**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.**

Solution

|  |
| --- |
| Name: |
| 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/ft3 = 3.9 lb



Sensible Heat 0°F to 32°F solid

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

A cloud of smoke

Description automatically generated with medium confidence

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

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

U-Factor

0.053

0.033

0.319

0.270

35 pts

Specifications

|  |  |
| --- | --- |
| Window Sizes  Bathroom 3 ft x 2 ft  Nook 3 ft x 3 ft  Living Room 6 ft x 4 ft and 5 ft x 3 ft  Master Bedroom 5 ft x 3 ft E  Door 21 ft2 E  Ceiling Height 8 ft  Wood Porch 4 ft x 18 ft | Walls R-19 (6” insulation)  Ceilings R-30 (10” insulation)  Windows R-3.13  Doors R-3.70  Floor SOG (2 in thick edge insulation, R=5) |

Logo, company name

Description automatically generatedDiagram, engineering drawing

Description automatically generated

15

15

21

15

24

9

21

6

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

1. 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 ft2 + 480 ft2 = 992 ft2

Window Area = 6 ft2 + 9 ft2 + 24 ft2 + 15 ft2 + 15 ft2 + 15 ft2 = 84 ft2

Door Area = 2 x 21 ft2 = 42 ft2

Net Wall Area = 992 ft2 – 84 ft2 – 42 ft2 = 866 ft2

**qtransmission = U x A x ∆T**

qWalls = 0.053 x 866 ft2 x (72°F - -15°F) = 3993 BTUH

qWindows = 0.319 x 84 ft2 x (72°F - -15°F) = 2331 BTUH

qDoors = 0.270 x 42 ft2 x (72°F - -15°F) = 987 BTUH

qCeiling = 0.033 x (32 ft x 30 ft) x (72°F - -15°F) = 2756 BTUH

qSlab = Uf x L = 45 x (2x32 ft + 2x30 ft) = 45 x 124 ft = 5580 BTUH

Total Heat Loss Due to Transmission = 15,647 BTUH

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

qinfiltration = 0.018 x V x ACH x ∆T

= 0.018 x (32 ft x 30 ft x 8 ft) x 1.2 x (72°F - -15°F)

= 0.018 x 7680 ft3 x 1.2 x (72°F - -15°F)

= 14,432 BTUH

1. Determine the Total Heat Loss.

qtotal = qtransmission + qinfiltration = 15,647 + 14,432 = 30,079 BTUH

1. 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.

25 pts

A picture containing diagram

Description automatically generated

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | 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 |
| RTotal | | 16.51 | 13.76 |

Determine the average U-Factor for the ceiling

22.5”

1.5”

RAVG = (1.5”/24”) x 13.76 + (22.5”/24”) x 16.51 = 0.86 + 15.48 = 16.34

UAVG = 1 / RAVG = 1 / 16.34 = 0.061

Total Heat Loss

Q = U x A x ∆T 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

1. 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

1. 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 ft2 x 12 ft = 54,000 ft3

CFM = 54,000 ft3 x 0.3 x hr / 60 min = 16,200 ft3/hr x hr / 60 min = 270 CFM

From Psychrometric Chart

Outdoor Air

DB = 90°F

WB = 73.5 °F

Enthalpy = 37.2 BTU / lb DA

Specific Volume = 14.2 ft3 / lb

Indoor Air

DB = 75°F

RH = 50%

Enthalpy = 28.4 BTU / lb DA

Specific Volume = 13.7 ft3 / lb

Energy of Incoming Air = (16,200 ft3 /hr x 37.2 BTU / lb DA) / 14.2 ft3 / lb = 42,439 BTUH

Energy of Indoor Air = (16,200 ft3 /hr x 28.4 BTU / lb DA) / 13.7 ft3 / 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)

Diagram

Description automatically generated