

**PRINCIPAL LEARNING  
LEVEL 3**

**ENGINEERING**

Mathematical techniques and applications for engineers

**F563**

**Tuesday 25 May 2010  
Afternoon**

**Duration: 2 hours**

Candidates answer on the Question Paper

**OCR Supplied Materials:**  
None

**Other Materials Required:**

- Scientific calculator



Candidate Forename		Candidate Surname	
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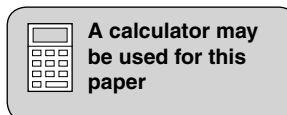
Centre Number						Candidate Number				
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**INSTRUCTIONS TO CANDIDATES**

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions in **Section A** and any **three** questions from **Section B**.
- Do **not** write in the bar codes.
- 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).

**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 **20** pages. Any blank pages are indicated.



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## Section A

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

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

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

- 2 Factorise the expression  $4x^2 + 14x - 6$ .

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

- 3 Simplify the expression  $(2x + 4)/3 - (x + 5)/6$ .

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

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

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

- 5 A chord of a circle of diameter 200mm subtends an angle of  $40^\circ$  at the centre. Calculate the length of the minor arc correct to 1 decimal place.

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

- 6 In a right-angled triangle ABC, angle C =  $46^\circ$  and length  $a = 125$  mm. If angle B is the right angle calculate the length  $c$  correct to 1 decimal place.

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

- 7 An alternating current is represented by  $i = 10 \sin \theta$ . Calculate, correct to 2 decimal place, the value of  $i$  when  $\theta = 60^\circ$ .

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

- 8 Calculate the area of a triangle ABC given  $b = 60$  mm,  $c = 100$  mm and angle  $A = 30^\circ$ .

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

- 9 Differentiate  $S = 6t^4 - 4t^3 + 2t^2$ .

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

- 10 Differentiate  $y = 2 \sin 3x + 4 \cos 5x$ .

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

- 11 Integrate  $8x^3 + 9x^2 + 12x$  with respect to  $x$ .

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

12 Find the area between the curve  $y = x^2$  and the  $x$  axis and between the values  $x = 0$  and  $x = 20$ .

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

13 Calculate the median point for the six given scores from a test paper.

15, 8, 9, 14, 12, 11.

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

14 A test on five variable resistors gave the following resistance readings:

15 ohms, 15.3 ohms, 15.6 ohms, 15.7 ohms and 15.9 ohms.

Calculate the arithmetic mean of the resistors.

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

15 A box contains two screwdrivers with red handles, three screwdrivers with yellow handles and five screwdrivers with green handles.

One screwdriver is taken out of the box and discarded. A second screwdriver is then taken out of the box.

If the first screwdriver had a green handle, what is the probability that the second screwdriver handle will also be green?

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

**Section B**

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

- 1 (a) Newton's law of cooling is given by  $x = x_0 e^{-kt}$ , where the temperature at zero time is  $x_0$  degrees Celsius and at  $t$  seconds is  $x$  degrees Celsius.

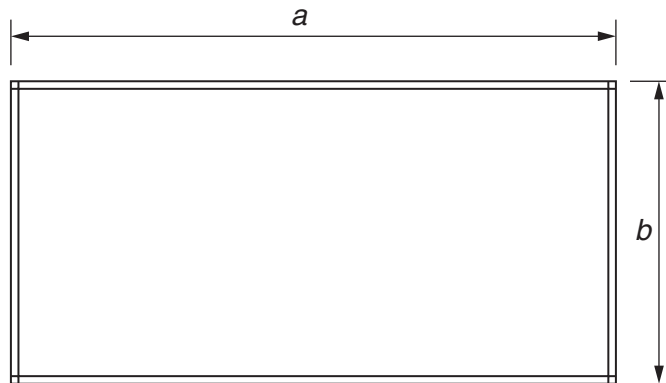
(i) Give the formula for the rate of change of temperature.

..... [1]

(ii) Calculate, correct to 3 decimal places, the rate of change of temperature after 40s given that  $x_0$  is 20°C and  $k = 0.04$ .

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

- (b) A container of rectangular cross-section is being designed to store components as shown in Fig. 1.



**Fig. 1**

Determine an expression for the cross-sectional area of the container in terms of dimension  $b$  when all four sides add up to an overall length of 240 mm.

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

(c) Calculate the maximum cross-sectional area of the container.

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..... [3]

[Total: 10]

- 2 (a) The gradient of a curve is given by the expression  $dy/dx = 4x - 3$ . Determine the equation of the curve.

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..... [3]

- (b) Integrate  $\sin 4x + 2 \cos 3x + \sqrt{x}$  with respect to  $x$ .

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..... [3]

- (c) A body moves in a straight line so that its velocity  $v$  metres per second after  $t$  seconds is given by  $v = 16t - 6t^2$ . Its initial distance from the origin is 30 m. Calculate its distance from the origin after 3s.

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..... [4]

[Total: 10]



- 3 A triangular prism OABC is being cut from a rectangular block by an oblique plane OAC as shown in Fig. 2.

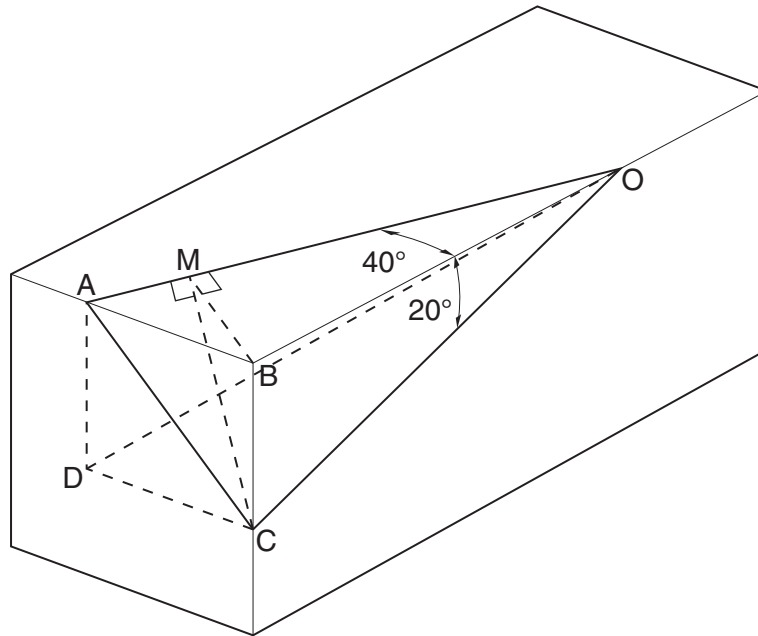


Fig. 2

- (a) (i) Give the formula for the length BM from the triangle OBM.

.....  
 ..... [1]

- (ii) Give the formula for the length BC from the triangle OBC.

.....  
 ..... [1]

- (b) Calculate, correct to 2 decimal places, the angle between the oblique plane OAC and the top surface of the block.

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

(c) (i) Give the formula for the length AB from the triangle OAB.

.....  
.....  
..... [1]

(ii) Calculate, correct to 2 decimal places, the angle COD where AD is perpendicular to the top face and CD is perpendicular to the front face of the block.

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..... [4]

[Total 10]

11  
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- 4 The path of a jet of water shown in Fig. 3 from a hose pipe at point A describes a parabola with an equation  $y = 0.8x - 0.02x^2$ , where  $y$  metres is the height of the water and  $x$  metres is the horizontal distance travelled.

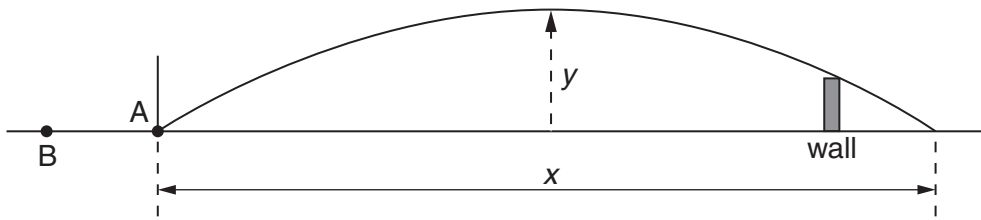


Fig. 3

- (a) Show that the water reaches a distance of 40m along the ground.

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.....

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..... [2]

- (b) Calculate the greatest height that the water achieves when it has travelled for half of its horizontal distance.

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..... [2]

- (c) The water just goes over a 3m high wall. Substitute  $y = 3$  m in the equation, and show that this can be arranged as  $2x^2 - 80x + 300 = 0$ .

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..... [2]

- (d) Calculate, correct to 2 decimal places, the distance of the wall from point A.

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..... [3]

- (e) The hose pipe is now moved from point A to point B. Calculate the distance that the hose pipe is moved.

.....  
..... [1]

[Total: 10]

- 5 (a) Draw, on the axes provided in Fig. 4 a normal distribution curve showing the position of the mean value.

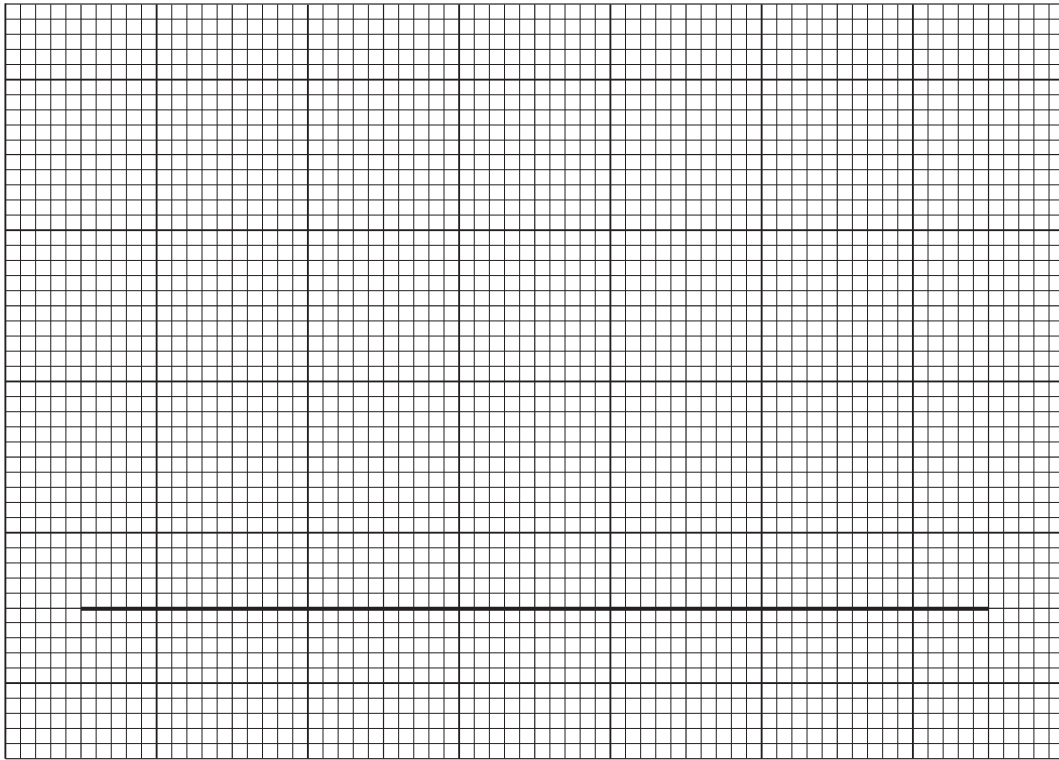


Fig. 4

[2]

- (b) State the percentage area under the normal curve bounded by

(i) one standard deviation on either side of the mean

.....

(ii) two standard deviations on either side of the mean.

..... [2]

- (c) The number of components per box in a sample of 63 boxes was as follows:

Number in box	35	36	37	38	39	40
Number of boxes	6	18	9	3	12	15

Draw, on the axes provided in Fig. 5 a histogram and a frequency polygon using the information provided in the table.

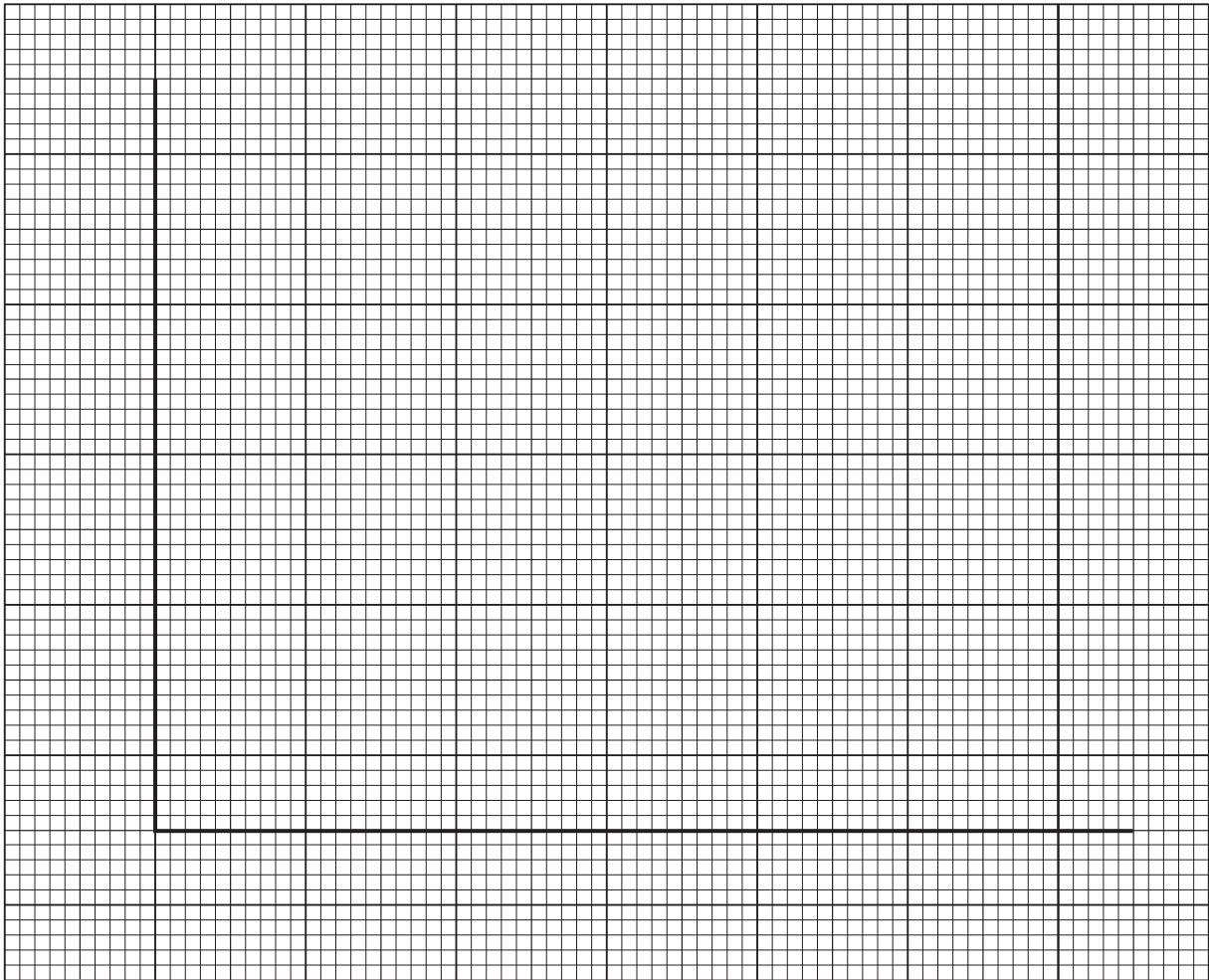


Fig. 5

[4]

(d) Explain how a frequency distribution can be changed to a cumulative frequency distribution.

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

[Total: 10]

6 (a) The equation  $S T^a f^b = c$  is used to find the expected life of a grinding tool where  $S$  is the cutting speed,  $T$  is the tool life in hours,  $f$  is the rate of feed and  $a$ ,  $b$  and  $c$  are constants.

(i) Transpose the equation to make  $T^a$  the subject.

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

(ii) Calculate, the tool life correct to 1 decimal place when  $S = 3$ ,  $a = 2$ ,  $b = 0.3$ ,  $c = 1900$  and  $f = 0.01$ .

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

(b) Solve the equation  $[(2x + 5)/(x - 3)] = [(6x + 4)/(3x - 1)]$ .

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

[Total: 10]



7 (a) The three sides of a triangle ABC have dimensions  $a = 125$  mm,  $b = 140$  mm and  $c = 230$  mm.

(i) State the cosine rule making  $\cos A$  the subject.

.....  
..... [1]

(ii) Determine, correct to 2 decimal places, the value of angle A.

.....  
.....  
..... [1]

(iii) Determine, correct to 2 decimal places, the values of angle B and C.

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..... [3]

(b) In a triangle ABC, angle  $A = 75^\circ$ , angle  $C = 50^\circ$  and side  $b = 150$  mm.

(i) Determine the value of angle B.

..... [1]

(ii) Calculate, correct to 2 decimal places, the length of side  $a$ .

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

(iii) Calculate, correct to 2 decimal places, the length of side  $c$ .

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..... [2]

[Total: 10]

8 The diagram in Fig. 6 shows the hobbies of a group of students.

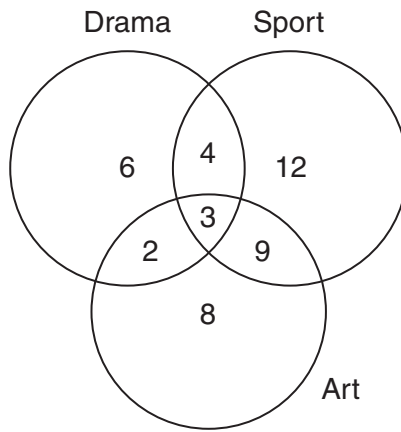


Fig. 6

(a) Calculate the total number of students.

.....  
 ..... [1]

(b) Calculate the total number of students.

(i) Whose hobbies **include** drama.

.....  
 ..... [1]

(ii) Whose only hobby is sport.

.....  
 ..... [1]

(c) State the number of students who study.

(i) Drama and Sport.

.....  
 ..... [1]

(ii) Sport and Art.

.....  
 ..... [1]

(iii) Sport, Drama and Art.

.....  
..... [1]

(d) A student is chosen at random.

(i) State the probability that the student studies both Drama and Art.

.....  
..... [1]

(ii) The student studies Drama. State the probability that the student also studies Art.

.....  
..... [1]

(iii) The student studies Sport. State the probability that the student also studies Drama.

.....  
..... [1]

(iv) The student studies both Drama and Art. State the probability that the student studies Drama, Art and Sport.

.....  
..... [1]

[Total: 10]

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