1

(a)
- States small angle approximations: $\sin\theta \approx \theta$ and $\cos\theta \approx 1 - \frac{\theta^2}{2}$ **M1**
- Substitutes into the expression: $\frac{1-\frac{\theta^2}{2}}{\theta}$ **M1**
- Multiplies numerator and denominator by 2 to reach $\frac{2-\theta^2}{2\theta}$ **A1**

(b)
- Substitutes $\theta = \frac{\pi}{24}$ into the approximation: $\frac{2-(\frac{\pi}{24})^2}{2(\frac{\pi}{24})}$ **M1**
- Evaluates to 7.57 (3sf) **A1**

(c)
- Calculates exact value $\approx 7.59575...$ and uses $\frac{\text{actual}-\text{approx}}{\text{actual}} \times 100$ **M1**
- Final answer 0.287% **A1**

(Total for question 1 is 6 marks)

2

(a)
- Uses $\tan(3x) \approx 3x$ and $\cos(2x) \approx 1 - \frac{(2x)^2}{2}$ **M1**
- Expands $(3x)(1-2x^2)$ **M1**
- Simplifies to $3x - 6x^3$ **A1**

(b)
- Substitutes $x = 0.1$ into $3x - 6x^3$ **M1**
- Final answer 0.294 **A1**

(c)
- Uses $\frac{0.30317...-0.294}{0.30317...} \times 100$ **M1**
- Final answer 3.02% **A1**

(Total for question 2 is 6 marks)

3

(a)
- Substitutes $\cos\theta \approx 1 - \frac{\theta^2}{2}$ and $\cos 2\theta \approx 1 - \frac{(2\theta)^2}{2}$ **M1**
- Expands $(1-2\theta^2)^2 = 1 - 4\theta^2 + 4\theta^4$ **M1**
- Combines terms: $4 - 2\theta^2 + 1 - 4\theta^2 + 4\theta^4 = 5 - 6\theta^2 + 4\theta^4$ **A1**

(b)
- Converts 3° to $\frac{\pi}{60}$ radians **M1**
- Substitutes into approximation to get 4.98358 **A1**

(c)
- Calculates exact value 4.98359... and finds error **M1**
- Final answer 0.000225% **A1**

(Total for question 3 is 6 marks)

4

- Uses $\sin 3\theta \approx 3\theta$ and $\cos 2\theta \approx 1 - \frac{(2\theta)^2}{2}$ **M1**
- Simplifies numerator to $12\theta^2$ and denominator to $2\theta^2$ **M1**
- Final answer 6 **A1**

(Total for question 4 is 3 marks)

5

- Identifies $\theta = \frac{\pi}{3}$ because triangle is equilateral **B1**
- Uses Area $= \frac{1}{2}r^2\theta \Rightarrow 24\pi = \frac{1}{2}r^2(\frac{\pi}{3})$ **M1**
- Finds $r = 12$ **A1**
- Perimeter $= r\theta + 2r = 4\pi + 24$ (Note: Markscheme provided 4π for arc length, but perimeter is $2r + l$) **A1**

(Total for question 5 is 4 marks)

6

(a)

- Uses cosine rule: $\cos\theta = \frac{6^2+6^2-8^2}{2(6)(6)}$ **M1**
- $\cos\theta = \frac{1}{9}$ **M1**
- $\theta = 1.459$ radians **A1**

(b)

- Area $= \frac{1}{2}(6^2)(1.459...)$ **M1**
- Final answer 26.3 cm^2 **A1**

(c)

- Area of triangle $= \frac{1}{2}(6)(6)\sin(1.459...) = 17.88...$ **M1**
- Shaded area $= 26.26... - 17.88...$ **M1**
- Final answer 8.38 cm^2 **A1**

(Total for question 6 is 8 marks)

7

(a)
- Arc length $= 5 \times 0.5$ **M1**
- Final answer 2.5 m **A1**

(b)
- Area $= \frac{1}{2}(5^2)(0.5)$ **M1**
- Final answer 6.25 m^2 **A1**

(c)
- Finds $MC = 2.5$ **B1**
- Uses cosine rule for BM: $BM^2 = 5^2 + 2.5^2 - 2(5)(2.5)\cos(0.5)$ **M1**
- $BM = 3.05$ **A1**
- Perimeter $= 2.5 + 2.5 + 3.05 = 8.05$ m **A1**

(d)
- Area of triangle $ABM = \frac{1}{2}(5)(2.5)\sin(0.5) = 2.996...$ **M1**
- Shaded area $= 6.25 - 2.996...$ **M1**
- Final answer 3.25 m^2 **A1**

(Total for question 7 is 12 marks)

8

(a)
- Arc length $= 7 \times 0.6 = 4.2$ cm **B1**

(b)
- Area $= \frac{1}{2}(7^2)(0.6) = 14.7$ cm^2 **B1**

(c)
- Angle $CAD = \frac{\pi}{2} - 0.6 = 0.971$ radians **B1**

(d)
- Area of triangle $CAD = \frac{1}{2}(7)(5)\sin(0.971) = 14.4$ cm^2 **M1**
- Total area $= 14.7 + 14.4 = 29.1$ cm^2 **A1**

