SCHEME
OF
STUDIES AND EXAMINATIONS

M.Tech. (Chemical Engineering)
w.e.f. 2009-2010

Department of Chemical Engineering

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY
MURTHAL (SONEPAT)
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## DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)
### SCHEME OF STUDIES & EXAMINATIONS
#### M. Tech. 1st YEAR (SEMESTER – II) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2009-10

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**Elective-I:**
1. CHE-554: PETROLEUM ENGINEERING
2. CHE-556: FLUIDIZATION ENGINEERING.

**Elective-II:**
1. CHE-560: CHEMICAL PROCESS INTEGRATION
2. CHE-562: RENEWABLE ENERGY TECHNOLOGIES.
## DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)
### SCHEME OF STUDIES & EXAMINATIONS
#### M. Tech. 2nd YEAR (SEMESTER – III) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2010-11

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CHE – 501 : MODELING AND SIMULATION
M. Tech. Semester - I (Chemical Engineering)

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UNIT-I: Introduction: Models and Model building. Use of Mathematical Models

UNIT-II: Modeling Fundamentals: Principles of formulation, Fundamental laws, Model characteristics, Development of mass, energy and momentum balance-equations; Lumped parameter models (steady-state and unsteady state) Distribution parameter models (steady-state and unsteady state) Stochastic models-discrete state/continuous state.


UNIT-IV: Reaction systems: Batch reactor, Reactor with mass transfer, Ideal and non-ideal binary Distillation Column, Batch Distillation with hold up, pH systems. Development of models for multistage processes, adsorption column, extraction, heat exchangers and evaporators.

UNIT-V: Simulation Case studies for simulation and Simulation examples. Numerical and software simulation techniques.

TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
CHE – 503 : ADVANCED TRANSPORT PHENOMENA
M. Tech. Semester - I (Chemical Engineering)

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Examination : 100 Marks

Total : 150 Marks

Duration of Examination : 3 Hours

UNIT-I: Momentum mass and energy balance equations; Equations of change for isothermal systems; Velocity distributions in flow systems; Interphase transport in isothermal Systems; Microscopic and macroscopic balance.

UNIT-II: Theories of turbulence- phenomenological and statistical; Turbulent transfer processes in single and multiphase systems; Temperature distribution in turbulent flow; Concentration fluctuation and time smoothed concentration; Turbulent mixing with first and second order reactions.

UNIT-III: Boundary layer theory; Steady state transport in boundary layers; Taylor dispersion in laminar tube flow.


TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.


UNIT-V: Phase Equilibria at Low to Moderate Pressures: Phase rule, Phase behavior for vapor liquid system, Margules equation, Van Laar equation, Wilson equation, NRTL equation. Dew point, Bubble point and flash calculations.


TEXT / REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
CHE – 507: APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

M. Tech. Semester - I (Chemical Engineering)

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UNIT-I: Introduction to numerical computations in chemical engineering: General introduction to the subject of numerical analysis, Representing numbers, Polynomial curve fit by least squares method and its application to chemical processes. Newton's divided difference interpolation, Forward differences with equally space base points, Bisection method for one variable, Fixed point iteration for one variable, Newton's method for one variable, Secant method for one variable, Regula Falsi for one variable.


TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
# CHE - 509: ADVANCED CHEMICAL REACTION ENGINEERING

**M. Tech. Semester - I (Chemical Engineering)**

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**UNIT-I:** Kinetics of Heterogeneous Reactions - Catalytic Reactions, Rate controlling steps, Langmuir-Hinshelwood kinetics, Rideal-Eiley Mechanism, Non catalytic fluid-solid reaction- Shrinking and Unreacted Core Model.

**UNIT-II:** Non-Ideal Flow-Residence Time Distribution, Dispersion Model, Tanks-in-Series Model, Mixing concepts, Segregated Flow Model.

**UNIT-III:** External Diffusion Effects in Heterogeneous Reactions Mass and Heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects. Modeling diffusion with and without reaction.

**UNIT-IV:** Internal Transport Processes in Porous Catalysts - Intra pellet mass and heat transfer, Evaluation of effectiveness factor, Mass and Heat transfer with reaction.

