

production management مدیریت عملیات

Operations Management

Layout Strategy

Jamshid Nazemi- production & operation management 6 1

production management مدیریت عملیات

Learning Objectives

Identify or Define:

- Fixed-position layout
- Process-oriented layout
- Work cells
- Focused work center
- Office layout
- Retail layout
- Warehouse layout
- Product-oriented layout
- Assembly-line factory

Jamshid Nazemi- production & operation management 6 2

production management مدیریت عملیات

McDonald's New Kitchen Layout

- Fifth major innovation - kitchen design
 - No food prepared ahead except patty
 - Elimination of some steps, shortening of others
 - New bun toasting machine (11 seconds vs 30 seconds)
 - Repositioning condiment containers (one motion, not two)
 - Sandwiches assembled in order
 - Production levels controlled by computer
 - Discard only meat when sandwiches do not sell fast enough
 - Savings of \$100,000,000 per year in food costs

Jamshid Nazemi- production & operation management 6 3

production management مدیریت عملیات

McDonald's New Kitchen Layout

- No food prepared ahead except patty
- Elimination of some steps, shortening of others
- New bun toasting machine (11 seconds vs 30 seconds)
- Repositioning condiment containers (one motion, not two)

Jamshid Nazemi- production & operation management 6 4

production management مدیریت عملیات

Innovation at McDonald's

- Indoor seating (1950's)
- Drive-through window (1970s)
- Adding breakfast to the menu (1980s)
- Adding play areas (1990s)

(three out of the four are layout decisions)

Jamshid Nazemi- production & operation management 6 5

production management مدیریت عملیات

Objectives of the Layout Strategy

- Develop an economical layout which will meet the requirements of:
 - product design and volume (product strategy)
 - process equipment and capacity (process strategy)
 - quality of work life (human resource strategy)
 - building and site constraints (location strategy)

Jamshid Nazemi- production & operation management 6 6

production management مدیریت عملیات

Types of Layouts

- Fixed-position layout
- Process-oriented layout
- Office layout
- Retail layout
- Warehouse layout
- Product-oriented layout

Jamshid Nazemi- production & operation management 6 7

production management مدیریت عملیات

What is Facility Layout

- Location or arrangement of everything within & around buildings
- Objectives are to maximize
 - Customer satisfaction
 - Utilization of space, equipment, & people
 - Efficient flow of information, material, & people
 - Employee morale & safety

Jamshid Nazemi- production & operation management 6 8

production management مدیریت عملیات

Strategic Importance of Layout

Proper layout enables:

- Higher utilization of space, equipment, and people
- Improved flow of information, materials, or people
- Improved employee morale and safer working conditions
- Improved customer/client interaction
- Flexibility

Jamshid Nazemi- production & operation management 6 9

production management مدیریت عملیات

Six Layout Strategies

- **Fixed-position layout**
 - large bulky projects such as ships and buildings
- **Process-oriented layout**
 - deals with low-volume, high-variety production ("job shop", intermittent production)
- **Office layout**
 - positions workers, their equipment, and spaces/offices to provide for movement of information

Jamshid Nazemi- production & operation management 6 10

production management مدیریت عملیات

Six Layout Strategies continued

- **Retail/service layout**
 - allocates shelf space and responds to customer behavior
- **Warehouse layout**
 - addresses trade-offs between space and material handling
- **Product-oriented layout**
 - seeks the best personnel and machine use in repetitive or continuous production

Jamshid Nazemi- production & operation management 6 11

production management مدیریت عملیات

Layout Strategies

Project (fixed-position)	Job Shop (Process-oriented)	Office	Retail	Warehouse (storage)	Repetitive /Continuous (product-oriented)
Examples					
Ingal Ship Building Corp.	Shouldice Hospital	Allstate Insurance	Kroger's Supermarket	Federal-Mogul's Warehouse	Sony's TV Assembly Line
Trump Plaza	Olive Garden	Microsoft	Walgreens	The Gap's distribution center	Dodge Caravans
Pittsburgh Airport			Bloomingdales		Minivans
Problem					
Move material to the limited storage areas around the site	Manage varied material flow for each product	Locate workers requiring frequent contact close to each other	Expose customer to high-margin items	Balance low-cost storage with low-cost material handling	Equalize the task time at each workstation

