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Ref. No.: ME/T/314/2017(OLD)(S)

BACHELOR OF MECHANICAL ENGG. EXAMINATION, 2017 (OLD)

(3rd Year, 1st Semester, Supplementary)

MACHINE DESIGN – II (OLD)

Time : **3 hrs** | Data if missing may be assumed reasonably | Full Marks: **100**

The symbols used in the questions, bear their usual meaning

Relevant tables are provided at the end

Answer any **Five (5)** questions

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1. Design a rigid flange coupling capable of transmitting 40 kW at 1000 rpm. Materials for shaft, key and bolt are to be suitably chosen. The coupling halves are made of grey cast iron FG200. Specify all the major dimensions of the coupling with appropriate notations and draw a free hand sketch of the coupling. [15 + 5]

2. a) A leather faced cone clutch transmits power at 500 rpm. The semi-cone angle is 12.5°. The mean diameter of the clutch is 300 mm, while the face width of the contacting surface of the friction lining is 100 mm. the coefficient of friction is 0.2 and the maximum intensity of pressure is limited to 0.07 N/mm^2. Calculate the force required to engage the clutch and the power transmitting capacity.

b) Explain how frequency of clutching operation is an important parameter in thermal analysis of clutches.

c) List the advantages of centrifugal clutch. [10 + 07 + 03]

3. a) A steel band with a tensile failure stress of 250 N/mm^2 is employed in a differential band brake (as shown in Fig Q3) with a factor of safety of 5. The belt is 100 mm wide and has a thickness of 3 mm. The coefficient of friction between the friction lining and the brake drum is 0.25. Calculate: (i) The tensions in the band, (ii) The actuating force and (iii) The torque capacity of the brake. Also find whether the brake is self-locking.

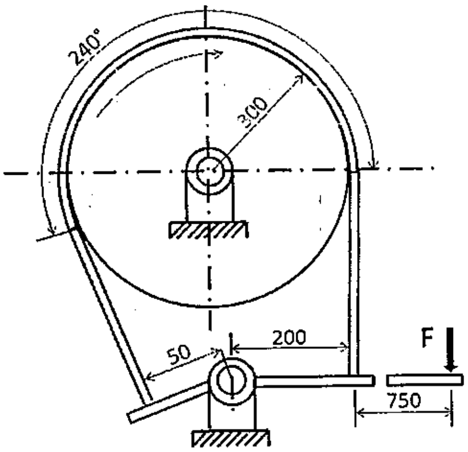

Fig Q3

b) What are the advantages of using disc brakes compared to shoe and band brakes?

c) Why the arms of a pulley are of elliptical cross section?

d) Explain why the major axis of the elliptical section (of arms) is preferably located in the plane of rotation of the pulley. [8 + 3 + 3 + 6]

4. a) Design a helical compression spring for a maximum load and deflection of 1000 N and 25 mm respectively and using a spring index value of 5. Assume the permissible shear stress for spring wire as 420 MPa and a modulus of rigidity of 84 kN/mm^2.

b) What is nipping of leaf springs?

c) A semi-elliptical leaf spring consists of two extra full-length leaves and eight graduated-length leaves, including the master leaf. The centre to centre distance between the two eyes of the spring is 1.0 m and width of each leaf is 50 mm. The maximum force acting on the spring is 10 kN. The spring is initially pre-loaded in such a way that when the load is maximum, the stresses induced in the leaves are equal to 350 N/mm^2. The modulus of elasticity is 207000 N/mm^2. Determine: (i) The thickness of leaves and (ii) The deflection of the spring at maximum load. [8 + 4 + 8]

5. a) A pair of spur gears consists of a 24 teeth pinion, rotating at 1000 rpm and transmitting power to a 48 teeth gear. The module is 6 mm and the face width is 60 mm. Both the gears are made of steel with an ultimate strength of 450 N/mm^2 and also heat treated to a surface hardness of 250 BHN. Assume that velocity factor accounts for the dynamic load. Calculate: (i) Beam strength, (ii) Wear strength and (iii) The rated power that can be transmitted by the gears if service factor and factor of safety are 1.5 and 2.0 respectively.
   b) What are the limitations of Lewis equation? What is the significance of Lewis form factor in the design of gears?
   c) What is undercutting in gears? [12 + (3 + 2) + 3]

