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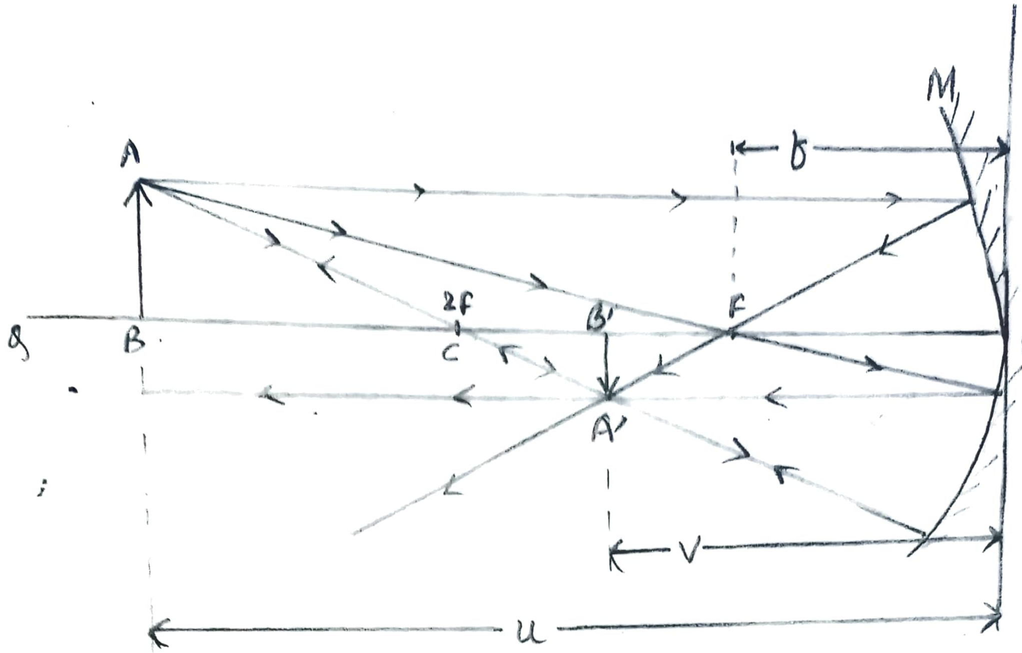
2) i)



Here, we take a concave mirror with pole at P and PQ is the principal axis.

Let, the object is placed at B (AB) at a distance u from the Pole.

The rays used are:

i) Ray from centre of curvature, C always retraces its path.

ii) A ray parallel to principal axis always passes through the ~~Cent~~ focus of the mirror (f)

iii) A ray passing through the focus from the object always goes parallel to principal axis (at infinity)

The point where all these 3 rays meet is called athe point of image formation. The image A'B' is formed which is real and inverted and diminished in size.

From the scale marked on optical bench, find the object length = u cm image distance, v cm and hence the focal length can be ~~measure~~ calculated from:

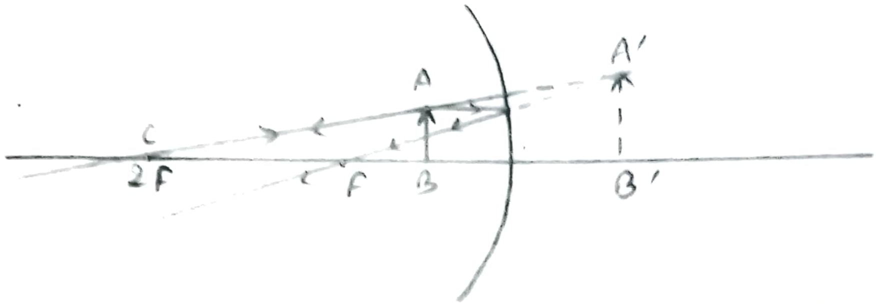
$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \text{or,} \quad f = \frac{uv}{u+v}$$

We can get different values of f, for different values of u. ~~&~~ and v. By taking their averages, the mean focal length can be calculated.

ii) To ~~get~~ obtain an image on a screen, the object should always be placed at a distance greater than its focal length, f.

ie; $u > f$.

Because ~~the~~ if object is placed betⁿ f and Pole, the image is virtual and cannot be obtained on the screen.



In the above case, ~~of~~ image is virtual, erect and enlarged but cannot be obtained on screen.

