# ECE 3318
# Applied Electricity and Magnetism

**Spring 2023**

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Dept. Of ECE

# Notes 5
## Grounding

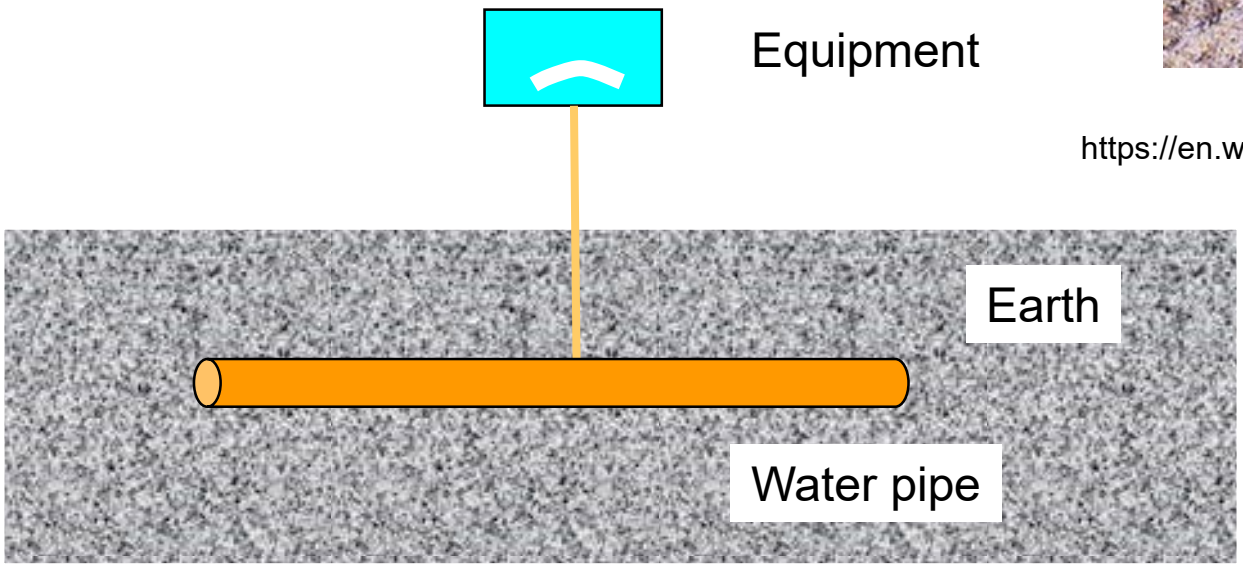
Notes prepared by the EM Group
University of Houston

# Grounding

## **Grounding:** connecting a conductor to the physical earth

- Safety reasons
- Noise reasons

Grounding system

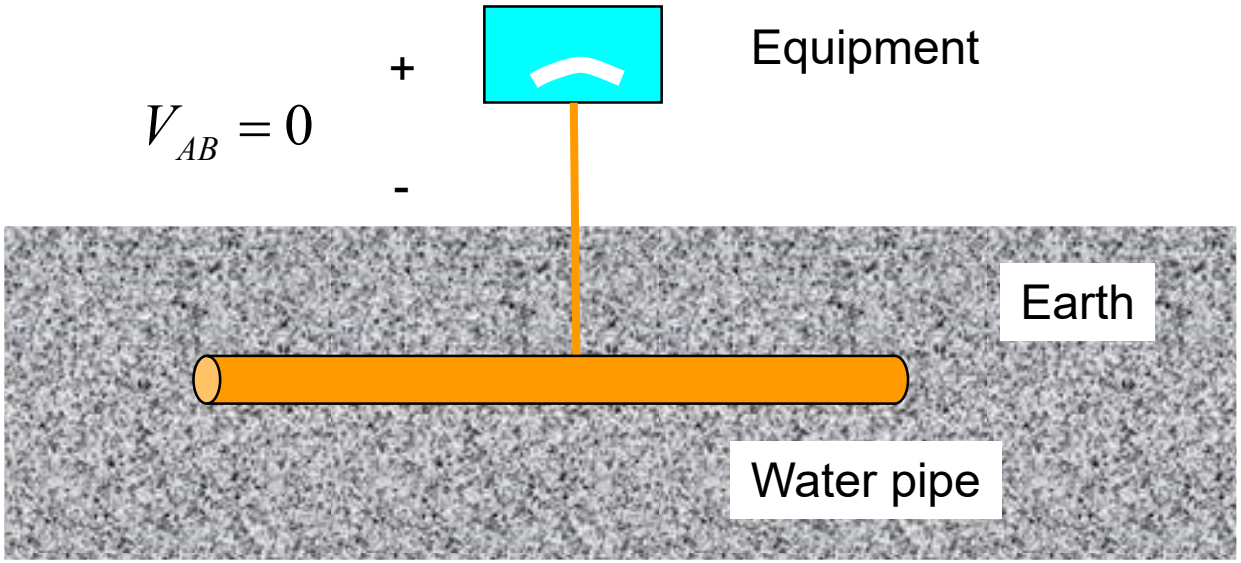



https://en.wikipedia.org/wiki/Ground_(electricity)

