747 Project Proposal 2017

(Due Tuesday, Nov 21, 5 pm, 747 hwk mailbox)

Velocity and Position Control of a Robot Vehicle and Auger Motor

Group member names:

Zhangxi Feng, Simon Popecki, Mike Locke, James Skinner, Matthew Westbrook

Objectives: The goal of this project is to develop an algorithm that controls the position and velocity of a robot vehicle as it approaches a measurable target position (mining area). A representation of an auger (mining apparatus) will be onboard the vehicle and its rotational speed will vary as the vehicle approaches the target position. O.K., but for the project you want to be more specific. Perhaps the vehicle approaches a wall at 90°.

Background and analysis: The LunaCats project aims to have the robot autonomously approach the mining area from the starting location using a non-wall based positioning system. Upon reaching the mining area, the auger mining system will be deployed and begin mining operation. The robot should reach the mining area as quickly as possible while not overextending into the mining area since mining is allowed as long as the mined materials are from the designated area. The auger would be velocity controlled in order to detect when the mining apparatus is digging the top level fine Martian simulant and when it is digging the lower level target material of gravel.

A mechanical and electrical model of the vehicle with a PID controller will be developed and implemented for the vehicle's movement towards the mining area. The mining auger's velocity will be controlled with the same velocity sensor feedback data for the purpose of this project but will be adjusted to measured values for the mining of sand versus gravel for the LunaCats project.

Experimental approach: An existing robot will be explain refitted to incorporate PID control. An ultrasonic sensor will be used to provide position data and a timer will be incorporated to generate the velocity data used for the feedback control. The auger motor speed will adjust according to the position of the vehicle. The vehicle will be designed to approach a wall and stop within 10 cm from the tip of the robot. The robot's speed will decrease linearly or more extravagantly (if time permits) as it approaches the wall, starting at a reasonably high speed such as 0.5 m/s, slowing down to 0 at the stopping point. The auger will begin at 0 rotational speed and accelerate up to a reasonably high speed such as 60 - 120 rpm. You need analysis (modeling) of the robot and design of the controller and then

Equipment needed: Does not need special equipment. Typical tools such as DMM would be needed for part measurements. A tachometer capable of measuring high velocities would be preferred for the auger, but it is optional.

experimental evaluation of the controller. First develop a block diagram of system

747 Project Proposal 2017
Quad-copter motor analysis

Group member names:
Huntington Welch
Xinglun Li
Nick Long
Kuldeep Prajapati

Talk to me before you begin the project. I'm not sure what your objectives are.

Objectives:

- Determine the time response of our quadcopter motors (just 1)
- Determine response of Arduino Controller to PID control
- Control Velocity of the quadcopter

Velocity control of motor or Vehicle?

Background and analysis:

- The QuadSat senior design project consists of developing four autonomous quadcopters that fly in formation. The autonomy payload uses a Rasberry Pi, but the controller is an Arduino.
- The Arduino will take inputs of desired quadcopter attitude, and then tell the electronic speed controllers (ESC's) what signal to send the motors.
- This project will consist of determining the system response (of one of four motors) using the Arduino PID controller and tachometer. define or explain.
- From the motor there are possible disturbances that causes errors in the step signals from the PID.

Experimental approach:

- Prior to primary experimentation a dc motor will be used to back-drive the test motor for determination of the motor constant and the load cell will be calibrated for a range of weights between 0 and 2 kg as a single motor-propeller combination is expected to produce between 500 and 1000g of thrust.

  Not so easy for brushless dc motor.
- An Arduino is connected to a DC brushless motor with a fixed propeller via an electronic speed controller (ESC). The Motor itself is fixed to a 10 lb. load cell for the purpose of measuring the thrust produced by the motor-propeller combination. A piece of reflective tape is adhered to the propeller's exposed face.
- The load cell signal is amplified and sent to the digital oscilloscope.
- A known signal is sent to the motor via the ESC and Arduino which produces rotation of the motor.
- An optical tachometer records the rotational velocity of the propeller (and motor). The tachometer reading is recorded.
- The lift generated by the propeller causes a change in the signal produced by the load cell and the response is recorded by the scope.
- The PID controller on the Arduino should help the motor follow (track) an input signal.

  Still not sure what you are controlling
- Appropriate gain values must be selected for the controller.

