CMGT 235 Electrical and Mechanical Systems
Exam #3 – Electrical Systems

Use the 2017 NEC. SHOW ALL WORK FOR FULL CREDIT

Name: Solution

[20 pts] 1. Open socket fixtures are specified for a hotel project being built in Oahu, HI. The lighting designer selected a decorative bulb that is a Vintage Edison style. The project is planning to have 820 rooms with two lights in each room. Each light is on 16 hours each day. The cost for electricity on Oahu is $0.26/kWh. Show all calculations. Round to whole numbers.

Two choices for light bulbs have been selected:
https://www.lowes.com/pd/Globe-Electric-Vintage-Edison-60-Watt-Dimmable-S-Vintage-Decorative-Incandescent-Light-Bulb-3-Pack/1001389656

https://www.lowes.com/pd/GE-Vintage-60-Watt-EQ-ST19-Warm-Candle-Light-Dimmable-Edison-Bulb-Light-Bulb-2-Pack/1000442601

A. Complete the table:

Light Bulb (Lamp)	Bulb Wattage	Color Temperature (Kelvin)	Rate Life (Hours)	Lumens	Light Bulb Base Type	Bulb Shape Code
1. Globe Electric Vintage Edison 60-Watt Dimmable S Vintage Decorative Incandescent Light Bulb	60	2700	3000	245	E-26	S
2. GE Vintage 60-Watt EQ ST19 Warm Candle Light Dimmable Edison Bulb Light Bulb	6	2200	10000	560	E-26	ST19

B. Calculate the following for each lamp:

Lamp 1. Globe Electric Vintage Edison 60-Watt Dimmable S Vintage Decorative Incandescent Light Bulb

Supplier Cost: $12.30 (3-pack)

Total Initial Cost for the lamps (assuming 15% breakage)

Cost = 820 x 2 x 1.15 x $12.30/3 = $7733

Total number of lamps that will be needed for one year of use (assuming no breakage)

Bulb life = 3000 hr / 16 hr/day = 187.5 days Will need to buy bulbs twice

Total = 1640 x 2 = 3280 bulbs

Total Power Annually

Power = 60 W x 2 x 16 hr/day x 365 day/yr = 700,800 kWh

Total Energy Cost Annually

Energy Cost = 700,800 kWh x $0.26/kWh = $182,208

Lamp 2. GE Vintage 60-Watt EQ ST19 Warm Candle Light Dimmable Edison Bulb Light Bulb

Supplier Cost: $18.00 (2-pack)

Total Initial Cost for the lamps (assuming 15% breakage)

Cost = 820 x 2 x 1.15 x $18.00/2 = $16,997

Total number of lamps that will be needed for one year of use (assuming no breakage)

Bulb life = 10000 hr / 16 hr/day = 625 days Will need to buy bulbs once

Total = 1640 bulbs

Total Power Annually

Power = 6 W x 2 x 16 hr/day x 365 day/yr = 70,080 kWh

Total Energy Cost Annually

Energy Cost = 70,080 kWh x $0.26/kWh = $18,220.80

C. The project owner isn't very bright and wants to use the cheaper bulbs to save money. What do you tell him?

Power is 90% savings and the bulbs last 3 times longer.

[18 pts]

2. A 50-story commercial mixed-use building project is in the site mobilization phase. The CE 7050 D manlift has been selected for the job and you are tasked with designing the feeder for it. The height between each concrete deck is 12 feet.

CE 7050 D Electrical Per Car

Voltage (V)	Phase	Freq. (HZ)	AMPS (up to 500 Ft)	AMPS (501 ft – 1080 ft)
480	3Ø	60	150A	220A

A. What is the maximum current required for operating two cars?

440A

B. What size THWN 75°C CU conductor is required by code for operating one car and where in the NEC do you find the answer?
Table 310.15(B)(16)

4/0

C. What size THWN 75°C CU conductor is required by code for operating two cars?

700 KCMIL

D. What would the the maximum allowable voltage drop (VD_{Line}) due to the feeder wire be if the NEC code recommendation is followed?