Jamshid Nazemi- production & operation management 6 12

production management مدیریت عملیات

Layout Example Office

Jamshid Nazemi- production & operation management 6 13

production management مدیریت عملیات

Requirements of a Good Layout

- an understanding of capacity and space requirements
- selection of appropriate material handling equipment
- decisions regarding environment
- identification and understanding of the requirements for information flow
- identification of the cost of moving between the various work areas

Jamshid Nazemi- production & operation management 6 14

production management مدیریت عملیات

Constraints on Layout Objectives

- Product design & volume
- Process equipment & capacity
- Quality of work life
- Building and site

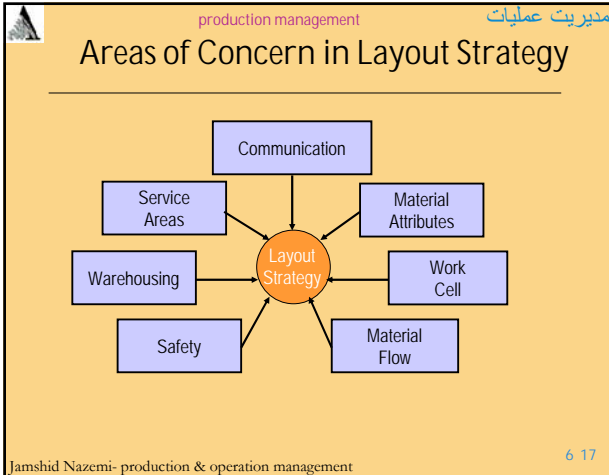
Jamshid Nazemi- production & operation management 6 15

production management مدیریت عملیات

Layout Strategies, Examples, and Criteria

Layout strategy	Example	Criteria
Service/retail	Drug store Grocery store Department store	Expose customer to high margin items
Storage	Distributor Warehouse	Minimize storage and handling costs
Product oriented	TV assembly line	Minimize line imbalance, delay, and idle time

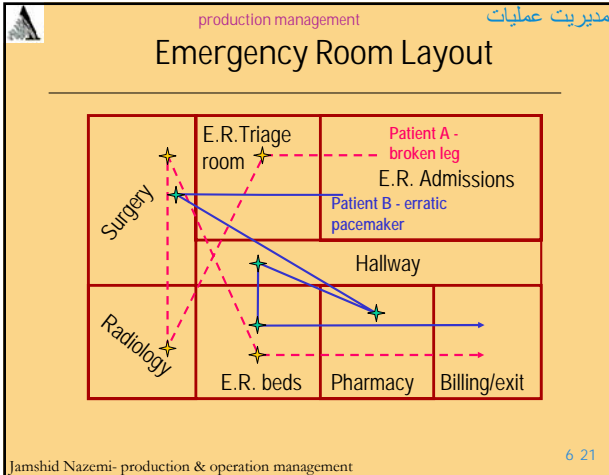
Jamshid Nazemi- production & operation management 6 16



- production management مدیریت عملیات
- ### Fixed Position Layout
- Design is for stationary project
 - Workers and equipment come to site
 - Complicating factors
 - Limited space at site
 - Changing material needs
- Jamshid Nazemi- production & operation management 6 18

- production management مدیریت عملیات
- ### Factors Complicating a Fixed Position Layout
- There is limited space at virtually all sites
 - At different stages in the construction process, different materials are needed
 - therefore, different items become critical as the project develops
 - The volume of materials needed is dynamic
- Jamshid Nazemi- production & operation management 6 19

- production management مدیریت عملیات
- ### Process Oriented Layout
- Design places departments with large flows of material or people together
 - Department areas having similar processes located in close proximity
 - e.g., All x-ray machines in same area
 - Used with process-focused processes
- Jamshid Nazemi- production & operation management 6 20



- production management مدیریت عملیات
- ### Steps in Developing a Process Oriented Layout
- 1 Construct a "from-to matrix"
 - 2 Determine space requirements for each department
 - 3 Develop an initial schematic diagram
 - 4 Determine the cost of this layout
 - 5 By trial-and-error (or more sophisticated means), try to improve the initial layout
 - 6 Prepare a detailed plan that evaluates factors in addition to transportation cost
- Jamshid Nazemi- production & operation management 6 22

production management مدیریت عملیات

Cost of Process Oriented Layout

$$\text{Minimize cost} = \sum_{i=1}^n \sum_{j=1}^n X_{ij} C_{ij}$$

where n = total number of work centers or departments
 i, j = individual departments
 X_{ij} = number of loads moved from department i to department j
 C_{ij} = cost to move a load between department i and department j

