

DC BRIDGES:-

Before discussing DC bridges, we will classify resistances according to their values.

- 1):- Low Resistance \Rightarrow ($0.1 \Omega - 1 \Omega$)
- 2):- Medium Resistance \Rightarrow ($1 \Omega - 0.1 M\Omega$)
- 3):- High Resistance \Rightarrow (greater than $0.1 M\Omega$)

Wheatstone Bridge:-

\rightarrow The wheatstone bridge was invented by Samuel Hunter christie in 1833 and improved by Sir Charles wheatstone in 1843.

\rightarrow It is used to measure an unknown electrical resistance (medium value).

\rightarrow The wheatstone bridge is the combination of 4 resistances forming a bridge.

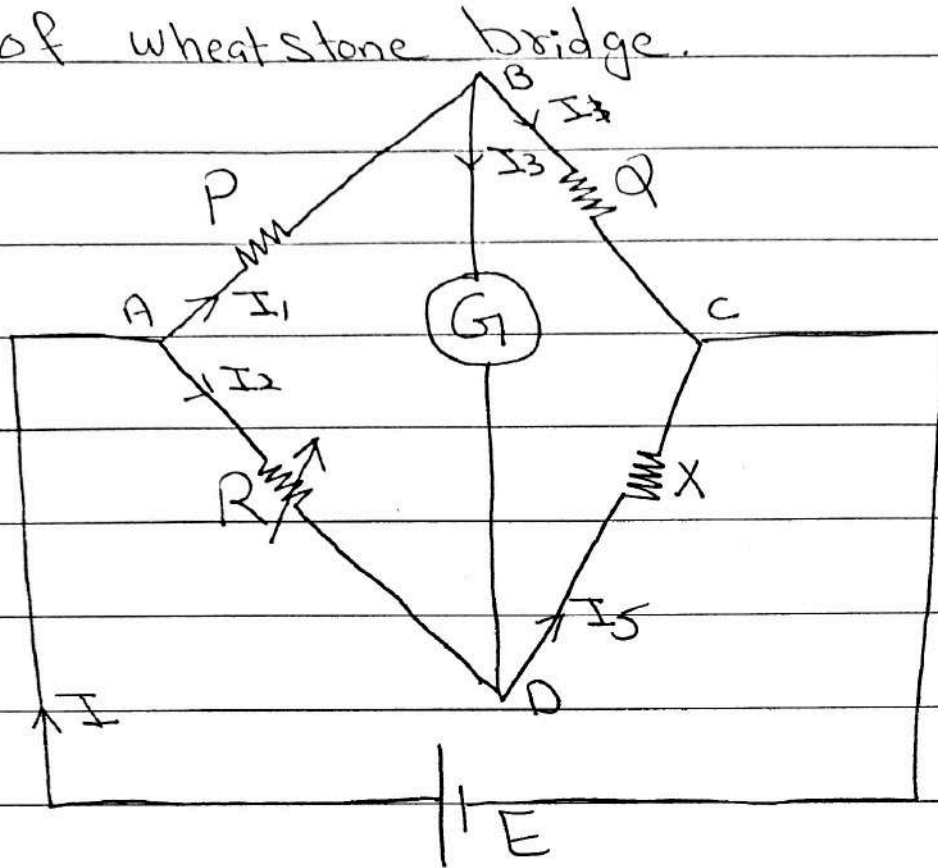
\rightarrow The four resistances in the circuit are referred to as arms of bridge.

\rightarrow The unknown resistance is connected with 2 known resistor and a galvanometer.

\rightarrow To find the value of unknown resistor, the deflection of galvanometer is made zero by adjusting

the variable resistor.

→ This point is known as balance condition of wheatstone bridge.



where, P, Q are known resistances

R is a variable resistor

X is unknown resistance

E is DC power supply

→ Now, in order to find the value of unknown resistor (X), we have to make the deflection of galvanometer equal to zero i.e. $I_3 = 0A$.

