What you should know for the Midterm Exam

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1. **Preliminaries - Policy**
   (a) A clearly organized and "handwritten" double-sided A4 sheet which includes student's name/number on both sides is allowed in the exam. Other notes of any form are not allowed.
   (b) The A4 sheet will be collected with your exam paper at the end of the exam. It will not be returned to you (but you can make a copy for yourself before the exam),
   (c) Basic scientific calculators are allowed in the exam,
   (d) Cell-phones and computers are not allowed and need to be switched-off at the beginning of the exam. Timekeeping is via wrist-watch only!

2. **Exam topics:**
   The midterm exam covers all topics from the beginning of the lecture until (and including) the analysis and design of PID controllers.

3. **Topic: EE302 preliminaries**
   You should know everything from EE302 that was discussed in class. To name a few of importance: time-domain response, first-order and second-order response, laplace-transform, stability, root-locus, bode-plot, performance parameters on time-domain response, state-space representation.

4. **Topic: "Mathematical modeling of dynamic processes and plants"**
   You should know:
   (a) what is a mathematical model and why we develop models for dynamic systems,
   (b) differences between a "simulation" and a physical experiment,
   (c) examples of systems for which physical experiments are difficult versus easy,
   (d) the general principle of conservation expressed as "*inflow-outflow=accumulation*",
   (e) how to build models of electrical (all types) and electro-mechanical (one and two mass, translational and/or rotational) systems,
   (f) how to build models of simple liquid level and flow systems including Bernoulli's Law,
   (g) how to build models of simple thermal flow and heat capacity systems,
   (h) be able to build approximate models from given component and interconnection descriptions of systems (e.g. economic model, ecological model in class),
   (i) what is "system identification" and its relation with system models,
   (j) what are "time constant", "ideal-delay", "gain" in a process,
   (k) general structure of a feedback controlled system and the meaning of all blocks,
   (l) the meaning and use of "operating point" or "steady state" values of process variables,
   (m) differences of "deterministic" versus "stochastic" models, "dynamic" versus "static" models, "continuous-time" versus "discrete-time" models, "nonlinear" versus "linear" models, "lumped-parameter" and "distributed-parameter" systems,
   (n) how to derive a state-space model if the states are defined,
   (o) how to find a simple discrete-time approximation of a continuous-time system using Newton's quotient (finite-difference) formula,
   (p) definition and meaning of "self-regulating" and "non self-regulating (integrating)" processes.

5. **Topic: Experimental modeling and identification of processes and plants**
   You should know:
   (a) what is dead-time (ideal-delay), its time and Laplace domain representations,
   (b) what is first-order-plus-dead-time (FOPDT) model for nonlinear or higher order linear systems,
   (c) how to fit an FOPDT model to experimental data and determine model parameters,
   (d) concept of "domain of validity" for a model.
   (e) How to obtain an FOPDT approximation to a higher order linear system

6. **Topic: General procedure for process modeling and design of controllers**
   You should know the "flowchart" of modeling and design that we have developed in class.

7. **Topic: Modes of Control and Design of Single-input Single-Output Feedback Controllers**
   You should know:
   (a) ON/OFF control and its behavior,
   (b) hysteresis and its use for ON/OFF control,
   (c) usefulness and drawbacks of ON/OFF control,
   (d) P-Only control and ITAE design for FODTP plant,
   (e) how to sketch approximate root-locus of feedback-controlled linear systems with P, I, D modes of control,
   (f) how the closed-loop root-locus is affected by the introduction of new poles and zeros into the open-loop path,
   (g) the relationship between the different modes of control (P, I, D) and newly introduced open-loop zeros and open loop poles,
   (h) how to interpret the changes in the root-locus in terms of the stability and performance of the closed-loop controlled system,
   (i) the "windup" problem with integral (I) control and approaches to fix it,
   (j) the reason of the "noise" problem with derivative (D) control and methods to fix it,
   (k) the "derivative of error" and "derivative of process variable" implementations of the derivative (D) term, the differences in behavior of the resulting controlled system,
   (l) different PID controller structures in industry,
   (m) advantages and disadvantages of open-loop testing and closed-loop testing based controller design,
   (n) the Zygler-Nichols continuous oscillations (cycling) method,
   (o) "Direct Design" method for Dependent Ideal P, PI controllers,
   (p) "Internal-Model-Control" design method for Dependent Ideal PID controller for the FOPDT plant.

8. **Topic: Matlab Simulink**
   You should know:
   (a) the difference between a fixed-time-step and variable-time-step solvers in Simulink,
   (b) the reason one might use one over the other.

9. **Topic: Video Assignments**
   You should be able to answer knowledge questions from the video assignments.

10. **Topic: Reading Assignments**
    You should be able to answer knowledge questions from the reading assignments.

Good Luck, November 2018.