# Production Automation
# IENG 450

Course instructor: Dr Samer Gowid

# Course contents

1. Automated manufacturing system types/technologies and automation principles and strategies
2. Basic elements of automation systems, advanced automation functions, and levels of automation
3. Hardware components of automated equipment
4. Process and discreet manufacturing industries and industrial control system types (discreet, continuous/analog)
5. Computer process control capabilities and forms (NC, CNC and PLC)
6. Fundamentals of robotics and kinematics
7. Automated materials handling systems and analysis of automated production systems

# Ch 1 Introduction

**Sections:**

1. Production Systems
2. Automation in Production Systems
3. Manual Labor in Production Systems
4. Automation Principles and Strategies

# What is a Production System ?

A collection of people, equipment, and procedures organized to accomplish the manufacturing operations of a company

**Two categories:**

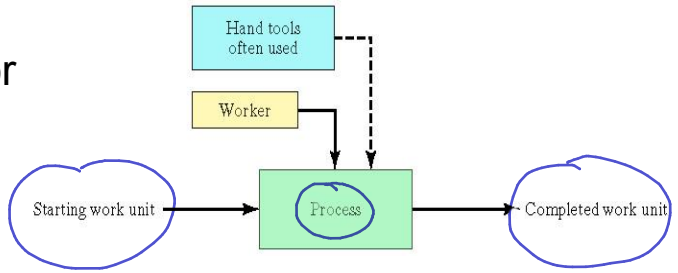
- **Facilities** – the plant layout or the way the equipment is physically placed and the manufacturing system or the logical grouping of equipment and workers (*Plant layout and Manufacturing systems*)

- **Manufacturing support systems** – the set of procedures used by a company to manage production and to solve technical and logistics problems in ordering materials, moving work through the factory, and ensuring that products meet quality standards (*logistics, management, accounting and billing, design, marketing departments*)

