MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 217: PRINCIPLES OF ENGINEERING DESIGN

DATE: 14/12/2020 **TIME: 2.00-4.00 PM**

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 ONE (30 MARKS)

a) Imagine that you are a design engineer working for a boat making start-up company and you have been tasked to design a diesel fishing boat.

i. Discuss any 5 design factors that you will put into consideration (5 marks)

ii. Explain how you will approach the design using the engineering design procedure (12 marks)

iii. Discuss 4 ways that you would use to lower the cost of the boat manufacture (8 marks)

iv. What steps would you take to ensure safety of the boat to avoid product liability? (3 marks)

b) What is the difference between a model and a prototype? (2 marks)

QUESTION TWO (20 MARKS)

a) Briefly describe the following mechanical controls systems and give examples of where they are used

i. Hand wheel (2 marks)

ii. Joystick (2 marks)

iii. Small crank (2 marks)

iv. Push buttons (2 marks)

v. Round knob (2 marks)

b) Differentiate between codes and standards (2 marks)

c) Highlight two design tools available to design engineers (2 marks)

d) Where can design engineers get technical information about the behaviour of the off-the-shelf engineering components? (2 marks)

e) Define the maximum normal stress theory for brittle materials (2 marks)

f) An aluminium rod has a radius of $2 \pm 0.22\ mm$. 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 $S_y = 500\ MPa$ and $S_{ut} = 580\ MPa$. Determine whether, the factor of safety meets the programme-mandated standard. (2 marks)

QUESTION THREE (20 MARKS)

a) Explain 5 factors that affect material selection in mechanical design of an engineering component (5 marks)

b) Plot a stress-strain curve of a ductile material and explain 5 points of interest to 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 FOUR (20 MARKS)

a) List 4 types of audiences that you may endeavour to sell your design idea to (4 marks)

b) Why is it important to include tolerance to your designs before sending them out for manufacturing? (1 mark)

c) Distinguish between the maximum shear stress theory and the distortion theory for ductile materials (4 marks)

d) A materials has a yield strength, $S_y = 500\ MPa$ and an ultimate tensile of $S_{ut} = 750\ MPa$. For $\sigma_1 = 300\ MPa, \sigma_2 = 200\ MPa\ and\ \tau_{max} = 90\ MPa$, estimate the factor of safety using:

i. The maximum shear stress theory (1 mark)

ii. The distortion theory (1 mark)

iii. The maximum normal stress theory (1 mark)

e) Discuss the ergonomic principles that should guide a design engineer (6 marks)

f) 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 $S_y = 240\ MPa$ and a design factor of 3.0. Determine the minimum diameter of a solid circular rod. (2 marks)

QUESTION FIVE (20 MARKS)

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)