Production Automation
IENG 360
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Lecture Series 1

Introduction to Automation

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Introduction to Automation

Aim:

- This topic introduces the historical and technological evolution of production automation, tracing the progression from early mechanized production to modern digitalized manufacturing systems.
- It establishes conceptual, historical, and technological foundations for all subsequent technical topics

Learning Objectives

By the end of this lecture, students will be able to:

- Describe the historical evolution of production automation
- Distinguish mechanization from automation
- Explain industrial automation systems
- Understand the role of digitalization in modern production
- Relate automation evolution to productivity and sustainability

Why Study the Evolution of Automation?

Automation did not emerge suddenly

Each stage solves the limitations of the previous one

Understanding evolution helps:

- Design better systems
- Select appropriate automation levels
- Anticipate future trends

Manual Work

Manual work refers to tasks that are carried out **entirely by human effort**, without the assistance of machines or automation. It usually involves **physical labor**, but it can also include repetitive clerical or cognitive tasks that are done by hand.

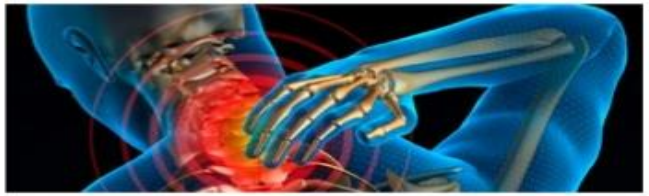
Key Features of Manual Work

1. **Human Effort Only** – Work is performed using human strength, skill, and time.
2. **Low Productivity** – It is slower compared to mechanized or automated work.
3. **Prone to Errors** – Mistakes are more common due to fatigue or inattention.
4. **Labor-Intensive** – Requires more workers for large tasks.
5. **Limited Scalability** – Hard to expand output without adding more human workers.

Manual Work and Side Effects

2. Damage to the musculoskeletal system of the body (muscles, ligaments, bones, joints, blood vessels and nerves) as a consequence of repetitive manual handling. These injuries are called 'musculoskeletal disorders' (MSDs) and can be divided into 3 groups:

- Neck and upper limb disorders
- Lower limb disorders
- Back pain and back injuries.



Stages of Evolution

Production systems evolved through stages:

1. Industrial Revolution & Industrialization
2. Mechanization
3. Automation
4. Industrial Automation
5. Digitalization (Industry 4.0)

Evolutionary Stages

Stage	Concept	Key Message
Stage 1	Industrial Revolution & Industrialization	Birth of factory-based production
Stage 2	Mechanization	Machines assist and replace human physical labor
Stage 3	Automation	Control systems reduce human intervention
Stage 4	Industrial Automation	Integrated automated production systems
Stage 5	Digitalization	Smart, connected, data-driven production

Industrial Revolution & Industrialization

Industrial Revolution

- **(Late 18th – 19th Century)**
- Introduction of steam power and basic machines
- Shift from manual craft to machine use
- Birth of factories
- **Key idea:** Machines appear, but control remains human

