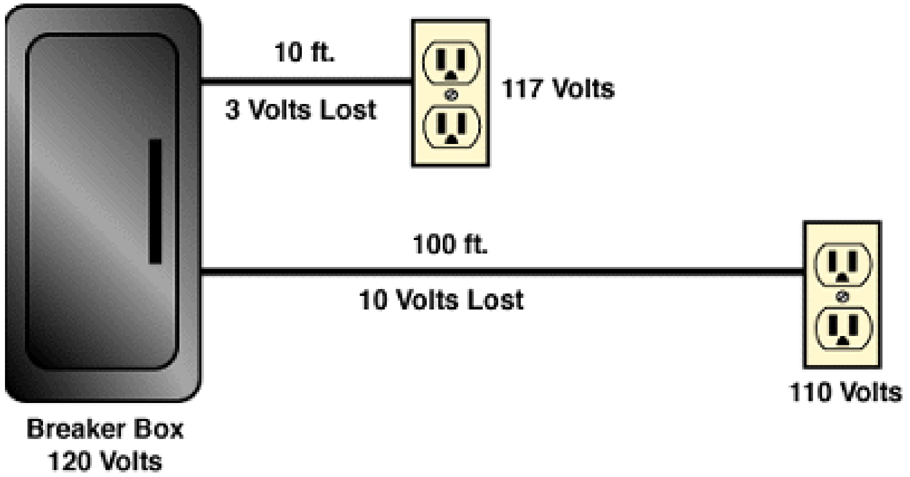
Voltage Drop



Voltage Drop

Electrical Calculations

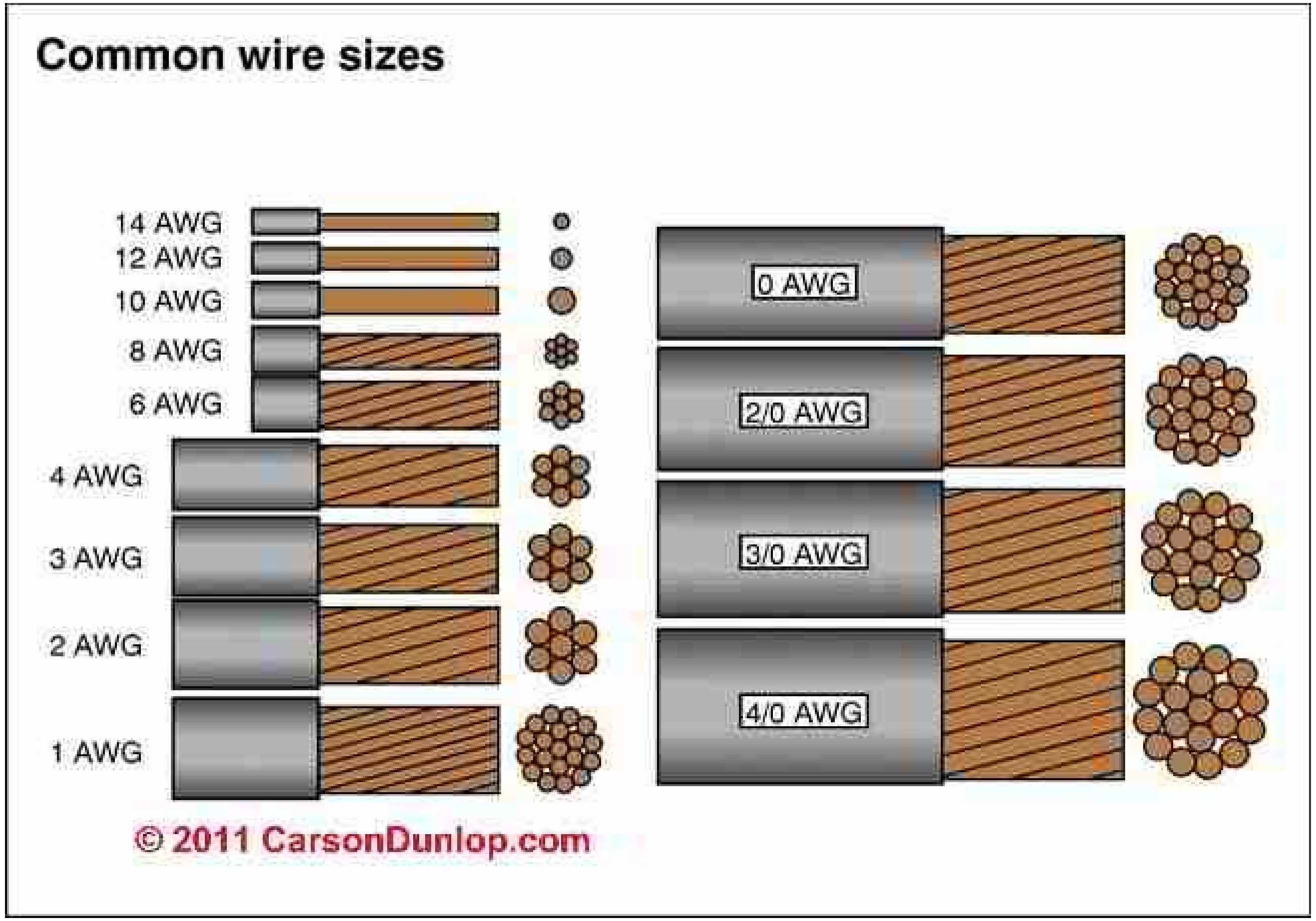
Most building electrical calculations solve for current or voltage drop.

