Graduate Certificate Program in Energy Conversion & Transport
Offered by the Department of Mechanical and Aerospace Engineering

Intended Audience: ☐Main Campus Students ☐Distance (online students) ☒ Both

Purpose:

The Department of Mechanical & Aerospace Engineering proposes the certificate program entitled "**Energy Conversion & Transport**". This certificate program offers an opportunity for professionals to expand their knowledge in energy conversion processes through a flexible graduate education program. The certificate will provide a solid foundation in energy conversion techniques with focus on alternative energy methodologies and practices that can be immediately applied to the work place. The certificate consists of **four courses** (to be chosen from a list of 17 MAE courses). The courses are selected to prepare professionals for enhancing their knowledge about energy conversion techniques with an emphasis on alternative & appropriate energy technologies that are being currently discussed to meet regional and global energy needs.

Admission:

The Energy Conversion & Transport graduate certificate program is open to all individuals holding a BS degree in an engineering or hard scientific discipline who have a minimum of two years of professional experience or are currently accepted into a graduate degree program at Missouri S&T.

In order to receive a Graduate Certificate, the student must have an average graduate cumulative grade point of 3.0 or better in the certificate courses taken under this program. Students admitted to the certificate program will have non-degree graduate status, but will earn graduate credit for the courses they complete. If the four courses sequence approved by the graduate advisor is completed with a grade of B or better in each of the courses taken, the student will upon application be admitted to the Master of Science program in Mechanical or Aerospace Engineering. The certificate courses taken by students admitted to the program will count towards the Master of Science degree. Once admitted to the program, a student will be given three years to complete the program as long as a B average is maintained in the courses taken.

Contributing Faculty:

- Banerjee, Arindam (Certificate Coordinator)
- Crosbie, Al
- Hosder, Serhat
- Isaac, K.M.
- Rovey, Josh
- Landers, Robert (Graduate Coordinator - MAE)
- Drallmeier, James
- Homan, Kelly
- Koylu, Umit
- Sheffield, John

Curriculum:

The Energy Conversion & Transport Graduate Certificate Program consists of 17 courses listed below, which are delivered as part of our regular master's degree programs in Mechanical & Aerospace Engineering. Students will be responsible for prerequisite knowledge as determined by course instructors. With the approval of the department,

appropriate courses may be substituted for a certificate course if that course is not available. A total of four courses from the list below are required for successful completion of the certificate. At least **two** of these courses must be from core MAE graduate courses (300-level) and at least **one** must be an advanced course (400-level).

Core Courses (Choose at least two):

Plasma Physics – ME/AE/NuE/Phys 301 (Online & Campus)
Applied Computational Methods – ME/AE 301 (Online & Campus)
Alternative Energy Engineering – ME/AE 301 (Online & Campus)
Fuel Cell Principle and Applications – ME 301 (Online & Campus)
Combustion – ME/AE 327 (Online & Campus)
Intermediate Fluid Mechanics – ME/AE 331 (Online & Campus)
Applied Energy Combustion – ME 335 (Online & Campus)
Computational Fluid Dynamics – ME/AE 339 (Online & Campus)
Solar Energy Technology-ME365 (Online & Campus)
Aerospace Propulsion Systems– AE 335 (Campus)
Intermediate Heat Transfer-ME/AE 325 (Campus)
Internal Combustion Engines – ME 333 (Campus)

Advanced Courses (Choose at least one)

Viscous Flows – ME/AE 423 (Online & Campus)
Heat Transfer by Convection – ME/AE 427 (Online & Campus)
Gas Dynamics– ME/AE 431 (Online & Campus)
Turbulence – ME/AE 435 (Online & Campus)
Physical Gas Dynamics – ME/AE 437 (Online & Campus)

Mechanical & Aerospace Engineering Course Descriptions:

ME/AE/NucE/Phys 301 Special Topics - Plasma Physics I (Lect 3.0) Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Wave phenomena in plasmas. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory.

ME/AE 301 Special Topics - Applied Computational Methods (Lect 3.0) Detailed study of various computational methods for efficient numerical solution of selected fluid/structural mechanics, thermodynamics, and controls problems in aerospace and mechanical engineering. In addition to basic numerical method techniques, topics to be covered include gradient-based optimization techniques, response surface approximation, and uncertainty quantification involving spectral approaches.

ME/AE 301 Special Topics – Alternate Energy Engineering (Lect 3.0) The course introduces the physics & methods of energy conversion from non-conventional energy sources (solar, wind, nuclear, biomass, geothermal, oceans and transportation sources). Coverage will include: advantages and disadvantages of energy sources, engineering challenges in harnessing such forms of energy, and evaluation and analysis of energy

systems for the future. Prerequisite ME225 or ME 231 or approval of instructor.

