Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 10

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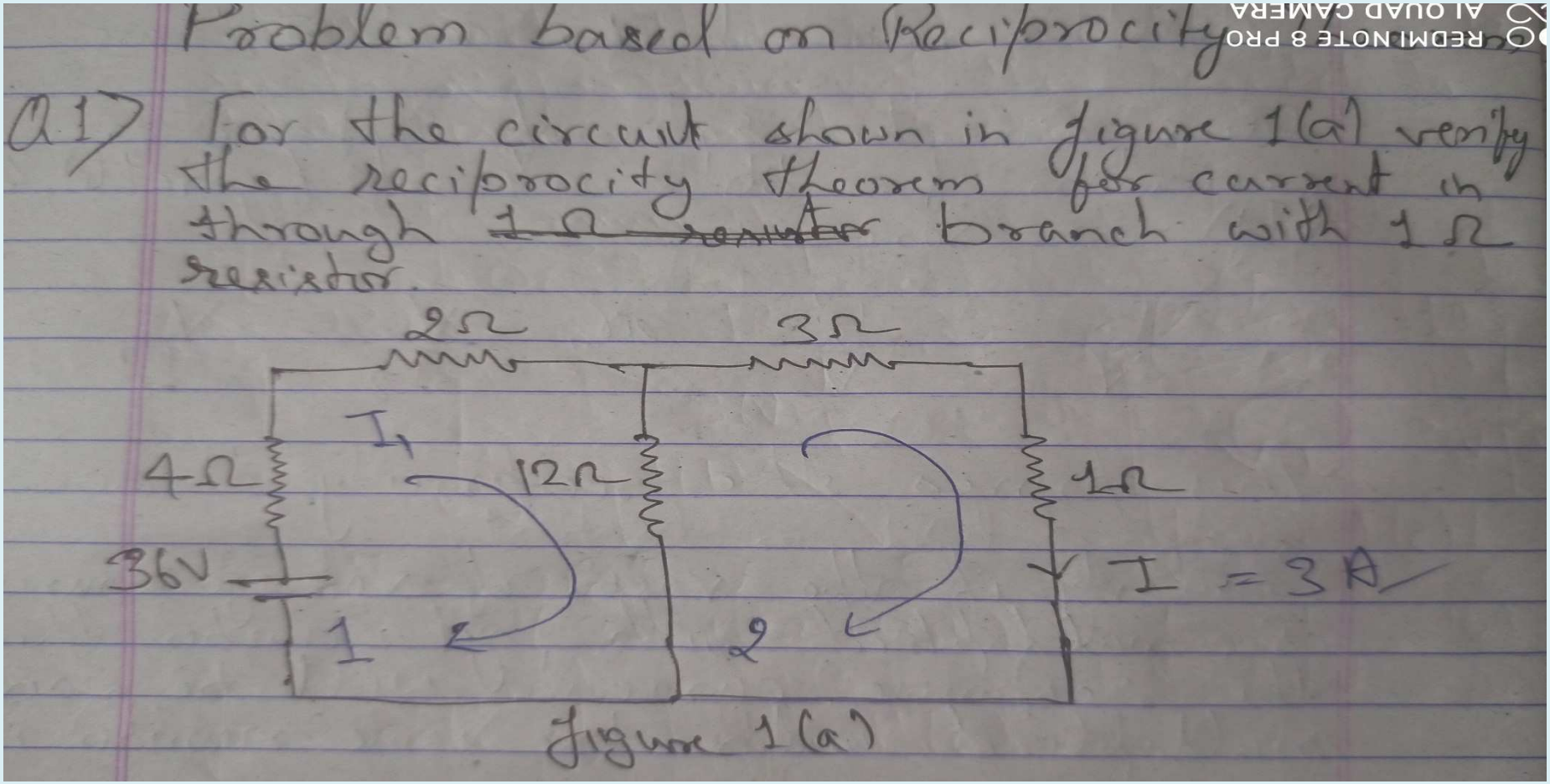
Circuit Theorem

In this lecture we will look some problem on 'Reciprocity' Theorem.



Circuit Theorem

Solution:- Let's 1st find current I passing through 1 Ω resistor.

We can redraw the circuit of figure 1(a) as below where series combination of 3Ω & 1Ω resistor can be replaced by 4Ω resistor parallel with 12 Ω resistor.

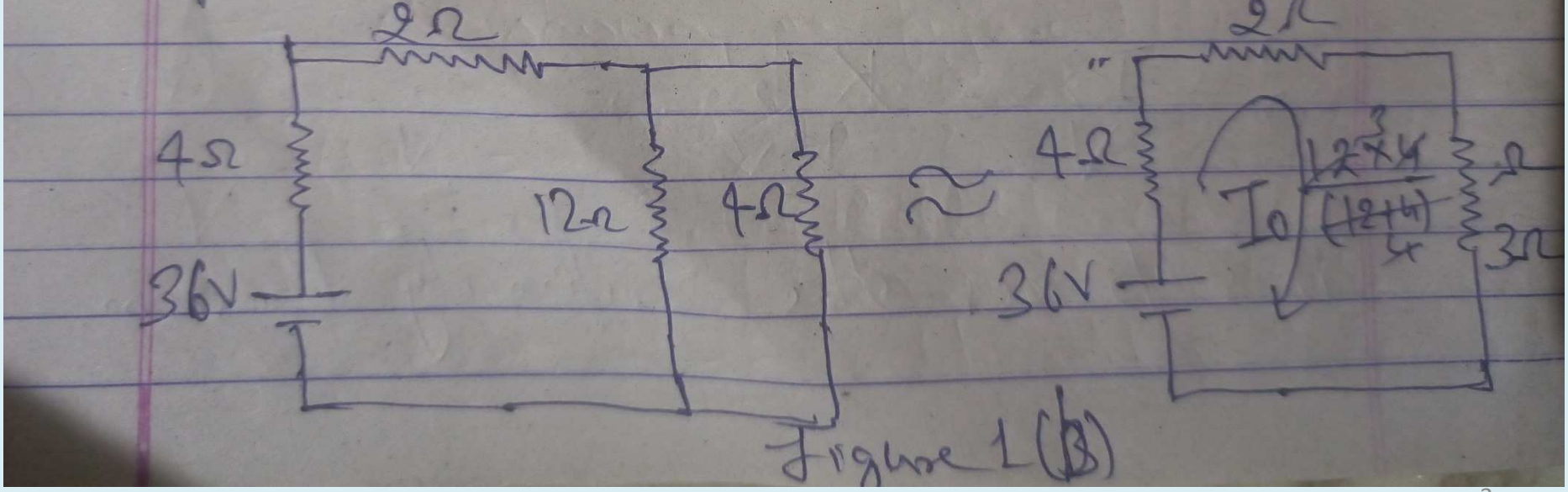


Figure 1(b)

Circuit Theorem

Now current I_o will be

$$I_o = \frac{36\ V}{(4\Omega + 2\Omega + 3\Omega)} = \frac{36\ V}{9\Omega}$$

$$= 4\ A$$

This 4A current will split between parallel resistor of 12Ω & 4Ω

So current I through 3Ω resistor is

$$I_{4\Omega} = I_{(3+1)\Omega} = \frac{4 \times 12}{(12+4)} 3A$$

$$I = 3A$$

Circuit Theorem

Now to verify reciprocity theorem we place 36V voltage source in series with 1Ω resistor and find current through 4Ω resistor. Redrawing the circuit as shown below,

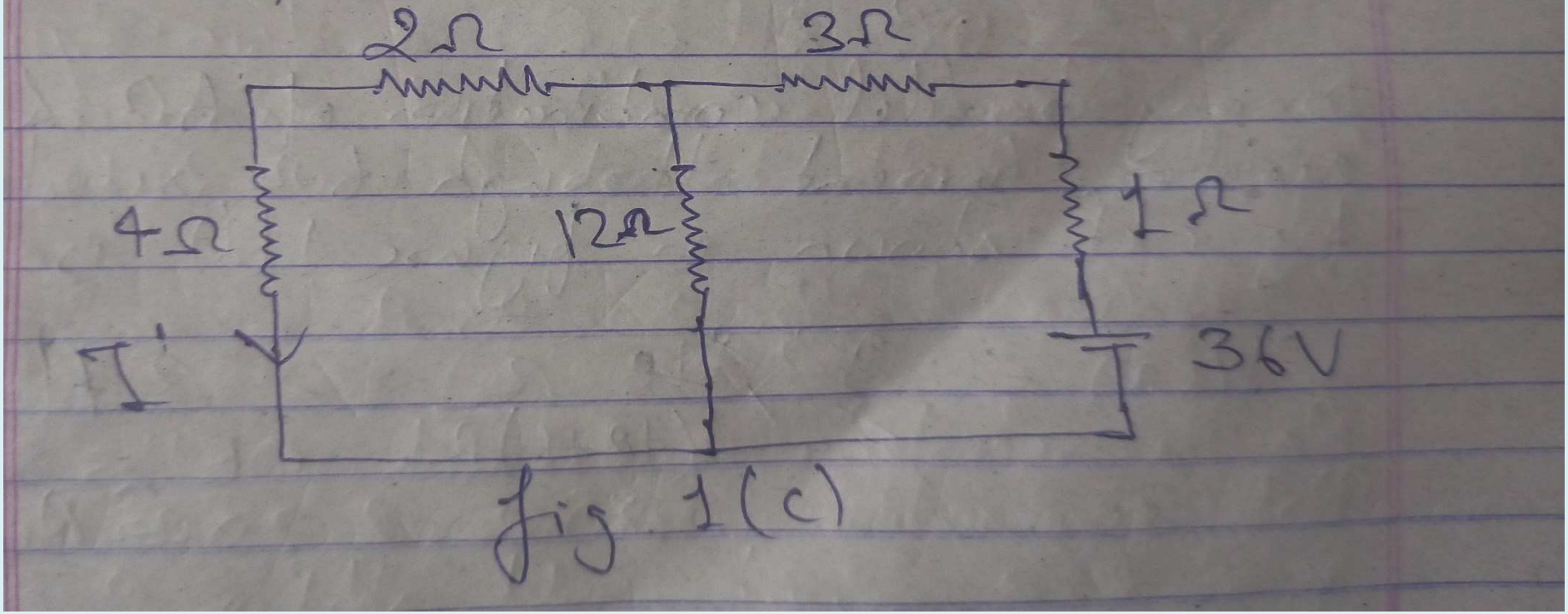
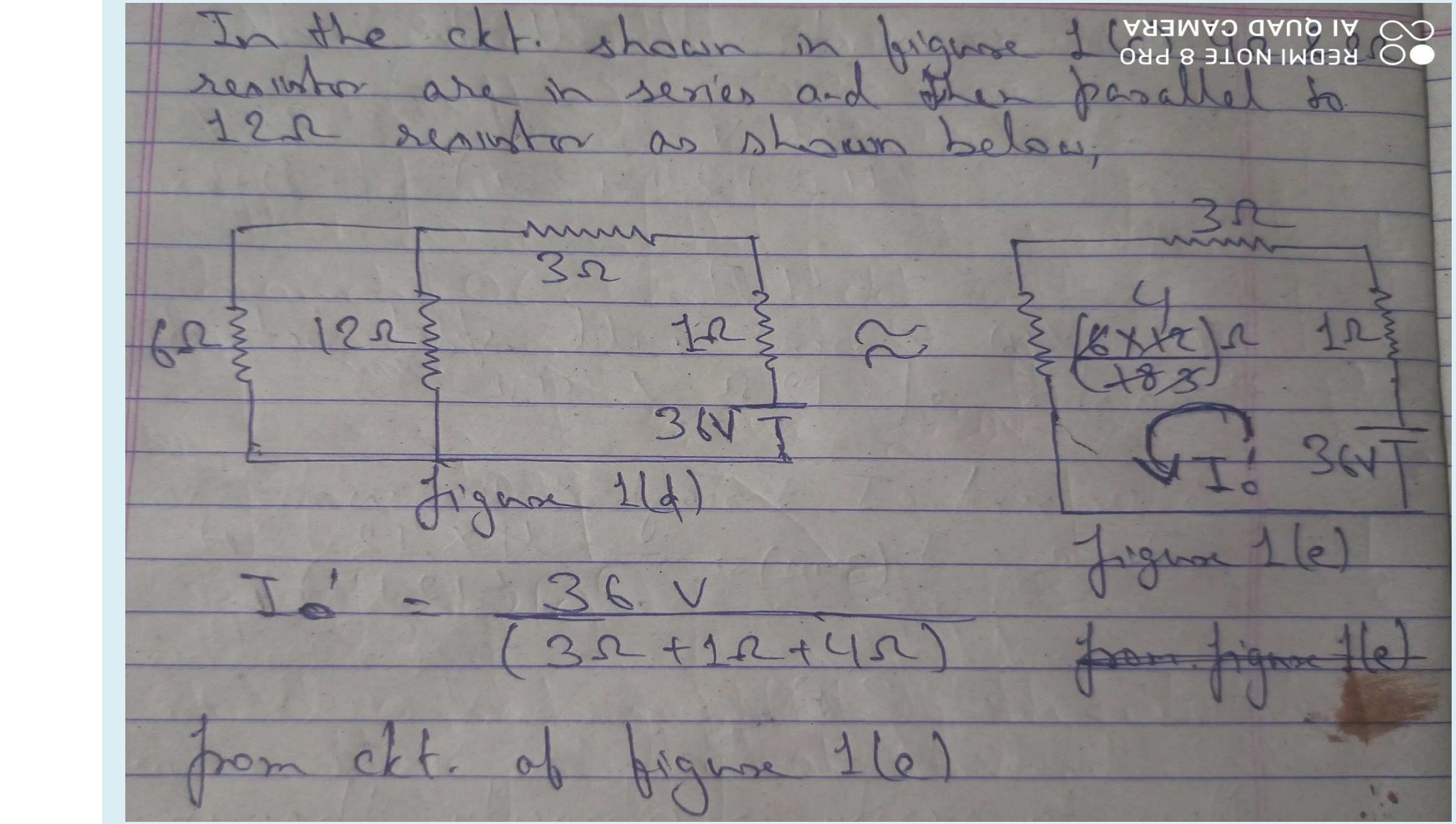


fig 1(c)

Circuit Theorem

In the ckt. shown in figure 1 (a) the 6Ω resistor are in series and then parallel to 12Ω resistor as shown below;



$$I_o' = \frac{36\ V}{(3\Omega + 1\Omega + 4\Omega)}$$

from ckt. of figure 1(e)

Circuit Theorem

from ckt. of figure 1(c)

$$I_o' = \frac{36\ V}{8\ \Omega} = \frac{9}{2}\ A$$

Now this $\frac{9}{2}$ A current will divide among parallel combination of 6Ω & 12Ω resistor. Current through 6Ω resistor of ckt. shown in figure 1(d) is

$$I_{(6\Omega)} = \frac{9}{2} \times \frac{12\ \Omega}{(12+6)\ \Omega} = 3\ A$$

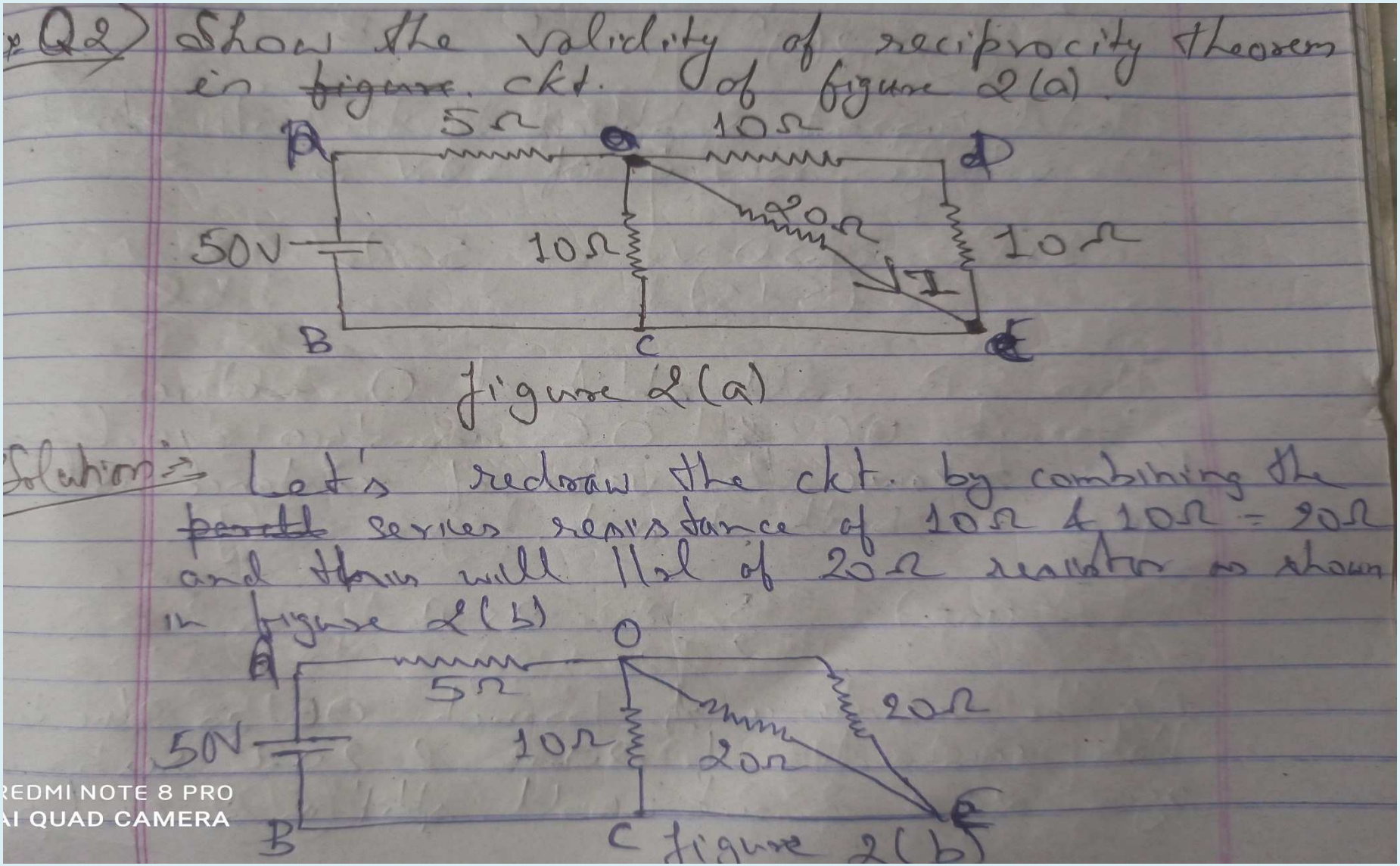
Circuit Theorem

So current I' i.e. $I_{(4\Omega)} = 3\,A$.

This means that the ckt. follows reciprocity theorem or we can say that reciprocity theorem is applicable in given problem circuit.

$$\frac{I}{V} = \frac{I'}{V} = \frac{3}{36} \quad \frac{1}{12}$$ Transfer Admittance

Circuit Theorem



Circuit Theorem

Now 20Ω is ||el 20Ω resistor, so,

$$Req(20||20) = \frac{20 \times 20}{(20+20)\Omega} = 10\Omega$$

This 10Ω is ||el to the 10Ω resistor of branch OC, so the ckt will be now,

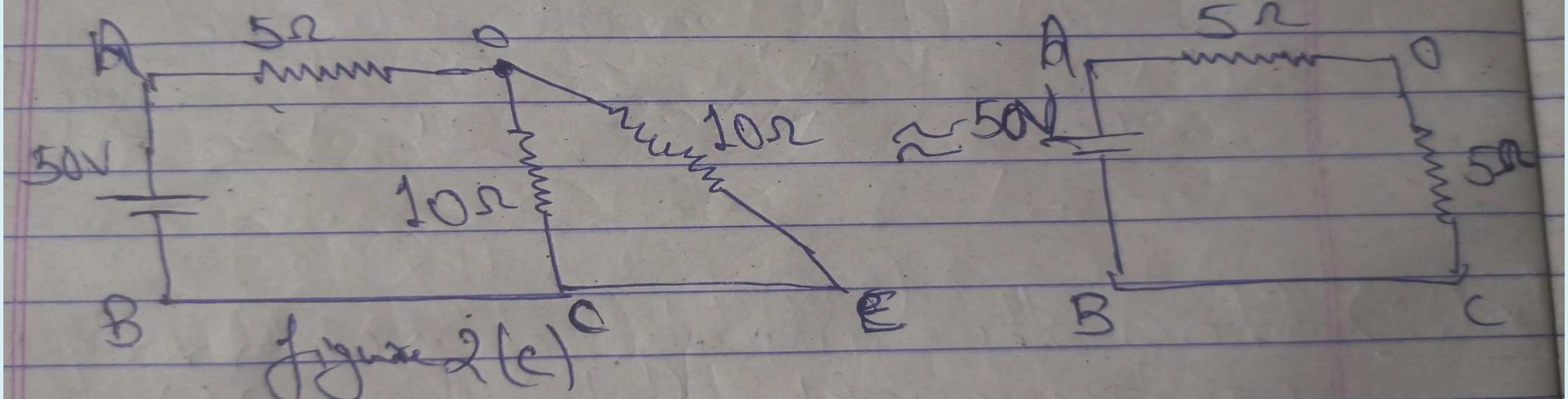


figure 2(c)

Total current supplied to the n/w due by the voltage source of 50V is,

Circuit Theorem

$$\therefore I_{total} = \frac{50\ V}{(5+5)\ \Omega} = 5\ A,$$

Thus 5 A will split at O between branch OC & OE in two equal parts because the value of resistance is equal in both branch.

$$I_{(10\Omega)} = \frac{5}{2}\ A = 2.5\ A.$$

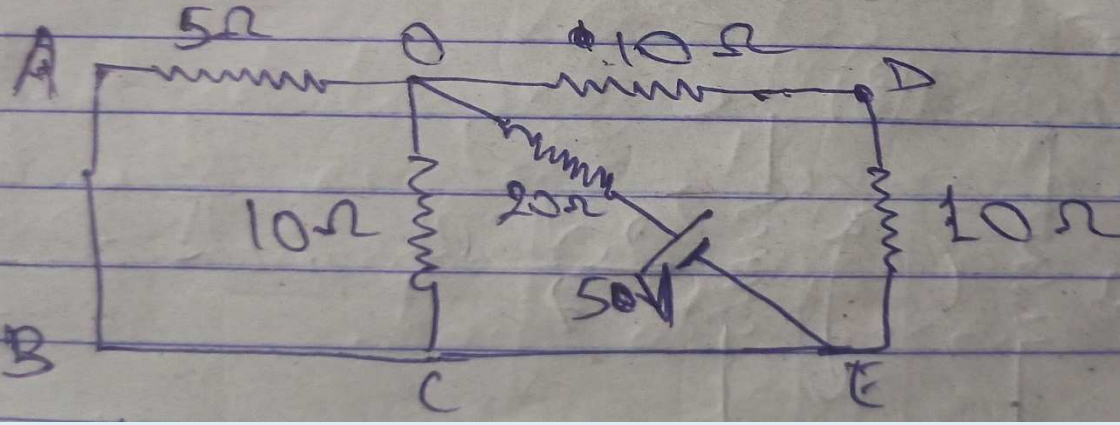
As the resistance of branch OE is due to IInd combination of 20 Ω & 20 Ω resistors so again 2.5 A current will split in 2 equal parts

Circuit Theorem

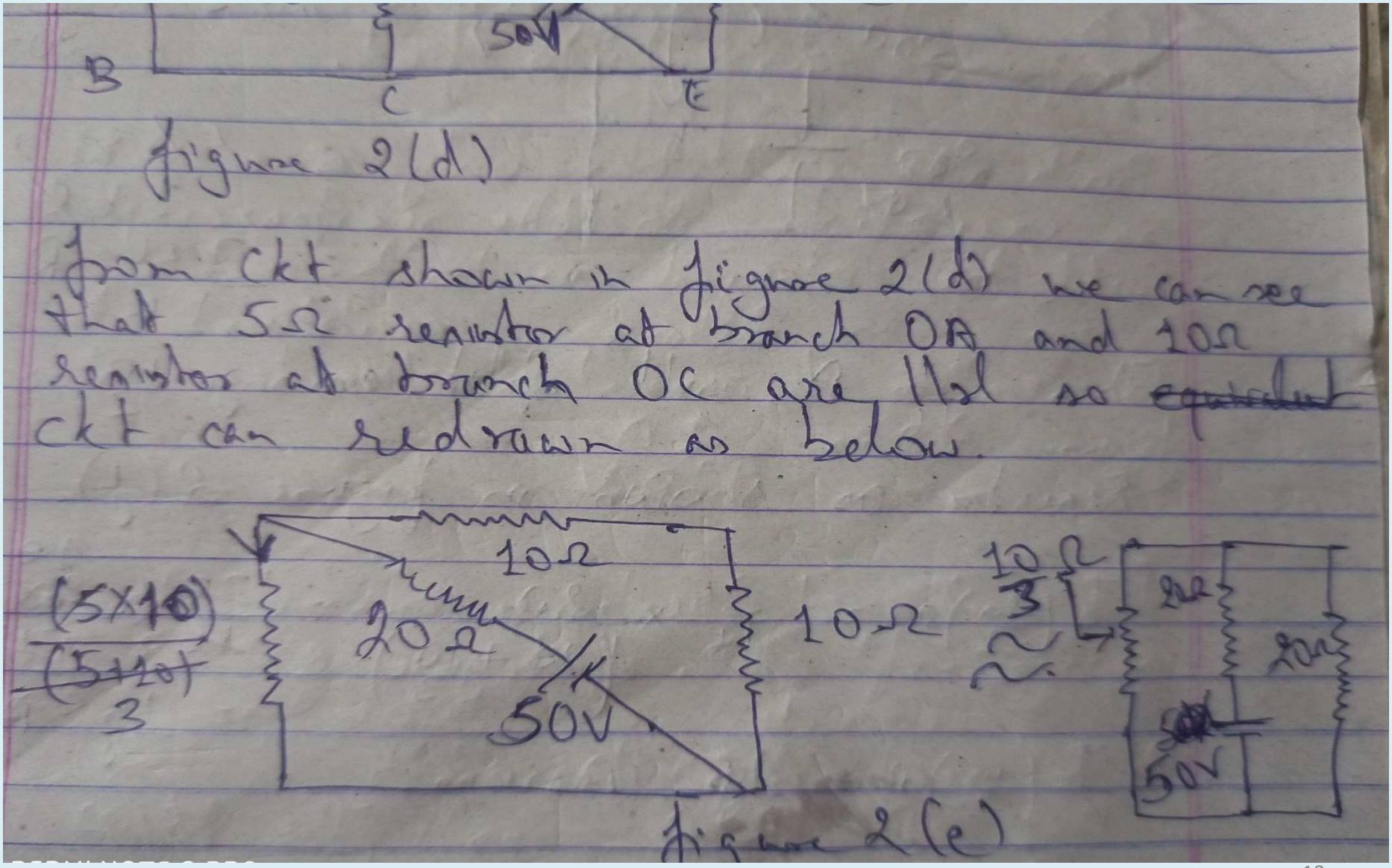
$I_{(20\Omega)} = \frac{2.5\ A}{2} = 1.25\ A$

So the current through branch OE is 1.25A i.e. through 20Ω resistor connected between branch OE.

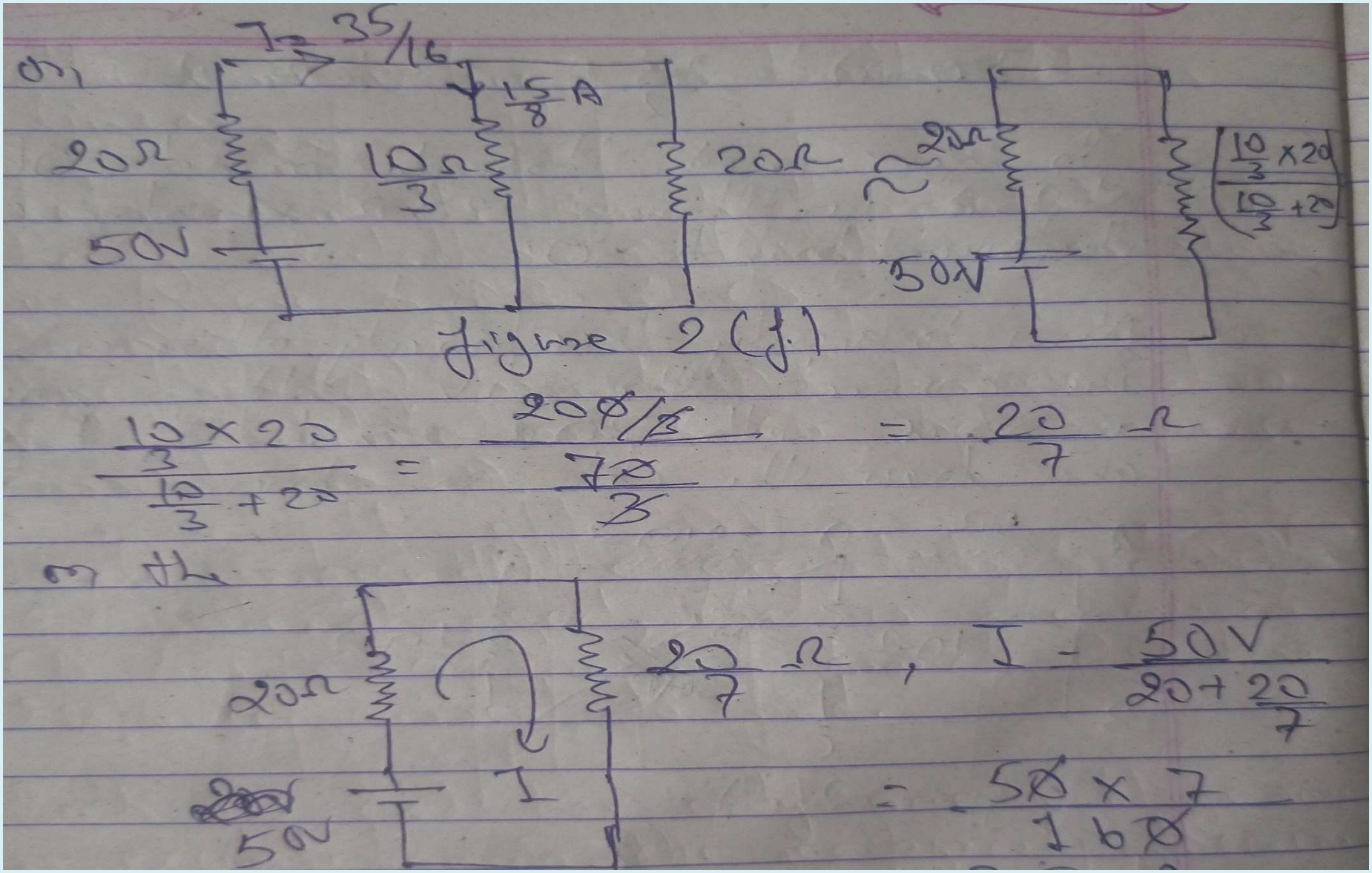
Now to verify reciprocity theorem, we connect the 50V voltage source in series with 20Ω resistor of branch OE. and draw the ckt as shown in figure 2(d)



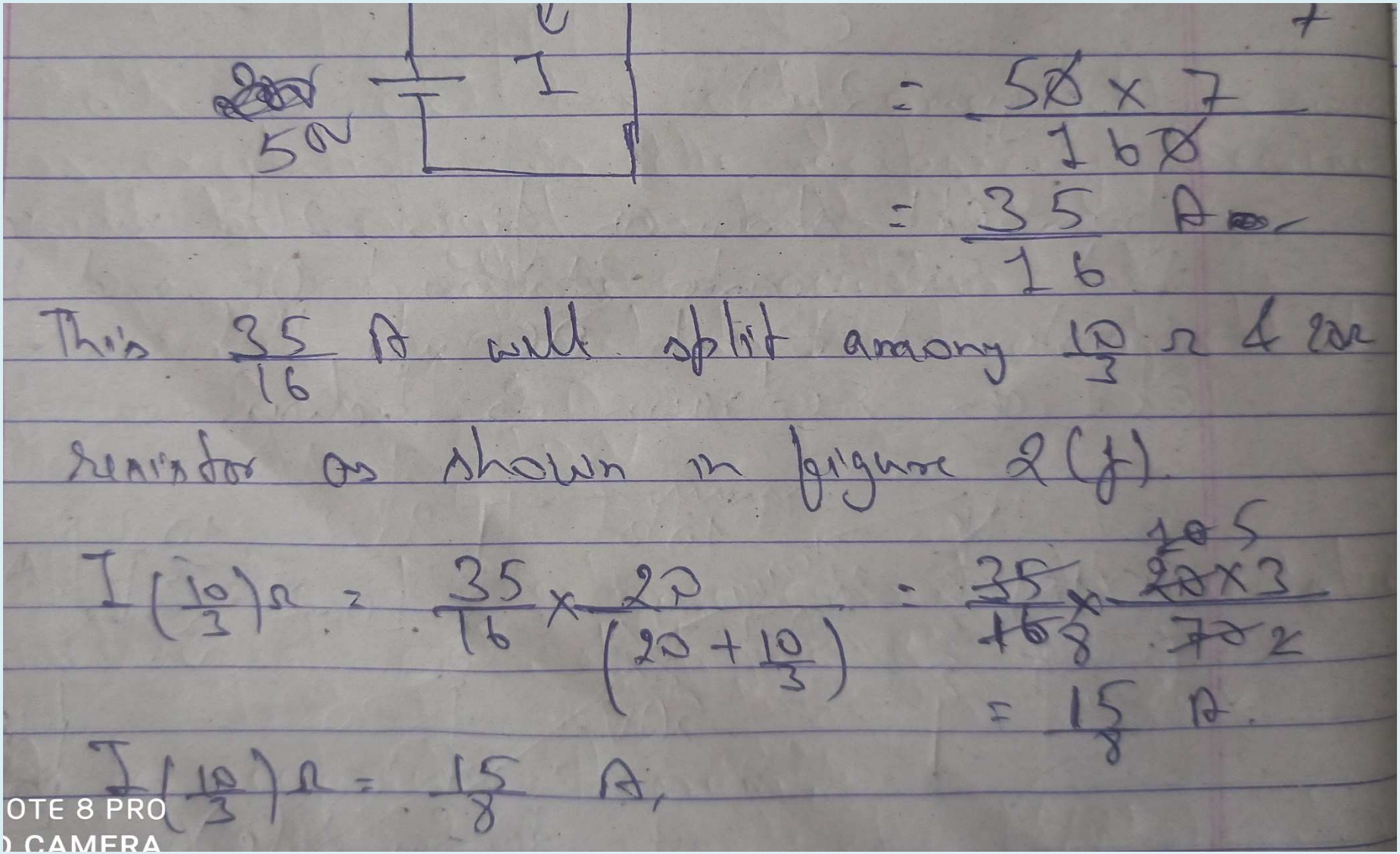
Circuit Theorem



Circuit Theorem



Circuit Theorem



$= \frac{50 \times 7}{160}$

$= \frac{35}{16}$ A

This $\frac{35}{16}$ A will split among $\frac{10}{3}\,\Omega$ & 4 Ω resistor as shown in figure 2(f).

$I_{(\frac{10}{3})\Omega} = \frac{35}{16} \times \frac{20}{(20 + \frac{10}{3})} = \frac{35}{16} \times \frac{20 \times 3}{70}$

$= \frac{15}{8}$ A.

$I_{(\frac{10}{3})\Omega} = \frac{15}{8}$ A.

Circuit Theorem

This $\frac{15}{8}$ A current will split among the 5 Ω & 10 Ω resistor of branch OA & OC respectively so, current through 5 Ω resistor is

$$I(5\Omega) = \frac{15}{8} \times \frac{10}{(10+5)} = \frac{10}{8}\ A = 1.25\ A$$

~~Hence~~ This verifies the applicability of reciprocity theorem

Circuit Theorem

Q3) Use the data of figure (a). Find the value of current I in the circuit of the figure (b).

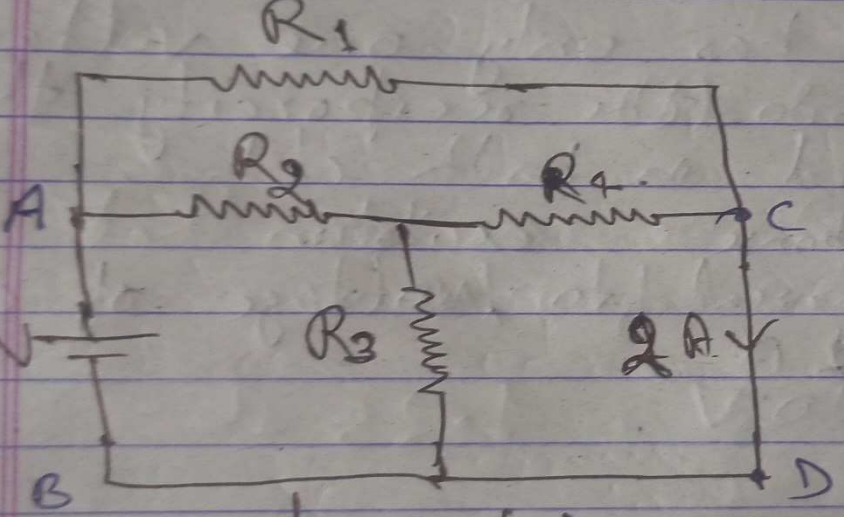


figure (a)

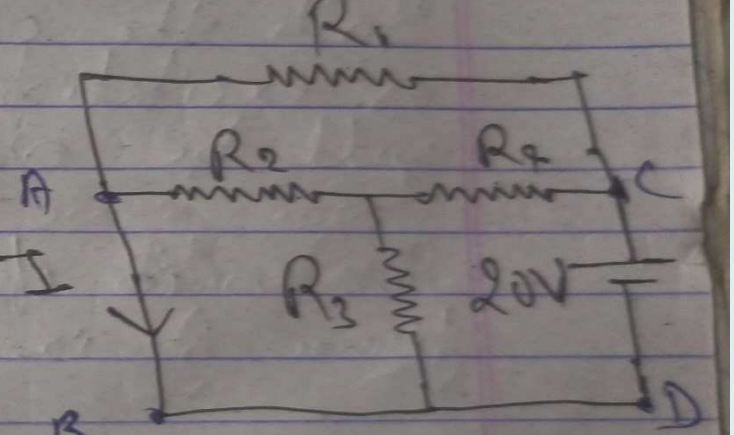


figure (b)

Soln:- As we can see that ckt of figure (a) & (b) are ~~same~~ having same connection of all resistor and having

Circuit Theorem

the same value., so both ckt is linear,

Let's name the branch of figure (a) & (b) having excitation and response as shown in figure. as AB & CD

In figure (A) branch AB has excitation Voltage while branch CD has response current I = 1A,

While in figure(B) the excitation and respons are interchanged, that is the branch CD has excitation and branch AB has response current to find.

Circuit Theorem

Both the ckt has only one voltage source as excitation. So the reciporcity theorem will be obeyed in both ckt.

So, ratio of response current to excitation voltage of ckt of figure A is, $\frac{2\,A}{10\,V}$

Now ratio of response current to excitation voltage of ckt of figure B is, $\frac{I}{20\,V}$

As per reciprocity theorem,

$\frac{I}{20\,V} = \frac{2\,A}{10\,V} \Rightarrow I = 4A$ ans

Circuit Theorem

Q4) For the n/w shown in below figure find the current I.

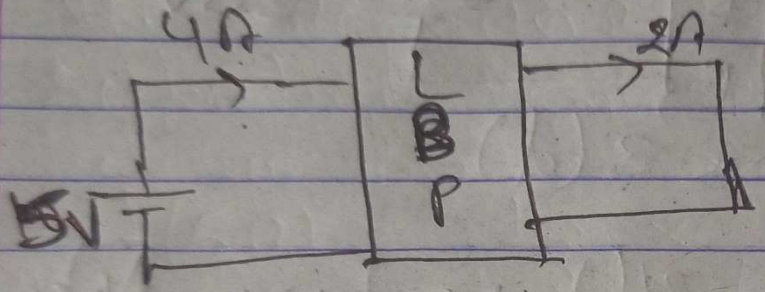


figure 3(a)

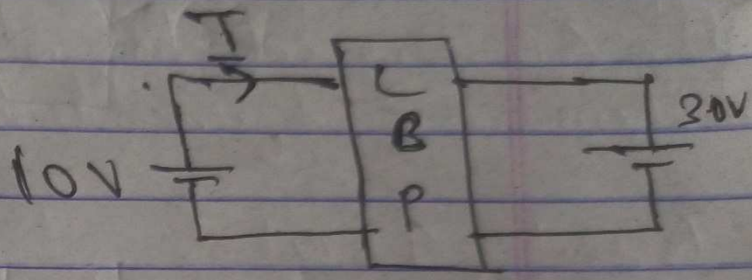


figure 3(b)

Sol: We have to find current I in figure 3(b).

As the n/w of figure 3(a) & 3(b) are L B P i.e. Linear, Bilateral & Passive so the reciprocity theorem is applicable

Circuit Theorem

In figure 3(a) the excitation voltage is 5V and response current is 2A, then according to reciprocity theorem if the excitation & response is changed then.

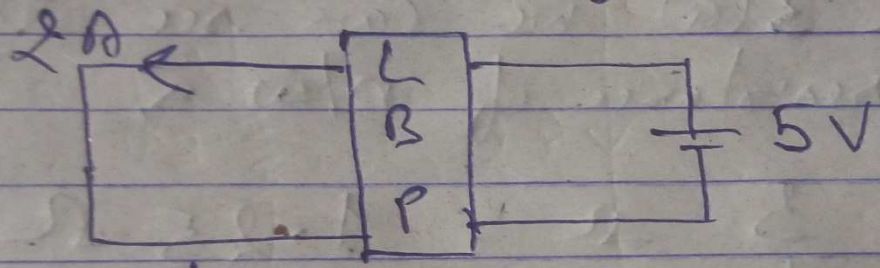


figure 3(c)

When we scale 5V by 6 then response current will also be $2 \times 6 = 12$A.

So the ckt n/w of figure 3(b) can be looked

Circuit Theorem

like,

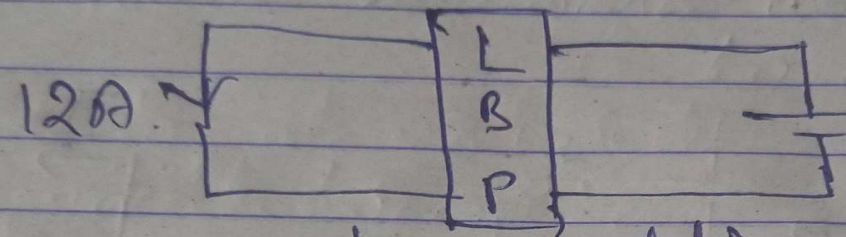
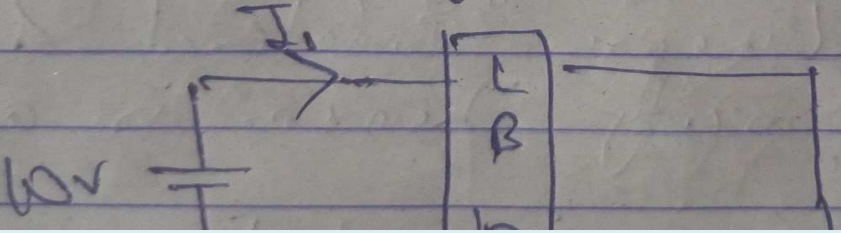


figure 3(d)

In n/w of figure 3(d) we have taken response due to only source that is 30V as per superposition theorem.

Now we will left 30V source and take 10V source find the current due to this,



Circuit Theorem

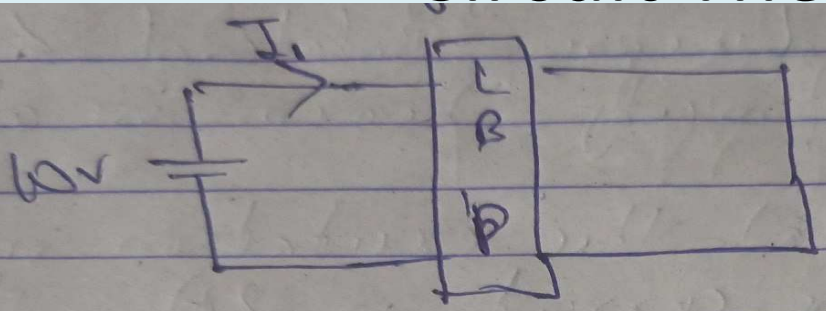


figure 3(e)

from figure 3(a) we can see that the internal resistance of n/w is,

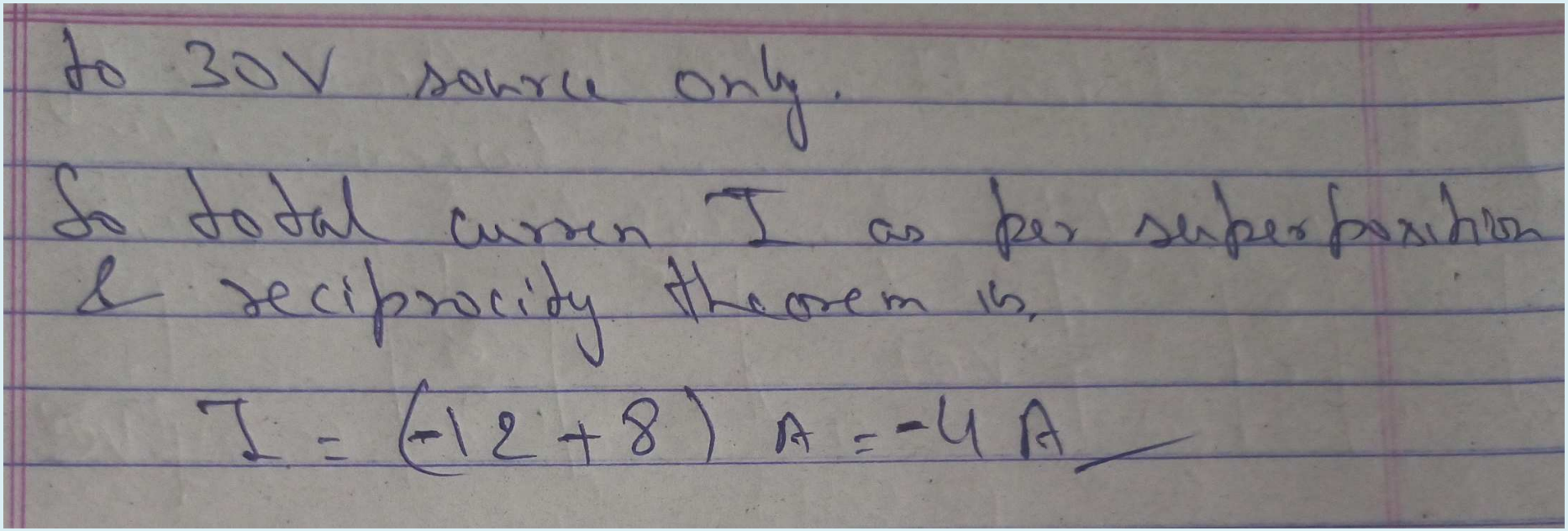
$$R_{in} = \frac{5}{4}\,\Omega = 1.25\,\Omega$$

So current I_1 due to 10V source is.

$$I_1 = \frac{10V}{1.25} = \frac{1000}{125}^{8}\,A = 8A,$$

The 8A is in opposite to 12A current due

Circuit Theorem



In next lecture we will discuss Star-Delta Transformation. For any query or problem discuss on What's App or contact on number available.

THANK YOU