

ENERGY COURSES AND CURRICULUM FOR MASTERS STUDENTS

Mechanical Engineering Department

Autumn Quarter

ME 529 -- Advanced Energy Conversion Systems

The course focuses on advanced energy conversion technologies that are currently on the market or are under development, and on the tools used by professionals for design and to evaluate system performance. The featured technologies include natural gas combined cycle, alternatively-fueled combined cycle (i.e., coal or biomass in integrated gasification combined cycle), supercritical Rankine cycle, biomass combustion systems, nuclear, and fuel cells. Each of these technologies is treated as a case study. We use the *availability analysis* approach, which is the way professionals design energy systems. The essential idea is that all energy resources have the potential to do work by virtue of being out of equilibrium with the environment. Examples include a hot gas stream that can go through a Carnot cycle, a high-pressure air stream that can go through a turbine, or a methane/air feed that can go through a fuel cell. The first example is out of thermal equilibrium, the second is out of mechanical equilibrium and the third is out of chemical equilibrium. Simple formulas allow the designer to (1) calculate the maximum possible work that can be extracted from each resource, and (2) identify where in a complex energy system that work potential is destroyed by irreversibilities. This information is then used to optimize system design. Thus, the course emphasizes both advanced technologies and the professional approaches used to evaluate their efficiencies.

Winter Quarter

ME 539 -- Renewable Energy I

The course focuses on solar energy and bio-energy technologies that are in use and are undergoing development. Energy metrics and production trends are introduced and used to determine how effectively renewable energy systems generate power and how they compare to fossil energy. Solar design principles are taught for application to heating and thermal power generation. This includes the methods for determining sun angles and intensities, which are necessary for solar collector design and site selection and for solar equipment performance calculations. Design concepts for solar homes are covered. Solar photovoltaic (PV) provides for direct generation of electricity from sunlight. Solar PV theory and system design and performance are taught, with case designs used as examples for learning. Recent developments in solar PV technology and market growth are discussed. Bio-energy technology offers the engineer many methods for using this renewable energy resource. Direct use of bio-energy, as in combustion and gasification systems, are examined relative to bio- and chemical-conversion of the raw bio-energy to an upgraded fuel, such as ethanol or bio-diesel. Global climate impacts of bio-energy are discussed.

Spring Quarter

ME 540 -- Renewable Energy II

The course focuses on wind and water power technologies that are in use and are undergoing development. Wind turbine design by linear and angular momentum methods and by blade element momentum theory are taught. These methods permit the engineer to determine wind turbine torque and power to as a function of turbine rotational speed, and allow blade size and angles to be selected for optimal performance. The main types of wind turbines are treated, including horizontal axis, vertical axis, constant speed, variable speed, and direct drive turbines. Wind speed distributions are used to determine average power and yearly energy generation by a turbine. Conditions for wind turbine site selection are examined. Water power is introduced by reviewing conventional hydroelectric power and applying the

energy equation for predicting system power. The course then turns to hydrokinetics, which involves using the kinetic energy of flowing water to generate power without impoundment of the water. This developing technology is the core of tidal and in-stream river turbines. The wind turbine design methods are modified by open channel flow theory and applied to tidal and in-stream turbines. Tidal flow conditions in estuaries, such as Puget Sound, are described. Hydrokinetic case studies are provided for tidal, river, and constructed waterways. The course is concluded with discussion of wave energy theory and machines that generate electricity from the motion of ocean waves.

Suggested Curriculum and Courses for Masters Students in Mechanical Engineering
Focusing on Energy

For students starting in Autumn. Non-thesis option assumed.

Credits per quarter for RAs and TAs: minimum = 10, maximum covered by tuition waiver = 11, covered by tuition waiver in summer = 2. Degree requirement = 42 credits.

Area	Autumn	Winter	Spring	Summer	Autumn
Engineering Analysis (required)	ME 564(3)	ME 565(3)			
Numerical Analysis (one course required)			ME 535(3)		AMATH 581(5) or AMATH 584(5)
Energy Conversion (core)	ME 529(4)	ME 539(4)	ME 540(3)		
Fluid Mechanics (core)	ME 431(4) ¹				
Thermodynamics (core)		ME 521(3)			
Special Project ²			ME 599B(x)	ME 599B(y)	ME 599B(z)
Other Courses Available (Confirm quarter course is offered with offering department. Check 400-level and non-ME credits permitted with ME Dept.)					
Courses germane to Water Power		OCEAN 420(4)	CEE 477(3)		
Renewable Energy Infrastructure					CEE 588(3)
Building Energy (HVAC)			ME 425(4)		
Fuel Cell Engineering			CHEM E 445(3)		
Energy Harvesting and Storage					ME 599L(3)
Heat Transfer			ME 532(3)		
Other Fluid Mechanics Courses			CEE 570(4)		ATM S 505(4)
Gas Dynamics		AA 400(3)			
Continuum Mechanics					ME 503(3) ³
Composite Materials Courses		ME 450(3)			MSE 475(4)
Dynamics and Vibrations					ME 588(3)
Power Systems Analysis					EE 454(4) ⁴
Running Total of Credits	11	21	31 minimum	31 minimum	42 minimum

¹ Offered as ME 599H/ME 599Y for graduate students

² ME Dept permits up to 6 credits of ME 599B (that is: x+y+z≤6). For students on MS thesis option, substitute 12 credits of ME 700

³ For students continuing for PhD

⁴ Check with instructor regarding prerequisite -- student should have knowledge of EE 351 prior to taking EE 454