CMGT 235 – Electrical and Mechanical Systems

Department of Construction Management ❀ California State University, Chico

Exam #1 [100 points]

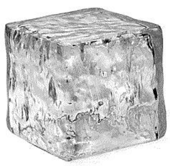
You may work together as a group or individually. Every student SHALL complete their own answer sheet.

Name:	Solution
Name:	
Name:	

15 pts 1. A 6 in x 6 in x 3 in ice cube is held in a freezer at 0°F. How much heat is required to turn the ice cube to steam?

Weight of Ice Cube

M = (0.5 ft x 0.5 ft x 0.25 ft) x 62.41 lb/ft^3 = 3.9 lb



Sensible Heat 0°F to 32°F solid

Q = M x C x ΔT = 3.9 lb x 1 Btu/lb°F x (32°F - 0°F) = 125 Btu

Latent Heat of Fusion 32°F to Melted

Q = 144 Btu/lb x 3.9 lb = 562 Btu

Sensible Heat Melted @32°F to 212°F

Q = M x C x ΔT = 3.9 lb x 1 Btu/lb°F x (212°F - 32°F) = 702 Btu

Latent Heat of Vaporization 212°F to Steam

Q = 970 Btu/lb x 3.9 lb = 3783 Btu

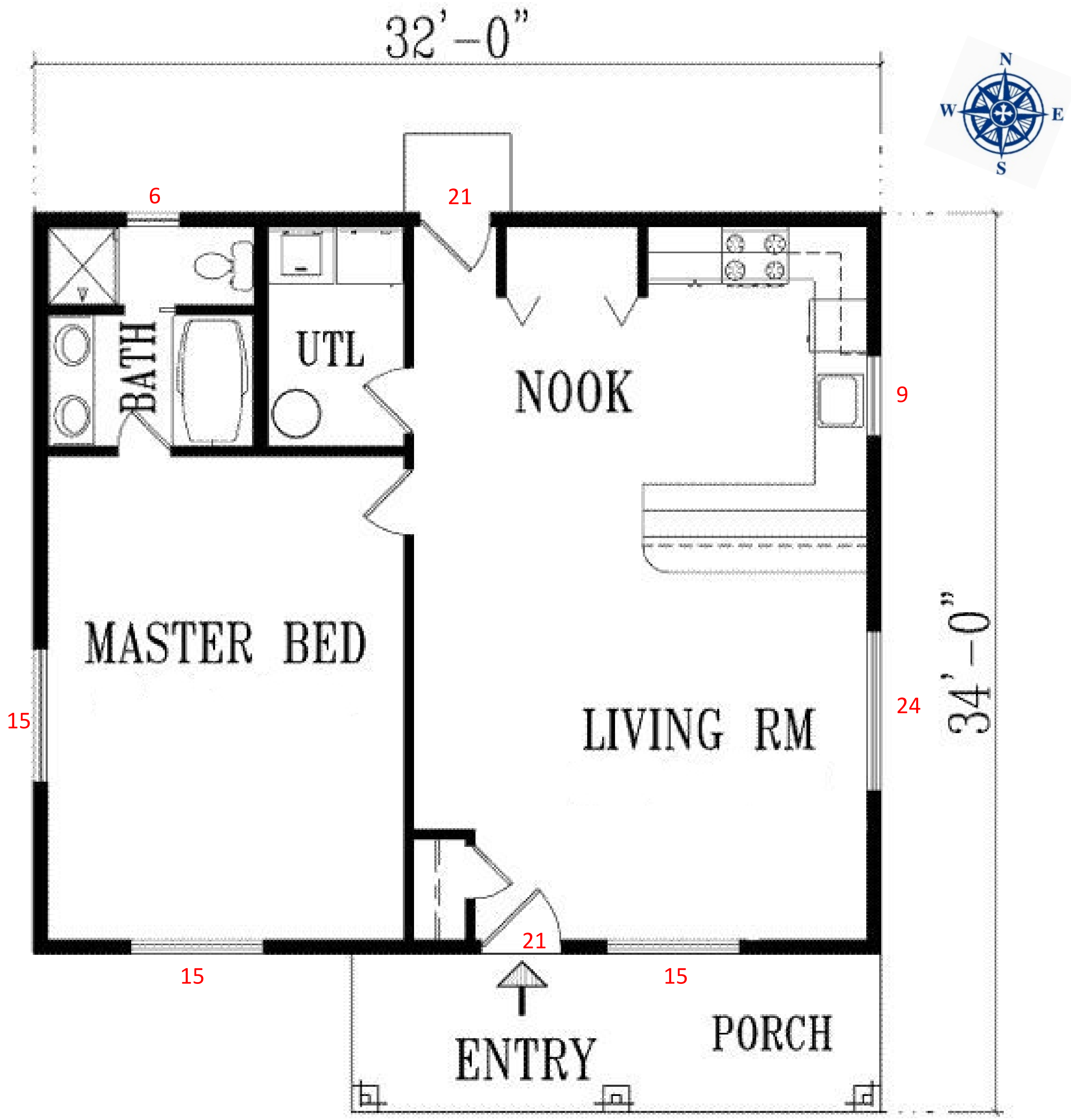
Total Heat (Enthalpy) = 125 Btu + 562 Btu + 702 Btu + 3783 BTU = 5,172 Btu

