC} \Rightarrow$) 8.67° (8.67097...°) (A1)
- (bearing $\Rightarrow$) 098.7° (098.6709...°) A1

[7 marks]

- (b) (distance between points D and E $\Rightarrow$) 13 (km) A1

points B, C, D, and E make a parallelogram **OR** DB and EC are parallel
and equal in length R1

Note: It is possible to award **A1R0** for this question part.

[2 marks]
[Total 9 marks]

5. (a) $\hat{VSM} = 135^\circ$ **A1**

Note: Maybe seen on the diagram.

[1 mark]

- (b) **METHOD 1**

attempt to use cosine rule

(M1)

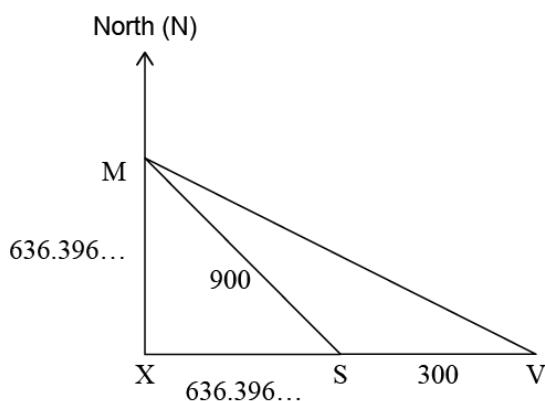
$$MV^2 = 900^2 + 300^2 - 2(900)(300)\cos(135)$$

(A1)

$$MV = 1130(\text{km}) \quad (1132.18\dots)$$

A1

METHOD 2



attempt to use Pythagoras

(M1)

$$MV^2 = (636.396\dots)^2 + (636.396\dots + 300)^2$$

(A1)

$$MV = 1130(\text{km})$$

A1

- (c) **METHOD 1**

[3 marks]

attempt to use sine rule

(M1)

$$\frac{\sin V}{900} = \frac{\sin 135}{\text{their } MV}$$

(A1)

$$\text{angle } V = 34.2^\circ \quad (34.2009\dots^\circ)$$

(A1)

Note: Award **(M1)(A1)** if $\hat{SMV} = 10.8^\circ$ is seen

$$\text{bearing} = 304^\circ \quad (304.200\dots^\circ)$$

A1

Note: Award **(M1)** for attempt to use trig, **(A1)** for correct substitution, **(A1)** for finding angle correctly and **A1** for correct bearing.

continued...

Question 5 continued

METHOD 2

attempt to use cosine rule

(M1)

$$\cos^{-1}\left(\frac{300^2 + \text{their MV}^2 - 900^2}{2 \times 300 \times \text{their MV}}\right)$$

(A1)

$$\text{angle } V = 34.2^\circ \quad (34.2009\dots^\circ)$$

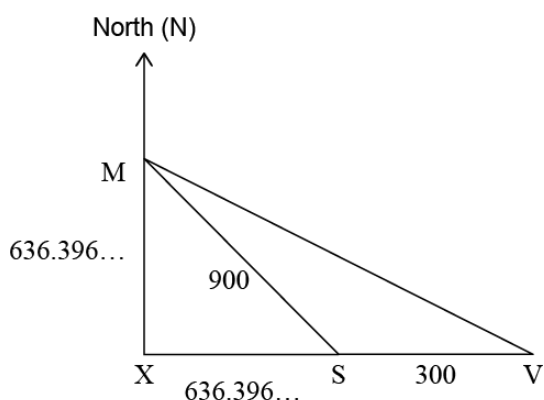
(A1)

Note: Award **(M1)(A1)** if $\hat{SMV} = 10.8^\circ$ is seen

$$\text{bearing} = 304^\circ \quad (304.200\dots^\circ)$$

A1

Note: Award **(M1)** for attempt to use trig, **(A1)** for correct substitution, **(A1)** for finding angle correctly and **A1** for correct bearing.

METHOD 3

attempt to use tan.