So, to obtain the image on screen, the object distance > focal length.

iii)

No. of observation		Position of source u (cm)	Position of Screen v (cm)	u (m)	v (m)	$\frac{1}{u}$ (m^{-1})	$\frac{1}{v}$ (m^{-1})	$\frac{1}{f}$ (m^{-1})	f (m) $f = 1/(1/f)$	~~f (m)~~
1	$u < v$	22	52.5	0.22	0.525	4.545	1.905	6.45	0.155	
2	$f < u < 2f$	25	40.7	0.25	0.407	4	2.457	6.46	0.155	
3		28	34.8	0.28	0.348	3.571	2.874	6.458	0.155	
4	$u > v$	35	29.5	0.35	0.295	2.857	3.39	6.25	0.16	
5	$2f < u$	40	26.5	0.4	0.265	2.5	3.774	6.274	0.159	
6		45	23.5	0.45	0.235	2.22	4.26	6.48	0.154	

Mean focal length $= \frac{\Sigma f}{N}$

$$= \frac{0.155 + 0.155 + 0.155 + 0.16 + 0.159 + 0.154}{6}$$

$$\simeq \left(\frac{0.938}{6}\right) m$$

$$\simeq 0.156\overline{3}\ m$$

$$\simeq 15.6\overline{3}\ cm$$

(3) i) In the 'R' arm, the resistances present ranges from 1 to 5000. There is also an infinity key which is used for checking if the circuit is connected correctly or not. Pair of ratio arms are each 10, 100, 1000 ohms.

ii) → If $S = 35.7\,\Omega$, then, in R arm, $35\,\Omega$ and $36\,\Omega$ will give opposite deflection. [one in right side & other in left side] [for 10 : 10 ratio in ratio arm].

→ For 100 : 10 ratio, no deflection is found at $\frac{P}{Q} = \frac{R}{X} = \frac{100}{10}$

where, X is unknown resistance.

Using this, $R = 10X = 10S$

$R = 10 \times 35.7\,\Omega$

$\Rightarrow \boxed{R = 357\,\Omega}$

iii)

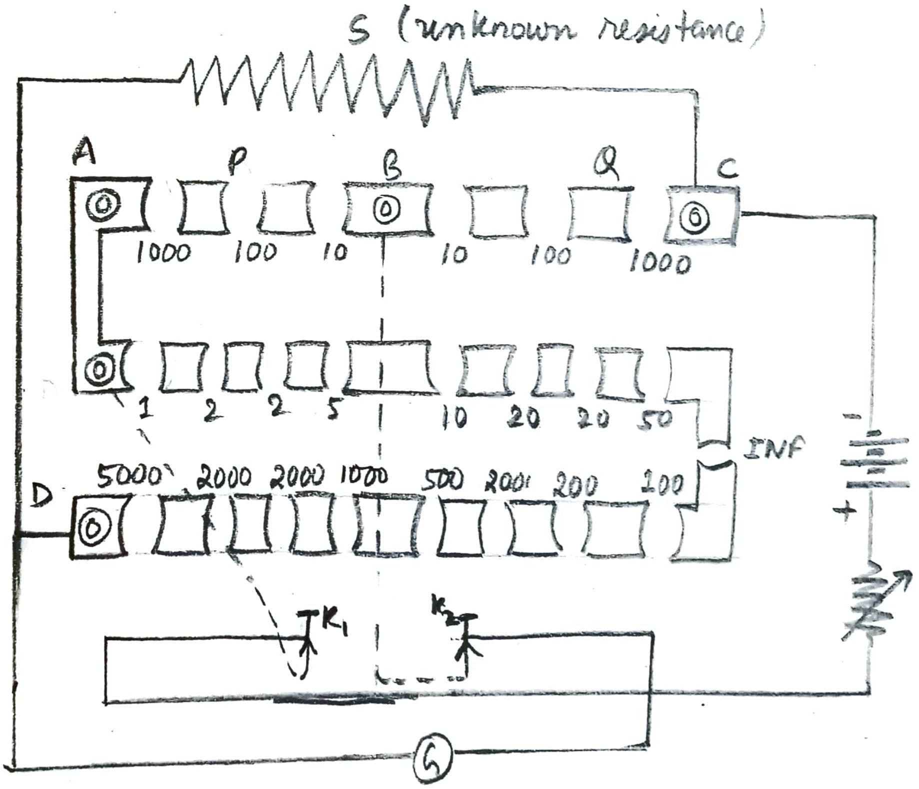
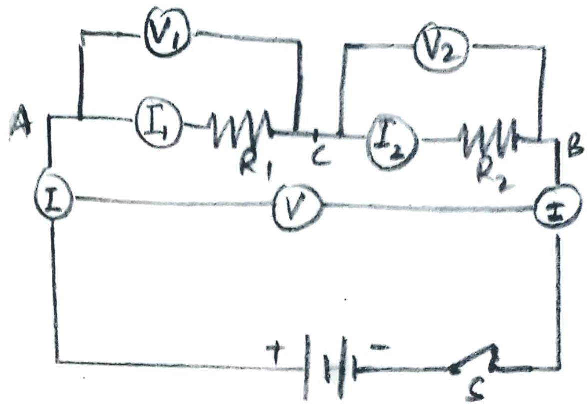
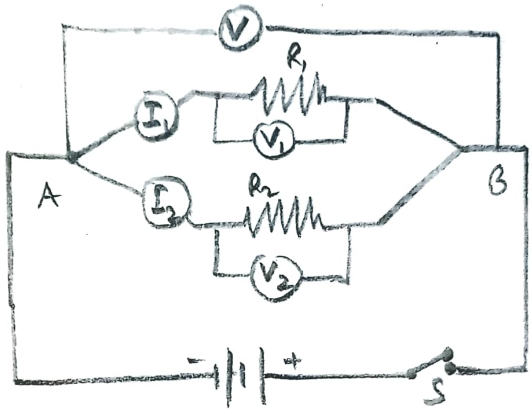