6. A steel pinion (σ_o = 103 MN/m^2, E = 2×105 N/mm^2) rotating at 900 rpm is to drive a cast iron spur gear (σ_o = 55 MN/m^2, E = 1.0×105 N/mm^2) at 144 rpm. The teeth are to have standard 20° stub involute profiles and the maximum power to be transmitted is 25 kW. Determine the proper module, number of teeth and the face width for these gears from the standpoint of strength, dynamic load and wear. Pinion is surface hardened to BHN250.
   Lewis form factor for pinion and gear are 0.115 and 0.161 respectively. Assume allowable bending stress σ_b = 0.5 σ_o. Load stress fatigue factor for steel pinion (BHN 250) and cast iron gear is 1310 kN/m^2. [20]

7. (a) What are advantages and limitations of worm and worm wheel as compared to other types of gear? A worm is to transmit 7.5 kW at 1500 rpm to a worm wheel, the pair being designated by 2/40/10/8. Normal pressure angle is 20° and coefficient of friction being 0.1. Determine the components of the tooth forces acting on the worm and the worm wheel.
   (b) In order to determine the beam strength of a helical gear, it is considered to be equivalent to a 'formative' or 'virtual' spur gear. Justify the statement and find out the relation between formative number of teeth and actual number of teeth. [(4 +8) + 8]

Table 1 List of materials and their properties

Grade	Tensile strength (N/mm^2)	Yield strength (N/mm^2)
	Cast Iron	
FG 150	150	--
FG 200	200	--
FG 260	260	--
FG 300	300	--
FG 400	400	--
	Plain carbon steel	
7C4	320	--
10C4	340	--
30C8	500	400
40C8	580	380
45C8	630	380
50C4	660	460
55C8	720	460

Table 2: Standard dimensions for leaves

Standard thickness of leaves (mm)	Standard width of leaves (mm)
3.2, 4.5, 5, 6, 6.5, 7, 7.5, 8, 9, 10, 11, 12, 14, 16	32, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 100, 125

Table 3: Standard size of spring wire diameter

SWG	*Diameter (mm)*	*SWG*	*Diameter (mm)*	*SWG*	*Diameter (mm)*	*SWG*	*Diameter (mm)*
7/0	12.70	7	4.470	20	0.914	33	0.2540
6/0	11.785	8	4.064	21	0.813	34	0.2337
5/0	10.973	9	3.658	22	0.711	35	0.2134
4/0	10.160	10	3.251	23	0.610	36	0.1930
3/0	9.490	11	2.946	24	0.559	37	0.1727
2/0	8.839	12	2.642	25	0.508	38	0.1524
0	8.229	13	2.337	26	0.457	39	0.1321
1	7.620	14	2.032	27	0.4166	40	0.1219
2	7.010	15	1.829	28	0.3759	41	0.1118
3	6.401	16	1.626	29	0.3454	42	0.1016
4	5.893	17	1.422	30	0.3150	43	0.0914
5	5.385	18	1.219	31	0.2946	44	0.0813
6	4.877	19	1.016	32	0.2743	45	0.0711

Table 4: Proportions of standard parallel, tapered and gib head keys

Shaft diameter (mm) upto and including	*Key cross-section*		*Shaft diameter (mm) upto and including*	*Key cross-section*	
	Width (mm)	*Thickness (mm)*		*Width (mm)*	*Thickness (mm)*
6	2	2	85	25	14
8	3	3	95	28	16
10	4	4	110	32	18
12	5	5	130	36	20
17	6	6	150	40	22
22	8	7	170	45	25
30	10	8	200	50	28
38	12	8	230	56	32
44	14	9	260	63	32
50	16	10	290	70	36
58	18	11	330	80	40
65	20	12	380	90	45
75	22	14	440	100	50

Table 5 Standard bolt size.

