**Course Title**: Introduction to *Machine Learning and Control for Building Energy Systems*

**Course Description**: This course introduces the principles of building energy optimization with a focus on the modeling and control of HVAC systems. The curriculum covers HVAC fundamentals, thermodynamics, and heat transfer, progressing to dynamic systems, control theory, and optimization techniques. Key topics include an introduction to system identification, machine learning, and optimal control applied to energy-efficient building management. The course concludes with hands-on coding assignments focusing on implementation of machine learning and control techniques for optimizing the energy efficiency of buildings using high-fidelity simulation frameworks.

**Syllabus:**

Week 1: Introduction to Building Energy Systems

Week 2: HVAC systems and heat transfer modeling

Week 3: Dynamical systems fundamentals

Week 4: Control systems fundamentals

Week 5: Constrained optimization fundamentals

Week 6: Machine Learning - with HVAC load forecasting example

Week 7: System identification - with thermal dynamics modeling example

Week 8: Optimal Control - with HVAC control example

Week 9: High-fidelity building emulators

Week 10: Practical implementation aspects of machine learning and control for buildings

Week 11: Project evaluation with presentations

**Prerequisites**

* Differential calculus
* Linear algebra
* Optimization

**Suggested References**

[Control Intro] <https://en.wikibooks.org/wiki/Control_Systems/Introduction>

[Control textbook] Nise, N. S. (2011). Control Systems Engineering (6th Ed.). Wiley.

[Thermodynamics Intro] Claire Yu Yan, Introduction to Engineering Thermodynamics, 2022

<https://open.umn.edu/opentextbooks/textbooks/introduction-to-engineering-thermodynamics>?

[Dynamical Systems] Michael Brin, Garrett Stuck, Introduction to Dynamical Systems. 2010

https://www.cambridge.org/core/books/introduction-to-dynamical-systems/E45AA9E4E6350D0D4EA4EC345E4A0DA3

[Optimization Advanced] S. Boyd and L. Vandenberghe, ”Convex optimization,” Cambridge University Press, 2004.

<https://web.stanford.edu/~boyd/cvxbook/>

[Model Predictive Control] James B. Rawlings, David Q. Mayne, Moritz M. Diehl, Model Predictive Control: Theory, Computation, and Design, 2022

<https://sites.engineering.ucsb.edu/~jbraw/mpc/>

[Advanced Building Control] Ján Drgoňa, et al., All you need to know about model predictive control for buildings, Annual Reviews in Control, Volume 50, 2020,

<https://www.sciencedirect.com/science/article/pii/S1367578820300584>

[Advanced Building Control] Zoltan Nagy, et al., Ten questions concerning reinforcement learning for building energy management, Building and Environment, Volume 241, 2023

<https://www.sciencedirect.com/science/article/pii/S0360132323004626>

**Course goals**

* Understand the fundamentals of building energy management: Gain a comprehensive understanding of building energy systems, including HVAC, thermodynamics, and heat transfer principles.
* Master HVAC system modeling and control: Develop skills to model and control HVAC systems to improve building energy efficiency.
* Apply principles of dynamical systems and control theory: Build foundational knowledge in dynamical systems and control theory to formulate building control problems.
* Learn system identification techniques: Gain expertise in system identification to model and analyze building energy behavior.
* Implement machine learning and control methods: Learn to use state of the art software tools to optimize the energy efficiency of building energy systems.
* Design and implement a comprehensive energy management project: Synthesize course concepts in a final project, showcasing an ability to design, optimize, and control energy systems in a simulated building environment.

**Grading and course expectation**

Both the graduate and undergraduate students of this course will be graded using the same policy:

* Participation 10%
* Homework 30%
* Project proposal 10%
* Project progress report 10%
* Project final report 20%
* Project presentation 20%