UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2022

Module Number: ME 4303 **Module Name: Design of Machine Elements**

[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 term "Fatigue strength" of a metal.

[2.0 Marks]

b) Explain how polishing can improve the fatigue strength of a machined shaft.

[2.0 Marks]

c) A hollow shaft of 50 mm outer diameter and 25 mm inner diameter is simultaneously subjected to a twisting moment of 100 Nm, an axial tension of 10 kN and a bending moment of 50 N-m.
Draw three separate sketches indicating the stress distibution induced in the shaft due to each of the above loading conditions.

[2.0 Marks]

d) Calculate the maximum direct and shear stresses induced in the shaft.
With usual notation, the sectional modulus of a circular hollow shaft is given by $Z = \frac{\pi}{32}\frac{d_o^4 - d_i^4}{d_o}$,

Twisting moment is given by $T = \frac{\pi}{16}\tau\frac{d_o^4 - d_i^4}{d_o}$

Maximum stresses are given by $\sigma_{max} = \frac{\sigma}{2} + \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2}$, $\tau_{max} = \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2}$

[2.0 Marks]

e) Explain whether the above shaft is able to withstand the same loads if the direction of the axial load is reversed. No re-calculation is expected.

[2.0 Marks]

Q2 a) Explain two advantages and one disadvantage of screwed joints when compared to rivetted joints.

[2.0 Marks]

b) Explain with sketches, the types of failures that can happen in screwed joints.

[2.0 Marks]

c) Figure Q2 shows a bracket designed to carry a vertical load 1.5 kN, applied at a distance 200 mm. The bracket is secured to the flat side of a vertical surface by four screws *A, B, C* and *D* such that *ABCD* forms a square of side 80 mm with center *G*. With the aid of a sketch of loading of each screw, identify the most stressed screw.

[2.0 Marks]

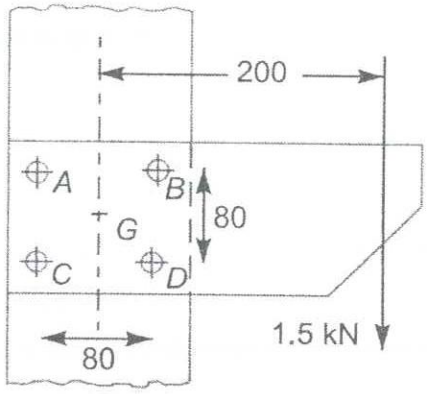

Figure Q2

d) Calculate the diameter of the screw carrying the highest load if the permissible shear stress is 65MPa.

[2.0 Marks]

e) Explain how the above joint could be improved by using an adhesive.

[2.0 Marks]

Q3 a) The ratio between tensions of tight side and slack side of a flat belt drive is given by $T_1/T_2 = e^{\mu\theta}$ with the usual notation. With the aid of a sketch explain why it is advisable to have the slack side on top of a belt drive.

[2.0 Marks]

b) A belt must transmit 18 kW at 1750 r.p.m. with the smaller pulley of diameter of 200 mm. Consider the allowable stress of the belt as 2 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 8 mm. Find the width of the belt. Centrifugal tension $T_c = mv^2$ with the usual notation.

[6.0 Marks]

c) Explain with a sketch, whether it is possible to slightly increase the power transmitted by introducing an idler pully to the above belt drive.

[2.0 Marks]

Q4 a) Explain the purpose of power screws in design of machines. What are the alternative mechanisms available for power screws?

[2.0 Marks]

b) A load of 20 kN is lifted through 170 mm by using a square threaded **screw under tension**, having pitch of 10 mm and mean diameter of 50mm. The external and internal diameter of the bearing surface of the collar are 60 mm and 10 mm respectively. Sketch the screw, nut collar arrangement.

[2.0 Marks]

c) If the coefficient of friction for the screw and the bearing surfaces may be taken as 0.08, find the work done in lifting the load and the efficiency of the screw, when

i) The load rotates with the screw

ii) The load rests on the loose head which does not rotate with the screw

Force P required at the circumference of the screw to lift the load is given by $P = W.\tan(\alpha + \varphi)$ where α and φ are helix angle and friction angle.

Torque T_1 required to overcome friction at the screw and the collar is given by $T_1 = \mu WR$ where R is the mean radius of the collar.

[4.0 Marks]

d) If the load must be applied by using the same screw arrangement, such that the screw undergoes compression, what are the additional design checks that you need to do?

[2.0 Marks]

Q5 a) Explain with the aid of suitable sketches, the requirement of having a friction clutch between an automobile engine and a manual gearbox.

[2.0 Marks]

b) Show that for a uniformly worn clutch, $pr = C(constant)$ where p is the pressure at a radial distance r on the clutch plate.

[2.0 Marks]

c) A multi-disc clutch has four friction contact pairs. The inside diameter of the contact surface is 120 mm. The maximum allowable pressure of the friction material is limited to 0.1 N/mm^2. Find the outer radius of the clutch plates for transmitting 25 kW at 1500 r.p.m. Assume uniform wear condition and coefficient of friction as 0.3.
Axial force on friction surfaces is given by $W = 2\pi C(r_1 - r_2)$, where r_1 and r_2 are outer and inner radii of the friction surfaces.
Torque transmitted by the clutch is given by $T = nW\mu R$ where R is the mean radius of the friction surfaces.

[4.0 Marks]

d) It is required to increase the power transmitted by the above clutch up to 30kW, using the same size and type of clutch plates. How would you achieve this?

[2.0 Marks]