VD_{Line} = 480 V x 3% = 14.4 V

E. Using the formulas provided for three phase voltage drop calculate the maximum length of the conductor for a feeder for operating two cars.

L = 14.4V x 1000 / 1.732 x 0.0184 x 440A = 1027 ft

F. What size PVC Sched 80 conduit is required for the conductors for operating two cars? Assume the ground conductor is the same wire size as the three phase conductors. Where in the NEC do you find the answer?
ANNEX C

4"

[8 pts]

3. Determine the minimum conduit size required by the NEC for the following conductors:

A. What is the smallest trade size EMT conduit required to enclose two No. 6, two No. 8, and four No. 10 THWN copper conductors in a conduit over 24 inches long?

QTY	GAUGE	TYPE	Cross-Section Area	
2	6	THWN	2 x 0.0507 = 0.1014	
2	8	THWN	2 x 0.0366 = 0.0732	
4	10	THWN	4 x 0.0211 = 0.0844	EMT
			Total Cross-Section Area 0.259	1"

B. What size RMC nipple does the NEC require to enclose 30 No. 10 THWN copper conductors that are installed between a panelboard and junction box?

1½"

C. What is the smallest trade size PVC Schedule 80 conduit required to enclose three No. 4 and one No. 6 THHN copper conductors in a conduit over 24 inches long?

QTY	GAUGE	TYPE	Cross-Section Area	
3	4	THHN	3 x 0.0824 = 0.2472	
1	6	THHN	1 x 0.0507 = 0.0507	PVC SCHED 80
			Total Cross-Section Area 0.2979	1¼"

[4 pts]

4. What is the maximum allowable trade size for the following conduit?

Electrical Metallic Tubing 4"

Rigid Metal Conduit 6"

[6 pts]

5. A disconnecting means shall be provided and be accessible, located within sight from all pools, spas, and hot tub equipment, and shall be located at least how many feet from the inside walls of the pool, spa, or hot tub?

5 ft

What size 2-pole circuit breaker would be required for an 8-kW hot tub connected to 240 V?

I = P / E = 8000 W / 240 V = 33.3 A 35A CB Required

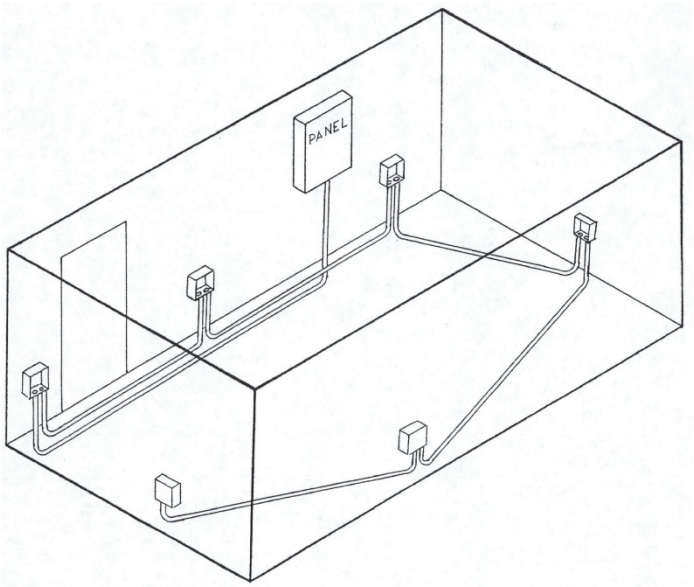
[12 pts] 6. The exercise room shown on the plan on the next page will require the material listed in the table for the electrical installation. The isometric drawing (not to scale) illustrates the horizontal and vertical installation of the conduit. Round all material quantities to a whole number. For Labor units use two decimals.

