

1.

(a) — 05.

$$\Delta E = I \omega^2 c_s$$

The energy stored in Flywheel:-

$$\Delta E = \text{Maximum K.E.} - \text{Minimum K.E.} \quad \text{LO 2}$$

$$= \frac{1}{2} I \omega_1^2 - \frac{1}{2} I \omega_2^2$$

$$= \frac{1}{2} I (\omega_1^2 - \omega_2^2)$$

$$= \frac{1}{2} I (\omega_1 - \omega_2) (\omega_1 + \omega_2)$$

$$= I (\omega_1 - \omega_2) \omega$$

$$= I \left(\frac{\omega_1 - \omega_2}{\omega} \right) \omega^2$$

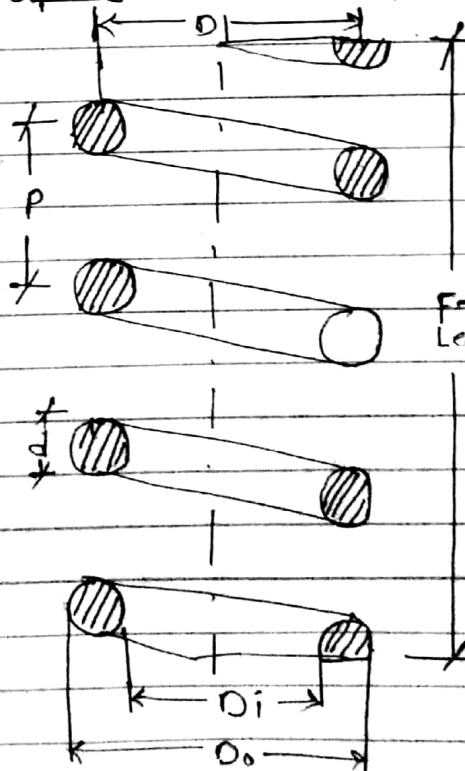
$$\left\{ \omega = \frac{\omega_1 + \omega_2}{2} \right\}$$

$$\text{LO 3} \left\{ \frac{\omega_1 - \omega_2}{\omega} = c_s \right\}$$

$$\Delta E = I \omega^2 c_s$$

— x — x — x —

(b) Spring Terminology:-



$$D = \frac{D_i + D_o}{2}$$

$$D_i = D - d$$

$$D_o = D + d$$

1) Spring index [C] LO 2

$$C = \frac{D}{d}$$

2) Solid length LO 3

$$= N_t d$$

3) Free length

$$= \text{Solid length} + \text{Total axial gap } \delta$$

4) pitch (P)

$$P = \frac{\text{free length}}{(N_t - 1)}$$

5) Stiffness (k)

$$k = \frac{P}{\delta}$$

6) Inactive coil

$$= N_t - N$$

1 c)

Requirement of good coupling:- 04

1. It should be easy to connect or disconnect.
2. It should transmit full power from one shaft to the other shaft without losses.
3. — " — hold shaft in perfect alignment.
4. — " — Reduce the transmission of shock from one shaft to another shaft.
5. It should have no projecting parts. 104M

Enlist practical app'n of coupling : 101M

— x — x —

- 1 d. Rolling contact Vs. sliding contact
 - Four comparative points — 103M
 - sketches — 102M

1 e. Strength of welded joint:-

Explain any one either strength of parallel Fillet weld or transverse Fillet weld.

$$P = 0.707 h l \tau$$

$$P = 1.414 h l \tau$$

105.

P = tensile force on plates (N)

h = leg of the weld (mm)

l = length of the weld.

2. (a) — Design procedure with correct calculation — 07
- Sketch + All dimension showing on it — 03

Ans:-

2 (b)

Given $P = 500 \text{ N to } 1000 \text{ N}$

$$\delta = 25 \text{ mm}$$

$$C = 8$$

$$S_{ut} = 1000 \text{ N/mm}^2$$

$$\tau = 0.5 S_{ut} = 500 \text{ N/mm}^2$$

$$G = 81370 \text{ N/mm}^2$$

Step-I Wire dia.

