Chapter 3: Productivity and Work Study

Repeated Questions:

1. Productivity:

- **Q.** What is Productivity? Discuss the factors affecting the productivity of a manufacturing organization. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

Answer:

Productivity: Productivity is the ratio of output produced to input utilized in a given period of time.

Productivity = Output / Input

Factors Affecting Productivity of a Manufacturing Organization:

- **Technological Factors:** Level of automation, machine capability, process technology, and equipment condition directly affect output per unit input.
- **Human Factors:** Skill, training, motivation, absenteeism, and labour turnover influence worker efficiency and output quality.
- **Material Factors:** Quality and availability of raw materials, inventory control, and material handling affect production continuity and waste.
- **Management Factors:** Planning, scheduling, supervision, and organizational structure determine how effectively resources are coordinated.
- **Environmental Factors:** Working conditions (light, ventilation, temperature, safety) affect worker performance and fatigue.
- **Government and Economic Factors:** Industrial policies, taxes, power availability, and market demand influence production levels.
- **Product Design and Standardization:** Simplified, standardized designs reduce variety and improve repetitive efficiency.

- **Q.** Define Productivity. Give various ways to improve productivity. **(SUMMER 2023, 4 Marks; SUMMER 2024, 3 Marks; WINTER 2025, 7 Marks OR)**

Answer:

Productivity: Productivity is the ratio of output to input, measuring how efficiently resources are converted into goods/services.

Productivity = Output / Input

Ways to Improve Productivity:

- **Work Study:** Method study to simplify work and time study to set standard times.
- **Training and Skill Development:** Upgrading worker skills reduces errors and improves speed.
- **Automation and Mechanization:** Replacing manual operations with machines increases output rate.
- **Better Material Handling:** Reducing movement time and damage.
- **Improved Layout:** Minimizing travel distance and bottlenecks.
- **Incentive Schemes:** Motivating workers through financial and non-financial rewards.
- **Quality Control:** Reducing rejects and rework.
- **Ergonomics:** Designing workstations to reduce fatigue and improve efficiency.

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2. Work Study and Method Study:

- **Q.** State objectives of work study. **(SUMMER 2023, 3 Marks; SUMMER 2025, 4 Marks OR)**

Answer:

Objectives of Work Study:

- **Improve Productivity:** Finding better ways of doing work.
- **Reduce Cost:** Eliminating unnecessary operations and waste.
- **Set Standard Time:** Establishing fair time for jobs.
- **Improve Working Conditions:** Designing safer and ergonomic workplaces.
- **Effective Utilization:** Optimizing use of men, machines, and materials.
- **Fair Wage Fixation:** Providing basis for incentive schemes.

- **Q.** What is method study? List the objectives of method study. **(SUMMER 2022, 4 Marks OR; WINTER 2025, 3 Marks)**

Answer:

Method Study: Method study is the systematic recording and critical examination of existing and proposed methods of doing work, to develop easier and more effective methods.

Objectives of Method Study:

- Improve methods of production.
- Reduce unnecessary movements and operations.
- Improve material flow and layout.
- Reduce fatigue and improve working conditions.
- Increase productivity and reduce cost.
- Establish standard methods for training.

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3. Process Charts and Diagrams:

- **Q.** Explain "String diagram" and its uses. **(WINTER 2023, 4 Marks; WINTER 2024, 4 Marks)**

Answer:

String Diagram: A string diagram is a scale model of the working area where thread/string is used to trace the path and measure the distance of movement of workers or materials.

Construction: Pins are fixed at locations on a board representing the layout; string connects pins to show movement path; length of string indicates distance travelled.

Uses:

- Measure actual distance travelled by material or worker.
- Identify backtracking and congested routes.
- Compare alternative layouts.
- Record complex movements in a compact form.

- **Q.** Explain the two-handed process chart with a neat sketch. **(SUMMER 2023, 4 Marks OR; WINTER 2025, 7 Marks)**

Answer:

Two-Handed Process Chart (Left-Hand/Right-Hand Chart): A chart recording the activities of both hands of an operator at a workstation, using process chart symbols.

Purpose: Shows idle time of each hand, unnecessary movements, and imbalance between hands.

Diagram Description: Two vertical columns—"Left Hand" and "Right Hand"—with rows showing activities in time sequence. Symbols (○ operation, → transport, D delay, □ inspection, ▽ storage) are placed in each column. Arrows connect simultaneous activities of both hands.

Example: Assembly of a bolt and nut—right hand picks bolt (→), left hand picks nut (→), both assemble (○), right hand places assembly (→), left hand waits (D).