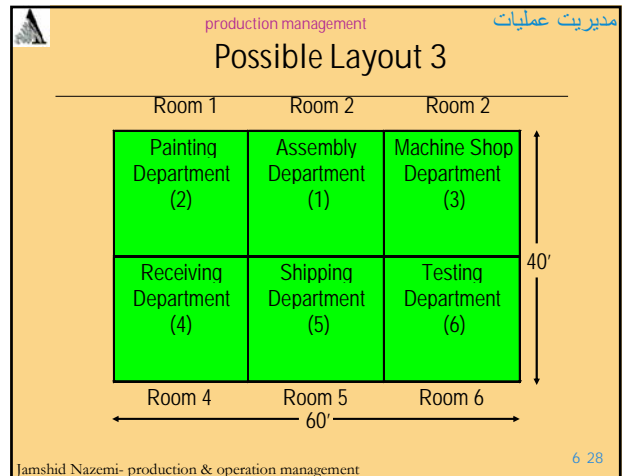
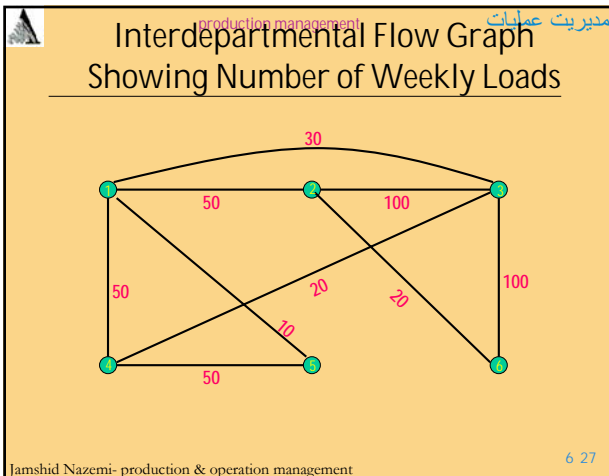
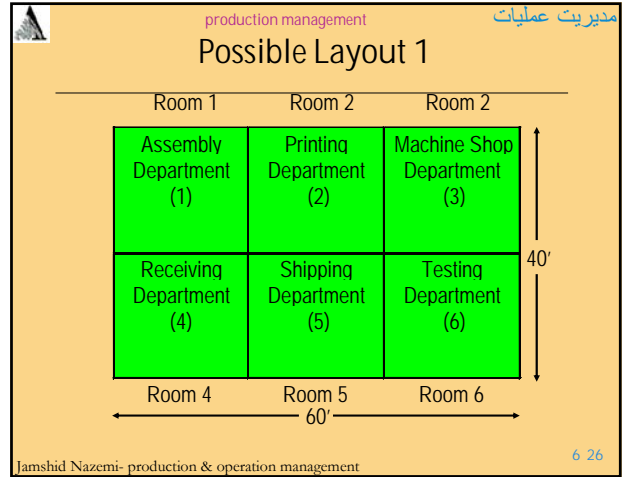
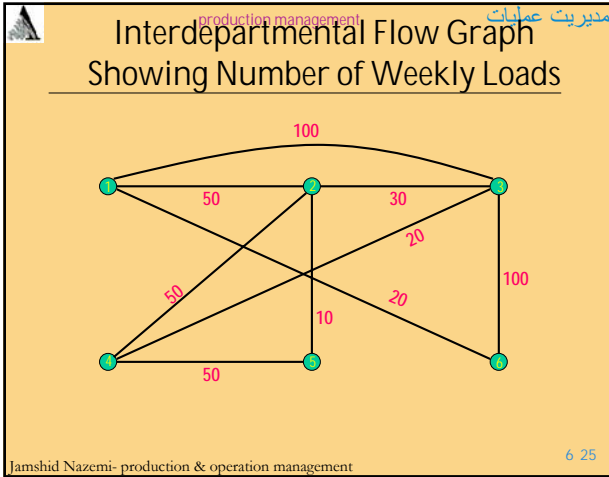
Jamshid Nazemi- production & operation management 6 23

production management مدیریت عملیات

Interdepartmental Flow of Parts

	1	2	3	4	5	6
1		50	100	0	0	20
2			30	50	10	0
3				20	0	100
4					50	0
5						0
6						

Jamshid Nazemi- production & operation management 6 24



production management مدیریت عملیات

Computer Programs to Assist in Layout

- CRAFT
- SPACECRAFT
- CRAFT 3-D
- MULTIPLE
- CORELAP
- ALDEP
- COFAD
- FADES - expert system

Jamshid Nazemi- production & operation management 6 29

production management مدیریت عملیات

Out Patient Hospital Example

CRAFT

Legend:

- A = xray/MRI rooms
- B = laboratories
- C = admissions
- D = exam rooms
- E = operating rooms
- F = recovery rooms

	1	2	3	4	5	6
1	A	A	A	A	B	B
2	A	A	A	A	B	B
3	D	D	D	D	D	D
4	C	C	D	D	D	D
5	F	F	F	F	F	D
6	E	E	E	E	E	D

Total cost: 20,100
Est. Cost Reduction .00
Iteration 0

	1	2	3	4	5	6
1	D	D	D	D	B	B
2	D	D	D	D	B	B
3	D	D	D	E	E	E
4	C	C	D	E	E	F
5	A	A	A	A	A	F
6	A	A	A	F	F	F

Total cost: 14,390
Est. Cost Reduction 70.
Iteration 3

Jamshid Nazemi- production & operation management 6 30

production management مدیریت عملیات

Cellular Layout Work Cells

- Special case of product-oriented layout - in what is ordinarily a process-oriented facility
- Consists of *different* machines brought together to make a product
- Temporary arrangement only
- Example: Assembly line set up to produce 3000 identical parts in a job shop

Jamshid Nazemi- production & operation management 6 31

production management مدیریت عملیات

Improving Layouts by Moving to the Work Cell Concept

Note in both (a) and (b) that U-shaped work cells can reduce material and employee movement. The U shape may also reduce space requirements, enhance communication, cut the number of workers, and make inspection easier.

(a)

Current layout—workers in small closed areas. Cannot increase output without a third worker.

Improved layout—workers can assist each other. May be able to add a third worker.

(b)

Current layout—straight lines make it hard to balance tasks because workers may not be able to divide tasks evenly.

Improved layout—in U shape, workers have better access. Four workers were reduced to three.

Jamshid Nazemi- production & operation management 6 32

production management مدیریت عملیات

Work Cells Some Advantages

- Reduced work-in-process inventory
- Less floor space required
- Reduced raw material and finished goods inventories required
- Reduced direct labor costs
- Heightened sense of employee participation
- Increased utilization of equipment machinery
- Reduced investment in machinery and equipment

Jamshid Nazemi- production & operation management 6 33

production management مدیریت عملیات

Work Cell Advantages

Jamshid Nazemi- production & operation management 6 34

production management مدیریت عملیات

Work Cell Floor Plan

Jamshid Nazemi- production & operation management 6 35

production management مدیریت عملیات

Requirements for Cellular Production

- Identification of families of products - group technology codes
- High level of training and flexibility on the part of the employees
- Either staff support or flexible, imaginative employees to establish the work cells initially
- Test (poka-yoke) at each station in the cell

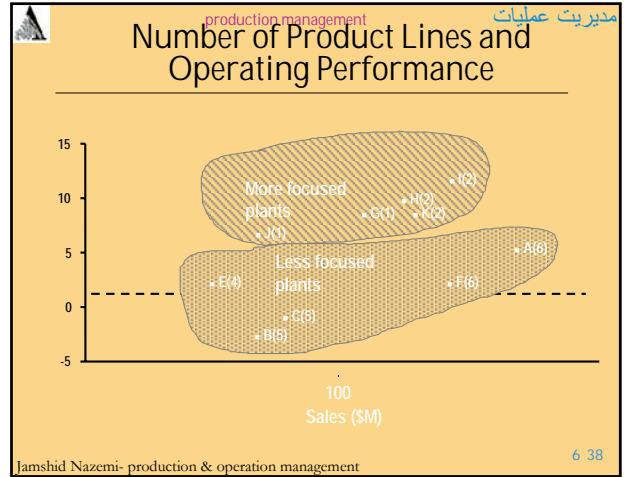
Jamshid Nazemi- production & operation management 6 36

production management مدیریت عملیات

Work Cells, Focused Work Centers and the Focused Factory

Work Cell	A temporary assembly-line-oriented arrangement of machines and personnel in what is ordinarily a process-oriented facility Example: job shop with rearranged machinery and personnel to produce 30 unique control panels
Focused Work Center	A permanent assembly-line-oriented arrangement of machines and personnel in what is ordinarily a process-oriented facility Example: manufacturing of pipe brackets at a shipyard
Focused Factory	A permanent facility to produce a product or component in a product-oriented facility Example: a plant to produce window mechanisms for automobiles