(M1)

$$\tan \hat{XMV} = \frac{636.396\dots + 300}{636.396\dots}$$

(A1)

$$\hat{XMV} = 55.7990\dots^\circ \text{) or } \hat{SVM} = 34.2\dots^\circ \text{ or } \hat{NMV} = 124.2\dots^\circ$$

(A1)

$$\text{bearing} = 304^\circ \quad (304.200\dots^\circ)$$

A1

Note: Award **(M1)** for attempt to use trig, **(A1)** for correct substitution, **(A1)** for finding angle correctly and **A1** for correct bearing.

[4 marks]
Total [8 marks]

7. (a) $y = 10 - x$ OE

A1A1**[2 marks]**

Note: Award **A1** for correct intercept seen, **A1** for fully correct equation.

Accept $y = -1x + 10$.

OE means for example $y - 7 = -1(x - 3)$ is **A1A1**

(b) (i) $(8, 4)$

A1

Note: Do not condone the omission of parenthesis.

(ii) 5

A1**[2 marks]**

(c) (i) 8

A1

(ii) **EITHER**

attempt to use Pythagoras theorem

(M1)

$$4 + (b - 5)^2 = 9 + (9 - b)^2$$

(A1)

$$(b =) \frac{61}{8} = 7.625 \quad \left(\frac{61}{8}, 7\frac{5}{8} \right)$$

A2

Note: Award **A1A0** for 7.63

OR

$$m(BD) = -\frac{4}{5}$$

(A1)

$$\text{midpoint } [BD] = (7.5, 7)$$

(A1)

Note: Gradient and midpoint may be implied by further working. Condone as interim coordinate 7.5, 7 instead of $(7.5, 7)$.

$$(y - 7) = \frac{5}{4}(x - 7.5)$$

substitute $x = 8$ in their perpendicular bisector

(M1)

$$b - 7 = \frac{5}{4}(8 - 7.5)$$

$$(b =) 7.625 \quad \left(\frac{61}{8}, 7\frac{5}{8} \right)$$

A1

Note: Award **A1A1M1A0** final answer of 7.63

OR

$$m(DF) = -4$$

(A1)

$$\text{midpoint } [DF] = (5.5, 7)$$

(A1)

continued...

Question 7 continued

Note: Gradient and midpoint may be implied by further working. Condone as interim coordinate 5.5, 7 instead of (5.5, 7)

$$(y - 7) = \frac{1}{4}(x - 5.5)$$

substitute $x = 8$ in their perpendicular bisector

(M1)

$$(8 - 7) = \frac{1}{4}(b - 5.5)$$

$$(b =) 7.625 \left(\frac{61}{8}, 7\frac{5}{8} \right)$$

A1

Note: Award **A1A1M1A0** final answer of 7.63

[5 marks]

Total [9 marks]

11. (a) use of Pythagoras in 3 dimensions (M1)
 $AB^2 = 2^2 + 3^2 + 1^2$
 $AB = 3.74 \quad (= 3.74165... = \sqrt{14})$ A1

[2 marks]

- (b) $1^2 + 6^2 + (k-1)^2 = 14 + 1^2 + 3^2 + (k-2)^2$ (M1)A1

Note: Award **M1** for use of Pythagoras in three dimensions, **A1** for correct use.

$$38 - 2k = 28 - 4k \quad (M1)$$

Note: Award **M1** for reducing equation to linear form.

$$k = -5 \quad A1$$

[4 marks]

- (c) EITHER

$$\cos(\hat{BAC}) = \frac{\sqrt{14}}{\sqrt{73}} \quad (M1)(A1)$$

OR

$$\sin(\hat{BAC}) = \frac{\sqrt{59}}{\sqrt{73}} \quad (M1)(A1)$$

OR

$$\tan(\hat{BAC}) = \frac{\sqrt{59}}{\sqrt{14}} \quad (M1)(A1)$$

Note: Award **M1** for use of trig ratio, **A1** for correct use.

THEN

$$\hat{BAC} = 64.0^\circ \quad (64.0282...^\circ) \quad (1.12 (1.11750...)) \quad A1$$

[3 marks]

Total [9 marks]

Q1.

