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Program: B. Sc. Engg (IPE)
Semester: 8th Semester

Date: 17 May, 2024
Time: 10:00 AM – 01:00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: IPE 4813
Course Title: Computer Integrated Manufacturing

Summer Semester: 2022-2023
Full Marks: 150
Time: 3 Hours

There are **6 (SIX)** questions. Answer **6 (SIX)** questions. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in brackets. Show all steps and calculations.

1. a) An FMS consists of four stations. Station 1 is a load/unload station with one server. Station 2 consists of three identical CNC milling machines. Station 3 consists of two identical CNC drill presses. 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 and whose mean transport time is 2.0 min. The FMS produces four parts, A, B, C, and D. The part-mix fractions and process routings for the four parts are presented in Table 1 below. Note that the operation frequency at the inspection station (f_{ijk}) is less than 1.0 to account for the fact that only a fraction of the parts are inspected. Solve for: (i) maximum production rate of the FMS, (ii) corresponding production rate of each part, (iii) utilization of each station in the system, and (iv) average utilization of the regular stations (excluding the part-handling system). (15) (CO 3) (PO 2) (K4,P1,P3)

Table 1: Part-mix fractions and process routings for the four parts

Part j	Part Mix p_j	Operation k	Description	Station i	Process Time t_{ijk}	Frequency f_{ijk}
A	0.1	1	Load	1	3.5 min	1.0
		2	Mill	2	20 min	1.0
		3	Drill	3	15 min	1.0
		4	Inspect	4	12 min	0.5
		5	Unload	1	1.5 min	1.0
B	0.2	1	Load	1	4 min	1.0
		2	Drill	3	16 min	1.0
		3	Mill	2	25 min	1.0
		4	Drill	3	14 min	1.0
		5	Inspect	4	15 min	0.2
		6	Unload	1	2 min	1.0
C	0.3	1	Load	1	3 min	1.0
		2	Drill	3	23 min	1.0
		3	Inspect	4	8 min	0.5
		4	Unload	1	1.5 min	1.0
D	0.4	1	Load	1	3 min	1.0
		2	Mill	2	30 min	1.0
		3	Inspect	4	12 min	0.333
		4	Unload	1	1.5 min	1.0

b) Figure 1 presents an FMS system for a sheet metal fabrication process. Analyse FOUR (4) elements in the systems that classifies it as a FMS system. (10) (CO 3) (PO 2) (K4,P1,P3)

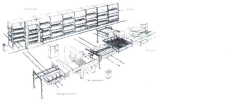

Figure 1: An FMS system for a sheet metal fabrication process

2. a) Identify part families and corresponding machine grouping for the following part machine incidence matrix using rank order clustering techniques are presented in Table 2. Comment on the obtained results and discuss pros and cons of this grouping method (10) (CO 3) (PO 2) (K4,P1,P3)

Table 2: Part-machine incidence matrix

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

b) A GT cell has four machines: 1, 2, 3, and 4. An analysis of 50 parts processed on these machines has been summarized in the from-to chart in Table 3. (5) (CO 3) (PO 2) (K4,P1,P3)

i. Determine the most logical machine sequence using the "Hollier method".

Table 3: From-To chart

	To			
From	1	2	3	4
1	0	5	0	25
2	30	0	0	15
3	10	40	0	0
4	10	0	0	0

ii. Additional information from 2b(i): 50 parts enter the machine grouping at machine 3, 20 parts leave after processing at machine 1, and 30 parts leave machine 4 after processing. Compute: (a) the percentage of in-sequence moves, (b) the percentage of by-passing moves, and (c) the percentage of backtracking moves for solution 2b(i). (10)

3. a) Suppose you own a general-purpose machine shop with machines integrated with CAD/CAM/CAPP system. What kind of CAPP system is suitable for your machine shop? Explain the required features of the CAPP system. (15) (CO 3) (PO 2) (K4,P1,P3)

b) The annual demand for a certain item made-to-stock = 15,000 pc/yr. One unit of the item costs \$20.00, and the holding cost rate = 18%/yr. Setup time to produce a batch = 5 hr. The cost of equipment downtime plus labor = \$150/hr. Determine the economic batch quantity and the total inventory cost for this case. (10) (CO 3) (PO 2) (K4,P1,P3)