► Current sets conductor size.

► Excess voltage drop may require an increase in conductor size.

Voltage Drop

AWG Conductor Sizes



THHN Wire stands for - Thermoplastic High Heat-resistant Nylon coated.

THHN is UL listed with a rated 90 degrees Celsius in dry locations or 75 degrees Celsius in wet applications with a THWN rating.

Voltage Drop

Excessive Voltage Drop

Excessive voltage drop in a circuit can cause:

- ► Lights to flicker or burn dimly
- ► Heaters to heat poorly
- ► Motors to run hotter than normal and burn out

This condition causes the load to work harder with less voltage pushing the current.

Voltage Drop

National Electrical Code (NEC)

The National Electrical Code recommends limiting the voltage drop from the breaker box to the farthest outlet for power, heating, or lighting to 3 percent of the circuit voltage.

This is done by selecting the right size of wire.

Voltage Drop

National Electrical Code (NEC)

Two Primary Electrical Design Concerns

- ► Current Required

- ► Voltage Drop

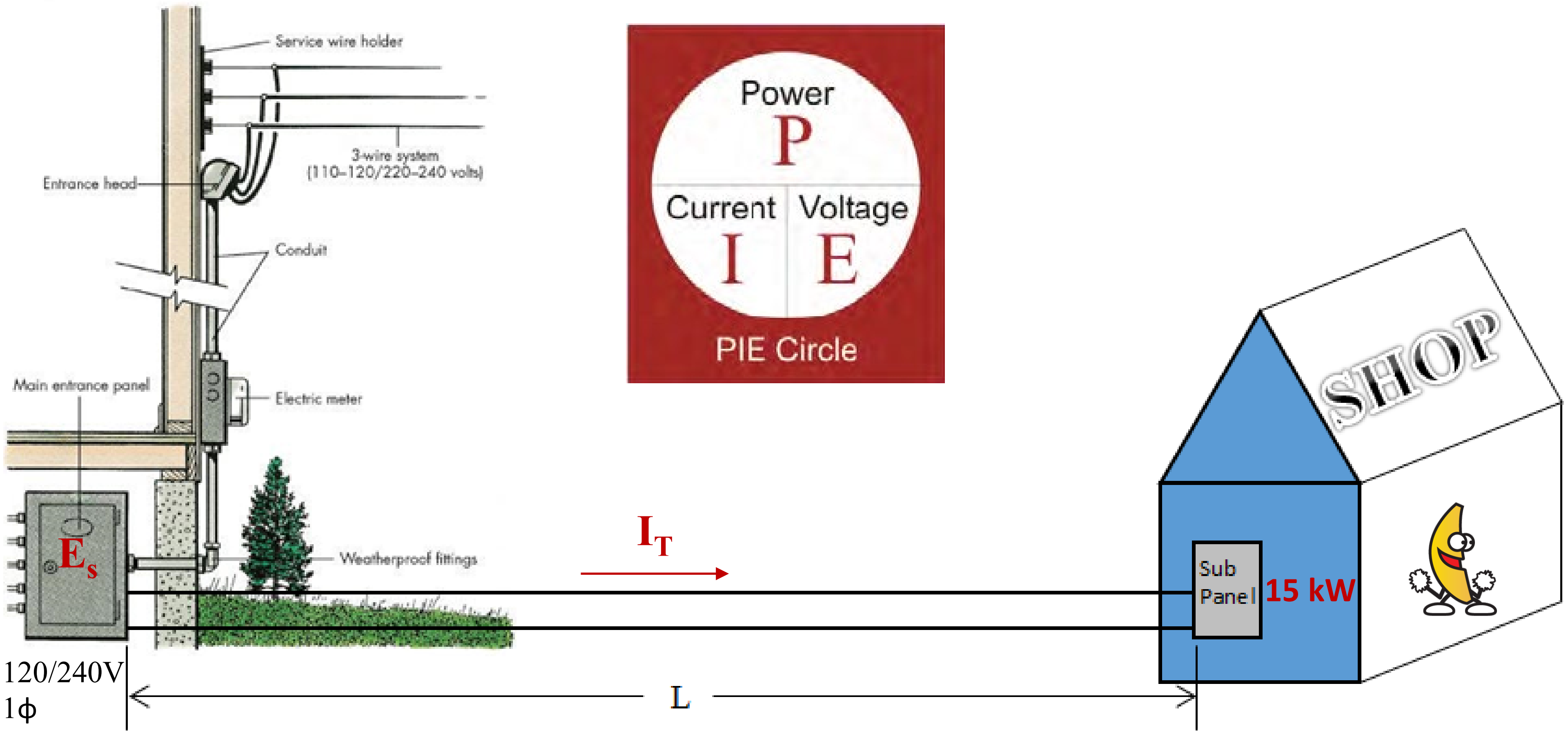
Voltage Drop

National Electrical Code (NEC)

Two Primary Electrical Design Concerns

- Current Required
- Voltage Drop

Voltage Drop



Total connected load for all the lights and equipment in the shop is 15 kW.

1 kW = 1,000 Watts

Voltage Drop

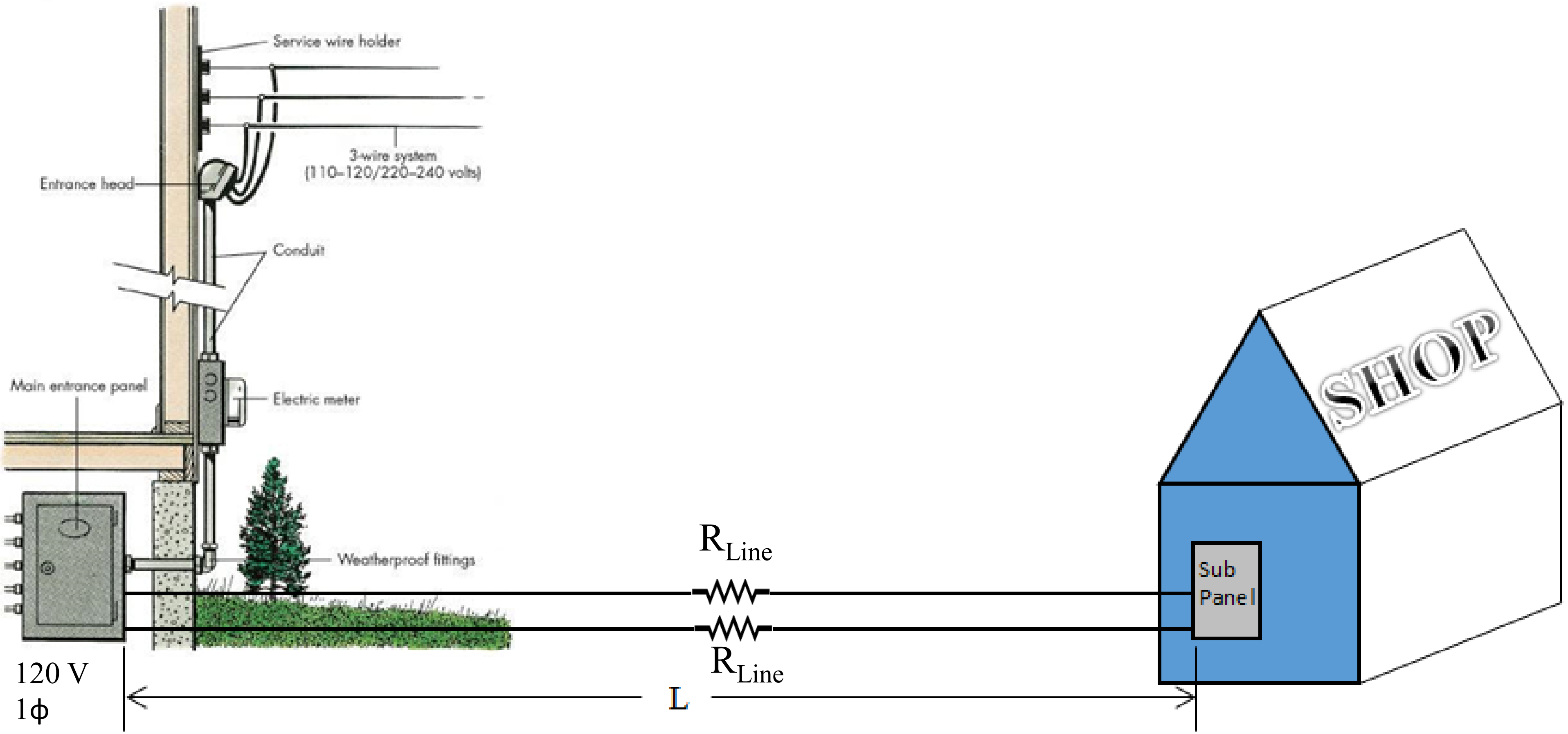
Find the current required for the shop's electrical service at:

Service Voltage = 120 V, 1ϕ	Service Voltage = 240 V, 1ϕ
$I = \frac{P}{E} = \frac{15{,}000\ W}{120\ V} = 125\ A$	$I = \frac{P}{E} = \frac{15{,}000\ W}{240\ V} = 62.5\ A$
NEC 310.15(B)(16) (75°)	NEC 310.15(B)(16) (75°)
Minimum Size Conductor **#1 AWG**	Minimum Size Conductor **#6 AWG**
Conductor Resistance **0.154** (Ω/1000 ft)	Conductor Resistance **0.491** (Ω/1000 ft)

Table 310.15(B)(16)

Table 8

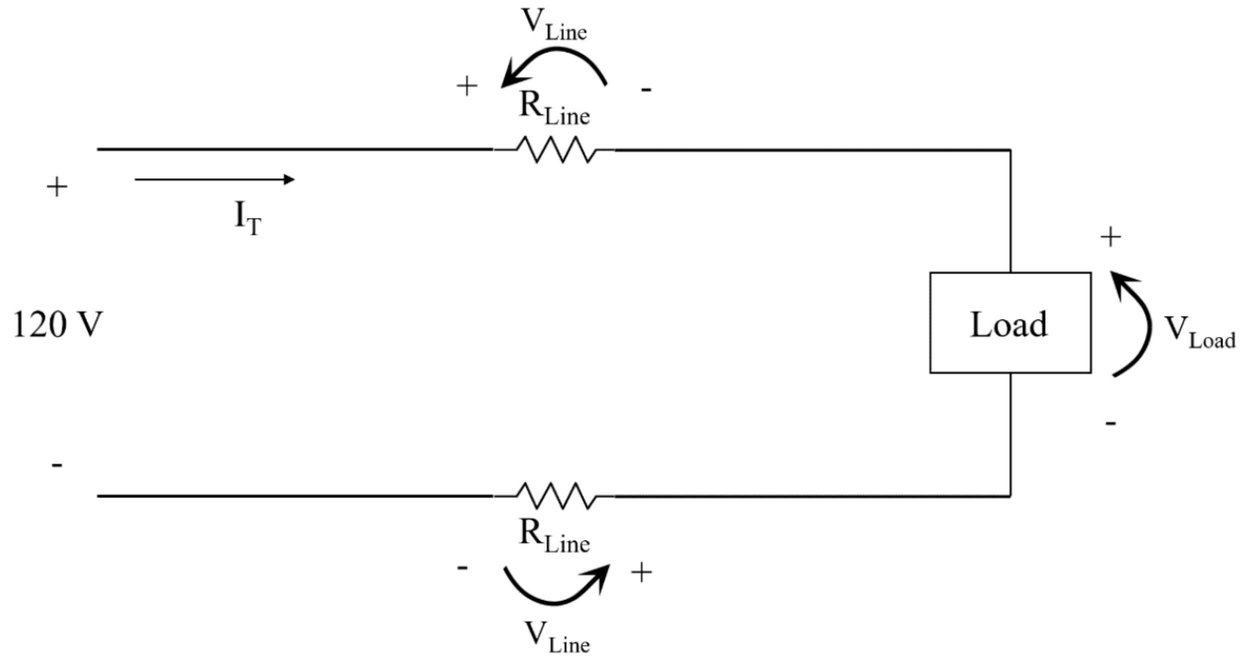
Voltage Drop

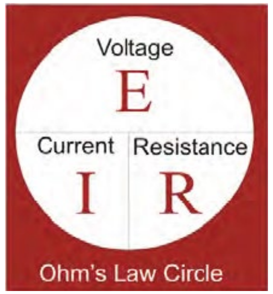


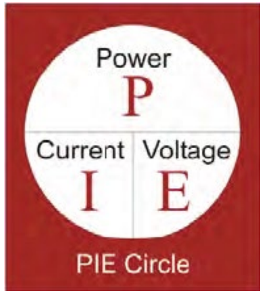
There is a Voltage Drop (VD) due to the Conductor Resistance

Voltage Drop

Kirchoff's Voltage Law







$\Sigma V_{Loop} = 0$

$120V - V_{Line} - V_{Load} - V_{Line} = 0$

$V_{Load} = 120V - \underbrace{V_{Line} - V_{Line}}_{VD_{Line}}$

$R_{Line} = (2 \text{ x Ohms per 1000 ft x L})$ [Note: this is the TOTAL resistance of the line, i.e. $R_{Line} + R_{Line}$]

$VD_{Line} = I_T \text{ x } R_{Line}$

$V_{Load} = 120V - VD_{Line}$

$\%VD = (V_{Load} / 120V) \text{ x } 100$

Voltage Drop

Case 1: 120 V, 125 A, #1 – Load Power 15kW

Supply Voltage = 120 V

Load Power = 15 kW

Supply Current = 125 A

Minimum Conductor Size = #1