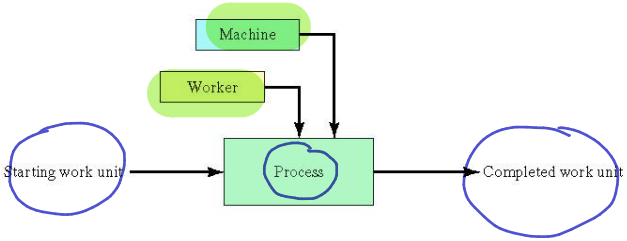
# Facilities: Manufacturing Systems

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

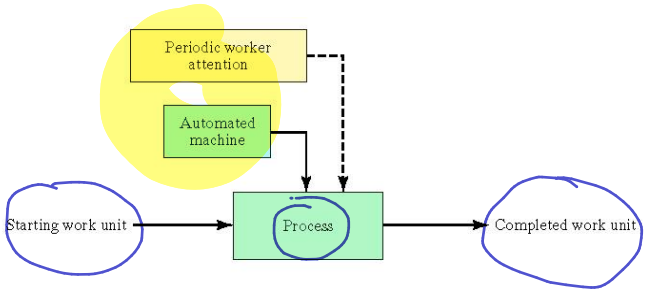



2. **Worker-machine systems** - a worker operating powered equipment

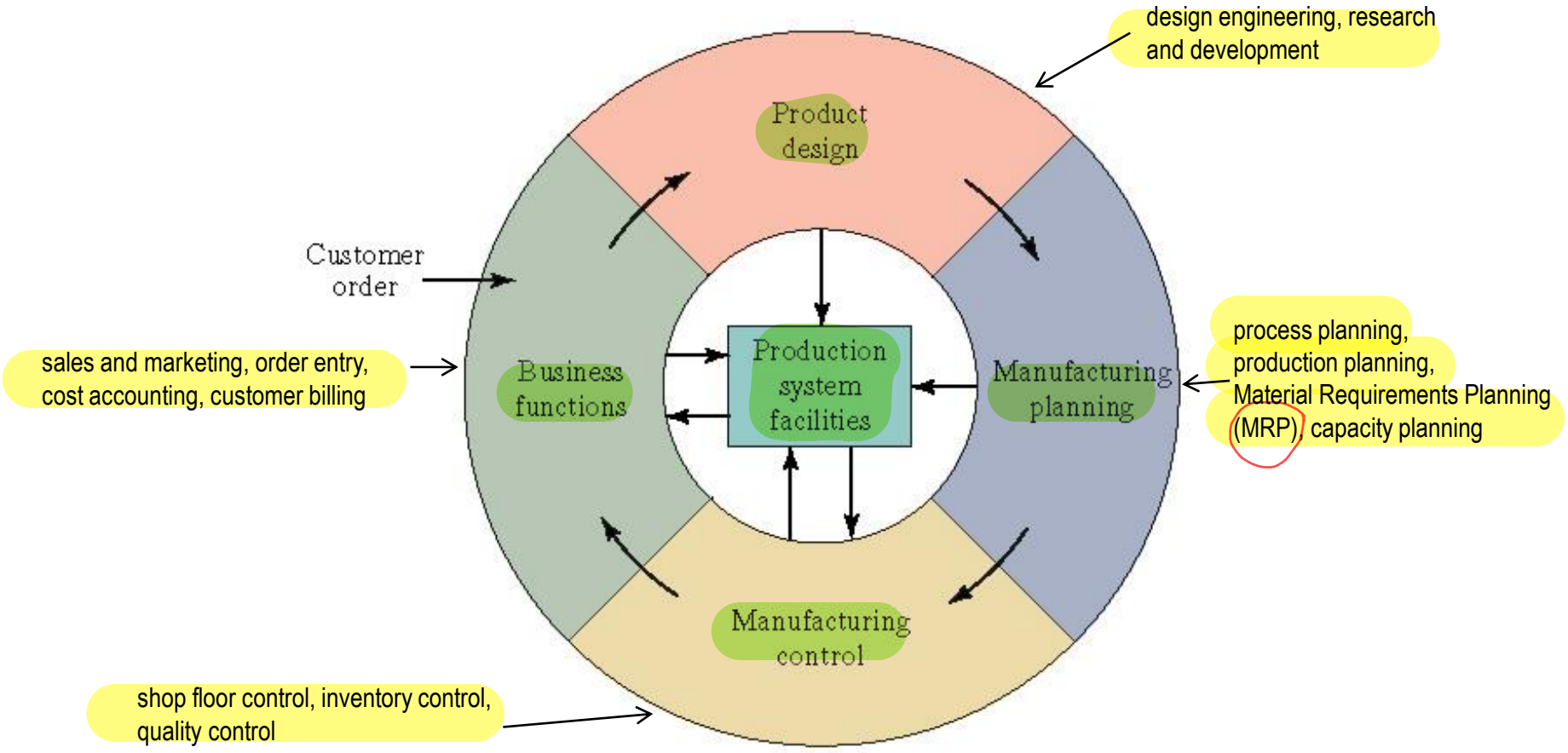



3. **Automated systems** - a process performed by a machine without direct participation of a human – with minimum participation

   (see the next three slides)



# Processing Cycle of Manufacturing Support Systems



# Manufacturing Support Systems

Involves a cycle of information-processing activities that consists of four functions:

1. **Business functions** - sales and marketing, order entry, cost accounting, customer billing

2. **Product design** - design engineering, research and development

3. **Manufacturing planning** - process planning, production planning, Material Requirements Planning (MRP), capacity planning

4. **Manufacturing control** - shop floor control, inventory control, quality control (see the cycle in the previous slide)

# Reasons for Automation

1. To increase labor productivity
2. To reduce labor cost
3. To mitigate the effects of labor shortages
4. To reduce or remove routine manual and clerical tasks
5. To improve worker safety
6. To improve product quality
7. To accomplish what cannot be done manually
8. To reduce manufacturing lead time * (initiation to completion)

*Lead time: period of time between a purchase order being placed and the manufacturer completing the order. **Lead time = pre-processing + processing + post-processing** , where: Pre-processing is a time needed for, handling the order, making sales order, and preparing supplies; Processing is a period when you make or collect the order.