# Grounding (cont.)

## Grounding:

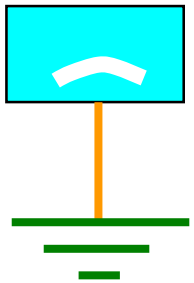
- Ensures that there is no voltage drop between equipment and ground.
- Ensures that there is no static electric field outside of equipment.
- Ensures that there is no static charge build up on equipment.




Physical grounding is usually to underground pipes and conductors.

# Grounding (cont.)

## Ground symbol:

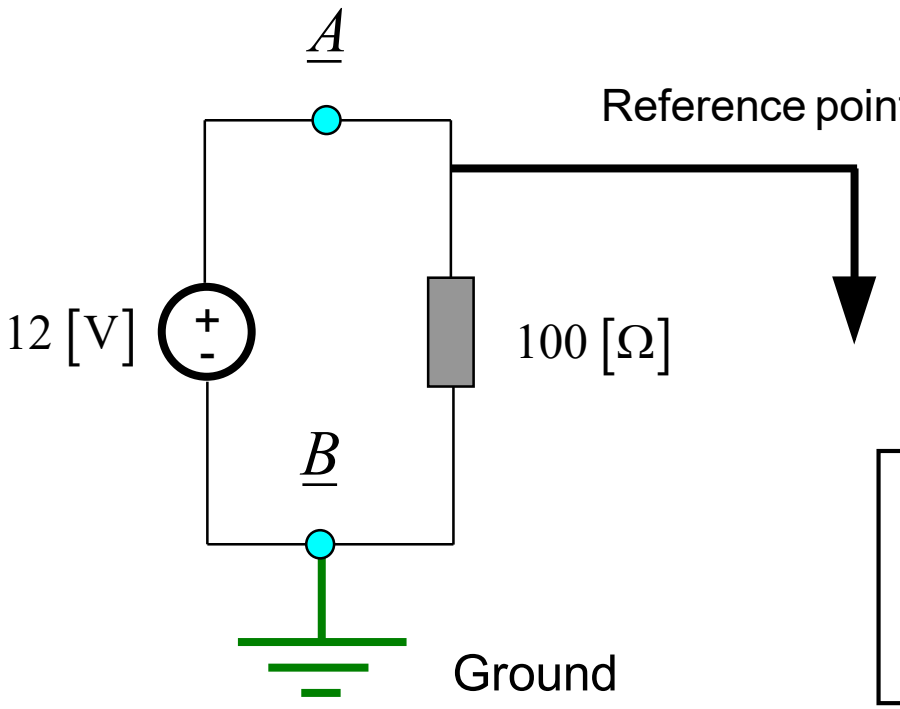



**Note:** Grounding is NOT is the same thing as choosing a reference point.

However, when a circuit is grounded, the ground is OFTEN chosen to be the reference point, and the voltage is usually assigned to be zero volts at the ground.

# Example

An unusual choice of reference point!



