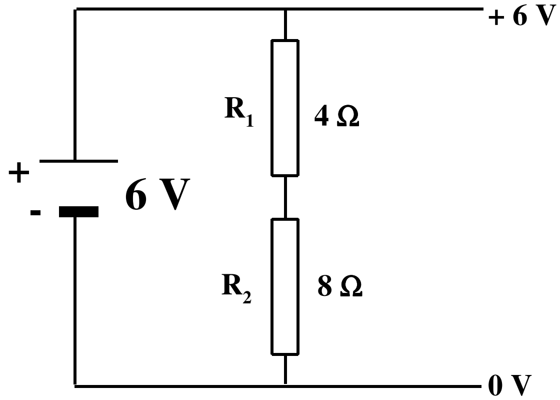
Voltage (Potential) Dividers

A **voltage** (**potential**) **divider** is simply **2 resistors connected across a power supply**, as shown:



$$\text{p.d. across } R_2 = \frac{R_2}{R_1 + R_2} \times V_s$$

$$= \frac{8}{4 + 8} \times 6\text{ V}$$

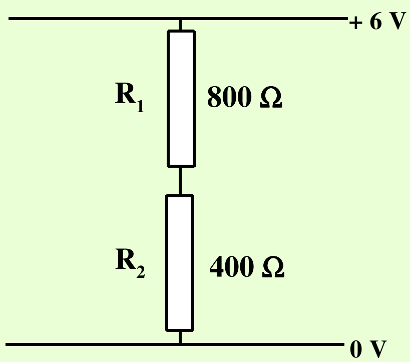
$$= \frac{8}{12} \times 6\text{V} = \underline{\underline{4\text{ V}}}$$

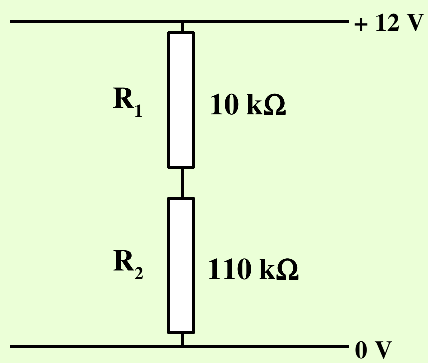
V_s = p.d. across R_1 + p.d. across R_2

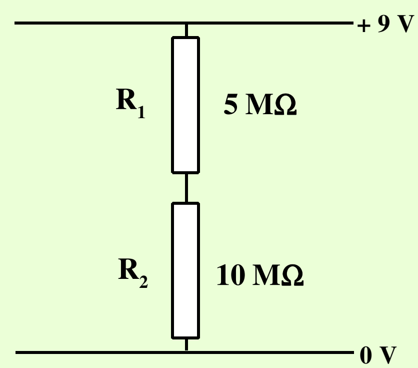
so, p.d. across R_1 = 6 V - 4 V = $\underline{\underline{2\text{ V}}}$

Paul set up each of these voltage (potential) divider circuits.

For each circuit, determine the potential difference (p.d.) across each resistor.

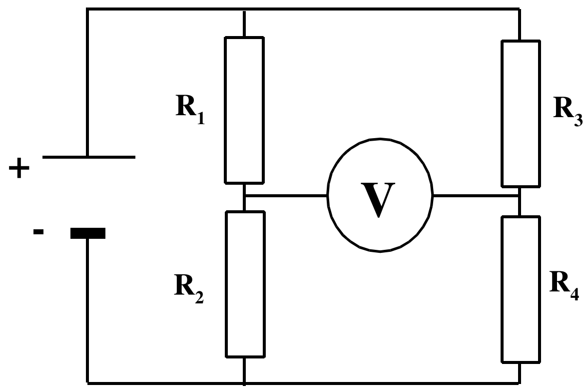


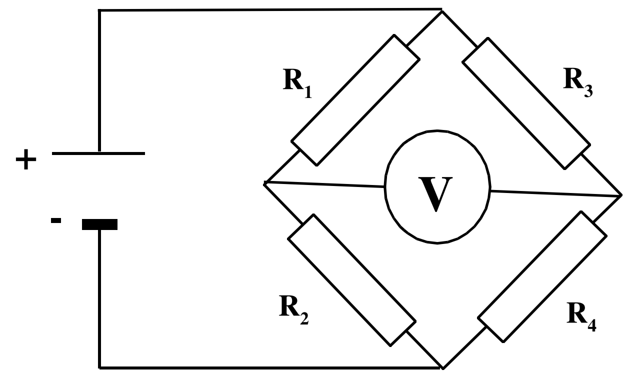




Wheatstone Bridge Circuits

A **Wheatstone Bridge** circuit consists of **2 voltage** (**potential**) **dividers** connected to a **power supply** with a **voltmeter** or sensitive **ammeter** connected between them, as shown:





1) Balanced Wheatstone Bridge

If the voltmeter reads **0 V**, we say the Wheatstone bridge is **balanced**.

