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

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX4306 Design of Machine Elements**
Academic Year	: 2023/24
Date	: March 15, 2025
Time	: 09.30 hrs. -13.30 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**, PART B. Part A consists of Question 1, and Part B consists of Questions 2, 3 and 4. **Answer all questions.**

2. Answers to the question in PART A carries **52** marks, whereas in PART B, each **16** marks.

3. **Attempt all parts in Question 1** in that given order. Spend no more than 2 hours and 45 minutes to for the Question 1 (PART A) and the 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 clearly stated and justified.

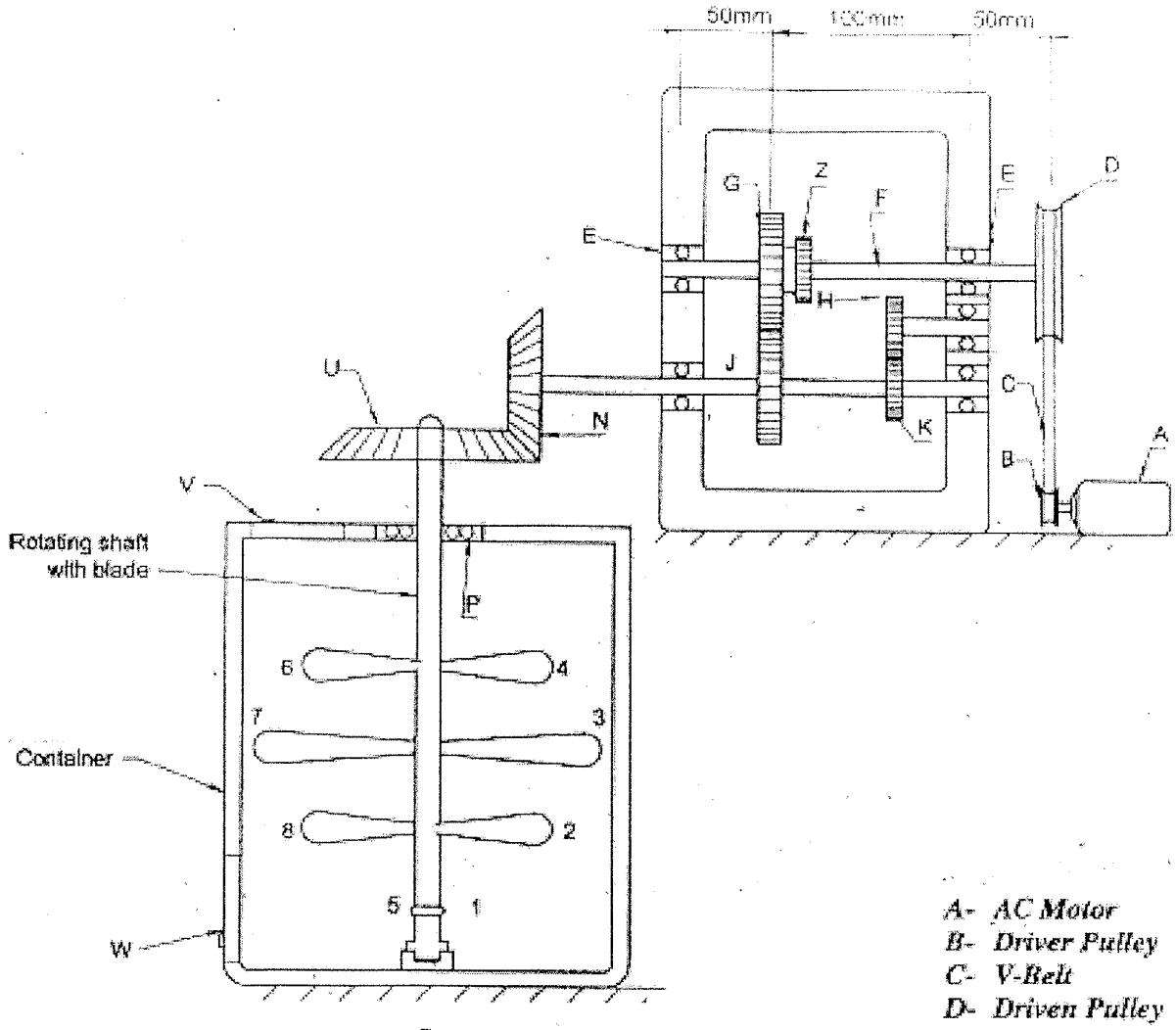
6. Wherever relevant use neatly drawn sketches to explain your answers.

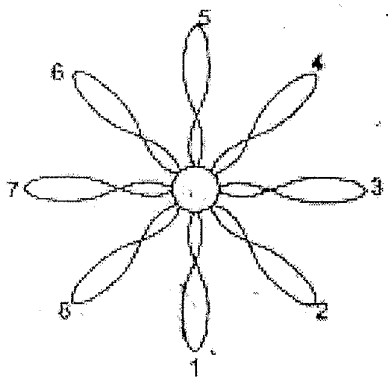
7. Any result from calculations should have units unless they are dimensionless.

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

PART A

Question 1





PLAN VIEW OF THE

SHAFT AND BLADE ASSEMBLY

(*Blade Shape is not Drawn Accurately*)

A- AC Motor
B- Driver Pulley
C- V-Belt
D- Driven Pulley
E- Bearings
F- Splined shaft
G- Cluster Wheel
H- Idler Wheel
J, K- Driven Gears
N- Bevel Pinion
U- Bevel Gear
P – Bearing
V- Loading Lid
W- Unloading Lid

Figure *Q*1-A

A company that produces food items like fruit juice, jams, cordials, etc. intends to expand their production. In the process of expansion, the company needs a high capacity/ heavy-duty blender, which can be used to mix and blend fruit, slices to make fruit pulps. These fruit pulps can be used in the production of juice and can be stored for future use. Figure *Q*1-A shows the layout of the proposed blender. The blender consists of a mixing chamber that meets the capacity requirement and has a vertical rotating shaft, to which blades are fixed, that serves the purpose of blending action.

The blender is driven by motor *A* through the gear mechanism shown in the figure. The pulley *B* on the motor shaft drives the pulley *D* by means of a suitable V–belt drive system. The horizontal splined shaft *F* mounted on two side frames by two identical rolling element bearings *E* carries a cluster wheel having two-wheel segments *G* and *Z*. The shaft *Q*, which carries the wheels *J*, *K* and *N* is mounted on the same side-frames through another pair of identical rolling element bearings. When the wheel segment *G* is in contact with the wheel *J*, power transmits to the screw through a pair of bevel gears (*N* and *U*) to rotate the vertical shaft to which the eight blades are firmly fitted. Whereas when *Z* is in contact with the idler wheel *H*, power is transmitted through *K* to the same pair of bevel gears to reverse the direction of motion to obtain the complete mixing effect.

As shown in the plan view of the shaft and the blade assembly, a pair of blades fitted diametrically opposite are alike and each of the four pairs are fixed on the same shaft at different levels, but they are equidistant. All blades are with the same dimensions.

Answer the following questions.

1. Estimate the power required to drive the blender. *[6 marks]*

2. Select a suitable motor power rating and its speed. *[4 marks]*

3. Design suitable belt drive system and standard pulleys. *[9 marks]*

4. Design the spur gear mesh of wheel *G* and *J*. *[9 marks]*

5. Determine the minimum diameter of the splined shaft. *[9 marks]*

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

7. Select an appropriate pair of rolling–element bearings to support the splined shaft. *[6 marks]*

8. Explain any modifications that you feel are necessary to improve this mechanism. *[3 marks]*

The following information are provided in support of the design analysis.

- Figure *Q*1-*B* shows the important dimensions of the blades.

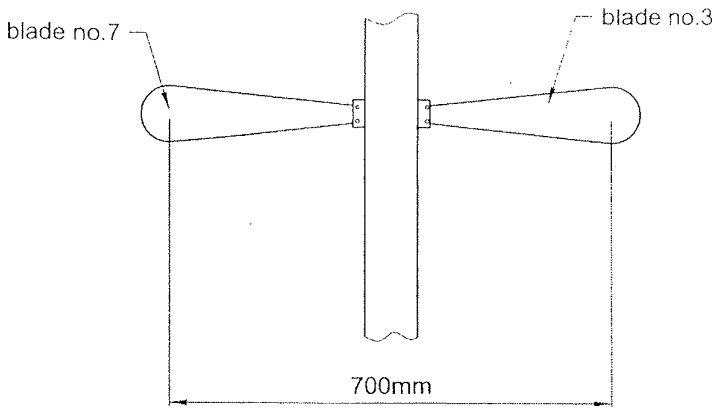


Figure *Q*1-*B*

The maximum speed of the blades is restricted to 80 *rev/min*.

A single blade is applied by fluid pressure of 7 KN/m^2 when the container is filled with food slices to its maximum level, and this amount of pressure is applied to the projected area of the blade, which is 250 cm^2. The distance between the centre of gravity of blade 3 and blade 7 is 700 *mm* as shown in the Figure *Q*1-*B*. They are alike.

- Axis of all the shafts in the gear wheels and pulleys lie on a same vertical plane.
- Efficiencies of the wheels can be considered as given below.

