

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Group 1		
Sl. No	Course Code	Course Name
1	16HCE11	Applied Mathematics in Chemical Engineering
2	16BCE152	Mathematical Modeling in Biochemical Engineering
3	16BCE12	Process Automation
4	16HCE21	Plant wide Control of Chemical Processes

Group-2		
Sl. No	Course Code	Course Name
1	16HCE13	Transport Phenomena
2	16HCE14	Chemical Equipment Design
3	16HCE23	Catalytic Reaction Engineering
4	16HCE12	Advanced Thermodynamics

Group-3		
Sl. No	Course Code	Course Name
1	16HCE24	Waste Management Techniques
2	16HCE151	Air Pollution Control and Design of Equipment
3	16BCE21	Bioseparation and Downstream Processing
4	16HCE154	Fuel Cell Technology

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Group-4		
Sl. No	Course Code	Course Name
1	16HCE251	Enzyme Engineering
2	16HCE254	Food Processing and Engineering
3	16HCE421	Fermentation Engineering
4	16CEE12	Applied Environmental Chemistry and Microbiology

Group-5		
Sl. No	Course Code	Course Name
1	16HCE152	Computational Fluid Dynamics
2	16HCE422	Total Quality Management
3	16CEE252	Environmental Planning and Management
4	16HCE424	Pharmaceutical Technology

Group-6		
Sl. No	Course Code	Course Name
01	16HCE253	Gasification Technology
02	16CEE152	Renewable and Alternative Fuels
03	16HCE153	Modern Separation Techniques
04	16HCE252	Interfacial Engineering

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE11	Group-1	Applied Mathematics in Chemical Engineering
Exam Hours:03		Exam Marks:100	
<p>Module 1. PROBABILITY AND SAMPLING THEORY: Definitions, Conditional probability, Probability Distributions- Bernoulli, Binomial, Poisson, uniform, exponential, normal and gamma. Random samples, central limit theorem, χ^2, t and F distributions. Estimation-point estimation, unbiasedness and consistency. Hypothesis testing-types of errors, significance level, Test concerning single mean, single variance and two means and two variance. Goodness of fit test.</p>			
<p>Module 2. DESIGN AND ANALYSIS OF EXPERIMENTS: Treatment and interpretation on engineering data: Curvefitting, Non-linear least square regression. Interpolation: Newton's Forward/Backward interpolation formula, Lagrange's interpolation formula and experiments, their application.</p>			
<p>Module 3. NUMERICAL SOLUTION OF LINEAR & NONLINEAR ALGEBRAIC EQUATIONS: Linear systems of equations, solutions by Creamer's Rule, Matrix methods, Gaussian, Gauss-Jordan, Jacobean, Gauss-Seidel and Relation methods. Formulation of linear and non-linear first and second order ordinary differential equations, higher order linear, differential equations for systems involving momentum, heat and mass transfer with and without chemical reactions and their analytical solutions.</p>			
<p>Module 4. NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS: Ordinary differential equations: Runge-Kutta, Euler's and Milne's predictor corrector methods. Solution of boundary value problems.</p>			
<p>Module 5. PARTIAL DIFFERENTIAL EQUATIONS: Solutions of elliptic, parabolic, and hyperbolic types of equations by Finite differences method.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. H.S. Mickley, T. K. Sherwood and C.E. Reid, “**Applied Mathematics in Chemical Engineering**”, II Tata McGraw Edn., Hill, New Delhi, 1978.
2. Jain M.K., **Numerical Solution of differential equations**, Wiley Eastern, 1987

Reference Books:

1. M. K. Jain, S.R.K. Iyengar and R. K. Jain, "**Numerical Methods for Scientific and Engineering Computations**", 1992.
2. Sheldon M. Ross, **Introduction to Probability and Statistics for Engineers and Scientists**, John Wiley, 1989.
3. Smith G.D., **Numerical Solution of partial differential equations**, Oxford University Press, 1978

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

02	16BCE152	Group-1	MATHEMATICAL MODELING IN BIOCHEMICAL ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. Numerical Techniques: Simultaneous linear algebraic equation– Gauss Jordan, Non-linear algebraic equation–Newton Raphson, Ordinary Differential Equation–R-K Method, Numerical Integration–Simpson’s 1/3 Rule . Applications: Vapor–Liquid equilibria for binary mixtures, Calculation of Bubble Point Dew point for ideal binary mixture</p>			
<p>Module 2. Bioreactor: Operational stages in a Bioprocess industry, biochemical reactor, continuous stirred tank bioreactor–process description, mathematical model, fed-batch bioreactor- model development</p>			
<p>Module 3. Design: Double Pipe Heat Exchanger (Area, Length and Pressure drop), Shell & Tube Heat Exchanger (Area, Number of tubes, Pressure drop)</p>			
<p>Module 4. Modeling: Applications of law of conservation of mass in mixing tank system, equilibrium still and single stage extraction. Heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, rate expression for series and parallel homogenous first order reactions.</p>			
<p>Module 5. Mathematical Modeling and Solutions to the Following: Basic tank model – Level V/s time, batch Distillation–Vapour composition with CSTRs in series.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			
<p>Text Books:</p> <ol style="list-style-type: none"> 1. Jenson, V. G. and Jeffreys, F. V.,Mathematical methods in Chemical Engineering,2nd edition, Academic press, Elsevier, India, 2012. 2. Jana, Aimya K., Chemical Process Modelling and Computer Simulation, 2nd edition, PHI Learning Private Limited, New Delhi, India, 2011. 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

3. William. L Luyben, Process Modeling Simulation and Control for Chemical
4. Engineering 2nd Edition, McGraw Hill, 1990.

Reference Books:

1. Gaikwad, R. W, and Dharendra, Process Modelling and Simulation, 2nd Edition, Denetted & Co., 2006.
2. Grewal, B. S., Higher Engineering Mathematics, 40th edition, Khanna Publishers, Delhi, India, 2009.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16BCE12	Group-1	PROCESS AUTOMATION
Exam Hours:03		Exam Marks:100	
<p>Module 1. REVIEW OF SYSTEMS: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Control valve types- linear, equal percentage and quick opening valves. Transient response. Block diagrams.</p>			
<p>Module 2. STABILITY ANALYSIS: Routh Hurwitz method, Root locus method, Frequency response, design of control system, controller tuning and process identification. Ziegler-Nichols and Cohen-Coon tuning methods, Bode-Nyquist Plots-Process modeling.</p>			
<p>Module 3. SPECIAL CONTROL TECHNIQUES: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, computing relays, simple alarms, Smith predictor, internal model control, theoretical analysis of complex processes.</p>			
<p>Module 4. MULTIVARIABLE CONTROL: Analysis of multivariable systems, Interaction, examples of storage tanks. Review of matrix algebra, Bristol arrays, Niederlinski index – Tuning of multivariable controllers.</p>			
<p>Module 5. 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.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Coughnour D R, “**Process system analysis and control**”- 2nd Edn., McGraw Hill, New York, 1991.
2. George Stephanopoulos, “**Chemical process control, An Introduction to Theory and Practical**” - Prentice Hall, New Delhi, 1998.

