OCR
Oxford Cambridge and RSA

Wednesday 25 May 2016 – Afternoon

LEVEL 3 CERTIFICATE
ENGINEERING

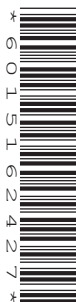**H865/01**   Mathematical Techniques and Applications for Engineers

Candidates answer on the Question Paper.	**Duration:** 2 hours
OCR supplied materials: None	
Other materials required: • Scientific calculator	

Candidate forename		Candidate surname	

Centre number					Candidate number				

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.

A scientific calculator may be used for this paper

OCR is an exempt Charity

Turn over

2

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

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.... **[2]**

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

....

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.... **[2]**

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

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.... **[2]**

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

Calculate the length of side AB if angle BAC = 40° and side AC = 20 mm.

....

....

.... **[2]**

3

7   Complete the table below.

ø radians	0	π/4	π/2	3π/4	π	3π/2	2π
cos ø							

[1]

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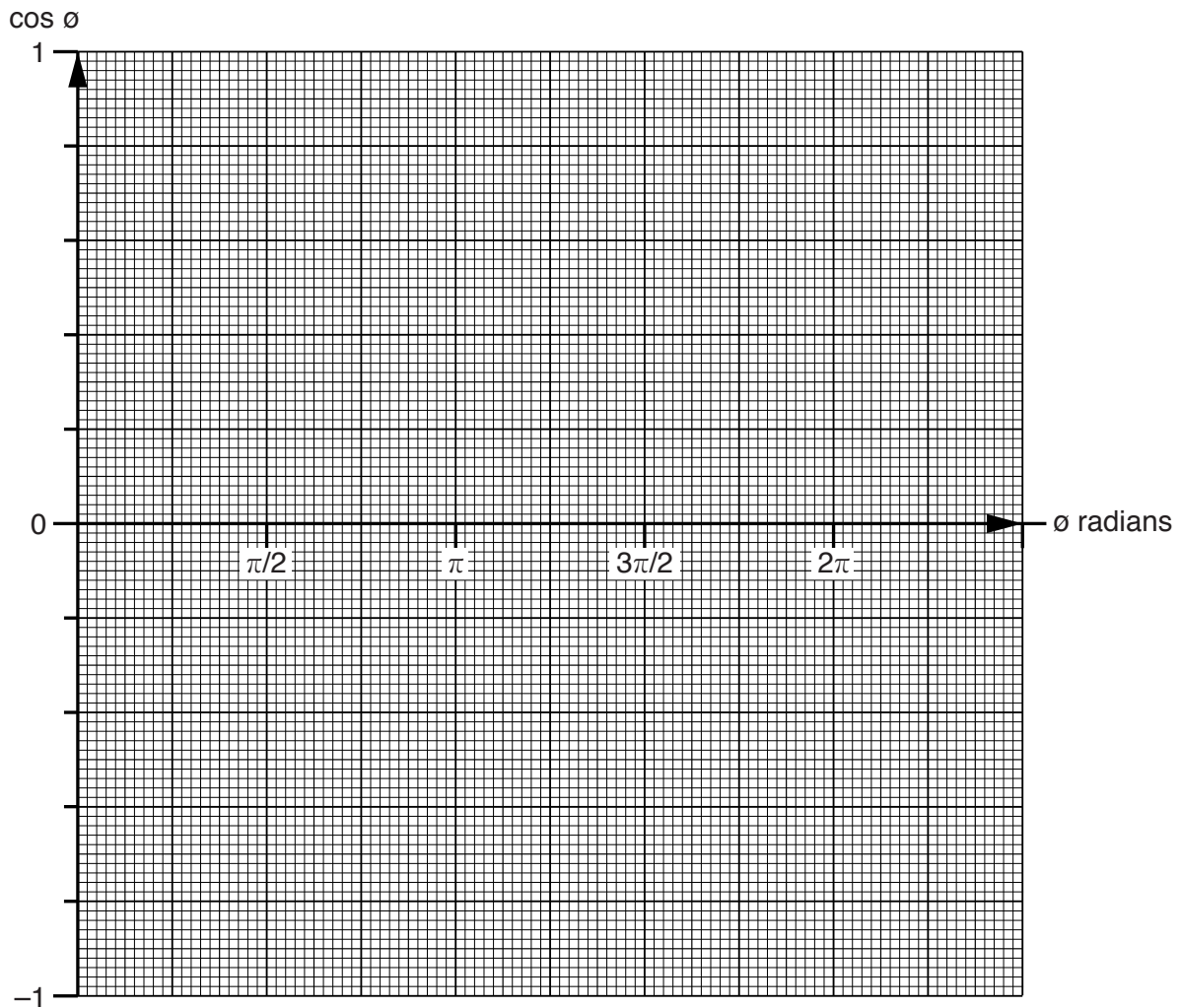
Fig. 1

[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]**

Turn over

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

....

....

.... **[2]**

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

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.... **[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.

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.... **[2]**

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

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.... **[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.

Number of packages

Number of components in package
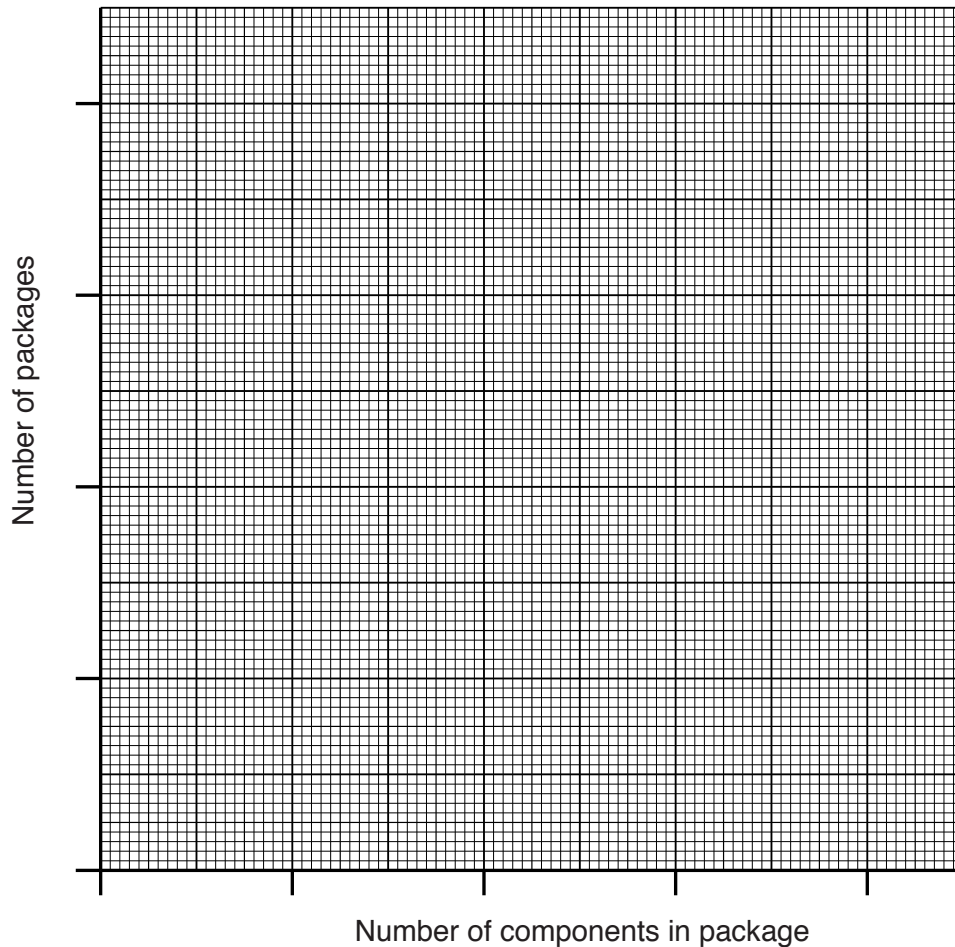
Fig. 2

[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]

Turn over

6

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]

7

SECTION B

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

1   **(a)**   The general gas law states $(P_1 V_1)/T_1 = (P_2 V_2)/T_2$.

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.

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.... **[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.

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.... **[5]**

[Total: 10]

Turn over

8

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

$$0.5F_1 - 1.2F_2 = -13$$
$$0.8F_1 + 0.3F_2 = 12.5$$

(a) Calculate the value of force F_1.

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....

.... **[3]**

(b) Calculate the value of force F_2.

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.... **[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]

9

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.

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.... **[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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.... **[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° with the ground.

Calculate

(i) the length of the ladder;

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.... **[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° and from B is y°.
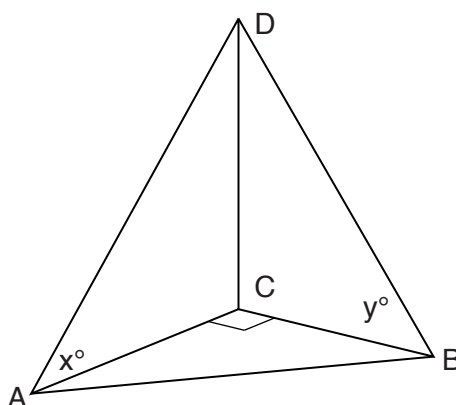
Fig. 3

Show that CD = AB/√[(cot x)^2 + (cot y)^2].

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.... **[6]**

[Total: 10]

5 (a) A rigid beam 10 m 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.

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.... **[3]**

(b) A cell is growing exponentially at the rate of $C = C_o e^t$ where $C_o = 20$ 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]

Turn over

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 $200\,\text{m}$. 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.

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.... **[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

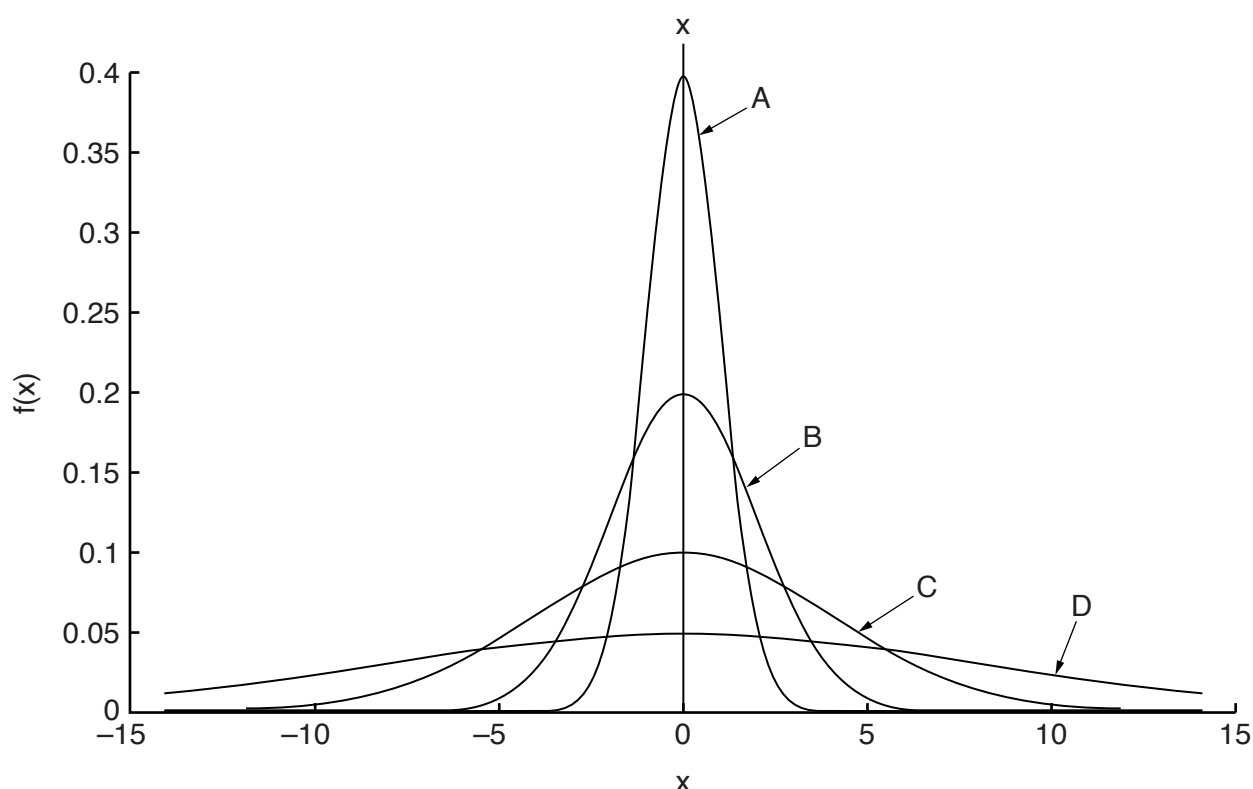8   Fig. 5 shows a set of probability distribution curves labelled A to D.

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'.

....

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.... **[2]**

(iv)   State the curve with the smallest standard deviation.

.... **[1]**

(v)   State the curve with the largest standard deviation.

.... **[1]**

(b) Calculate the mean and standard deviation for the following data.

6   7   9   13   11   8

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.... **[4]**

[Total: 10]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE

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