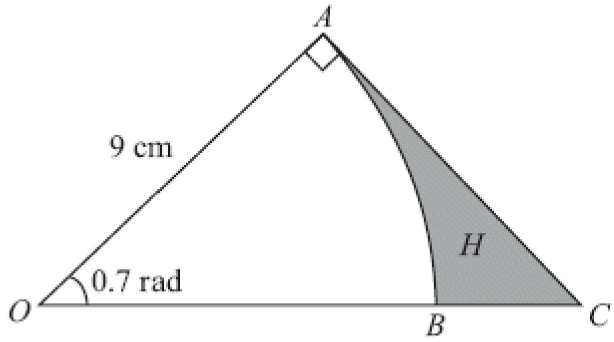
1.



The diagram above shows the sector OAB of a circle with centre O, radius 9 cm and angle 0.7 radians.

(a) Find the length of the arc AB.
(2)

(b) Find the area of the sector OAB.
(2)

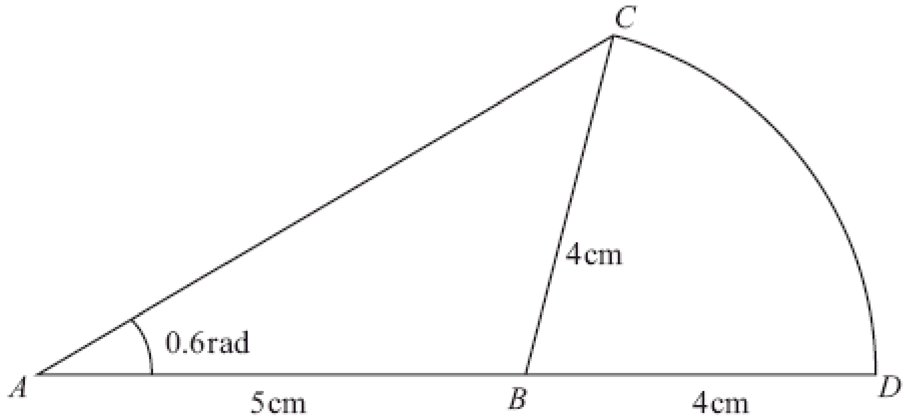
The line AC shown in the diagram above is perpendicular to OA, and OBC is a straight line.

(c) Find the length of AC, giving your answer to 2 decimal places.
(2)

The region H is bounded by the arc AB and the lines AC and CB.

(d) Find the area of H, giving your answer to 2 decimal places.
(3)
(Total 9 marks)

2.



An emblem, as shown in the diagram above, consists of a triangle ABC joined to a sector CBD of a circle with radius 4 cm and centre B. The points A, B and D lie on a straight line with AB = 5 cm and BD = 4 cm. Angle BAC = 0.6 radians and AC is the longest side of the triangle ABC.

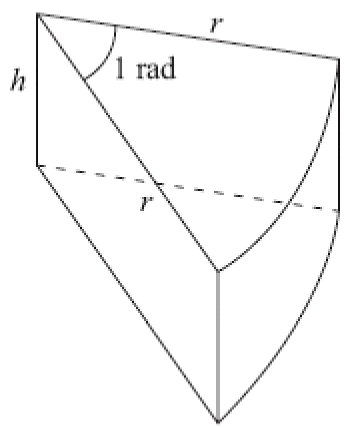
(a) Show that angle ABC = 1.76 radians, correct to 3 significant figures.

(4)

(b) Find the area of the emblem.

(3)
(Total 7 marks)

3.



The diagram above shows a closed box used by a shop for packing pieces of cake. The box is a right prism of height h cm. The cross section is a sector of a circle. The sector has radius r cm and angle 1 radian.

The volume of the box is 300 cm^3.

(a) Show that the surface area of the box, S cm^2, is given by

$$S = r^2 + \frac{1800}{r}$$

(5)

(b) Use calculus to find the value of r for which S is stationary.

(4)

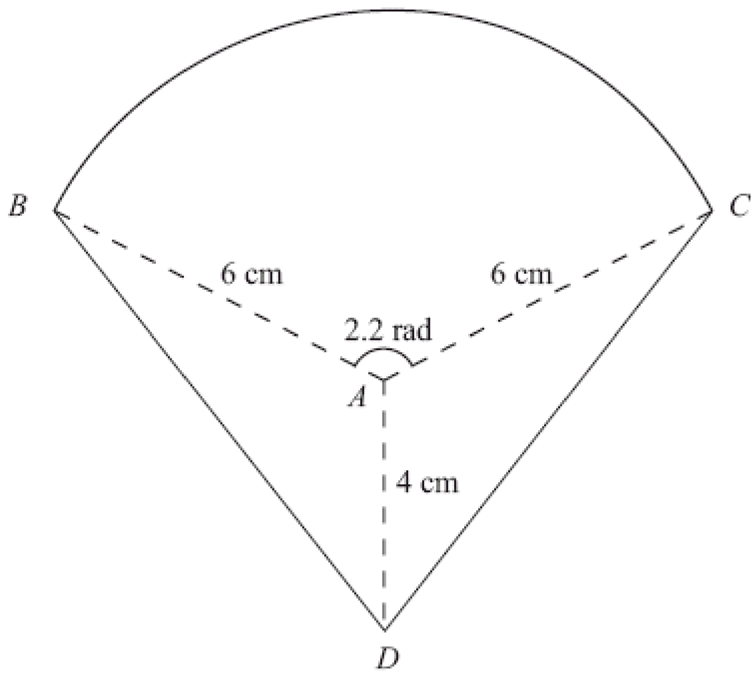
(c) Prove that this value of r gives a minimum value of S.

(2)

(d) Find, to the nearest cm^2, this minimum value of S.

(2)
(Total 13 marks)

4.



The shape *BCD* shown above is a design for a logo.

The straight lines *DB* and *DC* are equal in length. The curve *BC* is an arc of a circle with centre *A* and radius 6 cm. The size of $\angle BAC$ is 2.2 radians and *AD* = 4 cm.

Find

(a) the area of the sector *BAC*, in cm^2,

(2)

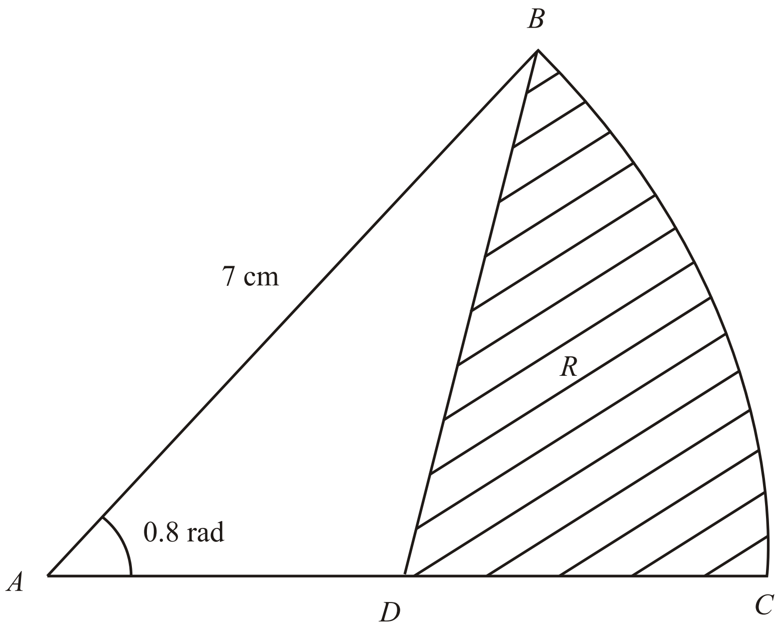
(b) the size of $\angle DAC$, in radians to 3 significant figures,

(2)

(c) the complete area of the logo design, to the nearest cm^2.

(4)
(Total 8 marks)

5.



The diagram above shows ABC, a sector of a circle with centre A and radius 7 cm.

Given that the size of $\angle BAC$ is exactly 0.8 radians, find

(a) the length of the arc BC,

(2)

(b) the area of the sector ABC.

(2)

The point D is the mid-point of AC. The region R, shown shaded in the diagram above, is bounded by CD, DB and the arc BC.

Find

(c) the perimeter of R, giving your answer to 3 significant figures,

(4)

(d) the area of R, giving your answer to 3 significant figures.