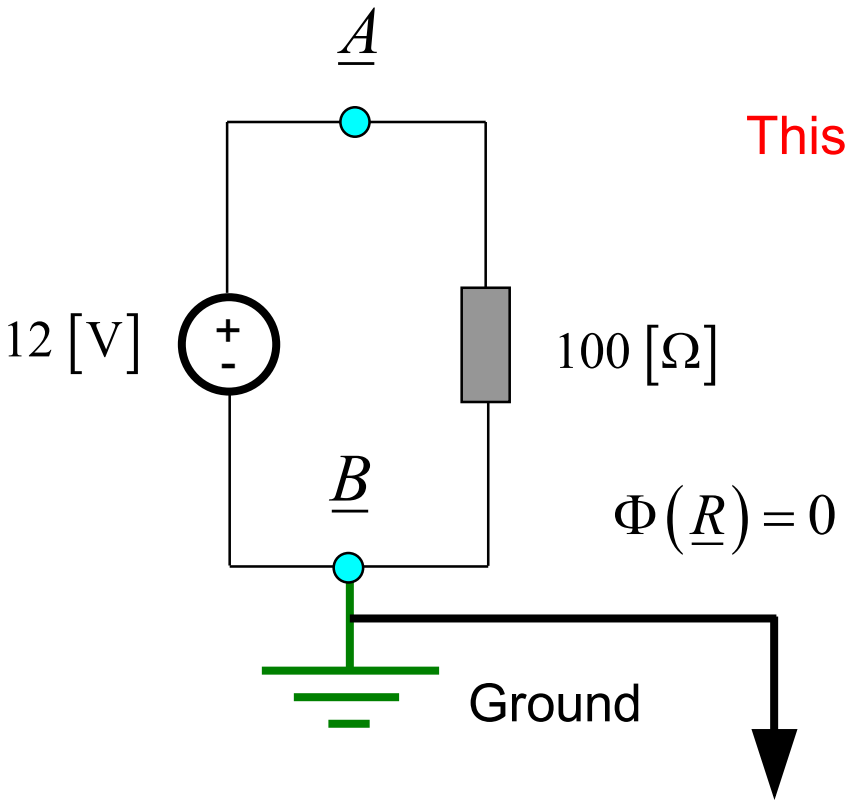

**Note:**
For most DC voltage sources, it is the negative terminal that is grounded (as shown here).

$$V_{AB} = \Phi(A) - \Phi(B) = 12$$

$$0 - \Phi(B) = 12 \quad \Rightarrow \quad \Phi_B = -12 \text{ [V]}$$

The potential of the earth is -12 [V] !

# Example (cont.)




This is the most common scenario:

- Ground is chosen as the reference.
- The reference voltage is chosen as zero.

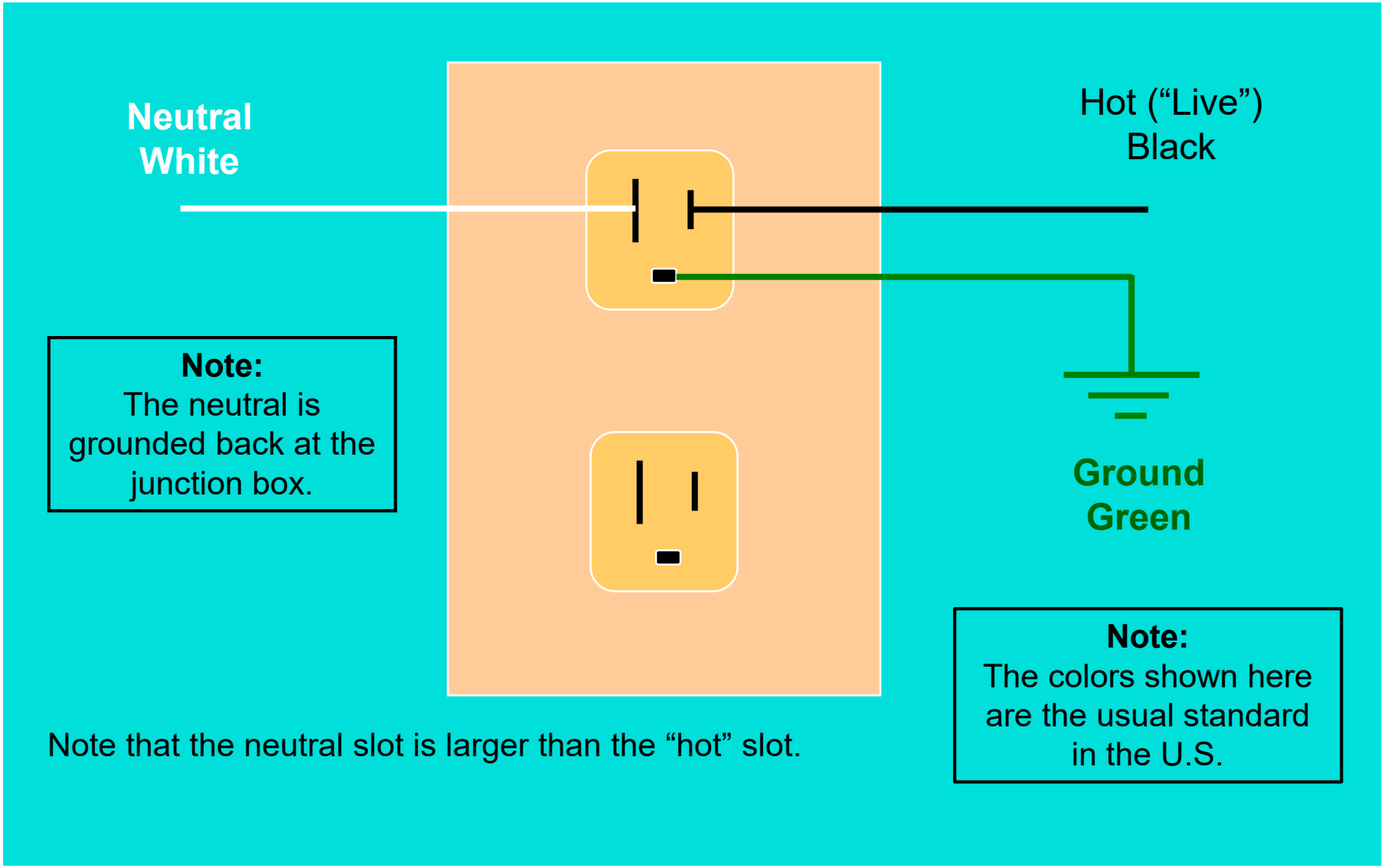
$\Phi(\underline{R}) = 0$

Reference point (choose 0 [V])