Fig: Post office Box circuit with external unknown resistance and biasing.

4 i)



Circuit for Series resistance with all measurable parameters



Circuit for parallel resistance combination with all measurable parameters.

(ii)

R_1 Ω	R_2 Ω	I A	V_1 V	V_2 V	V	$R_1 exp = V_1/I$ (Ω)	$R_2 exp = V_2/I$ (Ω)	$R_{Th} = R_1+R_2$ (Ω)	$R_{exp} = R_1exp + R_2exp$ (Ω)	$R_{ac} = V/I$ Ω
100	20	0.027A	0.65V	2.85	3.5	23.81	104.396	120	128.206	128.4 Ω

→ Here, $V_1 = V - V_2$
$= 3.5 - 2.85$
$= 0.65V$

→ $I = \frac{V}{R_{ac}} = \frac{3.5}{128.4} = 0.0273A$

→ $R_1 exp = \frac{V_1}{I} = \frac{0.65}{0.0273} = 23.81\Omega$

→ $R_2 exp = \frac{V_2}{I} = \frac{2.85}{0.0273} = 104.396\Omega$

Now,
$R_{Th} = R_1 + R_2$
$= 100 + 20$
$= 120\Omega$

$R_{exp} = R_1 exp + R_2 exp$
$= 23.81 + 104.396\Omega$
$= 128.206\Omega$

iii) ~~So~~ To check our calculation of results in:

a) Series: we ~~verify is~~ check if $\underline{V_1 + V_2 = V}$ and compare R_{Th}, R_{exp} & R_{ac}.

b) Parallel: we check if $\underline{I_1 + I_2 = I}$

and compare R_{Th}, R_{exp}, R_{ac}.

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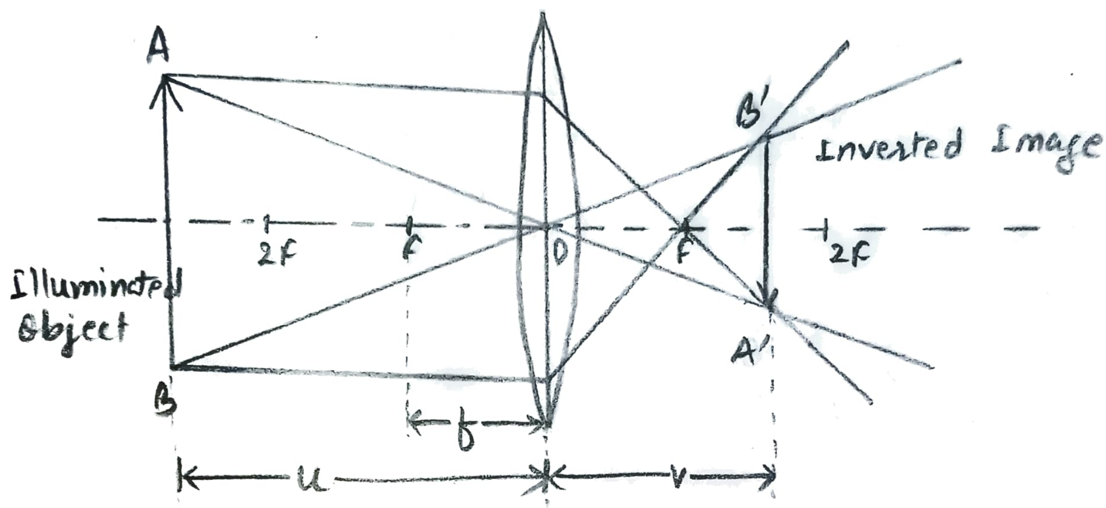
5. i) $\underline{u > 2f}$ then, $\underline{f < v < 2f}$