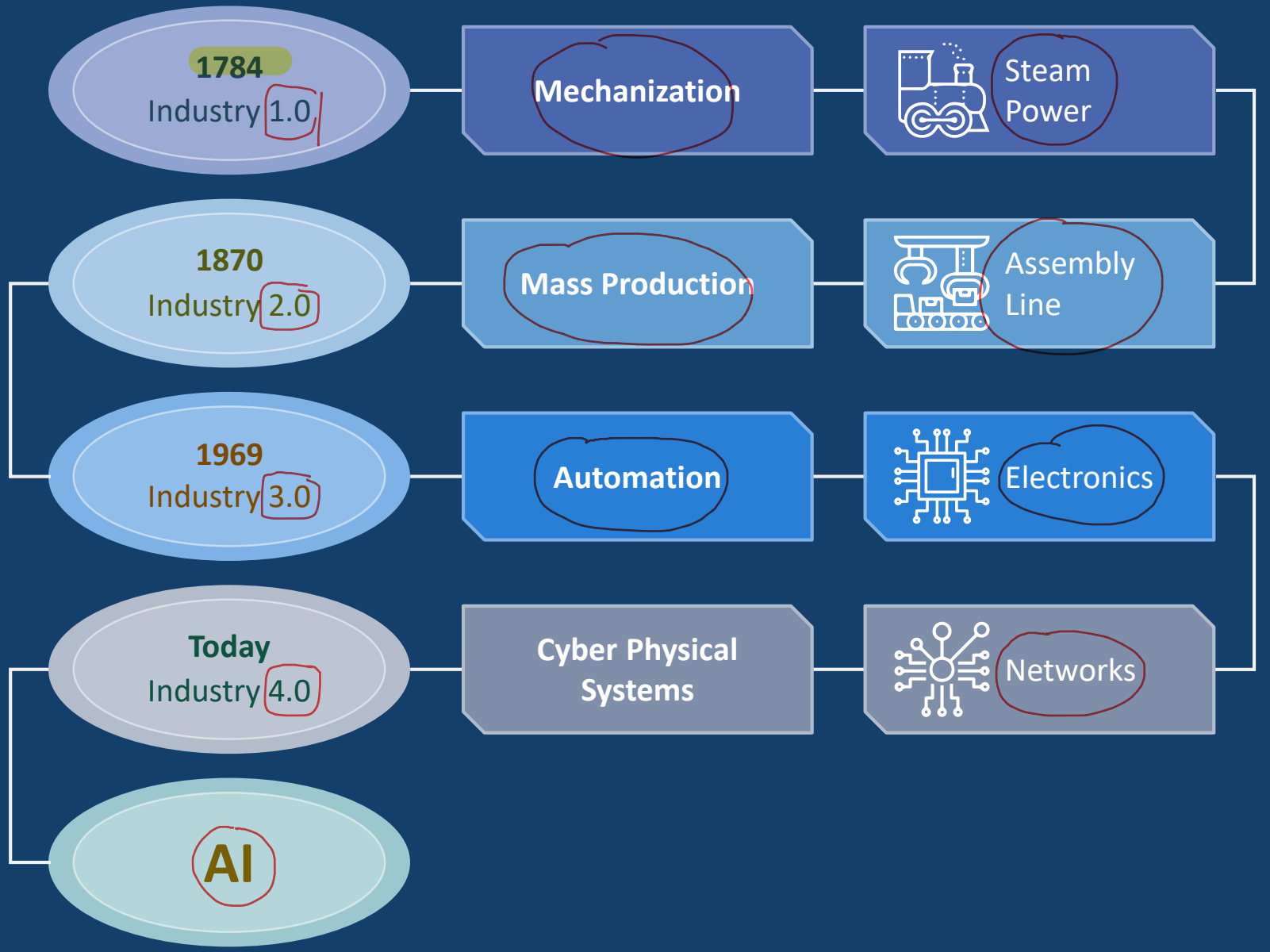
Industrialization

- Large-scale factory production
- Division of labor
- Standardization of products
- Rapid increase in output

Impact:

- Higher productivity
- Urbanization
- Workforce transformation

Industrial Revolution Time Lines and Technologies



What is Industrialization?

Definition

Industrialization is the process by which an economy or society transforms from being primarily agricultural and manual-work–based into one that is dominated by industry, manufacturing, mechanization, and modern technology.

It involves the large-scale use of machines, factories, and division of labor to produce goods and services more efficiently.

Key Features of Industrialization

- Shift from Agriculture to Industry – Production moves from farms to factories
- Use of Machines – Mechanization replaces manual labor for mass production
- Urbanization – People move from rural areas to cities for factory jobs
- Mass Production – Standardized goods produced at large scale
- Improved Transportation & Communication – Railways, shipping, and telegraph systems developed
- Rise of Capital Investment – Large factories and infrastructure required financial backing
- New Labor Systems – Division of labor, specialization, and time discipline introduced.

What is Mechanization?

