King Saud University
College of Engineering
Industrial Engineering Department

IE 360 - CAD/CAM (CAM part)	Midterm exam 1434-1435 Second semester	Date: 09/07/1435 Time allowed: 1:30 Hrs

Question (1): **Total Mark (5)**

a) Write a part program manually to machine the part shown below. Use canned cycles where appropriate. The part thickness is 1.0 inch. The dimensions are all in inches and the tool start position is at the point (X-3, Y-3). Use the following machining parameters and tools:
   1. Milling profile – The spindle speed is 500 rpm, the feedrate is 5.0 ipm, the tool is named T01 and its diameter is 1.0 inch.
   2. Milling slot – The spindle speed is 500 rpm, the feedrate is 4.0 ipm, the tool is named T02 and its diameter is 0.5 inch.
   3. Drilling – The three holes are drilled to a depth of 1.0 inch using a drill speed of 400 rpm and a feedrate of 4.0 ipm, and the tool is named T03.

- **Answer: (Mark: 3.5)**

%

:1000

N5 G20 G91

1. Milling profile (Mark: 2.0)

N10 T01 M06

N15 S500 M03

N20 G00 X-3.0 Y-3.0 Z1.0

N25 G01 X2.5 Y2.5 Z-3.0 F5 M08

N30 X7.0

N35 G03 X1.5 Y1.5 I0.0 J1.5 (or G03 X1.5 Y1.5 R1.0)

N40 G01 Y2.5

N45 X-1.25

N50 G02 X-0.25 Y0.25 I0.0 J0.25 (or G03 X-0.25 Y0.25 R0.75)

N55 G01 Y2.25

N60 G03 X-1.5 Y1.5 I-1.5 J0.0 (or G03 X-1.5 Y1.5 R1.0)

