**Name:** **Register Number:** **Class:**

南僑中學

# NAN CHIAU HIGH SCHOOL

## PRELIMINARY EXAMINATION (2) 2018
## SECONDARY FOUR EXPRESS

**ADDITIONAL MATHEMATICS** **4047/01**
**Paper 1** **11 September 2018, Tuesday**

**Additional Materials : Writing Papers (7 sheets)** **2 hours**
**Graph Paper (1 sheet)**

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on the separate writing papers provided.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
If working is needed for any question it must be shown with the answer.
Omission of essential working will result in loss of marks.
Calculators should be used where appropriate.
If the degree of accuracy is not specified in the question, and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
For $\pi$, use either your calculator value or 3.142, unless the question requires the answer in terms of $\pi$.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total of the marks for this paper is 80.

Setter: Ms Renuka Ramakrishnan



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## *Mathematical Formulae*

### 1. ALGEBRA

*Quadratic Equation*

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

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

*Binomial expansion*

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

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

### 2. TRIGONOMETRY

*Identities*

$$\sin^2 A + \cos^2 A = 1$$
$$\sec^2 A = 1 + \tan^2 A$$
$$cosec^2 A = 1 + \cot^2 A$$

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

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

*Formulae for $\Delta ABC$*

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

$$a^2 = b^2 + c^2 - 2bc \cos A$$
$$\Delta = \frac{1}{2} bc \sin A$$



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**Answer ALL Questions**

**1** **(i)** On the same axes, sketch the curves $y = \frac{2}{x^2}$ and $y^2 = 128x$. [2]

**(ii)** Find the coordinates of the point of intersection of the two curves. [2]

**2** **(i)** Factorise completely the cubic polynomial $2x^3 - 11x^2 + 12x + 9$. [3]

**(ii)** Hence, express $\frac{6x^3-33x^2+35x+51}{2x^3-11x^2+12x+9}$ in partial fractions. [5]

**3** A quadratic curve passes through $(0, -1)$ and $(2, 7)$. The gradient of the curve at $x = -2$ is $-8$. Find the equation of the curve. [5]

**4** **(i)** Show that $\cos 3\theta - \cos\theta = -2 \sin 2\theta \sin\theta$. [3]

**(ii)** Hence find the values of $\theta$ between $0°$ and $360°$ for which $\cos 3\theta - \cos\theta = \sin 2\theta$. [3]

**5** The volume of a right square pyramid of length $(3 + \sqrt{2})$ cm is $\frac{1}{3}(29 - 2\sqrt{2})$ cm$^3$. Without using a calculator, find the height of the pyramid in the form $(a + b\sqrt{2})$ cm, where $a$ and $b$ are integers. [5]

**6** The roots of the quadratic equation $6x^2 - 5x + 2 = 0$ are $\frac{2}{\alpha}$ and $\frac{2}{\beta}$.

**(i)** Find the value of $\frac{\alpha}{\alpha+2} + \frac{\beta}{\beta+2}$. [5]

**(ii)** Find a quadratic equation whose roots are $\frac{\alpha}{\alpha+2}$ and $\frac{\beta}{\beta+2}$. [2]



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**7** A particle moves in a straight line such that, $t$ seconds after leaving a fixed point $O$, its velocity, $v$ ms$^{-1}$, is given by $v = t^2 - 5t + 4$.

**(i)** Find the acceleration of the particle when it first comes to an instantaneous rest. [3]

**(ii)** Find the average speed of the particle for the first 5 seconds. [4]

**8** The following table shows the experimental values of two variables, *x* and *y*, which are related by the equation $y = ab^{x+1}$, where *a* and *b* are constants.

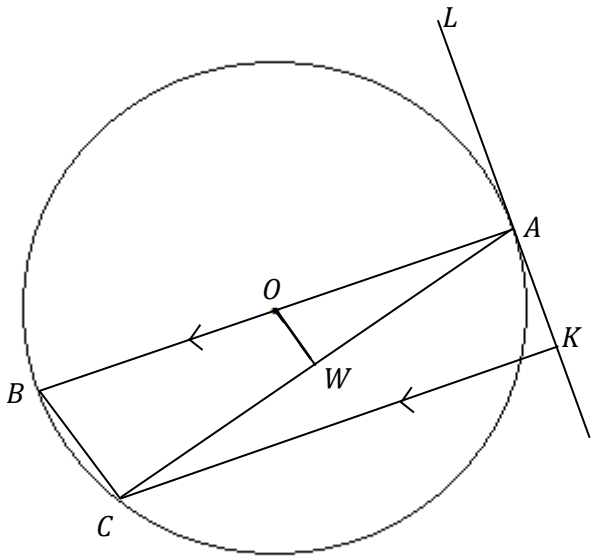
| $x$ | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| $y$ | 10.12 | 10.23 | 10.35 | 10.47 |

**(i)** On graph paper, plot $\lg y$ against $x$ and draw a straight line graph. The vertical $\lg y$ – axis should start from 0.995 and have a scale of 4 cm to 0.005. [3]

**(ii)** Use your graph to estimate the value of *a* and of *b*. [4]

**(iii)** Explain how the value of $a$ and of $b$ will change if a graph of $\ln y$ against $x$ was plotted instead. [1]

**9**




In the diagram, *A*, *B* and *C* are three points on the circle such that *AB* is the diameter of the circle and *W* is the midpoint of *AC*. *AB* and *CK* are parallel to each other and *KL* is a tangent to the circle at *A*.

**(i)** Prove that *OW* is parallel to *BC*. [2]

**(ii)** Prove that Angle $AWO =$ Angle $AKC$. [3]



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**10** Diagram I shows a right angled $\Delta ABC$, with hypotenuse $AB$ of length 4 m. This triangle is revolved around $BC$ to generate a right circular cone as shown in Diagram II.

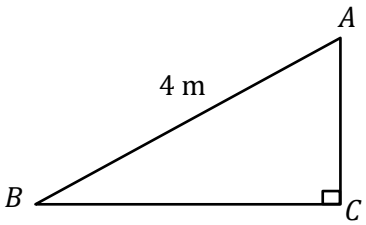



Diagram I

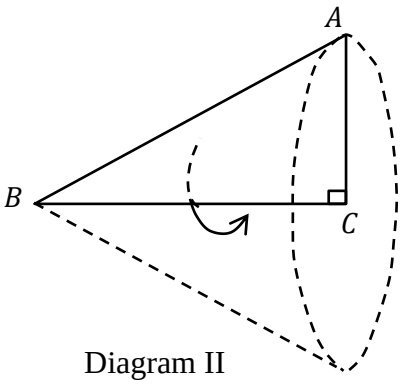



Diagram II

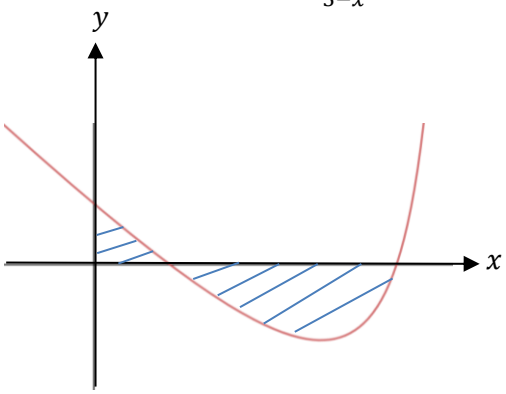
**(i)** Find the **exact** height that gives the maximum volume of the cone. [6]

