SYDNEY TECHNICAL HIGH SCHOOL



TRIAL HIGHER SCHOOL CERTIFICATE 2002

MATHEMATICS EXTENSION 2

General Instructions

- Reading time 5 minutes
- Working time 3 hours
- Write using black or blue pen
- Approved calculators may be used
- All necessary working should be shown in every question
- A table of standard integrals is supplied at the back of this paper
- Start each question on a new page
- Attempt all Questions 1 − 8
- All questions are of equal value

Name	<u> </u>
Class	•

Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	TOTAL

Question 1 15 marks

Marks

a) Find
$$\int \sin^3 x \, dx$$

b) Find
$$\int \frac{dx}{\sqrt{2x-x^2}}$$

c) Use partial fractions to find
$$\int \frac{5}{(x-3)(2x-1)} dx$$

d) Evaluate
$$\int_0^{\frac{\pi}{2}} \frac{dx}{2 + \cos x}$$
 using the substitutuion $t = \tan \frac{x}{2}$

e) Find
$$\int e^x \sin x \, dx$$

Question 2 15 marks (Use a new page)

Marks

a) Express
$$\frac{2+3i}{1+i}$$
 in the form $x+iy$.

b) Given
$$\omega = -1 + i\sqrt{3}$$
 find i) $|\omega|$

ii)
$$arg(\omega)$$

iii)
$$\omega^5 + 16\omega$$
 in the form $x + iy$

i)
$$|z-1| \leq |z-i|$$

ii)
$$\operatorname{Re}(\frac{2}{z}) \le 1$$

d) One of the square roots of
$$a + 3i$$
 is equal to $3 + bi$

where a and b are real. Find the value of a and b.

$$|z-3| \le 3$$
 and $0 \le \arg(z) \le \frac{\pi}{2}$

Question 3 15 marks (Use a new page)

Marks

- a) Consider the function $f(x) = \frac{x}{\ln x}$
 - i) State the natural domain of f(x)

1

ii) Show that the curve y = f(x)

2

has a minimum turning point at the point (e, e).

iii) Find the point of inflexion of the curve y = f(x).

1

iv) Sketch the curve y = f(x) showing the important features.

2

b) $P(cp, \frac{c}{p})$ and $Q(cq, \frac{c}{q})$ where p, q > 0 are two distinct points on the hyperbola H with equation $xy = c^2$.

i) Show that the equation of the tangent to H at $P(cp, \frac{c}{p})$

2

is given by $x + p^2 y = 2cp$.

ii) The tangents to H at $P(cp, \frac{c}{p})$ and $Q(cq, \frac{c}{q})$ meet at T

2

Find the coordinates of T.

iii) Find the equation of the chord PQ.

2

iv) Given that the chord PQ passes through the point (2c,0)

1

find a relationship between the parameters p and q.

v) Find the equation of the locus of T as P and Q move about H

2

according to the restriction in part iv).

Give a complete description of this locus.

Question 4 15 marks (Use a new page)

Marks

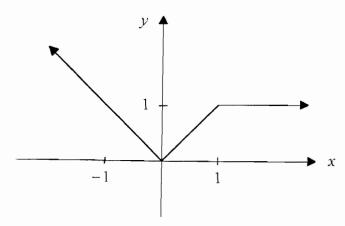
a) The area bounded by $y = \frac{1}{x+1}$, the x axis

and the lines x = 0 and x = 2 is rotated about the line x = 2.

Use cylindrical shells to find the volume of the solid of revolution formed.

b) Find the equation of the ellipse with centre the origin, 3 which has a focus at (2,0) and the corresponding directrix is x=4.

c)



The diagram shows the graph of the function y = f(x).

