UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2017

Module Number: ME 4302 **Module Name: Design of Machine Elements**

[Three Hours]

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

Q1. a) A simply supported shaft carries a pulley with a belt drive at its mid-span for transmitting the torque. With the aid of a labeled sketch, indicate the most stressed location of the shaft and all possible stresses induced on it.

[2.0 Marks]

b) Explain the significance of the rigidity of the above simply supported shaft.

[2.0 Marks]

c) A simply supported shaft of 50 mm diameter has to transmit a torque of 800 Nm under an axial tensile load of 20 kN. A critical location of the shaft experiences a bending moment of 750 Nm. Find the maximum direct stress $\sigma_{t(max)}$ and the maximum shear stress τ_{max} induced at the critical location of the shaft. You may use the following equations for your calculations.

Note: with usual notation,

$$\sigma_{t(max)} = \frac{\sigma_t}{2} + \frac{1}{2}\left[\sqrt{(\sigma_t)^2 + 4\,\tau^2}\right]$$

$$\tau_{max} = \frac{1}{2}\left[\sqrt{(\sigma_t)^2 + 4\,\tau^2}\right]$$

Sectional module Z of the shaft,

$$Z = \frac{\pi}{32} \times d^3$$

Bending Stress σ_b,

$$\sigma_b = \frac{M}{Z}$$

[4.0 Marks]

d) If the shaft in (c) above has to rotate at 1500 rpm under the same loading conditions, explain the other factors that you would consider in your design calculations.

[2.0 Marks]

Q2. a) Briefly discuss the advantages of V-belt drives over the flat belt drives.

[2.0 Marks]

b) Obtain the expressions for;

i. Ratio between the slack side tension and the tight side tension of a V-belt drive.

ii. Centrifugal tension of a belt in terms of mass per unit length and belt speed.

iii. Power transmitted in terms of belt tension.

[4.0 Marks]

c) A V-belt drive has a driving pulley having an effective diameter of 300 mm, running at 1000 rpm to a driven pulley of 400 mm. Find the number of belts required to transmit 100 kW of power with the following requirements.
The grove angle (2β) of the pulley = 40°, allowable stress =2.2 MPa, cross sectional area of the belt =350 mm^2, friction coefficient between the belt and the pulley material = 0.3, density of the belt material = 1100 kg/m^3, and the angle of lap of belts over the driving pulley is 151°.

[4.0 Marks]

Q3. a) What are the factors to be considered when deciding the capacity of brake systems?

[1.0 Marks]

b) Stating any assumptions, obtain an expression for the braking energy required to reduce the speed of a vehicle of mass M from V_i to V_f, with a vertical climb h.

[2.0 Marks]

c) Obtain an expression for the braking torque of the band brake system shown in Figure Q3.

[2.0 Marks]

d) The required brake torque for the band brake arrangement shown in Figure Q3 is 360 Nm. Find the brake force P required at the end of the lever, if the drum diameter is 400 mm, b= 200 mm, l=800 mm, θ= 270 and the coefficient of friction is 0.3.

[3.0 Marks]

f) Would the brake force P you obtained in (d) above be adequate, if the drum rotates counterclockwise? Briefly explain your answer with a neat sketch (**do not recalculate**).

[2.0 Marks]

Q4. a) Briefly describe the advantages of screwed joints over riveted and welded joints.

[2.0 Marks]

b) A bracket is bolted to a steel column by six bolts of equal size as shown in Figure Q4. With the aid of a sketch, explain the forces acting on each bolt and determine the most stressed out bolt.

[3.0 Marks]

c) The bracket in Figure Q4 carries a load of 50 kN at a distance of 150 mm from the centre of column. If the maximum stress in the bolts is to be limited to 150 MPa, determine the diameter of a bolt.

[3.0 Marks]

d) In a subsequent development, it is required to increase the load from 50kN to 75 kN. Recommend and explain two design changes for the above development if the bracket itself is sufficiently strong.

[2.0 Marks]

Q5. a) Graphically explain the combined effect of direct shear stress and torsional shear stress induced in a helical spring wire.

[2.0 Marks]

b) Show that the stiffness W/δ of a helical spring of circular wire is given by $Gd^4/8D^3n$ where W is the axial load, δ is the axial deflection, G is the modulus of rigidity of the spring material, d is the wire diameter; D is the mean diameter of the spring, and n is the number of turns of the spring.

[3.0 Marks]

c) An object of mass 5000 kg, moving at a speed of 5 km/h has to be stopped by four buffer springs. The maximum compression of the springs is 250 mm.

i. Sketch the variation of speed *against* the distance after the object contacts the springs.

ii. Find the number of turns in each spring of mean diameter 150 mm. The diameter of spring wire is 25 mm. Take $G = 84$ kN/mm.

[3.0 Marks]

d) Explain the term "buckling and surge of springs", its possible negative effects on the above mechanical system and how it could be avoided.

[2.0 Marks]

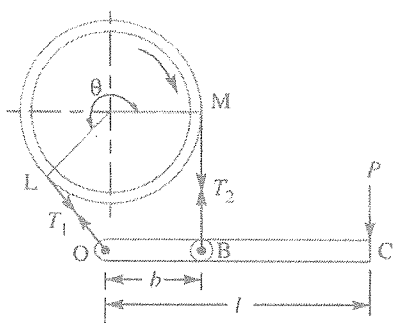

Figure Q3

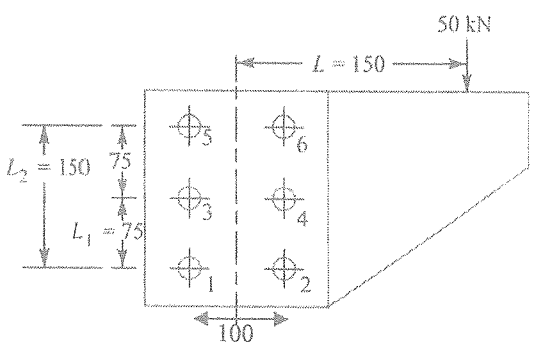

Figure Q4