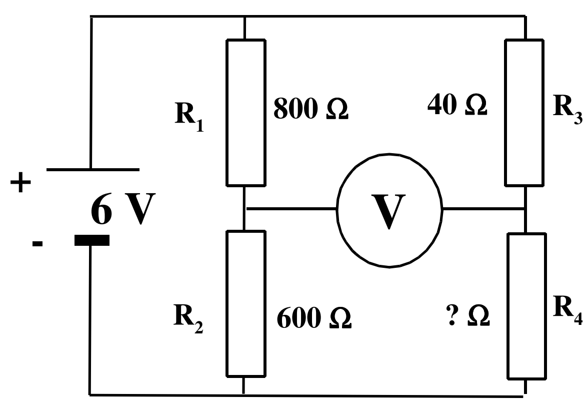
This only happens when:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

The voltage of the battery voltage has no effect on this ratio - If you change the battery voltage, the reading on the voltmeter will still be **0 V**.

Typical Problem

The Wheatstone bridge circuit shown is balanced (the voltmeter reads 0 V). Determine the resistance of R_4.



Wheatstone bridge is balanced, so:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \qquad \frac{800}{600} = \frac{40}{R_4}$$

Cross-multiplying, $800 \times R_4 = 600 \times 40$

so, $R_4 = \frac{600 \times 40}{800} = \underline{\underline{30\ \Omega}}$

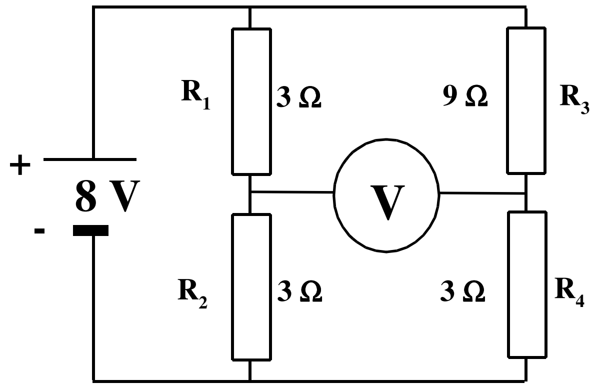
2) Unbalanced Wheatstone Bridge

If the voltmeter **does not read 0 V**, we say the Wheatstone bridge is **unbalanced**.

$$\frac{R_1}{R_2} \textbf{ does not equal } \frac{R_3}{R_4}$$

Typical Problem

The Wheatstone bridge circuit shown is unbalanced. Determine the reading on the voltmeter:



$$\text{p.d. across } R_2 = \frac{R_2}{R_1 + R_2} \times V_s$$

$$= \frac{3}{3+3} \times 8\text{ V}$$

$$= \frac{3}{6} \times 8\text{ V} = \underline{4\text{ V}}$$

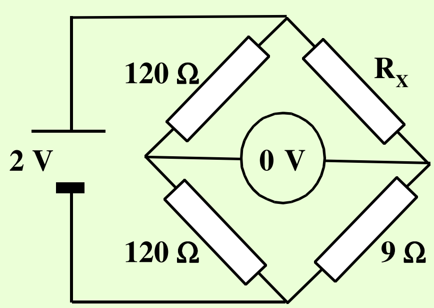
$$\text{p.d. across } R_4 = \frac{R_4}{R_3 + R_4} \times V_s$$

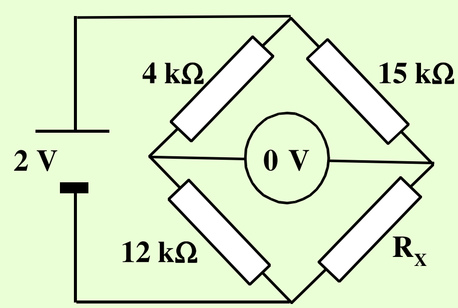
$$= \frac{3}{9+3} \times 8\text{ V}$$

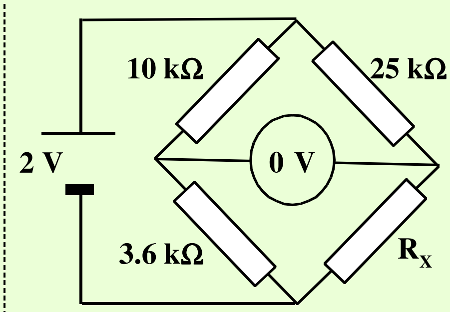
$$= \frac{3}{12} \times 8\text{ V} = \underline{2\text{ V}}$$

