Qst. No.	Scoring Indicator	Split up score	Sub Total	Total
I				
1	Factor of Safety is the ratio of ultimate stress to design stress	2	2	
2	Square thread,ACME,Buttress (Any two)	2	2	
3	High strength,Good Machinability, Good wear resistance,Low notch sensitivity .(Any two)	2	2	10
4	The stationary period of follower during a part of CAM rotation	2	2	
5	Cast Iron,Steel,Bronze ,Plastic	2	2	
II				
1	Load,Mechanism,Selection of material,Manufcturing process,Shape and size,Effect of environment,Reliability, cost, Life (Any six)	6*1	6	
2	$P_1 = 65$ KN $P_2 = 20$ KN $k = \frac{a}{1+a} = \frac{.01}{1+.01} = .0099$	3		
	Resultant Load $P = P_1 + kP_2$ $= 65 + .0099 \times 20$ $= 65.198$ KN	3	6	
3	The design of shafts subjected to torsion is usually based on the formula for torsional strength which is given as Torque, $T = \tau \left(\frac{J}{R}\right)$ where J = Polar moment of inertia, mm^4 $= \frac{\pi D^4}{32}$ for solid shaft $= \frac{\pi}{32}(D_o^4 - d_i^4)$ for hollow shaft with internal diameter d and external diameter D R = radius of the shaft, mm = D/2	2	6	

4

The term $\left(\frac{J}{R}\right)$ is called *Polar section modulus* and is represented by Z_p.

$$\therefore \quad T = \tau . Z_p$$

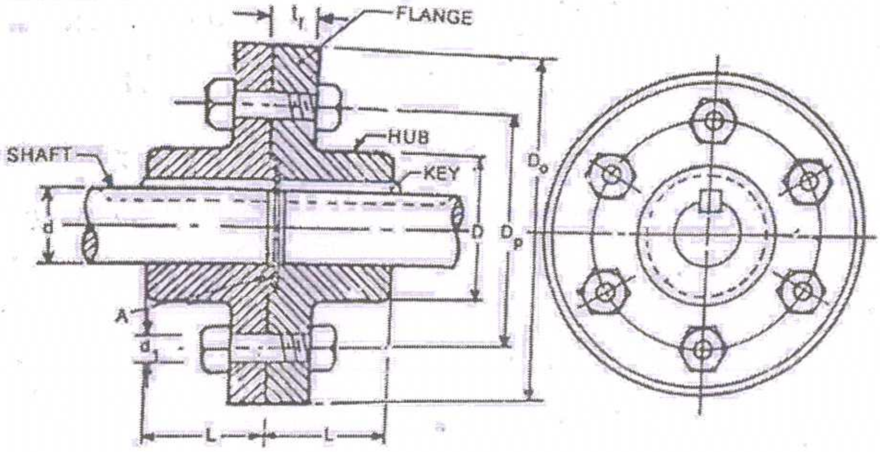
For solid circular shafts, $Z_p = \frac{\pi D^3}{16}$

For hollow circular shafts, $Z_p = \frac{\pi(D_o^4 - d_i^4)}{16\, D}$ 4

$$\therefore \quad T = \tau . \frac{\pi D^3}{16} \quad \text{for solid circular shafts}$$

$$= \tau . \frac{\pi(D_o^4 - d_i^4)}{16\, D} \quad \text{for hollow circular shafts.}$$

$$= \tau . \frac{\pi D_o^3(1-K^4)}{16}, \text{ where } K = \frac{d_i}{D_o}$$



4 6

Labelling 2

5

Advantages :