**(ii)** Show that this maximum volume is obtained when $BC : CA = 1 : \sqrt{2}$. [2]

**11** The equation of a curve is $y = \frac{4-5x+x^2}{5-x}$, $x \neq 5$.

**(i)** Find the set of values of $x$ for which $y$ is an increasing function of $x$. [3]

**(ii)** The diagram below shows part of the curve $y = \frac{4-5x+x^2}{5-x}$, $x \neq 5$.




By expressing $\frac{4-5x+x^2}{5-x}$ in the form $ax + \frac{b}{5-x}$, where $a$ and $b$ are constants, find the total area of the shaded regions. [5]



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**12** A circle $C_1$, with centre $C$, passes through four points $A, B, F$ and $G$. The coordinates of $A$ and $B$ are (0, 4) and (8, 0) respectively. The equation of the normal to the circle at $F$ is $y = -\frac{4}{3}x + 4$.

**(i)** Show that the coordinates of $C$ is (3, 0). [5]

**(ii)** Hence find the equation of the circle. [2]

Another circle $C_2$ passes through the points $C, F$ and $G$.

**(iii)** Given that $GF$ is the diameter of the circle, calculate the radius of $C_2$. [2]

**- End of Paper -**

**Answer Key**

1ii) $\left(\frac{1}{2}, 8\right)$

2i) $(x-3)^2(2x+1)$

2ii) $3 + \frac{2}{2x+1} - \frac{1}{x-3} + \frac{3}{(x-3)^2}$

3) $y = 2x^2 - 1$

4ii) $\theta = 90°, 180°, 210°, 270°, 330°$

5) $(7 - 4\sqrt{2})cm$

6i) $\frac{17}{13}$

6ii) $x^2 - \frac{17}{13}x + \frac{6}{13} = 0$

7i) $-\frac{3m}{s^2}$

7ii) 1.63 $m/s$

8ii) $b = 1.01, a = 9.89$

8iii) remain unchanged

10i) $\frac{4\sqrt{3}}{3}\ cm$

11i) $3 < x < 7, x \neq 5$

11ii) 2.35 $units^2$

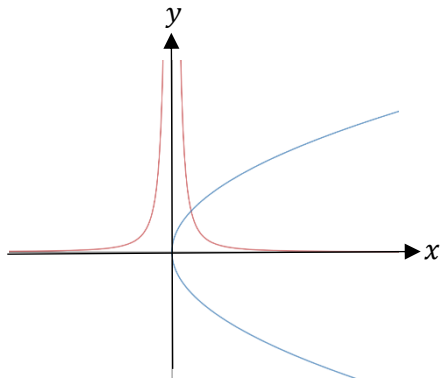
12ii) $(x-3)^2 + y^2 = 25$

12iii) 3.54 $units$



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# NCHS 2018 Prelim 2 AM Paper 1 Solutions

| | | |
|---|---|---|
| **1i** |  | G1: graph of $y = \frac{2}{x^2}$<br>G1: graph of $y^2 = 128x$ |
| **1ii** | $\left(\frac{2}{x^2}\right)^2 = 128x$<br>$x^5 = \frac{4}{128}$<br>$x = \frac{1}{2}$<br>$\rightarrow y = 8$<br>$\left(\frac{1}{2}, 8\right)$ | M1: Equating both functions<br><br>A1: award only if written as coordinates |
| **2i** | Let $f(x) = 2x^3 - 11x^2 + 12x + 9$<br>$f(3) = 0$<br>$\therefore (x-3)$ is a factor of $f(x)$.<br><br>$f(x) = (x-3)(2x^2 - 5x - 3)$<br>$= (x-3)^2(2x+1)$ | M1: show 1st factor using factor theorem<br><br>M1: Find quadratic factor (by long division/synthetic method)<br>A1 |
| **2ii** | $\frac{6x^3 - 33x^2 + 35x + 51}{2x^3 - 11x^2 + 12x + 9} = 3 + \frac{-x + 24}{(x-3)^2(2x+1)}$<br><br>$\frac{-x+24}{(x-3)^2(2x+1)} = \frac{A}{2x+1} + \frac{B}{x-3} + \frac{C}{(x-3)^2}$<br><br>$-x + 24 = A(x-3)^2 + B(x-3)(2x+1) + C(2x+1)$<br><br>➔ Using substitution/comparing coefficient<br>$A = 2, B = -1, C = 3$<br><br>$\therefore \frac{6x^3 - 33x^2 + 35x + 51}{2x^3 - 11x^2 + 12x + 9}$<br>$= 3 + \frac{2}{2x+1} - \frac{1}{x-3} + \frac{3}{(x-3)^2}$ | M1: Change to proper fraction<br><br>M1: Split correctly to respective partial fractions<br><br>M2: Using substitution/comparing coefficient to find A, B and C<br><br>A1 |

