ARC 523, Fall 2023 **Assignment #1**
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PEAK HEATING LOAD CALCULATIONS

Parameters

- Floor area: 2,500 sq-ft (50 ft × 50 ft)
- Ceiling height: 10 ft
- Windows: 30 ft × 5 ft (North, South, East, and West elevations each)
- Doors: 4 ft × 8 ft (North and South elevations each)
- T_{room}: 68°F (for all three city cases below)
- Construction Type: Medium (for ACH calculations)
- T_{design} (Charlotte, NC): 22°F
- T_{design} (Denver, CO): 1°F
- T_{design} (Washington, DC): 17°F

Calculations

1) Calculate the peak heating loads (Btu/hr) of the house when located in the cities below.

1-1) **Charlotte, NC** (Charlotte AP); HDD65 = 3348

	U-Value (Btu/hr-sqft-F)	F-Value (Btu/hr-ft-F)	Area (sqft)	Perimeter (ft)	U*A (Btu/hr-F)	F*P (Btu/hr-F)
Roof	0.034		2,500		85	
Wall	0.065		1,336		87	
Window	0.650		600		390	
Door	0.320		64		20	
Floor		0.807		200		161.33
(UA)env					582.32+161.33=743.65	

(UA)inf = 1.08 * cfm = 1.08 * 334.2 =	360.90
Where: = cfm (ft3/min) = ACH * Space Volume * (hr/60-min) = 0.802/hr (from table) * 25,000 ft3 * (hr/60-min) = 334.2 (ft3/min or cfm)	

(UA)tot = (UA)env + (UA)inf = 743.65 + 360.90 =	1,104.55

$Q_{Heat,Peak}$ = (UA)tot * ΔT_{design} = 1,104.55 (Btu/hr-F) * (68-22) °F = 50,809.15 Btu/hr	50,809.15

1-2) **Denver, CO** (Denver AP); HDD65 = 6023

	U-Value (Btu/hr-sqft-F)	F-Value (Btu/hr-ft-F)	Area (sqft)	Perimeter (ft)	U*A (Btu/hr-F)	F*P (Btu/hr-F)
Roof	0.034		2,500		85	
Wall	0.065		1,336		87	
Window	0.650		600		390	
Door	0.320		64		20	
Floor		0.869		200		173.82
(UA)env					582.32+173.82=756.14	

(UA)inf = 1.08 * cfm = 1.08 * 369.2 =	398.70
Where: = cfm (ft3/min) = ACH * Space Volume * (hr/60-min) = 0.886/hr (from table) * 25,000 ft3 * (hr/60-min) = 369.2 (ft3/min or cfm)	

(UA)tot = (UA)env + (UA)inf = 756.14 + 398.70 =	1,154.84

$Q_{Heat,Peak}$ = (UA)tot * $\triangle T_{design}$ = 1,154.84 (Btu/hr-F) * (68-1) °F = 77,373.99 Btu/hr	77,373.99

1-3) **Washington, DC** (Washington National AP); HDD65 = 4125

	U-Value (Btu/hr-sqft-F)	F-Value (Btu/hr-ft-F)	Area (sqft)	Perimeter (ft)	U*A (Btu/hr-F)	F*P (Btu/hr-F)
Roof	0.034		2,500		85	
Wall	0.065		1,336		87	
Window	0.650		600		390	
Door	0.320		64		20	
Floor		0.820		200		163.92
(UA)env					582.32+163.92=746.24	

(UA)inf = 1.08 * cfm = 1.08 * 342.5 =	369.90
Where: = cfm (ft3/min) = ACH * Space Volume * (hr/60-min) = 0.822/hr (from table) * 25,000 ft3 * (hr/60-min) = 342.5 (ft3/min or cfm)	

(UA)tot = (UA)env + (UA)inf = 746.24 + 369.90 =	1,116.14

$Q_{Heat,Peak}$ = (UA)tot * $\triangle T_{design}$ = 1,116.14 (Btu/hr-F) * (68-17) °F = 56,922.97 Btu/hr	56,922.97

2) Analyze your results, comparing the peak heating loads between the cities.

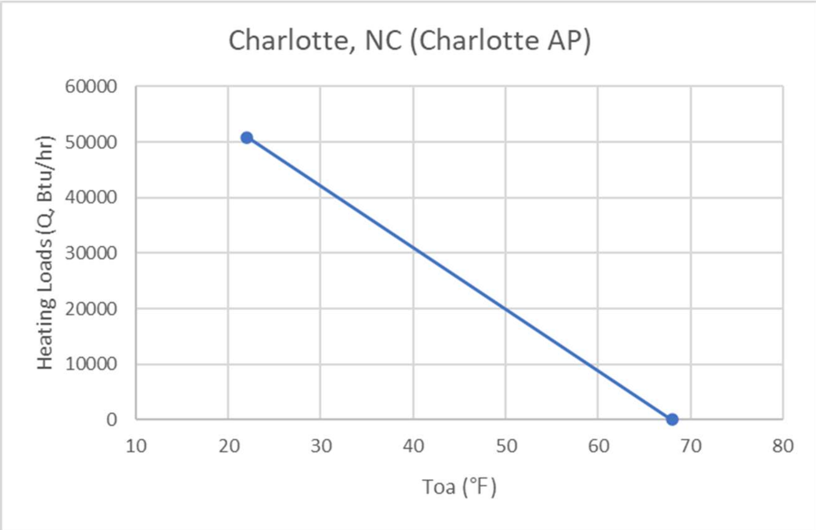
2-1) 1. Denver, CO (Denver AP): $Q_{Heat,Peak} = 77{,}373.99$ Btu/hr

