July 2015

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation: $\frac{3x}{5} - \left(\frac{x-9}{20}\right) = 3.75$ (8)

2. A rectangular lead block measures 0.25 m x 15 cm x 12 cm and is recast into a solid sphere with 2.5% material wastage.

   Determine the diameter of the sphere. (8)

3. (a) State the Theorem of Pythagoras. (2)

   (b) The diagonal of a rectangle exceeds the length by 3.25 cm, and the width is 11 cm.

   Calculate the length of the rectangle. (6)

4. The formula shown allows the stress in thick cylinders to be calculated.

   $$\frac{D}{d} = \left(\frac{f+P}{f-P}\right)^{1/2}$$

   Express f in terms of the other quantities. (8)

5. (a) Produce a simple diagrammatic sketch of a double purchase (double reduction) crab winch. (4)

(b) Using the sketch in Q5(a) show that the movement ratio (V.R.) is equal to: (6)

$$MR = \frac{L}{r} \times \frac{product\ of\ followers}{product\ of\ drivers}$$

Note: L is the length of the effort handle
r is the radius of the load drum

6. The velocity of a 36 kg mass is increased uniformly from 2.4 m/s to 3.2 m/s in 2.2 seconds.

The mass is then uniformly retarded at 0.3 m/s^2 until the mass just comes to rest.

Calculate EACH of the following:

(a) the accelerating force required; (3)

(b) the time taken for the mass to come to rest; (2)

(c) the distance travelled during the retardation period in Q6(b). (3)

7. (a) Define the radian. (2)

(b) Calculate the number of degrees in 2.62 radians. (2)

(c) Calculate the number of times a point on a flywheel passes an observer if the flywheel has an angular velocity of 2.73 rad/s and the count time is 45 seconds. (4)

11. The coefficient of friction between a mass of 35 kg and a horizontal plane is 0.51.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration if a force of 285 N is now applied; (4)

(c) the time taken to travel 4.6 m from rest under the action of the accelerating force. (4)

12. A rectangular sheet of metal, x cm by y cm has squares of z cm cut from each corner. The sheet is then folded to form a shallow tray of depth z cm.

Write and simplify an expression to give the volume of the tray in terms of x, y and z. (8)

1. Solve for x in the following equation: $\frac{3x}{5} - \left(\frac{x-9}{20}\right) = 3.75$ (8)

Expand brackets

$$\frac{3x}{5} \quad \frac{-x+9}{20} = 3.75$$

multiply through by 20

$$12x - x + 9 = 75$$

collect like terms

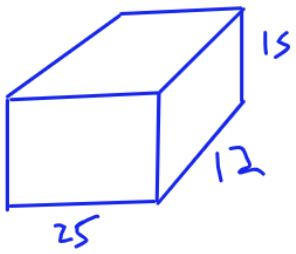
$$11x = 66$$

divide through by 11

$$x = 6$$

2. A rectangular lead block measures 0.25 m x 15 cm x 12 cm and is recast into a solid sphere with 2.5% material wastage.

Determine the diameter of the sphere. (8)



$Vol = 4500\ cm^3$ calculate volume in cubic cm

$Vol = 4500 \times 0.975 = 4387.5\ cm^3$ calculate after 2.5% loss

Sphere

$Vol = 4387.5\ cm^3$ use volume of sphere formula

$\frac{4}{3}\pi r^3 = 4387.5$

$r = 10.15$

$d = 20.31138\ cm$

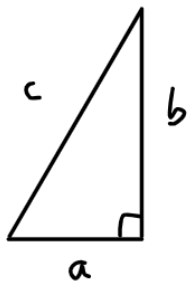
3. (a) State the Theorem of Pythagoras. (2)

(b) The diagonal of a rectangle exceeds the length by 3.25 cm, and the width is 11 cm.