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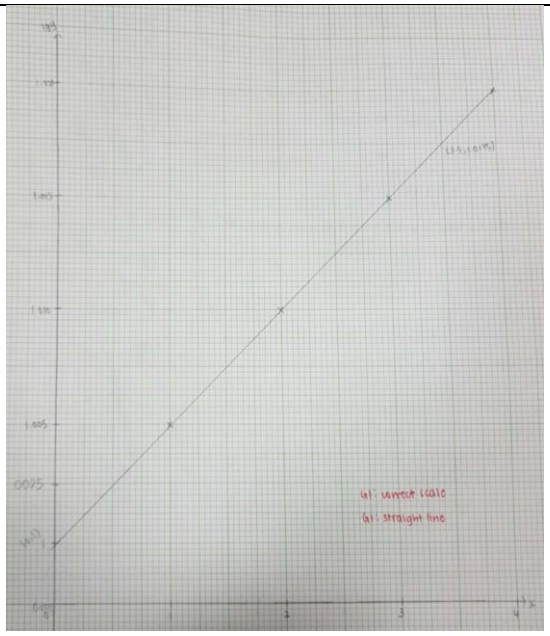
| | | |
|---|---|---|
| **3** | $y = ax^2 + bx + c$<br>When $x = 0, y = -1 \rightarrow c = -1$<br><br>$\frac{dy}{dx} = 2ax + b$<br>$When\ x = -2, \quad \frac{dy}{dx} = -8$<br>$-4a + b = -8$<br>$b = 4a - b$ --- (1)<br><br>Sub $y = 7$ and $x = 2$ into $y = ax^2 + bx - 1$<br>$7 = 4a + 2b - 1$<br>$b = 4 - 2a$ --- (2)<br><br>From (1) and (2),<br>$4a - 8 = 4 - 2a$<br>$a = 2$<br>$\rightarrow b = 0$<br><br>$\therefore$ equation of curve:$y = 2x^2 - 1$ | B1: writing quad eqn in a general form<br>A1: Solving for c<br><br>M1: differentiate quad function<br><br>M1: forming 2 simultaneous equations and solving it<br><br>A1 |
| **4i** | $\cos 3\theta - \cos\theta$<br>$= \cos(2\theta + \theta) - \cos\theta$<br>$= \cos 2\theta \cos\theta - \sin 2\theta \sin\theta - \cos\theta$<br>$= \cos\theta\,(\cos 2\theta - 1) - \sin 2\theta \sin\theta$<br>$= \cos 2\theta\,(-2\sin^2\theta) - \sin 2\theta \sin\theta$<br>$= -2\sin^2\theta \cos 2\theta - \sin 2\theta \sin\theta$<br>$= (-2\sin\theta\cos\theta)\sin\theta - \sin 2\theta \sin\theta$<br>$= -\sin 2\theta \sin\theta - \sin 2\theta \sin\theta$<br>$= -2\sin 2\theta \sin\theta$ | M1: applying addition formula to $\cos(2\theta + \theta)$<br>M1: changing $\cos 2\theta - 1 = -2\sin^2\theta$<br><br>A1: changing $-2\sin^2\theta \cos 2\theta = -\sin 2\theta \sin\theta$ |
| **4ii** | $\cos 3\theta - \cos\theta = \sin 2\theta$<br>$\sin 2\theta + 2\sin 2\theta \sin\theta = 0$<br>$\sin 2\theta(1 + 2\sin\theta) = 0$<br>$\sin 2\theta = 0 \quad or \quad \sin\theta = -0.5$<br>$2\theta = 180, 360, 540 \quad or \quad \theta = 210, 330$<br>$\theta = 90, 180, 270$<br>$\therefore \theta = 90°, 180°, 210°, 270°, 330°$ | M1 apply hence + factorization<br><br>A1 solve $\sin 2\theta = 0$ correctly<br>A1 solve $\sin\theta = -0.5$ correctly |
| **5** | $\frac{1}{3}\left(3 + \sqrt{2}\right)^2 h = \frac{1}{3}\left(29 - 2\sqrt{2}\right)$<br>$h = \frac{29 - 2\sqrt{2}}{11 + 6\sqrt{2}}$<br>$= \frac{\left(29 - 2\sqrt{2}\right)\left(11 - 6\sqrt{2}\right)}{49}$<br>$= \frac{319 - 174\sqrt{2} - 22\sqrt{2} + 24}{49}$<br>$= \frac{343 - 196\sqrt{2}}{49}$<br>$= \left(7 - 4\sqrt{2}\right)cm$ | M1: forming an equation<br>M1: Calculating $\left(3 + \sqrt{2}\right)^2$<br><br>M1: Rationalising denominator<br><br>M1: Simplifying after expansion<br>A1 |

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| | | |
|---|---|---|
| **6i** | $\frac{2}{\alpha}+\frac{2}{\beta}=\frac{5}{6}$<br>$\frac{2(\alpha+\beta)}{\alpha\beta}=\frac{5}{6}$ --- (1)<br><br>$\left(\frac{2}{\alpha}\right)\left(\frac{2}{\beta}\right)=\frac{1}{3}$<br>$\alpha\beta=12$ --- (2)<br><br>Sub (2) into (1)<br>$\alpha+\beta=5$<br><br>$\frac{\alpha}{\alpha+2}+\frac{\beta}{\beta+2}=\frac{\alpha(\beta+2)+\beta(\alpha+2)}{(\alpha+2)(\beta+2)}$<br>$=\frac{2\alpha\beta+2(\alpha+\beta)}{\alpha\beta+2(\alpha+\beta)+4}$<br>$=\frac{17}{13}$ | M1: applying concept of sum and product of roots<br>A1: $\alpha\beta$<br><br>A1: $\alpha+\beta$<br><br>M1<br><br>A1 |
| **6ii** | $\left(\frac{\alpha}{\alpha+2}\right)\left(\frac{\beta}{\beta+2}\right)=\frac{\alpha\beta}{(\alpha+2)(\beta+2)}$<br>$=\frac{6}{13}$<br><br>$\therefore$ Equation : $x^2-\frac{17}{13}x+\frac{6}{13}=0$<br>$or\ 13x^2-17x+6=0$ | M1<br><br>A1 |
| **7i** | When v = 0,<br>$t^2-5t+4=0$<br>$(t-4)(t-1)=0$<br>$t=1\ \ or\ \ t=4$<br><br>$a=\frac{dv}{dt}$<br>$=2t-5$<br>When $t=1, a=-3m/s^2$ | M1<br><br>A1: Differentiate correctly<br><br>A1 |
| **7ii** | $s=\int t^2-5t+4\,dt$<br>$=\frac{1}{3}t^3-\frac{5}{2}t^2+4t+c$<br>When $t=0, s=0\rightarrow c=0$<br>$\therefore s=\frac{1}{3}t^3-\frac{5}{2}t^2+4t$<br><br>When $t=1, s=\frac{11}{6}m$<br>$t=4, s=-\frac{8}{3}m$<br>$t=5, s=-\frac{5}{6}m$ | A1: integrate correctly<br>(look out for +c, unless definite integral) |

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<table>
<tr><td></td><td>$\therefore Average\ Speed = \dfrac{\frac{11}{6} + \left(\frac{11}{6} + \frac{8}{3}\right) + \left(\frac{8}{3} - \frac{5}{6}\right)}{5}$<br>$= 1\frac{19}{30} m/s$ or 1.63 $m/s$</td><td>M1: Calculating distance in 5th sec<br>M1: formula for average speed<br>A1</td></tr>
<tr><td>8</td><td><br>$y = ab^{x+1}$<br>$lgy = (x+1)lgb + lga$<br>$lgy = xlgb + (lgb + lga)$<br><table><tr><td>x</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>lg y</td><td>1.005</td><td>1.010</td><td>1.015</td><td>1.020</td></tr></table></td><td>G1: correct scale<br>G1: straight line<br><br>M1: table of values</td></tr>
<tr><td>8ii</td><td>$\lg b = \dfrac{1.0175 - 1}{3.5}$<br>$= 0.005$<br>$b = 1.01\ (3sf)$<br><br>$\lg b + \lg a = 1$<br>$\lg a = 1 - 0.005$<br>$a = 9.89\ (3sf)$</td><td>M1<br><br>A1<br><br>M1<br><br>A1</td></tr>
<tr><td>8iii</td><td>The values of $a$ and $b$ will remain unchanged.</td><td>B1</td></tr>
<tr><td>9i</td><td>O is the midpoint of AB and W is the midpoint of AC,<br>By Midpoint Theorem, BC parallel to OW.</td><td>M1<br>A1</td></tr>
<tr><td>9ii</td><td>$Angle\ AOW = Angle\ ABC\ (corr\ angles, OW//BC)$<br>$Angle\ ABC = Angle\ CAK (alt\ segment\ theorem)$<br>$\rightarrow Angle\ AOW = Angle\ CAK$<br>$Angle\ BAC = Angle\ ACK\ (alt\ angles, AB//CK)$<br>$\therefore Angle\ AWO$<br>$= 180° - Angle\ BAC - Angle\ AOW\ (Angle\ sum\ of\ \Delta)$<br>$= 180° - Angle\ ACK - Angle\ CAK$<br>$= Angle\ AKC$ (shown)</td><td>M1<br>M1<br><br>A1</td></tr>
</table>