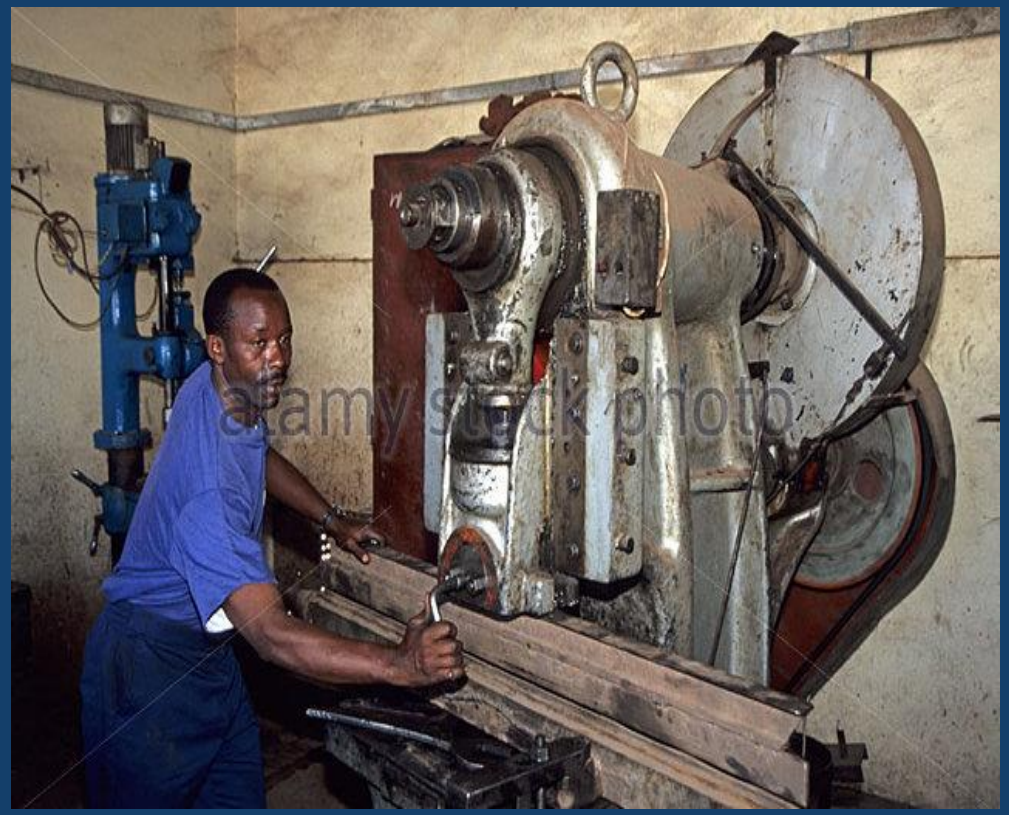
Mechanization

- Machines replace **human physical effort**
- Still human-operated
- Examples:
  - Mechanical looms ✓
  - Conveyor belts ✓
  - Power presses ✓
- **Key distinction:**
  → Human decides *when* and *how* the machine works

Limitations of Mechanization

- Requires continuous human supervision
- Inconsistent quality
- Limited speed and precision
- High dependency on operator skill
- → Leads to the need for **automation**

Mechanization
Use of Powered Equipment and Machines



Mechanization and Automation

What is Automation?

- Machines perform tasks **with minimal human intervention**
- Use of control systems and feedback
- Repeatable and consistent operations
- **Examples:**
  - Automatic filling machines
  - Temperature-controlled furnaces

Mechanization vs Automation

Mechanization	Automation
Human-controlled	System-controlled
Physical assistance	Decision & control
Operator-dependent	Repeatable & precise

Industrialization vs. Mechanization vs. Automation

- **Mechanization**: Use of machines to assist physical work (e.g., tractor).

- **Industrialization**: Large-scale societal/economic shift using machines and factories.

- **Automation**: Systems and machines not only replace physical labor but also decision-making.

