

# UPPSC-AE

# 2021

## Uttar Pradesh Public Service Commission

Combined State Engineering Services Examination  
**Assistant Engineer**

### Mechanical Engineering

### Industrial Engineering

Well Illustrated **Theory** with  
**Solved Examples** and **Practice Questions**



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# Industrial Engineering

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# Introduction to Production & Industrial Management

## 1.1 Production

- Production is any process which transforms a set of input elements like men, materials, capital, information and energy into a specified set of output elements like finished products and services in proper quantity and quality, thus achieving the objectives of an enterprise.
- There are four recognized factors of production:
  - Nature (Land and other natural resources)
  - Labour (human efforts)
  - Capital (factory building, machinery, tools, raw materials etc.)
  - Enterprise (activity that organizes other factors of production into an operating unit).
- **Productivity:** Productivity may be defined as the ratio between output and input. Output is the number of items produced and input is the various resources employed, e.g., land and building, equipment and machinery, material, labour etc. to produce the output items.

### 1.1.1 Purpose to Increase Productivity

#### For Management:

- To produce good earning (profits)
- To clear the debts or loans acquired from different sources
- To sell more, and
- To stand better in the market

#### For Workers:

- Higher wages
- Better working conditions
- Higher standard of living
- Job security and satisfaction

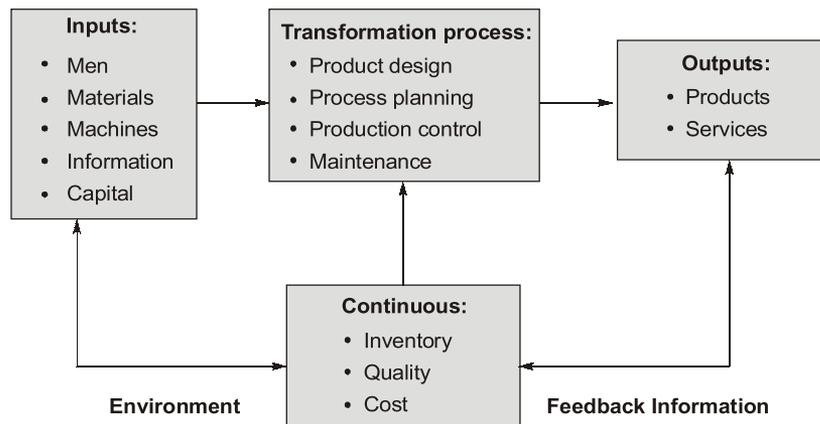
#### For Customers:

- Reduced price of products
- Better quality of products

## 1.2 Concept of Production

Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs having the required quality level.

Edwood Buffa defines production as 'a process by which goods and services are created'.



*Schematic of Production System*

## 1.3 Production/Industrial Management

- Industrial management is a process of planning, organizing, directing and controlling the activities of the production function.
- Its objective is to produce goods, services of right quality and right quantity at the right time and right cost.

### 1.3.1 Scope

- Industrial managers are concerned with planning, organizing, and controlling the activities which affect human behaviour through models.
- Scope of industrial management includes the activities listed below:
  1. Location of facilities
  2. Plant layouts and material handling
  3. Product design
  4. Process design
  5. Production, planning and control
  6. Quality control
  7. Material management
  8. Maintenance management



# Plant/Store Location and Layout

## 2.1 Introduction

- Plant layout means the disposition of the various facilities (equipment, materials, manpower etc.) and services of the plant within the area of the site selected previously.
- Plant layout begins with the design of the factory building and goes upto the location and movement of the work table. All the facilities like equipments, raw materials, machinery, tools, fixtures, workers etc. are given a proper place.
- In a good plant layout bottlenecks and points of congestions are eliminated so that it permits materials to move through the plant at the desired speed with the lowest cost.
- A good layout minimizes the movement of finished and semi-finished product. So that material handling cost is reduced.