(i) Can be adopted for combined radial and axial loads without any complications

(ii) More compact design

(iii) Low starting friction

(iv) Easier to provide lubrication 3*1

(v) Reliable in service

(vi) Accurate alignment of parts can be maintained

Disadvantages : 6

(i) Generally more expensive

(ii) Wornout of contact surfaces causes noise 3*1

(iii) Design of bearing housing is complicated, and

(iv) Require good quality of lubricant

6	Types of Governors 1. Centrifugal a. Pendulum Type b. Porter c. Proell d. Hartnell e. Wilson Hartnel f. Hartung g. Pickering 2. Inertia	6*1	6	30
7	Due to difference in tension, the belt exert tangential force on pulley which is equal to $(T_1 - T_2)$. Let 'N' be the angular speed, in 'rpm', of pulley. Linear speed of the belt, $v = \frac{\pi d N}{60}$, m/s Work done = tangential force × distance W.D/sec $= (T_1 - T_2) \cdot \frac{s}{t}$ $= (T_1 - T_2)\, v$, N m/s $(v = s/t)$ Power $= (T_1 - T_2) \cdot v$, watts $(1\ W = N\ m/s)$ .... (i) Also, $\frac{T_1}{T_2} = e^{\mu\theta}$ .... (ii) From equations (i) and (ii) Power, $P = T_1 \left(1 - \frac{1}{e^{\mu\theta}}\right) \cdot v$ watts. where T_1 = Tension in the tight side, N v = Linear speed of belt, m/s μ = Coefficient of friction θ = Angle of lap, in rad.	6	6	42
		4	6	
				10
		4	6	

III a	I a. $D = .3m = 300\,mm$ $n = 6$ $\sigma_t = 30\ N/mm^2$ $p = 1.2\ N/mm^2$ Total pr = gauge pr + atm pre $= 1.2 + .1 = 1.3\ N/mm^2$	2		15
	Force $P = \frac{\pi D^2}{4} p$ —— ① Resistance(stud) $= \frac{\pi}{4} d_c^2 \sigma_t n$ —— ② Equating ① & ② $\frac{\pi D^2}{4} p = \frac{\pi}{4} d_c^2 \sigma_t n$ $d_c = \sqrt{\frac{D^2 \times p}{\sigma_t \times n}} = \sqrt{\frac{300^2 \times 1.3}{30 \times 6}}$ $= 25.49\,mm$	4	8	
	Nominal dia $d = \frac{25.49}{.84} = \underline{30.35\,mm}$ Bolt Size = $\underline{M33}$	2		
b	$W = 3000\,N$ $d_m = 75\,mm$ $p = 12\,mm$ $\mu = .075$	1		
	$\tan\alpha = \frac{p}{\pi d_m} = \frac{12}{\pi \times 75} = .051$ $\alpha = \tan^{-1} .051 = 2.919$ $\phi = \tan^{-1}\mu = \tan^{-1} .075 = 4.289$ $P_{ideal} = W \tan\alpha = 3000 \times \tan 2.419$ $= 152.97$ $P_{act} = W \tan(\alpha + \phi)$ $= 3000 \times \tan(2.919 + 4.289)$ $= 379.41$	4	7	
	~~$\eta = \frac{P_{ideal}}{P_{actual}} = \frac{379.41}{152.97}$~~ $\eta = \frac{P_{ideal}}{P_{actual}} = \frac{152.97}{379.41} = 40.3\%$	2		

4

IV a	Design Procedure State the problem Study the Mechanism Analyse the problem Select the mechanism & material Determine the size of part Modify the design Make final drawings. Explain each step	8*1	8	15
b	**Given : Nominal diameter of bolt, d = 30 mm** **Initial load, P = 2840 d** $= 2840 \times 30 = 85200$ **Stress induced in the bolt** $\sigma_t = \frac{4P}{\pi d_c^2}$ **where d_c = core diameter** **Assuming V-threads,** $d_c = d - 1.732\ p = 30 - 1.732 \times 2$ $= 30 - 3.464 = 26.536$ mm $\therefore \quad \sigma_t = \frac{4 \times 85200}{\pi (26.536)^2} = 154.06$ N/mm^2 **Ans.**	3 4	7	
V a	$P = 1\ MW = 10^6\ W$ $N = 300$ rpm $\tau = 60$ N/mm^2 $T_{max} = 1.3\ T_{mean}$ $T_{mean} = \frac{60P}{2\pi N} = \frac{60 \times 10^6}{2\pi \times 300} = 31.84$ KNm $T_{max} = 1.3\ T_{mean} = 41.39$ kNm $T_{max} = \tau \times \frac{\pi D^3}{16}$ $D = \sqrt[3]{\frac{16 \times 41.39}{60 \times \pi}} = 152.02$ mm	4		