Beginnings of Industrialization

01
Industrial Revolution
Great increase in machine production that began in England in the 18th century.

02
Enclosure
Large closed-in field for farming.

03
Crop Rotation
Planting a different crop in another field each year.

04
Industrialization
Process of developing machine production of goods.

05
Factors of Production
Conditions needed to produce goods and services.

06
Factory
Building where goods are made.

07
Entrepreneur
Person who organizes, manages, & takes on the financial risk of business enterprise.

Impact of Industrialization

01 A major role in economic development for underdeveloped countries.

02 Provided a secure basis for the rapid growth of income.

03 Helped in raising the standard of living.

04 Provided employment, meeting high-income demands.

05 It brings in technological progress and change in the outlook of the people.

06 Has decreased the dependency on foreign resources.

07 The government took over the sick units, which the public sector financial institutions cannot rehabilitate.

INDUSTRIALIZATION IN DIFFERENT FIELDS

Successful Industrialization

Industrialization Benefits & Challenges

Benefits	VS	Challenges
Created Jobs	01	Crowded Cities
Wealthy middle class	02	Pollution
Wages rose	03	Struggle for survival in slums
Labor unions win the right to bargain.	04	Harsh working conditions in factories and mines
Reformers improved working conditions	05	Child labour

Key Features of Automation

Key Features of Automation

1. **Reduced Human Involvement** – Systems work automatically once programmed or set.
2. **Consistency and Accuracy** – Fewer errors compared to manual or mechanized work.
3. **Speed and Efficiency** – Tasks are performed faster and continuously.
4. **Control Systems** – Often uses sensors, software, and feedback loops.
5. **Scalability** – Can handle large volumes of work without adding more workers.

Industrial Automation

Industrial Automation

- Automation applied specifically to **industrial production**

Core components:

- Sensors
- Actuators
- Controllers (PLCs)
- Machines & production lines

Goal: Efficient, safe, and reliable production

Typical Industrial Automation System

Conceptual structure:

- Input: Sensors (temperature, position, pressure)
- Processing: PLC / controller
- Output: Motors, valves, robots
- Feedback loop