  Efficiency of bevel wheels = 92%
  Efficiency of spur wheels = 94%
  Efficiency of Belt drive = 90%

- All the spur wheels have a module of 4 *mm* and a pressure angle of 20°.
- Belt drive has an approximate speed ratio of 2.5 and centre distance between pulleys is approximately 500 *mm*. This system is required to operate for over 16 hours a day and in continuous service.
- Diameter of the splined shaft refers to its minor (minimum) diameter, and neglect the effects of splines when designing the shaft for strength.
- Assume that the splined shaft experiences maximum state of stress when the pair of wheels *G* and *J* transmits power.

END OF QUESTION 1 AND PART A

PART B

Question 02

a. *It is said that 'Sometimes the problem is to discover what the problem is'.*
In line with this statement, explain the importance of identifying the **problem** clearly before proceeding with designing. *[4 marks]*
Note: *you may use examples to clarify your explanation.*

b. Humans have been designing for past decades, and there are literally millions of artifacts that worked and worked well, such as spacecraft, which landed on the moon. Explain clearly, why it is still necessary to study and redefine/amend the design processes. *[6 marks]*

c. Figure.*Q2a*, Figure.*Q2b*, Figure.*Q2c* and Figure.*Q2d* show different types of wheelchairs, and they possess considerable differences in the configurations, components, size, etc. Quoting at least five (05) main features (such as difference in seating arrangement) explain why these wheelchairs are so differently designed. *[6 marks]*

Note*: you may answer the question considering the design intent and rationale of each design.*

Figure.*Q1a*

Figure.*Q1b*

Figure.*Q1c*

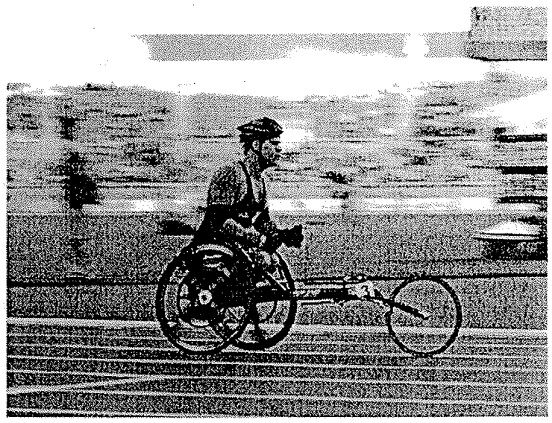


Figure.*Q1d*

Question 3

a. Describe with neat sketchers, the following in the context of designing machine members.

i. Fatigue failures. *[2 marks]*
ii. Fatigue endurance limit. *[2 marks]*
iii. Stress concentration. *[2 marks]*
iv. Residual stress. *[2 marks]*

b. Write short notes on each of the following.

i. Interchangeability in mass production. *[2 marks]*
ii. Fits and tolerances. *[2 marks]*
iii. Hole basis system and shaft basic system. *[2 marks]*
iv. Unilateral and bilateral systems of tolerances. *[2 marks]*

Question 4

Figure *Q*4 illustrates a bracket, which requires supporting a load of 45 *kN*. The bracket is riveted to a steel column by nine (9) identical rivets following the configuration shown in the figure. Determine the size of the rivet if the shear stress is not to exceed 40 *MPa*. *[16 marks]*

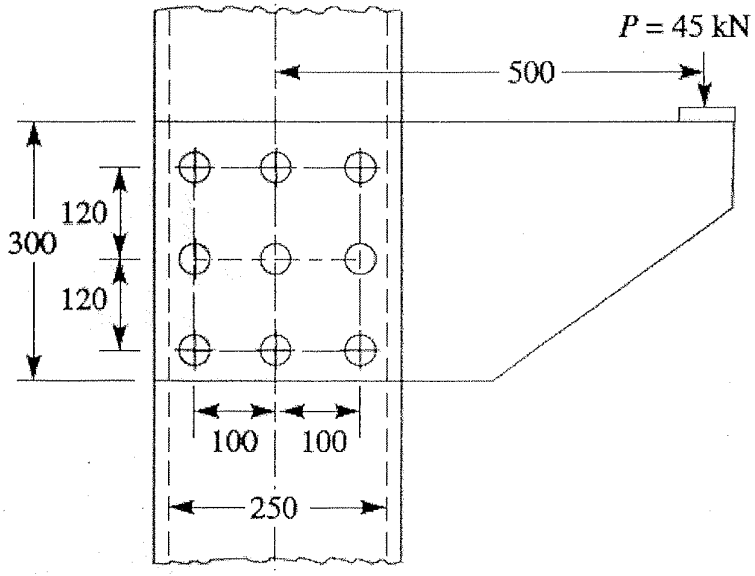


Figure *Q*4 (all dimensions are in *mm*)

.. *END OF THE PAPER* ..