Student Exam No.:- __________

GANPAT UNIVERSITY

B. Tech Sem. VII Mechanical Engineering
CBCS Regular Examination Nov/Dec. 2015
(2ME702) Design of Mechanical Systems

[Time: 3 Hours] [Total Marks: 70]

Instructions:

(1) Attempt all questions.
(2) Assume suitable data if necessary.
(3) Figures to the right indicate full marks.
(4) Use of scientific calculator is allowed.

SECTION - I

Que. 1 Attempt the followings.

(a) Attempt the followings: [4]

(1) Which one is incorrect for ball bearing.
(a) $C_o = P.M$ (b) $C_o = kdLz/5$ (c) $C_o = kd^2z/5$ (d) $C_o = Pz/5$

(2) What is the ratio of l/d for needle bearing?
(a) > 4 (b) < 4 (c) ≤ 4 (d) ≥ 4

(3) What is 'k' in the equation, $P = kd^2$ and it depends on what parameters?

(4) Average life of bearing is 60 million revolutions and it is running at 1000 rpm. Find average life of bearing in hours.

(b) Classify the bearings in the form of chart. Show the designation of rolling contact bearings with neat sketch and explain it with its meaning. [4]

(c) A set of taper roller bearing having face to face arrangement in which $F_{r1} = 800$ N, $F_{r2} = 1000$ N and $F_a = 650$ N. Assume bearing pairs to be 32007X, having C = 40200 N, e = 0.46 and y = 1.3 and $K_a = 1$. Calculate the equivalent load for the given bearing. [4]

OR

Que. 1 Attempt the followings.

(a) Explain different types of the ball bearings with their load carrying capacities using neat sketches. [4]

(b) A single row deep groove ball bearing operates for extra light load having the 15 mm diameter. The bearing subjected to an axial thrust of 1000 N and radial load of 2200 N. Find the expected life that 50% of the bearings will complete under this condition. [8]

Que. 2 Attempt the followings.

(a) Explain the causes of bearing failure and their remedies. [4]

(b) The following data is given for a hydrostatic thrust bearing: [8]
Thrust load = 400 KN, shaft speed = 700 rpm, shaft diameter = 480 mm, recess diameter = 240 mm, oil film thickness = 0.15 mm, viscosity of lubricant = 160 SUS, specific heat of lubricant = 1.76 KJ/kg °C, and specific gravity of lubricant = 0.86, calculate: (i) supply pressure, (ii) flow required in lit/min, (iii) frictional power loss, (iv) pumping power loss, and (v) temperature rise. Assume that the total power loss in the bearing is converted into frictional heat.

OR

Que. 2 Attempt the followings.

(a) Enlist the type of power losses in hydrostatic step bearing and Explain the power loss which is inversely proportional to the fluid film thickness. [4]

(b) A ball bearing working under cyclic load. For first cycle bearing operates for 0.01296 L_{h10} million revolutions under a radial load of 3000 N, for second cycle 0.03456 L_{h10} million revolutions under a radial load of 7000 N and for third cycle 0.0162 L_{h10} million revolutions under a radial load of 5000 N respectively. The basic dynamic capacity of the bearing is 30.7 KN and the total equivalent dynamic load is 6066.89 N. Determine the followings: (i) life of bearing in million revolutions for each cycle (ii) average speed of bearing rotation (ii) life of bearing in hours with 95 % reliability. [8]

Que. 3 Attempt the following.

(a) Explain the design of spindle on the basis of torsional and lateral rigidity. [3]

(b) Explain the classification of design parameters related to optimum design with their characteristics. [3]

(c) A tensile bar of length 200 mm is subjected to the constant tensile force of 5000 N. If the factor of safety is 3, derive equation for the objective of minimizing the material cost. [5]

SECTION-II

Que. 4 Attempt following.

(a) Define the interference and undercutting in involute gears. Enlist and explain the methods to eliminate interference. [3]

(b) A pair of 20° involute full depth spur gears is to be designed to transmit 100 kW from a pinion running at 750 rpm. The gear speed is to be 150 rpm. The operation is intermittent. Take k = 0.111 for 20° involute full depth involute system. Surface endurance limit for steel may be obtained by (2.8 × BHN − 70) N/mm^2. Young's modulus for the material of pinion and gear is 2.1 × 10^5 N/mm^2 and 1.05 × 10^5 N/mm^2 respectively. Face width of gear = 10m (m=module). Following specifications are available. [8]

Material	Allowable stress, MPa	BHN
Pinion: forced steel, C – 30	166	145
Gear: C. I. grade 35	116	160

Assuming K_f = 1.5, find:

(i) Module, face width, and number of teeth on pinion and gear.

