CMGT 235 – Electrical and Mechanical Systems

In Class Activity #1 – Heat Load Calculation for a Small Building

Name: Solution #1

Name: ____________________

Name: ____________________

R-Value Table

Building Component	R-Value
Wildebeest snout siding	0.81
Weevil Hide sheathing	0.98
Wookie fiber insulation	3.78 per inch of thickness
Wombat Fur insulation	3.70 per inch of thickness
Wabbit foot wallboard	16.80 per inch of thickness
2x4 Wood Stub	4.38
Walleye Scales	0.78
Walrus Tusk	0.33
Windows per/sf	2.30
Doors	5.60
Inside Air Film	0.68
Outside Air Film	0.17
Air space	0.72 per inch of thickness

1. **Determine the R-Value and U-Factor for the Wall:**
   A. **Wall Assembly (At Framing)**

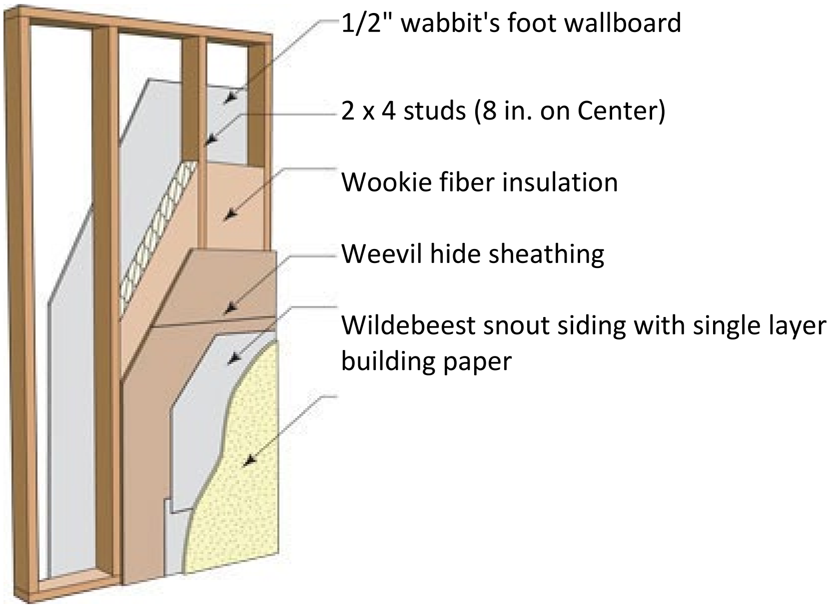
Wall R Value	R-Value		Total R-Value
Outside Air Film	0.17		0.17
Wildebeest Snout Siding	0.81		0.81
Weevil Hide Sheathing	0.98		0.98
2x4 Wood Stud	4.38		4.38
1/2" Wabbit Foot Wallboard	16.80	per/in	8.40
Inside Air Film	0.68		0.68
Total R			15.42
U-Factor (use three decimals)			0.065

   B. **Wall Assembly (At Insulation)**

Wall R Value	R-Value		Total R-Value
Outside air film value	0.17		0.17
Wildebeest snout siding	0.81		0.81
Weevil Hide sheathing	0.98		0.98
3-1/2" Wookie fiber insulation	3.78	per/in	13.23
1/2" Wabbit foot wallboard	16.80	per/in	8.40
Inside air film value	0.68		0.68
Total R			24.27
U-Factor (use three decimals)			0.041

C. Determine the average U-Factor for the wall assembly. SHOW ALL WORK

Wall Assembly



Hint: Determine the percentage of wall that is 2x4 stud and the percentage that is insulated.

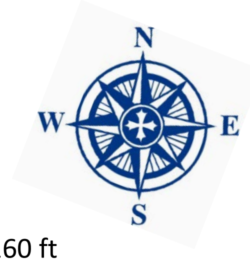
U-Factor Average = 0.065 x (1.5/8) + 0.041 x (6.5/8) = 0.065 x 0.1875 + 0.041 x 0.8125 = 0.045

D. Ceiling Assembly

Ceiling R Value	**R-Value**		**Total R-Value**
18″ Wombat fur	3.70	per/in	66.60
1/2" Wabbit foot wallboard	16.80	per/in	8.40
10″ air space	0.72	per/in	7.20
Inside air film value	0.68		0.68
Outside air film value	0.17		0.17
<u>Total R</u>			83.05
U-Factor (use three decimals)			0.012