Equipment needed:

- Optical Tachometer
- Propeller
- Two DC Brushless Motors (test and backdrive) — not easy to do!
- Arduino
- ESC
- Reflective Tape
- 10 lb. Load Cell
- Propeller
- Motor
- Amplifier
- NI Pxi-5142 Digital Oscilloscope
- NI Pxi-4110 Power Supply
- NI Pxi-5412 Waveform Generator
- NI LabView Signal Express
- BNC and Banana Plug Cables

747 Project Proposal 2017

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DC Motor Velocity Control for Senior Project

Group member names: Dan Berry
Kristopher Fargo
Erik Gustafson
Brad Olsen

Objectives:

The goal of this final project is to incorporate analysis for DC motor control to our senior capstone project. Our project requires precise synchronization between two brushless DC servo motors. They have a built in incremental encoder to provide feedback signals. Through the use of this signal, we hope to be able to control the motor velocity using a network controlled microprocessor. The first challenge is to be able to interpret the signals provided by the encoder, and translate them into usable tachometer output. Then we will use the tachometer in a feedback control system to accurately set the velocity of the motor. O.K.

Background and analysis:

The senior project to which this final project is intended to apply is a demonstration of time sensitive networks for the industrial automation use case. The goal of the demonstration is to be able to synchronize two DC motors in velocity and phase in order to change the behavior of a rope that spans between the two. The motors will be controlled across a network by receiving signals over a standard ethernet network. The signals are time-sensitive, meaning they require the synchronization error between devices to be minimal (around 100 nanoseconds at most). The rope spanning the two motors will produce a desired transverse/standing wave pattern, depending on the input provided to them. This project in particular is focused on getting useful output from the motor's incremental encoder as well as controlling the velocity in RPM to a specified value. Later on, the RPM input signal will come from across the network, and the motor will adjust using a systems controller.

Experimental approach:

The output from the built-in incremental encoder will be analyzed and processed to achieve a functional tachometer signal. The signal will be observed and recorded using an oscilloscope and each square wave pulse will be counted either by a digital counter IC, or by a microcontroller. The counter will ideally convert the pulses seen from the encoder into a signal representing the step count. As there are 1000 encoder steps per revolution, a minimum of a 16 bit counter is required. The counter (digital or analog) will then be translated into motor velocity by dividing the observed count over time. An alternative to a bit counter is to simply detect the frequency of the square wave in kilohertz, the kilohertz reading would be equivalent to the velocity in rev/sec. ✓

From a more technical perspective, the encoder is a differential signal, therefore an op-amp will be required to add the plus and negative leads from the encoder, this will dramatically reduce the
?
signal noise. We plan to use a LM741 op-amp or similar, which will require its own power supply. We do not intend to have any additional gain, since the voltage output of the encoder is sufficient for most digital inputs at 5 volts.

You need model of motor for PI design, so find K and τ of motor experimentally.

After completing the steps required to measure the velocity of the motor in RPS, a digital speed controller will be implemented. The gains will be adjusted so that when a desired input RPM or RPS is entered, the motor will adjust accordingly. These particular motors have a very fast response time, and we are not sure if that is desired for the overall project, therefore by creating our own PI controller, we can adjust the time constant if necessary.

Through analysis we will determine the response of our controller and its error and accuracy. We will also determine whether PI is sufficient or if we can utilize a PID controller. The response characteristics will be provided in the final report.

You need to design your PI Controller for appropriate gains.

Equipment needed:

- Brushless DC servo motor – Leadshine BLM57130-1000 (provided)
- Servo drive – Leadshine ACS606 (provided)
- Power Supply (provided)
- Arduino (provided)
- Clock counter (provided)
- Differential Operational Amplifier (required)
- Oscilloscope (required)
- Breadboard (required)

Motor Velocity Control Using an IMU

Group Members:
Lena Downes
Neil Mistretta
Kim Radzelovage
Seamus Sargeant
Chris Urbanski

Objectives:

Determine the accuracy of using an IMU to measure velocity. Use the velocity measurements to implement velocity controls for a motor. o.k.

Background and Analysis:

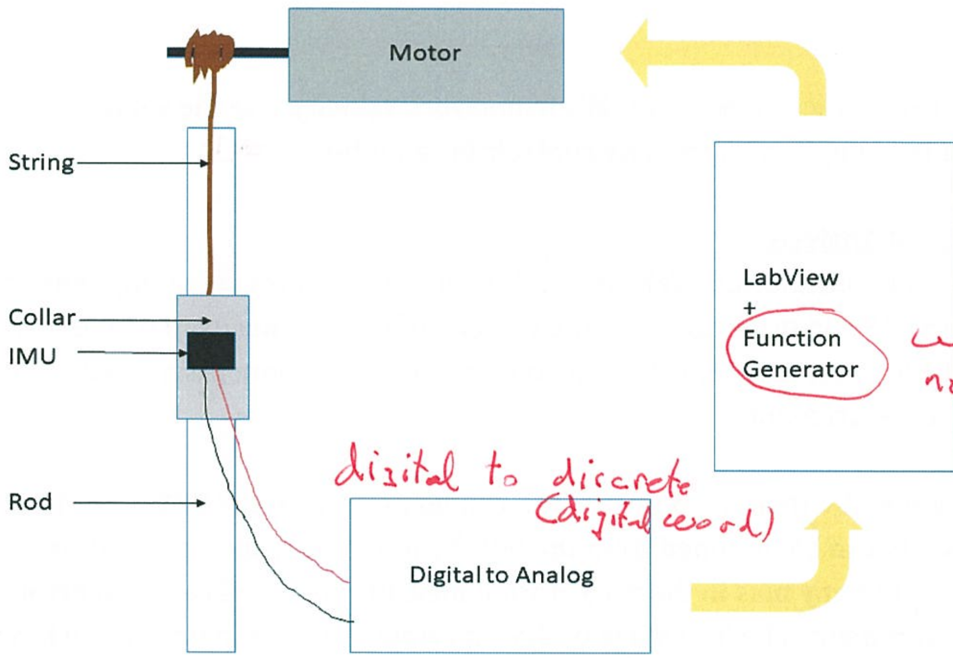
The UNH Autonomous Surface Vehicle (ASV) team is in the process of implementing speed controls on the ASV. In order to do so, the velocity of the ASV needs to be measured. The ASV has a GPS for position, velocity, and acceleration measurements as well as an IMU for acceleration measurements.

When testing the ASV indoors, only the IMU can be used since the GPS is not functional indoors. Velocity can be obtained from the IMU by integrating the acceleration measurements but any bias in the acceleration measurement will cause an error in the velocity measurement. The first stage of the experiment will be to determine how accurately velocity can be measured using an IMU. If the velocity measurement is reliable, the second stage will be to use the velocity measurement to control the velocity of a motor.

Experimental Approach:

The first part of the experiment, determining the accuracy of the IMU to measure velocity, involves constraining the linear motion of the IMU so that acceleration in one direction can be integrated and converted to velocity. Constrained motion will be achieved by mounting the IMU on a collar, which will be placed on a rod. This collar will then be moved by a string attached to the collar and the spool attached to the motor shaft. The IMU signal will be integrated through an Arduino or the NI software to obtain velocity. A tachometer will also be attached to the motor to measure its rotational velocity. The linear velocity of the IMU can be determined by knowing the circumference of the spool. The velocities measured using the integrated IMU will be compared to the velocity measured the tachometer in order to determine the accuracy of the IMU for measuring velocity. If the IMU produces satisfactory velocity readings, we will proceed to the next step of the experiment.

The second part of the experiment uses the same rod-collar setup from the first part. The IMU will be attached to the collar and to the motor by the string, and the IMU readings will be converted from digital to analog using the converter, and this signal will be fed back to the motor through LabView and the function generator. The velocity measured by the IMU will be fed back to the motor to control its speed.



digital to discrete (digital word)

why is this needed?

Figure 1: The figure above shows the proposed experimental setup

Equipment Needed:

- SparkFun 9DoF Razor IMU
- NI- DAQ
- Motor from lab 5 ?
- Tachometer " " 5 ?
- String
- PVC stand with collar
- Arduino

You also need to ~~Tap~~ design & implement digital level. Controller. If IMU doesn't work, use tach signal as feedback.

747 Project Proposal 2017

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DC Brushed Motor Velocity Control

Group member names: Timothy Morales, Ryan Nagelschmidt, Tony Cafiso, Shelby Strickland

Objectives: We aim to perform velocity control on a DC brushed motor (50:1 gear ratio). It is our intent to use PI (proportional-integral) control. The motor is attached to an encoder, whose signal will be used to find the velocity output of the motor via LabView. o.k.