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| | | |
|---|---|---|
| **10i** | Let $AC = r$ and $BC = h$<br>$r^2 = 16 - h^2$<br><br>$V = \frac{1}{3}\pi r^2 h$<br>$= \frac{1}{3}\pi(16 - h^2)h$<br>$= \frac{16}{3}\pi h - \frac{1}{3}\pi h^3$<br><br>$\frac{dV}{dh} = \frac{16}{3}\pi - \pi h^2$<br>$When \frac{dV}{dh} = 0,$<br>$\frac{16}{3}\pi = \pi h^2$<br>$h = \frac{4}{\sqrt{3}}\left(rej\ h = -\frac{4}{\sqrt{3}}\ since\ h > 0\right)$<br><br>$\frac{d^2V}{dh^2} = -2\pi h$<br>$= -\frac{8}{\sqrt{3}}\pi\ (< 0)$<br>$\therefore h = \frac{4}{\sqrt{3}} = \frac{4\sqrt{3}}{3}\ cm$ | M1: Finding r/s between h and r<br><br>M1: finding V in terms of one variable<br><br>M1: differentiation<br><br>M1: Stationary point<br><br>M1: Prove Max<br><br>A1 |
| **10ii** | $r^2 = 16 - \left(\frac{4}{\sqrt{3}}\right)^2$<br>$r = \frac{4\sqrt{2}}{\sqrt{3}}$<br>$\frac{h}{r} = \frac{\frac{4}{\sqrt{3}}}{\frac{4\sqrt{2}}{\sqrt{3}}}$<br>$\frac{h}{r} = \frac{1}{\sqrt{2}}$<br>$\therefore BC : CA = 1 : \sqrt{2}$ | M1<br><br>A1 |
| **11i** | $\frac{dy}{dx} = \frac{(2x-5)(5-x) - (4-5x+x^2)(-1)}{(5-x)^2}$<br>$= \frac{10x - 2x^2 + 5x - 25 + 4 - 5x + x^2}{(5-x)^2}$<br>$= \frac{-x^2 + 10x - 21}{(5-x)^2}$<br>Since $(5-x)^2 > 0$, for y to be an increasing function,<br>$-x^2 + 10x - 21 > 0$<br>$x^2 - 10x + 21 < 0$<br>$(x-3)(x-7) < 0$<br>$3 < x < 7, x \neq 5$ | M1: Applying quotient rule<br><br>M1<br><br>A1 |

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| | | |
|---|---|---|
| **11ii** | When $y = 0$<br>$4 - 5x + x^2 = 0$<br>$(x-4)(x-1) = 0$<br>$x = 4\ or\ x = 1$<br><br>$\frac{x^2 - 5x + 4}{5 - x} = \frac{-x(5-x)+4}{(5-x)}$<br>$= -x + \frac{4}{5-x}$<br><br>Area of shaded region<br>$= \int_0^1 -x + \frac{4}{5-x}\ dx + \left\lvert \int_1^4 -x + \frac{4}{5-x}\ dx \right\rvert$<br>$= [-0.5x^2 - 4\ln(5-x)]_0^1 + \lvert[-0.5x^2 - 4\ln(5-x)]_1^4\rvert$<br>$= 0.39257 + \lvert -1.95482 \rvert$<br>$= 2.35\ units^2\ (3sf)$ | M1<br><br>M1, M1<br><br>M1: correct integration<br><br>A1 |
| **12i** | Gradient of AB $= -\frac{1}{2}$<br>Midpoint of AB = (4,2)<br><br>Eqn of perpendicular bisector of AB:<br>$y - 2 = 2(x-4)$<br>$y = 2x - 6$<br>Sub $y = 2x - 6$ into $y = -\frac{4}{3} + 4$,<br>$2x - 6 = -\frac{4}{3} + 4$<br>$x = 3$<br>$\rightarrow y = 0$<br>$C\ (3, 0)$ | M1: Midpoint<br><br>M1: gradient =2<br>M1: forming equation<br><br>M1: Solving simultaneous<br><br>A1 |
| **12ii** | Radius $= \sqrt{(3-0)^2 + (0-4)^2}$<br>$= 5\ units$<br>Equation of circle: $(x-3)^2 + y^2 = 25$<br>Or $x^2 + y^2 - 6x - 16 = 0$ | M1: Finding radius<br><br>A1 |
| **12iii** | $Angle\ GCF = 90°\ (Angle\ in\ Semicircle)$<br>$GF^2 = 5^2 + 5^2$<br>$GF = \sqrt{50}$<br>$Radius\ of\ C_2 = \frac{1}{2}\sqrt{50}$<br>$= \frac{5}{2}\sqrt{2}\ units$<br>$or \quad = 3.54\ units\ (3sf)$ | M1<br><br>A1 |

**END ☺**

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# NAN CHIAU HIGH SCHOOL

## PRELIMINARY EXAMINATION (2) 2018
## SECONDARY FOUR EXPRESS

**ADDITIONAL MATHEMATICS** **4047/02**
**Paper 2** **12 September 2018, Wednesday**

**Additional Materials : Writing Paper (8 sheets)** **2 hours 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number on all the work you hand in.
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Answer **all** questions.
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Calculators should be used where appropriate.
If the degree of accuracy is not specified in the question, and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
For $\pi$, use either your calculator value or 3.142, unless the question requires the answer in terms of $\pi$.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total of the marks for this paper is 100.

Setter: Mdm Chua Seow Ling



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## *Mathematical Formulae*

### 1. ALGEBRA

*Quadratic Equation*

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

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

*Binomial expansion*

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

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

### 2. TRIGONOMETRY

*Identities*

$$\sin^2 A + \cos^2 A = 1$$
$$\sec^2 A = 1 + \tan^2 A$$
$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

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

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

*Formulae for $\Delta ABC$*

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

$$a^2 = b^2 + c^2 - 2bc \cos A$$
$$\Delta = \frac{1}{2} bc \sin A$$



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**Answer ALL Questions.**

**1.** **(i)** Given $\frac{3\lg 3x-2\lg x}{4} = \lg 3$, find the value of $x$. [3]

**(ii)** Given $\log_{(x-2)} y = 2$ and $log_y(x+k) = \frac{1}{2}$, find the value of $k$ if $k$ is an integer. [3]

**2.** **(i)** Show that $\frac{\mathrm{d}}{\mathrm{d}x}\left[ln\left(\frac{\sin x}{1-\cos x}\right)\right] = -\frac{1}{\sin x}$. [4]

**(ii)** Hence evaluate $\int \sin^2 x + \frac{2}{\sin x}\mathrm{d}x$. [4]

**3.** It is given that $y_1 = -2\cos x + 1$ and $y_2 = \sin\frac{1}{2}x$.
For the interval $0 < x < 2\pi$,

**(i)** state the amplitude and period of $y_1$ and of $y_2$, [2]

**(ii)** sketch, on the same diagram, the graphs of of $y_1$ and $y_2$, [4]

**(iii)** find the $x$-coordinate of the points of intersection of the two graphs drawn in **(ii)**, [3]

**(iv)** hence, find the range of values of $x$ for which $y_1 \leq y_2$. [2]

**4.** Some liquid is poured onto a flat surface and formed a circular patch. This circular patch is left to dry and its surface area decreases at a constant rate of 4 $cm^2/s$. The patch remains circular during the drying process. Find the rate of change of the circumference of the circular patch at the instant when the area of the patch is 400 $cm^2$. [4]

**5.** **(i)** In the expansion of $\left(2+\frac{4}{x^4}\right)\left(kx^3-\frac{2}{x}\right)^{13}$ where $k$ is a constant and $k \neq 0$, find the value of $k$ if there is no coefficient of $\frac{1}{x}$. [5]

**(ii)** Given the coefficients of $\frac{1}{x}$ and $\frac{1}{x^2}$ in the expansion of $\left(1-\frac{c}{x}\right)^n$ are $-80$ and 3000 respectively. Find the value of $c$ and of $n$ where $n$ is a positive integer greater than 2 and $c$ is a constant. [5]



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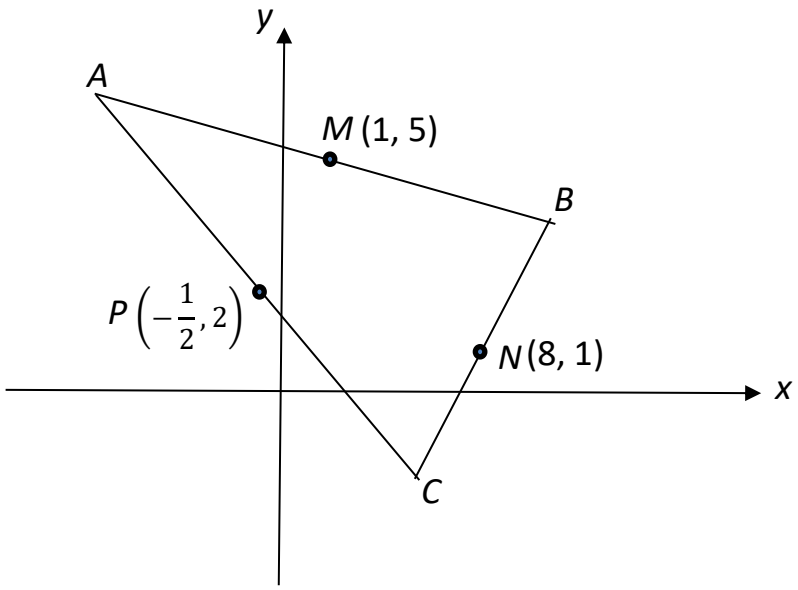
**6.** Curve $A$ is such that $\frac{dy}{dx} = 27(2x-1)^2$ and curve $B$ is such that $\frac{dy}{dx} = -27(2x-1)^3$, and the $y$-coordinates of the stationary points for both curves are $-4$.

**(i)** Find the coordinates of the stationary points for curve $A$ and $B$. [2]

**(ii)** Determine the nature of the stationary points for curve $A$ and $B$. [4]

**(iii)** Find the equations of curve $A$ and $B$. [4]

**7.** The diagram shows a triangle $ABC$. The mid-points of the sides of the triangle are $M(1,5)$, $N(8,1)$ and $P\left(-\frac{1}{2},2\right)$.




**(i)** State and explain which line is parallel to $AB$. [1]

**(ii)** Find the equation of the line $AB$. [3]

**(iii)** Find the equation of the line $AC$. [3]

**(iv)** Show the coordinates of $A$ is $\left(-7\frac{1}{2},6\right)$. [3]

**(v)** Find the area of the quadrilateral $AMNP$. [2]



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**8.** Diagram I and II show two types of isosceles triangular cards, $\Delta OAB$ with $\angle AOB = \theta$, $OA = OB = 3$ cm and $\Delta OMN$ with $OM = ON = 2$ cm. These two types of cards are connected as shown in diagram III where $\angle AON = 120^{\circ}$.

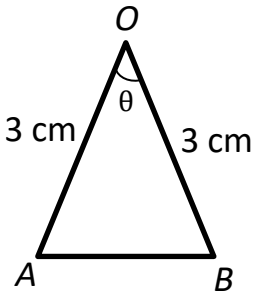



Diagram I

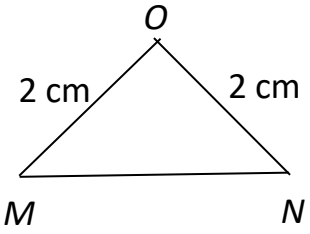



Diagram II

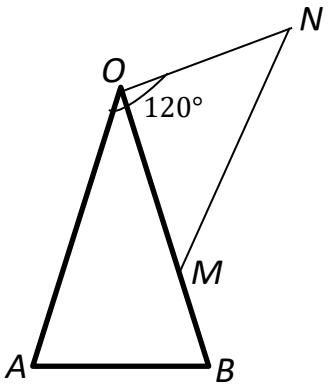



Diagram III

Three sets of cards from diagram III are connected as shown in diagram IV.

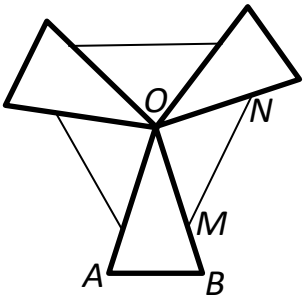



Diagram IV

**(i)** Show that the area of all the connected cards in diagram IV, $A$ cm$^2$ is given by $A = \frac{33}{2} \sin\theta + 3\sqrt{3}\cos\theta$. [3]

**(ii)** Express $A$ in the form $A = R\cos(\theta - \alpha)$, where $R > 0$ and $0° < \alpha < 90^{\circ}$. [3]

**(iii)** Find the value of $\theta$ for which $A = 15$, where $0° < \theta < 90^{\circ}$. [3]

**(iv)** Find the maximum value of $A$ and the corresponding value of $\theta$. [2]



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**9.** In an experiment to study the growth of a certain type of bacteria, the bacteria are injected into a mouse and the mouse's blood samples are collected at various time interval for testing. The blood test result shows that the population, *P*, of the bacteria is related to the time, *t* hours, after the injection, by the equation $P = 550 + 200e^{kt}$ , where *k* is a constant. It takes **one day** for the population of bacteria to double.

**(i)** Find the population of the bacteria at the start of the experiment. [1]

**(ii)** Find the value of *k*. [2]

**(iii)** Find the percentage increase of the population of the bacteria when $t = 30$. [4]

**(iv)** The line $P = mt + c$ is a tangent to the curve $P = 550 + 200e^{kt}$ at the point where $t = 30$. Find the constant value of *m* and of *c*. [3]

**(v)** At $t = 50$, an antibiotics dosage is injected into the same mouse to stop the growth of bacteria. The dosage is able to kill the bacteria at a constant rate of 25 bacteria per hour. How much time needed for the dosage fully take its effectiveness? Hence sketch the graph of *P* against *t* for the whole experiment. [4]

**10.** A curve has the equation of $y = p(x-2)^2 - (x-3)(x+2)$ where *p* is a constant and $p \neq 1$.

**(i)** Find the range of values of *p* for which curve has a minimum point. [2]

Given that the curve touches the *x*-axis at point *A*.

**(ii)** Show that $p = \frac{25}{16}$. [3]

**(iii)** Find the coordinates of point *A*. [4]

**(iv)** Given that the line $y = mx + 2$ intersects the curve $y = p(x-2)^2 - (x-3)(x+2)$ at two distinct points where one of the points is at point *A*. Another line of the equation $y = mx + c$, is a tangent to the same curve at point *B*. Find the value of *c* where *m* and *c* are constants. [5]

End of Paper



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Answers

1$i$) $x = 3$,

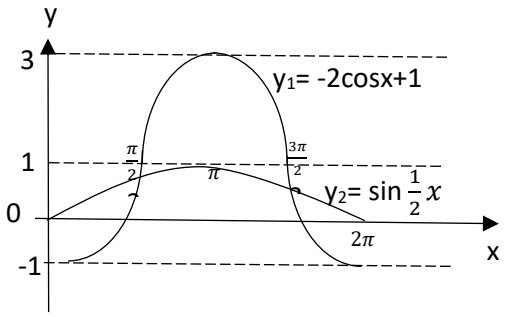
1$ii$) $k = -2$

2ii) $\frac{1}{2}x - \frac{1}{4}sin2x - 2ln\left(\frac{sinx}{1-cosx}\right) + c$

3ii)

Amplitude of $y_1$ = 2, Period of $y_1$ = $2\pi$

Amplitude of $y_2$ = 1, Period of $y_2$ = $4\pi$




3iii) x = 1.39, 4.89

3iv) $0 < x \leq 1.39$ Or $4.89 \leq x < 2\pi$

4) - k = $\frac{2}{5}$

5i) k = $\frac{2}{5}$

5ii) c = 5, n = 16

6i) $\left(\frac{1}{2}, -4\right)$

6ii) $\left(\frac{1}{2}, -4\right)$ $is\ point\ of\ inflexion - Curve\ A$, $\left(\frac{1}{2}, -4\right)$ $is\ a$ max $stationary\ poin\,t - curve\ B$

6iii) $y_A = \frac{9}{2}(2x-1)^3 - 4$, $y_B = -\frac{27}{8}(2x-1)^4 - 4$

7i) Line PN is parallel to AB (Mid-Point Theorem)

7ii) $y = -\frac{2}{17}x + 5\frac{2}{17}$

7iii) $y = -\frac{4}{7}x + \frac{12}{7}$

7v) A = 27

8ii) $A = \frac{3\sqrt{133}}{2}\cos(\theta - 72.5°)$ $= 17.3\cos(\theta - 72.5°)$

8iii) $42.6°$

8iv) Max A = $\frac{3\sqrt{133}}{2}$ =17.3, $\theta = 72.5°$

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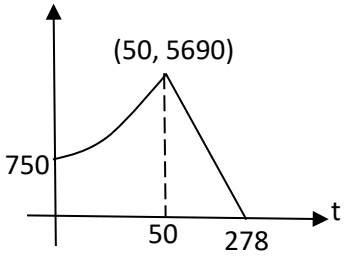
9i)750

9ii) k = $\frac{1}{24}\ln\frac{19}{4}$ = 0.0649

9iii) 160 %

9iv) m =91.1, c = -779

9v)




10i) p >1

10iii) $A\left(\frac{14}{3}, 0\right)$

10iv) c = $\frac{94}{49}$



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## 2018 NCHS A-Math Prelim 2/ Paper 2 solution

**(1i)**

$$\frac{3\lg 3x - 2\lg x}{4} = \lg 3$$

3lg 3x -2lg x = 4lg3

$$\lg(3x)^3 - lgx^2 = lg3^4$$

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

$$27x = 81$$

x = 3

**(1ii)**

$$\log_{(x-2)} y = 2$$

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

$$y^{\frac{1}{2}} = x - 2$$

$$log_y(x+k) = \frac{1}{2}$$

$$x + k = y^{\frac{1}{2}}$$

x+ k = x-2

k = -2

$$\frac{1}{log_{(x-2)} y} = \frac{1}{2}$$

$$\log_y(x-2) = \frac{1}{2}$$

$$log_y(x+k) = \frac{1}{2}$$

k = -2

**(2i)**

$$\left[ln\left(\frac{\sin x}{1-\cos x}\right)\right]$$

$$= lnsinx - ln(1-cosx)$$

$$\frac{\mathrm{d}}{\mathrm{d}x}\left[ln\left(\frac{\sin x}{1-\cos x}\right)\right] =$$

$$\frac{\mathrm{d}}{\mathrm{d}x}[lnsinx - ln(1-cosx)]$$

$$= \frac{cosx}{sinx} - \frac{-(-sinx)}{1-cosx}$$

$$= \frac{cosx}{sinx} - \frac{sinx}{1-cosx}$$

$$= \frac{cosx(1-cosx) - sin^2x}{sinx(1-cosx)}$$

$$= \frac{cosx - cos^2x - sin^2x}{sinx(1-cosx)}$$

$$= \frac{cosx - 1}{sinx(1-cosx)}$$

$$= -\frac{1}{\sin x}$$ (shown)

