UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2016

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

[Three Hours]

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

Q1. a) Derive the equation for torque (twisting moment) by considering a shaft subjected to a torsion **T**. The length and the radius of the shaft are **L** and **r** respectively. Take τ, G, θ, and J as torsional shear stress, modulus of rigidity, angle of twist and polar second moment of area respectively.

[3.0 Marks]

b) A steel shaft ABCD which is given in ***Figure Q1*** having a total length of 3.5 m consists of three sections as follows;

AB is a hollow section having outside and inside diameters of 100 mm and 62.5 mm respectively. BC is a solid shaft with of 100 mm. CD is also a solid shaft having a diameter of 87.5 mm. All sections are made out of same material. The maximum shear stress in the hollow portion is 47.5 MPa and modulus of rigidity (G) of the material is 82.5 GPa.

i) If the angle of twist is same for each of the sections, determine their individual lengths. [3.0 Marks]

ii) Find the value of applied torque for hollow shaft. [2.0 Marks]

iii) Find the total angle (end-to-end) of twist. [2.0 Marks]

Q2. a) Write a short note on stress concentration of an element.

[1.0 Mark]

b) Explain **four** methods of reducing stress concentration. Provide neat sketches for each.

[2.0 Marks]

c) A bearing has a nominal diameter of 50 mm and the diametric clearance is ideally 0.1 mm. The shaft and the inner part of the bearing can be made to (plus or minus) ± 0.02 mm.

i) Find the maximum shaft diameter

ii) Find the minimum shaft diameter

iii) Find the optimal hole diameter

(Q2 is continued on page 02)

iv) Find the maximum hole diameter

v) Find the minimum hole diameter

[5.0 Marks]

d) Clearly show the dimensions of the shaft and the inner part of bearing by means of a sketch using maximum material condition.

[2.0 Marks]

Q3 a) State **three** advantages of V-belts over flat belts

[2.0 Marks]

b) The ratio of tight-side tension to slack-side tension of a flat belt drive is given by $e^{\mu\theta}$. with the usual notation. Modify this relationship in order to obtain the relevant equation for V-belt drives.

[2.0 Marks]

c) A V-belt drive transmits 20 kW of power at 1800 rpm from a motor through a 250 mm diameter pulley. At the other end the driven pulley diameter is 900 mm. The angle of the pulley groove β is 40° and coefficient of friction μ between the belt and the pulleys is 0.2. If the density of belt material is 1200 kg / m^3, cross-sectional area is 230 mm^2 and the allowable stress for the belt is 2 MPa, calculate the number of belts required.

The distance between the centers of the two pulleys is 1,200 mm.

[3.0 Marks]

d) It is proposed to replace the motor of the above Q3(c) with a 20 kW, 1500 rpm motor. Identify the issues that may raise in this context and discuss the relevant modifications which may have to be done specifically with the belt drive.

[3.0 Marks]

Q4. a) State four important applications of springs.

[1.0 Mark]

b) Graphically describe the stresses induced in a circular metal wire used for helical springs.

[3.0 Marks]

c) Prove that the shear stress induced in the spring wire is given by the below formula. (All are in usual notation)

$$\tau = \frac{8WD}{\pi d^3}\left(1 + \frac{d}{2D}\right)$$

[3.0 Marks]

d) Explain the below key practical design considerations of the springs.

i) Natural frequency

ii) Buckling

[3.0 Marks]

Q5. a) Briefly Explain **three** purposes of shaft couplings.

[1.0 Mark]

b) The compression coupling relies on the friction force between the shaft and the muff. Show that the maximum torque that can be transmitted by a compression coupling is given by the below formula (All are in usual notation).

$$T = \frac{\pi^2}{16}\mu(d_b)^2\sigma_t n d$$

[2.0 Marks]

c) You are required to design a muff coupling to connect two shafts transmitting 40 kW at 120 rpm. The permissible shear stress for the shaft is 30 MPa. The material of muff is cast iron with permissible shear stress of 15 MPa. Friction coefficient between muff and the shaft is 0.3. The coupling uses 8 bolts and the allowable tensile stress of bolt material is 30 MPa. Find the diameter of the bolts and check the shear strength of the muff.

For calculation, you may use the following relationships and data with usual notation.

Diameter of muff $D = 2d + 13\ mm$

Length of the muff $L = 3.5\ d$

Torque transmitted by a hollow shaft is given by;

$$T = \frac{\pi}{16}\tau\left[\frac{(D^4 - d^4)}{D}\right]$$

[4.0 Marks]

d) In a modification to the above in-line shaft arrangement described in Q5 (c), the two shafts will now intersect at an angle of 25°. Propose a suitable coupling for the new arrangement and discuss design issues relevant to your proposal.

[3.0 Marks]

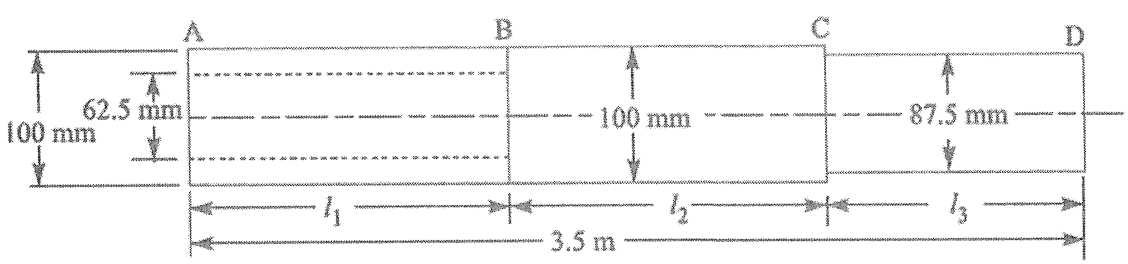

Figure Q1