ME447 Black – On Campus & Outreach Sections

Spring 2008 Blue Underline – On Campus Sections Only

Weekly Schedule *Red Italic– Outreach Sections Only*

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Week 1

- Reading/Video/Web
  - Lecture 01 – Course overview
  - Lecture 01.5 – Microcontroller & C Intro (Handout only – No Video)
  - Lecture 02 – Open-Loop and Closed Loop Process Control
  - Lecture 03 – Matlab Basics For Control Engineering
  - *Lecture 04 – Computer Architecture*
  - Bollinger & Duffie Ch 1
- Lab 0.5 preparation Lab 0.5 Downloading Code to the Microcontroller System

- Lab 1 preparation Lab 01 Motor Control Introduction
  - Dorf –Modern Control Systems 10th Edition Section 2.10
    - Figure out how to paste m-code and plots into Word
  - controller configuration & program
  - plots from Matlab (preferable) or Excel to Word
  - Equation in Word

- Lab 0.5 Downloading Code to the Microcontroller System
  - Microcontroller Control Platform
  - CodeVisionAVR

- Lab 01 Motor Control Introduction
  - Motor/power amplifier
    - components
    - operation
    - specifications
  - ATMEL controller
    - capabilities
    - 'C' language & programming
  - LabVIEW Interface
    - Access
    - Components
    - Operation
    - Data logger
  - Effect of motor control gain
    - gain changing
    - step response
    - response data to Excel
    - plots to Word
  - Report preparation

- **Work To Hand In**
  - **Thursday - Lab 01 report Due 5:00 PM US CENTRAL TIME**

Week 2

- Reading/Video/Web
  - Harrison & Bollinger Ch 2 (except Sec 2-4)
  - Bollinger & Duffie Sec 2.1,2
  - Lecture 05 – Continuous process modeling
  - Lecture 06 – Model linearization and validity
  - Lecture 07 – Discrete process modeling
  - *Lecture 08 – Computer Input/Output*

- Lab 02 – Motor Velocity Model preparation
  - Model from parameters

- Lab 02 – Motor Velocity Model
  - ATMEL controller
    - Encoder
    - D/A
  - Velocity step response
  - Models
    - from response data
    - from parameters
    - comparison of models
    - comparison of responses
  - Report preparation

- **Work To Hand In**
  - **Thursday - Lab 02 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #1 - Bollinger & Duffie Prob 2.20(a,d,f,g) - differential eqns only Due 5:00 PM US CENTRAL TIME**

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Week 3

- Reading/Video/Web
  - Bollinger & Duffie Sec 2.3; 9.1-3
  - Lecture 09 – Discrete Controller Modeling
  - Lecture 10 – Discrete System Simulation
  - Lecture 11 – Sequential Logic Control
  - *Lecture 12 – Computer Control Software*

- Lab 03 – Proportional Control Implementation preparation
  - Block Diagram
  - Simulation
  - P Control Software

- Lab 03 – Proportional Control Implementation
  - ATMEL controller
    - sampling using time delay
    - P control software
  - Sample period adjustment
    - minimum sample period
    - setting desired period
  - Increasing sample period
    - compare position step responses
  - Simulation
  - Report preparation

- **Work To Hand In**
  - **Thursday - Lab 03 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #2 - Bollinger & Duffie Prob 2.14,15 Due 5:00 PM US CENTRAL TIME**

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Week 4

- Reading/Video/Web
  - Bollinger & Duffie Sec 9.4,6,7
  - Lecture 13 – State Transition Diagrams
  - Lecture 13 – Addendum (Notes only – No Video)
  - Lecture 14 – Programmable Logic Controllers
  - *Lecture 15 – Programming Control Systems*
  - *Lecture 16 – Components of Interfaces*
  - Lecture 49 – Interrupt Driven Control

- Lab 04 – Pencil Sharpening Cycle preparation
  - Cycle state transition diagram
  - Velocity Command Generation Scheme

- Lab 04 – Pencil Sharpening Cycle
  - ATMEL logic I/O
  - sampling with interrupts
  - design of cycle
  - state transition diagram for cycle
  - translation to "C"
  - report preparation

- **Work To Hand In**
  - **Thursday - Lab 04 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #3 - Bollinger & Duffie 9.3, 9.11(a) Due 5:00 PM US CENTRAL TIME**
    - **use method in notes**

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Week 5

- Reading/Video/Web
  - Bollinger & Duffie Sec 2.4(rev); 11.1,2,4
  - Lecture 17 – Laplace Transformation
  - Lecture 18 – Z Transformation
  - *Lecture 19 – I/O Interfaces*
  - *Lecture 20 – D/A & A/D Converter Interfaces*