Background and analysis: Our senior project, ET NavSwarm, uses 4 of these motors to drive our bots. By integrating this control system, the bots will be able to track straight, as well as better maneuver through given environments. These bots operate using a tank-drive system, meaning each side of the bot operates independently, but the front and back of each side operate together. Using the PI control, the encoder will be able to provide a feedback signal to the motors, therefor allowing the bots to correct for different velocities in each set of ? motors.

Experimental approach: Analog or digital signals?

Our first goal will be to get a voltage output from the encoder, and convert the signal into a velocity signal. Using this signal we can find the time constant of the motor as well. We will then build an op-amp and from there, be able to test the PI controller response. If a successful proportional-integral motor response is implemented for one motor, then testing will be done to get the system to work in parallel with two motors, or even a testable rover.

Equipment needed:
Op amp and bread board from lab 5
Motor
Encoder
Tachometer
NI Systems

You need tests to find motor model parameters K and τ so you can design the PI Controller

How will you find a voltage signal (velocity) from encoder? NI system?

747 Project Proposal 2017

Servomotor Parameter Analysis

Group member names:

Charles Bauer, Matthew Diorio, Jon Lewis, Jackson Riedel, Timothy Russell

Objectives: The objective of this project is to determine the system parameters of various servomotors that will be used to control crucial elements of the Aerocats Advanced team plane. Determining the time constant, position, velocity and acceleration of the linear and rotational servomotors will help us to understand how the plane responds to different inputs.

Background and analysis: The UNH Aerocats advance team will be designing and manufacturing a plane that will be used to compete in SAE's Aero East competition in Lakeland, FL. The objective of the competition is to have a remote controlled plane that will take-off, drop a humanitarian pay-load package, and land successfully. The planes control surfaces, such as ailerons, rudders, and flaps will be controlled by various servomotors. These servos are connected to a microcontroller which will receive signal from the pilot's controller. The pay-load bomb bay doors are going to be triggered and opened by using a pin and linear servo/solenoid.

Finding the parameters of the motors will be critical in determing how the control surfaces respond and how accurately the humanitarian packages can be dropped. We want to be able to compare position outputs to integrated velocity and acceleration outputs to determine the accuracy in our results. Using force sensors will allow us to determine the torque delivered by the servomotors. This will tell us if the motors are strong enough to overcome the wind and air pressure on the control surfaces.

Are the servo's geared?

Experimental approach:

1. Calibrate sensors using a range of known masses to measure the corresponding sensor output voltage.
2. Determine minimum voltage required to operate servo.
3. Record servo response using LVT to input commands from microcontroller at a range of voltages, minimum voltage found from step 2 to 7V.
4. Repeat step 3 using LVDT. why use both sensors?
5. Repeat step 3 using Accelerometer. → why?
6. Measure force of servo using strain gauge / force sensor at each input voltage. how will you do this?
7. Repeat steps 2-6 for solenoid.

I'm not clear on your objective and experimental approach. See Me before you begin project.

Equipment needed

- 1 high torque rotational servomotor
- 1 linear servomotor/solenoid.
- Microcontroller
- Calibration masses.
- LVT
- LVDT
- Accelerometer
- Strain Gauge Force Sensor
- Power Supply
- Oscilloscope.

747 Project Proposal 2017

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House Temperature Control

Group member names:

Nick Doiron
Sam Whitmore

Objectives:

The objective of this project is to develop an on-off controller to maintain a target temperature inside of a test environment.

Background and analysis:

Temperature control is an important consideration in residential and other settings. As it relates to our senior project, a cooling system must monitor the temperature of its environment in order to dictate cooling load requirements.

Required analysis for this project includes thermal modeling of the house, electrical modeling of the controller, and development of a code to operate the controller.

Experimental approach:

The first task will be to develop the test environment. This will consist of creating the "house" and sizing an appropriate heating element. From here, our experimental set up will consist of an amplified thermocouple signal fed into labview. An algorithm will be developed in labview such that depending on thermocouple readings, a heating element will be turned on or off.

The heating element will be powered using amplified output from the DAQ. by relay.

Thermocouples will also be calibrated beforehand to give reference to the readings they will gather during experimental testing.

You also need to model control system and simulate in Simulink. $\frac{K}{\tau s+1}$

Equipment needed:

- NI USB DAQ
- Labview
- House environment
- Heating element
- Thermocouple
- Thermal bath
- Thermocouple amplifier
- Power amplifier
- Power supply
- Relay

747 Project Proposal 2017

Modeling and Testing of House Heating Control

Group member names: Jim Fey and Kyle Reisert

and Controller

Objectives: The goal of this project is to develop a model for the heating/cooling of a model house. The house temperature will then be controlled either continuously, or using a simple on off controller, based off the temperature measured by a thermocouple. Comparing this temperature to our desired temperature will allow us to effectively maintain a comfortable house temperature.