5

	For hollow shaft $T_{max} = \tau \pi \frac{D^4 - d^4}{16 D_o}$ $d = .5D$ $= \frac{\tau \pi \cdot .9375 D^3}{16}$ $D = \sqrt[3]{\frac{16 \times 41.39 \times 10^6}{60 \times \pi \times .9375}} = 155.32$ $d = 77.67$ % saving in material = $\frac{(152.02)^2 - (155.32^2 - 77.67^2)}{152.02^2}$ $= .217 \cong \underline{21.7\,\%}$	4	8	15
b	$K = .6$ Dia of solid = D Dia of hollow = D_o Dia of (inside) hollow d_i $\boxed{D = D_o}$ $K = \frac{d_i}{D_o} = .6$ $\frac{W_H}{W_S} = \frac{\frac{\pi}{4}(D_o^2 - d_i^2) l \times density}{\frac{\pi}{4} D^2 l \times density} = \frac{D_o^2 - d_i^2}{D^2} = 1 - K^2$ $= 1 - .6^2 = \underline{.64}$	3		
	Torque: $\frac{T_H}{T_S} = \frac{\pi D_o^3/16\,(1-K^4)}{\pi D^3/16} = 1 - K^4$ $= 1 - .6^4 = .8704$	3	7	
	Stiffness $\frac{S_H}{S_S} = \frac{\frac{\pi}{32}(D_o^4 - d_i^4)}{\frac{\pi}{32} D^4} = 1 - K^4$ $= 1 - .6^4 = \underline{.8704}$	2		

VI a	**Given :** Power, $P = 100\ kW = 100 \times 10^3\ W$ Speed, $N = 200$ r.p.m. **For shaft :** Permissible shear stress, $\tau = 50\ N/mm^2$ Permissible crushing stress, $\sigma_c = 100\ N/mm^2$ **For muff :** Permissible shear stress, $\tau_1 = 15\ N/mm^2$ **Torque transmitted by shaft** $T = \frac{60 \times P}{2\pi N}$ $= \frac{60 \times 100 \times 10^3}{2 \times \pi \times 200} = 4774.648\ Nm = 4774648\ Nmm$ **Torque transmitted by shaft,** $T = \frac{\pi d^3}{16} . \tau$ *or* $d = \sqrt[3]{\frac{16 \times T}{\pi . \tau}} = \sqrt[3]{\frac{16 \times 4774648}{\pi \times 50}}$ $= 78.66\ mm = 79\ mm$	3		
	Design of Muff : Outside diameter, $D = 2d + 13$ $= 2 \times 79 + 13 = 171\ mm$ Inside diameter = diameter of shaft, d $= 79\ mm$ Length of muff $L = 3.5\ d = 3.5 \times 79 = 276.5\ mm$	3	9	
	Check for induced shear stress : The muff is designed to transmit full power of shaft. Consider muff as hollow shaft, then $T = \tau_1 \frac{\pi(D^4 - d^4)}{16\ D}$ *or* $\tau_1 = \frac{16\ D.\ T}{\pi(D^4 - d^4)}$ $= \frac{16 \times 171 \times 4774648}{\pi(171^4 - 79^4)} = 5.1\ N/mm^2$ Since the shear stress induced is less than the permissible value, the design is safe. **Design of Key :** Since $\sigma_c = 2\tau$: Adopt square key which is equally strong in shear and crushing. Thus, width of key $= \frac{d}{4} = \frac{79}{4} = 19.75 = 20\ mm$ Thickness, $t = 20\ mm$ Length of key in each shaft, $l = \frac{3.5d}{2} = \frac{3.5 \times 79}{2}$ $= 138.5\ mm = 139\ mm$ **Check for Induced Stresses :** Considering shear strength $T = w.l.\tau. \frac{D}{2}$ *or* $\tau = \frac{2T}{w.l.D} = \frac{2 \times 4774648}{20 \times 139 \times 79} = 43.5\ N/mm^2$ Considering crushing strength : $T = \frac{t}{2}\ l.\sigma_c. \frac{D}{2}$ *or* $\sigma_c = \frac{4T}{t.l.D} = \frac{4 \times 4774648}{20 \times 139 \times 79} = 87\ N/mm^2$ Since the induced stresses are less than the permissible values the design is safe.	3		