- (a) attempt to substitute coordinates A and C in the formula for midpoint in 3D **(M1)**

$$\left(\frac{-2+1}{2}, \frac{0+3}{2}, \frac{0+0}{2} \right)$$

$$(-0.5, 1.5, 0) \text{ OR } \left(-\frac{1}{2}, \frac{3}{2}, 0 \right) \quad \mathbf{A1}$$

Note: Award at most **M1A0** for answers not given as coordinates. Accept $x = -0.5, y = 1.5, z = 0$.

- (b) 5 (cm)

[2 marks]**A1****[1 mark]**

- (c) attempt to substitute coordinates C and H in the formula for distance
between two points in 3D **(M1)**

$$\sqrt{(1 - (-0.5))^2 + (3 - (1.5))^2 + (0 - (5))^2}$$

$$5.43 \text{ (5.43139...) (cm)} \quad \mathbf{A1}$$

Note: If use of 2D has been penalized in part (a), do not penalize in part (c)

[2 marks]**Total [5 marks]**

Q5.(a) midpoint of $[AB]$: $(4, 6.5)$ **(A1)**gradient of $[AB]$: $\frac{1}{2}$ **(A1)**gradient of perpendicular line: -2 **(M1)**

Note: Award **M1** for gradient of perpendicular line. Allow follow through from their gradient of $[AB]$.

$$y - 6.5 = -2(x - 4) \text{ OR } y = -2x + 14.5 \quad \mathbf{A1}$$

[4 marks](b) Option 3 **A2****[2 marks]**

Note: Award **A1A0** if 2 options are selected and 1 of them is Option 3. Award **A0A0** in all other cases.

(c) attempt to find distance $(6, 4)$ to D or to draw a circle with radius 3 on the diagram **M1**

$$\sqrt{2^2 + 2^2} = \sqrt{8}, 2.82842...$$

Yes (she is experiencing excellent coverage) **A1****EITHER** $2.83 \text{ (km)} < 3 \text{ km}$ **R1****OR** $(6, 4)$ is within a radius of 3 km from site D **R1**

Note: Allow follow through for the **R1** from their distance. Award at most **M0R1FTA0** for comparing their distance with 3 km. Condone truncated 2 or 3 sf values for the **R** mark.

Do not award **A1R0**.*continued*

Question 5 continued.

Note: Allow the use of point B for candidates who assume the new towers have not yet been built.

attempt to find distance $(6, 4)$ to B or to draw a circle with radius 3 on the diagram **M1**

$$\sqrt{4^2 + 1^2} = \sqrt{17} = 4.12310\dots$$

No (she is not experiencing excellent coverage) **A1**

EITHER

$4.12 \text{ (km)} > 3 \text{ km}$ **R1**

OR

$(6, 4)$ is not within a radius of 3 km from site B **R1**

[3 marks]

Total [9 marks]

Q6.

(a) attempt to use the cosine rule formula (M1)

$$(NV =) \sqrt{20^2 + 25^2 - 2 \times 20 \times 25 \cos 55.5^\circ} \quad (A1)$$

$$= 21.4(\text{m})(21.4148...) \quad A1$$

[3 marks](b) **EITHER**

attempt to use the sine rule formula (M1)

$$\frac{\sin \hat{PNV}}{25} = \frac{\sin 55.5^\circ}{21.4148...} \quad (A1)$$

OR

attempt to use the cosine rule formula (M1)

$$\cos \hat{PNV} = \frac{20^2 + 21.4148...^2 - 25^2}{2 \times 20 \times 21.4148...} \quad (A1)$$

THEN

$$\hat{PNV} = 74.2^\circ (74.1749...) \quad A1$$

[3 marks](c) recognition that shortest distance is perpendicular to NV (M1)
(may be seen on diagram)

use of right-angled triangle or other valid method (M1)

$$\sin 74.1749... \times 20 \quad \text{OR} \quad \frac{1}{2} \times 20 \times 25 \times \sin 55.5^\circ \times \frac{2}{21.4148...}$$

$$= 19.2(\text{m})(19.2419...) \quad A1$$

Note: Accept 19.3 (m) from using their 3 sf value in $\frac{1}{2} \times 20 \times 25 \times \sin 55.5^\circ \times \frac{2}{21.4148...}$

[3 marks]**Total [9 marks]**

4. (a) (4,1,0)

A1A1

Note: Award **A1** for 4 seen as the x -coordinate or 1 seen as the y -coordinate, **A1** for all coordinates correct and in the correct order. Accept $x = 4, y = 1, z = 0$.

(b) correct substitution into distance formula

[2 marks]
(A1)

$$\sqrt{(13-13)^2 + (25-1)^2 + (7-0)^2} \text{ OR } \sqrt{0^2 + 24^2 + 7^2}$$

Note: Accept omission of $(13-13)^2$ or 0^2 .

$$(AC =) 25 \text{ (cm)}$$

A1
[2 marks](c) **Method 1**

24 and 7 seen

A1

$$24^2 + 7^2 = 25^2 \text{ OR } 625 = 625 \text{ OR (angle B =) } \cos^{-1}\left(\frac{7^2 + 24^2 - 25^2}{2(7)(24)}\right) = 90^\circ$$

R1

Note: Accept $AB^2 + BC^2 = 625$ as long as the length of AB and of BC are defined.

therefore $\triangle ABC$ must be a right-angled triangle**AG****Method 2**A relevant statement describing $\vec{AB}$ and $\vec{BC}$, such as: $AB \parallel y\text{-axis}$ **AND** $BC \parallel z\text{-axis}$ **OR** x -coordinates are the same for A and B **AND** y -coordinates are the same for B and C **A1**AB perpendicular to BC since x -axis is perpendicular to z -axis **R1**therefore $\triangle ABC$ must be a right-angled triangle **AG****[2 marks]**

(d) width of 9 or correct cross-section area(84) seen

(A1)

correct substitution into volume formula

(A1)

$$V = \frac{1}{2}(24)(7)(9)$$

$$(\text{Volume} =) 756 \text{ cm}^3$$

A1

Note: Do not award final **A1** if correct units are not included.

[3 marks]

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- (e) correct substitution using *their* AB from part (c) or (d) and *their* original volume from part (d)

(A1)

$$(AX \Rightarrow) 24 \times \sqrt{\frac{625}{756}}$$

$$21.8 \text{ (cm)} \quad (21.8217\dots \text{ (cm)})$$

A1
[2 marks]

- (f) multiplying 625 by 1.1 or 1.2 or 0.025

(M1)

$$625 \times 1.1 \times 0.025 \times 1.2$$

(A1)

$$(\text{price} \Rightarrow) 20.63 \quad (20.625) \text{ (USD)}$$

A1
[3 marks]
[Total 14 marks]

5. (a) (i) attempt to substitute any given coordinates into midpoint formula (M1)

$$(12, 12.5) \text{ or } (12, \frac{25}{2}) \quad \text{A1}$$

Note: Award **A0** if parentheses are omitted.

- (ii) attempt to find gradient of BC using coordinates of B and C (M1)

$$(\text{gradient of BC} =) \frac{12-13}{16-8} \left(= -\frac{1}{8} = -0.125 \right) \quad \text{(A1)}$$

$$(\text{gradient of } \perp =) 8 \quad \text{A1}$$

Note: Follow through within question part for final **A1** from their gradient of BC only if the gradient is seen.

- (iii) **EITHER**

$$8(x-12) = y-12.5 \quad \left(8(x-12) = y-12\frac{1}{2} \right) \quad \text{A1}$$

OR

$$y = 8x - 83.5 \quad \left(y = 8x - 83\frac{1}{2} \right) \quad \text{A1}$$

[6 marks]

- (b) (i) **EITHER**

B is expected to respond since (14, 10) lies in the same cell (of the Voronoi diagram) as fire station B **R1**

OR

B is expected to respond since (14, 10) is closer to B than to any other fire station **R1**

OR

B is expected to respond since it's the closest (nearest responder) to (14, 10) **R1**

OR

Fire station B will respond as the fire is within B's boundaries/area/region. **R1**

Note: Do not award **R1** unless the statement refers to both the distance (closer) to B (or located in the B cell) **and** the responder (point B or fire station B) For example, award **R0** for "Point B is closer to (14, 10)" as there is no reference to a responder.

