M. Tech. DEGREE
(Chemical Engineering)

SYLLABUS FOR
CREDIT BASED CURRICULUM
2010 – 2011 onwards

Department of Chemical Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015.
M.TECH. Chemical Engineering
Course Structure and Scheme of Evaluation (Semester – wise)
[The total minimum number of credits = 61]

Course Structure and Scheme of Evaluation (Semester - wise)

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of the subject</th>
<th>Hours per week</th>
<th>Credits</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>L  T  P</td>
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</tr>
<tr>
<td>CL 601</td>
<td>Advanced Process Control</td>
<td>2  1  0</td>
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</tr>
<tr>
<td>CL 603</td>
<td>Process Modelling &amp; Simulation</td>
<td>2  1  0</td>
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<tr>
<td>CL 605</td>
<td>Bioprocess Engineering</td>
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<td>CL 607</td>
<td>Chemical Reactor Analysis &amp; Design</td>
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<td></td>
<td>Elective – I</td>
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<td>Elective – II</td>
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<td>CL 625</td>
<td>Chemical Engineering Lab</td>
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Total Credits in Semester I 20

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<tr>
<th>Code</th>
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<tr>
<td></td>
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<td>L  T  P</td>
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<tr>
<td>CL 602</td>
<td>Fluid Particle Technology</td>
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<tr>
<td>CL 604</td>
<td>Process Engineering Design</td>
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<tr>
<td>CL 606</td>
<td>Advanced Fluid Dynamics &amp; Heat Transfer</td>
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<td></td>
<td>Elective – III</td>
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<td>Elective - IV</td>
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<td>Elective – V</td>
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Total Credits in Semester II 20

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
<td>CL 647</td>
<td>PROJECT WORK</td>
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Total Credits in Semester III 12

<table>
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<tr>
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<tbody>
<tr>
<td>CL 648</td>
<td>PROJECT WORK</td>
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Total Credits in Semester IV 12

Total Credits in the Course 64
### Elective I & II:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CL 609</td>
<td>Computational Techniques in Engineering</td>
</tr>
<tr>
<td>CL 611</td>
<td>New Separation Techniques</td>
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<tr>
<td>CL 613</td>
<td>Nano Technology</td>
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<tr>
<td>ME 733</td>
<td>Analysis and Design of Pressure Vessels</td>
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<td>Any PG Elective from other Department</td>
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### Elective III, IV & V

<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>CL 608</td>
<td>Pinch Technology</td>
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<tr>
<td>CL 610</td>
<td>Principles &amp; Practice of Energy Conservation</td>
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<tr>
<td>CL 612</td>
<td>Water and Land Pollution Control Plant Design</td>
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<tr>
<td>CL 614</td>
<td>Pharmaceutical Technology</td>
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<tr>
<td>CL 712</td>
<td>Computational Fluid Dynamics</td>
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<tr>
<td>MT 712</td>
<td>Corrosion Science &amp; Engineering</td>
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### List of Reserved Electives:

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>CL 615</td>
<td>Scale - up Methods</td>
</tr>
<tr>
<td>CL 616</td>
<td>Food Processing</td>
</tr>
<tr>
<td>CL 617</td>
<td>Risk Analysis &amp; HAZOPS</td>
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<tr>
<td>CL 618</td>
<td>Pollution Prevention Fundamentals</td>
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<tr>
<td>CL 619</td>
<td>Industrial Safety And Management</td>
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<tr>
<td>CL 620</td>
<td>Air Pollution Control Equipment Design</td>
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<tr>
<td>CL 621</td>
<td>Optimization Techniques</td>
</tr>
<tr>
<td>CL 622</td>
<td>Bio-energy Engineering</td>
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<tr>
<td>CL 623</td>
<td>Polymer Dynamics</td>
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</table>
CL 601 ADVANCED PROCESS CONTROL


Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, Smith predictor, internal model control.

Multivariable Control Analysis: Introduction to state-space methods, Control degrees of freedom analysis and analysis, Interaction, Bristol arrays, Niederlinski index - design of controllers, Tuning of multivariable controllers.

Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems. Design of digital controllers. Introduction to PLC and DCS.

TEXT BOOKS:

REFERENCES:
CL 603 PROCESS MODELLING AND SIMULATION

Introduction to modelling, a systematic approach to model building, classification of models. Conservation principles, thermodynamic principles of process systems.

Development of steady state and dynamic lumped and distributed parameter models based on first principles. Analysis of ill-conditioned systems.


TEXT BOOKS:

REFERENCES:

Enzyme technology, Enzymes: Classification and properties -Applied enzyme catalysis - Kinetics of enzyme catalytic reactions - Microbial metabolism - Metabolic pathways - Protein synthesis in cells.


Bioreactor and product recovery operations: Operating considerations for bioreactors for suspension and immobilized cultures, Selection, scale-up, operation of bioreactors - Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes; oxygen uptake rates and determination of oxygen transfer rates and coefficients; role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems.

Introduction to Instrumentation and Process Control in Bioprocesses: Measurement of physical and chemical parameters in bioreactors - Monitoring and control of dissolved oxygen, pH, impeller speed and temperature in a stirred tank fermenter.

TEXT BOOKS:

REFERENCE:
CL 607 CHEMICAL REACTOR ANALYSIS AND DESIGN

Analysis of Noncatalytic fluid solid reaction: Kinetics of non-catalytic fluid-particle reactions, various models, application to design.

Catalyst preparation and characterization: Catalysis - Nature of catalyses, methods of evaluation of catalysis, factors affecting the choice of catalysts, promoters, inhibitors, and supports, catalyst specifications, preparation and characterization of catalysts, surface area measurement by BET method, pore size distribution, catalyst, poison, mechanism and kinetics of catalyst, deactivation.

Physical adsorption and chemical adsorption: Fluid-fluid reactions different regimes, identification reaction regime, application to design. Physical absorption with chemical reaction, simultaneous absorption of two reacting cases consecutive reversible reactions between gas and liquid, irreversible reactions, estimation of effective interfacial area in absorption equipment.

Reaction kinetics, accounting porous nature of catalyst: Heterogeneous catalytic reactions - effectiveness factor, internal and external transport processes, non-isothermal reacting systems, uniqueness and multiplicity of steady states, stability analysis.

Modeling of chemical reactors: Modeling of multiphase reactors - Fixed, fluidized, trickle bed, and slurry reactors.

TEXT BOOKS:

REFERENCES:
CL 602 FLUID PARTICLE TECHNOLOGY

Applications of fluidized beds: Introduction, Industrial application of fluidized beds, Physical operations and reactions.


Elutriation and entrainment: TD and also distribution of solid in a fluidized bed. Circulation systems.

Design of fluidized bed systems: design of fluidization columns for physical operations, catalytic and non-catalytic reactions, three phase fluidization.

TEXT BOOK:

REFERENCE:
CL 604 PROCESS ENGINEERING DESIGN

Phase separation equipment design: Design of filter press, Centrifuge, Cyclone (Hydro as well as air) Drier, and Crystallizer.

Design of double heat exchangers, Shell and Tube Heat exchangers, Condensers and Evaporators

Design of storage tank and supports: Design of vertical and horizontal storage tank, Design of Saddle, Skirt, and Lug supports

Design of Reaction vessel, storage tank, Pressure vessel,

Design of mass transfer equipments: Design of distillation column, Absorption tower both plate as well as packed type, cooling tower and extraction columns

TEXT BOOKS:
2. Coulson and Richardson Chemical Engineering Vol.VI, Pergamon Press, 1983

REFERENCES:
1. Perry Chemical Engineer’s Hand book by Perry, McGraw-Hill, 2009
Properties of fluids and multiphase flow: Introduction: Fluids and fluid properties, basic equations for flowing streams, flow of incompressible fluids, Newtonian, non-Newtonian and non-viscous fluids, determination of flow properties of fluids, flow in pipes and tanks, flow through packed bed and fluidized beds.


Heat transfer in fluids: Combination of heat transfer resistance, Multidimensional Steady and Unsteady state heat conduction, Unsteady state heating and cooling of solid objects, Convection heat transfer co-efficient, Heat transfer during Laminar and Turbulent flow in closed conduits- Empirical correlation for high Prandtl Number of fluids, Dimensional analysis in convection heat transfer

Analogy and recent developments in heat exchangers: Analogy between momentum and heat transfer. Recent developments in the design of compact heat exchangers, insulation-design and selection.


TEXT BOOKS:

REFERENCES:
ELECTIVES

CL 609 COMPUTATIONAL TECHNIQUES IN ENGINEERING

Design and analysis of experiments: Treatment and interpretation on engineering data: Curve fitting, Non-linear least square regression. Interpolation: Newton's Forward/Backward interpolation formula, Lagrange's interpolation formula and experiments their application. Tests of significance, Analysis of variance.

Formulation of physical problems: Mathematical statement of the problem, Representation of problems, Formulation on Socuene extraction in single & multiple stages, Radial heat transfer through a cylindrical conductor, salt accumulation in stirred tank.


Finite differences: Finite differences, Partial differential equations, Solutions of elliptic, parabolic, and hyperbolic types of equations.

TEXT BOOKS:

REFERENCE:
CL 611 NEW SEPARATION TECHNIQUES


Membrane Separations: Types and choice of membranes, their merits, commercial, pilot plant polarization of membrane processes and laboratory membrane permeators, dialysis, reverse osmosis, ultra filtration, Concentration and economics of membrane operations, Design controlling factors.

Separation by Sorption Techniques: Types and choice of adsorbents, chromatographic techniques, Types, Retention theory mechanism, Design controlling factors ion exchange chromatography equipment and commercial processes, recent advances and economics.

Ionic Separations: Controlling factors, applications, Theory mechanism and equipments for electrophoresis, dielectrophoresis and electro dialysis - commercial applications - Design considerations.


TEXT BOOKS:

REFERENCES:
CL 613 NANO TECHNOLOGY

Supramolecular Chemistry: Definition and examples of the main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supramolecular structures.

Physical Chemistry of Nanomaterials: Students will be exposed to the very basics of nanomaterials; a series of nanomaterials that exhibit unique properties will be introduced.

Methods of Synthesis of Nanomaterials. Equipment and processes needed to fabricate nano devices and structures such as bio-chips, power devices, and opto-electronic structures. Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches.

Biologically-Inspired nanotechnology basic biological concepts and principles that may lead to the development of technologies for nano engineering systems. Coverage will be given to how life has evolved sophisticatedly; molecular nanoscale engineered devices, and discuss how these nanoscale biotechnologies are far more elaborate in their functions than most products made by humans.

Instrumentation for nanoscale characterization. Instrumentation required for characterization of properties on the nanometer scale. The measurable properties and resolution limits of each technique, with an emphasis on measurements in the nanometer range.

TEXT BOOKS:

1. Supramolecular Chemistry by Jean-Marie Lehn, Wiley VCH, 1995
2. Supramolecular Chemistry by Jonathan Steed & Jerry Atwood, John Wiley & Sons, 2004
Pinch Location: Locating the pinch, significance of pinch, pinch in grid representation, Threshold problems, capital cost implication of the pinch.

Targeting: Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, continuous targeting.


Pinch Design and Optimization: Networks for maximum energy recovery, Pinch design method, Flexibility criteria of the pinch, cp table, the tick of heuristic, case studies, optimization of heat exchanger network optimality for a minimum area network, Sensitivity analysis.


TEXT BOOKS:
1. V. Uday Shenoy “Heat Exchanger network synthesis" Gulf Publishing Co, USA, 1995

REFERENCES:
CL 610 PRINCIPLES AND PRACTICE OF ENERGY CONSERVATION

Introduction: General principles of energy conservation. Sectorial energy conservation possibilities, electricity conservation, industrial transportation and residential sectors.


Energy conservation in boilers: Practical applications of energy conservation: steam balances using the steam turbine, returning the condensate to boilers, flashing condensate to lower pressure, Furnace efficiency: effect of flue gas and combustion air temperature, reducing flue gas temperature, steam tracing, Heat recovery.

Energy conservation in pumps including Variable Drives and Variable Frequency Drives, Piping systems, Dryers and evaporators: Pumps, Fans and blowers, Piping systems design for energy efficiency, Multiple effects, gravity feed evaporators, thermo-compression, vapour - recompression systems - Drying: Convective dryers.

Energy Conservation: Case studies Ceramic industry (Glass, porcelain), Cement, Refineries, Iron and steel, Pulp and Paper

TEXT BOOKS:

REFERENCES:
CL 612 WATER AND LAND POLLUTION CONTROL PLANT DESIGN


Advanced Wastewater and Water Treatment: Carbon adsorption - Ion exchange - Membrane processes - Nutrient (nitrogen and phosphorus) removal - Design of plant for treatment and disposal of sludge


TEXT BOOKS:

REFERENCES:
CL 614 PHARMACEUTICAL TECHNOLOGY

Introduction to Physical Pharmaceutics - Metrology and calculations, Molecular structure, properties and states of matter, Solutions, Phase equilibria, Micromeritic and Powder Rheology, Surface and Interfacial phenomena, Dispersion systems, Diffusion & Dissolution, Kinetics and drug stability, Viscosity & Rheology, and Polymer science and applications.

Formulations and Development

Packaging

Introduction to Industrial Processing

Transport Phenomena (Fluid Flow, Heat Transfer and Mass Transfer)

Particulate Technology (Particle Size, Size reduction, Size Separation, Powder Flow and Compaction)

Unit Operations (Mixing, Evaporation, Filtration, Centrifugation, Extraction, Distillation, and Drying)

Materials of Pharmaceutical Plant Construction

Good Manufacturing Practice (GMP’s) Guideline

TEXT BOOKS:

REFERENCE BOOKS:
1. Physical Pharmacy by Alfred Martin, Lippincott Williams & Wilkins, 2006
Conservation Laws of Fluid Motion and Boundary Conditions: Governing equations of fluid flow and heat transfer, Equations of state, Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations

Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The k-e model, Reynolds stress equation models, Algebraic stress equation models


**TEXT BOOKS:**


**REFERENCE BOOKS:**

CL 615 SCALE -UP METHODS

Principals of Similarity, Pilot Plants & Models: Introduction to scale-up methods, pilot plants, models and principles of similarity. Industrial applications.

Dimensional Analysis and Scale-Up Criterion: Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering.

Scale-Up of Mixing and Heat Transfer Equipment: Typical problems in scale-up of mixing equipment and heat transfer equipment

Scale-Up of Chemical Reactors: Kinetics, reactor development & scale-up techniques for chemical reactors.

Scale-Up of Distillation Column & Packed Towers: Scale-up of distillation columns and packed towers for continuous and batch processes

TEXT BOOKS:

REFERENCE:
CL 616 FOOD PROCESSING


Unit Operations in Food Processing: Fluid flow, thermal process calculations, refrigeration, evaporation and dehydration operations to food processing. Heat processing of foods - modes of heat transfer involved in heat processing of foods.


Separation And Mixing Process In Food Industries: Conversion operations. Size reduction and screening of solids mixing and emulsification, filtration and membrane separation, centrifugation, crystallization, extraction.


