ME 5506 **Applied Linear Control**

Instructor:	Dr. Steve Southward, Associate Professor, ME Department
Classroom:	Blacksburg: 261 Durham
Time:	12:30 – 1:45 Tuesday & Thursday
Office:	139 Durham (only one day ~every two weeks)
Telephone:	434-766-6794
Email:	scsouth@vt.edu
Office Hours:	By appointment, or online using Skype
Textbook:	There is no formal textbook for this course. Course notes will be provided, reference papers will be cited (where applicable), and a list of useful reference books is provided below.

Course Description

Develop an applied understanding of the analysis and design of sampled-data systems, extraction of discrete-time dynamic models from experimental data, and implementation of dynamic compensators on digital processors. Design experience with LQR optimal control and an introduction to Kalman filtering. Realistic design problems with numerical simulations of practical implementations.

Prerequisites:

- Linear feedback control theory: both state-space and classical
- Analysis and manipulation of block diagrams
- Laplace transforms – from the time domain to the *s*-domain and vice versa
- Frequency response of common transfer functions (first-order, second-order)
- Frequency-domain feedback control design techniques (e.g. lead-lag and PID)

Mandatory software:

- MATLAB 7.14 R2012a (or later), Simulink, and Control System Toolbox
- PowerPoint, Word, and Equation Editor (built-in to Word)
- PDF Conversion Software

Course Goals: In this course, you will learn how to:

- Convert and implement discrete time dynamic compensators
- Design appropriate anti-alias and anti-imaging filters for a control implementation
- Extract dynamic system models from experimental data for use in design and analysis
- Design state- and output-feedback controllers using LQR optimal control

Course Topics:

- Sampled data systems
- Digital controller architectures and anti-aliasing/anti-imaging
- Z-transform and difference equations
- Continuous-to-discrete transformations (SISO and MIMO)
- Discrete state-space, IIR, and FIR realizations
- Frequency response and transfer functions
- Parametric and non-parametric system identification with experimental data
- Discrete time SISO and MIMO feedback control
- LQR Optimal Control
- Kalman Filtering and stochastics

Grading: (NOTE: There will be NO Final Exam for this class)

Homework:	10%
Quizzes:	20%
Midterm Exam:	20%
Midterm Project:	25%
Final Project:	25%

Assignment & Exam Policy:

- All assignments and exams MUST be the result of your own effort. The VT Graduate Honor Code will be strictly enforced (http://ghs.graduateschool.vt.edu)
- All graded assignments MUST be submitted electronically through Scholar
- No graded assignments will be accepted past the due date/time; note that all submissions are automatically time/date stamped
- All assignments are due by midnight of the published due date
- Electronic submissions must be PDF documents
- Handwritten documents may be scanned for submission as a PDF; however, they must be EXCEPTIONALLY neat, legible, and <1 Mb per assignment
- No hardcopy submissions to my department mailbox or office will be accepted
- No extra credit will be assigned and no grades will be dropped

Grading Policy:

- Homework solutions will be discussed in class after the due date
- After submitting homework assignments, each student will be responsible for assigning their own grade (subject to the VT Graduate Honor Code)
  - 2 points for attempting ALL problems and getting >80% correct answers
  - 1 point for attempting ALL problems and getting >40% correct answers
  - 0 points otherwise
- Each student is responsible for electronically submitting their homework grade through a VT Survey link that will be provided for each homework

Useful References:

The following is a list of books that you might find useful as references for ME 5506 (no need to purchase!):

1. Dorf, R.C., Bishop, R.H., *Modern Control Systems*, Addison-Wesley, Reading, MA, 1995.
2. Levine, W., *The Control Handbook*, CRC Press, 1996.
3. Papoulis, Athanasios, *The Fourier Integral and its Applications*, New York, McGraw-Hill, 1962, ISBN: 9780070484474
4. Oppenheim, Alan V., Ronald W. Schafer, and John R. Buck. *Discrete-Time Signal Processing*. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1999. ISBN: 9780137549207.
5. Papoulis, Athanasios, *Probability, Random Variables, and Stochastic Processes*, New York, McGraw-Hill, 4th Ed., 2002, ISBN: 9780071226615
6. Ljung, Lennart. *System Identification: Theory for the User*. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1999. ISBN: 9780136566953.
7. Juang, Jer Nan, *Applied System Identification*, Prentice-Hall, 1993, ISBN: 9780130792112
8. Mendel, Jerry, *Lessons in Estimation Theory for Signal Processing, Communications, and Control*, 2nd Ed., Prentice-Hall, 1995, ISBN: 9780131209817
9. Goodwin, Graham, and Kwai Sang Sin. *Adaptive Filtering, Prediction, and Control*. Englewood Cliffs, NJ: Prentice-Hall, 1984. ISBN: 9780130040695.
10. Grewal, Mohinder, and Andrews, Angus, *Kalman Filtering: Theory and Practice using MATLAB*, 3rd Ed., Wiley-IEEE Press, 2008, ISBN: 9780470173664