Reference Books:

1. Smith C A and Corripio A B “**Principles and practice of automotive process control**”- John Wiley, New York, 1976.
2. Luyben “**Process Modelling, Simulation and Control for chemical Engineers**”-2nd edn., McGraw Hill, 1990.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16HCE21	Group-1	PLANT WIDE CONTROL OF CHEMICAL PROCESS
Exam Hours:03		Exam Marks:100	
<p>Module 1. REVIEW OF PROCESS DYNAMICS: First order systems – thermometer, level tank, CSTR, Secondorder system – U tube manometer, Damped vibrator.</p>			
<p>Module 2. FEED BACK CONTROL: Feedback controllers, PID Controller design and tuning, Zeigler–Nichols controller tuning. STABILITY: Concept and Criterion, Routh test, Root locus, frequencyresponse analysis. Bode diagrams, Phase margin and gainmargin.</p>			
<p>Module 3. ADVANCED CONTROL TECHNIQUES: Cascade, feed forward and feed backward, ratio control,selective and adaptive control, smith predictor and internal module controller.</p>			
<p>Module 4. MULTI VARIABLE CONTROLLER: Features and examples of multi input and multi output processes,design of cross controller, relative gain array, Niderlinski index. CONTROL STRUCTURES FOR UNIT OPERATIONS: Simple distillation column, heat exchanger, evaporator, andreactor.</p>			
<p>Module 5. PLANT WIDE CONTROL FOR IMPROVED ECONOMICS: Process operation for a given throughput and for maximumthroughput, concept of bottleneck constraint, application of optimizing controllers for throughput maximization on casestudy processes.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Coughnour D R, **Process system analysis and control**, 2nd Edition, McGraw Hill, New York, 1991.
2. George Stephanopoulos, **Chemical process control**, An Introduction to Theory and Practice, Prentice Hall, New Delhi, 1998

Reference Books:

1. Smith C A and Corripio A B, **Principles and Practice of Automotive Process Control**, John Wiley, New York, 1976.
2. Luyben, Process Modelling, **Simulation and Control for Chemical Engineers**, 2nd Edition McGraw Hill, 1990.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE13	Group-2	TRANSPORT PHENOMENA
Exam Hours:03		Exam Marks:100	
<p>Module 1. BASIC CONCEPTS: Newtonian fluids, Non Newtonian Fluids, Analogies between Momentum, Heat and Mass Transport, Rheological behavior of fluids, Differential balance equations for heat, mass and momentum.</p>			
<p>Module 2. MOMENTUM TRANSPORT (LAMINAR FLOW): Steady state Shell momentum balances, Boundary conditions applicable to momentum transport problems (flow over flat plate, flow through circular tube and annulus)</p>			
<p>Module 3. INTERPHASE AND MULTIPHASE MOMENTUM TRANSFER: Friction factor (qualitative treatment only), Introduction to velocity distributions in Turbulent flow (Fluctuations and Time smooth Quantities) and Equation of Change for Isothermal system (Equation of Continuity and Motion), Macroscopic Balance for Isothermal Systems (Mass, Momentum and Mechanical Energy Balance). Formation of bubbles and drops and their size distribution, Solid-fluid systems - forces acting on stagnant and moving solids.</p>			
<p>Module 4. CONVECTION: Heat Transfer coefficient, Free and Forced convection, film type and drop wise condensation and equations for heat transfer coefficients for both, Heat transfer in boiling liquids. RADIATION: The spectrum of electromagnetic radiation, absorption and emission at solid surfaces, Planck's distribution law, Wein's displacement law and Stefan- Boltzmann law, Lambert's cosine law, heat exchange by radiation between two black surface elements.</p>			
<p>Module 5. MASS TRANSPORT: Fick's law of diffusion, Diffusion with homogeneous and heterogeneous chemical reaction, convective mass transfer coefficient, theories of ordinary diffusion in liquids.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Bird R.B., W.E. Stewart and E.N. Lightfoot, **Transport Phenomena**, John Wiley and Sons, Academic Press, 1994
2. B. M Suryavashi and L. R Dongre, **Transport phenomena**, Niraliprakashann, 4th edition.

Reference Books:

1. Welty, J.R., C.E. Wicks and R.E. Wilson, **Fundamental of Momentum, Heat and Mass Transfer**, John Wiley and Sons, 4th Edn., John Wiley, 2000.
2. Sissom L.E. and D.R.Pitts, **Elements of Transport Phenomena**, McGraw Hill, New York, 1972.
3. Brodkey R.S. and H.C.Hershey, **Transport Phenomena, A United Approach** McGraw Hill, 1988
4. Warren L. McCabe, Julian C. Smith, Peter Harriott, **Unit Operations of Chemical Engineering**. Mcgraw-hill, 7th Edition