- (ii) Award **R1** for any viable reason such as:

- fire station B might have already responded to a different fire
- a different fire station might have more manpower or equipment available to fight the fire
- a different fire station might respond to assist fire station B if the fire is large
- the Voronoi diagram only considers straight-line distances, so a different fire station might have a shorter driving route to the fire

R1
[2 marks]

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(c) (i) attempt to calculate the length DB (M1)

a correct expression for DB A1

$$(DB =) \sqrt{\left(11\frac{1}{3} - 16\right)^2 + \left(7\frac{1}{6} - 12\right)^2}$$

$$DB = 6.71855$$

AG

(ii) METHOD 1

$$(DC =) \sqrt{\left(11\frac{1}{3} - 8\right)^2 + \left(7\frac{1}{6} - 13\right)^2}$$

A1

DC = 6.71855 therefore, the fire is equidistant from all 3 fire stations R1

so, any of the fire stations would be expected to respond AG

Note: Do not award **A0R1**. Do not award **R1** if **AG** statement is not seen.

METHOD 2

The intersection of bisector AB and bisector BC :

$$y = 8x - 83.5 \text{ and } y = 0.5x + 1.5 \text{ have an intersection at } D\left(11\frac{1}{3}, 7\frac{1}{6}\right)$$

A1

Note: Calculator solve is acceptable but D must be clearly identified from a calculation of intersecting lines.

Since D is the intersection of the bisector lines, the fire at D is equidistant from all 3 fire stations R1

so, any of the fire stations would be expected to respond AG

Note: Do not award **A0R1**. Do not award **R1** if **AG** statement is not seen.

[4 marks]

- (d) (i) **METHOD 1: Dividing into two triangles**
- $(0.5 \times 20 + 1.5 =) 11.5$ seen in an area calculation (A1)
- $(20 - 7.75 =) 12.25$ or $(20 - 11.3333... =) 8.66666...$ seen (A1)
- substitution into triangle area formula for either triangle (M1)
- $(A =) 0.5 \times (20 - 7.75) \times 7.16666... + 0.5 \times 11.5 \times (20 - 11.3333...)$ (A1)
- 93.7291... (sq. units)
- 94 (sq. units) A1

Note: Answer must be given as a whole number to award final **A1**.
Award (A1)(A1)(M1)(A1)A0 for an answer of 93.7 without working.

- METHOD 2: Dividing vertically into triangle and trapezoid**
- $(0.5 \times 20 + 1.5 =) 11.5$ seen in an area calculation (A1)
- attempt to substitute into area of trapezoid formula (M1)
- $(A =) 0.5 \times (7.16666... + 11.5) \times (20 - 11.3333...)$

Note: Lengths of parallel sides must be seen to award the **M1**.

- correct calculation of right triangle area (A1)
- $(A =) 0.5 \times (11.3333... - 7.75) \times 7.16666...$
- $(A =) 0.5 \times (11.3333... - 7.75) \times 7.16666... + 0.5 \times (7.16666... + 11.5) \times (20 - 11.3333...)$ (A1)
- 93.7291... (sq. units)
- 94 (sq. units) A1

Note: Answer must be given as a whole number to award final **A1**.
Award (A1)(M1)(A1)(A1)A0 for an answer of 93.7 without working.

