Second Semester Examination
2020/2021 Academic Session

July/August 2021

EPP 212 – ADVANCED MANUFACTURING TECHNOLOGY

Duration : 2 hours 30 minutes (plus 30 minutes submission)

Please check that this examination paper consists of SIX (6) pages pages including appendixes before you begin the examination.

Instructions : Answer ALL **THREE (3)** questions.

Answer to each question must begin from a new page.

1. [a] A machining center as shown in Figure 1 is an advanced computer-controlled machine that performs a variety of machining operations on different surfaces and different orientations of a workpiece without the need to remove it from your workholding device.

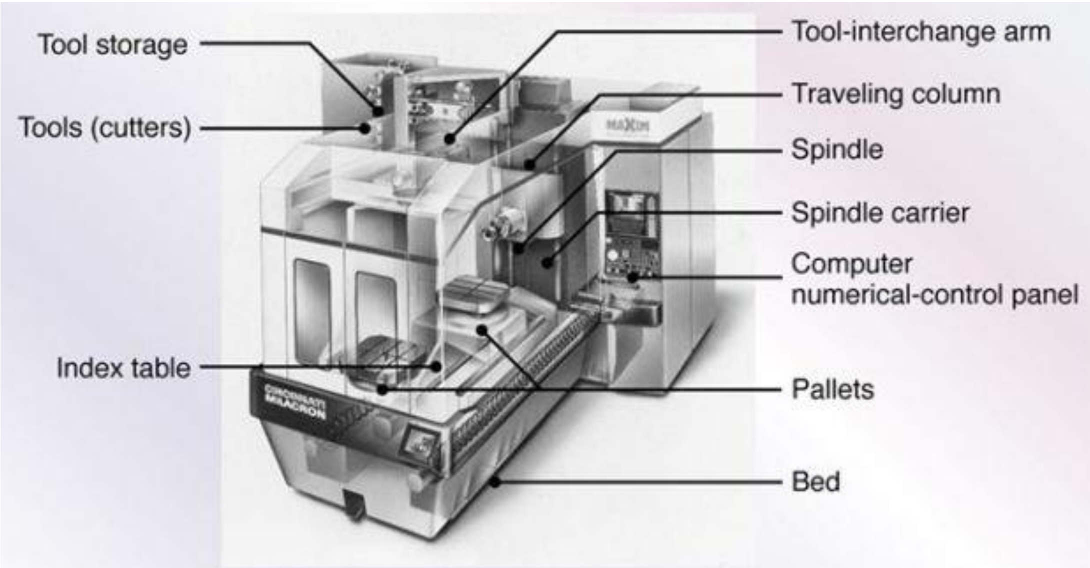

Figure 1

(i) Describe types and sizes of workpieces that would not be suitable for machining on a machining center. With sketches, provide **TWO (2)** specific examples.

(4 marks)

(ii) Based on Figure 1 above, identify **TWO (2)** components of machine tools that could be made of composites (polymer, metal or ceramic matrix) and justify why composites would be suitable for each component that you have selected.

(2 marks)

(iii) During machining process of an alloy steel bar, a very high amplitude and audible vibrations has occurred. As an engineer, you need to improve and modify the above machine structure (Figure 1) to solve that problem. Identify **TWO (2)** factors that induce the above problem and with the help of sketches, justify the **TWO (2)** modifications that you can make.

(6 marks)

2. [a] Referring to Table Q2(i) and Q2(ii) given in Appendix 1, identify the MOST SUITABLE advanced machining process based on the provided criteria and justify its selection considering material removal mechanism and material properties for the following cases.

(i) Produce a mould from tool steel for injection moulding process with machining tolerances ± 0.02mm, that have a deep cavity with the surface roughness of 80.00µm.

(ii) Produce 10 through holes with a radius of 0.50mm on ceramic material with 10.00mm thickness for turbine blade manufacturing. Surface roughness must not be beyond 30.00µm with machining tolerances at ± 0.0015mm.

(6 marks)

[b] A CNC programme commonly has THREE distinct sections. Name the THREE section and give example of a programme line for each section.

(2 marks)

[c] An engineering component made of aluminum as shown in Figure 2[c] need to be machined using CNC milling machine by Company A. Using standard G-code programming, prepare a complete code for machining the part that would give the shortest time and optimum machining sequence. You need to justify your approach and answer. State all conditions and assumptions you have used.

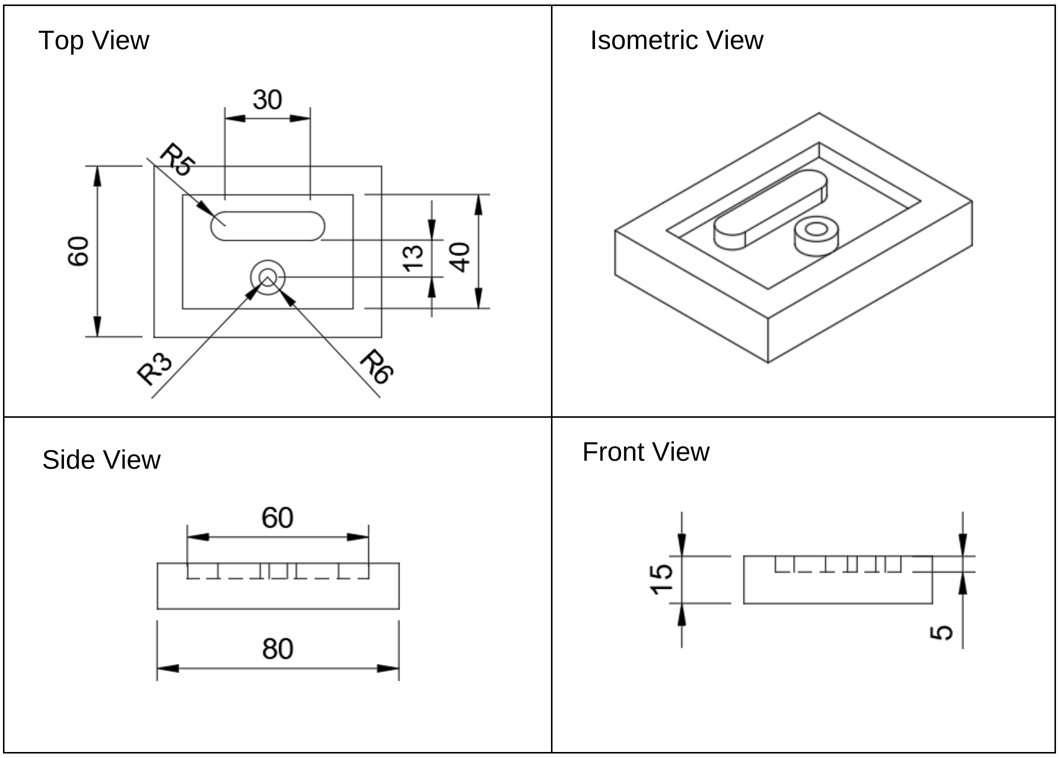

Figure 2[c]: Aluminum part for CNC machining

(6 marks)

3. [a] Since 1986, 3D printing has evolved from a technology that caters for just prototype for fabrication into wide range of applications across many fields including direct manufacturing, medical, aerospace, automotive, arts and architecture, construction, etc. From your observation, what are the factors that contribute to this rapid change and diversification of the technology. List FIVE (5) factors that contribute to the evolution and justify your answer.

(7 marks)

[b] An archeologist is discovering an exciting artifact with valuable historical value that could potentially change the narrative of how and when dinosaur really began to extinct in the past. The artifact is however very fragile, with some parts already fragmented, some parts are missing too. Further study and experimentation are needed in order to form clear judgement and to come to more accurate conclusions. Come up with your strategy in order to fully utilize 3D printing technology to help scientist discover more valuable information from the artifact.

