Ref. No.: Ex/ME(M2)/PC/B/T/323/2023(S)

B.E. MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER

SUPPLEMENTARY EXAM 2023

Subject: DESIGN OF MACHINE ELEMENTS-III

Time: 3 hrs **Full Marks: 100**

Instructions:

Answer any five from the questions given below.

Assume any missing data

1. A helical compression spring is required to deflect through approximately 25 mm when the external force acting on it varies from 500 to 1000 N. The spring index is 8. The spring has square and ground ends. There should be a gap of 2 mm between adjacent coils when the spring is subjected to the maximum force of 1000 N. The spring is made of cold-drawn steel wire with ultimate tensile strength of 1000 N/mm2 and permissible shear stress in the spring wire should be 50% of the ultimate tensile strength (G = 81 370 N/mm2).

Design the spring and calculate: - (i) wire diameter; (ii) mean coil diameter; (iii) number of active coils; (iv) total number of coils; (v) solid length; (vi) free length; (vii) required spring rate; and (viii) actual spring rate **[20]**

2. (a) What are graduated length and full-length leaves in multi-leaf spring?

(b) What is nip of leaf spring?

(c) A semi-elliptic spring used for automobile suspension, consists of two extra full-length leaves and eight graduated-length leaves, including the master leaf. The centre-to centre distance between the two eyes is 1 m. The leaves are made of steel 55Si2Mo90 (S_{yt} = 1500 N/mm^2 and E = 207 000 N/mm^2) and the factor of safety is 2. The maxi mum spring load is 30 kN. The leaves are pre-stressed so as to equalize stresses in all leaves under maximum load. Determine the dimensions of the cross-section of the leaves and the deflection at the end of the spring. **[3+2+15]**

3. (a) What are the advantages of 20° full-depth involute teeth gears?

(b) Define herringbone gear?

(c) What is pitting?

(d) State two advantages of internal gears

(e) A pair of spur gears with 20° full-depth involute teeth consists of a 20 teeth pinion meshing with a 41 teeth gear. The module is 3 mm while the face width is 40 mm. The material for pinion as well as gear is steel with an ultimate tensile strength of 600 N/mm^2. The gears are heat treated to a surface hardness of 400 BHN. The pinion rotates at 1450 rpm and the service factor for the application is 1.75. Assume that velocity factor accounts for the dynamic load and the factor of safety is 1.5. Determine the rated power that the gears can transmit.

[2+2+2+2+12]

4. **(a)** Deduce the beam strength equation for helical gears?

   (b) Deduce the wear strength equation for helical gear?

   (c) A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 100 teeth gear. The pinion rotates at 720 rpm. The normal pressure angle is 20°, while the helix angle is 25°. The face width is 40 mm and the normal module is 4 mm. The pinion as well as the gear is made of steel 4OC8 (Sut = 600 N/mm2) and heat treated to a surface hardness of 300 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 and calculate the power transmitting capacity of gears

   [4+4+12]

5. **(a)** What is thick cylinder?

   (b) What are the methods of pre-stressing the cylinder?

   (c) Deduce a relation for designing the wall thickness of pressure vessels?

   (d) A high-pressure cylinder consists of a steel tube with inner and outer diameters of 20 and 40 mm respectively. It is jacketed by an outer steel tube, having an outer diameter of 60 mm. The tubes are assembled by a shrinking process in such a way that maximum principal stress induced in any tube is limited to 100 N/mm2. Calculate the shrinkage pressure and original dimensions of the tubes (E = 207 kN/mm2). **[1+2+3+14]**

6. **(a)** Write the classification of bevel gear?

   (b) Define pitch cone and cone distance?

   (c) Deduce the force analysis of bevel gear?

   (d) A pair of bevel gears, with 20° 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/mm2). The gear teeth are lapped and ground

(Class-3) and the surface hardness is 400 BHN. The pinion rotates at 500 rpm and receives 2.5 kW power from the electric motor. The starting torque of the motor is 150% of the rated torque. Determine the factor of safety against bending failure and against pitting failure.

[3+3+4+10]

7. **(a)** What are the advantages of worm gear drives?

   (b) What kind of contact occurs between worm and worm wheel? How does it differ from other types of gears?

   (c) What are the four important parameters that are required to specify the worm gear drive?

   (d) Why is the efficiency of worm gear drive low?

   (e) A pair of worm and worm wheel is designated as 2/52/10/4. 10 kW power at 720 rpm is supplied to the worm shaft. The coefficient of friction is 0.04 and the pressure angle is 20°. Calculate (i) the center distance; (ii) the speed reduction; (iii) the dimensions of the worm; and (iv) the dimensions of the worm wheel. (v) Calculate the tangential, axial and radial components of the resultant gear tooth force acting on the worm wheel.

[2+2+2+2+12]

8. Write Short Notes: **[4 x 5 = 20]**

   (i) Solid and Compressed Length (Spring)
   (ii) Surge in spring
   (iii) Module in gear
   (iv) Contact ratio of gear
   (v) Undercutting of gear

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

Module (m) (mm)	*Class - 1*	*Class - 2*	*Class - 3*
Up to 4	0.050	0.025	0.0125
5	0.056	0.025	0.0125
6	0.064	0.030	0.0150
7	0.072	0.035	0.0170
8	0.080	0.038	0.0190
9	0.085	0.041	0.0205
10	0.090	0.044	0.0220

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