**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. Use your own paper.**

**Keep all answers in the same numerical order as the exam.**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Solution**

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| 15 pts  10 pts  15 pts  10 pts  10 pts  20 pts  10 pts  10 pts | 1. How much energy must be removed to turn a two-gallon jug filled with water from a faucet that is at 50°F into ice at -15°F?   One gallon of water weighs 8.34 lb  M = 2 x 8.34 lb = 16.68 lb    Sensible Heat -15°F to 32°F solid  Q = M x C x ∆T = 16.68 lb x 1 Btu/lb°F x (32°F - - 15°F) = 784 Btu    Latent Heat 32°F to Melted  Q = 144 Btu/lb x 16.68 lb = 2402 Btu    Sensible Heat Melted @32°F to 50°F  Q = M x C x ∆T = 16.68 lb x 1 Btu/lb°F x (50°F - 32°F) = 300 Btu  Total Heat (Enthalpy) = 784 Btu + 2404 Btu + 300 Btu = 3486 Btu   1. How much heat is required to heat a 1 ft3 block of aluminum from 50°F to 105°F?  |  |  |  | | --- | --- | --- | | Material | ρ (lb/ft3) | C Btu/lb °F | | AL | 169 | 0.215 | | Steel | 489 | 0.12 |   Aluminum (AL)  Q = M x C x ΔT  Q = 1 ft3 x 169 lb/ft3 x 0.215 x (105°F - 50°F)  Q = 1998 Btu  For the same amount of heat energy and temperature conditions what volume (ft3) of steel is required?  Steel  Q = M x C x ΔT  1998 Btu = M x 0.12 x (105°F - 50°F)  M = 1998 Btu / (0.12 x 55°F)  M = 303 lb  V = 303 lb / 489 lb/ft3 = 0.62 ft3   1. A 3000 ft2 building has an annual heating requirement of 30,000 Btu/ft2/yr. Compare the cost of heating by propane at $2.00/gallon in an 85% efficient furnace versus heating by an 100% efficient electric furnace at $0.06/kWh.   Propane  91,502 BTUs/gallon  Electricity  1kWh = 3412 Btu  Qtotal = 30,000 Btu/ft2/yr x 3000 ft2  Qtotal = 90,000,000 Btu/yr  Propane Cost  85% efficient furnace  At 85% efficiency, each gallon of propane will produce a net heating value of  0.85 x 91,502 Btu = 77,777 Btu  Cost = (90,000,000 Btu/yr / 77,777 Btu/gal) x $2.00 / gallon = 1,157 gal x $2.00/gal = $2,314/yr  Electricity Cost  100% efficient electric furnace  Cost = (90,000,000 Btu/yr x 1 kwh/3412 Btuh) x $0.06/kwh = 26,377.49 kwh/yr x $0.06/kwh = $1,583/yr   1. A wall is constructed as follows:   4ʺ face brick  1ʺ air space  Nominal 1ʺ foil-faced polyisocyanurate sheathing  2 x 4 wood studs 16ʺon center with R13 batt insulation  1/2ʺ drywall   1. If the wall is 80% insulated area, 20% framed area, what will be the U-factor of the wall?   Insulated Area   |  |  | | --- | --- | | Material | R-Value | | 4ʺ face brick | 0.44 | | 1ʺ air space | 1.00 | | 1ʺ foil-faced polyisocyanurate sheathing | 7.20 | | R13 batt insulation | 13.0 | | 1/2ʺ drywall | 0.45 | | Total R-Value | 22.09 | | U-Factor | 0.045 |   Framed Area   |  |  | | --- | --- | | Material | R-Value | | 4ʺ face brick | 0.44 | | 1ʺ air space | 1.00 | | 1ʺ foil-faced polyisocyanurate sheathing | 7.20 | | 2x4 wood stud | 4.38 | | 1/2ʺ drywall | 0.45 | | Total R-Value | 13.47 | | U-Factor | 0.074 |   U-Factor = 0.8 x 0.045 + 0.2 x 0.074 = 0.051   1. What is the heat load for a wall 8 ft high by 200 ft long if the outside temperature is 42°F and the inside temperature is 78°F using this construction?   Q = A x U x ΔT = (8 ft x 200 ft) x 0.051 x (78°F - 42°F)  Q = 2938 Btu   1. An LED lamp produces 800 lumens and uses 8W. An incandescent lamp produces 800 lumens and uses 60W. 2. Determine the BTUs per hour for each lamp.   LED Lamp  q = 8W x 3.41 BTU / Wh = 27.28 Btu/hr  Incandescent Lamp  q = 60W x 3.41 Btuh / Wh = 204.6 Btu/hr   1. If both lamps are on for 12 hours, determine the total amount of heat produced by each lamp.   Qtotal = (27.28 Btu/hr x 12 hr) + (204.6 Btu/hr x 12 hr) = 327.36 Btu + 2455.2 Btu = 2782.56 Btu   1. Complete the following: 2. What size (kw) electric heater is required to heat a space from 60°F DB to 80°F DB, assuming the electric heater has a 1000 CFM blower?   q = 1.1 x CFM x ΔT q = 1.08 x CFM x ΔT  q = 1.1 x 1000 CFM x (80°F - 60°F) q = 21,600 Btuh  q = 22,000 Btuh  P = 22,000 Btuh x 1 kW/3,412 Btuh P = 6.3 kw  P = 6.5 kw   1. If the initial RH is 60%, use a psychrometric chart to determine the final RH.   RH = 30%   1. What is the change in enthalpy (∆ enthalpy, Btu)?   ∆ enthalpy, Btu = 26.55 Btu/lb - 21.6 Btu/lb   1. Using the formula, Heat Load = 4.45 x CFM x (∆ enthalpy, Btu), calculate the heat load and compare your result to the solution in A.   Heat Load = 4.45 x 1000 CFM x (26.55 Btu/lb - 21.6 Btu/lb) = 22,000 Btu (same as A.)   1. Estimate infiltration and ventilation air quantities for a 2900 sq. ft. movie theater. The conditioned space has an average height of 20 feet, and the theater seats 200 people. The ACH = 8.0. The required ventilation per person is 20 CFM. Inside temperature is 72°F and the outside temperature is 48°F.   qinfil = C x ACH x V x ∆T where C is the heat capacity of air (use 0.018 Btu/ft3 x °F)  qinfil = (0.018 Btu/ft3 x °F) x 8.0 x (2900 ft2 x 20 ft) x (72°F - 48°F)  qinfil = (0.018 Btu/ft3 x °F) x 8.0 x (58,000 ft3) x (24°F)  qinfil = 200,448 Btuh  qventilation = 1.1 x Qairflow x ∆T qventilation = 1.08 x Qairflow x ∆T = 103,680 Btuh  qventilation = 1.1 x (200 x 20 CFM) x (72°F - 48°F)  qventilation = 1.1 x (4000 CFM) x (24°F)  qventilation = 105,600 Btuh   1. For a 3.5-ton 8ʺ air conditioner supply duct use the Residential Duct Sizing Chart (attached) to determine:   CFM = 3.5 ton x 400 CFM /ton = 1,400 CFM   1. The rectangular duct height size (inches) required   30ʺ x 8 ʺ   1. The equivalent round duct size (inches) required   16ʺ |

**Residential Duct Sizing Chart**

A screenshot of a cell phone

Description automatically generated