

## 5.1 COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING

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2 - 8

### RATIONALE

Computer plays a very vital role in present day life, more so, in the professional life of Diploma engineers. In order to enable the students use the computers effectively in problem solving, this course offers the modern programming language C along with exposure to various engineering applications of computers. The knowledge of C language will be reinforced by the practical exercises during the course of study. Introduction to data base management system is also a very significant field with vast employment potential.

### DETAILED CONTENTS

1. Algorithm and program Development (04 periods)
  - 1) Steps in development of a program
  - 2) Flow-charts, algorithm development
  - 3) Introduction to various computer languages
  - 4) Concept of interpreter, compiler, high level language (HLL), machine language (ML) and Assembly Language
  
2. Programme Structure (C Programming) (24 periods)
  - a) History of 'C', data types, input output statements, arithmetic and logical operations, data assignments, precedence and associativity
  - b) I/O statements  
Assignment, Variables, arithmetic operation- their precedence, data type's standard I/O function, formulated I/O
  - c) Control Statements  
Logical and relational operators; if-else, while, do- while, for loops, breaks, switch statements
  - d) Functions:  
Function declaration, parameter passing- by value, storage classes (Local, Global and Static variables), standard library functions
  - e) Arrays:  
Single and multi-dimensional arrays, character arrays
  - f) Pointers:  
To various data types, pointers in parameters passing, pointers to function
  - g) Structures:  
Definition of a structure, pointer to structure, union and array of structure
  - h) Strings:  
String processing, functions and standard library function
  - i) Data files  
File handling and manipulation, file reading and writing, Binary and ASCII files, file records using standard function type mouse

3. Software Applications (04 periods) Computer application overview through various applications software related to Chemical Engineering

### **LIST OF PRACTICALS**

1. Programming exercise on executing a C Programme
2. Programming exercise on editing a C programme
3. Programming exercise on defining variables and assigning values to variables
4. Programming exercise on arithmetic and relation operators
5. Programming exercise on arithmetic expressions and their evaluation
6. Programming exercise on reading a character
7. Programming exercise on writing a character
8. Programming exercise on formatting input using print
9. Programming exercise on formatting output using scan
10. Programming exercise on simple IF statement
11. Programming exercise on IF... ELSE statement
12. Programming exercise on SWITCH statement
13. Programming exercise on GOTO statement
14. Programming exercise on DO-WHILE statement
15. Programming exercise on FOR statement
16. Programming exercise on one dimensional arrays
17. Programming exercise on two dimensional arrays
18. Simple Programmes related to chemical industry in C++ like
  - a) Calculation of heat exchanger area
  - b) Calculation of cylinder area
  - c) Conversion of various units
  - d) Calculation of volumetric flow rate and similar problems
19. Exposure of software packages related to chemical engineering

### **INSTRUCTIONAL STRATEGY**

This course is a highly practical and self- study oriented courses. The teachers are expected to explain the theoretical part and make the students to execute and debug different programmes. The PC need to have either Turbo C or Borland C compiler as well as Visual Basic compiler.

### **RECOMMENDED BOOKS**

1. Programming in C by Schaum series McGraw Hill
2. Programming in C by Kerning Lan and Richie; Prentice Hall of India, New Delhi
3. Programming in C by Balaguru Swamy, Tata McGraw Hill, New Delhi.
4. Let us C- Yashwant kanetkar, BPB Publications, New Delhi
5. Vijay Mukhi Series for C and C++
6. Programming in C by R Subburaj, Vikas Publishhing House Pvt. Ltd., Jangpura, New Delhi
7. Programming in C by Kris A Jansa, Galgotia Publications Pvt. Ltd., Daryaganj, New Delhi
8. Programming in C by BP Mahapatra, Khanna Publishers, New Delhi
9. Elements of C by MH Lewin, Khanna Publishers, New Delhi
10. The Complete Referance to Visual Basic 6, by Noel jerke, Tata McGraw Hill, New Delhi
11. Web site [www.Beyondlogic.org](http://www.Beyondlogic.org)
12. Pointers in C by Yashwant Kanetkar, BPB Publishers New Delhi
13. Programming in Applications by Chandershekhar, Unique International Publications, Jalandhar
14. The essentials of Computer Organizing and Architecture by Linda Null and Julia Labur, Narosa Publishing House Pvt. Ltd., New Delhi