- **Q.** Explain the travel chart in brief. **(WINTER 2023, 3 Marks; WINTER 2025, 4 Marks OR)**

Answer:
Travel Chart: A travel chart is a matrix showing the number of trips (or weight moved) between different locations/departments in a given period.

Features:

- Rows and columns represent locations.
- Entries show number of trips from one location to another.
- Helps identify dominant material flow paths.
- Used to evaluate and improve layouts by reducing heavy flows.

Example: A 3×3 matrix showing trips between Store, Machine Shop, and Assembly—higher values indicate routes needing improvement.

- **Q.** Explain the Operation Process Chart with a suitable example. / Discuss the Operation Process Chart by considering any appropriate example. **(SUMMER 2023, 4 Marks; SUMMER 2024, 7 Marks)**

Answer:
Operation Process Chart: A chart showing the sequence of operations and inspections in manufacturing a product, along with materials introduced at each stage.

Symbols: ○ Operation, □ Inspection.

Example — Manufacturing of a Steel Pin:

Diagram Description: Vertical flow starting from "Steel bar stock" (▽). Arrow down to ○ "Cut to length", then ○ "Turning", then □ "Inspection — diameter", then ○ "Drilling", then □ "Final inspection", then ▽ "Finished pin". A horizontal branch shows "Cutting tool" added at the drilling operation.

Purpose: Shows overall process sequence and where materials enter; useful for method study and cost estimation.

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4. Motion Study and Therbligs:

- **Q.** Explain the principles of motion economy and work place design. **(SUMMER 2023, 7 Marks; WINTER 2024, 7 Marks OR; WINTER 2025, 7 Marks)**

Answer:
Principles of Motion Economy:

- **Use of Human Body:** Both hands should start and finish together; use natural curved motions; use momentum to assist motion.
- **Arrangement of Workplace:** Tools and materials placed in fixed, convenient locations; use gravity bins; provide proper chair and work height.
- **Design of Tools and Equipment:** Use fixtures to hold work; combine two or more tools; use foot-operated devices where possible.

Workplace Design:

- Work area should be within normal and maximum reach.
- Materials placed in order of use.
- Proper lighting, ventilation, and noise control.
- Adjustable work height to reduce fatigue.
- Minimize lifting and carrying.

- **Q.** What is therbligs? Explain any two therbligs with their abbreviation and symbol. **(SUMMER 2023, 4 Marks; WINTER 2024, 4 Marks; SUMMER 2026)**

Answer:
Therbligs: Therbligs are the basic fundamental hand motions (18 in number) used in micromotion study to describe manual activities.

Two Therbligs Explained:

- **Grasp (G):** Grasping an object. Symbol: ∩ (open hook/magnet shape). Abbreviation: G.
- **Transport Loaded (TL):** Moving an object with the hand. Symbol: ∪ (open bowl/dish with an object in it). Abbreviation: TL.

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5. Work Measurement:

- **Q.** What is Work measurement? List the various techniques of work measurement and also explain how the Standard time is calculated. **(WINTER 2023, 7 Marks; WINTER 2025, 7 Marks OR; SUMMER 2026)**

Answer:
Work Measurement: Work measurement is the application of techniques to determine the time required by a qualified worker to perform a job at a defined level of performance.

Techniques of Work Measurement:

- Time study (stop-watch)
- Predetermined Motion Time Systems (PMTS) — MTM, PMT
- Work sampling
- Standard data
- Analytical estimating

Calculation of Standard Time:

- Observed Time (OT) = Σ Element times / Number of cycles
- Normal Time (NT) = OT × Rating Factor
- Standard Time (ST) = NT + Allowances
- ST = NT × (1 + Allowance factor)

Allowances include personal, fatigue, and delay allowances.

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6. Ergonomics:

- **Q.** Define ergonomics and explain how it helps to improve system performance. **(SUMMER 2023, 7 Marks OR; WINTER 2024, 7 Marks)**

Answer:
Ergonomics: Ergonomics is the scientific study of the relationship between man and his working environment, aimed at designing work systems for safety, comfort, and efficiency.

How Ergonomics Improves System Performance:

- **Reduced Fatigue:** Proper workstation design (height, reach, seating) reduces physical strain.
- **Improved Safety:** Reduces accidents and musculoskeletal disorders.
- **Increased Productivity:** Comfortable workers perform faster with fewer errors.
- **Better Quality:** Reduced human error leads to fewer defects.
- **Lower Absenteeism:** Healthy working conditions reduce sick leave.
- **Optimal Man-Machine Interface:** Controls and displays designed for human capabilities.