## 2.2 Objectives of Plant Layout

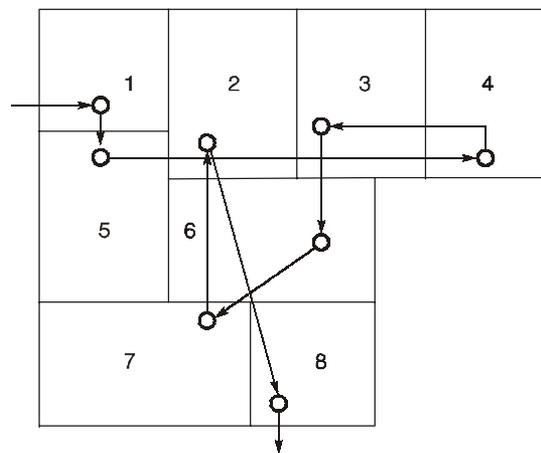
- To achieve better quality
- To minimize production delays
- Simplification, safety and integration
- To utilize maximum floor area

## 2.3 Principles of Plant Layout

1. **Principle of integration:** A good layout is one that integrates men, materials, machines and supporting services and others in order to get the optimum utilization of resources and maximum effectiveness.
2. **Principle of minimum distance:** This principle is concerned with the minimum travel of man and material.
3. **Principle of cubic space utilization:** The good layout is one that utilizes both horizontal and vertical space, height is also to be utilized effectively.
4. **Principle of flow:** A good layout is one that makes the material to move in forward direction towards the completion stage.
5. **Principle of maximum flexibility:** The good layout is one that can be altered without much cost and time.
6. **Principle of safety, security and satisfaction:** A good layout is one that gives due consideration to workers safety and satisfaction and safeguards the plant and machinery against fire, etc.
7. **Principle of minimum handling:** A good layout is one that reduces the material handling to the minimum.

## 2.4 Process Layout

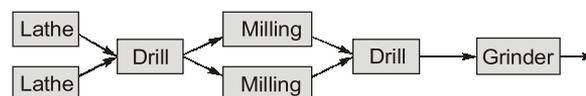
- It is also known as functional layout.
- It is characterized by keeping similar machines or similar operations at one location. For example: all lathes will be at one place, all milling machines at another and so on.
- Process layout is generally employed for industries engaged in job order production and non-repetitive kind of maintenance or manufacturing activities.
- It gives *better product quality*, because supervisors and workers attend to one type of machine and operation.
- For same amount of production, process layout needs more space.



- |                    |                          |                      |
|--------------------|--------------------------|----------------------|
| 1. Store room      | 2. Inspection Department | 3. Broaching section |
| 4. Milling section | 5. Lathe section         | 6. Shaper section    |
| 7. Drill section   | 8. Stock room            |                      |

## 2.5 Product Layout

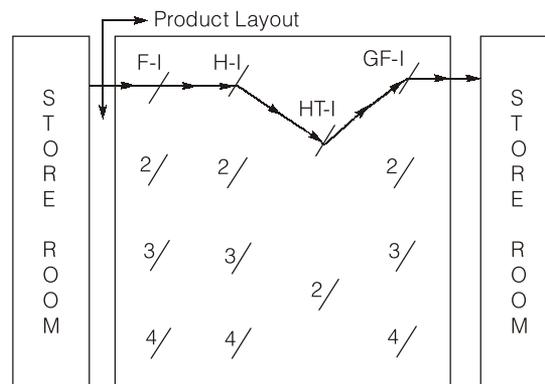
- It is also known as line layout.
- It implies that various operations on raw materials are performed in a sequence and the machines are placed along the product flow line, i.e., machines are arranged in the sequence in which the raw material will be operated upon.
- This type of layout is preferred for *continuous production* i.e. involving a continuous flow of in process material towards the finished product stage.
- In this layout less space requirement for the same volume of production.
- This layout offers automatic material handling, lesser material handling movements, times and costs benefits are gained.