N65 G01 X-5.5

N70 Y-8.0

N75 G00 Z3.0 M09

N80 X-2.5 Y-2.5

N85 M05

2. Milling slot (Mark: 0.5)

N90 T02 M06

N95 S500 M03

N100 G00 X2.75 Y2.75 M08

N105 G01 X1.75 Y1.75

N110 Z-3.0 F4.0

N115 X2.0

N120 Z3.0

N125 Y2.0

N130 Z-3.0

N135 X-2.0

N140 G00 Z3.0 M09

N145 X-4.5 Y-6.5

3. Drilling (Mark: 1.0)

N150 T03 M06

N155 S400 M03

N160 G00 X2.5 Y2.5 M08

N165 G98 G81 X1.5 Y6.5 Z-3.0 R0.5 F4

N170 X1.5

N175 X1.5

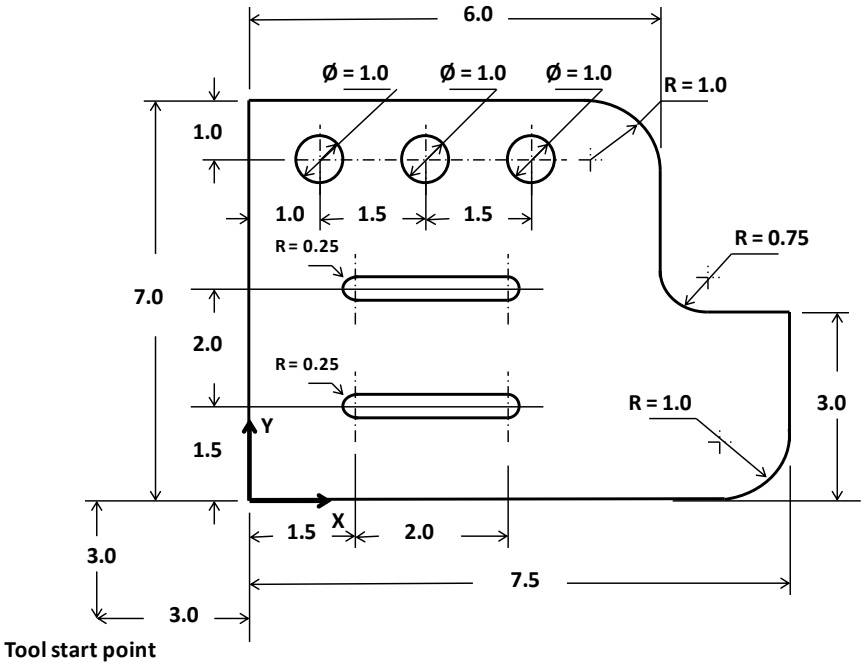
N180 G00 Z3.0 M09

N185 X-7.0 Y-9.0

N190 M05

N195 M30

b) Write an APT program using the *macro facility* to drill the three 1.0-inch diameter holes. Use the tool start position shown, a drill speed of 500 rpm and a feedrate of 3.55 ipm. The machine that performs the drilling is number 5 and its controller is coded as DRILL.



- **Drilling APT program using the macro facility: (Mark: 1.5)**

PARTNO QUESTION2-b-DRILLING

MACHIN/DRILL, 5

CUTTER/1.0

P0 = POINT/-3.0, -3.0, 0.0

SPINDL/500

FEDRAT/3.55

COOLNT/ON

FROM/P0

CALL/DRILL, X = 1.0, Y = 6.0, Z = 1.0, DEPTH = 3.0 (assuming that the *z* axix is at the top surface)

CALL/DRILL, X = 2.5, Y = 6.0, Z = 1.0, DEPTH = 3.0

CALL/DRILL, X = 4.0, Y = 6.0, Z = 1.0, DEPTH = 3.0

GOTO/P0

COOLNT/OFF

END

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FINI
        DRILL = MACRO/X, Y, Z, DEPTH
        GOTO/X, Y, Z
        GODLTA/0, 0, -DEPTH
        GODLTA/0, 0, DEPTH
TARMAC
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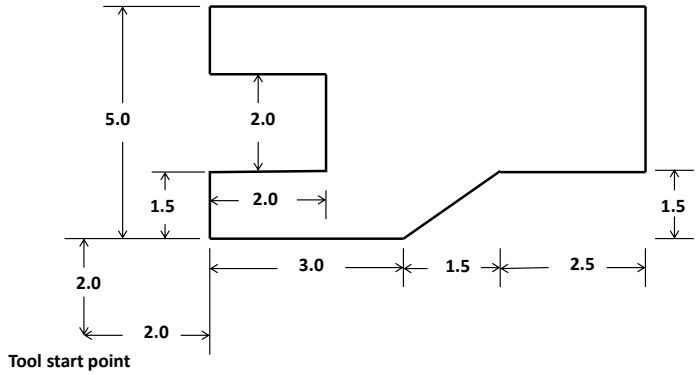
Question (2): **Total Mark (5)**

a) Answer the following questions: **Mark (2.5)**

1. The control loop unit is part of the machine control unit and its role is to read and decode the programme of instructions and provide data to the data processing unit (F).
2. In continuous-path (contouring) machining, the cutting tool performs operations on the workpiece at specific points (F).
3. On a vertical milling CNC machine, the z axis is parallel to the tool axis and a motion in the positive z direction moves the tool towards the workpiece (F).
4. Hierarchical codes are much easier to construct and modify than chain codes (F).
5. Production flow analysis (PFA) is an approach for identifying part families and associated machine groupings based on part design data rather than production route sheets (F).

b) Write an APT program to mill the contour of the part shown in the following figure. Use an end-mill cutter with a diameter of 0.75 inch, a cutting speed of 580 rpm and a feedrate of 2.3 ipm. Milling machine name is MILL5. The part thickness is 1.5 inch.



Milling APT program: Mark (2.5)

