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/MEX5277 Machine Design-Paper I**
Academic Year	: 2019/20
Date	: October 10, 2020
Time	: 1430 -1630hrs
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. Illustrate the categories of engineering fits between two mating components? [*3 marks*]

ii. In an assembly drawing the symbolic representation, 40 H_8/f_7, is given. What information would you extract from it? [*3 marks*]

b. Explain (using relevant mathematical formulas) the self-locking and non-self-locking concepts of a nut and screw pair. Quote an example each where mechanical systems work, using self-locking and non-self-locking concepts. [*9 marks*]

c. Outline the basic design requirements, that should be given due consideration when designing a machine (or a machine component). Quoting appropriate examples, clearly explain the reasons for considering the outlined requirements. [*10 marks*]

Question 02

a. List six (06) factors that influence the magnitude of safety factor. [*3 marks*]

b. Answer the following, *(use examples and sketches if necessary)*
   i. State what Residual stress is, and also explain how residual stresses are formed in engineering components. [*5 marks*]
   ii. Why it is necessary to consider stress concentration factor when designing engineering components. [*5 marks*]

c. A square shaped base plate is fixed at its four corners using nuts and bolts, which one fixation is shown in Fig.*Q*2. The bolt specification is M20. The plate rests on 4 washers of 22mm internal diameter and 50mm external diameter. Upper washers located between the nut and the base plate if of 22mm internal diameter and 44mm external diameter. With the self-weight total load on the base plate is 120kN.

   i. Calculate the stress on the lower washer is the nuts are not tightened. [*6 marks*]
   ii. If the nuts are tightened as such it induces a tension of 5kN at each bolt, calculate the stress in both upper and lower washers. [*6 marks*]

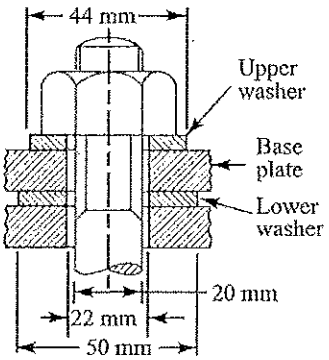

Fig.*Q*2

Question 03

Write short notes on the following.
Note: you may use neat sketches wherever necessary.

a. The importance of considering the Ergonomics Factors in designing of artifacts. Quote two (02) engineered products and explain how the ergonomic factors are given due consideration. [*7 marks*]

b. L_2, L_{2h} and L_{2s} life of bearings and the correlation of each other. [*6 marks*]

c. Fatigue failures in engineering components. Also discuss how experimentally evaluate the fatigue endurance limit of a material. [*6 marks*]

d. Interchangeability of components. [*6 marks*]

End of PART A

PART B

Question 04

a. List three (3) advantages and three (3) disadvantages of Welded joints over Riveted joints. **[6 marks]**

b. A rectangular plate shown in the Fig.*Q*4 made out of steel is of 200*mm* length and 100*mm* in deep. The plate is welded as a cantilever to a vertical column and supports a single concentrated load of 60*kN* acting at the edge of the plate. Determine the size of the weld needed to hold the load. The maximum shear stress of the weld material 140MN/m^2. **[19 marks]**

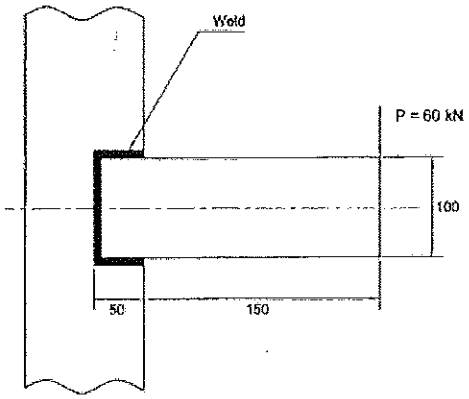

Fig.*Q*4 (dimensions are in *mm*)

Question 05

Fig.*Q*5 shows a band break which consists of a straight arm 750*mm* long pivoted at *O*. The arm *OC* is placed perpendicular to the vertical centre line going through *D*. The break band has a contact of 270°, where one end of the band is fastened to the fixed pin *O* and the other end is fixed to break arm at *B*, 125*mm* away from pin *O*. Diameter of the drum is 600*mm* and which is running at 200*rpm*. The coefficient of friction is 0.25.

a. Calculate the minimum pulling force (*P*) necessary on the end of the break arm to stop the wheel if 35*kW* is to be absorbed. Clearly state the direction of the pull. **[15 marks]**

b. If the thickness of the band is 2.5*mm*, calculate the required width of the band, if the maximum tensile stress is 50*MPa*. **[10 marks]**

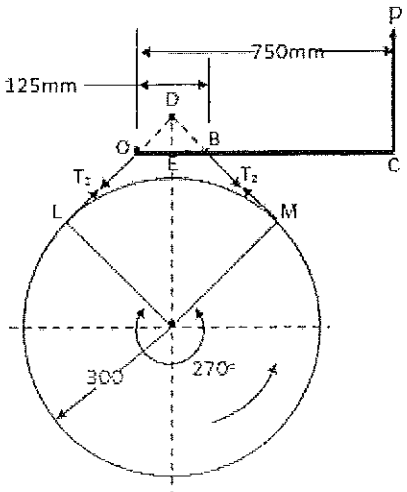

Fig.*Q*5

Question 06

a. State, Second moment of area (I) and Polar moment of area (J). [*3 marks*]

b. Write Torsional equation and Bending equation. Define all the notations used. [*4 marks*]

c. Show that the induced stress of a shaft subjected to a bending moment, can be derived as (in usual notations), [*3 marks*]

$$\sigma = \frac{32M}{\pi d^3}$$

d. The cantilevered shaft is subjected to vertical load of $3kN$ at C, an axial pulling force of $15kN$ and a pure torque of $1000Nm$ as shown in Fig.$Q6$. The diameter of the shaft is $50mm$ and the length is $250mm$. Calculate the maximum and minimum principle stresses and maximum shear stresses at points A and B. [*15 marks*]

The maximum and minimum principle stresses and maximum shear stress of a member subjected to direct stresses of σ_1 and σ_2 and shear stress of τ, is given respectively by,

$$\sigma_{max} = \frac{\sigma_1 + \sigma_2}{2} + \frac{1}{2}\sqrt{(\sigma_1 - \sigma_2) + 4\tau^2} \quad \sigma_{min} = \frac{\sigma_1 + \sigma_2}{2} - \frac{1}{2}\sqrt{(\sigma_1 - \sigma_2) + 4\tau^2}$$

, and

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_1 - \sigma_2) + 4\tau^2}$$

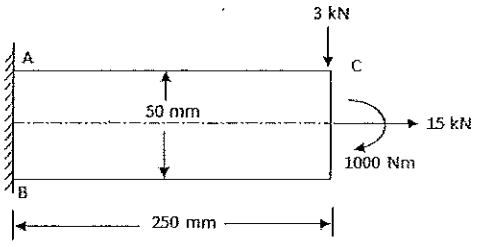

Fig.$Q6$

Question 07

An electric motor transmits 15 kW at 1750 rpm through a horizontal belt drive system to a centrifugal blower, which rotates at 600 rpm. The centre distance between the pulleys is twice the diameter of the larger pulley. The density and the maximum allowable shear stress of the belt material are 1500 kg/m^3 and 4 MN/m^2 respectively and the peripheral velocity of the belt is 20 m/s. Determine,

a. diameters of the pulleys. [*8 marks*]
b. belt length. [*4 marks*]
c. cross-sectional area of the belt. [*4 marks*]
d. minimum initial tension for operation without slip. [*5 marks*]
e. resultant force on the rotor of the blower when operating with initial tension 50 per cent greater than the minimum value. [*4 marks*]

The coefficients of friction between the belt and the motor pulley and that between the belt and blower pulley are 0.5 and 0.4 respectively.

Note: *The total length (L) of the belt of a belt drive system can be given by,*

$$L = \pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{x},$$

where r_1 *and* r_2 *are the radii of larger and smaller pulleys respectively, and* x *is the distance between the centres of two pulleys.*

Question 08

a. Illustrate Collar Friction, within the context of power screws/screw joints. [*3 marks*]

b. Derive the torque required to lift a load by a screw and nut with square threads is given by, [*4 marks*]

$$T = W\frac{d}{2}\tan(\alpha + \phi)$$

Where,

T = Torque required to overcome friction between the screw and the nut
W = Load to be lifted vertically
a = Helix angle of the square thread and ϕ = Angle of friction
d = Mean diameter of the screw

c. A designer proposed a differential type screw jack using two right handed single start square screws, as shown in the Fig.*Q*8. Upper screw which supports the load has 16*mm* pitch and the lower screw which fixed to the base has 12*mm* pitch. In operation neither screw rotates. The outside screw diameter is 50mm and the Coefficient of thread friction is estimated to be 0.15.

i. What would be the efficiency of the screw jack? [*12 marks*]
ii. What load can be raised if the shear stress of the screws is limited to $28MN/m^2$? [*6 marks*]

Note: *In square thread, Thread depth* $= \frac{1}{2} \cdot$ *Thread Pitch*

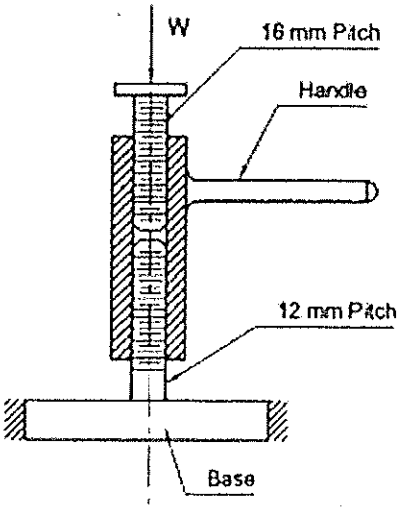

Fig.*Q*8