B	F.O.S. = 4. $n = 8$ $D_p = 120$ mm $T = 2500$ Nm $= 2.5 \times 10^6$ Nmm $\sigma_{max} = 350$ N/mm² $\tau = \frac{350}{4} = 87.5$ $T = \tau \times \frac{\pi d_1^2}{4} \cdot n \cdot \frac{D_p}{2}$ $2.5 \times 10^6 = 87.5 \times \frac{\pi d_1^2}{4} \times 8 \times \frac{120}{2}$ $d_1 = 8.7 \cong 9$ mm	2 4	6	15
VII a	$D = 100$ mm $R = 50$ mm $d = 60$ mm $r = 30$ mm $\mu = .05$ $p = .15$ $N = 5$ rps $W = p \times$ bearing area $= .15 \times \pi (50^2 - 30^2) = 753.6$ $T = \frac{2}{3} \mu W \left[\frac{R^3 - r^3}{R^2 - r^2}\right]$ $= \frac{2}{3} \times .05 \times 753.6 \times \frac{50^3 - 30^3}{50^2 - 30^2}$ $= 1538.6$ Nmm $= 1.53$ Nm Power loss $= 2\pi N T$ $= 2\pi \times 5 \times 1.53$ $= 48.33$ W	2 3 3	8	

<table>
<tr><td>b</td><td>

d = 60 mm
l = 90 mm
N = 450 rpm
Z = ·06 kg/m.s
c = ·2 mm

Sommerfield No. = $\frac{ZN}{p}\times\left(\frac{d}{c}\right)^2 = 14.3\times10^6$

$\frac{\cdot 06\times450}{p}\times\left(\frac{60}{\cdot 2}\right)^2 = 14.3\times10^6$

$p = \frac{\cdot 06\times450\times\left(\frac{60}{\cdot 2}\right)^2}{14.3\times10^6} = \cdot 16$ N/mm2

</td><td>4</td><td>7</td><td>15</td></tr>
<tr><td></td><td>

W = p × d × l
= ·16 × 60 × 90
= 917.622

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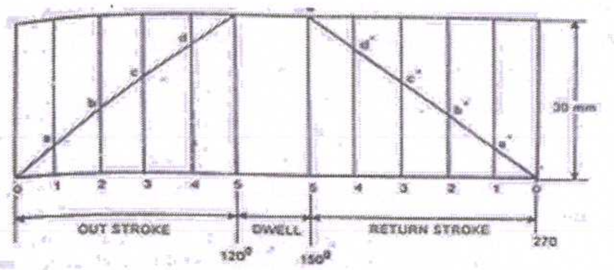
<tr><td>VIII

a</td><td>



SCALE 10 mm = 30°

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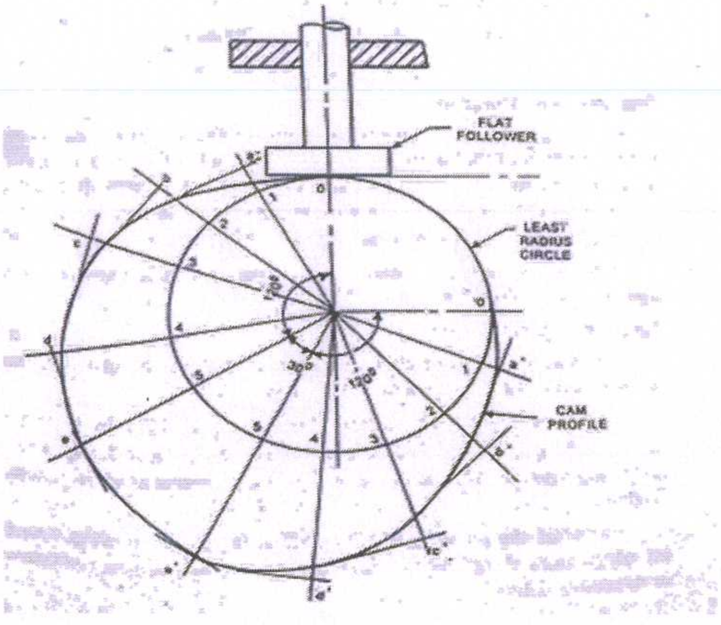

