

**PRINCIPAL LEARNING  
LEVEL 3**

**ENGINEERING**

Mathematical techniques and applications for engineers

**H865**

**Thursday 26 May 2011  
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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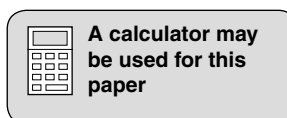
Centre number						Candidate number				
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**INSTRUCTIONS TO CANDIDATES**

- Write your name, 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.



## Section A

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

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

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

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

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

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

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

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

.....  
.....  
..... [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.

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

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

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

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

.....  
.....  
.....

[2]

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

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

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

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

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

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

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

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

12 Evaluate

$$\int_2^4 (3x + 4) dx.$$

.....

.....

..... [2]

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

.....

.....

..... [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.

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

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

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

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

Transpose the formula to make  $R_2$  the subject.

.....  
.....  
.....  
.....  
..... [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.

.....  
.....  
.....  
.....  
..... [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  $F_2$

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

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

.....  
.....  
..... [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.

(b) Calculate the angle at a power factor of 0.6 lagging. [1]

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

(c) Calculate the current taken by the capacitor. [3]

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

(d) Calculate the capacitive reactance. [2]

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

(e) Calculate, correct to the nearest whole number, the value, in microfarads, of the capacitor. [3]

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

[Total: 10]  
Turn over

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

.....

.....

.....

..... [3]

- (b) An aerial mast AB, 4 m tall, as shown in Fig. 1, is erected on a roof sloping at  $15^\circ$  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.

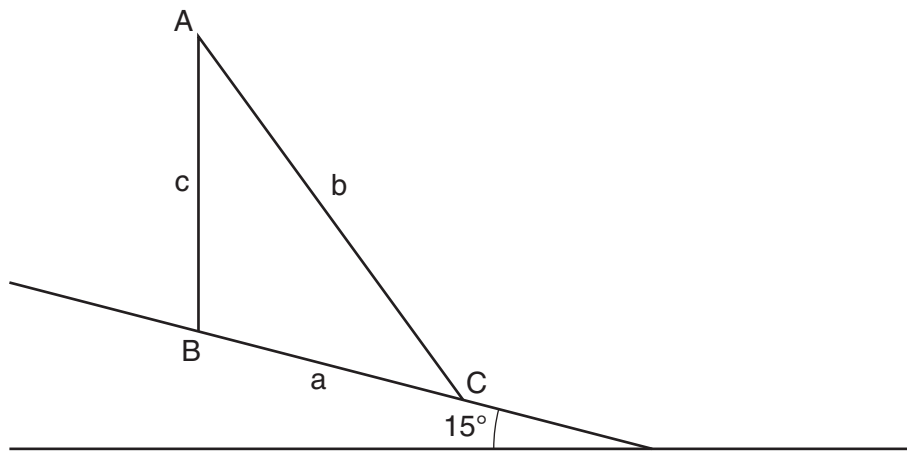


Fig. 1

Calculate:

- (i) angle ABC.

..... [1]

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

.....

.....

.....

.....

..... [3]



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

.....

.....

.....

