COVENANT UNIVERSITY

MECHANICAL ENGINEERING

POSTGRADUATE CURRICULUM

2018

DEPARTMENT

OF

MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING

The Department of Mechanical Engineering offers, Masters in Engineering (M.Eng), M.Phil/Ph.D and Ph.D programmes with the following options:

- *Industrial and Production Engineering;*
- *Metallurgical and Materials Engineering;*
- *Thermo-fluid and Energy Systems; and*
- *Mechatronics Engineering*

1.0 PREAMBLE

The Department of Mechanical Engineering offers Masters in Engineering (M.Eng), M.Phil/Ph.D and Ph.D programmes with options in Industrial and Manufacturing Engineering, Metallurgical and Materials Engineering, Thermo-fluid and Energy Systems and Mechatronics in an intellectually and academically stimulating environment. Our programmes takes pride in the collegial student-faculty relationship it provides and in its preparation of students for successful careers in industry, government and academia.

The Department of Mechanical Engineering started as a full-fledged Department in the 2005/2006 Academic Session with 6 postgraduate students and 6 academic staff (Full time and Adjunct) at commencement in the College of Science and Technology of the University. Since the inception, the department had graduated 16 PGD, 12 M.Eng and 9 PhD students till date. The department had undergone NUC resource verification in 2009 for postgraduate programme and has been providing advanced postgraduate education in the fields of Thermo fluid/Energy system, Metallurgical and Materials Engineering, Industrial and Production Engineering and Mechatronics Engineering.
The Department of Mechanical Engineering has a functional Postgraduate Committee comprises of 9 – Professors, 2 – Associate Professors, 4 – Senior Lecturers and 6 – Lecturer I. The Department of Mechanical Engineering has a total number of 18 – M.Eng and 9- PhD students and 23 Faculty for Postgraduate programme.

1.1 VISION OF THE PROGRAMME

The vision of the programme is to produce a total graduate empowered with the standards and practice of Mechanical Engineering in the field and beyond who will fit properly into the African Industrial and Manufacturing Sectors. The programme also plan and design, construct, operate and manage, or conduct research and development on engineering systems. These systems include design, fabrication and constructions, buildings services, interpretation of designs, deployment of plans, experimental design and analysis and protection of man and his environment.

1.2 MISSION OF THE PROGRAMME

The mission of the programme is to prepare our students for leadership roles in the mechanical engineering profession by:

i. offering a quality education by fostering a distinctive curriculum and accentuating design and project-based learning;
ii. committing to individual development while emphasizing the values of teamwork in a culturally diverse and multidisciplinary environment; and
iii. encouraging graduate research and nurturing creative solutions to complex engineering problems.
iv. teaching modern Mechanical Engineering using trendy resources viz-a-viz man power, machines and information and communication technology (ICT). The main focus is to harness all available resources to achieve food security through design/development of tropical machines for processing and the development of technology aimed at boosting energy.

1.3 PHILOSOPHY OF THE PROGRAMME

The Philosophy of the programme is to nurture post graduates students by leveraging on sound foundational training and skills in mechanical engineering in order to become globally relevant in the industrial and

academic domains. The programme is also committed to marry theory with practical effectively and hence produce graduates who will be empowered to strengthen the weak or virtually non-existent manufacturing base of the Africans and change the status of our industries from being "packaging' to `manufacturing'; Producing highly creative and innovative post graduates that are competent enough to be self-employed in the field of Industrial and Manufacturing Engineering, Metallurgical and Materials Engineering, Thermo-fluid and Energy Systems and Mechatronics and its allied disciplines, or in the least be immediately employable.

1.4 AIM OF THE POSTGRADUATE PROGRAMME

The aim of the programme is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through course work providing depth in one area of specialization and breadth in complementary areas. Areas of specialization range from automatic controls, energy systems, design, thermal power plant, fluid mechanics, heat transfer, and solid mechanics to Metallurgical engineering.

1.5 OBJECTIVES OF THE POSTGRADUATE PROGRAMME

Specifically, the objectives of the postgraduate programmes are to:

i. facilitate post graduates with good grasp of a broad spectrum of engineering principles and acquisition of practical work experience;
ii. inculcate entrepreneurial, marketing and management skills in the post graduates and also engage extensively in mechanical engineering research and development;
iii. train and produce post graduates who will be alert to the engineering needs of their environment and be very willing and eager to meet these needs and will have the scientific and technical background for successful careers in diverse organizations;
iv. train and produce men and women who are equipped with all necessary tools (theoretical, spiritual, physical and intellectual) to design and manufacture machines and components for the benefit of their environment and mankind in general.
v. provide post graduates student with knowledge and competitive skills to enhance their performance and to enable them to assume broader responsibilities in the rapidly changing environment in the context of the global and contemporary knowledge economy;
vi. develop manpower that will be motivated and equipped to successfully pursue careers in a wide range of whether in engineering, or in other fields that would foster the attainment of the Vision 20:2020 and the Sustainable Development Goals; and
vii. bring up post graduates of the program that will be leaders, and effective communicators, both in the profession and in the community and will have a professional and ethical approach to their careers with a strong awareness of the social contexts in which they work.

Table 1: LIST OF ACADEMIC STAFF FOR POSTGRADUATE PROGRAMME

S/N	NAME	AREA OF SPECIALIZATION	DISCIPLINE	QUALIFICATION	DESIGNATION
1	Prof. S. O. Oyedepo	Thermo-Fluid / Energy Systems	Mechanical Engineering	B.Eng, M.Sc., Ph.D, REng, MNSE	Professor (HOD)
2	Prof. C. A. Loto	Corrosion Science & Engineering	Metallurgy/ Materials Engineering	B.Sc, M.Sc., Ph.D., CENG, REng, MNSE	Professor
3	Prof. A. O. Inegbenebor	Metallurgical & Materials Engineering	Metallurgy/ Materials Engineering	M.Sc., Ph.D., COREN REG, MNSE, Inst. Material (UK)	Professor
4	Prof. F. A. Oyawale	Industrial & Production Engineering	Industrial & Production Engineering	BSIE, M.Sc, Ph.D, MNSE, Reg Eng COREN	Professor
5	Prof. C.A. Bolu	Mechatronics Engineering	Mechatronics Engineering	BSc, M.Eng, PhD, FNIIE, FNSE, FAEng	Professor
6	Prof. O. O. Ajayi	Energy System, Design and Production Technology	Mechanical Engineering	B.Sc, M.Sc., Ph.D, REng, MNSE	Professor
7	Prof. J.O. Okeniyi	Ergonomics & Production, Work Station Design and Analysis	Industrial & Production Engineering	B.Sc, M.Eng, Ph.D, COREN, MNSE	Professor
8	Prof. O. S. Ohunakin	Thermo Fluid & Energy System	Mechanical Engineering	B.Sc, M.Eng, Ph.D, COREN, MNSE	Professor
9	Prof. R.T. Loto	Corrosion/Material Engineering	Metallurgy/ Materials Engineering	B. Tech, M.Sc, Ph.D, COREN, MNSE	Professor
10	Dr. O.S. Fayomi	Material Development & Characterization	Metallurgy/ Materials Engineering	HND, B.Tech, M.Eng, Ph.D, COREN, MNSE	Senior Lecturer
11	Dr. O. A. Omotosho	Corrosion Science & Engineering	Metallurgy/ Materials Engineering	B.Sc, M.Eng, COREN, MNSE	Senior Lecturer
12	Dr. O. Kilanko	Design and Manufacturing	Mechanical Engineering	B.Sc, M.Eng, Ph.D, COREN, MNSE	Lecturer I
13	Dr. P. O. Babalola	Internal Combustion Engines/Renewable Energy	Mechanical Engineering	B.Sc, M.Eng, Ph.D, COREN, MNSE	Lecturer I
14	Dr. M. O. Udo	Production & Design, Thermo-fluid in Material options	Metallurgy/ Materials Engineering	B.Sc, M.Eng, Ph.D, COREN, MNSE	Lecturer I
15	Dr. R. O. Leramo	Design and Manufacturing	Mechanical Engineering	B.Sc, M.Eng, PhD, COREN, MNSE	Lecturer I
16	Dr. O.O. Joseph	Corrosion and Structural Integrity	Metallurgy/ Materials Engineering	B.Sc, M.Eng, PhD, COREN, MNSE	Lecturer I
17	Dr. S.A. Afolalu	Design & Production/Applied Mechanics	Mechanical Engineering	B.Eng, M.Sc, PhD, COREN, MNSE	Lecturer I
18	Dr. A.A Abioye	Modelling & Simultation of Microstructures and Furnace Environment	Metallurgy/ Materials Engineering	B.Sc, M.Sc, PhD, COREN, MNSE	Lecturer II
19	Dr. S. Ongbali	Production Performance & Modelling of Time Function Operations	Industrial & Production Engineering	B.Eng, M.Sc, PhD, COREN	Lecturer II

ADJUNCT LECTURERS

S/N	NAME	AREA OF SPECIALIZATION	QUALIFICATION	DESIGNATION	COURSE(S) TAUGHT
1	Prof. Chinonye Moses	Strategic Management and Entrepreneurship	B.Sc, MBA, M.Sc, Ph.D	Professor	Entrepreneurial Development Studies (EDS)
2	Dr. Tuesday Owoeye	Languages	B.A, M.A, Ph.D	Senior Lecturer	Total Man Concept (TMC)

