NORMANHURST BOYS HIGH SCHOOL

# MATHEMATICS ADVANCED

2020 Year 11 Course Assessment Task 4
Friday, 11 September 2020

**General instructions**

- Working time – 2 hours.
  (plus 5 minutes reading time)
- Write using blue or black pen. Where diagrams are to be sketched, these may be done in pencil.
- NESA approved calculators may be used.
- Attempt all questions.
- At the conclusion of the examination, bundle the booklets used in the correct order within this paper and hand to examination supervisors.

**SECTION I**

- Mark your answers on the answer grid provided

**SECTION II**

- Commence each new question on a new booklet. Write on both sides of the paper.
- All necessary working should be shown in every question. Marks may be deducted for illegible or incomplete working.

**NESA STUDENT #: ..... CLASS: ……**

Marker's use only

| QUESTION | 1-5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARKS | /5 | /5 | /9 | /10 | /9 | /7 | /5 | /10 | /15 | /10 | /85 | |

# Section I

**5 marks**
**Attempt Questions 1 to 5**
**Allow approximately 10 minutes for this section**

Mark your answers on the answer grid provided.

**1.** What is the value of $\sqrt{48} - \sqrt{12}$ ? **1**

(A) 2 (B) $\sqrt{12}$ (C) $\sqrt{24}$ (D) 6

**2.** What are the $x$ intercepts of the parabola $y = x^2 - 2x - 3$ ? **1**

(A) $-3$ and $-1$
(B) $-3$ and 1
(C) $-1$ and 3
(D) 1 and 3

**3.** Which of the following statements is correct for the function $y = 2\sin 2x$ ? **1**

(A) It has range [-2, 2] and period $\pi$.
(B) It has range [-2, 2] and period $2\pi$.
(C) It has range [-1, 1] and period $\pi$.
(D) It has range [-1, 1] and period $2\pi$.

**4.** If $a = e^x$, what is the value of $log_e \frac{1}{a^2}$? **1**

(A) $-x^2$
(B) $-2x$
(C) $2x$
(D) $x^2$

**5.** If $y = \sqrt{2x+1}$, what is the expression for $\frac{dy}{dx}$? **1**

(A) $\frac{dy}{dx} = 2\sqrt{2x+1}$
(B) $\frac{dy}{dx} = \frac{1}{2\sqrt{2x+1}}$
(C) $\frac{dy}{dx} = \frac{1}{\sqrt{2x+1}}$
(D) $\frac{dy}{dx} = \frac{2}{\sqrt{2x+1}}$

# Section II

**75 marks**
**Attempt Questions 6 to 14**
**Allow approximately 1hour 50 minutes for this section.**

Write your answers in the writing booklets supplied. Additional writing booklets are available.
Your responses should include relevant mathematical reasoning and/or calculations.

**Question 6** (5 marks) **Marks**

(a) Fully simplify and leave the answer without negative index: **1**

$y^{\frac{3}{8}} \times y^{\frac{5}{8}} \times y^{-2}$

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(b) Given that $\log_y x = 2.75$ and $\log_y z = 0.25$, find the value of $\log_y \sqrt{xz}$. **2**

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(c) Fully factorise: $80x^4 - 5y^4$ **2**

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**Question 7** (9 marks)

(a) Evaluate **2**

$$\lim_{x\to\infty} \frac{10x^2 - 5x}{2x^2 + 8x}$$

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(b) Solve for $x$: $3^x + 3^{x+1} - 36 = 0$ **2**

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(c) Solve by completing the square: $x^2 - 6x - 7 = 0$. **2**

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(d) Simplify the following, expressing your answer with a rational denominator: **3**

$$\frac{\sqrt{5}-\sqrt{3}}{\sqrt{5}+\sqrt{3}}$$

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**Question 8** (10 marks)

(a) Find the domain and the range of the following function: **2**

$$y = \sqrt{x^2 - 4}$$

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(b) State whether the following function is even, odd or neither: **2**

$$f(x) = x^3 - x + 1$$

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(c) Consider the following piecewise function:

$$f(x) = \begin{cases} x+3 & \text{for } x < -1 \\ x^2 & \text{for } -1 \leq x \leq 1 \\ \sqrt{x} & \text{for } x > 1 \end{cases}$$