Jamshid Nazemi- production & operation management 6 37

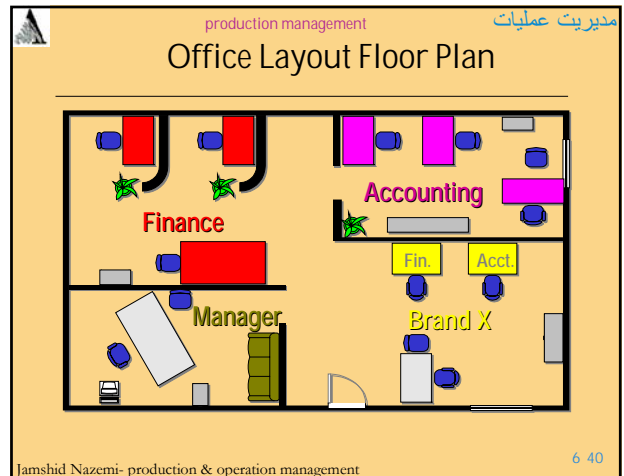


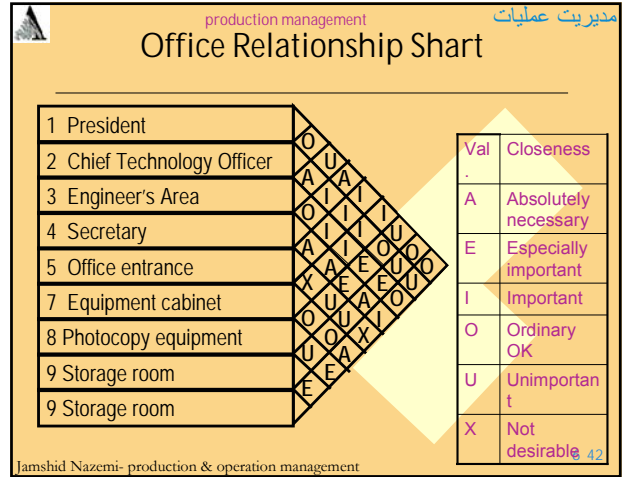
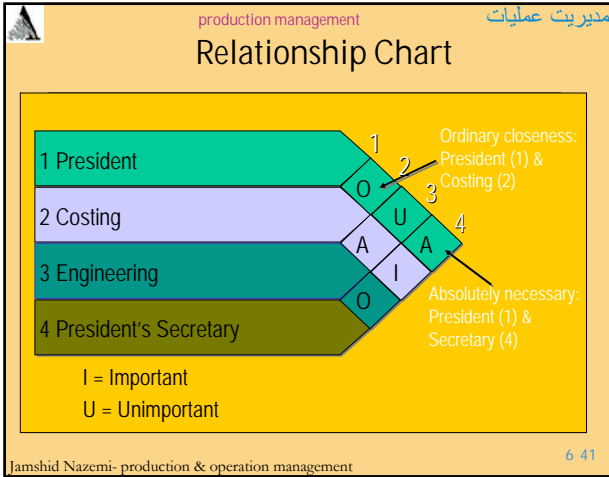
production management مدیریت عملیات

Office Layout

- Design positions people, equipment, & offices for maximum information flow
- Arranged by process or product
 - Example: Payroll dept. is by process
- Relationship chart used
- Examples
 - Insurance company
 - Software company

Jamshid Nazemi- production & operation management 6 39





production management مدیریت عملیات

Retail/Service Layout

- Design maximizes product exposure to customers
- Decision variables
 - Store flow pattern
 - Allocation of (shelf) space to products
- Types
 - Grid design
 - Free-flow design

