DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY LUCKNOW

STUDY & EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH 2nd YEAR
MECHANICAL ENGINEERING

(Plastics Engineering)

(EFFECTIVE FROM THE SESSION: 2019-20)

SEMESTER- III													
Sl. No.	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	KOE031-38/KAS302	Engg. Science Course/Maths IV	3	1	0	30	20	50		100		150	4
2	KAS301/ KVE401	Technical Communication/ Universal Human Values	2 3	1 0	0 0	30	20	50		100		150	3
3	KPE301	Thermodynamics of Polymers	3	1	0	30	20	50		100		150	4
4	KPE302	Rheology of Polymers	3	1	0	30	20	50		100		150	4
5	KPE303	Fundamental of Polymer Science	3	0	0	30	20	50		100		150	3
6	KME352	Material Testing Lab	0	0	2				25		25	50	1
7	KPE352	Polymer Rheology Lab	0	0	2				25		25	50	1
8	KPE353	Identification of Polymers Lab	0	0	2				25		25	50	1
9	KPE354	Mini Project or Internship Assessment*	0	0	2			50				50	1
10	KNC301/ KNC302	Computer System Security/Python Programming	2	0	0	15	10	25		50			0
11		MOOCs (Essential for Hons. Degree)											
		Total										**950**	**22**
*The Mini Project or internship (3-4 weeks) conducted during summer break after II semester and will be assessed during III semester.													

SEMESTER- IV													
Sl. No.	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	KAS402/ KOE041-48	Maths IV/ Engg. Science Course	3	1	0	30	20	50		100		150	4
2	KVE401/ KAS401	Universal Human Values/ Technical Communication	3 2	0 1	0 0	30	20	50		100		150	3
3	KPE401	Plastics Materials-I	3	0	0	30	20	50		100		150	3
4	KPE402	Plastics Processing-I	3	1	0	30	20	50		100		150	4
5	KPE403	Polymerization Engineering	3	1	0	30	20	50		100		150	4
6	KPE451	Synthesis and Polymerization Lab	0	0	2				25		25	50	1
7	KPE452	Plastics Processing-I Lab	0	0	2				25		25	50	1
8	KPE453	Industrial visit	0	0	2				25		25	50	1
9	KNC402/ KNC401	Python Programming/Computer System Security	2	0	0	15	10	25		50			0
10		MOOCs (Essential for Hons. Degree)											
		Total										**900**	**21**

SEMESTER-III

THERMODYNAMICS OF POLYMERS

L-T-P
3-1-0

Objectives:
To familiarize the students with concepts of basic thermodynamics and polymer systems.

UNIT-I:
Fundamental concepts and definitions, Temperature and zeroth law of thermodynamics, Equation of states, P-V-T- relationships and application, First law of thermodynamics: Application of first law to different processes in close and open systems, Limitations of first law.

UNIT-II:
Second law of thermodynamics, entropy concept, entropy and lost work calculations, Microscopic interpretation of entropy, Mathematical statement of second law, Carnot cycle for an ideal gas, Refrigeration cycle, criterion of irreversibility, Third law of thermodynamics and its applications, free energy functions and their significance.

UNIT-III:
Constitution and Architecture of Polymers. Glassy, Crystalline and Molten States of Polymers: Thermodynamics of Melting of Polymers, Kinetics of Crystallization (Avram Equation), Thermodynamics of Glass Transition, Free Volume theory.

UNIT-IV:
Polymer Chain Conformations: Random flight model for polymer, The Gaussian Chain, Chain Conformation under an External Field, Excluded Volume Effect and Theta Condition, Rotational Isomeric States. Mechanical Behavior of Polymers: Rubber Elasticity, Network Model. Viscosity of Polymer Solutions.

