

## Coffee Conundrum Handout

Isaac Newton determined a formula for the temperature ( $T$ ) of a liquid  $t$  minutes after it is placed in a room with a specific temperature, called the environmental temperature, or  $T_e$ . The formula depends on the initial temperature of the liquid ( $T_i$ ) and a constant  $k$ , which depends on the properties of the specific liquid as well as properties of the environment (humidity, air pressure, etc.). The formula is:

$$\text{Newton's Law of Cooling: } T(t) = T_e + (T_i - T_e)e^{-kt}$$

Use Newton's law of cooling to solve the following problem.

The latest trendy coffee chain, Moondoe's Coffee, wants to sell refillable thermal mugs for its environmentally conscious costumers. They have determined that, in order for their coffee to taste its best, it must be brewed between 200°F and 220°F. However, it must then cool to 180°F to be safe to drink. Unfortunately, though, if the temperature drops below 130°F, the coffee is too cool to taste good. Therefore, Moondoe's is searching for a container that fits the following criteria:

1. Capable of safely holding coffee up to a temperature of at least 200°F;
2. Cools coffee at the maximum safe temperature of 180°F as quickly as possible;
3. Keeps liquids between 180°F and 130°F for as long as possible.

Moondoe's has researched three different thermal mug products. Advertisements for the three products make the following claims:

- A. When used at room temperature (70°F), Amos's Amazing Aerothermos can withstand coffee up to 220°F and cools it to a drinking temperature of 180°F in just three minutes!
- B. When used at room temperature (70°F), Bobo's Mug for Your JoJoe can withstand coffee up to 200°F and will maintain the temperature of your coffee between 180°F and 130°F for a full hour!
- C. When used at room temperature (70°F), Caite's Cool Coffee Carafe can withstand coffee up to 210°F and keeps coffee within the proper drinking temperature range four times as long as Amos's Amazing Aerothermos!

Given this information and Moondoe's three requirements, which thermal mug should they offer their customers?