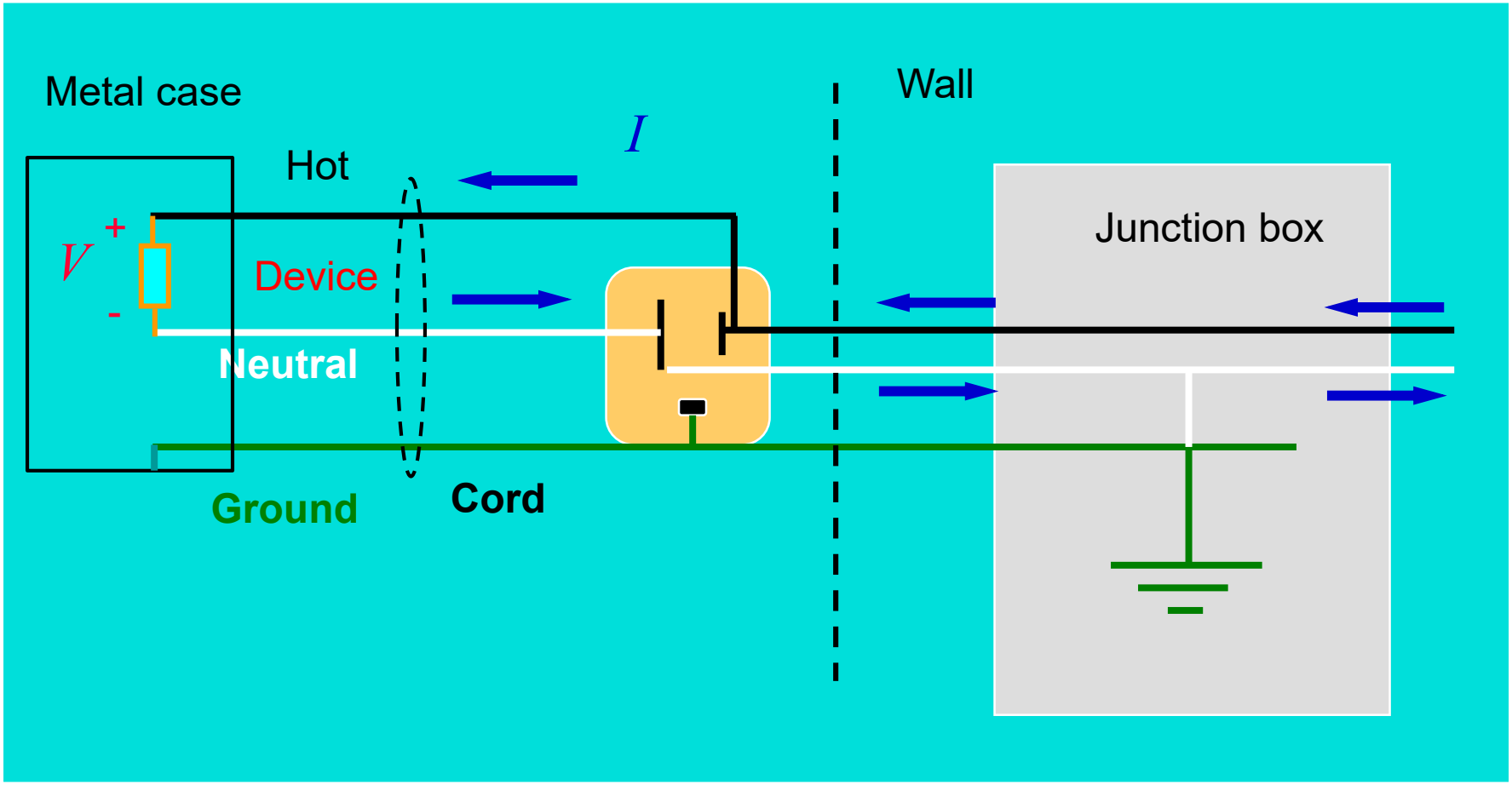
$$V_{AB} = \Phi(\underline{A}) - \Phi(\underline{B}) = 12$$

$$\Phi(\underline{A}) - 0 = 12 \quad \Rightarrow \quad \Phi_A = +12[\mathrm{V}]$$