$R_{Line} = (2 \times 0.154\ \Omega \times L) / 1000$

$R_{Line} = (2 \times \text{Ohms per 1000 ft} \times L)$

$VD_{Line} = I_T \times R_{Line}$

$V_{Load} = 120V - VD_{Line}$

$\%VD = (V_{Load} / 120V) \times 100$

Length (ft)	R_{Line} (Ω)	VD_{Line} (V)	V_{load} (V)	% VD
90	0.02772	3.465	117	2.89
120	0.03696	4.62	115	3.85
150	0.0462	5.775	114	4.81
230	0.07084	8.855	111	7.38

Voltage Drop

Case 2: 120 V, 125 A, #1/0 – Load Power 15kW

Supply Voltage = 120 V

Load Power = 15 kW

Supply Current = 125 A

Minimum Conductor Size = ~~#1~~ **#1/0**

R_{Line} = (2 x 0.122 Ω x L) / 1000

Length (ft)	**R_{Line} (Ω)**	**VD_{Line} (V)**	**V_{Load} (V)**	**% VD**
90	0.02196	2.745	117	2.29
120	0.02928	3.66	116	3.05
150	0.0366	4.575	115	3.81
230	0.05612	7.015	113	5.85

Voltage Drop

Case 1: 120 V, 125 A , #1 – Load Power 15kW

Length (ft)	R_{Line} (Ω)	VD_{Line} (V)	V_{Load} (V)	% VD
90	0.02772	3.465	117	2.89
120	0.03696	4.62	115	3.85
150	0.0462	5.775	114	4.81
230	0.07084	8.855	111	7.38

Case 2: 120 V, 125 A, #1/0 – Load Power 15kW

Length (ft)	R_{Line} (Ω)	VD_{Line} (V)	V_{Load} (V)	% VD
90	0.02196	2.745	117	2.29
120	0.02928	3.66	116	3.05
150	0.0366	4.575	115	3.81
230	0.05612	7.015	113	5.85