# Automation in Production Systems

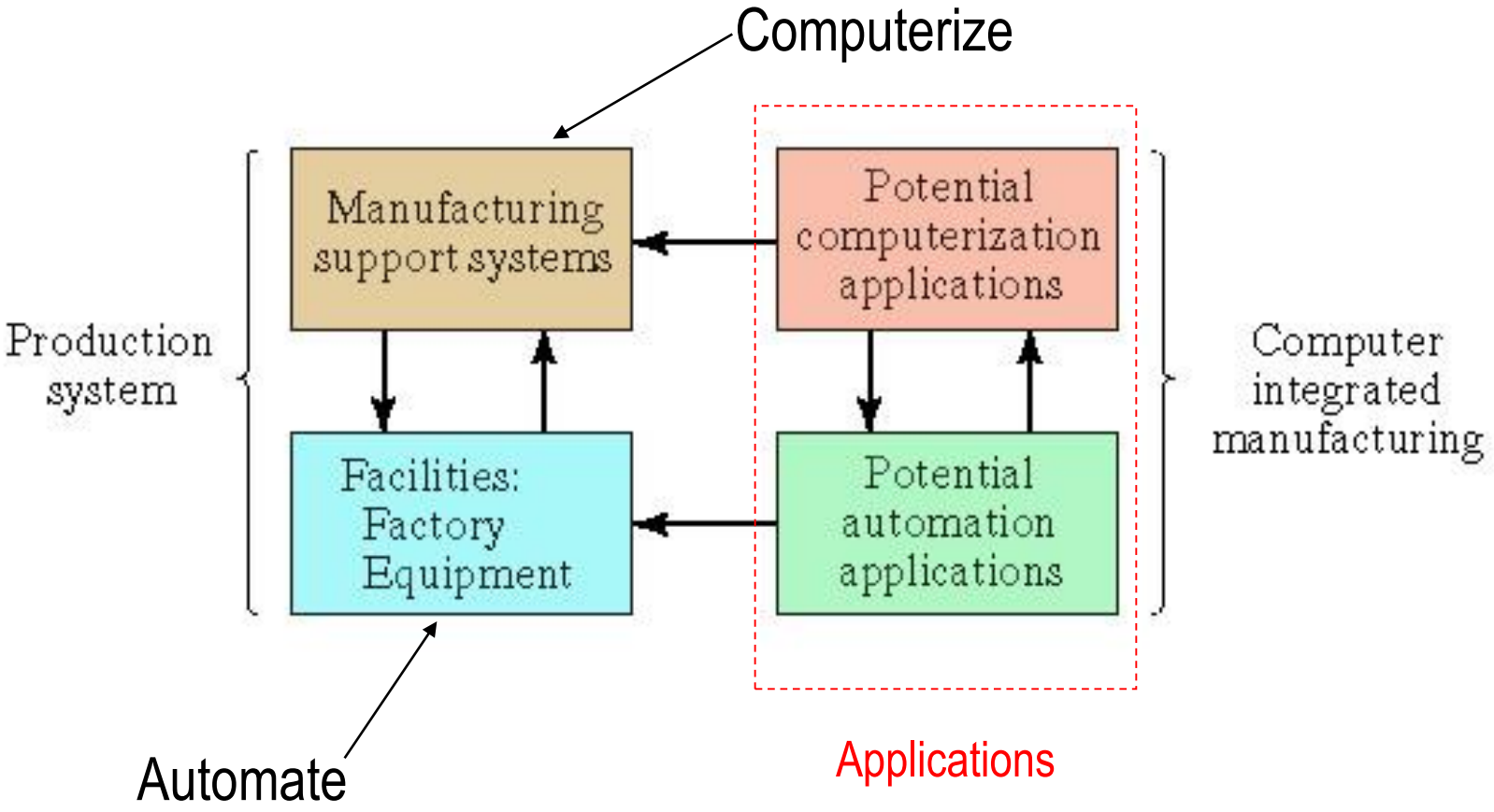
**Two categories of automation** in a production system:

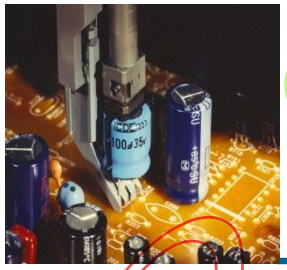
1. **Automation** of manufacturing/production systems in the factory

2. **Computerization** of the manufacturing support systems

- The two categories overlap because manufacturing support systems are connected to the factory manufacturing systems
  - The fully automated system is called **Computer-Integrated Manufacturing (CIM)** system

