GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

<u>Section A</u>

1. (a) Evaluate x in the expression. When a = 0.2, b = 2, c = 4, d = 16:

$$x = \frac{a \times (3 + b)^2 \times c^{(1/2)}}{(\sqrt{d})^{(1/2)}}$$

(4)

(b) Simplify the following expression:

$$\frac{3X}{2} - \frac{2X}{3} + \frac{4X}{5}$$

(4)

2. (a) Rearrange the following expression to make c the subject:

$$x = \frac{ab + c}{a + c}$$

(5)

(b) Simplify the following expression:

$$\frac{a^3 \times b^4 \times c \times a^6}{a^3 \times c^2 \times b^2 \times a \times b \times a^5}$$

(3)

3. (a) Plot the data in Table Q3 on a graph. (4)

(b) Determine the equation describing the data. (4)

(c) Determine the value of y when x is 2.5. (2)

X	-1	0	1	2	3	4
Y	-1	2	5	8	11	14

Table Q3

[OVER

4. For the shape shown in FIG Q4, determine EACH of the following:

    (a) the length of the side CD; (4)

    (b) the total area of both shapes. (4)
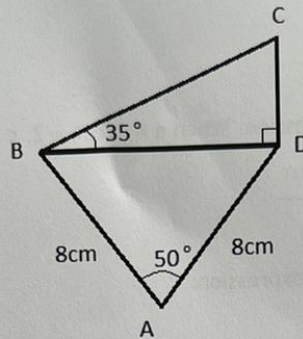

FIG Q4

5. Describe EACH of the following:

    (a) an equilateral triangle; (2)

    (b) a scalene triangle; (2)

    (c) an isosceles triangle; (2)

    (d) a tangent to a circle. (2)

6. It is required to cast a hollow bronze sphere 25 cm in diameter by melting a 15 cm cube of bronze and pouring it into a spherical mould. The mould will be rotated until the bronze solidifies to ensure an even wall thickness.

    Determine EACH of the following:

    (a) the average wall thickness of the finished sphere; (5)

    (b) the outside surface area of the finished sphere. (3)

Section B

7.   A 50 kg mass has its velocity uniformly increased from stationary to 4 m/s in 20 seconds. The mass is then decelerated at 0.3 m/s² until it comes to a stop.

Determine EACH of the following:

(a) the accelerating force required;

(4)

(b) the time taken in the deceleration phase;

(4)

(c) the total distance travelled.

(2)

Note: any effects of friction may be ignored

8.   A simply supported beam is shown in FIG Q8. The beam has a mass of 400 kg and carries a uniformly distributed load of 4 kN/m over a length of 3 m starting from point C, 1.0 m from point A.
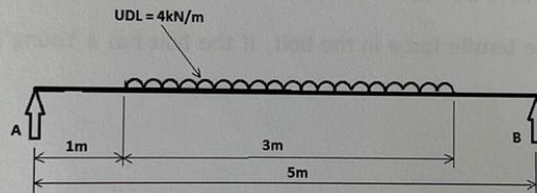
UDL = 4kN/m

FIG Q8

Determine EACH of the following:

(a) the reaction force reaction at point A;

(7)

(b) the reaction force reaction at point B.

(1)

(2)

9.   (a) Define momentum.

(1)

(b) State Newton's Law of force.

(2)

(c) State the relationship between force and momentum.

(2)

(d) Taking atmospheric pressure to be 1.01325 bar, calculate the mass of air acting downwards onto a square meter of the earth's surface.

(3)

10. A stationary packing case with a mass of 50 kg has a force applied to it which causes acceleration in a horizontal plane. The force of 120 N is applied at an angle of 10° below the horizontal, pulling the block.

    Determine the acceleration of the block, if the coefficient of friction is 0.2. (8)

11. A worm/wheel gear with an overall efficiency of 78% has a single start thread and carries an effort pulley with a diameter, d = 30 mm. The wheel has 120 teeth and a load pulley of diameter, D = 300 mm.

    (a) Sketch the general arrangement of the machine. (2)

    (b) Determine the effort required to lift a load of 800 kg. (6)

12. (a) Explain the difference between shear stress and direct stress. (2)

    (b) A high tensile steel bolt with a diameter of 40 mm is tightened with a torque wrench to achieve a strain of 0.0005.

        Determine the tensile force in the bolt, if the bolt has a Young's Modulus of 200 GPa. (6)

1. (a) Evaluate x in the expression. When a = 0.2, b = 2, c = 4, d = 16:

$$x = \frac{a \times (3 + b)^2 \times c^{(1/2)}}{(\sqrt{d})^{(1/2)}}$$

(4)

$$x = \frac{0.2\left(3+2\right)^2 \times \sqrt{4}}{\sqrt{\left(\sqrt{2}\right)}}$$

$$= \frac{0.2 \times 25 \times 2}{\sqrt{\sqrt{2}}} = \frac{10}{} = 8.408964$$

(b) Simplify the following expression:

$$\frac{3X}{2} - \frac{2X}{3} + \frac{4X}{5}$$

(4)

$$\frac{9x - 4x}{6 \quad 6}$$

$$\frac{5x + 4x}{6 \quad 5}$$

$$\frac{25x + 24x}{30} = \frac{49x}{30} \quad or \quad 1\frac{19}{30}x$$

2. (a) Rearrange the following expression to make c the subject:

$$x = \frac{ab + c}{a + c}$$

(5)

$$x = \frac{ab + c}{a + c}$$

$$(a + c)\, x = ab + c$$

$$ax + cx = ab + c$$

$$cx - c = ab - ax$$

$$c(x - c) = ab - ax$$

$$c = \frac{ab - ax}{x - c}$$

(b) Simplify the following expression:

$$\frac{a^3 \times b^4 \times c \times a^6}{a^3 \times c^2 \times b^2 \times a \times b \times a^5}$$