**(2ii)**

$$\int \sin^2 x + \frac{2}{\sin x}\,dx$$

$$= \int \frac{1-cos2x}{2} + \frac{2}{sinx}\,dx$$

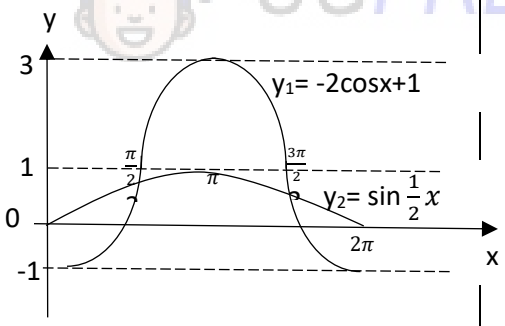
$$= \frac{1}{2}x - \frac{1}{4}sin2x - 2ln\left(\frac{sinx}{1-cosx}\right) + c$$

**(3i)**

Amplitude of $y_1$ = 2, Period of $y_1 = 2\pi$

Amplitude of $y_2$ = 1, Period of $y_2 = 4\pi$

**(3ii)**




**(3iii)**

$$-2\cos x + 1 = \sin\frac{1}{2}x$$

$$-2\left(1 - 2sin^2\frac{x}{2}\right) + 1 = sin\frac{1}{2}x$$

$$4sin^2\frac{x}{2} - sin\frac{1}{2}x - 1 = 0$$

$$sin\frac{1}{2}x = 0.6403882$$

$$\alpha = 0.69500$$

$$\frac{1}{2}x = 0.69500, \qquad \pi - 0.69500$$

= 0.695 or 2.4466

x = 1.39, 4.89

**(3iv)**

$0 < x \leq 1.39$ Or $4.89 \leq x < 2\pi$

**(4)**

$$A = \pi r^2$$

$$\frac{dA}{dr} = 2\pi r$$

$$C = 2\pi r$$

$$\frac{dC}{dr} = 2\pi$$

$$\pi r^2 = 400$$

$$r = \frac{20}{\sqrt{\pi}}$$

$$\frac{dA}{dr} \text{ x } \frac{dr}{dt} = \frac{dA}{dt}$$

$$2\pi r \text{ x } \frac{dr}{dt} = -4$$

**(4)**

$$\frac{dr}{dt} = \frac{-4}{2\pi r}$$

$$\frac{dC}{dt} = \frac{dC}{dr} \text{ x } \frac{dr}{dt}$$

$$\frac{dC}{dt} = 2\pi \text{ x } \frac{-4}{2\pi r}$$

$$= \frac{-4}{r}$$

$$= \frac{-4}{\left(\frac{20}{\sqrt{\pi}}\right)}$$

$$= -\frac{\sqrt{\pi}}{5}$$ cm/s

= - 0.354 cm/s

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| | | | |
|---|---|---|---|
| (5i) | $\left(2+\frac{4}{x^4}\right)\left(kx^3-\frac{2}{x}\right)^{13}$<br>$=\left(2+\frac{4}{x^4}\right)\left(\frac{1}{x}, \quad x^3\right)$<br>$\left(kx^3-\frac{2}{x}\right)^{13}=\binom{13}{r}(kx^3)^{13-r}\left(-\frac{2}{x}\right)^r+\cdots$<br>$=\binom{13}{9}(kx^3)^4\left(-\frac{2}{x}\right)^9+\binom{13}{10}(kx^3)^3\left(-\frac{2}{x}\right)^{10}+\cdots$<br>$=715k^4x^{12}\left(-\frac{512}{x^9}\right)+286k^3x^9\left(\frac{1024}{x^{10}}\right)+\cdots$<br>$=-366080k^4x^3+\frac{292864}{x}k^3+\cdots$<br>$=\left(2+\frac{4}{x^4}\right)(-366080k^4x^3+\frac{292864}{x}k^3+\cdots)$<br>$=\frac{585728k^3}{x}-\frac{1464320}{x}k^4+\cdots$<br>$585728k^3-1464320k^4=0$<br>$k^3(585728-1464320k)=0$<br>k = $\frac{2}{5}$ | (5ii) | $\left(1-\frac{c}{x}\right)^n=\binom{n}{1}\left(-\frac{c}{x}\right)+\binom{n}{2}\left(-\frac{c}{x}\right)^2+\cdots$<br>$=-\frac{nc}{x}+\frac{n(n-1)}{2}.\frac{c^2}{x^2}+\cdots$<br>- nc = - 80<br>nc = 80<br>$\frac{n(n-1)c^2}{2}=3000$<br>$n^2c^2-nc^2=6000$<br>$80^2-80c=6000$<br>c = 5 , n =16 |
| (6i) | Curve A --- $\frac{dy}{dx}=27(2x-1)^2$<br>$27(2x-1)^2=0$<br>$x=\frac{1}{2}$<br>$\left(\frac{1}{2},-4\right)$ | (6i) | Curve B --- $\frac{dy}{dx}=-27(2x-1)^3$<br>$-27(2x-1)^3=0$<br>$x=\frac{1}{2}$<br>$\left(\frac{1}{2},-4\right)$ |
| (6ii) | Curve A --- x = 0.4, x = 0.5, x = 0.6<br>$\frac{dy}{dx}>0 \quad \frac{dy}{dx}=0 \quad \frac{dy}{dx}>0$<br><br>$\left(\frac{1}{2},-4\right)$ *is point of inflexion* | (6ii) | Curve A --- x = 0.4, x = 0.5, x = 0.6<br>$\frac{dy}{dx}>0 \quad \frac{dy}{dx}=0 \quad \frac{dy}{dx}<0$<br><br>$\left(\frac{1}{2},-4\right)$ *is a maximum stationary point* |
| (6iii) | $y_A=\frac{27(2x-1)^3}{3(2)}+c$<br>c = -4<br>$y_A=\frac{9}{2}(2x-1)^3-4$ | (6iii) | $y_B=\frac{-27(2x-1)^4}{4(2)}+c$<br>c = -4<br>$y_B=-\frac{27}{8}(2x-1)^4-4$ |
| (7i) | Line PN is parallel to AB (Mid-Point Theorem) | | |
| (7ii) | $m_{PN}=\frac{2-1}{-\frac{1}{2}-8}=-\frac{2}{17}, \quad m_{AB}=-\frac{2}{17}$<br>$y=-\frac{2}{17}x+c_1$<br>$5=-\frac{2}{17}(1)+c_1 \quad c_1=5\frac{2}{17}$<br>$y=-\frac{2}{17}x+5\frac{2}{17}$ | (7iii) | $m_{MN}=\frac{5-1}{1-8}=-\frac{4}{7}, \quad m_{AC}=-\frac{4}{7}$<br>$y=-\frac{4}{7}x+c_2$<br>$2=-\frac{4}{7}(-\frac{1}{2})+c_2 \quad c_2=\frac{12}{7}$<br>$y=-\frac{4}{7}x+\frac{12}{7}$ |
| (7iv) | $-\frac{2}{17}x+5\frac{2}{17}=-\frac{4}{7}x+\frac{12}{7}$<br>$x=-7\frac{1}{2}$<br>$y=-\frac{4}{7}\left(-\frac{15}{2}\right)+\frac{12}{7}$<br>$y=6$<br>$\left(-7\frac{1}{2},6\right)$ Shown | (7v) | A = $\frac{1}{2}\begin{vmatrix} -\frac{15}{2} & -\frac{1}{2} & 8 & 1 & -\frac{15}{2} \\ 6 & 2 & 1 & 5 & 6 \end{vmatrix}$<br>$=\frac{1}{2}\left(\frac{61}{2}-\left(-\frac{47}{2}\right)\right)$<br>= 27 |

