



# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

Module Number: ME 6303

Module Name: Computer Aided Manufacturing

[Three Hours]

[Answer all questions, each question carries ten marks]

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- Q1. a) Describe how useful the Distributed Numerical Control (DNC) system for Computer Aided Manufacturing. [2.0 Marks]
- b) Write the minimum number of axes for CNC machine to orientate the tool in all directions in 3D space. Specify the main structural configurations of CNC machine with that number of axes. [3.0 Marks]
- c) List the main categories of machine tool guideways. [2.0 Mark]
- d) Explain three mechanisms that are used to drive the CNC rotary tables by emphasizing the merits and demerits. [3.0 Marks]
- e) Differentiate the semi-closed loop controlling and full-closed loop controlling principles which are used in CNC machines. [2.0 Mark]
- Q2. a) Classify the production machine categories used in modern manufacturing environment. Describe each category. [3.0 Marks]
- b) List the material handling functions that must be provided in a manufacturing system. [3.0 Marks]
- c) Write the factors that define and distinguish manufacturing system. [3.0 Marks]
- d) Describe the capabilities that the manufacturing system must possess for it to be flexible. [3.0 Marks]
- Q3 a) Write a program to machine the part given in Figure Q3-1. Start from the header of the program. You are advised to use 500mm/min as feed rate, 1000 rpm for spindle speed and the left hand cutter compensation. Write the program for only one pass. The tool T01 is a flat end mill with 10mm diameter. Use 5mm above the surface as Z safe level and G54 as the work origin offset. All required G codes and M codes are given in Appendix 1.

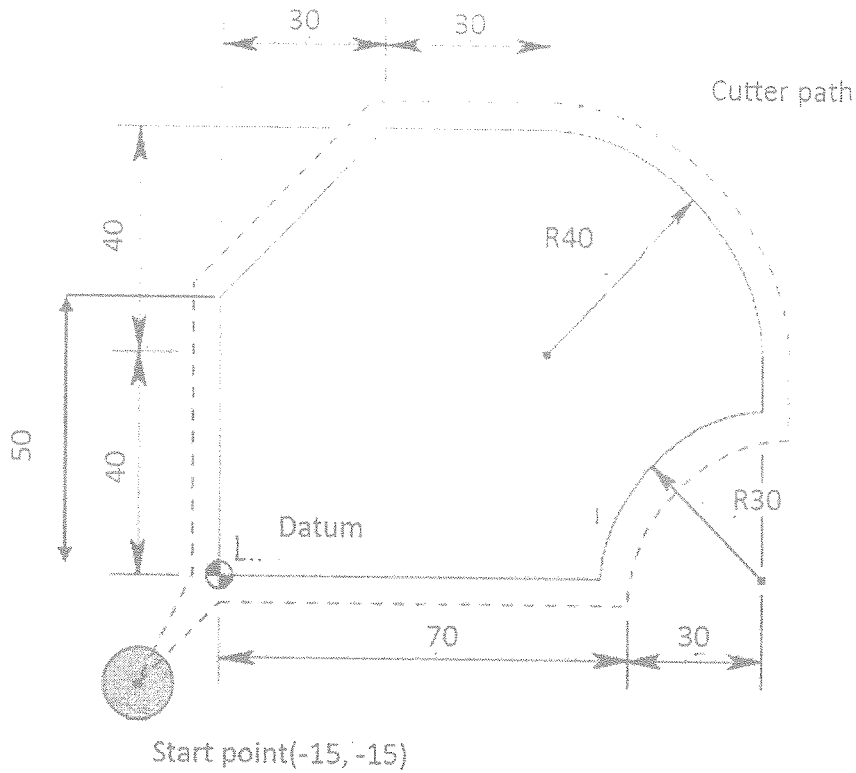


Figure Q3-1 all dimensions are in mm

- b) Write a program to machine the circular groove shown in dotted line of Figure Q3-2. The depth of the groove is 2mm and width of the groove is 10mm. The tool T02 is flat end mill with 10mm diameter. Start from the header of the program and use G55 as work origin offset, 500mm/min as feed rate and 2000rpm as spindle speed. Use 5mm above the surface as Z safe level. All required G codes and M codes are given in Appendix 1. [8.0 Marks]