(ii) Check the gears for dynamic load and wear load

Take $y = 0.154 - \frac{0.912}{z}$ & $K_v = \frac{4.5}{(4.5+V)}$, k_s =1, Take minimum number of teeth on pinion as 20.

OR

Que. 4 Attempt following.

(a) Explain force analysis of helical gear with neat sketch. [3]

(b) A pair of parallel helical gears consisting of a 20 teeth pinion meshing with 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 gear are made of steel 40C8 (S_{ut} = 600MPa) 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 the gears. [8]

Que. 5 Attempt following.

(a) Explain the design procedure for determining thickness of piston head based on strength and heat dissipation criterions. [4]

(b) The cylinder of a four-stroke diesel engine has the following specifications: Cylinder bore = 150 mm, maximum gas pressure = 3.5 MPa, cylinder material = Grey cast iron FG 200 (S_{ut} = 200N/mm^2), factor of safety = 5, Poisson's ratio = 0.25. Determine the thickness of the cylinder wall. Also calculate the apparent and net circumferential and longitudinal stresses in the cylinder wall. [8]

OR

Que. 5 Attempt following.

(a) Explain the guideline for design of piston rings. Show figures wherever necessary. [4]

(b) The following data is given for a four stroke diesel engine: [8]
Cylinder bore = 250 mm, length of stroke = 300 mm, speed = 600 mm, indicated mean effective pressure = 0.6 MPa, mechanical efficiency = 80%, maximum gas pressure = 4 MPa, fuel consumption = 0.25 kg per BP per h, higher calorific value of fuel = 44000 kJ/kg. Assume that 5% of the total heat developed in the cylinder is transmitted by the piston. The piston is made of gray cast iron FG 200 (S_{ut} = 200N/mm^2 and k = 46.6 W/m/°C) and the

factor of safety is 3. The temperature difference between the center and the edge of the piston head is 220 °C. (i) calculate the thickness of piston head by strength consideration (ii) calculate the thickness of the piston head by thermal consideration (iii) which criterion decides the thickness of piston head? (iv) state whether the ribs are required? (v) If so, calculate the number and thickness of piston ribs. (vi) state whether a cup is required in the top of the piston head. (vii) if, so calculate the radius of the cup.

Que. 6

(a) **Attempt following (any one).** **[4]**

(1) Derive the equation for effort requires to raise the load for pulley system.

(2) Explain factors for the selection of material handling equipment.

(b) In oil drilling rig a 6 × 37 wire rope with pulley tackle is used for providing a lifting capacity of 10 tonnes. The tackle has three pulleys at the top and same at the bottom. The ultimate tensile strength of the rope is 1600 MPa and E_r = 1.05 x 10^5 MPa. Design the rope. Assume 10% overload. Take C = 1.05, factor of safety as 4. Also design pulley using empirical formulas. Refer **Fig. 1** and **Fig. 2**. **[8]**

Table 1: Equivalent loads with taper roller bearing mountings

Load Case	Equivalent axial loads
$F_{r1} \geq F_{r2}$ $F_a \geq 0$	$F_{a1} = I = F_{r1}/2y$ $F_{a2} = F_a + I$
$F_{r1} < F_{r2}$ $F_a \geq 0.5(F_{r2} - F_{r1})$	$F_{a1} = I = F_{r1}/2y$ $F_{a2} = F_a + I$
$F_{r1} < F_{r2}$ $F_a < 0.5(F_{r2} - F_{r1})$	$F_{a2} = I = F_{r2}/2y$ $F_{a1} = I - F_a$

Table 2: Radial and thrust factors for single –row deep groove ball bearing

F_a/C_0	$(F_a/VF_r) \leq e$		$(F_a/VF_r) > e$		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

Table 3: Dimensions and basic capacities of single-row deep-groove ball bearing

Bearing Number	Principal Dimensions			Basic Capacity	
	Bore 'd' mm	Outside Diameter 'D' mm	Width 'B' mm	Static 'C_0' kN	Dynamic 'C' kN
6002	15	32	9	2.5	5.59
6202	15	35	11	3.75	7.80
6302	15	42	13	5.40	11.40

Table 4: Selection of D_{min}/d

No. of bands	D_{min}/d	No. of bands	D_{min}/d	No. of bands	D_{min}/d	No. of bands	D_{min}/d
1	16	5	26.5	9	32	13	36
2	20	6	28	10	33	14	37
3	23	7	30	11	34	15	37.5
4	25	8	31	12	35	16	38

