HEAT TRANSFER LAB EXPERIMENT:
THE CAR-in-the-SUN PROJECT
TASK 1

OVERVIEW OF THE 'CAR-in-the-SUN' Lab Project:
This Heat Transfer Laboratory experiment consists of a study of the (Sun) radiation heating effects on a closed system (the Car). Everyone is aware of the all too familiar and tragic news stories of the accidental death of infants who are left in a closed automobile that has been parked and exposed to the direct heating of the sun. Even on cold days, the incident radiation heating can cause the vehicle's interior temperature to reach 120 F. This heat transfer project will help to study this problem via (the student's) computer model and propose a solution. To do this in the time permitted (i.e. several class room periods of 100 minutes each) the Heat Transfer Lab Project is constructed in several parts. The experiment uses a 1:6 scaled model of a Chrysler PT Cruiser as the closed system. The in-lab portion of the experiment uses a heat lamp to simulate the sun's incident solar radiation. The student will utilize the temperature measurement devices (TCs and thermometers) as well as their previously prepared computer model of the car heating for measuring the temperatures within the lab model vehicle. The results of the in-lab experiment will help to identify various values for heat transfer parameters so that the student's computer model can be used to predict the heating effects of the sun when, in the last part of the experiment, a full size PT Cruiser is placed in direct sunlight. The complete experiment will have the students perform the following tasks, in this order.

TASK 1. Measure of the incident radiation from the heat lamp that serves in the laboratory as a substitute for the sun's incident energy.

TASK 2. Measure the temperature transients (i.e. the temperature change as a function of time) of several points within the car's interior.
TASK 3. Measure the effects of energy absorbing materials added to the vehicle's interior to reduce the heating effect and/or increase the temperature transients.
TASK 4. Measuring the Nusseult-Reynolds No. Relationship for the PT-Cruiser
TASK 5. (Revised) Predicting the Actual Temperature Transient for a Full Size Chrysler PT Cruiser.
TASK 6. Determining the A/C cooling requirements for the full-size PT-Cruiser

TEST PROTOCOL

TASK 1 EXPERIMENT TEST PROTOCOL

Task 1 requires the measurement of the incident energy heat flux (btu/hr/ft^2) that is produced by the heat lamp. The heat lamp that is used in the experiment serves to simulate the sun. The amount of energy released by the lamp (AND ABSORBED by the car's material of construction) as a function of distance from the lamp is unknown. It is necessary to measure the heat flux from the heat source given that the amount of heat flux that is incident on the vehicle is critical to the modeling of the vehicle's heating.

The following steps are to be followed:

1. To measure the energy flux from the lamp, the rear hatch-back door is removed from the PT Cruiser model and placed a fixed distance from the heat lamp (approximately 3 ft.).
2. A ½" thick piece of insulation is cut to cover the back of the plastic door. Before the insulation is secured to the door, a TC must be installed on the back of the clear plastic and the opaque plastic. Certainly before the TCs are used they must be calibrated using ice water and boiling water as two standard reference points.
3. A third and fourth TC is installed on the front (uncovered) portion of the hatch-back door.
4. The instrumented door is now to be placed securely in front of the heat lamp at a distance of approximately 3 ft. and the temperature is to be recorded manually every 30 seconds. Thermometers should be used to measure the air temperature in several positions around the instrumented door. Be sure that these thermometers are not also directly heated by the heat lamp during this measurement.
5. Data reduction of this data involves plotting the temperature transients that have been recorded in Step 4 and then determining the energy heat flux (Btu/hr/ft^2) using the student's "Car-in-the-Sun" computer (spreadsheet) model.

TASK 2. TEMPERATURE TRANSIENT MEASURMENTS OF THE ENTIRE PT CRUISER

Task 2 of the Car-in-the-Sun Experiment measures the temperature transients of several points within the PT-Cruiser scaled model. The principal purpose of TASK 2 is to record the temperatures that are reached by the closed system (the car) and then "calibrate" the student's computer model with the necessary constants and heat fluxes (measured in Task 1) until the vehicle's heating has been modeled by the computer simulation. The student will be required to modify his/her spreadsheet computer model to accommodate three temperature transients instead of using the existing simpler model that uses only one temperature. In addition to the temperature thermocouples (TCs) that were used in TASK 1 (attached to the rear door) the student

will install three addition TCs inside the vehicle. Two TCs will be attached to the front and rear (plastic) seats. A third will be attached to the underside of the vehicle's roof. Two addition thermocouples will be used to monitor the vehicle's interior air temperature. These later temperatures will be monitored by using a steel and brass thermometer that is attached to a computer recording system. The computer monitoring systems has been previously wired to the PC and is ready for operation.

The following Steps should be taken to complete TASK 2 of the Lab.