# Computer Integrated Manufacturing (CIM)





# Two Types of Modern Manufacturing Automation Approaches and Technologies

- **(a) Automated Manufacturing systems** - integration and coordination of multiple automated or manual workstations
  - **Automated Manufacturing System** - automated equipment instead of labor-operated equipment
    - **Fixed/hard automation** – high-production rate/ no flexibility
    - **Programmable Automation** – low-production rate/medium flexibility
    - **Flexible Automation** – medium-production rate/ high flexibility (also called Flexible Manufacturing Systems (FMS))
  - **Computer-Integrated Manufacturing (CIM)** - to integrate design, production, and logistics (*automated manufacturing system* + *computerized manufacturing support systems*)
- **(b) Automated materials handling technologies** - because manufacturing usually involves a sequence of machines which should be connected by an automated materials handling system, e.g.; transfer lines (or manufacturing line)

Example of an automatic transfer line: https://www.youtube.com/watch?v=Hg-FjrD6Bbo

# Automated Manufacturing Systems

**Three basic types:**

1. Fixed automation
2. Programmable automation
3. Flexible automation

The designer choice should be based on the following factors: **product variety** and **production quantity**.

# 1- Fixed Automation

A manufacturing system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration

Question 3 10 out of

What manufacturing automation strategy would you recommend to achieve a high overall production quantity?

**Typical features:**

- Suited to high production quantities and High production rates
- High initial investment for custom-engineered equipment
- Relatively inflexible in accommodating product variety (drawback)
- Shortest manufacturing lead time

Manufacturing Lead Time

The manufacturing lead time is the time period between the placement of an order and the shipment of the completed order to the customer. This includes order preparation time, queue time, setup time, run time, move time, inspection time, and put-away and shipment time

# 2- Programmable Automation

A manufacturing system designed with the capability to change the sequence of operations to accommodate different product configurations – long lead time -

**Typical features:**

- High investment in general purpose equipment
- Low production rates
- Flexibility to deal with variations and changes in product configuration
  - Most suitable for batch production
- Physical setup and part program must be changed between jobs (batches)- relatively long manufacturing lead time

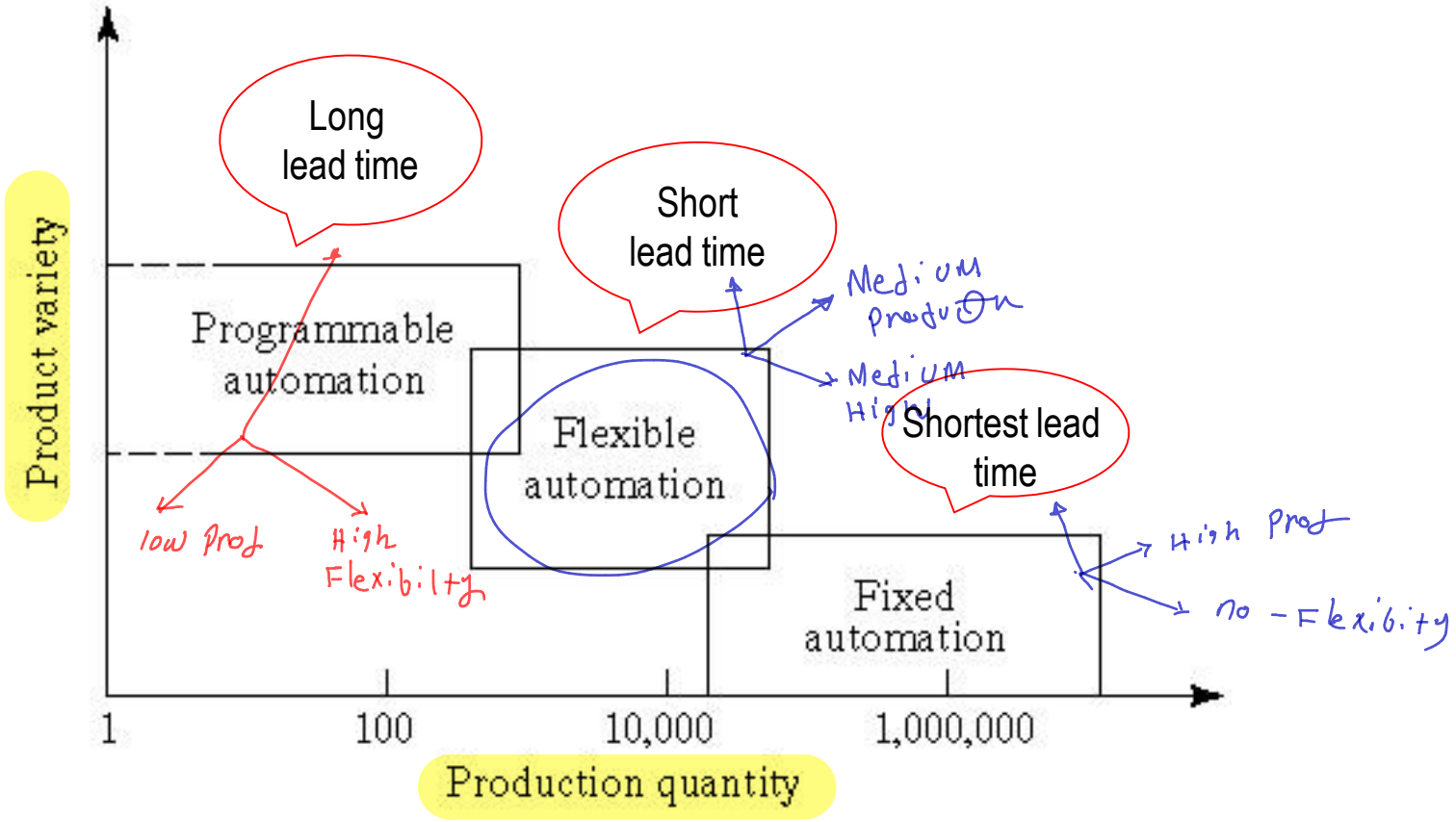
# 3- Flexible Automation (FMS)

