

Cairo University  
Faculty of Engineering  
Chemical Engineering Department  
B.Sc Students

# Plant Design

## Introduction

Ahmed Gaber, October 2021

# Lecture Outline

1. What is a project ?
2. What is a process plant ?
3. The project and its management
4. The engineering work and its management
5. Course outline

# 1. What is a project?

1. The “contents” of every project are unique. Once the activity becomes repetitive, it is not any more a “project”, it becomes a “process”.
2. A project changes the state of something. This can be either “hard” e.g building a new plant OR “soft” e.g building a new organization.
2. A project consists of a number of related “activities”, upon completion  $\Rightarrow$  finished project.
3. A project has defined start and end points.
4. A project requires that people and resources are brought together to implement the required “change”  $\Rightarrow$  then dispersed upon its completion.

# What makes a project successful?

1. Client requirements are clearly understood and agreed.
2. “Scope of Work” (what), “time schedule” (when) and “cost estimate” (at what cost) are agreed with both client and project team.
3. Risks and uncertainties are understood and accepted by all involved.
4. People, skills and resource requirements are defined and are made available when needed.

## What makes a project successful ? (cont'd)

5. Objectives, priorities and responsibilities are clearly defined for every member in project team.
6. Working relationships are managed in order to produce a committed project team.
7. The right people are informed of the right information at the right time.
8. Safety, quality , cost and progress are **controlled** through the life of the project.

# What is different in Process Plant Projects?

1. Unique circumstances of **feedstocks, products, capacity** and **environment**  
→ unique design of each plant.
2. Process plants are built around hundreds of items of processing equipment **(unit operations)**. Each piece of equipment has its design and operational characteristics.
3. Both plant design and its construction employ many types of specialists (civil, mechanical, electrical, instrumentation,.....)

## What is different in Process Plant Projects? (cont'd)

4. Plant operation can be HAZARDOUS. Design should **prevent, minimize, control, monitor, and manage hazards**. Environmental impacts should also be considered.
5. Technology development is rapid & continuous. This impacts process and plant design.
6. The project schedule cannot be generated in any mechanistic way.
7. There is always certain value associated to early plant completion.
8. The plant has to be constructed **ON SITE**, to suit its site, wherever that may be.

## 2. What is a conventional process plant ?





A conventional process plant is a factory which transforms materials in bulk. The feedstock and products may be transported by pipeline, conveyors, trucks.

Examples of process plants: oil refineries, sugar mills, metallurgical extraction plants, fertilizer factories. The products are commodities rather than articles.



# Major items in process plants

1. Process equipment
2. Materials transport and handling equipment
3. Material storage facilities
4. Utilities (compressed air, steam, water, nitrogen .... process reagents & catalysts may be included).

<b>1.Process equipment</b>	crushers, reactors, heaters, dryers, ...	
<b>2.Materials handling Equipment</b>	pumps belt conveyors bucket elevators blowers	
<b>3.Material Storage facilities:</b>	raw materials storage intermediate storage product storage	
<b>4.Process utilities:</b>	compressors boilers cooling towers	
All four categories Include items of mechanical equipment, namely :machinery, tanks, pumps, conveyors, ...		



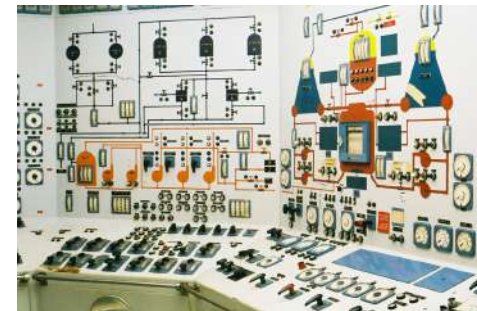
## 5. Electric power reticulation

- \* driving process machinery
- \* lighting
- \* powering instrumentation



## 6. Instrumentation

- \* monitoring
- \* control





## 7. Structures

- \* support plant equipment
- \* enclosures



## 8. Foundations

- \* support the structures
- \* support plant items
- \* support other civil works





## 9. Plant Buildings

such as control rooms, substations, laboratories, workshops ,  
admin. offices



# Process Plant Building Blocks



1. Process equipment  
2. Materials handling  
3. Materials storage

4. Process Utilities

5. Electric Power reticulation

9. Plant Buildings

7. Structures

8. Foundations

6. Instrumentation

Offsite facilities: access roads, bulk power, water supply ,  
industrial wastewater treatment plants, ...



