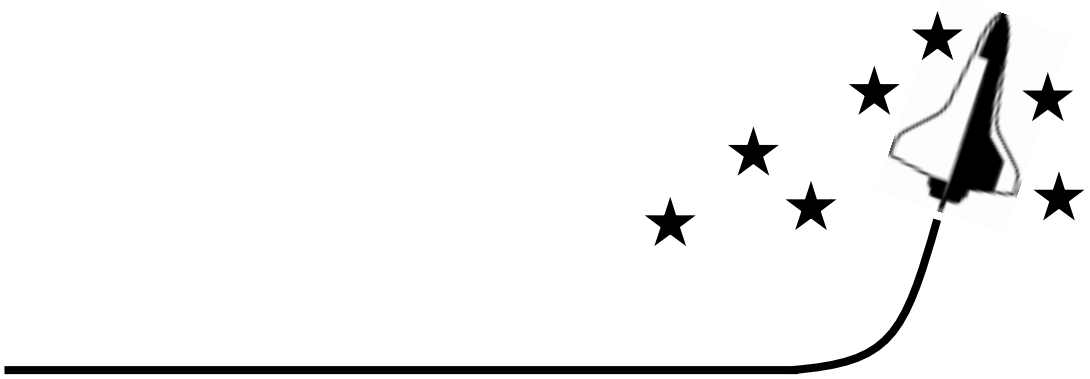
FACULTY NOTES

The LTAs and Spinoffs are designed so that each professor can implement them in a way that is consistent with his/her teaching style and course objectives. This may range from using the materials as out-of-class projects with minimal in-class guidance to doing most of the work in class. The LTAs and Spinoffs are amenable to small group cooperative work and typically benefit from the use of some learning technology. Since the objective of the LTAs and Spinoffs is to support the specific academic goals you have set for your students, the Faculty Notes are not intended to be prescriptive. The purpose of the Faculty Notes is to provide information that assists you to take full advantage of the LTAs and Spinoffs. This includes suggestions for instruction as well as answers for the exercises.



FACULTY NOTES

SPINOFF 11A

Newton's law of Cooling and Heating: Vaporization of Liquid Helium

Solution

We start with the following general function that relates the temperature, *T*, of a liquid to the time, t, that it has been cooling down or heating up.

$$T = T_S + (T_0 - T_S)e^{-kt} \tag{1}$$

We are given that the ambient temperature is 80º F. This is equivalent to 26.66º C as shown in the conversion below.

$$(80^\circ \text{F} - 32^\circ \text{F})\frac{5}{9} = 26.6^\circ \text{C}$$

The ambient temperature, T_S = 26.66º C and the temperature at time 0, T_0 = –271.5º C. Substituting into equation 1, gives:

$$T = 26.66 + (-271.5 - 26.66)e^{-kt} \tag{2}$$

Since the temperature is –271º C when t = 10 minutes, we can use equation 2 to write the following:

$$-271 = 26.66 + (-271.5 - 26.66)e^{-k\cdot 10} \tag{3}$$

We now solve equation 3 for k to obtain:

$$-10k = \ln\left(\frac{-297.66}{-298.16}\right) \Rightarrow k = \frac{-0.0016783596}{-10} = 0.000168$$

Thus, the equation that describes the relationship between the temperature of the helium and the time is:

$$T = 26.66 - 298.16e^{-0.000168t}$$

We are now able to find the time when the temperature reaches –269.5º C.

$$-269.5 = 26.66 - 298.16e^{-0.000168t} \Rightarrow -0.000168t = \ln\left(\frac{-296.16}{-298.16}\right) \Rightarrow t = 40.06 \text{ minutes}$$