PROJECT LEAD THE WAY

PLTW

Igniting imagination and innovation through learning.

Heat Loss and Gain

O'Keefe - LBHS

Heat Loss and Gain

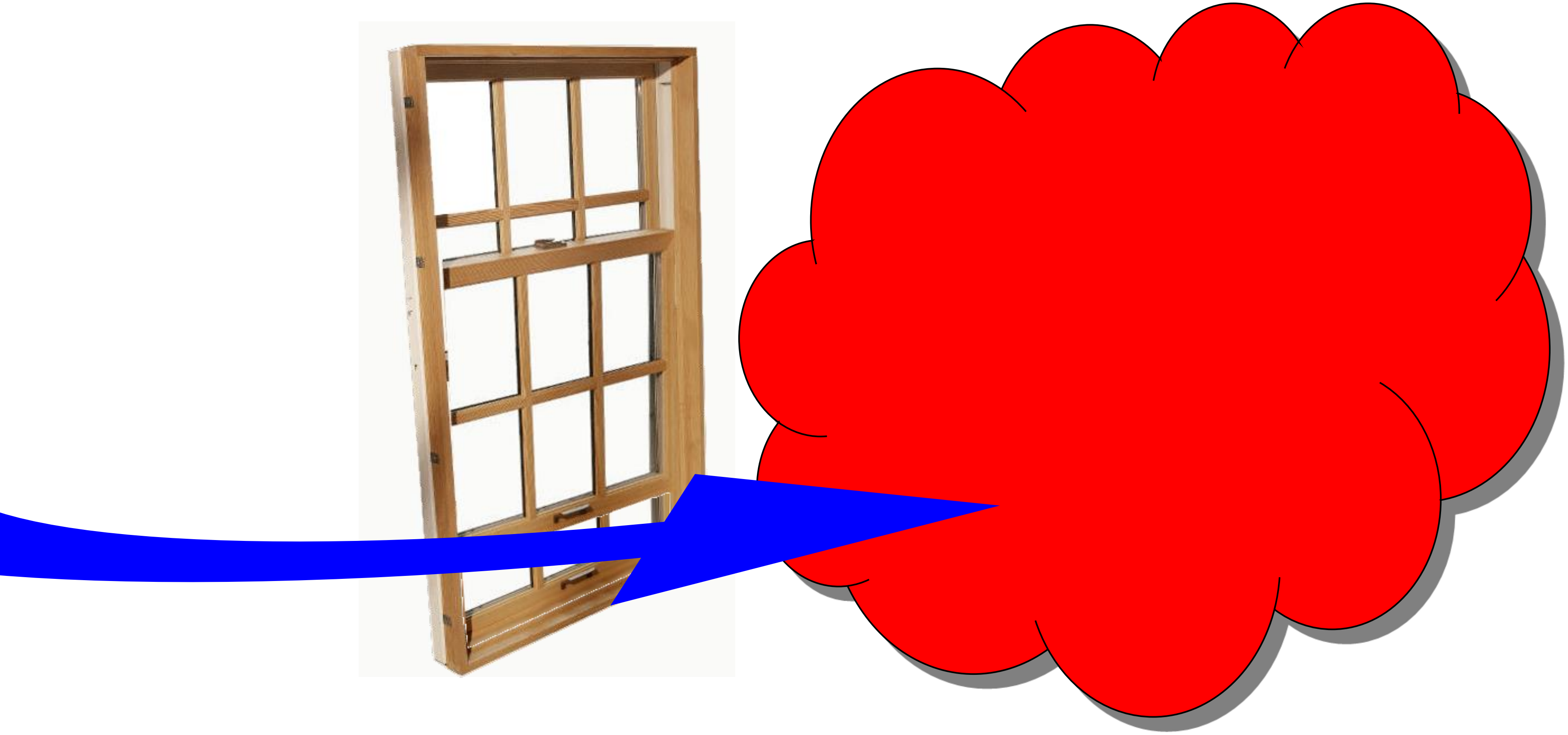
- Heat Transfer
- Winter Heat Loss
- Summer Heat Gain
- British Thermal Units (Btu)
- Formula for Heat Load
- Heat Loss Through a Wall
- Wall R-Value
- Convert R-Value to U-Value
- Using Engineering Design Data
- ΔT = Temperature Differential
- Total Heat Transmission Load

Heat Transfer

Thermal Conduction: The process of heat transfer through a solid by transmitting kinetic energy from one molecule to the next.