Voltage Drop

Case 3: 240 V, 62.5 A, #6 – Load Power 15kW

Supply Voltage = 240 V

Load Power = 15 kW

Supply Current = 62.5 A

Minimum Conductor Size = #6

$R_{Line} = (2 \times 0.491\ \Omega \times L) / 1000$

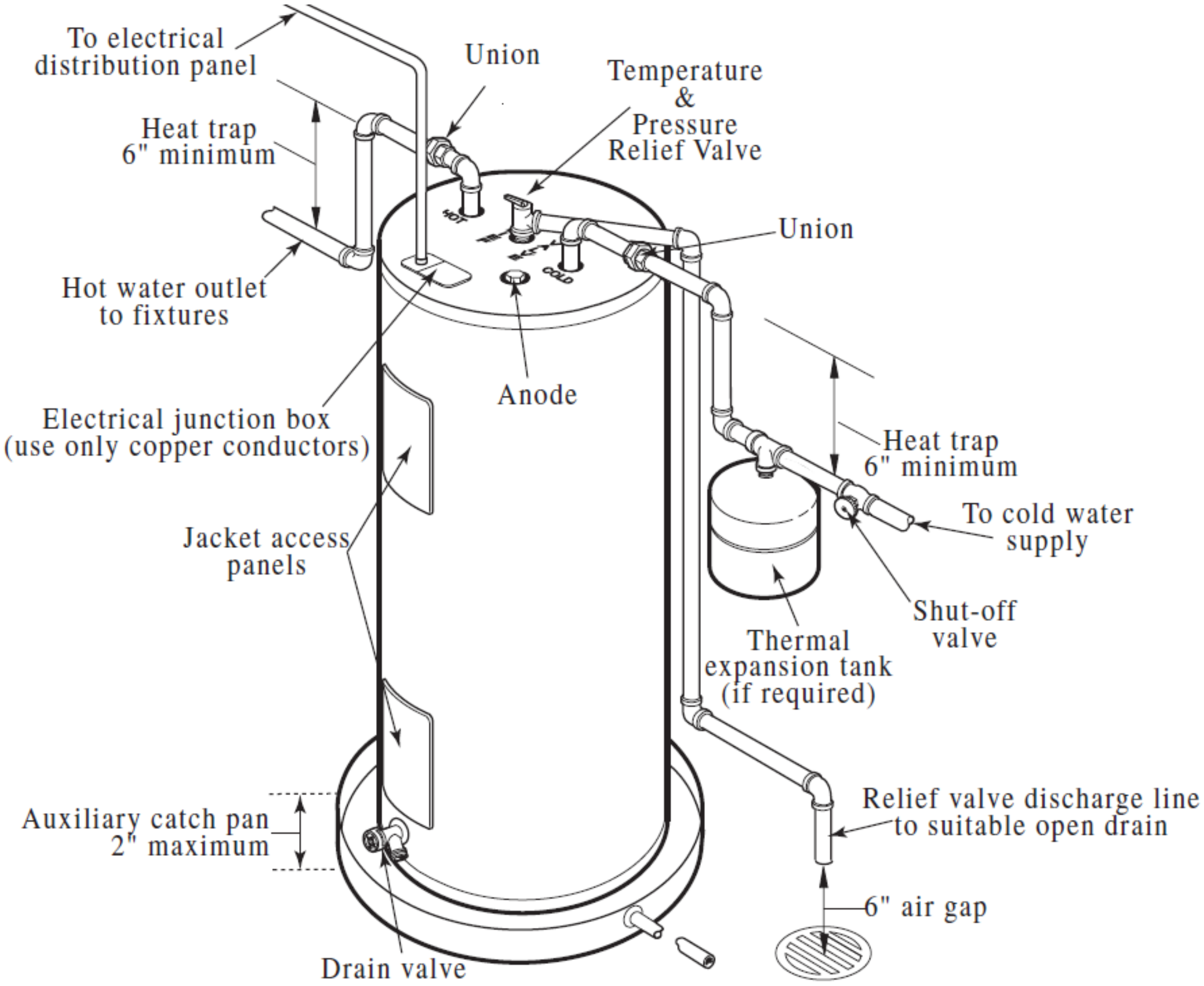
Length (ft)	R_{Line} (Ω)	VD_{Line} (V)	V_{Load} (V)	% VD
90	0.08838	5.52375	234	2.30
120	0.11784	7.365	233	3.07
150	0.1473	9.20625	231	3.84
230	0.22586	14.11625	226	5.88

Voltage Drop

Example #2

A residential electric water heater is rated at 4.5 kW and operates at 208V (single phase wiring).