Table 5: Characteristics of different wire ropes

Rope	Ultimate strength	Wire dia. d_w mm	Area (A) mm^2	Recommended sheave dia. (D) Minimum mm	Recommended sheave dia. (D) Advisable mm	Applications
6 × 7	$480d^2$	0.11d	$0.38d^2$	45d	72d	Mines, haulage Trameways
6 × 19	$510d^2$	0.07d	$0.4d^2$	45d	30d	Hoisting rope
				100d	60d	Cargo cranes, Ore, Dock Quaries, Mines hoist
				30d	20d	Derricks, elevators, well drilling
6 × 37	$480d^2$	0.045d	$0.4d^2$	18d	27d	Cranes, High speed Elevators and small shears
8 × 19	$440d^2$	0.05	$0.35d^2$	21d	31d	Extra flexible hoisting rope

Where d is in mm and also $d = 1.5\, d_w\sqrt{i}$, i = No. of wires in rope.

Table 6: Standard rope diameter (IS:2266)

8	10	12	14	16	18	20	22	24	26
28	30	32	36	38	40	44	48	52	

Table 7: Expected error 'e' in tooth profile (mm)

Module mm	Class – 1 Commercial gears	Class – 2 Carefully cut gears	Class – 3 Precision gears
Up to 4	0.05	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
12	0.100	0.050	0.0250
16	0.110	0.055	0.0230
25	0.120	0.060	0.0330

Table 8: Value of 'C' in N/mm

Tooth profile	Material of pinion and gear	C N/mm
$14\frac{1}{2}^{\circ}$ Involute	CI & CI	5610e
	Steel & CI	7700e
	Steel and Steel	11220e
20° Full depth Involute	CI & CI	5815e
	Steel & CI	7990e
	Steel and Steel	11630e
20° stub Involute	CI & CI	6030e
	Steel & CI	8285e
	Steel and Steel	12060e

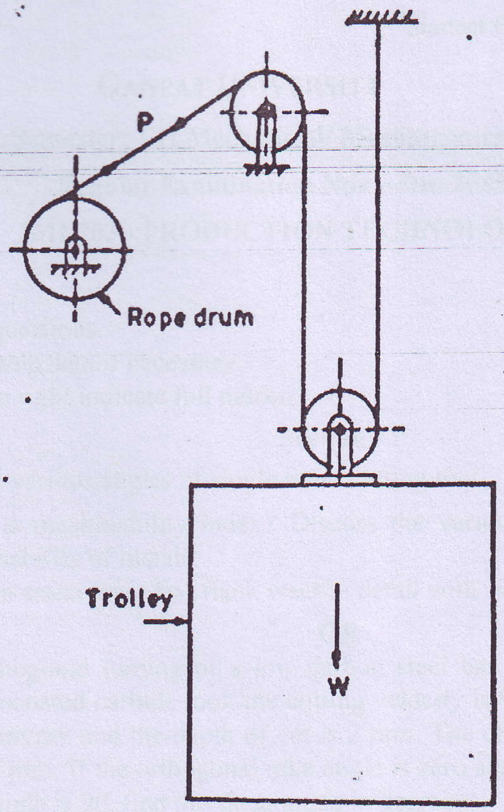

Fig. 1

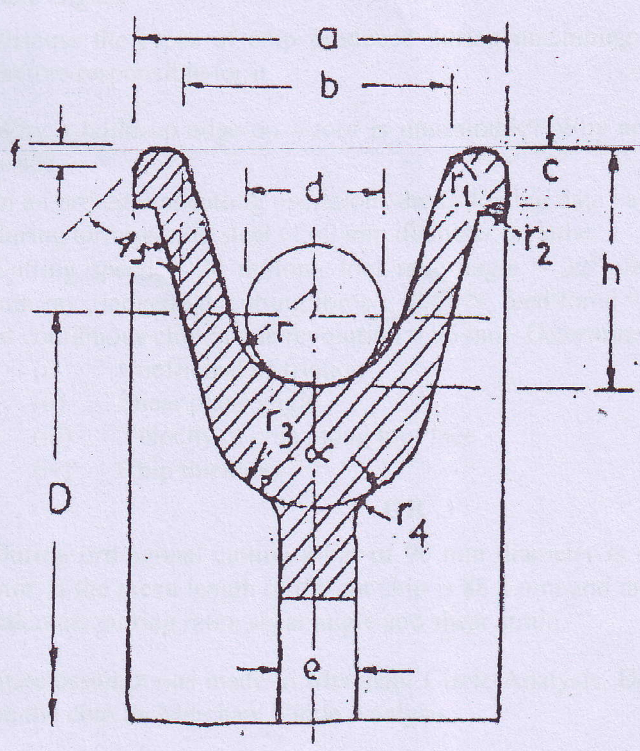

Fig. 2

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