# Grounding in Power Systems



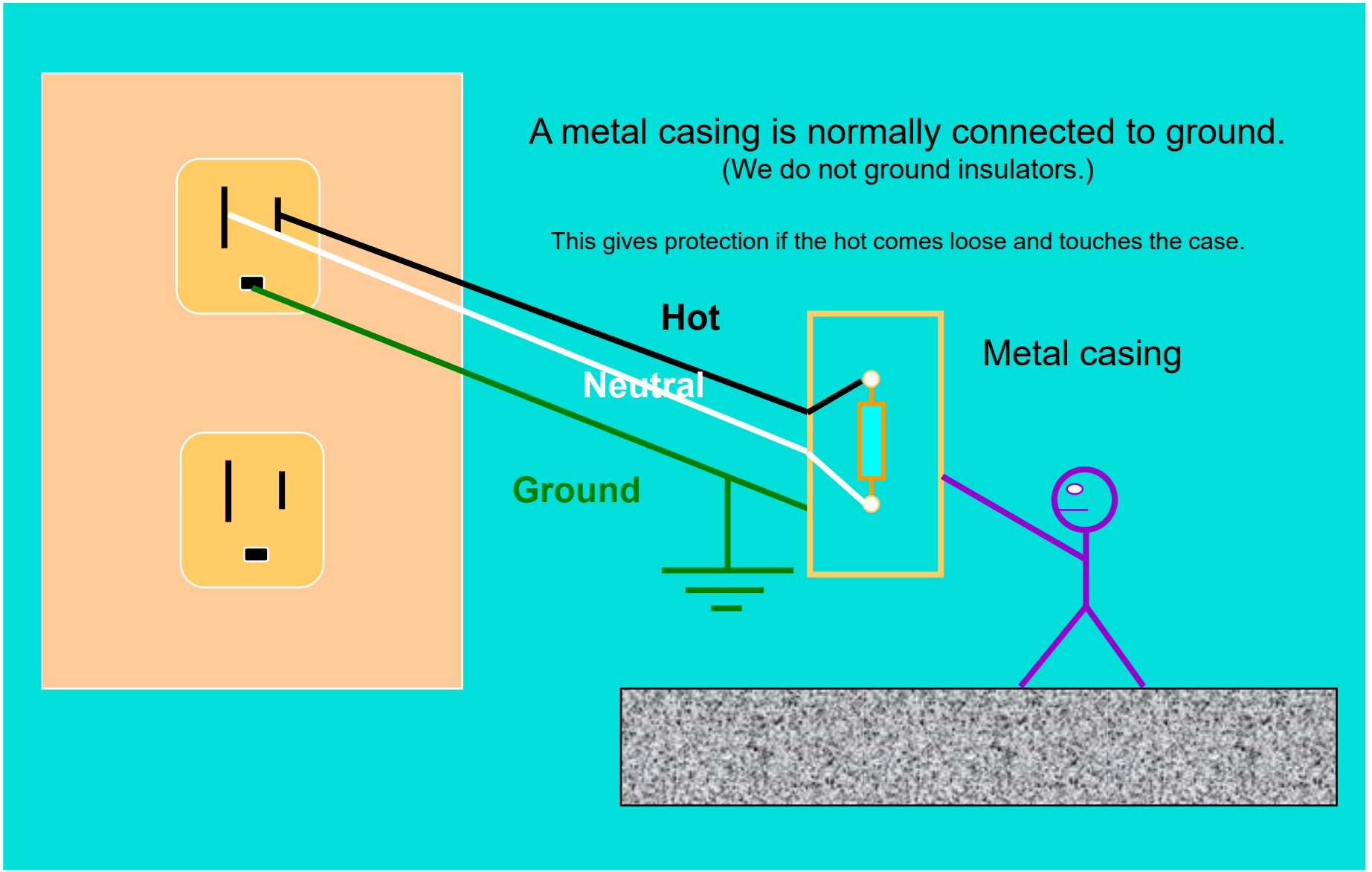
# Grounding in Power Systems (cont.)