- Lab 05 – Introduction to PLC preparation

- Lab 05 – Introduction to PLC
  - PLC architecture
  - I/O
  - ladder diagrams
  - timing
  - other functions
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 05 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #4 - Bollinger & Duffie 9.16,18 Due 5:00 PM US CENTRAL TIME**

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Week 6

- Reading/Video/Web
  - Bollinger & Duffie Sec 11.4
  - Harrison & Bollinger Sec 7.4,5
  - Lecture 21 – Z Transforms of Process Models
  - Lecture 22 – Block Diagram Manipulation
  - *Lecture 23 – Data Sampling*
  - *Lecture 24 – Position Sensors*
  - ~~*Lecture 25 – Miscellaneous Sensors*~~ *(Not Currently Available)*

- Lab 06 – Hydraulic Press Control preparation

- Lab 06 – Hydraulic Press Control
  - hydraulic cycle
  - state transition diagram
  - ladder diagram
  - report preparation

- Pneumatic demo (Time Permitting)

- Sample Quiz Problems (if available)

- **Quiz 1 On Campus in class**

- ***Quiz 1 Due 5:00 PM US CENTRAL TIME day of On Campus Quiz 1***

  - ***Coordinate with Engineering Outreach***

- **Work To Hand In**
  - **Thursday - Lab 06 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #5 - Bollinger & Duffie Prob 11.5,8,9,10 Due 5:00 PM US CENTRAL TIME**
    - **Express you TFs in terms of z^{-1}**
    - **Collect terms in TFs by powers of z^{-1}. i.e $\frac{(a+b)z^{-1}}{1+ dz^{-1} + (d+e)z^{-2}}$**

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Week 7

- Reading/Video/Web
  - Bollinger & Duffie Sec 2.5,6(rev); Chap 3
  - Lecture 26 – Discrete System Response
  - Lecture 27 – Steady-State Response and Final Value Theorem
  - Lecture 28 – Matlab Controls Tools

- Matlab control tutorial (Dorf & Bishop Section 13.12 & Lecture 28)

- Lab 07 – P, PI, & PD Control preparation
  - block diagram
  - Matlab 'c2d' function
  - transfer function from parameters
  - velocity gain
  - difference equation from transfer function
  - PID control equation
  - closed-loop simulation
  - D/A voltage limit

- Lab 07 – P, PI, & PD Control
  - closed loop control program
  - define merit function
  - find best P control
  - find best PI control
  - find best PD control
  - effect of D/A limiting
  - report preparation

- Quiz 1 Discussion

- **Work To Hand In**
  - **Thursday - Lab 07 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #6 - Bollinger & Duffie Prob 3.2(f),3.10 Due 5:00 PM US CENTRAL TIME**
    - **Express you TFs in terms of z^{-1}**
    - **Collect terms in TFs by powers of z^{-1}. i.e $\frac{(a+b)z^{-1}}{1+ dz^{-1} + (d+e)z^{-2}}$**
    - **Replace: $B = z^{-1}$**

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Week 8

- Reading/Video/Web
  - Lecture 29 – Systems With Disturbances
  - Lecture 30 – Partial Fraction Expansion
  - Lecture 31 – Stability

- Lab 08 – Systems With Disturbances preparation
  - output/command transfer function
  - error/disturbance transfer function
  - disturbance response
  - final value of error
  - steady-state error vs gain
  - stiffness vs gain
  - stiffness transfer function

- Lab 08 – Systems With Disturbances
  - PID control equation
  - stiffness with P control
  - stiffness with PD control
  - stiffness with PI control
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 08 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #7 - Bollinger & Duffie Prob 2.29,30,31 Due 5:00 PM US CENTRAL TIME**

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Week 9

- Reading/Video/Web
  - Bollinger & Duffie Sec 2.6; 4.1,2
  - Lecture 32 – Direct Controller Design
  - Lecture 33 – Dynamics Associated with Root Locations in the Z-Plane
  - Lecture 34 – Pole placement Using Analytical Methods

- Lab 09 – Variation of Poles With Gain preparation
  - block diagram
  - gain for time constant
  - gain for no overshoot
  - gain for 50% overshoot
  - max gain for stability
  - time constants, damping ratios, natural frequencies

