

**PRINCIPAL LEARNING  
LEVEL 3**

**ENGINEERING**

Mathematical techniques and applications for engineers

**H865**

**Tuesday 19 January 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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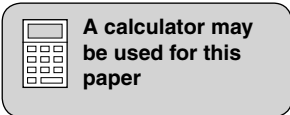
Centre Number						Candidate Number				
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**INSTRUCTIONS TO CANDIDATES**

- 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, however additional paper may be used if necessary.

**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.



## Section A

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

- 1 Remove the brackets and simplify  $(x - 5)(x - 2)$ .

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

- 2 Factorise the expression  $x^2 + 3x - 40$ .

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

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

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

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

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

- 5 Calculate, to the nearest degree, the angle of lap if 480 mm of a belt are in contact with a pulley of diameter 200 mm.

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

- 6 In a right angle triangle ABC, angle A =  $36^\circ$  and length  $a = 75$  mm. Calculate to 1 decimal place the length  $b$  if angle B is the right angle.

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

- 7 Draw, on the axes provided in Fig. 1 the curve  $y = \cos \theta$  for values of  $\theta$  from 0 to  $360^\circ$ .

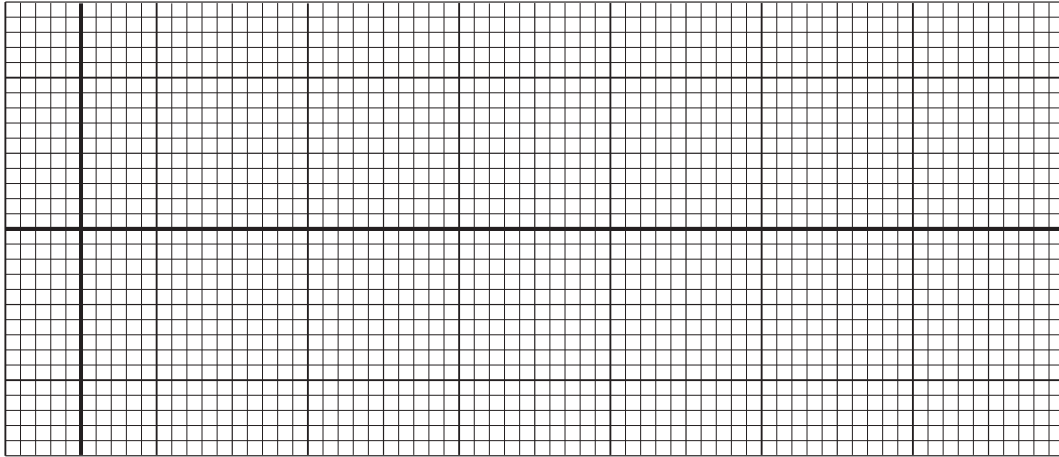


Fig. 1

[2]

- 8 Verify that ' $\sin^2 x + \cos^2 x = 1$ ' is true when  $x = 150^\circ$ .

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

- 9 Differentiate with respect to  $x$ ,  $y = 5x^4 - 4x^3$ .

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

10 Differentiate with respect to  $x$ ,  $y = 4e^x + \ln(2x)$

.....

.....

..... [2]

11 Integrate  $5x^4 + 8x^3 + 3x^2$  with respect to  $x$ .

.....

.....

..... [2]

12 Find the integral  $\int 8 \sin 4x \, dx$ .

.....

.....

..... [2]

13 A road safety officer records the speed of cars. The table below shows the speeds recorded and the volume of traffic.

Speed (s) km/h	30 to 35	35 to 40	40 to 45	45 to 50	50 to 55
Number of cars – frequency	6	13	18	15	8

Draw on the axes provided in Fig. 2 a histogram to show the speed of the cars.