A Simple product layout

## 2.6 Combination Layout

- A combination of process and product results in combination layout.
- A combination layout is possible where an item is being made in different types and sizes. In such cases machinery is arranged in a process layout but the process grouping (a group of number of similar machines) is then arranged in a sequence to manufacture various types and sizes of products.
- No matter the product varies in size and type, the sequence of operations remains same.
- For example hacksaws, circular metal saws, wood saws etc. can be manufactured on a combination layout.



F = Blank forging hammers;  
H = Hobbing machines for cutting gear teeth  
HT = Heat treatment furnaces;  
GF = Gear finishing machines

## 2.7 Fixed Position Layout

- In the types of layouts discussed earlier, the product moves past stationary production equipments, whereas in this case the reverse applies, men and equipment are moved to the material, which remains at one place and the product is completed at that place where the material lies.
- It is used in ship building, aircraft manufacturing and large pressure vessel fabrication.
- There is maximum flexibility for all sorts of changes in product and process.
- It involves high equipment handling cost.

## 2.8 Group Layout (or Cellular layout)

It is a combination of the product and process layout. If there are m-machines and n-components, in a group layout (group-technology layout), the m-machines and n-components will be divided into distinct number of machine-component cells (groups) such that all the components assigned to a cell have same process of manufacturing.

- The main objective is to minimize inter-cell movements.



**Example - 2.1** Which one of the following combinations is valid for product layout?

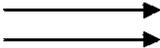
- (a) General purpose machine and skilled labour.
- (b) General purpose machine and unskilled labour.
- (c) Special purpose machine and semi-skilled labour.
- (d) Special purpose machine and skilled labour

**Solution: (c)**

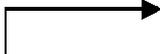
## 2.9 Flow Pattern

- One of the most important objectives of plant layout is to achieve an optimum effective flow of materials (raw materials and in process materials) through the plant. Naturally, the principle of minimum movements forms the basis for optimum effective flow.
- The principle of minimum movements reduces material handling costs; in process inventory and space for processing.
- While designing a new plant layout, generally the flow patterns are decided first.

### Types of Flow Pattern

- **Line flow** 

Preferred in buildings where length is more but width is less.

- **L-type flow** 

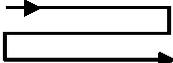
Used where buildings are more wide but less long as compared to line flow type buildings.

- **Circular flow** 

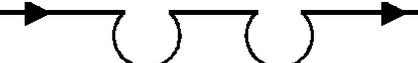
Preferred for rotary handling systems. Different work stations are located along the circular path.

- **U-type flow** 

Supervision is simpler as compared to others, it is preferred in square-shaped buildings.

- **S or inverted S** 

Preferred in square shaped buildings having production lines longer than U-type. The system is compact and supervision is efficient.

- **Combination of line flow and circular type** 

As compared to line flow, this system needs lesser building lengths.

## 2.10 Product Planning

- It may be defined as evaluation of the range, mix, specification and pricing of existing and new products in relation to meet the future market requirements and competition.
- Product planning serves as an input to process design.
- The product planning function often includes:
  - Marketing and marketing analysis
  - The performance of feasibility studies
  - Advanced planning

## 2.11 Product Development

- Development involves design/redesign and fabrication of new or modified product and then testing it to find out its usefulness.
- Product development is essential to meet changing customer needs.
  - Improved manufacturing and low cost products
  - For maintaining sales position and profit margin

### Products can be developed by:

- (i) **Imitation:** Marketing another product similar to one in the market.
- (ii) **Adaptation:** Developing an improved product from the one already existing in the market.
- (iii) **Invention:** Thinking about a new advance and acceptable product which is not existing in the market and then producing it.
- Product development may involve a small refinement or a major redesign.