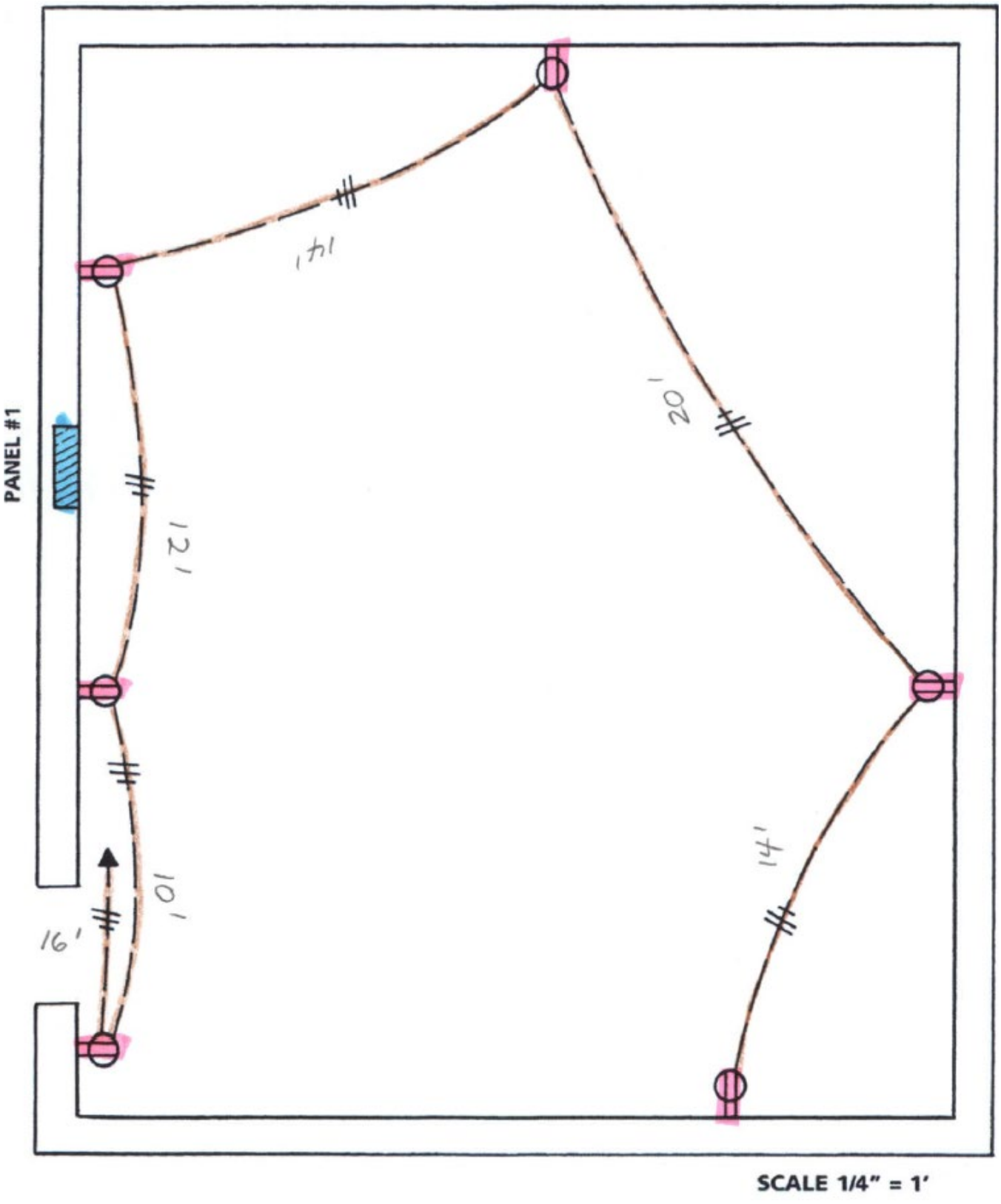
Construction	Raceway
Framed walls, plaster finish	Installed below slab floor, stubbed up into wall space
5" SOG floor	3/4" GRS (also called GRC or RMC)
Receptacles mounted 18" AFF	1 Coupling (CPLG) comes with every 10 FT piece of GRS
Panel mounted 30" AFF	Stub Ups (vertical length)
	3/4" GRS Field Bends

