OCR
RECOGNISING ACHIEVEMENT

PRINCIPAL LEARNING
LEVEL 3

ENGINEERING

F563

Mathematical techniques and applications for engineers

Candidates answer on the question paper.

OCR supplied materials:
None

Other materials required:
- Scientific calculator

Thursday 26 May 2011
Afternoon

Duration: 2 hours

OCE/28614

F563

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. Pencil may be used for graphs and diagrams only.
- 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).
- Answer **all** the questions in **Section A** and any **three** questions from **Section B**.
- 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 calculator may be used for this paper

Section A

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

1 Remove the brackets and simplify $2a(3b - 4c)$.

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

2 Factorise the expression $x^2 - 10x + 25$.

.....

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

3 Simplify the expression $a/(b + c) + d/(c + b)$.

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

4 Solve the equation $4x + 8 = 2(5x + 6)$.

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

5 Determine, to the nearest degree, the angle subtended by a circular arc of length 40 mm on a circle of radius 100 mm.

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

6 If $\sin A = (7.82 \sin 33°)/6.93$, calculate, to the nearest degree, acute angle A.

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

7 From first principles show that $\sin 45° = 1/\sqrt{2}$

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

8 Find, correct to one decimal place, the area of a triangle whose sides are 40, 50 and 60 mm in length.

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

9 Differentiate $y = \cos x + \sin x$ with respect to x.

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

10 Differentiate $3x^2 + \ln(4x)$ with respect to x.

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

11 Integrate $12x^5 + 5x^4$ with respect to x.

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

12 Evaluate

$$\int_{2}^{4} (3x + 4)\, dx.$$

.....

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

13 Explain what is meant by the term 'relative frequency' with reference to a set of data values.

.....

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

14 A box contains 40 brass washers and 60 steel washers. Determine the probability of selecting at random

(a) a brass washer

.....

(b) a steel washer.

.....

[2]

15 Calculate the mean value for the data shown in the table below.

(a) .....

.....

.....

(b) Complete the table.

x	**x - mean**
3	
8	
10	
Total	

[2]

Section B

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

1 **(a)** The formula $\frac{1}{2}mv^2 = mgh + \frac{1}{2}mu^2$ is used in a system in which mechanical energy is conserved.

(i) Transpose the formula to make u the subject.

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

(ii) Calculate, to one decimal place, a value for u when $g = 9.8\,ms^{-2}$, $h = 25\,m$ and $v = 30\,ms^{-1}$.

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

(b) The total resistance R of two resistors connected in parallel is given by $1/R = 1/R_1 + 1/R_2$.

Transpose the formula to make R_2 the subject.

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

[Total: 10]

2 **(a)** In a calculation to find the reactions at the supports of a beam, the following equations were used.

$$P + Q = 36$$

$$15P = 3Q$$

Find the values of P and Q.

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

(b) The forces F_1 and F_2 acting on a bolt are resolved horizontally and vertically, giving the simultaneous equations shown below.

$$4F_1 - 2F_2 = 18$$

$$6F_1 - 14F_2 = 38$$

(i) Find the values of F_1 and F_2

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

(ii) Check that the values you have found for F_1 and F_2 are correct.

.....

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

[Total: 10]

3 A workplace operates on a 230 volt single phase 50 hertz supply and takes a load current of 40 amperes at 0.6 power factor lagging.

(a) The power factor needs to be changed to unity. Draw a phasor diagram to represent this situation.

[1]

(b) Calculate the angle at a power factor of 0.6 lagging.

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

(c) Calculate the current taken by the capacitor.

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

(d) Calculate the capacitive reactance.

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

(e) Calculate, correct to the nearest whole number, the value, in microfarads, of the capacitor.

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

[Total: 10]

4 **(a)** In a right-angled triangle PQR, angle P = 36° and length p = 105 mm.
Calculate, correct to one decimal place, the length of side r.

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.....

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

(b) An aerial mast AB, 4 m tall, as shown in Fig. 1, is erected on a roof sloping at 15° to the horizontal.

A support cable is fixed to the top of the mast at point A and to the roof at point C. The distance BC is 5 m.

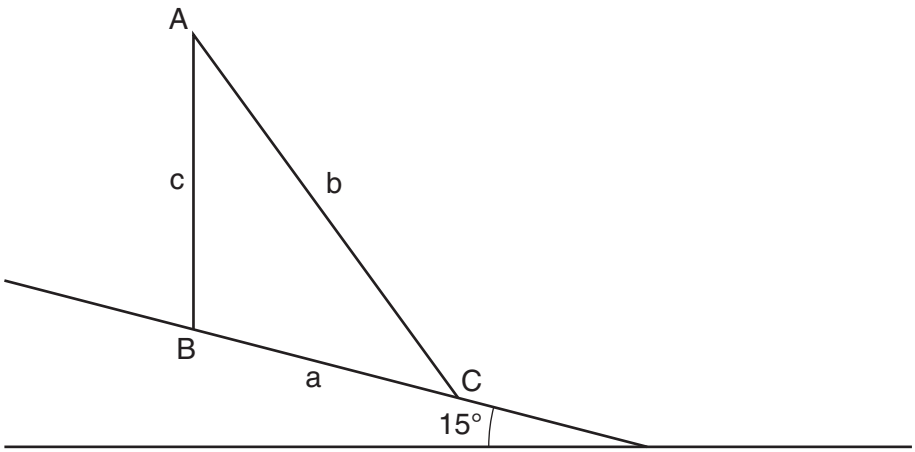

Fig. 1

Calculate:

(i) angle ABC.

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

(ii) to one decimal place, the length of the support cable AC.

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

(iii) to the nearest degree, the angle ACB.

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

[Total: 10]

5 The velocity v metres per second of an object between times t = 0 and t = 6 seconds is given by $v = -2t^2 + 4t + 3$.

(a) Complete the table below and then plot the velocity-time graph of the object on the axes provided in Fig. 2.

time (t) s	0	1	2	3	4	5	6
velocity (v) ms^{-1}							

[2]

Fig. 2

(b) Estimate, from your graph, correct to one decimal place, the time when the velocity is zero.

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

(c) Calculate, correct to one decimal place, the area above the curve and below the horizontal axis.

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

(d) The area below the curve and above the horizontal axis is 9.6.
Calculate the distance travelled from 0 to 6 seconds.

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

[Total: 10]

6 The angular displacement θ radians of the spoke of a wheel is given by $\theta = \sin 4t$ where t is the time in seconds.

Calculate, correct to two decimal places:

(a) the angular velocity after 2.5 seconds.

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

(b) the smallest positive value of time t for which the angular velocity is 3 radians per second.

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

(c) the angular acceleration after 2 seconds.

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

(d) the smallest positive value of time t for which the angular acceleration is $8\,\text{rad}\,\text{s}^{-2}$.

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

[Total: 10]

7 **(a)** State the addition law for probability and the multiplication law for probability, explaining the conditions under which each is valid.

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

(b) A box contains 64 round-head screws, 76 flat-head screws and 30 countersunk screws.

Determine, correct to three decimal places, the probability that there are two round-head screws and either a flat-head screw or a countersunk screw when three screws are drawn at random, without replacement.

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

[Total: 10]

8 **(a)** Two machines in a workshop are used to cut ribbon from a large roll. Each ribbon must be 900 mm long with a tolerance of ±2 mm. Each machine has been tested by taking a sample of 100 ribbons from its output. The results are shown in the table below.

Machine	mean length	variance
1	900	10
2	898	3

One of the machines is to be removed from the workshop.

State which machine should be removed giving reasons for your answer.

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

(b) The incomplete table below shows the distribution of the ages of machines in another workshop.

(i) Complete the table below. **[1]**

Age of machine (years)	frequency	cumulative frequency
2	4	
2.5	8	
3	14	
3.5	14	
4	5	
4.5	3	

(ii) Draw, on the axes provided, a cumulative frequency polygon for the readings given.

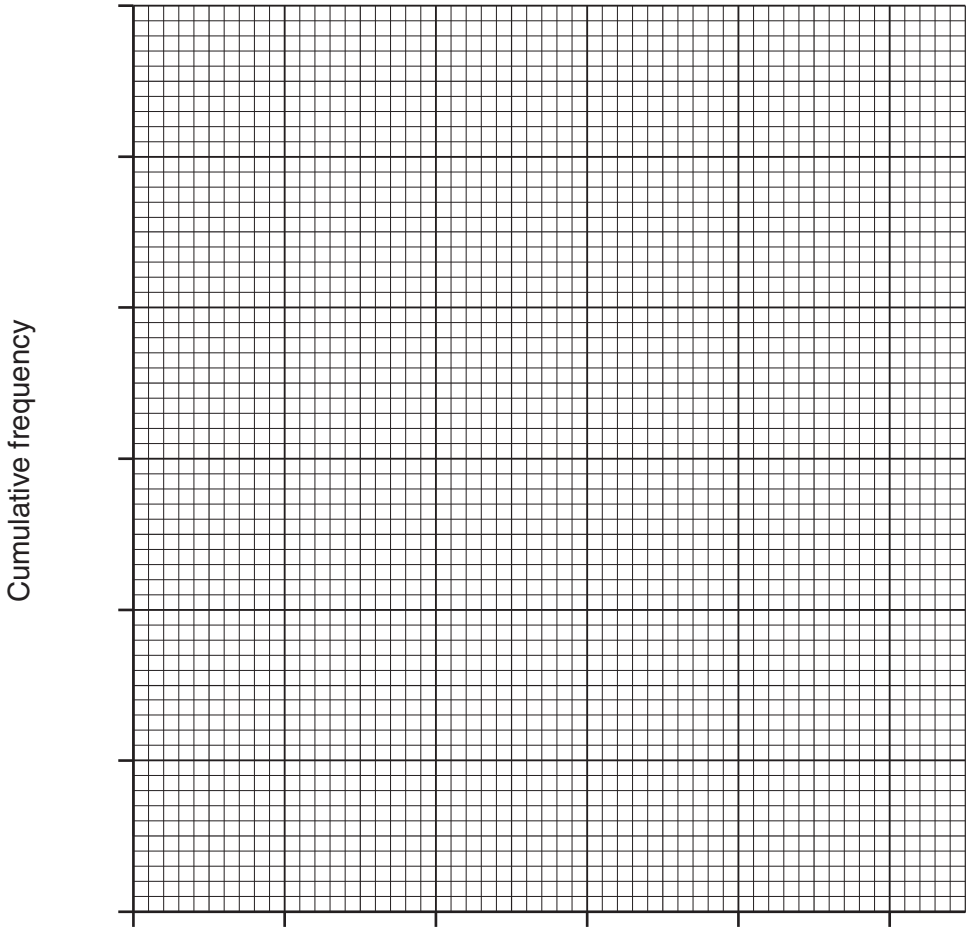

Fig. 3

[3]

(iii) Estimate the median age of the machines.

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

(iv) Estimate the lower and upper quartiles.

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

(v) Find the inter-quartile range.

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

[Total: 10]

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