Ref No: EX/ME/T/325/2017(OLD)

BACHELOR OF MECHANICAL ENGINEERING, 3RD YR 2ND SEM (OLD) EXAMINATION, 2017

Subject: Machine Design III

Time: 3 hours

Full marks: 100

(Make reasonable and suitable assumptions whenever necessary)

(Design tables are enclosed with this question paper)

(Answer any five questions)

1. (a) Prove that the shrinkage pressure **P** and interference ∂ are related by $\boldsymbol{\partial} = \frac{PD_2}{E}\left[\frac{2D_2^2(D_3^2-D_1^2)}{(D_3^2-D_2^2)(D_2^2-D_1^2)}\right]$,

   where the terms have usual meaning.

   (b) A thick cylinder is made of ductile material with closed ends having inner diameter D_i and subjected to internal pressure P_i. According to the distortion energy theory of failure, $\sigma = S_{yt} / FOS = \sqrt{\frac{1}{2}[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2]}$ where σ_1, σ_2 and σ_3 are principal stresses. Apply this theory to prove that the cylinder wall thickness is given by: $t = \frac{D_i}{2}[(\frac{\sigma}{\sigma-\sqrt{3}P_i})^{1/2}-1]$. Symbols have usual meaning. 12 + 8

2. (a) Derive the expression for radial stress (σ_r) and tangential stress (σ_t) of a thick cylinder pressure vessel subjected to internal pressure p_i . Sketch the stress distributions along the thickness of the cylinder.

   (b) State the applicability of the Clavarino's Equation and derive it. 13 + 7

3. (a) Assuming the relevant velocity profile of the fluid flow between two parallel plates, prove that π pi /2 X $[(R_o^2-R_i^2)/\log_e(R_o/R_i)]$ is the load carrying capacity of a hydro-static bearing, where p_i is the inlet pressure and R_o and R_i are the outer are inner radii respectively.

   (b) Following data is given for the hydrostatic thrust bearing

   shaft diameter = 400 mm; recess diameter = 250 mm; shaft speed = 720 rpm; viscosity of lubricant = 30 cP. Film thickness : 0.15 mm. Specific gravity : 0.86, Specific heat : 1.75 KJ/Kg ^{0}C Supply pressure : 5 MPa. Calculate (i) the load bearing capacity of the bearing (ii)Flow

[Turn over

requirement (iii) pumping power loss. (iv) Frictional power loss (v) temperature rise. Assume that the total power loss in the bearing is converted into frictional heat. 10 +10

4. (a) Derive Stribeck equation for static load bearing capacity of rolling element bearing mentioning its assumption.

   (b) A single row deep groove ball bearing is subjected to a radial force of 8 kN and a thrust force of 3 kN. The shaft rotates at 1200 r.p.m.The expected life of the bearing is 20, 000 hour. The diameter of the shaft is 75 mm. Select a suitable ball bearing for this application. 10 +10

5. (a) State and derive Petroff's Equation mentioning the assumption.

   (b) A ball bearing is operating on a work cycle consisting of three parts – a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle, and radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10000 hours. Calculate the dynamic load carrying capacity. 10 +10

6. Explain the polygonal effect in the chain drive with help of sketches.

   b) A simple chain No. 10B is used to transmit power from a 1400 r.p.m. electric motor to a line shaft running at 350 r.p.m. The number of teeth on the driving sprocket wheel is 19.The operation is fairly smooth with moderate shock. Calculate a) the rated power for which the chain drives can be recommended; b) the tension in for this rated power; c) the factor of safety of the chain based on the breaking load. 10 +10

7. Write short notes on : (Any four)

   (a) Design of ball bearings under cyclic loading.

   (b) Autofrettage

   (c) Lami's and Birnie's equation

   (d) Advantages and disadvantages of chain-sprocket drives

   (e) Sphere as ideal Pressure Vessel

RELATED TABLES ARE SUPPLIED HERE WITH.

