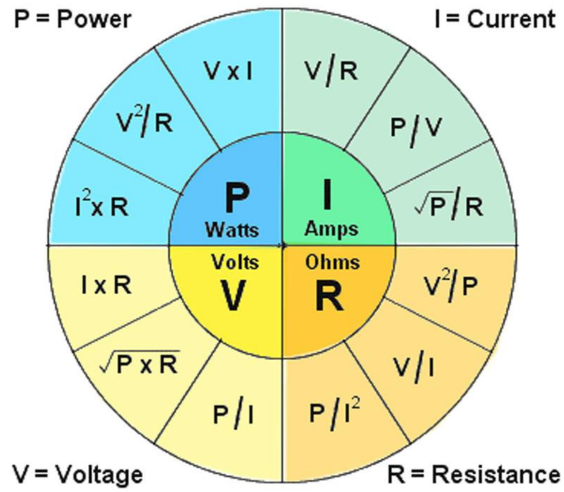
Basic electrical formulas:

Chart on left shows the formulas used to calculate electricity.
Power (watts), current (amperage), resistance, voltage.
You must know at least two factors for correct calculations.

http://waterheatertimer.org/Formulas-for-Ohms-law.html



Notice there are several ways to calculate each factor.
Resistance Ohms = volts ÷ amps (V/I)
Resistance Ohms = $volts^2$ ÷ watts (V^2/P)
Resistance Ohms = watts ÷ $amps^2$ (P/I^2)
Example: test 4500 watt 240 volt water heater element
Correct ohm reading = 240^2 (V^2) ÷ 4500 (P) = 12.8 ohms

volts x amps = watts (power)
Power (watts) = V (volts) x I (amps)
What is maximum wattage that can be achieved from 240 volt circuit with 30 amp breaker.
240 volt x 30 amp = 7200 watt.

Example: 4500 watt element, 240 volt water heater circuit, how many Amps are used?
4500 watt ÷ 240 volt = 18.75 amps

http://waterheatertimer.org/Figure-Volts-Amps-Watts-for-water-heater.html

volts = amps x resistance (ohms)
V = I x R is sometimes shown as E (energy) = IR
If the multimeter reads 12 amps on the wire and resistance on the load is 10 ohms, how many volts are present?
12 ohms x 10 amp = 120 volt

1000 watts = 1 kilowatt (Kw)
Run 100 watt light bulb for 10 hours = 1000 watt hours = 1 kilowatt hours (Kwh)
If electricity costs 18¢ per Kwh, then running 100 watt bulb for 10 hours costs 18¢
If you use 100-watt-equalivalent LED bulb, it consumes 20 watts for same lumens of light.
Run LED bulb for 10 hours x 20 watts = 200 kilowatt (Kw) or .2 Kwh costing 3.6¢ instead of 18¢.

.002931 Kw needed to raise 1 pound of water 1°F

http://waterheatertimer.org/How-many-kilowatts-needed-to-heat-water.html

1 horsepower = 745.6998 watts
If you have 2 Hp motor and 240 volt circuit, what size circuit breaker and wire are needed?
You have watts and volts, but don ’t know what amp circuit breaker.
Motors are inductive load, and require more amps when starting.
The inrush needed for motor start means the calculation for motors is not straightforward.
Standard Charts are needed that show amp draw, overcurrent protection and wire size.

http://waterheatertimer.org/Color-codewire.html#motor

What size wire is used for 30 amp breaker?

Specific size wire is used for each size circuit breaker
Distances over 100 feet require larger wire and breaker
Standard Charts are needed
http://waterheatertimer.org/Color-codewire.html

Volts and amps on a wire are inversely proportional.
When volts go up, amps go down.
When volts go down on the line, then amps go up.
If you have a 8000 watt lighting system that can be wired for either 120 volts or 240 volts, which is the best choice?
8000 watts divided by 240 volts = 33.3 amps requiring 40 amp breaker and #8 gauge wire.
8000 watts divided by 120 volts = 66.6 amps requiring 70 amp breaker and #4 gauge wire.
Larger wire costs more, especially if the load is spread over a large area like commercial lighting. The mathematics shows that using 240 volts is a less expensive way to handle the 8000 watt load.

