DC BRIDGES:-

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

1):- Low Resistance => ($0.1\Omega - 1\Omega$)

2):- Medium Resistance => ($1.1\Omega - 0.1M\Omega$)

3):- High Resistance => (greater than $0.1M\Omega$)

Wheatstone Bridge:-

→ The wheatstone bridge was invented by Samuel Hunter christie in 1833 and improved by Sir chaules wheatstone in 1843.

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

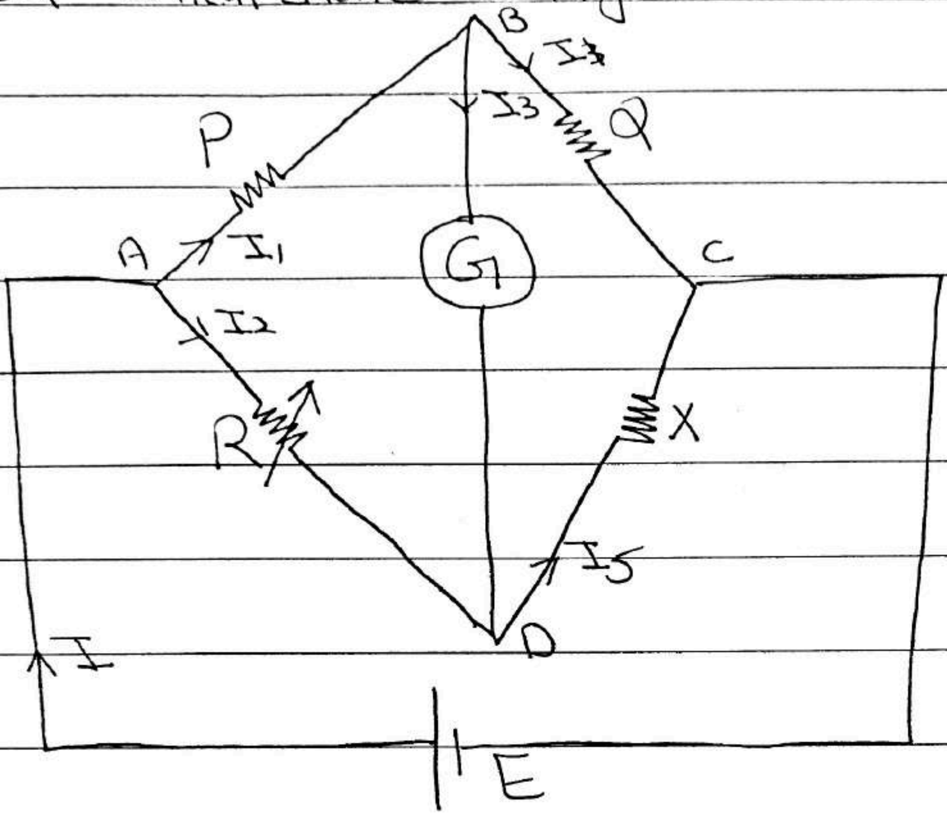
→ The wheatstone bridge is the combination of 4 resistances forming a bridge.

→ The four resistances in the circuit are refered to as arms of bridge.

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

→ 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 $I_3 = 0A$

$I_5 = I_2$

& $I_4 = I_1$

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

$V_{BC} = V_B - V_C = I_1 Q$ — (2)

$V_{AD} = V_A - V_D = I_2 R$ — (3)

$V_{DC} = V_D - V_C = I_2 X$ — (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 prooved below:-

As we know that $V_{BD} = V_B - V_D = I_3 G$

So $V_{BD} = I_3 G$

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

$V_{BD} = 0V$

or $V_B - V_D = 0$

or $V_B = V_D$ (prooved)

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

(1) => $V_{AB} = V_A - V_D = I_1 P$ — new eq (1)

$V_{BC} = V_D - V_C = I_1 Q$ — new eq (2)

Now comparing new eq^n (1) with eq^n (3)

$\Rightarrow I_1 P = I_2 R$

or $\frac{I_1}{I_2} = \frac{R}{P}$ ——— (5)

comparing new eq^n (2) with eq^n (4)

$\Rightarrow I_2 X = I_1 Q$

or $\frac{I_1}{I_2} = \frac{X}{Q}$ ——— (6)

By comparing eq^n (5) & (6), we can say that:

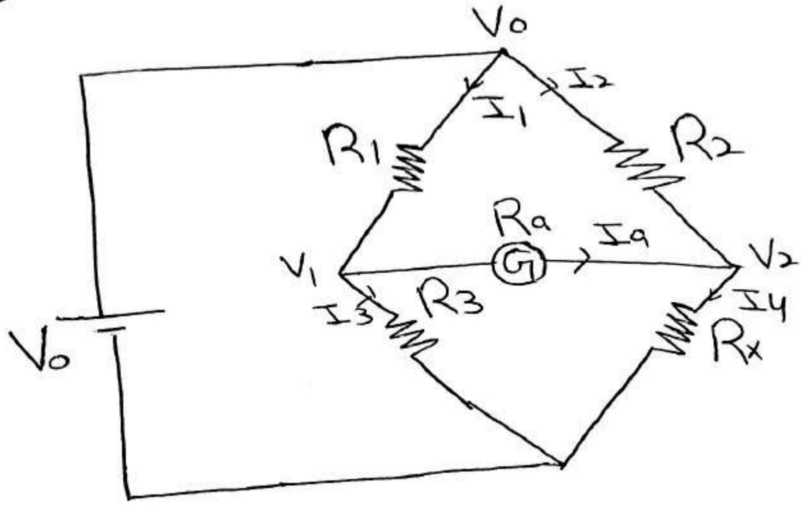
$\frac{R}{P} = \frac{X}{Q}$

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

(4)

