

Electrical Systems

Electrical Plans

- Essential to ensure
 - Proper wiring
- National Electrical Code (NES)

Electrical Plans

- Consider electrical needs
 - Office equipment
 - Lighting
 - Entertainment systems
 - Communication systems
 - Security systems
 - Future needs

Outlets

- Placement determined by
 - Code requirements
 - Furniture arrangements
 - Personal preference



Outlets

- Code states
 - Placed no more than 12' apart
 - Minimum 3 per room



Outlets

- Ground Fault Circuit Interrupter (GFCI)
 - Turns off when current leaving outlet is not equal to the current returning

Outlets

- GFCI should be used
 - Kitchen
 - Bathroom
 - Garage
 - Outdoors
 - Unfinished areas & crawlspace

Outlets

- Do not place outlets back to back in same wall
- Weatherproof outlets should be used outside
 - 1 per side



Electrical systems



- Components
 - Conductors – wiring
 - Breakers
 - Service electrical panel
 - Outlets
 - Lights

Electrical systems

- Electrical circuit consists of all wiring controlled by one circuit breaker
- Circuit breaker is used as a protective device for the circuit



Emergency systems

- Properly size system to run necessary equipment
- What needs to run?
- What type of generator?
- Connection to generator
 - Outdoor connection
 - Double throw disconnect switch

Lighting plan

- Types of lighting
 - General
 - Task
 - Accent
 - Natural

Table 15-2. Recommended lighting levels for various tasks.

See Table 15-3 to get a perspective on illumination levels.

Task	Illumination level (foot-candle)*
General lighting	2-10
Dining	10-20
Kitchen general	20-50
Detailed work	50-100
Laundry	20-50
Normal reading	20-50
Prolonged reading or studying	50-100

* 1 foot-candle = 1 lumen per square foot

Lighting plan

- General -Overall illumination
 - Chandeliers
 - Ceiling
 - Wall mounted
 - Recessed
 - Track



Lighting plan

- Task – illumination for specific activities
- Provide glare free & shadowless light
 - Track
 - Recessed
 - Pendant
 - Portable lamps



Lighting plan

- Accent – spotlights items
- Adds drama to room
 - Track
 - Recessed
 - Wall mounted



Lighting plan

- Natural lighting
 - Windows
 - Skylight



Lighting plan



- Factors for determining lighting
 - Size of room
 - Mood to create
 - Type of activities to occur

Lighting plan

- Lighting performance characteristics
 - Power use
 - Total light emitted
 - Efficiency
 - Color rendering index
 - Lifespan

Lighting plan

- Power use
 - Amount of electricity a bulb uses
 - Measured in watts
-

Lighting plan

- Total light emitted
 - Amount of light produced
 - Measure in lumens
-

Lighting plan

- Efficiency
 - Total light emitted divided by power use
 - Lumens/watts
-

Lighting plan

- Color rendering index
 - CRI
 - Effect light source has on perceived colors
 - High CRI = all colors look natural
 - Low CRI = color may not be noticeable
-

Lighting plan

- Lifespan
 - Expected life of light source
 - Measured in hours
-

Lighting options

- Incandescent
- Fluorescent



Lighting options

□ Incandescent

- Light needed for short periods of time
- Operates well in all environment
- Turn on & off frequently
- Low cost
- Good CRI
- Light efficiency low
- Short life span



Lighting options

□ Fluorescent

- Should not be turned on & off frequently
- Turns on slower
- More expensive
- Better efficiency
- Less power used
- Less CRI
- Long lifespan



Table 15-4. Characteristics of lights.

Total amount of light emitted is equal to the average lumens. Efficiency (lumens per watt) is based on converting electricity into light.

Lamp	Rated size (watts)	Power use (watt)*	Total light emitted(lumens)	Efficiency (lumens/watt)*	CRI	Lifespan (hours)
Incandescent						
Standard	40	40	450	10	100	1,500
	60	60	780	13	100	1,000
	100	100	1,580	16	100	750
	150	150	2,500	17	100	750
	300	300	5,860	20	100	750
Fluorescent						
Compact						
Spiral, T3	26	26	1,700	65	82	8,000
Spiral, T4	42	42	2,650	63	82	10,000
Blak, T4	29	29	1,200	60	82	12,000
	28	28	1,750	63	82	12,000
Tube (T8) (cool white or warm white)						
24-inch	17	19	1,325	70	75	20,000
48-inch	32	35	2,800	80	82	20,000
	44	50	4,000	80	86	18,000
60-inch	55	61	5,050	83	86	18,000
96-inch	51	56	4,000	71	75	7,500
	86	95	8,200	86	86	24,000

Cost comparison

- What would be the cost difference if you replaced a 60-watt incandescent bulb with a spiral T3 26-watt fluorescent bulb? Assume that the cost for electricity is \$0.10/kW-hr. Assume initial cost of the bulbs are \$1.50 for the incandescent and \$6.00 for the fluorescent.

