

INC (EN-3603/4223)- Instrumentation & Control

Control - SPRING 2016

Course Abstract: Control is a relatively complex subject affecting almost every aspect of our lives. This course will provide a foundation for understanding the dynamic (changing over time) behavior of all *systems*: mechanical, electrical, fluid, nuclear, biological and even economic. These systems are modeled and analyzed using a variety of methods, and the dynamic behavior is simulated in software. A *controller* is typically designed by adding closed-loop feedback and controller dynamics to improve the quality of the system response to a variety of inputs. This course will prepare you for graduate classes in modern control, for work in automatic control system design and advanced controller applications. The class will also prepare you for the “Modeling of Engineering Systems” and the “Analysis of Engineering (Dynamic) Systems” sections of the Engineer in Training Examination (Professional Engineering).

TEXT: **Modeling and Analysis of Dynamic Systems**
Close, C.M., and Frederick, D.K.
3rd Edition (copyright 2002), John Wiley & Sons

INSTRUCTOR: **Dr. John J. Bausch**
Email: jbausch@maritime.edu
Phone: (508) 830-5000 (x-2029)
Room: HA-222 (Harrington 2nd Deck)

CLASS: Monday, Wednesday, and Friday
Section EN-4223-x11-from 08:00 to 08:50 Hours (1st Period)
Room: BR-222 (Bresnahan Electronics & Controls Laboratory)

NLAB: Instrumentation & Controls Laboratory
Tuesday x25@NOON and x27@1400 in BR-222 (EIC Lab)
NLab is only required for ESE-ABET Students

STCW: Both Class and Lab are required to satisfy USCG-STCW.
The STCW Knowledge elements are listed on the next page.

This course is an acceptable substitute for EN-3216 **Operational Controls**, The STCW requirements of EN-3216 will be met with a “C-” or better.

ATTENDANCE:
Attendance is tracked to satisfy USCG-STCW requirements.
Lack of regular attendance will impact your Final Grade.

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GRADING:

Grades are based on homework (PSets and iLabs), quizzes, and exams.

iLabs are electronic assignments using Matlab/Simulink, and are designed to demonstrate competency in each part of the Instrumentation & Control class:

1) Modeling, 2) Analysis, and 3) Controller Design.

INC Assignments are made via email.

Late work will NOT be accepted.

INC COURSE GRADE METRIC:

Each Exam will build-on and APPLY the Knowledge from previous Exams.

Exam1 (Modeling)	20%
Exam2 (Analysis)	20%
Exam3 (Control - Final)	20%
Quizzes (anytime baby!)	20%
Homework (PSets & iLabs)	20%
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Total Grade	100%

INC USCG-STCW Elements:

Covers instrumentation and control fundamentals and applications to facility systems including documentation. Both analog and digital control systems are covered. It is also an introduction to programmable logic controllers. This course addresses the following STCW Knowledge elements:

- OICEW-A4.1 Basic construction and operation principles of automatic control systems
- OICEW-A5.1 Operational characteristics of control systems
- OICEW-B1.1 Basic configuration and operation principles of sequential control circuits
- OICEW-B1.2 Flowchart for automatic and control systems
- OICEW-B1.2 Functions, characteristics and features of control systems for machinery
- OICEW-B1.3 Various automatic control methodologies and characteristics
- OICEW-B1.3 Proportional–Integral–Derivative (PID) control characteristics
- OICEW-B1.3 Associated system devices for process control
- OICEW-B1.3 Configuration and operation principles of control systems
- OICEW-B2.5 Function and performance tests of electronic monitoring systems
- OICEW-B2.5 Function and performance tests of electronic automatic control devices
- OICEW-B2.5 Function and performance tests of electronic protective devices

INC-Syllabus with Outcomes by Chapter & Activity

INC- Instrumentation and Control, gives students the engineering tools needed to study a wide variety of dynamic systems and controllers, regardless of their physical origin (i.e., Mechanical, Electrical, Thermal, Economic, Social; the changes in any dynamic system). The textbook (Modeling and Analysis of Dynamic Systems) includes detailed modeling of mechanical, electrical, electro-mechanical, thermal, and fluid systems. In this class, dynamic models are developed in the form of state-variable equations, input-output differential equations, transfer functions, and block diagrams. The Laplace transform is used for analytical solutions (calculation-based), and additional computer solutions are based on Matlab/ Simulink software. Application case studies look at marine and power systems, and related components. The final third of the class examines the design tools for closed-loop feedback control systems using Matlab & Simulink.

