Seat no:______

GANPAT UNIVERSITY
B. TECH. VII MECHANICAL ENGINEERING
REGULAR EXAMINATION NOV./DEC.-2011
ME 702 DESIGN OF MECHANICAL SYSTEM

[Time: 3 Hour] [Total marks: 70]

Instructions:
(1) All questions are compulsory.
(2) Right figure indicate full marks.
(3) Assume suitable data if necessary.
(4) Only scientific calculator is allowed.

SECTION-I

Que.1 Attempt the followings.

(a) Differentiate between the basic static capacity and basic dynamic capacity of bearings. Explain the designation of rolling contact bearings. [4]

(b) Use the following data given for a hydrostatic step bearing: [8]
Thrust load = 400000 N, shaft speed = 700 rev/min, shaft diameter = 0.48 m, recess diameter 0.24 m, oil film thickness = 0.15 mm, viscosity of lubricant = 160 SUS, specific heat of lubricant = 1.76 kJ/kg °C, specific gravity of lubricant = 0.86. Calculate: (i) supply pressure, (ii) flow requirement in lit/min, (iii) friction power loss, (iv) pumping power loss, and (v) temperature rise. Assume that the total power loss is converted into frictional heat.

OR

Que.1 Attempt the followings.

(a) Prove that the frictional power loss is inversely proportional to the oil film thickness. [4]

(b) A single-row deep groove ball bearing number 6207 is subjected to a combined load of 1.82 kN radially and 1.365 kN axially at 1200 rev/min. The outer ring rotates and the bearing is subjected to moderate shock with load factor having minimum value. Find the average expected life of this bearing in hours. If the bearing is subjected to moderate shock with load factor having maximum value then find the average expected life of this bearing in hours. Also comment on your result with respect to the load factor and average expected life of the bearing. [8]

Que.2 Attempt the followings.

(a) Define reliability of bearing. Explain the three parameter Weibull distribution with neat sketch. [4]

(b) Determine the thickness of the crown of an aluminium alloy piston for single acting four-stroke engine on the basis of heat dissipation from the following data: [8]
Piston diameter = 90 mm, Speed = 1500 rpm, Length of the stroke = 99 mm, Mean effective pressure = 0.7 N/mm^2, *bsfc* = 0.26 kg/kWh, L/r ratio = 4, Heat conducted through the piston crown = 10 % of heat generated during combustion, Calorific value of the fuel = 42 MJ/kg, Assume mechanical efficiency of engine as 80 %, Max. explosion pressure is 8 times the mean effective pressure, allowable stress for aluminium alloy = 55 N/ mm^2, Heat conductivity of the piston material = 1600 J/s m^2 °C/ mm, take Tc − Te = 110 °C. Also calculate: (i) Indicated power (ii) Break power (iii) Fuel consumption (iv) Heat supplied (v) heat flow rate.

OR

Que.2 Attempt the followings.

(a) A ball bearing operates for cyclic loading in which it is operated under 1.8 kN equivalent dynamic load of 36 million revolutions for first cycle, 3.9096 kN of 90 million revolutions for second cycle, 7.5 kN of 324 million revolutions for third cycle and 2.4 kN [4] of 72 million revolutions for fourth cycle. Determine the suitable bearing from manufacturer's catalogue. The shaft diameter is 55 mm. Also find the average speed of the bearing.

(b) Design a connecting rod for a petrol engine from the following data: Diameter of piston = 110 mm, mass of reciprocating parts = 2 kg, length of connecting rod = 325 mm, stroke = 150 mm, speed = 1500 rpm with possible over speed upto 2500 rpm, compression ratio = 4:1, maximum explosion pressure, p_c = 2.5 MPa. Take I section for connecting rod. Consider width of flange B = 4t, height of I section H = 5t, web thickness = t, factor of safety = 5, σ_{cr} = 460 N/mm^2, Rankine constant for both ends hinged, a = 1/6250, allowable bearing pressure = 15 N/mm^2. Calculate: (i) the outer diameter of the piston pin, (ii) length of the small end, (iii) inner diameter of the small end, (iv) outer diameter of the small end, (v) diameter of the crank pin, (vi) length of the crank pin, and (vii) thickness of bush. Assume suitable data wherever necessary. Here given notations are as per usual practices. [8]

Que.3 Attempt the followings.

(a) Explain the back to back method of mounting two taper roller bearings on a shaft with neat sketch. [2]

(b) Explain three different parameters which are express functional requirements on undesirable effects for most design equations of mechanical elements. [2]

(c) In a light weight equipment, a shaft is transmitting a torque of 900 Nm and is to have a rigidity of 90 Nm/degree. Assume a factor of safety 1.5 based on yield stress. Select the suitable material for shaft based on weight MSF and cost MSF. Made selection of shaft for minimum weight and minimum cost. Assume maximum shear stress theory of failure. Use the following data for the materials: [7]

Material	Mass density (kg/m^3)	Material cost (Rs./N Weight)	Yield strength (MPa)	Shear Modulus (GPa)
Steel	8500	16	130	80
AL-Alloy	3000	32	50	26.7
Titanium Alloy	4800	480	90	40
Magnesium Alloy	2100	32	20	16

SECTION - II

Que:4 Attempt the followings.