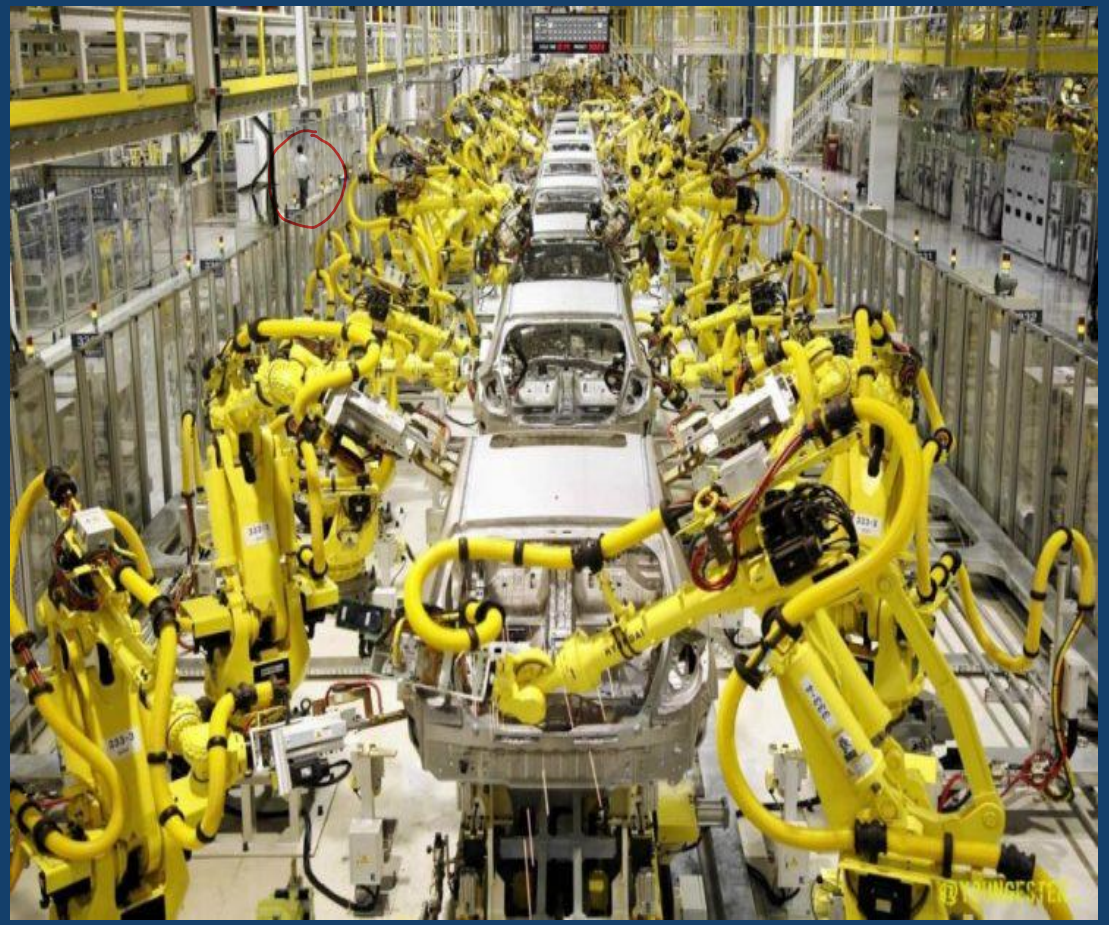
→ Foundation of modern factories

WHAT IS INDUSTRIAL AUTOMATION?

INDUSTRIAL AUTOMATION

Industrial automation is a set of technologies that uses control systems and devices, such as computer software and robotics, to enable automatic operation of industrial processes and machinery without the need for human operators. Industrial automation eliminates the possibility of human error, reduces costs, saves time, and achieves higher performance.

Automation is the technology by which a process or procedure is performed with MINIMAL HUMAN ASSISTANCE