so, p.d. across voltmeter (voltmeter reading) = 4 V - 2 V = **2 V**

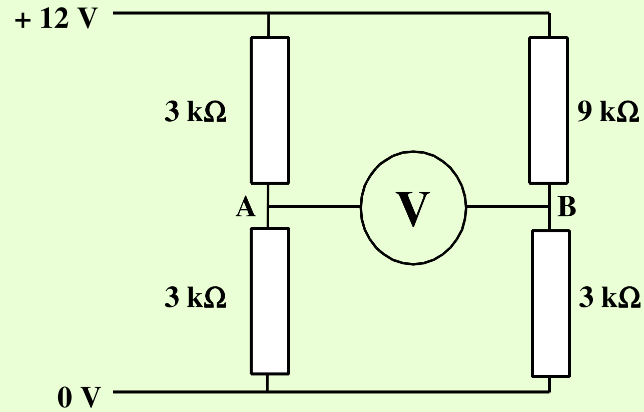
Calculate the value of the unknown resistance (R_x) in each case:

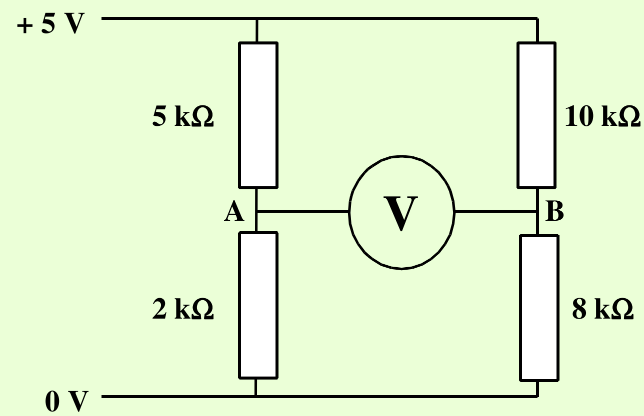


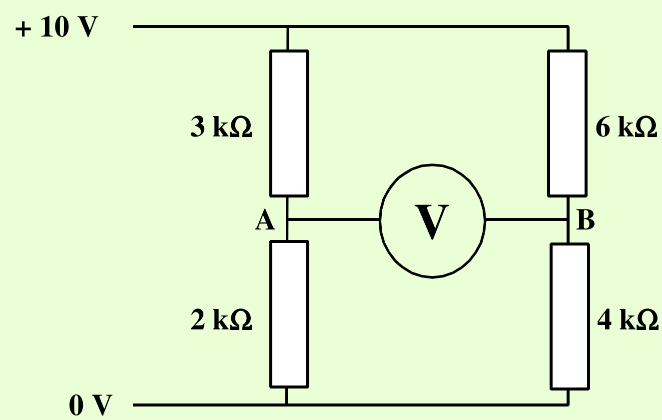


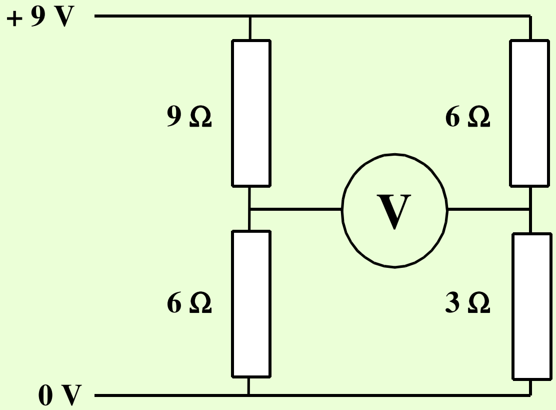


In each case, calculate the potential difference (p.d.) across AB, i.e., the voltmeter reading:







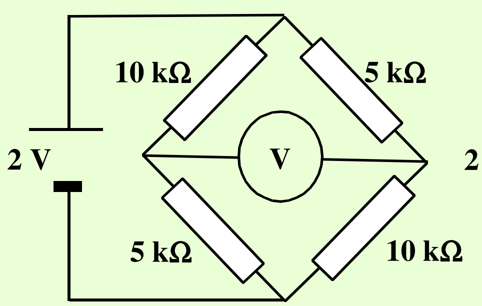


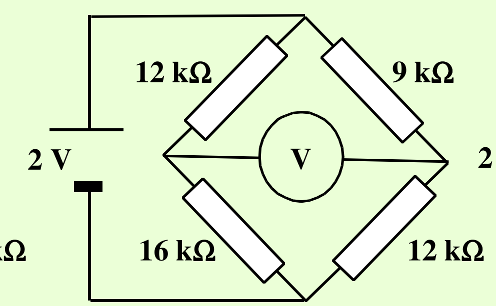
(a) Determine the reading on the voltmeter.