$$K = \frac{4C-1}{4C-4} + \frac{0.615}{C} = \frac{31}{28} + \frac{0.615}{8} = 1.184$$

$$K = 1.184$$

$$\tau = K \left(\frac{8PC}{\pi d^2} \right) \quad \text{or} \quad \tau = K \left(\frac{8PD}{\pi d^3} \right)$$

$$500 = 1.184 \left(\frac{8 \times 1000 \times 8}{\pi d^2} \right)$$

$$d^2 = 1.184 \left[\frac{8 \times 8 \times 1000}{\pi \times 500} \right]$$

$$d = 6.945 \text{ mm} \approx 7 \text{ mm}$$

LO4M

Step-II Mean coil dia

56 mm

$$D = C \times d = 8 \times 7 = 56 \text{ mm}$$

LO1M

Step-III Number of active coils:

$$\delta = \frac{8PD^3}{Gd^4} N \Rightarrow N = 7$$

LO1M

Step-IV Total No. of coils:

$$N_t = N + 2 \quad (\text{For square \& ground end})$$

$$= 7 + 2$$

$$N_t = 9$$

LO1M

Step-V :- Solid Length

$$= N_t \times d$$

$$= 9 \times 7$$

$$= 63 \text{ mm.}$$

Step-VI :- Free length

The actual defⁿ of spring under the max^m force,
1000N

$$\delta = \frac{8 P D^3 N}{G \cdot d^4}$$

$$= \frac{8 \times 1000 \times (56)^3 \times 7}{81370 \times (7)^4}$$

$$\delta = 50.33 \text{ mm}$$

∴ Gap b/w adj. coil = 2mm

Total axial gap will be

$$= (N_t - 1) \times 2$$

$$= 8 \times 2 = 16$$

∴ Free length = solid Length + total axial gap + δ

$$= 63 + 16 + 50.33$$

$$= 129.337 \text{ mm.}$$

LO1M

Step-VII Required spring rate

$$K = \frac{P_1 - P_2}{\delta} = \frac{1000 - 500}{25} = 20 \text{ N/mm}$$

$$K = 20 \text{ N/mm}$$

LO1M

Step-(VIII) Actual spring rate

$$K = \frac{G \cdot d^4}{8 D^3 N} = \frac{81370 \times 7^4}{8 \times 56^3 \times 7} = 19.87 \text{ mm}$$

$$K = 19.87 \text{ mm}$$

LO1M

LO1M

3. (a) Given: $P = 15 \text{ kW} = 15 \times 10^3 \text{ W}$

$$N = 200 \text{ rpm}$$

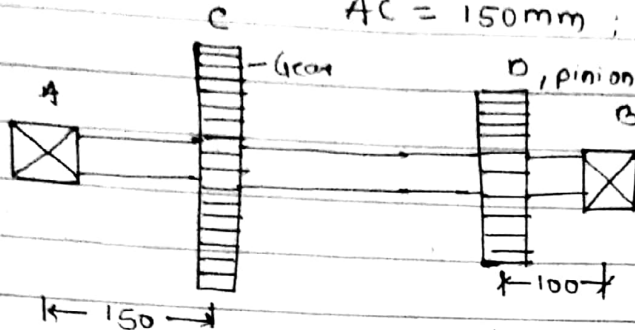
$$AB = 750 \text{ mm}$$

[01 marks]

$$T_o = 30; m_o = 5 \text{ mm}$$

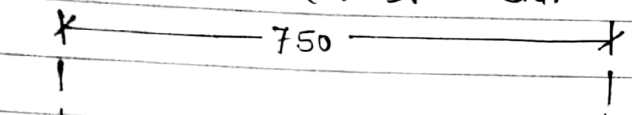
$$BD = 100 \text{ mm}; T_c = 100; m_c = 5 \text{ mm}$$

$$AC = 150 \text{ mm}; \tau = 54 \text{ MPa} = 54 \text{ N/mm}^2$$

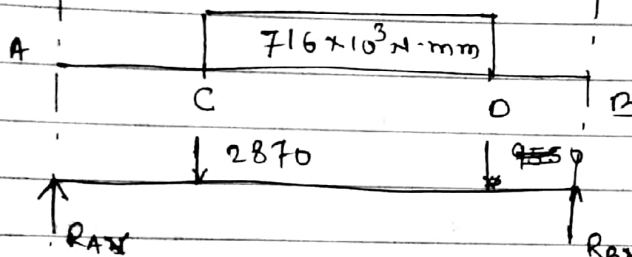


[04 marks]

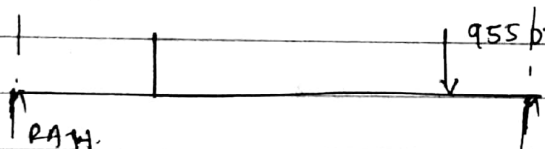
(a) space dra.



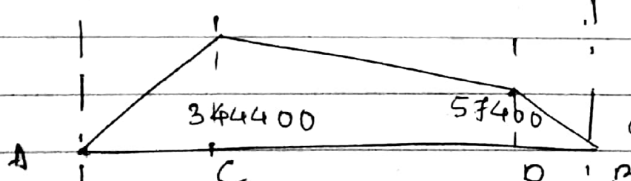
(b) Torque dra.



