MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EMM 217: PRINCIPLES OF ENGINEERING DESIGN

DATE: **TIME:**

INSTRUCTIONS

1. ***This paper contains FIVE questions.***
2. ***Question ONE is compulsory and carries 30 marks.***
3. ***Four remaining questions carry 20 marks each.***
4. ***Attempt question ONE and any other TWO.***

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Differentiate between the following:

(i) Standards and codes (2 marks)

(ii) Developmental, adaptive and new design (3 marks)

(iii) The maximum shear stress and the maximum distortion energy theories of failure (2 marks)

b) Imagine that you have been hired as a design engineer by a new company and you have been tasked to design an Ugali cooker.

(i) Explain **FOUR** questions that will guide your design problem definition (4 marks)

(ii) Discuss **FIVE** levels of analysis that you would conduct on potential solutions to this design problem (5 marks)

(iii) Using examples, explain how you would design for safety (3 marks)

(iv) Once you build a prototype for the Ugali cooker, you will need to develop a testing protocol to guide its performance evaluation. Specify **TEN** questions that may form part of your testing protocol (5 marks)

(v) Suppose your prototype fails the testing protocol, discuss **TWO** ways that you may opt to proceed with your design (2 marks)

c) A tensile-testing apparatus is to be constructed that must withstand a maximum load of 220,000 N. The design calls for two cylindrical support posts, each of which is to support half of the maximum load. Furthermore, plain-carbon (1045) steel ground and polished shafting rounds are to be used; the minimum yield and tensile strengths of this alloy are 310 MPa and 565 MPa respectively. Specify a suitable diameter for these support posts if you are to use a factor of safety of 5 (4 marks)

QUESTION TWO (20 MARKS)

a) Assume that you are hired as a design engineer for a company that plans to make motorised fishing boats. The company is considering using one of the materials listed in Table Q3(a) to design the hull (body) of the boat. The right candidate should have a minimum yield strength of $250\ MPa$ and a minimum Brinell Hardness Value (BHV) of 99.

Table Q3(a)

Material	**Yield strength (MPa)**	**Tensile strength (MPa)**	**Hardness (BHN)**	**Cost per kilogram (Kes)**
Mild steel	370	440	130	70
Aluminium 6061	276	310	95	400
316L Stainless steel	332	673	230	422

(i) Using the material selection criteria, explain how you would select the best candidate for use. (10 marks)

(ii) Discuss **FOUR** steps that you would take to avoid product liability (4 marks)

(iii) Discuss **FOUR** design constraints that you may encounter in this design (6 marks)

QUESTION THREE (20 MARKS)

a) Discuss **SIX** factors that you would consider when determining the optimum factor of safety for an engineering component or product. (6 marks)

b) Discuss how the information about materials used to make engineering design products is generated and stored. (3 marks)

c) Identify any **THREE** of the biggest issues facing humanity currently that may require an engineering solution and propose possible solutions for each (6 marks)

d) Explain **FIVE** differences between a model and a prototype (5 marks)

QUESTION FOUR (20 MARKS)

a) Discuss how the **THREE** ergonomic principles learnt in class can be applied to the design of an intensive care unit (ICU) hospital bed. (6 marks)

b) Provide **FOUR** reasons why you think standards and codes are important in mechanical engineering design**.** (4 marks)

c) Why is it important to include tolerance to your designs before sending them out for manufacturing? (2 marks)

d) A material 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 **FIVE** manufacturing costs that you have to take into account when determining the cost of a design product (5 marks)

QUESTION FIVE (20 MARKS)

a) Engineering design is a highly iterative process. Explain (2 marks)

b) The manufacturability of an engineering product is one of the key design factors that have to be considered early in the design cycle. Discuss **FOUR** practical steps that you can take to ease the manufacturability of an engineering product (8 marks)

c) Noise is a nuisance in design and ought to be eliminated as much as possible. Suppose a part of your design product is making unnecessary noise, what FOUR things can you do to resolve the issue? (4 marks)

d)

(i) What is a machine element? (1 mark)

(ii) Differentiate between a clutch and a break (2 marks)

(iii) Explain **THREE** factors that you would consider when selecting a bearing for a given task (3 marks)