Table 1 Dimensions and breaking loads of roller chains

ISO chain number	Pitch p (mm)	Roller diameter d_1 (mm)	Width b_1 (mm)	Transverse pitch p_t (mm)	Breaking load for single strand chain (kN)
06 B	9.525	6.35	5.72	10.24	10.7
08 B	12.70	8.51	7.75	13.92	18.2
10 B	15.875	10.16	9.65	16.59	22.7
12 B	19.05	12.07	11.68	19.46	29.5
16 B	25.40	15.88	17.02	31.88	65.0
20 B	31.75	19.05	19.56	36.45	98.1
24 B	38.10	25.40	25.40	48.36	108.9
28 B	44.45	27.94	30.99	59.56	131.5
32 B	50.80	29.21	30.99	58.55	172.4
40 B	63.50	39.37	38.10	72.29	272.2

Table 2 Power rating for simple roller chain

Pinion speed (r.p.m.)	Power (kW)				
	06 B	08 B	10 B	12 B	16 B
50	0.14	0.34	0.64	1.07	2.59
100	0.25	0.64	1.18	2.01	4.83
200	0.47	1.18	2.19	3.75	8.94
300	0.61	1.70	3.15	5.43	13.06
500	1.09	2.72	5.01	8.53	20.57
700	1.48	3.66	6.71	11.63	27.73
1000	2.03	5.09	8.97	15.65	34.89
1400	2.73	6.81	11.67	18.15	38.47
1800	3.44	8.10	13.03	19.85	—
2000	3.80	8.67	13.49	20.57	—

Table 3 Service factor (K_s)

Type of input power	Type of driven load: Smooth	Moderate shock	Heavy shock
(i) I.C. Engine with hydraulic drive	1.0	1.2	1.4
(ii) Electric motor	1.0	1.3	1.5
(iii) I.C. Engine with mechanical drive	1.2	1.4	1.7

Table 4. Tooth correction factor (K_2)

Number of teeth on the driving sprocket	K_2
15	0.85
16	0.92
17	1.00
18	1.05
19	1.11
20	1.18
21	1.26
22	1.29
23	1.35
24	1.41
25	1.46
30	1.73

Table 5: Performance Characteristics for full journal bearings

L/D	ε	S	$\left(r/c\right)\mu$	$\phi°$	$\bar{Q} = \frac{Q \cdot 2\pi}{\omega r L c}$
$\frac{1}{4}$	0.1	15.9	-	83	3.45
	0.2	7.58	153	75	3.76
	0.3	4.69	98.5	68	4.07
	0.4	2.85	61.4	61	4.37
	0.5	1.78	40.0	54	4.68
	0.6	1.07	26.7	47	4.99
	0.7	0.591	16.6	39	5.30
	0.8	0.266	8.93	31	5.60
	0.9	0.0738	3.49	8	5.91
$\frac{1}{2}$	0.1	4.30	-	81	3.43
	0.2	2.01	40.9	75	3.72
	0.3	1.235	25.7	68	4.00
	0.4	0.785	17.11	62	4.29
	0.5	0.497	11.95	55	4.57
	0.6	0.320	8.08	48	4.85
	0.7	0.185	5.48	41	5.13
	0.8	0.092	3.25	33	5.41
	0.9	0.032	1.59	23	5.69
1	0.1	1.35	-	79	3.37
	0.2	0.632	12.9	74	3.59
	0.3	0.382	8.04	68	3.79
	0.4	0.261	5.80	62	3.99
	0.5	0.179	4.31	56	4.16
	0.6	0.120	3.21	50	4.33
	0.7	0.0765	2.36	43	4.48
	0.8	0.0448	1.71	36	4.62
	0.9	0.0191	1.06	25	4.76
$\propto$	0.1	0.247	-	69	3.03
	0.2	0.123	2.57	67	2.83
	0.3	0.0823	1.90	64	2.52
	0.4	0.0628	1.53	62	2.26
	0.5	0.0483	1.32	58	1.91
	0.6	0.0389	1.20	54	1.56
	0.7	0.0297	1.10	49	1.16
	0.8	0.0211	0.962	42	0.76
	0.9	0.00114	0.721	32	0.41