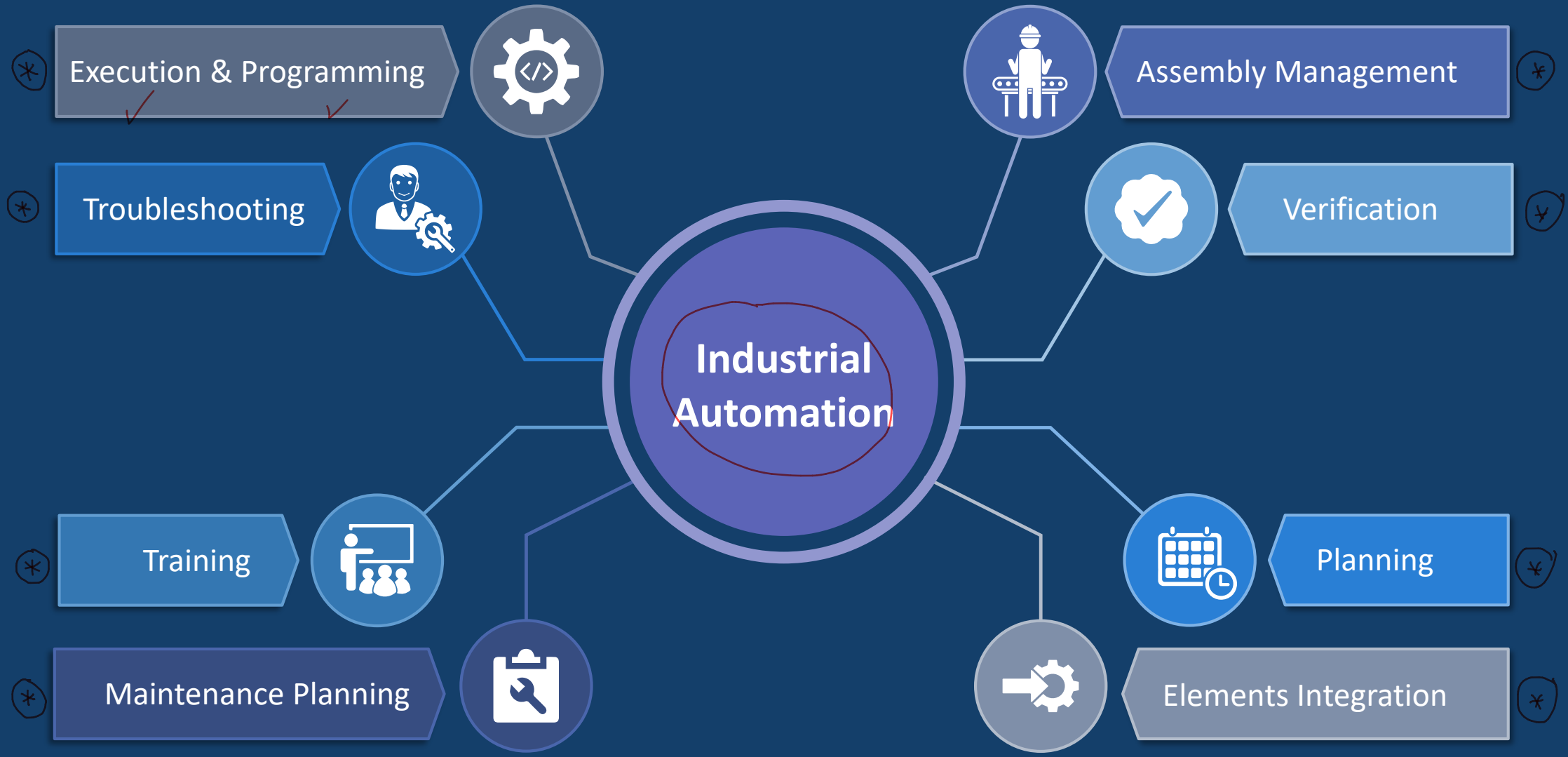


Benefits of Industrial Automation

- Increased productivity
- Improved quality and consistency
- Reduced human error
- Enhanced safety
- Lower long-term operational cost

Advantages of Industrial Automation

Steps to Follow to Implement an Industrial Automation System



Levels in Industrial Automation

Industrial Automation Applications

Digitalization

Definition

Process of using digital technologies (computers, sensors, internet, cloud, big data, IoT, AI, etc.) to transform processes, services, and business models

It is not just about replacing paper with computers (that's digitization) — it's about re-thinking and improving how work is done through smart, connected, data-driven systems

Key Features of Digitalization

- Data-Driven – Information is collected, processed, and analyzed in real time
- Connectivity – Systems, devices, and people are interconnected (IoT, cloud)
- Smart Decision-Making – AI, analytics, and dashboards support or automate choices
- Customer-Centric – Improves services, personalization, and accessibility
- Business Transformation – Enables new business models (e.g., e-commerce, ride-sharing, telemedicine).

Digitalization in Production

- Integration of digital technologies
- Data-driven decision-making
- Connectivity across systems

Key technologies:

- IoT
- Cloud computing
- AI and analytics
- Cyber-physical systems

Examples of Digitalization

1. Smart Cities: IoT waste bins that send alerts and optimize truck routes.
2. Healthcare: Electronic medical records (EMR) accessible across hospitals
3. Education: Online learning platforms with real-time analytics
4. Banking: Mobile apps for payments, transfers, and fraud detection
5. Manufacturing: Industry 4.0 with digital twins, predictive maintenance, and real-time monitoring

Digitalization vs. Digitization

Digitization = Converting analog → digital (e.g., scanning paper documents into PDFs)

Digitalization = Using digital tools to transform processes (e.g., replacing manual patient logbooks with an integrated hospital information system that automates reporting).

From Automation to Smart Production

Traditional Automation

- Fixed logic
- Limited flexibility

Digitalized Production

- Adaptive systems
- Real-time monitoring
- Predictive maintenance
- → Often referred to as **Industry 4.0**

Key Takeaways

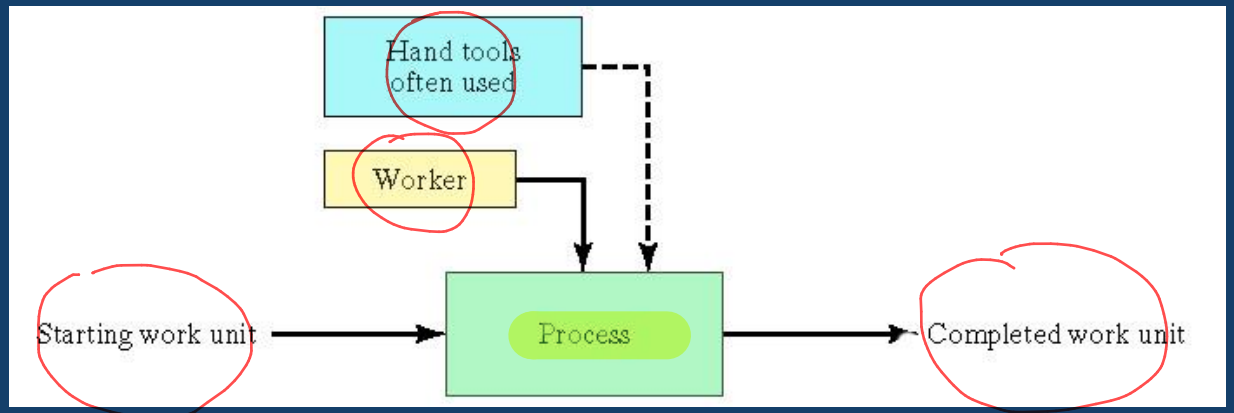
- Production automation is evolutionary, not sudden
- Mechanization ≠ Automation
- Industrial automation enables modern manufacturing
- Digitalization represents the future of production
- Understanding evolution improves system design decisions

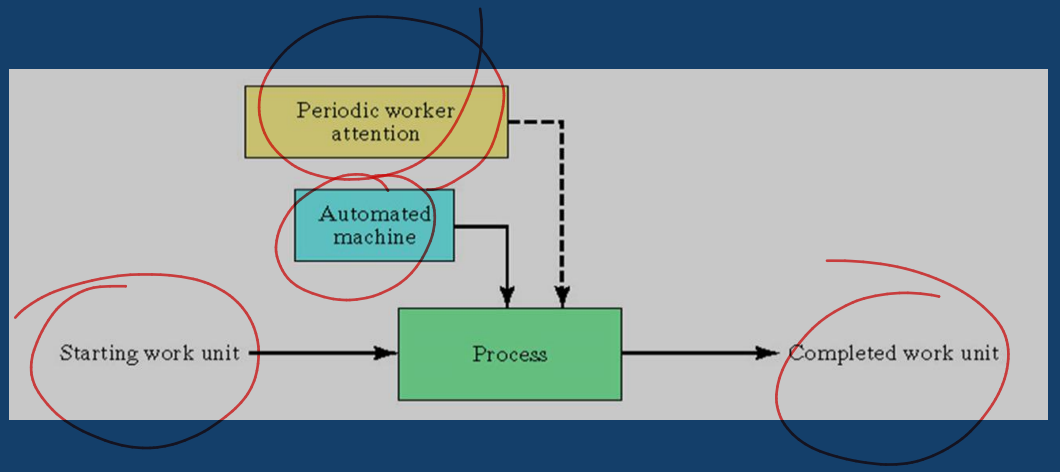
Automation in Production Systems

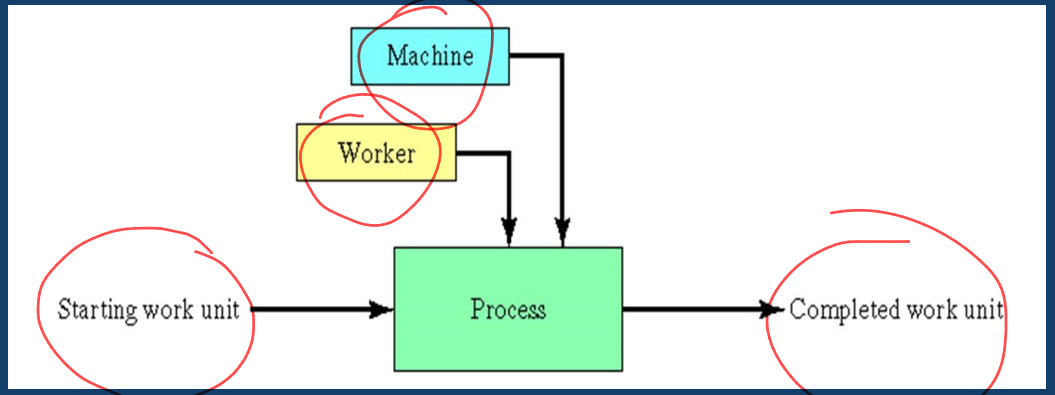
Three categories in terms of the human participation in the processes performed by the manufacturing system:

1. Manual work systems - a worker performing one or more tasks without the aid of powered tools, but sometimes using hand tools
2. Worker-machine systems - a worker operating powered equipment
3. Automated systems - a process performed by a machine without direct participation of a human

Automation in Production SystemsManual Work System

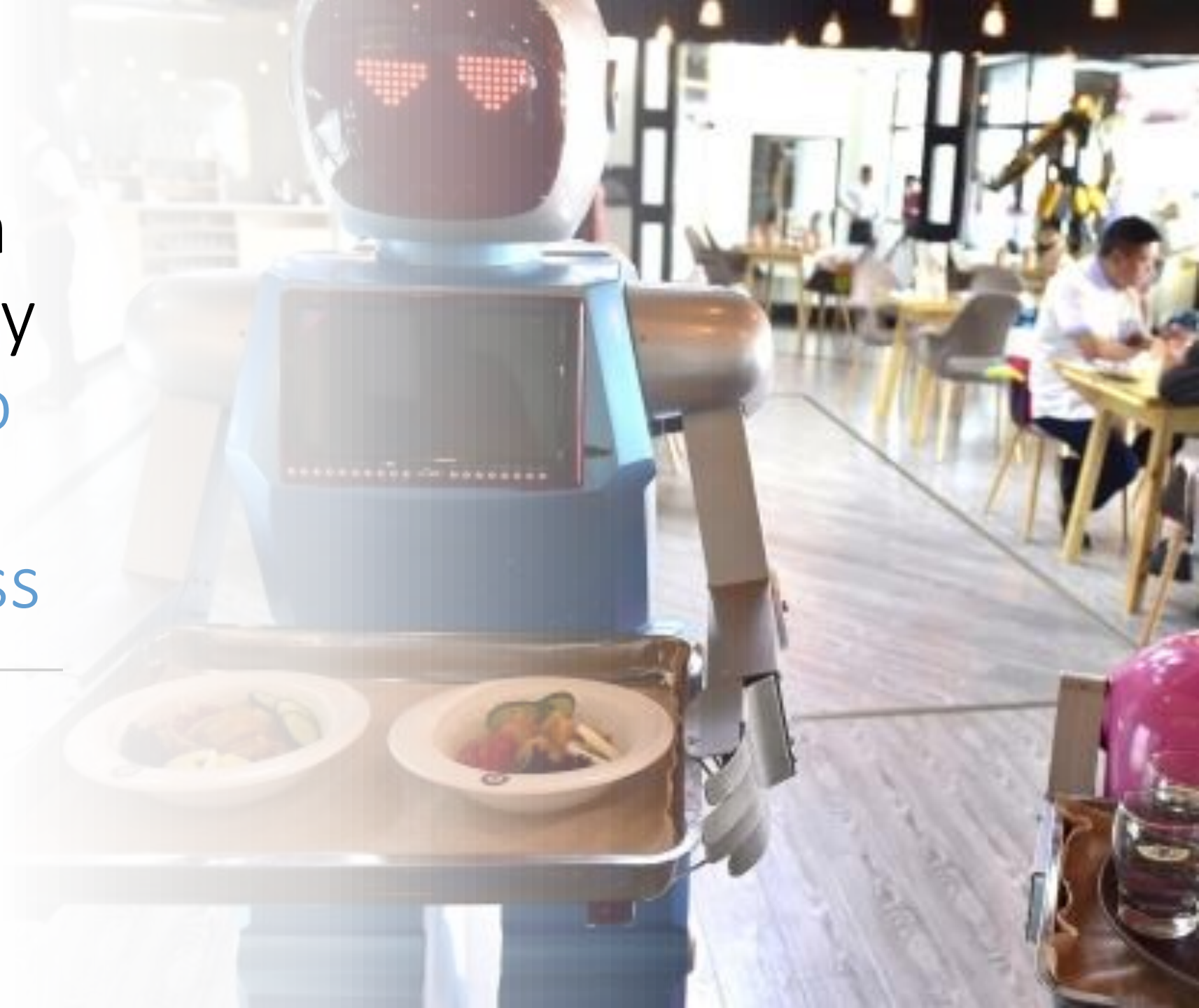






Automation in Service Industry

Automation to Replace Waiter/Waitress



Automation to replace Chefs what are the pros and cons?

Japan’s robot chefs aim to show how far automation can go - AI

Automation in Healthcare

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Thank You