Designation	*Nominal or major dia d/D (mm)*	*Pitch (p) (mm)*	*Pitch diameter d_p/D_P (mm)*	*Minor diameter* d_c (mm)	D_c (mm)	*Tensile stress area (mm^2)*
M 4	4	0.70	3.545	3.141	3.242	8.78
M 5	5	0.80	4.480	4.019	4.134	14.20
M 6	6	1.00	5.350	4.773	4.917	20.10
M 8	8	1.25	7.188	6.466	6.647	36.60
M 10	10	1.50	9.026	8.160	8.376	58.00
M 12	12	1.75	10.863	9.853	10.106	84.30
M 16	16	2.00	14.701	13.546	13.835	157
M 20	20	2.50	18.376	16.933	17.294	245
M 24	24	3.00	22.051	20.319	20.752	353
M 30	30	3.50	27.727	25.706	26.211	561
M 36	36	4.00	33.402	31.093	31.670	817
M 42	42	4.50	39.077	36.479	37.129	1120
M 48	48	5.00	44.752	41.866	42.587	1470
M 56	56	5.50	52.428	49.252	50.046	2030
M 64	64	6.00	60.103	56.639	57.505	2680
M 72	72	6.00	68.103	64.639	65.505	3460
M 80	80	6.00	76.103	72.639	73.505	4340
M 90	90	6.00	86.103	82.639	83.505	5590
M 100	100	6.00	96.103	92.639	93.505	7000

Table 6: Form Factors *y – for use in Lewis strength equation*

Number of Teeth	*14.5° Full-Depth Involute or Composite*	*20° Full-Depth Involute*	*20° Stub Involute*
12	0.067	0.078	0.099
13	0.071	0.083	0.103
14	0.075	0.088	0.108
15	0.078	0.092	0.111
16	0.081	0.094	0.115
17	0.084	0.096	0.117
18	0.086	0.098	0.120
19	0.088	0.100	0.123
20	0.090	0.102	0.125
21	0.092	0.104	0.127
23	0.094	0.106	0.130
25	0.097	0.108	0.133
27	0.099	0.111	0.136
30	0.101	0.114	0.139
34	0.104	0.118	0.142
38	0.106	0.122	0.145
43	0.108	0.126	0.147
50	0.110	0.130	0.151
60	0.113	0.134	0.154
75	0.115	0.138	0.158
100	0.117	0.142	0.161
150	0.119	0.146	0.165
300	0.122	0.150	0.170
Rack	0.124	0.154	0.175

Table 7: Values of Surface Endurance Limit and Stress Fatigue Factor

Average Brinell Hardness Number of steel pinion and steel gear		*Surface Endurance Limit s_{es} (MN/m²)*	*Stress Fatigue Factor K(kN/m²)*	
			14.5°	20°
150		342	206	282
200		480	405	555
250		618	673	919
300		755	1004	1372
400		1030	1869	2553
Brinnel Hardness Number, BHN				
Steel pinion	*Gear*			
150	C.I.	342	303	414
200	C.I.	480	600	820
250	C.I.	618	1000	1310
150	Phosphor Bronze	342	317	427
200	Phosphor Bronze	445	503	689
C.I. Pinion	C.I. Gear	549	1050	1420
C.I. Pinion	C.I. Gear	618	1330	1960

Table 8 Values of deformation factor C – for dynamic load check

Material		*Involute tooth form*	*Values of deformation factor (C) in N/mm*				
			Tooth error in action (e) in mm				
Pinion	*Gear*		0.01	0.02	0.04	0.06	0.08
Cast iron	Cast iron		55	110	220	330	440
Steel	Cast iron	14½°	76	152	304	456	608
Steel	Steel		110	220	440	660	880
Cast iron	Cast iron		57	114	228	342	456
Steel	Cast iron	20° full depth	79	158	316	474	632
Steel	Steel		114	228	456	684	912
Cast iron	Cast iron		59	118	236	354	472
Steel	Cast iron	20° stub	81	162	324	486	648
Steel	Steel		119	238	476	714	952

Table 9: Partial List, Material Factor Cm

Gear		*Pinion*		
Material	*BHN*	*Material*	*BHN*	C_m
I	160-200	II	210-245	0.30
II	245-280	II	285-325	0.40
II	285-325	II	335-360	0.50
II	210-245	III	500	0.40
II	285-325	IV	550	0.60
III	500	IV	550	0.90
IV	500	IV	550	1.00

