

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - 5 SEMESTER – MID TERM – W26 – ANSWER BANK

Subject Name & Code:

BASICS OF INDUSTRIAL ENGINEERING - BE05000321

1) Explain the factors affecting plant location and discuss their importance in selecting a suitable site. (7 Marks)

Definition:

- Plant location = Selection of geographical site for manufacturing facility.

Factors Affecting Plant Location:

A. Primary Factors:

- Raw Materials:** Near source (sugar mill near sugarcane fields)
- Market:** Near customers (bakery near residential areas)
- Transport:** Access to roads, railways, ports
- Labour:** Skilled workforce availability & cost
- Utilities:** Power, water, fuel availability
- Land:** Cost, availability, topography

B. Secondary Factors:

- Government Policies:** Tax incentives, subsidies, regulations
- Climate:** Suitability for process
- Community:** Housing, schools, hospitals
- Environment:** Pollution control requirements

Importance:

- Long-term decision** - Cannot change frequently
- Affects 10-25%** of total operating costs
- Determines competitive position** (delivery speed, customer service)
- Growth potential** - Space for future expansion

2) Explain the principles of plant layout with suitable industrial examples. (7 Marks)

Definition:

- Plant layout = Physical arrangement of machinery, equipment, workstations for efficient flow.

Principles with Examples:

Principle	Explanation	Example
Integration	Unified whole; no isolated units	Toyota's integrated assembly line
Minimum Distance	Shortest material movement path	U-shaped layout reduces walking
Flow	Smooth, continuous, unidirectional	Car assembly conveyor line
Cubic Space	Use floor & vertical space	Amazon multi-level racking

Principle	Explanation	Example
Safety	Safe, comfortable working conditions	Ergonomic workstations
Flexibility	Easy rearrangement for changes	Modular movable equipment
Accessibility	Easy maintenance access	Clear aisles between machines
Minimum Handling	Reduce material handling	Gravity roller conveyors
Economy	Cost-effective design	Group technology layout
Minimize WIP	Balance production stages	Kanban system limiting inventory

3) Explain the working procedure of CRAFT and CORELAP. Give at least three differences between them. (7 Marks)

CRAFT (Computerized Relative Allocation of Facilities Technique):

Working Procedure:

1. **Input:** Initial layout, Flow matrix, Cost matrix, Department dimensions
2. **Calculate initial** material handling cost
3. **Generate alternatives** via pairwise exchanges (2-way & 3-way)
4. **Evaluate** cost savings for each exchange
5. **Implement** best exchange
6. **Repeat** until no improvement possible

Key Feature: Pairwise exchange heuristic approach

CORELAP (Computerized Relationship Layout Planning):

Working Procedure:

1. **Input:** Relationship chart (A,E,I,O,U,X ratings), Department areas
2. **Convert ratings to scores:** A=6, E=5, I=4, O=3, U=2, X=1
3. **Calculate TCR** (Total Closeness Rating) for each dept
4. **Select first dept** with highest TCR
5. **Place remaining** depts based on adjacency relationships
6. **Avoid** X-rated depts adjacent
7. **Fill grid** considering area requirements

Key Feature: Construction algorithm based on relationships

Differences (Minimum 3):

Aspect	CRAFT	CORELAP
Basis	Quantitative (material flow cost)	Qualitative (relationship ratings)
Input	Flow matrix, cost matrix	REL chart
Method	Improvement algorithm	Construction algorithm
Starting Point	Requires initial layout	Starts from scratch

Aspect	CRAFT	CORELAP
Objective	Minimize handling cost	Maximize closeness rating

4) Explain the principles of plant layout and their role in improving productivity. (7 Marks)

Principles: (Refer to Question 2 for detailed principles)

Role in Improving Productivity:

Principle	Productivity Impact
Minimum Distance	15-30% reduction in handling time
Flow	20-40% increase in production rate
Cubic Space	25-50% space utilization improvement
Flexibility	30-50% reduction in setup time
Safety	10-20% reduction in absenteeism
Integration	15-25% reduction in lead time
Minimum Handling	10-30% cost savings on handling

5) Analyze different flow patterns and recommend a suitable pattern for a given manufacturing process. (7 Marks)

Types of Flow Patterns:

