UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination (C-23) in Engineering: April 2026

Module Number: ME3204 Module Name: Manufacturing Processes and Practices

Section A : Multiple Choice Questions (MCQ)

[One Hour]

Read all the instructions carefully

- Section A of the examination paper consists of 40 multiple-choice questions.
- Each question carries **0.50 marks**.
- A penalty of **0.25 marks** will be deducted for each incorrect response.
- No penalty will be applied for unanswered questions.
- The minimum attainable mark for Section A - MCQ is **zero**.

- Indicate your answers clearly on the answer sheet provided.
- For each question, clearly mark "**X**" on the letter ⓐ, ⓑ, ⓒ, or ⓓ that corresponds to the correct response on the provided answer sheet, using either a black or blue pen.
- Response marked in pencil will not be accepted and will be treated as unmarked.
- Only one of the responses given is correct for each question.
- Do not select more than one response for a single question, multiple responses will be considered incorrect.

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1. A company manufactures customized vessels (*e.g., offshore support ships and naval patrol vessels*) in small batches to meet specific customer requirements, with a high degree of flexibility. Which manufacturing system is **most** appropriate for this company ?

   a) Repetitive manufacturing
   b) Continuous manufacturing
   c) Job shop manufacturing
   d) Flow line manufacturing

2. In workshop safety, the "*3D environment*" refers to conditions that are _____.

   a) Dangerous, Difficult, and Dirty
   b) Dangerous, Deadly, and Damage
   c) Deadly, Difficult, and Damage
   d) Digital, Dynamic, and Data-driven

3. Which of the following violates the fundamental assumptions of Merchant's analysis in orthogonal cutting ?

   a) Plane shear surface
   b) Presence of side flow of chips
   c) Constant cutting speed
   d) Continuous chip formation without BUE

4. During a turning operation, AISI 304 stainless steel work material is machined under low cutting speed, moderate feed and higher depth of cut. Under such conditions, the **most likely** outcome is the formation of _____.

a) Built-Up Edge (BUE)
b) Continuous chip without BUE
c) Discontinuous chip
d) Brittle fracture of material

5. Match the manufacturing process with its **most** appropriate classification :

1. Rolling	A. Material removal with reduction in mass
2. Welding	B. Plastic deformation under compressive stress
3. Drilling	C. Increase in material mass through joining
4. Powder coating	D. Surface modification via electrostatic deposition

a) 1-D, 2-C, 3-B, 4-A
b) 1-A, 2-B, 3-C, 4-D
c) 1-B, 2-A, 3-D, 4-C
d) 1-B, 2-C, 3-A, 4-D

6. Which statements about workplace hazards and safety systems are correct ?

A. Physical hazards always require direct physical contact to cause harm.
B. Ergonomic hazards may arise from repetitive motion and poor posture.
C. Work organization hazards relate to psychological and social stressors.
D. Mechanical hazards are exclusively associated with rotary systems.

a) None of the above
b) B and C
c) A, B and C
d) All of the above

7. Occupational health and safety management system involves the _____ of hazard identification, prevention, training, and management leadership.

a) isolation
b) delegation
c) integration
d) elimination

8. A manufacturing engineer observes excessive tool wear and poor surface finish while machining a hardened steel. Which of the following is the **most** appropriate solution ?

a) Use uncoated carbide tools
b) Increase depth of cut
c) Increase feed rate & reduce cutting speed
d) Use coated carbide or ceramic tools

9. **Assertion** (A): Increasing cutting speed reduces the formation of Built-Up Edge.

Reason (R): Higher cutting speeds increase temperature at the tool-chip interface, reducing material adhesion.

a) A is true, but R is false
b) Both A and R are true, and R is the correct explanation
c) A is false, but R is true
d) Both A and R are true, but R is not the correct explanation

10. The primary role of hazard signs in a workplace is to _____ risks and required precautions to workers.

a) communicate
b) replace
c) eliminate
d) control

11. Which of the following statements is **most** accurate regarding brazing ?

a) Filler material is not used
b) It is a temporary joining process
c) Base metal is not melted
d) Base metal is melted to form the joint

12. In Minimum Quantity Lubrication (*MQL*), which of the following best describes how the lubricant is delivered to the cutting zone during machining operations ?

a) Gravity flow
b) High-pressure liquid jet
c) Capillary action
d) Atomized air-oil mixture

13. During high-speed machining, a cutting tool loses its hardness and undergoes plastic deformation at the cutting edge. This type of failure is classified as:

a) Fracture failure
b) Temperature failure
c) Abrasive failure
d) Adhesion failure

14. During the machining of ductile materials under stable cutting conditions, which of the following factors **most** favor the formation of continuous chip without Built-Up Edge ?

