

Problem 1.C1

Sometimes we can develop equations and solve practical problems by knowing nothing more than the dimensions of the key parameters in the problem. For example, consider the heat loss through a window in a building. Window efficiency is rated in terms of “R value,” which has units of $(\text{ft}^2 \cdot \text{hr} \cdot ^\circ\text{F})/\text{Btu}$. A certain manufacturer offers a double-pane window with $R = 2.5$. The same company produces a triple-pane window with $R = 3.4$. In either case the window dimensions are 3 ft by 5 ft. On a given winter day, the temperature difference between the inside and outside of the building is 45°F .

- (a) Develop an equation for the amount of heat lost in a given time period Δt , through a window of area A , with a given R value, and temperature difference ΔT . How much heat (in Btu) is lost through the double-pane window in one 24-h period?
- (b) How much heat (in Btu) is lost through the triple-pane window in one 24-h period?
- (c) Suppose the building is heated with propane gas, which costs \$3.25 per gallon. The propane burner is 80 percent efficient. Propane has approximately 90,000 Btu of available energy per gallon. In that same 24-h period, how much money would a homeowner save per window by installing triple-pane rather than double pane windows?
- (d) Finally, suppose the homeowner buys 20 such triple pane windows for the house. A typical winter has the equivalent of about 120 heating days at a temperature difference of 45.8°F . Each triple-pane window costs \$85 more than the double-pane window. Ignoring interest and inflation, how many years will it take the homeowner to make up the additional cost of the triple-pane windows from heating bill savings?