DESIGN OF MECHANICAL SYSTEMS - II
(MECH 3251)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The pitch circle diameter and number of teeth in a spur gear are d' and z respectively. The module m is defined as

(a) $\left(\frac{\pi d'}{z}\right)$ (b) $\left(\frac{z}{d'}\right)$ (c) $\left(\frac{d'}{z}\right)$ (d) $(d'z)$

(ii) Involute profile is widely used for gear tooth because
(a) pressure angle remains constant
(b) face and flank form a continuous curve
(c) involute rack has straight sided teeth
(d) all the above factors.

(iii) If z is the actual number of teeth on a helical gear and ψ is the helix angle for the teeth, then the formative number of teeth is

(a) $z\cos^3\psi$ (b) $\frac{z}{\cos^3\psi}$ (c) $z\cos^2\psi$ (d) $\frac{z}{\cos^2\psi}$

(iv) Two bevel gears with 25 and 50 teeth are in mesh with each other. The pitch angle of gear is

(a) $\left[\frac{\pi}{2} - \tan^{-1}(0.5)\right]$ (b) $\sin^{-1}(0.5)$

(c) $\sin^{-1}(0.5)$ (d) $\left[\frac{\pi}{2} - \sin^{-1}(0.5)\right]$

(v) The disk brake torque is linearly proportional to the actuating force.
(a) Yes (b) No, it is proportional to its square
(c) Proportional to its cube (d) Independent of force.

(vi) If we exclude the cost factor, which bearing is preferred?
(a) Hydrostatic (b) Hydrodynamic
(c) Both are equally preferred (d) Cannot be determined.

(vii) The torque transmitting capacity of cone clutch increases as its semi vertical angle increase.
(a) True (b) Decreases
(c) Remains constant (d) None of the listed.

(viii) A seamless cylinder of storage capacity of 0.03 m³ is subjected to an internal pressure of 21MPa. The ultimate strength of material of cylinder is 350N/mm^2. Determine the length of the cylinder if it is twice the diameter of the cylinder.
(a) 540 mm (b) 270 mm (c) 400 mm (d) 350 mm

(ix) A _____ bearing supports the load acting along the axis of the shaft.
(a) Thrust (b) Radial (c) Longitudinal (d) Transversal

(x) Class 1 pressure vessels are used to contain
(a) Lethal substances (b) Light duties applications
(c) None of the listed (d) LPG.

Group – B

2. (a) A pair of spur gears with a centre distance of 495 mm is used for the speed reduction of 4.5:1. The module is 6mm. Calculate the number of teeth on the pinion and the gear.

(b) 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 and face width = 30 mm. Both gears are made of steel with an ultimate tensile strength of 600 N/mm2. 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.
Calculate tooth form factor using equation $\left(y = 0.154 - \frac{0.912}{z}\right)$ where z' is the number of teeth. Take velocity factor as $C_v = \frac{3}{3+v}$, where pitch line velocity v is in m/s.

2 + (3 + 3 + 4) = 12

3. The layout of a double-reduction helical gearbox is shown in Fig.1. Pinion A is the driving gear and 17 kW power at 1200 rpm is supplied to it through its shaft no. 1. The number of teeth on different helical gears are z_A = 24, z_B = 60, z_C = 24 and z_D = 72. The normal pressure angle for all gears is 20°. For the pair of helical gears A and B, the helix angle is 30°, and the normal module is 5 mm. For the pair C and D, the helix angle is 25° and the normal module is 6 mm. Pinion A has right-handed helical teeth, while the pinion C has left-handed helical teeth. The bearings B_1 and B_2 are mounted on shaft no.2 in such a way that bearing B_1 can take only radial load, while the bearing B_2 can take both radial as well as thrust load. Determine the magnitude and direction of bearing reactions on shaft no. 2.

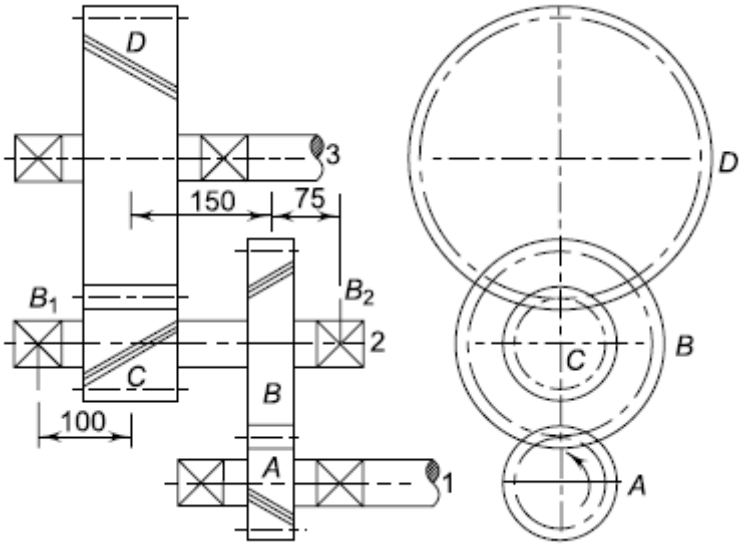

Fig.1

(7 + 5) = 12

Group – C

4. (a) 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.