A. High cutting speed
B. Low tool–chip friction
C. Large feed rate and depth of cut
D. Sharp cutting edge

a) A, B, and D
b) A and C
c) B, C, and D
d) All of the above

15. In orthogonal cutting, the cutting edge is _____ to the direction of tool motion.

a) inclined
b) random
c) perpendicular
d) parallel

16. Regarding tool wear mechanisms, which of the following statements are correct ?

A. Abrasive wear is caused by hard particles scratching the tool surface.
B. Diffusion wear is dominant at low cutting temperatures.
C. Adhesion wear involves material transfer between tool and workpiece.

a) All of the above
b) A and C
c) B and C
d) None of the above

17. In high-speed machining where heat generation is significant and chip evacuation is critical, which cutting fluid application method is **most** effective ?

a) Mist application
b) Jet application
c) MQL application
d) Flood application

18. Which of the machining operations is **not** typically associated with oblique cutting ?

a) Drilling with a twist drill
b) Milling using a helical cutter
c) Cut-off operation with a parting tool
d) Turning with a straight cutting tool

19. The primary function of cutting fluids at **low cutting speeds** is to _____ the cutting process.

a) lubricate
b) cool
c) speed
d) deform

20. Which of the following material is **most** used in **modern aircraft** manufacturing, particularly for primary structural components such as the fuselage and wings ?

a) Titanium alloys
b) Stainless steel
c) Aluminum alloys
d) Carbon fiber composites

21. Ti-6Al-4V exhibits poor machinability primarily due to its _____, which leads to high cutting temperatures.

a) high density
b) high ductility
c) low hardness
d) low thermal conductivity

22. During a turning operation, a cutting tool has a tool life of 60 minutes at a cutting speed of 120 m/min. If the tool life exponent is 0.25, what will be the tool life when the cutting speed is increased to 150 m/min ?

a) 30 min
b) 38 min
c) 45 min
d) 52 min

23. Which of the following manufacturing processes involves a transformation in geometry without altering the material mass, primarily through plastic deformation ?

a) Machining
b) Casting
c) Forging
d) Welding

24. In a machining operation, the instrument used to directly measure cutting force and thrust force is the _____.

a) Dynamometer
b) Tachometer
c) Laser Interferometer
d) Force meter

25. Arrange the following materials in order of increasing melting point:
Al, Ti-6Al-4V, AISI 304

a) Ti-6Al-4V < AISI 304 < Al
b) Al < Ti-6Al-4V < AISI 304
c) AISI 304 < Al < Ti-6Al-4V
d) Al < AISI 304 < Ti-6Al-4V

26. Which class of materials is **most** suited for applications requiring lightweight structures with high fatigue resistance and corrosion resistance ?

a) Ferrous metals
b) Non-ferrous metals
c) Fiber-reinforced composites
d) Thermoplastics

27. Which of the method provides the **most** accurate measurement of temperature at the tool tip during machining ?

a) Tool-work thermocouple
b) Temperature-indicating paints
c) Optical pyrometer
d) Infrared thermometer

28. Which of the following is a unique requirement of Electron Beam Machining (EBM) that is **not** required in Laser Beam Machining (LBM) ?

a) High energy density beam
b) Non-contact machining
c) Operation in a vacuum chamber
d) Capability to machine hard materials

29. In Electrical Discharge Machining (EDM), material removal occurs due to _____ within the dielectric fluid under a high electric potential.

a) mechanical shearing
b) abrasive erosion
c) electrochemical dissolution
d) vaporization caused by spark discharge

30. Which type of tool wear is **most commonly** used as the criterion for tool life evaluation in standard practice ?

a) Crater wear
b) Flank wear
c) Notch wear
d) Built-up edge

31. Which of the following tool materials is **not** suited for machining ferrous materials due to chemical interaction at elevated temperatures ?

a) Carbide
b) Cubic Boron Nitride (CBN)
c) Ceramic
d) Polycrystalline Diamond (PCD)