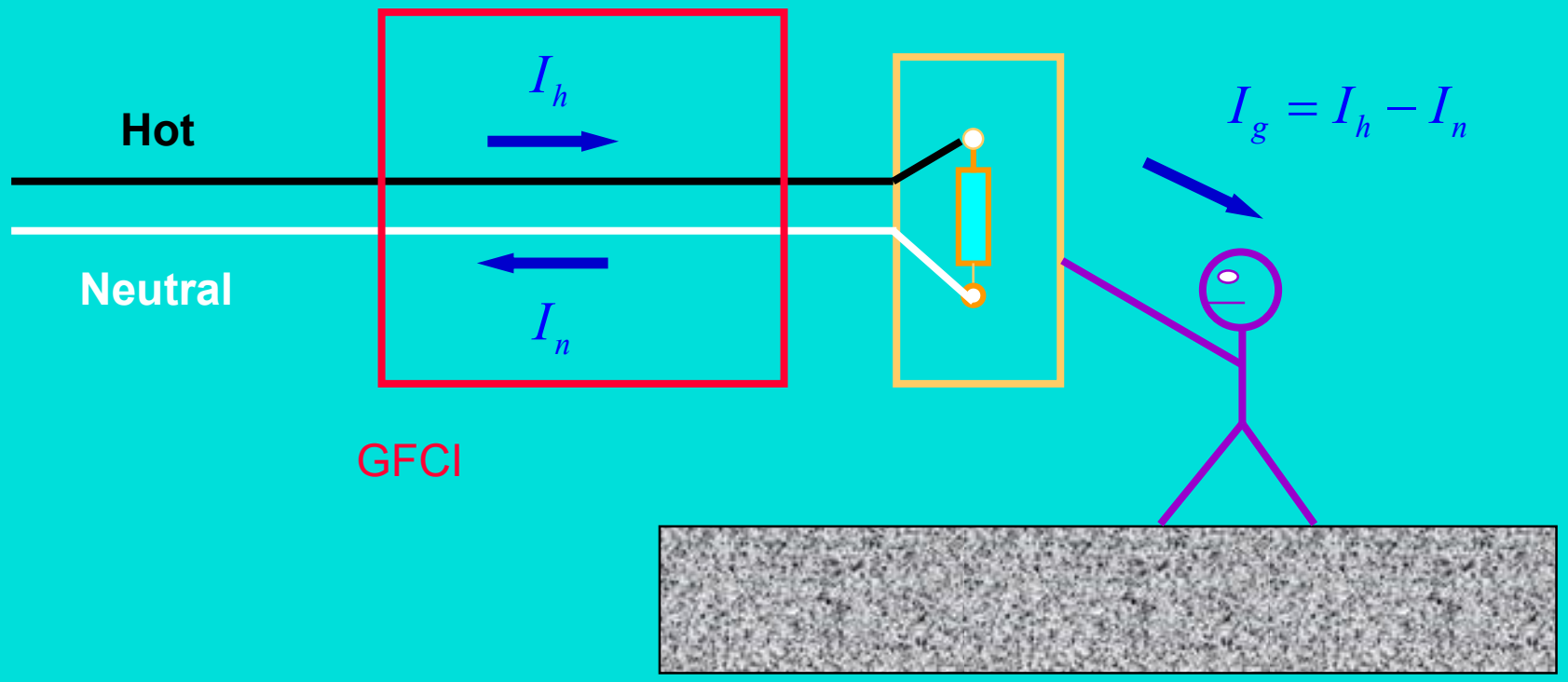

The neutral wire is grounded back at the junction box.

**Note:**
The voltage of the neutral wire at the device is not exactly the same as that of ground, because the neutral wire has a resistance.

# Ground Protection



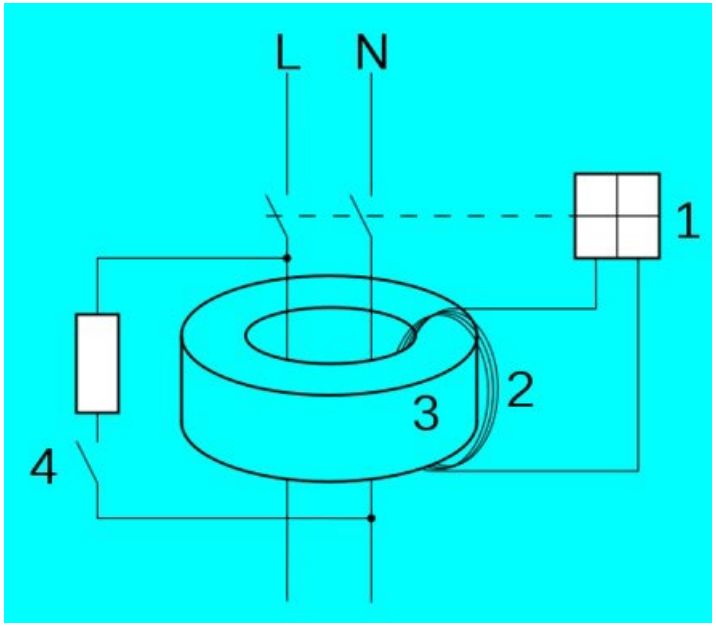
# GFCI (Ground Fault Circuit Interrupter)




In normal operation, $I_g = 0$.