(a) Explain the design procedure of hook for trapezoidal section using empirical formulas with neat sketch. [4]

(b) The 6 x 19 wire rope is used to lift the cage of a vertical mine hoist 400 m deep. The weight of cage is 1200 kg (mass) and it has to lift 3000 kg of ore at a speed of 15 m/s which is to be attain in 10 seconds. Take $\frac{D_{min}}{d} = 75$. Assume factor of safety of 5 and E = 8 x 10^4 N/mm^2. Weight of rope per metre = 0.0034 d^2 kg. Cross sectional area of rope = 0.38 d^2. Ultimate stress for rope wire is 1800 N/mm^2. Determine diameter of rope. Take wire diameter = 0.0063 m. [8]

OR

Que:4 Attempt the followings.

(a) Discuss the loading on a rope drum highlighting its design. [4]

(b) In an oil drilling rig a 6 x 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 Er = 1.05 x 10^5 MPa. Design the rope giving a neat sketch of the hoisting arrangement. Assume 10% overload. Take C = 1.05, factor of safety as 4. [8]

Que:5 Attempt the followings.

(a) Explain force analysis of spur gears with neat sketch. Also show F.B.D. of spur gears. **[4]**

(b) A herringbone speed reducer consists of 26 teeth pinion driving a 104 teeth gear. The gears have a normal module of 2 mm. The pressure angle is 20° and helix angle is 25°. The pinion receives 100 kW power through its shaft and rotates at 3600 rpm. The face width of each half is 35 mm. The gears are made of alloy steel 30Ni4Cr1 (σ_{ut} = 1500 N/mm^2) and heat treated to a surface hardness of 450 BHN. The service factor is 1.25. Determine the factor of safety against bending failure and against pitting failure. **[8]**

OR

Que:5 Attempt the followings.

(a) Explain herringbone gear and double helical gear with neat sketch and explain their advantages and disadvantages. **[4]**

(b) It is required to design a pair of spur gears with 20° full depth involute teeth consisting of a 20 teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 kW, 1450 rpm electric motor. The starting torque of the motor can be taken as 150 % of the rated torque. The material for the pinion is plain carbon steel Fe410 (σ_{ut} = 410 N/mm^2), while the gear is made of grey cast iron FG200 (σ_{ut} = 200 N/mm^2). The factor of safety is 1.5. Design the gears based on Lewis equation and using velocity factor to account for the dynamic load. Take pitch line velocity = 5 m/s, b/m = 10. **[8]**

Que:6 Attempt the followings.

(a) Why the efficiency of worm gear drive is low? **[2]**

(b) Why worm and worm wheel operate inside an oil reservoir? **[2]**

(c) Define following terms related to bevel gears: **[3]**
(i) Pitch cone, (ii) Pitch angle, (iii) Face angle

(d) Explain the interference and under cutting with respect to the gear design. **[4]**

Table 1: Basic capacities of single row deep groove ball bearing

Bearing No.	C(N)	Co (N)
6207	25500	15300
6011	28100	21200
6211	43600	29000
6311	71500	45000
6411	99500	62000

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

F_a/C_0	F_a/C_0		$(F_a/VF_r) \geq e$		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: Load factors

Type of Application	Load Factor
Precision gearing	1.0 – 1.1
Commercial gearing	1.1 – 1.3
Applications with poor bearing seals	1.2
Machinery with no impact	1.0 – 1.2
Machinery with light impact	1.2 – 1.5
Machinery with moderate impact	1.5 – 3.0

Table – 4

No. of bands	1	2	3	4	5	6	7	8	9	10
D_{min}/d	16	20	23	25	26.5	28	30	31	32	33

Table – 5

Rope	Ultimate strength N	Wire dia. d_w mm	Area (A) mm	Recommended sheave dia. (D) Min. mm	Advisable mm	Applications
6 x 7	480 d^2	0.11 d	0.38 d^2	45 d	72 d	Mines, hailage, Tramways
6 x 19	510 d^2	0.07 d	0.4 d^2	30 d	45 d	Cargo cranes
6 x 37	480 d^2	0.045 d	0.4 d^2	18 d	27 d	Overhead Cranes
8 x 19	440 d^2	0.05 d	0.35 d^2	21 d	31 d	Extra flexible hoisting rope

Table - 6 Values of the Lewis form factor Y for 20° full involute system

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 – 7 Recommended series of module (mm)

Choice -1	1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 8.0, 10, 12, 16, 20
Choice -2	1.125, 1.375, 1.75, 2.25, 2.75, 3.5, 4.5, 5.5, 7, 9, 11, 14, 18

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