B.Sc. (GENERAL) DEGREE

POLYMER SCIENCE & TECHNOLOGY

SYLLABUS & GUIDELINES

REVISED IN JANUARY 2014

DEPARTMENT OF CHEMISTRY
FACULTY OF APPLIED SCIENCES
UNIVERSITY OF SRI JAYEWARDENEPURA

Polymer Science and Technology Course Units

- Core Courses * - Optional Courses [a] - Compulsory Courses

Course Title	**:**	**PST 101 2.0 Introduction to Polymers**
Number of lecture hours	**:**	30
Number of Tutorial hours	**:**	6
Lecturer in Charge	**:**	Prof. L. Karunanayake

Objectives:

- Introduction to the subject of polymer chemistry.
- Introduction to concept of average molar masses and molar mass distributions
- Study conformations, thermal properties and thermal transitions of polymers
- Elastomers, plastics and fibers
- Fundamentals of Step-growth polymerization
- Introduction to Chain/addition polymerization- ionic and free radical polymerization

Course Content:

1. Monomers and Polymers. Prerequisite to qualify as a monomer (1h)
2. Differentiation of Polymers from simple molecules (1h)
3. Basic concepts of joining monomer molecules to form dimers, trimmers, oligomers and polymers (1h)
4. Classifications of polymers. Different approaches of categorizing polymers (1h)
5. Monomers, homo-polymers, co-polymers and ter-polymers, graft polymers and IUPAC Nomenclature (2h)
6. Different average molar masses, their definitions and molar mass distributions, and polydispersity (4h)
7. Introduction to polymer conformations, amorphous and semi-crystalline polymers and their molecular structures, relation between chemical structure and morophology (4h)
8. Thermal behavior of polymers and thermal transitions.Graphical depiction of thermal behavior of polymers.Glass transition temperature (T_g), Melting temperature (T_m), Crystallization temperature (T_c),Differences in the thermal behavior of crystalline, amorphous and semi crystalline polymers, Significant of the knowledge of T_g, T_m, T_c of polymers in choosing the correct material for polymer industry (6h)
9. Examples of Elastomers, plastics and fibers and their properties (2h)
10. Step-growth polymerization and examples, Carother's equation and mechanisms of polymerization. Control of molar mass, Schotten-Baumann reaction, Salt dehydration reaction, ester interchange reaction and step polyaddition. Stoichiometric control of molar mass and the extended Carother's equation. Examples, linear (thermoplastic) and non-linear (thermosettings) (4h)

11. Chain/addition polymerization- ionic and free radical polymerization. Initiation, propagation and termination.

(4h)

Learning outcomes:

- Students would be comprehended of basics of polymer chemistry.
- Students would learn concept of average molar masses and molar mass distributions
- Students would learn conformations, thermal properties and thermal transitions of polymers
- Students would be introduced elastomers, plastics and fibers that are used in the industry
- Students would learn fundamentals of Step-growth polymerization
- Students would learn fundamentals of Chain/addition polymerization- ionic and free radical polymerization

Method of assessment:

End of semester 2 h theory paper

References:

1. Textbook of polymer science, 3rd ed., Fred W. Billmeyer, Jr., Wiley-Interscience, New York
2. Polymers: Chemistry and Physics of Modern Materials, Third Edition , J.M.G. Cowie, Valeria Arrighi, CRC Press
3. Principles of Polymerization, 4th Edition, George Odian, Wiley

Course Title	**:**	**PST 102 1.0 Inorganic Polymers**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Prof. Sudantha Liyanage

Objectives:

- Overview the area of inorganic polymers.
- Familiarize the nomenclature, structure and properties, preparation and industrial applications of commonly used inorganic polymers.

Course content:

1. Categories of Inorganic Polymers
   Graphite, Diamond, Fullerene, Glass, Ceramics, Silica, Silicates, Silicones, Aluminum Silicates and Related Compounds
   Disadvantages in inorganic polymers over organic polymers
   Structure and the Physical, Chemical properties of Graphite, Diamond and Fullerene
   (4h)
2. Silica and silica based products
   Structure, properties and industrial applications of Quartz (Eg:-Granite), Glass; Properties, Manufacturing processes and techniques, Types of glass, Uses of different kinds of glass, Cement and Asbestos
   (4h)
3. Aluminosilicates
   Classification and structures of Aluminosilicates, Examples of natural Aluminosilicates and their utilization in industry.
   (3h)
4. Chemistry of Silicone
   Nomenclature and the classes of silicone polymers, Structure and properties, Preparation of silicones, Industrial applications of silicone polymers
   (4h)

Learning outcome:

- Students should be able to select the inorganic polymers for the suitable application.
- Students should be able to relate the chemical structures of inorganic polymers to the properties.

References:

1. Inorganic Chemistry by J. D. Lee
2. Inorganic Chemistry by Cotton &Willinson

Course Title	**:**	**PST 108 1.0 Statistics for Polymer Science**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. Dilru Ratnaweera

Objectives:

- Overview of the basic statistic concepts
- Introduce probability distribution functions
- Describe basic hypothesis testing methods for data analysis

Course content:

1. Basic introduction
   Population, sample, accuracy, precession, repeatability, reproducibility, significant figures
   (1h)
2. Location statistics
   Mean, median and mode
   (1/2 h)
3. Measure of dispersion/variability
   Range, inter quartile range, variance, coefficient of variance, slandered deviation, standard error
   (1 ½ h)
4. Probability
   Properties/rules of probability, elementary and composite events, relative frequencies, permutations of ordered sequences, expectation value, probability distribution functions and their applications (mainly focuses on the normal distribution function and provide brief introduction to uniform distribution, binomial distribution, Poisson distribution and log normal distribution)
   (4h)
5. Hypothesis testing
   Basic steps, one tailed and two tailed tests, z-test, t-test, Chi-square test
   (4h)
6. Error propagation
   (1 ½ h)
7. Sampling techniques
   Ways to chose samples to represent the whole population, non probability sampling and bias, random sampling, cluster sampling, systematic sampling
   (1 ½ h)
8. Statistical analysis software and graphical data representation:
   (1h)

Learning outcomes:

- Be able to describe basic statistical concepts
- Be able to utilize statistical tools to validate experimental data
- Be able to utilize the statistics knowledge to maintain the accuracy in laboratory practicals and research projects
- Be able to utilize the statistics knowledge in advanced courses in polymer science and technology program

Method of assessment:

End of semester 1h theory paper

References:

1. Introductory Statistics, Neil A. Weis, Pearson; 9 edition (January 6, 2011),ISBN-10: 0321691229, ISBN-13: 978-0321691224
2. An Introduction to Statistics, George Woodbury , Publication Date: August 29, 2001 , ISBN-10: 0534377556 , ISBN-13: 978-0534377557 , Edition: 1
3. Introductory Statistics, Prem S. Mann, Publication Date: February 17, 2006 , ISBN-10: 0471755303 , ISBN-13: 978-0471755302 , Edition: 6

Course Title	**:**	**PST 111 1.0 Polymers with Special Functionalities**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. K. M. Thilini D. Gunasekara

Objectives:

- To present innovation, invention, imagination and creativity in modern Polymer Science and Technology
- To introduce different types of functional polymer
- To elaborate the structure and property relationship of polymers

Course content:

1. Introduction: revolution in materials science

   (1/2 h)
2. Smart Polymers

   Introduction: Can a piece of plastic think? Definition, applications, external triggers, Photo-responsive materials, Thermo-responsive material, chemical responsive materials, electro-responsive materials

   (3½ h)
3. Liquid crystal polymers

   Introduction to Low Molar Mass Liquid Crystals and Definitions, Liquid Crystalline Polymers, Properties of liquid crystal polymers, Liquid crystalline phases, Applications and limitations

   (3h)
4. Multi block polymers

   Advantages of having multi blocks, Factors controlling the self-assembly of multi-block polymers, Phase diagram of multi block polymers (copolymers), Applications of multi-block polymers, Reversible Addition-Fragmentation chain Transfer

   (3h)
5. Conducting polymers

   Electron conducting polymers, Proton conducting polymers, Ion conducting polymers, Application of conducting polymers

   (4h)

6. Self healing polymers
   Introduction to self-healing phenomenon, Self-healing mechanisms, Applications (1h)

Learning outcomes:

- Students will learn characteristics of various functional polymers
- Students will be able to correlate the specific properties with the polymeric structure
- Identified the latest advances and applications in Polymer science and technology

Method of assessment:

End of course 1h theory paper

References:

1. Smart polymers- applications in biotechnology and biomedicine by Igor Galaev and Bo Mattiasson, CRC press, 2008
2. Liquid Crystalline Polymers By A. M. Donald, A. H. Windle, S. Hanna, Cambridge university press, 2005

Course Title	:	**PST 105 2.0 Basic Chemical Engineering and Polymer Industry**
Number of lecture hours	:	30
Number of Tutorial hours	:	6
Lecturer in Charge	:	Visiting Lecturer

Objectives:

- To introduce technologies related to polymer industry
- To provide knowledge on raw materials and energy sources used in the polymer industry
- To provide understanding on the basic concepts of unit operations, process development, flow sheeting, material and energy balances
- To provide knowledge on ancillary services and related instruments required to the process industry

Course content:

1. Introduction to polymer industry
   Technologies, processes (2h)
2. Natural resources
   Materials from geosphere, biosphere, hydrosphere and atmosphere, sources of energy (3h)
3. Concepts of unit operations

Anatomy of a process, introduction to unit operations, reactor systems, product separation processes (chemical, physical and mechanical), purification and product storage

(4h)

4. Process development

   Objectives, process development procedure (laboratory scale, mini plant, pilot plant, industrial scale), design constraints

(4h)

5. Process Flow sheeting

   Block diagram, process flow diagram, material and energy balance sheets and pipe and instrumentation diagram

(4h)

6. Material and energy balances

   Calculations relating to reactive and non- reactive systems with single and multiple inputs and outputs

(10h)

7. Utilities

   Ancillary services, related instruments (boilers, steam distribution and traps, chillers, compressors, pumps, valves)

(3h)

Learning outcomes:

- Be able to indentify various chemical, physical and biological operations involved in the polymer industry
- Be able to develop a process from laboratory scale to industrial scale
- Be able to generate process flow sheets based on basic design criteria
- Be able to identify the ancillary services required for the polymer industry and select instruments accordingly

Method of Assessment:

End of semester 2h theory paper

References:

1. Basic principles of and calculations in Chemical Engineering by David M Himmelblau
2. Chemical Engineering Volume 1-6, by JM Coulson and JF Richardson
3. Introduction to materials and energy balances by GV Reklaitis
4. Transport processes and unit operations by CJ Geankoplis

Course Title	**:**	**PST 107 1.0 Degradation and Stability of Polymers**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. K. M. Thilini D. Gunasekara

Objectives:

- To provide a general understanding of polymer degradation and stability.
- Understand the structure relationship with degradation processes
- Explore current stabilization techniques

Course Content:

1. Introduction

   General aspects of polymer degradation and stability, Advantages and disadvantages of polymer degradation, General factors of polymer degradation, Introduction to common degradation processes, Miscellaneous types of degradation processes: Degradation by, Ionizing radiation, mechano-degradation, biodegradation, chemical agents

   (2h)

2. Thermal Oxidation and Degradation

   Thermal oxidation; thermal autoxidation, Mechanism, structure stability relationship, Stabilizers: free radical traps, electron donors, H-donors, metal ion deactivators, peroxide decomposers, combination of stabilizers: additive effect, antagonistic effect, synergistic effect

   Thermal Degradation; Mechanism: random scission and sequential elimination

   (5h)

3. Ozone Degradation

   Introduction, general observation, stabilization: waxes, other physical methods, antiozonernts

   (2h)

4. Photodegradation

   Mechanism of oxidative photodegradation, primary/secondary photochemical initiation, dark reactions, methods of stabilization: light screeners, UV stabilizers and quenchers

   (5h)

5. Importance of degradation

   Environmental pollution, precautions: reduce, recycle, reuse, greener plastics

   (1h)

Learning outcomes:

- Be able to understand the fundamentals of polymer degradation and stability
- Indentify structure relationship with degradation processes
- Be able to understand current stabilization techniques

Method of assessment:

End of semester 1h theory paper

References:

1. Polymer Degradation and Stabilization by By Norman Grassie, Gerald Scot
2. Polymer Stabilization by W. Lincolin Hawains

3. Fundamentals of Polymer Degradation and Stabilization by N.S. Allen, M. Edge

Course Title	**:**	**PST 109 1.0 Fundamental of Polymer Physics**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. K. M. Thilini D. Gunasekara

Objectives:

- To introduce the physical properties of polymers and their applications
- To identify the correlation of physical properties of polymers with their structure
- To provide basic concepts, theories/models and tools of analysis of viscoelastic materials

Course content:

1. Introduction to physical properties of polymers
   Mechanical and rheological properties, Deformation of polymers (types and forces that can make deformations), tensile strength, stress-strain diagrams, elastic deformation/plastic deformation, young's modulus, yield strength, ultimate strength, strain hardening, necking, brittle/ductile materials, static testing, poisons ratio, change of modulus with temperature, compressed deformation, shear deformation
   (5h)
2. Structure/property relationship
   Roles of polymer architecture, intermolecular forces and physical entanglements on polymer packing and physical properties
   (1h)
3. Mechanical models describing viscoelastic material
   Ideal solids/ideal liquids and their governing equations, Newtonian/ non Newtonian fluids, viscoelastic materials, introduction to shear thinning/ shear thickening and thixotropic and rheopectic fluids, spring and dashpot model, Maxwell model, Kelvin model, multi-element models
   (2½ h)
4. Hysteresis effect
   Definition, types of hysteresis, Creep, Stress relaxation, explaining the hysteresis effect using mathematical models (Maxwell model, Kelvin model, multi-element models)
   (2½ h)
5. Intermittent loading
   Introduction to Superposition principle, Boltzman superposition principle, time – temperature superposition
   (2 h)
6. Dynamic response
   Dynamic response on ideal solid/ideal liquids/viscoelastic materials, governing equations, storage modulus/los modulus/damping, major methods employed to analyze the dynamic behavior of polymeric materials (Dynamic Mechanical Thermal Analysis (DMTA/DMA), Dielectric Thermal Analysis (DTA))

(2 h)

Learning outcomes:
Students should:

- be able to describe mechanical and rheological properties of polymers and factor controlling such properties
- be able to express concepts and mechanism behind viscoelastic nature, creep, stress relaxation, dynamic response of polymers
- be able to introduce major analytical tools that can be used to analyze dynamic behavior of polymers

Method of assessment:

End of semester 1h theory paper

Reference:

1. Physical Properties of Polymers Handbook by James E. Mark, Springer, 2007
2. Rubinstein, M., Colby, R.H., Polymer Physics, Oxford University Press, 2003.
3. Gedde, U.W., Polymer Physics, Kluwer Academic Publishers, 1995.

Course Title	**:**	**PST 112 1.0 Dry Rubber Technology**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. Susantha Siriwardena (Visiting)

Objectives:

- To explore the available raw materials to be used in rubber based product manufacture
- To understand the functions of different rubber ingredients
- To select and use of different rubber ingredients in rubber product manufacture
- To develop skills to achieve desired curing characteristics
- To understand the basic rubber compounding principles and compounding process
- To develop confidence on rubber compound design and manufacturing methods of rubber products

Course content:

1. Brief introduction to dry rubber technology
   Including Brief introduction to compounding and compounding principles: definition of compounding, compounding principles
   (1h)
2. Introduction
   Raw materials available-NR (local Crepe/Scrap Crepe, TSR) & Synthetic rubbers
   (3h)
3. Brief overview on quality testing of raw materials
   (1h)

4. Mastication
   Importance of mastication and its effect on processing and performance of final product, factors affecting the efficiency of mastication
   (1h)
5. Dry rubber other ingredients used in dry rubber industry
   Types and classes of ingredients (for latex based and dry rubber based industries) such as fillers, accelerators, activators, anti-degradents, processing aids, miscellaneous ingredients and special additives, dry rubber compounding.
   (4h)
6. Assessment of rubber compounds
   Quality, economics aspects of compounding
   (1h)
7. Vulcanization
   Rheograph, study of curing characteristics, vulcanization techniques, vulcanization systems, effect of vulcanization on the performance
   (2h)
8. Brief introduction to shaping methods used for making rubber based product
   Moulding, calendaring extrusion, injection moulding
   (2h)

Learning Outcomes:

- Be able to select types and grades of rubber and other ingredients for the manufacture of different types of rubber products
- Be able to understand the functions of various rubber ingredients
- Be able to analyze the cure characteristics of a rubber compound and interpret cure curves
- Be able to predict the product performance of a given rubber compound and supervise a rubber manufacturing production flow line under guidance of a technical expert

Method of assessment:

End of course 1h theory paper 80% and 20% class tests and assignments

References:

1. Polymer industry in Sri Lanka, edt. Sudantha Liyanage, published by the University of Sri Jayewardenepura of Sri Lanka.
2. Basic Chemistry and Technology of Industrial Polymers, Kanthappu Subramaniam, 2012.
3. Handbook of Rubber Technology: Volume 1, Natural and synthetic rubber and technology of vulcanization by J. M. Martin, W. K. Smith; edited by S. C. Bhatia, CB Publishers, 2007
4. Handbook of Fillers, George Wypych. Chem. Tech Publishing, 2000; Polymer Lattices, Science and Technology, D. C. Blackley, CHAPMAN & Hall, London, 1997

Course Title	:	**PST 206 1.0 Analytical Methods and Testing of Polymers**
Number of lecture hours	:	15
Number of Tutorial hours	:	3
Lecturer in Charge	:	Dr. K. M. Thilini D. Gunasekara

Objectives:

- Provide a general understanding of analytical methods of polymers
- Understand the basic theory behind the instrumentation
- Explore standard testing methods of plastics

Course content:

1. General overview
   Review of key concept in polymer analysis and testing
   (1/2 h)
2. Absorption Spectroscopy:
   a) IR spectroscopy
      Theory behind IR, Instrumentation, characteristic group absorption, interpretation of spectra, attenuated total reflectance (ATR) method, FTIR method. Application of IR: Analyze structure of monomers/polymers, tacticity/ crystallinity, extent of chemical reactions, investigation of unknown compounds, quality control, IR as semi-quantitative/ quantitative analysis, Polymer Degradation, reaction mechanism, Rate of chemical reactions, Additives Analysis
      (3h)
   b) NMR Spectroscopy
      Theory behind NMR, Applications: Copolymer composition analysis, sterioisomerization, tacticity, monomer/polymer characterization, solid state NMR
      (2h)
   c) UV visible Spectroscopy
      Theory of UV visible spectroscopy, Applications, Identification and analysis (Oxidation, Discoloration) of polymer by UV spectroscopy, Analysis of oxidative degradation of polymers (In PVC, Polyethylene), staining techniques to identify polymer
      (1/2 h)
3. Thermal analysis:
   a) Thermogravimetric Analysis (TGA)
      Theory behind TGA, Instrumentation, typical TGS curves, applications: thermal stability, material characterization, compositional analysis, simulation of industrial processes, kinetic studies
      (2h)
   b) Differential Scanning Calorimetry (DSC)
      Theory behind DSC, Instrumentation, typical DSC curves, applications: melting process, enthalpy of fusion, purity, transition processes
      (2h)
   c) Dynamic Mechanical Analysis (DMA)
      Instrumentation, Common clamping geometries, DMA curves, Time-Temperature Correspondence, The Crankshaft Model, applications

(1h)

4. Gel Permeation Chromatography (GPC)
   Theory behind GPC, Instrumentation, applications

(1h)

5. Plastic testing
   Impact strength, Flexural strength, Fatigue and flexing, Abrasion resistance, mold shrinking, density, viscosity, thermal conductivity, Deflection temperature, flammability, melt index, UV resistance, permeability, secular gloss, index of refraction, arc resistance, resistivity, dialectic constant

(2h)

6. Scanning electron microscope, Transmission electron microscopy, X-ray Diffraction Methods

(1h)

Learning outcomes:

- Understand the principles of characterization techniques of polymers
- Be able to interpret spectrums, plots and curves
- Be able to select appropriate techniques to provide specific information on polymer
- Aware about the current testing approaches

Method of assessment:

End of semester 1h theory paper

References:

1. Composition and failure analysis of polymers (a practical approach) by John Scheirs
2. Campbell, C., Polymer Characterization: Physical Technique, Chapman and Hall, 1989.
3. Industrial plastics – theory and applications by Richardson and Loensgard
4. Spectrometic Identification of organic compounds by Robert Silverstein

Course Title	:	**PST 207 1.0 Solution Properties and Thermodynamics of Polymers**
Number of lecture hours	:	15
Number of Tutorial hours	:	3
Lecturer in Charge	:	Dr. M. A. B. Prashantha

Objectives:

- To improve visualization skill of conceptual approach to the model development of dissolution process of small molecular substances and very long chain molecular substance.
- To understand the fascinating art of model development for polymer solutions using basics of thermodynamics.
- To familiarize the theory of solubility parameter, Flory-Huggins theory and interaction parameter.
- To understand the behavior of linear polymer molecule in diluted solution.
- To select suitable solvent for the given polymer to make a polymer solution.

Course content:

1. Introduction to the thermodynamic approach for mixing of two components
   $\Delta G_{mix} = nRT[x_A lnx_A + x_B lnx_B]$, $\Delta S_{mix} = -nR[x_A lnx_A + x_B lnx_B]$
   Statistical thermodynamics approach for the entropy of mixing.
   (3h)
2. Interpretation of dissolution process of polymer
   Effect of chemical structure, Chain length, Morphology, Fickian and non-Fickian diffusion of solvent, hydrodynamic volume and its equilibrium
   (2h)
3. Quantitative interpretation of the effect of thermodynamics functions to the dissolution process of polymer
   $\Delta G = \Delta H - T\Delta S$
   Good solvent and non-solvent, solubility of polydispersed system, solubility of crystalline and amorphous polymer, fractional precipitation
   (3h)
4. Mathematical models for solubility of polymers parameter (Scachard-Hilderbrad and Hansen)
   (4h)
5. Flory-Huggins theory of polymer solution and interaction parameter
   (3h)
6. Chain size and chain statistics of linear polymer in solution, end-to-end distance, unperturbed dimension and radius of gyration
   (1h)

Learning outcomes:

- Students should be able to understand the fascinating art of model development using basics of thermodynamics to get a simplified equation based on measurable quantities.
- Students should be able to read literature to understand current developments in the subject are.

- Students should be able to use the thermodynamics approach to select a suitable solvent or solvent system to form a polymer solution using the given the given polymer

Method of Assessment:

End of semester 1h theory paper

References:

1. Text book of polymer science, Fred W. Billmeyer, A Wiley International Publication
2. Polymers: Chemistry and Physics of Modern Materials, Third Edition , J.M.G. Cowie, Valeria Arrighi, CRC Press
3. Physical chemistry, P. W. Atkins, Oxford University Press

Course Title	**:**	**PST 214 1.0 Rubber Based Industries**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. L. M. K. Tilekeratne (VL)

Objectives:

- Present an overview of the economic importance of the rubber industry to Sri Lanka
- Provide a knowledge on Raw Rubber Industry
- Provide a knowledge on all aspects of rubber products manufacture
- Provide a basic knowledge on machinery used in the rubber processing industry
- Provide a knowledge on cost cutting in products manufacture, and on costing and marketing a product
- Provide knowledge sufficient to manufacture good quality raw rubber if they have a rubber property

Course content:

1. National and International rubber statistics
   World demands and demand variation for natural and synthetic rubber and leading produces, numerous applications of natural and synthetic rubber, the challenges of local rubber industry, master plan of local rubber industry and its sustainability. Economic importance of the rubber industry to Sri Lanka
   (3h)
2. Dry rubber industry and manufacturing processes
   Deferent categories of tyres, main components of Solid tyres and pneumatic tyres and the principle steps in the manufacture of them, Extruded products
   (3h)
3. Latex industry and manufacturing processes
   Dipped Products, Foam rubber, Rubberized Coir and moulded toys
   (4h)
4. Reclaim rubber manufacturing process

Advantages of reclaim rubber, applications of reclaimed rubber and manufacturing process, Tyreretrading

(3h)

5. Rubber plantation

   Tapping technology and latex yield, factors affecting to the quality of field latex

(2h)

Learning outcomes:

- Be able to understand the economic importance of converting raw rubber to end products for export.
- Be able to improve the quality of raw rubber produced to gain a higher price
- Be able to start a rubber based industry at a low investment after graduation.

Method of assessment:

End of semester 1h theory paper

References:

1. Chemistry of Rubber like elements. Editor Bateman
2. Polymer Chemistry Editor- Morris Morten
3. Hand Book of Rubber Processing and Culture, RRISl publication Editor L. M. K. Tillekeratne
4. International Rubber Study Group Bulletins.
5. Rubber Technology and Manufacture C M Blow, CRC Press, Division of the Chemical Rubber Co. Cleveland, Ohio, US

Course Title	**:**	**PST 216 1.0 Latex Technology**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Visiting Lecturer

Objectives:

- Provide a general understanding of natural and synthetic rubber latex and its industrial applications
- Provide different processing techniques used in Latex industry

Course content:

1. Introduction to Natural rubber latex
   Composition of Natural Rubber (NR) Latex, Non-rubber substances in the NR latex and importance, Architecture of the rubber particle in NR latex
   (2h)
2. Preservation of NR latex
   Spontaneous coagulation, Preservation by ammonia (HA Latex, LA Latex, LA-TZ Latex), Factors affecting on the stability of preserved natural rubber latex
   (2h)
3. Concentrating methods of NR latex
   Centrifugation and different fractions of latex, Creaming, Evaporation, ISO standard for concentrated NR latex
   (2h)
4. Stabilization of NR latex
   Stabilizers (Fixed alkali, Surface active materials, protective colloids)
   (1h)
5. Synthetic lattices
   Different types of synthetic latices (Styrene butadiene latex, nitrile butadiene latex, Polychloroprene latex)
   (2h)
6. Latex Compounding
   Latex compounding ingredients (vulcanizing agents, Accelerators, Activators, Antioxidants, Fillers, special additives based on the application), Preparation of dispersions and emulsions, Machinery and equipment used for preparing dispersions and emulsions of compounding ingredients
   (2h)
7. Prevulcanized and postvulcanized NR Latex
   Preaparation of prevulcanization latex, Comparison of prevulcanized and post vulcanized latex
   (1h)
8. Techniques used in Latex industry and latex allergy
   Dipping (Straight dipping process, Coagulant dipping process, Heat sensitive dipping), Forming (Dunlop process and Talalay process), Casting, Extrusion for elastic threads, Adhesives and surface coating, Latex allergy
   (3h)

Learning outcomes:

- Student should be able to understand the chemical and physical changes during storage and processing of latex.

- Student should be able to use the basic knowledge to understand the manufacturing process in latex industry.

Method of assessment:

End of semester 1h theory paper

References:

1. Polymer lattices science and technology, D. C. Blackley, Wiley interscience, 1997
2. Basic chemistry and technology of industrial polymer, Andra Digital printer, Kanthappu Subramaniam, 2012

Course Title	**:**	**PST 217 1.0 – Plastic Materials**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Prof. L. Karunanayake

Objectives:

- To introduce the commodity plastics.
- To provide basic knowledge on common polymerization techniques used for commodity plastics commercially.
- To demonstrate relationship between structure and properties of commodity plastics.
- To provide students with the knowledge on application of commodity plastics.

Course content:

1. Introduction

   (2h)
2. Common polymerization techniques used for commodity plastics commercially

   Polymerization techniques and their relationship to properties will be discussed.

   (5h)
3. Structure and properties of commodity plastics

   Effect of conformational changes and other factors effecting properties will be discussed

   (5h)
4. Applications

   Commercial applications and formulations used for them with reasons will be discussed

   (3h)

Learning outcomes:

The students should have knowledge on types and grades of commodity plastics available in the market, on polymerization techniques used and their effects on properties, on structure and property relationship. Finally, they should have a basic idea of selecting materials for common plastic products

Method of assessment:

End of semester 1 h theory paper

References:

1. Industrial polymers handbook: Products, Processes, Applications (V1,2& 3)Edited by E. S. Wilks, Wiley-VCH Verlag GmbH, Weinheim
2. Processes, Applications Industrial Polymers, Monograph No.24, L. Karunanayake, Institute of Chemistry Ceylon
3. Brydson, J.A. - Plastics Materials 7th Ed. (Butterworth 1999)

Course Title	**:**	**PST 205 1.0 Plastic Technology**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Prof. L. Karunanayake

Objectives:

- Fundamentals of polymer compounding, mixing and blending
- Introduction to polymer processing

Course content:

1. What is polymer compounding? Why it is necessary to mix polymers with other ingredients. How do you compound polymers and instruments used in compounding? Factors effecting mixing. (5h)
2. Choice of a blender, mixing techniques and mixers, master-batches. (3h)
3. Plastic processing techniques and equipment. Extrusion, injection moulding, calendaring, blow moulding, film forming, fiber spinning and coatings. (7h)

Learning outcomes:

- Fundamentals of mixing, compounding and blending would be learnt
- Compounding and mixing techniques would be learnt.
- Plastic processing techniques would be learnt.

Method of assessment:

End of semester 1h theory paper

References:

1. Outlines of Polymer Technology: Processing Polymers, R. Sinha, Prentice-Hall India.
2. Polymer Processing Fundamentals, Tim A. Osswald, Hanser.

Course Title	**:**	**PST 213 1.0 Kinetics of Polymerization**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. M. A. B. Prashantha

Objectives:

- To impart the knowledge of historical development of chemical kinetics of polymerization.
- To understand the distribution of weight fractions with the number average degree of polymerization.
- To impart the knowledge of reactivity ratio of copolymerization.
- To impart the knowledge of reaction mechanism of polymerization and electronic environment of monomers.

Course content:

1. Introduction to the classification systems of polymers based on polymerization
   Carother classification system based on polymerization reactions, Flory classification system based on reaction mechanism, Lenze classification system for the step- growth polymerization.
   (2h)
2. Introduction to the polymerization systems
   Bulk polymerization, Solution polymerization, suspension polymerization and emulsion polymerization.
   (4h)
3. Determination of copolymer composition using rate constants
   Monomer reactivity ratio, homo-propagation, cross propagation, composition of co-monomer feed and copolymer
   (2h)
4. Reaction Kinetics of Step-growth polymerization
   Historical development of the equal reactivity of functional groups, Polyesterification as a typical example for the step-growth polymerization, Second order reaction kinetics, concentration of monomers and i^{th}mers at a given moment, Polyesterification under non-equilibrium condition (presence of weak acid and strong acid as catalyst, self catalysed polyesterification), Agreements and disagreements 3rd order reaction kinetics, Reaction kinetics of polyesterification and experimental determination using acid value, Gel point calculations., Shultz-Flory distribution for linear step-growth polymerization
   (3h)
5. Reaction kinetics of chain polymerization
   Initiation, propagation, termination and chain transfer stages, Introduction to ionic polymerization, free radical polymerization and coordination polymerization, Electronic environment of monomers, typical examples for cationic and anionic polymerization mechanisms, Reaction kinetics of vinyl radical polymerization and kinetic chain length.
   (4h)

Learning outcomes:

- Students should be able to understand the practical importance of the knowledge of kinetics of polymerization.

- Students should be able to read literature to understand current developments in the subject are.
- Students should be able to use the basics of chemical kinetics with suitable modifications to develop mathematical relation in order to quantitatively describe the polymerization systems.

Method of assessment:

End of semester 1h theory paper

References:

1. Text book of polymer science, Fred W. Billmeyer, Wiley Interscience Publication
2. Polymer science and technology, Joel R. Fried, Prentice-Hall of india
3. Fundamental of Polymer science, Paul.C. Painter, Michel M. Coleman, Technomic publication.

Course Title	**:**	**PST 218 1.0 Engineering Plastics**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. Olga Gunapala

Objectives:

- To teach the specialties of engineering plastics.
- To provide basic knowledge on common manufacturing methods of engineering plastics employed in commercial industry.
- To give general knowledge on structure and properties of industrially important grades of engineering plastics.
- To provide students with the best and most current knowledge of processes and technologies related to engineering plastics.
- To build the capability of understanding the area of applications of engineering plastics, product and components design

Course content:

1. Introduction

   Explaining the similarities and differences of the engineering plastics when compared to thermosets and general-purpose thermoplastics, Understanding the unicity of engineering plastics leading to superior performance in terms of transparency, heat resistance, dimensional stability and mechanics.

   (2h)
2. Common Manufacturing methods of engineering plastics employed in commercial industry.

   (2h)
3. Structure and properties of amorphous engineering plastics

   Polycarbonate (PC), Polyphenylene Oxide (Modified PPO), Polyphenylene Ether (Modified PPE), Thermoplastic Urethane (TPU)

   (3h)

4. Structure and properties of semi crystalline engineering plastics
   High performance processable PolyAcetal (PA), Polyethylene Terepthalate (PET) as a material for manufacture of precision mechanical parts, sustaining high loads and enduring wear, PolybutyleneTerepthalate (PBT), Ultra High Molecular Weight Polyethylene (UHMW-PE)

   (3h)
5. Processing and application of engineering plastics
   Handling and Processing characteristics of engineering plastics, Manufacturing methods: Reactive casting and non reactive casting, Semi-product Extrusion and injection molding, Machining, Annealing, Welding, Bonding, Cleaning; Techniques employed for manufacture of products made of glass reinforced engineering plastics.

   (5h)

Learning outcomes:

- Be able to understand the properties of commercial grades of engineering plastics available at market
- Be able to select correct materials, and processing methods for a given plastics product
- Be able to apply principles of polymer technology to the solution of problems related to plastic product manufacturing, design and optimization of plastic process parameters, plastics mold design and optimization, die design and plastic product design

Method of Assessment:

End of course 01 h theory paper-70%
Assignment-30%

References:

1. Brydson, J. A. (John Andrew), Plastics materials British Library Cataloguing in Publication Data, 1997-7th ed.668.4
2. Advanced polymer processing operations Edited by Nicholas P. Cheremisinoff, Ph.D. Wesiwood, New Jersey, U.S.A.1998

Course Title	:	**PST 219 1.0 Polymer Rheology, Viscosity and Rubber Elasticity**
Number of lecture hours	:	15
Number of Tutorial hours	:	3
Lecturer in Charge	:	Dr. Dilru Ratnaweera

Objectives:

- Overview of basic concepts of rheology and their applications in polymer processing
- Introduction to molecular origin of flow behavior
- Introduce methods used for rheological measurements

Course content:

1. Introduction to basics in rheology
   Overview of the scope of rheology as it applies to polymer science, rheology in engineering context, rheology of polymer melt, factors affecting rheological properties of polymers, stress (organization of stress components in the polymer melt, typical stress tensors), flow velocity (velocity gradient, rate of deformation), relationship between stress and rate of deformation
   (2 ½ h)
2. Flow regimes
   Laminar vs. turbulent flows, Reynolds number
   (½ h)
3. Viscoelastic models
   Brief overview of the Kelvin and Maxwell models and explain creep, relaxation and recovery stages of viscoelastic materials, 3 element model, burger model and viscoelastic models with higher number of spring and dashpot elements
   (2h)
4. Rheological flow behaviors
   Ideal solid and fluid, non-Newtonian fluids, time-independent fluids, time dependent fluids, viscoelastic fluids, Bingham fluids and yield point, power law model for time-independent fluids (Herschel & Bulkley model, Ellis model, Casson model), temperature dependent flow behaviors
   (3h)
5. Molecular origin of flow behavior
   Overlap parameter, dealing with entanglements, repetition of polymer chains, tube model, explaining rheological phenomenon using tube model
   (2h)
6. Rheological challenges during polymer processing
   Die swelling, shark skin, die lip build up, challenges in co-extrusion, pressure drop and effect of melt elasticity on melt processing
   (2h)
7. Rheological measurements: (Rheometry)
   Capillary rheometer, concentric cylinder rheometer, cone and plate rheometer, melt flow indexer, Mooney viscometer
   (3h)

Learning outcomes:

- Be able to understand the importance of polymer rheological properties.
- Student will be able to understand responses of a polymers under applied stress

- Be able to describe major methods used to measure polymer melt rheology
- Student will be able to identify the rheological challenges in polymer melt processing

Method of assessment:

End of semester 1h theory paper

References:

1. Introduction to polymer rheology, Montgomery T. Shaw, ISBN: 978-0-470-38844-0
2. Applied Polymer Rheology: Polymeric Fluids with Industrial Applications, Marianna Kontopoulou , ISBN: 978-0-470-41670-9
3. Polymer Rheology, R. S. Lenk, ISBN 978-94-010-9668-3, ISBN 978-94-010-9666-9

Course Title	:	**PST 212 1.0 Laboratory Practical**
Number of practical hours	:	45
Lecturer in Charge	:	Dr. M. A. B. Prashantha

Each practical class is limited to 3 hours and hence each practical is designed to carry out within the time frame to gain the basic understand.

1. Synthesis of glyptal / Glycerylpthalate
   Objectives
   - Provide hands on experience on synthesis of branched polyester polymer through condensation polymerization.
   - Provide hands on experience on fluidity changes during the polymerization.
   - Provide hands on experience on gelation and importance of controlling the gelation.
   - Provide the hands on experience to physical properties of highly cross-linked thermoset plastic material.
   - Provide the hands on experience to use the FTIR technique to identify the development of new functional group.