4. a) Figure 2 shows an example of a part delivery system for an assembly process. The part delivery system is to be designed for effective part delivery and assembly process. Suggest and analyse an element that must be incorporated in the delivery system to ensure a complete and effective part delivery process. (10) (CO 4) (PO 2) (K4,P1,P3)

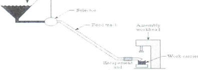

Figure 2: A part delivery system for an assembly process

b) Figure 3 illustrates an automatic stacking program that requires both a timer and a counter. In this process, conveyor M1 is used to stack metal plates onto conveyor M2. The photoelectric sensor provides an input pulse to the PLC counter each time a metal plate drops from conveyor M1 to M2. When 15 plates have been stacked, conveyor M2 is activated for 5s by the PLC timer. The operation of the program can be summarized as follows: (15) (CO 4) (PO 2) (K4,P1,P3)

- When the start button is pressed, conveyor M1 begins running.
- After 15 plates have been stacked, conveyor M1 stops and conveyor M2 begins running.
- After conveyor M2 has been operated for 5s, it stops and the sequence is repeated automatically.
- The activation of the timer resets the counter and provides a momentary pulse to automatically restart conveyor M1.

Construct the ladder logic diagram for the system.

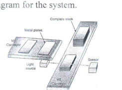

Figure 3: Automatic stacking process

5. An automated assembly line is to be designed and setup for a new manufacturing facility in Gazipur Manufacturing Industrial Zone. (CO 4) (PO 2) (K4,P1,P3)

   i. Discuss the characteristics of the manufacturing operations that would grant the needs of automatic assembly systems. (10)

   ii. Discuss several potential automatics assembly system configurations (with sketches) that can be applied in this manufacturing operation facilities. (15)

6. a) Consider the fluid storage tank illustrated in Figure 4. When the start button X1 is depressed, this closes the control relay C1, which energizes solenoid S1, which opens a valve allowing fluid to flow into the tank. When the tank becomes full, the float switch FS closes, which opens relay C1, causing the solenoid S1 to be deenergized, thus turning off the in-flow. Switch FS also activates timer T1, which provides a 120-second delay for a certain chemical reaction to occur in the tank. At the end of the delay time, the timer energizes a second relay C2, which controls two devices: (1) It initiates timer T2, which waits 90 sec to allow the contents of the tank to be drained, and (2) it energizes solenoid S2, which opens a valve to allow the fluid to flow out of the tank. At the end of the 90 sec, the timer breaks the current and deenergizes solenoid S2, thus closing the outflow valve. Depressing the start button X1 resets the timers and opens their respective contacts. Construct the ladder logic diagram for the system. (10) (CO 4) (PO 2) (K4,P1,P3)

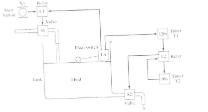

Figure 4: Fluid filling operation

   b) Construct the ladder logic diagram for die stamping process as shown in Figure 5. Two sensors are used, an upper limit switch, LS2 that indicates when the piston is fully retracted and a lower limit switch, LS1 that indicates when the piston is fully extended. A master switch, M1 is used to start the process and shut it down. When the master switch is turned on, the piston reciprocates between the extended and retracted positions. This is achieved with an up-and-down solenoid, S1 and S2. When the master switch is turned off, the piston returns to the retracted position, and all solenoids are off. (15) (CO 4) (PO 2) (K4,P1,P3)

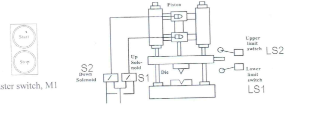

Figure 5: Die stamping process

FORMULA SHEET

$$EOQ = \sqrt{\frac{2D_a C_{su}}{C_h}}$$

$$TIC = \frac{C_h Q}{2} + \frac{C_{su} D_a}{Q}$$

$$TC = D_a C_{pc} + \frac{C_h Q}{2} + \frac{C_{su} D_a}{Q}$$

$$WL_i = \sum_j \sum_k t_{ijk} f_{ijk} P_j$$

$$n_i = \sum_i \sum_j \sum_k f_{ijk} P_j - 1$$

$$R_p^* = \frac{s^*}{WL^*}$$

$$U_i = \frac{WL_i}{s_i}(R_p^*) = \frac{WL_i}{s_i}\frac{s^*}{WL^*}$$

$$BS_i = WL_i(R_p^*) = WL_i \frac{s^*}{WL^*}$$