

## The Coffee and Tea Heat Transfer Dilemma.

OR

Should the cream or milk be added to the coffee or tea upon purchase or just prior to consumption.

### The Situation:-

You have just purchased a cup of Coffee or tea. The waiter brings it to your table. At that moment you remember that you have to “Feed” your parking meter which is some distance away.

The **Question is “Should you add the cream or milk Before you Leave to feed your meter or Upon your Return .**

**What action will minimize The Heat Energy Transfer and thus have the coffee or Tea at a Higher Temperature upon your return.**

### Materials & Method:-

This question often a point of acute controversy amongst discerning Coffee and Tea drinkers may be resolved by Experiment and Calculation involving Calculus.

#### [A] An Experimental Method Using ThermoSense & ThermoSoft Mk1.

Materials and Method:-

(i) Materials.

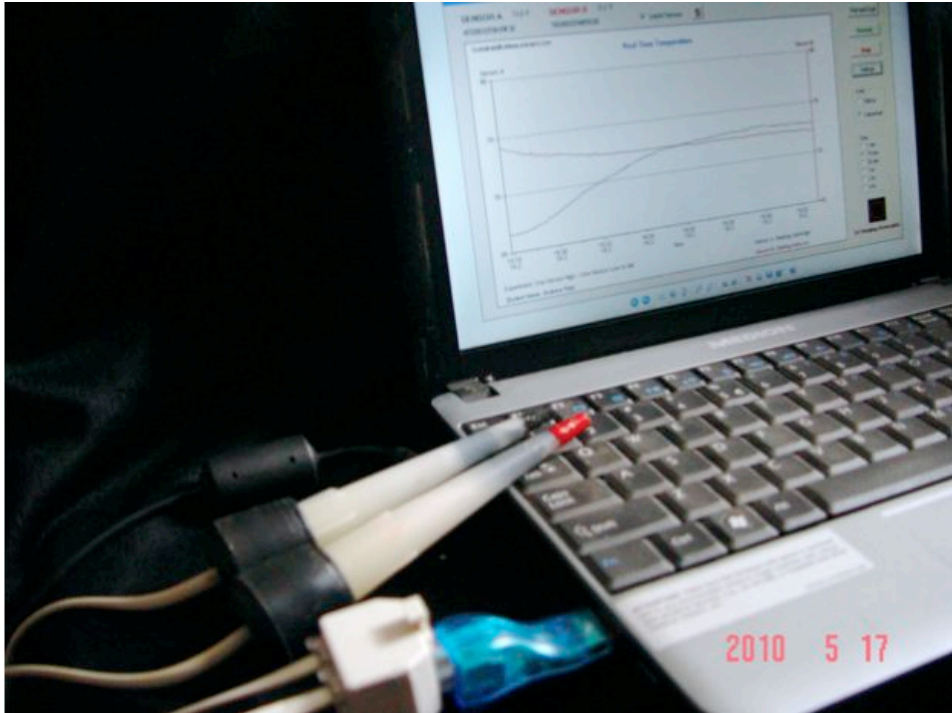


(a) Two identical Styrofoam cups which are open to the atmosphere; capable of holding 200 ml of Coffee or Tea and 30 ml of cream or milk.

(b) Two identical small cups capable of holding 30 ml of cream or milk.

(c) Coffee and milk or alternatively simulate with water.

(d) ThermoSense Mk1 Hardware and ThermoSoft Mk1 Software connected and ready to run on a standard windows PC.



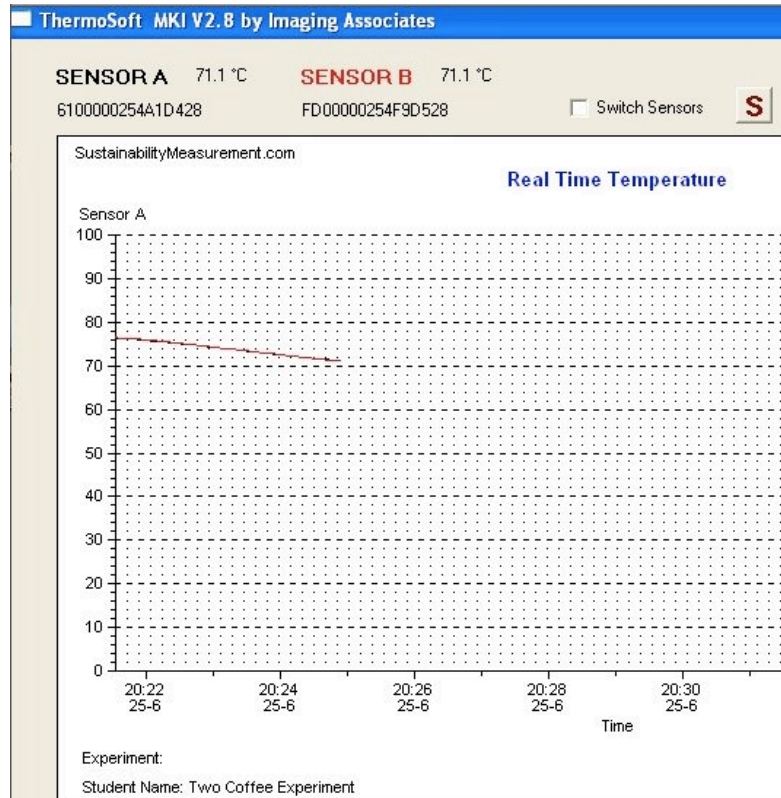
Note:

\* The the Styrofoam cup must be able to hold the 200 ml of coffee or Tea along with the 30 ml of cream or milk as well as a ThermoSense Mk1 cone temperature sensor.

(ii) Method:-

(a) Before the start of the experiment make sure that the **Red** and **Black** graph traces are assigned to the **Red** and **Black** cone temperature sensors.

- (b) Make sure that the two cone are at the same temperature before they are immersed in the coffee or tea. Best done by having their two tips touching in the surrounding air ( $T_s$ ) or as suggested in Application Note “ThermoSoft Mk1 Familiarization & Tracking”.



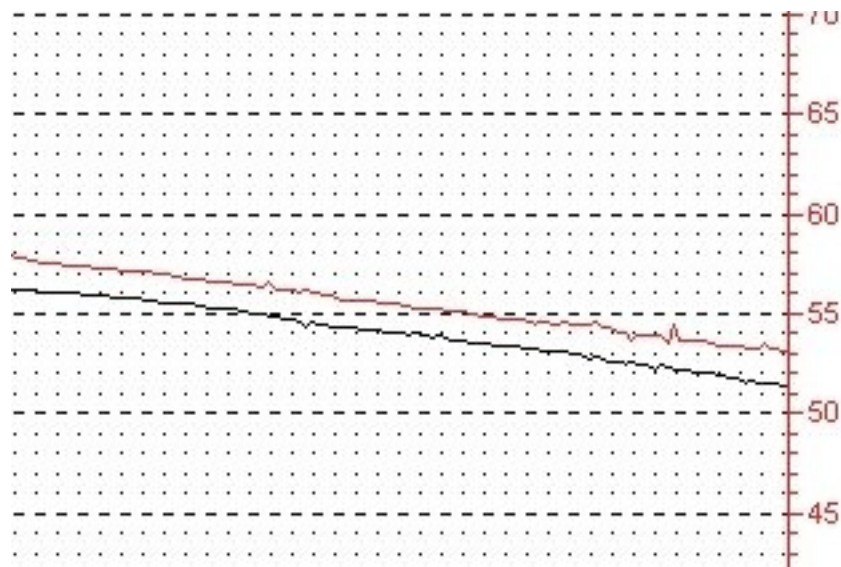
The Graph above shows the two cone sensors tracking closely before Cream or Milk is added and located as suggested in (c) below.

- (c) Locate the two Styrofoam cups in a still air environment to avoid forced evaporation during the experiment.
- (d) Make sure the two small containers containing the cream or milk are both removed from the refrigerator at the start of the experiment at the same time
- (e) Fill both Styrofoam Cups with 200 ml of hot water ( say  $T_c=80^{\circ}\text{C}$  ) .
- (f) Place one thermoSense Cone sensor upright into each cup.
- (g) Start ThermoSoft Mk1 with a **15 minute Experiment time duration**.
- (h) After 2 minutes Add one Small cup of cream or milk to Red Cup.
- (g) After 6 minutes Add the other small cup of cream or milk to the Black Cup.

**NO GRAPH SHOWN HERE --- YOU TO FIND OUT**

**FOR ACTIONS (h) & (g) ABOVE**

(i) At the end of 15 minutes Print Graph and numerical temperature data for class discussion and individual interpretation.



The Graph above shows the end portion of the Experiment after 15 minutes.

Which Coffee or Tea is Hotter upon your return from the parking meter ?

Compare your findings with your intuitive feelings as to cup which would be hotter.

This problem is not trivial as those who decide to resolve the matter mathematically will find out!

Repeat and refine the experiment ----- Obtaining Faithful Temperature Measurements requires attention to detail and patience. Newton and Fourier did not have the advantages of modern temperature measuring instrumentation!

(B) Mathematical Solution;-

For advanced students familiar with Calculus use as appropriate some of the measured data as you see fit, to present algebraic expressions for the Heat Energy Transfer and Temperature decrease with respect to time.

You may wish to do this from first principles as well as using curve fitting techniques available in Excel or Advanced Scientific Calculators.