i. Find the value of $3f(4) + f(-2) - f\left(-\frac{1}{2}\right)$. **3**

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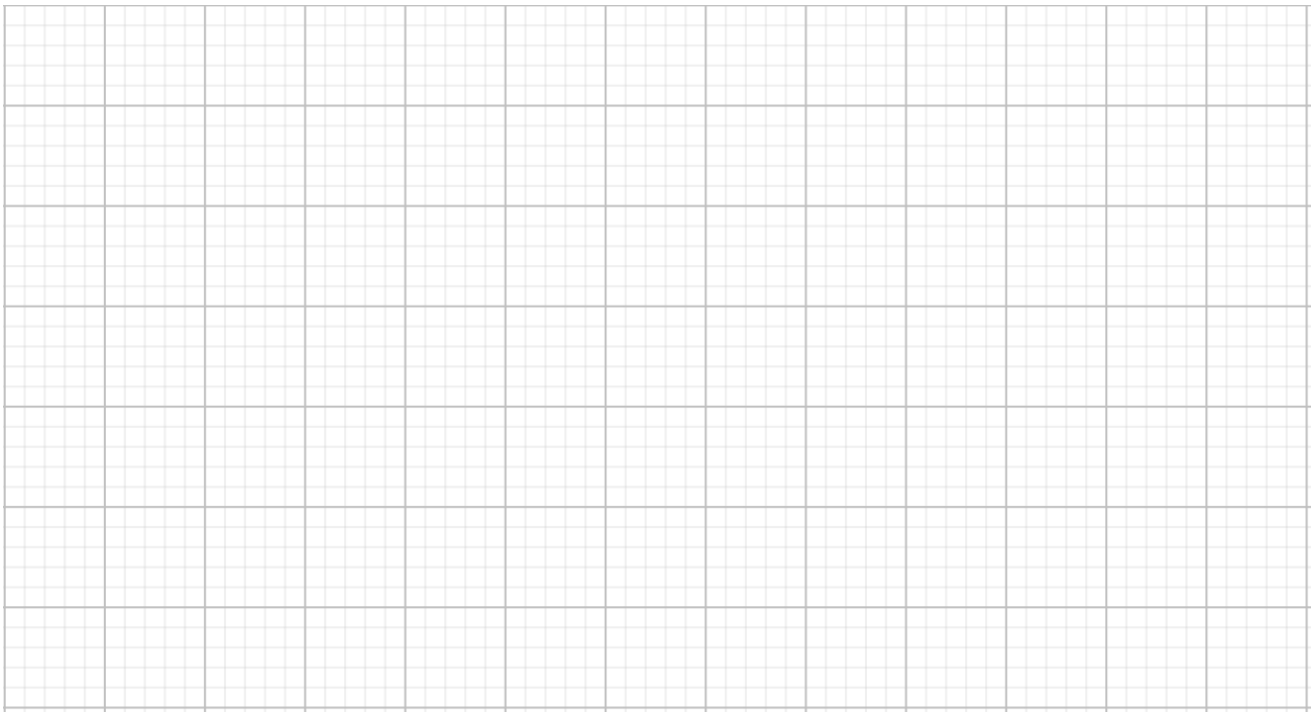
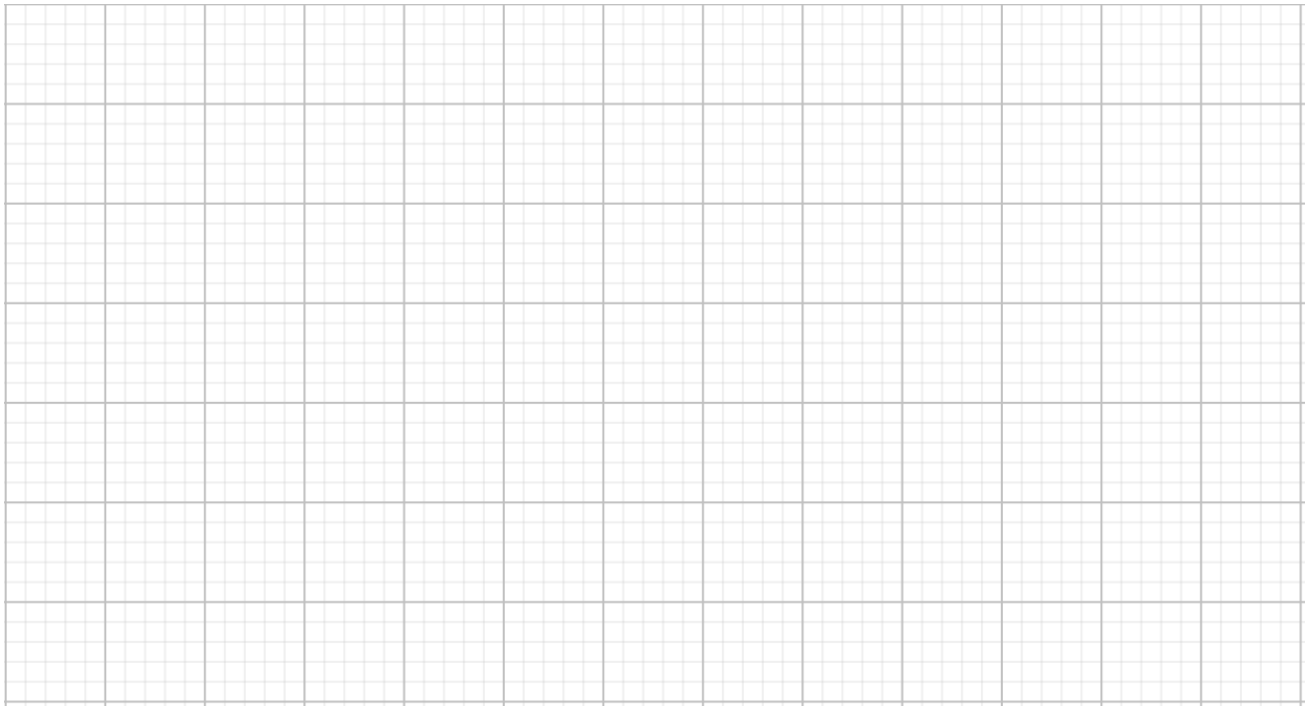
ii. Sketch the above piecewise function. **3**



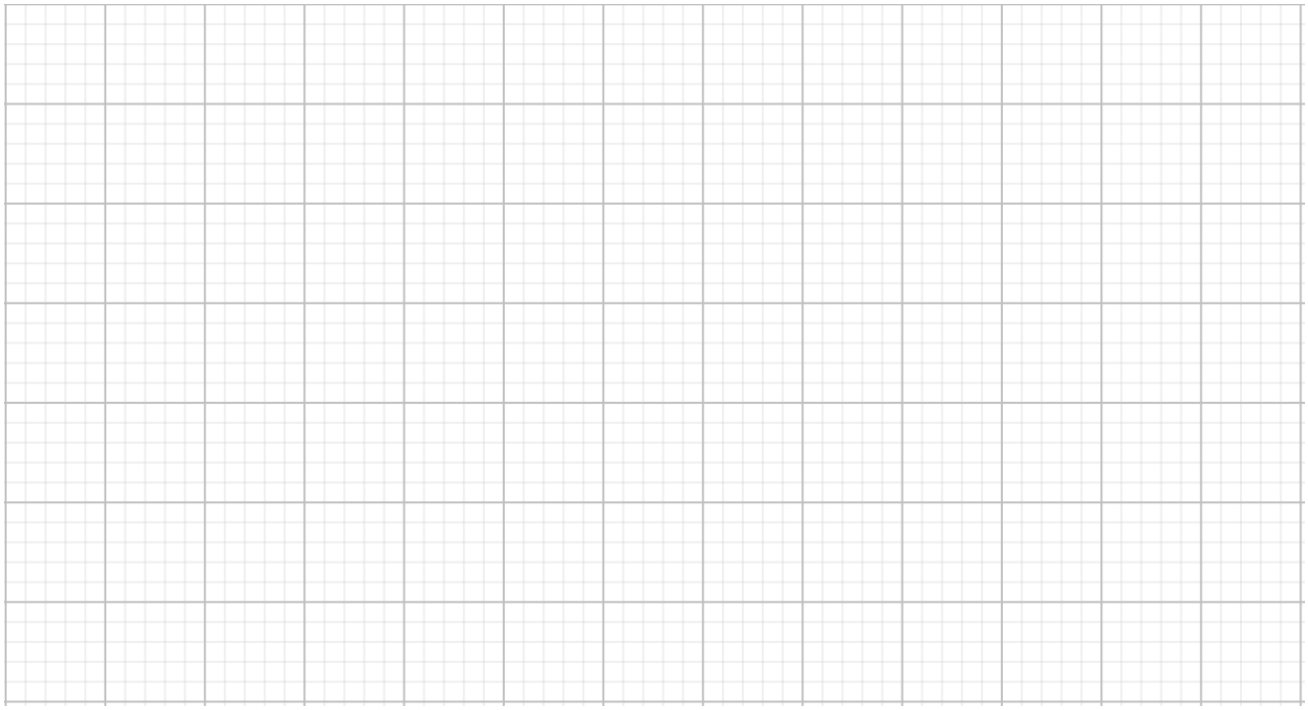
**Question 9** (9 marks)

Sketch the following, showing all important features:

(a) $f(x) = (x-1)(x-2)(x+2)$ **2**



(b) $y = |x+3| - 2$ **2**



(c) $y = 2\,sin\,3x$ for $0 \leq x \leq 2\pi$ **3**

(d) $y = -e^x + 2$ **2**

**Question 10** (7 marks)

(a) Simplify the following: $\tan^2\theta \cos^2\theta + \cot^2\theta \sin^2\theta$ **2**

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(b) Prove the following trigonometric identity: **3**

$$\frac{\cos\theta}{1+\sin\theta} + \frac{1+\sin\theta}{\cos\theta} = 2\,sec\,\theta$$

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(c) Solve $\sqrt{3}\tan x = -1$ for $0° \leq \theta \leq 360°$. **2**