The GFCI circuit trips when $|I_h - I_n| > 5$ [mA] (USA)

# GFCI (cont.)



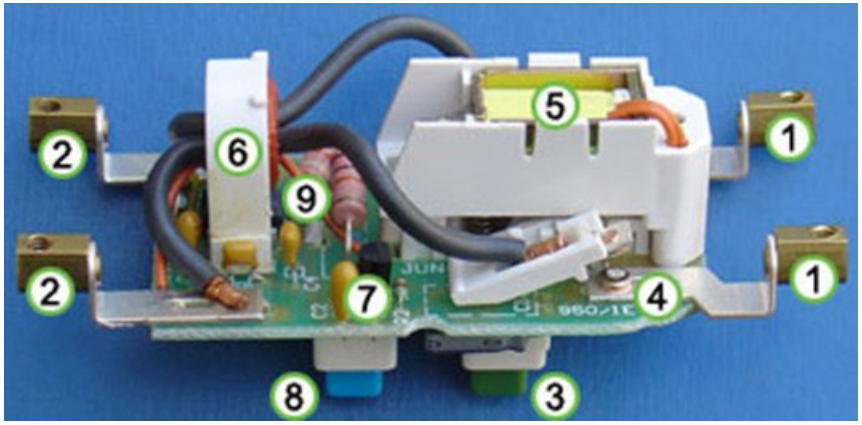

## Principle of operation:

**1.** Electromagnet with electronics
**2.** Current transformer secondary
**3.** Transformer core
**4.** Test switch
**L** Live (hot) conductor
**N** Neutral conductor

A solenoid (electromagnet) normally keeps the contacts (L and N) closed. When the sensing circuit detects a signal (due to an imbalance of the currents), the current to the solenoid stops, and the contacts open by spring action.

http://en.wikipedia.org/wiki/Residual-current_device

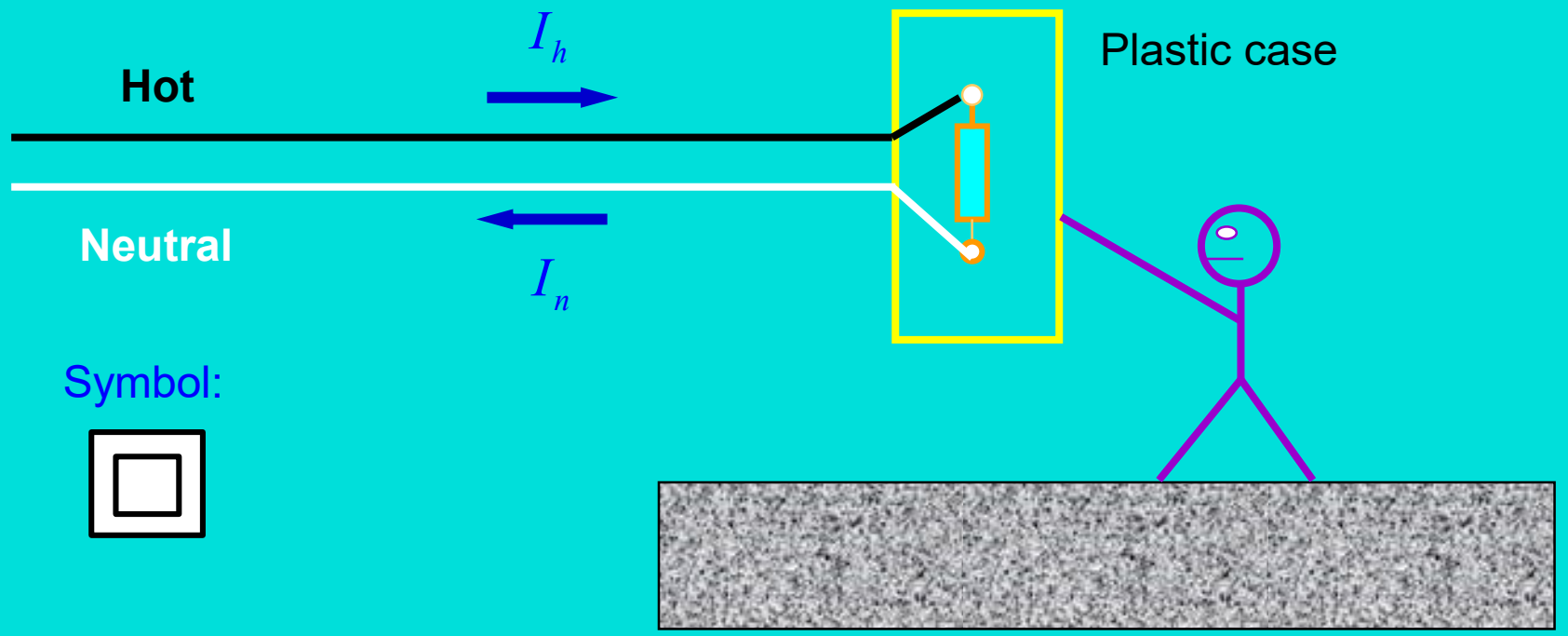
# GFCI (cont.)