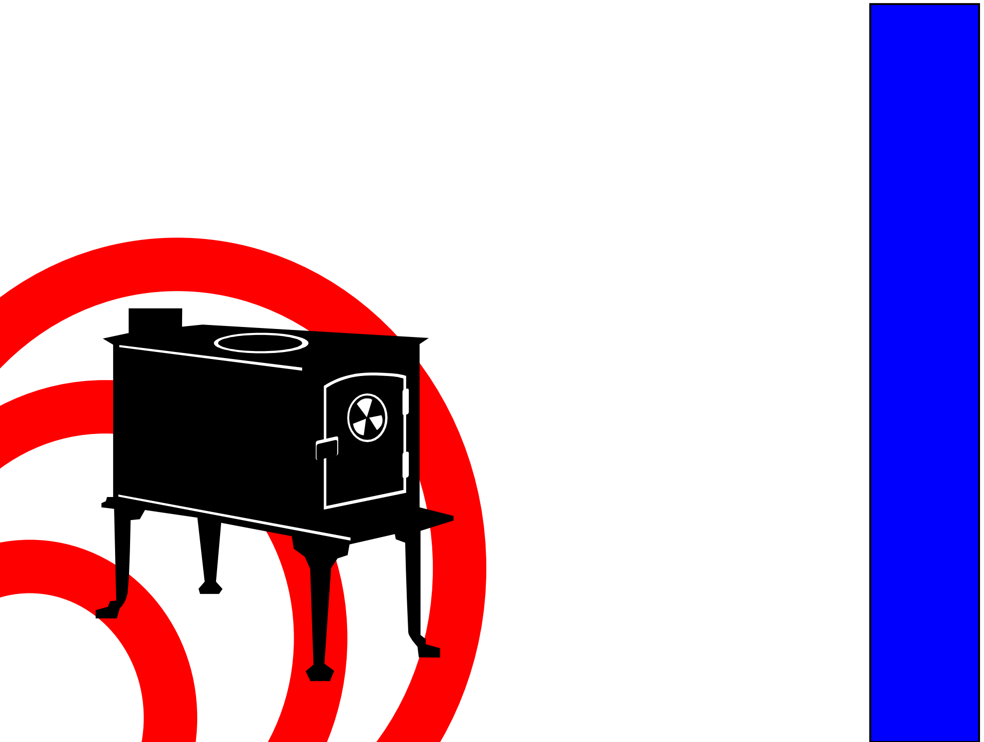
Heat Transfer

Thermal Convection: Heat transmission by the circulation of a liquid or gas.