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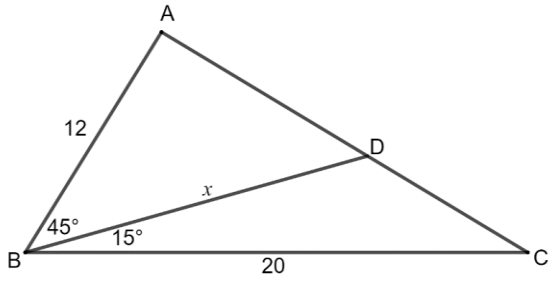
**Question 11** (5 marks)

Consider the diagram given below:




(a) Find the exact area of $\Delta ABC$. **2**

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(b) Hence, find the value of $x$. **3**

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**Question 12** (10 marks)

For the function $y = x^3 - 6x^2 + 9x$

(a) Find the stationary points and determine their nature. **4**

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(b) Find the coordinates of any points of inflexion. **2**

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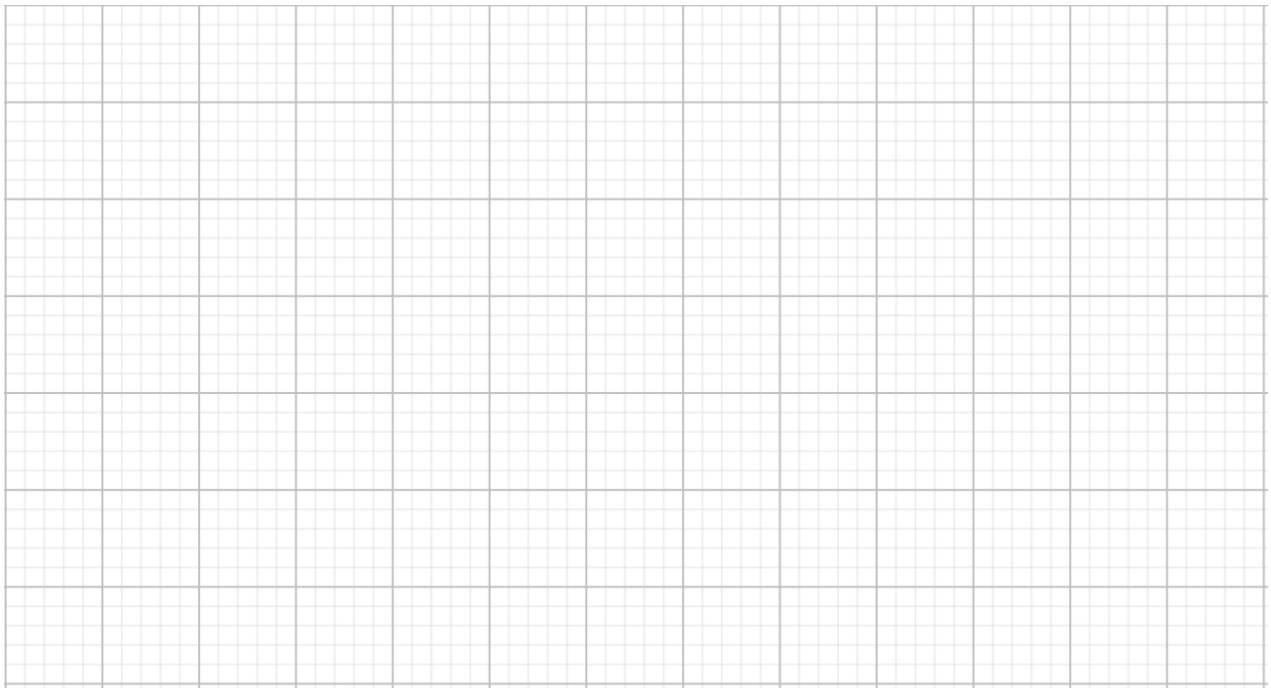
(c) Sketch the curve in the domain $0 \leq x \leq 4$. **3**



(d) For what values of $x$ is the function decreasing? **1**

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**Question 13** (15 marks)

(a) Differentiate $f(x) = x^2 - 3x + 5$ using first principles. **3**

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(b) Differentiate the following:

i. $x^2\sqrt{2x+1}$ **3**

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ii. $\frac{e^{5x-x^3}}{1-x}$ **3**

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(c) Find the equation of the tangent to the curve $y = 3x^3 - 2x^2 + 1$ at $x = 1$. **3**

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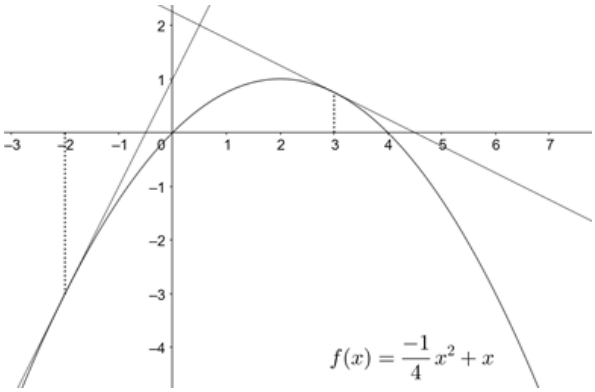
(d) The graph of $f(x) = -\frac{1}{4}x^2 + x$ is given below:




i. Find the expression for $f'(x)$. **1**

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**ii.** Hence, show that the illustrated tangents are perpendicular. **2**

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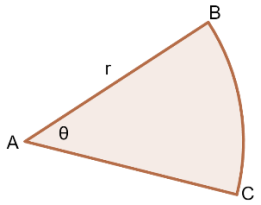
**Question 14** (10 marks)

(a) $ABC$ is a sector of a circle with radius $r$ as shown




It is given that the perimeter of the sector is equal in magnitude to the area of the sector.

i. Show that $\theta = \frac{4}{r-2}$ radians. **2**

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ii. Hence, show that the area of the sector ABC is equal to $\frac{2r^2}{r-2}$. **2**

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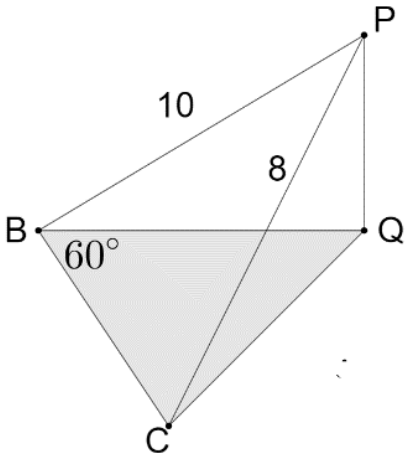
(b) A vertical post $PQ$ with height $h$ metres is held by two ropes $PB$ due west and $PC$ due south of it.

It is given that $\angle QBC = 60°, PB = 10$ m, $PC = 8$ m $and$ $\angle BCQ = 30°$.




i. Show that $\frac{CQ}{BQ} = \sqrt{3}$ **1**

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ii. Hence, show that 3

$$\frac{64 - h^2}{100 - h^2} = 3$$

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iii. Find the value of *h*. **2**

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# Answer Sheet for Section I

Mark answers to Section I by fully blackening the correct circle

**NESA STUDENT #: .....**

**1** – (A) (B) (C) (D)

**2** – (A) (B) (C) (D)

**3** – (A) (B) (C) (D)

**4** – (A) (B) (C) (D)

**5** – (A) (B) (C) (D)

# 2018 Mathematics Extension 1 HSC Course Assessment Task 1 Student Self Reflection

1. In hindsight, did I do the best I can? Why or why not?

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2. Which topics did I need more help with, and what parts specifically?