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| | | | |
|---|---|---|---|
| (8i) | $A = 3\left[\frac{1}{2}(3)(3)sin\theta + \frac{1}{2}(2)(2)\sin(120-\theta)\right]$<br>$=3\left[\frac{9}{2}sin\theta + (2)(sin120cos\theta - sin\theta cos120)\right]$<br>$=3\left[\frac{9}{2}sin\theta + 2(\frac{\sqrt{3}}{2}cos\theta - sin\theta(-\frac{1}{2}))\right]$<br>$=3\left[\frac{9}{2}sin\theta + \sqrt{3}cos\theta + sin\theta)\right]$<br>$= \frac{33}{2}\sin\theta + 3\sqrt{3}\cos\theta$ (shown) | (8ii) | R = $\sqrt{\left(\frac{33}{2}\right)^2 + (3\sqrt{3})^2} = \sqrt{\frac{1197}{4}} = \frac{3\sqrt{133}}{2}$<br>tan$\alpha = \frac{\frac{33}{2}}{3\sqrt{3}}$<br>$\alpha = 72.5198$<br>$A = \frac{3\sqrt{133}}{2}\cos(\theta - 72.5°)$<br>$=17.3\cos(\theta - 72.5°)$ |
| (8iii) | $\frac{3\sqrt{133}}{2}\cos(\theta - 72.5198°) = 15$<br>$\cos(\theta - 72.5198°) = 0.86711$<br>cos $\alpha_1$= 0.86711<br>$\alpha_1$= 29.8755<br>$\theta - 72.5198 = 29.8755, -29.8755$<br>$\theta = 102.4\ (reject)\ \ or\ \ 42.6°$ | (8iv) | Max A = $\frac{3\sqrt{133}}{2}$=17.3<br>$\cos(\theta - 72.5198°) = 1$<br>cos $\alpha_2$= 1<br>$\alpha_2$= 0<br>$\theta - 72.5198 = 0$<br>$\theta = 72.5°$ |
| (9i) | $P = 550 + 200e^{kt}$<br>P = 550 + 200<br>= 750 | (9ii) | $2(750) = 550 + 200e^{k(24)}$<br>$e^{24k} = \frac{19}{4}$<br>24k = ln$\frac{19}{4}$<br>k = $\frac{1}{24}$ln$\frac{19}{4}$ = 0.0649 |
| (9iii) | $P = 550 + 200e^{\left(\frac{1}{24}\ln\frac{19}{4}\right)(30)}$<br>$P = 550 + 200e^{\left(\frac{30}{24}\ln\frac{19}{4}\right)}$<br>= 1952.4811<br>$\frac{1952.4811-750}{750}$x100 = 160 % | (9iv) | $\frac{dP}{dt} = 200ke^{kt}$<br>$\frac{dP}{dt} = 200ke^{k(30)}$<br>$m = 200\left(\frac{1}{24}ln\frac{19}{4}\right)e^{\left(\frac{30}{24}\ln\frac{19}{4}\right)}$<br>m = 91.053<br>m =91.1<br>P = mt + c<br>1952.481 = 91.053(30) + c<br>c = -779 |
| (9v) | P<br>(50, 5690)<br>750<br>50 278 t | (9v) | $\frac{5688.169-0}{50-t}$ = -25<br>t = 277.56<br>t = 278<br>278 – 50 = 228 h |
| (10i) | $y = p(x-2)^2 - (x-3)(x+2)$<br>$\frac{dy}{dx} = 2p(x-2) - [(x-3) + (x+2)]$<br>$= 2p(x-2) - 2x + 1$<br>$\frac{d^2y}{dx^2} = 2p - 2 > 0$<br>$2p - 2 > 0$, p >1 | (10i) | OR<br>$y = (p-1)x^2 + x - 4px + 4p + 6$<br>(p - 1) > 0<br>(happy face since it is a min quadratic curve)<br>p >1 |
| (10ii) | $p(x-2)^2 - (x-3)(x+2)$<br>$p(x^2 - 4x + 4) - (x^2 - x - 6) = 0$<br>$px^2 - x^2 - 4px + x + 4p + 6 = 0$<br>$b^2 - 4ac = (-4p+1)^2 - 4(p-1)(4p+6)$<br>$=16p^2 - 8p + 1 - 16p^2 - 8p + 24$<br>= -16p+25<br>-16p + 25 =0<br>p = $\frac{25}{16}$ (shown) | (10iii) | y = p$x^2 - x^2 - 4px + x + 4p + 6$<br>y = p$x^2 - x^2 - 4px + x + 4p + 6$<br>$y = \frac{25}{16}x^2 - x^2 - 4\left(\frac{25}{16}\right)$x + x + $4\left(\frac{25}{16}\right)$ + 6<br>$y = \frac{9}{16}x^2 - \frac{21}{4}x + \frac{49}{4}$<br>$\frac{9}{16}x^2 - \frac{21}{4}x + \frac{49}{4} = 0$<br>$9x^2 - 84x + 196 = 0$<br>$(3x-14)^2 = 0$<br>$x = \frac{14}{3}$<br>$A\left(\frac{14}{3}, 0\right)$ |

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|---|---|---|---|
| (10iv) | $y = mx + 2$<br>$0 = m\left(\frac{14}{3}\right) + 2$<br>$m = -\frac{3}{7}$<br>$y = -\frac{3}{7}x + c$<br>$\frac{dy}{dx} = -\frac{3}{7}$<br>$2p(x-2) - 2x + 1 = -\frac{3}{7}$<br>$2\left(\frac{25}{16}\right)(x-2) - 2x + 1 = -\frac{3}{7}$<br>$x = \frac{30}{7}$<br>$y = \frac{9}{16}x^2 - \frac{21}{4}x + \frac{49}{4}$<br>$y = \frac{9}{16}\left(\frac{30}{7}\right)^2 - \frac{21}{4}\left(\frac{30}{7}\right) + \frac{49}{4}$<br>$y = \frac{4}{49}$<br>$y = -\frac{3}{7}x + c$<br>$\frac{4}{49} = -\frac{3}{7}\left(\frac{30}{7}\right) + c$<br>$c = \frac{94}{49}$ | | |

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