2. Synthesis of linear polyester
   Objectives
   - Provide hands on experience on synthesis of linear polyester polymer through condensation polymerization.
   - Provide hands on experience on fluidity changes during the polymerization.
   - Provide hands on experience for comparing the fluidity changes during the polyesterification process to synthesis linear polyester and branched polyester.

3. Controlling the functionality to overcome gelation
   Objectives
   - Provide hands on experience to understand the effect of functionality to the gel point.
   - Provide hands on experience to understand the effect of functionality to the properties of polymers.

- Provide the hands on experience to use the FTIR technique to identify the development of new functional group.

4. Synthesis of unsaturated polyester.
    - Provide hands on experience on synthesis of unsaturated thermoset polyester polymer through condensation polymerization.
    - Provide hands on experience on crosslinking of unsaturated polyesters using crosslinking agent.
    - Provide the hands on experience to use the FTIR technique to identify the development of new functional group.

5. Synthesis of PVA polymer slime
   Objectives
    - Provide the hands on experience on synthesis of network polymer using organic polymer and inorganic compound.
    - Provide hands on experience to understand the importance of hydrogen bonding to form polymer having gel behavior.

6. Study the influence of PET to the concentration of NaOH.
   Objectives
    - Provide the hands on experience on studying the reaction kinetics of depolymerization of PET.
    - Provide the hands on experience to understand the importance of planning and controlling of the laboratory conditions to conduct kinetic study.

7. A Rapid, Economical, and Eco-Friendly Method to Recycle Terephthalic Acid from Waste PET Bottles (Depolymerization of PET)
   Objectives
    - Provide the hands on experience on depolymerization of PET and separation of products.
    - Provide hands on experience to understand the effect of strong alkali medium to PET.

8. Synthesis of Polysulfide rubber
   Objectives
    - Provide the hands on experience on synthesis of polysulphide rubber
    - Provide hands on experience to understand the importance polysulphide to impart rubbery behavior.
    - Provide hands on experience to understand the application of sulpher as inorganic substance to synthesis polymers.

9. Emulsion Polymerization of Styrene
   Objectives
    - Provide the hands on experience on Emulsion Polymerization of Styrene
    - Provide hands on experience to understand the importance of additives used in formula.
    - Provide hands on experience to make a film using the emulsion.

10. Glycolysis of PET to BHET
    Objectives

- To provide opportunity to familiarize the glycolysis of PET
- To provide opportunity to isolate BHET and evaluate the purity.

11. Rubber compounding using two roll mill and determination of properties
    Objectives
    - To provide opportunity to familiarize the two roller mill operations.
    - To provide opportunity to experience the effect of mastication to the physical properties of natural rubber and make rubber compound.

12. Factory visits and report writing.
    Objectives
    - To provide opportunity to observe unit operations, manufacturing techniques and quality management systems in rubber and plastics based industries.
    - To provide opportunity to observe unit operations, manufacturing techniques and quality management systems in paint manufacturing industries.

Course Title	**:**	**PST 301 1.0 Polymer Blends & Composites**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Visiting Lecturer

Objectives:

- To teach basic phase separation concept in polymer blends and composites
- Learn ways of improving the compatibility of the components in polymer blends/composites
- To deliver the structure – property relationship of polymer composites/blends
- To explore various types of polymer blend/composites available in the polymer filed

Course content:

1. Introduction to polymer blends and composites
   Definitions, benefits and problems of blends/composites over conventional polymers, phase behavior and phase separation in polymer blends (also briefly review the thermodynamics of mixing), phase diagrams, rheology and morphology of polymer blends
   (3h)
2. Ways of overcoming phase separation
   Theoretical aspects of interfaces (surface energies and interfacial tension), determination of interfacial parameters, compatibilization by addition of a compatibilizer, reactive compatibilization of polymer blends (direct covalent crosslinking, graft copolymer formation, covalent crosslinking mediated by an activating agent, covalent crosslinking mediated by a coupling agent, and ionic interactions)
   (4h)

3. Properties and performances of polymer blends
   Mechanical properties (tensile strength, tensile modulus, elongation, toughness, compressive strength, rigidity, fracture mechanics), thermal properties, flammability, electrical and optical properties
   (2h)
4. Natural polymer blends and composites
   Blends and composites based on starch, cellulose and natural polymers
   (1h)
5. Fiber reinforced composites
   Reinforcing mechanism, types of fiber reinforces composites and their preparation methods.
   (1h)
6. Biodegradable composites
   Starch-based, polylactide -based, natural rubber/clay based
   (1h)
7. Polymer nanocomposites
   Advantages over micro and macro scale composites, effect of particle size on properties, preparation and advantages of commercially available polymer nanocomposites, future trends
   (2h)
8. Role of polymer blends' technology in polymer recycling
   (1h)

Learning outcomes:
Students will be able to understand

- challenges in making polymer blends/composite
- ways to overcome above challenges
- why composites/blends have superior properties compared to their individual counterparts and how they contribute to property improvement
- advantages of nanocomposites over conventional composites

Method of assessment:

End of semester 1h theory paper

References:

1. Polymer blends handbook, Volume1, L. A. Utracki, ISBN-10: 1402011105, ISBN-13: 978-1402011108
2. Biodegradable polymer blends and composites from renewable resources, Long Yu, ISBN: 978-0-470-14683-5

Course Title	**:**	**PST 307 1.0 Introduction to Die and Mold Designing**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Visiting Lecturer

Objectives:

- To identify basic concepts in designing dies and moulds for polymer processing.
- To relate material properties and product requirements to the design features in dies and moulds.
- To identify and product defects related to die and mould design.

Course content:

1. Product designing and process selection
   Basic requirements in process selection based on type and grade of polymer, shape, size and design features of the product and production scale. Identification of main requirements in products conducive to each processing technique.
   (3h)
2. Injection Mould designing
   Basic design procedure to satisfy product and material requirements. Function and essential design features in injection mould components such as sprue, runners and gates, Standard mould set with guide bars, guide sleeves and other guiding elements, Ejector pins and special components for ejection, Ejector set guiding elements, Core pins, Core moving elements, Cold runner system components, Hot runner system components, Fastening and closing elements, elements for lifting the mould.
   (4h)
3. Types of extruder dies
   Sheet extrusion dies, flat-film and blown-film dies, pipe and tubing dies, profile extrusion dies; and co-extrusion dies
   (2h)
4. Extrusion Die designing
   Basic design procedure to satisfy product and material requirements. Function and essential design features in extrusion die components such as the manifold, die land, choke bar, dekle rods, die lips, and mandrels.
   (3h)
5. Processing defects of injection moulded and extruded products
   Short shots, flashing, shrinkage, sink marks and warping of injection moulded products. Die swell, warping, melt fracture, shark skin, orange peel and Bambooing of extruded products.
   (3h)

Learning Outcomes:

- Be able to identify basic concepts in designing dies and moulds for polymer processing.
- Be able to provide a description, rationalization of polymer processing techniques
- Be able to explain product designing process

Method of assessment:

End of semester 1h theory paper

References:

1. How to make injection moulds – Menges / Michaeli / Mohren
2. Extrusion Dies for Plastics and Rubber: Design and Engineering Computations, Walter Michaeli, Hanser Publishers, Jan 1, 2003 - Technology & Engineering

Course Title	**:**	**PST 303 1.0: Polymer Coatings and Paint Industry**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	3
Lecturer in Charge	**:**	Dr. Dilru Ratnaweera

Objectives:

- Overview of the basic concepts of paints and polymer coatings
- Describe the functions of different components in coatings/paints
- Introduce basics of formulation of paints/coatings
- Recent advancements and future directions in polymer coatings/paints industry

Course content:

1. Introduction to surface coatings and paints
   Types of coatings, classification, major ingredients of paints (pigments, resin, solvent, additives, and driers) and their functions, solvent based and water based paints
   (1h)
2. Methods of making polymeric coatings
   Applying with brush, dip coating, spin coating, doctor blading, spraying
   (1h)
3. Pigments
   Different types of pigments (color pigments, hiding pigments, barrier pigments, inhibitive pigments, reinforcing pigments, extender pigments, and sacrificial pigments), physics behind the role of pigments
   (1h)
4. Pigment dispersion
   Wetting of pigments and wetting agents, dispersion of pigments and techniques used in dispersion, stabilization of pigments (electrostatic and steric stabilization methods), states of pigment dispersions, pigment dispersants (polymeric dispersants (anchoring groups and polymer chains), surfactants, anchoring mechanisms of dispersants to pigments), problems due to poor stabilization of pigments (flooding and floating of pigments, poor color strength, syneresis, poor gloss level)
   (2h)
5. Resins
   Different curing mechanisms for various resins, curing agents, alkyd resins and their modifications, epoxy resins, polyurethane resins and their modifications,

acrylic resins, silicon coatings, energy curable resins (free radical curing and cationic curing)

(3h)

6. Other ingredients and their functions

   Solvents, anti skimming agent, anti settling agents, anti floating and anti-flooding agents, flow controlling and leveling agents, deforming agents, fungicides and preservatives

   (2h)

7. Formulation

   Volume of solid, pigment volume concentration, critical pigment volume concentration, formulating paints, dry film thickness, wet film thickness

   (2h)

8. Coating and paints testing

   Adhesion testing (cross cut test, tensile method, knife cutting method, blister method), cohesion testing, impact effect on coating, pigment stability tests (rub test, pour out test)

   (2h)

9. Recent advancements and future directions in paints/coatings

   Conjugated polymer coatings for light harvesting, structured coatings from block polymers, super hydrophobic and super oliophobic coatings, self healing and stimuli responsive coatings

   (1h)

Learning outcomes:

- Be able to describe important components of paints/surface coatings.
- Be able to describe major testing methods used to check the quality of coatings.
- Be able to describe ways to overcome challenges during formulating paints
- Be able to understand the novel trends in polymer coatings

Method of assessment:

End of semester 1h theory paper

References:

1. Paint and surface coatings theory and practice (2nd edition), R. Lambourne and T. A. Strivens, ISBN 1-8557-3348 x
2. Coating materials and surface coatings, Arthur A. Tracton, ISBN 1-4200-4404-4
3. Surface Coatings: Science and Technology (2nd edition), Swaraj Paul , ISBN: 978-0-471-95818-5

Course Title	**:**	**PST 305 1.0 Laboratory Practical**
Number of practical hours	**:**	45 (15 days)
Lecturer in Charge	**:**	Dr. K. M. Thilini D. Gunasekara

Allocation of marks:

Item	Marks
Attendance (80 % required)	10
Laboratory reports	20
Pre-lab / Post-lab questions	20
Assessments	20
Final exam	30
Total	100

List of Experiments:

1. Experiment 1: The determination of zinc, calcium and magnesium in rubber compounds using EDTA
   Objectives:
   - To determine metal cations of a given NR sample

2. Experiment 2: Experimental determination of latex properties -total solid content (TSC) and dry rubber content (DRC)
   Objectives:
   - Understand how to determine the total solid content (TSC) of given NR latex
   - Understand how to determine the dry rubber content (DRC) of given NR latex

3. Experiment 3: Manufacture of surgical gloves using coagulant dipping method
   Objectives:
   - To get the basic knowledge about dipped products of NR latex
   - To gain hands on experience of manufacturing a glove.

4. Experiment 4: Determination of Mechanical stability (MST) of given NR latex
   Objectives:
   - Understand how to determine the Mechanical stability (MST) of given NR latex

5. Experiment 5: Experimental determination of volatile fatty acid number (VFA)
   Objectives:
   - Learn how to determine volatile fatty acid number of given NR latex
   - Understand the importance of VFA

6. Experiment 6: Experimental determination of KOH number and alkalinity of a given NR sample
   Objectives:
   - Learn how to determine KOH number and alkalinity of a given NR sample

7. Experiment 7: Study of Brookfield Digital Viscometer
   Objectives:
   - Measure the viscosity of a fluid using rotational viscometer,
   - Determine the viscosity of different liquids.

8. Experiment 8: Determination of the molar mass of a polymer using viscosity measurements
   Objectives:
   - Measure the viscosity of a fluid using Ubbelohde viscometer

9. Experiment 9: Determination of carboxylic acid and ester
   Objectives:
   - Learn how to determine the Acid number and the saponification value of a given resin

10. Experiment 10: Universal Testing Machine
    Objectives:
    - To Identify the functions of Universal Testing Machine

11. Experiment 11: The Condensation Polymerization of Phenol and Formaldehyde : Bakelite
    Objectives:
    - To gain an understanding of preparation of synthetic polymers

12. Experiment 12: Polymer analysis by FTIR, UV-Vis
    Objectives:
    - To gain experience with FTIR and UV-Vis instrumentation

13. Experiment 13: A Silly Polymer
    Objectives:
    - To cross-link a polymer and observe the changes in the physical properties as a result of this cross-linking

Course Title	**:**	**PST 314 2.0 Industrial Management and Marketing**
Number of lecture hours	**:**	30
Number of Tutorial hours	**:**	2
Lecturer in Charge	**:**	Dr. Pahan Godakumbura

Objectives:

- Prepare and shape students to managerial post to cater current industrial needs.
- Enhance the practical, technical as well as the theoretical knowledge in managing people with specialized skills.
- Enhance the problem solving skills in relation to the company survival, growth and development.
- Increase the demand in graduates to the research and development field in industry

Course Content:

1. Introduction to Management
   Managerial roles, managerial levels, Characteristics of a good manager, Evolution of management theory: The Scientific approach, The Classical approach, Behavioral approach, Management functions, Planning, Organizing, Leading, Controlling, Organization behavior
   (8h)
2. Human Resources Management
   Staffing, Benefits of human resources planning, the process of staffing, Job analysis, Job description, Job specification, Recruitment and Retention, Career planning, Performance appraisal, Employee training and development, Training techniques
   (6h)
3. Principles of Marketing management
   Marketing concept (7 Ps), Tools of marketing, Product life cycles, Market Search, Industry Analysis on Porters Five forces model, Boston matrix
   (8h)
4. Production / Operation and Lean Management
   - Steps in operational management: Selecting, Designing, Operating, Controlling, Updating, Competition, changes in organizational objectives and personnel
   - Steps in Production Planning and Control: Routing, scheduling, dispatching, Inspection and Follow up
   - Functions of production operations management: Design and Development, Capital equipment, Site selection, Facilities layout, Work design and Measurement, Purchasing/Materials Management, Inventory control
   (6h)
5. 5S concepts
   (2h)

Method of assessment:

Assessments 1: 15%

1. Market search, documentation and Oral presentation (5 to 7 min)
   Identify a product and does a Market search. Eg "Beverage: any product item, coca cola".

- Market search is a process of gathering information and analyzing about the market or customers to find out the needs, market size and competition.
- Documentation: Based on your findings, predict the future of the product. (How will it go for next 3 years, demand and supply etc...)
- Assignment requirement: Minimum 5 pages (single side), single spaced, Font: TNR 12, can include figures, tables and properly reference them.
- No copying with each other, or plagiarisms

Survey design

1. Identify and study about a market product thoroughly.
2. Collect information/data by consulting managers and consumers.
3. Process information and analyze the current situation.
4. Predict future trends based on collected data.
5. Provide outcomes, benefits and recommendation for the predicted product.