TEXT BOOK:

REFERENCES:
CL 617 RISK ANALYSIS & HAZOPS


Consequence Analysis - Fire and Explosion models: Radiation - Tank on fire - Flame length - Radiation intensity calculation and its effect to plant, people & property, UCVCE - Explosion due to - Deflatration - Detonation - TNT, TNO & DSM model - Over pressure - Effects of explosion - Risk contour - Flash fire - Jet fire - Pool fire - BLEVE - Fire ball.


TEXT BOOKS:

REFERENCES:
CL 618 POLLUTION PREVENTION FUNDAMENTALS

Pollution Prevention in industries: Environment friendly chemical processes - Properties and fates of environmental contaminants - Regulations for clean environment and implications for industries - Improved manufacturing operations.

Life Cycle Assessment and Environmental Audit: Life cycle assessment and pollution prevention economics - Hazard and risk Analysis - Pollution prevention planning - Design for the environment.


TEXT BOOKS:
2. T.K. Roy, (Editor), Chemical Technology for better Environment, Allied publishers Ltd, Chennai 1998

REFERENCES:
CL 619 INDUSTRIAL SAFETY AND MANAGEMENT

Hazards: Chemical hazards classification. Radiation hazards and control of exposure to radiation. Types of fire and fire prevention methods. Mechanical hazards. Electrical hazards


TEXT BOOKS:

REFERENCES:
CL 620 AIR POLLUTION CONTROL EQUIPMENT DESIGN

Air Pollutant Sources, Effects and Clean Air Acts: Pollution of air: Sources and effects of air pollutants on physical environment and living systems, Monitoring air pollution, Air pollution Laws and Minimum national standards.

Air Pollutant Formation, Dispersion, Analysis: Formation of pollutants through large-scale combustion of fossil fuels, mineral processing, automobiles in urban areas and at source minimisation of release - Meteorological aspects of air pollutant dispersion. Chemical reactions in a contaminated atmosphere, urban air pollution, acid rain Air sampling and measurement, Analysis of air pollutants

Air Pollution Control Methods for Particulates Removal: Control Methods - Source Correction methods - Particulate emission control: Dry techniques industrial dust collectors, cyclone and multiclone separators, bag filters, electrostatic precipitators, relative merits and demerits, choice of equipments, design aspects economics. Wet techniques wet dust collection, wet cyclone, empty scrubber, column (packed) scrubber, ventury scrubber, suitability, merits and demerits, design aspects and economics.

Control of Specific Gaseous Pollutants: Cleaning of Gaseous effluents - Control of sulphur dioxide emission by various methods - Control of nitrogen oxides in combustion products - Control of release of carbon monoxide and hydrocarbons to the atmosphere.

Noise Pollution and Control: Sound pressure, Power and Intensity - Measures of Noise- Outdoor noise propagation- Indoor Noise propagation- Noise Control

Hazardous Waste Management and Risk Assessment: Types of hazardous Wastes-Health effects - Nuclear fission and radioactive waste treatment and disposal methods. Risk assessment

**TEXT BOOKS:**

**REFERENCES:**
CL 621 OPTIMIZATION TECHNIQUES.

General: Functions of single and multiple variables - optimality criteria, direct and indirect search methods.

Linearization: Constraint optimality criteria, transformation methods based on linearization.

Quadratic and Geometric Programming: Quadratic and geometric programming problems, calculus of variations.


Artificial Intelligence in Optimization: Introduction to Artificial Intelligence in optimization.

TEXT BOOK:

REFERENCE:
CL 622 BIOENERGY ENGINEERING

Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification - Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels- Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass.


TEXT BOOKS:
REFERENCES:
CL 623 POLYMER DYNAMICS

Introduction to Polymers: Polymer Melts and Solution.


Dilute Solutions: Elastic Dumbell Model and bead-rod-spring model for polymer chain, the Rouse and Zimm Models


REFERENCES: