UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: January 2022

Module Number: ME 4303 **Module Name: Design of Machine Elements (C18)**

[Three Hours]

[Answer **all questions**, each question carries ten marks]

Clearly state all assumptions. Provide sketches and diagrams where required. Symbols stated herein denote standard parameters.

Q1 a) With the aid of suitable diagrams explain the terms "Fatigue" and "Endurance strength" of a meterial.

[2.0 Marks]

b) Explain with a suitable sketch how machining, grinding, and polishing of a shaft can gradually improve its endurance strength and costs involved in such improvements.

[2.0 Marks]

c) A circular shaft of diameter 60mm is simply supported at 500mm span and carries a steady concentrated load of 2.5*W* at the center. A completely reveresed variable load of amplitude 1.5*W* is then applied at the same point along with the steady load of 2.5*W*. Assumuming the factor of safety *F.S* as 1.3, find the maximum value of *F* if the material properties of the shaft are as folows;
Ultimate stress = 700 MPa, Yield stress = 500 MPa, Endurance strength = 330 MPa.
Take a size factor of 0.85 and surface finish factor of 0.9.
With usual notation, $\frac{1}{F.S} = \frac{\sigma_m}{\sigma_u} + \frac{\sigma_v * K_f}{\sigma_e * K_{sur} * K_{sz}}$
Sectional modulus of a circular shaft $Z = \pi d^3/32$

[4.0 Marks]

d) If it is required to transmit an additional axial compressive load simultaneousely with the fluctuating load described above, explain the sterss and deflection situation you would expect.

[2.0 Marks]

Q2 a) The function of riverts in a joint is to make a tight and strong connection. Brifly explain why the strength and tightness are necessery for a joint?

[2.0 Marks]

b) What are the types of failures that can happen in riveted joints?

[2.0 Marks]

c) Explain with the aid of a sketch, advantage of hot riveting over cold riveting

[2.0 Marks]

d) A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are:
tensile stress σ_t =120 MPa; shear stress τ =100 MPa ; crushing stress σ_c =150MPa
Find the efficiency of the joint by taking the strength of the rivet in double shear as twice than that of single shear.

[4.0 Marks]

Q3 a) Write down the types of joints that are used to make endless belts.

[2.0 Mark]

b) Write down four types of flat belt drives that are used to transmit power from one pulley to another.

[2.0 Marks]

c) You are asked to design a rubber belt to drive a dynamo which generates 20 kW at 2250 r.p.m. and fitted with a pulley with the diameter of 200 mm. Assume dynamo efficiency to be 85%. Consider the allowable stress for belt as 2.1 MPa, density of rubber as 1000 kg/m^3, angle of contact as 165°, coefficient of friction between belt and pulley as 0.3 and thickness of the belt as 10 mm. Use $(T_1/T_2)=e^{\mu\theta}$, where T_1, T_2, μ and θ are tension in the tight side, tension in the slack side, coefficient of friction and angle of contact respectively. In your design, find the standard width of the belt. Explain all the calculation steps.

[6.0 Marks]

Q4 a) A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed.
Describe four applications of springs with examples.

[1.0 Mark]

b) i. Discuss the types of springs based on the shape and purpose?
ii. Briefly discuss Belleville springs and Helical springs with suitable sketches.

[2.0 Marks]

c) Consider a part of the compression spring shown in **Figure Q4 (c)**.

i) Show that torsional shear is $\tau_1 = \frac{8WD}{\pi d^3}$ and direct shear is $\tau_2 = \frac{4W}{\pi d^2}$

ii) Using those relations, find the total shear stress (minimum and maximum).

You may use the following relationship with usual notations.

$$\frac{T}{j} = \frac{\tau}{r} = \frac{G\theta}{L}$$

[3.0 Marks]

d) Design and draw a valve spring of a petrol engine for the following operating conditions:

- Spring load when the valve is open = 400 N
- Spring load when the valve is closed = 250 N
- Maximum inside diameter of spring = 25 mm
- Length of the spring when the valve is open = 40 mm
- Length of the spring when the valve is closed = 50 mm
- Maximum permissible shear stress = 400 MPa

Note: The Table 1 and following relations have been given with usual notations

$$\delta = \frac{8WD^3 n}{Gd^4}$$

$$p = \frac{free\ length}{n' - 1}$$

$$L_F = n'.d + \delta_{max} + 0.15\delta_{max}$$

i) Mean diameter of the spring coil

[1.0 Mark]

Q4 Continued..

ii) Number of turns of the coil

[1.0 Mark]

iii) Free length of the spring

[1.0 Mark]

iv) Pitch of the coil

[1.0 Mark]

Q5 a) i) What are the two main types of clutches commonly used in engineering practice? Discuss them briefly with suitable sketches.

ii) What is the purpose of having a clutch between an automobile engine and a manual gearbox? Discuss briefly.

[2.0 Marks]

b) Discuss five characteristics of the material which used for lining of friction surfaces of a clutch.

[1.0 Mark]

c) Discuss the designing considerations of friction clutch.

[2.0 Marks]

d) A plate clutch having a single driving plate with contact surfaces on each side is required to transmit 110 kW at 1250 r.p.m. The outer diameter of the contact surface is to be 300 mm. The coefficient of friction is 0.4.

i) Assuming a uniform pressure of 0.17 N/mm^2; determine the inner diameter of the friction surfaces.

Take, $R = \frac{2}{3}\left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]$ for a uniform pressure condition with usual notations

ii) Assuming the same dimensions and the same total axial thrust, determine the maximum torque that can be transmitted and the maximum intensity of pressure when uniform wear conditions have been reached.

[5.0 Marks]

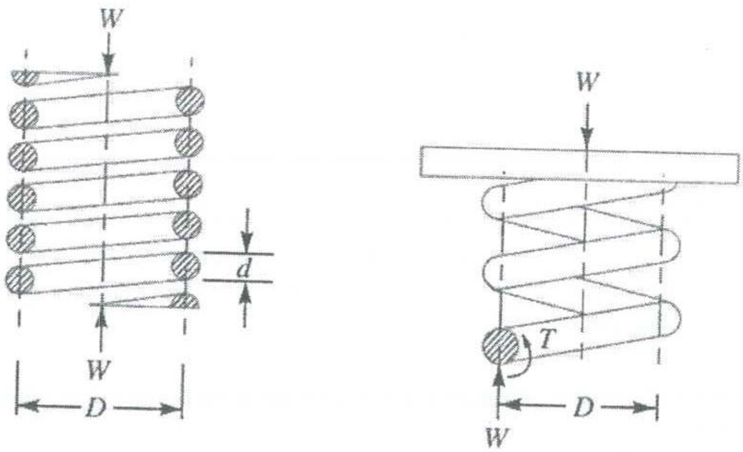

Figure Q4(c) Free body diagram of axial loaded helical spring

Table 1: Q4) d) Standard Wire Gauge (SWG) number and corresponding diameter of spring wire

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