UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY : : CHENNAI 600 025

REGULATIONS - 2015

CHOICE BASED CREDIT SYSTEM

M.E. MANUFACTURING ENGINEERING

(Specialization with Green Manufacturing) (Part Time)

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

1. The graduates acquire ability to create environmental oriented models, design and analyze essential production operational skills, mechanism and automation system.
2. The graduates use their talent, self-confidence, knowledge and engineering practice which facilitate them to presume position of scientific and/or managerial leadership in their career paths towards green manufacturing.
3. The graduates apply their consciousness of moral, professional responsibilities and motivation to practice life-long learning in a team work environment.

PROGRAMME OUTCOMES (PO)

a. Graduate will demonstrate strong basics in mathematics, science and engineering which serve as the foundation for the Programme.

b. Graduate will demonstrate the ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.

c. Graduate will become familiar with modern engineering tools and analyze the problems within the domains of Green Manufacturing as the members of multidisciplinary teams.

d. Graduate will acquire the capability to identify, formulate and solve engineering problems related to production engineering.

e. Graduate will demonstrate an understanding of professional and ethical responsibility with reference to their career in the field of production engineering.

f. Graduate will be able to communicate effectively both in verbal and non verbal forms.

g. Graduate will be trained towards developing and understanding the impact of environmental oriented components on global, economic, and societal context.

h. Graduate will be capable of understanding the value for life-long learning.

i. Graduate will demonstrate knowledge of contemporary issues pertaining to the health and well being of desirable living forms inhabiting the environment.

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j. Graduate will demonstrate the ability to use the techniques, skills and modern engineering tools necessary for engineering practice in the field of Production Engineering.

k. Graduate will be able to design and develop innovative/ manufacturable / marketable / environmental friendly products useful to the nation and the society.

l. Graduate will be able to manage any organization well and will be able to emerge as a successful entrepreneur.

Mapping of PEOs with POs

Programme Educational Objectives	Programme Outcomes											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12
I	√	√	√					√		√		
II				√	√		√	√			√	√
III			√		√	√	√	√	√			

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR 1	SEM 1	Green Manufacturing Design	√	√					√	√		√	√	√
		Green Manufacturing Practices	√	√	√	√			√			√	√	
	SEM 2	Statistical Techniques for Green Manufacturing	√		√	√						√		
		Environment Sustainability and Impact Assessment	√	√	√	√			√			√	√	
YEAR 2	SEM 3	Quantitative Techniques for Green Manufacturing	√		√	√	√		√		√	√	√	
		Green Supply Chain Management	√		√	√	√		√		√	√	√	
		Lean Manufacturing System and Applications	√	√	√	√			√			√	√	
		Case Studies in Green Manufacturing Practice	√		√	√		√	√	√		√	√	√
	SEM 4	Green Manufacturing Management	√		√	√	√		√		√	√	√	
		Optimization Techniques for Green Manufacturing	√		√	√	√		√		√	√	√	
		Computer Aided Modelling and Simulation Lab	√		√	√		√	√			√	√	√
YEAR 3	SEM 5	Project Phase – I	√	√	√	√	√	√	√	√	√	√	√	√
	SEM 6	Project Phase – II	√	√	√	√	√	√	√	√	√	√	√	√

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UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M.E. MANUFACTURING ENGINEERING (SPECIALIZATION WITH GREEN MANUFACTURING) (Part Time)

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	GR7101	Green Manufacturing Design	PC	3	3	0	0	3
2.	GR7102	Green Manufacturing Practices	PC	3	3	0	0	3
3.		Elective I	PE	3	3	0	0	3
			TOTAL	**9**	**9**	**0**	**0**	**9**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	GR7201	Environment Sustainability and Impact Assesment	PC	3	3	0	0	3
2.	GR7202	Statistical Techniques for Green Manufacturing	FC	3	3	0	0	3
3.		Elective II	PE	3	3	0	0	3
			TOTAL	**9**	**9**	**0**	**0**	**9**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	GR7301	Green Supply Chain Management	PC	3	3	0	0	3
2.	GR7302	Lean Manufacturing System and Application	PC	3	3	0	0	3
3.	GR7303	Quantitative Techniques for Green Manufacturing	FC	3	3	0	0	3
PRACTICALS								
4.	GR7311	Case Studies in Green Manufacturing Practice	PC	4	0	0	4	2
			TOTAL	**13**	**9**	**0**	**4**	**11**

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SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	GR7401	Green Manufacturing Management	PC	3	3	0	0	3
2.	GR7402	Optimization Techniques for Green Manufacturing	FC	3	3	0	0	3
3.		Elective III	PE	3	3	0	0	3
PRACTICAL								
4.	GR7411	Computer Aided Modelling Simulation Lab	PC	4	0	0	4	2
			TOTAL	**13**	**9**	**0**	**4**	**11**

SEMESTER V

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective IV	PE	3	3	0	0	3
2.		Elective V	PE	3	3	0	0	3
3.		Elective VI	PE	3	3	0	0	3
PRACTICAL								
4.	GR7511	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER VI

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	GR7611	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 67

FOUNDATION COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	GR	Statistical Techniques for Green Manufacturing	FC	3	3	0	0	3
2.	GR	Quantitative Techniques for Green Manufacturing	FC	3	3	0	0	3
3.	GR	Optimization Techniques for Green Manufacturing	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	GR	Green Manufacturing Design	PC	3	3	0	0	3
2.	GR	Green Manufacturing Practices	PC	3	3	0	0	3
3.	GR	Environment Sustainability and Impact Assesment	PC	3	3	0	0	3
4.	GR	Green Supply Chain Management	PC	3	3	0	0	3
5.	GR	Lean Manufacturing System and Applications	PC	3	3	0	0	3
6.	GR	Green Manufacturing Management	PC	3	3	0	0	3
7.	GR	Modeling Simulation Lab	PC	4	0	0	4	2
8.	GR	Case Studies in Green Manufacturing Practice	PC	3	0	0	3	2

PROFESSIONAL ELECTIVES (PE)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CI7251	Additive Manufacturing	PE	3	3	0	0	3
2.	GR7001	Design for Environment	PE	3	3	0	0	3
3.	GR7002	Energy Management	PE	3	3	0	0	3
4.	GR7003	Energy Saving Machinery and Components	PE	3	3	0	0	3
5.	GR7004	Green Building	PE	3	3	0	0	3
6.	GR7005	Green Chemistry	PE	3	3	0	0	3

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7.	GR7006	Green Electronics Manufacturing	PE	3	3	0	0	3
8.	GR7007	Green Energy System	PE	3	3	0	0	3
9.	GR7008	Hazardous Managment	PE	3	3	0	0	3
10.	GR7009	Legal Aspects of Environmental Engineering	PE	3	3	0	0	3
11.	GR7010	Quality Mangement in Green Manufacturing	PE	3	3	0	0	3
12.	GR7011	Recyclic Packaging Systems	PE	3	3	0	0	3
13.	GR7012	Safety Engineering	PE	3	3	0	0	3
14.	GR7013	Solid Waste Management	PE	3	3	0	0	3
15.	GR7014	Sustainability Practice	PE	3	3	0	0	3
16.	GR7015	Sustainable Manufacturing Systems	PE	3	3	0	0	3
17.	GR7016	Waste Stream Mapping	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	GR	Project Phase I	EEC	12	0	0	12	6
2.	GR	Project Phase II	EEC	24	0	0	24	12

GR 7101 GREEN MANUFACTURING DESIGN L T P C
3 0 0 3

OBJECTIVE:

- To introduce the concept of Green Manufacturing Design to the students

UNIT I INTRODUCTION 9

Environmental effects of design – Environmental damage – In efficient energy use – Design for recycling.

UNIT II ENVIRONMENTAL LIFE CYCLE ASSESSMENT 9

Material flow and cycles – Material recycling – Emissionless manufacturing.

UNIT III GREEN DESIGN METHODS 9

Mass balance analysis – Green indicate – Design for disassembly design for recycle – Rist analysis – Material selection.