Draw separate sketches of the following

i)
$$y = f(-x)$$
 1

ii)
$$y = f|x|$$

iii)
$$y = \ln(f(x))$$

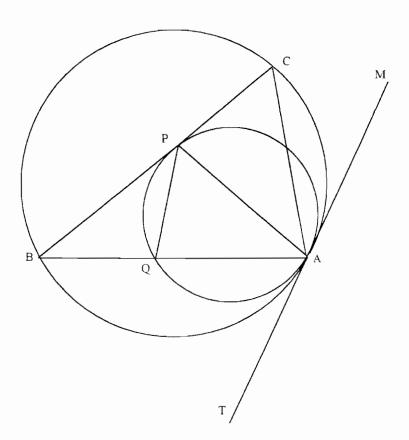
$$iv) \quad x = f(y)$$

d) If ω is a complex root of $z^3 = 1$ find the value of

i)
$$1 + \omega + \omega^2$$

ii)
$$\frac{1}{3+5\omega+3\omega^2} + \frac{1}{7+7\omega+9\omega^2}$$

a)



Two circles touch internally at A. MT is a common tangent.

A tangent to the inner circle at P cuts the outer circle at B and C.

The interval $\ensuremath{\mathit{AB}}$ cuts the inner circle at $\ensuremath{\mathcal{Q}}$.

The intervals \it{PA} , \it{CA} and \it{PQ} have been drawn.

Neatly draw the diagram on your answer sheet.

Prove that PA bisects $\angle BAC$.

Question 5 (Continued)

Marks

b) The equation $2x^4 - 3x^2 - 2x + k = 0$ has a triple root.

4

4

Find the value of k.

- c) Solve $x^4 6x^3 + 15x^2 18x + 10 = 0$ over the complex field given that 1+i is a solution.
- d) On an Argand diagram ΔPOQ is a right angled isosceles triangle.

O is the origin, P lies in the first quadrant and Q lies in the second.

$$\angle POQ = 90^{\circ}$$
.

Given that OP represents the complex number a+ib,

Write down the complex number represented by

1

Question 6 15 marks (Use a new page)

Marks

a) The function f is given by

$$f(x) = e^{\frac{x}{1+kx}}$$
 where k is a positive constant.

i) Given that the tangent to y = f(x) at the point (a, f(a)) 3 passes through the origin show that

$$k^2a^2 + (2k-1)a + 1 = 0$$
.

ii) Deduce that there is no such tangent as in part i) if 4k > 1.

 $\begin{array}{c} A \\ R \\ X \\ C \\ \end{array}$

ABC is a triangle. The line RQ produced meets BC produced at P. CX is drawn parallel to QR.

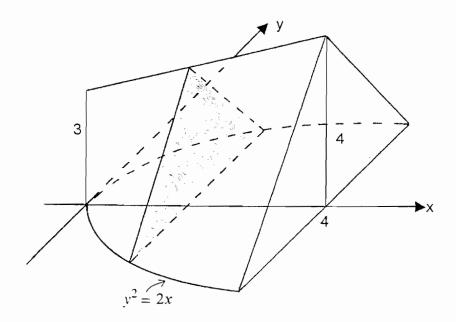
Show that
$$\frac{BP}{PC} \times \frac{CQ}{QA} \times \frac{AR}{RB} = 1$$

(This is known as Menelaus' Theorem.)

Question 6 (Continued)

Marks

c)



The base of the above solid is the area enclosed by $y^2 = 2x$ and x = 4.

Each cross section of the solid by planes perpendicular to the x axis is an isosceles triangle with the equal sides meeting above the base of the solid. A typical cross section of thickness Δx has been shaded.

The perpendicular height of the solid at x = 4 is 4 and the perpendicular height of the solid at x = 0 is 3.

A straight line joins the vertex of the triangle at x = 4 to the point 3 above x = 0.

- i) Show that the perpendicular height of the solid as a function of x 2 is given by $\frac{1}{4}x+3$
- ii) Find the volume of the solid.

Question 7 15 marks (Use a new page)

Marks

a) Given that $I_n = \int x^n e^{2x} dx$

i) Show that
$$I_n = \frac{x^n e^{2x}}{2} - \frac{n}{2} I_{n-1}$$

ii) Use the above result to find $\int x^2 e^{2x} dx$.

b) A particle of mass 2kg is propelled from the origin along the x axis with an initial velocity of Qm/s.

The only forces acting on the body in the direction of the x axis are friction which is a constant 16 Newtons and air resistance which equals v^2 Newtons where v is the velocity of the particle t seconds after leaving the origin.

i) Explain why
$$\frac{dv}{dt} = -8 - \frac{1}{2}v^2$$
.

ii) Show that
$$t = \frac{1}{2} \tan^{-1} \left(\frac{4Q - 4v}{16 + Qv} \right)$$
 5

iii) By using
$$\frac{dv}{dt} = v \frac{dv}{dx}$$

find an expression for v in terms of x.

Question 8 15 marks (Use a new page)

Marks

a) Solve the equation

4

$$\sin(x+10^{\circ}) = \cos(4x)$$
 for $0^{\circ} \le x \le 180^{\circ}$.

b) Use Mathematical Induction to prove that

4

$$\tan \theta + 2 \tan 2\theta + \dots + 2^{n-1} \tan(2^{n-1}\theta) = \cot \theta - 2^n \cot(2^n \theta)$$
for all positive integers n .

c) The function f(x) is given, for x > 0, by

$$f(x) = 2\log_e x - \frac{x^2 - 1}{x}.$$

i) Show that the only zero of f(x) occurs at x = 1.

3

Justify your answer.

ii) Let
$$g(x) = \frac{x \log_e x}{x^2 - 1}$$
, for $x > 0$ and $x \ne 1$.

Show that
$$0 < g(x) < \frac{1}{2}$$
.

STANDARD INTEGRALS

$$\int x^n dx = \frac{1}{n+1} x^{n+1}, \quad n \neq -1; \quad x \neq 0, \text{ if } n < 0$$

$$\int \frac{1}{x} dx = \ln x, \quad x > 0$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax}, \quad a \neq 0$$

$$\int \cos ax \, dx = \frac{1}{a} \sin ax, \quad a \neq 0$$

$$\int \sin ax \, dx = -\frac{1}{a} \cos ax, \quad a \neq 0$$

$$\int \sec^2 ax \, dx = \frac{1}{a} \tan ax, \quad a \neq 0$$

$$\int \sec ax \tan ax \, dx = \frac{1}{a} \sec ax, \quad a \neq 0$$

$$\int \frac{1}{a^2 + x^2} dx = \frac{1}{a} \tan^{-1} \frac{x}{a}, \quad a \neq 0$$

$$\int \frac{1}{\sqrt{a^2 - x^2}} dx = \sin^{-1} \frac{x}{a}, \quad a > 0, \quad -a < x < a$$

$$\int \frac{1}{\sqrt{x^2 - a^2}} dx = \ln\left(x + \sqrt{x^2 - a^2}\right), \quad x > a > 0$$

$$\int \frac{1}{\sqrt{x^2 + a^2}} dx = \ln\left(x + \sqrt{x^2 + a^2}\right)$$

NOTE: $\ln x = \log_e x$, x > 0

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	$\int_{-\infty}^{\infty} \frac{\xi}{x} + 2x$
	72.732
	5- [(-1) + 3.2) - (0)]
	5 / 5
	5 en with
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	I-4 0 < 0
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b)	-
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	<u>c</u>
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To be to Name 29	Teacher's Name:Student's Name/N°:
Teacher's Name: Student's Name/N°:	(i) dd = - (3+ (4)
	5+ £ \$ = = = dt
	2 d = - dt
$\therefore T_n = (x^n) \left(\frac{1}{2} e^{\lambda n} \right) - \int (n x^{n-1}) \left(\frac{1}{2} e^{\lambda n} \right) dn$	and the same of th
$=\frac{x\cdot e}{2}-2\int x^{2}e^{2x}dx$	1. Substitute = - Sub
The state of the s	
= x^e _ 1 _ 1	when the vac
2 2 2	C = 1 ta-1 =
ii) $I_{L} = \int x^{2} e^{-dx}$	'
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AND THE RESIDENCE OF THE CONTROL OF	ton 24 . tan (tan " = -ta." =)
= {x e - 1xe + 1 } e da	
= tre + te + te	= ton ton & - ton fa-1 \$
= 2 (2 - 2 + 2) + c	1 + (+a++-" = >+ + + + - 5)
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acher's Name: Student's Name/N°:	
14) V da = -3-2v	Q3 qy Sin(260) = Gy+2
The second secon	
V dV = -1 d ≈	1_ Co; (90-(4+10)) = Control
integration.	$\therefore q_0 - (x_{(0)}) = n_0 36^{\circ} \cdot t + x$

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	(16,2) = - + 2,10
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	L 1-0 ~= a x 20
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	AND THE RESIDENCE WAS ASSESSED FOR A SECURIOR OF THE PARTY OF THE PART
	21 = ln/16+2) - ln/16-v)
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	The Committee of the South Committee of the Committee of
	$x = h\left(\frac{6.64}{6.62}\right)$
	(6-8)
	"
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	THE TRANSPORT OF A PROPERTY OF THE PROPERTY OF
	$e^{-x^2} = (u, a^2) e^{-x}$
	v= (16+Q) e-16
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Teacher's Name; Student's Name/N°:
a, Sin(2610) = G, +2
1'- Cos (90-(410)) Con+24
10 - (num) = n-360° 1+2
50-7 = 1430 1490 50-7 = 1 14 20 - 470 -50 = 1430 -50 3x = 1430 -50
$2 = \frac{1}{2} \left(\frac{n_0}{n_0} \frac{3n^2 - 5n^2}{n_0} \right)$
1-0 X = 16° 121 2 = 73) 1°
1EI X 2 58°
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$f(x) = \frac{1}{2} \int_{-\infty}^{\infty} x - \frac{1}{2} \int_{-\infty}^{\infty} $
$f(0) = \frac{1}{2} - 1 - x^{-1}$ $= \frac{2x - x - 1}{x^{2}}$ $= -(x^{-1}x - 1)$ $= -(x^{-1}x - 1)$ $= \frac{2x - x - 1}{x^{2}}$ which to regard to find value of $x = 1$ and $x = 1$. Concady be one given
$\frac{1}{ x } = \frac{1}{2x} - 1 - x$ $= \frac{1}{2x^{-2x-1}}$ $= -(x^{-2x-1})$ $= -(x^{-1})$ which is regarded for all values of $x = x > 0$ energy $x = 1$ for only the one gives
$\frac{1}{ x } = \frac{1}{2x} - 1 - x$ $= \frac{1}{2x^{-2x-1}}$ $= -(x^{-2x-1})$ $= -(x^{-1})$ which is negative for all values of $x = 1$ are given and $x = 1$. Consulty the cost $x = 1$.
$\frac{1}{(x)} = \frac{1}{2x} - 1 - x$ $= \frac{2x - x^2 - 1}{x^2}$ $= -(x - 3x)$
$\frac{1}{(x)} = \frac{1}{2x} - 1 - x$ $= \frac{2x - x^2 - 1}{x^2}$ $= -(x - 3x)$
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$= -(x^{-1})^{\frac{1}{2}}$ $= -(x^{-1})^{\frac{1}{2}}$ which is regarded for all values of $x > 0$ energy $x = 1$ for only be one given
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5(1) >0 for all x >0 x d/

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Q8 c)	i) (c-d).
	$g(z) = z^{-1}$
	g(x) = x'-1
	$= \frac{2}{2^{(1)}} \cdot \frac{1}{2} \left(\frac{1}{2} \ln n \right)$
	$= \frac{1}{2} \left[\frac{1}{2} \left(\frac{1}{2} \right) + \frac{2}{2} \frac{1}{2} \right]$
	= [[] + x(0)]
for 04	. ⊃i < ⊃i ~ < ♡
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	- 2(A) < 2
	$a(b) \leq \frac{1}{4}$
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