

# **ME 431 INTERNAL COMBUSTION ENGINES**

## **Preliminary Course Syllabus, Spring 2009**

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**Course Secretary:** Mary Newby, 863-6272, 105 Research Building East, (mln7@psu.edu)

Teaching Assistant: to be determined

**Class Hours and Location:** MWF 11:15-12:05 107 Wartik

### **Office Hours:**

- Rich Yetter: MW 3:30-4:30 in 111 Research Building East. Other times can be arranged by appointment. E-mail also works well for specific questions.

### **Course Objectives (Mapping to Program Outcomes shown in brackets):**

- A. Learn to classify different types of internal combustion engines and their applications [3c].
- B. Apply principles of thermodynamics, fluid mechanics, and heat transfer to the design and analysis of engines and engine components [1a, 2b, 2e].
- C. Become aware of the relevance of environmental and social issues on the design process of internal combustion engines [3b].
- D. Develop mathematical methods for designing components and systems [2c,2f]
- E. Apply numerical methods to perform design calculations [3f, 4d, 4e].
- F. Advance proficiency in professional communications and interactions [3d, 3f].

### **Course Outcomes (Mapping to Course Objectives shown in brackets):**

1. Demonstrate a basic understanding of engine function, performance, and design methodology [D].
2. Demonstrate an understanding of the relationships between the design of the IC engine and environmental and social issues [C].
3. Identify engine types and components [A].
4. Perform preliminary design of internal combustion engines for sizing of engines for particular application [B,D].
5. Analyze thermodynamic cycles for Otto and Diesel cycles [B].
6. Construct a thermodynamic model of a spark ignition engine to predict the work output by developing a zero dimensional two-zone finite heat release model for cycle analysis [D, E].
7. Perform numerical experiments on single cylinder engine with professional commercial software code [E].
8. Determine and understand the effects of spark timing, valve timing, A/F ratio, engine geometry, fuel type, and manifold tuning on engine performance and emissions [B].
9. Prepare a written report on the design and the performance and emissions analysis of an internal combustion engine [B, E, F].
10. Demonstrate professionalism in interactions with colleagues, faculty, and staff [F].

### **Teaching / Learning Strategies:**

- Lecture/discussion
- Discussion groups
- Active problem solving
- Term project

### **Reference Textbook:**

Internal Combustion Engines: Applied Thermal Sciences, 2nd Edition, Colin R. Ferguson and Allan T. Kirkpatrick, John Wiley and Sons, NY, 2000.

### **Relevant Reference Texts (all on reserve in Engineering Library):**

Engines: An Introduction, John L. Lumley, Cambridge University Press, 1999.

Introduction to Internal Combustion Engines by Richard Stone, 3<sup>rd</sup> Edition, 1999, SAE International.

This book will serve as a reference. The textbooks by Lumley, Heywood, and Stone are also recommended for reading.

Internal Combustion Engine Fundamentals, John B. Heywood, McGraw-Hill, Inc., NY, 1988.

The Internal Combustion Engine in Theory and Practice, Vol. 1: Thermodynamics, Fluid Flow, Performance 2<sup>nd</sup> Edition, Charles F. Taylor, The MIT Press, Massachusetts Institute of Technology, Cambridge, MA, 1985.

The Internal Combustion Engine in Theory and Practice, Vol. 2: Combustion Fuels, Materials, Design 2<sup>nd</sup> Edition, Charles F. Taylor, The MIT Press, Massachusetts Institute of Technology, Cambridge, MA, 1985.

An Introduction to Combustion: Concepts and Applications 2<sup>nd</sup> Edition, Stephen R. Turns, McGraw-Hill, Inc., NY 1996.

Other paper/preprint/article materials will be put on the Angel website from which you may make personal copies should you desire to do so. Another important resource is the Society of Automotive Engineers (SAE); the library has literally 1000's of SAE papers on microfiche; SAE also has a website ([www.sae.org](http://www.sae.org)).

**Projects and Teams:**

Much of the work in this course will be performed by teams. Teams will consist of two to three people. A course project will involve a number of interim tasks and task reports, a team self-evaluation will be completed at each key milestone. Also I will request that each team keep a log of meetings.