An extension of programmable automation in which the system is capable of changing over from one job to the next with no lost time between jobs

**Typical features**:

- High investment for custom-engineered system
- Medium production rates
- High flexibility to deal with soft product variety
- Continuous production of variable mixes of products - relatively short manufacturing lead time

# Product Variety and Production Quantity for Three Automation Types




Ch 1
Ch 2

# Group discussion

- Which manufacturing system is best suited for the production of

a. Medium product variety

Flexible Manufacturing System

b. Wide product variety and a small production rate

Programmable Manufacturing System

c. Single product and a high production rate

Hard Manufacturing System

- Sort the manufacturing systems, in ascending order, according to their manufacturing lead-times

1- Hard (Shortest or NA), 2-Flexible (short ) and 3- Programmable (longest)

# Computerized Manufacturing Support Systems – Computer-Integrated-Manufacturing (CIM)

**Objectives of automating the manufacturing support systems:**

- To reduce the amount of manual and clerical effort in product design, manufacturing planning and control, and the business functions
- Integrates computer-aided design (CAD) and computer-aided manufacturing (CAM) in a CAD/CAM module

Hence,

- CIM includes CAD/CAM and the business functions of the firm

Example: Much **clerical effort** is expended by the store when inventory is managed by strictly manual procedure, including data entry, records, inventory control, …, all other administrative work.

# Manual Labor in Production Systems

Is there a place for manual labor in the modern production system?

- Answer: YES

- Where?
  1. Labor in manual factory operations
  2. Labor in manufacturing support systems

# Labor in Manual Factory Operations

The long term trend is toward greater use of automated systems to substitute for manual labor

- When is manual labor justified?
  - Some countries have very low labor rates (salaries), then automation cannot be justified
  - Task is too technologically difficult to automate
  - Short product life cycle requires high manufacturing flexibility
  - Customized product requires human flexibility
  - To cope with ups and downs in demand
  - To reduce risk of product failure

# Labor in Manufacturing Support Systems

- *Product designers* who bring creativity to the design task
- *Manufacturing engineers* who
  - Design the production equipment and tooling
  - Plan the production methods
- Equipment maintenance
- Programming and computer operation
- Engineering project work
- Plant management
- Sales and marketing

# Automated Manufacturing System components

- Production Lines
  - Production Cells
  - Machines
    - Actuators
    - Sensors
- Assembly Lines
  - Assembly Cells
  - Machines
    - Actuators
    - Sensors
- Material Handling Systems
  - Transfer lines
  - Robots
- Storage Systems (ASRS)

# Automated Manufacturing Systems

**Include**

- Automated machine tools
- Transfer/flow/manufcaturing lines
- Automated assembly systems
- Industrial robots that perform processing or assembly operations

- Automated material handling and storage systems to integrate manufacturing operations
- Automatic inspection systems for quality control

# Automation Principles and Strategies

1. The USA Principle
2. Automation Migration Strategy

Important

# U.S.A Principle

1. Understand the existing process
   - Input/output analysis
   - Charting techniques and mathematical modeling

2. Simplify the process
   - Reduce unnecessary steps and moves by eliminating unneeded processes and by combining operations (*performing more than one operation at a given machine*)