Procedure

1. Measure and color the horizontal length of each conduit and write the length on the plan next to the conduit.
2. Add 2 ft for each vertical conduit to a receptacle box and 3 ft of vertical conduit at the panel to get the total length of conduit. Record the quantity in the table.
3. Multiple the total length of conduit by 3 (each conduit has three conductors) and allow an additional 12 inches per conductor at each box and 24 inches per conductor at the panel to get the total length of wire (#12 THHN). Record the quantity in the table.
4. Complete the takeoff by counting and coloring the remaining items. Allow 2 locknuts and 1 plastic bushing per connector. Note: 1 Coupling (CPLG) comes with every 10 FT piece of GRS
5. Using the NECA Manual of Labor Unit look up each items labor unit and record it in the table. Extend the labor and place the total in the box.

Material	QTY	Labor Unit	Per	Extended Labor
3/4" GRS	110	6.00	C	6.60
3/4" GRS CPLG	---	---	---	---
3/4" GRS CONNECTOR	---	---	---	---
3/4" LOCKNUT	24	0.12	E	2.88
3/4" PLASTIC BUSHING	12	0.12	E	1.44
4" SQUARE BOX 3/4" KO	6	30.00	C	1.80
4" SQ P RING 3/4" Rise	6	15.00	C	0.90
1-HOLE STRAP	12	4.00	C	0.48
ANCHOR	12	22.00	C	2.64
#12 THHN	369	6.00	M	2.21
DPLX RECEP	6	30.00	C	1.80
DPLX RECEP PLATE	6	10.00	C	0.60
100A 24 CKCT PANEL FLUSH	1	2.40	E	2.40
20A SP CB	1	0.34	E	0.34
Total				24.09





