B.E. Mechanical Engineering - Third Year - Second Semester Examination – 2019

Subject: **MACHINE DESIGN III**

Time: Three hours **Full Marks: 100**

Answer Question No. 1 and any FIVE from the rest.

Different parts of the same question should be answered together. Assume any missing data.

Q. 1	(a) A pair of worm gears is designated as 2/54/10/5. Find the centre distance, speed reduction, dimensions of the worm and wheel. (b) Explain the modifications required in Lewis equation and Buckingham's equation in case of bevel gears compared to spur gears. What is virtual or formative bevel gear? (c) State the reasons for adopting involute curve for gear tooth profile. What is full depth involute gear tooth system? Explain hunting tooth. (d) Explain the basic modes of gear tooth failure. How can these be avoided? (e) Explain the basic procedure for the selection of rolling element bearing from manufacturer's catalogue. (f) Explain polygonal effect in chains. Hence show that a driving sprocket should have at least 17 teeth for smooth operations. (g) Prove that for uniform radial and tangential stress distribution in a disk, rotating at a uniform angular velocity ω, it should be manufactured with a thickness variation $h = C \exp(-\rho\omega^2 r^2 / 2\sigma)$, where C = a constant, ρ = density of disk material and σ = the allowable uniform strength. (h) Derive Stribeck's equation for static load carrying capacity of rolling element bearings. 5 x 8
Q. 2	It is required to design a pair of 20^0 full depth involute teeth spur gear speed reducer for a compressor running at 250 rpm driven by a 7.5 kW, 1000 rpm electric motor. The centre distance between axes of gear shafts should be exactly 250 mm. The starting torque of the motor can be taken as 150% of the rated torque. The material for the pinion and the gear is plain carbon steel 50C4 (S_{ut}=700 N/mm^2). The deformation factor (C) for such material combination and 20^0 involute teeth is nearly 11400 N/mm^2. The factor of safety can be taken as 2 for preliminary design based on velocity factor. (i) Design the gears, specify their dimensions. (ii) Assume that machining grade for gears is Grade 6, for which tolerance (e, micron) on adjacent pitch is given as e= 8+0.63 [m+0.25sqrt(PCD)]. Calculate the dynamic load using Buckingham's equation: $P_d=21v(Ceb+P_t)/[21v+\text{sqrt}(Ceb+P_t)]$. (iii) Calculate the effective load using: $P_{eff}=C_sP_t+P_d$. (iv) Find the actual factor of safety against bending failure. (v) Use same factor of safety against pitting failure to find suitable surface hardness for the gears. Lewis form factor Y (z: no of teeth) for 20^0 full-depth involute system can be taken from the following Table.

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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

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Q. 3 A steel disk (σ_y = 350 N/mm^2, E = 210 kN/mm^2, ν = 0.28, ρ = 8.1 g/cc) of uniform thickness having inner and outer radii of 100 mm and 500 mm respectively is shrink fitted on a shaft with a shrink fit allowance of 1 part in 1000. If the material of the disk and shaft is same, determine the induced stresses in the disk due to shrink fit. At what rotational speed would the shrink fit loosen up and what would be the induced stresses at that speed? 12

Q. 4 Explain the construction and working principle of a chain drive system, appending neat sketches of the components of the drive system.
With the help of a sample table, explain the specification of a power transmission chain. Why is the number of pitch selected as an even number and how is the distance between the axes of the two sprockets evaluated?
What are the factors influencing the determination of design power of a chain drive system? Briefly discuss about the factors. 12

Q. 5 The magnitude of a radial force P (in N) acting on a ball bearing varies in a sinusoidal manner given by $P = 750(1-\cos\theta)$ where θ is the angle of rotation ($0 \le \theta \le 2\pi$) and the speed of rotation is 720 rpm. Determine the dynamic load capacity of the bearing for a life of 8000 hr. 12

Q. 6 A pair of bevel gears, with 20^0 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/mm^2). The gear teeth are lapped and ground (class-3) for which maximum expected error between two meshing teeth is 0.0125 mm and the surface hardness is 400 BHN. The pinion rotates at 600 rpm and receives 3 kW power from the electric motor. The starting torque of the motor is 120% of the rated torque. Determine the factor of safety against pitting failure. 12

Q. 7 A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 120 teeth gear. The pinion rotates at 720 rpm. The normal pressure angle is 20^0, the helix angle is 25^0. The face width is 40 mm and the normal module is 4 mm. The pinion as well as gear is made of steel 40C8 (S_{ut}=600 N/mm^2) and heat treated to a surface hardness of 310 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. Calculate the power transmitting capacity of gears. 12