Cost comparison

- 60 watt bulb lasts 1,000 hours
- T3 bulb lasts 8,000 hours
- Show savings, must use longest length of time

Cost comparison

- Calculate cost for electricity over 8,000 hours
- Incandescent
 - $60 \text{ watt} * 8,000 \text{ hr} * \$0.10/\text{kW-hr}$
 - = \$48.00
- Fluorescent
 - $26 \text{ watt} * 8,000 \text{ hr} * \$0.10/\text{kW-hr}$
 - = \$20.80

Cost comparison

- Cost for bulbs over 8,000 hours
- Incandescent
 - 1,000 hrs/bulb means 8 bulbs used
 - 8 bulbs* \$1.50/bulb = \$12.00
- Fluorescent = \$6.00

Cost comparison

- Total cost
- Incandescent
 - \$48.00 + \$12.00 = \$60.00
- Fluorescent
 - \$20.80 + \$6.00 = \$26.80

- Cost difference = \$33.20

Lighting options



- Switches
 - Located 48" above floor
 - 30" - 40" for wheel chair
 - Most single pole
 - 3 way used for specific locations
 - Switch on outlets used for lamps

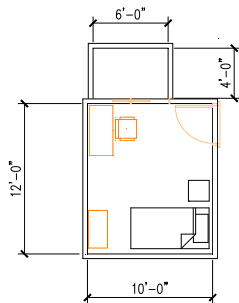
Lighting options

- Switches
 - Do not place them
 - Behind doors
 - Hard to reach locations
 - Near bathtub or shower



Example

- What type and how much lighting is needed in a 10' by 12' bedroom with a desk.



Example

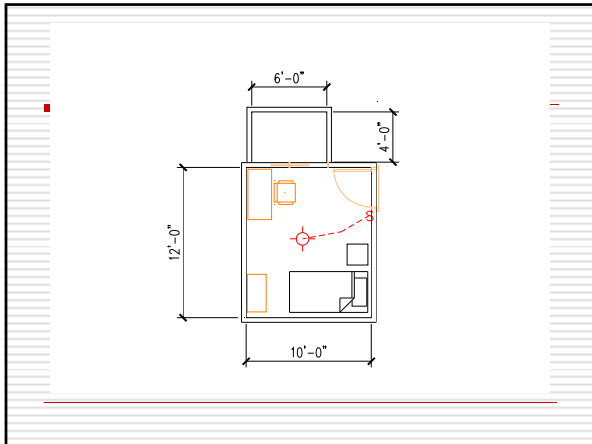
- What type of lighting is needed?
- Table 15-2
 - Normal reading for room
 - 20-50 lumens/ft²
 - General lighting for closet
 - 2-10 lumens/ft²
 - Prolonged studying for desk
 - 50-100 lumens/ft²

Example

- Room lighting
- Area = 10' * 12' = 120 ft²
- Minimum
 - 20 lumens/ft² * 120 ft² = 2400 lumens
- Maximum
 - 50 lumens/ft² * 120 ft² = 6000 lumens
- Should use high CRI

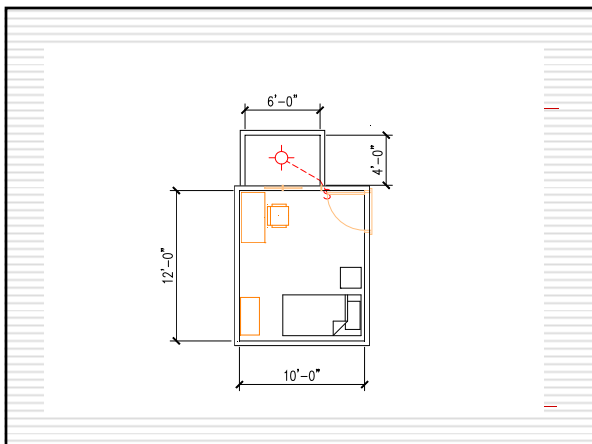
Example

- Room lighting
- Use 2 fluorescent spiral T3 since this light will stay on for long periods of time
- Placed in center of room on ceiling
- Single pole switch used for light fixture



Example

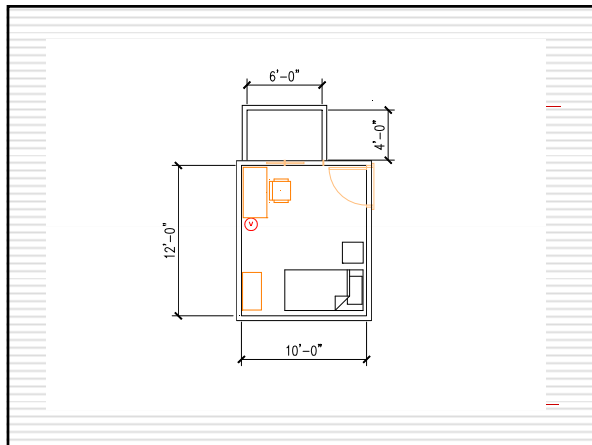
- Closet lighting
 - Area
 - $6' \times 4' = 24 \text{ ft}^2$
 - $10 \text{ lumens/ft}^2 \times 24 \text{ ft}^2 = 240 \text{ lumens}$
 - Light will be turned on & off frequently
 - 60 watt bulb on ceiling with glazed shielding
 - Single pole switch

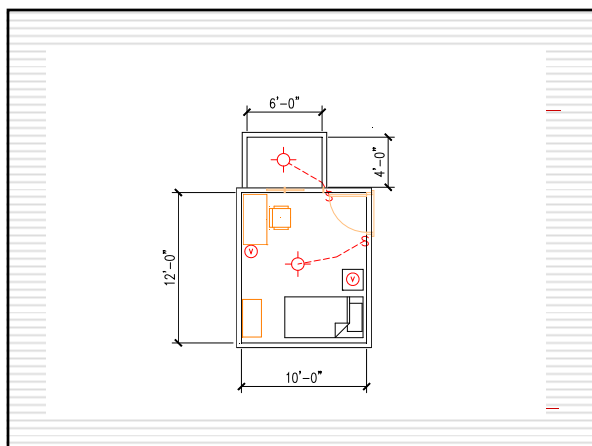


Example

□ Desk

- $2.5' * 4' = 10 \text{ ft}^2$
- Minimum
 - $50 \text{ lumens/ft}^2 * 10 \text{ ft}^2 = 500 \text{ lumens}$
- Maximum
 - $100 \text{ lumens/ft}^2 * 10 \text{ ft}^2 = 1000 \text{ lumens}$
- Lamp or light under shelf would work for spotlighting desk area
- Lamp w/ 100 watt bulb or spiral T3 fluorescent





Kitchen Electrical Needs



Kitchen electrical needs

- Need more outlets
- Within 24" of appliance
- No more than 10 outlets per circuit
- Outlets above counter backsplash
- All GFCI outlets
- Required 2 – 20 amp circuits

Kitchen electrical needs

- 1 GFCI within 24" of outside edge of sink
- In each wall longer than 12"
- No point along counter top is more than 24" from a receptacle
- No higher than 20" above counter
- Any counter 12" wide & 24" long should have an outlet

Bathroom

- All outlets GFCI
- 20 amp circuit
- General & task lighting required
- Pole switch at door entrance

Bathroom

- Lighting in shower or tub must be suitable for wet conditions
- No hanging fixtures around tub
 - 3 ft horizontally
 - 8 ft vertically from top of the bath tub rim

Bedrooms

- Can use 15 or 20 amp circuits
- No point along wall is over 6 ft from outlet
- Any 2 ft long of unbroken wall along floor line by doorway or opening requires a receptacle
- 12" – 18" from floor

Bedrooms

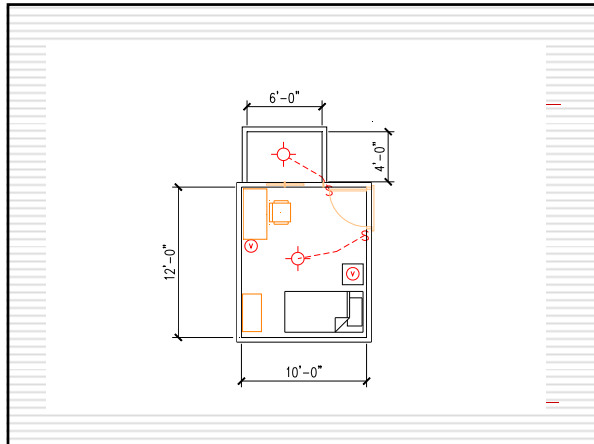
- At least 2 receptacles not covered by furniture
- Outlet behind bed must be protected from bed touching it
- Child safety protection covering for outlets

Office

- Lighting
 - Ambient – overhead fixtures
 - Task – desktop lamp
 - General – ceiling lighting
- No glare on computer screen
- No heavy shadows
- Task lighting on document areas

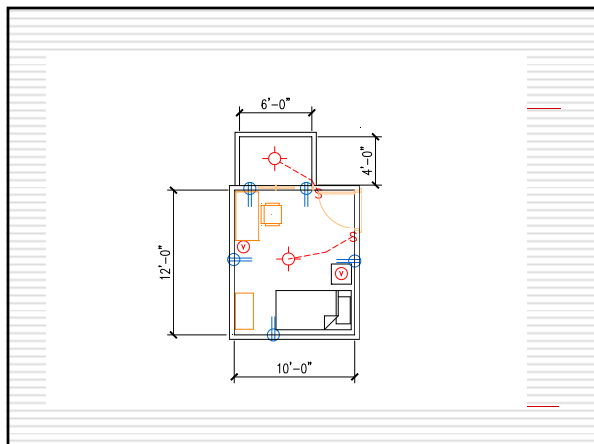
Example

- Place receptacles in the appropriate places in the bedroom used in the preceding example



Example

- Receptacle every 12' = 1 per wall
- None needed in closet
- 1 placed near desk
- Extra outlet on wall near closet
- At least 2 outlets easily assessable

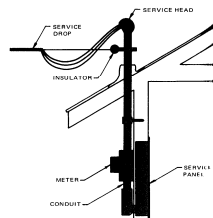


Electrical Service

- Service to house usually 240 V – 200 A
 - Minimum 220 V – 100 A
- Underground
- Overhead

Service drop

- Must be at least 10 ft above ground
- 12 ft above driveway
- No conductor closer than 3 ft from window, door or porch



Drawing is courtesy of Architecture Residential Drawing and Design

Electrical Service

- Size of wiring
 - Size of service entrance
 - Amount of amperage supplied
- #12 wire recommended for branch lighting circuits
- #14 minimum permitted by NEC

SERVICE ENTRANCE CONDUCTOR SIZES (WHEN DEMAND FACTOR IS 80 PERCENT OR LESS)				
Number of Wires	Open Air Installation		Installed in Conduit	
	Size	Amperage	Size	Amperage
3	4	70	4	110
3	2	100	2	140
3	1/0	150	1/0	200
3	2/0	175	2/0	225
3	3/0	200	3/0	260

These sizes are for copper wire. If aluminum wire is used, at least one size larger will be required to handle the amperage indicated.

Table is courtesy of Architecture Residential Drawing and Design

Electrical Panel

- Needs to be within 15-20 ft of where electricity enters house.
- Main disconnect to house

Electrical Panel

- NEC recommends 100 amp minimum service
- Most houses have between 150 & 200 amp service
- Breakers come in various sizes
 - Most common 50 & under
 - 15
 - 20
 - 30
 - 40
 - 50
 - 60
 - 70
 - 100
 - 125
 - 150
 - 175
 - 200

Electrical Panel

- Circuit breakers used for overcurrent protection on individual branches
 - Protects wires from over heating
- Branch circuits used to divide electricity thru out house
 - Use smaller wire
 - If circuit blows, only that branch is without electricity

Branch circuits

Types

- Lighting
 - Used for lighting
 - Permanently installed or outlets used for 120V devices
- Special appliance
 - Usually in kitchen
 - Toaster, mixers, blenders. Use large amps
- Individual appliance
 - Permanently installed appliances
 - Water heaters, range, dryer

