ABBOTSLEIGH

AUGUST 2003
YEAR 12
ASSESSMENT 4
TRIAL HIGHER SCHOOL CERTIFICATE
EXAMINATION

Mathematics Extension 1

General Instructions

- Reading time – 5 minutes.
- Working time – 2 hours.
- Write using blue or black pen.
- Board-approved calculators may be used
- A table of standard integrals is provided with this paper
- All necessary working should be shown in every question

Total marks - 84

- Attempt Questions 1-7
- All questions are of equal value

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Answer each question in a SEPARATE writing booklet. Extra booklets are available.

Question 1 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) Solve $\dfrac{4}{x-1} \geq 1$ **3**

(b) A is the point $(-2,-1)$ and B is the point $(1,5)$. Find the coordinates of the point Q which divides AB externally in the ratio $5:2$. **2**

(c) Given $f(x) = \tan^{-1}(\sin x)$ find $f'(\pi)$ **2**

(d) Prove $\dfrac{1+\sin x-\cos x}{1+\sin x+\cos x} = \tan\dfrac{x}{2}$ **2**

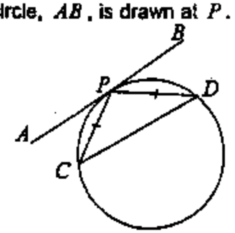
(e) Find the exact value of $\displaystyle\int_0^{\frac{\sqrt{3}}{2}} \frac{dx}{\sqrt{(3-4x^2)}}$ **3**

End of Question 1

Question 2 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) Solve the equation $2\sin^2\theta = \sin 2\theta$ for $0 \le \theta \le 2\pi$ **2**

(b) PC and PD are equal chords of a circle.
A tangent to the circle, AB, is drawn at P.



Copy the diagram into your answer booklet and prove that AB is parallel to CD. **2**

(c) (i) Find $\int \frac{x}{x+9}\,dx$ **2**

(ii) Evaluate $\int_0^4 x\sqrt{x^2+9}\,dx$ using the substitution $u = x^2 + 9$ **3**

(d) (i) Sketch $y = |x+1|$ **1**

(ii) Using your graph, or otherwise, solve $|x+1| > -2x$ for x **2**

End of Question 2

Question 3 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) For the polynomial $P(x) = x^3 - kx^2 - x + 2$

(i) Find the value of k if $x-1$ is a factor of $P(x)$ **1**

(ii) Hence factorise $P(x)$ completely. **2**

(b) Find the term which is independent of x in the expansion of $\left(x^2 + \frac{2}{x}\right)^9$ **2**

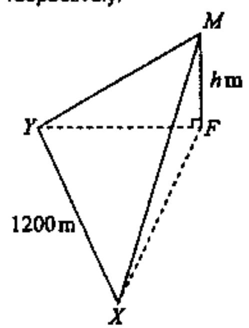
(c) For the function $f(x) = 4\sin^{-1}(x-2)$

(i) Evaluate $f\left(1\frac{1}{2}\right)$ **1**

(ii) Sketch $y = f(x)$ clearly indicating the domain and range. **2**

(iii) Find $\int_1^3 4\sin^{-1}(x-2)\,dx$ **1**

(d) In the diagram, Point X is due south and point Y is due west of the foot, F, of a mountain. From X and Y, the angles of elevation of the top of the mountain M are 35° and 43° respectively.



Not to scale

If X and Y are 1200 metres apart, show that the height, h metres, of the mountain is given by $h = 1200\left(\tan^2 55° + \tan^2 47°\right)^{-\frac{1}{2}}$ and evaluate h. **3**

End of Question 3

Question 4 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) (i) Sketch the graph of $y=\cos x, -\pi \le x \le \pi$ and use this graph to show that $\cos x + x = 0$ has only one solution. **2**

(ii) Use Newton's method with a first approximation of $x=-1$ to find a second approximation to the root of $\cos x + x = 0$. **2**

(b) The inside of a vessel used for water has the shape of a solid of revolution obtained by the rotation of the parabola $9y = 8x^2$ about the y-axis. The depth of the vessel is $8\,\text{cm}$.