   (b) A pair of cast iron bevel gears connect two shafts at right angles. The pitch diameters of the pinion and gear are 80 mm and 100 mm respectively. The tooth profiles of the gears are of $\left(14\ {}^{1}/_{2}^{\circ}\right)$ composite form. The allowable static stress for both the gears is 55 MPa. If the pinion transmits 2.75 kW at 1100 r.p.m., find the module and number of teeth on each gear from the standpoint of bending strength. The tooth form factor may be taken as $\left(0.124 - \frac{0.684}{z'}\right)$ where z' is the number of teeth on equivalent formative spur gear. Take velocity factor as $C_v = \frac{3}{3+v}$, where pitch line velocity v is in m/s. The face width may be taken as $\frac{1}{3}$ of the slant height of the pitch cone.

4 + (4 + 4) = 12

5. A high pressure vessel consist of steel tube with inner & outer diameter 20 mm & 40 mm respectively. It is a jacketed by an outer tube having outer diameter 60 mm. The tubes are assembled by shrinking processes in such a way that maximum principal stress induced in any tube is limited to 100 N/mm^2. Assume modulus of elasticity is 207 kN/mm^2. Calculate.
   (i) Shrinkage pressure
   (ii) Original Dimensions of tube.

(6 + 6) =12

Group – D

6. (a) A cone clutch is required to transmit 30 kW at 500 rpm. Coefficient of friction 0.25 and permissible intensity of pressure is 0.30, semi-cone angle of the cone is 150, and taking the outer diameter as 300 mm calculate
   (i) Inner diameter of cone clutch
   (ii) Face width
   (iii) Force required to engage, Assume uniform wear theory.

   (b) A single plate clutch consists of one pair of contacting surfaces. Because of space limitations, the outer diameter of the friction disk is fixed as D. The permissible intensity of pressure is pa and the coefficient of friction μ. Assuming uniform wear theory, plot the variation of torque transmitting capacity against the ratio of diameters (d/D). Show that the torque transmitting capacity of the clutch is maximum, when (d/D) is equal to 0.577.

(3 + 2 + 2) + 5 = 12

7. (a) An internal expanding shoe brake has face width 40 mm and maximum intensity of pressure is limited to 1 MPa. The coefficient of friction is 0.30, Assuming angle of beginning of friction material as 00, and angle where the lining ends as 1200,radius of brake drum as 125mm, vertical distance of pivot from drum center as 86.6mm, horizontal distance from drum center as 50mm, angle φ = 90°, calculate
   (i) The actuating force
   (ii) Torque absorbing capacity of brake.

   (b) What do you mean self-locking and self-energizing block brakes?

(4 + 3) + 5 = 12

Group – E

8. A single row deep groove ball bearing No. 6002 is subjected to an axial thrust of 1000N and a radial load of 2200 N. Find the expected life that 50% of the bearing will complete under this condition.

Table 2: Dimensions and static dynamic load capacities of single row deep groove ball bearings

Principal dimensions (mm)			Basic load ratings (N)		Designation
d	D	B	C	C_0	
15	24	5	1560	815	61802
	32	9	5590	2500	6002
	35	11	7800	3550	6202
	42	13	11400	5400	6302

Table 3: X and Y factors for single groove ball bearings

(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

0.04	1	0	0.56	1.8	0.24
0.07	1	0	0.56	1.6	0.27
0.13	1	0	0.56	1.4	0.31
0.25	1	0	0.56	1.2	0.37
0.5	1	0	0.56	1.0	0.44

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9. The following data is given for 360° hydrodynamic bearing:
Journal diameter 100 mm
Bearing length 50 mm
Journal Speed 1440 rpm
Minimum oil-film thickness 15 microns
Viscosity of lubricants = 30 CP
Specific gravity of lubricant = 0.86
Specific heat of lubricant = 2.09 KJ/kg°C
Fit between the journal and bearing is normal running fit H 7 e 7.
Calculate,
1) The coefficient of friction;
2) The power lost in friction;
3) The load carrying capacity of bearing;
4) The total flow requirement of lubricant
5) Side leakage
6) The rise in temperature of lubricant
Use following tables
Table 1 : Dimensional performance parameters for full journal bearing with side flow.

$\frac{l}{d}$	$\frac{h_0}{c}$	ε	S	$\left(\frac{r}{c}\right)f$	$\frac{Q}{r c n_s l}$	$\frac{Q_s}{Q}$	$\frac{P_{max}}{p}$
1/2	0.2	0.8	0.0923	3.26	5.41	0.874	3.745
1/2	0.4	0.6	0.319	8.10	4.85	0.730	2.739

(2 + 2 + 2 + 2 + 2 + 2) = 12

Department & Section	Submission Link
ME	https://classroom.google.com/c/MzY5NDg2MzA3Njg4/a/MzY5NDg2MzA3OTA5/details