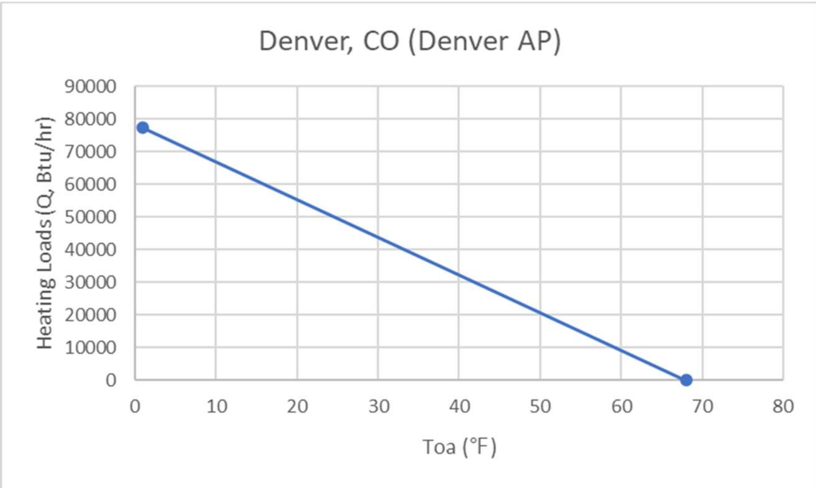
2. Washington, DC (Washington National AP): $Q_{Heat,Peak} = 56{,}922.97$ Btu/hr

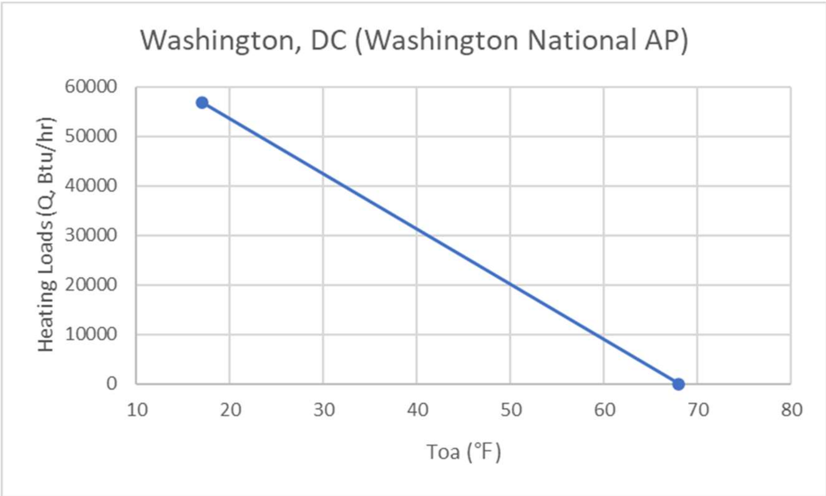
3. Charlotte, NC (Charlotte AP): $Q_{Heat,Peak} = 50{,}809.15$ Btu/hr

- The order of the above rank is the same as the ranking for heating degree days(HDD). HDD indicates how much heating is required in cold weather conditions. The more days heating is needed, the higher the HDD value, indicating that the area is exposed to cold weather. Therefore, a higher HDD implies larger peak heating loads. For these reasons, the rank I suggested earlier is reasonable.

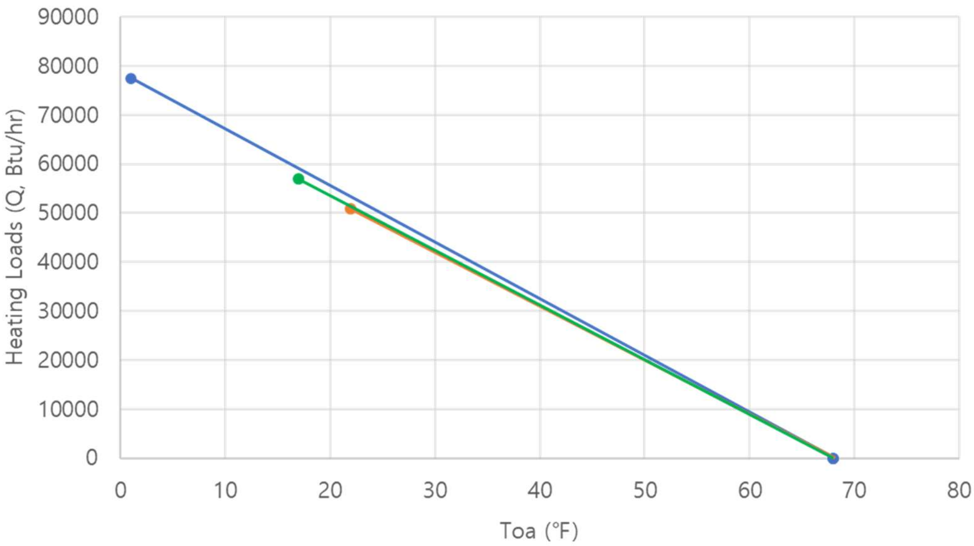
2-2) Heating loads VS Temperature change







2-3) Combine all three graphs into one



2-4) Ideas and strategies to reduce the heating loads

- One way to reduce (UA)env is by choosing building envelope materials with a low U-value, and for flooring materials, selecting those with a low F-value. Additionally, there is a strategy to enhance the building's air tightness performance to reduce (UA)inf.