Here the object distance is u and image distance is v. Therefore, focal length, f can be calculated from using the formula:

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \text{(with sign)}$$

If we consider signs as u -ve and v +ve then, (Cartesian sign convention).

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

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ii) → To find approximate focal length of a convex lens, we keep ~~object at~~ the light source (object) at a large distance and the image formed is at focus of lens. Hence, the approximate focal length is found out.

→ It is called approximate (not exact/actual) focal length because the ~~light sour~~ exact infinity is not possible. The light source is not placed at a very very large distance. ~~Hence~~ Moreover, we ~~cannot~~ ~~never~~ cannot put the object at exact infinity and hence, cannot get exact focus point.

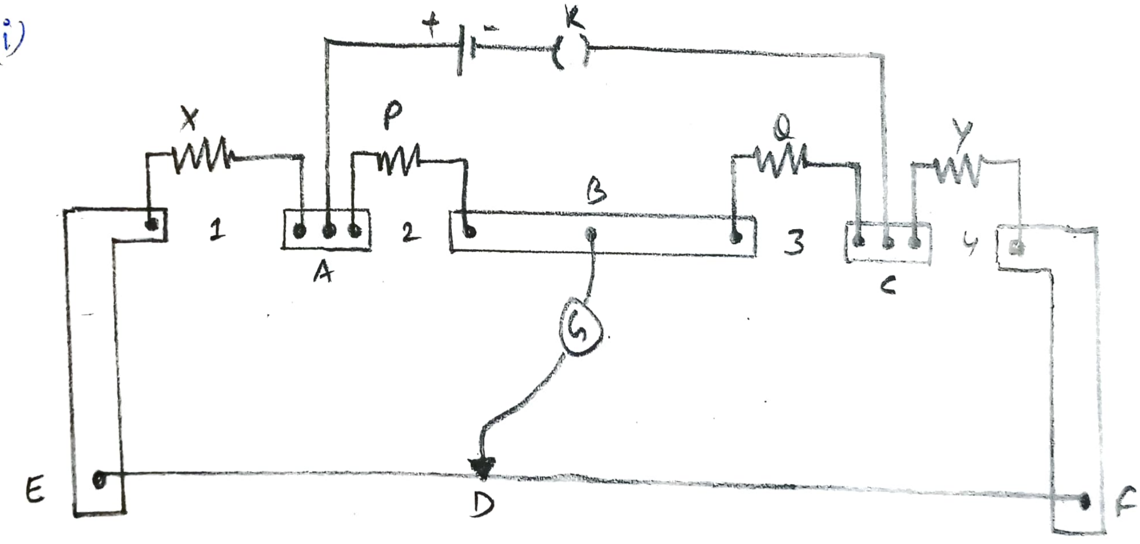
(vii)

No. of obs.	image	Screen (cm)	Source (cm)	Screen (cm)	u (cm)	v (cm)	u (m)	v (m)	$\frac{1}{u}$ (m^{-1})	$\frac{1}{v}$ (m^{-1})	$\frac{1}{f}$ (m^{-1})	f (m)
1	$f<u<2f$	80	100	9.1	20	70.9	0.2	0.709	5	1.41	6.41	0.156
2			102	23.5	22	56.5	0.22	0.565	4.545	1.77	6.315	0.158
3			105	35.5	25	44.5	0.25	0.445	4	2.25	6.25	0.16
4	$u>2f$	80	115	50.5	35	29.5	0.35	0.295	2.857	3.39	6.247	0.16
5			120	54.7	40	25.3	0.4	0.253	2.5	3.952	6.452	0.155
6			125	57.1	45	22.9	0.45	0.229	2.22	4.367	6.587	0.152

Mean focal length $= \frac{\Sigma f}{N} = \frac{0.941}{6} \simeq 0.156\ m = 15.6\ cm$

$= \frac{0.877}{6} \simeq 0.146\ m \simeq 14.6\ cm$

(6.) (i)



Cary Foster's bridge circuit with baising & proper labeling.