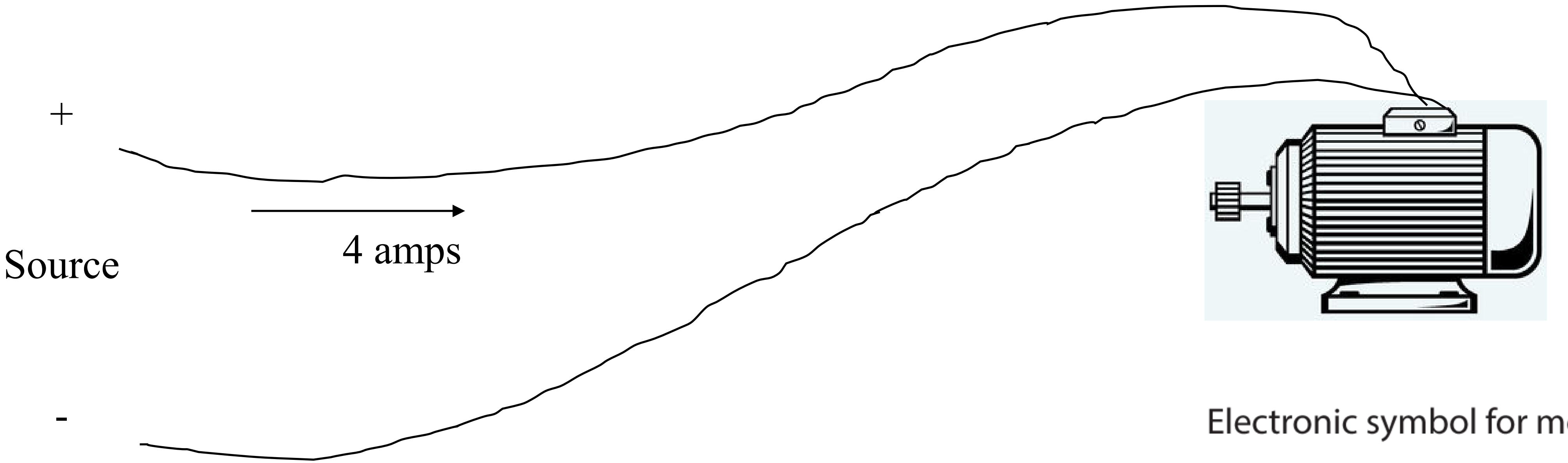
1. Determine the recommended Over Current Protection (OCP)
   (Circuit Breaker amperage rating)
2. Determine the copper wire size AWG based on NEC.



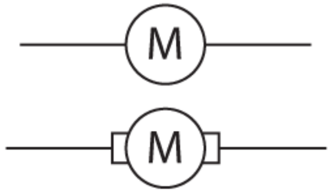
Voltage Drop

Example #3

A current of 4 amps is flowing in a conductor that has a resistance of 2Ω per 1,000 feet. Find the voltage drop if the distance from the source to the load is 1,000 feet.



