

**Wednesday 25 May 2016 – Afternoon**

**PRINCIPAL LEARNING LEVEL 3  
ENGINEERING**

**F563/01** Mathematical Techniques and Applications for Engineers

Candidates answer on the Question Paper.

**OCR supplied materials:**

None

**Other materials required:**

- Scientific calculator

**Duration: 2 hours**



Candidate forename		Candidate surname	
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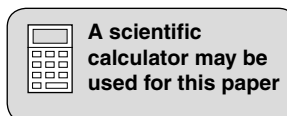
Centre number						Candidate number				
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**INSTRUCTIONS TO CANDIDATES**

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions in **Section A** and any **three** questions from **Section B**.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- This document consists of **16** pages. Any blank pages are indicated.



## SECTION A

Answer **all** questions in the spaces provided.

- 1 Remove the brackets and simplify the expression  $2x - (3x + 4) - 5x + 6$ .

.....  
 ..... [2]

- 2 Factorise the expression  $x^2 - 8x + 15$ .

.....  
 ..... [2]

- 3 Simplify the expression  $[(2x + 3)/4] - [(x - 5)/8]$ .

.....  
 .....  
 ..... [2]

- 4 Solve the equation  $3(4x - 5) = 6(7x - 2)$ .

.....  
 .....  
 ..... [2]

- 5 Using complementary angles, determine the value of  $\sin 40^\circ / \cos 50^\circ$ . Show all workings.

.....  
 .....  
 ..... [2]

- 6 In a triangle ABC, angle ABC is a right angle.

Calculate the length of side AB if angle BAC =  $40^\circ$  and side AC = 20 mm.

.....  
 .....  
 ..... [2]

7 Complete the table below.

$\theta$ radians	0	$\pi/4$	$\pi/2$	$3\pi/4$	$\pi$	$3\pi/2$	$2\pi$
$\cos \theta$							

[1]

Draw, on the grid in Fig. 1, a graph of  $y = \cos \theta$  using the information from the table.

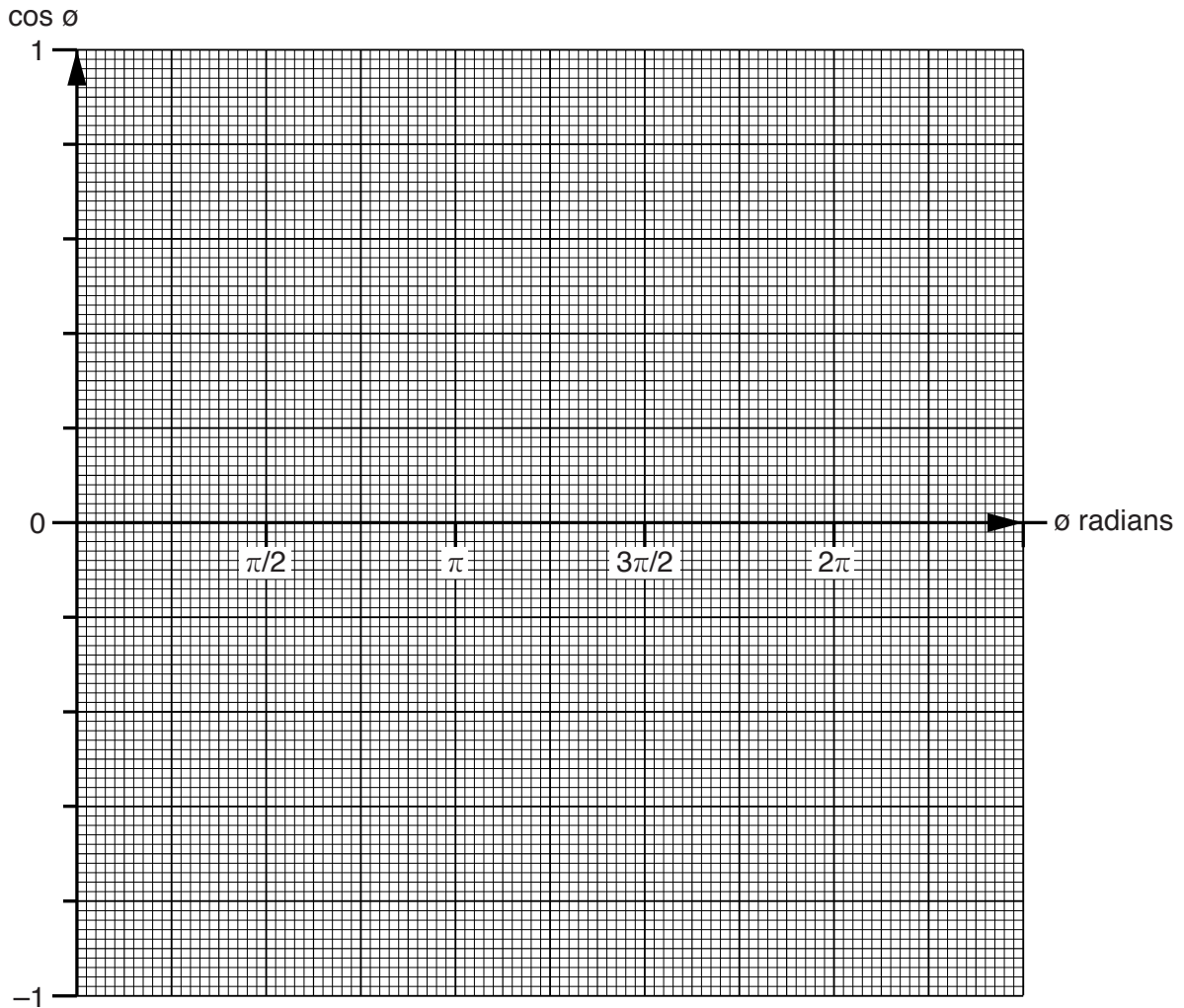


Fig. 1

[1]

8 A circle has a radius of 2 m. Calculate the angle subtended in radians by an arc of length 3.142 m.

.....

.....

..... [2]

9 Differentiate  $y = 3 \ln 2x$  with respect to  $x$ .

.....  
.....  
..... [2]

10 Differentiate  $y = 5 \sin 4x$  with respect to  $x$ .

.....  
.....  
..... [2]

11 Using integration, calculate the area between the straight line  $y = x$  and the  $x$  axis between the values  $x = 0$  and  $x = 5$ . Show all workings.

.....  
.....  
..... [2]

12 Integrate  $\sin x + \cos x$  with respect to  $x$ .

.....  
.....  
.....  
..... [2]

13 In a sample of 20 packages, the number of components per package was as follows.

Number of components in package	20	21	22	23
Number of packages	2	4	6	8

Draw a bar chart from the information in the table on the grid in Fig. 2.

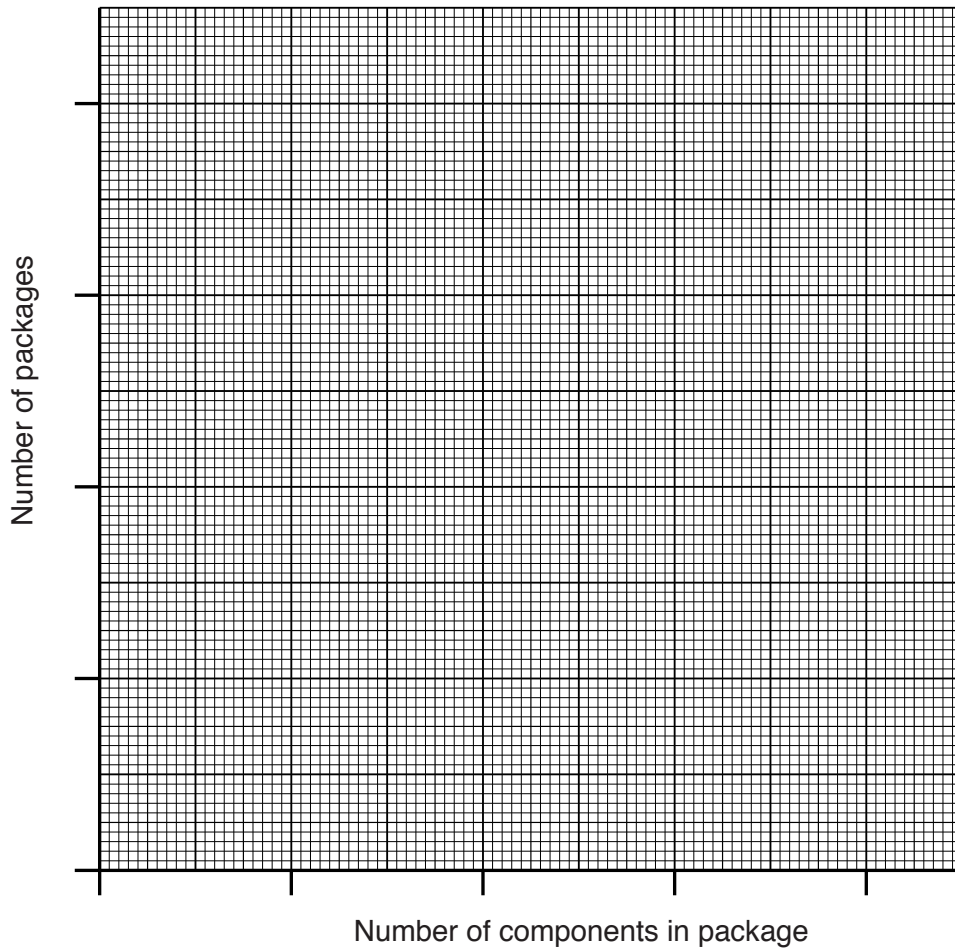


Fig. 2

[2]

14 Determine the mean of the following data to **two** decimal places.

-8°C 6°C 2°C -4°C 3°C 2°C

.....

..... [2]

15 Tick the right hand column to indicate which **two** situations describe independent events.

Situations	Independent events
Assume that a parcel contains components of different colours. Student 1 picks out a black component and keeps it. Student 2 picks out a green component at random.	
Student 1 throws a dice and scores a five. Student 2 throws the same dice and scores a two.	
Student 1 picks out a black card at random from a pack of cards and then replaces it. Student 2 then picks out a red card at random from the same pack.	
A student's car breaks down when driving to college. The student is late for his first lesson on the same day.	

[2]

**SECTION B**

Answer any **three** questions in the spaces provided.

- 1 (a) The general gas law states  $(P_1V_1)/T_1 = (P_2V_2)/T_2$ .

Transpose the formula to make  $T_2$  the subject.

.....  
.....  
..... [2]

- (b) The coefficient of restitution  $e$  is given by the formula  $e = (V_2 - V_1)/(U_1 - U_2)$ .

Transpose the formula to make  $U_1$  the subject.

.....  
.....  
.....  
.....  
.....  
..... [3]

- (c) The mass  $m$  of an object is given by the formula  $m = m_0 / [\sqrt{1 - V^2 / C^2}]$ .

Transpose the formula to make  $V^2$  the subject.

.....  
.....  
.....  
.....  
.....  
..... [5]

**[Total: 10]**

2 The forces  $F_1$  and  $F_2$  acting on a bolt are resolved horizontally and vertically, giving the simultaneous equations shown:

$$\begin{aligned} 0.5F_1 - 1.2F_2 &= -13 \\ 0.8F_1 + 0.3F_2 &= 12.5 \end{aligned}$$

(a) Calculate the value of force  $F_1$ .

.....  
.....  
.....  
.....  
..... [3]

(b) Calculate the value of force  $F_2$ .

.....  
.....  
.....  
.....  
..... [3]

(c) Carry out a check to confirm that the values you have found for  $F_1$  and  $F_2$  are correct.

.....  
.....  
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.....  
.....  
.....  
..... [4]

[Total: 10]



3 The current  $i$  in an a.c. circuit at time  $t$  seconds is given by:

$$i = 50 \sin (100 \pi t + 0.3) \text{ amperes.}$$

(a) Calculate the value of the current when  $t = 0$ .

.....  
.....  
.....  
.....  
..... [2]

(b) Calculate the value of the current when  $t = 0.005$  seconds.

.....  
.....  
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..... [3]

(c) Calculate the time when the current first reaches 25 amperes.

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.....  
.....  
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..... [5]

[Total: 10]

- 4 (a) A ladder leans against the side of a building with its foot 1.5 m from the building.

The ladder is making an angle of  $75^\circ$  with the ground.

Calculate

- (i) the length of the ladder;

.....  
 ..... [2]

- (ii) the vertical distance between the ground and the top of the ladder.

.....  
 ..... [2]

- (b) Fig. 3 shows a mast CD standing on level ground.

The base of the mast, point C, is due north of point A and due west of point B.

The angle of elevation of the top of the tower as measured from A is  $x^\circ$  and from B is  $y^\circ$ .

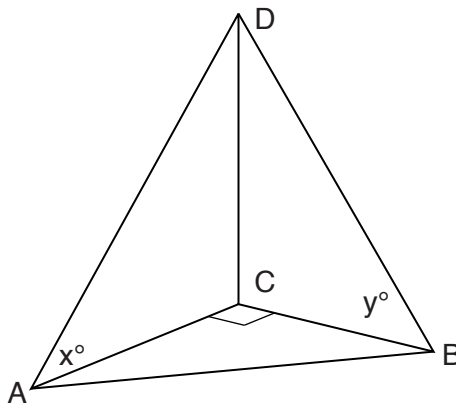


Fig. 3

Show that  $CD = AB/\sqrt{(\cot x)^2 + (\cot y)^2}$ .

.....  
 .....  
 .....  
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 ..... [6]

[Total: 10]

- 5 (a) A rigid beam 10m in length and supported at each end is carrying a uniformly distributed load.

The bending moment  $B$  newton metres, at a distance  $s$  metres from each end of the beam, is given by the equation  $B = 500s - 50s^2$ .

Calculate the rate of change of the bending moment  $B$  at a distance  $s$  of 4 metres from one end of the beam.

.....  
.....  
.....  
..... [3]

- (b) A cell is growing exponentially at the rate of  $C = C_0 e^t$  where  $C_0 = 20$  and  $t$  is the time in hours. Calculate the rate of growth of the cell after 4 hours.

.....  
.....  
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.....  
.....  
..... [3]

- (c) An alternating voltage is given by  $v = 40 \sin 150t$  where  $t$  is the time in seconds. Calculate the rate of change of voltage when  $t = 0.01$  seconds.

.....  
.....  
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..... [4]

[Total: 10]

6 A ball is released from a balloon which is rising at the rate of  $5 \text{ ms}^{-1}$ . The ball is released from a height of 200m. The velocity  $v$  of the ball  $t$  seconds after it is released is given by  $v = 5 - 10t \text{ ms}^{-1}$ .

Calculate

(a) the greatest distance above the ground reached by the ball;

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..... [4]

(b) the time for the ball to reach the ground after it had been released from the balloon;

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.....  
..... [3]

(c) the velocity of the ball when it reaches the ground.

.....  
.....  
..... [3]

[Total: 10]

7 (a) Fig. 4 shows eight numbered boxes which are placed in a container and shaken.

10	11	12	13	14	15	16	17
----	----	----	----	----	----	----	----

Fig. 4

One box is taken at random from the container.

Among the possible outcomes are:

- W: The number on the box is less than 13
- X: The number on the box is a multiple of 3
- Y: The number on the box is a prime number
- Z: The number on the box is 13.

(i) Tick which of the following outcomes are mutually exclusive.

- W and X
- W and Z
- X and Y
- Y and Z

[2]

(ii) Determine the probability of selecting a box numbered 10 or a box numbered 17.

.....  
 ..... [2]

(iii) Determine the probability of selecting a box with a prime number or a box which is a multiple of 4.

.....  
 ..... [2]

(b) The basic law for probability is

$$P(A \cup B) = P(A) + P(B) - P(A \cap B).$$

Write down what each part of the law means.

- $P(A \cup B)$  .....
- $P(A)$  .....
- $P(B)$  .....
- $P(A \cap B)$  .....

[4]

[Total: 10]

Turn over

8 Fig. 5 shows a set of probability distribution curves labelled A to D.

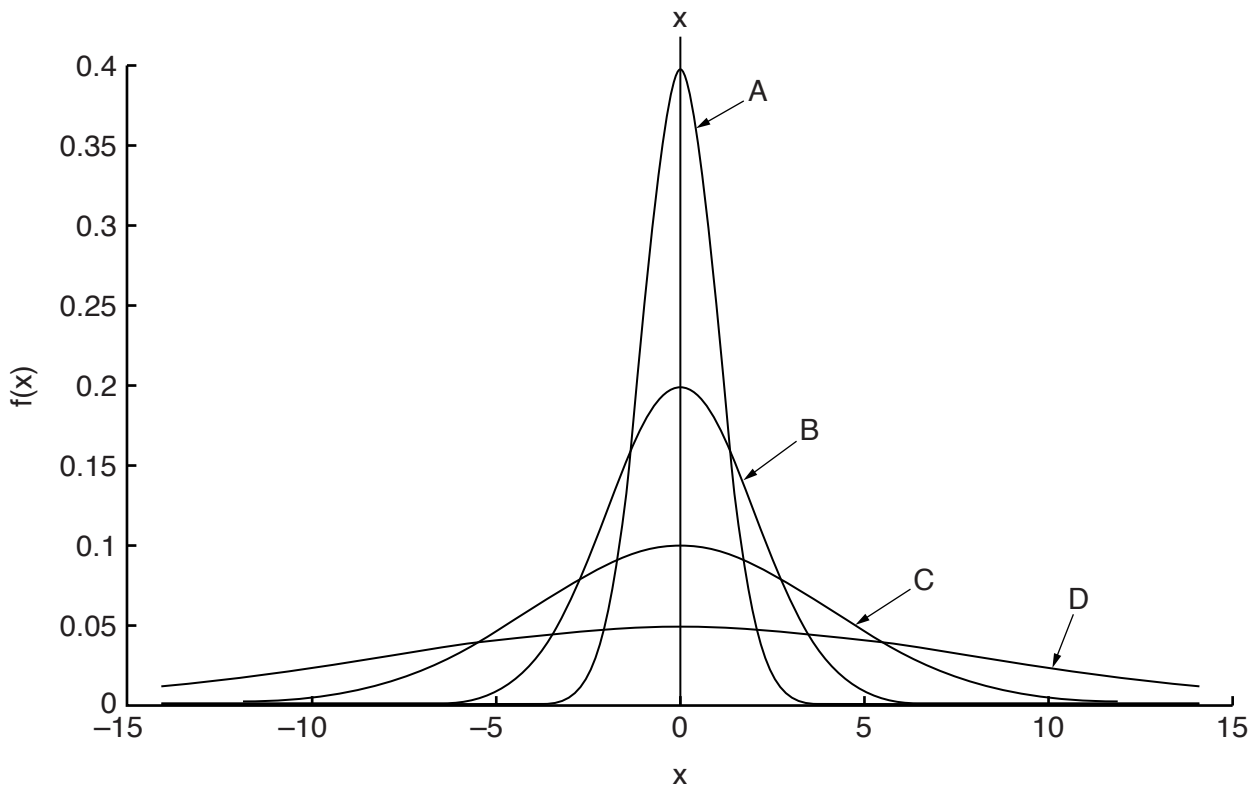


Fig. 5

- (a) (i) One name for this type of probability distribution curve is 'bell shaped'.  
 Give another name for this type of curve.  
 ..... [1]
- (ii) State the curve with the largest spread.  
 ..... [1]
- (iii) Explain what is meant by the term 'standard deviation'.  
 .....  
 .....  
 ..... [2]
- (iv) State the curve with the smallest standard deviation.  
 ..... [1]
- (v) State the curve with the largest standard deviation.  
 ..... [1]



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