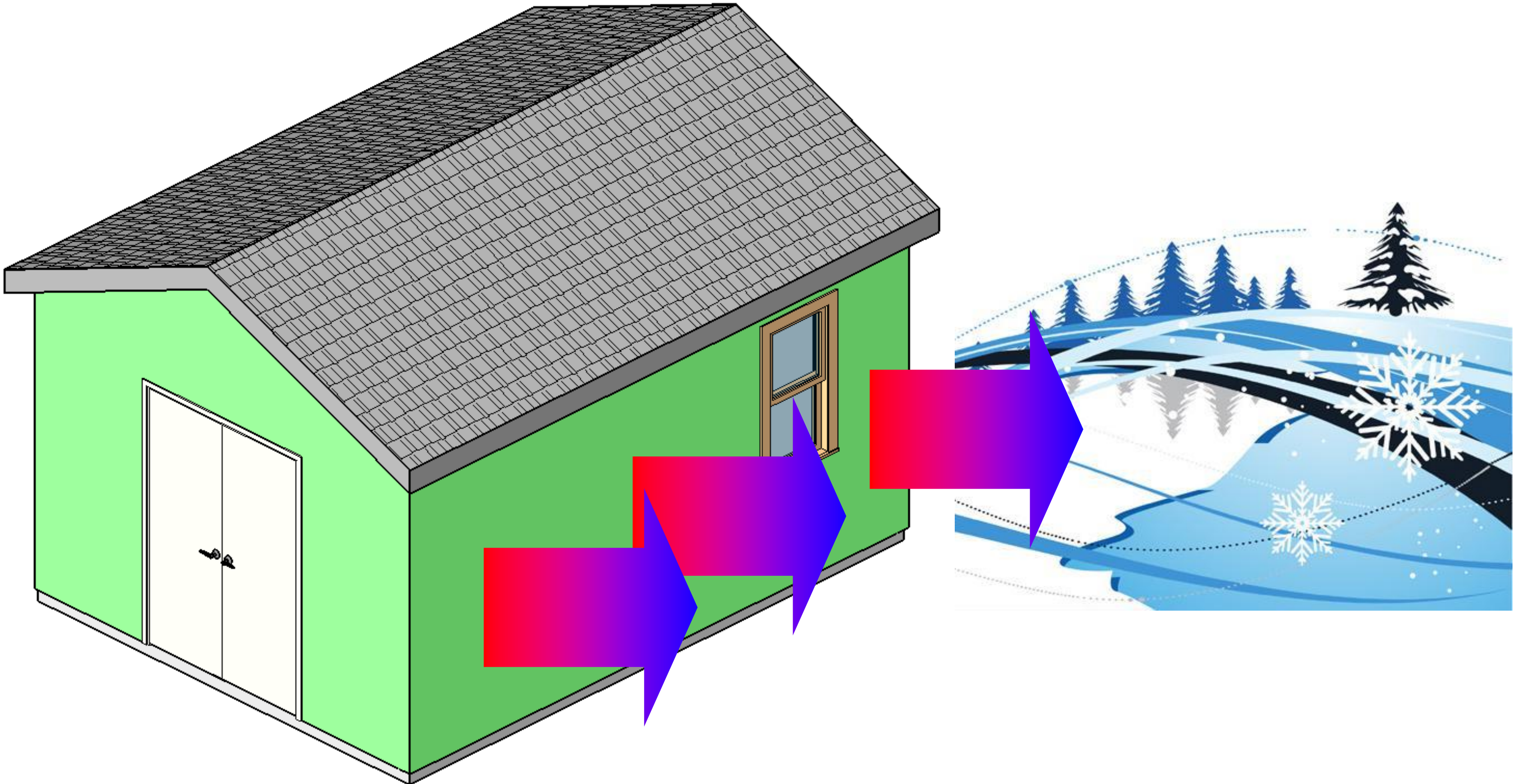
Heat Transfer

Radiant Heat: Energy radiated or transmitted as rays, waves, or in the form of particles.



Heat Transfer

Heat escapes through walls and openings when the temperature outside is lower than the temperature inside.