UNIT-V:
Thermodynamics of Polymers Solutions: Dilute, Semi dilute and Concentrated Solutions, Flory-Huggins Theory, Phase Equilibria in Polymer Solutions, Critical Fluctuations and Spinodal Decomposition Osmotic Pressure- MW Measurement, Zima Diagram - MW Measurement, Viscosity of Dilute Solution - MW Measurement, Screening Effect.

Course Outcomes:
After completion of this subject student is able to learn polymer features in thermodynamics.

Books and References:

1. Introduction to Chemical Engineering Thermodynamics / J.M. Smith, H.C. Van Ness, M.M. Abbott / 7th Ed / McGraw Hill.
2. Chemical Engineering Thermodynamics/ Rao/ University Press.
3. A Textbook of Chemical Engineering Thermodynamics/ K.V. Narayanan/ Prentice – Hall of India Pvt. Ltd.
4. Polymer Chemistry, 2/e, P. C. Hiemenz and T. P. Lodge, CRC Press, Boca Raton, 2007.
5. Essentials of Polymer Science and Engineering, Mike Coleman and Paul Painter, DesTech Publications, 2008.
6. Introduction to polymer science and chemistry: a problem solving approach, Manas Chanda, CRC/Taylor and Francis, Boca Raton, 2006.

RHEOLOGY OF POLYMERS

L-T-P
3-1-0

Objectives:
To familiarize the students with the basics of polymer deformation and flow properties.

UNIT-I:
Units and dimensions-Properties of fluids-mass density, specific weight, specific volume, specific gravity, viscosity, surface tension and capillarity-Terminologies of fluid flow-Laminar and turbulent flow of Newtonian fluids-Power law-Reynolds number and its significance.

UNIT-II:
Introduction to polymer rheology, Newtonian and non-Newtonian fluids, shear stress, shear strain and shear rate, shear modulus, bulk modulus, Zero shear viscosity, Dependence of viscosity with temperature, shear stress, Viscoelasticity - effect of rate of strain, temperature and time on mechanical behavior of polymeric materials.

UNIT-III:
Measurement of viscosity and normal stresses. Dynamic flow behavior, time dependent fluid responses. Capillary rheometers, cone and plate viscometer, parallel-plate rheometer, oscillating disc rheometer, Mooney viscometer. Rheology of modified polymer systems.

UNIT-IV:
Rheology of polymeric liquids: polymer chain conformation, zero shear viscosity, rheology of dilute polymer solutions, entanglement, effect of long chain branching, effect of molecular weight distribution. Measurements of rheological properties.

UNIT-V:
Rheology in polymer processing operations: Calendaring and two roll mill, Twin screw extruders, Blow molding, Wire coating, Thermoforming, Sheet extrusion, Internal mixers, Rubber extrusion.

Course Outcomes:
On completion of the course, students will understand the basics of fluid mechanics and Rheology. Will be able to analyses the rheological properties of polymer systems using rheometers.

Books and References:
1. Rheology: Concepts, Methods, and Applications/ A.Y. Malkin, A.I. Isayev/ ChemTec Publishing.
2. Rheology and Processing of Polymeric Materials Vol. 1/ Oxford University Press.

3. Melt Rheology and its Role in Plastic Processing: Theory and applications/ Dealy&Wissbrun/ Chappman and Hall.
4. Vishu shah “Plastics testing technology hand book”.

FUNDAMENTALS OF POLYMER SCIENCE

L-T-P
3-0-0

Objectives:
To familiarize the students about the fundamental theories of polymer science.

UNIT-I:
History of polymer science, Classification of Polymers, Functionality and structure ofpolymers, Physical properties and characterization of polymers, effect of structure onproperties of polymers, Inorganic polymers. Concept of macromolecules. Stereochemistry ofpolymers.

UNIT-II:
Introduction, Chain & step growth polymerization, Polymerization techniques, Kinetics ofPolymerization (Free radical, Cationic, Anionic polymerization, Polycondensation).

UNIT-III:
Molecular weight, Number average and weight average molecular weight, Sedimentation andViscosity average molecular weight, Molecular weight and degree of polymerization,Polydispersity, Size of polymer molecules.

