

# ME 4610/5610

## Advanced Machining Processes

### General Course Information

### Spring 2009

#### Instructor

William J. Endres, Associate Professor

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*Who am I?* I grew up in the Northwest suburbs of Chicago (Park Ridge). I attended the University of Illinois at Urbana-Champaign where I received my B.S. (1988), M.S. (1990) and Ph.D. (1992) degrees, all in Mechanical Engineering. I spent 7 years at U. of Michigan before coming to MTU in 2001. Besides my work at MTU, I do have other interests, including recently founding a technology development company, as well as broomball, ice hockey, roller hockey, camping, and listening to music, though not much time for the latter. I have three children.

*Office:* Location: 826 R. L. Smith  
Phone: 487-2567  
(tentative) Regular Hours: Tuesday, 12:00 p.m. – 2:00 p.m.  
Thursday, 1:00 p.m. – 2:00 p.m.  
Other Hours: By appointment, or anytime I am in my office  
and my **door is open**. But, **not right before**  
**class** from 8:00 – 9:00 a.m.; thanks.

#### Course Format

*Lecture:* Time: MWF, 9:00 – 10:00 a.m.  
Homework: Generally assigned on Monday and  
due the following Monday.  
Quizzes: Every other Wednesday.  
(each answer which has something to do with  
the question's topic will get credit)

*Laboratory:* Time: Tu 10:00 a.m. – 12:00 p.m., B007, typ.  
Th 2:00 p.m. – 4:00 p.m., B007, typ.  
Quantity: Planning on 5-6 laboratory experiments.  
Reports: Typed text with neat, hand- or computer-  
drawn sketches – **as brief as possible**.

#### Grading

HW Assignments (10) Total:	20%
Lab Assignments (6) Total:	20%
Quizzes (best 5 of 6) Total:	5%
Exams (2) Total:	30%
Final Project:	25%

#### Assignment Preparation, Submission and Re-grade Policy

*Preparation:* Assignments (homework, laboratory and projects) will be assigned either to each individual student or, in some cases such as laboratory reports, to a pre-defined team. All assignments are to be completed by the individual or team per the assignment. The term 'You' in the following refers to either an individual student or a team of students for team assignments.

You are allowed and encouraged to consult with other students in the current class during the solution of assignments; but all final written and computer work is to be generated by you working alone. You are not allowed to transcribe the work, either in scrap or final form, of another student; you are expected to work out the details of the assignments on your own when producing the final document to be submitted for grade. You are also not allowed to possess,

## General Course Information

look at, use, or in anyway derive advantage from the existence of solutions prepared in prior years, whether these solutions were former students' work product or copies of solutions that had been made available by an instructor.

Violation of this policy is grounds for the instructor to initiate a disciplinary action. If you have any questions about this policy, **please** do not hesitate to contact me.

**Submission:** All assignments are due in class on the due date, unless otherwise stated. It is preferred that the assignment be submitted at the start of class. Assignments turned in after I leave lecture but before 8:00 a.m. the following morning will be accepted with a 25% penalty. Assignments submitted later than that but before the end of the next day will be graded if you want, but will not receive credit.

**Re-grade:** Any request for re-grade (homework assignments, quizzes, laboratory/project reports, exams, etc.) must be made/submitted within one (1) week of when the graded work is returned with the original grade, no exceptions.

### Course Objectives

1. To teach the mechanistic modeling technique for manufacturing processes using static models of machining processes to illustrate.
2. To teach the use of design of experiments and how to interpret the data through semi-empirical model building.
3. To teach basic geometry, mechanics and thermal issues associated with chip formation.
4. To teach the effects of tooth shape on machining force components and surface finish.
5. To teach the effects of process kinematics on force signatures and surface finish.

### Course Outcomes

#### General

1. Understand the basic techniques of mechanistic modeling with its application to manufacturing processes.
2. Be able to plan and diagnose machining processes used in practice via a qualitative understanding of their thermo-mechanical behavior.

#### Specific

3. Understand the mechanical aspects of orthogonal cutting mechanics.
4. Understand the thermal aspects of orthogonal cutting mechanics.
5. Be able to extend, through mechanistic modeling techniques, the orthogonal-model concepts to oblique cutting.
6. Be able to extend, through mechanistic modeling techniques, the orthogonal and oblique cutting concepts to three-dimensional processes used in practice.
7. Be able to model, in an industrially-useful manner, forces for three-dimensional machining processes used in practice.
8. Be able to model the deterministic components of surface generation for three-dimensional machining processes used in practice.
9. Be able to calibrate empirical force models by designing an experiment, conducting the experiment, and identifying model parameters.
10. Understand the practical aspects of tool wear and tool life, and their influence on economics.

## General Course Information

### Course Outline

The items in *Italics* are in the text but are not covered due to lack of time.

#### **An Introduction to Machining Processes**

#### **1 Machining Process Modeling and Analysis**

- 1.1 General Terminology
- 1.2 Motivation for Process Modeling
- 1.3 Machining Economics
- 1.4 The Mechanistic Modeling Approach
- 1.5 *Static vs. Dynamic Modeling*

#### **2 Orthogonal Cutting-Process Mechanics**

- 2.1 Orthogonal Process Geometry
- 2.2 Chip Characterization
- 2.3 Force – Process-Geometry Relations
- 2.4 Stress and Strain
- 2.5 Specific Energy and Force Prediction
- 2.6 Empirical Specific Energy Modeling

#### **3 Fundamental Three-Dimensional Processes**

- 3.1 The Oblique Cutting Process
- 3.2 The Turning and Facing Processes
- 3.3 The Boring Process
- 3.4 Modeling the Effects of Runout

#### **4 More Geometrically Complex Processes**

- 4.1 The Face Milling Process
- 4.2 The End Milling Process
- 4.3 The Drilling Process

#### **5 Machined Surface Characterization**

- 5.1 Overview
- 5.2 Surface Error Components
- 5.3 Surface Characterization Parameters
- 5.4 Turning, Boring, Drilling, and Face Milling

#### **6 Thermal Energy and Temperature**

- 6.1 *Thermal Energy Generation*
- 6.2 *Cutting Temperature Models*

#### **7 Tool Wear, Tool Life and Machining Economics**

- 7.1 Tool Wear in Cutting
- 7.2 Tool Life Models for Cutting
- 7.3 A Time, Cost and Profit Model
- 7.4 Economics-Based Optimization

#### **8 Reality Issues in Machining**

- 8.1 Chip Control
- 8.2 *Tool Materials and Selection*
- 8.3 Vibration and Chatter