VISITING LECTURERS

S/N	NAME	AREA OF SPECIALIZATION	QUALIFICATION	DESIGNATION	COURSE(S) TAUGHT
1	Prof. Esther T. Akinlabi	Modern & Advanced Manufacturing Processes			
2	Prof. Idowu P. Popoola				
3	Dr. Stephen A. Akinlabi				
4	Prof. I.S. Dunmade	Modelling & Engineering Management	B.Eng., , M.Eng, Ph.D, COREN, MNSE	Professor	Production Engineering, Project Management & Control Engineering
5	Prof. M.A Waheed	Thermo- Fluids/Energy Systems	B.Eng, M.Eng, PhD, MNSE, COREN	Professor	Conductive Heat Transfer, Energy Optimization Techniques
6	Dr. M.K Odunfa	Thermo Fluids/ Energy Systems	B.Sc, M.Sc, PhD, MNSE, COREN	Senior Lecturer	Advanced Internal Combustion Engine, Advanced Fluid Mechanics

2.0 ACADEMIC CONTENT

The criteria for admission into the Mechanical Engineering Postgraduate programmes are as follows:
Basic Requirements:
All candidates must have five Credit passes including English, Mathematics, Physic, and Chemistry O'Level.

2.1 Admission Requirements:

a. Postgraduate Diploma, PGD

A graduate from a recognized University with at least a pass degree or a holder of a minimum of upper Credits in the Higher National Diploma HND, from a recognized institution. Holders of the HND at lower Units with a minimum of five (5) years post-qualification relevant experience may be considered.

b. Master of Science (M.Eng) Mechanical Engineering

i. Admission is open to candidates with a first degree in Mechanical Engineering (B.Sc/B.Eng Mechanical Engineering) with a minimum of Second Class Lower Division

from Covenant University, or any other university recognized by the Senate of Covenant University;

ii. Candidates with third class degree of Mechanical Engineering from Covenant University or any recognized University will be deemed eligible if such candidates have obtained an additional PGD with a minimum CGPA of 3.50 in Computer Science from a recognized university;

iii. Candidates with at least a lower credit in Higher National Diploma (HND) from a recognized Polytechnic **and** a PGD from an approved University with a minimum CGPA of 3.50 may be considered for admission; and

iv. In addition to the above qualifications, candidates shall be required to participate in a postgraduate screening exercise.

c. M.Phil Mechanical Engineering

I. Admission is open to candidates with at least M.Sc Degree in Mechanical Engineering with a minimum CGPA of 3.00.

II. In addition to the above qualifications, candidates shall be required to participate in a postgraduate screening exercise.

d. M.Phil/Ph.D Mechanical Engineering

i. Admission is open to applicants who possess a M,Sc/M.Eng degree in Mechanical Engineering or its equivalent with CGPA of 3.50 - 3.99 from Covenant University or any other recognized university;

ii. Candidates with a M.Phil degree with a minimum CGPA of 3.50 in Mechanical Engineering from Covenant University or any other recognized University is eligible and can be considered for admission; and

iii. In addition to the above qualification requirements, candidates shall be required to participate in a postgraduate screening exercise to qualify for admission.

e. Ph.D Mechanical Engineering by Coursework and Research

i. A candidate with academic Master's degree (M.Sc/M.Eng) in **Mechanical Engineering**, with a minimum Cumulative Grade Point Average (CGPA) **of not less than** 4.00 on a 5-point scale or weighted average of 60% from Covenant University or any recognized university shall be eligible for admission into the Ph.D **Mechanical Engineering** programme;

ii. Candidate who possesses M.Phil with a minimum CGPA of 4.00 on a 5-point scale or weighted average of 60% in **Mechanical Engineering** from Covenant University or any other recognized university is eligible for admission;

iii. In addition to the above qualification requirements, candidates shall be required to participate in a postgraduate screening exercise to qualify for admission.

2.2 Duration of Programme

a. Master's Degree Programme

i. Full-time: A minimum of three (3) semesters and a maximum of six (6) semesters
ii. Part-time: A minimum of four (4) semesters and a maximum of eight (8) semesters.

b. Master of Philosophy (M.Phil)

Full-time M.Phil Mechanical Engineering programme shall last for four (3) semesters **only**.

c. Master of Philosophy/Doctor of Philosophy (M.Phil/PhD)

Full-time: The duration of the programme shall be two (2) semesters of course works and two (2) years of doctoral research provided the candidate demonstrate ability to transfer into the Ph.D research. The candidates will be required to submit a supervised research report at the end of the programme.

d. Ph.D Mechanical Engineering by Coursework and Research

Full-time Ph.D Mechanical Engineering degree programme shall last for a minimum of six (6) Semesters and maximum of eight (8) semesters. This includes one (1) semester of coursework and five (5) to seven (7) maximum semesters of research.

3.0 Staffing Requirements

Teachers of postgraduate courses, except the PGD, should normally be holders of a Ph.D, provided that those who teach Ph.D courses are of the rank of at least Senior Lecturer.

3.1 Requirements for Student Supervision

Subject to individual University peculiarities, requirements for supervision of postgraduate students shall be as follows:

a. At least one supervisor for each postgraduate student on the masters and the PGD and at least two (2) for the Ph.D programme shall be appointed.

b. All lecturers qualified to teach postgraduate courses and who are not registered postgraduate students shall be eligible to supervise PGD and Masters programmes. For the Ph.D, supervisors must be of a rank not lower than senior lecturer and must not be registered postgraduate students.

c. A supervisor shall guide a student in his/her studies and the department shall keep a record of the candidate's progress and submit a regular progress report through the Dean to the Board of Postgraduate Studies.

d. A supervisor may be changed where and when necessary subject to the approval of the board of Postgraduate Studies.

e. Where a student does part or all his required courses in another institution, the external supervisor shall only be required to submit a written report on the candidate at the end of the programme. Such a supervisor shall not normally be required to participate in the oral examination of the candidate.

4.0 EXAMINATIONS

4.1 Course Work

a. For all postgraduate coursework, the minimum pass score shall be 50%; continuous assessment shall constitute not less than 30% of the examination for each course;

b. Any student who fails in any course, shall repeat such a course; and

c. Any student whose Cumulative Grade Point Average (CGPA) falls below 2.50 at the end of 2 consecutive Semesters shall be required to withdraw from the programme.

The scoring and grading of courses shall be as follows:

Marks	**Letter Grades**	**Grade Points**
70 and above	A	5
60 -69	B	4
50 -59	C	3
0 -49	F	0

4.2 Thesis or Dissertation

A panel of examiners shall be composed to orally assess a thesis or dissertation according to individual University regulations, but the examination shall at least be guided by the following:

a) Postgraduate Diploma Project Report: An external examiner shall read and grade the report. The final grade for the project report shall be the average of the separate grades of an internal assessment process and the external examiner's assessment.

b) Master Thesis: The minimum composition of the examination panel shall comprise:

i. External Examiner;
ii. Head of Department;
i. Supervisor;
ii. Co-supervisor (if any); or at least one other member of the Department (if no co-supervisor); and.
iii. One member appointed by the Postgraduate School.

Note that all master's degree programmes shall be subject to external examination and moderation.

c) Ph.D Thesis: The minimum composition of the examination panel shall comprise:

i. External Examiner;
ii. Head of Department who must be a Ph.D holder;
iii. Supervisor;
iv. Co-supervisor;

v. One other member of the Department who is not below the rank of a Senior lecturer or an academic staff from a related Department within the Faculty who must be a Ph.D holder; and
vi. A representative of the Board of the School of Postgraduate (PG) Studies.

4.3 Graduation

For the PG programmes, classification of certificates shall be based on the following:

CGPA	4.50	-	5.00 ----------	Distinction
	3.50	-	4.49 ----------	Upper Credit
	2.50	-	3.49 ----------	Lower Credit
	1.50	-	2.49 ----------	Pass

5.0 GENERAL COURSE REQUIREMENTS

Courses specified for engineering disciplines are just suggestions of common courses in the various fields of engineering. Each Department (or University) offering listed programmes is free to add as many optional or required courses as it deems fit.

5.1 M.Sc/M.Eng./M.Tech. Requirements

A total of 48 Units comprising 41 Units of Coursework, 1 unit of Seminar and 6 Units of Research.

5.2 M.Phil. Requirements

A minimum of 36 Units comprising 24 Units of Coursework, 3 unit of Seminar and 9 Units of Research.

5.3 Ph.D Requirements

For Ph.D programmes, candidates shall be required to have taken the core/compulsory courses prescribed for the M.Sc./M.Eng. as prerequisites. This is in addition to the minimum 21 units which include research and seminars prescribed for the Ph.D.

Table 2: Showing Graduation Requirements

Level	Core Courses	University Courses	Elective Courses	Dissertation /Thesis	Total
PGD					
M.Eng	34	2	6	6	48
M.Phil	30	2	6	6	44
M.Phil/Ph.D	21	2	6	12	41
Ph.D	12	2	3	12	29

6.0 COURSE STRUCTURE

Table 3: M.Eng. Programme Year 1 by Semesters.

M.Eng. (Industrial and Production Engineering Option) (1st Year)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE811	Advanced Numerical Analysis	C	3		MCE812	Advanced Statistical Methods for Engineers	C	3		
	MCE813	Production and Operations management	C	3		MCE814	Engineering Economics	C	3		
	MCE815	Production Engineering	C	3		MCE816	Quality Control and Management	C	3		
	MCE827	Project Planning and Control	C	3		MCE826	Queuing Theory and Scheduling	C	3		
	CUR811	Research Methodology	C	3		MCE804	Engineering Colloquium (Seminar)	C	1		
	Sub Total			**15**		***Sub Total***			**13**		**28**
University Courses	EDS811	Entrepreneurial Development Studies	U	1							
	TMC811	Total Man Concept	U	1							
	Sub Total			**2**							2
	Total			**17**		**Total**			**13**		**30**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 1) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 4) Select (3 Units) from Electives***					
	MCE 817	Fracture Control for Design	E	3		MCE848	Mathematical Programming	E	3		
	MCE818	Fatigue	E	3		MCE828	Reliability Engineering	E	3		
	MCE826	Queuing Theory and Scheduling	E	3		MCE837	Facility Engineering	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**20**		***Total***			**16**		**36**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 2) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 5) Select (3 Units) from Electives***					
	MCE829	Supply Chain Management and Logistics	E	3		MCE840	Management of Innovation & Engineering Management	E	3		
	MCE836	Decision Analysis	E	3		MCE838	Value Engineering	E	3		
	MCE835	Production Scheduling	E	3		MCE801	Materials Selection	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**23**		***Total***			**19**		**42**

NB:
***C – Compulsory Courses**
***E – Elective Courses**
***CC – Course Code**
***Area of specialisation here captures three (3) different areas**
***NUC BMAS must be followed strictly in crafting out the Compulsory and Elective Courses**

Table 4: M.Eng. Year 2 by Semesters

M.Eng. (Industrial and Production Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE800	Research/Project Dissertation Begins	C			MCE800	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 5a. M.Phil (Direct) Year 1 by Semesters.

M.Phil Year 1 (Industrial and Production Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	CUR911	Research Methodology	C	3		MCE812	Advanced Statistical Methods for Engineers	C	3		
	MCE811	Advanced Numerical Analysis	C	3		MCE814	Engineering Economics	C	3		
	MCE813	Production and Operations management	C	3		MCE 825	Quality Assurance	C	3		
	MCE815	Production Engineering	C	3		MCE826	Queuing Theory and Scheduling	C	3		
	MCE 819	Supply Chain Management and Logistics	C	3		MCE 827	Decision Analysis	C	3		
	MCE905	Seminar1 in area of specialisation	C	3		MCE957	Seminar2 in area of specialisation	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective Course	MCE 917	Knowledge Modelling & Management/Business Intelligence	E	3		MCE 916	Reliability Engineering	E	3		
	Sub Total			3		**Sub Total**			3		6
	Total			**21**		***Total***			**21**		**42**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										**2**
	Total			**21**					**21**		**42**

Table 5b: M.Phil Year 2 by Semesters

M.Phil Year 2 (Industrial and Production Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE900	Research/Project Dissertation Begins	C			MCE900	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 6:M.Phil/Ph.D Year 1 by Semesters.

M.Phil/Ph.D (Industrial and Production Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	**Course Title**	**Status**	**Units**	**Pre-Requisite**	**Course Code**	**Course Title**	**Status**	**Units**	**Pre-Requisite**	
Compulsory Courses	CUR911	Research Methodology	C	3		MCE 923	Computer Aided Design and Manufacturing	C	3		
	MCE911	Advanced Numerical Analysis	C	3		MCE914	Engineering Economics	C	3		
	MCE913	Production and Operations management	C	3		MCE 916	Reliability Engineering	C	3		
	MCE920	Advanced Manufacturing Technology	C	3		MCE932	Seminar I	C	3		
	MCE903	Seminar in area of specialisation	C	3		MCE934	Seminar II	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective	MCE926	Queuing Theory & Scheduling	E	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		
	MCE936	Decision Analysis	E	3							
	MCE935	Production Scheduling	E	3							
	Sub Total			**3**		**Sub Total**			**12**		**15**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total			**2**							**2**
	Total			**21**		***Total***			**30**		**51**

Table 12:Ph.D Direct Year 1

Ph.D (Industrial and Production Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	CUR911	Research Methodology	C	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		**12**
	MCE911	Advanced Numerical Analysis	C	3		MCE932	Seminar I	3			
	MCE913	Production and Operations management	C	3		MCE934	Seminar II	3			
	MCE920	Advanced Manufacturing Technology	C	3							
	MCE903	Seminar in area of specialisation	C	3							
	Sub Total			**21**					**12**		**33**
Elective	MCE 926	Queuing Theory & Scheduling	E	3							
	MCE 936	Decision Analysis	E	3							
	MCE 935	Production Scheduling	E	3							
	Sub Total			**3**							**3**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										
	Total			**24**					**12**		**36**

COURSE DESCRIPTION

Production/Industrial/Manufacturing Engineering Option (Masters, M.Phil./Ph.D and Ph.D)

MCE 811/911: Advanced Numerical Analysis (3 units)

Interpolation, numerical integration, Non-linear equations, numerical solution of ordinary and partial differentia; equations. Numerical analysis of matrices, including solution of linear systems and eigen value/eigen vector calculations. Practical computational methods emphasized and basic theory developed through simple models. Review of finite element theory in linear static and dynamic analyses. Theory and element selection. Development of computer programs for simple problems. Utilization of existing computer packages. Application to mechanical engineering problems. Material and geometric non-linearity, various formulation and solution methods, convergence. Fracture mechanics problems. Non-linear transient conduction, convection, and radiation boundary conditions. Fluid flow problems.

MCE 813/913: Production and Operations Management (3 Units)

Introduction. Location Selection and Plant Layout. Design of Manufacturing. Systems. Factory Dynamics. Just-in-Time Production. Theory of Constraints. Demand Forecasting. Inventory and Materials Management. Production Planning Models. Methods and Measure. Operations Schedule. Advanced Topics.

MCE 814/914: Engineering Economics (3 Units)

Rationale: All engineering and management decisions have economic consequences, such as profitability and risk. This course is aimed at providing the necessary background and techniques for economic evaluation of decision alternatives. Topic such as time value of money, depreciation and taxation, cost estimation and cost control, risk and uncertainty in decision-making, and replacement analysis are included. Basic Concepts in Engineering Economics. Economic Evaluation of Alternatives. Replacement Analysis. Accounting Concepts. Depreciation and Taxation. Product Costing and Cost Estimation. Risk and Uncertainty. Deterministic Capital Budgeting Models.

MCE 812/912: Advanced Statistical Methods for Engineers (3 Units)

Introduction to probability and stochastic processes. Experimental Methods in Human Factors

Research.Design of experiments in Human Factors research, with an emphasis on t he use of statistical packages and data analysis tools. Topics covered will include analysis of variance, non- parametric statistics, balanced and unbalanced block desi gns (including Latin squares), confidence intervals, etc. Stress is given to practical problems and the intuitive understanding of applied statistics.

MCE 816/916: Quality Control and Management (3 Units)

Rationale: To present quality as a strategic business weapon, and to detail the ways and means of achieving it in an organization. The managerial aspects and statistical procedures of quality control are treated in depth. Catalog Description: Quality System, Quality Management System, Planning and Operations for Quality, Statistical Methods for Quality Control.

MCE 817/917: Fracture Control for Design (3 Units)

Transition temperature, linear-elastic and elastic-plastic theory, experimental testing methods, fracture-resistant design methodology, application to mechanical and structural components.

MCE 818/918: Fatigue (3 Units)

Review of smooth-body fatigue: high-cycle; cumulative damage; cycle counting methods; cracked-body fatigue theory; effects of load history and stress ratio; numerical crack-growth prediction models; application to components and structures; crack detection methods.

MCE 820/920: Advanced Manufacturing Technology (3 Units)

Basic metal removal processes. Introduction to the mechanics of the processes. Economics of simple processes. Introduction to machine selection, flexibility, and automation. Organization of manufacturing, process planning, group technology, facilities layout, and production scheduling.

MCE 826/926: Queuing Theory and Stochastic Processes (3 Units)

Queuing Theory

A course in queuing theory, emphasizing general methods in the study of Markovian and non-Markovian systems, tandem queues, networks of queues, priority and bulk queues.

Stochastic Processes

A course on the fundamentals of stochastic processes and their application to mathematical models in operational research. Topics discussed will include a review of probability theory, Poisson processes, renewal processes, Markov chains and other advanced processes.

Emphasis on applications in inventory, queuing, reliability, repair and maintenance, etc.

MCE 827/927: Project Planning and Control (3 Units)

Project organisation and definition of objectives. Collecting, generating and analysis of project statistical data. Project task elements identification and diagramming, planning and progressing. Construction, fabrication or maintenance project scheduling and evaluation using CPM and PERT techniques. Feasibility studies to include technical and economic studies of projects. PRINCE2 techniques and Project Management Institute approach, using the PMBOK.

MCE 828/928: Reliability Engineering (3 Units)

The goal of the course is to introduce students to principles of reliability from a practical point of view. The course covers principles of quality, principles of reliability, reliability of systems, failure rate data and models, quality and reliability in design and manufacturing, and reliability and availability in maintenance including cost models.

Some other topics could be covered, depending on timing. Amoderate knowledge of prob ability and statistics is a requirement.

MCE 829/929: Supply Chain Management and Logistics (3 Units)

This course is to provide students with a framework for understanding the defining supply chain systems while developing an understanding of the complexity, opport unities, and pitfalls of management issues regarding these systems. Topicswill inclu de inventory theories, transportation, postponement strategies, supply chain dynamic s, value of information, supply chain flexibility, and risk management. We will focu s on the analytical decision support tools (both models and applications) as wellas on the organizational models thatsuccessfully allow companies to develop, implement and sustai n supplier management and collaborative strategies.

MCE 830/930: Advanced Materials Engineering (3 Units)

Tensile instability, crystallography, theory of dislocations, plasticity, hardening mechanisms, creep and failure, electron microscopy, composite materials. Fundamentals and techniques of optical and electron microscopy as applied to the determination of physical, chemical and structural properties of materials behavior in practice.

MCE 831/931: Maintenance Engineering (3 Units)

Determination of optimal maintenanceand replacement practices for components and capi tal equipment; resources of manpower and machineryrequired for implementation of m aintenance practices; and the use of mathematical models in the development of a maintenance information system.

MCE 834/934: Quality Assurance (3 Units)

Awareness of the importance of quality has increased dramatically. Continuous quality i mprovement is a key factor leading to company´s success and an enhanced compet itive position. The course covers the following topics: Quality Assurance. Introduction to quality engineering. Loss function. Quality standards: ISO 9000 and QS 9 000. TQM. Quality cost analysis.Process modeling and hypothesis testing. Statistical process control for long and short production runs. Process capability analysis. Capability indexes. Fitting
the distribution. Elements of the likelihood theory. Weibull analysis. Six sigma quality. An overview of the quality standards in acceptance sampling.

MCE 835/935: Production Scheduling (3 Units)

This course takes a practical approach to scheduling problems and solution techniques, motivating the different mathematical definitions of scheduling with real world scheduling systems and problems. Topics covered include: job shop scheduling, timetabling, project scheduling, and the variety of solution approaches including constraint programming, local search, heuristics, and dispatch rules. Also covered will be information engineering aspects of building scheduling systems for real world problems

MCE 836/936: Decision Analysis (3 Units)

The purpose of this course is to provide a working knowledge of methods of analysis of problems and of decision making in the face of uncertainty. Topics include decision trees, minimax and bayeses criterion, subjective probability assessment, multi-attribute utility approaches, goal programming, Analytic Hierarchy Process and the psychology of decision making.

MCE 837/937: Facility Engineering (3 Units)

Facility design functions and economics. Product and process engineering. Flow analysis and design. Facility layout, using manual and computer routines, plant and machine location from qualitative and quantitative consideration. Analytical methods. Packaging, storage and material handling systems.

MCE 838/938: Value Engineering (3 Units)

The concept of value, productivity, functionality, marketability and their mutual relationship. Product and project analysis: identification of alternative components, features and materials and their selection. Value systems design, analysis and evaluation. The value engineering and analysis problem, level of value engineering. Solution procedures to the value engineering problem. Value engineering and real-life applications. Product, project and system cost estimate and reduction.

MCE 840/940: Management of Innovation & Engineering Management (3 Units)

This course will provide students with the core concepts of innovation including: strategic thinking, transformational change management, innovative enterprise design & development and sustaining a culture of innovation. This seminar course will equip students with the knowledge and the skills to manage innovation at strategic and operational levels. The management of innovation is interdisciplinary and multi-functional, requiring the international alignment of market forces, technological systems and organizational change to improve the competitiveness and effectiveness of organizations and society.

MCE 848/948: Mathematical Programming (3 Units)

LinearProgramming:

Formulation of linear programming problems, some applications. Simplex method, revised simplex method, duality, dual simplex method. Parametric linear programming and post-optimality analysis. Transportation problems. Integer linear programming. Flows in networks. General Level Course.

Integer Programming

Branch and bound, implicit enumeration, cutting planes, all integer tableau methods, quadratic 0-1 algorithms, commercial software, Benders' decomposition, Lagrangian relaxation, column generation, several practical applications from the literature.

Dynamic Programming

Introduction to dynamic Programming. Non-Linear Optimisation. This course will consist of two parts.

Part 1: (Non-linear programming) Theory and applications of non-linear optimization.

Convex sets, convex and concave functions, Kuhn-Tucker conditions.
Duality in non-linear programming.
Computational methods for quadratic and convex programming.
Geometric programming.
Part 2: (Network Flow Optimization) Graph models for networks, Network flow problems and solution algorithms, applications; maximum flow, shortest route, assignment, and minimum cost flow problems.

MCE 849/949: Knowledge Modelling & Management/Business Intelligence (2 Units)

Theme: Qualitative, symbolic representations of information and knowledge, presentation and access to information. Types of knowledge: conceptual level (concepts, relations, attributes, truth, uncertainty, meta, axioms), generic level (time, activity, state, causality, space).
Representation methods: relational, object oriented & conceptual. Networks and distributed representations. Access to information: Query Languages (SQL), Network Services (ISO mail standards), KQML (Knowledge Query and Manipulation Language). Interface technologies: X/Motif, windows.

Table 8: M.Eng. Programme Year 1 by Semesters - (Metallurgical and Materials Engineering Option)

M.Eng. (Metallurgical and Materials Engineering Option) (1st Year)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE809	Advanced Chemical Metallurgy	C	3		MCE802	Advanced Physical Metallurgy	C	3		
	MCE893	Phase Transformations	C	3		MCE894	Advanced Corrosion Engineering	C	3		
	MCE895	Advanced Materials processing	C	3		MCE896	Fracture and Failure analysis	C	3		
	MCE897	Advanced Mineral processing	C	3		MCE898	Advanced Metallurgical Thermodynamics	C	3		
	CUR811	Research Methodology	C	3		MCE802	Engineering Colloquium (Seminar)	C	1		
	Sub Total			**15**		***Sub Total***			**13**		**28**
University Courses	EDS811	Entrepreneurial Development Studies	U	1							
	TMC811	Total Man Concept	U	1							
	Sub Total			**2**							2
	Total			**17**		**Total**			**13**		**30**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 1) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 4) Select (3 Units) from Electives***					
	MCE 812	Advanced Composite Materials	E	3		MCE 818	Thermodynamics and Kinetics in Material Science	E	3		
	MCE 817	Surface Engineering	E	3		MCE 816	Advanced Structure and Properties of Materials	E	3		
	MCE 805	Powder Metallurgy	E	3		MCE 802	Solidification Processing	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**20**		***Total***			**16**		**36**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 2) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 5) Select (3 Units) from Electives***					
	MCE 819	Biomaterials	E	3		MCE 810	s Selection	E	3		
	MCE 815	Advanced Welding Technology	E	3		MCE 808	Iron and Steel Making	E	3		
	MCE 803	Dislocation Theory	E	3		MCE 806	Fine Particles Technology	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**23**		***Total***			**19**		**42**

Table 9: M.Eng Year 2 by Semesters

M.Eng (Metallurgical and Materials Engineering Option) Year 2											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE800	Research/Project Dissertation Begins	C			MCE800	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 10a. M.Phil (Direct) Year 1 by Semesters.

M.Phil Year 1 (Metallurgical and Materials Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE809	Advanced Chemical Metallurgy	C	3		MCE802	Advanced Physical Metallurgy	C	3		
	MCE893	Phase Transformations	C	3		MCE894	Advanced Corrosion Engineering	C	3		
	MCE895	Advanced Materials processing	C	3		MCE896	Fracture and Failure analysis	C	3		
	MCE897	Advanced Mineral processing	C	3		MCE898	Advanced Metallurgical Thermodynamics	C	3		
	CUR811	Research Methodology	C	3		MCE8008	Iron and Steel Making	E	3		
	MCE	Seminar1 in area of specialisation	C	3		MCE957	Seminar2 in area of specialisation	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective Course	MCE 905	Powder Metallurgy	E	3		MCE 904	X-Ray Crystallography	E	3		
	Sub Total			3		**Sub Total**			3		6
	Total			**21**		***Total***			**21**		**42**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										**2**
	Total			**21**					**21**		**42**

Table 10b: M.Phil Year 2 by Semesters

M.Phil (Metallurgical and Materials Engineering Option) Year 2											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE900	Research/Project Dissertation Begins	C			MCE900	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 11:M.Phil/Ph.D Year 1 by Semesters.

M.Phil/Ph.D (Metallurgical and Materials Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	**Course Title**	**Status**	**Units**	**Pre-Requisite**	**Course Code**	**Course Title**	**Status**	**Units**	**Pre-Requisite**	
Compulsory Courses	CUR911	Research Methodology	C	3		MCE918	Thermodynamics and Kinetics in Material Science	C	3		
	MCE909	Advanced Chemical Metallurgy	C	3		MCE916	Advanced Structure and Properties of Materials	C	3		
	MCE993	Phase Transformations	C	3		MCE910	Advanced Process Metallurgy	C	3		
	MCE995	Advanced Materials processing	C	3		MCE932	Seminar I	C	3		
	MCE903	Seminar in area of specialisation	C	3		MCE933	Seminar II	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective	MCE 905	Powder Metallurgy	E	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		
	MCE997	Advanced Mineral processing	E	3							
	MCE999	Electronic Materials	E	3							
	Sub Total			**3**		**Sub Total**			**12**		**15**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total			**2**							**2**
	Total			**21**		***Total***			**30**		**51**

Table 12:Ph.D Direct Year 1

Ph.D (Metallurgical and Materials Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	CUR911	Research Methodology	C	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		**12**
	MCE909	Advanced Chemical Metallurgy	C	3		MCE932	Seminar I	3			
	MCE993	Phase Transformations	C	3		MCE934	Seminar II	3			
	MCE995	Advanced Materials processing	C	3							
	MCE903	Seminar in area of specialisation	C	3							
	Sub Total			**21**					**12**		**33**
Elective	MCE 905	Powder Metallurgy	E	3							
	MCE897	Advanced Mineral processing	E	3							
	MCE999	Electronic Materials	E	3							
	Sub Total			**3**							**3**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										
	Total			**24**					**12**		**36**

COURSE DESCRIPTION

Metallurgical and Materials Engineering Option (Masters, M.Phil./Ph.D and Ph.D)

MCE 802/902: Advanced Physical Metallurgy (3 Units)
Description of metallurgical microstructures and their effect on physical properties such as mechanical and magnetic properties; development of microstructures by phase transformations and plastic deformation. Thermal stability of various microstructures. Nucleation phenomena; growth kinetics; transformations. Advanced dislocation theory. Processing of metals and alloys: casting rolling forging extrusion and others. Engineering stress and strain of metals: elastic and plastic deformation of metals, poisson's ratio, shear stress and strain, engineering stress-strain diagram and interpretations, plane stress and strain, stress and strain transformation, mohr's Circle etc. phenomenon of plastic deformation of metals (studies will comprise single and polycrystalline metals). Hardening mechanisms. Solid-solution strengthening of metals. Recovery and recrystallization of plastically deformed metals.

MCE 804/904: X-Ray Crystallography (3 Units)
Properties of X-Ray: Production, absorption, scattering; physics of diffraction and interpretation thereof. Instrumentation and interpretation of diffraction patterus; the Laue, Debye-scherrer, weissemberg and precission techniques. Experimental methods; analysis of noncrystalline materials.

MCE 808/908: Transport Phenomena (3 Units)
Fluid flow, heat and mass transport with applications to metallurgical processes. Dimensional analysis, modeling and predication of process behaviour in industrial systems such as steelmaking, continuous casting, vacuum degassing, heterogeneous processes and heat treatment.

MCE 809/909: Advanced Chemical Metallurgy (3 Units)
Physical chemistry principles and application to chemical metallurgy with emphasis on kinetics and mechanisms of important reactions in chemical metallurgy systems; recent advances in science and technology of chemical metallurgy systems; recent advances in science and technology of chemical metallurgy and their actual or potential application to metal recovery.

MCE 810/910: Advanced Process Metallurgy (3 Units)
Study of integrated metallurgical systems involving the major unit processes of pyrometallurgy, hydrometallurgy, electrometallurgy. Extractive metallurgy of the more common metals such as iron, copper, zinc, lead, tin, aluminum, as well as the less common ones such as titanium, molybdenum, silver, gold, chromium and niobium. Refining processes including precipitation, segregation, distillation, etc.

MCE 894/994: Advanced Corrosion Engineering (3 Units)
Emphasis on corrosion damage and its underlying principles. The thermodynamics and kinetics of electrochemical corrosion of metals and alloys. The eight forms of corrosion-uniform attack, galvanic corrosion, pitting, intergranular, selective leaching, erosion corrosion and stress corrosion are discussed extensively, together with their prevention techniques. Materials selection for use in corrosive environments. Treatment of

environmental degradation of non-metals (Ceramics, silicate glasses, concrete, etc) and polymers. Introduction and definition. Corrosion mechanisms. Environment impact on metals: different types of environment and their interaction with metal. Forms of corrosion. High temperature corrosion. Corrosion testing and evaluation. Corrosion prevention and protection. Green Inhibitors. Adsorption studies and corrosion kinetics.

MCE 896/996: Fracture and Failure analysis (3 Units)

Advanced treatment of Hooke's Law. Fracture of single and polycrystalline materials; fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics. Advanced mechanical testing – simulative and non-simulative tests. The dependent failure of engineering materials. Non-destructive test (NDT). Lubrication, wear and metrology. The course deals with fatigue and fatigue related fractures of materials, cyclic deformation response in ductile materials including both single- and poly-crystals, mechanisms of fatigue crack nucleation and propagation in ductile materials, microstructural approach for fatigue mechanisms, principles of fracture mechanics and its application in fatigue fracture, small cracks, effect of mean stress on materials response under cyclic loading conditions, cyclic creep, and fatigue in brittle materials, Tensile instability, crystallography, theory of dislocations, plasticity, hardening mechanisms, creep and fracture.

MCE 897/997: Advanced Mineral Processing (3 Units)

Analysis of mineral concentration operations with emphasis on the metallurgical, economic and environmental aspects of the processes; surface chemistry (electrical double layer, zeta potential, Gibb's equation, chemisorption, etc), chemistry of flotation, flotation of oxides, sulphides and silicates. Tailings disposal.

MCE 898/998: Advanced Metallurgical Thermodynamics (3 Units)

Review of basic principles of thermodynamics, advanced treatment of the thermodynamics properties of materials. Application of thermodynamics to the chemical behaviour of elements, compounds and solutions; free energy-composition diagrams. Application of thermodynamic principles to the development and use of phase diagrams.

MCE 899/999: Electronic Materials (3 Units)

Materials and physics of aspects of semiconductor, optical and magnetic devices; energy bandstructure, crystal structure, crystal defects and impurity effects, relationship of material characteristics and physical properties; production of electronic materials and devices; single crystal growth, epitaxy, metallization, iron implantation, lithography and etching, characterization techniques; X-ray diffraction, photoluminescence.

MCE 820/920: Solidification Processing (3 Units)

Principles of control of structure, properties and shape in processes involving liquid-solid and vapour-solid transformation. Heat flow, fluid flow, solute redistribution, nucleation and interface kinetics, thermodynamics of solidifications, processing and properties and relationships. Applications in metal casting, Zone refining, rapid solidification technology RST), and welding.

MCE 803/903: Dislocation Theory (3 Units)

Basic concepts of dislocation; glide and climb, perfect/impact dislocation, stacking faults, jogs. Stress around dislocation, pile-ups and cracks. Energy of dislocation and effect on mechanical properties. Interactions in straight and loop dislocations; effect of dislocations; effect of dislocations on thermal properties of crystals, the line tension of dislocations and boundary condition problems. Application of dislocation theory to metallurgical processes like work-hardening, strain ageing, creep etc.

MCE 805/905: Powder Metallurgy (3 Units)

Powder metallurgy production techniques and their advantages, powder grading sizing blending, compaction and sintering technology, heat treatment of components produced by powder metallurgy technique; application of powder metallurgy in protection and repair of worn and corroded components.

MCE 806/906: Fine Particles Technology (3 Units)

Physical, chemical and engineering aspects of size reduction, communition theories, determination of breakage and selection functions, fine particle characterization and processing, filtration, thickening and classification, fluidization in extractive metallurgy and slurry pipeline systems.

MCE 807/907: Flotation Theory and Practice (3 Units)

Study of the relationship between surface properties and the flotation behaviour of metallic and non-metallic minerals; types of collectors, frothers and modifiers, mechanism of collection, flotation kinetics, commercial flotation equipment and industrial flowsheet; auxiliary operations including dewatering, tailings disposal, materials handling, etc.

MCE 808/908: Iron and Steel Making (3 Units)

Iron Ore benefication, agglomeration techniques, palletizing, balling, sintering, briquetting; fluxes for iron and steel making; fuels for iron and steel making; analysis of blast furnace and direct reduced iron technology; cast and wrought iron production; refining of steel; open-hearth, converter, and electric arc processes; de-phosphorization and desulphurization reactions, degasification; ferro-alloys and alloy steel production.

MCE 809/909: Hydrometallurgy (3 Units)

Extraction of non-ferrous metals from ores, concentrates and secondary metals by wet processes; thermodynamics, kinetics, electrochemical and mineralogical aspects of leaching; practical leaching systems including bacterial aided ones; recovery of metal values from leachates by chemical precipitation gaseous reduction, cementation, ion exchange and solvent extraction.

MCE 810/910: Biomaterials (3 Units)

Engineered materials in medical applications with an emphasis on material properties, functionality, design, and material response in biological environment.

MCE 811/911: Advanced Biomaterials (3 Units)

Formation and structure-function relations of biological materials, the interaction of tissue-synthetic biomaterials, advanced biomaterials design, biomimetic processing and current progress in drug delivery systems and biomedical devices.

MCE 812/912: Advanced Composite Materials (3 Units)

Understanding the properties and mechanical behaviour of composite materials. Emphasis on analysis, design, and manufacturing. Covers basics for understanding composite materials. Topics include introduction to composite materials, properties and forms of constituent materials, consideration of composite behavior and failure modes, characterization of material performance and testing, introduction to available manufacturing techniques, laboratory demonstrations and case studies.

MCE 813/913: Biomimetic Materials (3 Units)

A comprehensive study of the structure-function relation of biological hard tissues, and their application to the design and processing of novel materials and devices.

MCE 814/914: Interfacial Phenomena (3 Units)

Thermodynamics of interfaces (liquid/liquid, liquid/vapour, liquid/solid, solid/solid, solid/vapour); interfacial free energy (surface tension measurements in liquids); structure of solid surfaces and interfaces; kinetics of interfacial reactions, electrical double layer theory, theory of flocculation, coagulation and dispersion of collordal suspensions; applications in flotation, agglomeration, liquid surfactant membranes, emulsion and foaming.

MCE 815/915: Advanced Welding Technology (3 Units)

Study of processing variables in joining materials by welding, brazing and adhesive banding. Theories and applications of arc, gas, resistance and solid state welding processes. Modern methods of welding, examination of macro-and micro-structures of welds and the heat affected zones (HAZ). Solidication mechanics, residual stress effects, distortion control. Weldability criteria for ferrous and non-ferrous alloys.

MCE 816/916: Advanced Structure and properties of materials (3 Units)

Introduction to modern ceramic engineering. Quantitative treatment of oxides, nitrides, silicates, borides, carbides, electro-ferroceramics, glass, polymers, biometrical and composite materials. Physical, thermal, electrical, magnetic and optical properties. Mechanical properties and their measurement. Time, temperatures and environmental effects on properties. Applications.

MCE 817/917: Surface Engineering (3 Units)

Introduction and definition. Tribology: Mechanism of friction and wear, concepts and theory of friction, classification of wear, testing, lubrication studies. Modification of metal Surfaces: this comprises studies on surface engineering to change the surface metallurgy and chemistry, and also to add surface coating. Design guidelines for surface engineering.

MCE 818/918: Thermodynamics and Kinetics in Material Science (3 Units)

Laws of classical and irreversible thermodynamics, phase equilibria, thermodynamic theo ry of solutions, thermodynamics and kinetics of chemical reaction, surface and interfacial

phenomena, stressed systems, diffusion, statistical thermodynamics of gases and condens ed matter.

MCE 819/919: Materials selection (3 Units)

Material choice concepts, Material selection for production processes.

Fundamentals of engineering economics, manufacturing economics modeling methods, and life-cycle environmental evaluation. Stiffness properties of metals. Some important mechanical properties of metals and alloys. Value analysis. Materials for airframes.

Table 13: M.Eng. Programme Year 1 by Semesters - (Mechatronics Engineering Option)

M.Eng. I (Mechatronics Engineering Option) (1st Year)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE811	Advanced Numerical Analysis	C	3		MCE878	Control Sensors and Actuators.	C	3		
	MCE877	Modeling of Mechatronic Systems	C	3		MCE880	Mechatronics System Instrumentation	C	3		
	MCE853	Experimental Design and Analysis	C	3		MCE882	Introduction to MEMS and VLSI, Micro-fabrication	C	3		
	MCE879	Introduction to Sensors and Actuators	C	3		MCE890	Signals & Systems	C	3		
	CUR811	Research Methodology	C	3		MCE804	Engineering Colloquium (Seminar)	C	1		
	Sub Total			**15**		***Sub Total***			**13**		**28**
University Courses	EDS811	Entrepreneurial Development Studies	U	1							
	TMC811	Total Man Concept	U	1							
	Sub Total			**2**							2
	Total			**17**		**Total**			**13**		**30**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 1) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 3) Select (3 Units) from Electives***					
	MCE891	Automotive Mechatronics	E	3		MCE888	Embedded Systems	E	3		
	MCE885	Automation & Control Systems	E	3		MCE892	Mechatronics in Rural Infrastructure Development	E	3		
	MCE889	Digital System & PLC	E	3		MCE884	Experimental Method in Mechanics	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**20**		***Total***			**16**		**35**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 2) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 4) Select (3 Units) from Electives***					
	MCE887	Mechatronics System Design	E	3		MCE886	Robotics Engineering	E	3		
	MCE895	Artificial Neural Network	E	3		MCE882	Intelligent Control	E	3		
	MCE883	Intelligent Robotic System	E	3		MCE840	Management of Innovation & Engineering Management	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**23**		***Total***			**19**		**42**

Table 14: M.Eng. (Mechatronics Engineering Option) **Year 2 by Semesters**

M.Eng. (Mechatronics Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE800	Research/Project Dissertation Begins	C			MCE800	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 15a. M.Phil (Direct) Year 1 by Semesters.

M.Phil (Mechatronics Engineering Option)Year 1											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE811	Advanced Numerical Analysis	C	3		MCE879	Control Sensors and Actuators.	C	3		
	MCE877	Modeling of Mechatronic Systems	C	3		MCE880	Mechatronics System Instrumentation	C	3		
	MCE853	Experimental Design and Analysis	C	3		MCE881	Introduction to MEMS and VLSI, Micro-fabrication	C	3		
	MCE878	Introduction to Sensors and Actuators	C	3		MCE890	Signals & Systems	C	3		
	CUR811	Research Methodology	C	3		MCE882	Intelligent Control	E	3		
	MCE905	Seminar1 in area of specialisation	C	3		MCE957	Seminar2 in area of specialisation	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective Course	MCE887	Mechatronics System Design	E	3		MCE886	Robotics Engineering	E	3		
	Sub Total			3		**Sub Total**			3		6
	Total			**21**		***Total***			**21**		**42**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										**2**
	Total			**21**					**21**		**42**

Table 16b: M.Phil Year 2 by Semesters

M.Phil. (Mechatronics Engineering Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE900	Research/Project Dissertation Begins	C			MCE900	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 17:M.Phil/Ph.D Year 1 by Semesters.

M.Phil/Ph.D : Mechatronics Engineering Option											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	**Course Title**	**Status**	**Units**	**Pre-Requisite**	**Course Code**	**Course Title**	**Status**	**Units**	**Pre-Requisite**	
Compulsory Courses	MCE911	Advanced Numerical Analysis	C	3		MCE988	Embedded Systems	C	3		
	MCE977	Modeling of Mechatronic Systems	C	3		MCE992	Mechatronics in Rural Infrastructure Development	C	3		
	CUR911	Research Methodology	C	3		MCE982	Introduction to MEMS and VLSI, Micro-fabrication	C	3		
	MCE903	Seminar in area of specialization	C	3		MCE932	Seminar I	C	3		
	MCE911	Advanced Numerical Analysis	C	3		MCE933	Seminar II	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective	MCE987	Mechatronics System Design	E	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		
	MCE983	Intelligent Robotic System	E	3							
	MCE989	Digital Systems & PLC	E	3							
	Sub Total			**3**		**Sub Total**			**12**		**15**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total			**2**							**2**
	Total			**21**		***Total***			**30**		**51**

Table 18:Ph.D Direct Year 1

Ph.D: Mechatronics Engineering Option											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE911	Advanced Numerical Analysis	C	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		**12**
	MCE977	Modeling of Mechatronic Systems	C	3		MCE932	Seminar I	C			
	CUR911	Research Methodology	C	3		MCE933	Seminar II	C			
		Seminar in area of specialization	C	3							
	MCE911	Advanced Numerical Analysis	C	3							
	Sub Total			**21**					**12**		**33**
Elective	MCE987	Mechatronics System Design	E	3							
	MCE 883	Intelligent Robotic System	E	3							
	MCE989	Digital Systems & PLC	E	3							
	Sub Total			**3**							**3**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										
	Total			**24**					**12**		**36**

COURSE DESCRIPTION

Mechatronics Option (Masters, M.Phil./Ph.D and Ph.D)

MCE 877/977: Modeling of Mechatronics Systems (3 Units)

Modeling of mechanical, electrical, fluid elements and mixed mechatronic systems. Signal processing, signal conditioning. Sensors, data acquisition systems, actuators. Undergraduate courses in Circuit theory and electronics will be encouraged for those who don't have that background.

MCE 878/978: Introduction to Sensors and Actuators (3 Units)

Measurement of motion, stress, force, torque, temperature, flow and pressure; Principles of sensors and signal conditioning methods; selection and sizing of actuators.

MCE 879/979: Control Sensors and Actuators (3 Units)

Review of control, instrumentation and design. Performance specification of control components, component matching, error analysis. Operating principles, analysis, modeling, design considerations of control sensors and actuators such as analog sensors for motion measurement, digital transducers, stepper motors, DC motors, induction motors, synchronous motors, and hydraulic actuators. Control techniques pertaining to actuators. Applications.

MCE 880/980: Mechatronics System Instrumentation (3 Units)

Architecture of mechatronics devices; integration of mechanical, electronics, sensors, actuators, computer and real time software systems; PLC and PC based systems; discrete and continuous automation system design.

MCE 881/981: Introduction to MEMS and VLSI, Micro-fabrication (3 Units)

Fundamentals of MEMS (MicroElectroMechanical Systems). Micro-fabrication of MEMS with solid-state technology. LIGA and micro injection molding. Physics of MEMS. Operational principles of various MEMS devices. Micro-fabrication of MEMS: solid-state technology and other micromachining techniques Engineering principles of various MEMS devices. Fundamentals of VLSI, Micro-fabrication

MCE 882/982: Intelligent Control (3 Units)

Review of traditional control techniques and comparison with intelligent control; methods of representing and processing knowledge; conventional sets and crisp logic; fuzzy logic control; hierarchical fuzzy control; control system turning; industrial applications.

MCE 883/983: Intelligent Robotic Systems (3 Units)

System components and organization. Modeling and advanced and control techniques. Vision, tactile, laser and proximity sensing. Task planning, part technique planning, planning with uncertainty. Robot learning. Online application collision avoidance, object interception, robotic assembly. Students will be required to present a research seminar.

MCE 884/984: Experimental Methods in Mechanics (3 Units)

Operating principles of transducers for measuring typical quantities; the construction of transducers and factors controlling their measurement accuracy; electronic signal conditioning equipment and computerize data acquisition system.

Table 19: M Eng Programme Year 1 by Semesters - (Thermo-Fluids and Energy Systems Option)

M.Eng (Thermo-Fluids and Energy Systems Option) 1st Year											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE811	Advanced Numerical Analysis	C	3		MCE850	Advanced Thermodynamics	C	3		
	MCE851	Advanced Fluid Mechanics	C	3		MCE852	Advanced Computational Methods	C	3		
	MCE853	Experimental Design and Analysis	C	3		MCE864	Renewable Energy Systems	C	3		
	MCE855	Conduction Heat Transfer	C	3		MCE868	Advance Energy Conversion and Management	C	3		
	CUR811	Research Methodology	C	3		MCE804	Engineering Colloquium (Seminar)	C	1		
	Sub Total			**15**		***Sub Total***			**13**		**28**
University Courses	EDS811	Entrepreneurial Development Studies	U	1							
	TMC811	Total Man Concept	U	1							
	Sub Total			**2**							2
	Total			**17**		**Total**			**13**		**30**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 1) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 4) Select (3 Units) from Electives***					
	MCE857	Materials for Clean Energy Technologies	E	3		MCE871	Advanced Power Plant Engineering	E	3		
	MCE865	Energy and Environmental Economics	E	3		MCE872	Convection Heat Transfer	E	3		
	MCE867	Energy Planning and Auditing	E	3		MCE876	Gas Dynamics	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**20**		***Total***			**16**		**36**
Electives: **One elective in the area of specialisation**	***Area of Specialisation Option (Option 2) Select (3 Units) from Electives***					***Area of Specialisation Option (Option 5) Select (3 Units) from Electives***					
	MCE871	Advanced Nanotechnology in Alternate Energy Systems	E	3		MCE856	Radiation Heat Transfer	E	3		
	MCE860	Advanced Internal Combustion Engines	E	3		MCE870	Advanced Energy Conversion Systems	E	3		
	MCE874	Energy Optimization Techniques	E	3		MCE869	Advanced Building Services	E	3		
	Sub Total			**3**		***Sub Total***			**3**		**6**
	Total			**23**		***Total***			**19**		**42**

Table 20: M.Eng Year 2 by Semesters

M.Eng. (Thermo-Fluids and Energy Systems Option) Year 2											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE800	Research/Project Dissertation Begins	C			MCE800	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 21a. M.Phil (Direct) Year 1 by Semesters.

M.Phil Year 1(Thermo-Fluids and Energy Systems Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE811	Advanced Numerical Analysis	C	3		MCE850	Advanced Thermodynamics	C	3		
	MCE850	Advanced Fluid Mechanics	C	3		MCE852	Advanced Computational Methods	C	3		
	MCE853	Experimental Design and Analysis	C	3		MCE864	Renewable Energy Systems	C	3		
	MCE855	Convection Heat Transfer	C	3		MCE868	Advance Energy Conversion and Management	C	3		
	CUR811	Research Methodology	C	3		MCE870	Advanced Energy Conversion Systems	E	3		
	MCE905	Seminar1 in area of specialisation	C	3		MCE957	Seminar2 in area of specialisation	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective Course	MCE871	Advanced Nanotechnology in Alternate Energy Systems	E	3		MCE856	Radiation Heat Transfer	E	3		
	Sub Total			3		**Sub Total**			3		6
	Total			**21**		***Total***			**21**		**42**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										**2**
	Total			**21**					**21**		**42**

Table 16b: M.Phil Year 2 by Semesters

M.Phil. (Thermo-Fluids and Energy Systems Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE900	Research/Project Dissertation Begins	C			MCE900	Research/Project Dissertation Continues	C	6		
		TOTAL					**TOTAL**		6		**6**
										TOTAL	**48**

Table 17:M.Phil/Ph.D Year 1 by Semesters.

M.Phil/Ph.D (Thermo-Fluids and Energy Systems Option)											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	**Course Title**	**Status**	**Units**	**Pre-Requisite**	**Course Code**	**Course Title**	**Status**	**Units**	**Pre-Requisite**	
Compulsory Courses	MCE911	Advanced Numerical Analysis	C	3		MCE950	Advanced Thermodynamics	C	3		
	MCE951	Advanced Fluid Mechanics	C	3		MCE952	Advanced Computational Methods	C	3		
	MCE953	Experimental Design and Analysis	C	3		MCE964	Renewable Energy Systems	C	3		
	CUR911	Research Methodology	C	3		MCE932	Seminar I	C	3		
	MCE903	Seminar in area of specialisation	C	3		MCE933	Seminar II	C	3		
	Sub Total			**18**		**Sub Total**			**18**		**36**
Elective	MCE967	Energy Planning and Auditing	E	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		
	MCE955	Convection Heat Transfer	E	3							
	MCE966	Conductive Heat Transfer	E	3							
	Sub Total			**3**		**Sub Total**			**12**		**15**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total			**2**							**2**
	Total			**21**		***Total***			**30**		**51**

Table 18:Ph.D Direct Year 1

Ph.D: Thermofluids and Energy Systems Option											
	ALPHA SEMESTER					OMEGA SEMESTER					
	Course Code	Course Title	Status	Units	Pre-Requisite	Course Code	Course Title	Status	Units	Pre-Requisite	
Compulsory Courses	MCE911	Advanced Numerical Analysis	C	3		MCE900	**Thesis:** ***College Proposal** ***College Post-Field** ***Oral Defence (Viva)**	C	12		**12**
	MCE964	Renewable Energy Systems	C	3		MCE932	Seminar I	3			
	MCE953	Experimental Design and Analysis	C	3		MCE934	Seminar II	3			
	CUR911	Research Methodology	C	3							
		Seminar in area of specialization	C	3							
	Sub Total			**21**					**12**		**33**
Elective	MCE967	Energy Planning and Auditing	E	3							
	MCE955	Convection Heat Transfer	E	3							
	MCE966	Conductive Heat Transfer	E	3							
	Sub Total			**3**							**3**
University Courses	EDS911	Entrepreneurial Development Studies IX	U	1							
	TMC911	Total Man Concept	U	1							
	Sub Total										
	Total			**24**					**12**		**36**

COURSE DESCRIPTION

Thermo-Fluids and Energy Option (Masters, M.Phil./Ph.D and Ph.D)

MCE 850/950: Advanced Thermodynamics (3 Units)

First and second laws of thermodynamics, equilibrium (principles and criteria for equilibrium, chemical and thermodynamic equilibrium), enthalpy, entropy and availability, one and two dimensional systems, Maxwell relations, principles of open and closed system, ideal and real gases, phase rule, equation of state and thermodynamic potentials, dilute gas properties, chemical reaction and heat of formation, combustion processes, third law of thermodynamics, kinetic theory, statistical thermodynamics (Boltzman and quantum). Introduction to statistical mechanics.

MCE 851/951: Advanced Fluid Mechanics (3 Units)

Governing equations; viscous incompressible flow, incompressible potential flow; incompressible boundary layers, stability and turbulence; compressible potential flow. Concept of continuum, thermodynamic relationships, methods of describing fluid flow and the kinematics of fluid flow, macroscopic properties of fluids, continuity equations. Langragian and Eulerian specifications, forces, stress and strain relations, Navier-Stokes equations and their solutions, inviscid compressible and incompressible flows, viscous compressible and incompressible flows, boundary conditions, flow through different channels, steady viscous incompressible pipe flow, creeping motion.

MCE 852/952: Advanced Computational Methods (3 Units)

Selected advanced topics in CFD, typically chosen from: Finite volume methods on curvilinear meshes and structured mesh generation. Finite volume methods on unstructured meshes. Multigrid methods for elliptic PDE's. Reynolds-averaged form of the Navier-Stokes equations and turbulence modeling. Three-dimensional flows. Compressible flows. Application of CFD to solving linear and non-linear partial differential equation with practical examples, application in combustion modelling, thermal analysis, laminar and turbulent flows, Finite difference etc.

MCE 853/954: Experimental Design and Analysis (3 Units)

Definitions of experiment, types of experiments, statistical design and analysis of engineering experiments: Statistical Tools: The Concept of Random Variable, Probability, Density Function, Cumulative Distribution Function, Sample and Population, Measures of Central Tendency of a Population, Population mean, Population median, Population mode. Measures of Central Tendency of a Sample (Sample mean, Sample median, Sample mode), Measures of Variability of a Population, Measures of Variability of a Sample, The Concept of Confidence Level, The Concept of Reliability, Degrees of Freedom, The Concept of Ranking (Median ranks, Other ranks, Suspended items). Statistical Distributions: Normal Distribution (The standardized normal variate, The cumulative distribution function, Log Normal Distribution), The Weibull Distribution (Two-parameter (θ, b) Weibull function, Three-parameter (θ, b, x_o) Weibull function), Exponential Distribution, Binomial Distribution, Hypergeometric Distribution, Poisson Distribution, Determination and

Application of Statistical Distributions. Experiments of Evaluation, Normal Distribution (Estimate of the uniformity of a product, Estimate of the quality of a product, Estimate of the population limits of a product), Weibull Distribution (Estimate of the uniformity of a product, Estimate of the quality of a product), Binomial Distribution, The Outliers (Modified three-sigma test, The Dixon method, The Grubbs method). Experiments Of Comparison: Preliminary Approach (Normal distribution, Weibull distribution), Detailed Approach (Absolute comparison of two products, Relative comparison of two products), Accelerated Experiments, Factorial Experiments, Sequential Experiments, Nonparametric Experiments, Fatigue Experiments, Analysis of Interference Data, Analysis of Systems, Analysis of Laboratory and Field Data, Correlation, Regression, And Variation Analysis, Renewal Analysis.

MCE 854/954: Fuel Cell Systems (3 Units)

Energy system architecture and electrochemical energy conversion; fuel cell thermodynamics and electrochemistry; Proton Exchange Membrane Fuel Cells (PMFCs) and Solid Oxide Fuel Cells (SOFCSs); hydrogen production, storage, and distribution.

MCE 855/955: Conduction Heat Transfer (3 Units)

Conduction: Derivation of heat conduction equation. Summary of basic 1D conduction. Fins with variable cross-section. Multi-dimensional steady and unsteady problems in Cartesian and Cylindrical coordinates. Semi-infinite solids. Duhamel's Superposition Integral. Solidification and Melting. Inverse heat conduction. Microscale heat transfer.

MCE 856/956: Radiation Heat Transfer (3 Units)

Monochromatic and goniometric surface properties. Energy exchange of grey, non-grey, diffuse, directional, or specular surfaces, Absorption coefficient and radiation intensity in gas radiation. Radiation between a gas and its enclosure. Radiation of luminous flames.

MCE 857/957: Materials for Clean Energy Technologies (3 Units)

Introduction to operation of gas turbines and fuel cells. Diffusion and migration in solids. Fundamental basis of ionic, electronic, and mixed conductivity in fuel cell materials. Thermal barrier coatings for gas turbines. Material constraints in wind turbines.

MCE 859/959: Combustion (3 Units)

Thermodynamics of combustion, stoichiometry, heat of formation and reaction. Equilibrium composition and adiabatic flame temperature. Chemical kinetics of combustion. Flames in premixed gases; laminar and turbulent flame propagation. Diffusion flames, pollutant emissions and combustion in IC engines.

MCE 860/960: Advanced Internal Combustion Engines (3 Units)

Analysis of spark and compression ignition engines. Calculation of fuel economy, power and emission. Practical considerations in engine design.

MCE 861/961: Theory of Ideal Fluids (3 Units)

Topics selected from the kinematics and dynamics of inviscid incompressible fluids in steady and non-steady motion; two-dimensional and axisymmetric potential flows; applications of conformal mapping; free streamline flows; vortex motions.

MCE 862/962: Low speed Aerodynamics (3 Units)

Circulation, vorticity and Kelvin's Theorem. Potential flow theory and the Kutta-Joukowski Law 2D Vortex Panel. Method Laminar and turbulent boundary layer computations. Lifting line theory. Vortex Lattice Method. High lift devices. Total airplane drag.

MCE 863/963: Experimental Fluid Mechanics (3 Units)

Modeling Test facilities. Wind tunnel force measurement. Theory of conventional and modern manometry. Classical velocimetry. Hotwire anemometry. Theory and application of laser Doppler velocimetry. Particle image velocimetry. Flow visualization techniques. Thermometry.

MCE 864/964: Renewable Energy Systems (3 Units)

Sources and types of renewable energies, the role of renewable energy sources (in cluding advantages and possible disadvantages over conventional sources), global en ergy consumption, solar energy resources, principles of solar- thermal and photovoltaic (PV) energy systems, availability of solar energy resources in Nigeria and globally, analysis of solar insolation and irradiation, wind energy resources, wind energy technology environmental impacts of wind turbines, development of wind energy for commercial purposes, assessment methods of wind energy resources for power generation (e.g. use of Weibull, normal and log- normal, unimodal and bimodal, Rayleigh, etc), geothermal resources, origin and types of geothermal energy, utilization of geothermal energy for power generation, operational problems of geothermal energy, wave and tidal power: meaning, availability, resource application, origin and characteristics, utilization technologies, operation and management, hydropower resources, availability in Nigeria, Small Hydro Power (SHP) systems, environmental impacts of large hydro power systems, principle of water recycling in hydro power systems, biomass energy and its application, principle of its availability, utilization of biomass for power generation, biomass for fuel production. Other renewable energy resources should be studied along the areas mention above for each.

MCE 865/965: Energy and Environmental Economics (3 Units)

Environmental impacts and regulations, Emission trading, International legislation on emission, energy and sustainable development, global energy access, renewable energy development in Africa, Europe, North and South America and Asia, geopolitics and energy prices, energy subsidies, environmental impact assessments of conventional and renewable energy sources, energy economics and green conservation, challenges of renewable energy development in developing nations

MCE 867/967: Energy Planning and Auditing (3 Units)

Sources of energy waste in industrial and domestic sectors, Measurement of energ y loss, Energy and equipment efficiency, measures of energy conversion, energy ma nagement in industry, energy audit and audit report, building heating and cooling l oads determination, ventilation and air-conditioning, ventilation and infiltration, industrial buildings, industrial heating process (high and low temperature heating, combustion efficiency). Group projects: the students will be required to choose practical case studies and carry out energy audit and energy efficiency study on any particular industry, commercial sector or residential building and come up with technical article which will provide recommendations for adequate energy management

MCE 871/971: Advanced Nanotechnology in Alternate Energy Systems (3 Units)

The unique surface properties and the ability to surface engineer nanocrystalline st ructures in devices renders nano- crystalline materials to be ideal candidates for use in structural materials, corrosion coatings, and catalysts in energy conversion devices such as electrolysers, energy storage media and fuel cells. These new devices are poised to have major impacts on power generation utilities, the automotive sector, and society at large. The differences in observed electrochemical behavior between amorphous, nano-crystalline and polycrystalline solid materials will be discussed in terms of their surface structure and surface chemistry. A group design project competition, sponsored by the Ontario Centre of Excellence in Energy, allows students from various disciplines to work together to formulate a proposal including technical, economic, and environmental solutions to a problem.

MCE 872/972: Convection Heat Transfer (3 Units)

Governing equations for laminar and turbulent flow. Forced convection in internal and external flow. Free, and combined free forced convection. Heat transfer at high velocities, in rarefied gases and in two-phase flow. Mass Transfer.

MCE874/974 Energy Optimization Techniques (3 Units)

Modelling overview-levels of analysis, steps in model development, examples of models. Quantitative Techniques: Interpolation-polynomial, Lagrangian. Curve-fitting, regression analysis, solution of transcendental equations. Systems Simulation-information flow diagram, solution of set of nonlinear algebraic equations, successive substitution, Newton Raphson. Examples of energy systems simulation Optimisation : Objectives/constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimisation- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions. Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate. Case studies of optimisation in Energy systems problems. Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis. Energy- Economy Models: Scenario Generation, Input Output Model. Numerical solution of Differential equations- Overview, Convergence, Accuracy. Transient analysis-application example.

MCE 875/975: Turbine Plant Performance (Wind, Gas & Steam Turbines) (3 Units)

Wind Turbines: Types and their specific advantages, basic components of wind tur bines and their underlining principles, Design and analysis of wind turbines, effect of turbulence, Betz law, capacity factor, the power curve, Gas Turbines: Principle of operation of the gas turbine power plants, basic components and their underlining principles, Design and analysis of gas turbines, optimization of gas turbines, performance evaluation, regeneration, reheat and inter-cooling, Steam Turbines: Principle operation of the steam turbine power plants, basic components and their underlining principles, Design and analysis of steam turbines, performance evaluation, fed trams optimization, reheat cycles.

MCE 876/976: Gas Dynamics (3 Units)

Introduction, One dimensional flow basics, Normal shock waves, Flow with heat addition – Rayleigh flow, Flow with Friction – Fanno Flow, Quasi One dimensional Flows, Oblique shock waves, Prandtl Meyer Flow.