1. Draw a sketch of the PT-Cruiser lab set-up as will be used in this Lab. be sure to mark clearly where the TCs will be installed, identify the TC measuring devices by model no. and manufacturer. Determine the total mass of the vehicle model Measure the overall major dimensions of the vehicle; including the thickness of the roof, door and hood. These dimensions must be complete enough to calculate a surface area and to estimate the masses of each of these components.
2. Re-attach the rear door hatch and check the operation of the thermocouples (TCs) that are still installed on the door.
3. Using ice water and boiling water check the calibration of the three TCs that will be used in this experiment.
4. Install two of these TCs to the front and rear seats using epoxy. These TCs must be attached to the TC display and/or several multi-meter recorders for instantaneous temperature measurements.
5. Insert the brass and steel thermometers (used with the PC monitoring system) into the vehicle via the rear (hatch) door and secure them to the seats to be able to measure the compartment **air** temperature in front of the front and rear seats. The leads for these thermometers will need to be taped to the rear of the vehicle and the rear door taped closed to prevent air from entering or exiting the system during heating.
6. Check the operation of all of the temperatures before starting the recording of the transient temperatures. Re-attach the heat lamps that were used in Task 1. They must be at the same distance away from the vehicle as was the rear door during Task 1 (check your Journal entry for this dimension). Turn on the heat lamps and record the temperature transients every 30 seconds. This will require several students to be positioned at the various TC recording devices and for two students to be recording the temperatures manually.
7. Shut off the heat lamp and using the fan, cool down the vehicle until the TCs and thermometers record room temperature. You should open the vehicle doors to more quickly cool the vehicle.
8. Repeat Step 6 with the fan operating at a LOW speed and oscillating.

TASK 3. Measuring the Effects of Energy Absorbing Materials Added to the Vehicle's Interior

The major objective of Lab No. 3 is to measure the effects that energy absorbing material have on the temperature transients in the vehicle. For example, the vehicle's air temperature may not increase as high as before or require a longer period of time to reach the same temperature by adding a material with a high specific heat capacity (C) to the seat cushions of the vehicle or perhaps the head-liner. It is also viable to consider adding tinted windows in order to change the amount of solar radiation energy that enters the vehicle.

In this Lab No. 3 a damp sponge will be used to simulate a material that has a high heat capacity (C) in order to demonstrate and measure the effects of a higher heat capacity material on the temperature of the air and seats.

The following steps must be followed:

1. Examine the PT-Cruiser Model and confirm that all of the pre-installed thermocouples and thermometers are still operating. Confirm the accuracy of the TC's or thermocouple by calibration with known temperatures, such as boiling water and ice-water.
2. Cut and shape two very thin sponges to the shape of the front seats. The sponge thickness should be approximately 1/8 inch. After successfully shaping the two sponges weigh each very carefully on a mass (100 gram max.) scale.
3. Wet the sponge but try to add only 50 % more water to the weight of the sponge. Measure the weights carefully and immediately before installing them on top of the front seats. Secure a thermocouple to the sponge and seal the doors.
4. Install the two 300 watt heat lamps at the same distance (16 inches) from the car body and at the same inclination as in the first two experiments.
5. Select students to take and call out the data. When everyone is in position, turn on the heat lamps and begin recording the transient temperatures for a minimum of 1020 seconds at 30 second intervals. During the testing, be sure to record any and all observations regarding water vapor formation on the windows, etc.
6. At the end of the experiment be sure you have all of the data. After the lab session continue to build your model of the vehicle's temperature response using this measured data and your spreadsheet model. You should be using the spreadsheet model that the Instructor sent to each student and that the student has modified to program the transient performance of the seat temperature.

TASK 4. Measuring Nussult-Reynolds No. for PT-Cruiser

The fourth task in this series of experiments is intended to measure and prepare a graph of Nusseults No. vs. Reynolds No. for the PT-Cruiser. The purpose of these experiments is to be able to predict the air-conditioning load for the full size vehicle in later Tasks. The Nusseult and Reynolds numbers are calculated using the 3-speed fan, the temperature thermocouples and the laboratory 1:6 model of the PT-Cruiser

installed in the 225 Forsyth lab. The following steps are followed to acquire the necessary data.

Step1. Calibrate the temperature thermocouples with ice-water and boiling water baths.
Step2. Check the operation of the thermocouple meter to be sure all TC channels are operating properly and recording temperatures. Set the variable speed fan on Low and adjust the heat lamps the necessary distance from the vehicle (see Task 1). Turn on the heat lamps after recording the initial temperatures of the PT-Cruiser.
Step 3. Install a pitot-tube and manometer in front of the PT-Cruiser model to measure the fan wind speed.
Step 4. Begin recording the skin temperature at 30 second intervals

Step 5. Repeat Steps 2, 3 and 4 using a fan speed of "Medium" and High"

Using the data recorded and the spreadsheet model that you have prepared for the experiment, vary the external heat transfer coef. until the measured and theoretical data match. Using the heat transfer coef.s measured for each fan speed, calculate the Nusseult's and Reynolds Numbers for each fan speed. The student should use the length of the top section of the vehicle and not the overall length of the vehicle as the characteristic dimension.

TASK 5 (Revised) Predicting the Actual Temperature Transient for a Full Size Chrysler PT Cruiser.

The fifth Task in the series of five Lab experiments was originally planned to measure the actual temperature change of the air, seat and skin of the full size PT Cruiser. In lieu of this experiment, the student will use the spreadsheet model that has been developed during this semester and 'calibrated' using the data from Labs 1, 2 and 3.

The attached manufacturer's information of the full size PT Cruiser should be used by the student to change the appropriate scaled parameters to the full size values. For example, the combined size of the windows in the1:6 scale model was given as approximately 5 " x 5". The full size windows are therefore approximately 30" x 30". This value should be input into the spreadsheet program in the appropriate box. Similarly, the mass and size of the seats should be input as100 lbm and _____ ft^2, respectively. Other changes to the sizes and/or weights should be increased by six times.

The resultant spreadsheet calculation is then an estimate of the temperature transient response for the full size PT Cruiser. This result should then be presented in the Final Project Report