MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 511: COMPUTER AIDED DESIGN/COMPUTER AIDED MANUFACTURING (CAD/CAM)

DATE: 17/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

This paper contains FIVE questions

Question ONE is compulsory and carries 30 Marks

Questions TWO – FIVE carries 20 Marks each. Attempt any two.

QUESTION ONE (30 MARKS)

a) Define the terms CAD, CAM and describe the relationship between CAD and CAM giving rise to CAD/CAM (5 marks)

b) State two benefits and two limitations of CAD/CAM. (4 marks)

c) Describe five ways in which the computer is used to assist in design (5 marks)

d) Describe briefly the following components of a CAD system.

   i. Hardware (2 marks)

   ii. Application software (2 marks)

   iii. Operating system (2 marks)

e) Describe the major advantages of numerical control over conventional methods of machine control (5 marks)

f) With the aid of a sketch, describe how a CAD data exchange file may be used between two CAD systems (3 marks)

g) Define Finite Element Analysis (2 marks)

QUESTION TWO (20 MARKS)

a) Describe the three stages in Finite Element Analysis (6 marks)

b) A cantilever beam with a rectangular cross-section is to be analysed for stress and deformation using a CAD software with a FEA module. Using sketches where necessary, describe the workflow in carrying this analysis. (7 marks)

c) What is the importance of carrying out analysis of a mechanical part or assembly in the design phase? (3 marks)

d) Describe two methods available for pre-processing while using a CAD system in conjunction with a FEA package (4 marks)

QUESTION THREE (20 MARKS)

a) Briefly describe the following solid representation schemes used in CAD systems

   i. Constructive solid geometry (CGS) (2 marks)

   ii. Boundary representation (B-rep) (2 marks)

   iii. Primitive instancing (2 marks)

b) A line with end points A(2, 3, 2) and B(10, 12, 8) is rotated 60° counter-clockwise about the z-axis, then translated by a vector $[5\ 4\ 8]^T$ and finally scaled by (2, 2, 3). Determine the final coordinates of the line (8 marks)

c) State two applications of wire frame models (1 marks)

d) State two advantages and two disadvantages of surface modelling (2 marks)

e) FigureQ3(e)shows a solid model represented using B-rep. Verify whether it satisfies modified Euler's formula,

$$V - E + F - H = 2(C - G)$$

(3 marks)

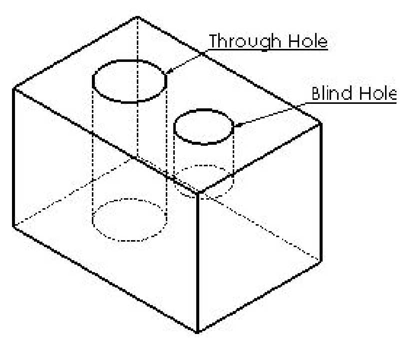

Figure Q3(e)

QUESTION FOUR (20 MARKS)

a) With the aid of sketches, describe two (2) motion control systems used in numerical control (NC) systems (4 marks)

b) List five factors used in rating NC machines (2.5 marks)

c) Figure Q4(c) is an illustration of a billet that is to be milled on a three axis CNC machine. Using the program table format provided in Table 1, write a program that can be used to effectively mill the profile. (13.5 marks)

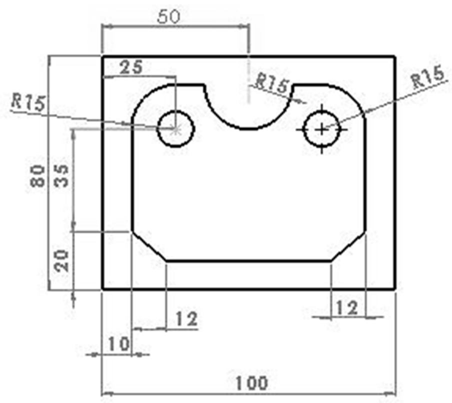

Figure Q4(c)

Billet size 100 x 80 x 40
Profile depth 10mm
Spindle speed 1500 rpm
Feed rate 100 mm/min (for both milling and drilling)

Table 1. NC part program manuscript

Description	N	G	G	G	X	Y	Z	R	I	J	K	M	T	D	S	F

QUESTION FIVE (20 MARKS)

a) Briefly describe the basic components of an industrial robot and show their relationship using a schematic diagram (8 marks)

b) Define the following terms used in relation to precision in robotics:

i. Accuracy (1 mark)

ii. Repeatability (1 mark)

c) Describe the three (3) methods used to program robots (3 marks)

d) A recently established organisation is considering the acquisition of a robot to speed up production. The robot is to pick up crates of small gas cylinders from a conveyer and stack them onto a waiting Automatically Guided Vehicle (AGV), which docks at a fixed position. Stacking is done such that the crates have to fit into each other precisely. Each crate weighs 250 kgs. The cost of the preferred robot must be kept at a minimum. Give a technical description of the most ideal robot to be used in the set-up described above.

(7 marks)

Appendix

Rotation about z

$$R_z = \begin{pmatrix} c & -s & 0 & 0 \\ s & c & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Where c = cos θ
s = sin θ

Translation matrix

$$T_r = \begin{pmatrix} 1 & 0 & 0 & dx \\ 0 & 1 & 0 & dy \\ 0 & 0 & 1 & dz \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Scaling matrix

$$S_r = \begin{pmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Table 2: G-Codes

G00	Rapid traverse	G21	Input in mm
G01	Linear interpolation	G28	Return to reference point
G02	Circular interpolation -CW	G40	Cutter diameter compensation-cancel
G03	Circular interpolation -CCW	G41	Cutter diameter compensation-left
G04	Dwell	G42	Cutter diameter compensation-right
G08	Acceleration	G43	Tool length compensation (+)
G09	Deceleration	G49	Tool length compensation - cancel
G17	X-Y plane	G80	Canned cycle cancel
G18	Z-X plane	G81	Basic drill cycle
G19	Y-Z plane	G90	Absolute programming mode
G20	Input in inches	G91	Incremental programming mode
G94	Feed per minutes	G92	Set x, y, z locations

Table 3: M-Codes

M00	Program stop	M06	Automatic Tool change
M01	Optional program stop	M07	Flood coolant on
M02	End of program	M08	Mist coolant on
M03	Spindle on CW	M09	Coolant off
M04	Spindle on CCW	M30	Program reset and rewind
M05	Spindle off	M13	Spindle forward and coolant on