

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme : Bachelor of Technology Honours in Engineering
Name of the Examination : Final Examination
Course Code and Title : DMX5577 Machine Design (Paper I)
Academic Year : 2020/21
Date : February 13, 2022
Time : 1400 -1600hrs
Duration : **2 hours**

General Instructions:

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. This question paper has Two Parts, Part A and Part B. Part A has three (03) questions and Part B has five (05) questions. Answer **only four (04)** questions selecting at least one (01) question from Part A.
4. **Assume any missing dimensions or design data. All such assumptions shall be clearly stated appropriately in the relevant answers.**
5. Any sketches that you provide to explain your answer shall be neatly drawn and labeled.

PART A

Question 01

- a. i. Distinguish between **ductile** and **brittle** materials, and list 3 examples for each type. [3 marks]
- ii. Define **proof stress** of a material. [3 marks]
- iii. What are **engineering** and **true** stress-strain curves. Illustrate using stress-strain diagram. [3 marks]
- b. Distinguish between **fatigue** and **creep** failures. Illustrate how fatigue and creep test results are presented. [6 marks]
- c. Define **hardness**. Explain the importance of appropriately hardening the surface of engineering components, and also explain how to improve the hardness of a surface of a metallic slab. [5 marks]
- d. What is **residual stress** and explain how to remove the undue residual stresses from an engineering component. [5 marks]

Question 02

- a. Discuss what kind of wear could occur in the following instances, clearly state the consequences due to such wear in each case. [10 marks]
- i. Screw tread of a micrometer screw gauge.
 - ii. Lead screw of a lathe.
 - iii. Main bearing of an automobile crankshaft.
 - iv. Impeller of a water pump.
 - v. Gear teeth surface.
- b. You are assigned to design four sets of 'table and a chair' to be used each set by a different user as explained next; 1. by the readers in a university library, 2. by the customers in a barber saloon, 3. in an open veranda of a mansion at Nuwaraeliya and 4. open restaurant adjoining the beach (near the sea) at Unawatuna.

Distinguish the properties and requirements of these four products paying attention to aspects such as conformability, manuarability, working environments, appearance, mechanical properties, material properties, etc. [15 marks]

Question 03

Write short notes on the following.

Note: you may use neat sketches wherever necessary.

- a. Selecting appropriate bearing for a load carrying shaft (*your answer shall address at least six factors needed to be considered in selection*). [6 marks]
- b. Second moment of area (I) and polar moment of area (J) and their relationship (*your answer shall state the equation/s to calculate these two parameters*). [6 marks]
- c. *It is said that more power could be transmitted by a V-belt drive than to a Flat belt drive. Do you agree? Justify your answer.* [6 marks]
- d. Stress concentration and stress concentration factor. Discuss how to compensate undue stress concentrations when designing machine components. [7 marks]

End of PART A

Question 04

- a. An axle of a wagon as shown in Figure.Q4 is a hollow cylinder of outside diameter two times the inside diameter. Two loads, each with 10 kN magnitude, are applied on the axle symmetrically with 1.4 m between them. Made of steel with UTS of 750 MPa and using a factor of safety of 5, calculate the diameters of hollow axle.

[12 marks]

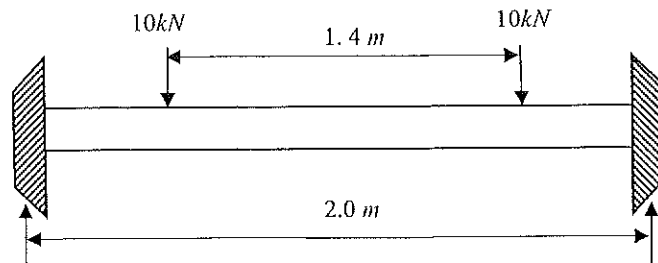


Figure.Q4

- b. A hollow shaft with diameter ratio of $3/8$ transmits 650 kW at 120 rpm . The maximum starting torque is 1.2 times the mean torque. The permissible shearing stress is 60 N/mm^2 . It is required that angle of twist in a length of 3 m should not be greater than 1.4 degrees. The modulus of rigidity of the shaft material is $84 \times 10^3\text{ N/mm}^2$. Calculate the shaft diameter.

[13 marks]

Question 05

- a. For a square thread show that in the presence of a thrust collar, the torque (T) required to lift an axial load (W) is given by,

[10 marks]

$$T = W \left[\frac{d}{2} \tan(\alpha + \phi) + \mu R \right]$$

Where,

 W - axial load on screw d - mean diameter of the thread ϕ - angle of friction α - helix angle μ - friction coefficient of nut on thrust collar R - mean radius of the thrust collar

- b. A double start square threaded screw is used to support a vertical load of 8 kN . The mean diameter of the thread is 100 mm and pitch is 20 mm . The axial thrust on the screw is taken by a collar bearing of 250 mm outside and 100 mm inside diameter. Find the force required at the end of a lever which is 400 mm long to lift and lower the load.

The coefficient of friction for the vertical screw and the nut is 0.5 and that for the collar bearing is 0.2.

[15 marks]

Question 06

- a. Figure.Q6 shows a cone clutch.

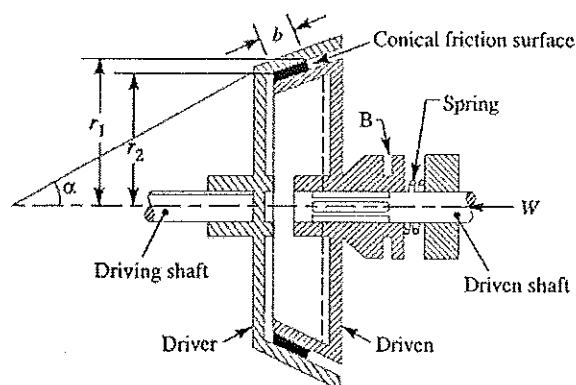


Figure.Q6

Considering the uniform pressure condition (new clutch), derive that the torque T which can be transferred by the clutch as, [12 marks]

$$T = \mu W_n R$$

Where,

$$W_n = W \operatorname{cosec} \alpha$$

W - load acting on the clutch

μ - coefficient of friction between the contact surfaces

r_1 - outer radius of friction surface

r_2 - inner radius of friction surface

$$R - \text{mean radius, } R = \frac{2}{3} \left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2} \right]$$

α - Semi angle of the cone

b - width of the friction surfaces

- b. Find the outer radius and inner radius of a cone clutch which is used to transmit 30 kW at 750 rpm. [13 marks]
Following data are provided.

Normal pressure between the contact surfaces (P_n) = 0.075 to 0.1 N/mm²

Load factor = 1.75

$$\mu = 0.2$$

Mean diameter of cone = 6 to 10 times of the diameter of the shaft

Mean diameter to face width ratio = 6

$$\alpha = 12\frac{1}{2} \text{ degrees}$$

Torque developed by the clutch, $T = 2 \pi \mu P_n R^2 b$

Question 07

- a. Sketch the following riveted joints.
- Double riveted lap joint. [3 marks]
 - Single riveted double strap butt joint. [3 marks]
- b. A bracket supporting a load P is attached to another metal frame by four similar rivets with a pitch of 200 mm as shown in Figure.Q7. Diameter of each rivet is 20 mm. Find the maximum value of P based on the working shear stress of 100 MPa for the rivet material. [19 marks]

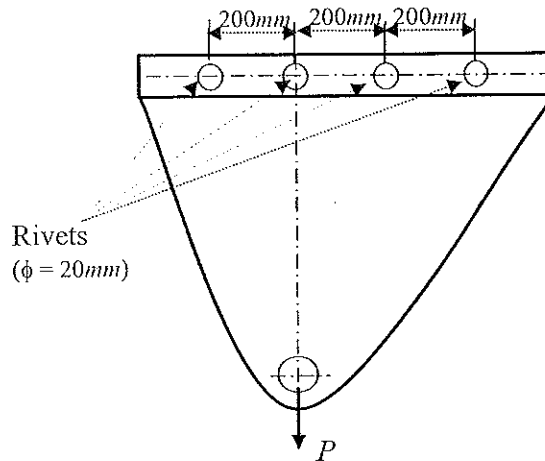


Figure.Q7

Question 08

A shaft transmits 20 kW at 200 rpm. The shaft carries a central load of 900 N perpendicular to its axis and is simply supported between two bearings at ends, 2.5 meters apart. The shaft is made from mild steel which has allowable shear stress of 42 MPa. Both maximum tensile and compressive stresses are not exceed 56 MPa.

- Determine the diameter of the shaft. [13 marks]
- Determine the required diameter of the shaft if the load is gradually applied. For rotating shafts with gradually applied loads the shock and fatigue factors, $K_m = 1.5$ and $K_t = 1$. [12 marks]

You may use the following equations (in usual notations), if necessary,

$$T_e = \sqrt{(K_m \cdot M)^2 + (K_t \cdot T)^2}$$

$$M_e = \frac{1}{2} \left[K_m \cdot M + \sqrt{(K_m \cdot M)^2 + (K_t \cdot T)^2} \right]$$

..... END OF THE PAPER