## 2.12 Process Planning

- Finding the most economical process of doing a work and (then) deciding how and where the work will be done.
- Process planning means the preparation of work detail plan.
- Different steps involved in process planning are:
  - Selection of process.
  - Selection of Material.
  - Selection of Jigs, Fixtures and other special attachments.
  - Selection of cutting tools and inspection gauges.
  - Preparing the process layout indicating every operation and the sequence in which each operation will be carried out.
  - Calculating the set up time and standard time for each operation.
  - Manifesting process planning by documents such as operation and route sheet.
- **Material Control:** It determines the requirements and control of material.
- **Tool Control:** Tool control implies:
  - Determining tool requirements
  - Procuring necessary tools
  - Controlling/maintaining tools once they have been procured
- In order to facilitate tool control and to limit the investment in tool inventory, it is important to standardize all the tools within an organization.

## 2.13 Group Technology

- Group technology or cellular manufacturing has become an increasingly popular concept in manufacturing which is designed to take advantages of mass production layout and techniques in smaller batch production systems.
- Group technology is the realization that many problems are similar and that by grouping similar problems, a single solution can be found to set of problems, thus saving time and effort.
- Group technology, in manufacturing, is the replacement of traditional shop manufacturing by the analysis and grouping of work into families and the formation of groups of machines to manufacture these families on a flow-line principle, with the objective of minimizing setting time and through put time.



### Example - 2.2 Travel chart mainly helps

- in improving the existing plant layout
- while selecting plant location
- while introducing new products
- none of these

**Solution: (a)**

Improving the existing plant layout. If the existing plant layout is designed in such a way that there is no optimum utilization of resources, then travel chart technique is applied to minimize the wastage of time, manpower and money.



## Student's Assignment

- Q.1** Function or process layout is also known as:
- Analytic layout
  - Hybrid layout
  - Synthetic layout
  - Static Product Layout
- Q.2** Which type of the layout is preferred in order to avoid excessive multiplication of facilities?
- Process layout
  - Product layout
  - Fixed position layout
  - Cellular manufacturing
- Q.3** Consider the following statements:  
A process layout
- has machines of same functions arranged in a place.
  - is suitable for batch production.
  - has machines of different functions arranged according to processing sequence.
  - is suitable for mass production
- Of these statements
- 1 and 2 are correct
  - 3 and 4 are correct
  - 2 and 3 are correct
  - 1 and 4 are correct
- Q.4** Tool and gauges are manufactured in which type of layout?
- Process layout
  - Product layout
  - Fixed position layout
  - Mixed type layout

- Q.5** Consider the following limitations :
1. Movement of machines and equipments for production centre is costly
  2. Long flow lines lead to expensive handling
  3. Breakdown in one machine leads to stoppage of production
  4. Large work-in-progress during production
  5. Higher grade skills are required
- Process layout has which of the above limitations?
- (a) 1, 2 and 4      (b) 2, 4 and 5  
(c) 2 and 3      (d) 1, 4 and 5
- Q.6** The layout suitable for the low production volume and high variety product is
- (a) Group layout      (b) Process layout  
(c) Product layout      (d) Static layout
- Q.7** Which one of the following combinations is valid for product layout?
- (a) General purpose machine and skilled labour  
(b) General purpose machine and unskilled labour  
(c) Special purpose machine and semi-skilled labour  
(d) Special purpose machine and skilled labour
- Q.8** Consider the following advantages:
1. Lower in-process inventory
  2. Higher flexibility in rescheduling in case of machine breakdown.
  3. Lower cost in material handling equipment.
- When compared to process layout, the advantage of product layout would include:
- (a) 1 and 2      (b) 1 and 3  
(c) 2 and 3      (d) 1, 2 and 3
- Q.9** Consider the following statements:  
In designing a plant layout, a "Product Layout" should be preferred if
1. the variety of the product is low.
  2. the variety of the product is very large.
  3. the quantity of production is very small in each variety.
  4. the quantity of production is very large in each variety.
  5. the in-process inspection is maximum.
  6. the in-process inspection is minimum.
- Which of the statements given above are correct?
- (a) 1, 3 and 6      (b) 1, 4 and 5  
(c) 2, 3 and 4      (d) 1, 4 and 6
- Q.10** Which of the following is an example of product layout?
- (a) Tool and gauges  
(b) Motor cycle assembly  
(c) Ball bearing manufacturing  
(d) Ship building
- Q.11** Product or mass layout is also known as:
- (a) Analytic layout      (b) Synthetic layout  
(c) Hybrid layout      (d) Static layout
- Q.12** Which one of the following is not an advantage of a product layout?
- (a) Reduced material handling  
(b) Better utilization of machines and men  
(c) Less floor area is occupied by the material in transit and for temporary storage  
(d) Less capital investment
- Q.13** Consider the following statements:
1. In product-flow layout, the arrangement of facilities within the plant is relatively inflexible.
  2. Process layout is typical in job shops and batch production.
- Which of the statements given above is/are correct?
- (a) 1 only      (b) 2 only  
(c) Both 1 and 2      (d) Neither 1 nor 2
- Q.14** In which of the following the combined layout is used?
- (a) When a large quantity of products is to be produced.  
(b) When a large variety of products is to be produced.  
(c) When the item is being made in different types of sizes.  
(d) When two heavy items are used as raw material.
- Q.15** Which is/are the examples of combined/hybrid layout?
- (a) Ball bearing manufacturing  
(b) Television manufacturing  
(c) Refrigerator manufacturing  
(d) All of the above