Assessment 2: 10%

Present your market search (5 to 7 min)

Assessment 3:

Final exam: 75% with

Condition: Two Assessments must be completed to sit the final exam

References:

1. Management (sixth edition), James A. F. Stoner
2. Management Theory and Practice, J. S. Chandan
3. Fundamentals of Management, (core concepts and applications) by Ricky W. Griffin

Course Title	**:**	**PST 310 1.0 Environment and Polymer Industry**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	1
Lecturer in Charge	**:**	Dr. S.D.M. Chinthaka

Objectives:

- Understanding major environmental issues and their relationship with the polymer industry.
- Provide the comprehensive understanding of the stability of polymeric materials in the environment.
- Rationalize the energy as the major consideration for polymer recycling.
- Explore the significance of recycling of plastics for the waste reduction
- Understanding the various recycling options available for used plastic materials

Course contents:

1. Local and global environmental issues, contribution from polymer industry to the global and local environmental issues. (1h)
2. Common polymeric materials and the basic impact of their synthesis and usage on the environment. (2h)
3. Polymer and the energy, the unique relationship between polymer industry and the energy, calorific value as the determining factor for polymer recycling. (2h)
4. Usage of plastics in packaging, agriculture, coating and in textile industry and their recycling potential. (5h)
5. Effect of the environment factors on the stability of polymeric materials. (2h)
6. Polymer recycling: potential, methods and options. (3h)

Learning outcomes:

- Students will be able understand the global and local environmental issues and the degree of their relationship to polymer industry.
- Students will be able to understand the effect of environmental factors on the stability of polymeric materials and how to stabilize plastics against environmental factors.
- Students will be able to determine whether recycling of polymers is economical over the use of virgin polymers based on calorific values.
- Students will be able to understand the recycling potential of plastics used in various industries.
- Students will be able to understand the techniques used to segregate various plastics in consumer products.

Method of assessment:

End of semester 1h theory paper

References:

1. Anthony L. Andrady, Plastics and the Environment, Wiley Interscience, Hoboken, New Jersey.
2. Stanley E. Manahan, Environmental Chemistry, 7th Edition, CRC press, Boca Raton, Florida.

Course Title	**:**	**PST 313 1.0 Introduction to Engineering Materials**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	1
Lecturer in Charge	**:**	Dr. Nilwala Kottegoda

Course content:

Structure, properties and applications of

i. Ceramics
ii. Metals
iii. Modern functional polymers
iv. Composites of ceramics, polymers and metals and their advanced derivatives
v. Smart materials
vi. Liquid crystals
vii. Biomaterials and their composites and derivatives

Learning Outcomes:

By the end of the module, students will be able to:

- Discuss the structural characteristics of ceramics, metals, modern polymers, composites of ceramics, polymers and metals and their advanced derivatives, smart materials, liquid crystals, biomaterials and their advanced derivatives.
- Explain the properties of ceramics, metals, modern polymers, composites of ceramics, polymers and metals and their advanced derivatives, smart materials, liquid crystals, biomaterials and their advanced derivatives.
- Predict structure property relationships in ceramics, metals, modern polymers, composites of ceramics, polymers and metals and their advanced derivatives, smart materials, liquid crystals, biomaterials and their advanced derivatives.
- Discuss the industrial applications of the ceramics, metals, modern polymers, composites of ceramics, polymers and metals and their advanced derivatives, smart materials, liquid crystals, biomaterials and their advanced derivatives.
- Gain fundamental understanding on how certain basic materials such as polymers, ceramics, metals and biomaterials are combined together to produce advanced functional materials.
- Design functional materials to achieve a given property or combined properties.

Method of Assessment:

End of semester 1h theory examination

Course Title	**:**	**PST 314 1.0 Rubber Materials**
Number of lecture hours	**:**	15
Number of Tutorial hours	**:**	1
Lecturer in Charge	**:**	Dr. Susantha Siriwardena

Objectives:

- To provide basic knowledge on Natural rubber manufacturing processes, available types, their properties and possible modifications
- To demonstrate relationship between structure and properties of natural rubber and synthetic elastomers
- To provide basic knowledge on available rubbery materials for industrial applications

Course content:

1. Introduction:
   Special features of rubbery materials, Rubber and elastomers
   (1h)
2. Natural Rubber (NR) manufacturing process:
   Types and grades: Sheet rubber, Crepe rubber; Technically specified rubber; modified grades of NR, Different raw rubber properties between different types and grades of NR; special features of NR, effects of non-rubbers present on the properties of NR
   (3h)
3. Quality parameters of NR:
   Dirt, ash, plasticity (P^o); Plasticity Retention Index (PRI); Volatile Matter content (VM), Nitrogen content
   (2h)
4. Properties of NR:
   Chemical properties, physical properties, electrical properties, swelling index, crystallinity, Solubility parameters thermal properties viscoelastic properties
   (2h)
5. Synthetic rubber:
   General purpose specialty elastomers, structure-property relationship, main characteristics
   BR, SBR, IR, IIR, NBR, EPDM, EPR, silicone Rubber
   (5h)
6. Industrial applications:
   Selection of different rubbers and synthetic elastomers for different industrial applications
   (2h)

Learning outcomes:

- be able to explain characteristic features of rubber materials
- be able to explain the manufacturing processes of different types of rubber
- be able to compare the different properties of different grades of natural rubber the importance of following the recommended procedures in the manufacturing process
- be able to suggest the remedial measures to overcome day to day problems found in the raw rubber manufacturing process

- be able to explain the special characteristics of natural rubber

- be able to compare the different properties of different types of synthetic rubbers
- be able to suggest suitable rubber types for particular industrial applications

Method of assessment:

End of semester 1h theory paper (80%)
Two class tests (10%)
One assignment (10%)

References:

1. Basic chemistry and Technology of Industrial Polymers, Kanthappu Subramanium, 2012.
2. Handbook of rubber technology: volume 1, Natural and synthetic rubber and technology of vulcanization by J.M. Martin,W. K. Smith; edited by S. C. Bhatia, CB Publishers, 2007
3. Rubber Technology: Compounding and Testing for Performance, ed. John S. Dick, Hanser publishers, 2001
4. Handbook of rubber technology: Volume 2, raw rubber processing, eds. Tillkeratna, K. Nugawela, A and Seneviratne, G., Rubber Research Institute of Sri Lanka, 2007

Course Title	**:**	**PST 309 3.0 Industrial Projects**
Lecturer in Charge	**:**	Dr. M. A. B. Prashantha

Duration:

30 days

Objectives:

- To expose students to industrial atmosphere to gain an insight and understanding of operations and management system of organization.
- To improve the ability to relate the lecture room knowledge to industrial practice.
- To get a feel of the work environment.
- To expose students to the industrial responsibilities and ethics.
- To develop skills in relation to:
  - i) interpersonal and problem solving.
  - ii) research and reporting.
  - iii) professional competence
- To prepare for employment after graduation.

Commencement:

At the beginning of second semester

Guidelines of training:

Organization has to design the training schedule to achieve the objectives under following topics.

- Production process
- Material Management system
- Quality controlling systems and type of testing
- Waste controlling
- New challenges
- Management practices and experience in management meeting
- Operational techniques
- Quality assurance system
- Lean manufacturing practices
- Fire protection

Evaluation:
Student should submit an approved report on training experience by the organization and conduct a 15 minutes presentation on his training experience. Report and the presentation will be evaluated.

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