

Wednesday 18 January 2012 – Morning

**PRINCIPAL LEARNING LEVEL 3
ENGINEERING**

F563/01 Mathematical Techniques and Applications for Engineers

Candidates answer on the Question Paper.

OCR supplied materials:
None

Other materials required:

- Scientific calculator

Duration: 2 hours



| | | | |
|-----------------------|--|----------------------|--|
| Candidate forename | | Candidate surname | |
|-----------------------|--|----------------------|--|

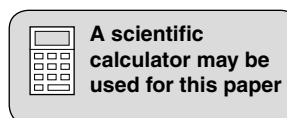
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|---------------|--|--|--|--|--|------------------|--|--|--|--|
| Centre number | | | | | | Candidate number | | | | |
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INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. 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.



Section A

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

- 1 Remove the brackets and simplify $-8(2x - 4)$.

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

- 2 Factorise the expression $x^2 - 9$.

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

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

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

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

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

- 5 A bicycle wheel has a diameter of 800 mm. Calculate, to the nearest millimetre, how far the bicycle will travel if the wheel turns through 250 revolutions.

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

- 6 In a right-angled triangle, ABC, B is the right angle, length a = 80mm and length b = 125mm. Calculate, correct to the nearest degree, angle A.

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

- 7 Draw, on the axes provided in Fig. 1, the curve $y = \cos \theta$ for values of θ from 0 to 360° . Label the x and y axes appropriately.

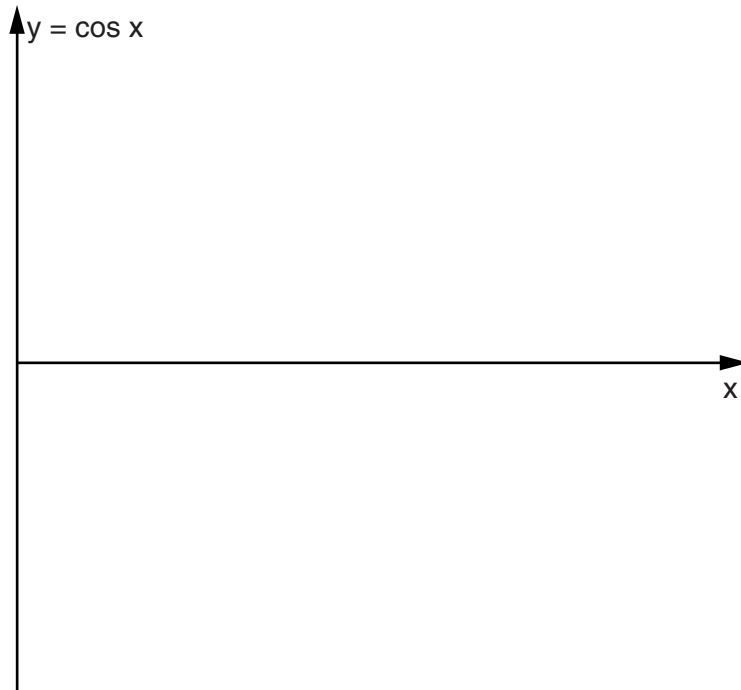


Fig. 1

[2]

- 8 Calculate, correct to 2 decimal places, the value of $\sin 50^\circ / \cos 60^\circ$.

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

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

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

10 Differentiate $y = \sin x + \ln(4x)$ with respect to x .

.....

 [2]

11 Integrate $\sin x$ with respect to x .

.....

 [2]

12 Calculate the value of the definite integral $\int_4^5 3x^2 \, dx$.

.....

 [2]

13 Determine the mode and median for the set of given values:

6, 9, 7, 11, 8, 10 and 7.

Mode

Median [2]

14 Complete the table shown below for cumulative frequency.

| | | | | |
|----------------------|-----------|-----------|-----------|-----------|
| Height (mm) | 141 – 150 | 151 – 160 | 161 – 170 | 171 – 180 |
| Frequency | 6 | 18 | 22 | 8 |
| Cumulative frequency | | | | |

[2]

15 In a box there are 15 good components and 9 damaged components.

Write down the probability of picking at random, a good component from the box.

State your answer in its simplest form.

..... [2]

[Total for Part A: 30]

Section B

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

Correct all answers to two decimal places.

- 1 (a) The volume of a cylinder is given by the formula $V = \pi r^2 h$.

Calculate the volume of the cylinder when $h = 80\text{ mm}$ and $r = 10\text{ mm}$.

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

- (b) (i) Transpose the formula $V = \pi r^2 h$ to make r the subject.

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

- (ii) Calculate the value of r when the volume $V = 10\,000\text{ mm}^3$ and $h = 100\text{ mm}$.

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

- (c) The reactance of a circuit is given by $X = \sqrt{Z^2 - R^2}$.
Find the impedance Z in terms of resistance R and reactance X .

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

[Total: 10]

2 (a) Solve the equation $2x^2 - 3x - 4 = 0$.

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

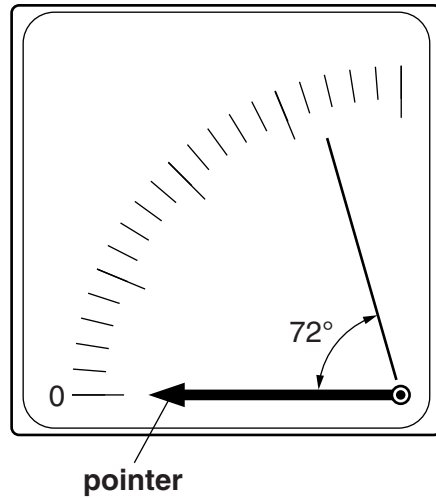
(b) The equation that refers to the motion of a particular vehicle is given by $s = ut + \frac{1}{2}at^2$ where s is the displacement, u is the initial velocity, a is the constant acceleration and t is the time for the motion.