METHOD 3: Dividing horizontally into triangle and trapezoid $(0.5 \times 20 + 1.5 =) 11.5$ seen in an area calculation**(A1)**

attempt to substitute into area of trapezoid formula

(M1)

$$(A =) 0.5 \times [(20 - 7.75) + (20 - 11.3333...)] \times 7.16666...$$

Note: Lengths of parallel sides must be seen to award the **M1**.

correct calculation of right triangle area

(A1)

$$(A =) 0.5 \times (20 - 11.3333...) \times (11.5 - 7.16666...)$$

$$(A =) 0.5 \times (20 - 11.3333...) \times (11.5 - 7.16666...) + 0.5 \times [(20 - 7.75) + (20 - 11.3333...)] \times 7.16666...$$

(A1)

93.7291... (sq. units)

94 (sq. units)

A1

Note: Answer must be given as a whole number to award final **A1**.
Award **(A1)(M1)(A1)(A1)A0** for an answer of 93.7 without working.

METHOD 4: Dividing into two triangles and rectangle $(0.5 \times 20 + 1.5 =) 11.5$ seen in an area calculation**(A1)** $(20 - 11.3333...)$ **OR** $(11.3333... - 7.75)$ **OR** $(11.5 - 7.16666...)$ seen**(A1)**

substitution into triangle area formula.

(M1)

$$0.5 \times (11.3333... - 7.75) \times 7.16666... + (20 - 11.3333...) \times 7.16666... + 0.5 \times (11.5 - 7.16666...) \times (20 - 11.3333...)$$

(A1)

93.7291... (sq. units))

94 (sq. units)

A1

Note: Answer must be given as a whole number to award final **A1**.
Award **(A1)(A1)(M1)(A1)A0** for an answer of 93.7 without working.

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METHOD 5: Calculus

A and C mid point (13, 10.5)

$$(\text{gradient of AC} =) \frac{13-8}{8-18} = -\frac{5}{10}$$

(gradient of $\perp$) = 2

$$\text{AC bisector } 2(x-13) = y-10.5 \quad \text{OR} \quad y = 2x - 15.5$$

A1

attempt to integrate their equation and given equation

(M1)

$$\text{area} = \int_{7.75}^{11.3} 2x - 15.5 \, dx + \int_{11.3}^{20} 0.5x + 1.5 \, dx$$

(A1)(A1)

Note: Award **A1** for each correct expression with correct limits.

93.7291... (sq. units))

94 (sq. units)

A1

Note: Answer must be given as a whole number to award final **A1**.
Award **A1(M1)(A1)(A1)A0** for an answer of 93.7 without working.

(ii) (1 sq unit = $2.5 \text{ km} \times 2.5 \text{ km}$ =) $6.25 \text{ (km}^2\text{)}$ **(A1)**

Note: Award **A1** for 6.25 seen.

$$(94 \times 6.25 \text{ km}^2)$$

$$588 \text{ (587.5) (km}^2\text{)}$$

A1

Note: Accept: 586 (585.807...) (km²) from $(93.7291... \times 6.25 \text{ km}^2)$.

[7 marks]
[Total: 19 marks]

6. (a) attempt to use cosine rule (M1)
 $\cos\theta = \frac{15^2 + 10^2 - 8^2}{2 \times 15 \times 10}$ (A1)
 29.5(°) **OR** 0.516 (29.5413..., 0.515594...) (A1)
[3 marks]

- (b) attempt to find the area of triangle ABC (substitution into the formula must be attempted) (M1)
 $\frac{1}{2} \times 15 \times 10 \times \sin(29.5413 \dots^\circ)$ (A1)
 (= 36.9788...)

attempt to find the area of sector ABD (substitution into the formula must be attempted) (M1)
 $\frac{29.5413 \dots}{360} \times \pi \times 10^2$ **OR** $\frac{1}{2} \times 10^2 \times 0.515594 \dots$ (A1)
 (= 25.7797...)

(36.9788... – 25.7797...)
 11.2 cm² (11.1991...)

A1

Note: Correct units are required to award the final **A1**.

[5 marks]
Total [8 marks]

12. (a) (i) every point in the shaded region is closer to B than any other police station **A1**
- (ii) point D is equidistant from A, C **and** B **OR** equidistant from the three sites **A1**
[2 marks]
- (b) $m_{AB} = -0.5$ **OR** $m_{BC} = 1$ **A1**

Note: Award **A1** for either perpendicular gradient seen. The gradient may be seen in the equation of the perpendicular bisector.

$$y - 5 = -0.5(x - 3) \quad \text{or} \quad y = -0.5x + 6.5$$

OR

$$y - 6 = 1(x - 10) \quad \text{or} \quad y = x - 4$$

M1

Note: Award **M1** for an attempt to find the equation of AB or BC. One equation consistent with their gradient is sufficient to award this mark. If the gradient is incorrect, it must be explicitly identified as the gradient of m_{AB} or m_{BC} .

EITHER (equating AB and BC)

$$y - 5 = -0.5(x - 3) \text{ or } y = -0.5x + 6.5 \quad \text{AND} \quad y - 6 = 1(x - 10) \text{ or } y = x - 4$$

(A1)

$$-0.5x + 6.5 = x - 4 \quad \text{OR} \quad \text{sketch of AB and BC with intersection marked}$$

(M1)

Note: Award **M1** for an attempt to find the intersection of their lines AB and BC.

OR (equating AB or BC to their respective edges, and using midpoint)

$$-0.5x + 6.5 = 2x - 6 \quad \text{OR} \quad x - 4 = -x + 13$$

(M1)

$$(\text{midpoint of AB}) \quad (5,4) \quad \text{OR} \quad (\text{midpoint BC}) \quad (8.5,4.5)$$

(A1)

Note: Award **M1** for an attempt to equate a line (AB or BC) and its associated perpendicular edge. This may be implied through the midpoint of AB (5,4) or BC (8.5,4.5) seen.

THEN

$$(7,3)$$

A1

[5 marks]

Total [7 marks]

5. (a) P

A1
[1 mark]

(b) attempt to find one distance

(M1) $\sqrt{116}(10.8, 10.7703\dots, 2\sqrt{29})$ **OR** $\sqrt{200}(14.1, 14.1421\dots, 10\sqrt{2})$ (seen)**A1**

Note: Award **(M1)** for attempt to find one distance (i.e. OQ or ON or OM or PQ or PN or PM).
 Award **(M1)A1** for finding correctly OQ = 10.8 or ON = 10.8 or OM = 14.1.
 Award **(M0)A1A0** for an unsupported final answer of "N & Q".
 To be awarded the final **A1** must consider point M.
 These values might be seen in working for part (a) and can be credited in part (b).

N and Q

A1
[3 marks](c) $x = 7$ **A1**

Note: Answer must be an equation for the **A1** to be awarded.

[1 mark]

(d) the gradient of MP is $\frac{10-(-5)}{10-0} = \frac{15}{10}$ (or $\frac{3}{2}$)**(A1)**

negative reciprocal of their gradient

(M1)gradient of perpendicular bisector = $-\frac{2}{3}$ midpoint_{MP} is $\left(\frac{10+0}{2}, \frac{10+(-5)}{2}\right) = \left(5, \frac{5}{2}\right)$ **(A1)** $y - \frac{5}{2} = -\frac{2}{3}(x - 5)$ **OR** $y = -\frac{2}{3}x + \frac{35}{6}$ **OR** $4x + 6y - 35 = 0$ **A1**

Note: Allow follow-through, within the question, for the final **A1** from their midpoint and gradient of perpendicular bisector (seen), if the **M1** has been awarded.

[4 marks]

Total [9 marks]

11. (a) attempt to use volume of cylinder formula or area of sector formula (M1)
- $$\pi \times 11^2 \times 10 \text{ OR } \frac{22.5}{360} \times \pi \times 11^2 \text{ OR } \frac{\pi \times 11^2}{16}$$
- $$(V =) \frac{\pi \times 11^2}{16} \times 10 \text{ OR } (V =) \frac{22.5}{360} \times \pi \times 11^2 \times 10 \quad (A1)$$
- $$= 238 \text{ cm}^3 \left(237.582 \dots, \frac{605}{8} \pi, 75.625 \pi \right) \quad A1$$

Note: Do not award the final **A1** if units are missing or incorrect. Award **(M1)(A1)A0** for “238” seen without working. Accept $75.6\pi \text{ cm}^3$ as a correct final answer.

[3 marks]

- (b) attempt find arc length OR area of one rectangle (M1)
- $$\frac{2 \times 11 \times \pi}{16} \text{ OR } 10 \times 11 \text{ OR } \frac{22.5}{360} \times 2\pi \times 11$$

$$\frac{2 \times 11 \times \pi}{16} \times 10 + 2 \times 10 \times 11 \quad (A1)$$

$$= 263 \text{ cm}^2 (263.196 \dots) \quad A1$$

Note: Do not award the final **A1** if units are missing or incorrect. Award **(M1)(A1)A0** for “263” seen without working. If units were penalized in part (a) then do not penalize here so it is possible to be awarded **(M1)(A1)A1ft**.

[3 marks]

Total [6 marks]

3. (a) Cosine rule and area of triangle formula

attempt to use cosine rule to find an angle

(M1)**EITHER**

$$(\theta =) \cos^{-1} \left(\frac{1600^2 + 1500^2 - 1400^2}{2 \times 1600 \times 1500} \right) (= 53.5764...(^{\circ}))$$

(A1)attempt to use area of triangle formula for **their angle**/expression**(M1)**

$$(A =) \frac{1}{2} 1600 \times 1500 \times \sin(53.57642636...(^{\circ}))$$

(A1)**OR**

$$(\theta =) \cos^{-1} \left(\frac{1400^2 + 1500^2 - 1600^2}{2 \times 1400 \times 1500} \right) (= 66.8676...(^{\circ}))$$

(A1)attempt to use area of triangle formula for **their angle**/expression**(M1)**

$$(A =) \frac{1}{2} 1400 \times 1500 \times \sin(66.8676036...(^{\circ}))$$

(A1)**OR**

$$(\theta =) \cos^{-1} \left(\frac{1600^2 + 1400^2 - 1500^2}{2 \times 1600 \times 1400} \right) (= 59.5559...(^{\circ}))$$

(A1)

attempt to use area of triangle formula for their angle/expression

(M1)

$$(A =) \frac{1}{2} 1400 \times 1600 \times \sin(59.5559...(^{\circ}))$$

(A1)**THEN**

$$966\,000 \quad (965\,579...)(\text{m}^2)$$

(A1)

$$9.66 \times 10^5 \quad (9.65579... \times 10^5)(\text{m}^2)$$

A1

Note: Follow through within the question for correctly converting their intermediate value into standard form (but only if their pre-conversion value is seen).

[6 marks]

(b) $\sqrt{300^2 + 200^2}$ **OR** $300^2 + 200^2 = d^2$
 361 (360.555...) (m)

(A1)**A1****[2 marks]**

(c) $360.555... \times 2 \times (\$)120$
 $(\$)86533.2...$
 $(\$)86533$

(A1)**A1**

Note: Accept 86640, 86544, and 86534,
 (from use of 3 sf, 4sf and 5sf answer to part(b), respectively).

[2 marks]

(d) (i) $1750 \times 60 - 86533$
 $(\$)18467$

(A1)**A1**

Note: Accept 18360, 18456, and 18466, from 3sf, 4sf and 5sf answers to part (b).

(ii) $N = 60$
 $PV = (\mp)86533$
 $FV = 0$
 $PMT = (\pm)1750$
 $P/Y = 12$
 $C/Y = 12$

(M1)(A1)

Note: Award **M1** for an attempt to use a financial app (at least 3 entries, not necessarily correct) or an attempt to use an annuity formula.
 Award **A1** for all entries correct in financial app or correct substitution in an annuity formula.
 Award **M0** for a substituted compound interest formula only.

$$7.89(\%) (7.88938....)$$

A1

Note: Accept 7.84(%) and 7.88(%), from 3sf and 4sf answers to part (b).

[5 marks]**Total [15 marks]**