UNIT IV DESIGN FOR ENVIRONMENT 9

Eco design – Industrial Ecology – Pollution prevention – Reduction of toxic emission.

UNIT V SUSTAINABLE ECONOMIC ENVIRONMENT 9

Solar energy devices – wind energy resources – Full cost accounting methodology – Selection of natural friendly materials.

TOTAL: 45 PERIODS

OUTCOMES:

- Students will understand the concepts of Green Manufacturing Design
- It will impart green design methods and to assess the life cycle of the product

REFERENCES:

1. Cairn and Francis – Costing the earth – Harvard Business School Press - 2009
2. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
3. World commission on Environment and Development (WCED), Our Common Future, Oxford University Press 2005.

GR7102 GREEN MANUFACTURING PRACTICES L T P C
3 0 0 3

OBJECTIVE:

- To introduce the concept of Green Manufacturing to the students

UNIT I AIR POLLUTION SAMPLING AND MEASUREMENT 4

Primary and Secondary Pollutants, Automobile Pollutants, Industrial Pollution, Ambient air quality Standards, Metrological aspects of air Pollution, Temperature lapse Rates and Stability-wind velocity and turbulence-Pump behavior dispersion of air Pollutants-solution to the atmosphere dispersion equation-the Gaussian Plume Model, Air pollution sampling-collection of gaseous air pollutants-collection of particulate pollutants-stock sampling, analysis of air pollutants-sulfur dioxide-nitrogen dixide, carbon monoxide, oxidants and ozone.

UNIT II NOISE POLLUTION & CONTROL 10

Frequency and Sound Levels, Units of Noise based power radio, contours of Loudness. Effect of human, Environment and properties, Natural and Anthrogenic Noise Sources, Measuring Instruments for frequency and Noise levels, Masking of sound, Types, Kinetics, Selection of different reactors used for waste treatment, Treatment of noise at source, Path and Reception, Sources of noise, Effects of noise-Occupational Health hazards, thermal Comforts, Heat Island Effects, Radiation Effects.

UNIT III WATER DEMAND, WATER QUALITY 10

Factors affecting consumption, Variation, Contaminants in water, Nitrates, Fluorides, Detergents, taste and odour, Radio activity in water, Criteria, for different impurities in water for portable and non portable use, Point and non-point Source of pollution, Major pollutants of Water, Water Quality Requirement for different uses, Global water crisis issues.

UNIT IV FIRE SAFETY 10

Basic Elements, Causes, Industrial Fires, Explosions, Effects on Environmental, Property & Human Loss, Prevention technique, Building Design, Fire Protection System, contingency plan, Emergency preparedness, Evacuation.

UNIT V SAFETY RADIATION PROTECTION 9

Radiation fundamentals-Types of radiation lonizing and Non-lonizing radiation, their uses and biological effects. Radioactive waste disposal radioactive soil, water and air and their fate. Treatment and disposal Liquid and solid Radioactive wastes.

TOTAL: 45 PERIODS

OUTCOMES:

- It will create the awareness of air and noise pollution and methods of measurements and control
- It will impart the knowledge of fire safety and its protection

TEXT BOOKS:

1. Dornfield David, Green Manufacturing, Springer, 2012
2. Davim.J.Pauls, Green Manufacturing Processes and Systems, Springer, 2013

REFERENCES:

1. Cairncrss and Francis – Costing the earth – Harvard Business School Press – 2009
2. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
3. World Commission on Environment and Development (WCED), Our Common Future, Oxford University Press 2005.

GR 7201 ENVIRONMENT SUSTAINABILITY AND IMPACT ASSESSMENT L T P C

3 0 0 3

OBJECTIVE:

- To introduce the concepts of Environmental Sustainability & Impact Assessment to the students

UNIT I ENVIRONMENTAL ASSESMENT - AN OVERVIEW 9

Environmental impact assessment objectives – Legislative development – European community directive – Hungarian directive.

UNIT II ENVIRONMENTAL DECISION MAKING 9

Strategic environmental assessment and sustainability appraisal – Socio economic impact assessment.

UNIT III ENVIRONMENTAL POLICY, PLANNING AND LEGISLATION 9

Regional spatial planning and policy – Cumulative effects assessment – Planning for climate change, uncertainty and risk.

UNIT IV TECHNICAL STUDIES AND METHODS 9

Casual network analysis – GIS and Expert systems in EIA.

UNIT V SUSTAINABLE URBAN ECONOMIC DEVELOPMENT 9

Spatial economics – Knowledge economy and urban regions.

TOTAL: 45 PERIODS

OUTCOMES:

- It will introduce the concepts of Environment Sustainability, Environmental decision making
- It will impart the basics of environmental policy, planning and various legislation

REFERENCES:

1. Clive George, C. Collin, H. Kirkpolarice – Impact Assessment and sustainable development – Edward Elgar Publishing (2007)
2. Robert B Gibsan, Sustainability Assessment, Earth Scan publishers (2005)
3. Simon Dresner, The principle of sustainability – Earth Scan publishers (2008)

GR 7202 STATISTICAL TECHNIQUES FOR GREEN MANUFACTURING L T P C
3 0 0 3

OBJECTIVE:

- To train the students so that students will be able to design experimental designs and use these concepts for research design

UNIT I PROBABILITY THEORY 14

Random variables – "probability density mass and distribution functions" – moment generating and characteristic functions – Binomial, Poisson, Normal distributions and their applications.

UNIT II SAMPLING THEORY 9

Sampling distributions – Standard error – t, F, Chi square distributions – application.

UNIT III ESTIMATION THEORY 5

Interval estimation for population mean, standard deviation, difference in means, ratio of standard deviations – point estimation.

UNIT IV TESTING OF HYPOTHESIS 12

Hypothesis testing – Small samples – Tests concerning proportion, means, standard deviations – Tests based on chi square.

UNIT V ANOVA 5

One, two factor models – Design of experiments

TOTAL: 45 PERIODS

OUTCOMES:

- It will train the students to understand the concepts of design of experiments
- It will deliver the knowledge of application of experiments towards research

TEXT BOOKS:

1. Levin and Rubin, Statistics for Management, Prentice Hall of India, 2001

REFERENCES:

1. Hooda, Statistics for Business and Economics, Macmillan India, 2001
2. John.E.Freunds, "Mathematical statistics with applications", Pierson Educations, 2004
3. Gupta and Kapoor, Fundamentals of Mathematical Statistics, Sultanchand, 2002.

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GR 7301 GREEN SUPPLY CHAIN MANAGEMENT L T P C
3 0 0 3

OBJECTIVE:

- To introduce the concepts of Green supply chain Management to the students.

UNIT I NEED FOR GREEN SUPPLY CHAIN MANAGEMENT (GSCM) 9

Green supply Chains – Need for Green Supply Chains – Implications of modern supply chain management – The supply chain strategy – Ingredients of green supply chain strategy.

UNIT II MEASURING AND MONITORING GREEN SUPPLY CHAINS 9

Evaluating the impact of GSCM activities on sustainability – Economic, Environmental and social impacts of GSCM Stages of GSCM - performance measurement.

UNIT III MANAGING GREEN SUPPLY CHAIN MANAGEMENT 9

Managing supply chain processes – Analysing and monitoring systematically – Green Supply Chain Segmentation – Estimating product life cycle – Designing GSCM – Ecological standards.

UNIT IV SUPPLY NETWORK REDESIGNING 9

Problem description – Challenges – Success factors – Transferability – Transportation issues in GSCM – Increasing transportation efficiency – Retail GSCM – Optimisation of goods collection.

UNIT V LOGISTICS AND GSCM 9

Railway transport – Challenges and issues – Transport market place – Transport exchange – GSCM enablers – Intermodel terminals – Cargo securing.

TOTAL: 45 PERIODS

OUTCOMES:

- It will provide the participants with a good knowledge on logistics and supply chain management
- It will teach how these topics can be related with the organization and their business needs.