- Lab 09 – Variation of Poles With Gain
  - closed loop control program
  - gain for time constant
  - gain for no overshoot
  - gain for 50% overshoot
  - max gain for stability
  - compare to theoretical
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 09 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #8 - Bollinger & Duffie Prob 4.1,12 Due 5:00 PM US CENTRAL TIME**
    - **Express you TFs in terms of z^{-1}**
    - **Collect terms in TFs by powers of z^{-1}. i.e $\frac{(a+b)z^{-1}}{1+ dz^{-1} + (d+e)z^{-2}}$**

Week 10

- Reading/Video/Web
  - Bollinger & Duffie Sec 12.1,2
  - Lecture 35 – Pole Placement Using the Root Locus (Graphical) Method
  - Lecture 36 – Root locus with Matlab
  - Lecture 37 – Integral Control

- Matlab root locus tutorial - Dorf & Bishop Section 13.12 (Example 13.11)

- Lab 10 – Design Using Root Locus preparation
  - 1st-order root locus
  - gain selection
  - root locus for motor with P control
  - gain selection

- Lab 10 – Design Using Root Locus
  - formulation for PI control
  - root locus
  - gain selection
  - comparison of methods
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 10 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #9 - Bollinger & Duffie 12.10,11,12 Due 5:00 PM US CENTRAL TIME**

Week 11

- Reading/Video/Web
  - Bollinger & Duffie Sec 12.4
  - Lecture 38 – Pole-Zero Cancellation
  - Lecture 39 – Aliasing

- Lab 11 – Aliasing preparation
  - A/D conversion
  - anti-aliasing filter response

- Lab 11 – Aliasing
  - high sampling rate
  - low sampling rate
  - response to command
  - response to noise
  - anti-alias filter
  - report preparation

- **Quiz 2 On Campus in class**

- ***Quiz 2 Due 5:00 PM US CENTRAL TIME day of On Campus Quiz 2***
  - ***Coordinate with Engineering Outreach***

- **Work To Hand In**
  - **Thursday - Lab 11 report Due 5:00 PM US CENTRAL TIME**

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Week 12

- Reading/Video/Web
  - Lecture 40 – Sample Period Selection
  - Lecture 41 – Process Model Simplification

- Lab 12 – Pole-Zero Cancellation preparation
  - set P gain without p-z
  - pole-zero cancellation
  - set P gain with P-z
  - comparison

- Lab 12 – Pole-Zero Cancellation
  - control implementation
  - testing
  - comparison
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 12 report Due 5:00 PM US CENTRAL TIME**

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Week 13

- Video/web lecture access
  - Lecture 42 – Feedforward Control
  - Lecture 43 – State Feedback Control

- Lab 13 – Command Feedforward Control preparation
  - block diagram
  - response without FF
  - design of FF control
  - response with FF
  - comparison

- Lab 13 – Command Feedforward Control
  - control software
  - 'sawtooth' command software
  - following error w/o FF
  - feedforward software
  - following error with FF
  - comparison with PI
  - report preparation

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 13 report Due 5:00 PM US CENTRAL TIME**
  - **Friday - Homework #10 - Bollinger & Duffie 4.17,21 Due 5:00 PM US CENTRAL TIME**

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Week 14

- Video/web lecture access
  - Bollinger & Duffie Sec 8.7
  - Lecture 44 – Stepping Motor Control

- Lab 14 – State Feedback Control preparation
  - block diagram
  - velocity loop design
  - position loop design

- Lab 14 – State Feedback Control
  - evaluate design
  - adjust velocity gain
  - adjust position gain
  - compare the theoretical
  - compare to PD and PZ

- Sample Quiz Problems (if available)

- **Work To Hand In**
  - **Thursday - Lab 14 report Due 5:00 PM US CENTRAL TIME**

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Week 15

- Video/web lecture access
  - Bollinger & Duffie Sec 8.7
  - Lecture 45 – System Design Example 1a
  - Lecture 46 – System Design Example 1b
  - *Lecture 47 – System Design Example 2*
  - *Lecture 48 – System Design Example 3*

- Lab 15 – Stepping Motor Control preparation
  - velocity calculations
  - acceleration calculations

- Lab 15 – Stepping Motor Control
  - motor specs
  - translator
  - constant velocity
  - constant acceleration
  - motion profile generation
  - max velocity & acceleration
  - report preparation

- **Work To Hand In**
  - **Friday - Lab 15 report Due 5:00 PM US CENTRAL TIME**

Week 16

- **Final Exam – Monday May 12 from 7:45 AM – 9:45AM: Room 2106, Mechanical Engineering**

- ***Final Exam – Outreach Section Due by 12:00PM Monday May 12 (Day of On Campus Final Exam)***
  - ***Coordinate with Engineering Outreach***