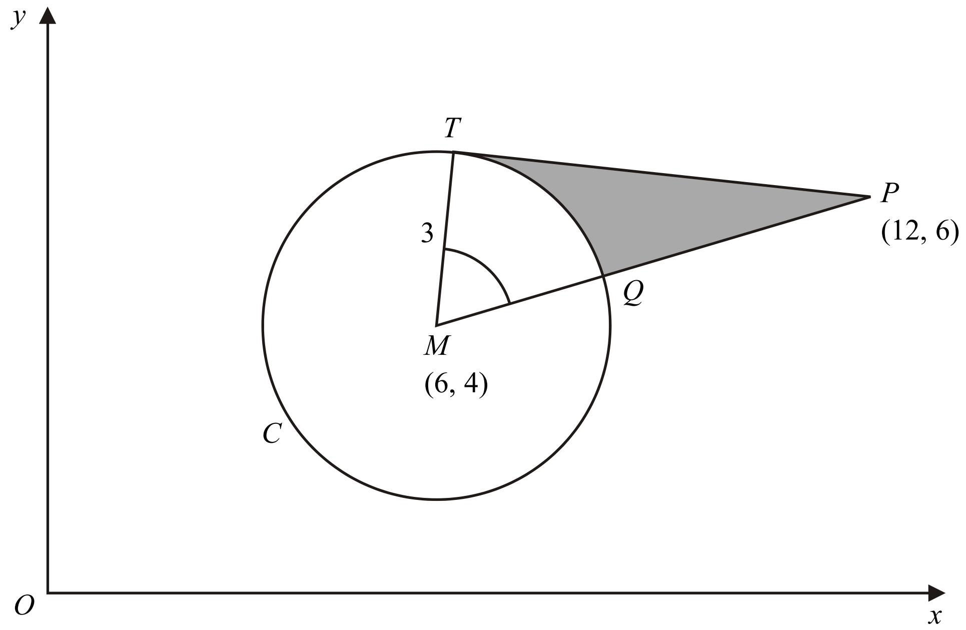
(4)
(Total 12 marks)

6. A circle C has centre M (6, 4) and radius 3.

(a) Write down the equation of the circle in the form

$$(x-a)^2+(y-b)^2=r^2.$$

(2)



The diagram above shows the circle C. The point T lies on the circle and the tangent at T passes through the point P (12, 6). The line MP cuts the circle at Q.

(b) Show that the angle TMQ is 1.0766 radians to 4 decimal places.

(4)

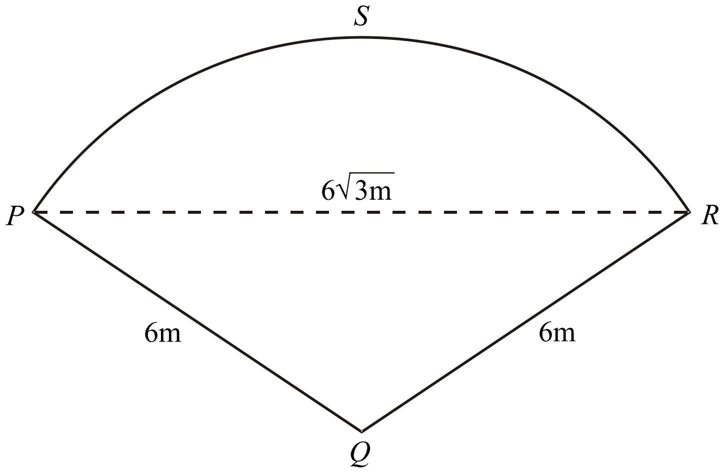
The shaded region TPQ is bounded by the straight lines TP, QP and the arc TQ, as shown in the diagram above.

(c) Find the area of the shaded region TPQ. Give your answer to 3 decimal places.

(5)

(Total 11 marks)

7.



The diagram above shows a plan of a patio. The patio *PQRS* is in the shape of a sector of a circle with centre *Q* and radius 6 m.

Given that the length of the straight line *PR* is $6\sqrt{3}$m,

(a) find the exact size of angle *PQR* in radians.

(3)

(b) Show that the area of the patio *PQRS* is 12π m^2.

(2)

(c) Find the exact area of the triangle *PQR*.

(2)

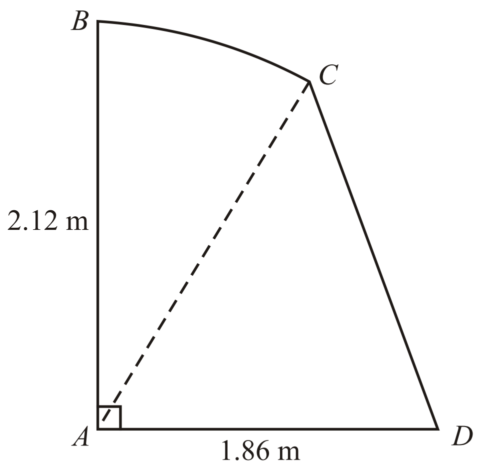
(d) Find, in m^2 to 1 decimal place, the area of the segment *PRS*.

(2)

(e) Find, in m to 1 decimal place, the perimeter of the patio *PQRS*.

(2)
(Total 11 marks)

8.



The figure above shows the cross section *ABCD* of a small shed.
The straight line *AB* is vertical and has length 2.12 m.
The straight line *AD* is horizontal and has length 1.86 m.
The curve *BC* is an arc of a circle with centre *A*, and *CD* is a straight line.
Given that the size of $\angle BAC$ is 0.65 radians, find

(a) the length of the arc *BC*, in m, to 2 decimal places,

(2)

(b) the area of the sector *BAC,* in m^2, to 2 decimal places,

(2)

(c) the size of $\angle CAD$, in radians, to 2 decimal places,

(2)

(d) the area of the cross section *ABCD* of the shed, in m^2, to 2 decimal places.

(3)
(Total 9 marks)

9.

Figure 1

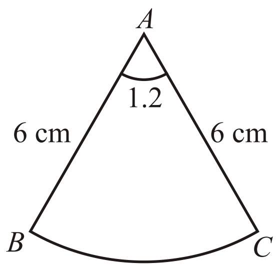


Figure 1 shows the cross-section ABC of a metal cutter used for making biscuits. The straight sides AB and AC are both of length 6 cm and $\angle BAC$ is 1.2 radians. The curved portion BC is an arc of a circle with centre A.

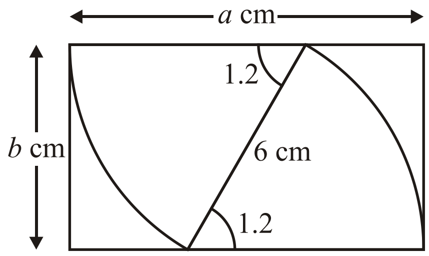
(a) Find the perimeter of the cross-section of the cutter.

(2)

(b) Find the area of the cross-section ABC.

(2)

Figure 2



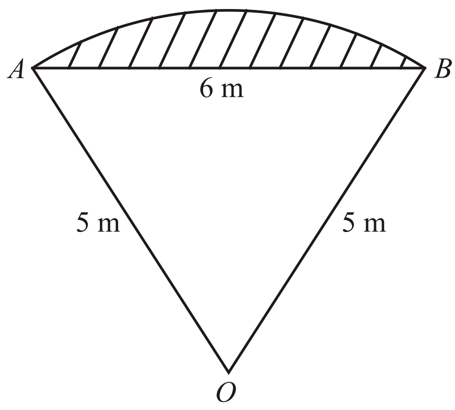
A pair of these cutters are kept together in a rectangular box of length a cm and width b cm. The cutters fit into the box as shown in Figure 2.

(c) Find the value of a and the value of b, giving your answers to 3 significant figures.

(4)

(Total 8 marks)

10.



In the figure above *OAB* is a sector of a circle radius 5 m. The chord *AB* is 6 m long.

(a) Show that $\cos\ A\hat{O}B = \dfrac{7}{25}$.

(2)

(b) Hence find the angle $A\hat{O}B$ in radians, giving your answer to 3 decimal places.

(1)

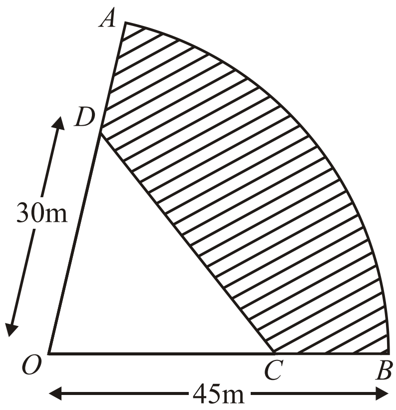
(c) Calculate the area of the sector *OAB*.

(2)

(d) Hence calculate the shaded area.

(3)
(Total 8 marks)

11.



A fence from a point A to a point B is in the shape of an arc AB of a circle with centre O and radius 45 m, as shown in the diagram. The length of the fence is 63 m.

(a) Show that the size of $\angle AOB$ is exactly 1.4 radians.

(2)

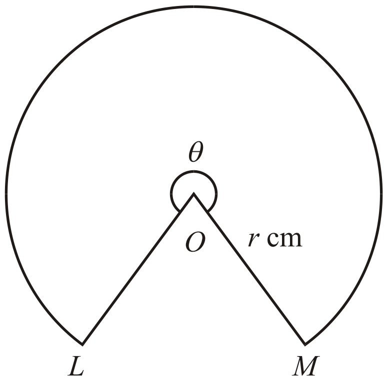
The points C and D are on the lines OB and OA respectively, with $OC = OD = 30$ m.

A plot of land $ABCD$, shown shaded in the figure above, is enclosed by the arc AB and the straight lines BC, CD and DA.

(b) Calculate, to the nearest m^2, the area of this plot of land.

(5)
(Total 7 marks)

12.



A major sector LOM of a circle, with centre O and radius r cm, has $\angle LOM = \theta$ radians, as shown in the diagram. The perimeter of the sector is P cm and the area of the sector is A cm^2.

(a) Write down, in terms of r and θ, expressions for P and A.

