

### Calculator Free Section

1. [6 marks]

Points **A** and **B** have position vectors  $\begin{pmatrix} 2 \\ 3 \\ -1 \end{pmatrix}$  and  $\begin{pmatrix} -1 \\ 15 \\ 5 \end{pmatrix}$  respectively.

Find the point **C** such that  $\mathbf{AB} : \mathbf{AC} = 3 : 5$ .

**2. [12 marks]**

For each of the following functions, find  $\frac{dy}{dx}$ .

(a)  $y = 2^{x^2} \cdot e^{\cos x}$

[4]

(b)  $y = \sqrt{\cos(\sin^2 x)}$

[4]

(c)  $\ln y = \frac{x}{x^2 + 1}$

**3. [5 marks]**

Use de Moivre's rule to determine the exact value of  $(1 + i)^5 - (1 - i)^5$ .

**4. [4 marks]**

For each of the following statements, circle either True or False.

If a statement is true, prove that it is true, showing your reasoning clearly.

If a statement is false, either explain why it is false, or provide an example to show the statement is false.

- (a) The vector  $\mathbf{c} = -2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$  is perpendicular to both the vectors  $\mathbf{a} = -2\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}$  and  $\mathbf{b} = \mathbf{i} - 3\mathbf{j} - 7\mathbf{k}$ .

**TRUE / FALSE**

[2]

- (b) If the matrices  $MN$  and  $NM$  are both defined, then the size of the matrices  $MN$  and  $NM$  is the same as the size of matrix  $M$  or matrix  $N$ .

**TRUE / FALSE**

[2]

5. [5 marks]

Evaluate the following limits, showing full reasoning.

(a) 
$$\lim_{x \rightarrow 0} \left( \frac{\sin\left(\frac{\pi}{2} + x\right) - 1}{x} \right)$$

[2]

(b) 
$$\lim_{\theta \rightarrow 0} \frac{x\sqrt{12}}{\sin 3x}$$

[3]

**6. [5 marks]**

In triangle  $ABC$ , point  $D$  is on  $BC$  such that  $AD$  is perpendicular to  $BC$  and  $|DB| = |DC|$ .

Prove that triangle  $ABC$  is an isosceles triangle.

7. [3 marks]

There are four types of predators on the island that take chicks from the nest; cats, rats, lizards and gulls. The matrix  $P$  shows the proportion of chicks lost each day to each type of predator at each site.

$$P = \begin{bmatrix} 0.015 & 0.01 & 0.005 & 0.018 \\ \text{cats} & \text{rats} & \text{lizards} & \text{gulls} \end{bmatrix}$$

The number of chicks at each nesting sites A, B and C in 2006 is given by the matrix

$$C = \begin{bmatrix} 10000 \\ 6500 \\ 9750 \end{bmatrix}$$

- (a) Which of the matrix products  $PC$  or  $CP$  is defined? Explain why.

[1]

- (b) (i) Form the matrix product that is defined and call it  $R$ .

- (ii) Explain the meaning of the information that matrix  $R$  contains.

[2]



### Calculator Assumed Section

1. [6 marks]

Determine the equation of the plane which passes through **A**  $\langle 3, 2, 6 \rangle$ , **B**  $\langle 1, -3, 10 \rangle$  and **C**  $\langle 10, 0, 5 \rangle$ .

**2. [6 marks]**

A plane passes through the point **A**  $(2, -3, 4)$  and has a normal vector of  $\begin{pmatrix} -1 \\ 5 \\ 3 \end{pmatrix}$ .

A line passes through **B**  $(16, -17, -8)$  and is parallel to the vector  $\begin{pmatrix} -2 \\ 3 \\ 1 \end{pmatrix}$ .

Determine where the line and plane intersect.

**3. [12 marks]**

Let  $W = \begin{bmatrix} d-2 & -3 \\ -1 & d \end{bmatrix}$ ,  $X = \begin{bmatrix} 2 \\ 3 \end{bmatrix}$ ,  $Y = \begin{bmatrix} -1 & -4 \end{bmatrix}$  and  $Z = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix}$ .

