GRADUATE COURSE CONTENTS OF MECHANICAL ENGINEERING TECHNOLOGIES PROGRAMME

MMT 502 Doctoral Seminar

MMT 503 Advanced Manufacturing Technology **2 2 3**
Metals and alloys, material inspection, production of ferrous, steel and non-ferrous metals and plastics, hardening, alloys of ferrous and non-ferrous materials, casting, powder metallurgy, metal processing routes, use of machine tools in production, computer aided design.

MMT 504 Mathematical Methods in Fluid Mechanics 3 0 3
Basic concepts, partial differential equations, boundary and initial conditions, linear, nonlinear and partial linear differential equations, solution methods, singularity method, use of function theory, analytic characteristic method

MMT 505 Experimental Methods in Heat Transfer **3 0 3**
Temperature measurements. Pressure measurements. Velocity measurements. Mass flow rate measurements. Concentration measurements. Flow monitoring. Heat flux measurements. Thermal conductivity and diffusion coefficients measurements. Error analyses. Performance characteristics of measuring instruments.

MMT 506 Hydraulic And Pneumatic Control **3 0 3**
Hydraulic and pneumatic systems, valves of direct, flow and pressure control, hydraulic and pneumatic circuit, hydraulic pumps, hydraulic motors, filters

MMT 507 Materials Technique **3 0 3**
General information about casting, solidification, alloying, plastics, heavy and light metals, alloying elements and their effects on alloys, production of machine and engine parts, improvement, uses, quality control, standardisation.

MMT 508 Advanced Refrigeration Technique **3 0 3**
Basic concepts of refrigeration and thermodynamics. Refrigeration systems. Mechanical vapour compression refrigeration. Basic elements and system analysis. I. law of thermodynamics analysis. I. law of thermodynamics applications. Analysis of the second law of thermodynamics. II. law of thermodynamics applications. Absorption cooling. Energy cost calculations. Residential and industrial applications.

MMT 509 Absorption Cooling Systems **3 0 3**
Introduction of Absorption Cooling System, explaining the working principle. Advantages and disadvantages of Absorption Cooling System. The types of refrigerants and absorbing fluids used in Absorption Cooling System and comparison of commonly used ammonia-water and LiBr-water pairs. Thermodynamic analysis of Absorption Cooling System. Simulation of absorption refrigeration system. Analysing the effects of operating temperatures of main elements on system performance. Thermodynamic analysis of two-stage systems, simulation, finding STK and ITK values. Introduction of Absorption Heat Amplifiers and explanation of the working principle.

MMT 510 General Thermodynamics **3 0 3**
Basic concepts of thermostatics, irreversibility, available energy, reversible work, thermodynamic relations, real gases, mixtures, gibbs function, chemical reactions, laws of thermodynamics, absolute entropy, ionisation.

MMT 512 Design of Heat Exchangers **3 0 3**
Classification and design methods of heat exchangers, flow forms of heat exchangers, calculation of total heat transfer coefficient, heat transfer relations; fouling factor, pressure drop; calculation of shell and tube type heat exchanger, compact heat exchanger.

MMT 513 Microcomputer and Programming **2 2 3**
Introduction and use of home and work computers, MS-DOS and CPM operating systems, BASIC commands and functions, shortening computation time, numerical integration, linear and multiple regression, finite differences, interpolation.

MMT 514 Technical Drawing with Computer **2 2 3**
A brief review of the basic theories of scale, geometric drawing and projection, sections, auxiliary views, intersections and angles, perspective, design and technical drawing, dimensioning, fitting and geometric tolerances, connection and standard machine elements, production processes, industrial terms, tool and machine design, computer aided drawing and production (graphic) information, applications.

MMT 515 Thermodynamic Analysis of Power Reactors **3 0 3**
Thermodynamic cycle and analysis of power plants, devices to improve the rankine cycle, T - H diagram of heat exchanger, economic analysis of power plants, depreciation coefficient, operating and fuel costs, calculation of energy cost.