[4.0 Marks]

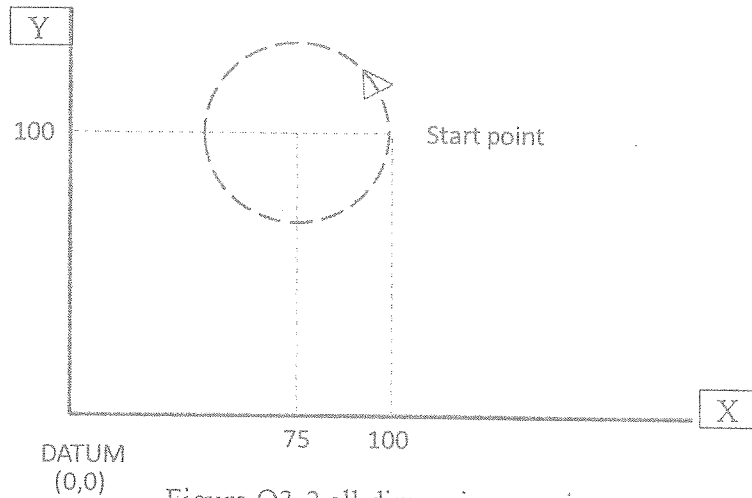


Figure Q3-2 all dimensions are in mm

- Q4 a) Write a program using drilling canned cycle to machine the holes shown in Figure Q4. You are advised to use tool T01, spindle speed 1000 rpm and feed rate 75mm/min for small holes and tool T02, spindle speed 750 rpm and feed rate 60mm/min for large holes. Start from the header of the program and use G56 as work origin offset. Use 12mm above the surface as Z safe level and retract point is 2mm above the datum. [Hint Drilling canned cycle: G..... X.....Y.....Z.....R....F.....]. All required G codes and M codes are given in Appendix 1.

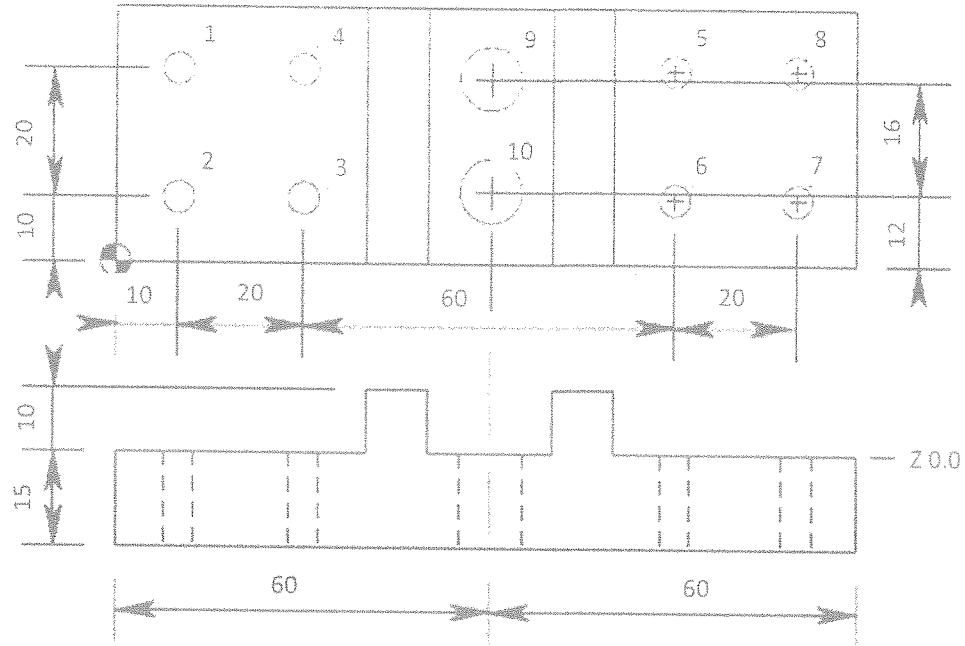


Figure Q4 all dimensions are in mm

- b) List four advantages of a layout which uses Group Technology (GT).

[6.0 Marks]

- c) Part-machine incident matrix is given in Table Q4. Use rank order clustering method to find the machine clusters. Write all the steps separately.

[2.0 Mark]

Table Q4

Machine	Part						
	A	B	C	D	E	F	G
1	1		1				1
2	1		1				1
3				1		1	
4				1			
5		1	1		1		
6				1		1	
7		1			1		

[4.0 Marks]

- Q5 A Flexible Manufacturing System (FMS) consists of four stations. Station 1 is load/unload station with one server. Station 2 performs milling operations with three identical servers. Station 3 performs drilling operations with two identical servers. Station 4 is an inspection station with one server that performs inspections on a sampling of the parts. The stations are connected by a part handling system that has two work carriers, whose mean transport time is 3.5 min. The FMS produces four parts A, B, C, and D. The part mix fractions and process routings for the four parts are shown in the table Q5. Note that the operation frequency at the inspection station  $f_{ijk}$  is less than 1.0 to account the fact that only a fraction of parts are inspected. [Note: Average work load  $WL_i = \sum_j \sum_k t_{ijk} f_{ijk} p_j$ , Average number of transport  $(n_t) = \sum_i \sum_j \sum_k f_{ijk} p_j - 1$ , Workload of handling system  $= n_t t_{n+1}$ , Workload per server  $= \frac{WL_i}{s_i}$ , Utilization at each station  $= U_i = \frac{WL_i}{s_i} \times \text{Maximum production rate}$ , Overall FMS utilization  $= \bar{U}_s = \frac{\sum_{i=1}^n s_i U_i}{\sum_{i=1}^n s_i}$  ]

Table Q5

Part $j$	Part mix $p_j$	Operation $k$	Description	Station $i$	Process time $t_{ijk}$	Frequency $f_{ijk}$
A	0.1	1	Load	1	4	1
		2	Mill	2	20	1
		3	Drill	3	15	1
		4	Inspect	4	12	0.5
		5	Unload	1	2	1
B	0.2	1	Load	1	4	1
		2	Drill	3	16	1
		3	Mill	2	25	1
		4	Drill	3	14	1
		5	Inspect	4	15	0.2
		6	Unload	1	2	1
C	0.3	1	Load	1	4	1
		2	Drill	3	23	1
		3	Inspect	4	8	0.5
		4	Unload	1	2	1
D	0.4	1	Load	1	4	1
		2	Mill	2	30	1
		3	Inspect	4	12	0.333
		4	Unload	1	2	1

Determine :

- i. Maximum production rate [6.0 Marks]
- ii. Corresponding production rate of each part [2.0 Marks]
- iii. Utilization of each station [3.0 Marks]
- iv. The overall FMS utilization [1.0 Mark]

#### Appendix 1

##### G - Codes

G00	Rapid positioning
G01	Linear interpolation
G02	Circular interpolation CW
G03	Circular interpolation CCW
G15	Selection of work coordinate system
G17	Plane selection: XY
G18	Plane selection: ZX
G19	Plane selection: YZ
G28	Machine zero return
G40	Cutter radius compensation cancel
G41	Cutter radius compensation, Left
G42	Cutter radius compensation, Right
G53	Tool length offset cancel
G54	Work coordinate offset 1
G55	Work coordinate offset 2
G56	Work coordinate offset 3
G80	Cancel fixed cycle mode
G81	Fixed cycle, Drill/ spot boring
G83	Fixed cycle, Deep hole drilling
G90	Absolute dimensioning
G91	Incremental dimensioning

##### M - Codes

M03	Spindle rotation, CW
M04	Spindle rotation, CCW
M05	Spindle stop
M06	Tool change
M07	Oil mist coolant ON
M08	Coolant ON
M09	Coolant OFF
M30	End of program