Ref. No.: Ex/ME/5/T/322/2025

Bachelor of Engineering(Mechanical Engineering). 3rd yr. 2nd Semester Exam 2025

Subject: Machine Design III Time: Three hours// Full marks: 100

Answer any five questions. All questions carry equal marks

(Any missing data may be chosen where ever required)

1. A compressor running at 400 rpm is driven by a 18 kW, 1600 rpm motor through 14-1/2 full depth gears. The center distance is 400 mm. Both the gears are made of steel with an ultimate tensile strength of 450 N/mm^2. They are heat treated to a surface hardness of 250 BHN. Assume that velocity factor accounts for the dynamic load. Assuming medium shock condition and factor of safety.
   i) Determine the Module, face width, and number of teeth on each gear
   ii) Check the gears for dynamic loading and wear. [14+6]

2. a) Define the dynamic load carrying capacity of rolling –contact bearing.
   b) Why ball and roller bearings are called antifriction bearing? [5+3+12]
   c) The radial load acting on a ball bearing is 6 kN and the expected life for 90% of the bearings is 9000 h. If the shaft rotates at 1500 rpm, find the dynamic load carrying capacity of the bearing.

3. i) What are the advantages of bevel gears ?

   ii) A pair of straight bevel gears has a velocity ratio of 2:1. The pitch circle diameter of the pinion is 80 mm at the large end of the tooth. A power of 6 kW is supplied to the pinion rotating at 800 rpm. The face width is 40 mm and the pressure angle is 20 deg. Determine the tangential, radial, and axial component of resultant tooth force acting on the pinion. [4+16]

4. i). Select a radial ball bearing to fit a portion of a shaft where the design diameter may be from 15 mm to 25mm, according to bearing selected. It must withstand a radial load of 839.5 N and a thrust load of 310 N and should have a L_{10} life of 2000 hr. at 5500rpm.

   ii). State whether the selected bearing can be used for 5 years (8 hr./day, 5 days/week, 50 weeks/year.) If not, what bearing would you recommend? [15+5]

5. i) What are the drawbacks of the worm gear drive?

   ii) A pair of worm gear wheel is designated as 3/60/10/6. The worm is transmitting 5 kW power at 1440 rpm to the worm wheel. The coefficient of friction is 0.1 and the normal pressure angle is 20 deg. Determine the components of gear tooth force acting on the worm and the worm wheel. [5+15]

6. Write short notes on : [4x5=20]

   a) "Lewis form factor", b) Stribeck equation

[Turn over

c) L_{50} life, d) Drawbacks of bevel gears

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	—

dimensions (mm)			ratings (N)		Designation
d	D	B	C	C_0	
12	21	5	1430	695	61801
	28	8	5070	2240	6001
	32	10	6890	3100	6201
	37	12	9750	4650	6301
15	24	5	1560	815	61802
	32	9	5590	2500	6002
	35	11	7800	3550	6202
	42	13	11400	5400	6302
17	26	5	1680	930	61803
	35	10	6050	2800	6003
	40	12	9560	4500	6203
	47	14	13500	6550	6303
	62	17	22900	11800	6403
20	32	7	2700	1500	61804
	42	8	7020	3400	16404
	42	12	9360	4500	6004
	47	14	12700	6200	6204
	52	15	15900	7800	6304
	72	19	30700	16600	6404
25	37	7	3120	1960	61805
	47	8	7610	4000	16005
	47	12	11200	5600	6005
	52	15	14000	6950	6205
	62	17	22500	11400	6305
	80	21	33800	19600	6405

Table 15.4 *X and Y factors for single-row deep groove ball bearings*[3]

$\left(\frac{F_a}{C_0}\right)$	$\left(\frac{F_a}{F_r}\right) \le e$		$\left(\frac{F_a}{F_r}\right) > e$		e
	X	Y	X	Y	
0.025	1	0	0.56	2.0	0.22
0.040	1	0	0.56	1.8	0.24
0.070	1	0	0.56	1.6	0.27
0.130	1	0	0.56	1.4	0.31
0.250	1	0	0.56	1.2	0.37
0.500	1	0	0.56	1.0	0.44

F_a / C_0	$F_a / F_r \le e$		$F_a / F_r > e$		e
	X	Y	X	Y	
0.025	1	0	0.56	2.0	0.22

0.040	1	0	0.56	1.8	0.24
0.070	1	0	0.56	1.6	0.27
0.130	1	0	0.56	1.4	0.31
0.250	1	0	0.56	1.2	0.37
0.500	1	0	0.56	1.0	0.44

z	Y	z	Y	z	Y
15	0.289	27	0.348	55	0.415
16	0.295	28	0.352	60	0.421
17	0.302	29	0.355	65	0.425
18	0.308	30	0.358	70	0.429
19	0.314	32	0.364	75	0.433
20	0.320	33	0.367	80	0.436
21	0.326	35	0.373	90	0.442
22	0.330	37	0.380	100	0.446
23	0.333	39	0.386	150	0.458
24	0.337	40	0.389	200	0.463
25	0.340	45	0.399	300	0.471
26	0.344	50	0.408	Rack	0.484

Grade	e (microns)
1	0.80 + 0.06 ϕ
2	1.25 + 0.10 ϕ
3	2.00 + 0.16 ϕ
4	3.20 + 0.25 ϕ
5	5.00 + 0.40 ϕ
6	8.00 + 0.63 ϕ
7	11.00 + 0.90 ϕ
8	16.00 + 1.25 ϕ
9	22.00 + 1.80 ϕ
10	32.00 + 2.50 ϕ
11	45.00 + 3.55 ϕ
12	63.00 + 5.00 ϕ

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

Take deformation factor (C) = 11400 N/mm^2 in all cases.

Table 1: Lewis Form factor (Y) , z = no of teeth pinion/gear