3. Automate the process
   - Automation migration strategy
   - Ten strategies for automation and production systems, click here for more information. Please read and understand the 10 automation strategies

# Automation Migration Strategy For Introduction of New Products (steps to a fully automated system)

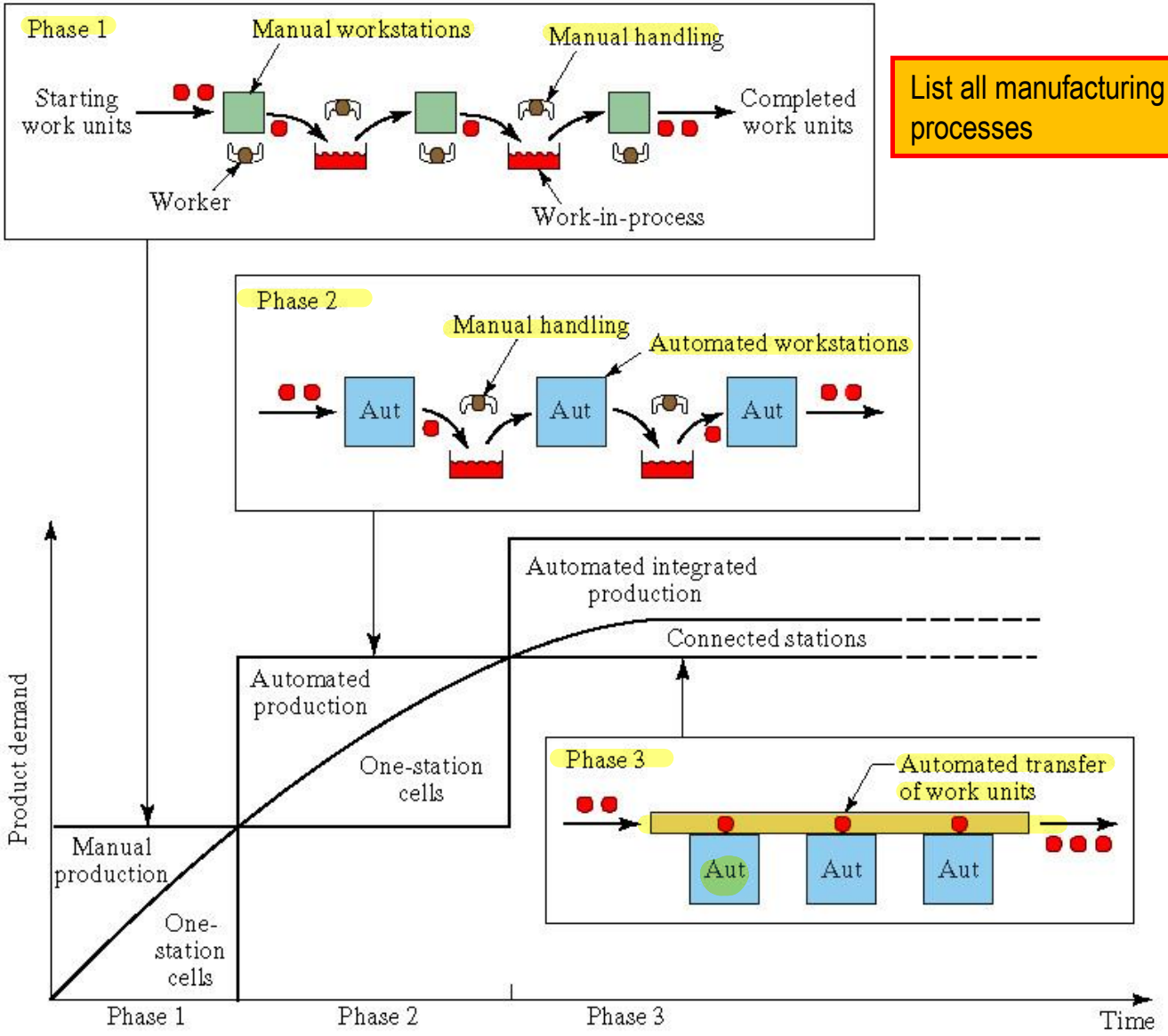
1. Phase 1 – Manual production
   - Single-station manned cells working independently
   - Advantages: quick to set up, low-cost tooling