## SUGGESTED DISTRIBUTION OF MARKS

<b>Topic</b>	<b>Time Allotted (Periods)</b>	<b>Marks Allocation</b>
1.	04	15
2.	24	70
3.	04	15
<b>Total</b>	<b>32</b>	<b>100</b>

SUGGESTION

## 5.2. CHEMICAL TECHNOLOGY - II

L T P  
5 - 4

### RATIONALE

A comprehensive study of the following chemical industries involving manufacturing process, availability of raw materials, production trend, preparation of flow sheet, engineering problems including materials of construction and uses.

### DETAILED CONTENTS

- 1. Fermentation Industries: -** (10 periods)  
Introduction, general characteristics of a fermentation process; Ethyl alcohol: Pertinent properties of ethyl alcohol, method of production of industrial ethyl alcohol by fermentation, chemical reactions, raw material requirements, process description with a neat flow diagram.
- 2. Sugar Industry: -** (10 periods)  
Properties of sucrose. Raw material requirements. Process description for the production of crystalline white sugar with the help of a flow sheet by products of the sugar industry.
- 3. Soaps and Detergent: -** (10 periods)  
Definition of soaps & detergent. Difference between soaps & detergents. Uses of soaps & detergents. Role of additives in a soaps & detergents, manufacturing process of soaps & detergents. Production with flow sheet.
- 4. Oil, Fat & Essential Oils :-** (10 periods)  
Edible oil & essential oils, chemical composition & physical properties of vegetable oils. Method of production of vegetable oils: Mechanical, solvent extraction & hydrogenation of oils with flow sheet.
- 5. Pulp and Paper Industry :-** (07 periods)  
Definition of pulp and paper, various types of raw materials for pulp & paper. Pulping process sulphite and sulfate with flow sheet.
- 6. Synthetic Fiber Industries :-** (09 periods)  
Definition of fiber. Raw materials of synthetic fiber industry. Classification of synthetic fibers.  
Cellulosic Fiber: - Basic chemistry of Viscose process, process description with flow-sheet.  
Polyamides: Basic chemistry of Nylon-6, Nylon-66. Properties and uses. Method of production of Nylon-6, Nylon-66 with flow-sheet. Method of production of Dacron, Terylene, PTFE.
- 7. Synthetic Rubber:** (06periods)  
Classification of natural and synthetic rubber, Chemistry and properties of natural rubber, method of manufacture of butadiene, styrene butadiene rubber with flow-sheet, Compounding of rubber, various ingredients used for rubber compounding.
- 8. Plastic Industries (introductory level):** (06 periods)  
Thermoplastic and thermosetting plastics, manufacturing process of polyethylene and polyvinylchloride

9. **Explosives:** (06 periods)  
What are explosives? Classification of explosives, Industrial uses of explosives, manufacturing process of nitroglycerine & trinitrotoluene (TNT).
10. **Pesticides:** (06 periods)  
What are pesticides, general methods of pest control? General method of classification of pest control. Name various pesticides & insecticides. Explain the manufacturing method of DDT; BHC & parathion with flow sheet along with major engineering problems.