32. Which cutting tool material is **most** suited for ultra-precision machining of non-ferrous materials and finishing operations ?

a) High-Speed Steel (HSS)
b) Diamond
c) Carbide
d) Cubic Boron Nitride (CBN)

33. In orthogonal cutting, an increase in the coefficient of friction at the tool-chip interface will **most** likely :

a) Not affecting shear angle
b) Reduce cutting force
c) Decrease shear angle and increase power
d) Increase shear angle and reduce power

34. In a thread cutting operation, the accuracy of the thread is checked using a _____.

a) Thread gauge
b) Plug gauge
c) Slip gauge
d) Feeler gauge

For **Questions 35 to 40**, select the most correct option from the following :

a). Both **statement (i)** and **statement (ii)** are true, and (ii) correctly explain (i)
b). Both (i) and (ii) are true, but (ii) does NOT explain (i)
c). (i) is true, but (ii) is false
d). (i) is false, but (ii) is true

35. **Statement (i)** Near-net shape components are typically achieved by combining primary manufacturing processes with minimal secondary machining operations.

Statement (ii) Primary manufacturing processes such as casting and forging alone always produce components within final dimensional tolerances, eliminating the need for any secondary processes.

36. **Statement (i)** Ergonomic hazards can affect workers even without direct physical contact with hazardous agents.

Statement (ii) Ergonomic hazards arise mainly due to improper workplace design, repetitive motion, and poor posture.

37. **Statement (i)** Increasing the rake angle always leads to an increase in shear angle during orthogonal cutting.

Statement (ii) According to Merchant's theory, shear angle depends only on rake angle and is independent of friction at the tool–chip interface.

38. **Statement (i)** In EDM, material removal occurs even in the absence of direct mechanical contact between tool and workpiece.

Statement (ii) The dielectric fluid in EDM acts solely as a coolant and does not influence spark generation or debris removal.

39. **Statement (i)** CBN tools are preferred over PCD tools for machining hardened ferrous materials.

Statement (ii) Diamond tools chemically react with iron at elevated temperatures, leading to rapid tool wear.

40. **Statement (i)** At very high cutting speeds, the cooling function of cutting fluids becomes more dominant than lubrication.

Statement (ii) Lubrication is more effective at low cutting speeds due to increased contact time at the tool–chip interface.

---------- ***End of Section A : Multiple Choice Questions (MCQ)*** ----------

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Module Number: ME 3204 Module Name: Manufacturing Processes and Practices

Section B : Essay and Descriptive Questions

[Two Hours]

[Answer **all questions**, each question carries **Ten (10)** marks]

Q1. **"Manufacturing processes"** constitute the integration of primary shaping operations, which create the basic geometry of components, with secondary precision processes that facilitate near-net shaping while enhancing dimensional accuracy and surface integrity.

a) Provide **two** examples of precision shaping processes employed in manufacturing that achieve higher dimensional accuracy through geometric transformation and material removal.

[2.0 Marks]

b) Briefly explain **two** advanced approaches or techniques that can be applied in **Q1. (a)** processes to achieve superior dimensional accuracy, tight tolerance limits, and enable the production of complex part geometries.

[4.0 Marks]

c) Briefly explain **two** limitations or challenges associated with the application of the advanced approaches or techniques explained in **Q1. (b)**, with reference to the use of nickel-based superalloys in the manufacture of aero-engine components.
(hint: consider physical and chemical properties of the material).

[4.0 Marks]

Q2. Merchant's Circle is employed to analyse cutting forces in machining operations, thereby enabling engineers to optimise cutting parameters with greater precision. This results in reduced power consumption, extended tool life, and superior surface finish.

a) Clearly state the underlying assumptions and, using the geometric relationships with rake angle (α), derive the equation for **chip thickness ratio** (r_c). Hence, prove that the shear plane angle (ϕ) can be expressed as follows :

$$\phi = \mathrm{Tan}^{-1}\left[\frac{r_c \cos\alpha}{1 - r_c \sin\alpha}\right]$$

[2.0 Marks]

Q2. Continues to the next page

Q2. b) With the aid of a force diagram, and by **stating all necessary assumptions**, derive the mathematical expressions for the following by resolving forces along the shear plane and the tool rake face incorporating relevant angles such as shear plane angle (ϕ) and rake angle (α).

i). Friction force and the normal force to the tool rake face.

[1.0 Marks]

ii). Shear force (*acts along the shear plane*) and Normal force to the shear plane.

[1.0 Marks]

iii). Coefficient of friction (μ) at the tool-chip interface.

[1.0 Marks]

c) A **Ti-6Al-4V alloy tube** with an outer diameter of 60 mm is being machined in a turning operation on a CNC lathe at a cutting speed of 90 m/min using a coated carbide cutting tool with a rake angle of 10°. The operation is performed with a feed rate of 0.12 mm/rev under dry cutting conditions. Force measurements obtained from a tool dynamometer indicate a cutting force of 300 N and a thrust force of 180 N. During machining, the length of the continuous chip produced per revolution is measured as 60 mm. Based on the given information,

i). Determine the shear plane angle [*hint: use* **Q2. (a)** *derived equation*].

[1.0 Marks]

ii). Construct the Merchant's Circle on the given graph sheet.

[2.0 Marks]

iii). Using the constructed Merchant's Circle in **Q2. (c) ii)**, determine the friction angle (β) and evaluate the coefficient of friction (μ) at the tool-chip interface.

[1.0 Marks]

iv). Determine the coefficient of friction (μ) at the tool-chip interface through a numerical approach.

[1.0 Marks]

Q3. Advanced machining processes provide significant advantages over traditional methods by enabling efficient machining of brittle and difficult-to-cut materials with minimal tool wear and thermal damage, while enabling the fabrication of highly intricate geometries with exceptional dimensional accuracy and surface integrity.

a) **Figure Q3.** illustrates a modern, non-traditional advanced machining process that is extensively employed in various industries, including aerospace and automotive.

i). State the name of the manufacturing process shown in **Figure Q3.**

[1.0 Marks]

Q3. Continues to the next page

Q3. a) ii). Briefly explain **one** advantage of this process over conventional machining.

[1.0 Marks]

iii). Briefly explain why this process is preferred over thermal machining methods for cutting Carbon Fibre Reinforced Polymer (CFRP) in aerospace component manufacturing.

[2.0 Marks]

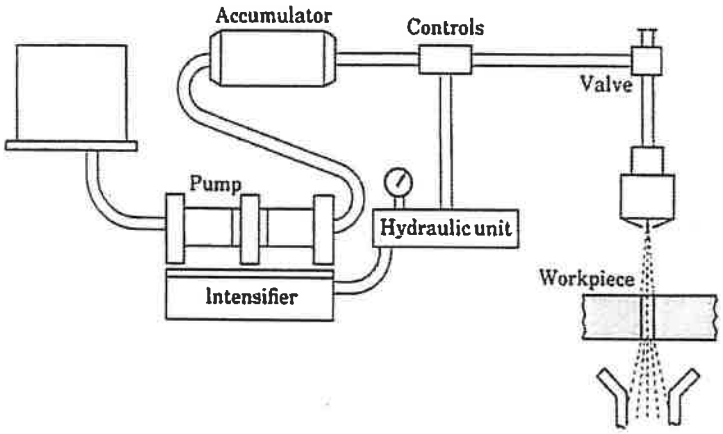

Figure Q3 : Non-traditional advanced machining process

b) With the aid of a clear diagram, illustrate **four types** of tool wear encountered in machining operations when using a single point cutting tool.

[2.0 Marks]

c) A nickel-based superalloy (**ISO S group**) is to be machined in high-speed conditions to achieve tight dimensional tolerances and superior surface integrity. Considering that only coated carbide and polycrystalline diamond tools are available, briefly explain **two** major considerations in selecting the **most appropriate** tool material. Thus, select the preferred tool and justify your selection based on the material's physical and chemical properties.

[2.0 Marks]

d) During a tool life experiment, a cutting tool employed in the turning of Inconel 718 superalloy under high-speed machining conditions exhibits a tool life of 2 minutes at a cutting speed of 3.5 m/s and 18 minutes at a cutting speed of 1.8 m/s.

i). Determine the constant parameters of the Taylor`s tool life equation.

[1.0 Marks]

ii). Estimate the tool life when the cutting speed is at 1.0 m/s.

[1.0 Marks]

---------- ***End of Section B : Essay and Descriptive Questions*** ----------