TEXT BOOKS:

1. 'Sustainable Supply Chain Management' Balkan Cetinkaya and Richard Cuthbertson (2^{nd}) – Springer 2011

REFERENCES:

1. Hsiao-fan wang and Surendra M.Gupta Green supply management Product life cycle approach McGraw Hill, 2011.

GR 7302 LEAN MANUFACTURING SYSTEM AND APPLICATIONS L T P C
3 0 0 3

OBJECTIVES:

- To study the various tools for lean manufacturing (LM).
- To apply the above tools to implement LM system in an organization.

UNIT I INTRODUCTION TO LEAN MANUFACTURING 7

Conventional Manufacturing versus Lean Manufacturing – Principles of Lean Manufacturing – Basic elements of lean manufacturing – Introduction to LM Tools.

UNIT II CELLULAR MANUFACTURING, JIT, TPM 9

Cellular Manufacturing – Types of Layout, Principles of Cell layout, Implementation. JIT – Principles of JIT and Implementation of Kanban. TPM – Pillars of TPM, Principles and implementation of TPM.

UNIT III SET UP TIME REDUCTION, TQM, 5S, VSM 10

Set up time reduction – Definition, philosophies and reduction approaches. TQM – Principles and implementation. 5S Principles and implementation - Value stream mapping - Procedure and principles.

UNIT IV SIX SIGMA 9

Six Sigma – Definition, statistical considerations, variability reduction, design of experiments – Six Sigma implementation

UNIT V CASE STUDIES 10

Various case studies of implementation of lean manufacturing at industries.

TOTAL: 45 PERIODS

OUTCOMES:

- It will impart the knowledge of cellular manufacturing, JIT and TPM
- It will teach how to reduce the manufacturing time by applying concepts of TQM, 5S and VSM

REFERENCES:

1. Design and Analysis of Lean Production Systems, Ronald G. Askin & Jeffrey B. Goldberg, John Wiley & Sons, 2003
2. Mikell P. Groover (2002) 'Automation, Production Systems and CIM.
3. Rother M. and Shook J, 1999 'Learning to See: Value Stream Mapping to Add Value and Eliminate Muda' , Lean Enterprise Institute, Brookline, MA.

GR 7303 QUANTITATIVE TECHNIQUES FOR GREEN MANUFACTURING L T P C

3 0 0 3

OBJECTIVE:

- To introduce the concepts of operations research to students so that these concepts, can be used in Green Manufacturing

UNIT I LINEAR PROGRAMMING 10

Graphical method – Simplex method – Maximization problems – Minimization problems Big M method– Duality in linear programming.

UNIT II TRANSPORTATION AND ASSIGNMENT METHODS 11

Transportation problem-Methods for finding initial feasible solution – Test for optimality – Maximization problem – Unbalanced problems – Assignment problems – Maximization problems – Maximization problems – Unbalanced problems.

UNIT III THEORY OF GAMES 9

Two person zero sum game – Pure strategies – Mixed strategies – Saddle point – Principle of dominance - Max-min and minimax principles - Algebraic method - Graphical method.

UNIT IV QUEUING THEORY AND SIMULATION 9

Poisson arrival – Poisson service – Single server queuing models – Multi server queuing models – Simulation – Montecarlo simulation – Random numbers.

UNIT V REPLACEMENT PROBLEMS 7

Replacement of equipment with increase of running cost with time – time value of money – Individual replacement policy – Group replacement policy - staffing problems.

TOTAL: 45 PERIODS

OUTCOMES

- The students will be able to study a given problem, formulate and model it suitably

- The student will select an appropriate optimization technique, solve, find and implement the optimal solution

TEXT BOOKS:

1. R. Panneerselvam, Operation Research, Prentice Hall of India, 2002

REFERENCES:

1. P.K.Guptha and Manmohan, Problems in Operations Research-Sultan chand & Sons, 1994
2. Ravindran, Philips and Solberg, Operations Research Principles and Practice, John Wiley & Sons, Singapore, 1992
3. J.K. Sharma, Operations Research – Theory and Applications – Macmillan India Ltd., 1997
4. Hamdy A.Taha, Operations Research – An Introduction, Prentice Hall of India, 1997

GR 7311 CASE STUDIES IN GREEN MANUFACTURING PRACTICE L T P C
0 0 4 2

OBJECTIVES:

To introduce the various live case studies from industries on Green Manufacturing to the students

OUTCOME:

The students will be able to analyze in a systematic way the various case studies and offer solutions to problems related to Green Manufacturing.

Each student will identify a case study from industries related to Green Manufacturing practices and the case study will be presented by students with solutions to the other students.

Evaluation will be done by a panel of faculty members identified for this purpose.

TOTAL: 60 PERIODS

GR 7401 GREEN MANUFACTURING MANAGEMENT L T P C
3 0 0 3

OBJECTIVES:

- The students will be able to use these techniques while managing the manufacturing activity operations.

UNIT I FORE CASTING 7

Purpose of fore casting – Forecasting methods – Opinion and judgemental method – Time series methods – Regression and correlation methods – Exponential smoothing.

UNIT II SCHEDULING AND SEQUENCING 9

Scheduling – Single criterion rules – Critical ratio – Sequencing – Two machine problems – Johnson's algorithm – Three machine machines - Machine problems – Graphical method.

UNIT III INVENTORY CONTROL 10

Purpose or inventory – Basic EOQ model - Quantity discounts – P system – Q system – ABC analysis– MRP – Manufacturing batch size model – Multi item EOQ models with constraints – Aggregate planning.

UNIT IV PROJECT MANAGEMENT 9

Project Network analysis – Critical path method (CPM) – Programme Evaluation and Review

Technique (PERT) – Project Crashing.

UNIT V PLANT ENGINEERING AND WORK STUDY 10

Plant location – Plant layout – Materials handling – Method study – steps in Method study – Work measurement – Time study – Work sampling.

TOTAL: 45 PERIODS

OUTCOMES:

- To implement the knowledge of forecasting, scheduling and sequencing the manufacturing product and processes
- It will develop the knowledge of inventory control, programme evaluation and plant engineering

TEXT BOOK:

1. Dr.R. Kesavan.C. Elanchezian and T.Sundar Selwyn, Engineering Management, Eswar Press, Chennai – 2005.
2. R. Paneerselvam, Production and Operations Management, Prentice Hall of India, 2002.

REFERENCE:

1. Dr.R. Kesavan, C.Elanchezian and B.Vijayaramnath, Production Planning and Control, Anuratha Publications, Chennai – 2008.
2. Martand T. Telsang, Production Management, S.Chand & Co., 2005.
3. Thomas E.Mortan, Production and Operations Management, Vikas Publications, 2003.

GR 7402 OPTIMIZATION TECHNIQUES FOR GREEN MANUFACTURING L T P C
3 0 0 3

OBJECTIVES:

- To make use of the above techniques while modeling and solving the engineering problems of different fields.

UNIT I INTRODUCTION 5

Optimization – Historical Development – Engineering applications of optimization – Statement of an Optimization problem – classification of optimization problems.

UNIT II CLASSIC OPTIMIZATION TECHNIQUES 10

Linear programming - Graphical method – simplex method – dual simplex method – revised simplex method – duality in LP – Parametric Linear programming – Goal Programming.

UNIT III NON-LINEAR PROGRAMMING 9

Introduction – Lagrangeon Method – Kuhn-Tucker conditions – Quadratic programming – Separable programming – Stochastic programming – Geometric programming

UNIT IV INTEGER AND DYNAMIC PROGRAMMING AND NETWORK TECHNIQUES 12

Integer programming - Cutting plane algorithm, Branch and bound technique, Zero-one implicit enumeration – Dynamic Programming – Formulation, Various applications using Dynamic Programming. Network Techniques – Shortest Path Model – Minimum Spanning Tree Problem – Maximal flow problem.

UNIT V ADVANCES IN SIMULATION 9

Genetic algorithms – simulated annealing – Neural Network and Fuzzy systems

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to study a given problem, formulate and model it suitably
- The student will select an appropriate optimization technique, solve, find and implement the optimal solution.