### LIST OF PRACTICALS

1. **Qualitative Organic Analysis:**  
Detection of primary elements and general characteristics of carboxylic acids (oxalic acid, tartaric acid, formic acid, acetic acid) phenol, alcohol (glucose, methyl, alcohol, ethyl alcohol) Aldehydes (formaldehyde and metaldehyde), acetone, aniline, chloroform, glycerin.
1. Preparation of phenyl (domestic disinfectant)
  2. Preparation of soap
  3. Preparation of detergent/liquid detergent
  4. Preparation of polystyrene

### INSTRUCTIONAL STRATEGY

As this subject involves study of lot of chemical industries, field visit is must to give details about the various unit operations and processes involved in chemical industries.

Small and simple experiments/practical will give idea about operational aspect of the chemical industries.

### SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	10	10
2	10	10
3	10	10
4	10	10
5	07	10
6	09	10
7	06	10
8	06	10
9	06	10
10	06	10
<b>Total</b>	<b>80</b>	<b>100</b>

### 5.3 PAINT TECHNOLOGY

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5 - -

#### RATIONALE

This specialized subject will enable the students to study the paint technology in detail along with its applications and defects. This subject is of importance in view of the increasing job potential in paint industry

#### DETAILED CONTENTS

1. **Introduction** (06 hrs)  
Definition of paint, primers, varnish, solvent, binder (resin) and additives and functions of each component. Pigment volume, concentration (PVC) and critical pigment concentration (CPC)
- d) **Synthetic resin-** Introduction, raw material, basic chemistry, properties and uses of such types of resins like alkyd resin, Epoxy resin, phenolics resins, polyester resin, silicone. (12 hrs)
3. **Solvents** (06 hrs)  
Classification of solvent and general properties of solvent
4. **Pigments** (06 hrs)  
Introduction, general physical Properties like colour, tinting strength, opacity, particle size, oil absorption. Classification of Pigment and name of pigments (organic and inorganic).
5. **Manufacturing Process** (06hrs)  
Paint manufacturing by ball mill and sand mill
6. **Coatings** (06 hrs)  
Type of coating –under coating, finishing coating.
7. **Primers** (08 hrs)  
Introduction, purpose of Primer, classification of Primer and uses.
8. **Paints** (08 hrs)  
Classification of paint(such as Latex, Emulsion, Glossy) and formulation and uses.
9. **Application Methods** (09 hrs)  
Introduction and different application methods such as brush coating, rolling coating, spray coating, Dip coating, powder coating, CED (cathodic electro disposition), advantages and disadvantages of these methods.

10. **Paint Defects** (06 hrs)

Introduction, causes and remedies methods of paint defects such as Settling, Brush drag, cracking, cratering, peeling, Pin holding, Wrinkling

11. **Testing Methods** (07 hrs)

Introduction and testing of different properties of paint and different coatings like viscosity, hardness, flexibility, covering power, gloss, impact resistance.

**INSTRUCTIONAL STRATEGY**

Extension lectures by a person from a paint industry will provide valuable inputs regarding latest techniques and new types of coatings/paints . Visits to paint industry like ICI paints, Asian Paints will provide the outlook of a paint plant, new equipment and techniques used in the plants and know how about the latest application technologies of paint. Visit to fully automated plants like ICI will also provide inputs about process control and instrumentation.

**RECOMMENDED BOOKS**

- a) Surface Coating by Swaraj Paul
- b) Outline of Paint Technology, Vol. 2 by WM Morgans

**SUGGESTED DISTRIBUTION OF MARKS**

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	06	05
2	12	15
3	06	10
4	06	10
5	06	10
6	06	10
7	08	08
8	08	08
9	09	08
10	06	08
11	07	08
<b>Total</b>	<b>80</b>	<b>100</b>

## 5.4 MASS TRANSFER OPERATIONS

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### RATIONALE

In this subject the basic concepts of mass transfer are covered to enable the students to understand working of various mass transfer equipment like distillation column, gas absorption column, dryers, cooling towers and extraction column etc. which are used in industries for purification of products.

### DETAILED CONTENTS

#### 1-Mass transfer

(20 Periods)

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, Maxwell law of diffusion, diffusivity, diffusion in the gas phase-Equimolecular counter diffusion and nondiffusing diffusion, diffusion in the liquid phase-Equimolecular counter diffusion and nondiffusing diffusion., Mass Transfer Coefficient. Film theory and penetration theory of Mass Transfer,

#### 2- Gas Absorption

(20 periods)

Condition of equilibrium between liquid and gas, mechanism of absorption two film theory. Diffusion of a gas through a stagnant gas, diffusion in liquid phase, rate of absorption, relation between film and overall coefficients, rate of absorption in terms of mole fraction, factors affecting transfer coefficients.

#### Packed Tower

Properties of tower packing, types of packing, Channeling, Minimum liquid gas ratio Loading and Flooding Capacity of packed tower Material balance and design equation, height of column based on conditions in gas film and liquid film, height of column based on overall coefficient, the operating line and graphical integration for height of column. Concept of transfer unit. H.E.T.P. for packed column of distillation, relation of H.T.U. to H.E.T.P... Derivation of the following relations

$$\begin{array}{l} \text{I.} \\ \frac{l}{K_G a} = \frac{l}{k_G a} + \frac{m}{K_L a} \\ \text{II.} \\ \frac{l}{K_L a} = \frac{l}{k_L a} + \frac{m}{k_G a} \end{array}$$

#### 3. Distillation

(30 Periods)

##### a) Various distillation methods

- i) Equilibrium or flash distillation
- ii) Differential distillation
- iii) Batch distillation
- iv) Vacuum and Steam distillation
- v) Azeotropic and Extractive distillation.

##### b) Types of distillation columns

i) Perforated plate or sieve plate column

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- ii) Bubble cap plate column
- iii) Packed column and fractionating column accessories.

**c) Boiling point diagrams**

Raoult's law; Henry's law, Relative volatility, constant boiling mixtures, equilibrium diagram and construction of equilibrium diagram, Fractionating column calculation-Heat & material balance, Reflux ratio, equilibrium plate, Location of feed plate. Sub cooled reflux; effect of reflux ratio, Total reflux, Minimum reflux ratio Entrainment; McCabe Thiele diagram-section above and below feed plate; Intersection of operating line. Location of q-line, derivation of q line, optimum reflux ratio, calculation of no. of equilibrium plates by Mc-Cable Thiele diagram. Overall plate efficiency.

**4. Extraction (08 Periods)**

- i) Applications of this extraction
- ii) Choice of solvent
- iii) Steps of extraction operation
- iv) Solid Liquid extraction, construction and description of
  - Moving solid bed Basket type oil seed extractor or Boll man extractor
  - Rotocel extractor
- v) Liquid extractor; description and construction of
  - Mixer settler extraction system
  - Spray and packed extraction tower

**5. Humidification (10 Periods)**

Definition and calculation of

- i) Humidity
- ii) Percentage humidity
- iii) Relative humidity
- iv) Humid volume
- v) Humid heat
- vi) Enthalpy and its calculation
- vii) Dry bulb and wet bulb-temp
- viii) Adiabatic saturation temperature
- ix) Use of humidity chart. Dew point, simple numerical problem using humidity chart, construction and description of cooling towers (Natural and induced draft)

**6. Drying (08 Periods)**

General drying behavior-Critical moisture content, equilibrium moisture contents, description and construction of dryer.

- i) Tray dryer
- ii) Screen conveyor dryer
- iii) Rotary dryer.

NOTE: - At least one question from each topic

## LIST OF PRACTICALS

1. To study the rate of drying in a vacuum dryer
2. To determine the pounds of volatile compounds distilled per unit pounds of steam distilled in a steam distillation operation
3. To determine rate of setting of crystals in a crystallizer
4. To study the rate of drying in rotary dryer
5. To determine drying rate for a wet materials
6. To determine drying rate for a wet material in a tray dryer
7. To study packed tower in various industries
8. To study various extractors in solvent extraction plant
9. To study a spray pond in a sugar and other industries for cooling system
10. To find out the drying characteristics of given sample and draw drying rate curve by infra-red moisture meter and rapid moisture meter
11. To study sketch and operation of strip chart recorder and directing pen recorder

## INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of column (packed/tray) and different types of packings/trays used in the column. This will also make the students aware of auxiliary equipment/manholes/supports used for the columns. Along with the theoretical part, emphasis should be given to problem solving and practices especially for distillation column, absorption and humidification.