- Q.16** The layout of ship building industry should be
- Process layout
  - Group layout
  - Fixed location layout
  - Product layout
- Q.17** Which of the following is/are advantages of static product layout/fixed position layout?
- Low investment cost
  - Minimum material movement
  - Total production cost is low
  - All of the above
- Q.18** The type of layout suitable for the use of concept, principles and approaches of 'group technology' is
- Product layout
  - Job-shop layout
  - Fixed position layout
  - Cellular layout
- Q.19** Which of the following principle of plant layout is/are the correct?
- Principle of overall integration
  - Principle of flow
  - Principle of flexibility
  - All of the above
- Q.20** Which of the following charts are used for plant layout design?
- Operation process chart
  - Man machine chart
  - Correlation chart
  - Travel chart
- Select the correct answer using the codes given below:
- 1, 2, 3 and 4
  - 1, 2 and 4
  - 1, 3 and 4
  - 2 and 3
- Q.21** Which one of the following is the basic objective of a good plant layout?
- New plant construction
  - Better use of labour
  - Improvement in production process as a whole
  - To meet customer's expectations

**ANSWER KEY**
**STUDENT'S  
ASSIGNMENT**

- |                |                |                |                |                |
|----------------|----------------|----------------|----------------|----------------|
| <b>1.</b> (a)  | <b>2.</b> (a)  | <b>3.</b> (a)  | <b>4.</b> (a)  | <b>5.</b> (b)  |
| <b>6.</b> (b)  | <b>7.</b> (c)  | <b>8.</b> (b)  | <b>9.</b> (d)  | <b>10.</b> (b) |
| <b>11.</b> (b) | <b>12.</b> (d) | <b>13.</b> (c) | <b>14.</b> (c) | <b>15.</b> (d) |
| <b>16.</b> (c) | <b>17.</b> (d) | <b>18.</b> (d) | <b>19.</b> (d) | <b>20.</b> (b) |
| <b>21.</b> (c) |                |                |                |                |

**HINTS & SOLUTIONS**
**STUDENT'S  
ASSIGNMENT**
**1. (a)**

Analytic layout is a layout where machines of same function arranged in a place.

**3. (a)**

- Process layout is suitable for batch production and machines of same functions are arranged in a place.
- Product layout is suitable for mass production and machines of different functions are arranged according to processing sequence.

**4. (a)**

In tool and gauges, the specification of every product is different, hence process layout should be used.

**5. (b)**

Limitations of process layout:

- Increased material handling requirements.
- Long production lines
- More complicated production control required.
- Increased work-in progress inventories.
- higher skill required to accommodate diversity of tasks to be accomplished.

Breakdown of one machine does not stop production in process layout.

**7. (c)**

Product layout

- Special purpose machine
- Semi-skilled labour