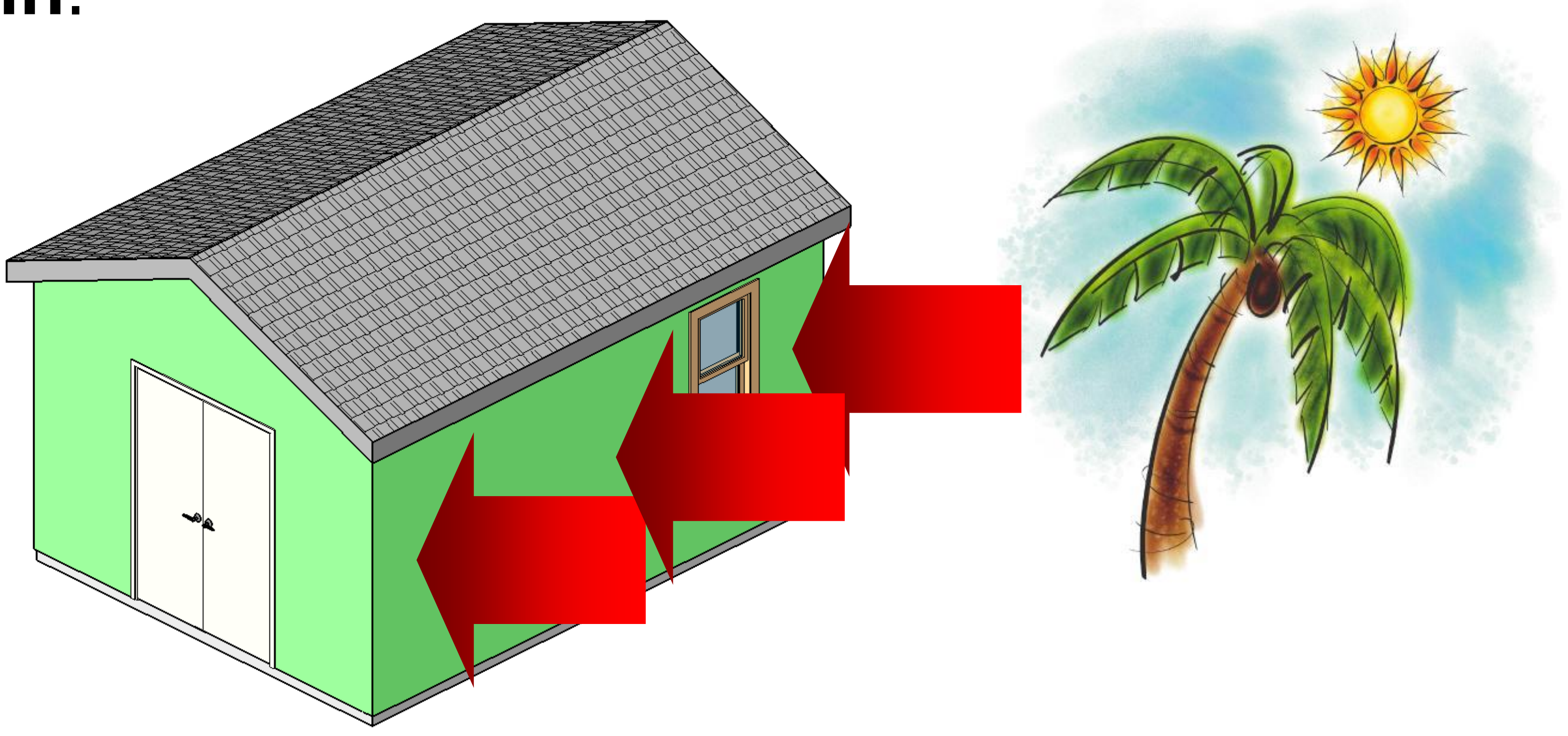


Winter Heat Loss

- Heat loss occurs through the building structure, including the walls, windows, doors, and roof.
- The structure requires additional heating due to the heat loss and incoming infiltrating air.

Summer Heat Gain

Heat enters through walls and openings when the temperature outside is warmer than the temperature inside. This is referred to as **heat gain**.



Summer Heat Gain

- *Solar* heat gain through walls, windows, door, and roof
- *Occupant* heat gain is about 250 Btu/h per occupant, or up to 715 Btu/h if occupant is exercising
- Cold mass heat gain from *equipment* such as computers, coffee makers, etc.
- *Lighting* heat gain

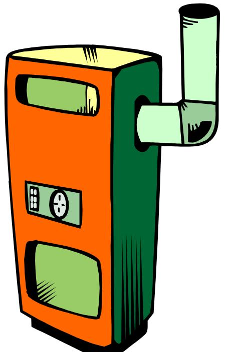
British Thermal Unit (Btu)

- Unit of energy used in the United States
- A Btu is defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit

One Btu is about the amount of energy produced by a burning match.

British Thermal Unit (Btu)

- **Fahrenheit** is a common temperature scale used by engineers in heating, ventilation, and air conditioning (HVAC).
- Btu/h is a way of measuring the heating power of a system such as a furnace or a barbecue grill.



British Thermal Unit (Btu)

- 1 watt is approximately 3.4 $\frac{\text{Btu}}{\text{hr}}$
- 12,000 $\frac{\text{Btu}}{\text{hr}}$ is referred to as a ton in most North American air conditioning applications

British Thermal Unit (Btu)

R-Value: The measurement of thermal *resistance* used to indicate the effectiveness of insulation.

Units: $\dfrac{ft^2 \cdot hr \cdot {}^\circ F}{Btu}$

U-Value (coefficient of heat conductivity):

The measure of the *flow of transmittance* through a material given a difference in temperature on either side.