Table 10 Values of tooth error vs module

Module (mm)	4	5	6	7	8	9	10	12	14	16
Tooth error (mm)	0.051	0.055	0.065	0.071	0.078	0.085	0.089	0.097	0.104	0.110

Table 11: Values of bending stress factor (Sb) for worm materials

Material	S_b
Phosphor-bronze (centrifugally cast)	7.00
Phosphor-bronze (sand-cast and chilled)	6.40
Phosphor-bronze (sand-cast)	5.00
0.4% Carbon steel-normalized (40C8)	14.10
0.55% Carbon steel-normalized (55C8)	17.60
Case-hardened carbon steels (10C4, 14C6)	28.20
Case-hardened alloy steels (16Ni80Cr60 and 20Ni2Mo25)	33.11
Nickel-chromium steels (13Ni3Cr80 and 15 Ni4Crl)	35.22

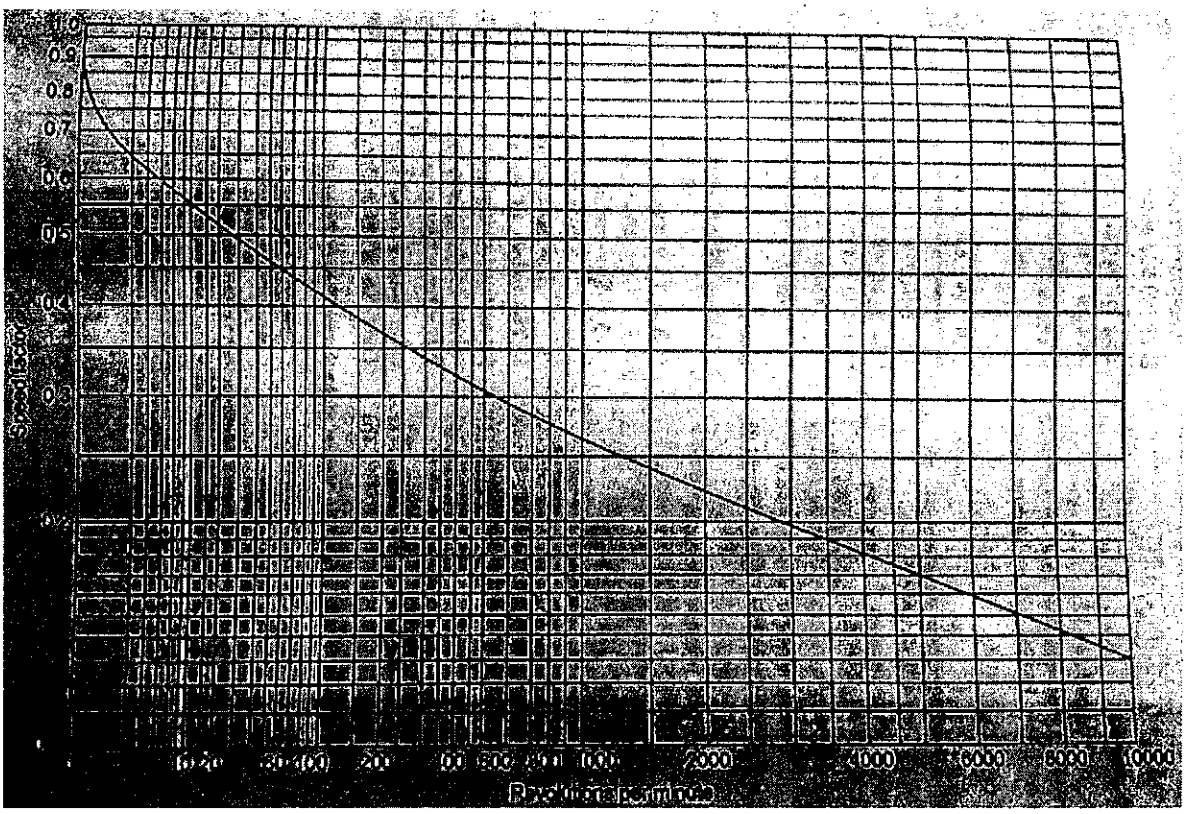

Fig 1: Speed factor for worm gears for strength

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