2. Phase 2 – Automated production
   - Single-station automated cells operating independently
   - As demand grows, automation can be justified

3. Phase 3 – Automated integrated production
   - Multi-station system with serial operations and automated transfer of work units between stations (transfer lines)

# Automation Migration Strategy

List all manufacturing processes

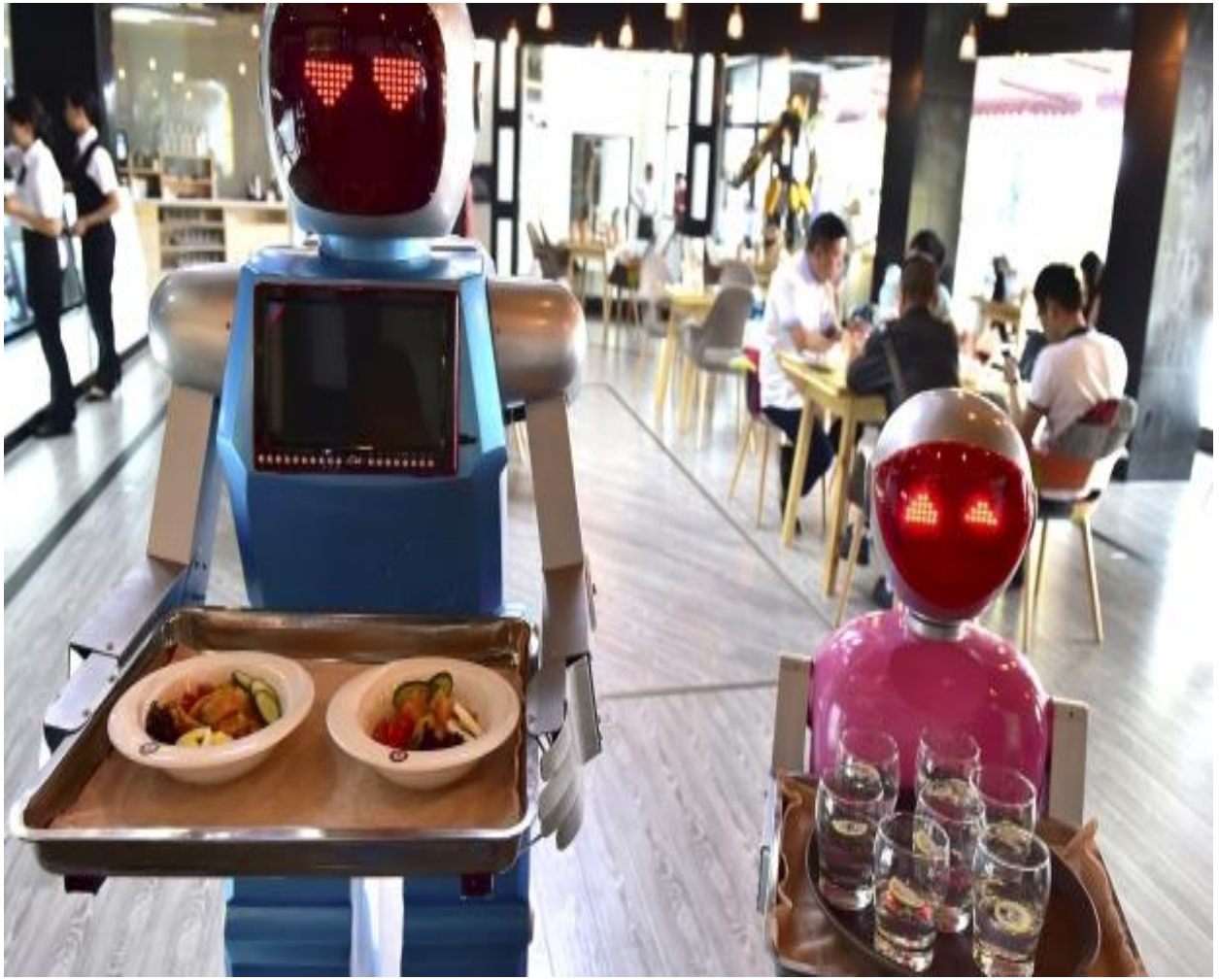


# Examples
# Automation in Healthcare

Click here to see how a surgery robot operates

# Automation in Service Industry

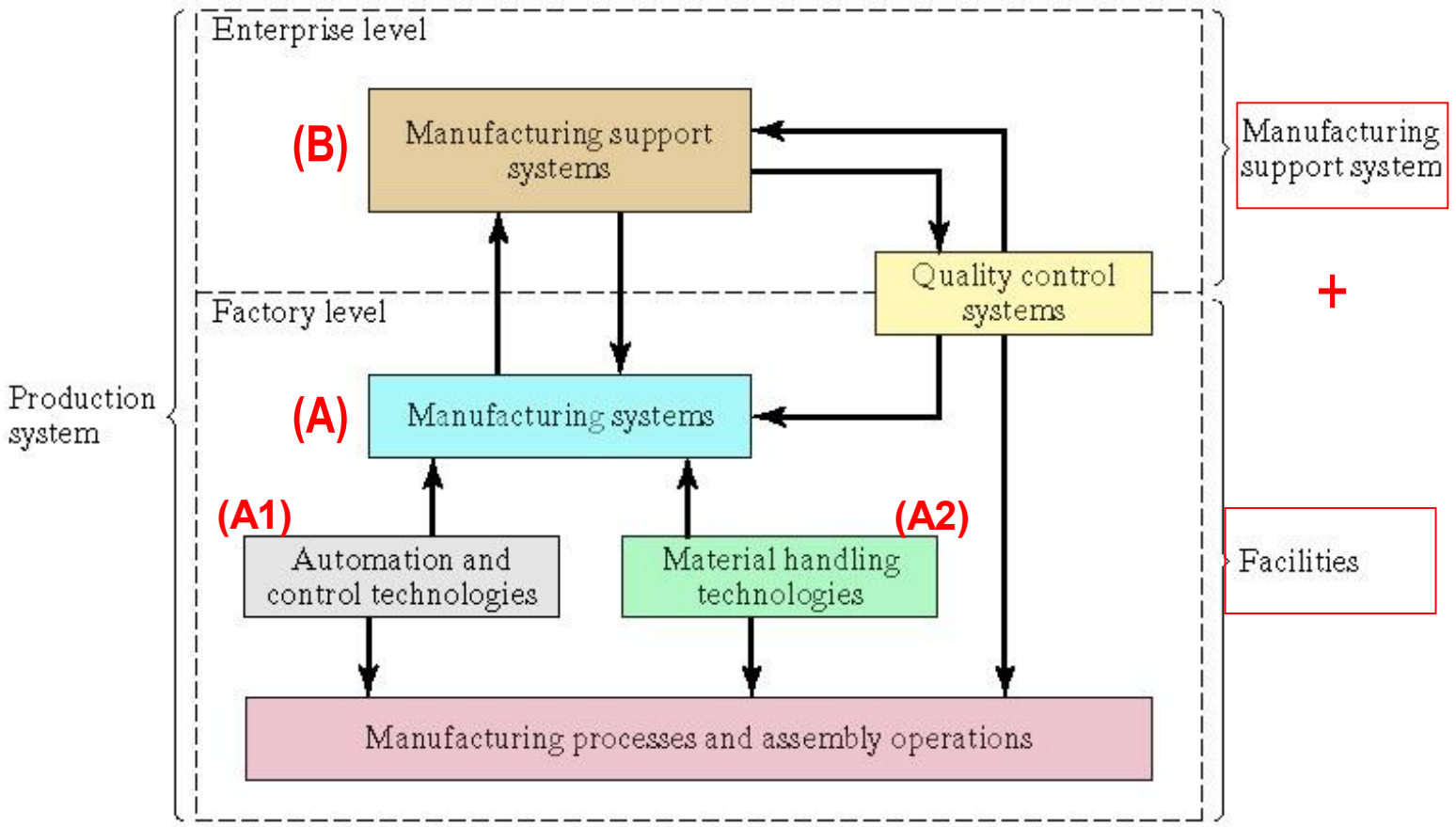
## Automation to Replace Waiter/Waitress



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

# Automation to replace Chefs

# Summary
# Automated Production System



# In-class assignment
# Group discussion

- Work in groups and discuss your solution with the other groups
- List the manufacturing processes
- Simplify the processes, if possible
- Identify the machines required
- Draw a layout for the production line and name all sections and equipment
- Apply U.S.A. principle

Note: Students are always encouraged to work in groups, debate and develop a solution