(i) Prove that the volume of water $h\,\text{cm}$ from its base is $\dfrac{9}{16}\pi h^2$ **1**

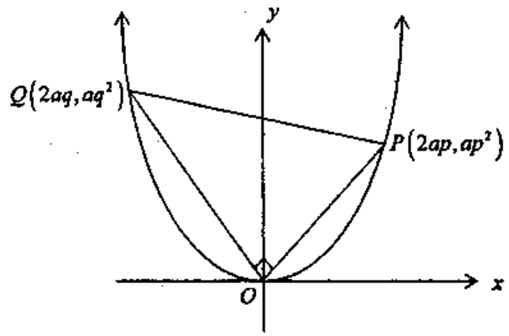
(ii) If water is poured into the vessel at a rate of $20\,\text{cm}^3/\text{sec}$, find the rate at which the level of water is rising when the vessel is half full. **3**

(c) Use the Principle of Mathematical Induction to prove that $2^{3n} - 3^n$ is divisible by 5 for all positive integers n. **4**

End of Question 4

Question 5 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) In the diagram, PQ is a variable chord of the parabola $x^2 = 4ay$. It subtends a right angle at the vertex O. Let p and q be the parameters corresponding to the points P and Q respectively.



(i) Show that the equation of the tangent to $x^2 = 4ay$ at P is $y - px + ap^2 = 0$ **1**

(ii) Hence, write down the equation of the tangent at Q, and then find R, the point of intersection of the two tangents drawn at P and Q. **2**

(iii) Find the gradients of OP and OQ and hence prove $pq = -4$ **2**

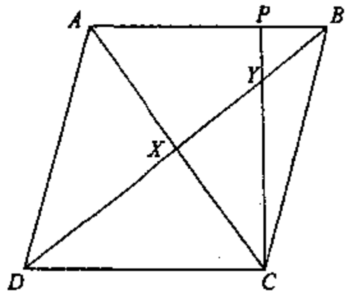
(iv) Show that the locus of R, the point of intersection of the two tangents drawn at P and Q is $y = -4a$ **1**

(b) By considering $f(x) = (1+x)^n$ in $\int_0^1 f(x)\,dx$, prove that

$$\sum_{r=0}^{n} \frac{1}{r+1}\binom{n}{r} = \frac{2^{n+1}-1}{n+1}$$ **3**

Question 5 continues on page 7

(c) $ABCD$ is a rhombus whose diagonals intersect at X. The perpendicular CP from C to AB cuts BD at Y.



Not to scale

Copy the diagram into your writing booklet and prove that B, P, X, C are concyclic. **3**

End of Question 5

Question 6 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) Find $\int \sin^2 x \cos^2 x \, dx$ **2**

(b) A particle moves in a straight line so that its velocity after t seconds is $v\,\text{ms}^{-1}$ and its displacement is x.

(i) Given that $\dfrac{d^2x}{dt^2} = 2x^3 - 10x$ and that initially $v = 0$ when $x = -1$, find v in terms of x. **3**

(ii) Explain why this motion can only exist between $x = -1$ and $x = 1$. **2**

(iii) Describe briefly what would have happened if the initial conditions were $v = 0$ when $x = 0$. **1**

(c) In a colony of 400 ants the number, N, diseased at time, t, is given by $N = \dfrac{400}{1 + ke^{-400t}}$ where k is a constant and t is time in years. (Assume one year is 365 days.)

(i) If at time $t = 0$ one ant was infected, after how many days will half the colony be infected? **3**

(ii) Show that eventually all the ants will be infected. **1**

End of Question 6

Question 7 (12 marks) Use a SEPARATE writing booklet. **Marks**

(a) A particle is projected from a point on level ground with a speed of $V\ \text{ms}^{-1}$ and angle of projection, α. Assume that acceleration due to gravity is $g\ \text{ms}^{-2}$ and that there is no air resistance.

(i) Show that the horizontal and vertical displacements, x and y, of the particle in metres from the point of projection at time t seconds after projection are given by **2**

$x = Vt\cos\alpha$ and $y = Vt\sin\alpha - \frac{1}{2}gt^2$

(ii) Show that the greatest height of the particle is $\dfrac{V^2\sin^2\alpha}{2g}$ **1**

(iii) Show that the range of the particle is $\dfrac{V^2\sin 2\alpha}{g}$ **1**

(iv) Two particles are projected from the same point on level ground with the same speed $V\ \text{ms}^{-1}$ and with angles of projection α and $90° - \alpha$ respectively.

The greatest heights the two particles reach are h_1 and h_2 respectively.