Jamshid Nazemi- production & operation management 6 43

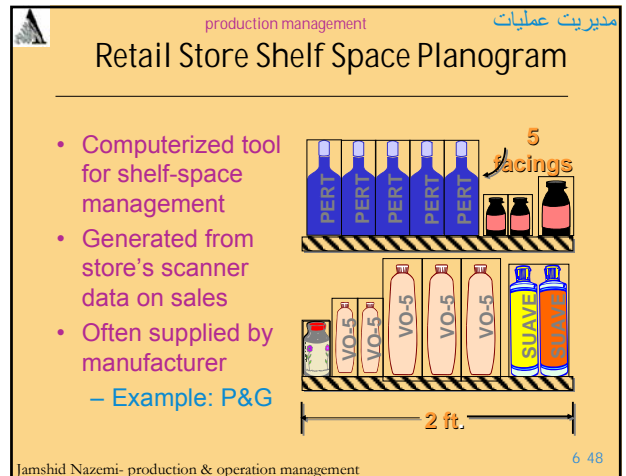
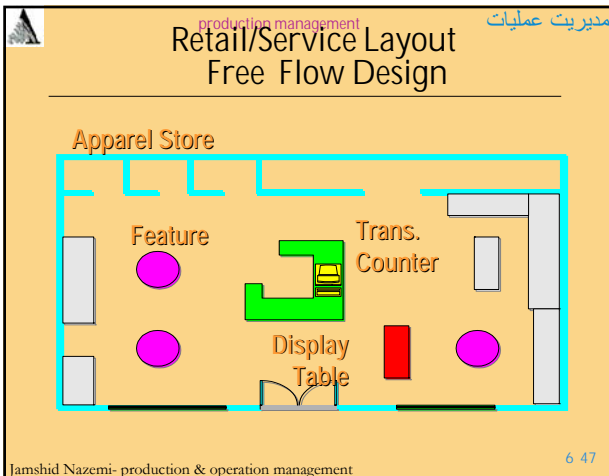
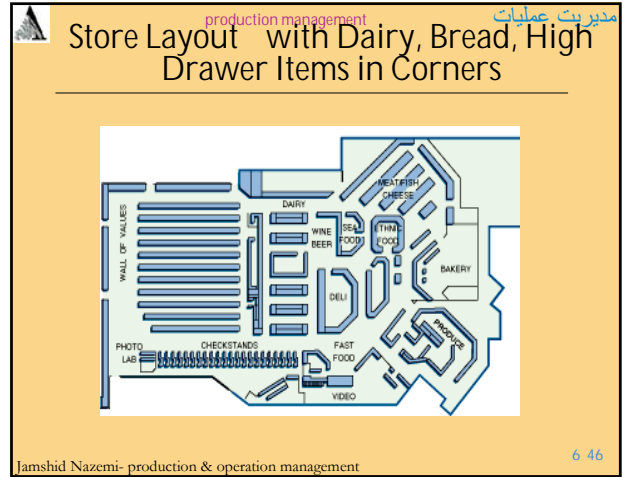
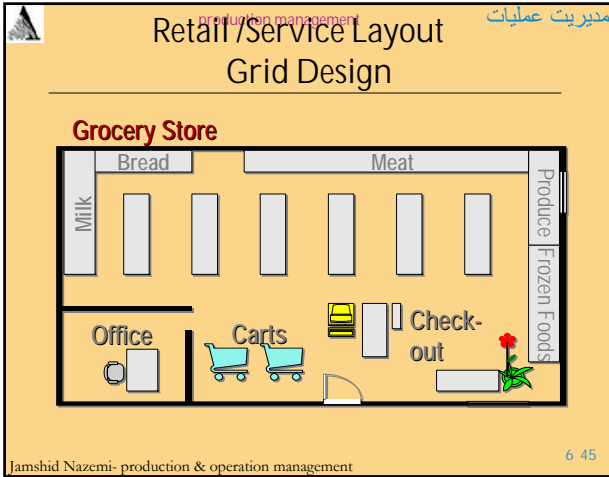
production management مدیریت عملیات

Retail Layouts

Some Rules of Thumb

- Locate high-draw items around the periphery of the store
- Use prominent locations such as the first or last aisle for high-impulse and high margin items
- Remove crossover aisles that allow customers the opportunity to move between aisles
- Distribute what are known in the trade as "power items" (items that may dominate a shopping trip) to both sides of an aisle, and disperse them to increase the viewing of other items
- Use end aisle locations because they have a very high exposure rate

Jamshid Nazemi- production & operation management 6 44



production management مدیریت عملیات

A Good Service Layout (Servicescape) Considers


- **Ambient conditions** - background characteristics such as lighting, sound, smell, and temperature.
- **Spatial layout and functionality** - which involve customer circulation path planning
- **Signs, Symbols, and Artifacts** - characteristics of building design that carry social significance

Jamshid Nazemi- production & operation management 6 49

production management مدیریت عملیات

Warehouse Layout

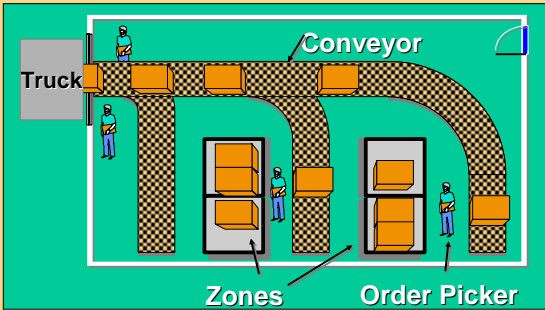
- Design balances space (cube) utilization & handling cost
- Similar to process layout
 - Items moved between dock & various storage areas
- Optimum layout depends on
 - Variety of items stored
 - Number of items picked



Jamshid Nazemi- production & operation management 6 50

production management مدیریت عملیات

Warehouse Layout Floor Plan




The diagram illustrates a warehouse floor plan with a central conveyor system. On the left, a truck dock is labeled 'Truck'. The conveyor system is labeled 'Conveyor'. Below the conveyor, there are two storage areas labeled 'Zones'. An 'Order Picker' is shown in the center, moving between the zones. The floor plan is color-coded with green for the main area and brown for the conveyor and zones.

Jamshid Nazemi- production & operation management 6 51

production management مدیریت عملیات

Cross Docking

- Transferring goods
 - from *incoming* trucks at receiving docks
 - to *outgoing* trucks at shipping docks
- Avoids placing goods into storage
- Requires suppliers provide effective addressing (bar codes) and packaging that provides for rapid transhipment



The diagram shows a cross-docking process. An 'In-coming' truck is on the left, and an 'Outgoing' truck is on the right. A worker is shown moving a box from the incoming truck to the outgoing truck. The worker is using a pallet jack to move the box.

Jamshid Nazemi- production & operation management 6 52

production management مدیریت عملیات

Random Stocking Systems Often:

- Maintain a list of “open” locations
- Maintain accurate records of existing inventory and its locations
- Sequence items on orders to minimize travel time required to pick orders
- Combine orders to reduce picking time
- Assign certain items or classes of items, such as high usage items, to particular warehouse areas so that distance traveled is minimized

Jamshid Nazemi- production & operation management 6 53

production management مدیریت عملیات

Product Oriented Layout

- Facility organized around product
- Design minimizes line imbalance
 - Delay between work stations
- Types: Fabrication line; assembly line

Jamshid Nazemi- production & operation management 6 54

production management مدیریت عملیات

Product Oriented Requirements

- Standardized product
- High production volume
- Stable production quantities
- Uniform quality of raw materials & components

Jamshid Nazemi- production & operation management 6 55

production management مدیریت عملیات

Product Oriented Layout Assumptions

- Volume is adequate for high equipment utilization
- Product demand is stable enough to justify high investment in specialized equipment
- Product is standardized or approaching a phase of its life cycle that justifies investment in specialized equipment
- Supplies of raw materials and components are adequate and of uniform quality to ensure they will work with specialized equipment

Jamshid Nazemi- production & operation management 6 56

production management مدیریت عملیات

Product Oriented Layout Types

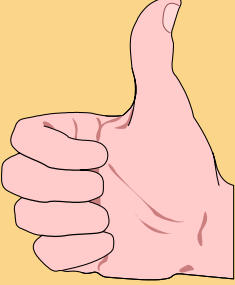
Fabrication Line	Assembly Line
<ul style="list-style-type: none"> Builds components Uses series of machines Repetitive process Machine paced Balanced by physical redesign 	<ul style="list-style-type: none"> Assembles fabricated parts Uses workstation Repetitive process Paced by tasks Balanced by moving tasks

Jamshid Nazemi- production & operation management 6 57

production management مدیریت عملیات

Product Oriented Layout Advantages

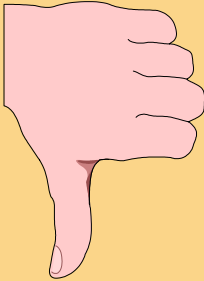
- Lower variable cost per unit
- Lower material handling costs
- Lower work-in-process inventories
- Easier training & supervision
- Rapid throughput



Jamshid Nazemi- production & operation management 6 58

production management مدیریت عملیات

Product Oriented Layout Disadvantages

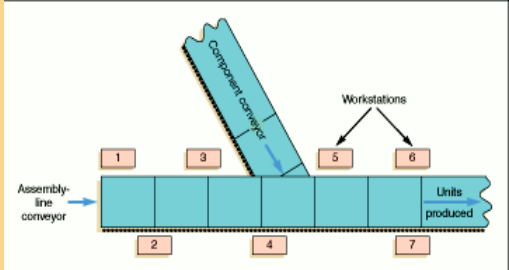


- Higher capital investment
 - Special equipment
- Any work stoppage stops whole process
- Lack of flexibility
 - Volume
 - Product

Jamshid Nazemi- production & operation management 6 59

production management مدیریت عملیات

An Assembly Line Layout



Jamshid Nazemi- production & operation management 6 60

production management مدیریت عملیات

Repetitive Layout

Note: 5 tasks or operations; 3 work stations

Jamshid Nazemi- production & operation management 6 61

production management مدیریت عملیات

Assembly Line Balancing

- Analysis of production lines
- Nearly equally divides work between workstations while meeting required output
- Objectives
 - Maximize efficiency
 - Minimize number of work stations

Jamshid Nazemi- production & operation management 6 62

production management مدیریت عملیات

Assembly Line Balancing The General Procedure

- Determine cycle time by taking the demand (or production rate) per day and dividing it into the productive time available per day
- Calculate the theoretical minimum number of work stations by dividing total task time by cycle time
- Perform the line balance and assign specific assembly tasks to each work station

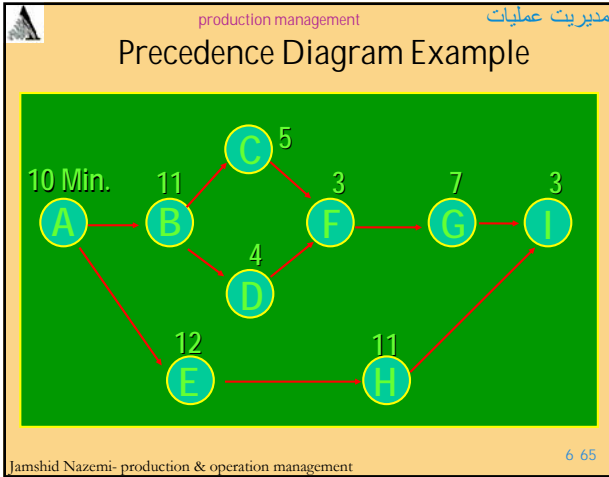
Jamshid Nazemi- production & operation management 6 63

production management مدیریت عملیات

Assembly Line Balancing Steps

1. Determine tasks (operations)
2. Determine sequence
3. Draw precedence diagram
4. Estimate task times
5. Calculate cycle time
6. Calculate number of work stations
7. Assign tasks
8. Calculate efficiency

Jamshid Nazemi- production & operation management 6 64



production management مدیریت عملیات

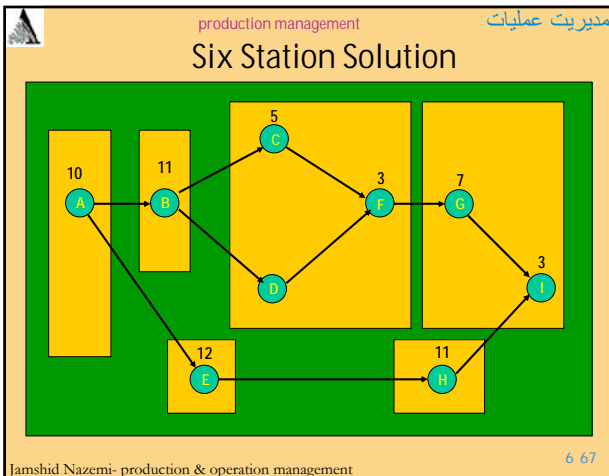
Assembly Line Balancing Equations

$$\text{Cycle time} = \frac{\text{Production time available}}{\text{Demand per day}}$$

$$\text{Minimum number of work stations} = \frac{\sum \text{Task times}}{\text{Cycle time}}$$

$$\text{Efficiency} = \frac{\sum \text{Task times}}{(\text{Actual number of work stations}) * (\text{Cycle time})}$$

Jamshid Nazemi- production & operation management 6 66



- production management مدیریت عملیات
- ### Layout Heuristics for Assigning Tasks in Assembly Line Balancing
- **Longest task time** - choose task with longest operation time
 - **Most following tasks** - choose task with largest number of following tasks
 - **Ranked positional weight** - choose task where the sum of the times for each following task is longest
 - **Shortest task time** - choose task with shortest operation time
 - **Least number of following tasks** - choose task with fewest subsequent tasks
- Jamshid Nazemi- production & operation management 6 68