MMT 516 Process Technique **3 0 3**

Types of heat exchangers, condensers, evaporators and separation process gas mixtures, enthalpy concentration diagrams, distillation, rectification and rectification columns, absorption and absorption columns, material exchange, drying and crystallisation processes.

MMT 517 Special Topics in Flow Dynamics 3 0 3

Introduction, fluid properties and their effects on some flow phenomena. Euler and Lagrange approximations, derivation of material derivative and kinematic conservation equations in Cartesian coordinates. Stress tensor and constitutive equations. Navier-Stokes equations in Cartesian coordinates. Derivation of the conservation equations in Curvilinear coordinates. Nondimensionalisation of equations. Exact solution of Navier-Stokes equations in Cartesian coordinates. Exact solution of Navier-Stokes equations in Curvilinear coordinates. Solution of Navier-Stokes equations in transient regime flows. Definition of turbulent flow, basic properties. Boundary layer concept, separation and transition. Laminar and turbulent boundary layer.

MMT 520 Motor Construction 3 0 3

Basic properties of engines and determination of main dimensions, thermodynamic calculations in engines, material selection of engine components, static, dynamic and thermal calculations of engine components, crank connecting rod and flywheel balancing calculations, engine project design, engine lubrication and cooling systems design and calculations, Turbocharged engines and calculations.

MMT 521 Internal Combustion Engines
2 0 2

Basic principles of engines, physical and chemical investigation of combustion, combustion chamber design, thermodynamic simulation method, supercharging theory, characteristics of engine performance.

MMT 522 Vehicle Construction 2 0 2

Vehicle types, main dimensions, maximum loaded weight, carrying capacity, axle loads, movement limits, power, braking, drive and driveline, engine types, clutches, torque changers, differential, chassis, wheel hangers and components, steering systems, multi-axle, articulated and tracked carriers.

MMT 524 Special Topics in Combustion Theory 3 0 3

Filling Variation and Volumetric Efficiency in Engines. Overfilling in Engines. Alternative (Non-Classical Engines). Modelling of Combustion in Engines. Cycle Simulation and Performance Calculation. Performance Emission Relationship in Engines.

MMT 525 Special Topics in Internal Combustion Engines 3 0 3

Filling Change and Volumetric Efficiency in Engines. Filling Variation and Volumetric Efficiency in Engines. Overfilling in Engines. Alternative (Non-Classical Engines). Modelling of Combustion in Engines. Cycle Simulation and Performance Calculation. Performance Emission Relationship in Engines.

MMT 526 Mixture formation in internal combustion engines 3 0 3

Historical development of mixture formation methods in petrol and diesel engines, description of the lamda air excess coefficient, and H/Y ratio values for the basic operating modes of the engine. Operating modes of a petrol engine [cold start, idling, acceleration, constant speed cruise, deceleration, full power]. Introduction of fuel injection systems in petrol engines (single point spray, CNP and GDI methods. In-cylinder air movements in petrol engines (turbulence, swirl, squish, tumble and combustion chamber types). Spray, ignition and combustion phases in petrol engines, the relationship between spray parameters and fuel consumption and emissions. Evaporation in the intake manifold in petrol engines. Mixture formation methods in diesel engines (classical mechanical pump systems and common rail diesel fuel injection systems). Fuel jet fragmentation, beam formation and effective parameters.

MMT 527 Lubrication Theories and Vehicle Lubricants 2 0 2

Friction, friction types, factors affecting friction force, ways to reduce friction, lubrication concept, definition, purpose, types, properties, lubrication-friction relations, main theories and opinions, engine and vehicle oils, types, classification, properties, oil standards, lubrication techniques and lubrication-maintenance relations, possibilities of using used oils, oil analysis, examination of the effects of oils on materials.

