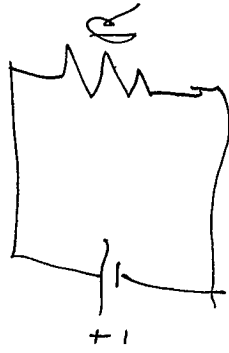
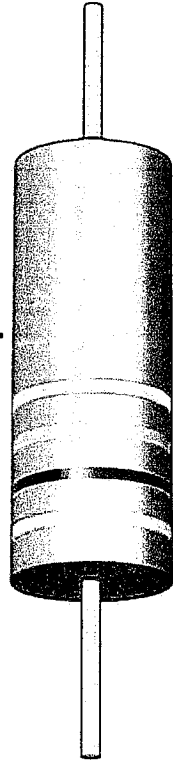


Lecture # 15

DC - circuits

Resistors used in circuits are often carbon cylinders.

(a)



(b)



Resistor symbol is a zigzag line.



(c)



Arrow represents the movable contact of a variable resistor.

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Black 0

Brown 1

Red 2

Orange 3

Yellow 4

green 5

blue 6

Violet 7

gray 8

white 9

Gold $10^{-1} \pm 5\%$

Silver $10^{-2} \pm 10\%$

None $\pm 20\%$

**First stripes represent digits:
yellow = 4 and violet = 7...**

**...and third stripe represents
power of ten: orange = 3,
so $R = 47 \times 10^3 \Omega$.**

**Remaining stripe indicates
tolerance: silver = $\pm 10\%$.**

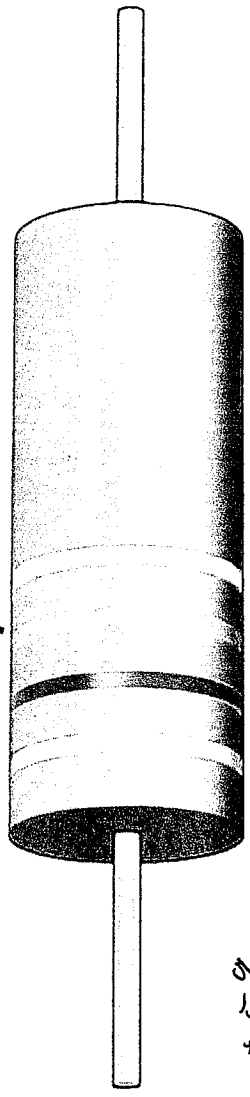


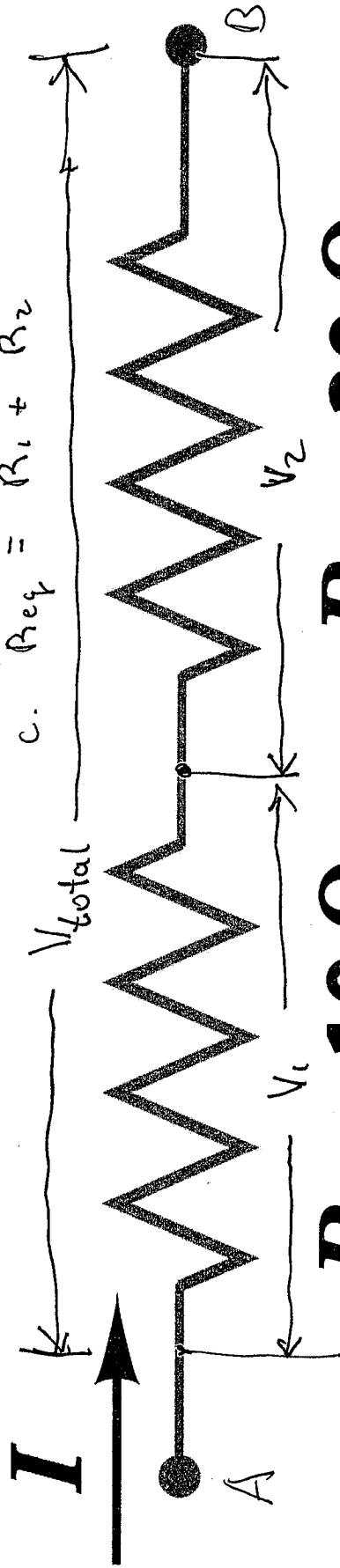
Figure 27-13 Physics for Engineers and Scientists 3/e
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Resistors in series