- Q1 - Locus

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- Q2 - Locus

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- Q3 – Series

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- Q4 – Euclidean Geometry

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- Q5 -

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3. What other parts from the feedback session can I take away to refine my solutions for future reference?

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(C) $-1$ and 3
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(C) $2x$
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**5.** If $y = \sqrt{2x+1}$, what is the expression for $\frac{dy}{dx}$? **1**

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(C) $\frac{dy}{dx} = \frac{1}{\sqrt{2x+1}}$
(D) $\frac{dy}{dx} = \frac{2}{\sqrt{2x+1}}$

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**Question 6** (5 marks) **Marks**

(a) Fully simplify and leave the answer without negative index: **1**

$y^{\frac{3}{8}} \times y^{\frac{5}{8}} \times y^{-2}$

$= y^{-1}$

(b) Given that $\log_y x = 2.75$ and $\log_y z = 0.25$, find the value of $\log_y \sqrt{xz}$. **2**

$\log_y \sqrt{xz} = \frac{1}{2} \log_y (xz)$

$= \frac{1}{2} [\log_y x + \log_y z]$

$= \frac{1}{2} [2.75 + 0.25]$

$= 1.5$

(c) Fully factorise: $80x^4 - 5y^4$ **2**

$= 5(16x^4 - y^4)$

$= 5((4x^2)^2 - (y^2)^2)$

$= 5(4x^2 - y^2)(4x^2 + y^2)$

$= 5(2x - y)(2x + y)(4x^2 + y^2)$

**Question 7** (9 marks)

(a) Evaluate **2**

$$\lim_{x\to\infty} \frac{10x^2 - 5x}{2x^2 + 8x}$$

$= \lim_{x\to\infty} \dfrac{10 - \frac{5}{x}}{2 - \frac{8}{x}}$

as $x \to \infty$, $\frac{1}{x} \to 0$

$\therefore \lim_{x\to\infty} \dfrac{10 - \frac{5}{x}}{2 - \frac{8}{x}} = 5$

(b) Solve for $x$: $3^x + 3^{x+1} - 36 = 0$ **2**

$3^x + 3(3^x) - 36 = 0$

let $3^x = y$

$\therefore \quad y + 3y - 36 = 0$

$4y - 36 = 0$

$y = 9$

$\therefore \quad 3^x = 9$

$3^x = 3^2 \quad \therefore x = 2$

(c) Solve by completing the square: $x^2 - 6x - 7 = 0$. **2**

$x^2 - 6x = 7$

$x^2 - 6x + 9 = 16$

$(x-3)^2 = 16$

$x - 3 = 4, \quad x - 3 = -4$

$x = 7, \quad x = -1$

(d) Simplify the following, expressing your answer with a rational denominator: **3**

$$\frac{\sqrt{5}-\sqrt{3}}{\sqrt{5}+\sqrt{3}}$$

$\frac{\sqrt{5}-\sqrt{3}}{\sqrt{5}+\sqrt{3}} \times \frac{\sqrt{5}+\sqrt{3}}{\sqrt{5}+\sqrt{3}}$

$= \frac{5 - 2\sqrt{15} + 3}{2}$

$= \frac{8-2\sqrt{15}}{2} = 4-\sqrt{15}$

**Question 8** (10 marks)

(a) Find the domain and the range of the following function: **2**

$$y = \sqrt{x^2 - 4}$$

D: $x^2 - 4 \geq 0$ Range: $y \geq 0$

$(x+2)(x-2) \geq 0$


$x \leq -2, \quad x \geq 2$

(b) State whether the following function is even, odd or neither: **2**

$$f(x) = x^3 - x + 1$$

$f(-x) = (-x)^3 - (-x) + 1$

$= -x^3 + x + 1$

$f(x) \neq f(-x)$ Not an even function

$f(-x) = -(x^3 - x - 1)$

$f(x) \neq -f(-x)$ Not an odd function

$\therefore f(x)$ is neither even nor odd.

(c) Consider the following piecewise function:

$$f(x) = \begin{cases} x+3 & \text{for } x < -1 \\ x^2 & \text{for } -1 \le x \le 1 \\ \sqrt{x} & \text{for } x > 1 \end{cases}$$

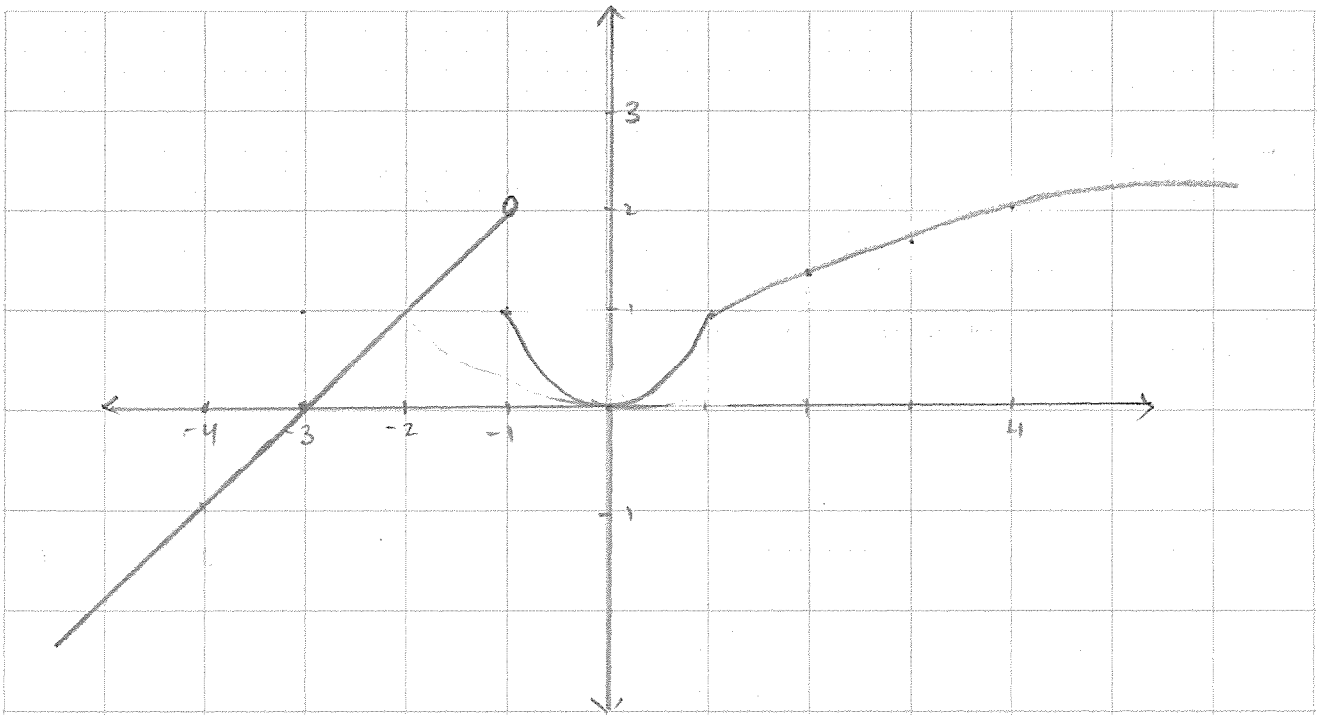
i. Find the value of $3f(4) + f(-2) - f\left(-\frac{1}{2}\right)$. **3**