(2)

Given that $r = 2\sqrt{2}$ and that $P = A$,

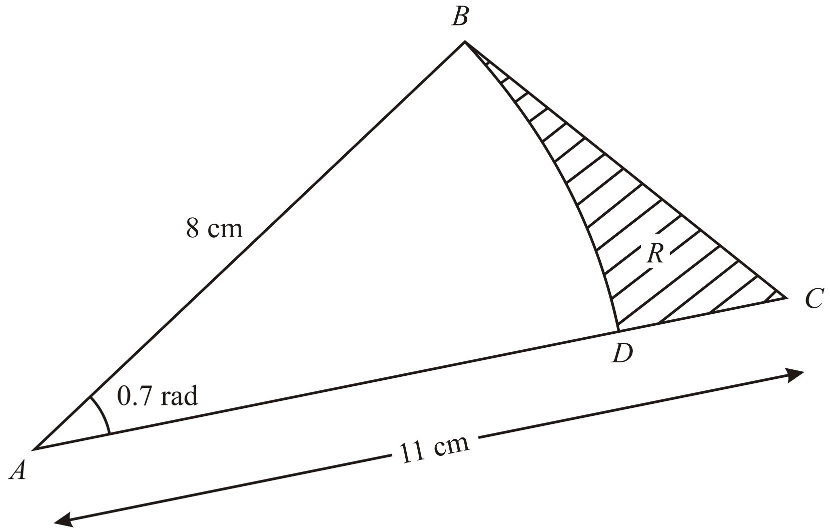
(b) show that $\theta = \dfrac{2}{\sqrt{2} - 1}$.

(3)

(c) Express θ in the form $a + b\sqrt{2}$, where a and b are integers to be found.

(3)
(Total 8 marks)

13.



This diagram shows the triangle ABC, with $AB = 8$ cm, $AC = 11$ cm and $\angle BAC = 0.7$ radians. The arc BD, where D lies on AC, is an arc of a circle with centre A and radius 8 cm. The region R, shown shaded in the diagram, is bounded by the straight lines BC and CD and the arc BD.

Find

(a) the length of the arc BD,

(2)

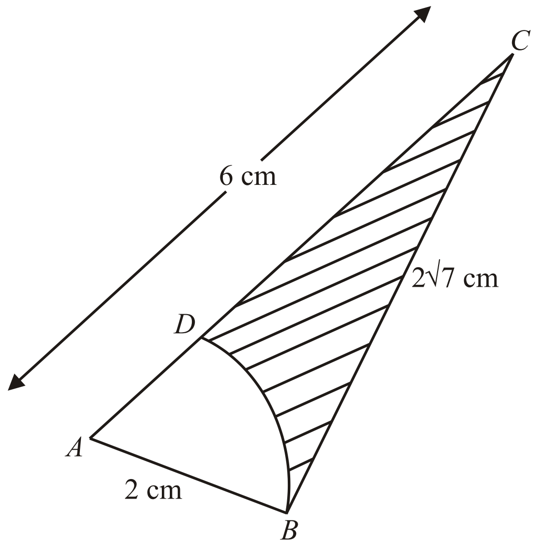
(b) the perimeter of R, giving your answer to 3 significant figures,

(4)

(c) the area of R, giving your answer to 3 significant figures.

(5)
(Total 11 marks)

14.



In ΔABC, AB = 2 cm, AC = 6 cm and $BC = 2\sqrt{7}$ cm.

(a) Use the cosine rule to show that $\angle BAC = \dfrac{\pi}{3}$ radians.

(3)

The circle with centre A and radius 2 cm intersects AC at the point D, as shown in the diagram above.

Calculate

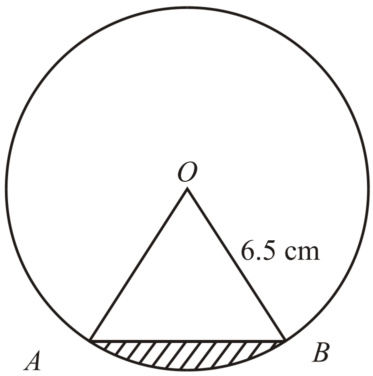
(b) the length, in cm, of the arc BD,

(2)

(c) the area, in cm^2, of the shaded region BCD.

(4)
(Total 9 marks)

15.



The diagram above shows the sector *AOB* of a circle, with centre *O* and radius 6.5 cm, and $\angle AOB = 0.8$ radians.

(a) Calculate, in cm^2, the area of the sector *AOB*.

(2)

(b) Show that the length of the chord *AB* is 5.06 cm, to 3 significant figures.

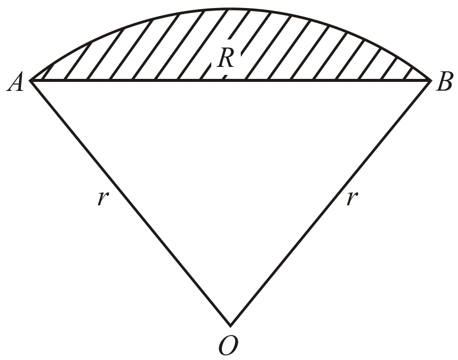
(3)

The segment *R*, shaded in the diagram above, is enclosed by the arc *AB* and the straight line *AB*.

(c) Calculate, in cm, the perimeter of *R*.

(2)
(Total 7 marks)

16.



The diagram above shows the sector OAB of a circle of radius r cm. The area of the sector is 15 cm^2 and $\angle AOB = 1.5$ radians.

(a) Prove that $r = 2\sqrt{5}$.

(3)

(b) Find, in cm, the perimeter of the sector OAB.

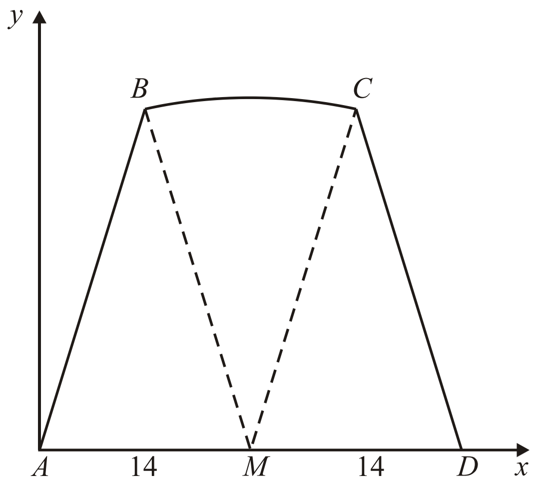
(2)

The segment R, shaded in the diagram above, is enclosed by the arc AB and the straight line AB.

(c) Calculate, to 3 decimal places, the area of R.

(3)
(Total 8 marks)

17.



The diagram above shows the cross-section *ABCD* of a chocolate bar, where *AB, CD* and *AD* are straight lines and *M* is the mid-point of *AD*. The length *AD* is 28 mm, and *BC* is an arc of a circle with centre *M*.

Taking *A* as the origin, *B*, *C* and *D* have coordinates (7, 24), (21, 24) and (28, 0) respectively.

(a) Show that the length of *BM* is 25 mm.

(1)

(b) Show that, to 3 significant figures, $\angle BMC = 0.568$ radians.

(3)

(c) Hence calculate, in mm^2, the area of the cross-section of the chocolate bar.

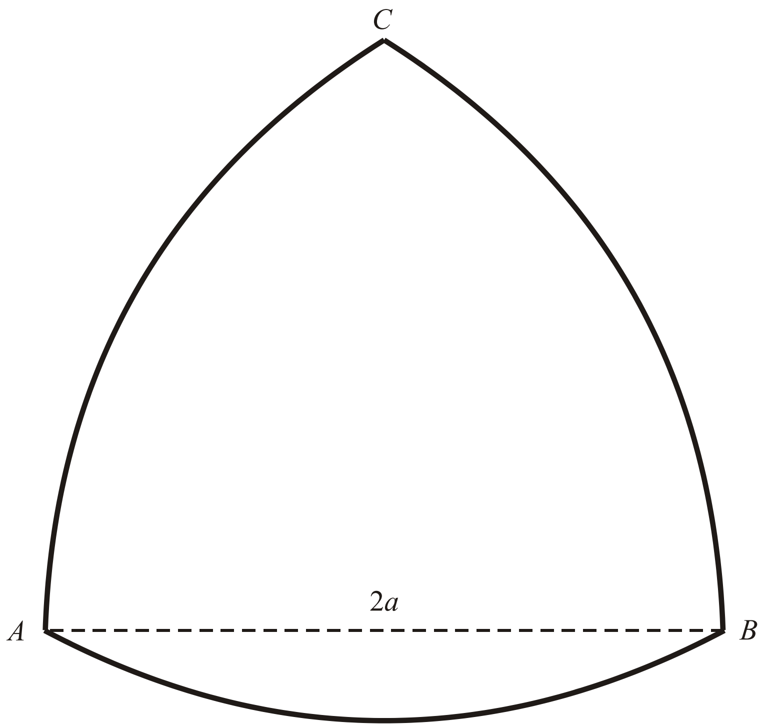
(5)

Given that this chocolate bar has length 85 mm,

(d) calculate, to the nearest cm^3, the volume of the bar.

(2)
(Total 11 marks)

18.



A flat plate S, which is part of a child's toy, is shown in the diagram above. The points A, B and C are the vertices of an equilateral triangle and the distance between A and B is $2a$. The circular arc AB has centre C and radius $2a$. The circular arcs BC and CA have centres at A and B respectively and radii $2a$.

(a) Find, in terms of π and a, the perimeter of S.

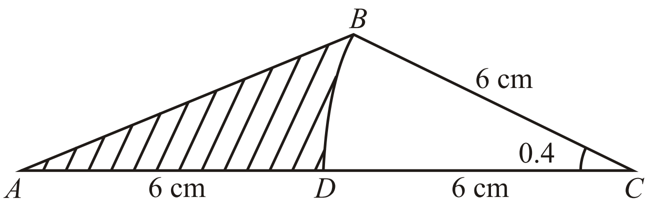
(2)

(b) Prove that the area of the plate S is

$$2a^2(\pi - \sqrt{3}).$$

(6)
(Total 8 marks)

19.