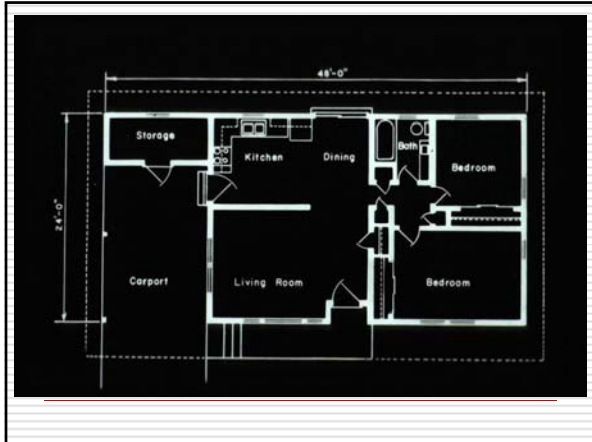
Branch circuits

Lighting circuits

- Use 12 wire
- 20 amp circuit
- Provides 2400 watt service
- NEC requires 3 watts/ft² of floor area
- 1 lighting circuit for every 400 to 800 ft²

Example

- How many lighting circuits are required for the this house?



Example

- Total floor area
 - $48' \times 24' = 1152 \text{ ft}^2$
- Lighting circuits
 - $1152 \text{ ft}^2 / 800 \text{ ft}^2 = 1.44$
 - Round up to 2

Branch circuits

- Special appliance circuit
 - 12 copper wire
 - 20 amp circuit
 - 2400 watt service
 - NEC requires a minimum 2 special circuits in kitchen
 - No lighting outlets allowed to be operated on these circuits

Branch circuits

□ Individual appliance circuit

- Appliances that require large amount of electricity
- Used on any appliance that has
 - 120 V permanently connected
 - Rated at or over 1400 watts
 - An automatically starting electric motor
- Could be either 120 or 240 Volt

TYPICAL APPLIANCE REQUIREMENTS				
Appliance or Equipment	Typical Watts	Usual Voltage	Wire Size	Recommended Fuse Size
Electric Range (with oven)	12,000	240	6	50-60 Amp.
Range Top (separate)	5,000	120/240	10	30 Amp.
Range Oven (separate)	5,000	120/240	10	30 Amp.
Refrigerator	300	120	12	20 Amp.
Home Freezer	350	120	12	20 Amp.
Automatic Washer	700	120	12	20 Amp.
Automatic Dryer (elec.)	5,000	120/240	10	30 Amp.
Dishwasher	1,200	120/240	12	20 Amp.
Garbage Disposal	300	120	12	20 Amp.
Roaster	1,400	120	12	20 Amp.
Rotisserie	1,400	120	12	20 Amp.
Furnace	800	120	12	20 Amp.
Dehumidifier	350	120	12	20 Amp.
Waffle Iron	1,000	120	12	20 Amp.
Band Saw	300	120	12	20 Amp.
Table Saw	1,000	120/240	12	20 Amp.
20,000 Btu Air Conditioner	1,200	120/240	12	20 Amp.
Bathroom Heater	2,000	120/240	12	20 Amp.
Ironer	1,500	120	12	20 Amp.
Water Heater	2,000-5,000	120	10	30 Amp.
Television	300	120	12	20 Amp.
Hand Iron	1,100	120	12	20 Amp.
Toaster	1,000	120	12	20 Amp.
Microwave Oven	1,450	120	12	20 Amp.
Trash Compactor	400	120	12	20 Amp.

Table is courtesy of Architecture Residential Drawing and Design.

Sizing Electrical Service for a House

□ Determined by NEC

- Standard Sizing Method – NEC 220.40
- Optional Sizing Method – NEC 220.80

Standard Sizing Method

- Easiest and most commonly used
 - Loads estimated for
 - Lighting & general use
 - 3 Watt/ft² for lighting
 - Special/small appliance circuits
 - 1,500 W/circuit
 - Laundry circuits
 - 1,500 W/circuit
-

Standard Sizing Method

- First 3,000 W has 100% demand factor
 - 3,001 – 12,000 W has 35% demand factor
 - Remaining load has 25% demand factor
-

Standard Sizing Method

- Add individual loads for range, dryer and other major appliances
 - Ranges - Use 8,000 W for ranges that are rated at 12,000 W and lower.
 - Dryer – 5,000 W or 100% of the nameplate rating
 - Use 75% factor if using 4 or more fixed appliances
-

Optional Sizing Method

- Used when multiple heating units used.
- Calculate
 - General Loads
 - Heating and AC loads

Optional Sizing Method

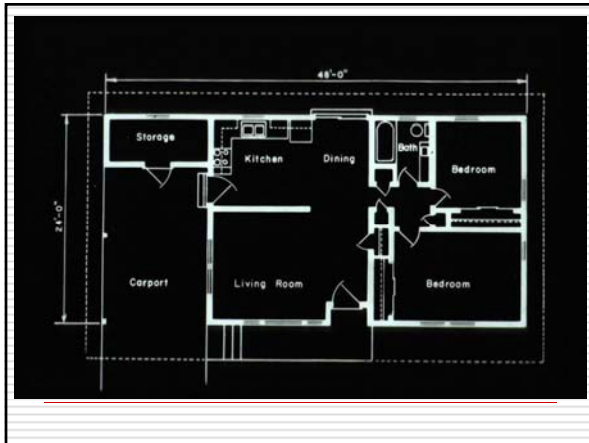
- General Loads
 - 3 Watt/ft²
 - rating for all permanent appliances
 - 1,500 Watt for each special/small appliance & laundry circuit
- First 10,000 Watt are 100% demand factor
- Remaining watts 40% demand factor

Optional Sizing Method

- Heating & AC Loads
 - 100% AC
 - 100% heat pump
 - 100% electrical thermal storage heating
 - 100% heat pump compressor & 65% of supplemental space heating unit
 - 65% electrical heating if less than 4 separately controlled units are used
 - 40% electrical heating if more than 4 separately controlled units are used

Example

- Calculate the electrical service needs for the house used in the previous example using the Standard Sizing Method.



Example

- Lighting circuits
 - $1152 \text{ ft}^2 * 3 \text{ watt/ft}^2$
 - 3456 Watt
- Special circuits
 - 2 in kitchen
 - 1500 watt/circuit
 - 3000 watts
- Laundry circuit
 - 1500 watts

Example

- Total Load
 - $3456 + 3000 + 1500 = 7956$ Watt
- First 3,000 W = 100% demand
 - 3000 W
- 3,001 – 12,000 W = 35% demand
 - $7956 - 3000 = 4956$ W * .35 = 1735 W
- Total
 - $3000 + 1735 = 4735$ Watt

Example

- Individual appliance circuit

Appliance	Watts
Range*	8,000
Water heater	5,000
Washer	700
Dryer	5,000
Furnace	800
Total	19,500

* Range nameplate rating is under 12,000 W

Example

- Total power used in house
 - $4,735 + 19,500 = 24,235$ watts
- Use 240 volt service entrance
 - $24,235$ watts/240 volts = 101 amps
- Should use 125 amp service for house

Electrical plan example

- House plan
- Show all electrical components
- Switches should be connected to lights with hidden lines
- Lighting fixture schedule
- Circuit data

Lighting Fixture Schedule

- # lights or outlets on circuit
- Location
- Watts
- manufacturer

LIGHTING FIXTURE SCHEDULE						
TYPE	MANUFACTURER	CATALOG NO.	NO. REQ'D.	MOUNTING HEIGHT	WATTS	REMARKS
A	SEARS	34K2546	2	7'-0"	100	BRUSHED ALUM.
B	LIGHTOLIER	4397	1	CEILING	100	
C	LIGHTOLIER	4393	2	CEILING	75	
D	SEARS	34K3119C	8	CEILING	80	PARTO START 40"
E	WOLFCRIST	60-22	4	CABLE PLAC	100	TWIN FLOODS
F	PROGRESS	P-180	2	CEILING	100	RECESSED 10" D.
G	SEARS	34K1880C	1	CEILING	200	POLISHED CHROME CHAND.
H	LIGHTOLIER	6349	2	6" ABOVE MIRROR	60	
I	ALCAID	220-HE	1	UNDER CABINET	60	
J	EMERSON	220	2	CEILING	60	FAN AND LIGHT COMBINATION
K	PROGRESS	P-234	2	10" BELOW CEILING	100	EXTERIOR - HANGING