(3)

$$\frac{a^3\, b^4\, c\, a^6}{a^3\, c^2\, b^2\, a\, b\, a^5} = \frac{b\, a}{c\, a} = \frac{b}{c}$$

3. (a) Plot the data in Table Q3 on a graph. (4)

   (b) Determine the equation describing the data. (4)

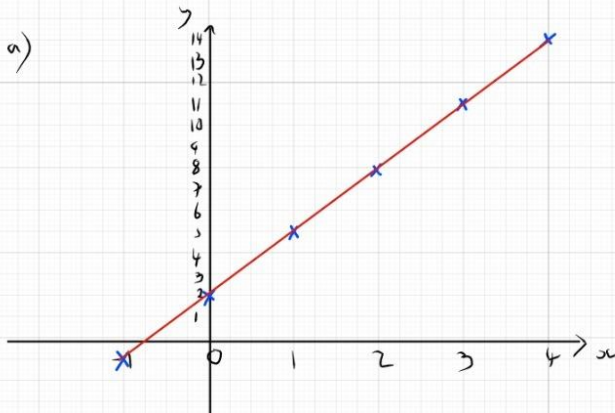   (c) Determine the value of y when x is 2.5. (2)

X	-1	0	1	2	3	4
Y	-1	2	5	8	11	14

Table Q3

b) $y = mx + c$

$m = \dfrac{5-2}{1-0} = \dfrac{3}{1} = 3$

$c = 2$

$y = 3x + 2$

c) $y = 3(2.5) + 2 = 9.5$

a)

4. For the shape shown in FIG Q4, determine EACH of the following:
   (a) the length of the side CD; (4)
   (b) the total area of both shapes. (4)

FIG Q4
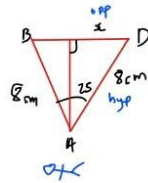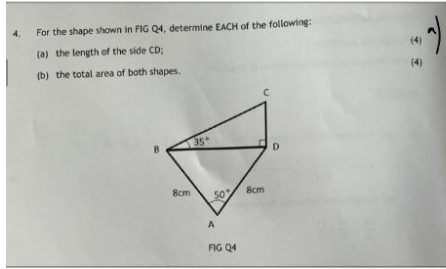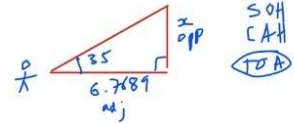
SOH
CAH
TOA

$\sin \theta = \dfrac{opp}{hyp}$

$\sin 25 = \dfrac{x}{8}$

$8 \sin 25 = 3.3809 \, cm \quad \times 2$

$BD = 6.76189 \, cm$
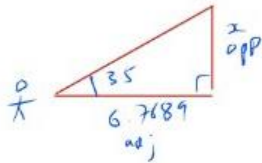
SOH
CAH
TOA

$\tan \theta = \dfrac{Opp}{Adj}$

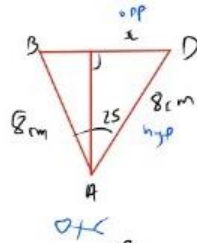$\tan 35 = \dfrac{x}{6.7689}$

$6.7689 \tan 35 = x = 4.73963$

b) Area

SOH
CAH
TOA

$\tan \theta = \dfrac{Opp}{Adj}$

$\tan 35 = \dfrac{x}{6.7689}$

$6.7689 \tan 35 = x = 4.73963$

$Area = \dfrac{b \cdot h}{2} = \dfrac{6.7689 \times 4.73963}{2}$

SOH
CAH
TOA

$\cos \theta = \dfrac{adj}{hyp}$

$\cos 25 = \dfrac{x}{8}$

$8 \cos 25 = x = 7.25046 \, cm$

$Area = \dfrac{b \cdot h}{2} = \left(\dfrac{6.7689 \times 7.25046}{2} \right) \times 2$

$16.0410 \, cm \quad + \quad 49.07765 \, cm^2$

$total = 65.11819 \, cm^2$

5. Describe EACH of the following:

    (a) an equilateral triangle; (2)

    (b) a scalene triangle; (2)

    (c) an isosceles triangle; (2)

    (d) a tangent to a circle. (2)

    a) 3 sides same length, 3 angles same size
    b) all sides differenet length, all angles diff values
    c) 2 sides same length, 2 angles same value
    d) a line that touches the outside of a circle (the circumference) it
    makes a 90° angle with the radius

6. It is required to cast a hollow bronze sphere 25 cm in diameter by melting a 15 cm cube of bronze and pouring it into a spherical mould. The mould will be rotated until the bronze solidifies to ensure an even wall thickness.