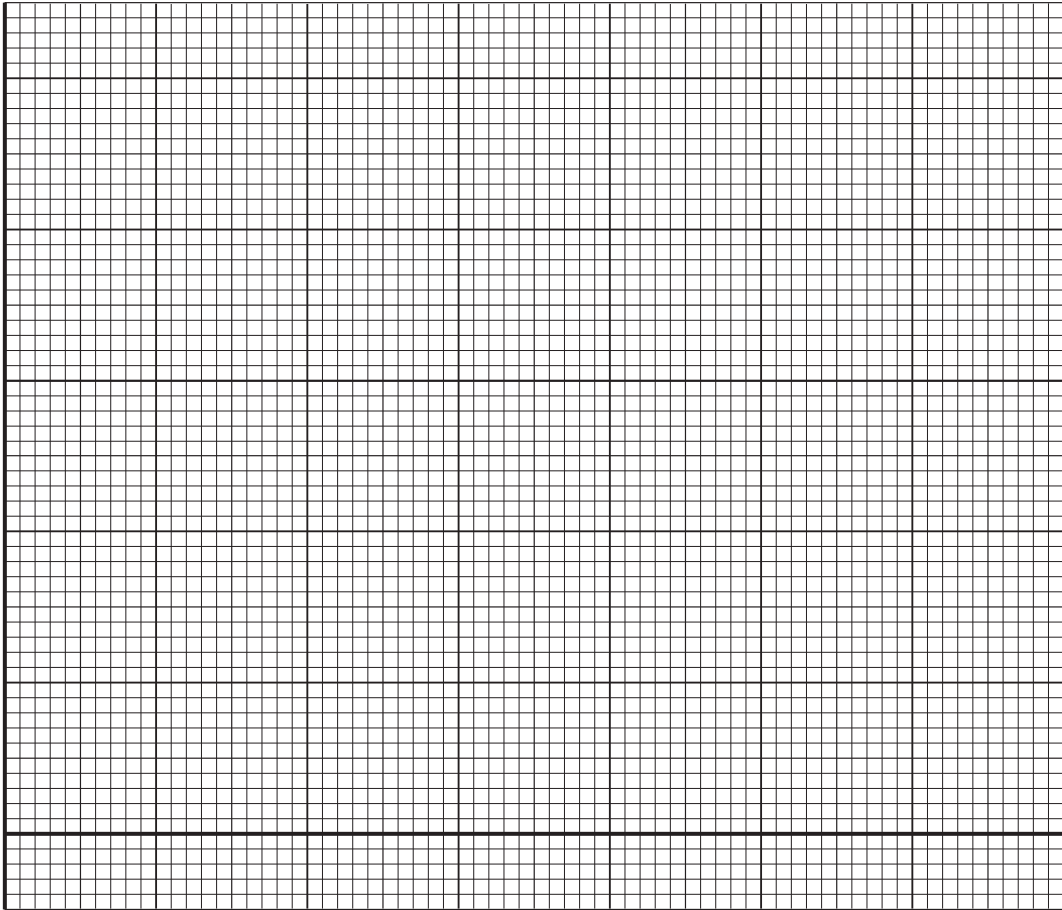


Fig. 2

[2]

- 14 Determine the mean, correct to 3 decimal places and the median point for the set of ungrouped data given below:

7, 11, 9, 14, 10, 12 and 8

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

- 15 The probability that a lathe is not being used in a workshop is  $\frac{1}{8}$ . State the probability that the lathe is being used. Give your answer as a fraction and a percentage.

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

Section B

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

- 1 (a) The period  $T$  seconds, of oscillation for a simple pendulum of length  $L$  is given by  $T = 2\pi \sqrt{L/g}$ .

Calculate, to 2 decimal places, the period  $T$  when  $L = 5$  m and  $g = 9.81 \text{ ms}^{-2}$ .

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

- (b) Transpose the formula  $T = 2\pi \sqrt{L/g}$  to make  $L$  the subject and calculate its value to 2 decimal places when  $T = 4$  s and  $g = 9.81 \text{ ms}^{-2}$ .

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

- (c) A carbon resistor has a resistance  $R_1$  of 100 ohms at a temperature  $t_1$  of  $30^\circ\text{C}$  and a resistance  $R_2$  of 98 ohms at a temperature  $t_2$  of  $70^\circ\text{C}$ .  
Given that  $R_1/R_2 = (1 + \alpha t_1)/(1 + \alpha t_2)$  where  $\alpha$  is the temperature coefficient of resistance calculate the temperature coefficient of resistance.

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

[Total: 10]

- 2 The relationship between the load  $W$  and the required effort  $E$  of a lifting machine is given by the formula:

$$E = aW + b$$

A lifting machine can lift 120N with an effort of 16N, and 480N with an effort of 34N.

- (a) Give **two** equations that can be solved to calculate the values of the constants  $a$  and  $b$ .

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

- (b) Calculate the value of the constants  $a$  and  $b$ .

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

- (c) Calculate the value of the load when the effort is 42N.

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

- (d) Calculate the value of the effort when the load is 300N.

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

**[Total: 10]**  
**Turn over**

3 (a) State the sine rule for a triangle ABC.

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

(b) In triangle ABC  $AB = 15\text{ m}$ ,  $AC = 18\text{ m}$  and angle  $ABC = 52^\circ$ .

Calculate to the nearest degree, the angle  $AcB$ .

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

(c) In the layout shown in Fig. 3, A and B represent the centres of two gears. An idler gear is to be positioned with its centre at C so that  $AB = 210\text{ mm}$ ,  $AC = 100\text{ mm}$  and  $CB = 170\text{ mm}$ .

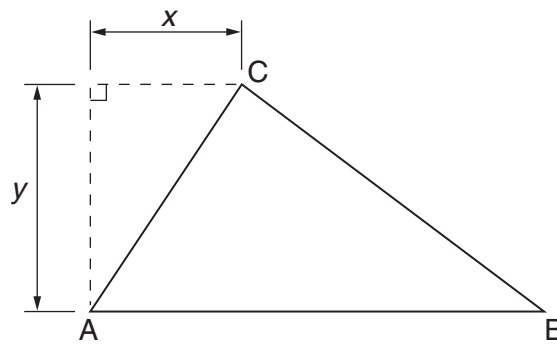


Fig. 3

Calculate:

(i) to the nearest degree, angle CAB.

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



(ii) to two significant figures, length  $x$ .

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

(iii) to two significant figures, length  $y$ .

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

[Total 10]

- 4 (a) Fig. 4 shows a cable strung between three pylons. The height of pylon A is 50m and the height of pylon C is 410m.

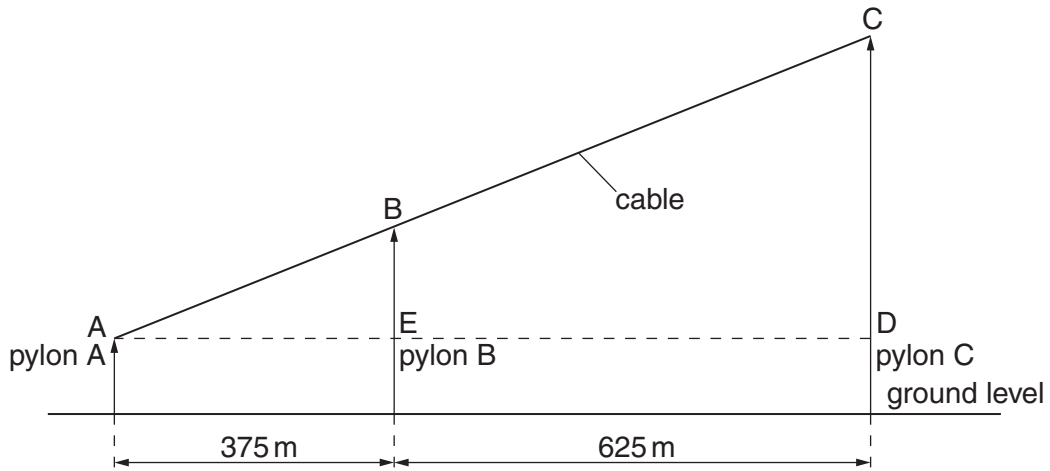


Fig. 4

Calculate:

- (i) the angle of elevation from the top of pylon A

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

- (ii) the height of pylon B

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

- (iii) the straight length of the cable required from pylon A to pylon C

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

- (iv) the actual length of the cable from A to C if 8% of the straight length is added for sagging

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

(b) A right-angle triangle is shown in Fig. 5.

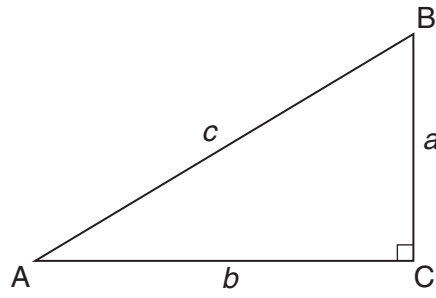


Fig. 5

Use the information shown in Fig. 5 to simplify the expression  $\sin A \cos A (1 + \tan^2 A)$ .

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..... [3]

[Total: 10]

5 The angle  $\theta$  radians turned through by a flywheel in  $t$  seconds is given by:

$$\theta = t^3 - 8t^2 + 16t + 20$$

If the angular velocity ( $\omega$ ) is  $d\theta/dt$  and the angular acceleration ( $\alpha$ ) is  $d\omega/dt$

(a) state the formula for angular velocity ( $\omega$ ).

..... [1]

Determine:

(b) the angular velocity ( $\omega$ ) for a time ( $t$ ) of 4 seconds

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

(c) the angular acceleration ( $\alpha$ ) for a time ( $t$ ) of 6 seconds

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

(d) to two decimal places, the time ( $t$ ) when the angular acceleration is zero

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

(e) the time ( $t$ ) when the angular velocity is zero.

.....

.....

.....

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.....