**UNIT-V:** Design of Heterogeneous Catalytic Reactors - Isothermal and adiabatic fixed bed reactors, Non-isothermal and non adiabatic fixed bed reactors. Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model.

**TEXT/REFERENCE BOOKS:**
2. Elements of Chemical Reaction Engineering, H. Scott Fogler-PHI
3. Chemical Reaction Engineering, O. Levenspiel -Willey Student Edition

**NOTE:** Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
Modeling and Simulation of Chemical Engineering Systems like:

1. Stirred tanks with/without heating jackets
2. Reaction systems
3. CSTR's isothermal and non-isothermal
4. Flash calculations
5. Multi-component distillation column
6. Batch distillation with constant and variable reflux
7. Batch distillation with holdup
8. Multistage absorption
9. Multistage adsorption
10. Extraction and leaching

Software such as Aspen Plus/Chem-CAD, MATLAB, C++ etc. may be used in modeling above problems.
CHE - 502: ADVANCED PROCESS DYNAMICS AND CONTROL
M. Tech. Semester - II (Chemical Engineering)

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UNIT-I: Closed-Loop Systems-First and Higher order systems, response to various inputs. Linear Closed-Loop Systems. Controllers and Final Control Elements. Control Valve – Valve Sizing, Valve Characteristics

UNIT-II: Stability and Frequency response-Routh Hurwitz method, Root locus method, Frequency response, design of control system, Zigler-Nichols and Cohen-Coon tuning methods, Bode diagrams, Bode stability criterion, Nyquist plots.

UNIT-III: Advanced Control Systems-Feedback- control of systems with Large Dead Time, Feed-forward and Ratio Control, Adaptive and Inferential Control Systems, Internal Model Control.

UNIT-IV: Multi-loop and Multivariable Control-Control Loop Interactions, Bristol’s Relative Gain Array Method, Singular Value Analysis, Tuning of Multi-loop PID Control system, Decoupling Control.

UNIT-V: Model Predictive Control-Overview, Predictions for SISO/MIMO Models, MPC calculations, Selection of Design and Tuning Parameters, Implementation of MPC.

UNIT-VI: Digital Sampling, Filtering, and Control-Sampling and Signal Reconstruction, Signal Processing and Data Filtering, z-Transform Analysis for Digital Control, Tuning of PID Controllers.

TEXT / REFERENCE BOOKS:
2. Chemical Process Control, G. Stephanopoulos-PHI

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
UNIT-I: Membrane separation-Characterization of membranes; transport through porous and non-porous membranes; reverse osmosis, electro dialysis, gas permeation; pervaporation, concentration, pressure, electrically and thermally driven membrane processes; membrane reactors; polarization; fouling; modules; energy requirements.

UNIT-II: Adsorptive separation-Definition; types of adsorption; adsorbent types, their preparation and properties; adsorption isotherms and their importance; equipment types for commercial processes; mathematical modeling with suitable initial and boundary conditions for different cases such as thermal swing, pressure swing and moving bed adsorption; chromatography.

UNIT-III: Other techniques-Reactive distillation; supercritical fluid extraction; surfactant based separations; cryogenic separation; ionic separation.

TEXT / REFERENCE BOOKS:
7. Supercritical Fluid Extraction by M A McHugh, V J Krukonis; Butterworth.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.
UNIT-I: Analysis of convective heat transfer-Convective heat transfer, boundary layer fundamentals, conservation of mass, momentum & energy for laminar & flow over a flat plate, boundary layer equations & similarity parameters, dimensional analysis, integral equations of the laminar boundary layer, analysis between momentum & heat transfer over a flat surface; turbulent flow & turbulent boundary layers analysis, analysis for turbulent flow over a flat surface.

UNIT-II: Heat transfer by natural convection-Temperature a velocity distribution in thermal boundary layers, governing equations of mass, momentum & energy for natural convection past vertical plane surface, approximate integral boundary layer analysis for natural convection, working correlations for various shapes, natural convection from finned surface, natural convection in enclosed spaces, mixed free & forced convection.

UNIT-III: Forced convection inside tubes & ducts- Analysis of laminar forced convection in long tube, correlations for laminar forced correction, analogy between heat & momentum transfer in turbulent flow, working correlations for turbulent forced convection, forced convection in non-circular sections. Forced convection over exterior surfaces: Flow over bluff bodies, local heat transfer coefficient distribution around cylinders, effect of various parameters on local heat transfer coefficient, heat transfer from tube bundles in cross flow, heat transfer from non-circular sections.

UNIT-IV: Heat transfer- heat transfer in fixed bed, heat transfer in fluidized bed, heat transfer in cyclone heat exchanger. Heat transfer by combined conduction, convection & radiation: Thermocouple lead error in surface temperature measurements, heat transfer from radiating fins, flat plate solar collector, the heat pipe.

TEXT / REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. Two questions are to be set from each unit.
UNIT-I: Scope and Purpose of Refining: Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, An overview of the entire spectrum of the refinery products, refinery configuration development, Physical-chemical characteristics of Petroleum and Petroleum products.

UNIT-II: Refinery Distillation Processes: Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crude oil distillation, vacuum distillation etc. Degree of separation (5-95 gap) and degree of difficulty of separation (At 50), Packie charts, ASTM, TBP and EFV Distillation.


UNIT-V: Two Phase Oil and Gas Separation equipment-Types, their description, vessel sizing. Theory of separation and separator design. Three Phase Oil Gas and Water Separators: Types of separators, their description. Various control and vessel internals, theory and sizing of three phase separator. LACT units.

TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
## CHE - 556: FLUIDIZATION ENGINEERING (ELECTIVE-I)

M. Tech. Semester - II (Chemical Engineering)

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### UNIT-I:
Introduction-Fluidization phenomenon, behaviour of fluidized beds and industrial applications

### UNIT-II:
Packed Bed-Flow of fluids, Darcy’s law and permeability, specific surface and voidage, general expressions for flow through beds, Carman –Kozeny equations, Molecular flow, Packing, Pressure drop

### UNIT-III:
Fluidized Beds- Properties of gas liquid and liquid-solid systems. Effect of fluid velocity on pressure gradient, minimum fluidizing, terminal velocity and pressure drop, types of fluidization, bubble formation, distributor, voidage, slugging and channeling, entrainment and elutriation

### UNIT-IV:
Application and Design Aspects-Heat and mass transfer in fluidized beds, introduction to design aspects of fluidized beds.

### UNIT-V:
Pneumatic and Hydraulic Conveying-Introduction, Pneumatic conveying of solids in vertical and horizontal conduits, hydraulic conveying of solids in vertical and horizontal conduits.

### TEXT/REFERENCE BOOKS:

**NOTE:** Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
CHE – 560 : CHEMICAL PROCESS INTEGRATION (ELECTIVE-II)
M. Tech. Semester - II (Chemical Engineering)

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UNIT-II: Combined heat & Power Integration, Heat engines & Thermal Pinch Diagram, Heat Pumps & Thermal Pinch diagram, cogeneration targeting


TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.
## CHE – 562 : RENEWABLE ENERGY TECHNOLOGIES (ELECTIVE-II)
### M. Tech. Semester - II (Chemical Engineering)

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### UNIT-I:
Principles of renewable energy: Fundamentals, scientific principles, technical implications and social implications.

### UNIT-II:

### UNIT-III:
Principles of photovoltaic generation of electricity; silicon cell, photon absorption, cell efficiency, solar cell construction, types and usage of photovoltaic systems.

### UNIT-IV:
Biofuels: Biofuel classification, combustion, pyrolysis, gasification and other thermo-chemical processes, production of alcohol and biogas. Trans-esterification of vegetable oils for biodiesel production, characterization of biodiesel, economics, current trends, and future prospects in usage of biodiesel.

### UNIT-V:

### UNIT-VI:
Biomass and other renewable sources of energy.

### TEXT/REFERENCE BOOKS:
1. D S Chauhan, S K Srivastava, "Non Conventional energy resources", New Age International (P) limited.