Power companies utilize the inverse relationship between volts and amps when transmitting electricity.
They transmit high voltage, low amperage electricity. This reduces heat loss from high amperage, and lets them use smaller wire and transmit electricity longer distance at less cost.
http://waterheatertimer.org/What-is-3-phase-electric.html

When wiring a house, the maximum is 12 boxes per circuit breaker
http://waterheatertimer.org/Basic-house-wiring.html

Commercial wiring is 3-phase while residential wiring is single phase.
What is the difference?
http://waterheatertimer.org/difference-between-single-phase-and-3-phase.html

More resources:
http://waterheatertimer.org/pdf/Basic-Water-heater-formulas-and-terminology.pdf
http://waterheatertimer.org/pdf/Water-heater-Formulas-and-terminology.pdf
http://waterheatertimer.org/pdf/Formulas-for-Three-Phase_Circuits.pdf

Electrical Formulas
For Finding Amperes, Horsepowers, Kilowatts and kVA

To Find	Single-Phase	Alternating Current Two-Phase[1]), Four-Wire	Three-Phase	Direct Current
Kilowatts	$\frac{I \times E \times pf}{1000}$	$\frac{I \times E \times 2 \times pf}{1000}$	$\frac{I \times E \times 1.73 \times pf}{1000}$	$\frac{I \times E}{1000}$
kVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 2}{1000}$	$\frac{I \times E \times 1.73}{1000}$	—
Horsepower (Output)	$\frac{I \times E \times \% EFF \times pf}{746}$	$\frac{I \times E \times 2 \times \% EFF \times pf}{746}$	$\frac{I \times E \times 1.73 \times \% EFF \times pf}{746}$	$\frac{I \times E \times \% EFF}{746}$
Amperes when Horsepower is Known	$\frac{HP \times 746}{E \times \% EFF \times pf}$	$\frac{HP \times 746}{2 \times E \times \% EFF \times pf}$	$\frac{HP \times 746}{1.73 \times E \times \% EFF \times pf}$	$\frac{HP \times 746}{E \times \% EFF}$
Amperes when Kilowatts is Known	$\frac{KW \times 1000}{E \times pf}$	$\frac{KW \times 1000}{2 \times E \times pf}$	$\frac{KW \times 1000}{1.73 \times E \times pf}$	$\frac{KW \times 1000}{E}$
Amperes when kVA is Known	$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{2 \times E}$	$\frac{kVA \times 1000}{1.73 \times E}$	—

Average Efficiency and Power Factor Values of Motors

When the actual efficiencies and power factors of the motors to be controlled are not known, the following approximations may be used.

Efficiencies[2])

Type	Power Factor
DC motors, 35 horsepower and less	80% to 85%
DC motors, above 35 horsepower	85% to 90%
Synchronous motors (at 100% power factor)	92% to 95%
"Apparent" Efficiencies (= Efficiency × Power Factor); Three-phase induction motors, 25 horsepower and less	70%
Three-phase induction motors above 25 horsepower	80%

Fault-Current Calculation on Low-Voltage AC Systems

In order to determine the maximum interrupting rate of the circuit breakers in a distribution system, it is necessary to calculate the current which could flow under a three-phase bolted short circuit condition. For a three-phase system the maximum available fault current at the secondary side of the transformer can be obtained by use of the formula:

$$I_{SC} = \frac{kVA \times 100}{KV \times \sqrt{3} \times \% Z}$$

where:

I_{SC} = Symmetrical RMS amperes of fault current.

kVA = Kilovolt-ampere rating of transformers.

KV = Secondary voltage in kilovolts.

% Z = Percent impedance of primary line and transformer.

1)In three-wire, two-phase circuits the current in the common conductor is 1.41 times that in either other conductor.