..... [3]

[Total: 10]

- 6 (a) (i) Give the integral which represents the area between the curve  $y = 6x^2$  and the  $x$  axis and between  $x = 2$  and  $x = 4$ .

..... [1]

- (ii) Calculate the value of the integral in (a)(i).

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

- (b) Draw, on the axes provided in Fig. 6 the graph  $y = 0.1(4 - x)(2 + x)$  from the ordinate  $x = 0$  to the ordinate  $x = +6$ .

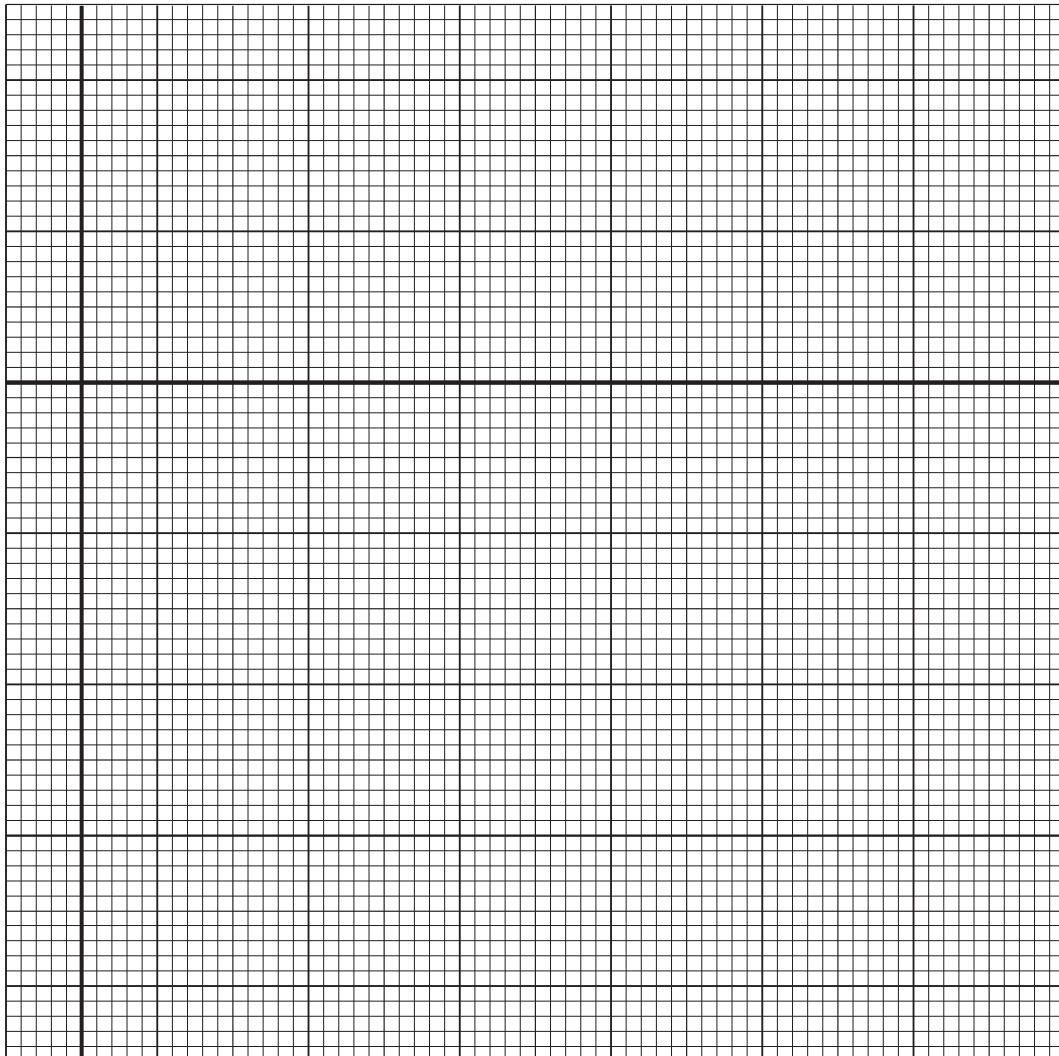


Fig. 6

[3]

- (c) Determine by integration the area enclosed by the curve  $y = 0.1(4 - x)(2 + x)$ , the  $x$ -axis and the given ordinates.

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..... [4]

[Total: 10]

- 7 The table below shows the distribution of grades of 400 iron castings for quality assurance purposes.

Grade	Number of castings
1–10	11
11–20	19
21–30	22
31–40	38
41–50	52
51–60	88
61–70	80
71–80	50
81–90	30
91–100	10

- (a) Construct a table showing the cumulative frequencies

Grades not more than										
Frequency										
Cumulative frequency										

[2]



(b) Draw, on the axes provided in Fig. 7 a graph of the ogive.

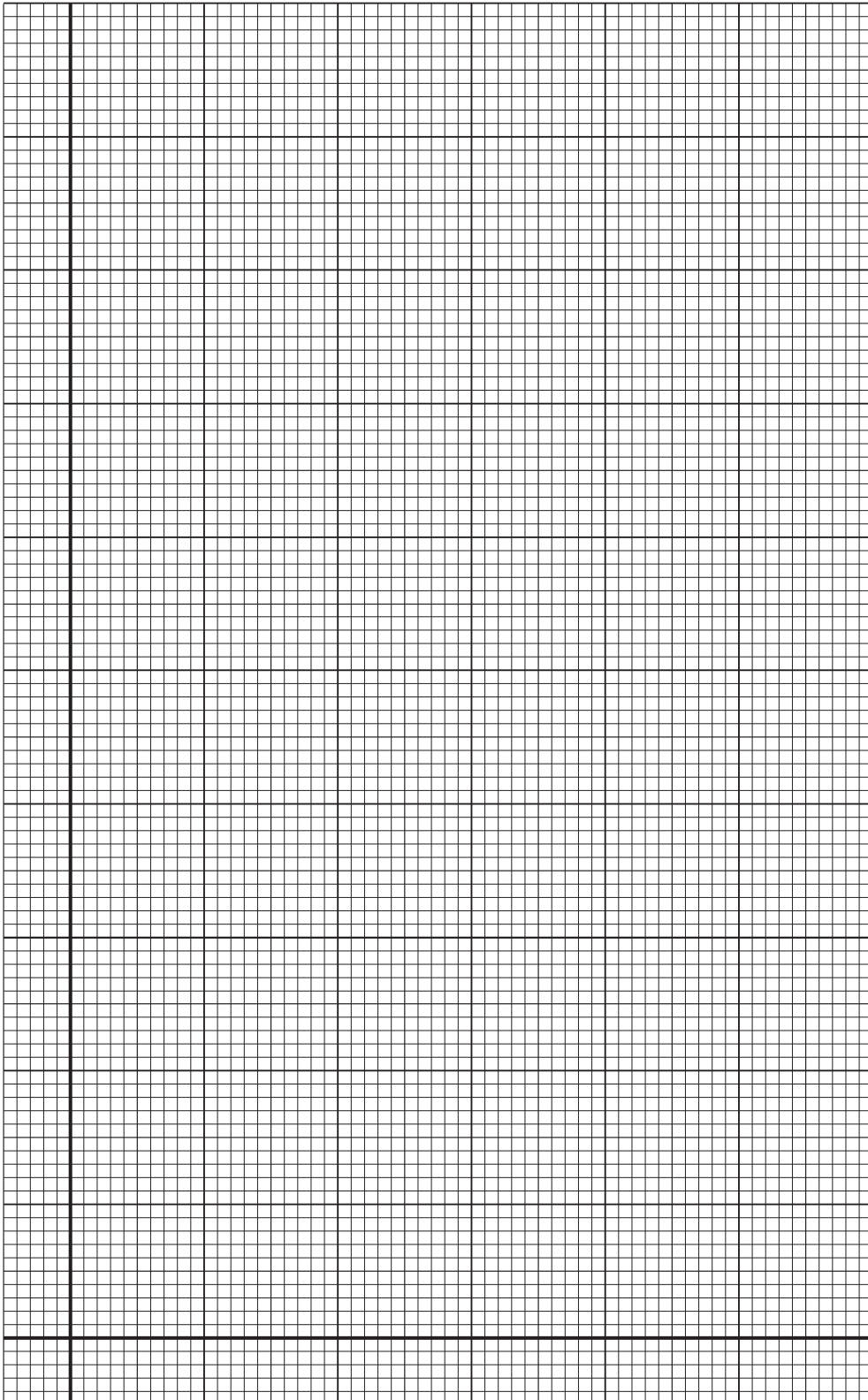


Fig. 7

[2]

(c) From the graph determine:

(i) the median mark

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

(ii) the upper and lower quartiles

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

(iii) the percentage number of castings that make a pass grade if the pass mark is 50.

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

[Total: 10]

8 (a) (i) Give the meaning of the term probability.

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

(ii) Explain what is meant by saying that two events are independent.

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

(b) A box contains 36 resistors and 39 capacitors. Determine the probabilities of selecting at random:

(i) a resistor

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

(ii) a capacitor.

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

(c) Two items are now selected at random without replacement. Determine the probability that they are both resistors.

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

[Total: 10]

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