UNIT-IV:
Glass transition temperature, Transitions, significance and factors influencing the Tg. Effectof Plasticizers on Tg. Glass transition of copolymers.Morphology and order of Polymers, Crystallinity in polymers, Degree of crystallinity andPolymer crystallization.Effect of crystallinity on properties of Polymers.

UNIT-V:
Polymer degradation and stability.Types of degradation.Mechanism of degradation.Factorsaffecting degradation.Polymer solutions.Process of dissolution of polymers.Thermodynamics of Dissolution.Flory-Huggins Theory, Viscosity of Polymeric solutions.

Course Outcomes:
On completion of the course, students will understand the basic fundamentals of polymer.

Books and References:

1. Plastics Material, Brydson, J.A
2. Text Book of Polymer Science, Billmeyer, Fred W.
3. Principles of Polymer Systems By Ferdinand Rodriguez
4. Principles of Polymer Chemistry By A. Ravve
5. Introduction of Polymer Science By Hans-Georg Elias
6. Polymer Science & Technology By Joel R. Fried.
7. Polymer Science ByGowariker V R, Vishwanathan NV, JayadevSreedhar.

MATERIAL TESTING LAB

L-T-P
0-0-2

Objectives:

- To understand the principles and performance characteristics different materials.
- To know about material properties.

List of Experiments: (At least 8 of the following)

1. Strength test of a given mild steel specimen on UTM with full details and stress versus strain plot on the machine.
2. Other tests such as shear, bend tests on UTM.
3. Impact test on impact testing machine like Charpy, Izod or both.
4. Hardness test of given specimen using Rockwell and Vickers/Brinell testing machines.
5. Spring index test on spring testing machine.
6. Fatigue test on fatigue testing machine.
7. Creep test on creep testing machine.
8. Experiment on deflection of beam, comparison of actual measurement of deflection with dial gauge to the calculated one, and or evaluation of young's modulus of beam.
9. Torsion test of a rod using torsion testing machine.
10. Study of NDT (non-destructive testing) methods like magnetic flaw detector, ultrasonic flaw detector, eddy current testing machine, dye penetrant tests.

Course Outcomes:

The students who have undergone the course will be able to measure various properties of materials.

RHEOLOGY OF POLYMERS LAB

L-T-P
0-0-2

Objectives:

- To understand the polymer rheology
- Determination of viscosity and related properties of polymer fluids.

List of Experiments:(At least 8 experiments)

1. Determination of viscosity of various thermoset and thermoplastic polymers by Brookfield viscometer.
2. Determination of "gel time" of various adhesives and polymers by Gelation Timer.
3. Determination of viscosity of PVC polymers by Ostwald viscometer.
4. To determine the viscoelastic properties of the given samples.
5. To determine the resistance to peel from a given samples.
6. Determination of molecular weight by viscosity.
7. Determination of rheology of Thixotropic polymers by Couette Viscometers.
8. Determination of rheology of Dilatants/Shear Thickening polymers by Couette Viscometers.
9. To determine the Viscosity Index of a given samples.

Course Outcomes:

The students who have undergone the course will be able to measure various rheological properties of polymer systems.

IDENTIFICATION OF POLYMERS LAB

L-T-P
0-0-2

Objectives:
To understand the basics of polymer identification

Minimum eight experiments out of the following:

1. Identification of unknown polymer using heating, burning, solubility.
2. Confirmatory chemical tests for Identification of unknown polymer .
3. Quantitative estimation of the basic raw materials and auxiliaries used in polymer such as phenol, urea, formaldehyde.
4. Quantitative estimation of the basic raw materials and auxiliaries used in polymer such as glycerol, plasticizer's initiators.
5. Quantitative estimation of the basic raw materials and auxiliaries used in polymer industries such as antioxidants, etc
6. Determination of purity of solvents, monomers and other auxiliaries.
7. Determination of physical properties - boiling point using standards techniques.
8. Determination of physical properties - melting point.
9. Determination of physical properties - refractive index.
10. Determination of physical properties - specific gravity of polymer materials

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Course Outcomes:
The students will be able to identify and determine the physical properties of different polymers.