REFERENCES:

1. R. Panneerselvam, "Operations Research", Prentice Hall of India Private Limited, New Delhi – 2005
2. J.K.Sharma, Operations Research – Theory and Applications – Macmillan India Ltd., 1997
3. Hamdy A. Taha, Operations Research – An Introduction, Prentice Hall of India, 1997
4. P.K. Guptha and Man-Mohan, Problems in Operations Research – Sultan chand & Sons, 1994
5. Ravindran, Philips and Solberg, Operations Research Principles and Practice, John Wiley & Sons, Singapore, 1992

GR 7411 COMPUTER AIDED MODELLING AND SIMULATION LAB L T P C
0 0 4 2

OBJECTIVES:

- To train the students to make use of software for modeling and simulation various applications in the field of green manufacturing engineering.

MODELING LAB EXPERIMENTS

1. 2D drafting of automobile components like engine crank shaft, connecting rod etc.
2. 2D drafting of pin joints, cotter joints and bearings.
3. Study of 3D Modelling software.
4. 3D modelling and Assembly of automobile components, Joints, Bearing, Couplings etc.

SIMULATION LAB EXPERIMENTS

1. One Dimensional FEA Problem.
   a. Truss structure analysis.
   b. Cantilever beam analysis.
   c. Temperature distribution problem.
2. Two Dimensional FEA Problems.
   a. Plane stress analysis.
   b. Axisymmetric analysis.
   c. Vibration Analysis.
3. Three Dimensional FEA Problem.
   a. 3D Shell Analysis.
   b. 3D Contact Analysis.
4. FEA Application in metal forming, Metal cutting, Casting process etc.
5. Preparation of Process Planning Sheet.
6. Simulation of simple mechanism using solid modeling software.
7. Routing & flow process chart.

TOTAL: 60 PERIODS

GR7511 **PROJECT WORK PHASE I** **L T P C**
0 0 12 6

OBJECTIVES

- A project topic may be selected based on the literature survey and the creative ideas of the students themselves in consultation with their project supervisor.
- The topic should be so chosen that it will improve and develop the skills to design, fabricate, analyse, test and research. Literature survey and a part of the project work be carried out in phase I.
- The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.
- A project report for phase I is to be submitted at the end.

EVALUATION

- Project work evaluation is based on the Regulations of the Credit system for the Post graduate programmes of Anna University

TOTAL : 90 PERIODS

OUTCOME

The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

GR7611 **PROJECT WORK PHASE II** **L T P C**
0 0 24 12

OBJECTIVES

- To continue the work from phase I and complete the project work in order to meet the stated objectives of the topic chosen.
- The progress of the project is evaluated based on a minimum of three reviews.
- The review committee may be constituted by the Head of the Department.
- A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Division based on oral presentation and the project report
- To improve the research and development activities of the students.

EVALUATION

- Project work evaluation is based on the Regulations of the Credit system for Post graduate programmes of Anna University

TOTAL = 180 PERIODS

OUTCOME

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

CI7251 **ADDITIVE MANUFACTURING** **L T P C**
3 0 0 3

OBJECTIVE:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications.

UNIT I INTRODUCTION: 8

Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits-Applications.

UNIT II REVERSE ENGINEERING AND CAD MODELING: 10

Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies.

UNIT III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS 10

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

UNIT IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS: 10

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

UNIT V OTHER ADDITIVE MANUFACTURING SYSTEMS: 7

Three dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.

TOTAL: 45 PERIODS

OUTCOME:

- On completion of this course, they will learn about a variety of Additive Manufacturing (AM) technologies, their potential to support design and manufacturing, case studies relevant to mass customized manufacturing, and some of the important research challenges associated with AM and its data processing tools

REFERENCES:

1. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.
2. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, second edition, World Scientific Publishers, 2010.
3. Gebhardt, A., “Rapid prototyping”, Hanser Gardener Publications, 2003.
4. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications : A tool box for prototype development”, CRC Press, 2011.
5. Kamrani, A.K. and Nasr, E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.
6. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

GR 7001 **DESIGN FOR ENVIRONMENT** **L T P C**
3 0 0 3

OBJECTIVES:

- To make the students to understand the importance of Design for Environment with respect to existing and future world.
- To make the students to understand the life cycle, concurrent and information obtained from nature.
- To understand the guidelines and rules for various forms of design
- To make the students to realize the decision making with respect to Environmental design
- To understand the applications and implementation of Design & Environment

UNIT I THE GREEN MOVEMENT **10**

Motivation force – Rediscovery of Ancient values – The global sustainability Agenda – The response of industry. External drivers: The voice of society – Green Expectation – Confronting climate change – Government initiatives: Stick and Carrot – Environmental Management System Standards – Sustainable Rating Schemes – Voluntary codes and principles – Business value drives.

UNIT II THE ART AND SCIENCE OF DESIGN FOR ENVIRONMENT **10**

Management environmental Innovation – The rise of green market – Integrated produce development – organizing for environmental Excellence – Practising concurrent engineering – Understanding product life cycle – Principles of design for environment – Lice cycle thinking – System perspective – Indicators and Metrics – Design strategies – Analysis method – Information technology – Learning from Nature – From principle to practices.

UNIT III DESIGN RULES AND GUIDELINES **10**

Design for Dematerialization – Design for Energy and material conservation – Design for source reduction – Design for servicization – Design for Detoxification – Design for release reduction – Design for hazard reduction – Design for Benign waste disposition.

UNIT IV ANALYSIS METHODS FOR DESIGN DECISIONS **8**

Tangible Evaluation – Quatitative Assessment – Environmental analysis – Foot print indicators, life cycle assessment, piedictive simulation – Risk Analysis – Financial analysis – Examples for DFE decisions – The challenges of Decision making – Product life cycle Management – Case study. Example Caterpiller: New Engines from OLD - 3M responsible innovation – Towards sustainable supply chain management.

UNIT V THE REAL WORLD PRACTISE OF DESIGN FOR ENVIRONMENT **7**

Electronic Equipment industries – Xerox coporation: reducting the footprint, Hewlett Packard: A green gaint – Sony Electronics: Innovation in design

Transportation Industry – Sustainable Mobility research – DFE in the transportation life cycle – General motors': Products and process Innovation – Toyota: the future of propulsion – Dupont: Eco efficient Automotive paint.

Chemical industries – Green and sustainable chemistry – Dow chemical : Raising the Bar – Dupont: Realizing sustainable growth – BASF: Beyond Eco-efficiency.

Medical and Pharmaceutical Industries – Johnson & Johnson: A matter of principle – Baxter – Saving and sustaining lives.

Consumer products industries – Kimberly Clark: Getting serious about DFE – Procter and Gamble: Ensuing a better quality.

TOTAL: 45 PERIODS

OUTCOMES:

- It will impart the knowledge of decision making with respect to environmental design

TEXT BOOKS:

1. Joseph Fiksel, "Design for Environment – A guide to sustainable Product Development", second edition, McGraw Hill, 2012.

REFERENCES:

1. Dorothy Mackenzie, “Green Design: Design for the Environment”, L.King, 1997.
2. Joseph Fiksel, “Design for Environment: Creating Eco-efficient products and processes, McGraw Hill, 1996.

GR 7002 ENERGY MANAGEMENT L T P C
3 0 0 3

OBJECTIVES:

- To introduce the concepts of Energy conservation and management to the students.

UNIT I ENERGY AND ENVIRONMENT 9

Introduction – Fossil fuels reserves – World energy consumption – Green house effect, Global warming – Renewable energy sources – Environmental aspects utilisation – Energy prizes – Energy policies.

UNIT II ENERGY CONSERVATION 9

Energy conservation schemes – Industrial energy use – Energy surveying and auditing – Energy index – Energy cost index – Energy conservation in engineering and process industry in thermal systems, in buildings and non-conventional energy resources schemes.

UNIT III ENERGY TECHNOLOGICES 9

Fuels and consumption – Boilers -0 Furnaces – Waste heat recovery systems – Heat pumps and refrigerators – Storage systems – Insulated pipe work systems – heat exchangers.

UNIT IV ENERGY MEASUREMENT AND MANAGEMENT 9

Energy management principles – energy resource management – Energy management information systems – Instrumentation and measurement – Computerized energy management.

