UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: September 2023

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 whenever required. Symbols stated herein denote standard parameters.

Q1 a) A cantelevered beam has a rectangular cross section of width b and depth h. The load - stress - deflection relationship is given by $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{r}$ and moment of inertia about the horizontal neutral axis of the rectangular section is given by $I = \frac{bh^3}{12}$ with the usual notation.

i) Explain why the beam strength is higher when $h>b$ compared to when $h<b$.

ii) Explain how the strength of a "C" section made out of sheet metal could be further improved by modifying the section.

[4.0 Marks]

b) Shock and impact loads on machine elements should be reduced if not avoided.

i) A tensile impact load is applied on the lower free end of a vertically hanging bar. Draw the graph of extension of the bar vs time and mark the instance that maximum stress of the bar occurs.

ii) When an axial tensile load of 8 kN is applied on a vertical bar of 12 mm diameter, it extends by 3 mm. Youngs modulus of the bar material is 200 kN/mm^2. Then the steady load is removed and a weight of 800 N falls through 80 mm height before hitting a collar at the lower end of the bar. What would be the maximum stress produced in the bar due to the fallen weight?
With usual notation the stress induced in a bar due to the application of impact load by a falling weight through a height of h is given by

$$\sigma_i = \frac{W}{A}\left\{1 + \sqrt{1 + \frac{2hAE}{Wl}}\right\}$$

[4.0 Marks]

c) If the stress value you found in (b) ii) above exceeds the allowable sterss of the bar, what design alternatives will you suggest for the safety of the bar?

[2.0 Marks]

Q2 a) Explain four advantages and two disadvantages of welded joints when compared to riveted joints.

[2.0 Marks]

b) Explain types of failures that can happen in welded joints

[2.0 Marks]

c) Lap welding is often used to join two plates.

i) Show that the throat area of a lap weld is given by $A = 0.707\ s \times l$ where s is the thickness of the plates and l is the weld length.

ii) A plate 100 mm wide and 10 mm thick is to be lap welded to another larger plate by means of double parallel fillets. The plates are subjected to a static load 80 kN applied parallel to the welds. Find the length of weld if the permissible shear stress in the weld is 55 MPa.

[4.0 Marks]

d) Explain whether the performance of the above joint could be improved by

i) adding two transverse welds.

ii) applying an adhesives between the two plates

[2.0 Marks]

Q3 a) The ratio between tensions of tight side and slack side of a V- belt drive is given by $T_1/T_2=e^{\mu\theta.cosec\beta}$ 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 drive consists of three V-belts in parallel on grooved pulleys of the same size. The angle of groove is 30° and the coefficient of friction 0.12. The cross-sectional area of each belt is 800 mm² and the permissible safe stress in the material is 3 MPa. The density of the belt material is 1000 kg/m³. Calculate the power that can be transmitted between two equal pulleys 400 mm in diameter rotating at 960 r.p.m. Centrifugal tension is given by $T_c=mv^2$ with usual notation

[6.0 Marks]

c) Explain whether it is advisable to reduce the rotating speed of the pullies, while the power transmitted remain same.

[2.0 Marks]

Q4 a) List <u>four</u> applications of springs, with an example for each of them

[1.0 Mark]

b) Referring to the cross section of a helical spring under compression, graphically indicate the direct shear stress, torsional shear stress and resultant stress.

[2.0 Marks]

c) Show that the spring rate constant is equal to $\frac{W}{\delta} = \frac{GD^4}{8nd^3}$ with the usual notation

[2.0 Marks]

d) A close coiled helical compression spring must be designed for supporting a load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress is 420 MPa and modulus of rigidity is 84 kN/mm².

i) Sketch the unloaded and loaded status of the spring

ii) Find the wire diameter and mean diameter of the spring. Twisting moment of the spring wire is given by $T = \frac{\pi}{16}\tau d^3$ with usual notation.

iii) Find the number of turns required in the spring

[3.0 Marks]

e) The natural frequency of a spring is given by $f_n = \frac{d}{2\pi n D^2}\sqrt{\frac{6Gg}{\rho}}$

Describe whether the spring in d) above is suitable for an oscillating application at 120 Hz.

