Course Description

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Course Project

Goal Identify a need during a camping trip that you could solve by designing a particular system that collects, stores and consumes renewable energy.

Objective

There are three main components in this project:

- Design the renewable energy system for a particular need during a camping trip,
- Model the three phases of the system: energy collection, energy storage and energy consumption.
- Simulate the designed system.

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Course Project

System Design

Establish the location of your camping trip. Create a scenario for the cabin of a real place in BC. The scenario is up to you, (mountain, island, desert, tundra, etc.). Every scenario presents different sources of energy (water streams, wind, solar radiation, ocean energy, etc).

Realistic Data. Investigate the conditions of this place during the period of the year you go camping.

For example, if you decided to collect energy from a water stream, the flow of water in the stream should be proportional to the rain precipitation at the location. It is important that you find an official reference (statistical data) to justify your energy input.

Course Project

Energy Collection. As a team, establish the energy source that you will be collecting. Design the energy source using the realistic data as your input variable. The sources of energy that are available must be renewable: solar, wind power, hydroelectric energy (potential/kinetic energy), geothermal, ocean energy (tidal and wave energy), etc., or generated by human energy: bicycle, kayak, walking, etc.

Course Project

Energy Storage. Energy is not always transformed and consumed directly from the source.

Establish a way of storing energy with the exception of chemical storage (batteries, etc.) Some alternatives are potential energy, kinetic energy, electrical potential, temperature differences, hydrogen storage, pressure, etc.

Energy Consumption. Employed the stored energy to power the system that will solve the camping need that you identified.

Course Project

Design Expectations

Since this is an open-ended design problem, there are no restrictions in terms of which system can produce the most energy. There will be a large quantitative difference in terms of collected energy among sources.

This project tests your ingenuity as an engineer. Try to be innovative, originality will be assessed.

It is possible to combine the collection of two or more energy sources to fulfill the requirements of the consumption.

This project requires the students to review the literature. Investigate the different energy sources and methods to store energy. In your report, you will have to present the different alternatives that are available and justify your selection.

Course Project

Modeling and Simulation

The objective of this project is to model your design in relation to the three phases. You will have to input the energy source with its variability during a period that you define (minutes, hours, days) and simulate the resulting output.

Schedule

These are the important dates for the project:

Project Proposal	Oct. 3
Revised Proposal	Nov. 14
Project Final Report	Nov. 30

Project Description

System Design:

Design Objectives: Establish your design objectives: What is what you want to accomplish with your design? This can be in relation to the consumption (end goal) but also based on how you want the system to be.

Originality: Teams that come up with exactly the same concept will be a metric for deduction in terms originality. There is a large variety of potential needs or applications. Also think about different methods for extracting, storing, and consuming energy.

Design Complexity: Students will be evaluated based on the complexity of their design.

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Alternative Concepts: Based on the conditions of your scenario, discuss at least three potential concepts (including your final concept) that can be implemented. You could use the same energy source, but the subsystems must be different. Include simple sketches of the different concepts.

Design Selection: Justify why and how you chose a particular concept. Describe the overall system, the subsystems and all the components interacting with one another (using graphs and schematic diagrams are highly recommended). Describe and justify any changes that you want to have with respect to the proposed system and conditions of your initial proposal.

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Modelling:

Data Collection (inputs): Introduce the location and conditions of the place your system is designed for. This data may be ambient temperature, precipitation, water flow, etc. Cite their source (reference), sampling frequency and the preferred method to interpolate them (in seconds). Plot these inputs before simulating the model.

Element Modelling: This will assess how realistic your design is in terms of the selection of "elements" that model that particular system. Note that this is not related to the scenario itself, camping, e.g., there is nothing that constrains you to have solar panels, flywheels, or underground thermal capacitors.

Project Description

System Modelling: The mathematical modeling of the system

- Introduce the constitutive equation for each element.
- Real systems have a large number of physical elements (> 50). Identify the most critical elements for the model. Although there is no particular number on how many elements you need, it is expected that you have around 12 elements in the whole system.
- The set of equations should be first written in a parametric manner, e.g., $Q_{wall\_1} = \frac{\mathrm{T}_1 - T_2}{R_{cond}}$, not $Q_{wall\_1} = 1234.5 \times (T_1 - T_2)$.
- Combine your equations in a clear, organized and systematic manner to reach the final set of state equations to be simulated
- Discuss the order of the system. Report the state variables, system inputs and outputs.

Project Description

Design Parameters:

- The used physical properties, e.g., k_{steel}, must be introduced in a table: symbol, definition and realistic value.
- Values for all physical properties used in the modeling should be written according to reliable engineering sources, and the references should be clearly cited in the report.

Note: During your simulation, you will obtain the response of the system. Inevitably, there will be the need to modify some of the initial parameters. For example, the heat transferred by a thermal capacitor was too fast, therefore it is necessary to change the material of the tank from steel to ceramic (reduce conduction). This is the biggest advantage of modeling and simulation: you can modify easily any parameter and run the simulation again at no cost.

Project Description

Simulation:

Linear Model: The simulation part will be divided in two parts:

Energy Storage: show how the energy storage element is "charged". *Energy Consumption:* show how this energy is "*consumed*" or employed in your application.

Perform the simulations using input data, design parameters and state equations. Use Maltlab's functions 'ss' and 'lsim'.

Linearized Model: At least one element* in your system should have a nonlinear behaviour. Linearize your equations around the operational point. Calculate the operational point.

Nonlinear Model: Simulate the system by considering at least two nonlinear terms*. Use Maltlab's function 'ode45'.

* The element(s) may be from either the Energy Storage or Energy Consumption subsystem.

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Outputs of the simulations:

- Plot the graphs (time vs output) for both Energy Storage and Energy Consumption subsystems, where time is defined along the *x* axis and the output of each subsystem along the *y* axis. Repeat the same for linear, linearized and non linear problems.
- Every figure should have clear caption, axes titles, legend, etc.
- If your system does not satisfy your expectations, you should change some design parameters, e.g., change material, dimensions, etc. Present some examples of your results based on your initial design parameters and discuss how your design evolved based on your new assumptions. Discuss your final design results.

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Other Documentation:

Design Reflection: Explain how successful your proposed concept and design parameters are in solving the problem. Assess your design strategy and make some suggestions for future work.

Drawings: Sketches illustrating system and/or CAD drawings must be included in your report.

References: Include references in relation to the data collection, system design, properties of the components, etc.

Other documentation: Include an abstract, introduction (describing the scenario of the cabin), conclusions, and appendices (e.g., datasheet of components).

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IMPORTANT: You should also submit your codes. You should upload a .zip or .rar file including all Matlab files that you have used. One of the files should run everything (main.m). It should do all the calculations and all the plots. We are going to execute that file in our own Matlab and see all your results without getting confused. All plots should be well configured in terms of having title, axes labels etc. Comments at the beginning of each Matlab file would help.