(Total for question 8 is 8 marks)

9

(a)
- Rearranges to $\cos x = 3x + 0.5$ **M1**
- States that the graphs of $y = \cos x$ and $y = 3x + 0.5$ only intersect once **A1**

(b)
- Uses $\cos\alpha \approx 1 - \frac{\alpha^2}{2}$ **M1**
- Sets up quadratic: $1 - \frac{\alpha^2}{2} - 3\alpha - 0.5 = 0 \Rightarrow \alpha^2 + 6\alpha - 1 = 0$ **M1**
- Solves for positive root: $\alpha = 0.162$ **A1**

(Total for question 9 is 5 marks)

10

(a)
- The student used degrees instead of radians in the formula $\frac{1}{2}r^2\theta$ **B1**

(b)
- Converts 40° to $\frac{2\pi}{9}$ radians **M1**
- Area $= \frac{1}{2}(6^2)(\frac{2\pi}{9}) = 4\pi$ cm^2 **A1**

(Total for question 10 is 3 marks)

11
- Uses $\sin\frac{x}{3} \approx \frac{x}{3}$ and $\tan\frac{x}{2} \approx \frac{x}{2}$ **M1**
- $y = 3 + 6(\frac{x}{3}) - 8(\frac{x}{2}) = 3 + 2x - 4x$ **M1**
- $y = 3 - 2x$, which is in the form $y = mx + c$ **A1**

(Total for question 11 is 3 marks)

12

(a)
- Finds coordinates of A ($y = 0$): $(x+2)^2 + 1 = 25 \Rightarrow x = -2 + \sqrt{24} \approx 2.90$ **M1**
- Finds coordinates of B ($x = 0$): $4 + (y+1)^2 = 25 \Rightarrow y = -1 + \sqrt{21} \approx 3.58$ **M1**
- Calculates chord length $AB = \sqrt{(2.90-0)^2 + (0-3.58)^2} \approx 4.61$ **M1**
- Uses cosine rule: $\cos\theta = \frac{5^2+5^2-4.61^2}{2(5)(5)}$ **M1**
- $\theta = 0.958$ radians **A1**

(b)
- Arc length $= 5 \times 0.958 = 4.79$ **M1**
- Perimeter $= 5 + 5 + 4.79$ **M1**
- Final answer 14.8 **A1**

(Total for question 12 is 8 marks)

13
- Completes the square to find r^2: $(x-3)^2 + (y+5)^2 = 222 + 9 + 25 = 256$ **M1**
- $r = 16$ **A1**
- Sector area $= \frac{1}{2}(16^2)(0.8) = 102.4$ **M1**
- Triangle area $= \frac{1}{2}(16^2)\sin(0.8) = 91.82...$ **M1**
- Segment area $= 102.4 - 91.82... = 10.6$ **A1**

(Total for question 13 is 5 marks)

14
- Uses $\tan 2\theta \approx 2\theta$ and $\cos 4\theta \approx 1 - \frac{(4\theta)^2}{2}$ **M1**
- Expression becomes $\frac{5\theta(2\theta)}{1-8\theta^2-1} = \frac{10\theta^2}{-8\theta^2}$ **M1**
- Final answer $-\frac{5}{4}$ **A1**

(Total for question 14 is 3 marks)

15

(a)
- Uses $\cos\theta \approx 1 - \frac{\theta^2}{2}$ and $\sin\theta \approx \theta$ **M1**
- Expands: $2(1 - \frac{\theta^2}{2}) + (\theta + 1)^2 = 2 - \theta^2 + \theta^2 + 2\theta + 1$ **M1**
- Simplifies to $2\theta + 3$ **A1**

(b)
- Uses $2\theta + 3 = 20\theta$ (since $\tan\theta \approx \theta$) **M1**
- $18\theta = 3 \Rightarrow \theta = \frac{1}{6}$ **A1**

(Total for question 15 is 5 marks)

16
- States $AC = 5\cos\theta$ **M1**
- Uses $\cos\theta \approx 1 - \frac{\theta^2}{2}$ **M1**
- $AC = 5 - 2.5\theta^2$ (or states $AC \approx 5$ as $\theta \to 0$) **A1**

(Total for question 16 is 3 marks)

17
- Sets up equations: $\frac{1}{2}r^2\theta = 1.872$ and $r\theta = 1.56$ **M1**
- Divides equations: $\frac{1}{2}r = \frac{1.872}{1.56} = 1.2$ **M1**
- $r = 2.4$ cm and $\theta = 0.65$ radians **A1**

(Total for question 17 is 3 marks)

18

(a)
- Arc length $= 9 \times 1.2 = 10.8$ cm **B1**

(b)
- Area $= \frac{1}{2}(9^2)(1.2)$ **M1**
- Final answer 48.6 cm^2 **A1**

(Total for question 18 is 3 marks)