Calculate the length of the rectangle. (6)

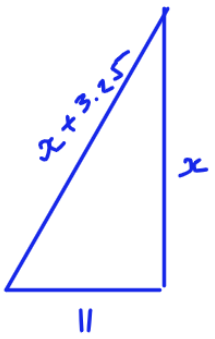
the sum of the squares of the two shorter sides of a right angled triangle are equal to the square of the longest side (hypotenuse)

$a^2 + b^2 = c^2$



this is a difficult (and rare) question!!

draw diagram



set up pythagoras

$x^2 + 11^2 = (x+3.25)^2$

expand brackets

$(x+3.25)(x+3.25)$

$x^2 + 11^2 = x^2 + 3.25x + 3.25x + 10.5625$

simplify, and collect like terms

$x^2 + 11^2 = x^2 + 3.25x + 3.25x + 10.5625$

$121 = 6.5x + 10.5625$

$110.4375 = 6.5x$

$16.990 = x$

4. The formula shown allows the stress in thick cylinders to be calculated.

$$\frac{D}{d} = \left(\frac{f+P}{f-P}\right)^{1/2}$$

Express f in terms of the other quantities. (8)

note: $\sqrt{x} = x^{1/2}$

$$\frac{D}{d} = \sqrt{\left(\frac{f+P}{f-P}\right)}$$

$$\left(\frac{D}{d}\right)^2 = \frac{f+P}{f-P}$$

$$\left(\frac{D}{d}\right)^2 (f-P) = f+P$$

$$f\left(\frac{D}{d}\right)^2 - P\left(\frac{D}{d}\right)^2 = f+P$$

$$f\left(\frac{D}{d}\right)^2 - f = P\left(\frac{D}{d}\right)^2 + P$$

$$f\left(\left(\frac{D}{d}\right)^2 - 1\right) = P\left(\frac{D}{d}\right)^2 + P$$

$$f = \frac{P\left(\frac{D}{d}\right)^2 + P}{\left(\left(\frac{D}{d}\right)^2 - 1\right)}$$

5. (a) Produce a simple diagrammatic sketch of a double purchase (double reduction) crab winch. (4)

(b) Using the sketch in Q5(a) show that the movement ratio (V.R.) is equal to: (6)

$$MR = \frac{L}{r} \times \frac{product\ of\ followers}{product\ of\ drivers}$$

Note: L is the length of the effort handle
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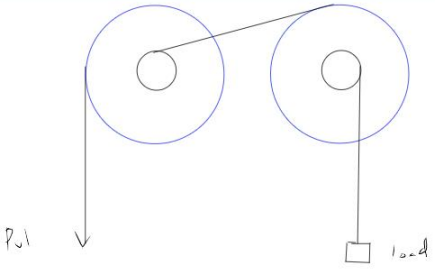
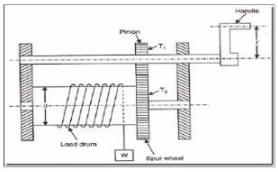




6. The velocity of a 36 kg mass is increased uniformly from 2.4 m/s to 3.2 m/s in 2.2 seconds.

The mass is then uniformly retarded at 0.3 m/s^2 until the mass just comes to rest.

Calculate EACH of the following:

(a) the accelerating force required; (3)

(b) the time taken for the mass to come to rest; (2)

(c) the distance travelled during the retardation period in Q6(b). (3)

$s = ut + \frac{1}{2}at^2$ $F = ma$

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

$v = u + at$

a) use

$v = u + at$

$3.2 = 2.4 + 2.2a$

$\frac{0.8}{2.2} = 0.363636 \ m/s^2$

s

$u = 2.4$

$v = 3.2$

$a = x$

$t = 2.2$

use $F = ma$

$F = 36 \times 0.363636 = 13.091 \ N$

b)

$s =$
$u = 3.2$
$v = 0$
$a = -0.3$
$t =$

$v = u + at$

$0 = 3.2 - 0.3t$

$\boxed{t = 10.667 \text{ sec}}$

c)

$s = 3.2(10.667) + \frac{1}{2}(-0.3)(10.667)^2$

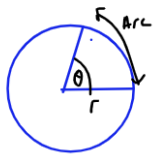
$= 17.067 \text{ m}$

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

$s = \frac{3.2}{2}(10.6667) = 17.067 \text{ m}$

7. (a) Define the radian. (2)
(b) Calculate the number of degrees in 2.62 radians. (2)
(c) Calculate the number of times a point on a flywheel passes an observer if the flywheel has an angular velocity of 2.73 rad/s and the count time is 45 seconds. (4)

a)



$2\pi = 360°$

$\text{Radian} = \frac{360}{2\pi} = 57.29°$

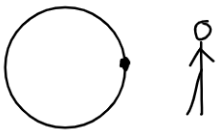
A radian is a measure of angle, There are 2pi radians in a full circle, and one radian is approxiamtely equivalent to 57.29 degrees.