Background and analysis:
Heating of homes, especially in the region we live, is a large cost that families must consider. We are setting out to model this concept, and optimize a controller that will maintain a comfortable internal temperature without using excess energy.
Fourier's law of heat conduction gives that:

$$Q = -k_t \frac{dT}{dx} A$$

where Q is the heat transfer, k_t is the thermal conductivity of the material, A is the surface area, and T is the temperature. This relationship is relatively simple, and considering the model house as a lumped parameter model will greatly simplify the analysis. This relationship gives us the heat transfer between the house and the surroundings, however in order to characterize the temperature decrease over time, we need to apply the relationship for thermal capacitance, given as:

$$Q = MC_p \frac{dT}{dt}$$

where M and Cp will be the mass and specific heat of the air inside the house. This time dependence of temperature is what we are really interested in. Newton's law of cooling tells us that this time rate of change of temperature is proportional to the difference in temperature between the body and its surroundings. With this understanding, we need to implement a controller that will maintain a "constant" internal temperature of the house. If this is an on off controller, this temperature will be relatively constant, in that it will fluctuate between some specified minimum and maximum allowed temperature. If the controller is continuous, we hope to maintain a more constant temperature than the on/off case. The controller feedback in both cases will be the internal temperature of the house, measured with the thermocouple. This will then be compared to the desired temperature, and will give us an error signal that we can use to control the process.

uniform

The scale house will be assumed to have spatially ~~constant~~ internal temperature, and the outside temperature will be varied/fixed based on the design of the experiment.

You need to design a controller based on experimentally determined thermal model! You can simulate controller and

Experimental approach:
The thermocouple will need to be calibrated using known temperatures and measuring the output voltage. It should be calibrated over the operating range of temperatures we expect to see in the experiment. This will give us a sensitivity. From the thermocouple, we will capture the temperature profile over time. With the controller inactive, we would be able to find the time constant of the cooling/heating process alone. As for actual experimentation, we would like to test the controller

Compare to experimental results.

under varying operating conditions (varying outside temperature). Depending on whether we implement an on/off controller or continuous control, we may also adjust the compensation for optimal performance. Overall, we would like to compare our experimental results to a theoretical prediction for whatever type of control we implement. If it is an on/off controller, we could develop a theoretical temperature prediction that would consist of some exponential decay until a minimum temperature threshold is reached. This would be followed by a period of exponential temperature increase when the controller is switched on, until some maximum temperature threshold is reached. This would be the theoretical response that we could compare the data to. This could all be done over different temperature gradients. It would also be interesting to measure the total power consumed under each scenario, as this is really the practical application, although we are not looking at changing the type of insulation.

741 and power
Use op-amps to make controller
This will not be an on/off controller.

Equipment needed:
- Thermocouple (as temperature measuring device)
- Power resistor (as heating element)
- Power source
- BNC cables
- Banana cables
- Oscilloscope
- Model house (potentially cardboard)
- Means of varying outside temperature (ice/cooler) ← This will be difficult

UNIVERSITY OF NEW HAMPSHIRE
DEPARTMENT OF MECHANICAL ENGINEERING

ME 747 - Experimental Measurement and Modeling of Complex Systems

The Hot Box - Project Proposal

Submitted: November 21st, 2017

James Ripley

Colin Rockwell

Andrew Stokes

Anthony Young

Objectives

The objective of this experiment is to design and implement a temperature control system for an enclosed space, simulating a home environment. The control system will keep the temperature inside the enclosed environment between a predetermined high and low value.

Background and Analysis

Heating and ventilation systems are crucial elements in both homes and office buildings all over the world. Heating, Ventilation and Air Conditioning (HVAC) systems function to maintain the comfort and safety of building occupants. Heating and air conditioning components assist us by controlling indoor climate and proper airflow, ensuring that we don't freeze or become overheated. Health benefits of a well-maintained HVAC system come into play with the prevention of mold, which frequently thrives in warm, damp areas [1].

