

HEAT FLOW

Unit 20 Dr. John P. Cise , Professor of Physics, Austin Com. College, 1212 Rio Grande St., Austin Tx. 78701 jpcise@austincc.edu & NY Times , December 27, 2016 by Jane E. Brody

7 Tips for Making It Through the Winter



INTRODUCTION: Layers of loose fitting clothing trap air which has a low specific heat of $C_{\text{AIR}} = 993 \text{ J/kg}\cdot\text{C}^\circ$ compared to water's high $C_{\text{H}_2\text{O}} = 4200 \text{ J/kg}\cdot\text{C}^\circ$. Purpose of this application is to show the amount of heat needed to heat up a 5 cm. thick layer around a standard body area of 2 m^2 is MORE for the layer being water vs. air. We will consider the layer needs to heat up from 0 to 21 C° (freezing to room temperature). Density of air $\rho_{\text{AIR}} = 1.275 \text{ kg./m}^3$, $\rho_{\text{H}_2\text{O}} = 1000 \text{ kg./m}^3$

QUESTIONS: (a) Find the volume of this 5 cm. thick, 2 m^2 area surrounding the human body?, (b) Find the mass of this layer if air , then if water?

The older I get, the harder I find it is to stay warm in winter, indoors or out, and I'm happy to share the measures I've found helpful, short of moving to the tropics. You don't have to be a senior citizen to succumb to the known hazards of winter weather. Of course, it helps to be financially able to implement the suggestions below, which is why I make it a point to donate dollars and goods to organizations that help protect the most vulnerable among us against cold-related injury and illness.

■ **Dress in Layers.** Let's start with the basics: What to wear. **Layers of loosefitting clothing trap the body's natural warmth, and do it best with an insulating inner layer** (for example, Heattech by Uniqlo) and an outer layer resistant to wind and water. The less body area exposed, the warmer you'll be. **If your clothing gets wet, it loses much if not most of its protection, carrying heat away from the body instead of keeping it in.** The warmest down-filled garment is ineffective when wet. [British scientists](#) who studied how people in eastern Siberia protect against the cold found that they typically wear four or more layers of clothing — generally of fur or other thick material — and do not begin to feel the effects of cold until temperatures drop below minus 4 degrees Fahrenheit. ■ **Protect the Extremities.** Hats that cover the ears (or earmuffs) are vital because the head has little insulation against the cold. Scarves keep the neck and chest warm and can be used to protect the face against wind. Mittens keep hands warmer than gloves, especially if they are fur-lined or heated with rechargeable batteries. For cold feet, there are lined waterproof boots rated by temperature, as well as battery-heated socks and insoles. Ugg boots are very toasty but not waterproof, and some find them too warm to wear indoors. Slip-resistant soles or cleats can help keep you upright on icy pavement.

QUESTIONS(CONTINUED): (c) Find amount of heat needed to warm up this layer of air from 0 to 21 C° ?
(d) Find amount of heat needed to warm up this 5 cm. thick by 2.0 m^2 layer of water from 1 to 21 C° ?
(e) How much more heat was needed to heat up this layer of water compared to heating up air?

HINTS: Heat $Q = c m \Delta t$, $V = A h$, density = mass/volume , $\rho = m/V$,

ANSWERS: (a) $V = 0.1 \text{ m}^3$, (b) $m_{\text{AIR}} = 0.1275 \text{ kg.}$, $m_{\text{H}_2\text{O}} = 100 \text{ kg.}$, (c) $Q_{\text{AIR}} = \sim 2,659 \text{ J}$, (d) $Q_{\text{H}_2\text{O}} = 8,820,000 \text{ J}$
(e) $Q_{\text{H}_2\text{O}} = \sim 3317 Q_{\text{AIR}}$ **COMMENT:** Thus, dry clothing provides a warm temperature layer preventing the need for heat to flow from body as when the layer is cold water. As long as the temperature of the surface above your body's 98.6 F° is also at that temperature NO heat will flow from your body.