SEMESTER-IV

PLASTICS MATERIALS –I

L-T-P
3-0-0

Objectives:
To enable the students, understand the preparation properties and applications of different classes of polymers.

UNIT-I:
Polymers, Definition and Classification of Plastics – General properties, Thermoplastics, Thermosetting, Engineering &High-performance plastics. Structure of Plastics: Molecules – Crystallinity – Effect of Crystallinity on properties – crosslinked plastics – Determination of Molecular weight – Effect of Molecular weight on processing and properties– Molecular weight distribution. Linear, Branched and cross linked structures in polymers. Glass transition temperature (Tg).

UNIT-II:
Introduction- Sources and manufacture of raw materials- basic chemistry- Methods of manufacture-Flow behavior- General properties and applications of Olefin Polymer and Co-polymers Vinyl chloride polymers and co-polymers.

UNIT-III:
Introduction – Sources and manufacture of raw materials –basic chemistry – Methods of manufacture–Flow behavior – General properties and applications of Styrene and Styrene co-polymers PMMA.Cellulose polymers.

UNIT-IV:
Introduction- Sources and manufacture of raw materials- basic chemistry- Methods of manufacture-Flow behavior- General properties and applications of Epoxy Plastics, Polyurethane (PU), Silicones.

UNIT-V:
Bio degradable and Bio Plastics, Principle and Mechanism of Plastics degradation, Natural Bio-degradable Polymers – Synthetic Biodegradable Polymers – Water soluble Polymers. Bio plastics types, properties and applications.

Course outcomes:
Upon completion of the course, the students will have the knowledge of manufacturing, properties and applications of variety of plastics.

Books and References:

1. Brydson, J.A “Plastics Material”.
2. Schwartz & good man “Plastics materials and processing”.
3. Irwin rubin “Hand book of Plastic Materials and Technology.

PLASTICS PROCESSING-I

L-T-P
3-1-0

Objectives:
To impart knowledge of plastics processing to the students.

UNIT-I:
Introduction to polymer processing – Plastics processing techniques.General description of extrusion processes, type of extruders, screw and their output in terms ofdrag, leakage and pressure flow, influence of screw dimensions and output, die and screwcharacteristics. Design of barrel and screw for commodity, heat sensitive and engineeringpolymers.Barrier Screws.

UNIT-II:
Individual extrusion systems, Dies, Sizing and Downstream equipments, Faults, Causes and Remedies for film, pipe, lamination, profiles, cables, sheet, Box Strapping.

UNIT-III:
Twin-screw extrusion and Co Extrusion systems. Casting of films. Multi layer systems for Films and Pipe. Faults, causes & remedies.

UNIT-IV:
General description of Compression and Transfer moulding and its application in processing of thermosetting materials.Faults, Causes & Remedies.

UNIT-V:
Calendaring and Milling: Introduction, calendar roll, calendar configuration and operations. Recycling of plastics.

Course Outcomes:
Upon completion student will have the knowledge of extrusion process, calendaring, compression and transfer molding.

Books and References
1. Berins, “Plastics engineering hand book” - society of the Plastics industry.
2. Allen, WS &baker,pn “Hand book of Plastics technology.
3. Chris Rauwendaal, “Polymer Extrusion” Hanser Publication.
4. Lyesew, A.I “Compression molding”.
5. BOBB “COMPRESSION & TRANSFER THEORY & TNCHNOLOGY”.
6. Harper “Handbook of Plastic Processes” Wiley Interscience.
7. R J Crawford “Plastics Engineering” Butterworths.

POLYMERIZATION ENGINEERING

L-T-P
3-1-0

Objectives:
To impart knowledge of all polymerization techniques.