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

02	16HCE14	Group-2	CHEMICAL EQUIPMENT DESIGN
Exam Hours:03		Exam Marks:100	
<p>Modules. Detailed Engineering Process & Mechanical Design aspects and sketching (The sketch shall include sectional front view, full Top/side view) of the following:</p> <ol style="list-style-type: none"> 1. Double pipe Heat Exchanger. 2. Shell and Tube Exchanger. 3. Horizontal and Vertical Condensers 4. Evaporator Single Effect 5. Bubble Cap Distillation Column 6. Absorption column 			
<p>Question paper pattern: This question paper will have two questions. Each full question consists of 100 marks. The students will have to answer one full question. Use of IS code books relevant to above designs and Perry's Chemical Engineers Handbook is permitted for examination.</p>			
<p>Text Books:</p> <ol style="list-style-type: none"> 1. Robert E Treybal, Mass Transfer operations, 3rd edition, McGraw Hill, 1981. 2. K A Gavhane – Mass Transfer, Nirali Prakashan. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Kern D.Q., Process Heat Transfer, McGraw Hill, 18th Reprint, 2008. 2. Coulson and Richardson, Chemical Engineering, Volume 6, Butterworth Heinemann, 1990. 3. B I. Bhat & Thakore, Process design, McGraw Hill 4. BIS 4503 – Code for shell and tube heat exchangers 5. Perry and Green, Chemical Engineering Handbook, 8th Edition, McGrawHill, 2008. 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16HCE23	Group-2	CATALYTIC REACTION ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. INDUSTRIAL CATALYSIS: Classification on catalyst- homogeneous, heterogeneous, Biocatalysts, Typical industrial catalytic processes, preparation of catalysts- laboratory techniques, Industrial methods, transition models, dual functional catalysts, zeolites, Enzymes, solid supportive materials, catalyst activation.</p>			
<p>Module 2. CATALYST CHARACTERIZATION: Surface area measurements, BET Theory, pore size distribution, Porosity-Chemisorption techniques, Static and dynamic methods, Crystallography and surface analysis techniques, XRD, XPS, ESCA, ESR, NMR, Raman and Molecular spectroscopy, surface acidity and toxicity, activity, life time, bulk density, thermal stability.</p>			
<p>Module 3. KINETICS OF HETEROGENEOUS REACTIONS (CATALYTIC): Catalytic Reactions, Rate controlling steps, Langmuir -Hinshelwood model, Riedel – Eiley Mechanism. CATALYST DEACTIVATION: Poisons, Sintering of catalysts, pore mouth plugging and uniform poisoning models, Kinetics of deactivation, Catalyst regeneration.</p>			
<p>Module 4. HETEROGENEOUS REACTIONS (NON-CATALYTIC): Introduction, non-catalytic fluid-fluid reactions. Non catalytic fluid-solid reactions & models for such reactions to determine time of conversion. NON IDEAL REACTOR ANALYSIS: Mixing concepts, Residence Time Distribution, Response Measurements, segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non ideal reactors, two parameter models for CSTR.</p>			
<p>Module 5. EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS: Surface kinetics & pore diffusion effects, Evaluation of effectiveness factor, DESIGN OF REACTORS FOR HETEROGENEOUS CATALYTIC & NON CATALYTIC REACTIONS: Design of reactors for non catalytic fluid-fluid and fluid-solid reactions.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Smith J.M, **Chemical Engineering Kinetics**, 3rd Edition, McGraw- Hill, 1984.
2. Bischoff and Froment, **Chemical Reactor Design and Analysis**, Addison Wesley, 1982.
3. Fogler H.S, **Elements of Chemical Reaction Engineering**, Prentice Hall, 1986.

Reference Books:

1. Octave Levenspiel, **Chemical Reaction Engineering** 3rd Edition, John Wiley and sons.
2. Emmett, P.H., **Catalysis, Vols. I & II**, Reinhold Publishing Corporation, NY, 1954
3. Thomas and Thomas, **Introduction to Heterogeneous Catalysts**, Academic Press. London, 1967.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16HCE12	Group-2	ADVANCED THERMODYNAMICS
Exam Hours:03		Exam Marks:100	
<p>Module 1. REVIEW OF FIRST & SECOND LAW OF THERMODYNAMICS: Applications solution thermodynamics – partial molar properties –Ideal & non ideal solutions -fugacity and its coefficient.</p>			
<p>Module 2. VLE: Determination of fugacity coefficient -Gibbs Duhem equation –azeotropic separation techniques VLE Correlation techniques –Van Laar, Margules, Wilson, NRTL and other types of correlation equation applications -High pressure VLE – Partially miscible systems.</p>			
<p>Module 3. CHEMICAL REACTION EQUILIBRIA: Industrial chemical reaction equilibria -homogeneous and heterogeneous systems - Effect of pressure and temperature – Complex reactions – liquid phase, vapor phase reactions.</p>			
<p>Module 4. THIRD LAW OF THERMODYNAMICS: Verification of third law, Applications and evaluation.</p>			
<p>Module 5. STATISTICAL THERMODYNAMICS: Energy levels, Boltzmann Distribution Law and Partition functions</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Jefferson W. Tester, Michael Modell, **Thermodynamics and Its Applications**, 3rd Edition, 1997.
2. J.M. Smith and Van Ness H.C, **Introduction to Chemical Engineering, Thermodynamics**”- ,McGraw Hill, 5th edition 1996.

Reference Books:

1. J.M. Smith and Van Ness H.C, **Introduction to Chemical Engineering Thermodynamics**”- ,McGraw Hill, 5th edition 1996.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE24	Group-3	WASTE MANAGEMENT TECHNIQUES
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION TO WASTE WATER: Ecosystem, characteristics, standards, effects of waste water on health, ecosystem, and materials. TREATMENT PHYSICAL: Introduction to screening, flow equalization, flocculation, grit removal, sedimentation, flotation. CHEMICAL: Introduction to coagulation, precipitation, oxidation, neutralization, chlorination. Detailed study on phosphorous and heavy metals removal.</p>			
<p>Module 2. BIOLOGICAL: Introduction to bacterial life cycle, cell culturing, types of biological processes, Aerobic process. Theory of aeration, factors affecting oxygen transfer, Mixing requirements, types of aerators. Nitrification & de-nitrification. Detailed study on Activated sludge process & trickling filter. ANAEROBIC PROCESS: Construction and working of UASBR, Rotating biological contactors. Algal ponds, Hyacinth and Duckweed, fish ponds.</p>			
<p>Module 3. SOLID WASTE: Sources, characteristics, present techniques of solid waste management, integrated solid waste management, measures and methods to assess solid waste quantities. Functional elements, Generation of solid waste, onsite handling. Collection SCS, HCS, and separation processes, source reduction, 3R's.</p>			
<p>Module 4. TRANSFORMATION: Thermal conversion techniques, Pyrolysis, Gasification, waste to energy, composting.</p>			
<p>Module 5. DISPOSAL: Site selection, landfill and engineering landfill, leachate and gas collection.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Arcivala S.J. and S.R.Asolekar, **Wastewater Treatment for Pollution Control and Reuse**, 3rd Edition, Tata McGraw Hill Pvt. Ltd., New Delhi, 2009.
2. Metcalf and Eddy, **Wastewater Engineering -Treatment, Disposal & Reuse**, Tata McGraw Hill, 1991
3. H.E. Babbilt and R.Baumann, **Sewage and Sewage Treatment**, 1986.