The diagram above shows a logo *ABD*.

The logo is formed from triangle *ABC*. The mid-point of *AC* is *D* and $BC = AD = DC = 6$ cm. $\angle BCA = 0.4$ radians. The curve *BD* is an arc of a circle with centre *C* and radius 6 cm.

(a) Write down the length of the arc *BD*.
(1)

(b) Find the length of *AB*.
(3)

(c) Write down the perimeter of the logo *ABD*, giving your answer to 3 significant figures.
(1)
(Total 5 marks)

1. (a) $r\theta = 9 \times 0.7 = 6.3$ (Also allow 6.30, or awrt 6.30) M1 A1 2

Note

M: Use of $r\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula).

(b) $\frac{1}{2}r^2\theta = \frac{1}{2} \times 81 \times 0.7 = 28.35$

(Also allow 28.3 or 28.4, or awrt 28.3 or 28.4) M1 A1 2

(Condone 28.35^2 written instead of $28.35\,\text{cm}^2$)

Note

M: Use of $\frac{1}{2}r^2\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula).

(c) $\tan 0.7 = \frac{AC}{9}$ M1

$AC = 7.58$ (Allow awrt) NOT 7.59 (see below) A1 2

Note

M: Other methods must be fully correct,

e.g. $\frac{AC}{\sin 0.7} = \frac{9}{\sin\left(\frac{\pi}{2} - 0.7\right)}$

$(\pi - 0.7)$ instead of $\left(\frac{\pi}{2} - 0.7\right)$ here is not a fully correct method.

Premature approximation (e.g. taking angle C as 0.87 radians):
This will often result in loss of A marks, e.g. $AC = 7.59$ in (c) is A0.

(d) Area of triangle $AOC = \frac{1}{2}$ (9 × their AC) (or other complete method) M1

Area of R = "34.11" – "28.35" (triangle – sector) or (sector – triangle) M1
(needs a value for each)

= 5.76 (Allow awrt) A1 3

[9]

2. (a)

Either $\frac{\sin(A\hat{C}B)}{5} = \frac{\sin 0.6}{4}$	**or** $4^2 = b^2 + 5^2 - 2 \times b \times 5 \cos 0.6$	M1
$\therefore A\hat{C}B = \arcsin(0.7058...)$	$\therefore b = \frac{10\cos 0.6 \pm \sqrt{(100\cos^2 0.6 - 36)}}{2}$ = [6.96 or 1.29]	M1

= [0.7835.. or 2.358] Use angles of triangle $A\hat{B}C = \pi - 0.6 - A\hat{C}B$ (But as AC is the longest side so) $A\hat{B}C$ = 1.76 (*)(3sf) [Allow 100.7° → 1.76] In degrees 0.6 = 34.377°, $A\hat{C}B$ =44.9	Use sine / cosine rule with value for b $\sin B = \frac{\sin 0.6}{4} \times b$ or $\cos B = \frac{25+16-b^2}{40}$ (But as AC is the longest side so) $A\hat{B}C$ = 1.76 (*)(3sf)	M1, A1	 4

Note

1st M1 for correct use of sine rule to find ACB or cosine rule to find b (M0 for ABC here or for use of sin x where x could be ABC)

2nd M1 for a correct expression for angle ACB (This mark may be implied by .7835 or by arcsin (.7058)) and needs accuracy. In second method this M1 is for correct expression for b – may be implied by 6.96. [Note 10 cos 0.6 ≈ 8.3] (do not need two answers)

3rd M1 for a correct method to get angle ABC in method (i) or sinABC or cosABC, in method (ii) (If sin B >1, can have M1A0)

A1cso for correct work leading to 1.76 3sf . Do not need to see angle 0.1835 considered and rejected.

1st M1 for a correct expression for sector area or a value in the range 11.0 – 11.1

2nd M1 for a correct expression for the area of the triangle or a value of 9.8

Special case

If answer 1.76 is assumed then usual mark is M0 M0 M0 A0.
A Fully checked method may be worth M1 M1 M0 A0.
A maximum of 2 marks. The mark is either 2 or 0.

Either **M1** for $A\hat{C}B$ is found to be 0,7816 (angles of triangle) then

M1 for checking $\frac{\sin(A\hat{C}B)}{5} = \frac{\sin 0.6}{4}$ with conclusion giving numerical answers

This gives a maximum mark of 2/4

OR **M1** for b is found to be 6.97 (cosine rule)

M1 for checking $\frac{\sin(ABC)}{b} = \frac{\sin 0.6}{4}$ with conclusion giving numerical answers

This gives a maximum mark of 2/4

Candidates making this assumption need a complete method.
They cannot earn M1M0.

So the score will be 0 or 2 for part (a). Circular arguments earn 0/4.

(b) $\lfloor C\hat{B}D = \pi - 1.76 = 1.38 \rfloor$ Sector area $= \frac{1}{2} \times 4^2 \times (\pi - 1.76)$

$= [11.0 \sim 11.1] \frac{1}{2} \times 4^2 \times 79.3$ is M0 — M1

Area of $\Delta ABC = \frac{1}{2} \times 5 \times 4 \times \sin(1.76) = [9.8]$ or $\frac{1}{2} \times 5 \times 4 \times \sin 101$ — A1 — 3

Required area = awrt 20.8 or 20.9 or 21.0 or gives 21 (2sf) after correct work.

Note

Ignore 0.31 (working in degrees) as subsequent work.

A1 for answers which round to 20.8 or 20.9 or 21.0. No need to see units.

[7]

3. (a) (Arc length =) $r\theta = r \times 1 = r$. Can be awarded by implication from later work, e.g. $3rh$ or $(2rh + rh)$ in the S formula. (Requires use of $\theta = 1$). — B1

(Sector area =) $\frac{1}{2} r^2 \theta = \frac{1}{2} r^2 \times 1 = \frac{r^2}{2}$. Can be awarded by implication from later work, e.g. the correct volume formula. (Requires use of $\theta = 1$). — B1

Surface area = 2 sectors + 2 rectangles + curved face

$(= r^2 + 3rh)$ (See notes below for what is allowed here) — M1

Volume = 300 = $\frac{1}{2} r^2 h$ — B1

Sub for h: $S = r^2 + 3 \times 3 \times \frac{600}{r} = r^2 + \frac{1800}{r}$ (*) — A1cso — 5

Note

M1 for attempting a formula (with terms added) for surface area. May be incomplete or wrong and may have extra term(s), but must have an r^2 (or $r^2 \theta$) term and an rh (or $rh\theta$) term.

(b) $\frac{dS}{dr} = 2r - \frac{1800}{r^2}$ or $2r - 1800r^{-2}$ or $2r + -1800r^{-2}$ — M1A1

$\frac{dS}{dr} = 0 \Rightarrow r^3 = ...,\ r = \sqrt[3]{900}$ or AWRT 9.7 (NOT – 9.7 or ± 9.7) — M1, A1 — 4

Note

<u>In parts (b), (c) and (d), ignore labelling of parts</u>

1st M1 for attempt at differentiation (one term is sufficient) $r^n \to kr^{n-1}$

2nd M1 for setting their derivative (a 'changed function') = 0 and solving as far as r^3 = ... (depending upon their 'changed function', this could be r = ... or r^2 = ...,etc., but the algebra <u>must deal with a negative power</u> of r and should be sound apart from possible <u>sign</u> errors, so that r^n = ... is consistent with their derivative).

(c) $\frac{d^2S}{dr^2} = ...$ and consider sign, $\frac{d^2S}{dr^2} = 2 + \frac{3600}{r^3} > 0$ so point is a minimum M1, A1ft 2

Note

M1 for attempting second derivative (one term is sufficient) $r^n \rightarrow kr^{n-1}$, and cosnsidering its sign. Substitution of a value of r is not required. (Equating it to zero is M0).

A1ft for a correct second derivative (or correct ft from their first derivative) and a valid reason (e.g. > 0), and conclusion. The actual value of the second derivative, if found, can be ignored. To score this mark as ft, their second derivative must indicate a minimum.

Alternative:

M1: Find value of $\frac{dS}{dr}$ on each side of their value of r and consider sign.

A1ft: Indicate sign change of negative to positive for $\frac{dS}{dr}$, and conclude minimum.

Alternative:

M1: Find value of S on each side of their value of r and compare with their 279.65.

A1ft: Indicate that both values are more than 279.65, and conclude minimum.

(d) $S_{\min} = (9.65...)^2 + \frac{1800}{9.65...}$

(Using their value of r, however found, in the given S formula) M1

= 279.65… (AWRT: 280) (Dependent on full marks in part (b)) A1 2

[13]

4. (a) $\frac{1}{2}r^2\theta = \frac{1}{2} \times 6^2 \times 2.2 = 39.6\,(\text{cm}^2)$ M1 A1 2

Note

M1: Needs θ in radians for this formula. Could convert to degrees and use degrees formula.

A1: Does not need units. Answer should be 39.6 exactly.
Answer with no working is **M1 A1**.
This **M1A1** can only be awarded in part (a).

(b) $\left(\frac{2\pi - 2.2}{2} = \right)\pi - 1.1 = 2.04\,(\text{rad})$ M1 A1 2

Note

M1: Needs full method to give angle in radians

A1: Allow answers which round to 2.04 (Just writes 2.04 – no working is 2/2)

(c)	$\Delta DAC = \dfrac{1}{2} \times 6 \times 4\sin 2.04$ (≈ 10.7)	M1A1ft	
	Total area = sector + 2 triangles = 61 (cm^2)	M1 A1	4

Note

M1: Use $\dfrac{1}{2} \times 6 \times 4\sin A$ (if any other triangle formula e.g. $\frac{1}{2} b \times h$ is used the method must be complete for this mark) (No value needed for A, but should not be using 2.2)
A1: ft the value obtained in part (b) – need not be evaluated– could be in degrees

M1: Uses Total area = sector + 2 triangles or other complete method

A1: Allow answers which round to 61. (Do not need units)

Special case degrees: Could get M0A0, M0A0, M1A1M1A0

Special case: Use $\Delta\, BDC - \Delta\, BAC$ Both areas needed for first **M1**

Total area = sector + area found is second **M1**

NB Just finding lengths BD, DC, and angle BDC then assuming area BDC is a sector to find area BDC is 0/4

[8]

5.	(a)	$r\theta = 7 \times 0.8 = 5.6$ (cm)	M1A1	2

M: Use of $r\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula).

(b)	$\dfrac{1}{2}r^2\theta = \dfrac{1}{2} \times 7^2 \times 0.8 = 19.6$ (cm^2)	M1A1	2

M: Use of $\dfrac{1}{2}r^2\,\theta$ (with θ in radians), or equivalent (could be working in degrees with a correct degrees formula).

(a) and (b): Correct answers without working score both marks.

(c)	$BD^2 = 7^2 + (\text{their } AD)^2 - (2\times 7 \times (\text{their } AD) \times \cos 0.8)$	M1	
	$BD^2 = 7^2 + 3.5^2 - (2 \times 7 \times 3.5 \times \cos 0.8)$ (or awrt 46° for the angle)	A1	
	($BD = 5.21$)		
	Perimeter = (their DC) + "5.6" + "5.21" = 14.3 (cm) (Accept awrt)	M1A1	4

1st M: Use of the (correct) cosine rule formula to find BD^2 or BD. Any other methods need to be complete methods to find BD^2 or BD.

2nd M: Adding their DC to their arc BC and their BD.

<u>Beware</u>: If 0.8 is used, but calculator is in degree mode, this can still earn M1 A1 (for the required expression), but this gives $BD = 3.50\ldots$
so the perimeter may appear as 3.5 + 5.6 + 3.5 (earning M1 A0).

(d) $\Delta\,ABD = \frac{1}{2} \times 7 \times (\text{their } AD) \times \sin 0.8$ (or awrt 46° for the angle) (ft their AD) M1A1ft
(= 8.78…)
(If the correct formula $\frac{1}{2}ab \sin C$ is <u>quoted</u> the use of any two of the sides of $\Delta\,ABD$ as a and b scores the M mark).
Area = "19.6" – "8.78…" = 10.8 (cm^2) (Accept awrt) M1 A1 4

1st M: Use of the (correct) area formula to find $\Delta\,ABD$. Any other methods need to be complete methods to find $\Delta\,ABD$.

2nd M: Subtracting their $\Delta\,ABD$ from their sector ABC.

Using segment formula $\frac{1}{2}r^2(\theta - \sin\theta)$ scores no marks in part (d).

Units (cm or cm^2) are not required in any of the answers.

[12]

6. (a) $(x-6)^2 + (y-4)^2 =;\ 3^2$ B1; B1 2

Allow 9 for 3^2.

(b) Complete method for MP: $= \sqrt{(12-6)^2 + (6-4)^2}$ M1

$= \sqrt{40}$ or awrt 6.325 A1

[These first two marks can be scored if seen as part of solution for (c)]

Complete method for $\cos\theta$, $\sin\theta$ or $\tan\theta$ M1

e.g. $\cos\theta = \dfrac{\text{MT}}{\text{MP}} = \dfrac{3}{\text{candidate's }\sqrt{40}}$ (= 0.4743) (θ = 61.6835°)

[If TP = 6 is used, then M0]

θ = 1.0766 rad **AG** A1 4

First M1 can be implied by √40 or √31

For second M1:

May find TP = $\sqrt{(\sqrt{40})^2 - 3^2} = \sqrt{31}$, then either

$\sin\theta = \dfrac{TP}{MP} = \dfrac{\sqrt{31}}{\sqrt{40}}$ (= 0.8803...) or $\tan\theta = \dfrac{\sqrt{31}}{3}$ (1.8859..) or cos rule

NB. Answer is given, but allow final A1 if all previous work is correct.

(c) Complete method for area *TMP*; e.g. = $\frac{1}{2}\times 3\times\sqrt{40}\sin\theta$ M1

= $\frac{3}{2}\sqrt{31}$ (= 8.3516..) allow awrt 8.35 A1

Area (sector)*MTQ* = $0.5 \times 3^2 \times 1.0766$ (= 4.8446…) M1

Area *TPQ* = candidate's (8.3516.. – 4.8446..) M1

= 3.507 awrt A1 5

[Note: 3.51 is A0]

First M1: (alternative) $\frac{1}{2}\times 3\times\sqrt{40-9}$

Second M1: allow even if candidate's value of θ used.
(Despite being given!)

[11]

7. (a) $\cos PQR = \dfrac{6^2+6^2-(6\sqrt{3})^2}{2\times 6\times 6}\left\{= -\dfrac{1}{2}\right\}$ M1, A1

$PQR = \dfrac{2\pi}{3}$ A1 3

N.B. $a^2 = b^2 + c^2 - 2bc\cos A$ is in the formulae book.

Use of cosine rule for cos *PQR.* Allow *A,* θ or other symbol for angle. M1

(i) $(6\sqrt{3})^2 = 6^2 + 6^2 - 2.6.6\cos PQR$: Apply usual rules for formulae: (a) formula not stated, must be correct, (b) correct formula stated, allow one sign slip when substituting.

or (ii) $\cos PQR = \dfrac{\pm 6^2 \pm 6^2 \pm (6\sqrt{3})^2}{\pm 2\times 6\times 6}$

Also allow invisible brackets [so allow $6\sqrt{3}^2$] in (i) or (ii)

Correct expression $\dfrac{6^2+6^2-(6\sqrt{3})^2}{2\times 6\times 6}$ o.e. (e.g. $-\dfrac{36}{72}$ or $-\dfrac{1}{2}$) A1

$\dfrac{2\pi}{3}$ A1

Alternative

$\sin\theta = \dfrac{a\sqrt{3}}{6}$ where θ is any symbol and $a < 6$. M1

$\sin\theta = \dfrac{3\sqrt{3}}{6}$ where θ is any symbol. A1

$\dfrac{2\pi}{3}$ A1

(b) Area = $\dfrac{1}{2}\times 6^2 \times \dfrac{2\pi}{3}$ m^2 M1

= 12π m^2 (*) A1cso 2

Use of $½r^2\theta$ with $r = 6$ and θ = their (a). For M mark θ does not have to be exact.
M0 if using degrees. M1

12π c.s.o. ($\Rightarrow$ (a) correct exact or decimal value)
N.B. Answer given in question A1

Special case:
Can come from an inexact value in (a)

$PQR = 2.09 \rightarrow$ Area = $\dfrac{1}{2} \times 6^2 \times 2.09 = 37.6$ (or 37.7) $= 12\pi$

(no errors seen, assume full values used on calculator) gets M1 A1.

$PQR = 2.09 \rightarrow$ Area = $\dfrac{1}{2} \times 6^2 \times 2.09 = 37.6$ (or 37.7) $= 11.97\pi$

$= 12\pi$ gets M1 A0.

(c) Area of Δ = $\dfrac{1}{2}\times 6\times 6\times \sin\dfrac{2\pi}{3}$ m^2 M1

= $9\sqrt{3}$ m^2 A1cso 2

Use of $½r^2\sin\theta$ with $r = 6$ and their (a).
$\theta = \cos^{-1}$ (their PQR) in degrees or radians
Method can be implied by correct decimal provided decimal is correct (corrected or truncated to at least 3 decimal places).
15.58845727 M1

$9\sqrt{3}$ c.s.o. Must be exact, but correct approx. followed by $9\sqrt{3}$ is okay (e.g. … = 15.58845 = $9\sqrt{3}$) A1cso

Alternative (using $½bh$)

Attempt to find h using trig. or Pythagoras and use this h in $½bh$ form to find the area of triangle PQR M1

$9\sqrt{3}$ c.s.o. Must be exact, but correct approx. followed by $9\sqrt{3}$ is okay (e.g. … = 15.58845 = $9\sqrt{3}$) A1cso

(d) Area of segment = $12\pi - 9\sqrt{3}$ m^2 M1

= 22.1 m^2 A1 2

Use of area of sector – area of Δ or use of $½r^2(\theta - \sin\theta)$. M1

Any value to 1 decimal place or more which rounds to 22.1 A1

	(e)	Perimeter = 6 + 6 + $\left[6\times\frac{2\pi}{3}\right]$m	M1	
		= 24.6 m	A1ft	2
		6 + 6 + [6 × their (a)].	M1	
		Correct for their (a)to 1 decimal place or more	A1 ft	

[11]

8.	(a)	$r\theta = 2.12 \times 0.65$ 1.38 (m)	M1 A1	2

M1: Use of $r\theta$ with r = 2.12 or 1.86, and θ = 0.65, or equiv. method for the angle changed to degrees (allow awrt 37°).