$= 3\sqrt{4} + (-2+3) - \left(-\frac{1}{2}\right)^2$

$= 6 + 1 - \frac{1}{4}$

$= \frac{27}{4}$

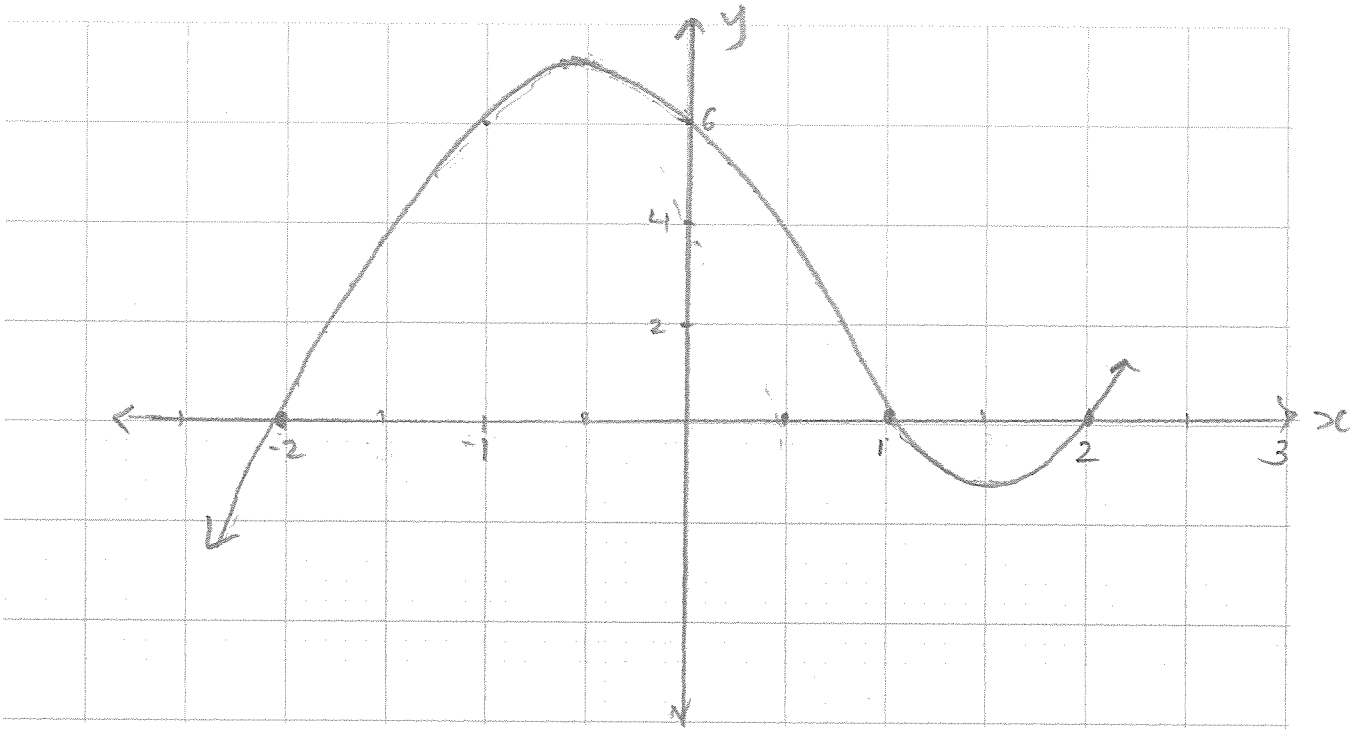
ii. Sketch the above piecewise function. **3**



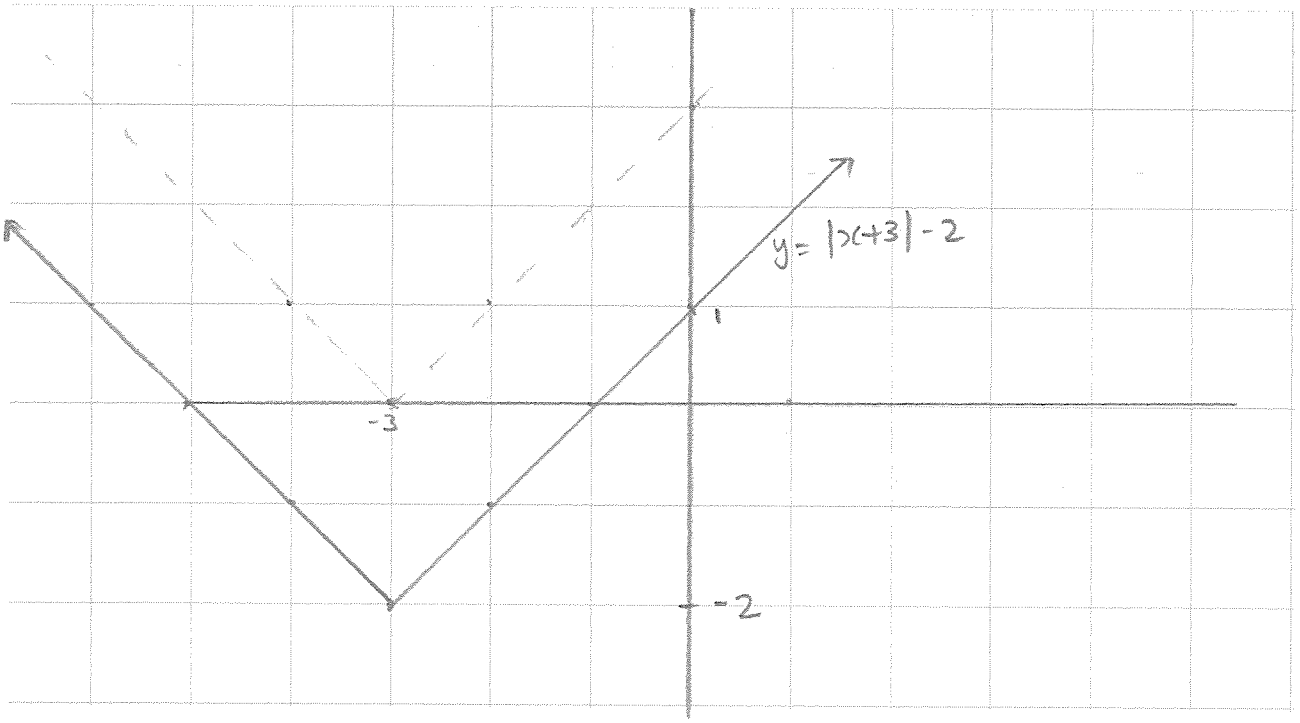
**Question 9** (9 marks)

