

5.7 PROJECT

USING NEWTON'S LAW OF COOLING TO AVOID COFFEE BURNS

Newton's Law of Cooling gives the temperature of an object (such as a pan or a cup of liquid) as it cools over time to the temperature of its surrounding environment (such as the air in a room). The law can be described with the following function.

$$T(t) = T_e + (T_0 - T_e)e^{-kt}$$

In this function, $T(t)$ is the temperature of the object at time t , in minutes. The value T_e represents the temperature of the surrounding environment, T_0 represents the initial temperature of the object, and k is a constant of variation, which depends on the object.

When brewing coffee, the ideal water temperature is between 195 and 205 degrees Fahrenheit. Suppose some freshly brewed 205 °F coffee was poured into a ceramic mug with no lid and left in a 73 °F room. Five minutes after being poured, the coffee is 161.9 °F. The constant of variation can be calculated as $k = 0.079$.

1. Use the given information to create a function for the temperature of the coffee as it cools over time.
2. Use the function from part 1 to calculate the temperature of the coffee at the time intervals stated in the following table. Round the temperatures of the coffee to the nearest tenth of a degree.

Time (minutes)	Temperature of Coffee (°F)	Time (minutes)	Temperature of Coffee (°F)
0		5	
1		6	
2		7	
3		8	
4		9	

3. Does the calculated value match the recorded value after 5 minutes? Explain why it does or does not match.
4. What is the lowest temperature that the coffee can reach in these conditions? Explain your reasoning.

According to the University of Wisconsin–Madison, hot liquids can cause third-degree burns at the following exposure periods and temperatures: 5 seconds at 140 °F, 2 seconds at 149 °F, and 1 second at 156 °F.

5. After how many minutes is the coffee safe to drink? Explain your reasoning.
6. A study of 300 participants showed that the preferred drinking temperature of coffee is between 125 °F and 165 °F. According to the table in part 2, when does the temperature of the coffee enter this preferred interval?
7. The same study determined that the optimal drinking temperature is approximately 136 °F. When is the coffee at that optimal temperature?
8. If a lid were added to the mug, would that change the cooling rate of the liquid? Explain your reasoning.