a. Current the same in each resistor

b. $V_{total} = V_1 + V_2$

c. $R_{eq} = R_1 + R_2$



$R_1 = 10\ \Omega$

$R_2 = 20\ \Omega$

$V_2 = I R_2$

Figure 27-18 Physics for Engineers and Scientists 3/e
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$$V_{total} = V_1 + V_2$$

$$I R_{eq} = I R_1 + I R_2$$

**For any number of resistors
connected in series, the net
resistance is the sum**

$$R = R_1 + R_2 + R_3 + \dots$$

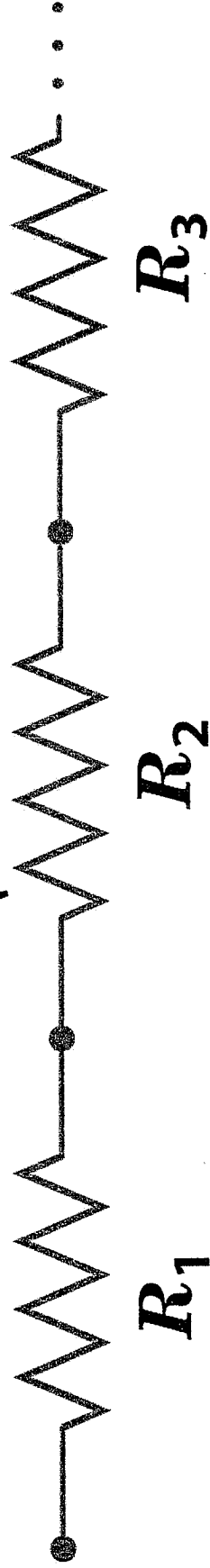
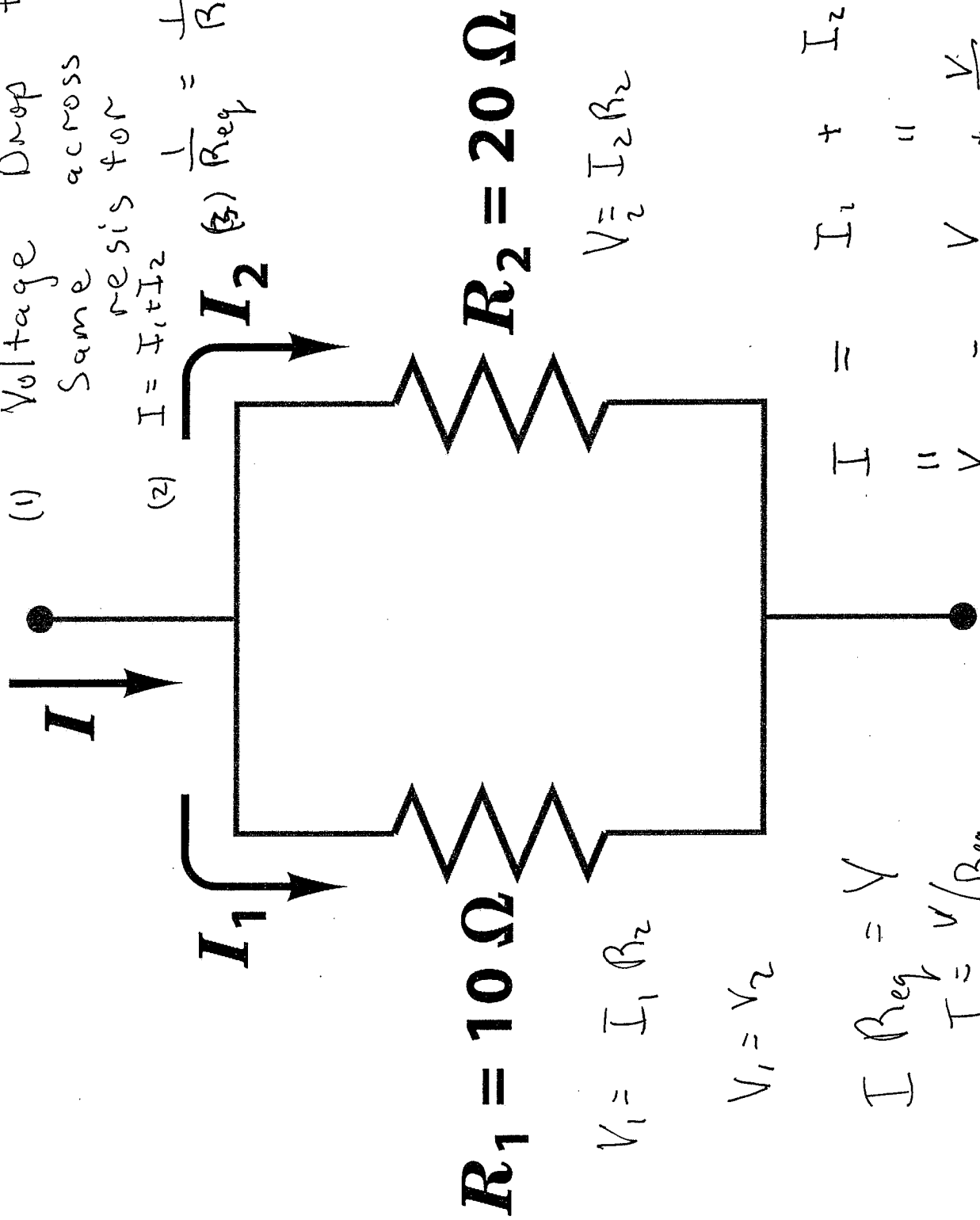


Figure 27-15 Physics for Engineers and Scientists 3/e
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Resistors in Parallel

(1) Voltage Drop the same across each resistor for

(2) $I = I_1 + I_2$
 (3) $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$



$R_1 = 10 \Omega$

$R_2 = 20 \Omega$

$V_1 = I_1 R_1$

$V_2 = I_2 R_2$

$V_1 = V_2$

$I R_{eq} = V$
 $I = V / R_{eq}$

$I = I_1 + I_2$
 $= \frac{V}{R_1} + \frac{V}{R_2}$
 $= \frac{V}{R_{eq}}$

Figure 27-19 Physics for Engineers and Scientists 3/e
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For resistors connected in parallel, the inverse of the net resistance is the sum of the inverses of individual resistances,
$$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + \dots$$

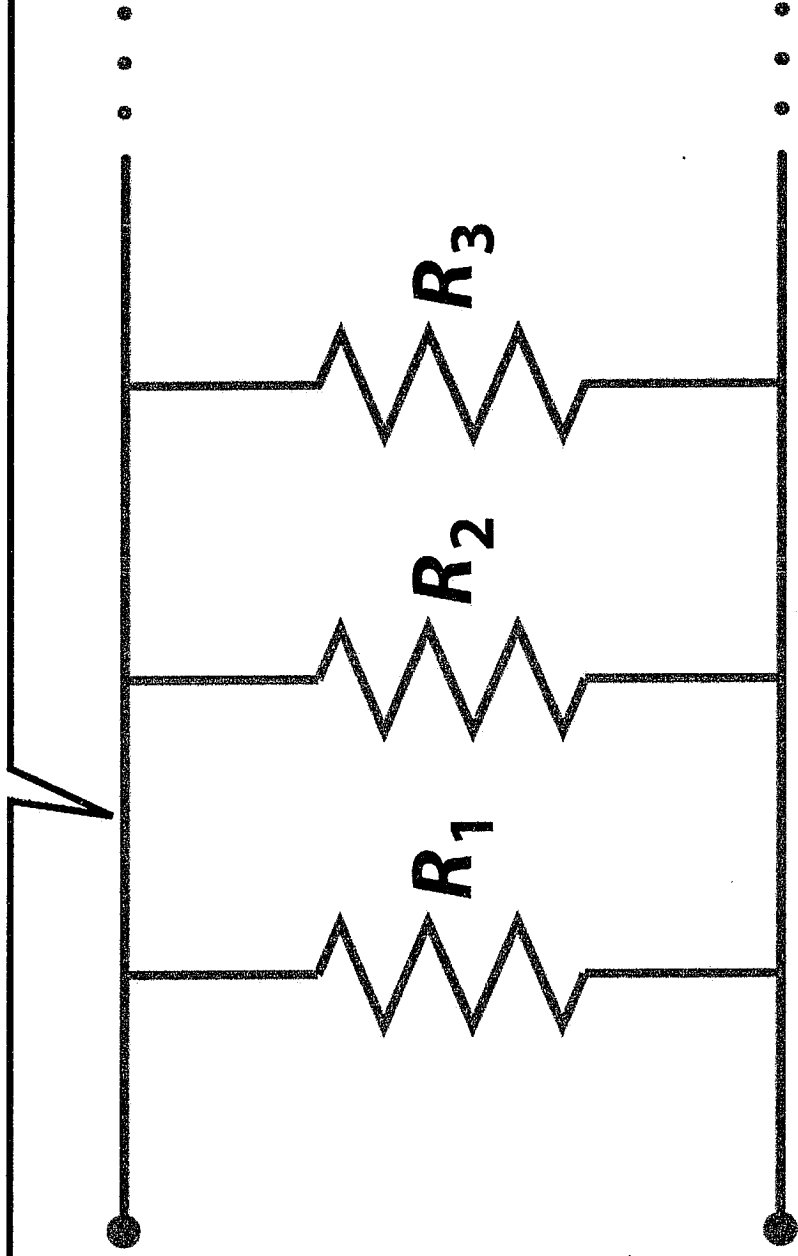


Figure 27-17 Physics for Engineers and Scientists 3/e
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Composite resistance of circuit.

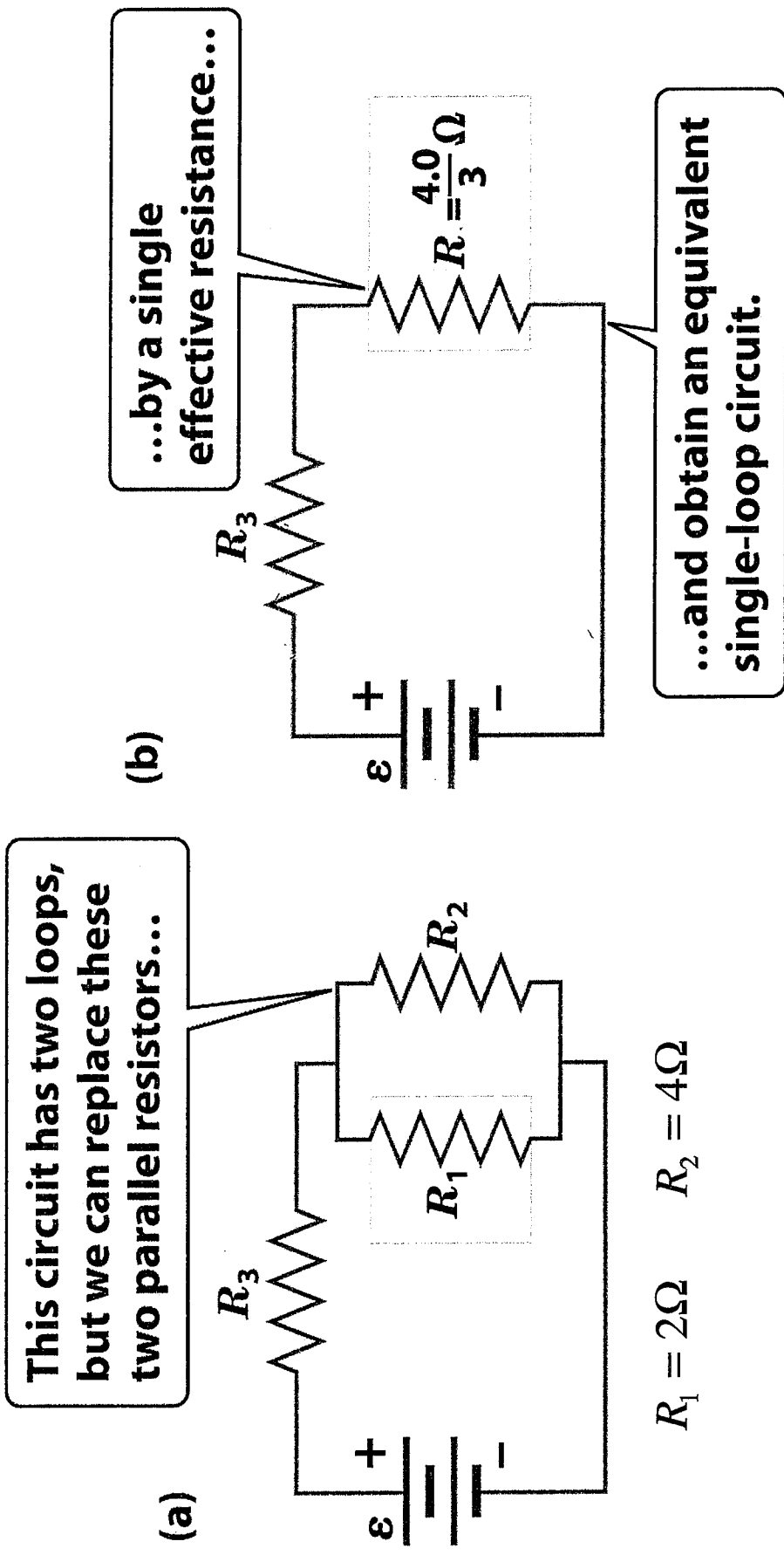


Figure 28-13 Physics for Engineers and Scientists 3/e
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Current Through battery $\equiv I_{\text{bat}} = \frac{\mathcal{E}}{R_{\text{eq}}}$

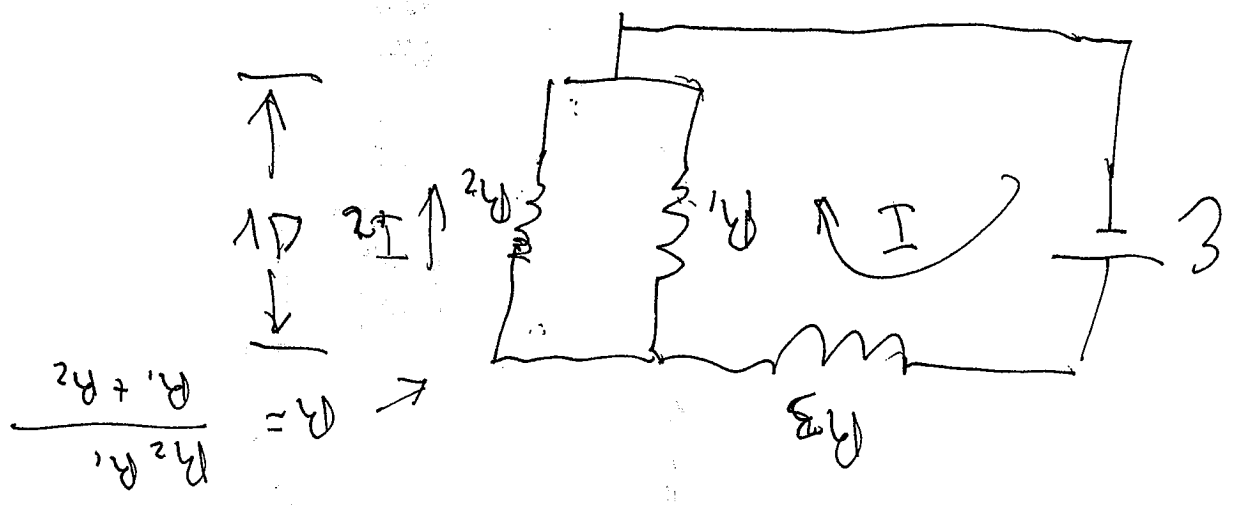
$R_{\text{eq}} = R_3 + R$

$$I_1 = \frac{\mathcal{E} R_2}{R_2 R_1 + R_3 R_2 + R_2 R_1} I_2 = \frac{\mathcal{E} R_1}{R_3 R_1 + R_3 R_2 + R_2 R_1}$$

$$I_2 = \frac{\Delta V}{R_2} = \frac{\mathcal{E} R_1}{(R_3 + R_2 R_1) (R_1 + R_2)}$$

$$\Delta V = I R = \frac{\mathcal{E} (R_3 + R_2 R_1)}{R_2 R_1} \cdot \frac{R_2 R_1}{(R_1 + R_2)}$$

$$I = \frac{\mathcal{E}}{R_3 + \frac{R_2 R_1}{R_1 + R_2}}$$

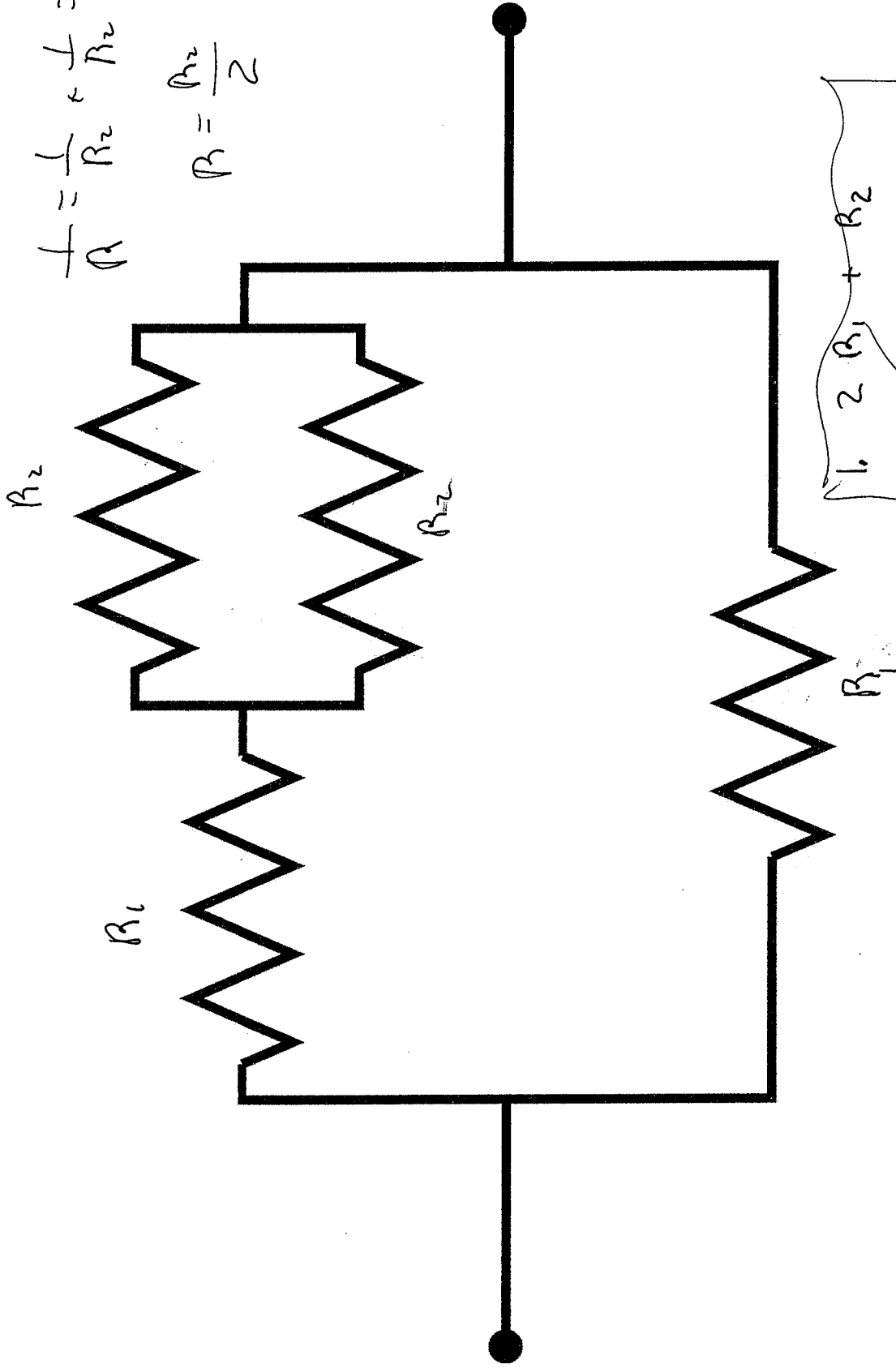


Current through R_2 ?

What is equivalent resistance?

$$\frac{1}{R} = \frac{1}{R_2} + \frac{1}{R_2} = \frac{2}{R_2}$$

$$R = \frac{R_2}{2}$$



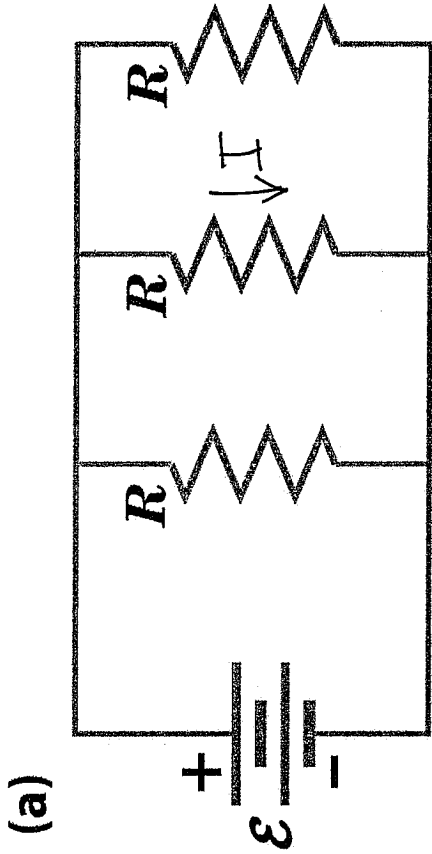
- ~~1. $2R_1 + R_2$~~
- ~~2. $2R_2 + \frac{R_1}{2}$~~
- ~~3. $2R_1 + R_2/2$~~

Figure 27-29 Physics for Engineers and Scientists 3/e
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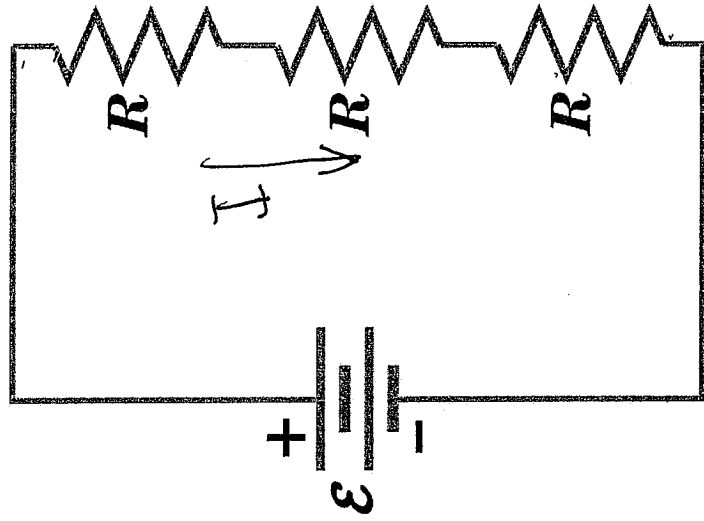
$$R_1 + \frac{R_2}{2}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_1 + \frac{R_2}{2}}$$

Current, I , Through R ?



(b) $I = \dots ?$



- (1) $\frac{\mathcal{E}}{R}$ in (a) ; $\frac{\mathcal{E}}{3R}$ in (b)
- (2) $\frac{\mathcal{E}}{3R}$ in (a) ; $\frac{\mathcal{E}}{R}$ in (b)
- (3) $\frac{\mathcal{E}}{R}$ in (a) ; $\frac{\mathcal{E}}{R}$ in (b)

Figure 28-21 Physics for Engineers and Scientists 3/e
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Direction of current (flow of positive charge) is also direction of potential decrease across resistor.