UNIT V ECONOMCIS AND FINANCE 9

Costing techniques – Cost optimization – Optimal target investment schedule – Financial appraisal and profitability – Project management.

TOTAL: 45 PERIODS

OUTCOMES:

- It will develop the concepts of energy conservation and management to students

TEXT BOOKS:

1. W.R. Murphy and G.Mc KAY “Energy Management Butterworths, London 2009

REFERENCES:

1. O. Callaghn. P.W. “Design and Management for Energy Conservation”, 2004 Pergamon Press, Oxford.
2. David Merick, Richard Marshal, “Energy, present and future options, Vol, I and II”, 2009 John Wiley and Sons.
3. Chaigier N.A. “Energy Consumption and Environment”, 2007 McGraw Hill.
4. Ikken P.A. Swart R.J. and Zwerves, S, “Climate and Energy”, 2008
5. Ray D.A. “Industrial Energy Conservation”, 2004 Pergamaon Press.

GR 7003 ENERGY SAVING MACHINERY AND COMPONENTS L T P C
3 0 0 3

OBJECTIVES:

- To introduce the various energy saving machineries and components to the students for the purpose conserving energy**.**

UNIT I BASICS OF ELECTRICAL ENERGY USAGE 9

Fuel to Power : Cascade Efficiency – Electricity Billing : Components & Costs – kVA – Need & Control – Determination of kVA demand & Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction – Demand Side Management (a brief)

UNIT II TRANSFORMERS & MOTORS 9

Transformer – Basics & Types – AVR & OLTC Concepts – Selection of Transformers – Performance Prediction - Energy Efficient Transformers - Motors : Specification & Selection – Efficiency / Load Curve – Load Estimation – Assessment of Motor Efficiency under operating conditions – Factors affecting performance – ill effects of Rewinding & Oversizing - Energy Efficient Motors – ENCON Scope

UNIT III FANS / PUMPS / COMPRESSORS 11

Basics – Selection – Performance Evaluation – Cause for inefficient operation – scope for energy conservation – methods (General & Latest) adopted for effecting ENCON – Economics of ENCON adoption in all the 3 utilities

UNIT IV ILLUMINATION AND ENERGY EFFICIENCY DEVICES 8

Specification of luminaries - Types - Efficacy - Selection & Application - ENCON Avenues & Economic Proposition - New Generation Luminaries (LED / Induction Lighting) - Soft Starters / Auto Star - Delta - Star Starters / APFC / Variable Speed & Frequency Drives - Time Sensors - Occupancy Sensors

UNIT V CASE STUDIES & CO2 MITIGATION 8

Case Study Evaluation for 3 / 4 Typical Sectors – PAT Scheme (an introduction) – CO2 Mitigation & Energy Conservation & Cost Factor

TOTAL: 45 PERIODS

OUTCOMES:

- It will introduce the various energy saving machinery and components among students
- It will teach the students various methods of conserving energy

REFERENCES

1. Hamies, Energy Auditing and Conservation ; Methods Measurements, management and Case
2. Study, Hemisphere, Washington, 1980
3. Trivedi, PR and Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
4. Handbook on Energy Efficiency, TERI, New Delhi, 2001
5. Peters et al. Sustainable Energy, beta – test – draft Kraushaar and Ristenen, Energy and
6. Problems of a Technical Society, 1993
7. Guide book for National Certification Examination for Energynagers and Energy Auditors (Couldbe downloaded from www.energymanagertraining.com)

GR 7004 GREEN BUILDING L T P C
3 0 0 3

OBJECTIVES:

- To introduce the concepts of green building management.

UNIT I GREEN CONCEPTS IN BUILDINGS 9

Green Building concepts and definition – Environmental implications of buildings on water, energy, waste disposal and carbon emissions – Building materials, sources, methods of production, embodied energy, maintenance and environmental implications.

UNIT II WATER MANAGEMENT IN BULDINGS 9

Water utilisation in buildings – Management of Sullage water sewage – Methods of waste water treatment and recycling – Low energy approaches to water management.

UNIT III ENERGY MANAGEMENT IN BUILDINGS 9

Energy requirements of building – Optimising the energy utility – Low energy concepts in lighting, ventilation and transportation of men and materials in buildings – Utility of energy efficient devices for lighting, heating and cooling – Methods of utilisation solar and wind energy.

UNIT IV THERMAL MANAGEMENT OF BUILDINGS 9

Thermal comfort in Buildings – Heat transfer characteristic of Building materials and building techniques – Implications of geographical locations and seasonal variations – Incidence of solar heat on buildings – Concepts of solar passive cooling and heating – Case studies on thermal management.

UNIT V MANAGEMENT OF SOLID WASTE AND BIOMASS 9

Low energy approaches in collection, storage, transport, recycling and disposal of solid wastes – Biomass resources for buildings – Green cover and built environment – Concepts of green composites.

TOTAL: 45 PERIODS

OUTCOMES:

- It will impart the knowledge of management of water, energy, power and wastes in buildings

TEXT BOOKS:

1. Jagadish K.S., Venkatramreddy B.U. and Nanjundarao K.S., Alternative Building materials and technologies, New age International, 2007.
2. Low energy Cooling for sustainable buildings, Johy Wiley & Sons, 2009
3. Dennis C Brewer, Green My Home: 10 steps to lowering energy costs and reducing your carbon foot print, Kaplam Publishing Ltd., 2008.

REFERENCES:

1. Sustainable Building Design Manual, Vol.1 & 2, Teri, New Delhi, 2004.
2. Climate Responsive Architecture, Tata McGraw Hill, 2001
3. Jerry Yudelson, Green Building through Integrated Design, McGraw Hill, 2009.

GR 7005 GREEN CHEMISTRY L T P C
3 0 0 3

OBJECTIVES:

- The idea behind an elective is to expose the students to a green chemistry on cutting edge technology.
- To enable the students to understand key aspects and applications of green chemistry in academic and industries and in modern research and developments.
- To enable students understand the products and its interaction with the environments. To enable students understand the basic building blocks of green chemicals.
- To enable the students to understand he Green chemical reactions and manufacture green materials for a safer world.

UNIT I INTRODUCTION TO GREEN CHEMISTRY 9

The needs for green chemistry- Definition – Twelve principles of green chemistry – Synthetic chemistry – Yield and atom economy – for soap manufacturing and methane combustion – risk – reduction of risk – risk of no risks – hazard and exposure – waste prevention – combining of atom to make new molecules and compounds.

UNIT II INTERACTION OF ENVIROMENTAL SPHERES 9

Introduction to environments – five environmental spheres(atmosphere – anthrosphere – biosphere – hydrosphere – geosphere) – and their interactions - environmental pollution and its prevention – green chemistry's root in the pollution prevention act.

UNIT III BASIC BUILDING BLOCKS OF GREEN CHEMICALS 9

Elements – atoms and atomic theory – hydrogen – helium – lithium – the second period of the periodic table – the special significance of eight outer shell electrons for green chemical synthesis – the brief periodic table to stable chemicals and sustainable development.

UNIT IV GREEN CHEMICAL REACTIONS 9

Introduction – manufacturing of materials safely without damaging the environment – chemical equations – balancing – alternate reaction path ways in green chemistry – role of green catalysts – types of chemical reactions – oxidation – reduction – stoichiometry – by mole – ratio method – industrial chemical reactions(Solvay process).

UNIT V SAFER MATERIALS FOR A SAFER WORLD 9

Introduction – chemical bonds and formation of green chemical compounds – electrons involved in chemical bonds and octet of electrons – ionic bonds – problems – ionic liquids – covalent bounds in hydrogen and other molecules – predicting covalent bonds – role of covalent bonds in green chemistry – chemical formulas – mole and percentage composition.

TOTAL: 45 PERIODS

OUTCOMES:

- It will create an exposure towards understanding the key aspects and application of green chemistry towards modern research and developments

TEXTBOOK:

1. Manahan, Stanley E., Green Chemistry and The Ten Commandments of Sustainability, Chemchar Research, Inc, Columbia, Missouri, USA, 2006.
2. Anastas, Paul T, and John C. Warner, Green Chemistry Theory and Practice, Oxford University Press, 1998.