Show that, for any α, $h_1 + h_2 = \frac{1}{2}R$ where R is the maximum range. **3**

(b) A_n and B_n are two series given by

$A_n = 1^2 + 5^2 + 9^2 + 13^2 + \ldots + (4n-3)^2$

$B_n = 3^2 + 7^2 + 11^2 + 15^2 + \ldots$ for $n = 1, 2, 3, \ldots$

(i) Find the nth term of B_n. **1**

(ii) If $S_{2n} = A_n - B_n$, prove that $S_{2n} = -8n^2$. **2**

(iii) Hence, or otherwise, evaluate **2**

$101^2 - 103^2 + 105^2 - 107^2 + \ldots + 2001^2 - 2003^2$

End of Paper

MATHEMATICS EXTENSION 1 - ASSESSMENT 4 TRIAL EXAMINATION AUGUST 2005

Question 1

(a) $\frac{4}{x-1} \geqslant 1$ $\boxed{x \neq 1}$

$4(x-1) \geqslant (x-1)^2$

$(x-1)^2 - 4(x-1) \leqslant 0$

$(x-1)[x-1-4] \leqslant 0$

$(x-1)(x-5) \leqslant 0$

$1 < x \leqslant 5$

(b) $A(-2,-1)$ $B(1,5)$ $5:-2$

$x = \frac{5\times 1 - 2\times -2}{5-2} = 3$ $y = \frac{5\times 5 - 2\times -1}{5-2} = 9$

$Q(3,9)$

(c) $f(x) = \tan^{-1}(\sin x)$

$f'(x) = \frac{\cos x}{1+\sin^2 x}$

$f'(\pi) = \frac{\cos \pi}{1+\sin^2 \pi} = -1$

(d) $LHS = \frac{1+\sin x - \cos x}{1+\sin x + \cos x}$

$= \frac{1 + \frac{2t}{1+t^2} - \frac{1-t^2}{1+t^2}}{1+\frac{2t}{1+t^2} + \frac{1-t^2}{1+t^2}}$

$= \frac{1+t^2+2t-1+t^2}{1+t^2+2t+1-t^2}$

$= \frac{2t^2+2t}{2+2t}$

$= \frac{2t(t+1)}{2(1+t)} = t = \tan\frac{x}{2}$

(e) $\int_0^{\sqrt{3}/2} \frac{dx}{\sqrt{3-4x^2}} = \int_0^{\sqrt{3}/2} \frac{dx}{2\sqrt{\frac{3}{4}-x^2}}$

$= \frac{1}{2}\left[\sin^{-1}\frac{2x}{\sqrt{3}}\right]_0^{\sqrt{3}/2}$

$= \frac{1}{2}\left(\sin^{-1} 1 - \sin^{-1} 0\right)$

$= \frac{\pi}{4}$

Question 2

(a) $2\sin^2\theta = \sin 2\theta$, $0 \leqslant \theta \leqslant 2\pi$

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

$\sin^2\theta - \sin\theta\cos\theta = 0$

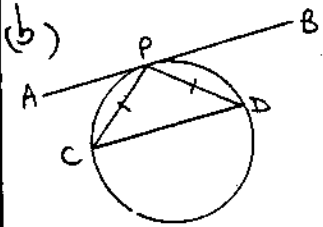
$\sin\theta(\sin\theta - \cos\theta) = 0$

$\sin\theta = 0$, $\sin\theta = \cos\theta$

$\tan\theta = 1$

$\theta = 0, \pi, 2\pi, \frac{\pi}{4}, \frac{5\pi}{4}$

(b)



$\angle PCD = \angle PDC$ given equal chords ΔPDC isosceles with equal base angle

$\angle BPC = \angle PCD$ angle between tangent + chord = $\angle$ in alternate segment

$\therefore \angle BPC = \angle PDC$

The alternate angles are equal

$\therefore$ AB parallel to CD

(c) (i) $\int \frac{x}{x+9}\,dx = \int \frac{x+9-9}{x+9}\,dx$

$= \int\left(\frac{x+9}{x+9} - \frac{9}{x+9}\right)dx$

$= \int\left(1 - \frac{9}{x+9}\right)dx$

$= x - 9\ln(x+9) + c$

(ii) $\int_0^4 x\sqrt{x^2+9}\,dx$ $u = x^2+9$, $\frac{du}{dx} = 2x$, $x=0$ $u=9$, $x=4$ $u=25$

