

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

MSc MECHANICAL ENGINEERING

SEMESTER TWO EXAMINATION 2021/2022

**MECHANICS, MATERIALS AND MANUFACTURE
PROCESSES**

MODULE NO: AME7009

Date: Thursday 19th May 2022

Time: 10:00 – 12:00

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions in total.

Answer ANY FOUR questions only.

All questions carry equal marks
of 25.

Marks for parts of questions are shown
in brackets.

Electronic calculators may be used if
necessary.

Q1. Ferrous Alloys

- a) Ferrite and Austenite are the key phases for strengthening steels. Briefly discuss the structure, properties of Austenite and Ferrite; Discuss the mechanisms of strengthening the steels and its effect on other mechanical properties. (12 marks)
- b) What is the effect of atomic packing factor (APF) on properties of a steel. Ferrite is of body centric cubic (BCC) crystal structure. Find the atomic packing factor (APF) of BCC.

APF can be defined as (Equation 1.1)

$$APF = \frac{V_s}{V_c} \dots \dots \dots (1.1)$$

where, V_s =volume of atoms in a unit cell and V_c =total unit cell volume

And, volume of a sphere can be defined as (Equation 1.2)

$$V = \frac{4}{3} \pi R^3 \dots \dots \dots (1.2)$$

where, R =radius of a sphere.

(7 marks)

- c) Transformation-induced plasticity (TRIP) are increasingly being used in automotive industries. Discuss the contribution of ferrite and martensite on the properties of TRIP. List five applications of TRIP in automotive industry.

(6 marks)

Total 25 Marks

School of Engineering
 MSc Mechanical Engineering
 Semester Two Examination
 Mechanics, Materials and Manufacture Processes
 Module No. AME7009

Q2. Non-ferrous Alloys

- a) Aluminium alloys is a widely used group of non-ferrous alloys. Give three typical examples of Aluminium alloys; discuss their compositions and properties with reference to typical applications.

(8 marks)

- b) Calculate the density of Aluminium based on their lattice parameters.

Aluminium has an atomic radius R of 0.143 nm, an face centric cubic (FCC) crystal structure, and an atomic weight of 26.982 g/mol. Compute its theoretical density and compare the answer with its measured density of 2.70 g/cc.

The crystal structure of a metallic solid permits computation of its theoretical density through the relationship (Equation 2)

$$\rho = \frac{nA}{V_c N_A} \dots \dots (2)$$

Where, n = number of atoms associated with each unit cell, A = atomic weight, V_c =volume of the unit cell, and N_A =Avogadro's number (6.023×10^{23})

(6 marks)

- c) Explain the typical heat treatment processes of Al-Cu alloys, discuss the microstructural changes and their influence on the properties.

(7 marks)

- d) Based on the property data given in the Table 2 below, calculate the strength to weight ratios and rank the Alloys from least to greatest according to the strength to weight ratio. Which alloy is the most suitable for light and strong structure and why?

Table 2

Alloy	Tensile Strength [MPa]	Density (kg/m ³)
Aluminium Bronze	551.485	4700
Plain Carbon Steel	398.826	7800
Aluminium Alloy 2024-T3	485	2780

(4 marks)

Total 25 Marks

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School of Engineering
MSc Mechanical Engineering
Semester Two Examination
Mechanics, Materials and Manufacture Processes
Module No. AME7009

Q3. Additive Manufacturing

- a) Why is additive manufacturing replacing conventional manufacturing in the industry? List seven additive manufacturing processes.
(5 marks)
- b) Explain the workflow of powder bed fusion (PBF) for a part made up of Ti-6Al-4V alloy.
(8 marks)
- c) Briefly discuss the advantages and disadvantages of photopolymerisation.
(5 marks)
- d) What are the factors which control the fused deposition modelling (FDM) printed part and why? List five applications of FDM.
(7 marks)

Total 25 Marks

PAST EXAMINATION PAPER

School of Engineering
MSc Mechanical Engineering
Semester Two Examination
Mechanics, Materials and Manufacture Processes
Module No. AME7009

Q4. Material Forming

- a) Provide a brief description of forging, extrusion, rolling and wire drawing along with their applications?
(8 marks)
- b) Explain cold, warm and hot metal forming processing along with its relative advantages and disadvantages.
(8 marks)
- c) Briefly describe the sheet metal forming with its application. What is the difference between blanking and punching? Show appropriate Figures to support your answer.
(4 marks)
- d) Describe the step-by-step process of die casting. Use appropriate Figures to support your answer. List four casting defects.
(5 marks)

Total 25 Marks

PAST EXAMINATION PAPER

School of Engineering
MSc Mechanical Engineering
Semester Two Examination
Mechanics, Materials and Manufacture Processes
Module No. AME7009

Q5. Material Cutting and Joining

- a) Briefly describe the metal cutting system? Explain the working principal of conventional lathe with appropriate Figure(s)?
(7 marks)
- b) What is the difference between permanent and temporary metal joining processes? Provide appropriate examples of permanent and temporary joining processes.
(5 marks)
- c) Explain the welding process? What are the factors which control the welding process and why?
(7 marks)
- d) Provide a brief description of gas welding, resistance welding and friction welding with appropriate Figures? List four examples of welding defects.
(6 marks)

Total 25 Marks

END OF QUESTIONS

END OF PAPER