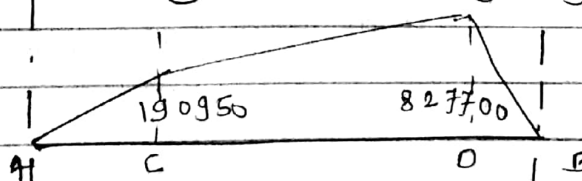
(c) vert. load dra



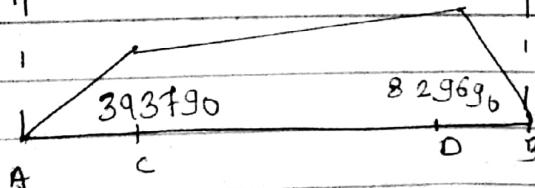
(d) Horizontal load dra.



(e) Vertical B.M. dia.



(f) Horizontal B.M. dia



(g) Resultant B.M. dia.

$$\text{Ans } d = 47 \text{ sag} = 50 \text{ mm}$$

$$\tau_e = \sqrt{m^2 + t^2} = 1096 \times 10^3 \quad [05 \text{ marks}]$$

$$T_c = \frac{\pi}{16} \tau d^3$$

3. (b)

Given $P = 25 \text{ kN}$, $e = 500 \text{ mm}$

$$(\sigma_t)_{\max} = 35 \text{ N/mm}^2$$

Step I Direct shear stress in bolt

$$P_1' = P_2' = \frac{P}{\text{No. of bolts}} = \frac{25 \times 10^3}{4} = 6250 \text{ N.}$$

The shear stress in each bolt is given by,

$$\tau = \frac{6250}{4} \text{ N/mm}^2 \rightarrow (1) \quad [03 \text{ Marks}]$$

Step-II Tensile stress in bolts:-

$$P_1'' = \frac{P e l_1}{2(l_1^2 + l_2^2)}$$

$$= 11270.49 \text{ N}$$

The tensile stress in bolt A is given by,

$$\tau = \frac{6250}{4} \text{ N} = \frac{11270.49}{4} \text{ N/mm}^2 \rightarrow (ii)$$

Step-III principal stress in bolts

[03 marks]

$$\sigma_t = \frac{\sigma_t}{2} + \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + (\tau)^2}$$

$$\sigma_1 = \left(\frac{14050.62}{4} \right) \text{ N/mm}^2$$

[03 Marks]

Step-IV size of the bolt

$$\frac{14050.62}{4} = 35$$

$$A = 401.45 \text{ N/mm}^2 \quad \left(A = \frac{\pi}{4} d_c^2 \right)$$

$$d_c = 22.60 \text{ mm}$$

[01 Marks]

M30

4. (a)

$$\tau_{\max} = 0.30 S_{yt}$$

$$\tau_{\max} = 0.18 S_{ut}$$

106

$$\tau_{\max} = \frac{16}{\pi d^3} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

K_b = combined shock & Fatigue factor applied ~~for~~ to B_m

K_t = — " — torsional moment.

(b) Given:

$$W = 10 \text{ kN}, N = 1400 \text{ rpm}, d = 100 \text{ mm}$$

$$\text{dia. clearance} = 100 \mu\text{m} \quad l/d = 1, \quad \frac{h_o}{c} = 0.3$$

From table:

Step-I Sommerfeld No.

$$l/d = 1 \quad \& \quad \left(\frac{h_o}{c}\right) = 0.3$$

$$S = \frac{0.0446 + 0.121}{2} = 0.0828$$

102 marks

Step-II viscosity of lubricant

$$p = \frac{W}{ld} = \frac{10000}{100 \times 100} = 1 \text{ N/mm}^2$$

$$c = \frac{1}{2} (\text{dia. clear.}) = 50 \times 10^{-3} \text{ mm} \quad 102 \text{ marks}$$

$$S = \left(\frac{\gamma}{c}\right)^2 \frac{\mu N}{p}$$

$$0.0828 = \left[\frac{50}{50 \times 10^{-3}}\right]^2 \frac{\mu (1400/60)}{1}$$

$$= 1 \times 10^6 \times \mu \quad 23.33$$

104 marks

$$\mu = 3.54 (10^{-9}) \text{ N-s/mm}^2 = 3.54 \text{ cP}$$

4 (c) Given $L_{10h} = 10000h$

Step-I Equivalent Load for complete work cycle

$$N_1 = \frac{1}{4} (1440) = 360 \text{ rev.}$$

$$N_2 = \frac{1}{2} (720) = 360 \text{ rev.} \quad \underline{02M}$$

$$N_3 = \frac{1}{4} (1440) = 360 \text{ rev.}$$

The avg. speed of rotation is given by,
 $N = N_1 + N_2 + N_3 = 1080 \text{ rpm}$