UNIT-I:
Industrial methods of polymerization such as bulk, solution, suspension, emulsion. Layoutand arrangement of polymer plant. Types of polymer production processes and reactors.Safety and plant automation.

UNIT-II:
Concept of stereo-chemistry of polymers, stereo-specific polymerization. Catalyst – theirutility in polymer manufacture, Zeigler Natta, Metallocene and other catalyst systems.

UNIT-III:
Copolymerization - Mechanism and Kinetics of free radical - Ionic copolymerization - Determination of Monomer reactivity ratios. Polymerization techniques - Bulk polymerization - Solution polymerization - Suspension polymerization - Emulsion polymerization - Interfacial condensation.

UNIT-IV:
Manufacturing details, properties and applications of various thermosetting resins such asphenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde and preparation ofmolding powders.

UNIT-V:
Production technology, properties and application of Polystyrene, Polyvinylchloride, andtheir copolymer grades.

Course Outcomes:
Upon completion student will have the knowledge of Polymerization techniques.

Books and References:
1. J. A. Brydson, " Polymer Materials ", Butterworth-Heinemann, 1990.
2. Mark &Overberger, " Encyclopedia of Polymer Science & Tech. " Wiley-Interscience, 1986.
3. J. Scheries& W. Kaminsky, " Metallocene based Polymers ", Wiley, 2000.
4. Vasant R. Gowariker, "Polymer Science ", New Age International, 1986.
5. Christopher C. Ibeh, " Thermoplastic Materials: Properties, Manufacturing Methods, and Applications ", Taylor and Francis Group, 2011.

SYNTHESIS AND POLYMERIZATION LAB

L-T-P
0-0-2

Objectives:
The student will have an understanding of the polymer synthesis by different techniques.

Minimum eight experiments out of the following:
1. Synthesis of a polymer by Bulk polymerization Techniques
2. Synthesis of a polymer by solution polymerization Techniques
3. Synthesis of a polymer by suspension polymerization Techniques
4. Synthesis of a polymer by emulsion polymerization Techniques
5. Determination of molecular weight by viscosity.
6. Preparation of phenol formaldehyde resin
7. Preparation of urea. formaldehyde resin
8. Preparation of unsaturated polyester resin
9. Determination of acid value in unsaturated polyester resin
10. Preparation of saturated polyester resin
11. Determination of acid value in saturated polyester resin
12. Synthesis of a copolymer based on any common monomers like styrene, acrylates, maleic anhydride, acrylic acid and methacrylic acid
13. Modification of epoxy resin modification of any natural polymer such as cellulose, rosin, naturalrubber, etc.
14. Depolymerization of waste thermoplastics such as polystyrene or polymethylmethacrylate.

Course Outcomes:
Upon completion student will have the knowledge of Polymerization & Synthesis techniques.

PLASTICS PROCESSING - I LAB

L-T-P
0-0-2

Objectives:
The student will have an understanding of the polymer processing by different processing techniques.

1. Extrusion Process – Free sketch of Machine, Study of Parts & their function. Practice on Die setting, Cycle time analysis, Start up and shut down Procedure.
2. Twin screw extrusion process, Study of Parts & their function. Practice on Die setting, Cycle time analysis, Start up and shut down Procedure.
3. Compression Moulding or Transfer Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
4. Blow moulding Process – Free sketch of Machine, Study of Parts & their function, Parison die. Practice on Die centering, Cycle time analysis, Start up and shut down Procedure.
5. Thermoforming (Vacuum forming) Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
6. Rotational Moulding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
7. Plastics coating Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
8. Plastics Sealing Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
9. Plastics welding Process – Free sketch of Machine, Study of Parts & their function. Cycle time analysis, Start up and shut down Procedure.
10. Calendaring process.
11. Two –roll mill process.

INDUSTRIAL VISIT

The student will have to visit the plastic processing and testing industries and record their observations in the same semester. The students will be evaluated on the basis of viva and technical report.