    Determine EACH of the following:

    (a) the average wall thickness of the finished sphere; (5)

    (b) the outside surface area of the finished sphere. (3)

Solutions to come later!

7. A 50 kg mass has its velocity uniformly increased from stationary to 4 m/s in 20 seconds. The mass is then decelerated at 0.3 m/s² until it comes to a stop.

Determine EACH of the following:

(a) the accelerating force required; (4)

(b) the time taken in the deceleration phase; (4)

(c) the total distance travelled. (2)

Note: any effects of friction may be ignored

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$s = \left(\frac{u+v}{2}\right)t$$

50kg

S
$u = 0$
$v = 4$
$a = x$
$t = 20$

a) $v = u + at$
$4 = 0 + 20x$
$\frac{4}{20} = x = 0.2 \, m/s^2$

$f = ma$
$F = 50 \times 0.2$
$F = 10N$

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$s = \left(\frac{u+v}{2}\right)t$$

50kg

S
$u = 4$
$v = 0$
$a = -0.3$
$t =$

b) $v = u + at$
$0 = 4 - 0.3t$
$0.3t = 4$
$t = \frac{4}{0.3} = 13.333 \, sec$

c)
$s = \left(\frac{4+0}{2}\right) 13.333$

$s = 26.667 \, m$

8. A simply supported beam is shown in FIG Q8. The beam has a mass of 400 kg and carries a uniformly distributed load of 4 kN/m over a length of 3 m starting from point C, 1.0 m from point A.

FIG Q8

Determine EACH of the following:

(a) the reaction force reaction at point A; (7)

(b) the reaction force reaction at point B. (1)

$UDL = 4 \times 3 = 12 KN$
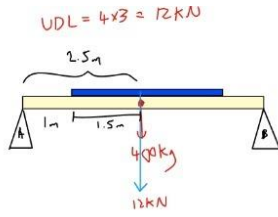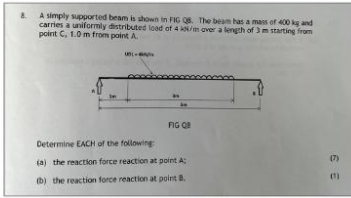
$Down\ force = Up\ force$

$7962 + R_A = 3924 + 12000$

$R_A = 7962\ N$

Name	Mass (kg)	Force (N)	Distance (m)	Moment (N m)	Direction
Beam	400	3924	1.5	9810	Clock
UDL		12000	2.5	30,000	Clock
R_b		x	5	$5x$	Anti.

$\sum$ clock moments $= \sum$ Anti clock moments

$9810 + 30,000 = 5x$

$\dfrac{39810}{5} = x = 7962$

$R_B = 79620\ N$
$7.962\ kN$

9. (a) Define momentum. (2)

   (b) State Newton's Law of force. (1)

   (c) State the relationship between force and momentum. (2)

   (d) Taking atmospheric pressure to be 1.01325 bar, calculate the mass of air acting downwards onto a square meter of the earth's surface. (3)

Solutions to come later!

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Determine the acceleration of the block, if the coefficient of friction is 0.2. (8)

SOH
CAH
TOA

Horizontal   Vertical

$\cos\theta = \dfrac{adj}{hyp}$ $\sin\theta = \dfrac{opp}{hyp}$

$\cos 10 = \dfrac{x}{120}$ $\sin 10 = \dfrac{y}{120}$

$120\cos 10 = x$ $120\sin 10 = y$

$118.1741\ N$ $20.83778\ N$
Push →   Down ↓
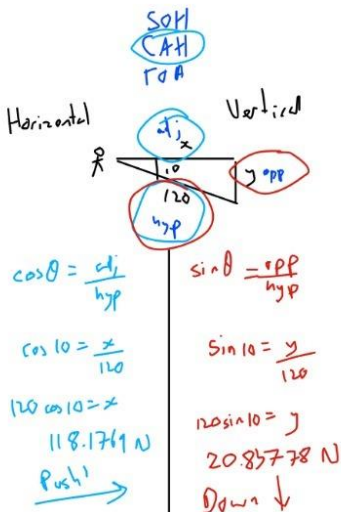
Net Vertical

$mg = 9.81 \times 50 = 450.5$

$450.5 + 20.83778 = 511.33778\ N$

total down $= 511.34\ N$

Fric $F = \mu N$

$F = 0.2 \times 511.34 = 102.26755\ N$

Net Horizontal

Push $-$ Fric

$118.1769 - 102.268$
$= 15.909344$

Accel

$F = ma$

$15.909344 = 50a$

$\dfrac{15.909344}{50} = 0.31817\ m/s^2$

11. A worm/wheel gear with an overall efficiency of 78% has a single start thread and carries an effort pulley with a diameter, d = 30 mm. The wheel has 120 teeth and a load pulley of diameter, D = 300 mm.

   (a) Sketch the general arrangement of the machine. (2)

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These I will do ASAP