# ME 560 Precision Machine Design and Instrumentation

**Instructor:** Professor Andre Sharon
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**Lecture hours/week**: 3 Mon 4 - 6, Wed 4 - 5
**Discussion hours/week**: 1
**Laboratory hours/week**: 0

**Semester credits**: 4

**Textbooks**:
Machine Design and Control – A Systems Level Approach, Custom Printing , J. Wiley

**Reference Books:**
Handbook of Modern Sensors: Physics, Designs, and Applications; Jacob Fraden, Springer-Verlag
Machinery's Handbook, Industrial Press
The Mechatronics Handbook, Robert Bishop, Ed., CRC Press

**Prerequisites**: Senior/Graduate standing with basic CAD experience or consent of instructor

**Course Description**:

This inter-disciplinary course teaches the student how to design, instrument, and control high-precision, computer-controlled automation equipment, using concrete examples drawn from the photonics, biotech, and semi-conductor industries. Topics covered include design strategy, high-precision mechanical components, sensors and measurement, servo control, design for controllability, control software development, controller hardware, as well as automated error detection and recovery. Students will work in teams, both in-classroom and out-of-classroom, to integrate and apply the material covered in class to a term-long multi-part design project in Pro-Engineer, Solid Works, or other comparable CAD system, culminating in a group presentation at the end of the semester.

**Syllabus:**

In additon to the fundamental principles of operation, these topics will be brought to life though selected case studies in the development of automatin equipment.

1. Machine Design and Instrumentation Strategy 1.0 wks
    - Examples of Precision Automation Equipment (slides & videos)
    - Design: Science or Art?
    - Design Strategies
    - Project Phases
    - Functional Requirements and Design Parameters

2. Design Team Formation and Projects Assignment 0.5 wks
3. Financial Justification and Project Planning 0.5 wks
    - Presentation and Justification to Management
    - ProForma Analysis
    - Return on Investment
    - Project Scheduling
4. Actuators 1.5 wks
    - Rotary Motors
    - Linear Motors
    - AC/DC
    - Stepper Motors
    - Hydraulic/Pneumatic Actuators
    - Solenoids and Voice Coils
    - Piezoelectric Actuators
5. Transmission Elements 1.5 wks
    - Gears
    - Lead/Ball Screws
    - Rack & Pinion
    - Belts/Chains
    - Mechanical Linkages
    - Backlash, Stiction, Friction
6. Joints and Bearings 1.0 wks
    - Rotary Pin Joints
    - Rotary Bearings
    - Bushings
    - Linear Bearings
7. Preliminary Design Review Presentations 1.0 wks
8. Sensors 2.0 wks
    - Incremental and Absolute Encoders
    - Tachometers
    - Accelerometers
    - Strain Guages
    - Force Sensors
    - Flow Sensors
    - Temperature Sensors
9. Servo Control and Design for Controllability 1.0 wks
    - System Modeling
    - Closed Loop Control
    - PID
    - System Response
    - Actuator/Sensor Location
10. Computer Control Software and Hardware 2.0 wks
    - C++ / Visual Basic
    - Graphical Programming Interface
    - Field Bus
    - Motion Controllers
    - Input/Output Devices
11. Vision and Image Processing 0.5 wks

- Cameras and Lenses
- Image Processing Strategies

12. User Interface, Error Detection and Recovery 0.5 wks
    - Operator/Administrator Mode
    - Real-time Fault Monitoring
    - Recovery
13. Critical Design Review Presentations 1.0 wks

**Grading**:

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|---|---|
| Term Project: | 70% |
| Quizzes: | 20% |
| Homework: | 10% |

**Course Goals**:

1. Equip engineering students with the knowledge and experience to design instrumented, computer controlled machinery.
2. Teach students how to financially justify and successfully execute a machine development project.
3. Give students interdisciplinary hands-on experience in the design of electro-mechanical systems.

**Course Outcomes**:

As an outcome of completing this course, students will:
A) Have the tools necessary to design and instrument computer-controlled machinery.
B) Understand basic actuator technologies.
C) Understand basic sensing technologies.
D) Understand basic machine control strategies.
E) Understand basic transmission elements.
F) Be able to size and select proper actuators, sensors, and controller hardware.
G) Have the knowledge to financially justify, plan and execute a machine development project.