Reference Books:

1. Martell, **Solid Wastes**, John Wiley, NY, 1975.
2. George Tchobanoglous *et al.*, **Integrated Solid Waste Management**, 2nd Edition, McGraw Hill & Co, 1993.
3. Frank Krieth, **Handbook of Solid waste**, McGraw Hill Inc., NY, 1996.
4. Jagbir Singh, and A.L. Ramanathan (Eds.), **Solid Waste Management Present and Future Challenges**, I.K. International House Pvt. Ltd., New Delhi, 2010.
5. C S Rao, **Environmental Pollution Control and Engineering**, New age international Pvt. Ltd, New Delhi 2009.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

02	16HCE151	Group-3	AIR POLLUTION CONTROL AND DESIGN OF EQUIPMENT
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION: Definition and concentrations, classification and properties of airpollutants, emission sources-natural and anthropogenic sources, effects of air pollution on flora and fauna, human health and materials. AIR POLLUTION LAWS AND STANDARDS: Meteorological aspects of air pollution dispersion- Temperature lapse rates and stability, wind velocity and turbulence, plume behavior, dispersion of air pollutants, solutions to atmospheric dispersion equation, the Gaussian plume model.</p>			
<p>Module 2. AIR POLLUTION SAMPLING AND MEASUREMENTS: Types of pollution sampling and measurements, ambient air sampling, Collection of gaseous air pollutants, collection of Particulate pollutants, stack sampling, analysis of air pollutants like sulphur dioxide, nitrogen oxide, carbon monoxide, oxidants and ozone, hydrocarbon, particulate matter.</p>			
<p>Module 3. AIR POLLUTION CONTROL METHODS AND DESIGN OF EQUIPMENTS: Control methods, source correction methods, cleaning of gaseous effluents, design of stacks and industrial ventilation systems.</p>			
<p>Module 4. PARTICULATE EMISSION CONTROL: Selection of particulate collector, design of gravitational settling chambers, cyclone separators, bag house filters, electrostatic precipitators, wet scrubbers</p>			
<p>Module 5. CONTROL OF GASEOUS EMISSIONS: Absorption by liquids, adsorption by solids, combustion. Air pollution control in specific industries, control of sulphur dioxide, nitrogen dioxides, carbon monoxides and hydrocarbon emissions. Acid rain, green house effects, important air pollution episodes.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Mudakavi J.R, **Principles and Practices of Air Pollution Control and Analysis**, I.K. International Publishing Home Pvt. Ltd., New Delhi, 2010.

Reference Books:

2. Martin Crawford, **Pollution control theory**, McGraw Hill, NY, 1976
3. Joe Ledbetter, **Air Pollution Part A&B**, Marcel Dekker, NY, 1972.
4. Cheremissinoff N, **Air Pollution Control**, Design Hand Book, Part I and II, Marcel Dekker, NY, 1977.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16BCE21	Group-3	BIOSEPARATION AND DOWNSTREAM PROCESSING
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION: Role and importance of downstream processing in biotechnological processes. Problems and requirements of byproduct purification. Economics of downstream processing in Biotechnology. Cost cutting strategies, Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes.</p>			
<p>Module 2. PRIMARY SEPARATION TECHNIQUES: Cell disruption methods for intracellular products, removal of insoluble, biomass (and particulate debris) separation techniques; flocculation and sedimentation, Centrifugation (ultra and differential) and filtration methods. Solid-liquid separation with theory of batch filtration, Theories of Centrifugal force, equipments and centrifugal filtrations, numerical.</p>			
<p>Module 3. ISOLATION AND PRODUCT PURIFICATION: Extraction: Principles of extraction, batch and staged extraction, differential extraction. Adsorption: Chemistry of adsorption, batch and continuous adsorption. Precipitation: Precipitation methods with salts, organic solvents, and polymers. Electrophoresis: Principle and Applications of Electrophoresis - their types, Iso-electric focusing</p>			
<p>Module 4. MEMBRANE SEPARATION PROCESSES: Membrane – based separations theory; Design and configuration of membrane separation equipment; Applications: Use of membrane diffusion as a tool for separating and characterizing naturally occurring polymers; enzyme processing using ultra filtration membranes; separation by solvent membranes; reverse osmosis.</p>			
<p>Module 5. FINISHING OPERATIONS AND FORMULATIONS: Finishing operations: crystallization: Basic concepts, crystal size distributions, batch and recrystallization. Drying: basic concepts, drying equipments, lyophilization, principle of lyophilization, working and applications of lyophilization and formulations.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Belter PA, Cussier E and Wei Shan Hu, **Bioseparation –Downstream processing for Biotechnology**, John Wiley & Sons, New York.1988.
2. Roger G Harrison, **Bioseparataions: Science and Engineering**, Oxford Publications, 2006.

Reference Books:

1. Verrall, M.S. Downstream processing of natural products: A practical handbook: John Wiley & Sons Ltd., England, UK. 1996.
2. Elliott Goldberg, Handbook of downstream processing, Blackie Academic and Professional, 1997.
3. Mulder, M. Basic principles of Membrane Technology: Kluwer Academic Publishers, Netherlands. 1996
4. Product Recovery in Bioprocess Technology - BIOTOL Series, VCH, 1990.
5. Asenjo J and Dekker M, **Separation Process in Biotechnology**, Marcell Dekker Publications,1993

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16HCE154	Group-3	FUEL CELL TECHNOLOGY
Exam Hours:03		Exam Marks:100	
<p>Module 1. OVERVIEW OF FUEL CELLS: Low and high temperature fuel cells; Types of fuel cells and applications.</p>			
<p>Module 2. FUEL CELL THERMODYNAMICS: Heat, work potentials, prediction of reversible voltage, fuel cell efficiency.</p>			
<p>Module 3. FUEL CELL REACTION KINETICS: Electrode kinetics, over voltages, Tafel equation, charge transfer reaction, exchange currents, electro-catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.</p>			
<p>Module 4. FUEL CELL CHARACTERIZATION: In-situ and ex-situ characterization, techniques, i-V curve, Frequency response analyses; Fuel cell.</p>			
<p>Module 5. BALANCE OF PLANT: Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, **Fuel Cell Fundamentals**, Wiley, NY(2006).
2. Bard, A. J. , L. R., Faulkner, **Electrochemical Methods**, Wiley, N.Y. (2004)
3. Basu, S. (Ed) **Fuel Cell Science and Technology**, Springer, N.Y. (2007).
4. Liu, H., **Principles of fuel cells**, Taylor & Francis, N.Y. (2006).

Reference Books:

1. M. M. MENCH, **Fuel Cell Engines**, Wiley, 2008.
2. M.T.M. Koper (ed.), **Fuel Cell Catalysis**, Wiley, 2009.
3. J.O'M. Bockris, A.K.N. Reddy, **Modern Electrochemistry**, Springer 1998.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE251	Group-4	ENZYME ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. STRUCTURES AND FUNCTIONS OF PROTEINS: Enzyme classification, based on structure classification of aminoacids, classifications of proteins, specificities of enzyme action, biosynthesis and properties of proteins.</p>			
<p>Module 2. KINETICS: Chemical mechanisms of enzyme catalyzed reactions, introduction to bioenergetics and kinetics, kinetics of multisubstrate bio reactions, investigations of active sites structures.</p>			
<p>Module 3. CHEMICAL NATURE OF ENZYME CATALYSIS: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behavior.</p>			
<p>Module 4. APPLICATIONS: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents</p>			
<p>Module 5. INSTRUMENTAL TECHNIQUES: Instrumental techniques available for using enzymatic analysis, applications in medicine, industries, and biotechnological applications</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Trevor Palmer, **Understanding Enzymes**, 4th Edition, Prentice Hall, 1991.

Reference Books:

2. Bailey and Ollis, **Biochemical Engineering Fundamentals**, 2nd Edition, McGrawhill, 1976.
3. John R. Whitaker, Alphons G J Voragen, and DWS Wong, **Handbook of Food Enzymology**, Marcel Dekker, New York, 2003.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

02	16HCE254	Group-4	FOOD PROCESSING AND ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION: General aspects of food industry, world food demand and Indian scenario, constituents of food, quality and nutritive aspects. Food additives, standards, deteriorative factors and their control, preliminary processing methods, conversion and preservation operation. ENERGY ENGINEERING IN FOOD PROCESSING: Generation of Steam, Fuel Utilization, Electric Power Utilization, Process Controls in Food Processing, Systems for Heating and Cooling Food Products. Thermal Properties of Foods, Modes of Heat Transfer - Freezing Systems, Frozen-Food Properties, Freezing Time refrigeration system for food products.</p>			
<p>Module 2. SEPARATION PROCESSES IN FOOD PROCESSING: Electro-dialysis Systems, Reverse Osmosis Membrane Systems, Membrane Performance, Ultra filtration Membrane Systems, Concentration Polarization. Types of Reverse-Osmosis and Ultrafiltration Systems, Drying Processes, Dehydration System, Dehydration System Design, Sedimentation, Centrifugation.</p>			
<p>Module 3. FOOD ADDITIVES: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-choking agents, leavening agents, nutrient supplements, nonnutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety.</p>			
<p>Module 4. FOOD CONTAMINATION AND ADULTERATION: Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. PACKAGING: Introduction, Food Protection, Product Containment, Product Communication, Product Convenience, Mass Transfer in Packaging Materials. Innovations in Food Packaging, Food Packaging and Product Shelf-life, Food canning technology, fundamentals of food canning technology. Heat sterilization of canned food, containers - metal, glass and flexible packaging. Canning procedures for fruits, vegetables, meats, poultry marine products.</p>			
<p>Module 5. MODERN TRENDS IN FOOD SCIENCE: Biotechnology in food. Bio-fortification, Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition labeling. Careers in food science and food industries.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. B. Srilakshmi, **Food Science** - 4th Edn-New Age International-2007.
2. N. Shakuntala Manay and M. Shadaksharamurthy, **Foods: Facts and Principles** – New Age Publishers - 2005.

Reference Books:

1. Rick Parker - Thomsan Detmer, **Introduction to Food Science** -2001.
2. G. Subbulakshmi and Shobha A. Udipi, **Food Processing and Preservation**, New Age International-2001.
3. Norman N. Potter and Joseph H. Hotchkin, **Food Science**, Publishing Co-1968.
4. John M DeMan, **Principles of Food Chemistry**, 3rd Edition - Springer-1999.
5. Heid, J.L. and Joslyn, M.A, **Fundamentals of Food Processing Operation**. The AVI Publishing Co; Westport, 1967.
6. Heldman, D.R. **Food Process Engineering**, The AVI Publishing Co; Westport, 1975.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16HCE421	Group-4	FERMENTATION ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. OVERVIEW: Fermentation industry growth prospects, general requirements of fermentation processes, basic configurations of fermenter and accessories, parameters to be monitored and controlled in fermentation processes. MICROBIAL KINETICS: Types of reaction, order of reaction, Michealis-Menten constant, effect of temperature on reaction rate, activated complexes, catalyzed reactions, thermal death of microorganisms, enzyme inhibition.</p>			
<p>Module 2. FERMENTATION ENGINEERING: Continuous fermentation, advantages and limitations, theory of single and two stage continuous fermentation systems application. Media formulation and preparations complex and synthetic media, Selection of components, buffers, Ph adjustment. STERILIZATION: Media and air-Batch and Continuous Insitu sterilization in fermenter.</p>			
<p>Module 3. PRODUCT ISOLATION: Selection and improvement of cultures – screening methods,culture preservation, strain improvement. Aseptic culturetransfer and incubation, inoculums age/size, studies on growthkinetics in batch, continuous and fed batch cultures. Details ofIndustrial manufacture of important biotechnological products.</p>			
<p>Module 4. BIO REACTOR CONFIGURATION: Ideal bioreactors, various configurations, Mechanical construction, various parts and accessories, Mass and Heat transfer: Agitation and aeration, Modes of reactor operations.</p>			
<p>Module 5. FERMENTATION PRODUCTS: Details of the process parameters and materials for the industrial manufacture of Antibiotics, solvents, amino acids, organic acids and biopharmaceuticals.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Stanbury, Whitaker & Hall – **Principles of Fermentation Technology** (1997)
2. Shuler and Kargi - **Bioprocess Engineering**, Prentice Hall of India Pvt. Ltd.(2002)
3. Bailey J.E. and Ollis, D.F. **Biochemical Engineering Fundamentals**, McGraw Hill, (1986).

Reference Books:

1. Pauline M Doran - **Bioprocess Engineering Principles** –, Academic Press, 1995.
2. James M.Lee - **Biochemical Engineering** by, Prentice Hall 1992

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16CEE12	Group-4	APPLIED ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY
Exam Hours:03		Exam Marks:100	
<p>Module 1. Introduction: Importance of Environmental Chemistry, types of reactions, redox reactions, reaction kinetics. Electrochemistry and its applications. Physical and equilibrium chemistry–fundamentals and applications. Trace Contaminants and their analyses. pH – Principle, Measurement, Numerical Examples, Buffers and Buffer index.</p>			
<p>Module 2. Colloidal Chemistry: Properties of colloids, colloidal dispersions, stability of colloids and applications. Applications of Organic Chemistry in Environmental Engineering.</p>			
<p>Module 3. Colourimetry: Principles and applications. Applications of Analytical Chemistry – emission and absorption techniques.</p>			
<p>Module 4. Water & wastewater analysis: Fluoridation, defluoridation, chlorination, BOD, DO, types and measurement of BOD, rate of BOD & theoretical oxygen removal, COD- determination & its application in wastewater treatment</p>			
<p>Module 5. Microbiology - Microorganisms of importance in air, water and soil environment Principles and applications of microscopy, microscopic flora and fauna of importance. Metabolism and metabolic pathways, Bioconcentration, Biomagnifications and Bioaccumulation. Bacteria – Morphology, typical growth curve and generation time, Measurement Techniques – APC, MPN (Probability and Thomas methods), and MFT. Monod’s equation and its applications. Algae - morphology, classification and their importance. Fungi - Protozoa - morphology, classification and their importance. Enzymes - classification, kinetics – Michaelis - Menten equation, factors influencing enzyme reaction. Virology - Types, characteristics and enumeration methodology.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Reference Books:

1. Pelczar M.J, Chan ECS, Krieg, NR “Textbook of Microbiology” 5th edition Tata McGrawHill Publishing Co. Ltd., New Delhi
2. McKinney R.E. “Microbiology for Sanitary Engineers”, Newyork McGraw Hill.
3. Sawyer C.N. and McCarty, P.L ., , “Chemistry for Environmental Engineering and Science”, 5th Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
4. Gaudy and Gaudy, “Microbiology for Environmental Scientists and Engineers”, McGraw Hill.
5. APHA, “Standard Methods for Examination of Water and Wastewater”; 21st Edition.
6. Stumn and Morgan, “Aquatic Chemistry”, John Willey & Sons Newyork. Relevant Journals

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE152	Group-5	COMPUTATIONAL FLUID DYNAMICS
Exam Hours:03		Exam Marks:100	
<p>Module 1. Introduction to CFD, Flow fields. Finite difference and finite element methods. Various numerical techniques for CFD.</p>			
<p>Module 2. Conservation laws of fluid motion and boundary conditions. (Governing equations of fluid flow and heat transfer. Differential and integral forms of the transport equations.) Navier-Stokes equations), Turbulence Modeling.</p>			
<p>Module 3. One- and two- dimensional steady & transient conduction - Steady one-dimensional convection and diffusion – Solution methodology: upwind scheme, exponential scheme, hybrid scheme, power law scheme – Explicit, Implicit, Crank-Nicolson schemes –Stability criterion.</p>			
<p>Module 4. Representation of the pressure gradient term and continuity equation – Staggered grid - Momentum equations – Pressure and velocity corrections - Pressure correction equation – SIMPLE algorithm - Boundary conditions for the pressure correction method.</p>			
<p>Module 5. About the CFD software for different applications and construction of geometry and Discretions using available commercial CFD solvers. (Tutorials) Creating and meshing a basic geometry. Any 5 Basic problems (eg. Basic flow studies in pipe modeling a mixing elbow (2-D). Modeling a three-pipe intersection (3-D). Modeling flow in a tank, modeling a combustion chamber (3-D).)</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Anderson, J.D., **Computational Fluid Dynamics: The Basics with Application**, McGraw-Hill Co. Inc.
2. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., **Computational Fluid Mechanics and Heat Transfer**, Hemisphere Publishing Corporation.
3. **Heat Transfer**, Hemisphere Publishing Corporation.

Reference Books:

1. Patankar, S.V., **Numerical Heat Transfer and Fluid Flow**, Hemisphere Publishing Corporation.
2. Ferziger, J.H. and Peric, M., **Computational Methods for Fluid Dynamics**, Springer.
3. Versteeg, H.K. and Malalasekera, W., **An Introduction to Computational Fluid Dynamics: The Finite Volume Method**, Prentice-Hall Inc.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

02	16HCE422	Group-5	TOTAL QUALITY MANAGEMENT
Exam Hours:03		Exam Marks:100	
<p>Module 1. CONCEPTS OF TQM : Basics of total quality, Guru's of TQM, Philosophy of TQM, customer focus, organization, quality philosophies of Deming.</p>			
<p>Module 2. TQM PROCESS: Quality control tools, cost of quality, quality circles, benchmarking, strategic quality planning.</p>			
<p>Module 3. TQM SYSTEMS: Quality policy deployment, quality function deployment, standardization, designing for quality, manufacturing for quality.</p>			
<p>Module 4. QUALITY SYSTEM: Need for ISO 9000 system, advantages, clauses of ISO 9000, Implementation of ISO 9000, quality auditing, case studies, introduction to other ISO systems.</p>			
<p>Module 5. IMPLEMENTATION OF TQM: KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			
<p>Text Books:</p> <ol style="list-style-type: none"> 1. Dale H. Besterfield, Total Quality Management, PHI, India. 2. Sharma D.D, TQM Principles, Practice and Cases, Chand and Sons, New Delhi. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Rose, J.E, Total Quality Management, Kogan Page Ltd. 1993. 2. John Bank., The Essence of Total Quality Management, PHI, 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16CEE252	Group-5	ENVIRONMENTAL PLANNING AND MANAGEMENT
Exam Hours:03		Exam Marks:100	
<p>Module 1. Environment and Sustainable Development: Carrying capacity, relationship with quality of life, carrying capacity and utilization. Engineering Methodology in Planning and its Limitations: Carrying capacity based short and long term regional planning.</p>			
<p>Module 2. Environmental Protection: Economic development and social welfare consideration in socio economic developmental and planning. Total cost of development and environmental protection cost.: Case studies on Regional carrying capacity</p>			
<p>Module 3. Engineering Economics: Value Engineering, Time Value of Money, Cash Flows, Budgeting and Accounting</p>			
<p>Module 4. Environmental Economics: Introduction, economic tools for evaluation, Green GDP, Cleaner development mechanisms their applications</p>			
<p>Module 5. Total Quality Management in environmental management and protection – ISO 9000, 14000 and 18000 series of standards. Environmental Audit – methods, procedure, reporting and case studies</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Reference Books:

1. Lohani B.N , “Environmental Quality Management”,South Asian Publishers, New Delhi
2. Chanlett, “Environmental Protection”, McGraw Hill Publication, Newyork.
3. Danoy G.E., and Warner R.F., “Planning and Design of Engineering Systems”, Unwin Hyman Publications.
4. MOEF, Government of India, “Carrying Capacity Based Developmental Planning Studies for the National Capital Region”, 1995-96.
5. NEERI, Nagpur, Annual Reports 1995 & 1996.
6. UNEP / UNDP – “Environmental Sustainable Development”.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16HCE424	Group-5	PHARMACEUTICAL TECHNOLOGY
Exam Hours:03		Exam Marks:100	
<p>Module 1. FORMULATIONS: Introduction, organoleptic properties, purity, particle size, shape and surface area. Solubilization, surfactants and its importance, temperature, pH, cosolvency, solid dispersion, cyclodextrin drug-dispersion system, Techniques for the study of crystal properties and polymorphism. Formulation stability studies. A consideration of physicochemical characteristics of new drug molecules with respect to different dosage forms.</p>			
<p>Module 2. TABLET MAKING: Compaction of powders with a particular reference to distribution and measurement of forces within the powder mass undergoing compression. Effect of particle size, moisture content, lubrication etc. On Strength of tablets. A brief study on formulation aspects of tablets such as Sublingual, buccal chewable and medicated lozenges. CAPSULE TECHNOLOGY: Manufacturing, equipment and machinery used in capsule technology. Formulation and evaluation of hard gelatin capsules and soft gelatin capsules.</p>			
<p>Module 3. DEVELOPMENT AND TESTING OF COSMETICS: Cleansing creams, acid creams, bleaching creams, suntan preparations, shampoos nail lacquers, lipsticks, manufacturing equipment used in preparation. The testing measures of the above listed cosmetics preparation. Mode of packaging, storage conditions. PARENTERAL TECHNOLOGY: Manufacturing of LVP, SVP, Sterilization and sterility testing of Parenterals, GMP regulations of parenteral technology. Optimization techniques in pharmaceutical formulation and processing: Concept of optimization, optimization parameters, classical optimization, statistical design and optimization methods.</p>			
<p>Module 4. MANUFACTURING TECHNIQUES: GMP Significance of pilot scale up phase to effect an orderly setup from the laboratory procedures and formulations to routine production procedures. Pilot study of some important dosage forms such as Tablets, Capsules, Injections and liquid orals and discussions on important parameters such as formula and equipment, product uniformity and stability. Raw materials and process, physical layouts personnel requirements and reporting responsibilities. Input Specifications and in process and finished product specifications.</p>			
<p>Module 5. INDUSTRIAL SAFETY: Industrial hazards due to fire accidents, mechanical and electrical equipment, chemical and pharmaceuticals. Monitoring and prevention systems. Industrial effluent treatment. Discussion on Industrial accident case studies, Environment and pollution Acts. PATENT INTELLECTUAL PROPERTY RIGHTS AND REGULATORY AFFAIRS: Definitions, Procedures for applying, Indian Scenario, GATT, TRIPS, TRIMS AND WTO Legal aspects, ISO 9000 series, Total Quality Management, GMP considerations.</p>			
Question paper pattern:			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Liberman, and Lachman, **The Theory and Practice of Industrial Pharmacy**, 3rd Edition, Lea & Febiger, Philadelphia, 1986
2. Jain N.K, **Pharmaceutical Product Development**, CBS Publications and Distributions, New Delhi, 2006.

Reference Books:

1. Sidnay H. Willing, Murray M. Tuckerman, and Williams Hitchings, **Good Manufacturing of Pharmaceuticals**, 3rd Edition, Marcell Dekker Inc., NY, 1982.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

01	16HCE253	Group-6	GASIFICATION TECHNOLOGY
Exam Hours:03		Exam Marks:100	
<p>Module 1. BIOMASS AND ITS PROPERTIES: Types and Sources of Biomass, Physical and Thermal Properties of Biomass, Proximate and Ultimate analysis, stoichiometric considerations, Equivalence Ratio, Thermochemical conversion processes, Types of gasifiers, gas yield and its composition.</p>			
<p>Module 2. THEORY OF GASIFICATION: Gasification reactions, Gasification processes - Drying, Devolatilization/Pyrolysis, combustion and gasification/reduction, Pyrolysis types and product yield, torrefaction, catalytic gasification.</p>			
<p>Module 3. GASIFICATION KINETICS: Kinetic models for gasification-Drying, Devolatilization/Pyrolysis, combustion and gasification/reduction, Chemical equilibrium, char reactivity, Effect of feed properties on gasification, Estimating Equilibrium Gas Composition.</p>			
<p>Module 4. DESIGN OF GASIFIERS: Energy and Mass Balance, Heat transfer in gasifiers, Gasifier Efficiency, sizing of downdraft biomass gasifier, design optimization.</p>			
<p>Module 5. GAS CLEANING TECHNOLOGIES: Tar formation, composition, reduction of tar by operating conditions, reduction by design, Particulate removal technologies, Environmental emissions.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. <p>The students will have to answer 5 full questions, selecting one full question from each module.</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Text Books:

1. Prabir Basu, **Biomass Gasification and Pyrolysis**, Elsevier Publishing, 2010.

Reference Books:

1. Christopher Higman and Maarenvander Burgt, **Gasification**, Elsevier Publishing, 2003.
2. John Rezaian and Nicholas P. Cheremisinoff, **Gasification Technologies - A Primer for Engineers and Scientists**, Taylor and Francis, 2005

02	16CEE152	Group-6	RENEWABLE AND ALTERNATIVE FUELS
Exam Hours:03		Exam Marks:100	
Module 1. Introduction to energy and resources – Renewable energy sources - Availability of solar energy – Sun-earth relationships - - Solar radiation measurement – Flat plate collectors – Solar water heating systems – Evacuated Tubular Concentrators - Solar air heating systems and applications – Concepts on solar drying, cooking, desalination, solar ponds and solar cooling - Passive heating and cooling of buildings – Basics of solar concentrators and types Solar thermal power generation			
Module 2. Biomass to energy conversion processes – Anaerobic digestion, process parameters, biogas composition, digester types, high rate anaerobic conversion systems – Alcohol from biomass – Biodiesel: preparation, characteristics and application - Biomass combustion and power generation – Briquetting – Gasification: Process, types of gasifiers, applications – Waste to energy technologies			
Module 3. Power in the wind - Types of wind mills – WEG components, Power curves and energy estimation– Indian wind potential. Small Hydro Power: Types, site identification, head and flow measurement, discharge curve, estimation of power potential and system components. Technologies for harnessing renewable energy sources like geothermal, wave, tidal and ocean thermal energy.			
Module 4. Fossil fuels and their availability - Potential alternative liquid and gaseous fuels - Merits and demerits of various alternative fuels - Engine requirements Methods of production - Properties - Blends of gasoline and alcohol - Performance in SI engines – Adaptability - Combustion and emission characteristics - Performance in CI engines – Emission characteristics - Properties of alcohol esters. Production and properties of CNG, LPG, hydrogen gas, biogas and producer gas - Performance and Storage, distribution and safety aspects			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

Module 5.

