



# SYDNEY BOYS HIGH SCHOOL

## 4 UNIT MATHEMATICS

### 1997 TRIAL HSC EXAMINATION

Time allowed: 3 hours (plus 5 minutes Reading Time)

Total Marks: 120

Examiner: C. Kourtesis

#### INSTRUCTIONS:

- Attempt *all* questions.
- *All* questions are of equal value.
- All necessary working should be shown in every question. Full marks may not be awarded if work is careless or badly arranged.
- Standard integrals are provided. Approved calculators may be used.
- *Each* question attempted is to be returned in a *separate* Writing Booklet clearly marked Question 1, Question 2 etc. on the cover. Each booklet must show your name.
- If required, additional Writing Booklets may be obtained from the Examination Supervisor upon request.
- This is a trial paper and does not necessarily reflect the format or content of the HSC examination for this subject.

Question 1 (15 marks)

(i)  $\int \frac{t^2 - 2}{t^3} dt$

2 (ii)  $\int xe^x dx$

3 (iii)  $\int \frac{2x dx}{(x+1)(x+3)}$

3 (b) By using the substitution  $u = x - 4$  evaluate

$$\int_4^{\dots} \frac{dx}{(x-3)(5-x)}$$

$\pi/2$

$$u_n = n\left(\frac{\pi}{2}\right)^{n-1} - n(n-1) u_{n-2}$$

2 (ii) Hence evaluate

$$\int_0^{\pi/2} x^2 \sin x dx.$$

Question 2 (15 marks)

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(a) The complex number  $w$  is given by  $w = -1 + \sqrt{3}i$

- 2 (i) Show that  $w^2 = 2\bar{w}$
- 2 (ii) Evaluate  $|w|$  and  $\arg w$ .
- 1 (iii) Show that  $w$  is a root of  $w^3 - 8 = 0$

(b) Sketch the locus of  $z$  satisfying:

2 (i)  $\operatorname{Re}(z) = |z|$

2 (ii)  $\operatorname{Im}(z) = 2 \operatorname{Re}(z) - 1$

3 (c) Given that  $a$  and  $b$  are real numbers and

$$\frac{a}{1+i} + \frac{b}{1+2i} = 1$$

find the values of  $a$  and  $b$ .

3 (d) The complex numbers  $z_1, z_2, z_3$  and  $z_4$  are represented in the complex plane by the points A, B, C and D respectively. Prove that:

If  $z_1 + z_3 = z_2 + z_4$  then ABCD is a parallelogram.

Question 3 (15 marks)

(a) The equation  $x^3 + bx^2 + x + 2 = 0$  where  $b$  is a real number has roots  $\alpha, \beta, \gamma$ .

2 (i) Obtain an expression in terms of  $b$  for

$$\alpha^2 + \beta^2 + \gamma^2$$

1 (ii) Hence determine the set of possible values of  $b$  if the roots of the above equation are all real.

2 (iii) Write down the equation whose roots are

$$2\alpha, 2\beta, 2\gamma$$

(c) If  $z$  represents a complex number such that

$$z^5 = 1 \text{ where } z \neq 1$$

2 (i) Deduce that  $z^2 + z + 1 + \frac{1}{z} + \frac{1}{z^2} = 0$

equation in (i) to a quadratic in  $x$ .

(iii) Hence deduce that

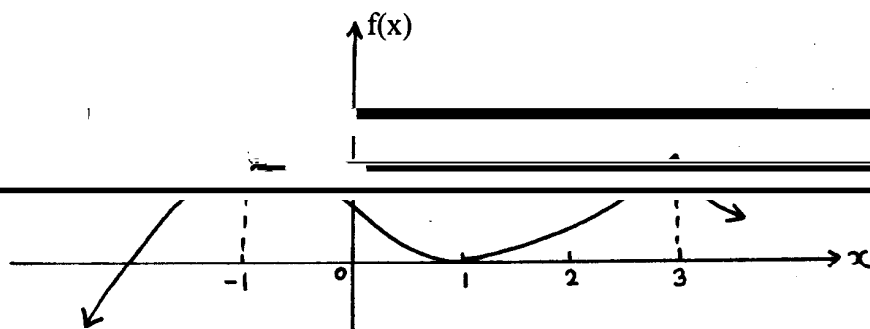
$$\cos \frac{2\pi}{5} \cos \frac{4\pi}{5} = -\frac{1}{4}$$

Question 4 (15 marks)

- 2 (ii) Hence or otherwise determine the values of  $x$  for which

$$\frac{1}{2}x + 1 \geq |1 - x|$$

- 3 (b)



The graph of the function  $f(x)$  is drawn above. Use this graph to sketch the graph of  $f'(x)$ , the derivative of  $f(x)$ .