$= \frac{1}{2}\int_0^4 \sqrt{x^2+9} \times 2x\,dx$

$= \frac{1}{2}\int_9^{25} \sqrt{u}\,du$

$= \frac{1}{2}\int_9^{25} u^{\frac{1}{2}}\,du$

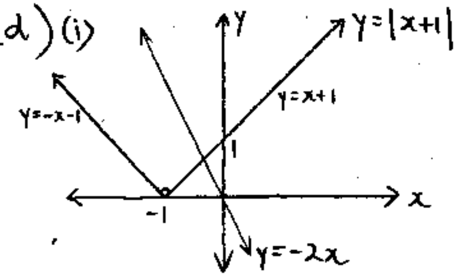
$= \frac{1}{2}\left[\frac{2}{3}u^{3/2}\right]_9^{25}$

$= \frac{1}{3}\left((\sqrt{25})^3 - (\sqrt{9})^3\right)$

$= \frac{1}{3}(125-27)$

$= \frac{98}{3}$

(d) (i)



(ii) One pt. of intersection

Solve $x+1 = -2x$

$3x = -1$

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

$\therefore |x+1| > -2x$ when $x > -\frac{1}{3}$

Question 3

(a) $P(x) = x^3 - kx^2 - x + 2$

(i) $x-1$ is a factor $\therefore P(1) = 0$

$0 = 1 - k - 1 + 2$

$k = 2$

(ii) $P(x) = x^3 - 2x^2 - x + 2$

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

$= (x-2)(x^2-1)$

$= (x-2)(x-1)(x+1)$

(b) $T_{k+1} = {}^9C_k \left(\frac{2}{x}\right)^k (x^2)^{9-k}$

$= {}^9C_k\, 2^k x^{-k} x^{18-2k}$

$= {}^9C_k\, 2^k x^{18-3k}$

term indept. of x ie x^0

$\therefore 0 = 18 - 3k$

$k = 6$

7^{th} term is independent of x

$T_7 = {}^9C_6\, 2^6$

$= 2^8 \times 3 \times 7$

$= 5376$

c) $f(x) = 4\sin^{-1}(x-2)$

(i) $f(1\tfrac{1}{2}) = 4\sin^{-1}(-\tfrac{1}{2})$

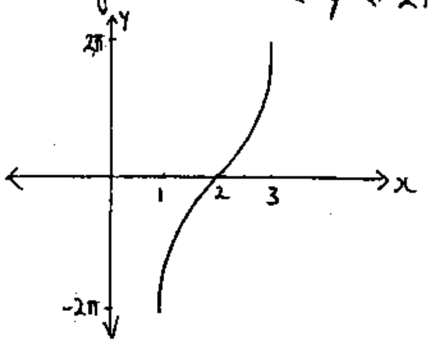
$= 4 \times -\frac{\pi}{6}$

$= -\frac{2\pi}{3}$

(ii) Domain $\quad -1 \leq x-2 \leq 1$

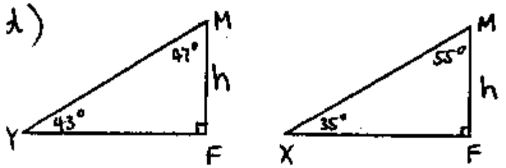
$1 \leq x \leq 3$

Range $\quad -2\pi \leq y \leq 2\pi$



(iii) $\int_1^3 4\sin^{-1}(x-2)\,dx = 0$

d)



In ΔMYF $\quad \tan 47° = \frac{YF}{h}$

$YF = h\tan 47°$

In ΔMXF $\quad \tan 55° = \frac{XF}{h}$

$XF = h\tan 55°$

In ΔYFX

$1200^2 = YF^2 + XF^2$ (Pythagoras)

$1200^2 = h^2\tan^2 47° + h^2\tan^2 55°$

$h^2(\tan^2 47° + \tan^2 55°) = 1200^2$

$h^2 = \frac{1200^2}{(\tan^2 47° + \tan^2 55°)}$

$h = \frac{1200}{\sqrt{\tan^2 47° + \tan^2 55°}}$

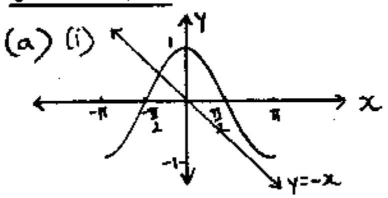
$h = 1200(\tan^2 47° + \tan^2 55°)^{-\frac{1}{2}}$

$h = 671.915\ldots$ m

$h \doteqdot 671.9$ m (to 1 dp)

Question 4

(a) (i)



$\cos x + x = 0 \Rightarrow \cos x = -x$

Consider $y = \cos x$ + $y = -x$

Graphs intersect at one pt. only

$\therefore$ $\cos x + x = 0$ has only one soln.

