

A voltmeter (V) also consists of a galvanometer and a resistor. But the resistor R_{ser} is connected in series, Fig. 19–31, and it is usually large, giving a voltmeter a high internal resistance.

Voltmeter uses series resistor

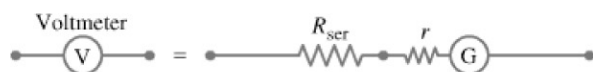


FIGURE 19–31 A voltmeter is a galvanometer in series with a resistor with high resistance, R_{ser} .

EXERCISE F Using the same galvanometer as in Example 19–14 with internal resistance $r = 30 \Omega$ and full-scale current sensitivity of $50 \mu\text{A}$, use Ohm’s law to determine the value of R_{ser} to make a voltmeter that reads from 0 to 15 V.

The meters just described are for direct current. A dc meter can be modified to measure ac (alternating current, Section 18–7) with the addition of diodes (Chapter 29), which allow current to flow in one direction only. An ac meter can be calibrated to read rms or peak values.

AC meters

Voltmeters and ammeters can have several series or shunt resistors to offer a choice of range. **Multimeters** can measure voltage, current, and resistance. Sometimes a multimeter is called a VOM (Volt-Ohm-Meter or Volt-Ohm-Milliammeter).

Multimeters

VOM

Ohmmeters

An **ohmmeter** measures resistance, and must contain a battery of known voltage connected in series to a resistor (R_{ser}) and to an ammeter (Fig. 19–32). The resistor whose resistance is to be measured completes the circuit. The needle deflection is inversely proportional to the resistance. The scale calibration depends on the value of the series resistor. Because an ohmmeter sends a current through the device whose resistance is to be measured, it should not be used on very delicate devices that could be damaged by the current.

The **sensitivity** of a meter is generally specified on the face. It may be given as so many ohms per volt, which indicates how many ohms of resistance there are in the meter per volt of full-scale reading. For example, if the sensitivity is $30,000 \Omega/\text{V}$, this means that on the 10-V scale the meter has a resistance of $300,000 \Omega$, whereas on a 100-V scale the meter resistance is $3 \text{ M}\Omega$. The full-scale current sensitivity, I_m , discussed earlier, is just the reciprocal of the sensitivity in Ω/V .

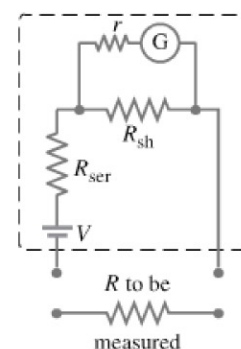


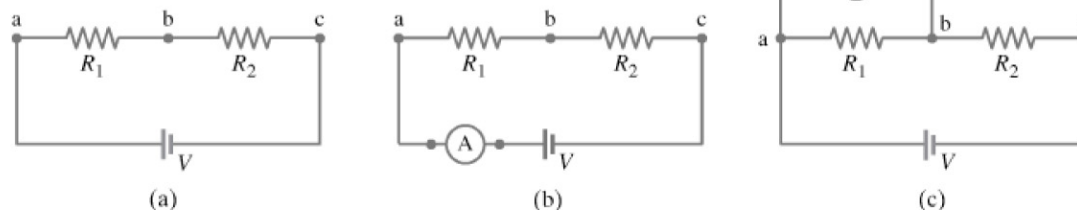
FIGURE 19–32 An ohmmeter.

*** How to Connect Meters**

Suppose you wish to determine the current I in the circuit shown in Fig. 19–33a and the voltage V across the resistor R_1 . How exactly are ammeters and voltmeters connected to the circuit being measured?

PHYSICS APPLIED
How to use meters correctly

FIGURE 19–33 Measuring current and voltage.



Because an ammeter is used to measure the current flowing in the circuit, it must be inserted directly into the circuit, in series with the other elements, as shown in Fig. 19–33b. The smaller its internal resistance, the less it affects the circuit.

Ammeter is inserted into the circuit

A voltmeter, on the other hand, is connected “externally,” in parallel with the circuit element across which the voltage is to be measured. It is used to measure the potential difference between two points. Its two wire leads (connecting wires) are connected to the two points, as shown in Fig. 19–33c where the voltage across R_1 is being measured. The larger its internal resistance, ($R_{\text{ser}} + r$) in Fig. 19–31, the less it affects the circuit being measured.

Voltmeter is connected in parallel