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

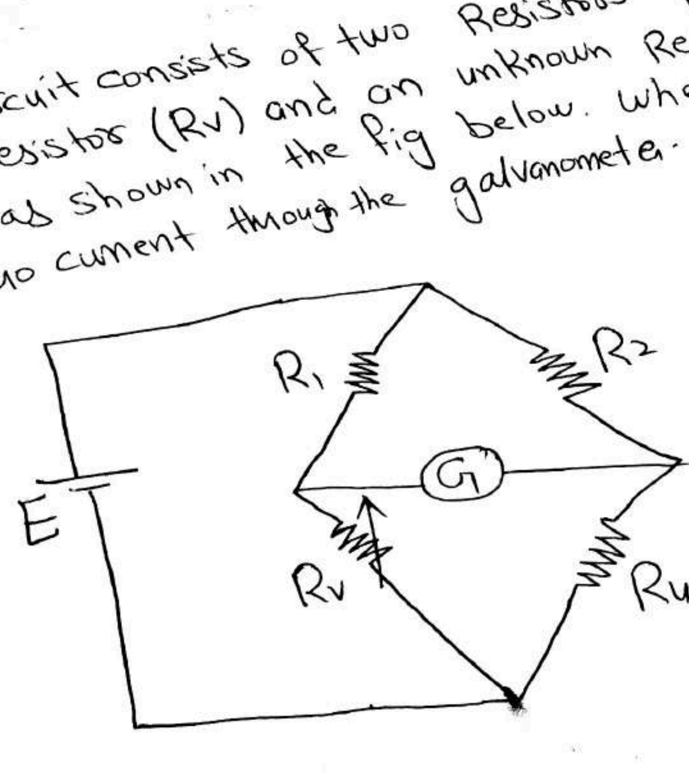
(i):- If $R_1 = 1\Omega$, $R_2 = 2\Omega$ and $R_x = 3\Omega$, to what value should R_3 be adjusted so as to acheive a balanced condition?



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

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

Q:- 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. are 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.



Sol^n:- $\frac{R_2}{R_1} = \frac{R_u}{R_V}$

or $R_u = \frac{R_2 R_V}{R_1}$

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

$\boxed{R_u = 3\Omega}$ Ans:-

Kelvin's Bridge:-

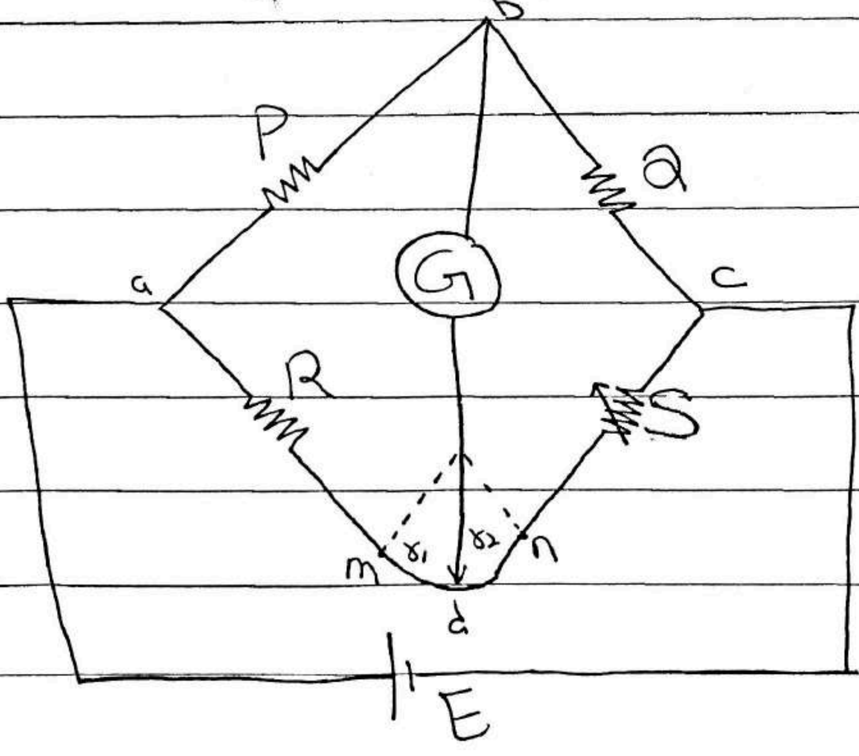
→ This bridge is modification of wheatStone bridge and is used to measure low resistances very accurately.

→ 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

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



Kelvin's Bridge

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

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

when G is connected to point m → $S + r$

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

when G is at point n → $R + r$

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

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 → high value of R.

when G is at point n → Low value of R.

Hence, r is divided into r_1 and r_2 by connecting G to point (d) such that:

$$\frac{r_1}{r_2} = \frac{P}{Q}$$

from eq (1):- $R + r_1 = \left(\frac{P}{Q}\right)(S + r_2)$ — (17)

→ adding 1 on both sides:- $\frac{r_1}{r_2} + 1 = \frac{P}{Q} + 1$

$$\frac{r_1+r_2}{r_2} = \frac{P+Q}{Q}$$

or $$\frac{r_2}{r_1+r_2} = \frac{Q}{P+Q}$$

$$\therefore \quad \frac{r_1}{r_1+r_2} = \frac{P}{P+Q}$$

$$\Rightarrow \quad r_1 = \frac{P}{P+Q}(r_1+r_2)$$

$$r_1 = \frac{P}{P+Q}(r)$$

Similarly $r_2 = \frac{Q}{P+Q}(r)$

from eq$_n$ (A):

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

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

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

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

The above eq$_n$ 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 $\frac{r_1}{r_2}$ is equal to $\frac{P}{Q}$.

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