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7. Line Balancing Terms:

- **Q.** Define the following terms: 1. Cycle time 2. Balance Delay 3. Line efficiency. **(SUMMER 2024, 3 Marks; WINTER 2024, 3 Marks)**

Answer:

- **Cycle Time (C):** Time interval between two successive units coming off the line. C = Available time per period / Required output per period
- **Balance Delay (BD):** Measure of idle time on the line due to imbalance. BD = [(nC − Σt(i)) / nC] × 100%, where n = number of workstations, C = cycle time, t(i) = task times.
- **Line Efficiency (LE):** Ratio of total task time to total available time on all stations. LE = [Σt(i) / nC] × 100%

Other Important Questions:

1. Productivity:

- **Q.** Explain the reasons for increase and decrease in productivity. **(WINTER 2022, 4 Marks)**

Answer:

Reasons for Increase in Productivity:

- Improved technology and automation.
- Better worker training and motivation.
- Simplified product design and standardization.
- Efficient material handling and layout.
- Effective management and planning.

Reasons for Decrease in Productivity:

- Obsolete machinery and equipment breakdowns.
- Poor working conditions and low morale.
- Frequent material shortages and supply delays.
- Excessive absenteeism and labour turnover.
- Poor supervision and lack of training.
- Increased rejects and rework.

- **Q.** Which are the various tools and techniques to improve productivity? **(SUMMER 2022, 3 Marks)**

Answer:

- Work Study (Method study + Time study)
- Industrial Engineering Techniques (layout, material handling, line balancing)
- Automation and Mechanization

- Quality Control and SQC
- Incentive and Wage Plans
- Ergonomics and Workplace Design
- Value Engineering
- Inventory Control

- **Q.** Define Production and Productivity. List the factors affecting the Productivity. **(SUMMER 2025, 3 Marks OR)**

Answer:

Production: Production is the process of converting raw materials into finished goods using men, machines, and methods.

Productivity: Productivity is the ratio of output to input.

Productivity = Output / Input

Factors Affecting Productivity:

- Technology and equipment
- Labour skill and motivation
- Material quality and availability
- Management effectiveness
- Working environment
- Government policies

- **Q.** Define the following: 1. Productivity 2. Work study 3. Ergonomics. **(SUMMER 2024, 3 Marks OR)**

Answer:

- **Productivity:** Ratio of output to input; measures efficiency of resource utilization.
- **Work Study:** Systematic examination of work methods and time to improve productivity; includes method study and work measurement.
- **Ergonomics:** Study of relationship between man and his working environment to design safe, comfortable, and efficient work systems.

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2. Method Study:

- **Q.** Explain the objectives of Method study. **(WINTER 2022, 4 Marks)**

Answer:

- **Method Improvement:** Develop simpler and more efficient work methods.
- **Waste Elimination:** Remove unnecessary operations, movements, and delays.
- **Productivity Enhancement:** Increase output per unit input.
- **Workplace Design:** Improve layout and working conditions.
- **Standardization:** Establish standard methods for consistent quality.
- **Cost Reduction:** Lower manufacturing cost through efficient methods.

- **Q.** List the criteria for selecting a particular job for method study. **(WINTER 2023, 3 Marks)**

Answer:

- **High Labour Cost:** Operations with high labour content.
- **Bottleneck Operations:** Processes causing production delays.
- **Repetitive Work:** Jobs done frequently in large quantities.
- **High Reject/Defect Rate:** Operations with quality problems.
- **Excessive Material Handling:** Long distances or frequent movement.
- **Workers' Complaints:** Jobs causing fatigue or dissatisfaction.

- **Q.** Write the basic procedure of the method study. **(SUMMER 2026)**

Answer:
Basic Procedure of Method Study:

1. **Select:** Choose the work to be studied.
2. **Record:** Record existing method using charts and diagrams.
3. **Examine:** Critically examine facts (question: what, why, where, when, who, how).
4. **Develop:** Develop improved method.
5. **Install:** Implement the new method with training.
6. **Maintain:** Monitor and maintain the new method.

- **Q.** Classify different recording techniques. **(SUMMER 2026 OR)**

Answer:
Recording Techniques:

- **Charts:** Operation process chart, flow process chart (material/man/equipment), two-handed process chart, multiple activity chart.
- **Diagrams:** Flow diagram, string diagram, travel chart.
- **Motion Study Records:** SIMO chart, chronocycle graph, cyclegraph.

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3. Process Charts and Diagrams:

- **Q.** Discuss the string diagram in detail. **(WINTER 2025, 3 Marks)**

Answer:
String Diagram: Scaled plan of work area using pins and thread to trace movement paths.

Example: A worker moving between lathe, drilling, and inspection stations—pins at each station, string shows the back-and-forth path and total length.

Advantages:

- Provides precise measure of distance travelled.
- Easy to identify redundant movements.
- Useful for complex and irregular paths.
- Visual comparison of old vs new layouts.
- Helps in layout improvement.

- **Q.** Discuss the String diagram by considering any appropriate example and also state its advantages. **(SUMMER 2024, 7 Marks OR)**

Answer:
String Diagram: Scaled plan of work area using pins and thread to trace movement paths.

Example: A worker moving between lathe, drilling, and inspection stations—pins at each station, string shows the back-and-forth path and total length.

Advantages:

- Provides precise measure of distance travelled.
- Easy to identify redundant movements.
- Useful for complex and irregular paths.
- Visual comparison of old vs new layouts.
- Helps in layout improvement.

- **Q.** What are the symbols used in the Flow Process chart? **(WINTER 2022, 3 Marks)**

Answer:

- ○ **Operation:** A task or activity performed on the material.
- → **Transport:** Movement of material from one place to another.
- □ **Inspection:** Checking quality or quantity.
- **D Delay:** Temporary waiting between activities.
- ▽ **Storage:** Material kept in store, not in process.

- **Q.** Draw and give the meanings of the following symbols used in process charts: (i) Operation (ii) Transport (iii) Storage (iv) Inspection & Operation. **(WINTER 2023, 4 Marks)**

Answer:

Symbol	Name	Meaning
○	Operation	Activity that changes or adds value to material
→	Transport	Movement of material between locations
▽	Storage	Material kept in store awaiting use
□	Inspection	Checking for quality/quantity
○ **inside** □	Combined Inspection & Operation	Simultaneous checking and processing

Diagram Description: Draw the symbols side by side with labels: circle (○) for operation, arrow (→) for transport, triangle (▽) for storage, square (□) for inspection, and square enclosing circle for combined inspection and operation.

- **Q.** What is SIMO chart? **(WINTER 2022, 4 Marks OR)**

Answer:
SIMO Chart (Simultaneous Motion Chart): A chart showing the simultaneous micromotion activities of two or more body parts (usually left and right hands) of an operator, recorded against time.

Features:

- Uses therbligs to describe motions.
- Shows time scale in winks (1/2000 minute).

- Records left-hand and right-hand motions side by side.
- Identifies ineffective motions and idle time.

Purpose: Detailed motion analysis for improving work methods and reducing cycle time.

- **Q.** Explain chronocycle graph. **(SUMMER 2026 OR)**

Answer:
Chronocycle Graph: A motion study record in which a small light is attached to the operator's hand/finger and photographed with a still camera and interrupted light source.

Features:

- Produces a 3D path of motion with direction and speed.
- Interrupted light gives dotted line—spacing indicates speed.
- Shows acceleration and deceleration.
- Used for micromotion analysis of highly repetitive tasks.

Purpose: To study and improve the path, speed, and smoothness of hand motions.

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4. Micromotion Study and Therbligs:

- **Q.** Prepare a list of Therbligs used in the industry. (Any Eight) **(WINTER 2025, 4 Marks OR)**

Answer:

- Search (Sh) — locating an object
- Find (F) — recognizing an object
- Select (St) — choosing among objects
- Grasp (G) — grasping an object
- Transport Loaded (TL) — moving with object
- Position (P) — placing object in position
- Assemble (A) — joining parts
- Inspect (I) — checking object
- Use (U) — using a tool
- Release Load (RL) — letting go of object

- **Q.** What is Therblig? State its importance in micro motion study. **(SUMMER 2024, 4 Marks OR)**

Answer:
Therblig: A therblig is a basic fundamental hand motion used to describe manual work in micromotion study (18 therbligs total).

Importance:

- Helps classify effective and ineffective motions.
- Identifies unnecessary motions for elimination.
- Enables detailed motion analysis of repetitive work.
- Helps design improved work methods.
- Forms basis for predetermined motion time systems (MTM, PMT).

- **Q.** State the importance of micromotion study. **(WINTER 2025, 4 Marks)**

Answer:

- **Detailed Motion Analysis:** Studies fundamental motions (therbligs) to identify waste.
- **Method Improvement:** Eliminates ineffective motions and improves work methods.
- **Time Reduction:** Reduces cycle time by simplifying motions.
- **Standardization:** Helps establish standard motion patterns.
- **Training:** Used for training operators in best methods.
- **Ergonomics:** Improves workplace design based on motion analysis.

