CMGT 235 – Electrical and Mechanical Systems

Department of Construction Management ֍ California State University, Chico

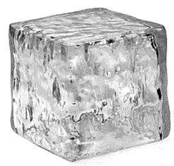
Exam #1 [100 points]

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**

15 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 ΔT = 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 ΔT = 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

10 pts 2. How much heat is required to heat a 1 ft^3 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)
$Q = M \times C \times \Delta T$
$= 1\ ft^3 \times 169\ lb/ft^3 \times 0.215 \times (105°F - 50°F)$
$= 1998$ Btu

For the same amount of heat energy and temperature conditions what volume (ft^3) of steel is required?
Steel
$Q = M \times C \times \Delta T$
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/ft^3 = 0.62 ft^3

15 pts 3. A 3000 ft^2 building has an annual heating requirement of 30,000 $Btu/ft^2/yr$. 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

Q_{total} = 30,000 $Btu/ft^2/yr$ x 3000 ft^2
= 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

10 pts 4. A wall is constructed as follows:

4" face brick
1" air space
Nominal 1" foil-faced polyisocyanurate sheathing
2 x 4 wood studs 16"on center with R13 batt insulation
1/2" drywall

A. If the wall is 80% insulated area, 20% framed area, what will be the U-factor of the wall?

Insulated Area

Material	R-Value
4" face brick	0.44
1" air space	1.00
1" foil-faced polyisocyanurate sheathing	7.20
R13 batt insulation	13.0
1/2" drywall	0.45
Total R-Value	22.09
U-Factor	0.045

Framed Area

Material	R-Value
4" face brick	0.44
1" air space	1.00
1" foil-faced polyisocyanurate sheathing	7.20
2x4 wood stud	4.38
1/2" 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

B. 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)
= 2938 Btu

10 pts 5. An LED lamp produces 800 lumens and uses 8W. An incandescent lamp produces 800 lumens and uses 60W.

A. 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

B. If both lamps are on for 12 hours, determine the total amount of heat produced by each lamp.

Q_{total} = (27.28 Btu/hr x 12 hr) + (204.6 Btu/hr x 12 hr) = 327.36 Btu + 2455.2 Btu = 2782.56 Btu

20 pts 6. Complete the following:

A. 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?

$q = 1.1 \times CFM \times \Delta T$
$= 1.1 \times 1000 \text{ CFM} \times (80°F - 60°F)$
$= 22{,}000$ Btuh

$q = 1.08 \times CFM \times \Delta T$
$q = 21{,}600$ Btuh

P = 22,000 Btuh x 1 kW/3,412 Btuh
= 6.5 kw

P = 6.3 kw

B. If the initial RH is 60%, use a psychrometric chart to determine the final RH.

RH = 30%

C. What is the change in enthalpy (Δ enthalpy, Btu)?

Δ enthalpy, Btu = 26.55 Btu/lb - 21.6 Btu/lb

D. Using the formula, Heat Load = 4.45 x CFM x (Δ 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.)

10 pts 7. 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.

$q_{infil} = C \times ACH \times V \times \Delta T$ where C is the heat capacity of air (use 0.018 Btu/ft^3 x °F)
$= (0.018 \text{ Btu/ft}^3 \times °F) \times 8.0 \times (2900 \text{ ft}^2 \times 20 \text{ ft}) \times (72°F - 48°F)$
$= (0.018 \text{ Btu/ft}^3 \times °F) \times 8.0 \times (58{,}000 \text{ ft}^3) \times (24°F)$
$= 200{,}448$ Btuh

$q_{ventilation} = 1.1 \times Q_{airflow} \times \Delta T$
$= 1.1 \times (200 \times 20 \text{ CFM}) \times (72°F - 48°F)$
$= 1.1 \times (4000 \text{ CFM}) \times (24°F)$
$= 105{,}600$ Btuh

$q_{ventilation} = 1.08 \times Q_{airflow} \times \Delta T = 103{,}680$ Btuh

10 pts 8. For a 3.5-ton 8" air conditioner supply duct use the Residential Duct Sizing Chart (attached) to determine:

CFM = 3.5 ton x 400 CFM /ton = 1,400 CFM

A. The rectangular duct height size (inches) required

30" x 8 "

B. The equivalent round duct size (inches) required

16"

Residential Duct Sizing Chart

Air Volume	Rectangular Duct Height (inches)					Equivalent Round	Air Volume
CFM	4"	6"	8"	10"	12"	Duct (inches)	CFM
50	6 x 4					5	50
75	6 x 4					6	75
100	8 x 4	6 x 6				6	100
125	10 x 4	6 x 6				7	125
150	10 x 4	8 x 6				7	150
175	12 x 4	8 x 6				8	175
200	14 x 4	8 x 6				8	200
225	16 x 4	10 x 6				8	225
250	16 x 4	10 x 6				9	250
275		12 x 6	8 x 8			9	275
300		12 x 6	8 x 8			9	300
400		14 x 6	10 x 8			10	400
500		18 x 6	12 x 8	10 x 10		11	500
600		20 x 6	14 x 8	12 x 10		12	600
700		24 x 6	16 x 8	12 x 10		12	700
800		26 x 6	18 x 8	14 x 10	12 x 12	13	800
900		30 x 6	20 x 8	16 x 10	12 x 12	14	900
1000			22 x 8	16 x 10	14 x 12	14	1000
1100			24 x 8	18 x 10	16 x 12	15	1100
1200			26 x 8	20 x 10	16 x 12	15	1200
1300			28 x 8	20 x 10	18 x 12	16	1300
1400			30 x 8	22 x 10	18 x 12	16	1400
1500				24 x 10	20 x 12	16	1500
1600				24 x 10	20 x 12	17	1600
1700				26 x 10	22 x 12	17	1700
1800				28 x 10	22 x 12	18	1800
1900				30 x 10	22 x 12	18	1900
2000					24 x 10	18	2000