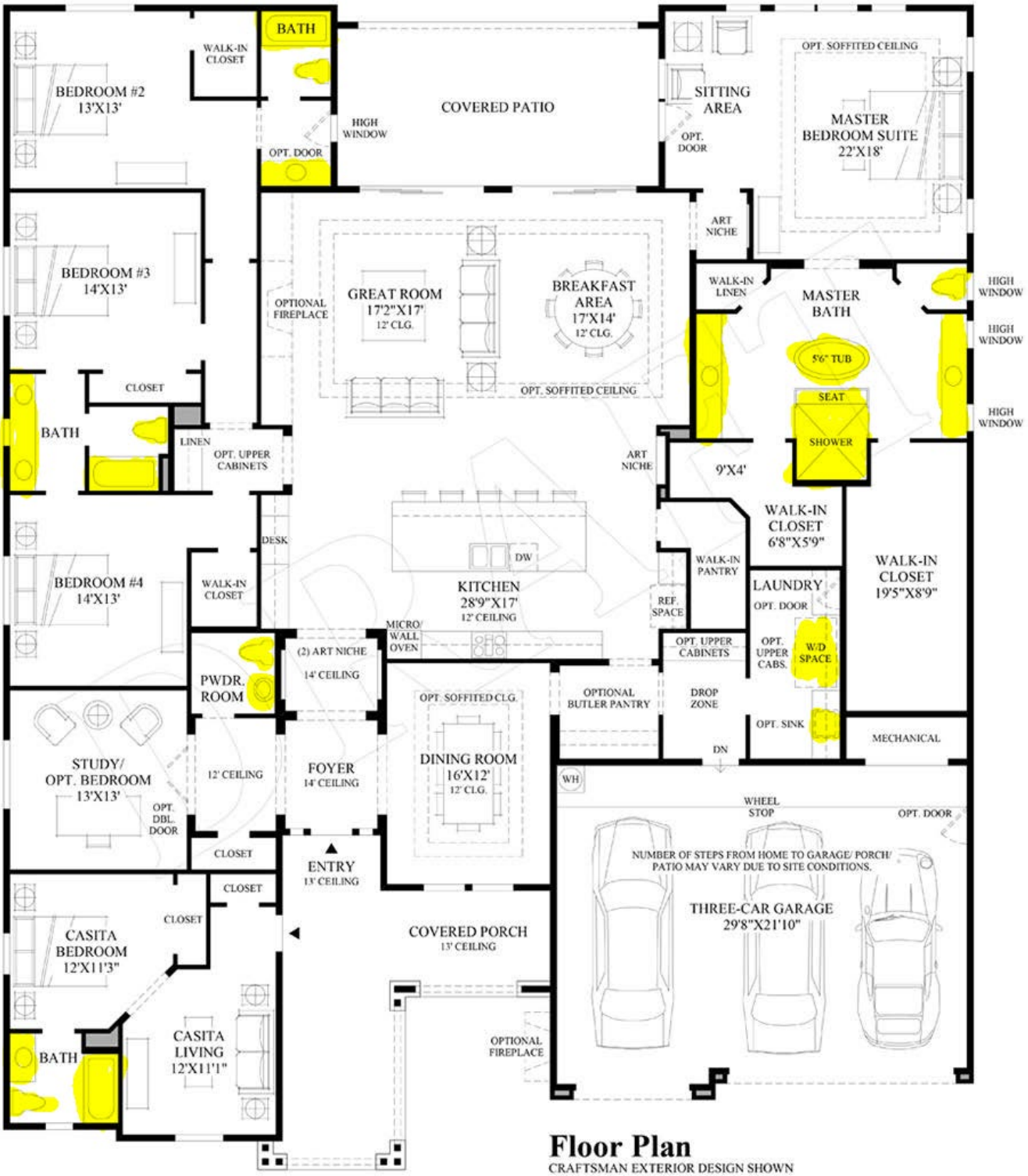
Horizontal = 86 ft

Vertical = 25 ft

Total = 110 ft

[12 pts] 7. Determine the Meter and Street Service size and the Building Supply size for the Dwelling shown. MDSSPA = 80 psi. The highest water outlet in the building is 15 feet above the source of supply. Pressure loss due to the meter is 5 psi. The water softener has a pressure loss of 18 psi. The maximum developed length of the piping between the source of supply and the furthest fixture is 120 feet. There are six ½" hose bibbs. The owner selected all the options as shown on the plan. Use 2016 California Plumbing Code.