→ This condition is called balanced condition of bridge.

When $I_3 = 0A$

$$I_5 = I_2$$

$$\text{Eqn } I_4 = I_1$$

$$\text{Also } V_{AB} = V_A - V_B = I_1 P \text{ --- (1) } (\because V = IR)$$

$$V_{BC} = V_B - V_C = I_1 Q \text{ --- (2)}$$

$$V_{AD} = V_A - V_D = I_2 R \text{ --- (3)}$$

$$V_{DC} = V_D - V_C = I_2 X \text{ --- (4)}$$

at balance condition, when $I_3 = 0A$, potential difference b/w point B and D is zero i.e

$V_B = V_D$ and it is proved below:-

$$\text{As we know that } V_{BD} = V_B - V_D = I_3 G_1$$

$$\text{So } V_{BD} = I_3 G_1$$

$$V_{BD} = (0)(G_1)$$

$$V_{BD} = 0V$$

$$\text{or } V_B - V_D = 0$$

$$\text{or } V_B = V_D \text{ (proved)}$$

Now putting $V_B = V_D$ in eqn (1) & (2)

$$\text{(1) } \Rightarrow V_{AB} = V_A - V_D = I_1 P \text{ --- new eqn (1)}$$

$$V_{BC} = V_D - V_C = I_1 Q \text{ --- new eqn (2)}$$

Now comparing new eq_n (1) with eq_n (3)

$$\Rightarrow I_1 P = I_2 R$$

$$\text{or } \frac{I_1}{I_2} = \frac{R}{P} \quad \text{--- (5)}$$

comparing new eq_n (2) with eq_n (4)

$$\Rightarrow I_2 X = I_1 Q$$

$$\text{or } \frac{I_1}{I_2} = \frac{X}{Q} \quad \text{--- (6)}$$

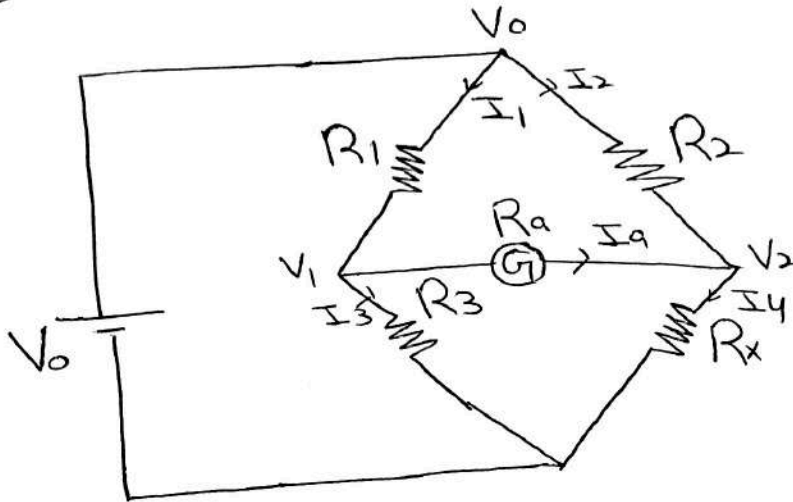
By comparing eq_n (5) & eq_n (6), we can say that:

$$\frac{R}{P} = \frac{X}{Q}$$

$$\text{or } \boxed{X = \left(\frac{R}{P} \right) Q}$$

Q:- For the W.S.B Show in below fig, solve the following problems:-

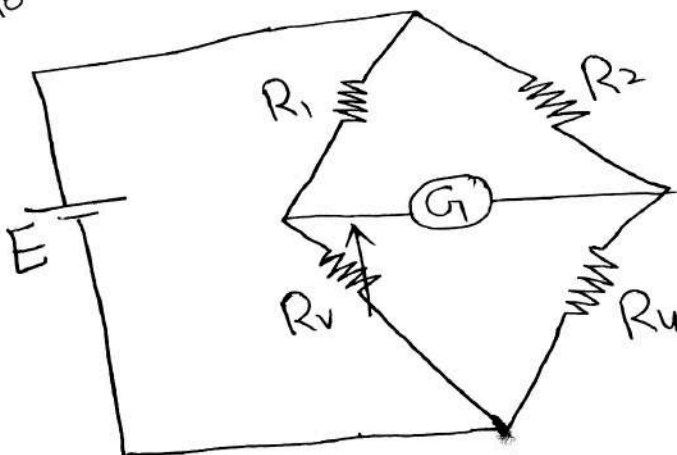
Q1:- If $R_1 = 1\Omega$, $R_2 = 2\Omega$ and $R_x = 3\Omega$, to what value should R_3 be adjusted so as to achieve a balanced condition?



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

$$R_3 = \frac{R_1 R_x}{R_2} = \frac{1 \times 3}{2} = \boxed{1.5\Omega} \text{ Ans.}$$

Q2:- A circuit consists of two resistors $R_1 = 6\Omega$ and $R_2 = 1.5\Omega$, a variable resistor (R_v) and an unknown resistor (R_u) and a 9V battery. connected as shown in the fig below. When R_v is adjusted to 12Ω , there is zero current through the galvanometer. Find the value of R_u .



$$\text{Sol.:- } \frac{R_2}{R_1} = \frac{R_u}{R_v}$$

$$\text{or } R_u = \frac{R_2 R_v}{R_1}$$

$$R_u = \frac{(1.5)(12)}{6}$$

$$\boxed{R_u = 3\Omega} \text{ Ans.}$$

Kelvin's Bridge:

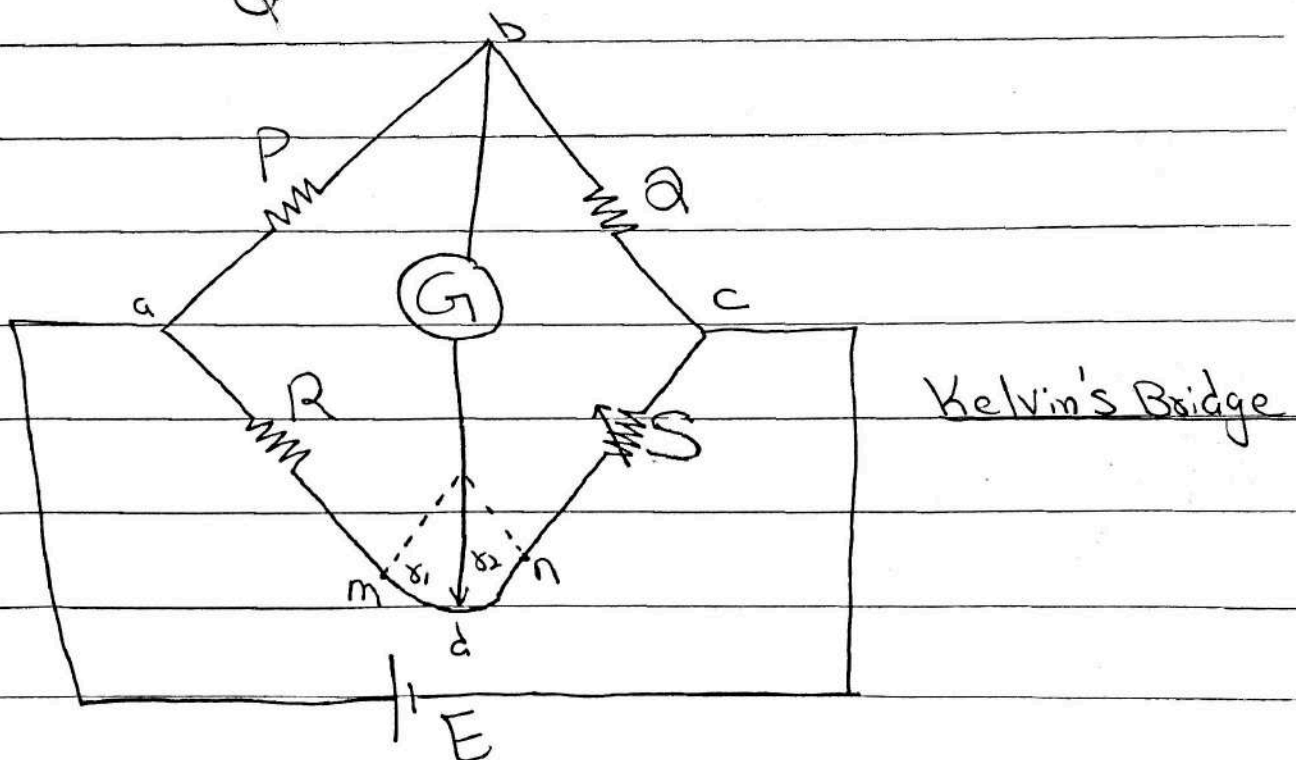
→ This bridge is modification of wheatstone bridge and is used to measure low resistances very accurately.

