

5.1. SPECIAL PURPOSE COATINGS

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RATIONALE

This subject is designed to make the students aware of speciality applications which are now being used in industries. This will make the students understand the wider scope of paints apart from regular application.

DETAILED CONTENTS

1. Exterior coatings, formulation considerations, solvent and water based coatings, primers, stoppers, undercoats, finish coats coatings for wood, masonry, metal etc., roof coatings, interior coatings, factors determining selection of coatings, solvent and water based systems, coatings for wood metal masonry etc., wall coating, floor paints, sealer, primers, stoppers, under coats, finish coats. (20 hrs)
2. Selection of decorative paints, factors in selection, water borne coatings (12hrs)
3. Industrial Coatings, substrates, application and cure, air drying, forced drying and stoving, clear finishes for metal and wood, furniture finishes, lacquers automotive coatings, materials of construction, primers, fillers, surface base coats, top coats, clear coats, refinishing etc. (12 hrs)
4. Aircraft and Marine Coatings: Air craft finishes, fabric air craft, metal skinned air craft modern aircraft finishes application, ships paints, fouling, organisms leaching rate, types of antifouling paints, recent developments, industrial structures and industrial buildings(chemical paints), primers, undercoats, finish coats non-convertible and convertible, red oxide-zinc chromate, zinc rich primers etch primers, conversion coatings etc. painting specification maintenance paintings, painting of concrete (12 hrs.)
5. : Power Coatings: manufacture of powders, powder classification, types of powder coatings, application, methods, uses. (12 hrs)
6. Recent Developments: Radiation curable coatings, photo polymerization, Optical coating-traffic/rail roads, nuclear power plant, radiation resistance coatings. (12 hrs)

INSTRUCTIONAL STRATEGY

Actual application should be shown by visits to sites.

RECOMMENDED BOOKS

1. Organic Coating Technology, Vol. I & . II by R.F. Paynl
2. Surface coating vol. I and II OCCA, Australia
3. Outlines of Paint Technology by W.M. Margans
4. Surface coatings science and technology by Swaraj Paul

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	20	25
2	12	15
3	12	15
4	12	15
5	12	15
6	12	15
Total	80	100

5.2 REACTION ENGINEERING

L T P
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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

- Chemical reaction of the type $aA+bB \rightarrow cC+dD$ and for
- 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:

- Irreversible unimolecular type first order reactions:
 - 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^{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 liner 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
Total	80	100

5.3. PAINT TECHNOLOGY- II

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RATIONALE

The subject prepares the student for industry as it specifies all application techniques in surface treatments. These are commonly used in all the paint related industries.

DETAILED CONTENTS

- 1 Objective of surface preparation and the phenomena, mechanical surface preparation and cleaning power tool cleaning, flame cleaning, blast cleaning etc. chemical surface preparation, solvent wiping and degreasing, alkali cleaning, emulsifiable solvent cleaning, steam cleaning, acid cleaning, pickling, phosphoric acid, electrolytic pickling etc. (15hrs)
- 2 :Chemical paint removal such as alkaline and solvent type removers etc. pretreatment chemical conversion coatings based on zinc manganese iron and chromium etc., chromate and other treatments, substrates and their specific preparations, classification and substrates surface preparation of metals, timber masonry, plastics etc. , previously painted surfaces .Homogeneous Reactions (18 hrs)
- 3 Common application techniques, importance of rheological behavior in paint application, brush application, conventional air spray, airless spray. Hot spray, duel component spray, electrostatic handgun and high speed disc systems dipping roller and coal coating, powder coating, electrodeposition principles, anodic and cathode deposition, miscellaneous application techniques vacuum impregnation, curtain coating, flow coating, silk screen slush coating, knife coating, calendar coating, centrifugal coating etc. (23 hrs.)
- 4: Curing of wet film paint shop services, paint shakers or tumblers, paint and distribution system, west treatment, paint shop troubles, inspection and service complains, finishing of specific items, motor, body, refrigerator and domestic appliances, machinery and casting etc. (12 hrs)
- 5: Paint defects, sources, leveling, sagging, drip marks, crawling, cratering, rinkling, peeling, classification, defects in the liquid paint, defects during application, defects during drying or curing, defects in the dry film in use, causes and rectification of defects and preventive measures refinishing and maintenance finishing (12 hrs.)

INSTRUCTIONAL STRATEGY

Practical aspects of surface treatment and application of techniques should be shown by visits to paint auto shop plants.

PRACTICALS

1. Study of different surfaces and their preparation for coatings.
 - i) Wood
 - ii) Metals
 - iii) Plastics
 - iv) Concrete/cement/bricks

2. Removal of paints from different substances:
 - i) use of sand paper
 - ii) use of solvents
 - iii) double coating layers

3. Oil and Cup viscometer, measurements of flow of different formulations vis-à-vis:
 - i) for different applications
 - ii) effect of additives
 - iii) effect of pigments
 - iv) effect of resins
 - v) Gardner Tube method Viscosity (A+OZ)

4. Various application techniques:
 - i) Brush
 - ii) Spray-gun
 - iii) Applicator (thin film)
 - iv) Rollers
 - v) Dip coating
 - vi) Knife coating

5. Analysis of defects in coatings.

Different defects: leveling, sagging, etc. use of microscopy and visual observation.

6. To find the grindness of Paint/Primer

RECOMMENDED BOOKS

1. Organic Coating Technology, Vol. I & . II by R.F. Paync
2. Outlines of Paint Technology by W.M. Margans
3. Good painting practices by Joseph Bijos
4. Surface coatings Science and Technology by Swaraj Paul

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	15	15
2	18	15
3	23	40
4	12	15
5	12	15
Total	80	100

5.4. RESIN TECHNOLOGY - II

L T P

5 - 4

RATIONALE

This subject deals with chemistry, raw materials, synthesis and formulation of various industrial resins used in coating industry.

DETAILED CONTENTS

- 1 Formaldehyde Based Resins/Amino Resins:: Phenol-formaldehyde resins (Norolocs and Resols) , Resin synthesis, use of phenolic resin in coatings (varnishes, automotive coating, metal coatings, marine paints), Amino Resins; Urea formaldehyde, Melamine formaldehyde resins, chemistry and synthesis of amino resins, Application in coatings (16 hrs.)
- 2 Silicon Resins,; Synthesis of silicone resins, structure property relationship, as coating binders, coating additives and coating modifiers. Application of silicone resins (14 hrs)
- 3 Epoxy Resins; Chemistry of Epoxy resin, Polyaddition (using polyamines and Polyamides) Manufacturing of epoxy resins (Taffy process and Fusion process), . Application of Epoxy resins (Industrial maintenance coatings, container coatings and heavy duty coatings) (18 hours)
- 4 Acrylic Resins: Structure- property relationship of acrylics (stability, hardness, flexibility, adhesion, solubility and cross linking), Application of thermoplastic and thermosetting acrylic resins, Modification of acrylic resins. (16 hrs)
- 5 Vinyl Resins: Types of vinyl resins, use of vinyl resins. (08 hrs)
- 6 Fluoropolymers: Introduction and properties of Fluoropolymers Importance and applications in high temperature and fire resistance coatings. (08 hrs)

INSTRUCTIONAL STRATEGY

As the subject involves synthesis of various resin used in paint industry. It can be made more interacting by showing various paint samples (automotive, wall coatings, high duty coatings etc.)so that students can appreciate different types of resin and their properties.

LIST OF PRACTICALS

1. To synthesize alkyd resins and test acid value and drying value
2. To synthesize urea formaldehyde resin and test the solubility
3. To synthesize phenolic resin and test the solubility and softening point
4. To prepare medium oil alkyd resin and test the acid value
5. To prepare oil and resins varnish.

RECOMMENDED BOOKS

1. Organic Coating Technology, Vol. II by H.F. Payne
2. Surface Coating, Science and Technology, Ed. 2, Swarj Paul(john Wiley), 1997.
3. Outlines of Paint Technology by W.M. Morgans
4. Organic Coatings Wicks W; Jones FN.; Pappas S.P.; & Wicks D.A. (John Wiley 3rd Edn. 2007).

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	16	20
2	14	20
3	18	20
4	16	20
5	08	10
6	08	10
Total	80	100

5.5 ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT

L T P
Periods per week 5 - -

RATIONALE

In the present day scenario, it has become imperative to impart entrepreneurship and management concepts to students so that a significant percentage of them can be directed towards setting up and managing their own small enterprises. This subject focuses on imparting the necessary competencies and skills of enterprise set up and its management.

DETAILED CONTENTS

SECTION – A ENTREPRENEURSHIP

1. Introduction (23 periods)
 - Concept /Meaning and its need
 - Qualities and functions of entrepreneur and barriers in entrepreneurship
 - Sole proprietorship and partnership forms of business organisations
 - Schemes of assistance by entrepreneurial support agencies at National, State, District level: NSIC, NRDC, DC:MSME, SIDBI, NABARD, Commercial Banks, SFC's TCO, KVIB, DIC, Technology Business Incubator (TBI) and Science and Technology Entrepreneur Parks (STEP)

2. Market Survey and Opportunity Identification (17 periods)
 - Scanning of business environment
 - Salient features of National and State industrial policies and resultant business opportunities
 - Types and conduct of market survey
 - Assessment of demand and supply in potential areas of growth
 - Identifying business opportunity
 - Considerations in product selection

3. Project report Preparation (14 periods)
 - Preliminary project report
 - Detailed project report including technical, economic and market feasibility
 - Common errors in project report preparations
 - Exercises on preparation of project report

SECTION –B MANAGEMENT

4. Introduction to Management (06 periods)

- Definitions and importance of management
- Functions of management: Importance and Process of planning, organising, staffing, directing and controlling
- Principles of management (Henri Fayol, F.W. Taylor)
- Concept and structure of an organisation
- Types of industrial organisations
 - a) Line organisation
 - b) Line and staff organisation
 - c) Functional Organisation

5. Leadership and Motivation (05 periods)

a) Leadership

- Definition and Need
- Qualities and functions of a leader
- Manager Vs leader
- Types of leadership

b) Motivation

- Definitions and characteristics
- Factors affecting motivation
- Theories of motivation (Maslow, Herzberg, McGregor)

6. Management Scope in Different Areas (10 periods)

a) Human Resource Management

- Introduction and objective
- Introduction to Man power planning, recruitment and selection
- Introduction to performance appraisal methods

b) Material and Store Management

- Introduction functions, and objectives
- ABC Analysis and EOQ

c) Marketing and sales

- Introduction, importance, and its functions
- Physical distribution
- Introduction to promotion mix
- Sales promotion

- d) Financial Management
- Introductions, importance and its functions
 - Elementary knowledge of income tax, sales tax, excise duty, custom duty and VAT
7. Miscellaneous Topics (05 periods)
- a) Customer Relation Management (CRM)
- Definition and need
 - Types of CRM
- b) Total Quality Management (TQM)
- Statistical process control
 - Total employees Involvement
 - Just in time (JIT)
- c) Intellectual Property Right (IPR)
- Introductions, definition and its importance
 - Infringement related to patents, copy right, trade mark

Note: In addition, different activities like conduct of entrepreneurship awareness camp extension lecturers by outside experts, interactions sessions with entrepreneurs and industrial visits may also be organised.

INSTRUCTIONAL STRATEGY

Some of the topics may be taught using question/answer, assignment or seminar method. The teacher will discuss stories and case studies with students, which in turn will develop appropriate managerial and entrepreneurial qualities in the students. In addition, expert lecturers may also be arranged from outside experts and students may be taken to nearby industrial organisations on visit. Approach extracted reading and handouts may be provided.

RECOMMENDED BOOKS

1. A Handbook of Entrepreneurship, Edited by BS Rathore and Dr JS Saini; Aapga Publications, Panchkula (Haryana)
2. Entrepreneurship Development published by Tata McGraw Hill Publishing Company Ltd., New Delhi
3. Entrepreneurship Development in India by CB Gupta and P Srinivasan; Sultan Chand and Sons, New Delhi
4. Entrepreneurship Development - Small Business Enterprises by Poornima M Charantimath; Pearson Education, New Delhi
5. Entrepreneurship : New Venture Creation by David H Holt; Prentice Hall of India Pvt. Ltd., New Delhi
6. Handbook of Small Scale Industry by PM Bhandari
7. Principles and Practice of Management by L M Prasad; Sultan Chand & Sons, New Delhi.

8. Entrepreneurship Development & management By V.K. Joshi, Jagdamba Publication, New Delhi

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Pds)	Marks Allotted (%)
1	23	30
2	17	20
3	14	15
4	6	10
5	5	05
6	10	15
7	5	05
Total	80	100

5.6 MASS TRANSFER OPERATIONS

L T P
6 - 4

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 hrs)

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, diffusion in the gas phase-Equimolecular counter diffusion, diffusion through a stationary gas (Stefan's Law), Comparison of mass transfer in equimolecular counter diffusion and in diffusion through a stationary gas, Mass Transfer Coefficient. Film theory and penetration theory of Mass Transfer, Diffusion in solids, Knudsen diffusion.

2. Gas Absorption (20 hrs)

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, Limiting flow rates-Loading and Flooding Capacity of packed tower, Material balance and design equation, operating line. Concept of transfer unit, capacity of packed tower.

Material balance and design equation, height of column based on conditions in gas film, based on condition in 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

$$1. \quad \frac{1}{K_G a} = \frac{1}{K_G a} + \frac{m}{K_L a}$$

$$II. \quad \frac{l}{K_L a} = \frac{l}{K_L a} + \frac{m}{K_G a}$$

3. Distillation (30 hrs)

- 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
 - 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; Mc-Cabfe 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 hrs)

- i) Applications of this extraction
- ii) Choice of solvent
- iii) Steps of extraction operation
- iv) Solid Liquid extraction, construction and description of
 - Stationary solid bed open tank and closed tanks
 - Moving solid bed Basket type oil seed extractor or Bollman extractor
 - Rotocel extractor
- v) Liquid extractor; description and construction of
 - Mixer settler extraction system
 - Spray and packed extraction tower
 - Agitated tower extractor
 - Perforated plate and baffle towers.

5. Humidification (10 hrs)

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 hrs)

General drying behaviour-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 traydryer
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 Trebel
2. Unit Operation by McCabe and Smith
3. Mass Transfer I & II by Bhattacharya
4. Mass Transfer by Gavanl
5. Mass Transfer by Badger

SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Hrs)	Marks Allotted (%)
1	20	10
2	20	20
3	30	40
4	08	10
5	10	10
6	08	10
Total	96	100

GENERIC SKILL DEVELOPMENT CAMP – I

As per general feedback received from the employers regarding Technician Engineers during formal interactions, the pass outs of polytechnics are labeled of falling short of employable skills which comprises of Communication, inter-personal relationship, leadership qualities, team work, problem solving, managing task, managing self etc. in addition to technical knowledge and skills. We have, therefore, added papers such as English and Communication Skills and Entrepreneurship Development and Management in the curriculum in addition to proposed camps of 3-4 days to be conducted in polytechnics on common and vital issues e.g. Environmental Awareness, Entrepreneurship Development and Generic Skill Development.

It is proposed that a camp of 3-4 days duration on Generic Skills Development (GSD) during 5th semester be organized by arranging expert lectures/discussion sessions either by polytechnic teachers or by eminent educationists from the neighborhood to deal with the following topics. Few students may also be encouraged to prepare on some of these topics and make presentation during the camp. Expert lectures must be followed by distribution of relevant handouts for further study. The attendance of students should be compulsory and marks be awarded under provision of Student Centred Activities.

It is envisaged that such camps will bring in a significant improvement in confidence level and personality of the pass outs from polytechnics.

Suggested list of topics for arranging lectures/discussion sessions:

1. Independent Study Technique
 - 1.1 Information search, information extraction, storage and retrieval
 - 1.2 Reading skills
 - 1.3 Life long learning
 - 1.4 Continuing education
2.
 - 2.1 Introduction
 - 2.2 Time Management
 - 2.3 Stress and emotions
 - 2.4 Health and hygiene
3. Task Management
 - 3.1 Task planning and organizing
 - 3.2 Task execution
 - 3.3 Task evaluation
 - 3.4 Event management
4. Action Research
 - 4.1 Importance and Scope
 - 4.2 Steps in action research
 - 4.3 Analysis of data
 - 4.4 Conclusions and report writing