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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	**: DMX4306 Design of Machine Elements**
Academic Year	: 2021/22
Date	: February 15, 2023
Time	: 1330 hrs. -1730 hrs.
Duration	: **4 hours**

General Instructions: *READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER*

1. This question paper has two parts, **PART A** and **PART B**. Answer the question (Question 1) in PART **A** which is **compulsory**, and any three out of five questions from **PART B.**

2. Answers to the question in PART A carries **50** marks, whereas in PART B, each **17** marks.

3. **Attempt all parts in Question 1** in that given order. Spend approximately 2 hours and 45 minutes to answer the question in PART A and rest for Questions in PART B.

4. Wherever appropriate, use the given catalogue, information, and data sheets, provided to you in the examination hall. At the end of the examination return all such material to the examiner/ supervisor of the examination hall. You will be provided with, *1.* Instruction booklet of spur and helical gear design, *2.* Motor catalog, *3.* Bearing selection manual, *4.* Handbook of metric keys and keyways and *5.* Handbook of V-belt drives as per your request.

5. **Any missing data can be sensibly and reasonably assumed**, but such assumptions are not acceptable unless they are justified and clearly stated.

6. Wherever relevant use neatly drawn sketches to explain your answers.

7. Any result from calculations should have units unless they are dimensionless.

8. All answers to the given questions should be underlined for the purpose of easy identification.

9. Write the question numbers to which you have answered, on the cover page.

PART A

Question 1

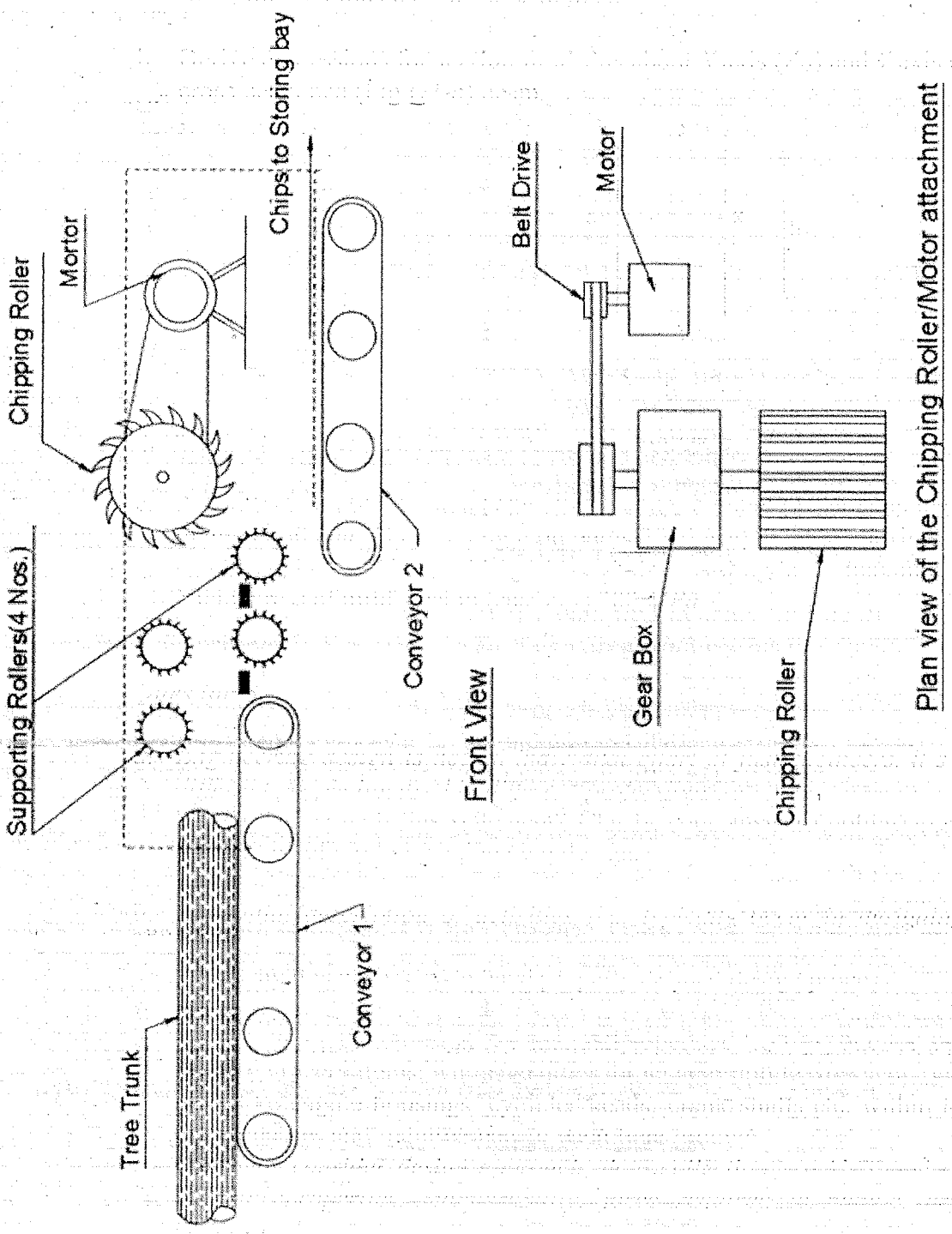

Fig.Q1 Layout of the main components of the wood-chipping machine (Not to scale)