MMT 529 Advanced Auto Electronics 3 0 3

Basic principles of electronics, structural properties of matter, the main elements used, their properties, electronic systems used in various motor vehicles, their circuits, circuit elements, properties, circuit operation, malfunctions, repair methods, recent developments in auto electrics.

MMT 530 Electronic Control Systems 2 2 3

Knock limiter, electronically controlled petrol injection systems, electronically controlled ignition systems, lambda exciter, developments in electronic control units and operating systems in the automotive industry.

MMT 532 Industrial Quality Control 2 0 2

Classical quality control concept and introduction, modern quality control concept and introduction, development process of modern quality control approach, quality control groups approach, total quality control approach, quality-cost relationship, quality improvement techniques, motivation programmes in quality control.

MMT 534 Tribological Systems 3 0 3

Adhesion contact resistance, types of wear, surface condition, contact with plies, effects of friction, wear flow rate, metal transfer, temperature and speed, crystal structure, rolling resistance.

MMT 535 Numerically Controlled Machines and Systems **3 0 3**

General systematics of machine tools, working principles and features of machine tools, programming process, control system of machine tools, developed NC systems, control circuits of NC machine tools, construction features of NC machine tools.

MMT 536 Damage Analysis **2 0 2**

Definition of damage, classification of damages, behaviour of material in mechanical stresses, static stress, dynamic stress, deformation rate, physical properties, technological properties, manufacturing defects, welding, abrasion, chemical damages.

MMT 537 Hard Metal Technique and Sintered Carbides **3 0 3**

Relationships between the basic deformation characteristics of transitions occurring in the internal structure of metals, deformation mechanisms for fatigue fracture, fracture toughness, toughness, elastic and plastic properties in hard metals and mechanical properties of microstructure.

MMT 538 Software Design in Glazing Systems **3 0 3**

Introduction to numerically controlled technology, programming of machine operations, APT language elements, definition of geometric quantities and cutter movement, machine properties, special positions, construction of APT program process, NC programming principles and creation in CAD / CAM systems, post processor and CLDATA

MMT 541 Machine Design **3 0 3**

Evaluation and design of construction, importance of fatigue and fracture in construction, analytical and numerical optimisation techniques in design, simulation, system analysis techniques, computer aided design, project.

MMT 542 Advanced Machine Elements **3 0 3**

Selection and calculation of frictionless bearings, lubrication, design of plain, ball and roller bearings, gears and design, design of chain and belt-pulley systems, power transmission and design of powertrain.

MMT 543 Automotive Systems Analysis **3 0 3**

Theoretical approaches in occupational and system analysis, programme development at different aims and levels in the automotive field, methods and processes, analysis methods, basic concepts and definitions, principles, methods and techniques of job analysis, analysis of engine and vehicle systems, arrangement of job and process sheets, their use in teaching.

MMT 546 Transport in Experimental Studies **2 2 3**

Basic principles of convection heat transfer, natural and forced convection in internal and external laminar flows, heat transfer, convection heat transfer in turbulent internal and external flows, natural convection in closed volumes, experimental convection, techniques for improving convection heat transfer in experimental studies, heat transfer in rotating flows, applications of the second law of thermodynamics in heat transfer.

MMT 547 Cutting Tool Technology **3 0 3**

Chip removal mechanics and chip formation, Machinable concept and machinability parameters, Tool life and tool life models, Cutting forces in chip removal, force measurement, cutting power, Effects of cutting parameters on chip removal, chip types, Heat and temperature distribution, effects of temperature on tool, Surface roughness and measurement, Calculation of surface quality, Cutting tool materials, Ideal tool properties, tool geometry, effects of rake angle, ISO tool norms according to workpiece materials, Cutting tool selection criteria and tool selection, Approach angle, negative and positive tools, effects of corner radius, Cutting tool coating methods and effects of coating, Insert and tool holder standards.