1. Straight Line (I-flow):

Raw → P1 → P2 → P3 → Finished

- **Use:** Long buildings, simple assembly

2. U-shaped Flow:

Raw → P1 → P2 → P3

← P5 ← P4 ← Finish

- **Use:** JIT, cellular manufacturing

3. L-shaped Flow:

P1 → P2 → P3

↓

Finish

- **Use:** L-shaped buildings

4. S-shaped Flow:

P1 → P2 → P3

↓

P6 ← P5 ← P4

- **Use:** Rectangular buildings, batch production

Selection Guide:

Manufacturing Type	Recommended Pattern	Reason
Continuous Production	Straight Line	High volume, standard product
Batch Production	L-flow or S-flow	Flexible routing
Job Shop	S-flow/Complex	Variable products
Assembly Line	U-flow	Compact, JIT compatible
Process Industry	Straight Line	Linear sequence

Example: Automobile Assembly (500 vehicles/day)

- **Recommended: U-shaped Flow**
- **Justification:** Compact, JIT compatible, efficient handling, flexibility for multiple models, minimal walking

6) Define productivity and explain its significance in an industrial organization. (4 Marks)

Definition:

- **Productivity** = Output / Input (ratio of goods/services produced to resources consumed)

Types:

Type	Formula
Labour Productivity	Output / Labour hours
Material Productivity	Output / Material consumed
Machine Productivity	Output / Machine hours
Total Factor Productivity	Output / (Labour+Capital+Materials)

Significance:

- **Profitability:** Higher productivity = Lower cost/unit = Higher profit
- **Competitiveness:** Lower prices or better quality
- **Resource Efficiency:** Better utilization of scarce resources
- **Employee Benefits:** Higher wages, better working conditions
- **Economic Growth:** National economic development
- **Customer Satisfaction:** Better quality at competitive prices

7) Evaluate the effect of improved utilization of manpower, machines and materials on overall productivity. (7 Marks)

1. Improved Manpower Utilization:

Aspect	Effect on Productivity
Training & Skills	Faster operations, fewer errors

Aspect	Effect on Productivity
Motivation	Higher output, better quality
Ergonomics	Reduced fatigue, fewer breaks
Multi-skilling	Flexible deployment, reduced idle time

Productivity Impact: +10-25% increase

2. Improved Machine Utilization:

Aspect	Effect on Productivity
Reduced Downtime	More production hours
Preventive Maintenance	Less breakdowns
Optimized Speeds/Feeds	Faster cycle times
Tool Management	Reduced setup times
Automation	Consistent quality, 24/7 operation

Productivity Impact: +15-30% increase

3. Improved Material Utilization:

Aspect	Effect on Productivity
Reduced Scrap	More output from same input
Better Inventory	Less WIP, faster flow
Quality Materials	Fewer defects, less rework
Waste Reduction	Lower material cost/unit

Productivity Impact: +10-20% increase

Overall Productivity Improvement:

Resource	Improvement Potential
Manpower	+10-25%
Machines	+15-30%
Materials	+10-20%

Resource

Improvement Potential

Combined Effect**+30-50%****8) Differentiate between an Operation Process Chart and Flow Process Chart with suitable examples. (7 Marks)****Operation Process Chart (OPC):****Definition:** Chart showing sequence of operations and inspections in a process (macro view).**Example - Making a Wooden Chair:**

text

Raw Wood → Cut to size (O) → Inspect (□) → Assemble (O) → Inspect (□) → Finish (O) → Final Inspect (□) → Pack

Flow Process Chart (FPC):**Definition:** Chart showing complete sequence of all activities including operations, transports, inspections, delays, storage.**Example - Making a Wooden Chair:**

text

Raw Wood → Transport (→) → Storage (▼) → Transport (→) → Cut (O) → Transport (→) → Inspect (□) → Assemble (O) → Delay (D) → Transport (→) → Finish (O) → Inspect (□) → Transport (→) → Pack (O)

Key Differences:

Aspect	Operation Process Chart	Flow Process Chart
Scope	Macro view	Micro view
Symbols Used	Operation, Inspection only	All 5 symbols
Detail	Less detailed	More detailed
Purpose	Overall process sequence	Detailed analysis & improvement
Shows	Major operations	All activities including waste
Time Analysis	Not included	Can include time
User	Top management	IE/Process engineers

9) Explain the construction and applications of a String Diagram in method study. (4/7 Marks)**Definition:**

- **String Diagram** is a scale plan of the workplace showing the path of movement of a worker/operator using a string/thread to measure distance travelled.

