NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Bachelor of Engineering (Hons) Degree Industrial and Manufacturing Engineering

ADVANCED MANUFACTURING TECHNOLOGY

EIE 5216

SECOND SEMESTER MAIN EXAMINATION

March 2025

This examination paper consists of **4** printed pages

Time Allowed: **3 HOURS**

Total Marks: **100**

Examiner's Name: **M. MUNYAU**

INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. This paper contains 7 questions
2. Answer any FIVE **(5)** Questions.
3. Each Question carries a total of 20 Marks.
4. Start the answer to each full question on a fresh page.

QUESTION 1

a) Describe the working principle, advantages, and limitations of Ultrasonic Machining (USM) process. Explain how USM can be used for:

- Machining of hard and brittle materials,
- Drilling and cutting of complex shapes, and
- Surface finishing and deburring.

Use relevant diagrams and examples to illustrate your answer. [10]

b) A manufacturing company wants to use a non-traditional machining process to drill precise holes in a ceramic component. The company is considering using either Electrical Discharge Machining (EDM) or Abrasive Jet Machining (AJM). Evaluate the suitability of each process for this application, considering factors such as:

- Material compatibility,
- Hole accuracy and surface finish,
- Process speed and efficiency, and
- Equipment and operating costs. [10]

QUESTION 2

a) A manufacturing company is considering integrating Rapid Prototyping into their production line to reduce lead times and increase product customization. However, they are concerned about the compatibility of Rapid Prototyping materials with their existing manufacturing processes. Analyse the potential application issues and propose a strategy for overcoming them. Consider the material properties, surface finish, and post-processing requirements of the Rapid Prototyping technology. [10]

b) Describe the process of Stereo lithography (SLA), a liquid-based Rapid Prototyping technique. Explain how the SLA machine creates a solid part from a liquid resin, layer by layer, and highlight the key process parameters that control the accuracy and surface finish of the final part. [10]

QUESTION 3

a) Describe the LIGA process, a microfabrication technique used to create high-aspect-ratio microstructures. Explain the steps involved in the LIGA process [7]

b) Compare and contrast Surface-Mount Technology (SMT) with Through-Hole Technology (THT) for Printed Circuit Board (PCB) assembly. Discuss the differences between:

- Component placement and orientation
- Soldering techniques and requirements
- PCB design and layout considerations
- Advantages and limitations of each technology [6]

c) A company wants to develop a wearable fitness tracker that requires a compact, lightweight, and high-performance PCB. Discuss the microfabrication processes and PCB fabrication techniques that can be used to meet these requirements [7]

QUESTION 4

a) Describe the principles and techniques used in Scanning Probe Microscopy [7]

b) Compare the Top-Down and Bottom-Up approaches to Nanofabrication [6]

c) A company is developing a new biosensor for detecting diseases. How can Nanotechnology be applied to enhance the sensitivity and specificity of the biosensor? [7]

QUESTION 5

a) Explain the concept of "Size Matters" in Nanoscience and its implications for material properties [5]

b) A researcher is developing a new energy storage device using Nanostructured materials. What are the potential benefits and challenges of using these materials in this application? [7]

c) Critically evaluate the role of Nanotechnology in addressing global challenges, such as energy sustainability, water purification, and healthcare. [8]

QUESTION 6

a) Explain the working principle of Selective Laser Sintering (SLS), a powder-based Rapid Prototyping technique. Describe how the SLS machine selectively fuses together powder particles, layer by layer, to create a solid part. Highlight the advantages and limitations of SLS, including its applications, material options, and post-processing requirements. [10]

b) A team of engineers is designing a new aircraft component using Topology Optimization. The component needs to be lightweight, strong, and resistant to fatigue. The team wants to produce a prototype using Rapid Prototyping. Which Powder-Based Rapid Prototyping technology would you suggest, and how would you optimize the process parameters to achieve the desired mechanical properties? [10]

QUESTION 7

a) Discuss the advantages and limitations of Non-Traditional Manufacturing (NTM) processes compared to Traditional Manufacturing (TM) processes. In your discussion, provide specific examples of industrial applications where NTM processes have been successfully adopted, and highlight the potential areas for future development and research. [20]

End of examination question paper.