Units: $\dfrac{Btu}{ft^2 \cdot hr \cdot {}^\circ F}$

Note that **R** = **1/U**

Formula for Heat Load

$$Q' = AU\,\Delta T$$

Where **Q'** = Total cooling/heating load in $\frac{\text{Btu}}{\text{hr}}$

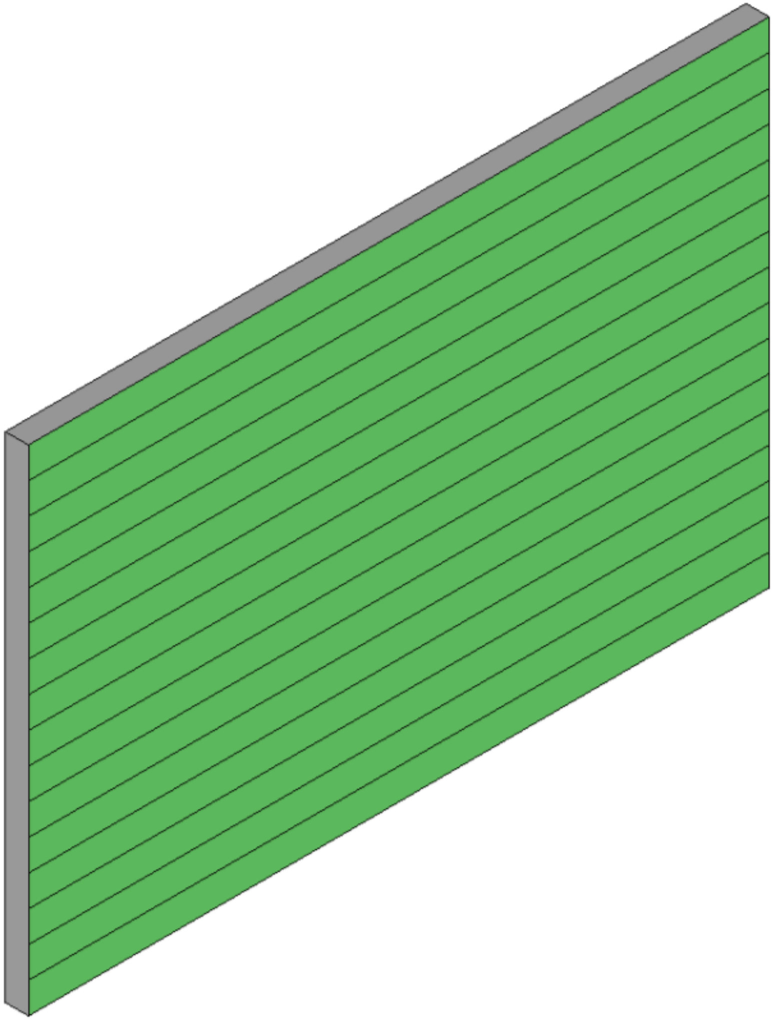
A = Area under investigation in ft^2

U = Coefficient of heat conductivity in $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot {}^\circ\text{F}}$

ΔT = Difference in temperature between outside and inside conditions in °F

Click here to return to calculation

Heat Loss Through a Wall



No windows or doors

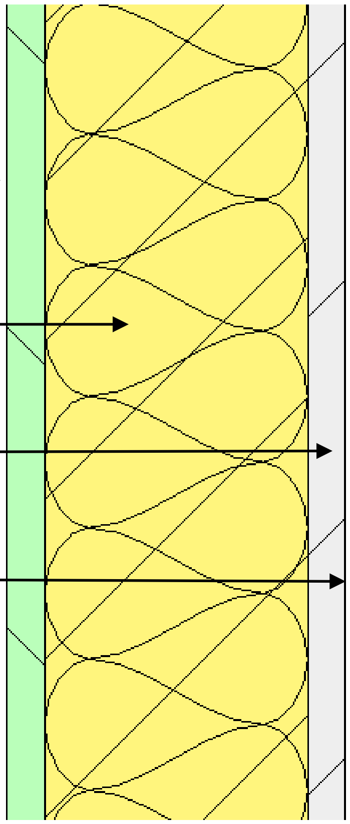
Height = 8 ft

Length = 12 ft

Area = 8 ft x 12 ft = 96 ft^2

Wall R-Value

Outside Air Film	neglect
Siding	1.05
Insulation	11.00
Drywall	0.68
Inside Air Film	0.68
Total R-Value	**13.41** $\frac{ft^2 \cdot hr \cdot {}^{\circ}F}{Btu}$