Arc length $= r\theta$

$\boxed{\frac{\text{Arc}}{r} = \theta}$

b) $\frac{2.62}{2\pi} \times 360 = 150.11°$

c)



Vel $= 2.73$ Rad/s $\xrightarrow{\div 2\pi}$ 0.434492946 Rev/sec

$t =$ 45 seconds

$t \times v =$ distance

$45 \times 0.434492946 = 19.552$ Revolutions

11. The coefficient of friction between a mass of 35 kg and a horizontal plane is 0.51.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration if a force of 285 N is now applied; (4)

(c) the time taken to travel 4.6 m from rest under the action of the accelerating force. (4)

$F_{fric} = \mu N$

$\mu = 0.51$

$N = mg = 9.81 \times 35 = 343.35$

$F_{fric} = 0.51 \times 343.35$

F_{fric} 175.1085 N

a) 175.1085 N

b) Net = Push − Friction

$285 - 175.1085 = 109.8915$ N

$F = ma$ $F = 109.8915$ $m = 35$

$\frac{109.8915}{35} = a = 3.139757 \text{ m/s}^2$

c) $s = 4.6$
$u = 0$
v
$a = 3.139757$
$t = x$

$s = ut + \frac{1}{2}at^2$

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

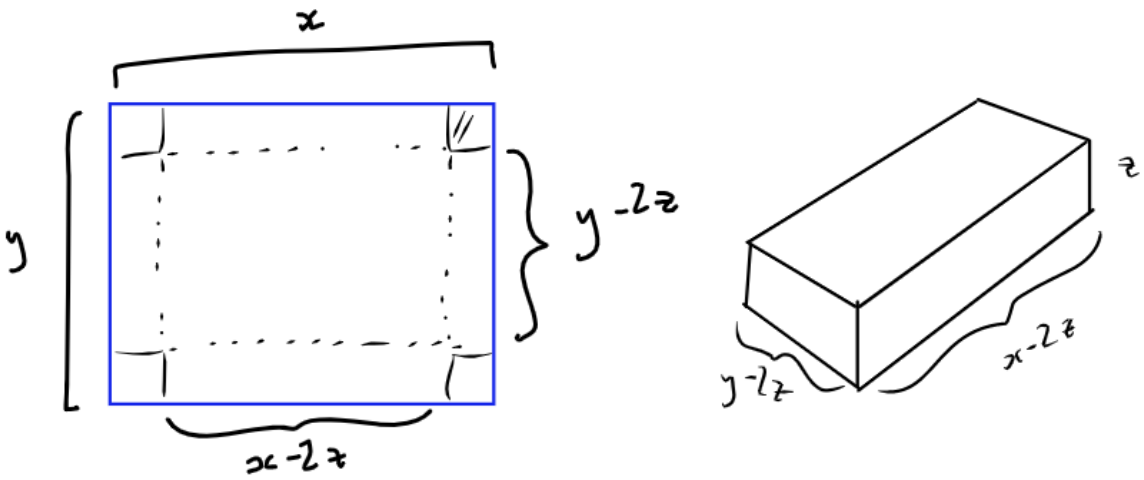
$v = u + at$

$4.6 = 0 + \frac{1}{2}(3.139757)t^2$

$2.93 = t^2$ $t = 1.71177$ sec

12. A rectangular sheet of metal, x cm by y cm has squares of z cm cut from each corner. The sheet is then folded to form a shallow tray of depth z cm.

Write and simplify an expression to give the volume of the tray in terms of x, y and z. (8)



$$\text{Vol} = (x-2z)(y-2z)z$$

$$(xy - 2zy - 2zx + 4z^2)z$$

$$= xyz - 2z^2y - 2z^2x + 4z^3$$