Sketch the following, showing all important features:

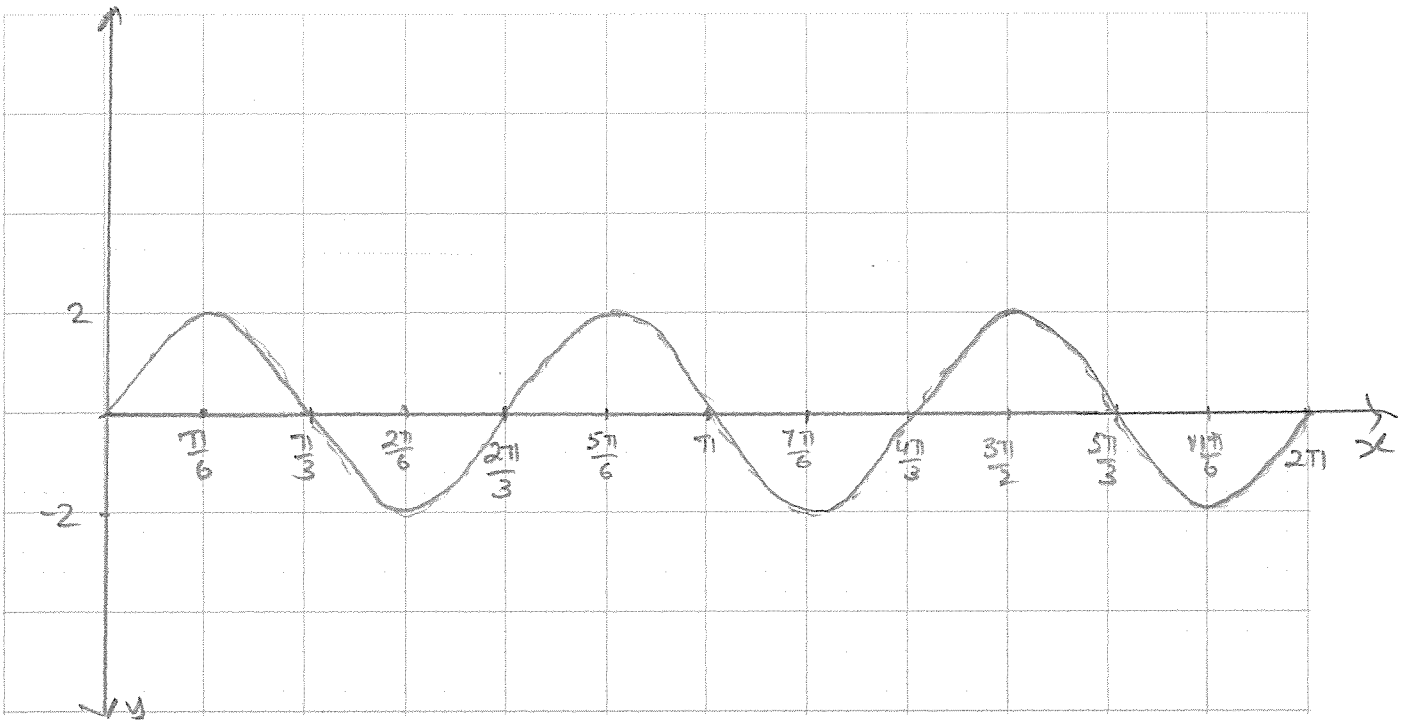
(a) $f(x) = (x-1)(x-2)(x+2)$ **2**



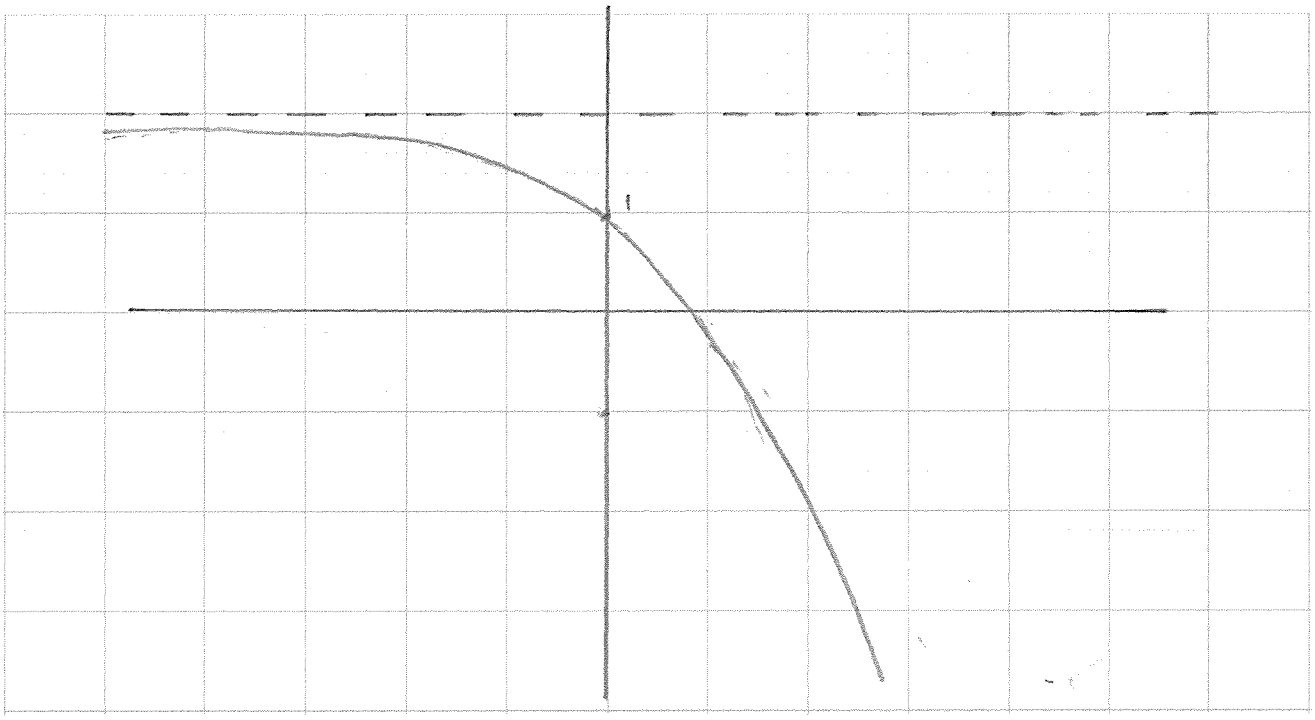

(b) $y = |x+3| - 2$ **2**



(c) $y = 2\sin 3x$ for $0 \leq x \leq 2\pi$ **3**




(d) $y = -e^x + 2$ **2**




$-e^x = -2$

$e^x = 2$

**Question 10** (7 marks)

(a) Simplify the following: $\tan^2\theta \cos^2\theta + \cot^2\theta \sin^2\theta$ **2**

$\frac{\sin^2\theta}{\cos^2\theta} \times \cos^2\theta + \frac{\cos^2\theta}{\sin^2\theta} \times \sin^2\theta$