REFERENCES:

1. Manahan, Stanley E, Fundamentals of Environmental Chemistry, 2nd edition., CRC Press/ Lewis Publishers, Boca, Raton Fl, 2000.
2. Ahluwalia, V. K., Kidwai M. New trends in green chemistry, Kluwer Academic, Dordrecnt, The Netherlands, 2004.
3. Ahluwalia. V.K, Green Chemistry, Environmentally Benign Reactions, CRC Press, Boca, Raton, FL, 2008.
4. Lancaster,M , Green Chemistry An Introductory Text, Royal Society of chemistry, Cambridge, 2002.

GR 7006 GREEN ELECTRONICS MANUFACTURING L T P C
3 0 0 3

OBJECTIVES:

- This course aims to provide students with knowledge on theories, eco-design concepts, methods and relevant hands-on experience for designing a range of sustainable green

electronic products.

- It is expected that students will develop their ability to address relevant issues on environmental impact; product design, operating life on lead free electronics assembly.

UNIT I INTRODUCTION OF GREEN ELECTRONICS 6

Environmental concerns of the modern society – Overview of electronics industry and their relevant regulations in China, European Union and other key countries. Restriction of Hazardous substances (RoHs) – Waste Electrical and electronic equipment (WEEE) – Energy using Product (EUP) and Registration Evaluation, Authorization and Restriction of Chemical substances (REACH).

UNIT II GREEN ELECTRONICS MATERIALS AND PRODUCTS 10

Introduction to green electronic materials and products – Lead (Pb) – free solder pastes, conductive adhesives, halogen-free substrates and components. Substitution of non-recyclable thermosetting polymer based composites with recyclable materials X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products. Tin Whiskers Growth in Lead-Free Electronic Assemblies – Factors Influence Whisker Growth – Ways to Mitigate Tin Whisker Risk – Use Finite Element Modeling to Assess Tin Whisker Risk – Evaluation of Tin Whisker Impact on High-Reliability Applications.

UNIT III GREEN ELECTRONICS ASSEMBLY AND RECYCLING 10

Green electronic Assembly – Soldering Process – Lead-Free Solder Tip and Bumps – Mitigate Deterioration of Lead-Free Tin Solder at Low Temperatures – Fatigue Characterization of Lead-Free Solders – Thermal Fatigue of Solder Joints, Fatigue Design of Lead-Free – Electronics – Fatigue Life Prediction Based on Field Profile, Fatigue Validation of Lead-Free Circuit – Flip-Chip Technology and Assembly process – card Assembly, surface mount technology – Management on e-waste recycle system construction, global collaboration and product disassemble technology.

UNIT IV FLIP-CHIP ASSEMBLY AND BONDING FOR LEAD-FREE ELECTRONICS 10

Flip-Chip Assembly Process – Placement and Under fill stage-FEM of Die stress – Gold stud Bump Bonding – Materials and Process Variations – Integrating Flip Chip into a Standard SMT Lead-Free Reflow soldering Techniques and Analytical Methods – Electro migration Analysis for Mean-Time-to-Failure Calculations – Gold-Tin Solder Integrating Vertical-Cavity Surface Emitting Lasers onto Integrated Circuits – Design and Processing of Flip-Chip Bonding Structures – Opto-Electronic Integration.

UNIT V CASE STUDIES 9

Lead-Free Electronic Design – Selection of the Package Type – Substrate or Die Attachment FR4 – Electrical Connections from Die to FR4 – Assess Impact of CTE Mismatch on Stress and Fatigue Life – Design Solder Balls for External Connection to PCB – Thermal Analysis of Flip-Chip Packaging – RLC for Flip-Chip Packages – Drop Test of Flip-Chip Packaging – Wei bull Distribution for Life Testing and Analysis of Test Data.

TOTAL: 45 PERIODS

OUTCOMES:

- To expose the students with knowledge on theories, eco-design concepts, methods and relevant hands on experience for designing a range of sustainable green products
- It will create the awareness on environmental impact, product design, operating life of electronics assembly

TEXT BOOKS:

1. John X.Wang ‘Green Electronics Manufacturing’, CRC Press Indian Prentice Hall, 2012
2. Sammy G Shina, ‘Green Electronics Design and Manufacturing’ Mc Graw Hill 2008
3. Lee Goldberg, “Green Electronics/Green Bottom Line, Newnes Publications 2000

GR 7007 **GREEN ENERGY SYSTEM** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the concept of green energy generation systems.

UNIT I ENERGY SOURCES 9

Energy sources; coal oil, natural gas; nuclear energy; hydro electricity, other fossil fuels; geothermal; supply and demand; depletion of resources; need for conservation; uncertainties; national and international issues.

UNIT II FORCASTING TECHNIQUES 9

Forecasting techniques, energy demand, magnitude and pattern, input and output analysis, energy modeling and optimal mix of energy sources. Energy - various forms, energy storage, structural properties of environment.

UNIT III GREEN CYCLES 9

Bio-geo-chemical cycles; society and environment population and technology. Energy and evolution, growth and change, patterns of consumption in developing and advances countries, commercial generation of power requirements and benefit.

UNIT IV GREEN PROCESSES 9

Chemical industries, classification, conservation in unit operation such as separation, cooling tower, drying, conservation applied to refineries, petrochemical, fertilizers, cement, pulp and paper, food industries, chloro alkali industries, conservation using optimization techniques.

UNIT V ANALYSIS OF ENERGY RESOURCES 9

Sources of continuous power, wind and water, geothermal, tidal and solar power, MHD, fuel cells, hydrogen as fuel. Cost analysis, capacity; production rate, system rate, system cost analysis, corporate models, production analysis and production using fuel inventories, input-output analysis, economics, tariffs.

TOTAL : 45 PERIODS

OUTCOMES:

- The students will learn to identify the green energy generation systems and will be able to introduce green energy system

REFERENCES

1. Krentz, J. H., Energy Conservation and Utilisation , Allyn and Bacur Inc., 1976.
2. Gramlay, G. M., Energy , Macmillan Publishing Co., New York, 1975.
3. Rused, C. K., Elements of Energy Conservation , McGraw-Hill Book Co., 1985.
4. Loftiness, R.L. – Energy Hand Book, Van Nostrand Reinhold Company, New York, 1978.

GR 7008 **HAZARDOUS MANAGEMENT** **L T P C**
3 0 0 3

OBJECTIVES:

- To impart the knowledge on different kinds of waste and their management

UNIT I HAZARDOUS WASTES 9

Hazardous waste definition terminology and classification – Sources of hazardous wastes – Need for hazardous waste management – Handling of hazardous waste, methods of collection, storage and transport – Sampling and analysis of hazardous materials.

UNIT II CHEMICAL AND BIOMEDICAL WASTES, TOXIC MATERIALS 9

Chemical wastes – Toxic materials – Physical, Chemical, Physiological classification – Domestic and industrial sources – Health and environmental effects with specific reference to acids, alkalis, lead, cadmium, chromium, sulphur, mercury and cyonides – Treatment and disposal techniques – Physical, chemical and bilogical processes. Biomedical wastes – Definition, sources, classification – collection, segregation – Treatment and disposal.

UNIT III NUCLEAR AND RADIATION WASTES 9

Definition – Classification – Types of exposures and injuries – Tolerance dose protection from x-ray gammaray, beta ray and neutron radiations – Wastes in mining and processing of nuclear materials – wastes generated in nuclear reactors – spent dual and other wastes collection, reprocessing, storage, transport and disposal – Decommissioning of Nuclear reactors – Health and environmental issues of nuclear wastes.

UNIT IV E-WASTES 9

Definition, classification and sources of e-waste – collection, segregation, transport, storage, recycling and disposal of e-wastes – Health and environmental issues of e-wastes – problems in developing nations.

UNIT V SCIENTIFIC LAND FILL 9

Concept and definition – Site selection and approval – Acceptable wastes for landfill – Design and construction – Liners, clay, geomembrane, HDPE, geonet, geotextile – Treatment and disposal of leachate – combined and separate treatment, site remediation – Remedial techniques.