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5. Time Study and Work Measurement:

- **Q.** List the equipment used for time study and explain the fly-back timing method. **(WINTER 2025, 3 Marks OR)**

Answer:

Equipment: Stop-watch (fly-back or non-fly-back), time study board, observation sheet, pencil, calculator.

Fly-Back Timing Method: In this method, the watch is reset to zero after each element by pressing a knob; the time of each element is read directly. It is faster and reduces calculation, but there is a slight error at reset.

- **Q.** How is time study carried out? Explain the equipment used for carrying out time study. **(SUMMER 2022, 7 Marks OR)**

Answer:

Time Study Procedure:

1. Select the job and operator.
2. Break job into elements.
3. Record method and working conditions.
4. Measure element times using stop-watch.
5. Rate operator performance.
6. Apply allowances.
7. Calculate standard time.

Equipment Used:

- **Stop-watch:** Fly-back or non-fly-back type for recording element times.
- **Time Study Board:** Holds watch and observation sheets.
- **Observation Sheet:** Records element times and ratings.
- **Pencil/Calculator:** For recording and calculations.
- **Measuring Instruments:** For measuring dimensions.

- **Q.** Explain fly back stop watch and non-fly back stop watch. **(SUMMER 2026, 3 Marks OR)**

Answer:

- **Fly-Back Stop Watch:** The watch is reset to zero after each element by pressing a knob; each element time is read directly. Faster but slight error at reset.
- **Non-Fly-Back Stop Watch:** The watch runs continuously; the observer notes the reading at the end of each element and subtracts consecutive readings. More accurate but requires calculation.

- **Q.** Define allowance. State the importance of allowance. **(SUMMER 2025, 3 Marks)**

Answer:

Allowance: Allowance is the time added to the normal time to account for legitimate interruptions, fatigue, and personal needs of the worker.

Importance:

- Compensates for personal needs (drinking water, rest).
- Accounts for fatigue from work.
- Covers unavoidable delays (tool breakage, material shortage).
- Makes standard time fair and achievable.
- Prevents worker dissatisfaction and rate-cutting.

- **Q.** Explain: 1) Observed time 2) Rating Factor 3) Standard time 4) Normal Time 5) Working environment 6) Anthropometry. **(SUMMER 2025, 4 Marks)**

Answer:

- **Observed Time (OT):** Average time taken by the worker as measured by stop-watch.
- **Rating Factor (RF):** Factor by which observed time is adjusted to reflect the worker's performance relative to standard (e.g., 100% = normal).
- **Standard Time (ST):** Time required by a qualified worker at normal pace with allowances. ST = NT × (1 + Allowance)
- **Normal Time (NT):** Observed time adjusted for rating. NT = OT × RF
- **Working Environment:** Surrounding conditions (light, temperature, noise, ventilation) affecting work performance.
- **Anthropometry:** Study of body dimensions used to design workplaces, tools, and equipment for comfort and efficiency.

- **Q.** Write short notes on: 1. MTM 2. PMT. **(SUMMER 2025, 4 Marks OR)**

Answer:

1. MTM (Methods-Time Measurement): A predetermined motion time system where basic motions (reach, move, grasp, etc.) have standard time values in TMU (1 TMU = 0.00001 hour). Used to set standard time without stop-watch.

2. PMT (Predetermined Motion Time): A family of systems (MTM, Work Factor, Basic Motion Time) that assign standard time values to fundamental motions. Used for estimating time before production begins.

- **Q.** Write in brief about work content. **(SUMMER 2023, 3 Marks OR)**

Answer:

Work Content: Work content is the total time required to perform a job using a specified method and including all necessary allowances.

Work Content = Basic Time + Allowances

It includes basic work, process time, and non-productive time (waiting, setup). Reducing work content through method improvement increases productivity.

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6. Ergonomics:

- **Q.** Write a short note on: Ergonomics. **(SUMMER 2025, 3 Marks OR)**

Answer:

Ergonomics (Human Factors Engineering): Study of designing work systems, tools, and workplaces to match human capabilities and limitations.

Key Areas:

- Anthropometry (body dimensions)
- Biomechanics (forces on body)
- Environmental factors (light, noise, temperature)
- Cognitive ergonomics (mental workload)

Benefits: Reduces fatigue and injury, improves productivity and job satisfaction.