## RECOMMENDED BOOKS

1. Mass Transfer Operations by Trybal
2. Unit Operation by McCabe and Smith
3. Mass Transfer I & II by Bhattacharya
4. Mass Transfer by Gavhane
5. Mass Transfer by Badger

## SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time period Allotted	Marks Allotted (%)
1	20	15
2	20	15
3	30	35
4	08	10
5	10	15
6	08	10
<b>Total</b>	<b>96</b>	<b>100</b>

## 5.5 POLYMER SCIENCE

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### RATIONALE

This specialized subject is taught in view of the growing employment potential in the field of polymers. This subject deals with polymerization techniques and important industrial polymers which will enable the diploma holder in chemical engineering to join polymer industry.

### DETAILED CONTENTS

- 1. Introduction (10 periods)**  
Monomer, polymer, functionality and structure of polymer, classification of polymers
- 2. Chemistry of Polymerization (20 periods)**  
Introduction, chain polymerization, step polymerization, polymerization techniques
- 3. Molecular Weight and Size (20 periods)**  
Average molecular weight, number – average and weight - average molecular weights, viscosity - average molecular weight, molecular weight and degree of polymerization, size of polymer molecules, methods for average molecular weight determination – end group analysis vapour pressure osmometry..
- 4. Kinetics of Polymerization (15 periods)**  
Introduction, free radical chain polymerization, cationic polymerization, anionic polymerization, polycondensation
- 5. Glass Transition Temperature (15 periods)**  
Glass transition temperature, factors affecting the glass transition temperature, glass transition temperature and molecular weight, glass transition temperature and plasticizers, glass transition temperature of co - polymers, glass transition temperature and melting point.

### INSTRUCTIONAL STRATEGY

Extension lectures by experts from polymer industry can enrich the students with better inputs regarding various types of techniques and latest developments in polymer industry. Also field visits must be encouraged to provide practical inputs and inputs regarding operational aspects of machinery used in polymer industry.

### RECOMMENDED BOOKS

1. Polymer Science and Engineering by Gowarikar
2. Polymer Science and Engineering by Fried
3. Polymer Science and Engineering by Anil Kher and SK Gupta
4. Polymer Science and Engineering by Ghosh

### SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	10	10
2	20	20
3	20	30
4	15	20
5	15	20
<b>Total</b>	<b>80</b>	<b>100</b>

## 5.6 REACTION ENGINEERING

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### RATIONALE

It is a core subject of chemical engineering and is essential for understanding the kinetics of various types of reaction vessels and the performance of reactive system used in industry.

### DETAILED CONTENTS

**1. Introduction:** (5 periods)

What is reaction engineering? Chemical kinetics & their dynamics classification of chemical reactions. Based on (i) Phases involved, (ii) Catalytic and non-catalytic reactions, (iii) Molecularity of a reaction, (iv) Heat effect, (v) based on order of reactions, (vi) reversible and irreversible reactions.

**2. Homogeneous Reactions:** (20 periods)

Rate of chemical reaction, factors affecting the rate of reaction. Concentration dependent term of a rate equation. Rate constant, Elementary and non-elementary reaction. Difference between elementary and non-elementary reactions. Molecularity of a reaction, order of a reaction. Difference between molecularity & order of reaction. Representation of an elementary & non-elementary reaction. Temperature dependent term of a rate of equation, Temperature dependency from Arrhenius law, collision theory & thermodynamics. Activation energy & its significance, activation energy & temperature dependency. Simple numerical problems,

**3. Interpretation of constant volume batch reactor data:** (35 periods)

Kinetic run, kinetic data or rate data, integral method of analyses of rate of data, differential method of analysis of rate of data. Integral V/s differential method, Constant volume batch reactor, conversion, relation of concentration and conversion for constant volume batch reactor.