$$P_e = \sqrt[3]{\frac{N_1 P_1^3 + N_2 P_2^3 + N_3 P_3^3}{N_1 + N_2 + N_3}} \quad \underline{03}$$

$$P_e = 3823 \text{ N}$$

Step-II Dynamic load carrying capacity of bearing

$$L_{10} = \frac{60 N L_{10h}}{10^6}$$

$$= 648 \text{ million rev.}$$

$$C = (P_e L_{10})^{1/3} = 33082 \text{ N} \quad \underline{02}$$

5. (a) Given: $N = 240 \text{ rpm}$

Energy at A = E

$$C_s = 0.02$$

$$B = E - 30$$

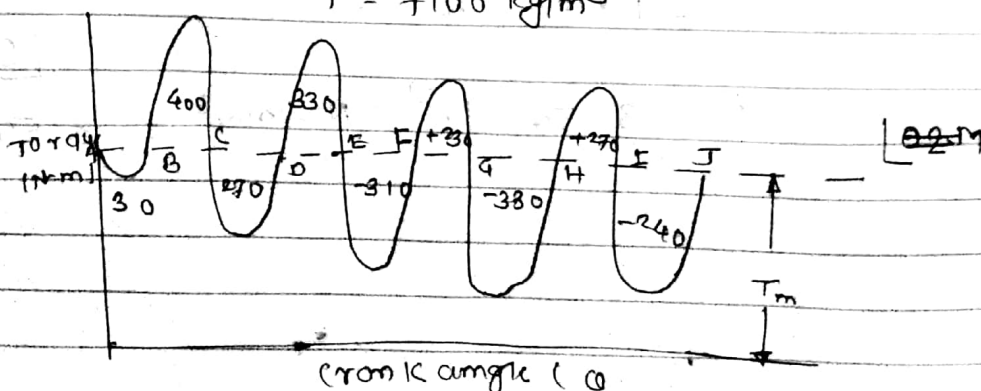
$$b/t = 1.5$$

$$C = E - 30 + 400$$

$$K = 0.9$$

$$D =$$

$$\rho = 7100 \text{ kg/m}^3$$



Step-I The energy output from Flywheel

It is assumed that the energy stored in flywheel is ΔE at point A

$$\text{Energy at B} = E - 30$$

$$\text{at C} = E - 30 + 400 = E + 370$$

$$\text{at D} = E + 370 - 270 = E + 100$$

$$\text{Maxm} \rightarrow \text{at E} = E + 100 + 330 = E + 430 \checkmark$$

$$\text{at F} = E + 430 - 310 = E + 120$$

$$\text{at G} = E + 120 + 230 = E + 350$$

$$\text{Minim} \text{ at H} = E + 350 - 380 = E - 30 \checkmark$$

$$\text{at I} = E - 30 + 270 = E + 240$$

$$\text{at J} = E + 240 - 240 = E$$

[02 M]

$$\Delta E = E_E - E_H$$

$$= E + 430 - E - 30$$

$$= 460 \times 2 \times \frac{\pi}{180} \times 1250$$

$$= 20,071.286 \text{ N-m}$$

[02 Marks]

$$\text{Step-II dimension of rim} = \omega = \frac{2\pi N}{60} = 25.132$$

$$I_r = \frac{\Delta E \cdot K}{\omega^2 C_s} = 1429.99 \text{ kg-m}^2$$

$$R \leq \frac{30}{\omega} \leq 1.19 \text{ m}$$

[02 Marks]

$$\boxed{R = 1.15 \text{ m}}$$

$$m_r = \frac{I_r}{R^2} = 1081.27 \text{ kg}$$

[02 Marks]

$$m_r = 2\pi R \left(\frac{b}{1000} \right) \left(\frac{t}{1000} \right) \rho$$

$$1081.27 = 2\pi \times 1.15 \left(1.5 \times 10^{-6} \right) \times 7100$$

$$t = 118.53 \approx 120 \text{ mm}$$

$$b = 180 \text{ mm}$$

[02 Marks]

$$\boxed{R = 1.15 \text{ m } \& 120 \times 180 \text{ mm}}$$

5. (b) Given $p = \pm 1000 \text{ N}$ $S_{ut} = 540 \text{ N/mm}^2$
 $q = 0.85$ $R = 90\%$ $N = 10,000 \text{ cycles}$