(b)	$\frac{1}{2}r^2\theta = \frac{1}{2}\times 2.12^2 \times 0.65$ 1.46 (m^2)	M1 A1	2

M1: Use of $\frac{1}{2}r^2\theta$ with r = 2.12 or 1.86,

and θ = 0.65, or equiv.

method for the angle changed to degrees (allow awrt 37°).

(c)	$\frac{\pi}{2} - 0.65$ 0.92 (radians) (α)	M1 A1	2

M1: Subtracting 0.65 from $\frac{\pi}{2}$, or subtracting awrt 37 from 90 (degrees), (perhaps implied by awrt 53).

<u>Angle changed to degrees wrongly and used throughout (a), (b) and (c):</u>

Penalise 'method' only once, so could score M0A0, M1 A0, M1 A0.

(d)	ΔACD: $\frac{1}{2}(2.12)(1.86)\ \sin\alpha$ (With the value of α from part (c))	M1	
	Area = "1.46" + "1.57", 3.03 (m^2)	M1 A1	3

First M1: Other area methods must be fully correct.

Second M1: Adding answer to (b) to their ΔACD.

<u>Failure to round to 2 d.p:</u>

Penalise only once, on the first occurrence, then accept awrt.

<u>If 0.65 is taken as degrees throughout</u>:

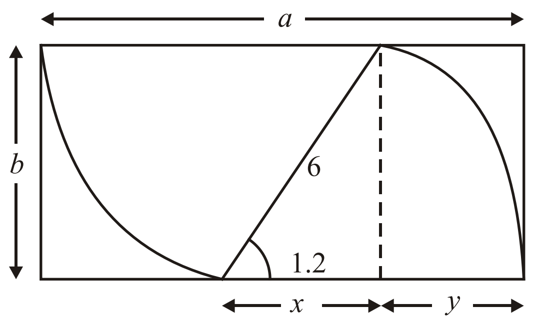
Only award marks in part (d).

[9]

9.	(a)	Arc is 6 × 1.2	Use of $r\theta$	M1	
		Perimeter is 6 × 1.2 + 6 + 6 + 6 = 19.2 (cm)		A1	2

(b)	Area is $\frac{1}{2} \times 6^2 \times 1.2 = 21.6$ (cm^2)	Use of $\frac{1}{2}r^2\theta$	M1 A1	2

(c)



		B1	
$x = 6\cos 1.2$	$(\approx 2.174\ ...)$	M1	
$y = 6 - x$	$(\approx 3.825\ ...)$		
$a = 6 + y \approx 9.83$	(cm)	M1 A1	4

Maximum of one mark is lost if answers not to 3 sig. figs

[8]

10. (a) $\cos\ A\hat{O}B = \dfrac{5^2 + 5^2 - 6^2}{2 \times 5 \times 5}$ or M1

$\sin\theta = \frac{3}{5}$ with use of $\cos 2\theta = 1 - 2\sin^2\theta$ attempted

$= \dfrac{7}{25}$ * A1cso 2

(b) $A\hat{O}B = 1.2870022...$ radians 1.287 or better B1 1

(c) Sector $= \frac{1}{2} \times 5^2 \times (b)$, $= 16.087.$ (AWRT)16.1 M1 A1 2

(d) Triangle $= \frac{1}{2} \times 5^2 \times \sin(b)$ or $\frac{1}{2} \times 6 \times \sqrt{5^2 - 3^2}$ M1

Segment = (their sector) – their triangle dM1
= (sector from c) – 12 = (AWRT)4.1 (ft their part(c)) A1ft 3

[8]

(a) M1 for a full method leading to *cosAOB* [N.B. Use of calculator is M0]
(usual rules about quoting formulae)

(b) Use of (b) in degrees is M0

(d) 1st M1 for full method for the area of triangle *AOB*
2n dM1 for their sector – their triangle. Dependent on 1st M1 in part (d).
A1ft for their sector from part (c) – 12 [or 4.1 following a correct restart].

11. (a) $r\theta = 45\theta = 63$, $\theta = 1.4$ (*) M1A1 2

M1 is for applying correct formula or quoting and attempting to use correct formula

(b) Area of sector $OAB = \frac{1}{2}r^2\theta = \frac{1}{2}45^2 \times 1.4$ (= 1417.5) M1A1

Area of triangle $OCD = \frac{1}{2}30^2 \times \sin 1.4$ (= 443.45) M1A1

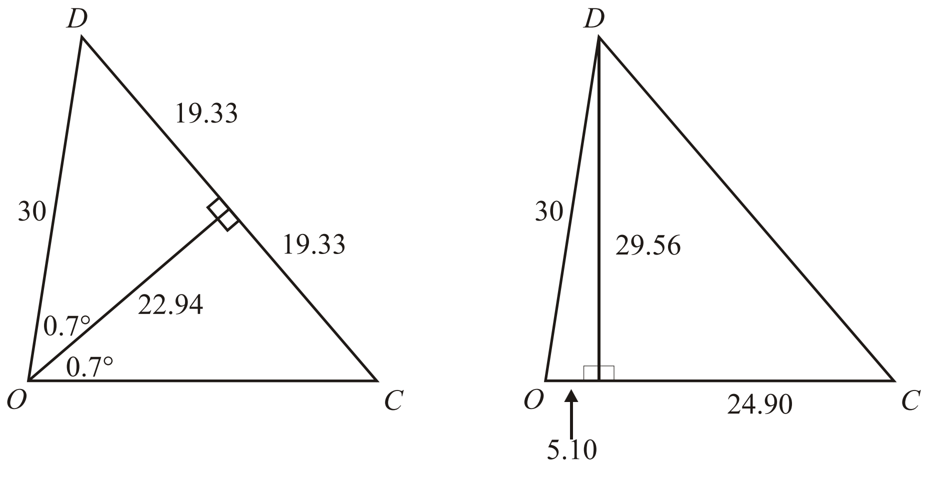
Shaded area = 1417.5 – 443.45…= 974 m^2 cao A1 5

For each area
M1 is for attempting to use correct formula or complete method in case of Δ *(*)*
A1 is for a numerically correct statement (answer is not required – just there as check)

Final A1 is for 974 only.

e.g. splitting triangle into two triangles:

For guidance



[7]

12.	(a)	$P = r\theta + 2r$, $\quad A = \frac{1}{2}r^2\theta$	B1, B1	2
	(b)	Substituting value for r and equating P to A.		
		$[2\sqrt{2}\,(2 + \theta) = \frac{1}{2}(2\sqrt{2}\,)^2\theta]$	M1	
		Correct process to find $\theta\,[\theta(\sqrt{2} - 1) = 2]$	M1	
		$\theta = \frac{2}{\sqrt{2}-1}$ (*) often see $\theta = \frac{4\sqrt{2}}{4-2\sqrt{2}}$	A1 c.s.o.	3
	(c)	Multiply numerator and denominator by $(\sqrt{2} + 1)$	M1	
		$2, +2\sqrt{2}$	A1, A1	3

[8]

13.	(a)	$r\theta = 8 \times 0.7, = 5.6(cm)$	M1, A1	2
	(b)	$BC^2 = 8^2 + 11^2 - 2 \times 8 \times 11 \cos 0.7$	M1	
		$\Rightarrow BC = 7.098$	A1	
		$\Rightarrow$ Perimeter = (a) + (11 – 8) + BC, = 15.7(cm)	M1, A1cao	4
	(c)	$\Delta = \frac{1}{2}ab\sin c = \frac{1}{2} \times 11 \times 8 \times \sin 0.7$, = AWRT 28.3	M1, A1	
		Sector = $\frac{1}{2}r^2\theta = \frac{1}{2} \times 8^2 \times 0.7$	M1, A1	
		Area of R = 28.345….. – 22.4 = 5.9455 = 5.95(cm^2)	A1	5

[11]

14.	(a)	$\cos A = \frac{6^2 + 2^2 - (2\sqrt{7})^2}{2 \times 6 \times 2}$	M1 A1	
		$\cos A = \frac{1}{2} \quad A = \frac{\pi}{3}$ radians (*)	A1	3
	(b)	$r\theta = \frac{2\pi}{3}$ (= 2.09) (Exact or at least 3 s.f.)	M1 A1	2
	(c)	Sector ABD: $\frac{1}{2}r^2\theta = \frac{1}{2} \times 2^2 \times \frac{\pi}{3}$ $\left(= \frac{2\pi}{3} \approx 2.094...\right)$	M1	
		Triangle ACB: $\frac{1}{2} \times 2 \times 6 \times \sin\frac{\pi}{3}$ $(= 3\sqrt{3} \approx 5.196\ldots)$	M1	
		Triangle – Sector = $3\sqrt{3} - \frac{2\pi}{3}$ (= 3.10175…)	M1 A1	4
		Allow 3.1 or a.w.r.t. 3.10		

[9]