(ii) Working Formula:

Let, the balanced point is located at a distance l_1 from ~~from~~ left pt. E.

Then, from balanced condition of wheatstone bridge, we get,

$$\frac{P}{Q} = \frac{R}{S} = \frac{X + l_1 \rho}{Y + (100 - l_1)\rho} \quad \text{--- (i)}$$

where,

ρ is the resistance per unit length.

X & Y are the known resistances.

→ If the positions of X & Y is reversed (interchanged) ie; X on right gap & Y on left gap; then, the balanced pt. is (say) l_2 from E.

Therefore, balanced condition can be written as:

$$\frac{P}{Q} = \frac{R}{S} = \frac{Y + l_2 \rho}{X + (100 - l_2)\rho} \quad \text{--- (ii)}$$

→ From eqn (i) & (ii), we see that LHS is same. So, ~~for~~ equating RHS, we get:

$$\frac{X + l_1 \rho}{Y + (100 - l_1)\rho} = \frac{Y + l_2 \rho}{X + (100 - l_2)\rho}$$

On adding 1 to both sides; we get:

$$\frac{X + Y + \cancel{l_1 \rho} + 100\rho - \cancel{l_1 \rho}}{Y + (100 - l_1)\rho} = \frac{X + Y + \cancel{l_2 \rho} + 100\rho - \cancel{l_2 \rho}}{X + (100 - l_2)\rho}$$

$$\Rightarrow \frac{X + Y + 100\rho}{Y + (100 - l_1)\rho} = \frac{X + Y + 100\rho}{X + (100 - l_2)\rho}$$

Clearly, the numerator is equal. On equating the denominators, we get,

$$X + (100 - l_2)\rho = Y + (100 - l_1)\rho$$

$$\Rightarrow Y = X - (l_2 - l_1)\rho$$

Now, if the value of $Y = 0$ ie; resistance is replaced by a metal strip

then, $X = (l_2 - l_1)\rho$

or, $(l_2 - l_1) = X/\rho$

→ Now for different values of X, a set of null pts., $(l_2 - l_1)$ is obtained. which can be plotted. The graph between $(l_2 - l_1)$ and X is a straight line whose slope gives the value of $1/\rho$ and hence, ρ ie, resistance per unit length can be calculated.

→ Moreover, the graph passes through because at balanced pt. (or null pt.) $l_1 = l_2$ and $X = Y$ iè, $X = 0$.

(iii)

no. of obs	X (Ω)	l_1 (cm	l_2 (cm)	$(l_2 - l_1)$ cm	$1/\rho = \frac{l_2 - l_1}{X}$ cm/Ω	ρ (Ω/cm)
1.	0.5	42.2	50.5	8.3	16.6	0.060
2.	1.0	38.5	54.2	15.7	15.7	0.064
3.	1.5	34.6	59.6	25	16.67	0.060
4.	2	30.4	63.5	33.1	16.55	0.060
						$\Sigma\rho$ = Total = 0.244 Ω/cm

$\Rightarrow$ mean $\rho = \frac{\Sigma \rho}{N} = \frac{0.244}{4} = 0.061$ Ω/cm.

Therefore, the Resistance per unit length, $\delta = 0.061$ cm

After Correction:

4. (ii) $V_1 = 2.85 V$ & $V_2 = ?$

R_1 (Ω)	R_2 (Ω)	I	V_1 (V)	V_2	V	$R_1 exp = V_1/I$	$R_2 exp = V_2/I$	$R_{Th} = R_1 + R_2$ (Ω)	$R_{exp} = (R_1 exp + R_2 exp)$	$R_{ac} = V/I$ Ω
100	20	0.027 A	2.85	0.65 V	3.5	105.5	24.07 Ω	120 Ω	129.57 Ω	128.4

(a) $I = \frac{V_1}{R_1 exp} = \frac{2.85}{105.5} = 0.027 A$

Also, $I = \frac{V}{R_{ac}} = \frac{3.5}{128.4} = 0.027 A$.

(b) Now, $V_2 = V - V_1 = 3.5 - 2.85 = 0.65 V$

(c) $R_2 exp = \frac{V_2}{I} = \frac{0.65}{0.027} = 24.07 \Omega$

(d) $R_{Th} = R_1 + R_2 = 120 \Omega$

(e) $R_{exp} = R_1 exp + R_2 exp$

$= (105.5 + 24.07) \Omega$

$= 129.57 \Omega$

Here, $R_{exp} > R_{ac} > R_{Th}$