- (a) Evaluate each of the following where possible. If not possible, state this clearly and indicate the reason for your decision.

(i)  $WX$

[2]

(ii)  $2Y + Z$

[2]

- (b) Determine  $W^{-1}$ , stating all the necessary restrictions on  $d$  so that  $W^{-1}$  exists.

[4]

- (c) Determine the matrix  $M$  which satisfies the equation:

$$MZ - \frac{1}{4}M = 2I$$

where  $I$  is the  $2 \times 2$  identity matrix.

**4. [10 marks]**

ABCD is a parallelogram with points E and F such that  $AE : EB = 1 : 2$  and  $BF : FC = 1 : 3$ . G is the point where AF and ED intersect.

Let  $AB = \mathbf{a}$  and  $AD = \mathbf{d}$ .

Determine in what ratios AF and ED intersect each other.

**5. [6 marks]**

Use the method of proof by exhaustion to prove that every integer which is a perfect cube is either a multiple of 9, or 1 more, or 1 less than a multiple of 9.

**6. [5 marks]**

- (a) Convert  $z = 6 \operatorname{cis} \left( \frac{2\pi}{3} \right)$  to exact rectangular form.

[1]

- (c) If  $w$  and  $z$  are both complex numbers, show that  $\frac{z}{w} = \frac{\overline{z \overline{w}}}{|w|^2}$ .

[4]

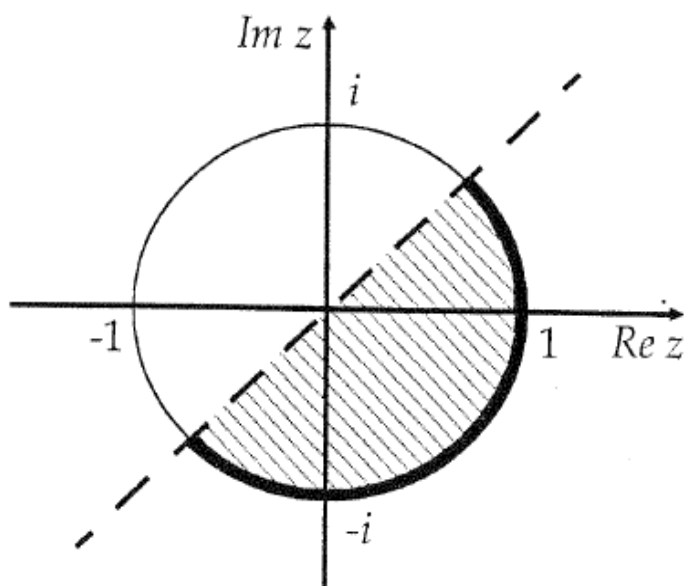
7. [5 marks]

Determine the equation of the tangent to the curve defined by  $y^3 + 2xy = 9$  at the point P whose coordinates are (4, 1).



8. [7 marks]