## **Classification of process plants according to the nature of materials to be processed:**

- fluids or solids
- hazardous or non-hazardous
- oil & gas , minerals, biomass

## **Classification according to type of Products:**

- fuels
- chemicals
- metals
- precious minerals
- food/feed products
- bio-based products

# Typical associations:

- Crude oil → fuels
- Biomass → food/feed products and bio-based products

## Other combinations:

- Raw materials begin solid -> Product (Fluid)
- Processed materials which become hazardous during processing such as explosives
- Food such as table salt which are minerals
- Fuels extracted from biomass



# Processes may be classified according to:

1. Complexity.
2. Severity of the associated physical continuous (T, P, corrosiveness, toxicity ..).
3. Continuous vs. Batch.
4. Technology maturity and market maturity of the process
5. Product specs, **how critical** (w.r.t contaminants allowed concentration)

e.g. salt for food vs. salt for industrial plant

# The process design/detailed design interface

The engineering work of a process plant may be separated into two parts:

Part 1:

The  
process  
package

The process technology which would be applicable to a plant built on any site and using combination of equip. from any vendor.

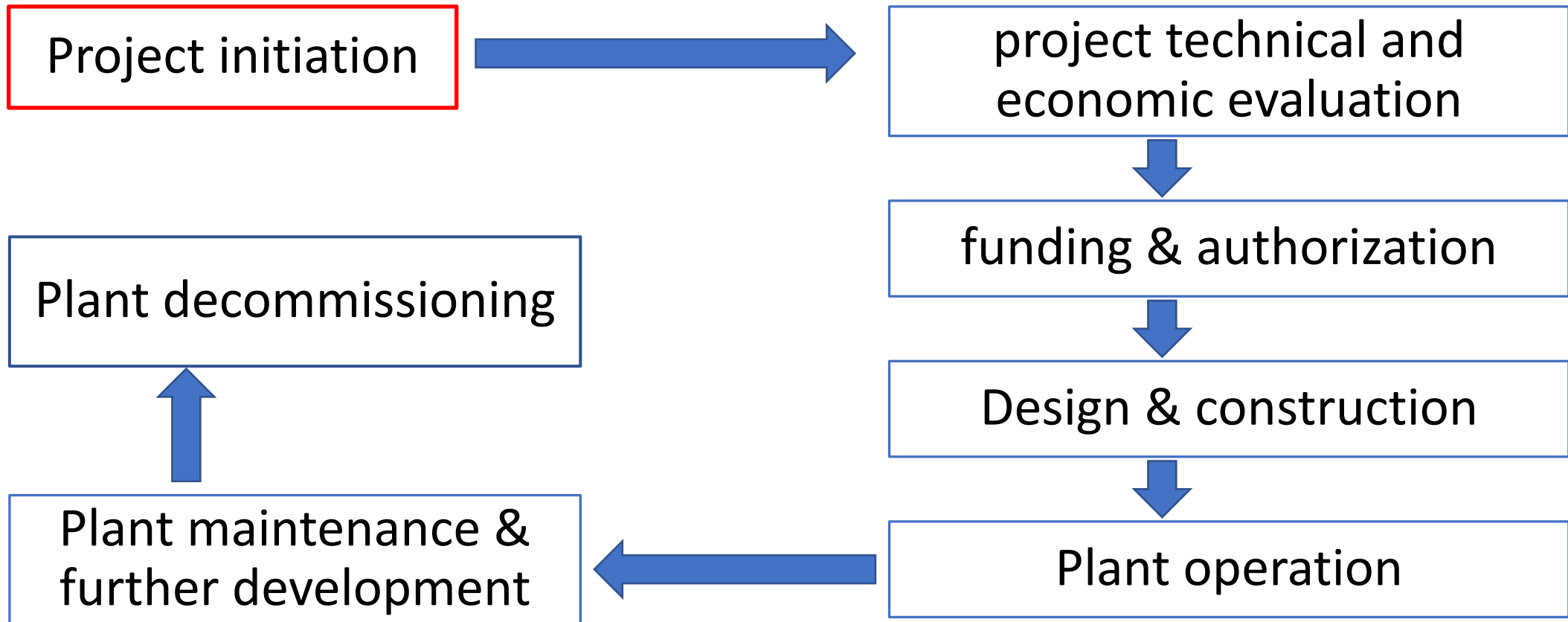
Part 2:

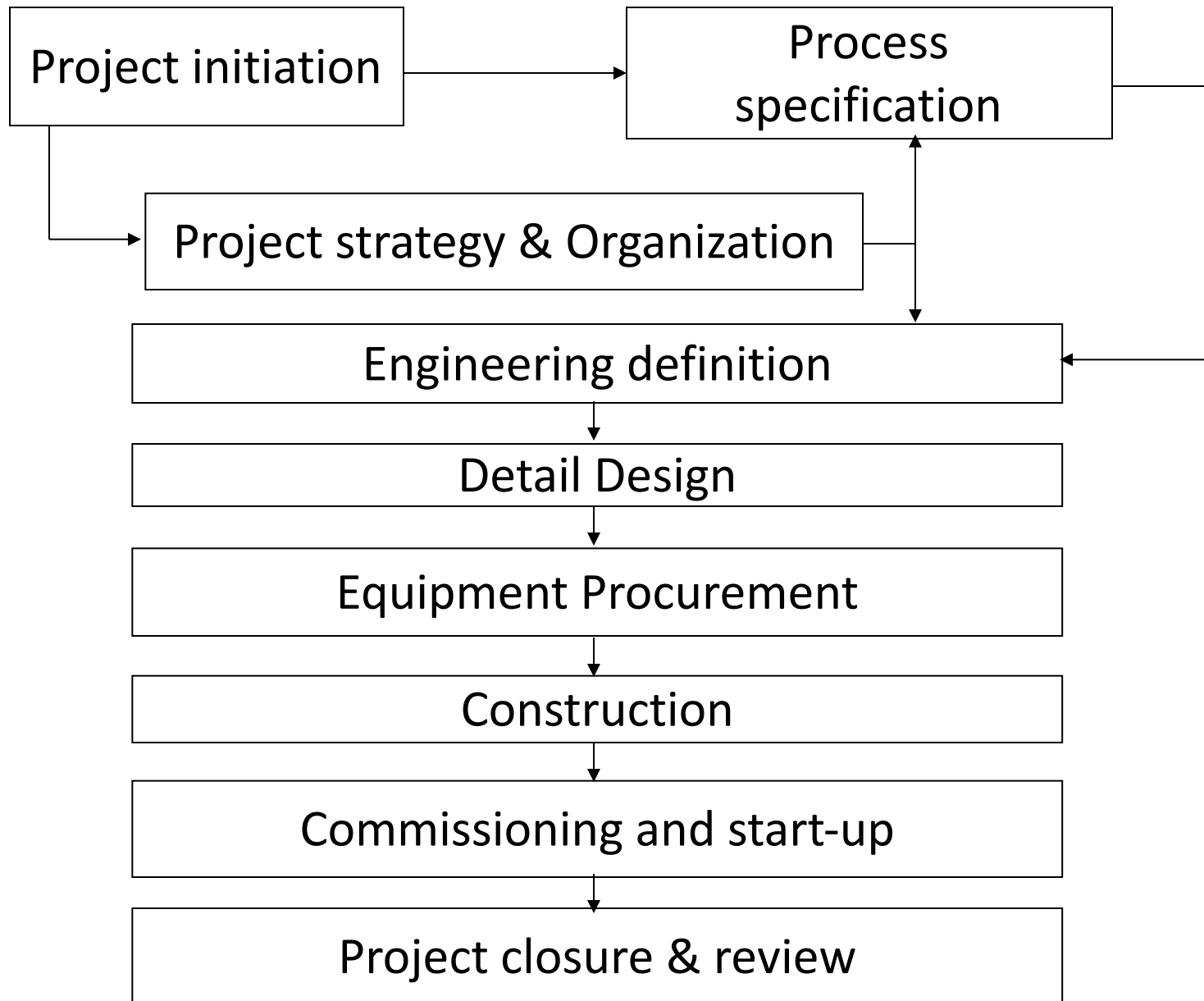
The detailed  
engineering  
package

The complete engineering design of the plant including actual equipment, designs, customized according to local regulations, local materials, layout specific to a specific site.