MMT 548 Reliability in Machine Design **3 0 3**

Reliability concept, statistical calculations and error analyses of reliability, reliability and statistical calculation methods in static and dynamic loading situations, reliability and statistical calculation methods in wear and corrosion phenomena, reliability of technical systems and functional elements

MMT 549 Maintenance Technique **3 0 3**

Importance and principles of maintenance, periodic maintenance, inspection, repair, wear and damage concepts, damage theory, wear, corrosion, fatigue and aging, damage to machine elements, determination of damage status, direct indirect diagnostic methods, repair technique, reliability theory, general statistical information, maintenance organisation, maintenance costs and budget.

MMT 550 Material Selection in Machine Design **3 0 3**

Materials used in machine design: Steels, cast irons, non-ferrous metals, plastics, composites. Bolt materials, materials to be joined by welding, shaft materials, spring materials, rolling bearing materials, plain bearing materials, gear wheel materials, chain and sprocket materials, belt and pulley materials, wire and rope materials, hydraulic and pneumatic cylinder materials, sealing elements materials.

MMT 551 Fatigue Behaviour of Light Metals **3 0 3**

Introduction to light metals, classification of aluminium and magnesium alloys, fatigue strength of welded and unwelded joints of aluminium, fatigue strength of welded and unwelded joints of magnesium, obtaining safe stresses, Gassner curves, notch stress methods in aluminium and magnesium alloys, elastic-plastic material behaviour, Ramberg - Osgood Rule, Coffin - Manson - Basguin Rule, crack life and calculation of local stresses, micro support effect, equivalent structural lengths.

MMT 552 Fatigue of Metals 2 2 3

Repetitive Loadings and Fatigue, Time change of force, Classification of repetitive loadings, General character of fatigue damage, Fatigue stress and fatigue fracture mechanism, Cause of fatigue fracture, Fatigue crack initiation, Growth and progression of fatigue crack, Factors that cause fatigue fracture and facilitate fracture, Macroscopic appearance and formation forms of fatigue fractures, Fatigue limit determination by general methods, Smith diagram, Explanation of fatigue strength with other curves, Factors Affecting Fatigue Strength and Methods of Increasing Strength, Effect of material type, composition and structure, Effect of surface conditions, Effect of temperature, Effect of stresses, Effect of frequency, Effect of corrosion, Effect of low repetition.

MMT 553 Extrusion Moulding Technology 3 0 3

Design of a part that can be moulded by extrusion moulding method, selection of mould material, preparation of mould set, manufacturing and heat treatment of extrusion mould of this part, assembly of mould elements, testing the mould on the bench, product control and elimination of possible errors.

MMT 554 Forging Moulds Technology 3 0 3

Introduction: definitions, general information, process variables. Forging machines: hydraulic, mechanical and screw presses, hammers. Open die forging. Closed die burr forging. Horizontal forging (piling). Electro-stacking. Forming with forging rolling mills. Cold heading (head inflation). Cold extrusion. Orbital forging.

MMT 555 Injection Moulding Technology 2 2 3

Work accidents and protection methods, Volume moulds and construction principles, Plastic, pressure die casting and hot forging moulds, Making standard mould elements, Volume mould making, assembly, testing, Detection and elimination of errors in the product. Realisation of developing technological applications related to the field.

MMT 556 Thermoset and Vacuum Moulding Technology 3 0 3

Moulding methods of thermoset products, thermoset mould design, manufacturing and assembly, trial production, the need for vacuum moulding and mould design principles, vacuum mould design and manufacturing, trial production, product defects and elimination methods in thermoset and vacuum moulding.

MMT 557 Design of Work Moulds 2 2 3

Design and construction principles of work moulds, positioning and positioning elements, drilling thimbles, standards and thimble plates, design of mould bodies and ready-made clamping elements, drilling, clamping, turning, milling, measuring, control, assembly etc. work moulds, standard mould elements, modular mould sets, automatic mould sets, cost calculations of designed moulds.

MMT 561 Selected Topics in Heat Transfer and Fluid Mechanics 3 0 3

Heat storage applications. general characteristics of sensible, latent and chemical storage systems, flow in storage systems, common properties and estimation of losses, sensible heat and chemical energy storage systems, materials used and storage materials. Loading and unloading mechanism and modelling, latent heat storage materials, general properties, storage forms, materials used, approach to system design, model solutions, parametric approaches and behaviour of different systems. System design and analysis of loading and unloading behaviour. Disintegration mechanism of liquids, effect of fluid properties and operating conditions, modelling spray formation, various sprays and analysis, design. Ejectors, application areas and modelling and analysis of ejectors. emission propagation and general characteristics. theoretical approach and analysis

MMT 562 Air Conditioning Technique 3 0 3

Heating, ventilation and air conditioning concepts, boilers and combustion systems, hot water heating systems, steam heating, low and high pressure steam systems, boiling water heating systems, ventilation and air heating, heat exchangers, boilers and booster installations, solar and biogas energy types, use of solar and biogas energy types in preheated heating installations.

MMT 563 Installation Project Techniques 1 2 2

Project techniques of hot water, steam and boiling water heating installations, project design of ventilation and air heating installations, project construction in air conditioning and air conditioning.

MMT 567 Advanced Electroerosion Manufacturing Methods
2 2 3

The importance of the electroerosion manufacturing method (EDM), places of use, chip removal mechanism, introduction of different types of EDM (wire erosion, milling with electroerosion, grinding with electroerosion, ultrasonic assisted electroerosion, micro electroerosion, etc.), analysis of frequencies used in the method, dielectric fluids, method parameters and results, circulation techniques, electrode selection design and wear, microstructure formed on the surface of workpieces according to method parameters.), analysis of frequencies used in the method, dielectric liquids, method parameters and results, circulation techniques, electrode selection design and wear,

examination of microstructure changes on the surface of workpieces according to method parameters, servo control systems in wire erosion machine, program preparation using apt language for the production of workpieces, application studies in wire erosion.

MMT 568 Macro Programming and Application in CNC Machines **2 2 3**

Working principles of CNC machines, definition of ISO and special cycle codes and their application to workpieces, definition of macro programming and its importance in industry, preparation of manufacturing programmes of geometric machine parts with mathematical equation by macro programming, application of macro programmes on two and three axis CNC machines.

MMT 569 Numerical Methods in Heat Transfer and Fluid Dynamics **3 0 3**

The essence and importance of numerical solution of differential equations. Error and error sources. Definition and properties of boundary and initial value problems. Classification and properties of partial differential equations. Discretisation of differential equations. Solution methods of systems of alcebric equations. Finite difference and finite volume solution techniques. Solution of parabolic differential equations: Explicit methods. Convergence, stability and compatibility. Solution of hyperbolic differential equations. Solution of elliptic differential equations. Solution strategies of Euler equations. Solution strategies of Navier-Stokes equations.

MMT 570 Heating, Ventilation, Air Conditioning **3 0 3**

Air Conditioning Systems. Characteristics of humid air and air conditioning processes. Characteristics of humid air and air conditioning processes. Heating and cooling load calculation. Energy Calculations. Fans and air distribution in buildings. Air conditioning installation main and auxiliary elements. Heat Transfer. Finned surfaces. Cooling.

MMT 571 Analysis and Design of Solar Thermal Systems **3 0 3**

Solar thermal conversion systems, system modules, solar radiation, types of solar collectors, analytical designs and disadvantages, storage of solar energy, heating and cooling loads, sizing of solar energy systems, solar energy application examples, isolation of systems and evaluation of meteorological data.

MMT 572 Industrial Flow Measurement Techniques **3 0 3**

Basic principles of fluid mechanics, linearisation and calibration, analogue and digital flow meters, general principles of pressure tube anenometry, properties of pyranometer and pitot tube in incompressible flows, measurement with multi-hole probe type pitot tube (5 probe), use of U and oblique manometers in pressure measurements, physical errors in pressure measurements, volumetric and mass flow determination.

MMT 574 Natural Gas and LPG Installation **2 2 3**

Introduction, introduction of natural gas, Turkish standards related to natural gas, types and properties of devices using natural gas, issues to be considered in the placement of devices, boiler rooms and ventilation, chimneys and properties of natural gas chimneys, natural gas installation equipment, design, commissioning and testing of natural gas installation, natural gas heating systems, air quality protection, limitations imposed by the regulation, definition of fuel gases, physical and chemical properties, LPG storage, introduction of gas consumption devices, introduction of gas installation, selection and placement of devices, design of the system, application of the installation and tests, safety and operating rules.

MMT 575 Finite Element Analysis of Thermo-Fluids **2 2 3**

Introduction to Finite Element Method, basic concepts and definitions. Elements and shape factor: One dimensional elements, Multi-dimensional elements, Element characteristics and formulation: Ritz method, Rayleigh-Ritz method, Weighted remainder method, Formulation of heat conduction equation, Interpolation functions and requirements, Continuous regime heat conduction analysis, Transient regime heat conduction analysis, Heat transfer by convection: Differential equations and SEM formulation, Solution algorithms, network structure and stability, Laminar non-isothermal flow analysis.

MMT 576 Heat Pump Theory and Practice **3 0 3**

Basic concepts. Heating systems. Mechanical vapour compression system. Basic elements and system analysis. I. law of thermodynamics analysis. I. law of thermodynamics applications. II. law of thermodynamics analysis. II. law of thermodynamics applications. Absorption heat pump. Absorption system cycle calculations. Solar energy assisted systems. Residential and industrial applications. Combined heat pump applications.

MMT 577 Solar Energy Applications **3 0 3**

Solar energy input. Solar radiation coming out of the atmosphere. Solar angles, solar constant, instantaneous radiation, daily average radiation. Solar radiation to the earth. Solar radiation measurement instruments. Flat solar collectors. Collector introduction, collector thermal analysis, useful energy, instantaneous efficiency. Concentrating solar collectors. Storage of solar energy. Solar hot water systems. Pumpless systems, pumped systems. Solar heating systems. Solar cooling systems. Steam and electricity generation with solar energy. Structure of solar cells. Photovoltaic Systems. Photovoltaic system design.

MMT 578 Plastic Injection Mould Design and Manufacturing Methods **2 2 3**

Plastic injection mould design and principles, Cooling systems, Shrinkage phenomena and effects, Production of plastic injection moulds, Injection process, Extrusion method, Pressure moulding, Blow moulding, Rotary moulding, Heat forming, Rolling, Casting method and production methods of plastics.

MMT 579 Sheet Metal Mould Design and Analysis **2 2 3**

Punching, Cutting Dies, Bending Dies, Calculation and design of die elements, Rounding dies, Step dies, Fasteners of die parts, Pins, Selection of die life and tolerances, Die cost economies and cost optimisation.

MMT 580 Mechanics of Machine Tools **3 0 3**

Structure of machine tools, Slideways and precision within standard tolerances, Motor, spindle and bearings of machine tools, Kinematics and control of machine tools, Cutting economy, Precision measurement, Examination of the relationship between cutting forces and surface roughness, Examination of the relationship between cutting forces and tool wear , Methods used in the measurement of heat and temperature generated during chip removal and the establishment of a mathematical model.

MMT 581 Advanced Machining Techniques **2 2 3**

Machining technology, chip formation, chip removal mechanics, heat generation and dissipation, effect of cutting speed, contact and friction, modelling of machining processes, tool damage, tool life, machinability, static and dynamic deformations in machining, dynamic behaviour, vibration, vibration, quoting, machining economics and optimisation.

MMT 583 Machine Tool Design **3 0 3**

Basic parameters affecting chip removal, analysis of cutting forces and the effects of these forces on the tool and machine, kinematics of motion transmission mechanisms in machine tools, stepped and stepless mechanisms, calculation and drawing of establishment and speed diagrams, design of body and slides, stop - start phenomenon in slides, effect of cutting forces on slides.

MMT 584 Plastic Deformation Technology **3 0 3**

Factors causing strength depletion. Mechanical behaviour of rigid bodies. Ideal systems and mechanical models. State of Stress: Concepts related to tensor representation, principal stresses and principal axes. Maximum shear stresses. Strain state. Composition equations, generalised Hooke's law, finite strain (rubber elasticity), viscoelasticity (rheological models). Plastic behaviour: Plastic deformation. Dislocations: Yield strength in a perfect crystal, types of dislocations, properties of dislocations, geometry of dislocations, interaction of dislocations. Micro plasticity of single crystals. Plastic deformation of polycrystalline metals. Strength increasing processes in metallic materials.

MMT 585 Computer Aided Design and Integrated Manufacturing Methods **2 2 3**

Machine elements and solid modelling, Surface modelling, Assembly systems, Determination of computer-aided design and manufacturing (CAD-CAM) systems and manufacturing stages of a product, Principles of computer-aided design, Manufacturing planning, Manufacturing control and development of integrated manufacturing strategies and determination of principles of use, Optimisation techniques in the selection of machine elements with the help of computer

MMT 586 Industrial Robots and Programming **2 2 3**

General structure of an industrial robot, Elements, Robot configuration types, Usage areas of robots, Robot programming methods and programming languages, Programming applications, General structure and logic of robot simulation programs, Introduction and use of a robot industrial simulation and package program and industrial robot applications.

MMT 588 Flow and Heat Transfer at the Micro Level **3 0 3**

Introduction to micro channel flows. Fundamentals of mass and momentum transfer at micro level. Fundamentals of heat transfer at micro level. Differences between micro and macro level analysis methods. Investigation of viscous effects at micro level. Investigation of diffusion mechanism at micro level. Solution methods of Boltzman Transport Equation for basic flow geometries. Solution methods of Boltzman Transport Equation for basic flow geometries. Investigation of engineering designs at micro level. Examination of literature approaches to research applications. Examination of micro-technology platforms involving multidisciplinary and fluid motion.

MMT 589 Convection Heat Transfer **3 0 3**

Heat Transport Basic Equations and Concepts. Momentum and Energy Equations, Boundary Layer, Turbulence, Inlet Zone. Flow through Channels. Laminar, Fully Developed and Turbulent Flow through Pipes, Flow through Ducts with Different Cross Sections, Developing Flow, Simulation. Flow from External Surfaces. Flow over a flat plate, Flow perpendicular to a pipe, Flow over a sphere. Flow Perpendicular to a Pipe Bundle, Heat Transport in Flow at High Velocities. Natural Convection. Natural convection in perpendicular plate. Natural convection from horizontal plate and pipe. Natural convection in closed volumes. Compound convection. Phase Change. Boiling and Evaporation. Condensation.

MMT 590 Fluid Power Systems and Control **3 0 3**

Defining the general properties of fluid power transmission systems. Derivation of basic equations of hydraulic and pneumatic systems. Investigation of compressibility, bulk modulus, fluid spring properties. Linearisation in fluid power systems. Analysis of electrohydraulic valve-cylinder systems. Analysis of hydraulic pump and motor systems. Analysing the use of accumulators in hydraulic systems. Efficiency calculation in systems using accumulators. Static-dynamic analysis of fluid power systems. Application and sample problem analyses. Course review and midterm exam. Examination of open-closed loop control of fluid power systems. Analysis of closed loop control of fluid power systems

and examination of servo mechanisms. Examination of limitations in acceleration and deceleration in closed loop systems.
MMT 600 Doctoral Thesis