(7 marks)

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APPENDIX 1

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General Characteristics of Advanced Machining Processes

Process	Characteristics	Process parameters and typical material-removal rate or cutting speed
Chemical machining (CM)	Shallow removal on large flat or curved surfaces; blanking of thin sheets; low tooling and equipment cost; suitable for low-production runs	0.0025–0.1 mm/min. (0.0001–0.004 in./min)
Electrochemical machining (ECM)	Complex shapes with deep cavities; highest rate of material removal among other nontraditional processes; expensive tooling and equipment; high power consumption; medium-to-high production quantity	V: 5–25 D.C.; A: 1.5–8 A/mm^2; 2.5–12 mm/min (0.1–0.5 in./min), depending on current density
Electrochemical grinding (ECG)	Cutting off and sharpening hard materials, such as tungsten-carbide tools; also used as a honing process; higher removal rate than grinding	A: 1–3 A/mm^2; typically 25 mm^3/s (0.0016 in^3/s) per 1000 A
Electrical-discharge machining (EDM)	Shaping and cutting complex parts made of hard materials; some surface damage may result; also used as a grinding and cutting process; expensive tooling and equipment	V: 50–380; A: 0.1–500; typically 300 mm^3/min (0.02 in^3/min)
Wire electrical-discharge machining	Contour cutting of flat or curved surfaces; expensive equipment	Varies with material and thickness

General Characteristics of Advanced Machining Processes

Process	Characteristics	Process parameters and typical material-removal rate or cutting speed
Laser-beam machining (LBM)	Cutting and hole making on thin materials; heat-affected zone; does not require a vacuum; expensive equipment; consumes much energy	0.50–7.5 m/min (1.67–25 ft/min)
Laser Microjet	Water-jet guided laser uses a 25–100 μm diameter stream to mill or cut; large depth of field; little thermal damage from laser machining	Varies with material; up to 20 mm in silicon, 2 mm in stainless steel; up to 300 mm/s in 50 μm thick silicon.
Electron-beam machining (EBM)	Cutting and hole making on thin materials; very small holes and slots; heat-affected zone; requires a vacuum; expensive equipment	1–2 mm^3/min (0.004–0.008 in^3/h)
Water-jet machining (WJM)	Cutting all types of nonmetallic materials; suitable for contour cutting of flexible materials; no thermal damage; noisy	Varies considerably with material
Abrasive water-jet machining (AWJM)	Single-layer or multilayer cutting of metallic and nonmetallic materials	Up to 7.5 m/min (25 ft/min)
Abrasive-jet machining (AJM)	Cutting, slotting, deburring, etching, and cleaning of metallic and nonmetallic materials; tends to round off sharp edges; can be hazardous	Varies considerably with material

Table 2 (i)

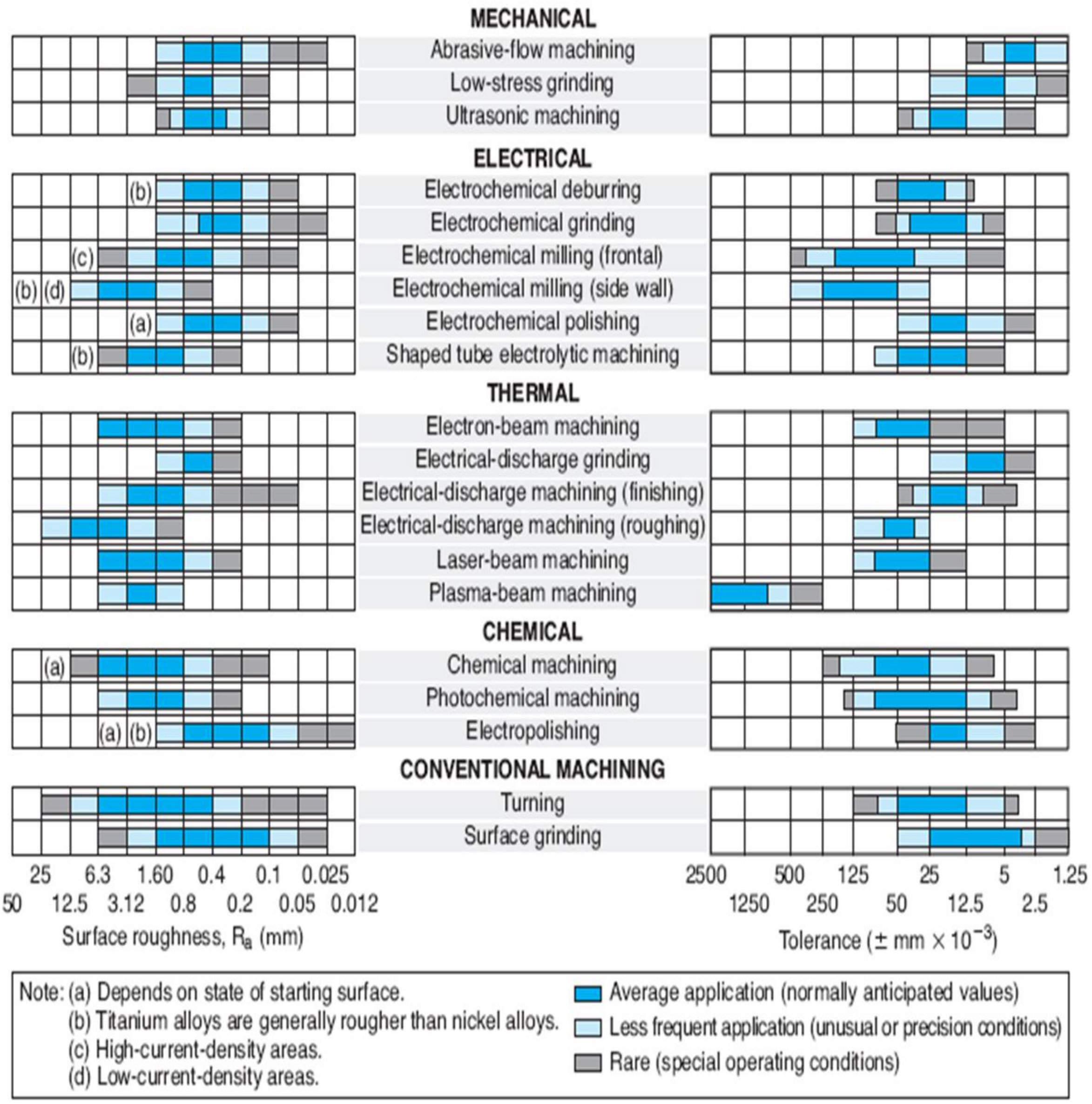
MECHANICAL
Abrasive-flow machining
Low-stress grinding
Ultrasonic machining
ELECTRICAL
Electrochemical deburring
Electrochemical grinding
Electrochemical milling (frontal)
Electrochemical milling (side wall)
Electrochemical polishing
Shaped tube electrolytic machining
THERMAL
Electron-beam machining
Electrical-discharge grinding
Electrical-discharge machining (finishing)
Electrical-discharge machining (roughing)
Laser-beam machining
Plasma-beam machining
CHEMICAL
Chemical machining
Photochemical machining
Electropolishing
CONVENTIONAL MACHINING
Turning
Surface grinding
(a)
(b)
(c)
(d)
25 6.3 1.60 0.4 0.1 0.025
50 12.5 3.12 0.8 0.2 0.05 0.012
Surface roughness, Ra (mm)
2500 500 125 25 5 1.25
1250 250 50 12.5 2.5
Tolerance (± mm × 10−3)
Note: (a) Depends on state of starting surface.
(b) Titanium alloys are generally rougher than nickel alloys.
(c) High-current-density areas.
(d) Low-current-density areas.
Average application (normally anticipated values)
Less frequent application (unusual or precision conditions)
Rare (special operating conditions)

Table 2 (ii)