Construction Procedure:

1. **Draw scale plan** of workplace layout on board/paper
2. **Mark all points** where operator visits

3. **Insert pins/nails** at all marked points
4. **Observe movements** and trace operator path
5. **String the path** using a thread following actual movement
6. **Measure string length** to calculate total distance
7. **Record time** for each movement
8. **Draw final diagram** with movement lines

Applications:

Application	Purpose
Workplace Layout	Optimize arrangement of equipment
Motion Analysis	Identify unnecessary movements
Material Flow	Analyze material handling paths
Operator Movement	Reduce walking distance
Workplace Improvement	Eliminate wasted motion
Balancing Work	Distribute workload evenly
Productivity Improvement	Reduce cycle time

10) Explain Therbligs and discuss their importance in improving manual operations. (4/7 Marks)

Definition:

- **Therbligs** are the fundamental elements of motion (basic building blocks) that constitute any manual operation. Developed by Frank and Lillian Gilbreth (reverse of "Gilbreth").

17 Therbligs:

Category	Therblig	Symbol	Description
Effective	Search	SH	Finding an object
	Select	ST	Choosing from many
	Grasp	G	Taking hold of object
	Transport Loaded	TL	Moving an object
	Position	P	Aligning object
	Assemble	A	Joining parts
	Use	U	Operating tool/equipment

Category	Therblig	Symbol	Description
	Disassemble	DA	Separating parts
	Inspect	I	Checking quality
	Transport Empty	TE	Moving empty hand
	Hold	H	Holding object

Importance in Improving Manual Operations:

1. **Identify Waste:** Distinguish effective vs ineffective motions
2. **Reduce Ineffective Motions:** Eliminate delays, unnecessary movements
3. **Optimize Motion Sequence:** Rearrange for efficiency
4. **Standardize Best Methods:** Use most efficient motion pattern
5. **Training:** Teach proper motion patterns
6. **Method Improvement:** Apply principles of motion economy
7. **Measurement:** Basis for PMTS (Predetermined Motion Time Systems)
8. **Ergonomics:** Reduce fatigue by eliminating unnecessary motions

Example Improvement:

- Before: Search → Select → Grasp → Transport → Position → Use (3 ineffective)
- After: Pre-position → Grasp → Use (0 ineffective)
- **Result:** 40-60% time reduction

11) Explain the principles of motion economy with suitable examples. (7 Marks)

Definition:

- **Principles of Motion Economy** are guidelines for designing efficient work methods to minimize worker fatigue and maximize productivity.

Three Categories:

A. Principles Related to Human Body:

Principle	Example
1. Both hands should begin/end simultaneously	Assembly using both hands
2. Hands should not be idle simultaneously	Alternating operations
3. Motions should be symmetrical & simultaneous	Two-handed screw tightening
4. Momentum should be used	Pendulum swing of tools
5. Continuous curved motions are preferred	Smooth assembly motions
6. Work should be within normal work area	Parts within easy reach

B. Principles Related to Workplace Layout:

Principle	Example
7. Definite location for tools/materials	Shadow boards for tools
8. Materials and tools should be pre-positioned	Gravity feed bins
9. Use gravity to feed materials	Sliding chutes
10. Use fixtures and jigs	Assembly fixtures
11. Foot-operated devices for heavy work	Foot pedal for press
12. Workstations arranged for natural rhythm	U-shaped cells

C. Principles Related to Equipment Design:

Principle	Example
13. Tools should reduce work	Power tools instead of manual
14. Equipment should combine operations	Multi-spindle drill
15. Equipment should operate automatically	Automatic conveyors
16. Controls should be at optimal positions	Control panel at elbow height
17. Proper lighting and ventilation	Task lighting
18. Use colour coding and visual controls	Colour-coded bins

Combined Example - Assembly Workstation:

Applied Principle	Implementation	Benefit
Definite location	Shadow board for tools	Reduced search time
Pre-positioned	Parts in angled bins	Reduced reach time
Both hands	Simultaneous assembly	50% time reduction
Proper lighting	Task light	Reduced errors
Foot-operated	Foot pedal for clamping	Free hands for assembly

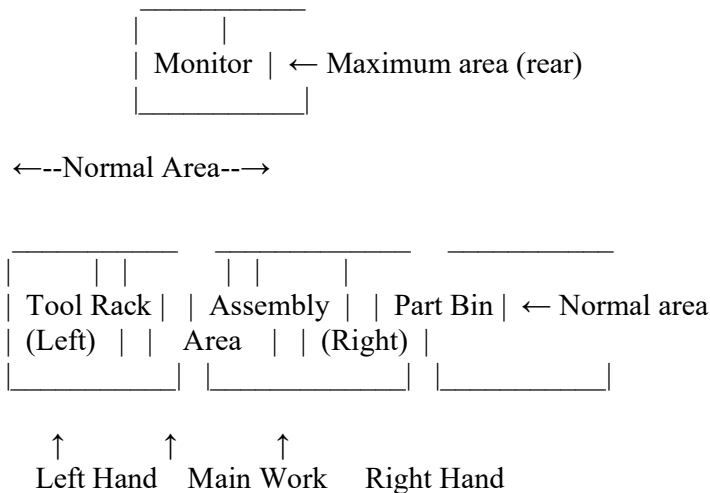
12) Design a suitable workplace arrangement based on the principles of motion economy and normal work areas. (7 Marks)

Normal Work Areas:

1. Normal Work Area:
2. Maximum Work Area:
3. Extra Reach Area:

Workplace Layout Design:
Assembly Workstation Design:

Top View (Scale Drawing):



Design Specifications:

Element	Position	Justification
Assembly Fixture	Centre, elbow height	Main work area, reduces bending
Left Part Bin	Left side, normal area	For left hand reach
Right Part Bin	Right side, normal area	For right hand reach
Tool Rack	Above assembly area	Easy visual access
Screw Driver	Pre-positioned in fixture	Reduces grasp/search time
Finished Product Bin	Below assembly area	Gravity feed
Reject Bin	Left side, lower	Away from main work area
Control Panel	Front, elbow height	Easy access, reduces reach

13) Differentiate between time study, work sampling and PMTS. (4/7 Marks)

1. Time Study:

Definition: Direct observation and timing of a worker performing a task to establish standard

time.

Procedure:

1. Select operator and method
2. Break task into elements
3. Time each element
4. Rating assessment
5. Add allowances
6. Calculate standard time

Advantages:

- Accurate, detailed analysis
- Direct observation

Disadvantages:

- Time-consuming
 - Disrupts worker
 - Requires trained analyst
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2. Work Sampling:

Definition: Statistical technique that estimates the proportion of time spent on activities by making random observations.

Procedure:

1. Define activities
2. Determine observations needed
3. Random observation schedule
4. Record activity at each observation
5. Calculate proportions

Advantages:

- Less time-consuming
- Less disruptive
- Can study multiple workers

Disadvantages:

- Less detailed
 - Requires statistical knowledge
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3. PMTS (Predetermined Motion Time Systems):

Definition: Uses pre-established time values for basic motions to set time standards without direct timing.

Examples: MTM (Methods-Time Measurement), MOST

Procedure:

1. Break task into basic motions
2. Assign standard time for each motion
3. Sum for total time
4. Add allowances

Advantages:

- No stopwatch needed
- Consistent standards
- Can evaluate before production

Disadvantages:

- Complex training required
 - May not suit all operations
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Comparison Table:

Aspect	Time Study	Work Sampling	PMTS
Basis	Direct timing	Random observation	Pre-established data
Equipment	Stopwatch	Observation sheet	Motion tables
Time	Continuous	Random intervals	Synthesized
Detail	High detail	Low detail	Very high detail
Cost	High	Low	Medium
Disruption	High	Low	None
Accuracy	Good	Statistical	Very consistent
Application	Repetitive work	Non-repetitive	New jobs, planning

14) Explain the principle and industrial applications of Predetermined Motion Time Standards (PMTS). (4/7 Marks)
Definition:

- **PMTS** is a work measurement technique that uses pre-established time values for basic human motions to set time standards without direct timing.