35 pts 2. For the tiny home plan shown the inside temperature is 72°F and the outside temperature is -15°F.

Specifications

Window Sizes				U-Factor
Bathroom	3 ft x 2 ft	Walls	R-19 (6” insulation)	0.053
Nook	3 ft x 3 ft	Ceilings	R-30 (10” insulation)	0.033
Living Room	6 ft x 4 ft and 5 ft x 3 ft	Windows	R-3.13	0.319
Master Bedroom	5 ft x 3 ft E	Doors	R-3.70	0.270
		Floor	SOG (2 in thick edge insulation, R=5)	

Door	21 ft^2 E
Ceiling Height	8 ft
Wood Porch	4 ft x 18 ft



Use 3-decimals for all U-factors. Round all calculations to whole numbers.

A. Determine the total heat loss due to transmission.

Gross Wall Area = 2 x 32 ft x 8 ft + 2 x 30 ft x 8 ft = 512 ft^2 + 480 ft^2 = 992 ft^2
Window Area = 6 ft^2 + 9 ft^2 + 24 ft^2 + 15 ft^2 + 15 ft^2 + 15 ft^2 = 84 ft^2
Door Area = 2 x 21 ft^2 = 42 ft^2

Net Wall Area = 992 ft^2 – 84 ft^2 – 42 ft^2 = 866 ft^2

$q_{transmission}$ = U x A x ΔT
q_{Walls} = 0.053 x 866 ft^2 x (72°F - -15°F) = 3993 BTUH
$q_{Windows}$ = 0.319 x 84 ft^2 x (72°F - -15°F) = 2331 BTUH
q_{Doors} = 0.270 x 42 ft^2 x (72°F - -15°F) = 987 BTUH
$q_{Ceiling}$ = 0.033 x (32 ft x 30 ft) x (72°F - -15°F) = 2756 BTUH
q_{Slab} = U_f x L = 45 x (2x32 ft + 2x30 ft) = 45 x 124 ft = 5580 BTUH

Total Heat Loss Due to Transmission = 15,647 BTUH

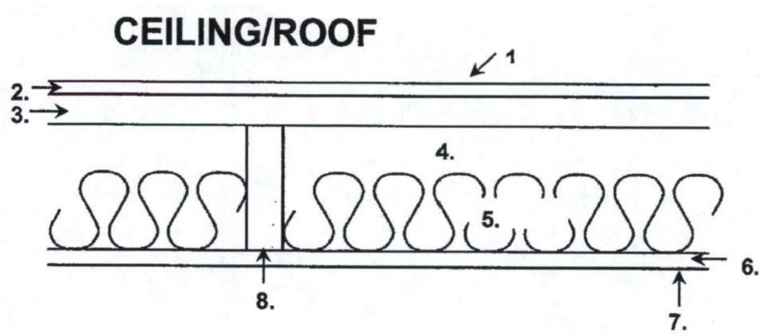
B. Determine the heat loss due to infiltration for an ACH = 1.2

