

USC, DEPARTMENT OF PHYSICS & ASTRONOMY

Graduate student problem competition

JAN 12–19, 2024

All graduate students are eligible to participate.

To submit your solution, e-mail it to bazaliy@mailbox.sc.edu

Temperature oscillations inside a refrigerator

You have a refrigerator installed in your kitchen. When air temperature in the kitchen is kept constant at $T_{air} = 20^\circ\text{C}$, and the refrigerator is turned on, you find that the temperature inside is 10°C .

In reality, air temperature in your kitchen oscillates with a period of $\tau = 24$ hours as day turns into night. Its time dependence is given by

$$T_{air}(t) = 20 - 5 \sin(2\pi t/\tau) \text{ } ^\circ\text{C}.$$

With variable air temperature, the temperature inside the refrigerator changes as well. In particular, when the refrigerator is turned off, your measurements show that the maximum temperature inside is 22°C .

You now do the following experiment. Initially, the refrigerator is turned off, its door is open, and temperature inside equals the air temperature. At $t = 0$ you close the door and turn the refrigerator on. Find the wait time before the temperature inside reaches 10°C for the first time. The answer should be given in hours, and you can use analytic and/or numeric techniques to find it.