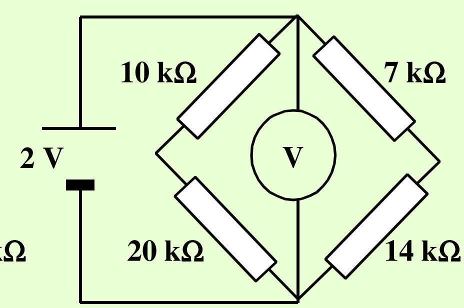
(b) State one alteration you could make to the circuit which would produce a "zero" reading on the voltmeter.

(a) Identify each of these circuits, using the following labels:

balanced Wheatstone bridge *unbalanced Wheatstone brige* *not a Wheatstone bridge*







(b) How do you know when a Wheatstone Bridge is balanced?

(c) For the unbalanced Wheatstone Bridge:

(i) Calculate the potential difference (p.d.) across the voltmeter;

(ii) State the direction of electron flow through the voltmeter.

Practical Application for a Wheatstone Bridge Circuit

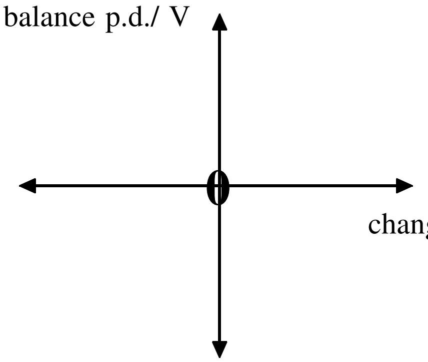
When a Wheatstone bridge circuit is **balanced**, the potential difference (p.d.) across the bridge is always __ V.

The formula connecting the resistors in the balanced Wheatstone bridge is:

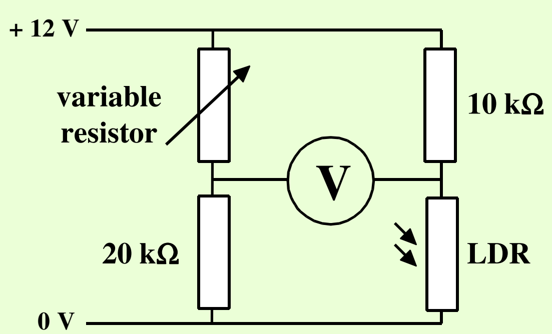
$$\frac{\quad}{\quad} = \frac{\quad}{\quad}$$

However, when the resistance of any **one** resistor in the Wheatstone bridge circuit is changed by a small amount, the bridge becomes _______________ and the above relationship no longer applies - An "out of balance" potential difference (p.d.) is created across the bridge.

The "out of balance" potential difference is directly proportional to the change in resistance for the **one** resistor, as shown on the graph below:



This forms the basis for many sensor devices - For example, a **light meter**.



In this Wheatstone bridge circuit, the variable resistor is adjusted until the bridge is balanced - The voltmeter will read ___ V.

As the light level changes, the resistance of the LDR will change, so the Wheatstone bridge will now be __________________.

An "out of balance" potential difference (p.d.) is created across the bridge, i.e., the voltmeter will show either a positive or negative voltage, depending on whether the light level has increased or decreased.

This "out of balance" potential difference is directly proportional to the change in light level. This allows us to calibrate the voltmeter (put a scale on it), so the voltmeter reading will give the actual value for the light level.

State what device this Wheatstone bridge circuit will be turned into if the LDR is replaced with a:

(a) thermistor: ____

(b) pressure sensitive resistor: __________________________

(c) strain sensitive resistor: ____________________________

Power

The **power** of a circuit component (such as a resistor) tells us how much **electrical potential energy** the component transforms (changes into other forms of **energy**) every second:

$$P = \frac{E}{t}$$

The following formulae are used to calculate **power** (**P**):

$$P = VI \qquad P = I^2R \qquad P = \frac{V^2}{R}$$

In each case, calculate the **power** of the resistor: