



MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 317: DESIGN OF MACHINE & MACHINE ELEMENTS

DATE: 21/4/2023

TIME: 11:00 – 1:00 PM

INSTRUCTIONS

- i) This examination contains **FIVE** questions.
- ii) You are required to answer **THREE** questions only
- iii) **Section A** (Question **ONE**) is compulsory
- iv) Attempt **ONE** question from **Section B** and **ONE** question from **Section C**
- v) Questions **ONE** carries **30 marks** and the **others** carry **20 marks** each.

QUESTION ONE (30 MARKS)

- a) List the **TWO** factors which determine the superiority of splines over the keys. (1 mark)
- b) Design a muff coupling for transmitting 45 kW at a speed of 350 rpm. The muff is made of CI and is used to connect two shafts. The allowable shear stress in the material of the shaft is 50 N/mm^2 . The material of the key and shaft is same and the coupling is required to transmit 25% overload. Allowable shear stress for cast iron is 16 N/mm^2 . (8 marks)
- c) Determine the maximum torsional moment that a 50 mm diameter solid steel shaft welded to a flat plate can sustain when the leg of the fillet weld is 12.5 mm. Assume that the stress is applied under static conditions, given that the allowable shear stress is 75 N/mm^2 . (3 marks)
- d) Enumerate **FOUR** desirable properties for the materials for shafts and axles. (2 marks)

- e) State **FOUR** basic functions of seals as applied in design. (2 marks)
- f) A small multiple-disc clutch is to be made up of 6 steel and 5 bronze disks, with an inner radius of 25 mm. Given $\mu=0.1$ and average unit pressure as 0.35 N/mm^2 , determine the outer and the axial pressure to transmit a torsional moment of 17.5 Nm. (7 marks)
- g) A full journal bearing of diameter 0.075 m and a length of 0.125 m is to support a load of $20 \times 10^3 \text{ N}$ at the speed of 1000 rpm. The bearing temperature is to be limited to 77°C in a room temperature of 38°C . The viscosity of the oil used is 0.0098 kg/ms at 116°C and energy dissipation coefficient of $209.34 \text{ W/m}^2^\circ\text{C}$. Find the amount of artificial cooling required, by means of external oil cooler. (7 marks)

QUESTION TWO (20 MARKS)

- a) Discuss **SIX** common general factors considered in a machine component. (6 marks)
- b) Derive the equation of a hollow shaft subjected to bending moment only. (6 marks)
- c) A solid circular shaft is subjected to a bending moment of 3,000 N-m and a torque of 10,000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and an ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft. (8 marks)

QUESTION THREE (20 MARKS)

- a) Enumerate **TWO** advantages and **TWO** disadvantages of woodruff key. (4 marks)
- b) A 45 mm diameter shaft is made of steel with yield strength of 400 MPa. A parallel key of size 14 mm wide and 9 mm thick made of steel with yield strength of 340 MPa is to be used. Find the required length of key, if the shaft is loaded to transmit the maximum permissible torque. Use maximum shear stress theory and assume a factor of safety of 2. (7 marks)
- c) Design and make a neat dimensioned sketch of a muff coupling which is used to connect two steel shafts transmitting 40 kW at 350 rpm. The material for the shafts and key is plain carbon steel for which allowable shear and crushing stresses may be taken as 40 MPa and 80 MPa respectively. The material for the muff is cast iron for which the allowable shear stress may be assumed as 15 MPa. (9 marks)

QUESTION FOUR (20 MARKS)

- a) List **FOUR** important characteristics considered in clutch material selection for lining of its friction surfaces. (2 marks)
- b) Derive the equation of total frictional torque of a cone clutch, considering uniform wear of the friction surfaces. (9 marks)
- c) Determine the principal dimensions of a cone clutch faced with leather to transmit 30 kW at 750 rpm from an electric motor to an air compressor. Sketch a sectional front view of the clutch and provide the main dimensions on the sketch. Assume: semi-angle of the cone = 12.5° ; $\mu = 0.2$; $\tau = 42 \text{ N/mm}^2$; mean diameter of cone = 6 to 10 d where d is the diameter of shaft; allowable normal pressure for leather and cast iron = 0.075 to 0.1 N/mm^2 ; load factor is 1.75 and mean diameter to face width ratio = 6. (9 marks)

QUESTION FIVE (20 MARKS)

- a) Enumerate **FOUR** requirements of the gasket material. (2 marks)
- b) List **SIX** guidelines to be followed in order to increase the life of a seal. (3 marks)
- c) Using a well labeled sketch, illustrate the belt/chain drive configuration. (5 marks)
- d) A belt 100 mm wide and 10 mm thick is transmitting power at 1,000 metres/min. The net driving tension is 1.8 times the tension on the slack side. If the safe permissible stress on the belt section is 1.6 MPa, calculate the maximum power that can be transmitted at this speed. Assume density of the leather as $1,000 \text{ kg/m}^3$. Calculate the absolute maximum power that can be transmitted by this belt and the speed at which this can be transmitted. (10 marks)