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Program: B. Sc. in Industrial and Production Engineering
Semester: 7th Semester

Date: 15 December, 2023
Time: 1:30 pm – 4:30 pm

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

Semester Final Examination
Course Number: IPE 4715
Course Title: Material Handling and Maintenance Management

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

There are **6 (SIX)** questions. Answer **all** of them. The symbols have their usual meanings. Marks of each question and the corresponding CO and PO are written in brackets. A formula sheet is provided at the end of this question paper. Show all steps and calculations.

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1. a) Distinguish between storage and warehouse. How do these terms differ in terms of their functions in material handling and maintenance management. 7.5 (CO1) (PO1)

   b) Discuss three objectives of packaging and provides examples to illustrate how packaging can contribute to achieving these objectives. 7.5 (CO1) (PO1)

   c) Describe an importance of packaging testing in ensuring product quality. States five example of specific tests commonly conducted on packaging materials to maintain of the packaged product. 10 (CO1) (PO1)

2. a) Each aisle of a four-aisle AS/RS contains 60 storage compartments in the length direction and 12 compartments vertically. All storage compartments are the same size to accommodate standard-size pallets of dimensions: $x = 42$ in and $y = 48$ in. The height of a unit load $z = 36$ in. Using the allowances, $a = 6$ in, $b = 8$ in, and $c = 10$ in, determine (a) how many unit loads can be stored in the AS/RS and (b) the width, length, and height of the AS/RS. 10 (CO2) (PO2)

   b) Consider the AS/RS from Question 2(a), in which an S/R machine is used for each aisle. The length of the storage aisle = 280 ft and its height = 46 ft. Suppose horizontal and vertical speeds of the S/R machine are 200 ft/min and 75 ft/min, respectively. The S/R machine requires 20 sec to accomplish a P&D operation. Determine (a) the single-command and dual-command cycle times per aisle and (b) throughput per aisle under the assumptions that storage system utilization = 90% and the number of single-command and dual-command cycles are equal. 15 (CO2) (PO2)

3. a) An automated guided vehicle system is being planned for a warehouse complex. The AGVS will be a driverless train system, and each train will consist of the towing vehicle plus four carts. The speed of the trains will be 180 ft/min. Only the pulled carts carry loads. The average loaded travel distance per delivery cycle is 1500 ft and the empty travel distance is the same. Anticipated travel factor = 0.95. Assume reliability = 1.0. The load handling time per train per delivery is expected to be 15 min. If the requirements on the AGVS are 35 cart loads per hour, determine the number of trains required. 7 (CO2) (PO3)

b) Major appliances are assembled on a production line at the rate of 50/hour. The products are moved along the line on work pallets (one product per pallet). At the final workstation, the finished products are removed from the pallets. The pallets are then removed from the line and delivered back to the front of the line for reuse. Automated guided vehicles are used to transport the pallets to the front of the line, a distance of 750 ft. Return trip distance (empty) to the end of the line is also 750 ft. Each AGV carries four pallets and travels at a speed of 250 ft/min (either loaded or empty). The pallets form queues at each end of the line so that neither the production line nor the AGVs are ever starved for pallets. Time required to load each pallet onto an AGV = 15 sec; time to release a loaded AGV and move an empty AGV into position for loading at the end of the line = 15 sec. The same times apply for pallet handling and release/positioning at the unload station located at the front of the production line. Assume availability = 100% and the traffic factor is 1.0 since the route is a simple loop. How many vehicles are needed to operate the AGV system? 8 (CO2) (PO3)

c) The from-to-chart below indicates the number of loads moved per 8-hour day (above the slash) and the distances in ft (below the slash) between departments in a particular factory. Forklift trucks are used to transport the materials. They move at an average speed = 275 ft/min (loaded) and 350 ft/min (empty). Load handling time (loading plus unloading) per delivery is 1.5 min and the anticipated traffic factor = 0.9. Availability = 95%, and worker efficiency = 110%. Determine the number of trucks required under each of the following assumptions: (a) the trucks never travel empty, and (b) the trucks travel empty at a distance equal to their loaded distance. 10 (CO2) (PO3)

	To Dept.	A	B	C	D	E
From Dept.	A	0/0	62/500	51/450	45/350	-
	B	-	0/0	-	22/400	-
	C	-	-	0/0	-	76/200
	D	-	-	-	0/0	65/150
	E	-	-	-	-	0/0