$= \sin^2\theta + \cos^2\theta$

$= 1$

(b) Prove the following trigonometric identity: **3**

$$\frac{\cos\theta}{1+\sin\theta} + \frac{1+\sin\theta}{\cos\theta} = 2\sec\theta$$

LHS $\frac{\cos\theta}{1+\sin\theta} + \frac{1+\sin\theta}{\cos\theta}$

$= \frac{\cos^2\theta + 1 + 2\sin\theta + \sin^2\theta}{(1+\sin\theta)\cos\theta}$

$= \frac{2 + 2\sin\theta}{1 + \sin\theta\cos\theta} = \frac{2(1+\sin\theta)}{(1+\sin\theta)\cos\theta}$

$= \frac{2}{\cos\theta} = 2\sec\theta$ RHS

(c) Solve $\sqrt{3}\tan x = -1$ for $0° \leq \theta \leq 360°$. **2**

$\tan x = \frac{-1}{\sqrt{3}}$

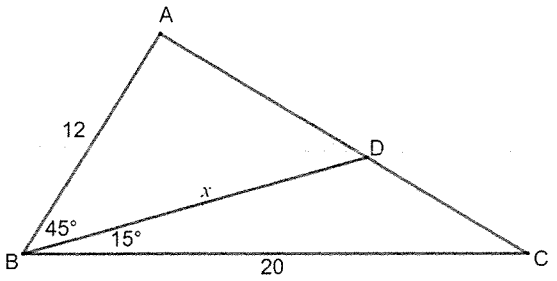
acute angle $= 30°$

$x = (180-30°), (360-30°)$

$= 150°, 330°$

**Question 11** (5 marks)

Consider the diagram given below:




(a) Find the exact area of $\Delta ABC$. **2**

$\text{Area}_{\Delta ABC} = \frac{1}{2} \times 12 \times 20 \times \sin 60^\circ$

$= \frac{240\sqrt{3}}{4}$

$= 60\sqrt{3}$ units$^2$

(b) Hence, find the value of $x$. **3**

$\frac{1}{2} \times 12 \times x \sin 45^\circ + \frac{1}{2} \times 20 \times x \sin 15 = 60\sqrt{3}$

$2x(3\sin 45^\circ + 5\sin 15^\circ) = 60\sqrt{3}$

$x = \frac{60\sqrt{3}}{2(3\sin 45^\circ + 5\sin 15^\circ)}$

$=$

**Question 12** (10 marks)

For the function $y = x^3 - 6x^2 + 9x$

(a) Find the stationary points and determine their nature. **4**

$y = x^3 - 6x^2 + 9x$

$\frac{dy}{dx} = 3x^2 - 12x + 9$

for st. points, $\frac{dy}{dx} = 0$

$3x^2 - 12x + 9 = 0$

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

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

$x = 3, x = 1$

when $x = 1$, $y = 1 - 6 + 9 = 4$

$x = 3$, $y = 27 - 54 + 27 = 0$

$\therefore$ St pts : $(1,4), (3,0)$

$y'' = 6x - 12$

when $x = 1$, $y'' = -6$

$y'' < 0$ $\therefore$ $(1,4)$ a maximum

when $x = 3$

$y'' = 6 \times 3 - 12 = 6$

$y'' > 0$

$\therefore$ $(3,0)$ is a minimum

(b) Find the coordinates of any points of inflexion. **2**

for Point of inflexion

$y'' = 0$

$6x - 12 = 0$

$x = 2$

$\therefore y = 8 - 6 \times 4 + 18$

$= 26 - 24 = 2$

$\therefore$ POI : $(2,2)$

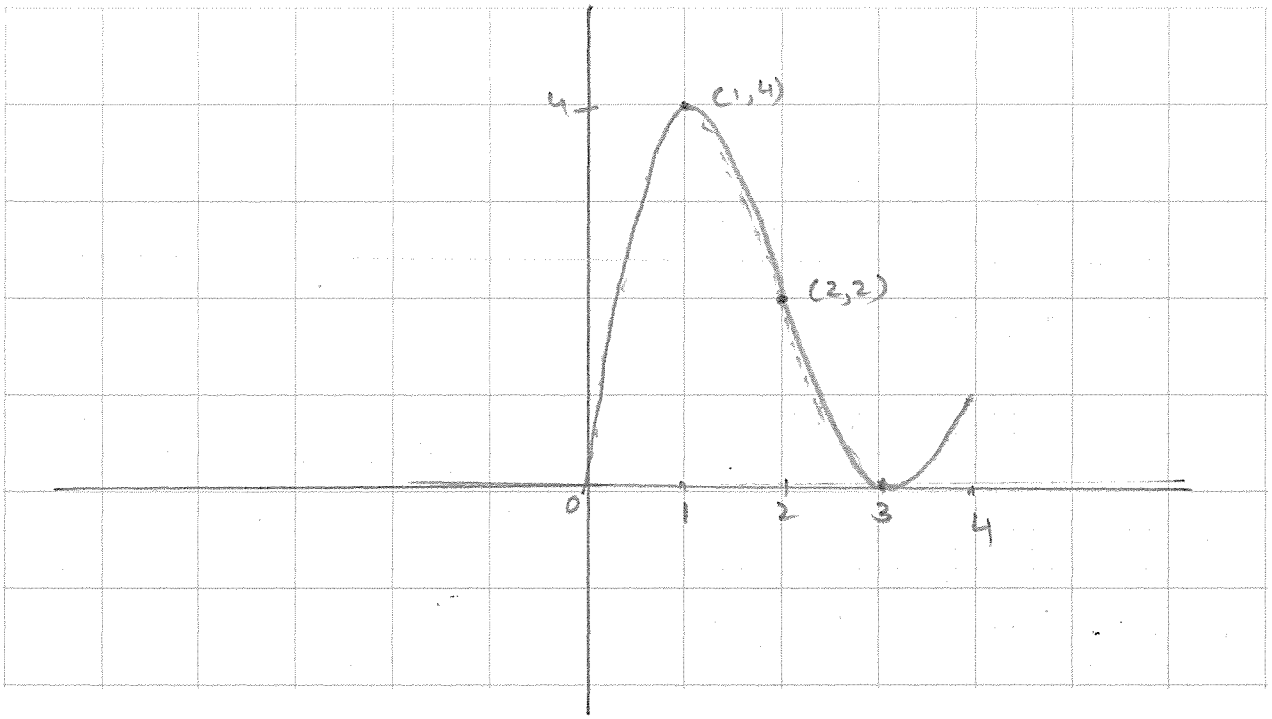
Test the nature

| $x$ | 1 | 2 | 3 |
|---|---|---|---|
| $y''$ | $-6$ | 0 | 6 |
| | \ | — | / |

at $x = 2$ change of concavity

$(2,2)$ is a point of inflexion.