Part I: Dynamic System Modeling

- Chap 1. Introduction: Develop an understanding of PID Controls & System I/O
- Chap 2. Translational Mechanical Systems: Develop LODE Models for MBK Translation
- Chap 3. Standard Forms for System Models: Develop A,B,C,D Modern Control Formats

Part II: Control System Analysis

- Chap 4. Block Diagrams and Computer Simulation: Apply Simulink to Part I LODEs
- Chap 7. Transform Solutions of Linear Models: Derive Laplace Transforms for LODEs
- Chap 8. Transfer Function Analysis: Develop 1^o, 2^o, & Nth^o System Transform solutions

Part III: PID Controller Design

- Chap 13. Block Diagrams for Dynamic Systems: Develop Closed Loop Control Systems
- Chap 14. Modeling, Analysis, and Design Tools: Develop PID Design Solutions
- Chap 15. Feedback Design with MATLAB: Examine practical PID Matlab Designs

iLabs: Develop a simple, physical Coke Can Parametric LODE Model

DC Servo-Motor Case Study: Develop a practical PID Control Example

- Examine a Combined Electro-Mechanical System
- Examine Closed-Loop Speed Controller Design
- Examine Closed-Loop Position Controller Design

Matlab/Simulink Software: Learn & Apply to Design & Implement.

- Use Matlab Controls Tutorials & Application Case Studies
- Apply Classical Laplace Transforms to Modeling & Simulation
- Use Simulink Tool Library Graphical Modeling & Simulation
- Apply Modern State-Space Matrix Modeling & Simulation

and will briefly discuss (time permitting): Chap 5. Rotational Systems, Chap 6. Electrical Systems, and Chap 10. Electro-Mechanical Systems (with models used as examples).

NLab (EN-3603L)

INC Laboratory - SPRING 2016

This laboratory supports course EN-3603:Instrumentation & Controls (INC). Preliminary labs involve several types of sensors and instrumentation; including PLC programming & operation. The N Labs then focus on digital PID controller design for dynamic systems using of Matlab and Simulink Software. Programming will involve both graphical Block Diagram methods and C-like command-based programming with M-File Scripts. Student Teams will maintain an NLab-NoteBook containing copies of their work for records and grading. This Laboratory will prepare you for graduate classes in Modern Control, and career work with advanced micro-processor-based control applications.

Text: **NLab Handouts will be given out in each Lab session.**
N Labs will build on material from the INC Course Text:
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Lab Instructor:

Dr. John J. Bausch
Email: jbausch@maritime.edu
Phone: (508) 830-5000 (x-2029)
Room: HA-222A

NLABs: **Tuesday Afternoon:**

Section x-25 Tues@ 12:00-13:40 (5th & 6th Period)
Section x-27 Tues@ 14:00-15:40 (7th & 8th Period)
Report to Lab as scheduled. There are **NO MAKE-UP Labs!!!**
ALL Lab Sections will MEET EVERY WEEK.
BR-222; the ECS Lab-Electronics & Control Systems

Grading: Grades are based on the cumulative **Lab Results** as documented in the **Team NLAB-NOTEBOOK**, two Team Projects, and on **INDIVIDUAL** lab participation. Lab participation is based on attendance and observed work. Assignments and updates are also made via email. **Late work will NOT be accepted without prior clearance.**

Evaluation: Cadets are expected to participate in **each lab** as part of a team.

Weekly Lab-work Results (10 Labs documented in Team NLab-Notebook)	50%
Final Submitted Version of Team NLab-Notebook (ONE per Team)	10%
Matlab/Simulink Dynamic MODELING Project (NLab11)	20%
<u>New Laboratory Exercise & Equipment DESIGN Project (NLab12)</u>	<u>20%</u>
Total Grade	100%