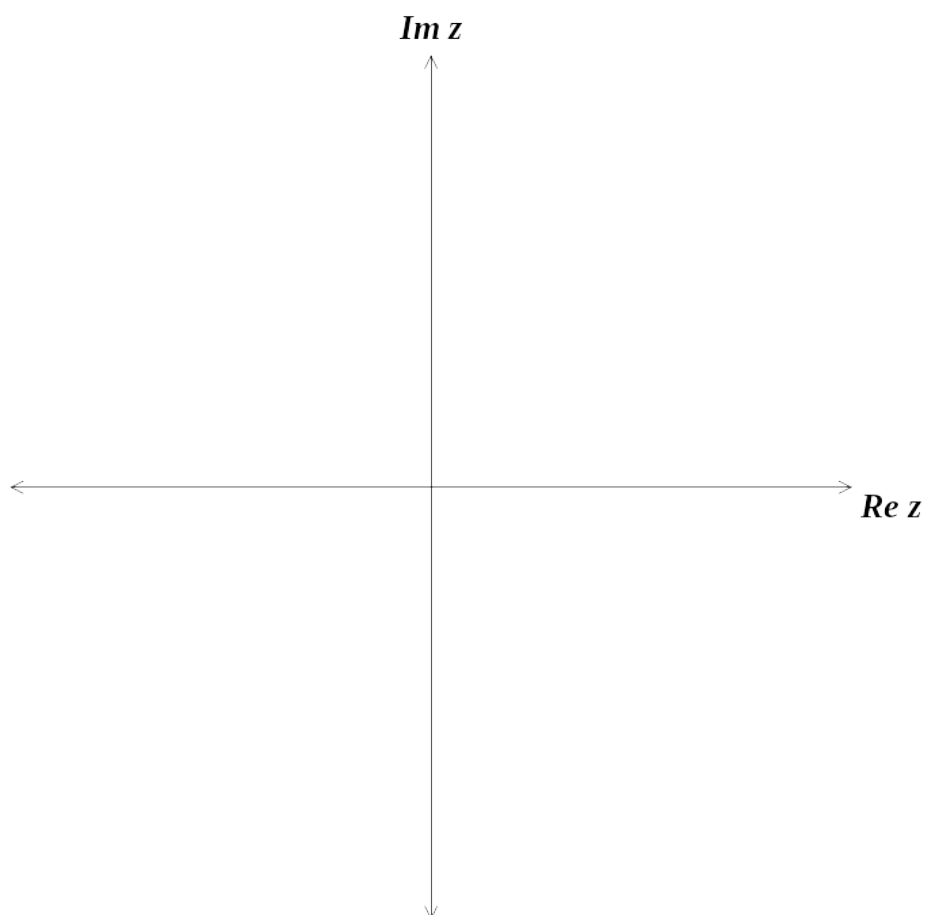
- (a) Write down the inequalities on the modulus and argument of the complex number  $z$  such that together they describe the set of points shaded below.



[3]

- (b) On the Argand plane provided, indicate the region defined by:

$$\{z : 3 \leq |z - 4i| \leq 4\} \cap \{z : -\frac{\pi}{4} \leq \text{Arg}(z - 4i) \leq \frac{\pi}{4}\}$$



[4]

**9. [10 marks]**

Two fighter jets are on a practice flight. At time  $t = 0$  seconds, Jet A is at position  $\begin{pmatrix} 4 \\ -5 \\ 6 \end{pmatrix}$  km

and jet B is at position  $\begin{pmatrix} 3 \\ 7 \\ -2 \end{pmatrix}$  km. Jet A is flying at a velocity of  $\begin{pmatrix} 200 \\ 350 \\ 450 \end{pmatrix}$  m/s while jet B has a

velocity of  $\begin{pmatrix} -300 \\ -450 \\ 250 \end{pmatrix}$  m/s.

(a) At what time are the two jets closest to each other?

- (b) Calculate the shortest distance between the two jets.

[4]

**10. [9 marks]**

A ladder 13 metres long rests against a vertical wall. If the bottom of the ladder slides away from the wall at the rate of 0.5 m/sec, and the bottom of the ladder is 5 feet from the wall,

- (a) how fast is the top of the ladder sliding down the wall?

[5]

- (b) at what rate is the angle between the ladder and the ground changing?

[4]

**11. [4 marks]**

The system of equations

$$2x + y + 7z = 9556$$

$$3x + y + 4z = 5899$$

$$5x + 2y + z = 3155$$

can be used to estimate the number of cats ( $x$ ), rats ( $y$ ), and lizards ( $z$ ), on an island used as a nature reserve.

- (a) Write this system of simultaneous linear equations in matrix form.

[1]

- (b) Write down the inverse matrix that can be used to solve this system of simultaneous linear equations.

[1]

- (c) Solve the system of simultaneous linear equations and hence estimate the number of cats, rats and lizards on the island.

[2]