15.	(a)	$\frac{1}{2}r^2\theta = \frac{1}{2} \times 6.5^2 \times 0.8 = 16.9$ (a.w.r.t. if changed to degrees)	M1 A1	2
	(b)	$\sin 0.4 = \frac{x}{6.5}$, $x = 6.5 \sin 0.4$, (where x is half of AB)	M1, A1	
		(n.b. 0.8 rad = 45.8°)		
		$AB = 2x = 5.06$ (a.w.r.t.) (*)	A1	3
		<u>Alternative:</u> $AB^2 = 6.5^2 + 6.5^2 - 2 \times 6.5 \times 6.5 \cos 0.8$	[M1]	
		$AB = \sqrt{6.5^2 + 6.5^2 - 2 \times 6.5 \times 6.5 \cos 0.8}$	[A1]	
		$AB = 5.06$	[A1]	
	(c)	$r\theta + 5.06 = (6.5 \times 0.8) + 5.06 = 10.26$ (a.w.r.t) (or 10.3)	M1 A1	2

[7]

16.	(a)	$\frac{1}{2}r^2\theta = \frac{1}{2}r^2 \times 1.5 = 15$	M1 A1	
		$r^2 = 20 = \sqrt{(4 \times 5)}$ $r = 2\sqrt{5}$ (*)	A1	3
	(b)	$r\theta + 2r = 3\sqrt{5} + 4\sqrt{5} = 7\sqrt{5}$ cm (or 15.7, or a.w.r.t 15.65….)	M1 A1	2
	(c)	ΔOAB: $\frac{1}{2}r^2 \sin\theta = 10 \sin 1.5$ (= 9.9749…)	M1	
		Segment area = 15 – ΔOAB = 5.025 cm^2	M1 A1	3

[8]

17.	(a)	$BM = \sqrt{(7^2 + 24^2)} = 25$ (*)	B1	
	(b)	$\tan\alpha = \frac{7}{24}$ or equiv. and $\angle BMC = 2\alpha$, or cosine rule	M1 A1	
		$\angle BMC = 0.568$ radians (*)	A1	
	(c)	ΔABM: $\frac{1}{2}(14 \times 24)$ (= 168 mm^2) (or other appropriate Δ)	B1	
		Sector: $\frac{1}{2}(25^2 \times 0.568)$	M1 A1	
		Total: "168 + 168 + 177.5" = 513 mm^2 (or 514, or 510)	M1 A1	
	(d)	Volume = "513" × 85 mm^3 (M requires unit conversion)	M1	
		= 44 cm^3	A1	

[11]

18.	(a)	Arc $AB = 2a \times \frac{\pi}{3}$ (using $r\theta$)	M1	
		Perimeter of $S = 3 \times \frac{2a\pi}{3} = 2a\pi$	A1	2
	(b)	Area of sector $ABC = \frac{1}{2}(2a)^2\frac{\pi}{3} = 2a^2\frac{\pi}{3}$	B1	
		Area of triangle $ABC = \frac{1}{2}(2a)^2\sin\frac{\pi}{3} = a^2\sqrt{3}$	M1 A1	
		Area of segment $= 2a^2\frac{\pi}{3} - a^2\sqrt{3}$	M1	
		Area of S = 3 (Area of segment ABC) + (Area of triangle ABC)	M1	
		$= 2\pi a^2 - 3a^2\sqrt{3} + a^2\sqrt{3}$		
		$= 2a^2(\pi - \sqrt{3})$	A1	6

[8]

19.	(a)	Arc $BD = r\theta = 0.4 \times 6 = 2.4$	B1	1
	(b)	Cosine Rule: $AB^2 = 6^2 + 12^2 - 2 \times 6 \times 12 \times \cos(0.4^c) = 47.36\ldots$	M1 A1	
		$\therefore AB = 6.88\ldots\ldots$	A1	3
	(c)	Perimeter = 6 + 6.88 + 2.4 = 15.3 (cm) (3 sig. figs)	B1 ft	1

[5]

1. In parts (a) and (b) of this question, most candidates were able to quote and accurately use the formulae for length of an arc and area of a sector. Wrong formulae including π were occasionally seen and it was sometimes felt necessary to convert 0.7 radians into degrees.

Despite the right-angled triangle, a very popular method in part (c) was to find the angle at C and use the sine rule. For the angle at C, many candidates used 0.87 radians (or a similarly rounded version in degrees) rather than a more accurate value. This premature approximation resulted in an answer for AC that was not correct to 2 decimal places, so the accuracy mark was lost.

In part (d), although a few candidates thought the region H was a segment, most were able to make a fair attempt to find the required area. There was again an unwillingness to use the fact that triangle OAC was right-angled, so that $\frac{1}{2}ab\sin C$ appeared frequently. Unnecessary calculations (such as the length of OC) were common and again premature approximation often led to the loss of the accuracy mark.

2. (a) This was a discriminating question, as the method required two stages of solution. Candidates could either find the angle ACB using a correct form of the sine rule, then use angles of a triangle, or they could first find the length AC, then use the sine rule. Finding length AC was complicated (requiring a correct cosine rule and use of a quadratic formula) and the former method was easier. Weaker candidates tried to use Pythagoras, despite the triangle not being right angled, or used the sine rule wrongly and manipulated their answer to give the printed solution. Others assumed the printed answer and attempted verification, but this sometimes resulted in circular arguments and frequently the verification was not conclusive due to the angle being given correct to 3sf. This verification method could earn a maximum of 2 out of 4 marks. Some candidates converted in and out of degrees, often successfully.

(b) Good candidates found the area of the triangle ABC and the area of the sector BCD and added these to give a correct answer. Weak candidates assumed that the emblem was a sector of radius 9 cm and angle 0.6 radians. Some made errors in their use of formulae and included pi erroneously, or neglected the ½ factor. A few used the wrong angle in their formulae or indeed used the wrong formula, confusing arc length or area of a segment with area of a sector.

3. Many candidates had difficulty in their attempts to establish the given result for the surface area in part (a) of this question. Solutions often consisted of a confused mass of formulae, lacking explanation of whether expressions represented length, area or volume. Formulae for arc length and sector area usually appeared at some stage, but it was often unclear how they were being used and at which point the substitution $\theta = 1$ was being made. It was, however, encouraging to see well-explained, clearly structured solutions from good candidates.

Having struggled with part (a), some candidates disappointingly gave up. The methods required for the remainder of the question were, of course, more standard and should have been familiar to most candidates.
In part (b), most candidates successfully differentiated the given expression then formed an equation in r using $\frac{dS}{dr} = 0$. While many solved $2r - \frac{1800}{r^2} = 0$ successfully, weaker candidates were sometimes let down by their algebraic skills and could not cope correctly with the negative power of r. A common slip was to proceed from $r^3 = 900$ to $r = 30$.

In part (c), the majority of candidates correctly considered the sign of the second derivative to

establish that the value of S was a minimum, although occasionally the second derivative was equated to zero.
Those who proceeded as far as part (d) were usually able to score at least the method mark, except when the value of r they substituted was completely inappropriate, such as the value of the second derivative.

4. There were no problems with part (a) in most cases, but a significant number used formulae for arc length, areas of segments, or areas of triangles instead of the correct formula for the area of a sector.

The main error in part (b) was taking π rather than 2π in their calculation. Many candidates converted into and out of degrees here making their working more complicated.

The method used in (c) was correct in most cases – but there was a sizeable minority who treated BDC as a sector thus scoring 0/4. A few cases were seen where DC was taken as base of the triangle ADC, calculated (via cosine rule) along with the height (found via first calculating one of the other angles) then used in ½ x base x height – much more complicated than 1/2absinC.

5. Many fully correct solutions to this question were seen. Those candidates who were unwilling to work in radians, however, made things more difficult for themselves (and sometimes lost accuracy) by converting angles into degrees.

In parts (a) and (b), those who knew the correct formulae scored easy marks while those who used formulae for the circumference and the area of a circle sometimes produced muddled working. A few thought that the angle should be 0.8π.

In finding the perimeter in part (c), most candidates realised that they needed to find the lengths *DC* and *BD*. It was surprising to see 4.5 occurring occasionally for *DC* as half of 7. In finding *BD*, most made a good attempt to use the cosine formula, although calculation slips were not uncommon. Some assumed that *BD* was perpendicular to *AC* and worked with Pythagoras' Theorem or basic triangle trigonometry, scoring no more than one mark in this part. In part (d) some candidates tried, with varying degrees of success, to use $\frac{1}{2}bh$ and some produced lengthy methods involving the sine rule. Occasionally the required area was interpreted as a segment and the segment area formula was used directly. Without any method for the area of an appropriate triangle, this scored no marks. Some did use the segment together with the area of triangle *BDC*, and although this was lengthy, the correct answer was often achieved.

6. Part (a) provided 2 marks for the majority of candidates but it was surprising, as the form was given, to see such "slips" as $(x - 6) + (y - 4) = 9$ or $(x - 6)^2 - (y - 4)^2 = 9$. There were some good solutions to part (b) but this did prove to be quite discriminating: Many candidates did not really attempt it; some actually used the given answer to calculate TP or PM, and then used these results to show that angle TMQ = 1.0766; and a large number of candidates made the serious error of taking TP = 6. It was disappointingly to see even some of the successful candidates using the cosine rule in triangle TMP, having clearly recognised that it was right-angled.

Part (c) was answered much better, with most candidates having a correct strategy. However, there were some common errors: use of the wrong sides in ½absinC; careless use of Pythagoras to give TP = $7(\sqrt{40+9})$; mixing up the formulae for arc length and sector area; and through inaccuracy or premature approximation, giving answers like 3.51 or 3.505.

