MASTER OF SCIENCE (MECHANICAL ENGINEERING)

PROGRAMME SPECIFICATIONS

The Master of Science in mechanical engineering offers a broad and diverse subject that derives its breadth from the need to analyse and design various mechanical components. Throughout the period of study, students may learn about materials, solid and fluid mechanics, thermodynamics, heat transfer, control, instrumentation and design to comprehend various mechanical systems. The breadth of the mechanical engineering discipline allows students a variety of career options. For those interested in applied scientific and mathematical aspects of the discipline, graduate study in mechanical engineering programme can lead to a career of research and teaching.

This programme is offered either on a full-time or part-time basis. The full-time programme is offered only at the UTM Main Campus in Johor Bahru while the part-time programme is offered at various learning centres throughout Malaysia. The normal full-time program can be completed in a minimum of one year, i.e. two long semesters and one short semester. The full-time student is allowed to take a maximum of 20 credits in a normal semester and 10 credits in a short semester. The part time student is allowed to take a maximum of 12 credits in a normal semester and 6 credits in a short semester. Assessment is based on coursework and final examinations given throughout the semester.

General Information

1. Awarding Institution			**Universiti Teknologi Malaysia**	
2. Teaching Institution			Universiti Teknologi Malaysia	
3. Programme Name			Master of Science (Mechanical Engineering)	
4. Final Award			Master of Science (Mechanical Engineering)	
5. Programme Code			MKMM	
6. Professional or Statutory Body of Accreditation			Malaysian Qualification Agency, MQA	
7. Language(s) of Instruction			English	
8. Mode of Study			Conventional	
9. Mode of operation			Self-governing	
10. Study Scheme (Full Time/Part Time)			Full Time / Part Time	
11. Study Duration			Minimum : 1 year Maximum : 4 years	
Type of Semester	No. of Semesters		No of Weeks/Semester	
	Full Time	Part Time	Full Time	Part Time
Normal	8	8	14	14
Short	4	4	8	8

Course Classification

Course Category	Code	Course	Credit	Percentage
University General Courses	U### ###3	University Elective	3	7.5%
Programme Core	MKMM 1213	Advanced Engineering Mathematics	3	22.5%
	MKMM 1223	Instrumentation, Measurement & Control	3	
	MKMM 1903	Research Methodology	3	
Project	MKMM 1914	Master Project I	4	25%
	MKMM 2926	Master Project II	6	
Programme Electives (choose 6 courses only)	MKMM 1133	Fatigue and Fracture Mechanics	3	45%
	MKMM 1153	Computational Method in Solid Mechanics	3	
	MKMM 1163	Advanced Material	3	
	MKMM 1183	Theories of Elasticity and Plasticity	3	
	MKMM 1233	Acoustics	3	
	MKMM 1243	System Modelling and Simulation	3	
	MKMM 1253	Advanced Industrial Automation	3	
	MKMM 1263	Conditional Monitoring	3	
	MKMM 1283	Vibration Measurements and Control	3	
	MKMM 1293	Structural Dynamics	3	
	MKMM 1313	Advanced Fluid Mechanics	3	
	MKMM 1323	Compressible Flow	3	
	MKMM 1333	Computational Fluid Dynamics	3	
	MKMM 1413	Advanced Thermodynamics	3	
	MKMM 1423	Energy Management	3	
	MKMM 1433	Advanced Heat Transfer	3	
	MKMM 1443	Advanced Combustion	3	
	MKMM 1453	Sustainable Energy Technology	3	
	MKMM 1463	Computational Heat Transfer	3	
	MKMM 1543	CAD and its Application	3	
	MKMM 1553	Engineering Optimization	3	
	MKMM 2123	Plates, Shells and Pressure Vessels	3	
	MKMM 2143	Advanced Mechanics of Composite structure	3	
	MKMM 2153	Structural Reliability	3	

	MKMM 2163	Crashworthiness and Structural Impact	3	
	MKMM 2213	Adaptive Control and Intelligent system	3	
	MKMM 2243	Robot Systems and Control	3	
	MKMM 2253	Advanced Control Engineering	3	
	MKMM 2283	Mechatronic System Design	3	
	MKMM 2413	Thermo Fluid Measurement and Diagnostic	3	
	MKMM 2443	Internal Combustion Engines	3	
	MKMM 2453	Advanced Refrigeration and Air Conditioning System	3	
	MKMM 2513	Design Engineering	3	
	MKMM 2523	Reliability Methods in Engineering Design	3	
	MKMM 2543	Graphics in CAD	3	
	MKMM 2553	Virtual Reality for Engineers	3	
Total Credit Value			**40**	**100%**

Program Educational Objectives (PEO)

PEO1: Graduate are able to apply the knowledge gained to identify, develop solution and solve problems related to mechanical engineering in various situations, effectively and ethically.

PEO2: Graduates are able to communicate and present ideas intellectually and effectively.

PEO3: Graduates are able to conduct research, manage and publish information and continue life-long learning

Program Learning Objectives (PLO)

PLO1: Demonstrate advanced knowledge and capabilities to further develop or use these for new situations in mechanical engineering.

PLO2: Demonstrate research skills in appraising available information and research evidence, and applying them in mechanical engineering contexts.

PLO3: Apply critical thinking and problem-solving skills in addressing mechanical engineering problems utilizing relevant tools and techniques.

PLO4: Perform research on mechanical engineering problems professionally, ethically and responsibly.

PLO5: Communicate technical knowledge and ideas effectively in written and oral forms.

PLO6: Adopt the latest relevant knowledge and technologies through life-long learning.

GRADUATION CHECKLIST

To graduate, students must pass all the stated courses in this checklist. It is the responsibility of the students to ensure that all courses are taken and passed. Students who do not complete any of the course are not allowed to graduate.

NO.	CODE	COURSE	CREDIT EARNED (JKD)	CREDIT COUNTED (JKK)	TICK (√) IF PASSED
UNIVERSITY GENERAL COURSES					
1	U### ###3	University Course Electives	3	3	
TOTAL CREDIT of UNIVERSITY GENERAL COURSES (a)			3	3	
PROGRAMME CORE COURSES					
1	MKMM 1213	Advanced Engineering Mathematics	3	3	
2	MKMM 1223	Instrumentation, Measurement & Control	3	3	
3	MKMM 1903	Research Methodology	3	3	
TOTAL CREDIT OF PROGRAMME CORE COURSES (b)			9	9	
MASTER PROJECT COURSES					
1	MKMM 1914	Master Project I	4	4	
2	MKMM 2926	Master Project II	6	6	
TOTAL CREDIT OF MASTER PROJECT COURSES (c)			10	10	
PROGRAMME ELECTIVES (6 COURSES)					
1	MKMM ###3	Elective 1	3	3	
2	MKMM ###3	Elective 2	3	3	
3	MKMM ###3	Elective 3	3	3	
4	MKMM ###3	Elective 4	3	3	
5	MKMM ###3	Elective 5	3	3	
6	MKMM ###3	Elective 6	3	3	
TOTAL CREDIT OF ELECTIVES COURSES (d)			18	18	
TOTAL CREDIT TO GRADUATE (a + b + c + d)			**40**	**40**	

COURSE SYNOPSIS

CORE COURSES

MKMM1213 - **Advanced Engineering Mathematics**
This course takes students into a mathematical realm needed by engineers to describe and solve advanced engineering problems. It first introduces Laplace transforms, series and several approximation schemes as tools for solving IVP in ordinary differential equations. The course also lays emphasis on partial differential equations as mathematical models, using wave, heat and potential equations to connect with engineering applications. Complex functions and conformal mappings are also addressed. Vectors and tensors are included to study the analytical geometry of space and extended to paths (lines, planes, surfaces and curves) and motions of objects (velocities and accelerations) moving in a plane or in space, and quantities that describe how an object's path can turn and twist in space.

MKMM 1223 - **Instrumentation, Measurement and Control**
The course shall cover the essentials of both instrumentation and control aspects for graduate students. It will emphasize on the concepts of instrumentation system, characteristics of instrumentation system, signal conditioning, transducers, output devices and continuing system. At the end of the course, students should be able to acquire knowledge on the important principles of an instrumentation system, relate and describe the operating principle and application of various transducers that are typically used in industry, design instrumentation system for measuring load, displacement, temperature and other physical quantities, select suitable instrumentation components and tools for intended application and solve problems related to basic instrumentation system. Special emphasis is given on the microcomputer-based application and data acquisition technique. The control section shall encompass the essence of control theory, mathematical modelling of dynamical system, time response, control action, stability analysis, frequency response and design of control system. A number of practical case studies shall be presented to include modelling and simulation of systems using MATLAB and Simulink.

MKMM 1903 - **Research Methodology**
This course aims to provide students with fundamental knowledge of research and the methodologies commonly used in engineering. It encompasses literature review, problem formulation, designing research methods, analysis methods and report writing

MKMM 1914 - **Master Project I**
The Master project is an essential course of the master programme where substantial piece of independent work is required. Master Project I requires a student to prepare a research proposal which will be conducted over two semesters (Projects I and II). Master Project I covers project introduction (problem statement, objective and scope), literature review, methodology, proposed method of solution, provide preliminary data and research model and planning for Projects I and II. The student is required to write a draft report and to present and defend his/her research proposal.

MKMM 2926 - **Master Project II**
Master Project II is a continuation of Master Project I. The student conducts the research work either in a laboratory, workshop, computer laboratory, or industry. The student then required to do data collection, analyses data and interpret the results to solve the research problem that has been identified in Master Project I. The student is required to write a complete report and defend the findings. On top of the report writing, student also requires to produce a technical article based on the project findings.

ELECTIVE COURSES - SOLID MECHANICS

MKMM 1133 - **Fatigue and Fracture Mechanics**
This course describes the theories of metal fatigue and fracture mechanics, and their applications to engineering structures. Both aspects of materials (metallurgical) and mechanics of the failure processes are discussed. Stress-life and strain-life approaches to fatigue analyses are described. Linear elastic fracture mechanics (LEFM) are elaborated. Fatigue crack propagation behaviour in pre-cracked solids is discussed. Relevant applications of fatigue, LEFM and fatigue crack growth analyses in design and life assessment of engineering structures are demonstrated

MKMM 1153 - **Computational Method in Solid Mechanics**
This course extends the undergraduate-level introduction to the Finite Element Method for obtaining approximate solution to a wide variety of engineering problems in mechanics of materials and structures. The scope of analysis covers elastic-plastic range of continuous materials behaviour, including low-cycle fatigue. Emphasis is placed on mathematical derivation of the constitutive equations for numerical implementation. Process and procedures in finite element modelling and simulation of realistic engineering problems are described and rigorously discussed using examples in plane, axi-symmetric and 3-D analyses in solid mechanics. Physical interpretation of full 3-D finite element simulation results is discussed.

MKMM 1163 - **Advanced Material**
This course familiarizes students in the latest developments on the various classes of new advanced materials relevant for applications in aerospace, automotive, biomedical and electronic industries. It also covers the core materials topics of metals, polymers, ceramics, composites, bio- and electronics materials, and emphasizes on the structure-properties-processing relationship that make the new and smart materials selected for high-end applications. At the end of the course students should be able to gain fundamental understanding of the structural, physical and mechanical properties of advanced materials and develop a specialized knowledge to select suitable materials for a high-level engineering project.

MKMM 1183 - **Theories of Elasticity and Plasticity**
This course introduces students to some major views and theories in the area of elasticity and plasticity. Evaluate the stress functions of plane stress and plain strain problems, in rectangular and polar coordinate systems. Determine the stress distributions and resultants in beams, plates, cylinders and disc by using the stress function concept. Determine the yielding of ductile materials, and comparison between Tresca and von Mises in σ, τ stress space. Evaluate the elastoplastic in bending and torsion and also elastic-plastic bending with strain

hardening in beams. Evaluate limit analysis of axially loaded member to derive initial yield surface and limit surface assuming perfectly plasticity and plot the interaction diagrams.

MKMM 2123 - **Plates, Shells and Pressure Vessels**
In this course, students are provided with the definitive concepts and principles of pressure vessel design. Students are introduced to the basic theories of elasticity, bending of rectangular and circular flat plates and background analysis of shell theory. Concepts of plasticity, limit analysis, shakedown, design-by-rule and design-by-analysis are covered. In the former the course covers topics built around the relevant Standards, principally the BS and ASME. Examples are used to illustrate the various topics required to design the majority of 'basic' pressure vessels. In the latter, students are provided with an introduction to the stress analysis of pressure vessels: shell analysis, finite element analysis and the basic concepts of DBA. Pressure vessel components are encompassed within topics including design of dished ends, including buckling aspects, design for external pressure, local loading, supports and mountings, nozzle design and branch connections. At the end of the course, students will be able to consider how the shape and configuration of the vessel will perform under service loading and design them so that they are fit for service.

MKMM 2143 - **Advanced Mechanics of Composite structure**
This course introduces students to some major views and theories in the area of composite materials especially in the polymer based composite learning with emphasis on the types of materials, production methods, failure analysis and the mechanics of laminated composites. It will examine some key issues in the mechanics of laminated composites with special focus on the stress-strain relationship and interaction to the extensional, coupling and bending stiffness matrices in promoting learning. Sandwich structures and inter-laminar fracture toughness will also be included in this syllabus. The course will also provide a visit to industries dealing with polymer based composite materials in order the students to understand more regarding the practical sides of the subject.

MKMM 2153 - **Structural Reliability**
This course is designed to acquaint the student with in-depth study of reliability engineering and its application in structural analysis.

MKMM 2163 - **Crashworthiness and Structural Impact**
The course introduces and provides the basic principles involved in the impact and design of crashworthy structures. It aims to extend the student's knowledge and understanding of the behaviour of materials and structures under large deformation effects due to the various impact loading conditions. The course covers local collapse, energy absorption capability and failure modes of crashworthy structures namely thick-walled structures, thin-walled tubular structures, honey-comb, metallic foam and polymeric foam. The students are duly exposed to crashworthiness design features and virtual work approach for calculating energy absorption capacity and identifying collapse mechanism by employing established theoretical models. Crash energy management is succinctly introduced in the context of structural design in overall crashworthiness requirement practically in impact applications namely automotive, aviation and marine structures. The impact behaviour of ductile material is of primary interest, in particular for simple structural members. An understanding of their response is an essential prerequisite for revealing the dynamic behaviour of a more complex system. Projects assigned

to the students require their skill in demonstrating typical crash simulation and impact analysis numerically. At the end of the course, students should comprehend the key issues of structural crashworthiness and demonstrate an understanding of energy absorption capability of structures. In the oral presentation and report writing, they also must be able to critically evaluate the crashworthiness of structures by using underlying principles of impact analysis.

ELECTIVE COURSES - ENGINEERING DESIGN

MKMM 1543 - **CAD and its application**
The principal objective of this course is to enable the student to use the computer in all aspects of the engineering design process. At the end of the class you should be able to use computers to understand the basic theories of CAD, model reasonably complex mechanical systems using a solid modelling tool, and perform basic engineering analysis using FEA to predict mechanical behaviour and modify designs for better performance.

MKMM 1553 - **Engineering Optimization**
Optimization involves finding the 'best' solution according to specified criteria. In Engineering Design, this might typically be minimum cost or weight, maximum quality or efficiency, or some of the performance index pertaining to a disciplinary objective. Realistic optimal design involves not only an objective function to be minimized or maximized, but also constraints that represent limitations on the design space. Numerical programming requires the mathematical representation of the design space (objective function and constraints) in terms of 'design variables- (parameters that signify some potential for change). Generally, the problem of interest in engineering is of a non-linear nature, in that the dependence of the objective function and constraints on the design variables is non-linear. This course introduces the traditional non-linear optimization methods that can be used to solve a wide range of problems across all engineering disciplines. By the end of the semester the student will have gained a basic knowledge of numerical optimization algorithms and will have sufficient understanding of the strengths and weakness of these algorithms to apply them appropriately in engineering design. Students will write simple code as well as use off-the-shelf routines to gain experience and appreciation.

MKMM 2513 - **Design Engineering**
This course is designed for students to gain detailed topical exposure to design methodologies and principles specific to the practice of mechanical design. Emphasis is on developing efficient and effective design techniques as well as project-oriented skills from both technical and non-technical consideration. At the end of this course, students should be able to identify and apply appropriate methodology in performing design tasks, recognize the fundamental principles of mechanical design and practices, and formulate and apply general problem solving strategy in the analysis of situation, problem and potential problem. At the end of this course, students should be able to identify and apply industry standards in design communication.

MKMM 2523 - **Reliability Methods in Engineering Design**
The course aims at providing understanding of the statistical nature of design parameters (i.e.: stress and strength) as well as material properties and design performance. These understandings are used to develop design for reliability concepts. The basic concepts are

extended to 'real world' problems, such as fatigue analysis, through class examples and case studies. Emphasis is placed on application to the optimization and reliability simulation of engineering designs. Some special topics on real life application are discussed. Although emphasis is on mechanical designs and structures, the concepts can be extended to other specialties in mechanical engineering (energy and fluids, and systems and dynamics). Knowledge in undergraduate level Probability and Statistic is recommended for this class.

MKMM 2543 - **Graphics in CAD**
The principal objective of this course is to enable the student to use the computer in all aspects of the engineering design process. At the end of the class you should be able to use computers to understand the basic theories of CAD, model reasonably complex mechanical systems using a solid modelling tool, and perform basic engineering analysis using FEA to predict mechanical behaviour and modify designs for better performance.

MKMM 2553 - **Virtual Reality for Engineers**
The course will introduce techniques used to synthesize and recreate the real world by imitating its physical, visual and audio stimuli and “immersing” a person in one such artificially created environment especially for engineers. To achieve this, OpenGL programming will be used and its applications will focus on kinematics such as robot arm, slider crank. This course will expose students to current research performed and look at future scope of the same.

ELECTIVE COURSES - SYSTEM DYNAMICS AND CONTROL

MKMM 1233 - **Acoustics**
This course prepares the future engineers with the physical principles of acoustics together with the tools and analysis techniques for sound measurements. Students will be taught on the physics of sound, measurement instrumentations, analysis techniques, sound inside room and enclosure, transmission of sound through structure and outdoor sound. Students will also be introduced and exposed to the typical acoustic and sound measurement instrumentations available in the acoustics laboratory. The project/s assigned to students during this course requires understanding on the basic principles of sound along with the use of sound measurement instrumentations and data analysis. At the end of this course, students should understand thoroughly all the underlying physical principles of acoustics and should be able to measure and analyze sound levels whenever required.

MKMM 1243 - **System Modelling and Simulation**
This course prepares the students to grasp the fundamentals of modelling and simulation concept, philosophy and its implementation. The course covers the importance, the dangers and pitfalls of modelling and simulation. The course shall also covers various types of models, validation of models; derivation of mathematical models of dynamical systems based on a number of techniques. Design tools, simulation software, verification tools and case studies shall be introduced to the students.

MKMM 1253 - **Advanced Industrial Automation**
Automation components, industrial pneumatics, industrial hydraulics, industrial sequences control system and application, programmable logic controller and microprocessor-based control, Computer Integrated Manufacturing (CIM), class projects.

MKMM 1263 - **Conditional Monitoring**
The course relates to practical aspects of maintenance and assets management practices in industry. It focuses on the condition base maintenance strategy where condition monitoring is the key aspects of its success. Several condition monitoring techniques such as vibration, ultrasonic, thermography, oil analysis/tribology based analysis, acoustic emission, temperature monitoring and performance monitoring are discuss in details. Important aspects of data acquisition, signal processing and data interpretation are covered in details. The course involves practical exercises to demonstrate and to apply knowledge in condition monitoring.

MKMM 1283 - **Vibration, Measurement and Control**
The course relates to practical aspects of vibration measurements and the control of vibration in mechanical and engineering systems. Cause and effects of vibration related failures are presented that highlight the importance of measurements, diagnosis, assessment and control of vibration in the industry. A review of vibration basics from a measurement perspective is presented. Important aspects of vibration data acquisition, signal processing and data interpretation are covered. Topics in vibration fault analysis, avoidance of vibration induced failures, reduction of vibration and design of control solutions are covered. The course involves measurements and design exercises to demonstrate and to apply knowledge in vibration instrumentation and control.

MKMM 1293 - **Structural dynamics**
Structural dynamics look into the vibrating or oscillating of mechanical structure subjected to dynamic loads. These structures are continuous system thus requiring wave propagation methods in determining the dynamic response of various beams, rods, shafts and plates. Mobility technique in determining and measuring the response of structures are introduced. Topics also cover on analytical and experimental modal analysis, determine the natural frequencies, damping and the corresponding mode shapes of structure in motion. Vibration measurement instrumentations are introduced and laboratory works are offered related to the mobility of structures and modal testing and analysis.

MKMM 2213 - **Adaptive Control and Intelligent system**
This course shall cover the essential and basic theory of adaptive control engineering and intelligent systems. It shall cover the followings: System identification using least squares, generalized least squares, recursive least squares, adaptation concepts, theory of adaptive algorithms, and their use in control and estimation, servo follower and regulator, self-tuning and adaptive model reference controllers. The intelligent system part shall cover the history, basic theory and architecture of Neural Network (MLP), Adaptive Recurrent Neural Networks and Genetic Algorithms. MATLAB and Simulink software package shall be demonstrated and used as a tool in solving system identification, adaptive control and artificial intelligent problems throughout the course.

MKMM 2243 - **Robot systems and control**
This course is designed to enable the students at graduate level to develop the necessary insight into the areas of robotic and control. It will examine the fundamental elements of robot system related to anatomy and configuration, robot main components, programming feature and methods and robot's performance specifications. The students are expected to acquire

analytical skills through the analyses of robot manipulators related to their kinematics, statics and dynamics which typically constitute the important prerequisites to designing the mechanical structure, planned trajectory path and control aspects. The robot control topic that is included in the later section provides a platform for the students to explore the various control algorithms that address the stability, accuracy and robustness of the systems. Particular emphasis is laid on the mathematical modelling and simulation of the control schemes. A number of case studies pertaining to selected robotic systems are expected to further strengthen the students understanding and insight into the actual systems.

MKMM 2253 - **Advanced Control Engineering**
This course prepares the students to grasps the concept, theory and application of topics of modern control system theory for advanced graduate students with adequate preparation in linear discrete and continuous system theory.

MKMM 2283 - **Mechatronic System Design**
The course is geared towards providing students with the necessary knowledge on various aspects of mechatronic system design (MSD). The topics in this course include introduction to MSD with emphasis on understanding the mechatronic philosophy, components and MSD vs traditional approach; mechatronic design and method that encompasses the modelling and simulation tool, the hardware and software implementation; controllers (PC, PLC and PIC) artificial intelligence (AI) and adaptive elements in mechatronic system; and practical case studies to demonstrate real-world applications.

ELECTIVE COURSES - THERMOFLUIDS

MKMM 1313 - **Advanced fluid mechanics**
This course is intended for graduate students wishing to major in Fluid Mechanic. In this course Fluid Mechanics is approached analytically starting with the derivation of basic governing equations for fluid dynamics namely continuity, momentum and energy equations in the differential form. These basic equations are then simplified further to suit viscous incompressible flow. Special forms of the governing equations are also introduced. The course begins with revision of the previous fluid mechanics basic theories. Next, viscous flow of incompressible fluids is attended. Classical exact solutions of the Navier-Stokes equation are established. Turbulence will also be discussed. Lastly, latest development in fluid mechanics solutions is introduced.

MKMM 1323 - **Compressible Flow**
This course is designed to cover the subject of gas dynamics which deals the behaviour of the fluid flows where compressibility plays a significant role. The course starts with the basic principles and thermodynamics concepts, then expose the students in analyzing one-dimensional isentropic flow processes in convergent-divergent nozzle together with area-March number relationships. It will emphasize on the analysis and the applications. The course will also provide the analysis of unsteady one-dimensional compressible flow and steady two-dimensional which includes small perturbation theory. At the end of the course, students should be able to demonstrate and apply the theory to solve the problem related to gas dynamics.

MKMM 1333 - **Computational fluid dynamics**
This is a graduate course in computational fluid dynamics, CFD. The idea is to give the students an in depth study of computer methods in solving fluid flow problems with and without heat transfer. In the first part, the governing equations of fluid flow are developed in differential form. Further simplifications are outlined and the initial and boundary conditions are applied accordingly to the respective problems. Discretization of the governing equations is then made. Finite different are used here. This is followed closely by applications of the computational methods to problems in fluid flow. At the end of the course the students are expected to be competent in CFD and should be able to read numerical fluid dynamics journal with ease.

MKMM 1413 - **Advanced thermodynamics**
This advanced course in engineering thermodynamics provides a strong foundation in the fundamentals of thermal sciences for further advanced research. Students are exposed to the restrictions on possible properties and systems. An advanced treatment of the First and Second law of Thermodynamics will be given. Energy analysis will be given in depth regarding fundamental concepts, techniques and application in various systems. A simplified treatment of statistical thermodynamics will be covered with emphasis on the wave functions (Schrodinger) which helps promote a greater understanding of the foundations, laws, properties and applications in thermodynamics. This is one of the fundamental courses in a postgraduate program in Thermal Engineering.

MKMM 1423 - **Energy Management**
This course will examine a wide array of new energy technologies being proposed to improve energy efficiency, promote the transition on renewable resources and reduce or eliminate adverse environmental impacts. It will review the energy cycle from exploration, extraction, conversion, distribution, and the application and impact of new technologies to increase the amount and delivery of traditional fuel supplies. Also, new technologies to produce energy from wind, water, solar, geothermal and biomass will be analysed. Research efforts in fuel cells, batteries, electric vehicles and engine efficiency by various organisations and governments are also examined.

MKMM 1433 - **Advanced heat transfer**
This course introduces a wider array of heat transfer phenomena beyond the undergraduate level including mass transfer, turbulence, and phase change phenomena in transient and steady state. A strong introduction to convection phenomena will be provided which is generally given a cursory coverage in introductory courses. Students will be taught tools for the application of theoretical approaches involving conduction, convection, radiation and multi-mode in engineering heat transfer analysis and design problems. Students are lead towards numerical solution methods to supplement the analytical approaches.
Note: Students should have completed a basic heat transfer course and acquainted with some spread sheet or numerical mathematics program available to them.

MKMM 1443 - **Advanced combustion**
This course explores deeper into the fundamentals of combustion. Multi component conservation equations are explored considering chemical reactions. Combustion process is also analysed from the point of view of chemical kinetics to gain better understanding of

species production especially pollutant formation. Numerical approach to solving combustion problems is introduced via equilibrium and kinetics packages. Detonation is given special treatment due to its increasing importance and potential for propulsion.

MKMM 1453 - **Sustainable energy technology**
This course explains the concepts of sustainable technology based on ethics, environments and economy (E3) and the role of sustainability in practical system applications and innovation. Historical approaches towards technology development and the rise of environmental problems are discussed. An industrial visit exposes the students to the role of energy management and best practices. Comprehension of the issues associated with sustainable energy technology are achieved through lectures, discussions, combined with reports and student presentations on the literature reviewed.

MKMM 1463 - **Computational heat transfer**
This is a graduate course in computational heat transfer, CHT. The idea is to give the students an in depth study of computer methods in solving heat transfer problems involving conduction and convection heat transfer. In the first part, the governing equations of conduction and convection are developed in differential form. Further simplifications are outlined and the initial and boundary conditions are applied accordingly to the respective problems. Discretisation of the governing equations is then made. Finite different are used here. This is followed closely by applications of the computational methods to problems in heat conduction and heat convection. At the end of the course the students are expected to be competent in CHT and should be able to read numerical heat transfer journal with ease.

MKMM 2413 - **Thermo Fluid Measurement and Diagnostic**
The course will explore the thermal and fluid measurement parameters such as velocity, pressure, temperature, heat flux, combustion pollutant, sprays and tools to measure them by both of intrusive and nonintrusive methods. The classical and popular tools such as pitot tubes, hot-wire anemometers and thermocouples will be discussed. It also introduces students to the basics of advanced optical of fluids and combustion flow diagnostics concepts, principles, and techniques. Quantitative and qualitative measurement techniques for reacting and non-reacting flows will be emphasized in this course. The course will be delivered through lectures, topic research and reviews, and presentations.

MKMM 2443 - **Internal Combustion Engines**
Engine Design and Operating Parameters, thermo chemistry of fuel-air mixtures, Properties of Working Fluids, Ideal Models of Models of Engine Cycles, Gas Exchange Process, SI Engine Fuel Metering and Manifold Phenomena, Combustion in Spark Ignition (SI) and Compression Ignition (CI) Engines.

MKMM 2453 - **Advanced refrigeration and air conditioning system**
This course is advanced course in refrigeration and air conditioning, and it explains the concepts of various refrigeration system, cryogenic system and the role of refrigerants in practical system applications and innovation. For air conditioning system including variable refrigerant flow (VRF), VAV, VAF and various refrigerant compressors.