 Ex/ME/T/324/2018

B.E. Mechanical Engineering - Third Year - Second Semester Examination – 2018

Subject: **MACHINE DESIGN III**

Time: Three hours **Full Marks: 100**

Different parts of the same question should be answered together.

CO1 [20]	Q. 1	**Answer any two from (a) to (c) in this block** 10 x 2 (a) State the reasons for adopting involute curve for gear tooth profile. What is full depth involute gear tooth system? Explain hunting tooth. Explain pitting and scoring of gears. (b) State and explain the factors that are considered for deciding the type of gear. (c) A pair of worm gears is designated as 2/54/10/5. Find the centre distance, speed reduction, dimensions of the worm and wheel.
CO2 [20]	Q. 2	**Answer any two from (a) to (c) in this block** 10 x 2 (a) A pair of spur gears with 20^0 full-depth involute teeth is to be designed based on Lewis equation. The velocity factor is to be used to account for dynamic load. The pinion shaft is connected to a 8 kW, 1440 rpm electric motor. The starting torque of the motor can be taken as 120% of the rated torque. The speed reduction is 4:1. The material for the pinion and the gear is plain carbon steel 40C8 (S_{ut}=600 N/mm^2). The factor of safety can be taken as 1.4. Design the gears. Lewis form factor Y (z: no of teeth) for 200 full-depth involute system can be taken from the following table.

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

(b) A pair of bevel gears, with 20^0 pressure angle, consists of a 20 teeth pinion meshing with a 30 teeth gear. The module is 4 mm, while the face width is 20 mm. The material for the pinion and gear is steel 50C4 (S_{ut}=750 N/mm^2). The gear teeth are lapped and ground (class-3) for which maximum expected error between two meshing teeth is 0.0125 mm and the surface hardness is 400 BHN. The pinion rotates at 600 rpm and receives 3 kW power from the electric motor. The starting torque of the motor is 120% of the rated torque. Determine the factor of safety against pitting failure.

(c) A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 120 teeth gear. The pinion rotates at 720 rpm. The normal pressure angle is 200, the helix angle is 250. The face width is 40 mm and the normal module is 4 mm. The pinion as well as gear is made of steel 40C8 (S_{ut}=600 N/mm^2) and heat treated to a surface hardness of 310 BHN. The service factor and the factor of safety are 1.5 and 2 respectively. Assume that the velocity factor accounts for the dynamic load. Calculate the power transmitting capacity of gears.

CO3 [20] | Q. 3

Answer any two from (a) to (c) in this block 10 x 2

(a) A steel disk ($E = 210$ kN/mm^2, $\nu = 0.28$) of uniform thickness having inner and outer radii of 75 mm and 400 mm is rotating at 1440 r.p.m. Determine the induced stresses in the disk.

(b) Prove that for uniform radial and tangential stress distribution in a disk, rotating at a uniform angular velocity ω, it should be manufactured with a thickness variation $h = C \exp(-\rho\omega^2 r^2 / 2\sigma)$, where C = a constant, ρ = density of disk material and σ = the allowable uniform strength.

(c) A steel disk ($\sigma_y = 350$ N/mm^2, $E = 210$ kN/mm^2, $\nu = 0.28$) of uniform thickness having inner and outer radii of 100 mm and 500 mm respectively is shrink fitted on a shaft with a shrink fit allowance of 1 part in 1000. If the material of the disk and shaft is same, determine the induced stresses in the disk due to shrink fit. At what rotational speed would the shrink fit loosen up and what would be the induced stresses at that speed?

CO4 [20] | Q. 4

Answer any two from (a) to (c) in this block 10 x 2

(a) State the advantages and disadvantages of chain drives. Explain the polygonal effect on chain drive. Explain the failure criteria that decide the power rating of roller chain. State the lubrication methods for chain drive.

(b) Derive Stribeck's equation for static load carrying capacity of rolling element bearings.

(c) Explain the basic procedure for the selection of a bearing from the manufacturer's catalogue.

CO5 [20] | Q. 5

Answer any one from (a) to (b) in this block 20

(a) A single-row deep groove ball bearing is used for a 30 seconds work cycle consisting of two parts as given in Table A. For this application, the static and dynamic load capacities are 50 and 68 kN respectively. Calculate the life of the bearing in hours. The load factors are given in Table B.

	Part I	Part II
Duration (s)	10	20
Radial load (kN)	45	15
Axial load (kN)	12.5	6.25
Speed (r.p.m.)	720	1440

Table A

F_a/C_o	$F_a/F_r \le e$ X	$F_a/F_r \le e$ Y	$F_a/F_r > e$ X	$F_a/F_r > e$ Y	e
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

Table B

(b) It is required to design a chain drive to connect a 12 kW, 1400 rpm electric motor to a centrifugal pump running at 700 rpm. Assume variable load with moderate shock, drop lubrication and 4 mm reduction in center distance to accommodate initial sag. The relevant design data is furnished in Tables 1 - 4. Design the chain drive and provide a proper roller chain along with its dimensions, determine the pitch circle diameters of driving and driven sprockets, the number of chain links and the correct centre distance between the axes of sprockets.

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