*If you are not prepared to perform your fair share of the work as part of a team you should drop this class immediately. Non-performance will result in failing the class.*

**Final Term Project:**

A final project will consist of designing and analyzing complete single and multicylinder engines inclusive of intake, cylinder and exhaust systems, or writing a report on a topic relevant to I.C. engines.

**Homework:**

Approximately 6 homework sets will be assigned throughout the semester. The homework sets will be individual assignments.

**Exams:**

Two exams will be given during class hours during the semester.

**Semester Projects:**

Approximately 4 semester projects will be assigned during the semester. These projects will be group projects with 2-3 people per group.

**Late Assignments:**

Unexcused late assignments will be penalized 20% of total points for each weekday they are late. After one week they will not be accepted because their value will be zero.

**Grading:**

Homework: 20%

Projects: 20%

Final Project: 20%

Exams: 40%

**Preliminary Course Outline:**

Class	Day	Date	Topics	Important Notes
<b>INTRODUCTION &amp; OVERVIEW</b>				
1	M	Jan. 12	Introduction, Syllabus	
2	W	14	Historical perspective	
3	F	16	4-Stroke Spark Ignition Processes and Timing, "Typical Numbers"	
4	W	21	Overview of SI Operation: combustion, mixture preparation, load control	
5	F	23	Overview of Diesel Operation: combustion, mixture preparation, load control	
6	M	26	Overview of 2-stroke engines	
<b>PERFORMANCE PARAMETER &amp; PRELIMINARY DESIGN</b>				
7	W	28	Slider crank, mean piston speed, Mean effective pressure	
8	F	30	Torque, work, power; Brake, friction and indicated torque and power; Measurement of torque;	
9	M	Feb. 2	Preliminary design methods, examples	
10	W	4	Other Important Parameters: volumetric efficiency, specific fuel consumption, fuel conversion efficiency, How can power be increased?	
<b>ENGINE CYCLES, THERMODYNAMIC MODELLING AND HEAT TRANSFER</b>				
11	F	6	Motivation, Real engine cycle, Idealized cycles	
12	M	9	Otto and Diesel Cycles: Constant gas properties	
13	W	11	Otto and Diesel Cycles: Variable gas properties; Realistic combustion model	
14	F	13	Intake and exhaust processes; Effect of residual gases	
15	M	16	Examples	
16	W	18	Heat Transfer Analysis in IC Engine	
<b>GAS EXCHANGE PROCESSES &amp; IN-CYLINDER MOTION</b>				
17	F	20	Overview, valves and valve train hardware, "typical numbers"	
18	M	23	Effect of intake valve closing and of intake manifold on volumetric efficiency	
19	W	25	In-cylinder charge motion: swirl, tumble and squish	<b>Tentative First Exam</b>
<b>SI ENGINE COMBUSTION AND EMISSIONS</b>				
20	F	27	Fuel-air mixing: Fuel injection and carburetion	
21	M	Mar. 2	SI combustion: phases and effects of key parameters	
22	W	4	How do flames propagate?, impact on engine operation and design	
23	F	6	Knock in SI engines: what, why, control, & octane	
<b>9-13</b>		<i>Spring Break</i>		
24	M	16	SI Emissions: Production and control	
25	W	18	SI Combustion chamber design choices and trade-offs	
<b>FORCED INDUCTION</b>				
31	F	20	Turbo- and supercharging, operation of turbocharger, compressor design	
32	M	23	Thermodynamic analysis of turbocharging	
33	W	25	Intercooling, Practical considerations for SI and CI engines	
<b>CI (DIESEL) ENGINE COMBUSTION AND EMISSIONS</b>				
26	F	27	Types of CI Engines: DI & IDI, Need for forced induction	
27	M	30	Fuels and fuel injection systems, Cetane number	
28	W	April 1	Diesel Combustion: phases and effects of key parameters	
29	F	3	Combustion of liquid fuels, impact on engine design and operation	
30	M	6	Diesel Emissions: Production and control	
<b>OTHER ENGINE TYPES</b>				
34	W	8	2-stroke SI engines, direct injected, stratified charge	
35	F	10	Rotary engines	
36	M	13	Hybrids, Fuel Cells, Electric	
37-43	Apr	15-29	<b>OTHER TOPICS &amp; PROJECT PRESENTATIONS</b>	<b>Tentative Second Exam</b>
44	May	1	Summary	