(ii) $f(x) = \cos x + x$

$f'(x) = -\sin x + 1$

$x_1 = -1$ (in radians)

$x_2 = x_1 - \frac{f(x_1)}{f'(x_1)}$

$= -1 - \frac{\cos(-1) - 1}{1 - \sin(-1)}$

$= -0.75036\ldots$

2nd approximation is

$x = -0.75$ (to 2 dp)

b) (i) $V = \pi\int_0^h \frac{9y}{8}\,dy$

$= \frac{9\pi}{8}\left[\frac{1}{2}y^2\right]_0^h$

$= \frac{9\pi}{8} \times \frac{1}{2}h^2 - 0$

$= \frac{9\pi h^2}{16}$

(ii) $\frac{dV}{dt} = 20 \qquad \frac{dV}{dh} = \frac{18\pi h}{16} = \frac{9\pi h}{8}$

Find h when $\frac{1}{2}$ full.

Full $\Rightarrow h = 8$ cm $\quad V = 36\pi$

$\frac{1}{2}$ full $\Rightarrow V = 18\pi = \frac{9\pi h^2}{16}$

$h^2 = 32$

$h = 4\sqrt{2}$.

$\frac{dV}{dt} = \frac{dV}{dh} \times \frac{dh}{dt}$

$20 = \frac{9\pi h}{8} \times \frac{dh}{dt} \qquad h = 4\sqrt{2}$

$\frac{20 \times 8}{9\pi \times 4\sqrt{2}} = \frac{dh}{dt}$

$\frac{dh}{dt} = \frac{40}{9\pi\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}}$

$= \frac{20\sqrt{2}}{9\pi}$ cm/sec

(c) $2^{3n} - 3^n$ divisible by 5.

Show true for $n=1$

$2^3 - 3^1 = 8 - 3$

$= 5$ which is $\div$ by 5

Assume true for $n=k$

ie assume $2^{3k} - 3^k = 5M$ where

M is a positive integer

Show true for $n = k+1$

$2^{3(k+1)} - 3^{k+1} = 2^{3k+3} - 3^{k+1}$

$= 2^3 \times 2^{3k} - 3 \times 3^k$

$= 2^3(5M + 3^k) - 3 \times 3^k$ using assumption

$= 40M + 8 \times 3^k - 3 \times 3^k$

$= 40M + 5 \times 3^k$

$= 5(8M + 3^k)$ which is divisible by 5

$\therefore$ true for $n=k+1$ if true for $n=k$

Since true for $n=1$ it is also true for $n = 1+1 = 2$ + thus true for $n = 2+1 = 3$ and so on for all positive integers n.

Question 5

(a) (i) $y = \frac{x^2}{4a} \Rightarrow y' = \frac{x}{2a}$

at $P(2ap, ap^2)$ $\quad m_T = \frac{2ap}{2a} = p$

eq. tangent $\quad y - ap^2 = p(x - 2ap)$

$y - ap^2 = px - 2ap^2$

$y - px + ap^2 = 0$

(ii) at Q tangent eq. $y - qx + aq^2 = 0$

$y = px - ap^2$, $y = qx - aq^2$

$px - ap^2 = qx - aq^2$

$px - qx = ap^2 - aq^2$

$x(p-q) = a(p-q)(p+q)$

$x = a(p+q) \quad p \neq q$

$y = ap(p+q) - ap^2$

$y = apq$

$R\,(a(p+q), apq)$

(iii) $m_{OP} = \dfrac{ap^2 - 0}{2ap - 0} = \dfrac{p}{2}$

Similarly $m_{OQ} = \dfrac{q}{2}$

$OP \perp OQ \quad \therefore m_{OP} \times m_{OQ} = -1$

ie $\dfrac{pq}{4} = -1 \Rightarrow pq = -4$

(iv) at R $\quad x = a(p+q)$

$y = apq$

from (iii) $pq = -4$ $\quad > y = -4a$ indept. of $p+q$

$\therefore$ locus of R is $y = -4a$

(b) $f(x) = (1+x)^n$

$$\int_0^1 (1+x)^n\,dx = \left[\frac{(1+x)^{n+1}}{n+1}\right]_0^1$$

$$= \frac{2^{n+1}}{n+1} - \frac{1^{n+1}}{n+1}$$

$$= \frac{2^{n+1} - 1}{n+1}$$

Also

$$(1+x)^n = \binom{n}{0} + \binom{n}{1}x + \binom{n}{2}x^2 + \dots + \binom{n}{r}x^r + \dots$$