..... [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) $\text{ms}^{-1}$							

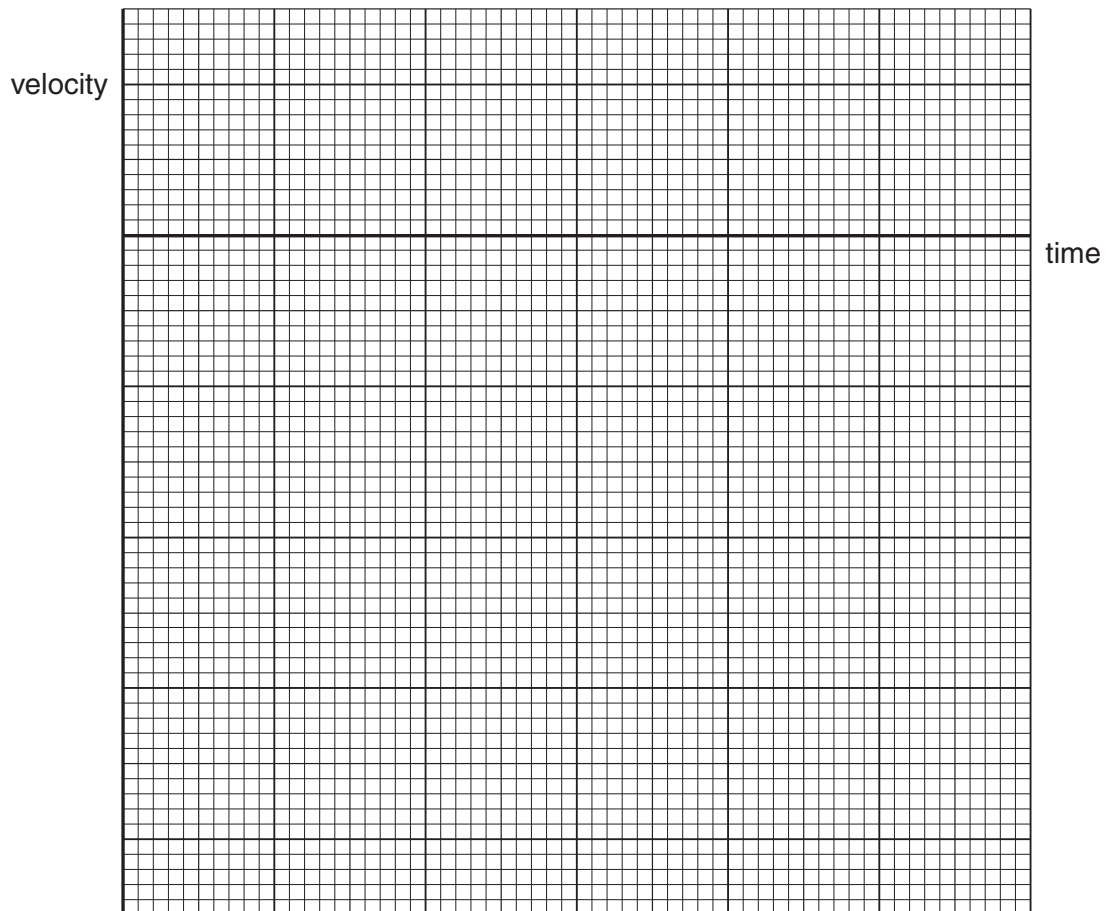


Fig. 2

[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  $\theta$  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.

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

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

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

- (c) the angular acceleration after 2 seconds.

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

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

.....  
.....  
.....  
.....  
..... [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  $\pm 2$  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.

.....

.....

.....

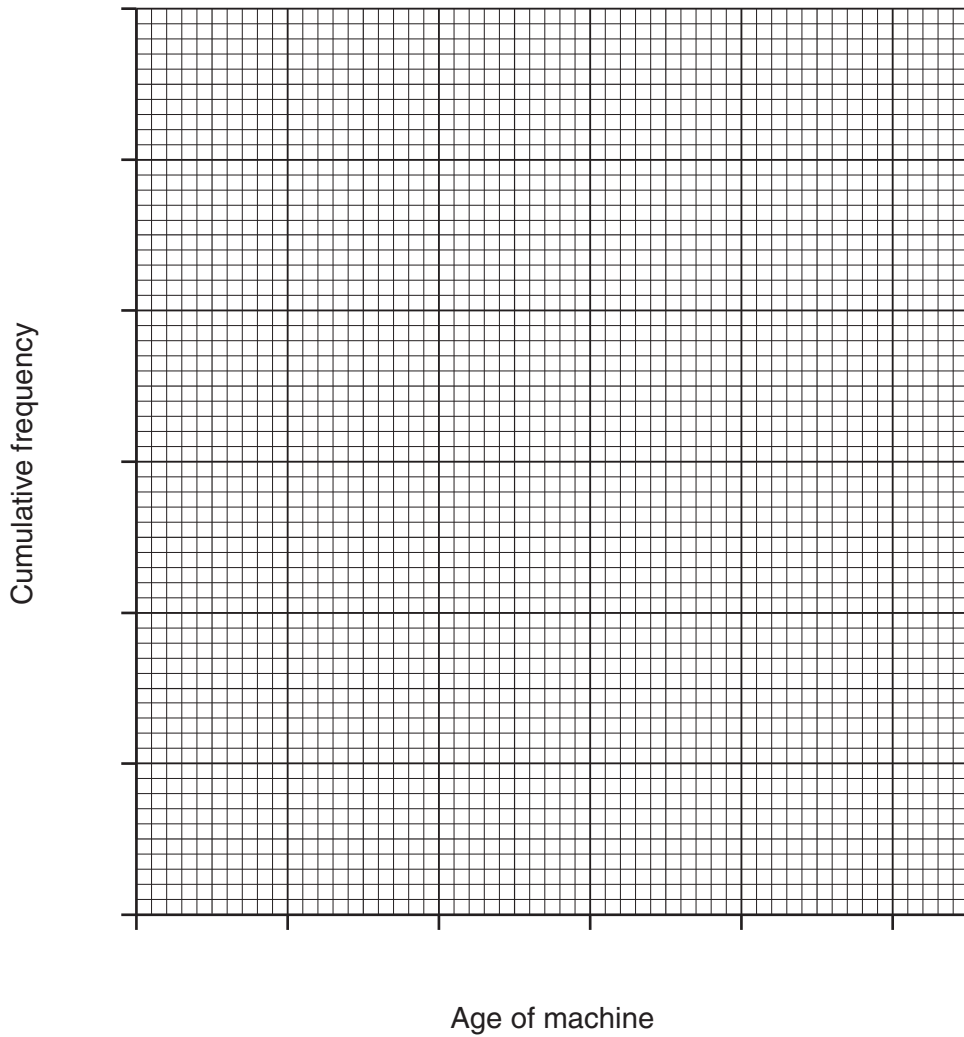
..... [2]

- (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.

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

(v) Find the inter-quartile range.

..... [1]

**[Total: 10]**

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