A company needs a large quantity of firewood to fuel its boilers and the design engineer has proposed a tree-log-chipping-machine to produce woodchips from tree trunks. The layout of the main elements of the tree-log-chipping-machine is given in Fig.$Q1$ (the complete frame/housing is not illustrated). Assume you are the newly recruited engineer to the company and the chief engineer requests you to design the main parts of the mechanism and to provide suggestions for improvements. Fig.$Q1$-b shows a 3D pictorial view developed by a modeling software.

The Conveyor-1 carries the Tree-trunk towards Supporting-rollers (4 Nos.), and the Supporting-rollers hold and push the Tree-trunk towards the Chipping-roller. Top Supporting-rollers (2 Nos.) rotate anticlockwise and the bottom rollers clockwise. All supporting rollers are of the same diameter and the push velocity is well matched with chipping rate of the tree-trunk to ensure the smooth and continuous chipping action. Chipping-roller consists of series of cutting edges around it, which cuts the Tree-truck to wood chips of appropriate size. The anti-clockwise rotation of the Chipping-roller allows the woodchips to fall under gravity to the Conveyor-2 which then transports to the storing bay (not shown in the figure). Four Supporting-rollers and the Chipping-roller operate by two separate drive systems. The Chipping-roller and its driving mechanism is illustrated in the Plan view of Fig.$Q1$, which the output of the Motor is attached to a V-belt drive and then the power is transmitted to the Chipping-roller through a speed reduction Gear drive. The Gear drive (with spur gears) consists of only one gear mesh.

The diameter of the Chipping-roller is 400 *mm*, and two cutting edges simultaneously engage in chipping action. A tangential force of 100 *N* exerts on one cutting edge when cutting. The maximum rotating speed of the Chipping-roller is restricted to 240 *rpm*. A dredging torque of 10 *Nm* exerts on the Chipping-roller at the start of cutting.

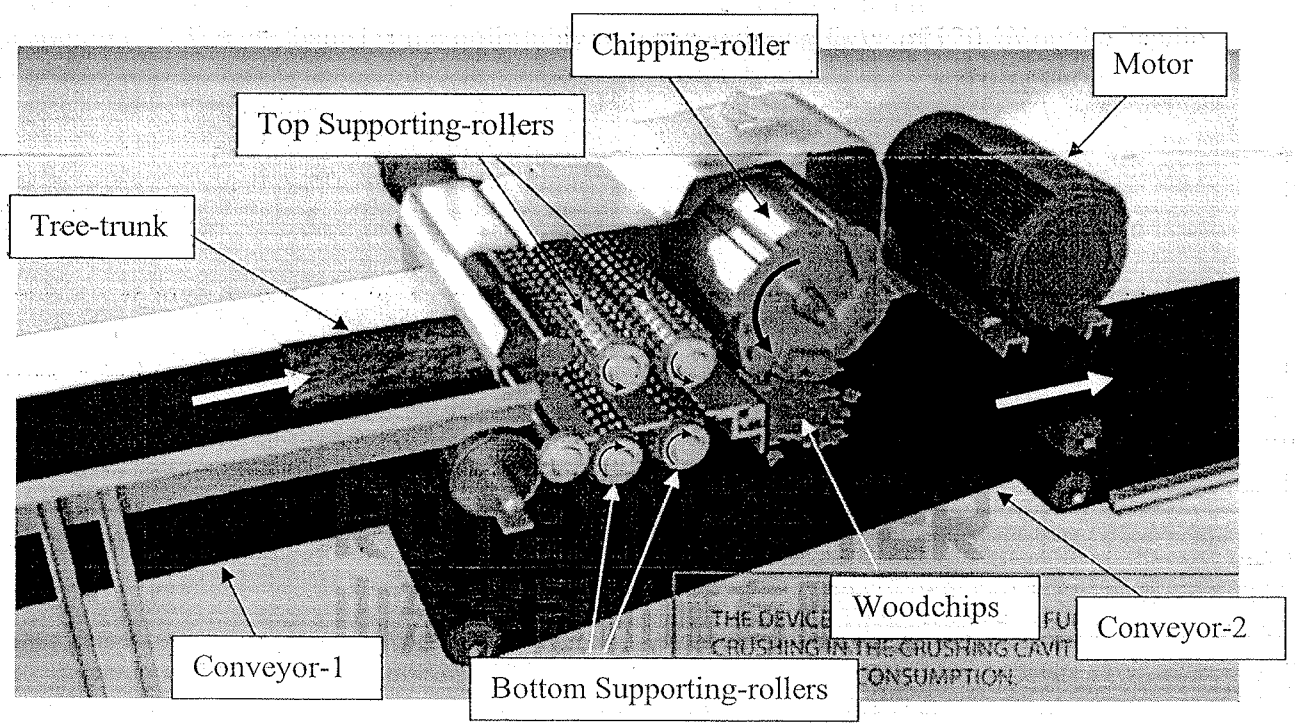

Fig.$Q1$-b: 3D pictorial view of the mechanism.

Answer the following questions.

1. Propose a drive system/s to operate the supporting rollers. (*You shall provide an illustration of the proposed system clearly showing the main components. Calculations are not necessary)* [*6 marks*]

2. Estimate the power required to operate the Chipping-roller at its full capacity, and select an appropriate motor. (*You may disregard the weight of the Chipping-roller and inertia effects of moving parts for power calculations. You shall select a 4-pole motor*) [*6 marks*]

3. Design a suitable V-belt drive system incorporating standard pulleys. [*9 marks*]

4. Design the pair of spur gears. [*9 marks*]

5. Determine the minimum diameter of the input shaft of the gear box. [*9 marks*]

6. Select a suitable key to the driven pulley. [*5 marks*]

7. Select an appropriate pair of rolling element bearings to input shaft of the gear box. [*4 marks*]

8. Indicate the most appropriate location/s which coupling/s needed to be incorporated and state the most suitable type of coupling for selected location/s. (*You may point out the location with the proposed coupling on the Fig.Q1 and attached it to the answer script*). [*2 marks*]

Note: *Assume the efficiency of the; gear mesh as 94%, belt drive as 90%, coupling 96%, and the bearings as 95%. The machine is required to operate for over 10 hours continuously a day. For power transmission shafts shock and fatigue factors for bending and torsion can be considered as 2 and 1.5 respectively. You may consider safety factors appropriately.*

END OF QUESTION 1 AND PART A

PART B

Question 2

a. Write the **Bending** equation and the **Torsion** equation. [*4 marks*]
Note: all notations used must be defined

b. Derive expressions for **section modulus** about *X* axis (Z_{xx}) and *Y* axis (Z_{yy}) for the rectangular cross-sectioned (Fig.*Q2-b*) beam. [*4 marks*]

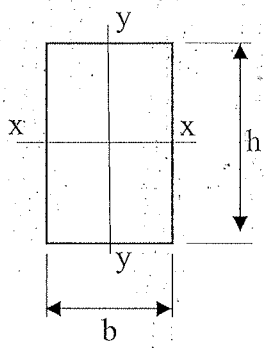

Fig.*Q2-b*

c. A combination of a torsion (*T*) and a bending moment (*M*) are applied on a mild steel shaft of a diameter 50 *mm*. The bending moment is 2000 *Nm*. Find the maximum value of the torque that can be applied without yielding of the shaft according to the maximum principal stress criteria. Yield stress of mild steel in tension is 200 *MPa*. [*9 marks*]

Question 3

a. *Engineering design is not an individual effort of just engineers, it's a collaborative effort of different people involved in different professions.*
Do you agree with this statement? Clarify your answer quoting appropriate examples within the context of modern engineering design. [*6 marks*]

b. *Sequential description of activities that typically occur in designing is called the "Design Process".*
State why it is necessary to have properly defined design process. [*5 marks*]

c. You are assigned to design two manually operated trolleys, one for a supermarket for shoppers to carry grocery items, while the other for an automobile workshop (garage) to transport engine parts like engine housings, cylinder heads, crank shafts etc. within the premises. Distinguish the properties and requirements of each final product.
(You may consider design approach, data collection, working environments, mechanical and material properties, manuarability, force required to handle, ergonomics and aesthetic factors.)
[*6 marks*]

Question 4

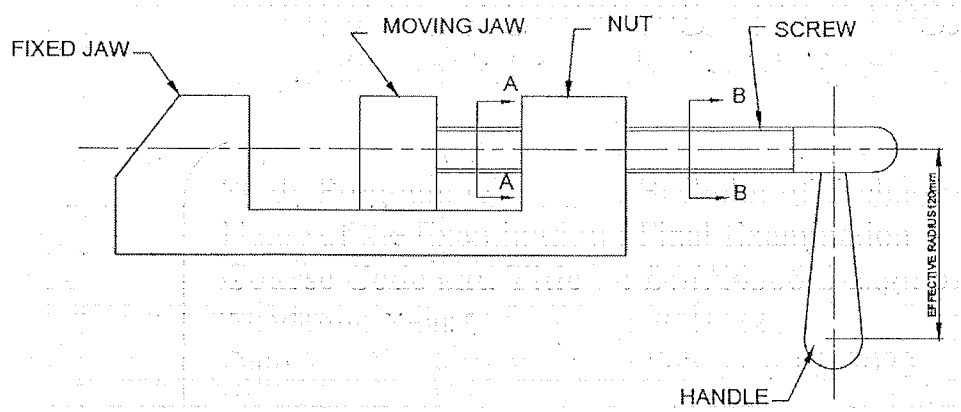

Fig.*Q*4

Fig.*Q*4 shows a machine clamp with following parameters.

Outside diameter of the screw = 12 *mm*
Root diameter of the screw = 10.16 *mm*
Pitch (single tread) of the screw = 1.5 *mm*
Collar friction coefficient = 0.15
Screw fiction coefficient = 0.15
Tread angle = 60°
Effective radius of the handle = 120 *mm*

The mechanist can comfortably exert a maximum force of 120 *kN* on the handle.

Determine,

a. the clamping force developed between the jaws of the clamp. [*11 marks*]
b. the efficiency of the clamp. [*6 marks*]

Question 5

a. Clearly illustrate the possible ways a riveted joint may fail. [*4 marks*]

b. Draw an example for an eccentrically loaded riveted joint and list the steps to be followed in designing such a joint. [*5 marks*]

c. Find the efficiency of a double riveted lap joint of 6 *mm* plates with 20 *mm* diameter rivets. Rivets are placed having pitch of 65 *mm*. The permissible tensile stress of plate material is 120 *MPa*, permissible shear stress of rivets is 90 *MPa* and permissible crushing stress of rivets is 180 *MPa*. [*8 marks*]

Question 6

Fig.*Q*6 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 an angle contact, 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* of power is to be absorbed. Clearly state the direction of the pull. [*10 marks*]

b. If the thickness of the band is 2.5 *mm*, calculate the required width of the band, if the maximum tensile stress of the band material is 50 *MPa*. [*7 marks*]

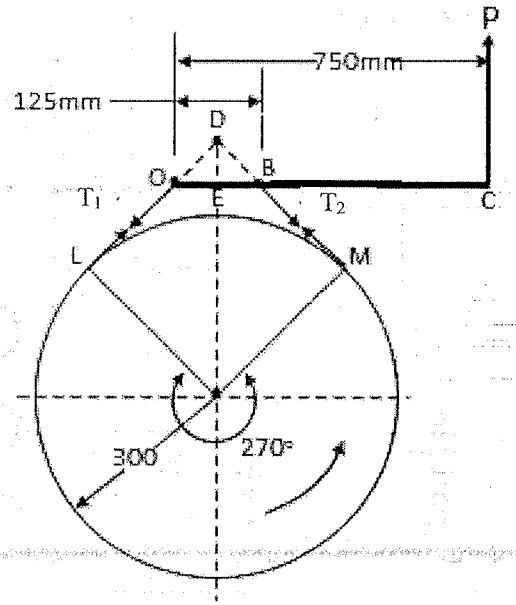

Fig.*Q*6

END OF PART B

END OF THE PAPER