[2.0 Marks]

Q5 a) Briefly describe four purposes of shaft couplings.

[2.0 Marks]

b) Design a flange coupling with 4 bolts to transmit a torque of 300 Nm between two shafts. The shafts are keyed to the flange hub. The **allowable stresses** are given below:

Shear stress on shaft =100 MPa

Bearing or crushing stress on shaft =250 MPa

Shear stress on keys =100 MPa

Bearing stress on keys =250 MPa

Shearing stress on flange material =200 MPa

Shear stress on bolts =100 MPa

Find the following, with reference to the dimensional relationships shown in Figure Q5

i) Shaft diameter

ii) Check whether the hub is safe against shear by considering it as a hollow shaft.

iii) Check whether the keys are safe against shear and crushing failure

iv) Check the flange strength against shear

v) Find the bolt diameter

[6.0 Marks]

c) It is suggested that the torque transmitted across the flange could be increased by using the friction between the flange faces. Comment on this suggestion based on your answers to Q5.b) above and suggest required changes if any.

[2.0 Marks]

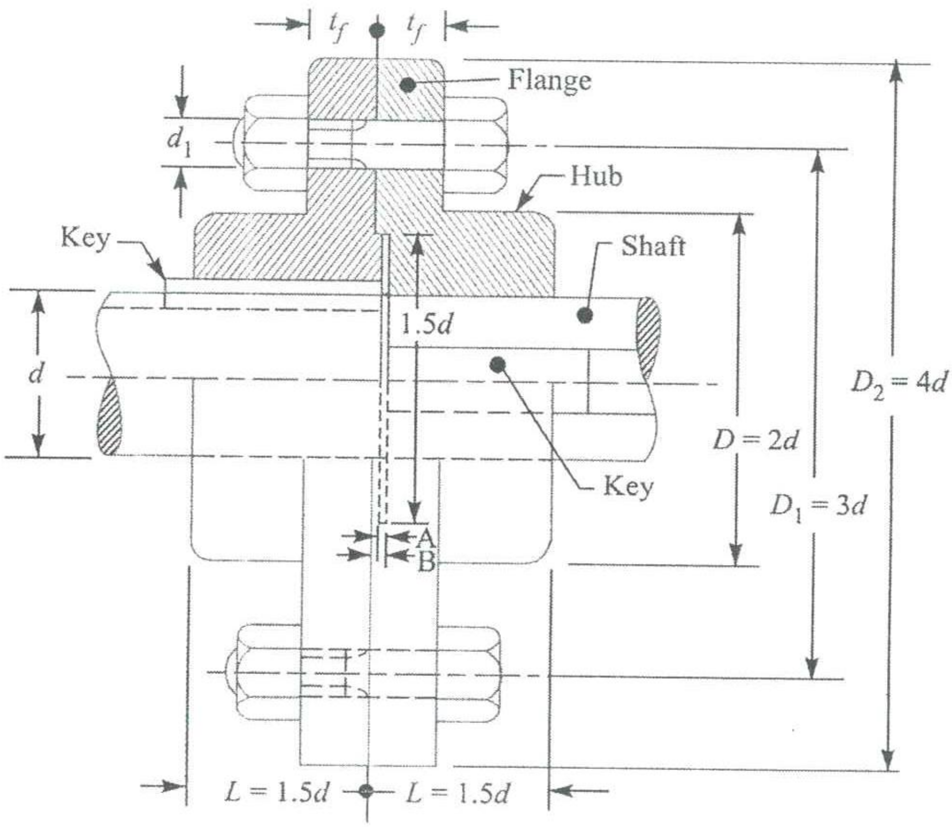

Figure Q5