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4</td><td></td><td></td></tr>
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b	$w = 30\ N$ $W = 320\ N$ $l = 300\ mm$ $r = 240\ mm$ $h = \sqrt{l^2 - r^2}$ $= \sqrt{300^2 - 240^2} = 180\ mm$ $\omega^2 = \left[\frac{w + \frac{W}{2}(k+1)}{m}\right]\frac{1}{h}$ $= \left[\frac{30 + \frac{320}{2}(1+1)}{30/9.8}\right] \times \frac{1}{.18}$ $= 635.18$ $\omega = 25.20$ $\omega = \frac{2\pi N}{60}$ $N = \frac{60\omega}{2\pi}$ $= \frac{60 \times 25.2}{2 \times 3.14} = 240.6\ rpm$	3 4	7	15
IX a	$N_1 = 1400\ rpm$ $d_1 = 450\ mm$ $d_2 = 750\ mm$ $d_3 = 500\ mm$ $d_4 = 700\ mm$ $S = 2\ \%$ $\frac{N_2}{N_1} = \frac{d_1}{d_2}\left(1 - \frac{S_1}{100}\right)$ $N_2 = \frac{450}{750}\left(1 - \frac{2}{100}\right) 1400$ $= 823.2\ rpm$ $\frac{N_4}{N_3} = \frac{d_3}{d_4}\left(1 - \frac{S_2}{100}\right)$ $N_2 = N_3 = 823.2\ rpm$ $N_4 = \frac{500}{700}\left(1 - \frac{2}{100}\right) \times 823.2$ $= 576.24\ rpm$	4 4	8	

10

b	$d = .75\,m = 750\,mm$ $V = \frac{\pi d N}{60} = \frac{\pi \times .75 \times 200}{60}$ $= 7.85\,m/s$ $\theta = 160^\circ = \frac{160 \times \pi}{180} = 2.79\,rad$	3	7	15
	$\frac{T_1}{T_2} = e^{\mu\theta} = e^{.25 \times 2.79} = 2.01$ $P = T_1\left(1 - \frac{1}{e^{\mu\theta}}\right).V$ $= 2.5\left(1 - \frac{1}{2.01}\right) \times 7.85$ $= 9.86\,kW$	4		
X A	Train Value $= \frac{N_D}{N_A} = \frac{1}{15}$ $\frac{N_D}{N_A} = \frac{T_A \times T_C}{T_B \times T_D} = \frac{1 \times 1}{5 \times 3}$ $\frac{T_A}{T_B} = \frac{1}{5} \quad \frac{T_C}{T_D} = \frac{1}{3}$ $T_A = 15 \quad T_B = 5 \times T_A = 75$	2	8	
	$T_A + T_B = T_C + T_D$ $15 + 75 = 90 = T_C + T_D$ $T_D = 3T_C \Rightarrow 4T_C = 90 \Rightarrow T_C = \frac{90}{4} = 22.5$	3		
	$T_D = 3 \times 22.5$ $= 67.5 \cong 68$	3		

B	$P_d = .2$ mm $m = \frac{1}{P_d} = \frac{1}{.2} = 5$ mm $\frac{d_1 + d_2}{2} = 600$ $d_1 + d_2 = 1200$ $\frac{d_1}{d_2} = \frac{N_2}{N_1} = \frac{360}{120} = 3$ $d_1 = 3d_2$ $4d_2 = 1200 \Rightarrow d_2 = 300$ $d_1 = 3 \times 300 = 900$ $d_1 = mT_1 \quad T_1 = \frac{d_1}{m} = \frac{900}{5} = 180$ $T_2 = \frac{d_2}{m} = \frac{300}{5} = 60$ Teeth of 1st gear = 180 Teeth on 2nd gear = 90	3 4	7	15

12