1) Input (hot and neutral)
2) Output (hot and neutral)
3) Reset button
4) Contacts
5) Solenoid
6) Sensing coil
7) Sensing circuitry
8) Test button
9) Test wire

http://en.wikipedia.org/wiki/Residual-current_device

# Double Insulated Tool




The device has two layers of insulation (usually the case is an insulating plastic case). It does not require a ground.

# Common Plugs (in US)

Two prong polarized plug

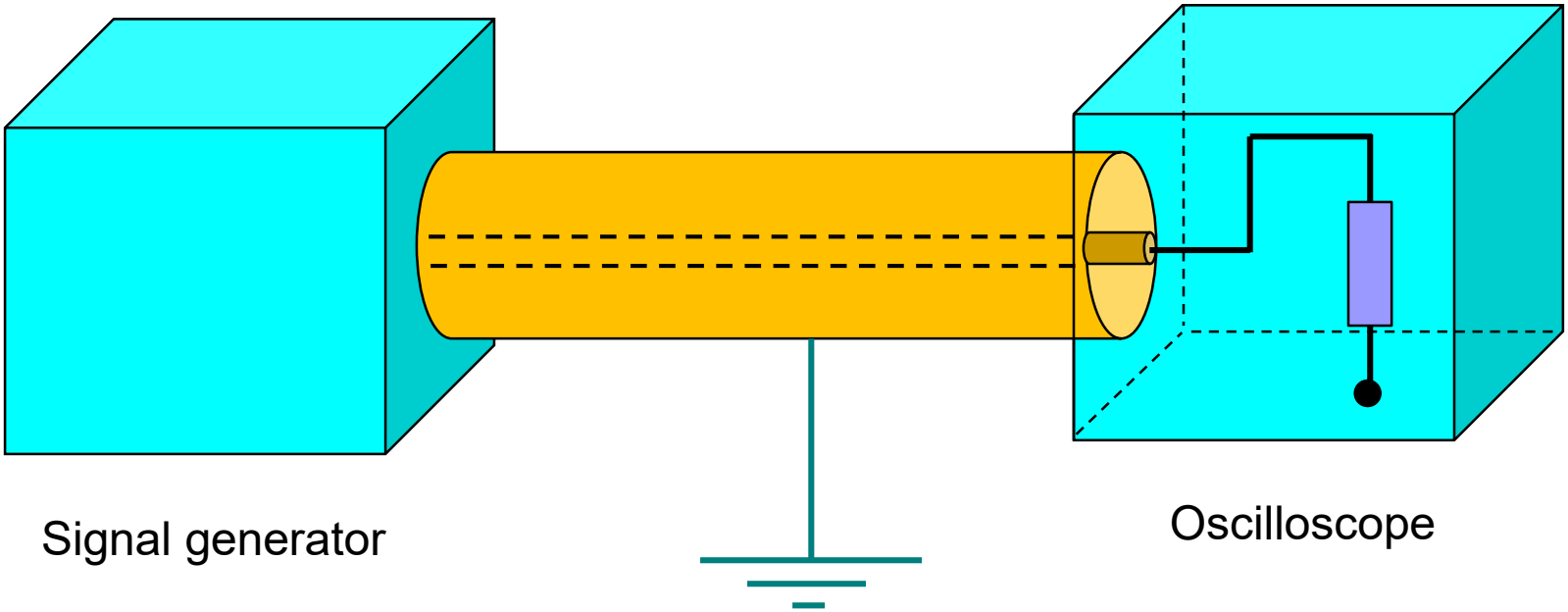
Three prong (grounded) plug

Three prong adapter (“cheater plug”)

# Safety Rules

- Make sure all power tools and equipment are grounded or double insulated.
- If a device has a three-prong connector (grounded plug) make sure that you do not defeat it by bypassing it (plugging it into a two-prong adapter).
- For appliances with a two-prong connection that are not double-insulated (e.g., household lamps), the plug is usually polarized (one prong is larger than the other). Respect this and do not try to plug it in the wrong way, to minimize shock hazard.
- For appliances with a two-prong connection that are not double-insulated (e.g., household lamps), be especially careful to avoid handling them in a wet environment. (The appliance can easily become “hot” if the wiring is faulty.)

# Grounding in Coax Systems




The outer conductor “shield” of the coax is grounded because it is connected to the metal chassis of the equipment, and this is grounded (via a three-prong plug).