Calculate the time for the motion over a displacement of 42 m if the initial velocity is 11 ms^{-1} and the acceleration is 6 ms^{-2} .

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

[Total: 10]

- 3 (a) Fig. 2 shows an analogue-type instrument with a pointer that moves through a quarter circle. The pointer has a radius of 30mm. Calculate the length of the arc made by the pointer if the angle subtended by the arc is 72° .



Not to scale

Fig. 2

.....

 [2]

- (b) The instantaneous value of an alternating current at time t seconds is given by $i = 25 \sin 400 t$ amperes.

Determine the:

- (i) peak value of the current in amperes
 [1]

- (ii) frequency of supply in hertz

 [2]

- (iii) periodic time in seconds

 [2]

- (iv) the current in amperes when $t = 15$ ms

 [3]

[Total: 10]

4 An outline diagram of a crank mechanism is shown in Fig. 3.

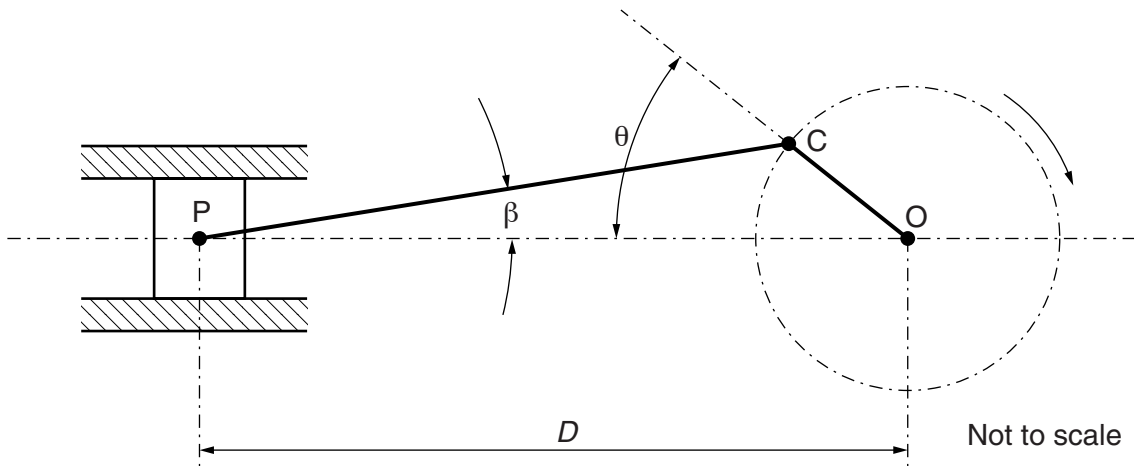


Fig. 3

Arm OC is 100 mm long and rotates clockwise about O. The connecting rod PC is 400 mm long and end P is constrained to move horizontally.

When angle θ is 55° calculate:

(a) angle β

.....

.....

.....

.....

.....

.....

.....

..... [5]

(b) distance D.

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 10]

Turn over

5 (a) Differentiate $y = 5e^{-3x}$ with respect to x .

..... [1]

(b) The distance s metre moved by a vehicle in time t seconds is given by the formula

$$s = t^3 - 2t^2 + 3t.$$

Calculate the:

(i) initial velocity of the vehicle.

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

(ii) velocity of the vehicle after 5 seconds.

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

(iii) acceleration of the vehicle after 5 seconds.

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

[Total: 10]

- 6 (a) A variable force F is related to distance s by the formula $F = 6s^2 + 4s$.
The work done by this force on an object is given by:

$$\text{work done} = \int_a^b F \, ds \text{ where the object is moving from } s = a \text{ to } s = b.$$

Calculate the work done by the force when s increases from 4.5 m to 6 m.

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

- (b) Calculate the area bounded by the curve $y = \cos x$ and the x axis between:

- (i) $x = 0$ and $x = \pi/2$

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

- (ii) $x = \pi/2$ and $x = \pi$

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

[Total: 10]

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

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

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

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

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

(i) a relay

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

(ii) a choke

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

(c) Two items are now selected at random from the same box without replacement. Determine the probability that they are both relays.

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

[Total: 10]

- 8 (a) Draw, on the axes provided in Fig. 4, a normal distribution curve.

The Normal Distribution



Fig. 4

[2]

- (b) A hardness test was carried out on a sample of sixty specimens of medium carbon steel. The results are shown in Table 1 below.

| | | | | | |
|------------------------|---|---|----|----|----|
| Maximum Hardness H_b | 2 | 6 | 7 | 8 | 10 |
| Frequency | 6 | 8 | 24 | 16 | 6 |

Table 1

(i) Complete Table 2 below.

| Raw score (x) | Frequency (f) | f x | x – mean | (x – mean) ² | f(x – mean) ² |
|---------------|---------------|---------------|----------|-------------------------|---------------------------------|
| 2 | 6 | | | | |
| 6 | 8 | | | | |
| 7 | 24 | | | | |
| 8 | 16 | | | | |
| 10 | 6 | | | | |
| | $\Sigma f =$ | $\Sigma fx =$ | | | $\Sigma f(x - \text{mean})^2 =$ |

[3]

Table 2

(ii) Calculate, the variance and standard deviation of the maximum hardness for this sample.

.....

.....

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.....

.....

.....

.....

.....

..... [5]

[Total: 10]

15
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