Find out the concentration of component B, C & D in

- (a) Chemical reaction of the type  $aA + bB \rightarrow cC + dD$  and for  
(b) For flow systems.

Analysis of total pressure data obtained in a constant volume system, use of ideal gas law. To calculate  $C_{A0}$ .

Integral method of analysis of rate data; integrated rate expression for different order of reactions:

**(A) Irreversible unimolecular type first order reactions:**

- i. Integrated rate equation or expression for the first order reaction in terms of concentration, relation between half-life and rate constant.
- ii. Integrated rate equation or expression for the first order reaction in terms of conversion

**(B) Irreversible bimolecular type second order reaction:**

- i. Integrated rate equation or expression for the second order reaction in terms of concentration. Relation between half-life and rate constant and concentration.
- ii. Integrated rate equation or expression for the second order reaction in term of conversion.
- iii. Integrated rate equation for second order reaction with  $C_{A0} \neq C_{B0}$  in terms of concentration.
- iv. Integrated rate equation or expression for second order reaction with  $C_{A0} \neq C_{B0}$ . In term of conversion.

- (C) **Zero order reaction:** zero order reaction in terms of concentration & Conversion. Characteristics of zero order reaction.
- (D) Empirical rate equation of  $n^{\text{th}}$  order. Determination of overall order of irreversible reaction from half-life, Irreversible reaction in parallel/series & homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions: Reversible reactions of unimolecular type first order reactions, reversible unimolecular type second order reactions.
- (E) **Differential method of analysis of data :**
- I) Step by step procedure for analysis of the complete rate equation by differential method.
- II) Variable volume batch reactor: - Unimolecular type general reaction expression in which the volume is a linear function of conversion of a reactant. An integrated rate expression for first order reaction for variable volume system. Integrated rate expression for zero order reaction for a variable volume system.
- Bimolecular type reactions: integrated rate expression for first & second order reactions. Simple numerical problems.

**4. Ideal Reactors:** (20 periods)

Classification of reactors based on

- a. Shape & size
  - i. Tank reactors
  - ii. Tubular reactors
- b. Based on mode of operation
  - i. Batch reactors
  - ii. Semi batch reactors
  - iii. Continuous flow reactors

Application, advantages, disadvantages and comparison of reactors.

Relation between  $C_A$  &  $X_A$ . Ideal batch reactor: - Performance/design equation for batch reactor for constant volume/constant density and for variable volume/density reaction system. The performance measures of flow reactors: - Space time and space velocity. Steady state mixed flow reactors (CSTR):- The performance equation for constant and variable volume/density reaction system. Steady state plug flow reactor: - Performance equation for plug flow reactor for first order reaction in case of constant density and variable density system. Holding time and space time for flow reactors.

**INSTRUCTIONAL STRATEGY**

Simple models can be made to show batch reactors, plug flow reactors and continuous reactors. Emphasis should be laid on problem solving / numerical solving for rate constants and temperature dependence of rate constant.

**RECOMMENDED BOOKS**

1. Chemical Reaction Engineering by Levenspiel, Job Wiley Publications
2. Chemical Engineering Kinetics by Smith, McGraw Hill Publication
3. Elements of Chemical Reaction engineering by Fogler, Prentice Hall of India
4. Reaction Kinetics for Chemical Engineering by Wales, McGraw Hill Publication
5. Chemical Reactin Theory – An Introduction by Denbigh and Turner, Cambridge University Press Publication

### SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	05	10
2	12	20
3	35	50
4	20	20
<b>Total</b>	<b>80</b>	<b>100</b>

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