### NOTE:
Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
List of Experiments:
1. Feed-backward control system
2. Feed-forward control system
3. Analysis of valve
4. Ratio Control system
5. Selective Control system
6. Cascade control system
7. Split range control system
8. Interacting and Non-interacting System
9. Multi-Process Trainer
10. PLC Trainer
CHE - 514 : SEMINAR-I
M. Tech. Semester - II (Chemical Engineering)

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<th>Credits</th>
<th>Class Work</th>
<th>Total</th>
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<td>2</td>
<td>2</td>
<td>50 Marks</td>
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The objectives of the course remain:

- To learn how to carry out literature search
- To learn the art of technical report writing
- To learn the art of verbal communication with the help of modern presentation techniques

A student will select a topic in emerging areas of Engineering & Technology and will carry out the task under the supervision of a teacher assigned by the department. He/She will give a seminar talk on the same before a committee constituted by the Chairperson of the department. The committee should comprise of 2 or 3 faculty members from different specializations. The teacher(s) associated in the committee will each be assigned 2 hours teaching load per week. However supervision of seminar topic will be in addition to regular teaching load.
CHE – 601 : OPTIMIZATION OF CHEMICAL PROCESSES
M. Tech. Semester - III (Chemical Engineering)

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<th>L</th>
<th>P</th>
<th>Credits</th>
<th>Class Work</th>
<th>Examination</th>
<th>Total</th>
<th>Duration of Examination</th>
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<tbody>
<tr>
<td>4</td>
<td>–</td>
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<td>50 Marks</td>
<td>100 Marks</td>
<td>150 Marks</td>
<td>3 Hours</td>
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UNIT-I: Introduction to optimization-Formulation of objective function, basic concepts- functions, regions, necessary and sufficient conditions for an extremum of an unconstrained function.

UNIT-II: One dimensional search - Scanning and bracketing; Newton, Quasi-Newton and secant method, Region elimination method; polynomial approximation methods.


UNIT-IV: Linear Programming-Formulation of LP problem, graphical solution of LP Problem, Simplex Method, Duality in Linear programming, two phase method

UNIT-V: Non-Linear Programming with constraints- Necessary and sufficiency conditions for a local extremum, quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method Novel techniques for optimization – Simulated Annealing, Genetic Algorithm, Differential Evolution etc. Use of MS Excel and MAT LAB is advised for solving problems

TEXT / REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
UNIT-I: Ecology and Environment, Sources of air, water and solid wastes, Air Pollution Micrometeorology, Control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers, Design and efficiencies, Combustion generated pollution, vehicles emission control, Case studies.

UNIT-II: Water Pollution: Water quality modeling for streams. Characterisation of effluents, effluent standards, Treatment methods, Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment, Tertiary treatments such as ozonisation, disinfection etc.

UNIT-III: Solid waste collection, treatment and disposal, Waste recovery system

TEXT/REFERENCE BOOKS:
1. Environmental and pollution Science by Ian L peeper, Charles P Garba and Mark L Bresseau; Publishers: Academic Press USA
2. Air pollution: H. C. Perkins; Mc Graw Hill
3. Waste Water System engineering: H W Parker; Prentice Hall of India

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.
The primary objective of this course is to develop in student the capacity for analysis & judgment and the ability to carry out independent investigation in design/development through a dissertation work involving creativity, innovation and ingenuity. The work must start with comprehensive literature search and critical appreciation thereof so as to select research problem the student wishes to work on.

Each student will carry out independent dissertation under the supervision of some teacher(s) who will be called Supervisor(s). In no case more than two supervisors can be associated with one dissertation work.

The dissertation involving design/fabrication testing/computer simulation/case studies etc. which commences in the III semester will be completed in IV Semester. The evaluation of the dissertation phase-I besides approval of the dissertation topic of the students will be done by a committee of three members constituted as under:

- Chairperson of Department : Chairperson
- M.Tech. Coordinator/Senior faculty : Member Secretary
- Respective dissertation supervisor : Member

The student will be required to submit two copies of his/her report to the department for record (one copy each for the department and participating teacher).
UNIT-I: Introduction to polymer science-Classification of polymers, polymer structure, polymer structure, molecular weight, chemical structure and thermal transitions. The synthesis of high polymers: Step growth polymerization, chain growth polymerization, polymerization techniques, reactions of synthetic polymers, special topics in polymer synthesis, chemical structure determination.


UNIT-V: Applications for polymers: membrane separations, Biomedical separations, applications in electronics, photonic polymers, drag reduction.

TEXT/REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.
UNIT-I: Fuel cell- Introduction; types of fuel cells; advantages and disadvantages. Thermodynamics- Work potential; electrode potential; reversible voltage; thermodynamic efficiency. Electrochemical reaction kinetics- Reaction rate; Exchange current density; Galvani potential; Butler-Volmer equation; Tafel equation.

UNIT-II: Charge transport- Forces for charge transport; voltage loss due to charge transport; transport resistances; electrolytes.

UNIT-III: Mass transport- Diffusive transport; convective transport; flow structure design. Modeling- Flux balance; governing equations.

UNIT-IV: Fuel cell characterization: In-situ technique: current-voltage measurement, electrochemical impedance spectroscopy, cyclic voltametry; Ex-situ technique: porosity determination, BET surface area determination, gas permeability, structure and chemical determination.

TEXT / REFERENCE BOOKS:
2. Fuel Cell Systems Explained by J Larminie, A Dicks; Wiley.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

UNIT-II: Hazards in work places- Nature and type of Work places, Types of hazards, hazards due to improper housekeeping, hazards due to fire in multi floor industries and buildings, guidelines and safe methods in above situations. Workers' exposures to hazardous chemicals, TLV s of Chemicals, Physical and Chemical properties of chemicals leading to accidents like fire explosion ingestion and inhalation, pollution in work place due to hazardous, dust, fumes and vapors, guidelines and safety methods in chemical handling, storage entry to confined space.

UNIT-III: Hazards in industries like fertilizer, heavy chemicals, petroleum, pulp and paper, tanneries, dies, paints, pesticides, glass and ceramics, dairy and sugar industries, guidelines for safeguarding personnel and safeguarding against water, land and air pollution in the above industries.


TEXT / REFERENCE BOOKS:

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two is to be set from each unit.)
## List of Experiments:

1. Determination of Dissolved oxygen
2. Determination of BOD
3. Determination of COD
4. Determination of Acidity
5. Determination of Alkalinity
6. Determination of Total Hardness
7. Determination of Dissolved Solids
8. Determination of Volatile matter
9. Determination of Sulphates
10. Determination of Chlorides
11. Determination of Heavy metals (Atomic Absorption Spectrophotometer with Hydride generator, HPLC)
12. Stack Gas Analysis – NOX, SOX, COX, SPM
CHE – 611 : SEMINAR-II
M. Tech. Semester - III (Chemical Engineering)

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The Dissertation started in IIIrd Semester will be completed in IV Semester and will be evaluated in the following manner.

**Internal Assessment**
Internal Assessment (Class work evaluation) will be effected as per ordinance through interim report, presentation and discussion thereon by the following committee of three members.

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
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<tbody>
<tr>
<td>Chairperson of Department</td>
<td>Chairperson</td>
</tr>
<tr>
<td>M.Tech. Coordinator/Sr. Faculty</td>
<td>Member Secretary</td>
</tr>
<tr>
<td>Respective dissertation Supervisor</td>
<td>Member</td>
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**External Assessment**
Final dissertation will be assessed by a panel of examiners consisting of the following

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<tbody>
<tr>
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<td>Chairperson</td>
</tr>
<tr>
<td>Respective Supervisor(s)</td>
<td>Member(s)</td>
</tr>
<tr>
<td>External expert</td>
<td>To be appointed by the University</td>
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</table>


2. The External Expert must be from the respective area of specialization. The Chairperson & M. Tech Co-ordinator with mutual consultation will divide the submitted dissertations into groups depending upon the area of specialization and will recommend the list of experts for each group separately to the VC for selecting the examiners with the note that an external expert should be assigned a maximum of FIVE dissertations for evaluation.

The student will be required to submit THREE copies of his/her report to the M.Tech. Co-ordinator for record and processing.