(c) Sketch the curve in the domain $0 \leq x \leq 4$. **3**




(d) For what values of $x$ is the function decreasing? **1**

function is decreasing for $1 < x < 3$

**Question 13** (15 marks)

(a) Differentiate $f(x) = x^2 - 3x + 5$ using first principles. **3**

$f(x+h) = (x+h)^2 - 3(x+h) + 5$

$\frac{f(x+h) - f(x)}{x+h-x} = \frac{x^2+2hx+h^2-3x-3h+5-x^2-3x+5}{h}$

$\frac{dy}{dx}$ $f'(x) = \lim_{h\to 0} \frac{f(x+h)-f(x)}{h}$

$= \lim_{h\to 0} \frac{2hx+h^2-3h}{h}$

$= \lim_{h\to 0} 2x-3+h$

$f'(x) = 2x-3$

(b) Differentiate the following:

i. $x^2\sqrt{2x+1}$ **3**

$u = x^2$, $v = (2x+1)^{\frac{1}{2}}$

$u' = 2x$, $v' = \frac{1}{2}(2x+1)^{-\frac{1}{2}} \times 2 = \frac{1}{\sqrt{2x+1}}$

$y' = uv' + vu'$

$= \frac{x^2}{\sqrt{2x+1}} + 2x\sqrt{2x+1} = \frac{x^2+4x^2+2x}{\sqrt{2x+1}} = \frac{5x^2+2x}{\sqrt{2x+1}}$

ii. $\frac{e^{5x-x^3}}{1-x}$ **3**

$u = e^{5x-x^3}$, $v = 1-x$

$u' = (5-3x^2)e^{5x-x^3}$, $v' = -1$

$y = \frac{vu'-uv'}{v^2} = \frac{(5-3x^2)(1-x)e^{5x-x^3} + e^{5x-x^3}}{(1-x)^2}$

$= \frac{e^{5x-x^3}[(5-3x^2)(1-x)}{(1-x)^2}$

$= \frac{e^{5x-x^3}(5-3x^2)}{1-x}$

(c) Find the equation of the tangent to the curve $y = 3x^3 - 2x^2 + 1$ at $x = 1$. **3**

$y' = 9x^2 - 4x$

at $x=1$, $m_{tangent} = 9-4 = 5$

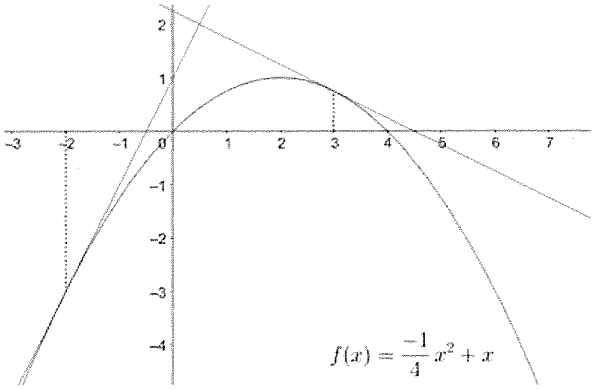
when $x=1$, $y = 3-2+1 = 2$ $(1,2)$

$\therefore$ eq. of tangent

$y-2 = 5(x-1)$

$y = 5x-3$

(d) The graph of $f(x) = -\frac{1}{4}x^2 + x$ is given below:




i. Find the expression for $f'(x)$. **1**

$f'(x) = -\frac{2x}{4} + 1 = -\frac{1}{2}x + 1$

ii. Hence, show that the illustrated tangents are perpendicular. **2**

$m_1 = f'(-2) = -\frac{1}{2} \times (-2) + 1 = 2$

$m_2 = f'(3) = -\frac{1}{2} \times 3 + 1$

$= -\frac{3}{2} + 1$

$= -\frac{1}{2}$

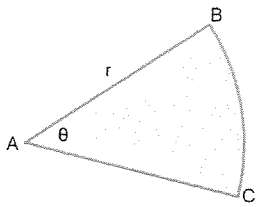
$f'(-2) \times f'(-3) = 2 \times -\frac{1}{2}$

$m_1 \times m_2 = -1$

$\therefore$ tangents at $x=-2$, and $x=3$ are perpendicular.

**Question 14** (10 marks)

(a) $ABC$ is a sector of a circle with radius $r$ as shown




It is given that the perimeter of the sector is equal in magnitude to the area of the sector.

i. Show that $\theta = \frac{4}{r-2}$ radians. **2**

Perimeter = area of sector

$2r + r\theta = \frac{1}{2}r^2\theta$

$2r\theta = \frac{1}{2}r^2\theta - 2\theta$

$4r = r^2\theta - 2\theta$

$\therefore r\theta(r-2) = 4r$

$\theta = \frac{4r}{r(r-2)} = \frac{4}{r-2}$

ii. Hence, show that the area of the sector ABC is equal to $\frac{2r^2}{r-2}$. **2**

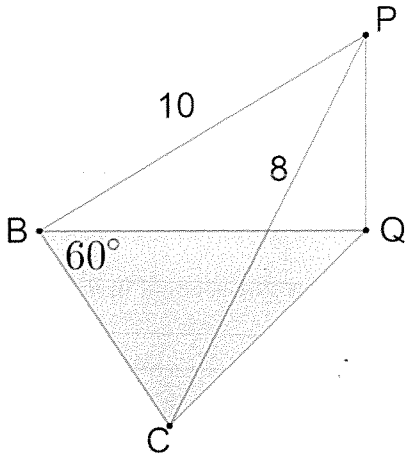
Area of the sector $= \frac{1}{2}r^2\theta$

$= \frac{1}{2}r^2 \cdot \frac{4}{r-2}$

$= \frac{2r^2}{r-2}$

(b) A vertical post $PQ$ with height $h$ metres is held by two ropes $PB$ due west and $PC$ due south of it.

It is given that $\angle QBC = 60°, PB = 10$ m, $PC = 8$ m *and* $\angle BCQ = 30°$.




i. Show that $\frac{CQ}{BQ} = \sqrt{3}$ **1**

$\frac{CQ}{BQ} = \tan 60°$ as $\angle BQC = 90°$

$\frac{CQ}{BQ} = \sqrt{3}$

ii. Hence, show that 3

$$\frac{64 - h^2}{100 - h^2} = 3$$

In $\triangle PCQ$, $8^2 - h^2 = CQ^2 = 64 - h^2$

In $\triangle PBQ$, $100 - h^2 = BQ^2$

$\therefore \frac{CQ^2}{BQ^2} = \left(\frac{CQ}{BQ}\right)^2 = (\sqrt{3})^2 = \frac{64-h^2}{100-h^2}$ [using Part (i)]

$\therefore \frac{64 - h^2}{100 - h^2} = 3$

iii. Find the value of $h$. **2**

$64 - h^2 = 300 - 3h^2$

$2h^2 = 300 - 64$

$h^2 = \frac{236}{2} = 118$

$= 10.86$ m

# Answer Sheet for Section I

Mark answers to Section I by fully blackening the correct circle

**NESA STUDENT #:** .....

1 – A (X) C D

2 – A B (X) D

3 – (X) B C D

4 – A (X) C D

5 – A B (X) D

# 2018 Mathematics Extension 1 HSC Course Assessment Task 1 Student Self Reflection

1. In hindsight, did I do the best I can? Why or why not?

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2. Which topics did I need more help with, and what parts specifically?

- Q1 - Locus

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- Q2 - Locus

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- Q3 – Series

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- Q4 – Euclidean Geometry

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- Q5 -

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3. What other parts from the feedback session can I take away to refine my solutions for future reference?

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