E = Volts I = Amperes

% EFF = Percent Efficiency pf = Power Factor

2)These figures may be decreased slightly for single-phase and two-phase induction motors.

http://waterheatertimer.org/Figure-Volts-Amps-Watts-for-water-heater.html

Table 13 Electrical formulas for Amperes, Horsepower, Kilowatts and KVA

To find	Single phase	3-phase	Direct current
Kilowatts	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$	$\frac{I \times F}{1000}$
KVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$	—
Horsepower (output)	$\frac{I \times E \times \%\ Eff \times PF}{746}$	$\frac{I \times E \times 1.73 \times \%Eff \times PF}{746}$	$\frac{I \times E \times \%Eff}{746}$
Amperes when Horsepower is known	$\frac{HP \times 746}{E \times \%Eff \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \%Eff \times PF}$	$\frac{HP \times 746}{E \times \%Eff}$
Amperes when Kilowatts is known	$\frac{KW \times 1000}{E \times PF}$	$\frac{KW \times 1000}{1.73 \times E \times PF}$	$\frac{KW \times 1000}{E}$
Amperes	$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$	—

E=Volts I = Amperes %Eff = Percent efficiency PF = Power factor HP = Horsepower KVA = Kilovolt-Amps

Average Efficiency and Power Factor Values of Motors:

When actual efficiencies and power factors of the motors to be controlled are not known, the following approximations may be used:

Efficiencies:

DC motors, 35 hp and less:	80% to 85%
DC motors, above 35 hp:	85% to 90%
Synchronous motors (at 100% PF):	92% to 95%

"Apparent" efficiencies (Efficiency x PF):

3-phase induction motors, 25 hp and less:	70%
3-phase induction motors above 25 hp:	80%

Decrease these figures slightly for single phase induction motors.

Table 14 Ratings for 3-Phase, Single-Speed, Full-Voltage Magnetic Controllers for NonpluggIng and Nonjogging Duty

Size of Controller	Continous Current Rating (A)	Horsepower at [1]				Service-Limit Current Rating (A)
		60 Hz 200 V	60 Hz 230 V	50 Hz 380 V	60 Hz 460 or 575 V	
00	9	1-1/2	1-1/2	1-1/2	2	11
0	18	3	3	5	5	21
1	27	7-1/2	7-1/2	10	10	32
2	45	10	15	25	25	52
3	90	25	30	50	50	104
4	135	40	50	75	100	156
5	270	75	100	150	200	311
6	540	150	200	300	400	621
7	810	—	300	—	600	932

[1] These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, use a larger controller to ensure its locked-rotor current rating is not exceeded.

Table 15 Ratings for 3-Phase, Single-Speed, Full-Voltage Magnetic Controllers for Plug-Stop, Plug-Reverse or Jogging Duty

Size of Controller	Continous Current Rating (A)	Horsepower at [1]				Service-Limit Current Rating (A)
		60 Hz 200 V	60 Hz 230 V	50 Hz 380 V	60 Hz 460 or 575 V	
0	18	1-1/2	1-1/2	1-1/2	2	21
1	27	3	3	5	5	32
2	45	7-1/2	10	15	15	52
3	90	15	20	30	30	104
4	135	25	30	50	60	156
5	270	60	75	125	150	311
6	540	125	150	250	300	621

[1] These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, use a larger controller to ensure its locked-rotor current rating is not exceeded.

Table 16 Power Conversions

From	to kW	to PS	to hp	to ft-lb/s
1 kW (kilowatt) = 10^{10} erg/s	1	1.360	1.341	737.6
1 PS (metric horsepower)	0.7355	1	0.9863	542.5
1 hp (horsepower)	0.7457	1.014	1	550.0
1 ft-lb/s (foot-pound per sec)	1.356×10^{-3}	1.843×10^{-3}	1.818×10^{-3}	1

VL = Line Voltage
VP = Phase (Element) Voltage
IL = Line Current (Amps)
ILL = Line Current (Unbalanced Phase)
IP = Phase Current (Amps)
WT = Total Watts
R1 = R2 = R3 = Element Resistance
Rc = Circuit Resistance in Ohms Measured from Phase to Phase