$q_{infiltration}$ = 0.018 x V x ACH x ΔT
= 0.018 x (32 ft x 30 ft x 8 ft) x 1.2 x (72°F - -15°F)
= 0.018 x 7680 ft^3 x 1.2 x (72°F - -15°F)
= 14,432 BTUH

C. Determine the Total Heat Loss.

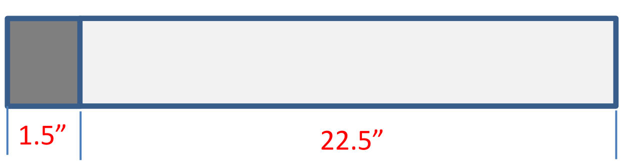
q_{total} = $q_{transmission}$ + $q_{infiltration}$ = 15,647 + 14,432 = 30,079 BTUH

25 pts 3. Calculate the total heat loss during a 24-hour period for a flat roof 55 ft X 70 ft. The roof is constructed per the detail below. The inside temperature is 70 °F and the outside temperature is 52 °F. Assume winter conditions. Use 2-decimals for R Values and 3-decimals for U-Factors. Round answer to a whole number.



		R (Between joist)	R (At joist)
1.	Air film outside	0.17	0.17
2.	3/8 in. Built-up roofing	0.33	0.33
3.	5/8 in. Plywood Sheathing	0.77	0.77
4.	1 ½ in. Air space	1.00	---
5.	R-13 Fiberglass Batt Insulation	13.00	---
6.	5/8 in. Gypsum board	0.56	0.56
7.	Air film inside	0.68	0.68
8.	Nominal 2-in x 12-in Doug Fir Joist @ 24 in. o.c. (1.5" x 11.25") R = 1.00	---	11.25
	R_{Total}	16.51	13.76

Determine the average U-Factor for the ceiling



R_{AVG} = (1.5"/24") x 13.76 + (22.5"/24") x 16.51 = 0.86 + 15.48 = 16.34

U_{AVG} = 1 / R_{AVG} = 1 / 16.34 = 0.061

Total Heat Loss

Q = U x A x ΔT x 24 hr = 0.061 x (55 ft x 70 ft) x (70°F - 52°F) x 24 = 101,455 BTU

Psychrometric Chart – See Chart on next page

10 pts 4. Given the ambient temperature is 70°F measured by a dry bulb thermometer and 60°F measured by a wet bulb thermometer, what is the relative humidity?

RH = 56%

Is this point an acceptable temperature and humidity for personal comfort all year for people in the USA?

No. Falls into the "Winter Comfort Zone" but not the "Summer Comfort Zone."

15 pts 5. A house is 4500 ft² and has 12 ft ceilings. For comfort, the homeowner specifies 0.3 changes of air per hour. The outside air temperature is 90°F dry bulb and 73.5° wet bulb. The air indoors is 75°F dry bulb 50% relative humidity. What is the amount of cooling required to provide the fresh air?

See page 6 - About the Psychrometric Chart (Power knot)

Volume = 4500 ft^2 x 12 ft = 54,000 ft^3
CFM = 54,000 ft^3 x 0.3 x hr / 60 min = 16,200 ft^3/hr x hr / 60 min = 270 CFM

From Psychrometric Chart
<u>Outdoor Air</u>
DB = 90°F
WB = 73.5 °F
Enthalpy = 37.2 BTU / lb DA
Specific Volume = 14.2 ft^3 / lb

<u>Indoor Air</u>
DB = 75°F
RH = 50%
Enthalpy = 28.4 BTU / lb DA
Specific Volume = 13.7 ft^3 / lb

Energy of Incoming Air = (16,200 ft^3 /hr x 37.2 BTU / lb DA) / 14.2 ft^3 / lb = 42,439 BTUH

Energy of Indoor Air = (16,200 ft^3 /hr x 28.4 BTU / lb DA) / 13.7 ft^3 / lb = 33,583 BTUH

Heat Difference = 42,439 BTUH - 33,583 BTUH = 8,856 BTUH

Cooling Needed = 8,856 BTUH / 12,000 BTU = 0.738 ton or about 0.75 ton (3/4-ton AC Unit)

Psychrometric chart at sea level (760 mm Hg)
US measurement units

power knot

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