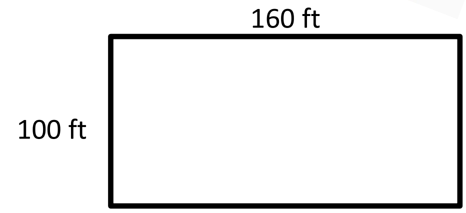
2. Building Construction Data

A. Calculate Building Volume



Building Dimensions

Length (ft)	160
Width (ft)	100
Ceiling Height (ft)	15
Volume per floor (ft^3) =	240,000
Total Building Volume (ft^3) =	720,000



B. Calculate Wall, Window, and Door Area

Wall Schedule

Description	**Length (ft)**	**Height (ft)**	**Area (ft^2)**
North	160	15	2400
East	100	15	1500
South	160	15	2400
West	100	15	1500
		Total	7800 (per floor)

Window Schedule

Quantity	**Width (ft)**	**Height (ft)**	**Area (ft^2)**
30	8	6	1440
		Total	1440 (per floor

Door Schedule

Quantity	**Width (ft)**	**Height (ft)**	**Area (ft^2)**
8	4	8	256
4	4	10	160
		Total	416

C. Calculate Net Wall Area

Net Wall Area = Total Wall Area – Total Window Area – Total Door Area

Net Wall Area = 23,400 – 4,320 – 416 = 18,664 ft^2

3. HEAT LOAD CALCULATION

A. Heat Loss Due to Infiltration

Method 1

Convection: BTUH heat gain/loss due to infiltration

q_{infil} = C x ACH x V x ΔT

C =	0.018 Btu/ft^3	
ACH =	3.0	
V =	720,000 ft^3	
ΔT =	42 °F	
q_{infil} =	1,632,960	BTUH

(Round q to Whole Number)

Method 2 (check of Method 1)

Step 1: Find cfm

CFM = (ACH x V) / 60

ACH =	3.0
V =	720,000 ft^3
time	60 min/hr
CFM =	36,000

BTUH = CFM x 1.08 x ΔT

Step 2: Insert step 1 cfm

CFM =	36,000
1.08	
ΔT =	42 °F
BTUH =	1,632,9600

B. Heat Loss Due to Ventilation

Convection: BTUH heat/gain loss due to ventilation

$q_{ventilation}$ = 1.08 x cfm $_{total\ vent.}$ x ΔT Heating Coil

	Number of	CFM	
15 CFM/Wallaby X	80 =	1200 CFM	
5 CFM/Weasels X	900 =	4500 CFM	
		5700	CFM total ventilation

CFM $_{total\ ventilation}$	5700	
ΔT =	47 °F	
$q_{ventilation}$	289,332 BTUH	

(Round q to Whole Number)

C. **Design Conditions**

Infiltration Data	
Building Volume	720,000
Air Changes/Hour	3.0
Infiltration CFM	36,000

Winter Design Criteria	
Mixed Air Temp	55 ^oF
Return Air Temp	62 ^oF
Outside Temp	36 ^oF
Supply Air Temp	108 ^oF
Daytime Setpoint	78 ^oF
Design ΔT	42 ^oF
Heating Coil Air ΔT	47 ^oF
Heating Coil Water ΔT	27 ^oF

D. **Heat Loss Due to Transmission** (Round q to Whole Number)

Component	**U-Factor (Btu/h x ft^2 x ^oF)**	**Area (ft^2)**	**ΔT (^oF)**	**$q_{Transmission}$ = U x A x ΔT (BTUH)**
Walls (Net)	0.045	18,664	42	35,275
Windows	0.435	4,320	42	78,926
Doors	0.179	416	42	3,127
Ceiling	0.012	16,000	42	8,064
			Total Envelope Heat Loss Due to Transmission	125,392

E. **Heat Loss Due to Convection** (From Page 5)

$q_{Infiltration}$ (BTUH)	1,632,960
$q_{Ventilation}$ (BTUH)	289,332

F. **Total Building Heat Load ($q_{total} = q_{Transmission} + q_{Infiltration} + q_{Ventilation}$)**

Total Heat Coil Load (BTUH)	2,047,685

Extra Credit

4. FAN AND PUMP DATA

A. CFM Req. to move across heating coil = [Total Space Heat Loss/Gain / Heating coil air ΔT] * 1.08

= (2,047,685/ 47) x 1.08 = 47,053 CFM

B. GPM Req. to flow through heating coil = Total Coil Load / (Heating coil water ΔT * 500)

= 2,047,685/ (27 x 500) = 152 GPM