ME 2450 Algorithms Integrated in Design 01

Name:	______________________
Due:	January 31, 2019
Collaborators:	______________________
	______________________

I declare that the assignment here submitted is original except for source material explicitly acknowledged.

I also acknowledge that I am aware of University policy and regulations on honesty in academic work, and of the disciplinary guidelines and procedures applicable to breaches of such policy and regulations, as contained in the University website.

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Name	Date
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Signature	Student ID

Score

Presentation:	/2
Technical Content:	/8
Total:	/10

Introduction

For this assignment you will also perform some initial modeling of your final design project train.

Algorithm Integration for Design

Estimating Work Potential

Before creating machines that take advantage of sustainable energy sources, it is desirable to determine whether it would be feasible to do so. Such feasibility studies can take into account economic factors, such as setup or maintenance costs and expected profits, as well as more traditional engineering factors, such as the safety of designs and the ease of replacing damaged parts. One such factor that should be considered is called exergy, which is an estimate of the maximum amount of useful work that we could expect to get from that source. (Exergy has the same units as energy, so in SI units it is in Joules, while in English units it may be in foot-pounds, calories, or Btu. Note: you should convert all measurements to SI units for your reported calculation.)

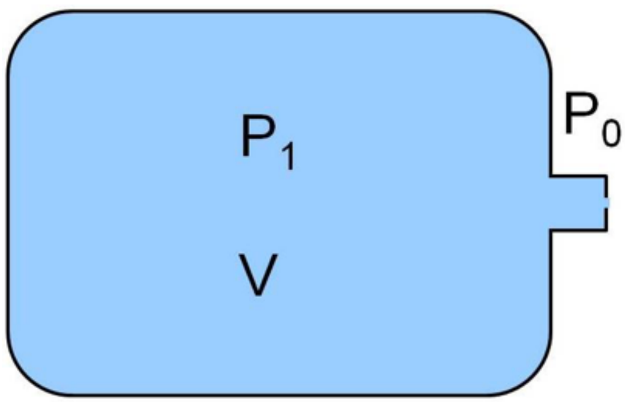

Figure 1: Schematic of a Compressed Air Tank. P1 indicates the pressure inside the tank, Po the atmospheric pressure outside of the tank, and V is the tank volume.

In the case of a tank of compressed air (Figure 1), exergy is the maximum amount of useful work we could expect to do by bringing the gas to the same state (i.e., pressure and temperature) as the environment. The work potential (exergy) of compressed air in a fixed-volume tank at the same temperature as its environment can be estimated using the formula:

$$X = P_1 V \left(\ln \frac{P_1}{P_0} + \frac{P_0}{P_1} - 1 \right) \tag{1}$$

where P_1 and P_0 are the pressure inside the tank and in the surrounding atmosphere, respectively, while V is the volume of the tank and X is the exergy. (Note that this is not a guarantee of the actual amount of energy you will be able to extract from the tank. It is an estimate of the most work that could be done if we used the gas in the most efficient way possible.)

Analyzing Error

Suppose that on a given day, the atmospheric pressure in Salt Lake City is $P_0 = 26.02$ inches Hg. You fill the tank with compressed air until the pressure gauge reads 50 psi (i.e., $P_1 = 50$ psi above the atmospheric pressure). For this calculation, choose a tank size of radius $r = 4.5$ inches, and a length $h = 0.55$ meters. Suppose you have a ruler capable of measuring the size of your tank with markings every $1/16$-inch. The pressure gauge on the pump you use to fill the tank has markings every 2 psi. The local atmospheric pressure is reported to the hundredths of an inch of mercury (in Hg).

(2 points) Perform an error propagation analysis on the exergy equation (using Equation 1) to determine:

- where the largest source of error is, and
- if it's worth your time and money to invest in better sensors.

System Modeling

(3 points) Evaluate the work potential (exergy) and:

- determine six combinations of tank geometry ($2 - 8$ inch diameters, $1 - 24$ inch lengths) and starting pressure ($0 - 150$ psi). That is, choose different combinations of tank radius (r), tank length (h) and starting pressure (P1) and suppose your train will use these hypothetical tanks as an energy source for a race. Report your 3 choices.
- Calculate the exergy and the average driving force that your train would experience over the course of the race (average force over the 10 m of the course). Report your results.
- Discuss the implications for your design options. (Note: The results should be typed and presented in a clear table. Please also include any Matlab or python codes or other calculations you have used).

(3 points) Develop a mathematical model of your train (recall the introduction in class). For this model, there are a number of assumptions you may make that will greatly simplify the problem. You may make assumptions, as long as you state them clearly and explain the rationale behind your assumptions and what affect those assumptions might have on the final result.

- Illustrate a free body diagram.
- Derive an equation to model the forces that might act on your train during the race. Note, this equation will be modified later to find the velocity of your train as it travels down the track. Show your work.

AID Submission

When you have completed the above activities, submit your results electronically (as a pdf) on Gradescope before midnight Jan. 31, 2019.