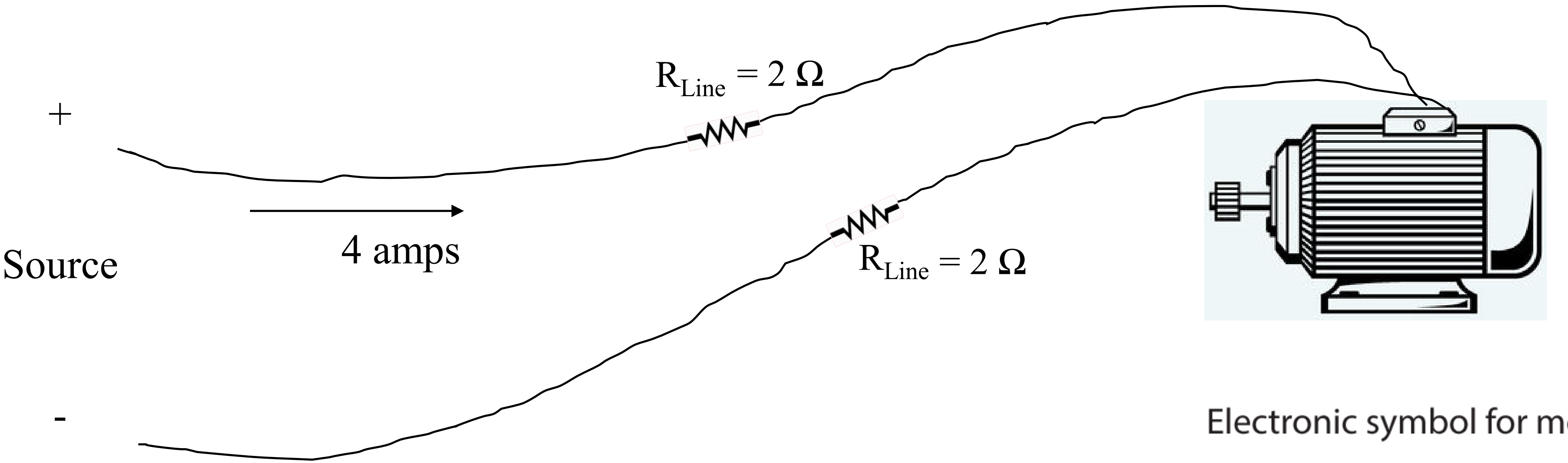
Electronic symbol for motor



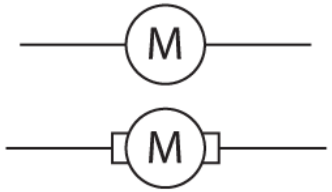
Voltage Drop

Example #3

A current of 4 amps is flowing in a conductor that has a resistance of 2Ω per 1,000 feet. Find the voltage drop if the distance from the source to the load is 1,000 feet.



Electronic symbol for motor



Supply Current = 4 A **R_{Line} = 4 Ω** **VD = 4 A x 4 Ω = 16 V**

Voltage Drop

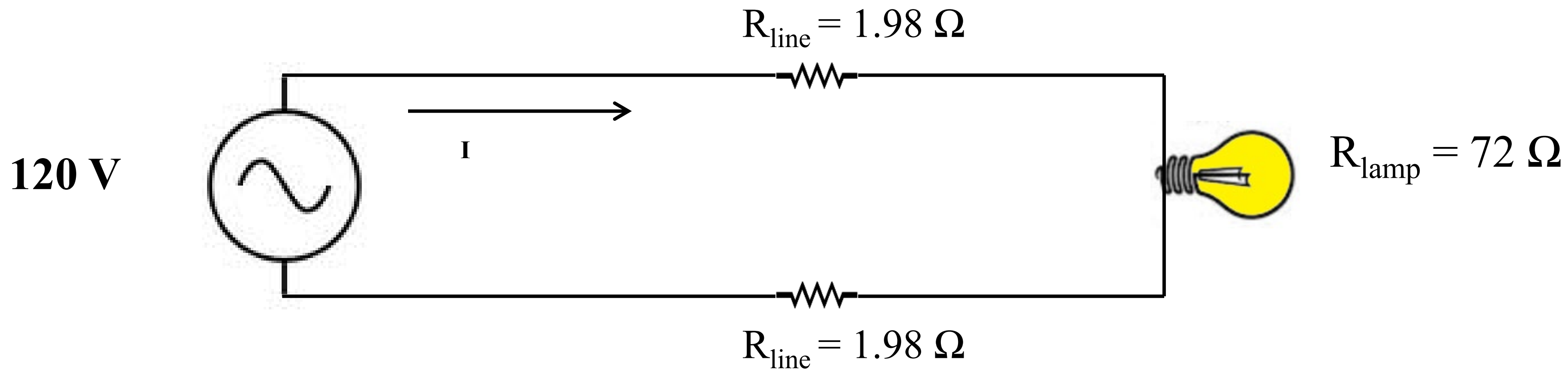
Example #4

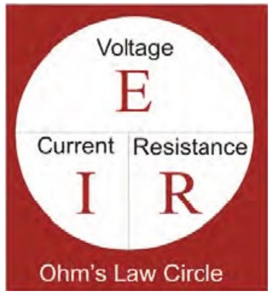
An extension power cord made of CU #12 THWN is powering a lamp 300 feet from the source. The lamp resistance is 72 Ω and the source voltage is 120 V. Find the voltage drop across the lamp.

Voltage Drop

Example #4

An extension power cord made of CU #12 THWN is powering a lamp 300 feet from the source. The lamp resistance is 72 Ω and the source voltage is 120 V. Find the voltage drop across the lamp.





R_{Line} = (2 x 1.98 Ω x L) / 1000 = (2 x 1.98 Ω x 300 ft) / 1000 = 1.188 Ω

I = 120 V / 73.188 Ω = 1.64 A

E_{lamp} = 1.64 A x 72 Ω = 118 V