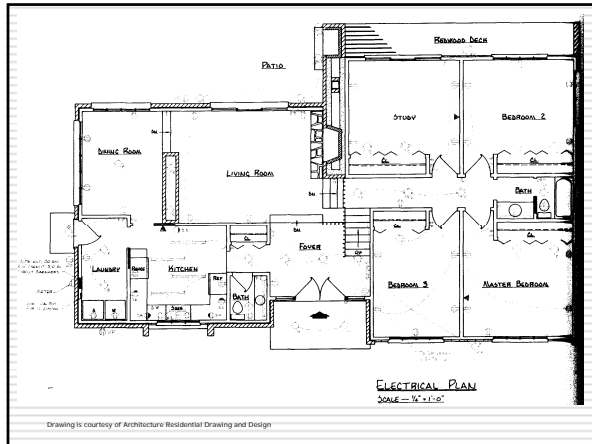
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E	WOLFCRIST	60-22	4	CABLE PLAC	100	TWIN FLOODS
F	PROGRESS	P-180	2	CEILING	100	RECESSED 10" D.
G	SEARS	34K1880C	1	CEILING	200	POLISHED CHROME CHAND.
H	LIGHTOLIER	6349	2	6" ABOVE MIRROR	60	
I	ALCAID	220-HE	1	UNDER CABINET	60	
J	EMERSON	220	2	CEILING	60	FAN AND LIGHT COMBINATION
K	PROGRESS	P-234	2	10" BELOW CEILING	100	EXTERIOR - HANGING

CIRCUIT DATA	
1	100' WATTAGE
2	100' WATTAGE
3	100' WATTAGE
4	100' WATTAGE
5	100' WATTAGE
6	100' WATTAGE
7	100' WATTAGE
8	100' WATTAGE
9	100' WATTAGE
10	100' WATTAGE
11	100' WATTAGE
12	100' WATTAGE
13	100' WATTAGE
14	100' WATTAGE
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37	100' WATTAGE
38	100' WATTAGE
39	100' WATTAGE
40	100' WATTAGE
41	100' WATTAGE
42	100' WATTAGE
43	100' WATTAGE
44	100' WATTAGE
45	100' WATTAGE
46	100' WATTAGE
47	100' WATTAGE
48	100' WATTAGE
49	100' WATTAGE
50	100' WATTAGE

Drawing is courtesy of Architecture Residential Drawing and Design

ELECTRICAL PLAN
2004 - M.A.S.D.



LIGHTING FIXTURE SCHEDULE						
TYPE	MANUF	CAT. NO.	NO. PER	MOUNTING HGT.	WATTS	REMARKS
A	PROGRESS	P4014	1	CEILING	240	CHANNLELIER
B	SEARS	SAK3149	2	CEILING	100	CEILING HUNGERS
C	SEARS	SAK3113	4	CEILING	80	RECESSED CEILING
D	PROGRESS	P7165	2	ABOVE ALUMIN	80	RAMP START
E	SEARS	SAK2734	2	CEILING	100	
F	PROGRESS	P1426	4	CEILING	100	RECESSED 10" SQ
G	PROGRESS	P1474	7	CEILING	100	RECESSED 8" RND
H	PROGRESS	P1441	2	12" BELOW CEI	100	EXT. HANGING
I	SEARS	SAK3146	4	7'-0"	100	BUSHED ALUM
J	PROGRESS	P1328	3	11'-0"	80	
K	SEARS	SAK1422	3	CABLE PEAR	150	TURN FLOORS
L	PROGRESS	P7002	1	UNDER CAB	40	

CIRCUIT DATA

LIGHTING CIRCUITS:
 4 CIRCUITS @ 1800 WATTS EACH (1750 WATTS @ 3 WATTS/SQ FT = 3500 WATTS A.M.) = 7200 WATTS

SPECIAL APPLIANCE CIRCUITS
 2 CIRCUITS @ 900 WATTS EACH (2 CIRCUITS IN KITCHEN, 2 CIRCUITS IN DWAP) = 1800 WATTS

INDIVIDUAL APPLIANCE CIRCUITS

1 CIRCUIT FOR REFRIGERATOR	= 2400 WATTS
1 CIRCUIT FOR DISHWASHER	= 2400 -
1 CIRCUIT FOR WASHER	= 2400 -
1 CIRCUIT FOR GAS RANGE	= 2400 -
1 CIRCUIT FOR OVEN RANGE	= 2400 -
1 CIRCUIT FOR WATER PUMP (230 VOLTS)	= 4800 -
1 CIRCUIT FOR TABLE SAW (230 VOLTS)	= 4800 -
2 SWAGE CIRCUITS	TOTAL = 18000 WATTS

DISTRIBUTION PANEL:
 150 AMP, 20 CIRCUIT, SQUARE D NO. QOC - 20 A 200

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