4. a) A recirculating conveyor has a total length of 450 m and a speed of 150 m/min. Spacing of part carriers = 8 m. Each carrier holds two parts. The time needed to load a part carrier = 0.35 min. Unloading time is the same. The required loading and unloading rates are 7 parts per min. Evaluate the conveyor system design with respect to the three Kwo principles. 7 (CO2) (PO3)

b) An overhead trolley conveyor is configured as a closed loop. The delivery loop has a length of 150 m and the return loop is 70 m. All parts loaded at the load station are unloaded at the unload station. Each hook on the conveyor can hold one part and the hooks are separated by 2 m. Conveyor speed = 0.65 m/sec. Determine (a) the number of parts in the conveyor system under normal operations, (b) the parts flow rate; and (c) the maximum loading and unloading times that are compatible with the operation of the conveyor system. 8 (CO2) (PO3)

c) A roller conveyor moves tote pans in one direction at 255 ft/min between a load station and an unload station, a distance of 300 ft. With one worker, the time to load parts into a tote pan at the load station is 3.5 sec per part. Each tote pan holds 15 parts. In addition, it takes 15 sec to load a tote pan of parts onto the conveyor. Determine (a) the spacing between tote pan centers flowing in the conveyor system and (b) the flow rate of parts on the conveyor system. (c) Consider the effect of the Unit Load Principle. Suppose the tote pans were smaller and could hold only one part instead of 10. Determine the flow rate of parts in this case if it takes 7 sec to load a tote pan onto the conveyor (instead of 15 sec for the larger tote pan), and it takes the same 3 sec to load the part into the tote pan. 10 (CO2) (PO3)

5. a) Explain how the integration of Automated Guided Vehicles (AGVs) in material handling processes contributes to enhancing efficiency. Provides examples of industries that have successfully implemented AGVs. 9 (CO3) (PO3)

b) Some production plants and storage facilities use manual method for storing and retrieving materials. Discuss how AS/RS automates the storage and retrieval processes, reducing the reliance on manual labor. Provide examples of specific tasks within the storage and retrieval process that AS/RS systems can perform without human intervention. 9 (CO3) (PO3)

c) Discuss the challenges linked with material handling of bulk loads in warehouse. Explore specific technologies and strategies employed to efficiently handle, store, and transport the bulk loads. 7 (CO3) (PO3)

6. a) Consider a manufacturing plant with a diverse range of machinery. One of the critical machines has been experiencing recurrent breakdowns, affecting overall production efficiency. Analyse a comprehensive maintenance strategy that incorporates predictive, preventive, and corrective maintenance techniques. The factors to be considered in prioritizing maintenance tasks and allocating resources effectively. Discuss how data analytics and condition monitoring can be leveraged to enhance the reliability of the equipment and minimize downtime. Provide examples to support your recommendations. 15 (CO4) (PO3)

   b) Imagine a manufacturing facility that produces highly customized engineering components. Discuss how the principles of Just-In-Time (JIT) manufacturing and the role of Kanban system can be adapted to meet the challenges of customization in engineering production. Support your answer with appropriate examples. 10 (CO4) (PO3)

FORMULA SHEET

$$WL = R_f T_c$$

$$AT = 60AF_t E_w$$

$$n_c = \frac{WL}{AT} = \frac{R_f}{R_{dv}}$$

$$T_c = T_L + \frac{L_d}{v_c} + T_U + \frac{L_e}{v_c}$$

$$R_f = R_L = \frac{v_c}{s_c} \le \frac{1}{T_L}$$

$$n_c = \frac{L_d + L_e}{s_c};\ N_p = \frac{n_p L_d}{s_c} = \frac{n_p n_c L_d}{L_d + L_e};\ R_f = \frac{n_p v_c}{s_c} \le \frac{n_p}{T_L};\ s_c = v_c T_L$$

$$\frac{n_p v_c}{s_c} \ge Max\{R_L, R_u\};\ \frac{v_c}{s_c} \le Min\left\{\frac{1}{T_L}, \frac{1}{T_U}\right\};\ \frac{n_p v_c}{s_c} \ge R_f$$

$$W = 3(x+a), L = n_y(y+b), H = n_z(z+c)$$

$$T_{cs} = 2Max\left\{\frac{0.5L}{v_y}, \frac{0.5H}{v_z}\right\} + 2T_{pd} = Max\left\{\frac{L}{v_y}, \frac{H}{v_z}\right\} + 2T_{pd}$$

$$T_{cd} = 2Max\left\{\frac{0.75L}{v_y}, \frac{0.75H}{v_z}\right\} + 4T_{pd} = Max\left\{\frac{1.5L}{v_y}, \frac{1.5H}{v_z}\right\} + 4T_{pd}$$

$$R_{cs}T_{cs} + R_{cd}T_{cd} = 60U$$

$$R_c = R_{cs} + R_{cd}$$

$$R_t = R_{cs} + 2R_{cd}$$