



MACHAKOS UNIVERSITY

(University Examinations 2018/2019)

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

**SECOND YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF
BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING**

EMM 217: PRINCIPLES OF ENGINEERING DESIGN

DATE: _____ TIME: 2 HOURS

INSTRUCTIONS

This paper contains FIVE questions.

Question ONE is compulsory and carries 30 marks.

Four remaining questions carry 20 marks each.

Attempt question ONE and any other TWO.

QUESTION 1 (30 MARKS)

- (a) What is the difference between a model and a prototype? **(2 Marks)**
- (b) Explain how the following design considerations influence engineering design **(7 Marks)**
- (i) Corrosion
 - (ii) Wear
 - (iii) Safety
 - (iv) Lubrication
 - (v) Weight
 - (vi) Aesthetics
 - (vii) Ergonomics
- (c) Differentiate between codes and standards **(2 Marks)**

- (d) Discuss 4 things that you may do to lower the cost of an engineering design (8 Marks)
- (e)
- (i) Define product liability (1 Marks)
- (ii) What steps can a designer take to ensure safety of product and avoid product liability? (3 Marks)
- (f) Define the maximum normal stress theory for brittle materials (2 Marks)
- (g) An aluminium rod has a radius of $2 \pm 0.22 \text{ mm}$. The stress analyst has calculated this rod will see a maximum tensile axial load ranging from 2000 to 2700 N. Any plastic deformation of this rod results in a loss of component functionality. The rod is part of a plane with a programme-mandated factor of safety, $n = 3$. The aluminium has a yield strength of $S_y = 500 \text{ MPa}$ and $S_{ut} = 580 \text{ MPa}$. Determine whether, the factor of safety meets the programme-mandated standard. (5 Marks)

QUESTION 2 (20 MARKS)

- (a) Name and explain each of the 6 steps of the engineering design process (12 Marks)
- (b) Highlight two design tools available to design engineers (2 Marks)
- (c) Where can design engineers get technical information about the behaviour of the off-the-shelf engineering components? (2 Marks)
- (d) List 4 types of audiences that you may endeavour to sell your design idea to (4 Marks)

QUESTION 3 (20 MARKS)

- (a) Explain 5 factors that affect material selection mechanical design of an engineering component (5 marks)
- (b) Plot a stress-strain curve of a ductile material and explain 5 points of interest for a design engineer (6 Marks)
- (c) Other than measuring the hardness value of a material, discuss 4 other instances where a hardness test may be necessary (4 Marks)
- (d)

- (i) Differentiate between brittleness and toughness **(2 Marks)**
- (ii) What 3 properties would you look for in a material to be used to design a component for a gas turbine (airplane engine)?
(3 Marks)

QUESTION 4 (20 MARKS)

- (a) Define the following dimensioning terminology
 - (i) Tolerance
 - (ii) Limits
 - (iii) Clearance
 - (iv) Interference
 - (v) Fit **(5 Marks)**
- (b) Why is it important to include tolerance to your designs before sending them out for manufacturing? **(2 Marks)**
- (c) Distinguish between the maximum shear stress theory and the distortion theory for ductile materials **(4 Marks)**
- (d) A materials has a yield strength, $S_y = 500 \text{ MPa}$ and an ultimate tensile of $S_{ut} = 750 \text{ MPa}$. For $\sigma_1 = 300 \text{ MPa}$, $\sigma_2 = 200 \text{ MPa}$ and $\tau_{max} = 90 \text{ MPa}$, estimate the factor of safety using:
 - (i) The maximum shear stress theory **(2 Marks)**
 - (ii) The distortion theory **(3 Marks)**
 - (iii) The maximum normal stress theory **(2 Marks)**
- (e) A rod with a cross-sectional area of A and loaded in tension with an axial force of P = 2000 N. Using a material strength $S_y = 240 \text{ MPa}$ and a design factor of 3.0. Determine the minimum diameter of a solid circular rod. **(2 Marks)**

QUESTION 5

(a) Describe 6 categories of machine elements that a mechanical engineer may be called upon to design (12

Marks)

(b) List 8 factors to consider when selecting a bearing for a design problem (4

Marks)

(c)

(i) What is a design constraint? (1 Mark)

(ii) Explain 3 common design constraints (3 marks)