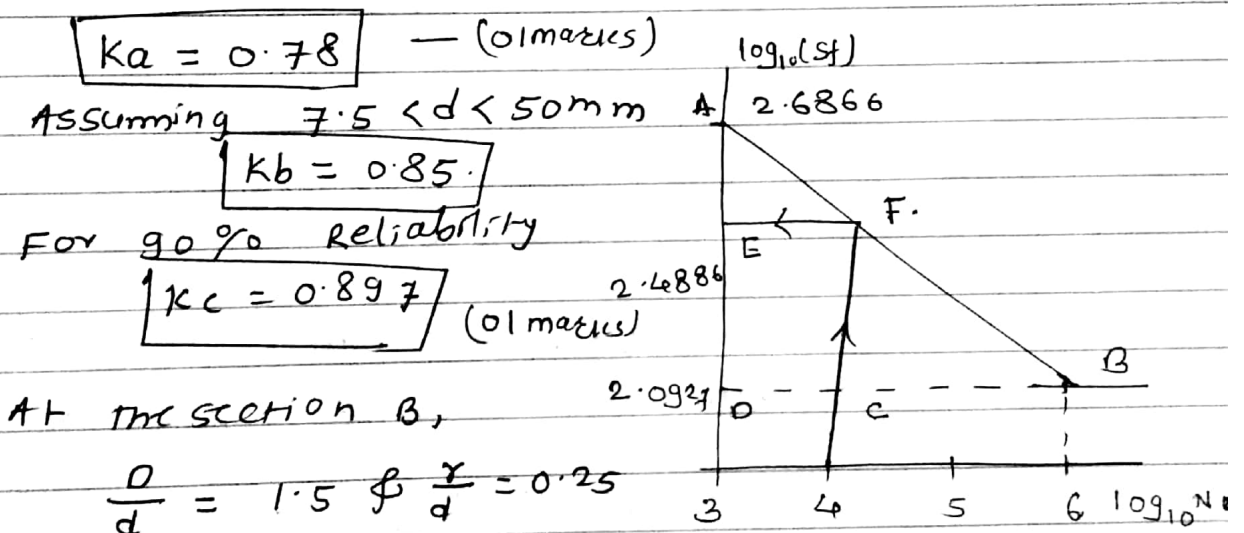
Step-I. Failure will occur at the section B. LO 1m

Step-II construction S-N dia.

LO 5

$$S_e' = 0.5 S_{ut} = 0.5 (540) = 270 \text{ N/mm}^2$$

From design data book OR charts.



$K_t = 1.35$ (01 marks)

Step-III: dia. of beam LO 3

$$K_f = 1 + q (K_t - 1)$$

$K_f = 1.2975$ — (01 marks)

$$A\bar{E} = \frac{A\bar{D} \times E\bar{F}}{D\bar{B}} = 0.198$$

$$K_d = \frac{1}{K_f} = 0.771$$

$$\log_{10}(S_f) = 2.6866 - A\bar{E} = 2.4886$$

$$S_f = 308.03 \text{ N/mm}^2$$

$K_d = 0.771$ — (01 marks)

$$S_f = \sigma_b = \frac{32 M_b}{\pi d^3}$$

$$S_e = K_a K_b K_c K_d S_e'$$

$$= 123.8 \text{ N/mm}^2$$

$d = 17.05 \text{ mm}$

$$\rightarrow 0.9 S_{ut} = 0.9 (540) = 486$$

$$\log_{10}(0.9 S_{ut}) = 2.6866$$

6. (a)

static load

Fatigue load.

6 point For each — 106M.

— x — x —

6. (b) Design consideration of welded assemblies.

- (i) select the material with high weldability.
 - (ii) Use minimum number of welds.
 - (iii) Do not shape the parts Based on casting or Forging.
 - (iv) Use standard components.
 - (v) Avoid straps, Laps & stiffeners.
 - (vi) select proper location of the welds.
 - (vii) prescribe correct sequence of welding.
- Any above Four point — explain in brief — 106.

6. (c)

(i) FG 200 — 102 marks

It is grey Cast iron having ultimate tensile strength of 200 N/mm^2

(ii) 30C8: — 102 marks

It is plain carbon steel with 0.30% C & 0.8 manganese.

(iii) 25Cr4Mo2 — 102 marks

It is an alloy steel having avg. 0.25% of carbon, 1% Cr & 0.2% molybdenum.

(iv) 16Ni3Cr2 — 102 marks

It is an alloy steel 0.8% Nickel, 0.6% chromium and 0.16% of carbon.