COURSES AND CURRICULUM FOR MASTERS STUDENTS
Design for Environment Focus
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 515 – Life Cycle Assessment

The course focuses on data development within the computational structure for Life Cycle Assessment (LCA) to analyze current and emerging technologies from materials acquisition (e.g., mining and agriculture) through end-of-life (e.g., materials recovery or disposal). Students select a technology of interest, often related to their thesis or dissertation and perform all LCA research phases (goal and scope definition, data development and solving the inventory, impact assessment, sensitivity analysis, and interpretation). Resource consumption, impacts to human health and ecosystems, and the contributions to climate change, ozone depletion, smog formation, and acidification are estimated. Assessments either identify opportunities for improvements or selects a superior alternative on the basis of pollution prevention and resource conservation.

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 415 – Sustainability and Design for Environment

The concepts and methodologies of sustainability, industrial ecology, pollution prevention, and Life Cycle Assessment are placed within the context of system design as students examine the practice of, opportunities for, and the role of the engineers in Design for Environment (DFE). Students work in interdisciplinary teams to benchmark and re-design a technology system of interest, including estimation of changes in environmental and socioeconomic impact.

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 Design for Environment

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)
DFE (core)	ME 501 (3) or ME 547 (4)	ME 515 (3)	ME 415 (3)		
Energy Conversion (core)	ME 529(4)	ME 539(4)	ME 540(3)		
Special Project [1]			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.)					
Environmental Management	PBAF 597 (4)	PBAF 590/ ENVIR 501 (3) IBUS 545 (4)	ENVIR 502 / MGMT 579 PBAF 583 (4) URBDP		PBAF 597 (4)

			598/498 (3)		
Manufacturing Systems	ME 501 (3)				
Risk Assessment	PBAF 580/ CEE 560/ ENV H 577 (3) SMA 521 (3)				PBAF 580/ CEE 560/ ENV H 577 (3) SMA 521 (3)
Linear and Non-Linear Systems	ME 547 (4) ME 510 (4)	ME 578 (3)			ME 547 (4) ME 510 (4)
Renewable Energy Infrastructure	CEE 588 (3)				CEE 588 (3)
Running Total of Credits	11	21	31 minimum	31 minimum	42 minimum

[1] ME Dept permits up to 6 credits of ME 599B (that is: $x+y+z \leq 6$). For students on MS thesis option, substitute 12 credits of ME 700