Various vegetables oils - Properties - Esterification – Performance and emission characteristics - Bio-diesel: Feed stock, characteristics, preparation (lab and commercial), storage, applications, environmental impacts, economics, and policy.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Frank Kreith and D.Yogi Goswami (2007), Handbook of Energy Efficiency and Renewable Energy, CRC Press.
2. John Twidell and Tony Weir (2006), Renewable Energy Resources, 2nd Edition, Taylor & Francis, USA. John A. Duffie and William A. Beckman (2006),
3. Solar Engineering of Thermal Process, 3rd Edition, John Wiley & Sons.
4. Gilbert M. Masters (2004), Renewable and Efficient Electric Power Systems, Wiley Interscience.
5. Osamu Hirao and Richard Pefley (1988), Present and Future Automotive Fuels, Wiley Interscience Publication, New York
6. Alcohols and Motor Fuels: Progress in Technology - Series No. 19 - SAE Publication USA C

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

03	16HCE153	Group-6	MODERN SEPERATION TECHNIQUES
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION: Review of conventional processes, Recent advances inseparation techniques based on size, surface properties, ionicproperties and other special characteristics of substances,Process concept, Theory and equipment used in cross flowfiltration, cross flow electro filtration, dual functional filter,Surface based solid -liquid separations involving a second liquid,Sirofloc filter.</p>			
<p>Module 2. MEMBRANE SEPARATIONS: Types and choice of membranes, Plate and frame, tubular, spiralwound and hollow fibre membrane and their relative merits,Commercial, pilot plant and laboratory membrane permeatorsinvolving dialysis, reverse osmosis, Nano filtration, ultrafiltration, Micro filtration and Donnan dialysis, Economics ofmembrane operations, Ceramic membranes.</p>			
<p>Module 3. SUPERCritical FLUID EXTRACTION: Concept, modeling, design aspects and applications SEPARATION BY ADSORPTION TECHNIQUES: Mechanism, Types and choice of adsorbents, Normal adsorptiontechniques, Affinity chromatography and immunechromatography. Types of equipment and commercial processes,recent advances and process economics.</p>			
<p>Module 4. IONIC SEPARATIONS: Controlling factors, Applications, Types of equipment employedfor electrophoresis, Dielectrophoresis, Ion exchangechromatography and electro dialysis, Commercial Processes.</p>			
<p>Module 5. MISCELLANEOUS SEPARATION TECHNIQUES: Separations involving Lyophilization, Pervaporation andpermeation techniques for solids, liquids and gases. Industrialviability and examples, Zone melting, Adductive crystallization,Oil spill Management, Industrial effluent treatment by moderntechniques.</p>			
<p>Question paper pattern:</p> <ul style="list-style-type: none"> • The question paper will have ten questions. • Each full question consists of 20 marks. 			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. King, C.J, **Separation Processes**, Tata McGraw Hill Publishing Co., Ltd., 1982.
2. Schoem, H.M, **New Chemical Engineering Separation Techniques**, Interscience Publishers, 1972.

Reference Books:

1. Lacey, R.E. and S.Loab, **Industrial Processing with Membranes**, Wiley Inter Science, New York, 1972.
2. Ronald W. Roussel, **Handbook of Separation Process Technology**, John Wiley, New York, 1987.
3. Kestory, R.E, **Synthetic polymeric membranes**, Wiley, New York, 1987.
4. M A Mchugh& V J Krukonis (Butterworth Heinmann), **Supercritical Fluid Extraction**.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

04	16HCE252	Group-6	INTERFACIAL ENGINEERING
Exam Hours:03		Exam Marks:100	
<p>Module 1. INTRODUCTION TO THE ENGINEERING OF INTERFACES: Definitions of fluid-fluid and fluid-solid interfaces, Occurrence of interfaces in science and engineering, Overview of industrial applications of various interfacial phenomena, Colloidal materials; Properties of colloidal systems, Experimental characterization of colloidal dispersions. SURFACE AND INTERFACIAL TENSION: Theoretical methods for the calculation of surface and interfacial tension, Experimental techniques for the determination of equilibrium and dynamic tension, Shape of the surfaces, curvature and radius of curvature, Young-Laplace equation, Kelvin equation, Pendant and sessile drops, Adams-Bashforth equation, Characterization of fluid-solid interfaces, Contact angle and wetting phenomena, Young-Dupre equation, Measurement of equilibrium and dynamic contact angles, Deposition of thin films, Mechanism of film nucleation.</p>			
<p>Module 2. INTRODUCTION TO INTERMOLECULAR AND SURFACE FORCES: van der Waals forces, Electrostatic double layer force, Disjoining pressure, DLVO theory, Non-DLVO forces. Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques, Applications of fluid-solid interfaces in crystallization, development of ceramic materials, catalysts, electronic products and Nano-materials.</p>			
<p>Module 3. ADSORPTION AT FLUID-FLUID AND FLUID-SOLID INTERFACES: Adsorption of surfactants, Gibbs and Langmuir monolayers, Gibbs adsorption equation, Surface equation of state, Surface pressure isotherm, Langmuir-Blodgett films and their applications, Radiotracer and neutron reflection techniques for studying adsorption at fluid-fluid interfaces, Henry, Freundlich, Langmuir, Frumkin and Davies adsorption isotherms, Brunauer-Emmett-Teller theory of adsorption, Adsorption hysteresis, Characterization of adsorption at fluid-solid interfaces by vacuum and non-vacuum techniques.</p>			
<p>Module 4. INTERFACIAL RHEOLOGY AND TRANSPORT PROCESSES: Surface shear viscosity, Surface dilatational viscosity, Boussinesq number, Interfacial tension gradient and Marangoni effect, Gibbs and Marangoni elasticity, Boussinesq-Scriven model; Interfacial turbulence, Motion of drops in a liquid, Thin liquid films, Disjoining pressure and body-force models, Stability of thin liquid film, Black films. EMULSIONS: Preparation, characterization and applications, Ostwald ripening, Flocculation and coalescence, Micro-emulsions, characterization and properties, Stability of microemulsions, Foams, preparation, characterization and stability, Structure of foams.</p>			
<p>Module 5. INTERFACIAL REACTIONS: Reactions at fluid-solid interfaces, Langmuir-Hinshelwood model, External and internal transport processes, Interfacial poly-condensation reactions, Fast and instantaneous</p>			

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Chemical/Petrochem Board)
As per 2017 Regulation

reactions at fluid-fluid interfaces, Reactions at bio-interfaces, Micellar catalysis, Phase transfer catalysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Adamson, A. W. and Gast, A. P., **Physical Chemistry of Surfaces**, John Wiley, New York, 1997.
2. Ghosh, P., **Colloid and Interface Science**, PHI Learning Pvt. Ltd., New Delhi, 2009.
3. Hiemenz, P. C. and Rajagopalan, R., **Principles of Colloid and Surface Chemistry**, Marcel Dekker, New York, 1997.
4. Stokes, R. J. and Evans, D. F., **Fundamentals of Interfacial Engineering**, Wiley- VCH, New York, 1997.

Reference Books:

1. Baszkin, A. and Norde, W., **Physical Chemistry of Biological Interfaces**, Marcel Dekker, New York, 2000.
2. Edwards, D. A., Brenner, H. and Wasan, D. T., **Interfacial Transport Processes and Rheology**, Butterworth-Heinemann, Boston, 1990.
3. Hunter, R. J., **Foundations of Colloid Science**, Oxford University Press, New York, 2005.
4. Israelachvili, J., **Intermolecular and Surface Forces**, Academic Press, London, 1992.
5. Slattery, J. C., **Interfacial Transport Phenomena**, Springer-Verlag, New York, 1990.