You are given that there are turning points at  $x = -1$  and  $x = 1$ .

- 3 (c) (i) Show that the curve  $y = \frac{x^3 + 4}{x^2}$  has one stationary point but no point of inflexion and is always concave up.
- 2 (ii) Find the equations of any asymptotes.
- 1 (iii) Sketch the curve.
- 2 (iv) From the graph find the values of  $k$  for which the equation

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

has three distinct real roots.

Question 5 (15 marks)

- 3 (a) The plan of a steeple is bounded by the curve  $y = \frac{1}{|x|}$  and the lines  $y = 1$  and  $y = 4$ .



Each horizontal cross-section is a square.  
Find the volume of the steeple.

- 1 (b) (i) Sketch the graph of  $2y = y^2 - x + 1$

By summing volumes of cylindrical shells show that the volume  $V$  of the resulting solid is

$$V = \frac{8\pi}{3} \text{ units}^3$$

- 4 (c) How many different ways are there of seating 4 married couples at a circular table with men and women in alternate positions and no wife next to her husband?

(Two seating arrangements are the same if each person has the same left and right hand neighbours).

Question 6 (15 marks)

(a) The tangent to the parabola  $x^2 = 4ay$  at the point  $P(2at, at^2)$  where  $t$  is the parameter, meets the directrix at  $Q$ .  $M$  is the midpoint of  $PQ$ .

2 (i) Show that the equation of the tangent at  $P$  is

$$x = \frac{y}{t} + at$$

3 (ii) Find the co ordinates of  $Q$  and  $M$

4 (iii) Hence prove that as  $P$  moves on the parabola  $x^2 = 4ay$  the locus of  $M$  is

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(b) A diameter  $AB$  of a circle  $APB$  with centre  $O$  is produced to  $C$  so that  $AB = 2BC$ .

$CT$  is the perpendicular from  $C$  to the tangent at  $P$ .

1 (i) Draw a clear diagram of the above

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4 (iii) Prove that  $BP = BT$ .

where  $g$  is the acceleration due to gravity.

- 5 (ii) A projectile is fired horizontally with initial velocity  $V$  from a point  $O$  which is at the top of a cliff so as to hit a fixed target in the water and it is observed that the time of flight is  $T$ . The target can also be hit by firing a projectile with initial velocity  $V$  at an angle  $\theta$  above the horizontal.  
(Air resistance is neglected for both cases).  
Show that the distance of the target from the point at sea-level vertically below  $O$  is given by

$$\frac{1}{2} g T^2 \tan^2 \theta$$

- (b) A particle of unit mass moves in a straight line under the action of a constant driving force  $F$ . It encounters a resistive force  $kv$  per unit mass where  $v$  is its speed and  $k$  is a positive constant.

(i) Write down the equation of motion.

(ii) Prove that if the speed increases from  $u$  to  $2u$  over a time interval

(iii) Find the distance moved in this time interval

2 (ii) Hence, or otherwise if  $a \neq b = 1$  prove that

$$a^2 + b^2 \geq \frac{1}{2}$$

2 (b) If  $a > b > 0$  prove that

$$4b < (\sqrt{a} + \sqrt{b})^2 < 4a$$

3 (c)  $P(x)$  is a polynomial of degree  $n$  with rational coefficients. If the leading

$$P'(x) = \frac{P(x)}{(x-\alpha_1)} + \frac{P(x)}{(x-\alpha_2)} + \dots + \frac{P(x)}{(x-\alpha_n)}$$

(d) If for  $1 \leq x \leq n$ ,  $f(x) \geq 0$  and  $f''(x) < 0$ , show, by comparing the area under the curve  $y = f(x)$  between  $x = 1$  and  $x = n$  with the area of a region consisting of a suitably chosen sequence of trapezia, that

$$\int_1^n f(x) dx > \frac{f(1) + f(n)}{2} (n-1)$$

5 (ii) If  $f(x) = \log_e x$  deduce that for  $n$  a positive integer

$$n! < n^{n+1/2} e^{1-n}$$