→ when we are implementing wheatstone bridge in the laboratory, we connect all the resistances through connecting wires.

→ Hence, these connecting wires also have some resistance and in order to measure it, we will use kelvin's bridge.

From W.S bridge, we know that

$$R = \frac{P * S}{Q} \text{ --- (1)}$$



→ In Kelvin bridge, we have a connecting wire b/w point m & n having a resistance (δ).

→ The galvanometer can connect both to point m & n.

when G is connected to point m $\rightarrow S + \delta$

$$\Rightarrow R = \frac{P}{Q} (S + \delta)$$

when G is at point n $\rightarrow R + \delta$

$$\Rightarrow R + \delta = \frac{P}{Q} \times S$$

It can be seen that in both of the cases, we are not getting actual value of unknown resistance (R).

i.e. when G is at point m \rightarrow high value of R .

when G is at point n \rightarrow Low value of R .

Hence, δ is divided into δ_1 and δ_2 by connecting G to point (d) such that:

$$\frac{\delta_1}{\delta_2} = \frac{P}{Q}$$

from eq. (1) :- $R + \delta_1 = \left(\frac{P}{Q}\right)(S + \delta_2)$ — (2)

→ adding 1 on both sides: $\frac{\delta_1 + 1}{\delta_2} = \frac{P}{Q} + 1$

$$\frac{\delta_1 + \delta_2}{\delta_2} = \frac{P+Q}{Q}$$

$$\text{or } \frac{\delta_2}{\delta_1 + \delta_2} = \frac{Q}{P+Q}$$

$$\therefore \frac{\delta_1}{\delta_1 + \delta_2} = \frac{P}{P+Q}$$

$$\Rightarrow \delta_1 = \frac{P}{P+Q} (\delta_1 + \delta_2)$$

$$\delta_1 = \frac{P}{P+Q} (x)$$

$$\text{Similarly } \delta_2 = \frac{Q}{P+Q} (x)$$

From eq. (A):

$$R + \frac{P}{P+Q} (x) = \frac{P}{Q} \left(S + \frac{Q}{P+Q} x \right)$$

$$R + \frac{P}{P+Q} x = \frac{P}{Q} S + \frac{P}{Q} \frac{Q}{P+Q} x$$

$$R + \frac{P}{P+Q} x = \frac{P}{Q} S + \frac{P}{P+Q} x$$

$$\boxed{R = \frac{P}{Q} S}$$

The above eq. Shows that if the galvanometer is

connected at point (d), then the resistance of lead will not affect the result.

→ But practically, finding point (d) is impossible such that ratio of $\frac{x_1}{x_2}$ is equal to $\frac{P}{Q}$.

→ Hence this Kelvin bridge is modified to Kelvin double bridge.