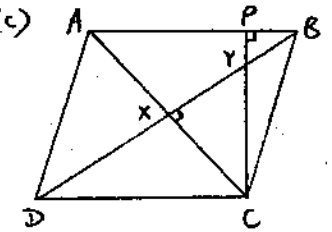
$$\int_0^1 (1+x)^n\,dx = \Big[\binom{n}{0}x + \tfrac{1}{2}\binom{n}{1}x^2 + \tfrac{1}{3}\binom{n}{2}x^3 + \tfrac{1}{r+1}\binom{n}{r}x^{r+1} + \dots \tfrac{1}{n+1}\binom{n}{n}x^{n+1}\Big]_0^1$$

$$= \binom{n}{0} + \tfrac{1}{2}\binom{n}{1} + \tfrac{1}{3}\binom{n}{2} + \dots + \tfrac{1}{r+1}\binom{n}{r} + \dots + \tfrac{1}{n+1}\binom{n}{n} - 0$$

$$= \sum_{r=0}^{n} \frac{1}{r+1}\binom{n}{r}$$

$$\therefore \sum_{r=0}^{n} \frac{1}{r+1}\binom{n}{r} = \frac{2^{n+1} - 1}{n+1}$$

(c)



$\angle BPC = 90°$ given

$\angle BXC = 90°$ given rhombus; diagonals bisect each other at right angles.

Interval BC subtends equal angles on the same side of it at points P and X

$\therefore$ B, C, X, P are concyclic

Question 6

(a) $\int \sin^2 x \cos^2 x \; dx$

$= \int (\sin x \cos x)^2\,dx$

$= \int \left(\tfrac{1}{2}\sin 2x\right)^2 dx$

$\int \sin^2 x \cos^2 x \; dx = \frac{1}{4}\int \sin^2 2x\,dx$

$= \frac{1}{4}\int \frac{1}{2}(1 - \cos 4x)\,dx$

$= \frac{1}{8}\left(x - \frac{1}{4}\sin 4x\right) + C$

$= \frac{x}{8} - \frac{1}{32}\sin 4x + C$

(b)(i) $\frac{d}{dx}\left(\tfrac{1}{2}v^2\right) = 2x^3 - 10x$

$\frac{1}{2}v^2 = \frac{x^4}{2} - 5x^2 + C$

$v = 0$ when $x = -1$

$0 = \frac{1}{2} - 5 + C$

$C = \frac{9}{2}$

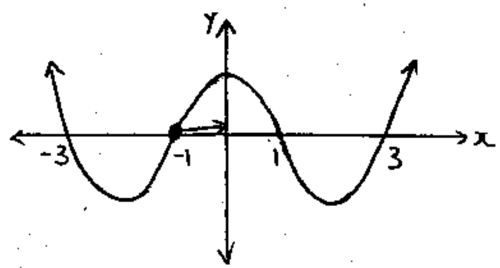
$\frac{1}{2}v^2 = \frac{x^4}{2} - 5x^2 + \frac{9}{2}$

$v^2 = x^4 - 10x^2 + 9$

$v = \pm\sqrt{x^4 - 10x^2 + 9}$

(ii) $v^2 = (x^2 - 9)(x^2 - 1)$

$v^2 = (x-3)(x+3)(x-1)(x+1)$



Starts at $x = -1$ and $v^2 \geq 0$

$\therefore$ only movement from $x = -1$ is to $x = 1$ + back. Exists between

(iii) If $x = 0$ then $a = 0$

With $v = 0$ and $a = 0$ there is no acceleration + no velocity $\therefore$ particle would not move.

(c) (i) $t = 0 \quad N = 1$

$1 = \dfrac{400}{1 + ke^0}$

$1 + k = 400$

$k = 399$

find t when $N = 200$

$200 = \dfrac{400}{1 + 399e^{-400t}}$

$1 + 399e^{-400t} = 2$

$399e^{-400t} = 1$

$e^{-400t} = \frac{1}{399}$

$-400t = \ln\frac{1}{399}$

$t = -\frac{1}{400}\ln\frac{1}{399}$

$= 0.0149\ldots$ years

$\doteqdot 5.5$ days

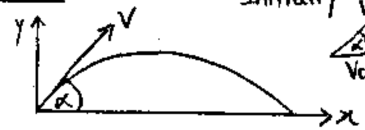
(ii) as $t \to \infty$

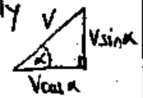
$e^{-400t} \to 0$

$\therefore N \to \dfrac{400}{1+0} = 400$

ie all the ants will be infected.

Question 7

(i) 

Initially 

Horizontal	Vertical
$\ddot{x} = 0$	$\ddot{y} = -g$
$\dot{x} = c_1$	$\dot{y} = -gt + c_3$
when $t=0$ $\dot{x} = V\cos\alpha$	when $t=0$ $\dot{y} = V\sin\alpha$
$\therefore c_1 = V\cos\alpha$	$\therefore c_3 = V\sin\alpha$
$\dot{x} = V\cos\alpha$	$\dot{y} = V\sin\alpha - gt$
$x = Vt\cos\alpha + c_2$	$y = Vt\sin\alpha - \frac{1}{2}gt^2 + c_4$
when $t=0$ $x=0$	when $t=0$ $y=0$
$\therefore c_2 = 0$	$\therefore c_4 = 0$
$x = Vt\cos\alpha$	$y = Vt\sin\alpha - \frac{1}{2}gt^2$

(ii) greatest ht when $\dot{y} = 0$

$$V\sin\alpha = gt$$
$$t = \frac{V\sin\alpha}{g}$$

$$y = V \times \frac{V\sin\alpha}{g}\sin\alpha - \frac{1}{2}g\,\frac{V^2\sin^2\alpha}{g^2}$$
$$= \frac{V^2\sin^2\alpha}{2g}$$

(iii) range $\Rightarrow y = 0$

$$0 = t\left(V\sin\alpha - \frac{1}{2}gt\right)$$
$$t = 0,\quad t = \frac{2V\sin\alpha}{g}$$

$$x = V \times \frac{2V\sin\alpha}{g}\cos\alpha$$
$$= \frac{V^2 \times 2\sin\alpha\cos\alpha}{g} = \frac{V^2\sin 2\alpha}{g}$$

(iv) max. range when $\sin 2\alpha = 1$

$$\therefore R = \frac{V^2}{g}$$

$$h_1 = \frac{V^2\sin^2\alpha}{2g} \qquad h_2 = \frac{V^2\sin^2(90-\alpha)}{2g}$$

$$h_1 + h_2 = \frac{V^2}{2g}\left(\sin^2\alpha + \cos^2\alpha\right)$$
$$= \frac{V^2}{2g}$$
$$= \frac{1}{2}R$$

(b) (i) $B_n = 3^2 + 7^2 + \ldots + (4n-1)^2$

n-th term $(4n-1)^2$

(ii) $S_{2n} = A_n - B_n$

$$= 1^2 + 5^2 + \ldots + (4n-3)^2$$
$$- 3^2 - 7^2 - \ldots - (4n-1)^2$$

$$S_{2n} = (1^2-3^2) + (5^2-7^2) + (9^2-11^2) + \ldots + \left[(4n-3)^2 - (4n-1)^2\right]$$

$$= (1-3)(1+3) + (5-7)(5+7) + \ldots + (9-11)(9+11) + \ldots + (4n-3-4n+1)(4n-3+4n-1)$$

$$= -2(4) - 2(12) - 2(20) - \ldots - 2(8n-4)$$
$$= -2\left(4 + 12 + 20 + \ldots + (8n-4)\right)$$
$$= -2\left(\frac{n}{2}\left(8 + (n-1)8\right)\right)$$
$$= -n(8 + 8n - 8)$$
$$= -8n^2$$

(iii) $101^2 - 103^2 + 105^2 - \ldots + 2001^2 - 2003^2$

starts from $n=26$ to $n=501$

$$S_{501} - S_{25} = -8(501)^2 + 8(25)^2$$
$$= -2003008$$