A. Highlight all the plumbing fixtures yellow.



B. Complete the following steps.

Step 1. Calculate the Available Water Pressure

Pressure = 80 psi – (15 ft x 0.433 psi/ft) – 5 psi – 18 psi = 51 psi

Step 2. Find the Effective Maximum Developed Length (DL) of Pipe

DL = 120 ft x 1.5 = 180 ft

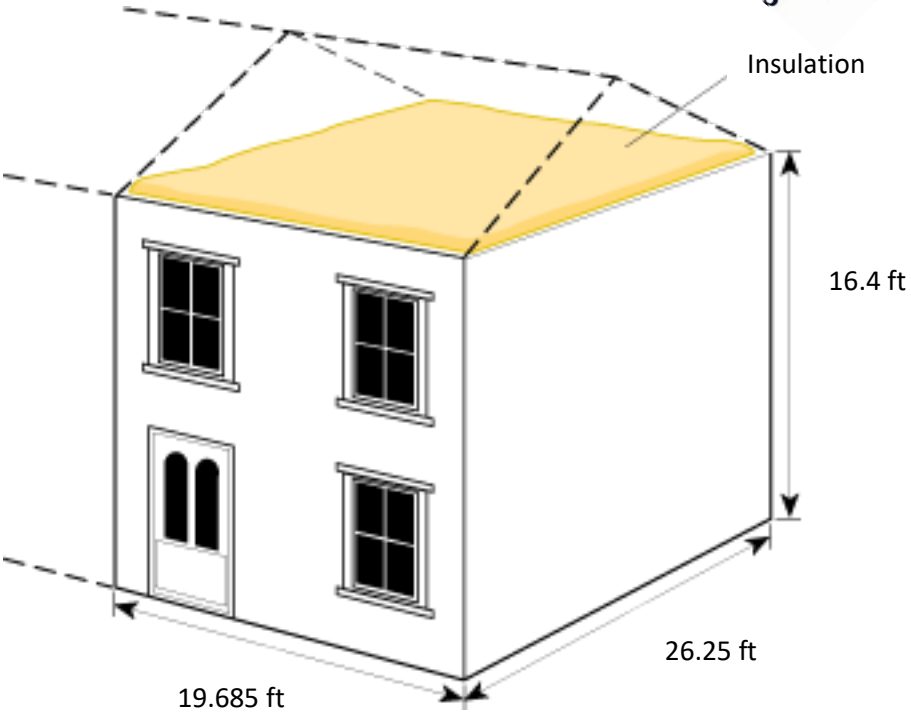
Step 3. Calculate the total WSFU

QTY	FIXTURE	WSFU	TOTAL WSFU
5	WC	2.5	12.5
7	LAV	1.0	7.0
3	BT/SHO	4.0	12.0
1	BT	4.0	4.0
1	SHO	2.0	2.0
1	KS	1.5	1.5
1	DW	1.5	1.5
1	CW	4.0	4.0
1	LT	1.5	1.5
6	1/2" HB	2.5 + 1.0	7.5
TOTAL WSFU			53.5

Step 4. Use the 2016 CPC Table 610.4 complete the table below for your results:

Pressure Range	46 – 60 PSI
Maximum Allowable Length	200 FT
Distribution Piping	**Pipe Size (inches)**
Meter and Street Service	1"
Building Supply	1½ "

[10 pts] 8. The inside temperature is 68 °F and the outside temperature is 20 °F.
Wall U-factor = 0.078
Window U-factor = 0.3
Door U-factor = 0.15
Window size = 24 in. X 48 in.
Door size = 36 in. X 80 in.



A. Determine the heat loss in the south wall.

Gross Wall Area = 19.685 ft x 16.4 ft = 322.8 ft2
Window Area = 3 x (2ft x 4ft) = 24 ft2
Door Area = 3 ft x 6.7 ft = 20 ft2

Net Wall Area = 323 – 44 = 279 ft2

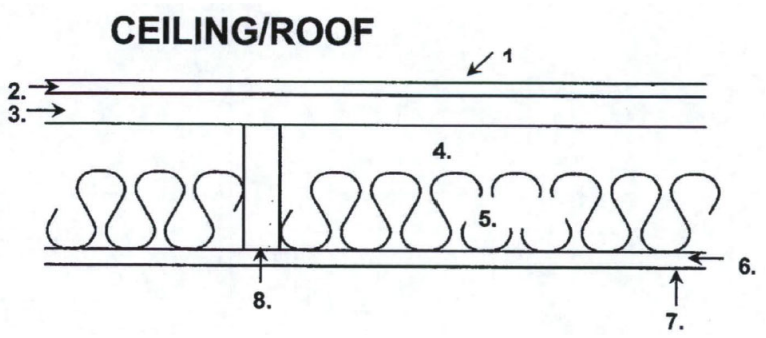
Area	U (Btu/hr x °F x ft^2)	A (ft^2)	ΔT (°F)	q = U x A x ΔT
Wall (Net)	0.078	279	48°F	1044.58
Windows	0.3	24	48°F	345.6
Door	0.15	20	48°F	144
			Total	1534 Btuh

B. Determine the transmission loss in the East wall.

q = U x A x ΔT
q = 0.078 Btu/hr x °F x ft^2 x (26.25 ft x 16.4 ft) x (68°F - 20°F)
q = 1612 Btuh

[10 pts] 9. Calculate the total heat loss during a 24-hour period for a flat roof 60 ft X 90 ft. The roof is constructed per the detail below. The inside temperature is 72°F and the outside temperature is 48°F. Assume winter conditions.

		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.	---	14.06	1-½" x 11-¼"
	R_{Total}	16.51	16.57	
	R_{Total} (96:4 ratio (between joist:at joist)	15.52		



$Q = U \times A \times \Delta T \times t$

$Q = [0.064 \text{ Btu/hr} \times °F \times ft^2] \times (60 \text{ ft} \times 90 \text{ ft}) \times (72°F - 48°F) \times 24 \text{ hr / day} = 199{,}066 \text{ Btu / day}$