National Technical Examinations May 2010

98-Ind-B3, Computer Aided Design and Computer-Assisted Manufacturing

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
2. This is a Closed Book exam. Candidates may use a Casio or Sharp approved calculator.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value.
5. Some questions require an answer in essay format. Clarity and organization of the answer are important.

Marking scheme:

	(a)	(b)	(c)	(d)
1.	6	7	7	
2.	10	10		
3.	7	7	6	
4.	6	7	7	
5.	5	5	5	5
6.	6	7	7	
7.	5	5	5	5

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1. Discuss and/or critique each of the following statements in the context of manufacturing:

   (a) "The key to effective manufacturing operations is to focus on bottlenecks."
   (b) "Ignore variance, and you will never gain control of your manufacturing line."
   (c) "To maximize efficiency, every machine must be utilized 100% of the time."

2. A two-week study was performed on a 12-station transfer line that is used to partially machine engine heads for a major automotive company. During 80 hours of observation, the line was down a total of 42 hours, and 1689 parts were completed. The accompanying table lists the machining operations performed at each station, the process times, and the downtime occurrences for the station (assume that all downtimes are of the same duration). Transfer time between stations is 6 seconds. Use appropriate methods to answer the questions below.

(a) Determine the line efficiency and production rate for the existing line configuration.
(b) Develop a new line configuration that will reduce the effect of the downtime, and calculate its effect on the production rate.

Station	**Operation**	**Process time (min)**	**Downtime incidents**
1	Load part (manual)	0.50	0
2	Rough mill top	1.10	15
3	Finish mill top	1.25	18
4	Rough mill sides	0.75	23
5	Finish mill sides	1.05	31
6	Mill surfaces for drill	0.80	9
7	Drill two holes	0.75	22
8	Tap two holes	0.40	47
9	Drill three holes	1.10	30
10	Ream three holes	0.70	21
11	Tap three holes	0.45	30
12	Unload and inspect part (manual)	0.90	0
	Totals:	**9.75**	**246**

3. A DC servo motor drives the x-axis of a NC milling machine table. The motor is coupled directly to the table leadscrew, and has a pitch of 6.25mm. An optical encoder is connected to the leadscrew using a 1:5 gear ratio (one turn of the leadscrew converts to five turns of the encoder disk.) The optical encoder emits 250 pulses per revolution. To execute a certain programmed instruction, the table must move from point (x=25.0mm, y=180.0mm) to point (x=87.5mm, y=35.0mm) in a straight-line trajectory at a feed rate of 200mm/min. Determine:
   (a) The control resolution of the system for the x-axis;
   (b) The rotational speed of the motor;
   (c) The frequency of the pulse train emitted by the optical encoder at the desired feed rate.

4. Discuss the potential influence of the following technologies on the manufacturing process.
   (a) RFID;
   (b) Bar Coding;
   (c) AS/RS.

5. Define and discuss the applicability of each of the following concepts in support of computer aided manufacturing.
   (a) Computer Aided Process Planning.
   (b) Concurrent Engineering.
   (c) Design for Manufacturing.
   (d) Manufacturing Execution Systems.

6. The following table lists the weekly quantities and routings of ten parts that are being considered for cellular manufacturing in a machine shop. Parts are identified by letters, and machines are identified numerically. For the data given:
   (a) Develop the part-machine incidence matrix.
   (b) Use an appropriate technique to identify the logical part families and machine groups.
   (c) Discuss the potential improvements expected from using the part families and machine groups that you developed in (b) above.

Part	**Weekly quantity**	**Machine Routing**
A	50	3 – 1 – 2 – 7
B	20	6 – 1 – 2
C	75	6 – 5
D	10	6 – 5 – 1
E	12	3 – 2 – 7 – 4
F	60	5 – 1 – 2
G	5	3 – 2

7. A flexible manufacturing cell consists of a manual load/unload station, three CNC machines and an automated guided vehicle system (AGVS) with two vehicles. The vehicles deliver parts between the individual machines. The workstations are listed in the table below, with the AGVS listed separately.

Station	Description	Servers
1	Load and unload	AS/RS
2	Milling	1 CNC mill
3	Drilling	1 CNC drill press
4	Grinding	1 CNC grinder
	AGVS	2 vehicles

The FMC is used to machine four parts. The product mix, routings and processing times for the parts are presented in the table below.

Part	Part mix	Routing (station times in parentheses in minutes)
A	25%	1(4) – 2(8) – 3(7) – 4(18) – 1(4)
B	33%	1(4) – 3(10) – 2(9) – 1(4)
C	12%	1(4) – 2(10) – 4(14) – 1(4)
D	30%	1(4) – 2(6) – 4(16) – 3(12) – 1(4)

The mean travel time of the AGV between any two stations is 2 minutes, including the time to transfer loads to and from the stations. Given that the loading on the system is maintained at 10 parts (in the system at all times), use an appropriate method to determine:

(a) The bottleneck station;
(b) The production rate of the system;
(c) The average time to complete a unit of production.
(d) Discuss the issues in choosing to use one, two or three AGV's in the FMC, and describe a method to choose the appropriate number of AGV's.