ME/AE 301 Special Topics – Fuel Cell Principle and Applications (Lect 3.0) Fuel cell fundamentals including thermodynamics, reaction kinetics, mass transport, characterization, and modeling are introduced. Different types of fuel cells such as proton exchange membrane and solid oxide are discussed with emphases on subsystem design and system integration as well as environmental impacts. Prerequisite ME221

ME/AE 325 Intermediate Heat Transfer (Lect 3.0) Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: ME 225.

ME/AE 327 Combustion Processes (Lect 3.0) Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: ME 221.

ME/AE 331 Intermediate Thermo-fluid Mechanics (Lect 3.0) Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics & MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: ME 231.

ME 333 Internal Combustion Engines (Lect 3.0) A course dealing primarily with spark ignition and compression ignition engines. Topics include: thermodynamics, air and fuel metering, emissions and their control, performance, fuels and matching engine and load. Significant lecture material drawn from current publications. Prerequisite: ME 221.

ME 335 Applied Energy Conversion (Lect 3.0) The study of the principles of energy conversion. Specific applications include fuel cells and other direct energy conversion devices used in plug-in hybrid electric vehicles.

AE 335 Aerospace Propulsion Systems (Lect 3.0) Study of atmospheric and space propulsion systems with emphasis on topics of particular current interest. Mission analysis in space as it affects the propulsion system. Power generation in space including direct and indirect energy conversion schemes. Prerequisite: AE 235.

ME/AE 339 Computational Fluid Dynamics (Lect 3.0) Introduction to the numerical solution of the Navier-Stokes equations, by finite difference methods, in both stream function-vorticity and primitive variable formulations. Course format emphasizes student development of complete computer programs utilizing a variety of solution methods. Prerequisites: Comp Sci 53 or 73 or 74; one course in fluid mechanics

ME 365 Solar Energy Technology (Lect 3.0) Introduction to the nature of solar radiation and associated thermal energy transfers. Methods of collecting and storing solar energy. Analysis and design of systems for utilizing solar energy, including heating and cooling. Prerequisites: ME 225 or consent of instructor.

ME/AE 423 Viscous Fluid Flow (Lect 3.0) Fundamentals of viscous fluids for incompressible and compressible flows governed by Navier-Stokes equations; exact, approximate, and numerical solutions for steady and unsteady laminar flows; stability, transition, and turbulence, CFD simulations of internal and external flows. Prerequisite: ME/AE 331 or ME/AE 339 or approval of instructor.

ME/AE 427 Heat Transfer by Convection (Lect 3.0) An analytical study of convective heat transfer in laminar and turbulent flows; forced convection, natural convection, and mixed convection; combined heat and mass transfer; heat transfer with change of phase; instability of laminar flow; current topics in convection. Prerequisite: ME/AE 325 or 331 or approval of instructor.

ME/AE 431 Gas Dynamics I (Lect 3.0) A critical analysis of the phenomena governing the flow of a compressible fluid; introduction to flow in two and three dimensions; Prandtl-Meyer expansions; small perturbations in subsonic and supersonic flows; method of characteristics. Prerequisite: ME/AE 331 or approval of instructor.

ME/AE 435 Turbulence in Fluid Flow (Lect 3.0) Fundamentals of statistical theory of turbulence; turbulence modeling for transport processes of heat, mass, and momentum; closure schemes for Reynolds-averaged Navier-Stokes equations in free turbulence and wall turbulence; CFD simulations of turbulent flows. Prerequisite: ME/AE 331 or ME/AE 339 or approval of instructor.

ME/ AE 437 Physical Gas Dynamics I (Lect 3.0) Features of high temperature gas flows including the development of the necessary background from kinetic theory, statistical mechanics, chemical thermodynamics and chemical kinetics. Equilibrium and non-equilibrium gas properties and gas flows are included. Prerequisite: ME/AE 331 or approval of instructor.

Proposed Offering Schedule:

Fall

ME/AE 301 (Alternative Energy Engineering)
ME/AE 325
ME/AE 327
ME 333 (Offered both in fall and spring)
ME 335
ME/AE 339
ME 365
ME/AE 423*
ME/AE 435* (*Offered every alternate Fall semester)

Spring

ME/AE/NE/ 301 (Plasma Physics)
ME/AE 301 (Applied Computational Methods)
ME/AE 301 (Fuel Cell Principle and Applications)
ME/AE 331
ME 333 (Offered both in fall and spring)
AE 335
ME/AE 427
ME/AE 431*
ME/AE 437* (*Offered every alternate Spring semester)

Prepared by: Dr. Arindam Banerjee on behalf of the ECT committee, MAE Department – Approved on February 10, 2010.