Convert R-Value to U-Factor

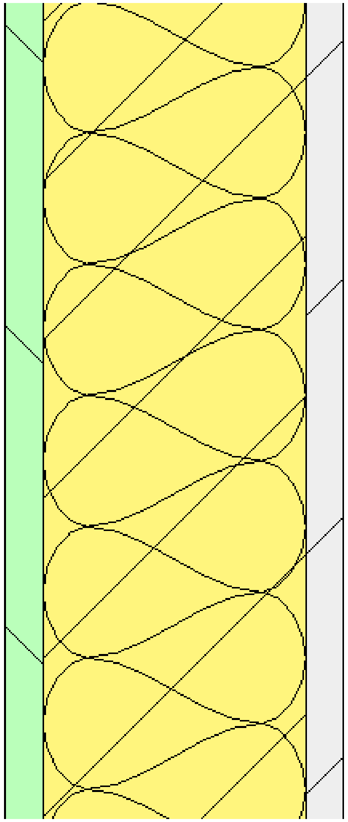
Total R-Value= **13.41** $\frac{ft^2 \cdot hr \cdot {}^\circ F}{Btu}$

$$U = \frac{1}{R}$$

$$U = \frac{1}{13.41} = 0.07457$$

U = .074 $\frac{Btu}{ft^2 \cdot hr \cdot {}^\circ F}$

(Do not round up)



Using Engineering Design Data

Choose your nearest location using the data from one of the following

- *International Plumbing Code*
- National Oceanic and Atmospheric Administration (NOAA) *Engineering Weather Data*
- Local weather data

Using Engineering Design Data

Design Criteria Data

Dry Bulb Temperature (T)	Design Value (°F)	Mean Coincident (Average) Values: Wet Bulb Temperature (°F)	Humidity Ratio (gr/lb)	Wind Speed (mph)	Prevailing Direction (NSEW)
Median of Extreme Highs	94	77	114	10.5	WSW
0.4% Occurrence	91	76	114	10.3	SW
1.0% Occurrence	89	75	111	10.1	SW
2.0% Occurrence	87	74	107	9.9	SW
Mean Daily Range	18	-	-	-	-
97.5% Occurrence	11	10	7	9.5	W
99.0% Occurrence	3	2	5	9.5	W
99.6% Occurrence	-3	-4	3	8.2	W
Median of Extreme Lows	-8	-8	3	9.5	W

Use this value for heating calculations. A 99% value has been exceeded 99% of the year. In other words, a little over 361 days in the year, the temperature exceeds this value (365 x .99 = 361.4 days).

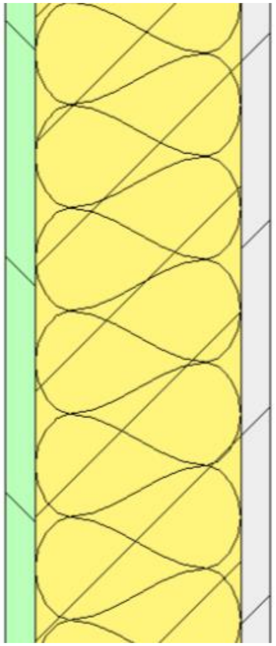
Use this value for cooling calculations. A 1% value has been exceeded only 1% of the year. In other words, during less than 4 days in the year, the temperature exceeds this value (365 x .01 = 3.65 days).

ΔT = Temperature Differential

The difference between the design outside temperature and the design inside temperature

Design Outside Temperature

3 °F



Design Inside Temperature

68 °F

Total Heat Loss
(or Transmission Load

$$Q' = AU\,\Delta T$$

$A = (8\text{ ft})\,(12\text{ ft}) = 96\text{ ft}^2$

$U = .074 \frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot {}^\circ\text{F}}$

$\Delta T = 68 - 3 = 65\ {}^\circ\text{F}$

$$Q' = (96\text{ft}^2)(0.074\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot {}^\circ\text{F}})(65\,{}^\circ\text{F}) = 462\frac{\text{Btu}}{\text{hr}}$$

Click here to see equation

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Image Resources

Microsoft, Inc. (n.d.). *Clip art*. Retrieved June 10, 2009, from http://office.microsoft.com/en-us/clipart/default.aspx