Ref. No.: Ex/ME(M2)/PC/B/T/323/2022

B.E. MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER - 2022

Subject: DESIGN OF MACHINE ELEMENTS-III

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

Instructions:

Answer any five from the questions given below.

Assume reasonably any data if it is not given.

1. **(a)** What is the significance of Wahl Factor in spring design?

   (b) Show by sketch the graduated length and full-length leaves in multi-leaf spring?

   (c) What is nip of leaf spring?

   (d) In an automotive plate clutch, six helical compression springs arranged in parallel provide the axial thrust of 1500 N. The springs are compressed by 10 mm to provide this thrust force. The springs are identical and the spring index is 6. The springs are made of cold-drawn steel wires with ultimate tensile strength of 1200 N/mm^2. The permissible shear stress for the spring wire can be taken as 50% of the ultimate tensile strength (G = 81 370 N/mm^2). The springs have square and ground ends. There should be a gap of 1 mm between adjacent coils when the springs are subjected to the maximum force. Design the springs 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. [3 +3+ 2+12]

2. The following data is given for a pair of spur gears with 20° full-depth involute teeth: number of teeth on pinion = 24, number of teeth on gear = 56, speed of pinion = 1200 rpm, module = 3 mm, service factor = 1.5, face width = 30 mm, both gears are made of steel with an ultimate tensile strength of. 600 N/mm^2. Using the velocity factor to account for the dynamic load, calculate (i) beam strength; (ii) velocity factor; and (iii) rated power that the gears can transmit without bending failure, if the factor of safety is 1.5. (iv) Effective load using Buckingham Equation. (v) Factor of safety on the basis of wear load. [20]

3. (a) What are the advantages of herringbone gear over double helical gear?

   (b) Why helical gear is preferred to spur gear for high speed application?

   (c) Explain the phenomena 'Surge' in spring.

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

   (e) What are the conditions of using Clavarino's equation for cylinder wall thickness?

   (f) Explain significance of Lewis Form Factor in gear design.

   (g) What are the advantages of internal gearing?

   (h) Write down the applicability of Lami's Equation.

   (i) What are the features of class I pressure vessel.

[Turn over

(j) Write down the ASME equation of **Tori-spherical head** and draw its sketch. [10x2]

4. A pair of parallel helical gears consists of 24 teeth pinion rotating at 5000 rpm and supplying 2.5 kW power to a gear. The speed reduction is 4:1. The normal pressure angle and helix angle are 20° and 23° respectively. Both gears are made of hardened steel (S_{ut} = 750 N/mm^2). The service factor and the factor of safety are 1.5 and 2 respectively. The gears are finished to meet the accuracy of Grade 4.

(i) In the initial stages of gear design, assume that the velocity factor accounts for the dynamic load and that the face width is ten times the normal module. Assuming the pitch line velocity to be 10 m/s, estimate the normal module.

(ii) Select the first preference value of the normal module and calculate the main dimensions of the gears.

(iii) Determine the dynamic load using Buckingham's equation and find out the effective load for the above dimensions. What is the correct factor of safety for bending?

(iv) Specify surface hardness for the gears, assuming a factor of safety of 2 for wear consideration. [20]

5. **(a)** A tube, with 50 mm and 75 mm as inner and outer diameters respectively, is reinforced by shrinking a jacket with an outer diameter of 100 mm. The compound tube is to withstand an internal pressure of 35 MPa. The shrinkage allowance is such that the maximum tangential stress in each tube has same magnitude. Calculate (i) the shrinkage pressure; and (ii) the original dimensions of tubes. Show the distribution of tangential stresses. Assume E = 207 kN/mm^2.

(b) As per maximum shear stress theory of failure prove that $t = \frac{D_i}{2}\left[\sqrt{\frac{\tau}{\tau - P_i}} - 1\right]$ for thick cylinder of ductile material with open ends. [10 +10]

6. A pair of straight bevel gears is mounted on shafts which are intersecting at right angles. Determine the Factor of safety against bending and pitting with the help of following data:

No of teeth in pinion: 30 No of teeth in gear: 45, Pressure Angle: 20 ^{0}

Power to be transmitted: 20 kW, pinion speed: 500 rpm, Service factor: 1.5

The pinion and gear are made of same material having UTS 600 M/mm^2. And heat treated to a surface hardness of 390 BHN. The error 'e' between the two meshing teeth is limited to 20 μm, The module is 6 mm and face width is 50 mm.

[20]

OR

7. **(a)** Why bevel gears are used?

(b) Explain the significance of Lewis form factor?

(c) Deduce the force analysis of bevel gear?

(d) 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. 5 kW power is supplied to the pinion, which rotates at 800 rpm. The face width is 40 mm and the pressure angle is 20°. Calculate the tangential, radial and axial components of the resultant tooth force acting on the pinion. [3+3+4+10]

8. (a) Prove that the thickness of a cylinder wall with closed ends as per Distortion energy theory of failure:

$$t = \frac{D_i}{2}\left[\sqrt{\frac{\sigma}{\sigma - P_i\sqrt{3}}} - 1\right]$$

(b) Prove that $\sigma_t = A + B/r^2$ *and* $\sigma_r = A - B/r^2$ for a thick cylindrical pressure vessel subjected to internal pressure, terms have usual meaning. Draw the tangential stress distribution in both cases when it is subjected to internal pressure p_i and external pressure p_o respectively. Assume radii ratio = 2.0 [6 +14]

<u>Additional Information</u>

Deformation factor (C) = 11400 N/mm² in all cases.

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

Table 2: Tolerances on adjacent pitch [$\Phi = m + 0.25\sqrt{d'}$]

Φ = tolerance factor, m = module, d' = p.c.d

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