Basic Principle:

- All manual work can be broken into basic motions
 - Each basic motion has a fixed time value
 - Total time = Sum of all basic motion times
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Industrial Applications:

Industry	Application	Benefit
Automotive	Assembly line balancing	Consistent standards
Aerospace	High precision assembly	Accurate estimates
Electronics	Circuit board assembly	Pre-production planning
Apparel	Sewing operations	Labour cost estimation
Warehousing	Picking operations	Productivity measurement
Healthcare	Medical procedures	Process improvement

Specific Applications:

1. **New Product Development:** Set time before production starts
2. **Workplace Design:** Evaluate alternative layouts

- Fatigue-related accidents = 15-20% of industrial accidents

3. Fatigue → Productivity:

Fatigue Effect	Productivity Impact
Slower work pace	Reduced output
More mistakes	Increased rework
More breaks	Reduced working time
Absenteeism	Lost work hours
Lower quality	More defects

Quantitative Effect:

- Fatigue reduces productivity by 15-25%
- Productivity loss due to fatigue = ₹2,000-5,000/worker/year

4. Safety → Productivity:

Safety Factor	Productivity Impact
Safe work environment	Higher morale, less concern
Reduced accidents	Less downtime
Proper safety training	Efficient work practices
Safety equipment	Fewer interruptions

Quantitative Effect:

- Good safety = 10-15% higher productivity
- Accident costs = Lost time + medical + investigation

Summary Relationship:

Factor	Impact	Next Effect
Good Ergonomics	↓ Fatigue 20-30%	↑ Safety, ↑ Productivity
Poor Ergonomics	↑ Fatigue 20-30%	↓ Safety, ↓ Productivity
Good Safety	↓ Accidents 30-50%	↑ Productivity 10-15%
Good Design	↓ Errors 20-40%	↑ Quality, ↑ Efficiency

16) Define ergonomics and explain its importance in industrial workplace design. (4

Marks)**Definition:**

- **Ergonomics** (Human Factors Engineering) is the scientific discipline concerned with designing products, equipment, and workplaces to fit the human body's capabilities and limitations.

Key Focus Areas:

- Physical ergonomics (body, postures, force)
 - Cognitive ergonomics (mental processes, decision-making)
 - Organizational ergonomics (systems, communication, work design)
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Importance in Workplace Design:**1. Worker Health & Safety:**

- Reduces musculoskeletal disorders
- Prevents repetitive strain injuries (RSI)
- Lower accident rates

2. Productivity:

- Improved work output
- Faster task completion
- Higher accuracy

3. Worker Comfort:

- Reduced fatigue
- Higher job satisfaction
- Lower absenteeism

4. Quality:

- Fewer errors and defects
- Consistent performance
- Better attention to detail

5. Cost Savings:

- Lower healthcare costs
- Reduced compensation claims
- Lower training costs

6. Compliance:

- Meets safety regulations
 - Reduces legal liability
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17) Explain the concept and applications of work sampling in industry. (4/7 Marks)**Definition:**

- **Work Sampling** is a statistical technique for estimating the proportion of time spent on various activities by making a large number of random observations of workers/machines.

Key Concepts:

1. Based on **random observations**
 2. Uses **statistical sampling** principles
 3. Estimates **proportion of time** for each activity
 4. **Confidence level** and **accuracy** determined statistically
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Working Procedure:**Step 1: Define Activities**

- Identify all activities to be studied

Step 2: Determine Sample Size

- Formula: $n = (Z^2 \times p \times q) / E^2$
- Where: Z = confidence level, p = estimated proportion
- $q = 1-p$, E = allowable error

Step 3: Plan Observation Schedule

- Random times (using random number tables)
- Ensure coverage of all work periods

Step 4: Conduct Observations

- Record activity at each observation
- Use observation sheet

Step 5: Calculate Proportions

- $p = \text{Observations of activity} / \text{Total observations}$

Step 6: Statistical Analysis

- Calculate confidence limits
- Determine if sample sufficient

Step 7: Interpret Results

- Time spent on each activity
- Identify improvement areas

Applications:

Industry	Application	Purpose
Manufacturing	Machine idle time study	Improve utilization
Warehousing	Order picking analysis	Productivity measurement
Healthcare	Nurse workload study	Staffing decisions
Office	Employee time distribution	Resource planning
Maintenance	Downtime analysis	Reliability improvement
Construction	Labour utilization	Cost control
Transportation	Driver waiting time	Route optimization
Service Industry	Customer waiting time	Service improvement
