

Course Project Description

Quality of life is improved with technology

Historically, engineering has been a main contributor for increase in life expectancy, improvement of health conditions, and increase in mobility and productivity, among others.

In our daily life, even the most basic elements such as water and electricity arrive to our homes through engineering systems.

Advancements in technologies have made possible to develop efficient systems of transportation, housing and shelter, agricultural production, sanitation and waste management, essential medical devices, medical care, etc.

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In remote areas of developing countries, there are undeveloped villages, where even the most basic needs of human beings are not present.

- Some small towns share common wells
- There is no electricity or heating systems
- People carry heavy items
- There is no proper sanitation
- Basic wood-burning cooking with no appliances
- Primitive agriculture
- Susceptible to natural disasters (flooding), wildlife, etc.

Solutions to all these problems are tackled with human labour.

Course Project



India



Mexico



Somalia



China

Course Project

Project Design, Model, and Simulate a System that can be used to solve the problem of an undeveloped village.

Problem Identification Identify a problem of an undeveloped village, preferably a place that you are familiar. In the selection of the problem try to be creative (preferably not just to light up a bulb). Ideally a problem that is particular or distinctive from the village. If possible, add pictures.

Goal Use a renewable energy source from that particular village or use the intrinsic energy of an existing system (energy dissipated by humans, animals, etc) to power the system that solves the problem. Your task in this project is to design a system that **collects, stores and consumes energy**.

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Project Outcomes

There are three main components in this project:

- Design a renewable energy system for a particular need of an undeveloped village.
 - Identify a set of design criteria (how you want the system to be)
 - Identify a set of design constraints (conditions that must prevail)
 - Develop at least three distinct solutions (whether three solutions for the same problem or a solution for three different problems)
 - Justify your selection.
- Model the three phases of the system: energy collection, energy storage and energy consumption.
- Simulate the designed system.

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System Design

Identify the problem. Establish the problem that you want to tackle and determine the source of energy that you will use.

Use Realistic Data. Investigate realistic statistical data regarding the selected source of energy, whether it is from a natural resource, i.e. wind power, solar radiation, precipitation, etc., or from a dissipating energy source.

Make sure to justify this data, i.e. official tables, graphs, calculation or experimentation.

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Energy Collection. Design the energy source using the realistic data as your input variable. The main source of energy must be a renewable source or an existing external force.

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, pressure, etc.

Energy Consumption. Employed the stored energy to power the system that will solve the problem and positively impacting the undeveloped village.

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Design Expectations

Since this is an open-ended design problem, there are no restrictions in terms of which system can produce the most energy. I expect all the projects to be different as there is a large number of problems which can be solved in different forms.

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 distinct alternatives that are available and justify your selection.

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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 ¹	Oct. 8
Revised Proposal (if required)	Oct. 22
Project Final Report	Nov. 26

¹The Proposal should include a description of the need or problem to be solved (a paragraph), three sketches of distinct solutions, and a description of the elements of the selected solution.

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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. Are there any constraints that you need to satisfy?

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 there are no budget restrictions, e.g., there is nothing that constrains you to have solar panels, flywheels, or underground thermal capacitors.

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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., $Q_{wall_1} = \frac{T_1 - T_2}{R_{cond}}$, 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.
- Develop the linear graph representation of the system.

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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.

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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.