### 3. The Project and its Management (A Brief Overview)

#### Project lifecycle:





**Project Process Model**

# Project master plan – contents:

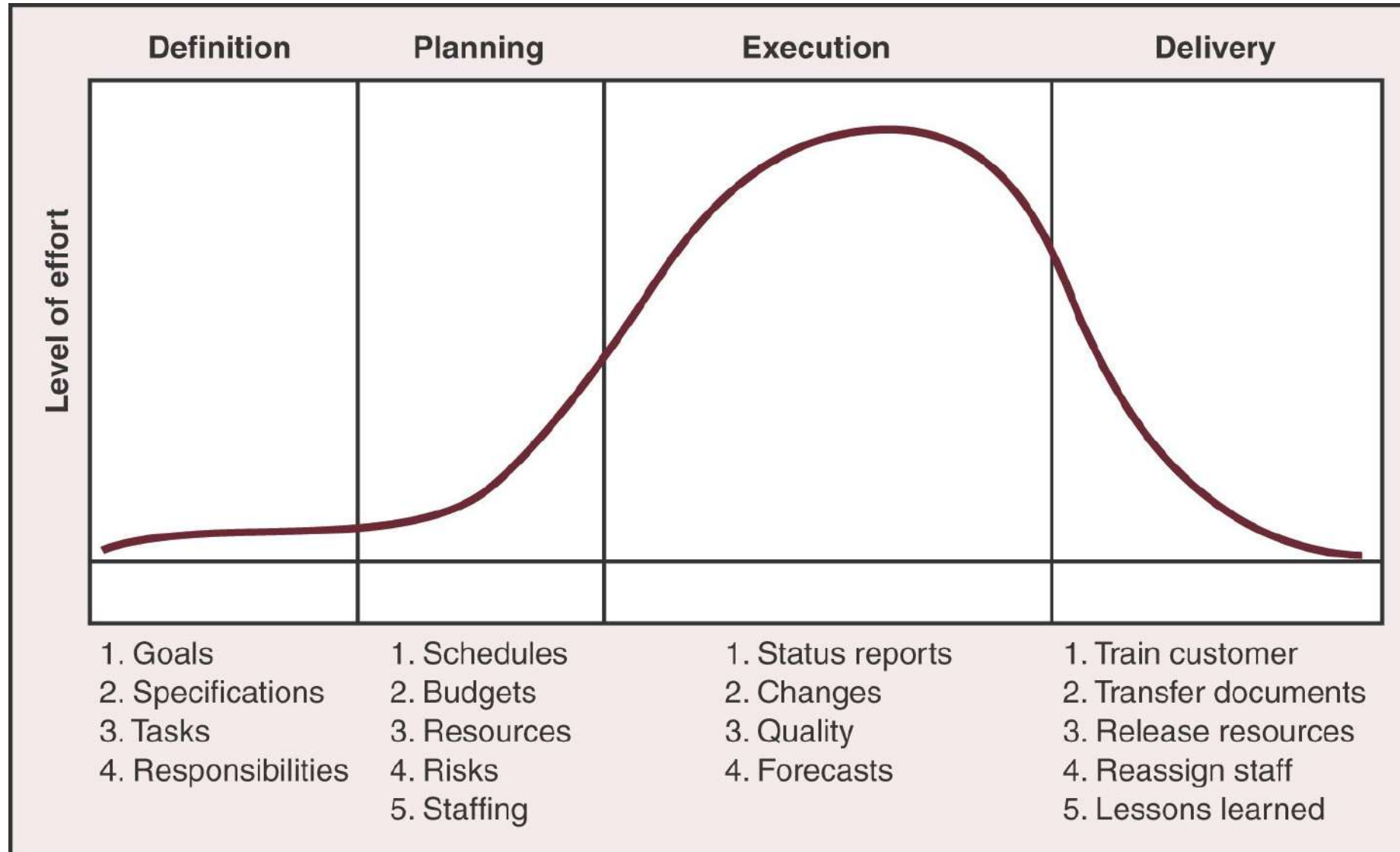
1. Clear definition of the project end-product and how its acceptability is decided (what).
2. Organization of the project team roles (who).
3. For each team member, define an operating plan (how).
4. The project budget (at what cost).
5. The project time-line (when).
6. A system for controlling the project (cost – time – quality).
7. **A resource plan:** HR, other resources – source, timing, cost.

# Managing the Project

**The main groups of operational activities are:**

1. Engineering Group
2. Procurement Group
3. Construction Group
4. Commissioning Group

# Project Life Cycle



## 4. The Engineering Work & its Management

### Stages of Project Engineering:

1. Define the Objectives.
2. Decide **how** the objectives will be achieved.
3. Plan in detail each work item (work package), develop schedule.
4. Do the engineering work, monitor, check.
5. Implement – through construction & procurement, check.
6. Commission, develop as built.



1. Define objectives.

2. Decide How



The conceptual design  
of the plant

**FREEZ?**



4. Project Plan

**FREEZ?**



5. Engineering work



Process package



Detailed engineering



6. Implementation



7. Commissioning

## 5. Course outline

Chapter 1: Introduction

Chapter 2: Site selection

Chapter 3: Siting and risk

Chapter 4: Process and plant design

Chapter 5: Plant layout introduction

Chapter 6: Layout considerations

## 5. Course outline Cont'd.

Chapter 7: Layout methods

Chapter 8: Selected process equipment

Chapter 9: Materials transfer systems

Chapter 10: Selection of plant components

Chapter 11: Introduction to project management

Chapter 12: Engineering contracts

Chapter 13: Project planning

# Review Question



1. In the introduction lecture to the course, we discussed the chemical process plants BUILDING BLOCKS.

Present the process plants building blocks diagrammatically or in a table format to show your understanding of each building block.

2. Based on the several classifications discussed of process plants:

Design a table to show your understanding of the classification methods.

3. Draw a diagram to show your understanding of the project life cycle.