TOTAL: 45 PERIODS

OUTCOMES:

- It will impart the knowledge of a various types of waste and their significance and effects on the environment
- It will develop the skill to deal with various issues due to wastes

TEXT BOOKS:

1. Bhide A.D., Sundaresan B.B., 'Solid Waste Management – Collection Procssing and Disposal', Mudrashilpa offset printers, Nagpur, 2001.
2. Glynm Henry and Heinke Gary W., Environmental Science and Engineering, Prentice Hall of India, New Delhi, 2004.

REFERENCES:

1. Safety Manual, Edel Engineering consultancy Pvt.Ltd., Chennai, 2000.
2. Biomedical waste (Management and Handling) Rules, 1998.

GR 7009 LEGAL ASPECTS OF ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on the policies, legislations, institutional frame work and enforcement mechanisms for environmental management in India.

UNIT I INTRODUCTION 9

Indian Constitution and Environmental Protection – National Environmental policies – Precautionary Principle and Polluter Pays Principle – Concept of absolute liability – multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto agreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air (P&CP) Act – Institutional framework (SPCB/CPCB/MoEF)

UNIT II WATER (P&CP) ACT, 1974 8

Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to

prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT III AIR (P&CP) ACT, 1981 8

Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 13

Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification – Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorization – Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards

UNIT V OTHER TOPICS 7

Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC - Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

TOTAL: 45 PERIODS

OUTCOMES:

- It adds the knowledge of various laws related to environmental and legal aspects

REFERENCES:

1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
2. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford University Press, New Delhi, 2001.
3. Greger I.Megregor, “Environmental law and enforcement”, Lewis Publishers, London. 1994.

GR 7010 QUALITY MANAGEMENT IN GREEN MANUFACTURING L T P C
3 0 0 3

OBJECTIVES:

- To provide the students with the knowledge of theory of quality tools, principles, management and quality systems

UNIT I INTRODUCTION 9

Introduction - Need for quality - Evolution of quality - Definition of quality - Dimensions of manufacturing and service quality - Basic concepts of QM - Definition of QM – QM Framework - Contributions of Deming, Juran and Crosby – Barriers to QM.

UNIT II QM PRINCIPLES 10

Leadership – Strategic quality planning, Quality statements - Customer focus – Customer orientation, Customer satisfaction, Customer complaints, Customer retention - Employee involvement – Motivation, Empowerment, Team and Teamwork, Recognition and Reward, Performance appraisal - Continuous process improvement – PDSA cycle, 5s, Kaizen - Supplier partnership – Partnering, Supplier selection, Supplier Rating.

UNIT III QM TOOLS & TECHNIQUES I 9

The seven traditional tools of quality – New management tools – Six-sigma: Concepts, methodology, applications to manufacturing, service sector including IT – Bench marking – Reason to bench mark, Bench marking process – FMEA – Stages, Types.

UNIT IV QM TOOLS & TECHNIQUES II 9

Quality circles – Quality Function Deployment (QFD) – Taguchi quality loss function – TPM – Concepts, improvement needs – Cost of Quality – Performance measures.

UNIT V QUALITY SYSTEMS 9

Need for ISO 9000- ISO 9000-2000 Quality System – Elements, Documentation, Quality auditing- QS 9000 – ISO 14000 – Concepts, Requirements and Benefits – Case studies.

TOTAL : 45 PERIODS

OUTCOMES:

- It will make the students to understand the various quality principles, tools and control techniques and to construct the various quality control charts
- It will develop design concepts for reliable system by implementing quality systems in industries.

TEXT BOOKS:

1. Dale H.Besterfiled, "Total Quality Management", Pearson Education Asia, Third Edition, Indian Reprint (2006).

REFERENCES:

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", (6th Edition), South-Western (Thomson Learning), 2005.
2. Oakland, J.S. "GQM – Text with Cases", Butterworth – Heinemann Ltd., Oxford, Third Edition (2003).
3. Suganthi,L and Anand Samuel, "Green Quality Management", Prentice Hall (India) Pvt. Ltd. (2006)
4. Janakiraman,B and Gopal, R.K, "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd. (2006)

GR 7011 RECYCLIC PACKAGING SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To introduce the concept of recycling, recycling techniques and recycling of various kinds of materials

UNIT I INTRODUCTION 9

Waste – Collection, sorting, cleaning – Recycling – Overview and growth – Characterization of waste streams – Processing facilities for recyclable materials.

UNIT II RECYCLING TECHNIQUES / METHODS 9

Recycling rate, material recovery facilities – Integrating recycling with landfills – Processing equipments.

UNIT III RECYCLING OF PAPER 9

Paper board / solid waste - Recycling of papers, pulp, construction and demolition of debris, house hold wastes.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT IV RECYCLING OF METALS 9

Recycling of Aluminium cans, scrap metals and steel cans, ferrous metals, non-ferrous metals

UNIT V RECYCLING OF PLASTICS AND GLASS 9

Recycling of tyres, batteries, glass beverage bottles, textiles, plastic bottles, rubber materials and tyres.

TOTAL 45 PERIODS

OUTCOMES:

- It will impart the concepts of recycling, recycling techniques
- It will teach the students to decide the appropriate method for recycling of various kind of materials

REFERENCES:

1. W.S. Allen/P.N.Baker, "Handbook of plastic Recycling", Alkem Quality Edition, Alkem Publishing,2009.
2. John Scheirs, "Polymer Recycling", Wiley Series in Polymer Science, 1997.
3. R.Mckinney, "Technology of paper Recycling", Blackie Academic and professional, 1997.
4. Herbert F.Lund, " McGraw-Hill Recycling Handbook", 2nd Edition, 2001

GR 7012 SAFETY ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To impart the basic knowledge of safety aspect in engineering industries

UNIT I SAFETY IN METAL WORKING AND WOOD WORKING MACHINES 9

General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines, Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

UNIT II PRINCIPLES OF MACHINE GUARDING 9

Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing-guard construction- guard opening. Selection and suitability: lathe-drilling-boring-milling-grinding-shaping-sawing-shearing-presses-forge hammer-flywheels-shafts-couplings-gears-sprockets wheels and chains-pulleys and belts-authorized entry to hazardous installations-benefits of good guarding systems.

UNIT III SAFETY IN WELDING AND GAS CUTTING 9

Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases-colour coding – flashback arrestor – leak detection-pipe line safety-storage and handling of gas cylinders.

UNIT IV SAFETY IN COLD FARMING AND HOT WORKING OF METALS 9

Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes , hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

UNIT V SAFETY IN FINISHING, INSPECTION AND TESTING 9

Heat treatment operations, electro plating, paint shops, sand and shot blasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation. Health and welfare measures in engineering industry-pollution control in engineering industry - industrial waste disposal.

TOTAL: 45 PERIODS

OUTCOMES:

- It will impart the knowledge of safety in industrial practices

REFERENCES

1. "Accident Prevention Manual" – NSC, Chicago, 1982.
2. "Occupational safety Manual" BHEL, Trichy, 1988.
3. "Safety Management by John V. Grimaldi and Rollin H. Simonds, All India Travelers Book seller, New Delhi, 1989.
4. "Safety in Industry" N.V. Krishnan Jaico Publishery House, 1996.
5. Indian Boiler acts and Regulations, Government of India.
6. Safety in the use of wood working machines, HMSO, UK 1992.
7. Health and Safety in welding and Allied processes, welding Institute, UK, High Tech. Publishing Ltd., London, 1989.

GR 7013 SOLID WASTE MANAGEMENT L T P C
3 0 0 3

OBJECTIVES:

- To introduce the concepts of storage, collection and safe disposal of solid wastes.

UNIT I INTRODUCTION 9

Need for solid waste management – Integrated solid waste management – Waste prevention – Life cycle assessment – Financial issues in solid waste management.

UNIT II WASTE QUANTITIES AND CHARACTERISTICS 9

Sources of solid waste – Quantities and composition – Physical, Chemical and Biological characteristics.

UNIT III STORAGE AND COLLECTION 9

Storage - Collection for low-rise detatched houses - Collection from low and medium rise apartments - Collection from high rise apartments - Vehicles for collection - Transfer and Transport.

UNIT IV MATERIALS RECOVERY 9

Hand sorting – Screans – Air classifiers – Since and float separators – inclined tables – Shaking tables – Optical sorting – Sorting by differential melting temperature – Sorting by selective dissolution – Magnetic, Eddy Current, crushing technique.

UNIT V REUSE AND RECYCLING 9

Composting – Road making – Stabilization – Deactivation – Metal removal and recovery – Aqueous treatment – Biological technologies.

TOTAL: 45 PERIODS

OUTCOMES:

- It will develop the concepts of storage, collection and safe disposal of solid wastes

REFERENCES:

1. Chandrappa, Ramesha – Solid work Management (2012) – Springer
2. George Tchbanoglous, Frank Kreith – Hand book of Solid Waste Management – 2002 – McGraw Hill

GR 7014 SUSTAINABLITY PRACTICE L T P C
3 0 0 3

OBJECTIVES:

- To introduce the various concepts of sustainability and its practices

UNIT I INTRODUCTION 9

The origins of sustainable development – Nature preservation and emergence of sustainable development - Ecology and balance of nature – Caring for earth.

UNIT II MAIN STREAM SUSTAINABLE DEVELOPMENT 9

Environmental population – Ecology modernization – Natural capital and sustainability – Mechanisms for main stream sustainable development – Deep Ecology and sustainability.

UNIT III ENVIRONMENT, DEGRADATION AND SUSTAINABILITY 9

Environmental degradation, over population and intensification – overgrazing and new range ecology - Environmental costs of development – Dams, People and resettlement.

UNIT IV ECOLOGY OF SUSTAINABILITY 9

Poverty, environment and degradation - Forest clearance and forest people - Ecology of conversation - Famine - Deforestation - Tropical deforestation

UNIT IV SUSTAINABILITY AND RISK SOCIETY 9

Risk society – Risk and environment – Environmental pollution – Manufacturing pollution – The problem of pesticides – Mainstreaming risk – Rain forest management reform – Community conservation.

TOTAL 45 PERIODS

OUTCOMES:

- It will develop the skills to create various sustainable development practices

REFERENCES:

1. Andrew Hoffman, Competitive Environmental Strategy -A Guide for the Changing Business Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy : Creation, implementation, Evaluation, The Federation Press, 2005

GR7015 SUSTAINABLE MANUFACTURING SYSTEM L T P C
3 0 0 3

OBJECTIVES:

- To introduce the various concepts associated with Manufacturing and Design for sustainability.

UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLANGES 9

Definition of sustainability – Environmental, Economical and Social dimensions of sustainability - Sustainable Development Models – Strong and Weak Sustainability – Defining Development- Millennium Development Goals – Mindsets for Sustainability : Earthly, Analytical, Precautionery, Action and Collaborative– Syndromes of Global Change: Utilisation Syndromes, Development Syndromes, and Sink Syndromes – Core problems and Cross Cutting Issues of the 21 Century - Global, Regional and Local environmental issues – Social insecurity - Resource Degradation – Climate Change – Desertification

UNIT II PRINCIPLES AND FRAME WORK 9

History and emergence of the concept of sustainable development - Our Common Future - Stockholm to Rio plus 20– Rio Principles of Sustainable Development – Precautionary Principle- Polluter Pays Principle – Role of Civil Society, Business and Government -Natural Step- Peoples Earth Charter – Business Charter for Sustainable Development –UN Global Compact – Agenda 21

UNIT III SUSTAINABILE LIVELI HOOD 9

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty -Millennium Development Goals, Indicators, Targets, Status and intervention areas - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

UNIT IV SUSTAINABLE SOCIO-ECONOMIC SYSTEMS 10

Protecting and Promoting Human Health – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity –Ecotourism - Urbanization and Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation – Sustainable Consumption and Production – Sustainable Mining - Sustainable Energy– Climate Change – Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

UNIT V ASSESSING PROGRESS AND WAY FORWARD 8

Sustainability in global, regional and national context – Rio Plus 20 - Measuring Sustainability – limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development -Hurdles to Sustainability - Operational guidelines –-Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning – Governance - Science and Technology- Sustainability Education

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to develop various sustainable development practices

REFERENCES:

1. Sayer, J. and Campbell, B., The Science of Sustainable Development : Local Livelihoods and the Global Environment (Biological Conservation, Restoration &Sustainability), Cambridge University Press, London, 2003.
2. Kirkby, J., O"Keefe, P. and Timberlake, Sustainable Development, Earthscan Publication, London,1993.
3. MoEF (2012), " Sustainable Development in India –stocktaking in the Run up to Rio plus 20", Ministryof environment and forests, Government of India, New Delhi.
4. United Nations. 2001. Indicators of Sustainable Development: Guidelines and Methodologies. New York: United Nations. 5 UNEP, 2011, Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, www.unep.org/greeneconomy, ISBN: 978-92-807-3143-9 6 World Bank (2012), "Inclusive Green Growth – The pathway to Sustainable development, World Bank- Washington D

GR 7016 **WASTE STREAM MAPPING** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce various concepts of waste stream mapping.

UNIT I MECHANICAL PROCESSING FOR MATERIAL RECYCLING 10

Resource recovery for sustainable development- Material and energy flow management and analysis - Systems and processes for reduction, reuse and recycling -Objectives of Waste Processing-Source Segregation and Hand Sorting-Waste Storage and Conveyance – Shredding – Pulping - Size Separation by Screens- Density Separation by Air Classification –magnetic and electromechanical separation processes- Design Criteria and Equipment selection.

UNIT II BIOLOGICAL PROCESSING FOR RESOURCE RECOVERY 10

Mechanisms of Biological Processing – Aerobic Processing of Organic fraction - Composting methods and processes- factors affecting- Design of Windrow Composting Systems- In Vessel Composting-Compost Quality Control- Vermiculture: definition, scope and importance - common species for culture - Environmental requirements - culture methods- Applications of vermiculture-Potentials and constraints for composting in India-Largescale and decentralized plants.

UNIT III BIO-CHEMICAL CONVERSION OF WASTE TO ENERGY 9

Principles and Design of Anaerobic Digesters – Process characterization and control- The biochemistry and microbiology of anaerobic treatment - Toxic substances in anaerobic treatment - Methane generation by Anaerobic Digestion- Anaerobic reactor technologies - Commercial anaerobic Technologies- Single stage and multistage digesters- Digester design and performance-Gas collection systems-Methane Generation and Recovery in Landfills – Biofuels from Biomass.

UNIT IV THERMO-CHEMICAL CONVERSION OF WASTE TO ENERGY 8

Principles and Design of Energy Recovery Facilities -Types and principles of energy conversion processes - Incinerator design - Mass Burn and RDF Systems- Composition and calorific value of fuels and waste, Determination of the stoichiometric air consumption, Calculation of the flue gas composition - grate firing designs, boiler design, removal of bottom ash, heat recovery- Emission Controls – flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans - Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc - Process characterization and control- waste heat recovery- Bottom ash: Quantity, quality, treatment, utilization, disposal- Facility design- decentralized mobile plants- Planning and construction of incineration plants.

UNIT V CASE STUDIES ON WASTE RECYCLING 8

Recycling technologies for paper, glass, metal, plastic – Used Lead Acid Battery Recycling –End of Life Vehicle Recycling – Electronic Waste Recycling – Waste Oil Recycling – Solvent Recovery - Drivers and barriers for material recycling: social, legal and economic factors - Environmental impacts of waste recycling - Design for the environment: the life cycle approach.

TOTAL: 45 PERIODS

OUTCOMES:

- The students will be able to identify various waste streams and reduce wastages

REFERENCES:

1. Aarne Veslind and Alan E Rimer (1981), “Unit operations in Resource Recovery Engineering “, Prentice Hall Inc., London
2. Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164
3. Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein*, Modern Composting Technologies* JG Press October 2005
4. Charles R Rhyner (1995), Waste Management and Resource Recovery, Lewis Publishers
5. Gary C. Young (2010) Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, John Wiley & Sons