This project will require us to build and develop an electrical and thermal model for the temperature control system used in our enclosed environment. The building portion of this project will require us to construct and wire a temperature dependent control system, we are currently unsure which type (P, I, PI) of controls we will use.

try all of them.

1. Model System (use exper. determined values).
2. Design Controllers
3. Simulate "

Experimental Approach

The thermocouple we will be using to measure the temperature in our enclosed environment will first need to be calibrated using two water baths, one at 0 degrees celsius and the other at 100 degrees celsius. From this calibration, assuming that the thermocouple reacts to temperature changes in a linear fashion, we can calculate their sensitivities which will be used to convert the thermocouple voltage data to temperature data. With the thermocouple calibrated we can then attach this to the inside of our enclosed cardboard environment. The most difficult part of this project will be deciding on how to connect the output of the thermocouple into a control system feedback loop. This feedback loop will constantly take temperature readings of the cardboard room while the it is being heated by the power resistor and then compare these readings to a predetermined temperature range. If this recorded temperature falls outside of the decided upon range , then an action will be performed (i.e. turning the 'heater' on or off).

I want you to use ~~analog~~ digital control, via Labview. Read in thermocouple and implement P, I, PI via digital control algorithm. Talk to me.

Equipment Needed

The equipment required to perform this experiment includes at least one thermocouple to measure the temperature inside the box and a coil/power resistor to act as a heat source. In order to calibrate the thermocouple we will need two water baths at fixed temperatures of 0 and 100 degrees celsius. 741 op amps will also be required to control the thermocouple and the power resistor. We will also need a large cardboard box with a lid, this enclosure will simulate a room in a house. This experiment will be run on the LabView equipment found in the S-Lab room.

747 Project Proposal 2017
Heater Control in a Model Building

Group member names:
Jonah Blum Nicholas Schott Ethan Setear Jeromey Green

Objectives: We will find the power over time necessary for a heating element to maintain acceptable temperature of a sealed room in an environment lower than the desired room temperature. We will create a control system to regulate the heater output according to the temperature in the room. We will also create a mathematical model to predict heater power requirements for a variety of outdoor conditions.

Use cardboard.

Background and analysis: The purpose of our senior project is to design a temporary refugee shelter for Eastern Europe. This shelter must be no more than 260ft^2, house 6-8 people, and provide all essential domestic systems, while conforming to ASHRAE standards for indoor air quality and thermal comfort and using no more than 3300W of electricity. Heater power consumption will play a critical role in the efficiency of our design. And because we can produce no more than 3300W of heat, the thickness of the insulation will be determined in part by the heater. To analyze the power necessary to run a heater in a shelter, we will build a scale model of the structure out of rigid foam. A small heating element will be placed inside the room and will be controlled using thermistors placed in the room. We will track the temperature inside the room and the power consumption of the heater. We will endeavor to have a constant ambient temperature. We will also find the thermal time constant of the room as a lumped model. This will allow us to derive the thermal resistance and capacitance of the structure. We can then model power requirements of the structure for a variety of ambient temperatures and wind conditions. Our end results will be a functioning heater control system and a mathematical model relating heater power consumption to ambient conditions, structure thermal properties, and desired room temperature. Must design controller.

Experimental approach: The thermistors in the heater control system will need to be calibrated. We plan to use water baths of known temperatures ranging from 32°F to 212°F for this calibration. Ambient external temperature will be measured using a liquid thermometer. Power input to the heater will be tracked and recorded over time. The measurement system used for this will depend on the heater that is employed, since the element may be set up to use 120V. Use heat bath.

To find the thermal time constant of the system, we will allow the structure to reach steady state with the heater, then turn the heater off and record the temperature decay. The resulting curve (approximately first order) will be analyzed for the thermal time constant. The desired temperature and power data for the controlled heater will be gathered after the heater cycles have become consistent or the heater is receiving steady power input (this depends on our type of control system). The power used by the heater over time will be compared for several ambient temperatures. Measure current into resistor, $P = i^2 R$.

Equipment needed:

-Model structure: this structure will have a square floor plan with a height approximately half the length of a side and will be constructed of rigid foam board glued together. The foam will have to be thin (small time constant) so that steady state is reached within a reasonable timespan. Use cardboard.

-Heating element (and power input measurement setup)

-Thermistors (and accompanying measurement setup)

-Control system (type not yet determined)

Should use on/off control via labview. See me for details.

1. Model House
2. Use experiments to find house model parameters
3. Design Controller
4. Simulate & compare to experiment.