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PARTNO QUESTION3-b-MILLING
MACHIN/MILL, 5
CUTTER/0.75
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P0 = POINT/-2.0, -2.0, 0.0
P1 = POINT/0.0, 0.0, 0.0
P2 = POINT/3.0, 0.0, 0.0
P3 = POINT/4.5, 1.5, 0.0
P4 = POINT/7.0, 1.5, 0.0
P5 = POINT/7.0, 5.0, 0.0
P6 = POINT/0.0, 5.0, 0.0
P7 = POINT/0.0, 4.0, 0.0
P8 = POINT/2.0, 4.0, 0.0
P9 = POINT/2.0, 1.5, 0.0
P10 = POINT/0.0, 1.5, 0.0
L1 = LINE/P1, P2
L2 = LINE/P2, P3
L3 = LINE/P3, P4
L4 = LINE/P4, P5
L5 = LINE/P5, P6
L6 = LINE/P6, P7
L7 = LINE/P7, P8
L8 = LINE/P8, P9
L9 = LINE/P9, P10
L10 = LINE/P10, P1
PL1 = PLANE/0.0, 0.0, -2.0, 3.0, 0.0, -2.0, 0.0, 1.5, -2.0
SPINDL/580
FEDRAT/2.30
COOLNT/ON
FROM/P0
GO/TO, L1, TO, PL1, TO, L10
GORGT/L1, PAST, L2
GOLFT/L2, TO, L3
GORGT/L3, PAST, L4
GOLFT/L4, PAST, L5
GOLFT/L5, PAST, L6
GOLFT/L6, PAST, L7
GOLFT/L7, TO, L8
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GORGT/L8, TO, L9
GORGT/L9, PAST, L10
GOLFT/L10, PAST, L1
GOTO/P0
COOLNT/OFF
END
FINI

Question (3): **Total Mark (5)**

a) What is the basic concept of group technology and what are the problems of implementing this concept in manufacturing companies?

- **Basic concept of group technology: Mark (0.5)**
  Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production. It is a management strategy to help eliminate waste caused by duplication of effort.

- **Problems of implementing group technology concept in manufacturing companies: Mark (0.5)**
  1. Identifying the part families
     - Reviewing all of the parts made in the plant and grouping them into part families is a substantial task.
  2. Rearranging production machines into group technology cells
     - It is time-consuming and costly to physically rearrange the machines into cells, and the machines are not producing during the changeover.

b) Apply the rank order clustering technique to the part-machine incidence matrix in the table that follows to identify logical part families and machine groups. Parts are identified by letters, and machines are identified numerically.

Answer: Mark (4)

	Parts								
Machines	A	B	C	D	E	F	G	H	I
1			1	1	1	1			
2	1	1			1				
3			1		1	1	1		
4	1	1		1					
5			1		1				
6								1	1
7	1			1					
8							1	1	1

	Parts									
Machines	A	B	C	D	E	F	G	H	I	
1			1	1	1	1				120
2	1	1			1					400
3			1		1	1	1			92
4	1	1		1						416
5			1		1					80
6								1	1	3
7	1			1						288
8							1	1	1	7
	256	128	64	32	16	8	4	2	1	

	Parts									
Machines	A	B	C	D	E	F	G	H	I	
4	1	1		1						128
2	1	1			1					64
7	1			1						32
1			1	1	1	1				16
3			1		1	1	1			8
5			1		1					4
8							1	1	1	2
6								1	1	1
	242	192	28	176	92	24	10	3	3	

	Parts									
Machines	A	B	D	E	C	F	G	H	I	
4	1	1	1							448
2	1	1		1						416
7	1		1							320
1			1	1	1	1				120
3				1	1	1	1			60
5				1	1					48
8							1	1	1	7
6								1	1	3
	256	128	64	32	16	8	4	2	1	

From the above Table, part families are {A, B, D}, {E, C, F}, and {G, H, I}, and the corresponding machine cells are {4, 2, 7}, {1, 3, 5}, and {8, 6}.

A list of the G and M codes:

➢ **G codes** ▪ G00: Rapid positioning ▪ G01: Linear interpolation ▪ G02: Circular interpolation (clockwise) ▪ G03: Circular interpolation (counterclockwise) ▪ G20: Inch units ▪ G21: Metric units ▪ G70: Profile finishing cycle (turning) ▪ G71: Profile roughing cycle for turning and boring ▪ G74: Peck drilling cycle along the z axis ▪ G81: Drilling cycle ▪ G90: Absolute positioning ▪ G91: Incremental positioning ▪ G98: Return to the initial plane	➢ **M codes** ▪ M30: Program end, reset to start ▪ M03: Spindle rotation normal – clockwise (CW) ▪ M04: Spindle rotation reverse – counterclockwise (CCW) ▪ M05: Spindle rotation stop ▪ M06: Tool change ▪ M08: Coolant on ▪ M09: Coolant off