7. Although many candidates used correct methods in this question, some accuracy marks were lost carelessly by failure to give answers in the format requested. As in Q6, some candidates had difficulty in working with radians. Most candidates quoted a correct form of the cosine rule (one form of which is in the formulae book) in part (a) and were able to substitute the correct values. However, some had difficulty in making cos *PQR* the subject of the formula or evaluating $(6\sqrt{3})^2$. Candidates who found sin($\frac{1}{2}$ *PQR*) were usually successful. Some candidates used the given answer in (b) to find the angle in (a) and so no credit was given in (a) if no valid method was seen. Despite the instruction in the question, a number of candidates gave the answer as 120° and attempted to use this in subsequent parts of the question. In part (b) the formula $\frac{1}{2}r^2\theta$ was usually sometimes misquoted, usually involving the loss of the $\frac{1}{2}$ or inserting π. Some candidates were quite creative at their attempts to reach the stated answer! Using a variety of methods, most candidates were able to attempt to find the area of the triangle in part (c) but it was common to see the answer given as a decimal rather than the exact answer of $9\sqrt{3}$. The methods in part (d) and (e) are well known to candidates and were applied successfully, although a few ignored the request for answers to be given to one decimal place.

8. There were many excellent solutions to the first two parts of this question, with most candidates sensibly using the formulae $r\theta$ and $\frac{1}{2}$ $r^2\theta$ rather than trying to convert to degrees. Conversion to degrees was rather more popular in part (c), however, and while many candidates did so correctly and converted their answer back into radians at the end, this was an inefficient method, likely to produce errors. Common wrong methods in part (c) were π – 65.0 and 1 – 65. 0 It was disappointing that, in part (d), many candidates were unable to obtain the correct area of triangle *ACD*. Some unnecessarily calculated a perpendicular height for the triangle (giving a greater risk of error), and some, using $\frac{1}{2}ab\sin C$, took both *a* and *b* to be 1.86. A few, having found the area of the triangle, forgot to add it to the area of the sector to give the required answer.

9. The first two parts of question 5 proved very easy but part (c) was very demanding and there many futile attempts to find the results using areas. All such attempts seen were circular and either should have given 0 = 0 or actually did give 0 = 0. *b* only needs simple trigonometry, $b = 6\sin 1.2 \approx 5.59$. Some very complicated attempts to find *a* were seen involving both the sine and cosine rules. The quickest method is to see that $a = 12 - 6\cos 1.2$.

10. The cosine rule was the most common approach to part (a) and most candidates were successful. Some were unable to rearrange the formula given in the booklet to obtain the angle and a others split the isosceles triangle in half but they rarely were able to provide a full proof (using double angle formulae for cos2*x*) as they resorted to their calculators. Surprisingly a number of candidates failed to score the mark in part (b). Some used degrees, a few then tried to convert this to radians but accuracy was sometimes lost; they seemed reluctant to adjust their calculator and work in radian mode. There was much confusion in part (c) with a number of candidates giving the area of the triangle (or occasionally the segment) rather than the sector. Often they recovered in part (d) and had simply misread the instruction or confused “triangle” with “sector”. Most knew how to find the area of the segment in part (d) and the formula for a segment was often quoted. Some struggled to find the area of the triangle, they did not attempt to use $\frac{1}{5}5^2\sin\theta$ but tried half base times height and sometimes used 5 cm as the height.

11. This was a good question for a large number of candidates.

There were a few candidates who had no idea how to tackle part (a) but, in general, the method mark was gained by the vast majority of candidates. Candidates who found the angle in degrees first and then converted to radians did often lose the A mark, however, because of lack of exactness.

In part (b) although a few candidates used a wrong formula for the area of a sector, e.g $\frac{1}{2}\pi r^2\theta$, finding the area of triangle *DOC* proved more of a problem. The most common errors seen were:

(i) giving the area of the triangle as ½ × 30 × 30 (in effect treating as right-angled) or as ½ x 30 × 30 × 1.4 (omitting "sin");

(ii) in splitting up the triangle and having a method error such as considering the altitude from *D* to *OC* as a line of symmetry;

(iii) after correctly stating "area = ½ × 30 × 30 × sin 1.4", using 1.4° rather than 1.4 radians so that the answer of 10.99 m^2, for the area of the triangle, was seen quite frequently.

The mark scheme was generous in the sense that the A marks for the area of the sector and the triangle only required a correct unsimplified statement (not the actual numerical answer), and so an error such as that in (iii) only lost the final mark in the question.. It was also common to see the final answer not given to the nearest m^2, as requested in the question.

12. (a) Most candidates had the area correct, but many had the perimeter as P=rθ only, and so were only able to go on and get an M1 in the next part. Another common mistake was to take the angle as (2Π-θ) or (360-θ) and so again only method marks could be obtained in part (b)

(b) The majority of candidates gained the M1 here, and generally those who had (a) correct had at least M2 in (b), and quite often all three marks.

(c) Generally this was very well answered. Even those who had very few marks in the first 2 parts were able to get full marks here. The most common errors were to get 4-1=3 as the denominator, or to do 2(√2+1)=2√2+1 as the numerator. Unbelievably some candidates took their wrong answer in (b) and tried to rationalise that in (c) rather than use the surd given on the question paper.

13. Part (a) was answered very well by almost all the candidates but part (b) caused problems for many. Some assumed the triangle was right angled at *B*, but many tried to use the cosine rule. Despite the formula being given in the new formula sheet a few candidates misquoted it (having sin(0.7) instead of cos(0.7)) and the radians caused some confusion with many choosing to use degrees and occasionally forgetting to use the degree formula for sector area in part (c). Of those who had a correct expression for *BC*, some could not evaluate it correctly and others rounded too soon. Most could identify the 3 lengths required for the perimeter but the final mark required an answer of 15.7 only and was sometimes lost due to previous errors or a failure to round at this final stage. Part (c) was, in the main, handled well and most found the area of the sector correctly but some elaborate, and sometimes incorrect, methods for finding the area of the triangle *ABC* were used. The intended approach was to use $\frac{1}{2}\times 8\times 11\times \sin(0.7)$ but some identified this formula but could not apply it correctly (*BC* was sometimes used instead of *AB* for example) and a few forgot to switch the mode on their calculator to evaluate sin(0.7). Nevertheless there were a number of candidates who scored full marks on this part of the question.

14. About half of the candidates failed to complete part (a) correctly, the main problems being the inability either to quote or to use the cosine rule correctly. For those whose method was correct, the actual calculation was usually well done and the use of radians in the given answer caused very few problems.

Answers for the arc length in part (b) were usually correct, and most candidates were able to quote and use the formula for the area of a sector to gain a mark in part (c). Completely correct solutions in part (c) were not common, however, because most candidates were unable to find the area of triangle *ABC*. The $\frac{1}{2}ab\sin C$ formula was sometimes wrongly used, while another popular approach was to attempt $\frac{1}{2}bh$, usually assuming that the triangle was right-angled. Rounding errors sometimes led to the loss of a mark in otherwise correct solutions.

15. Apart from occasional confusion between sectors and triangles, or arcs and chords, candidates did well on this question. Those who unnecessarily converted radians into degrees had more opportunity to make mistakes in their calculations, and parts (a) and (c) were completed successfully more often than part (b). In part (a), the formula for the area of a sector was usually quoted correctly, as was that for the length of the arc in part (c).

Although the given answer for the length of the chord in part (b) appeared to help candidates, there were cases where insufficient working was shown, or where calculations were insufficiently accurate to justify the 3 significant figure answer. The use of sine in a right-angled triangle and use of the cosine formula were equally popular methods for those attempting this part. In part (c), some candidates found only the arc length rather than the complete perimeter of the segment, and a few found the area of the segment.

16. In part (a), most candidates remembered the formula for the area of a sector of a circle and managed to score at least 2 of the 3 marks available. To complete the proof here, however, it was necessary show the equivalence of $\sqrt{20}$ and $2\sqrt{5}$, and many failed to do this. To write $\sqrt{20} = 4.472 = 2\sqrt{5}$ was, of course, unacceptable.

Finding the perimeter of the sector *OAB* in part (b) proved more difficult for many candidates. Some appeared to be considering the triangle *OAB,* and others the segment, while a significant minority failed to use the formula for the length of an arc. Candidates familiar with the $\frac{1}{2}ab\sin C$ formula often produced concise, accurate solutions to part (c), but where $\frac{1}{2}bh$ was used, calculations tended to lose the accuracy necessary to be able to give the final answer to 3 decimal places. Triangle *OAB* was sometimes assumed to be equilateral or right-angled.

Overall, it was pleasing in this question to see that many candidates were confident in using radians and were not tempted to convert their angles into degree measure.

17. Almost all candidates scored the first mark, using Pythagoras' Theorem to show that the length of *BM* was 25 mm. In part (b), however, some candidates thought they needed to start using formulae for arcs and sectors and did not realise that any trigonometry was required. Those who used trigonometry in a right-angled triangle or the cosine rule in triangle *BCM* were usually successful, often preferring to work in degrees and then convert their answer to radians. Occasionally insufficient accuracy was shown to justify the given answer 0.568 radians, and a mark was lost.

The formula $\frac{1}{2}r^2\theta$ was well known, though sometimes used with $r = 24$ instead of $r = 25$, but mistakes in calculating the area of the triangles or in combining the right components to find the total area of cross-section in part (c) were not uncommon.

Apart from $V = lbh$ and other uncertainty over how to find the volume of the chocolate bar in part (d), the main difficulty was that of converting the units from mm to cm . Few candidates managed this successfully.

18. No Report available for this question.

19. No Report available for this question.