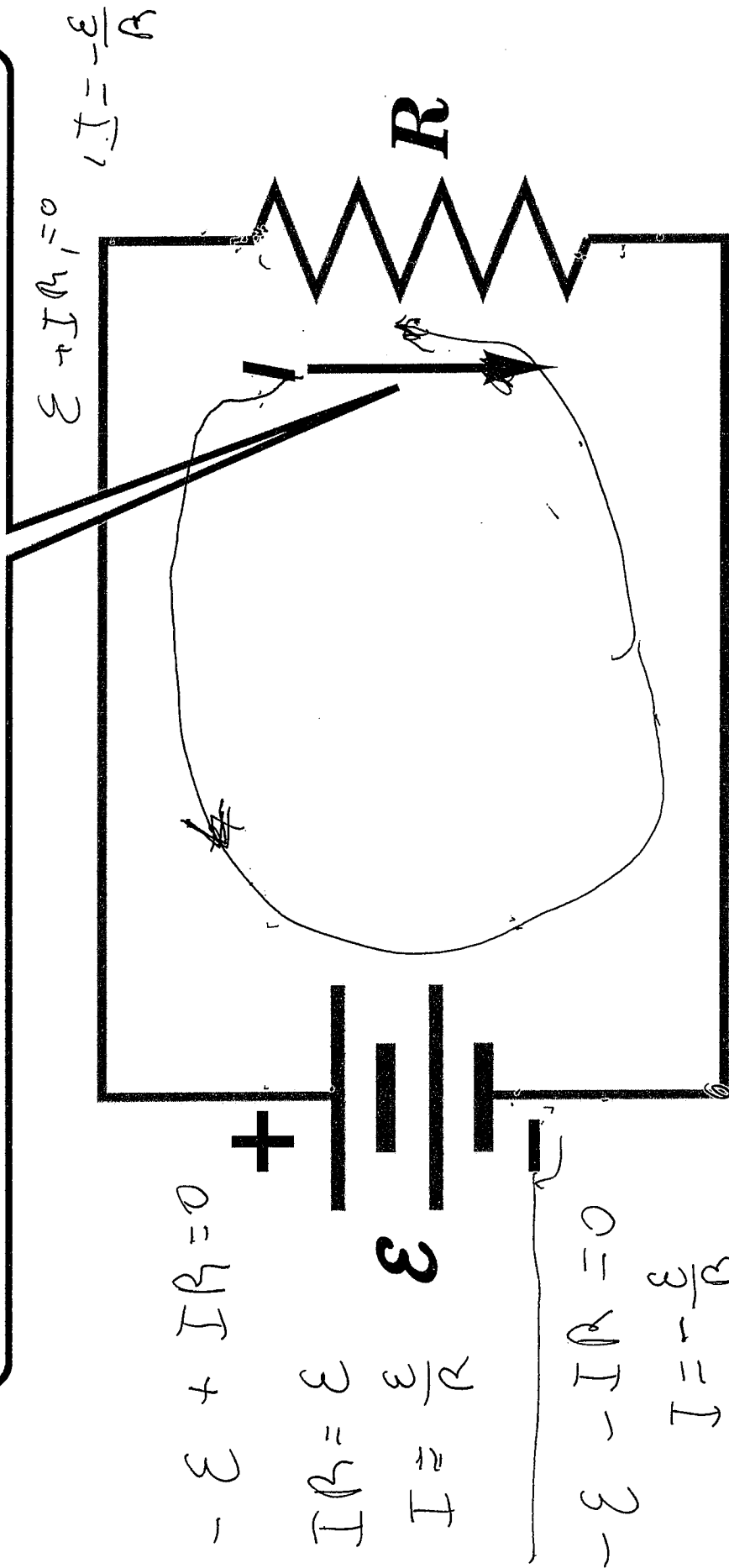
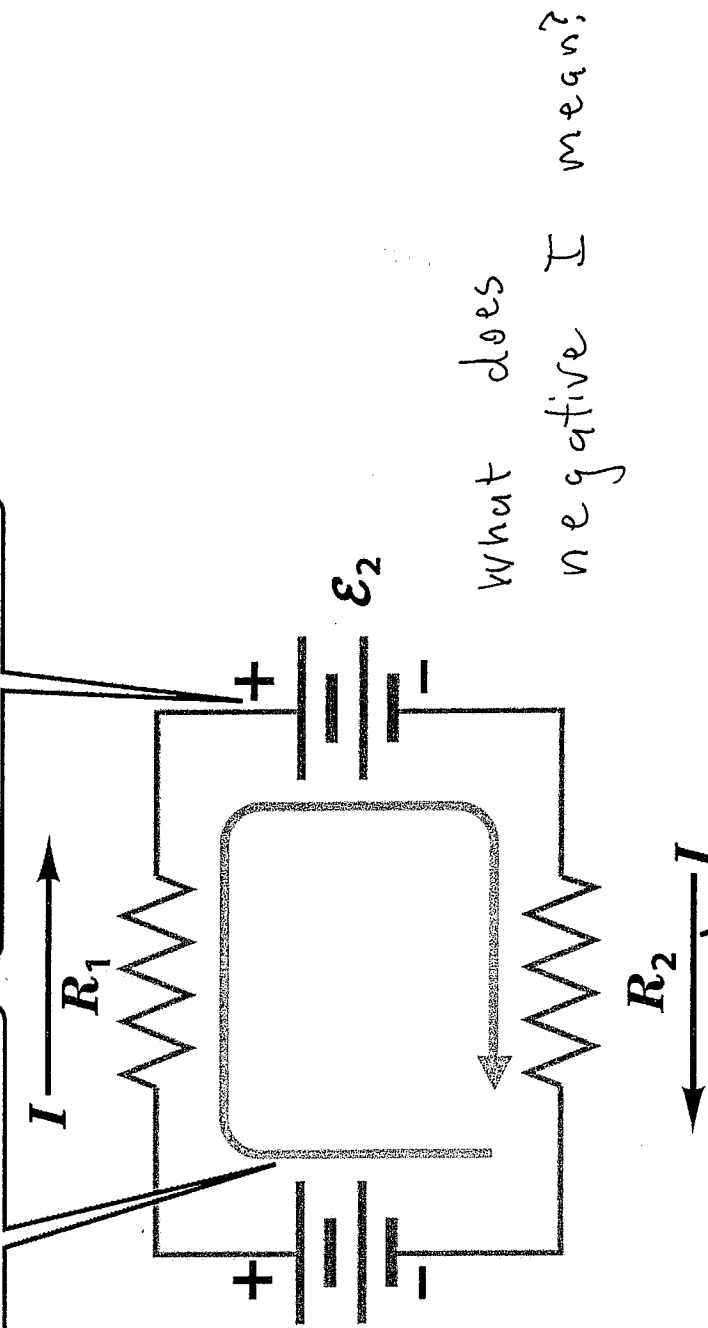


Figure 28-9 Physics for Engineers and Scientists 3/e
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Kirchoff's Voltage Law: "Voltage Drop Around a circuit vanishes"

Then a starting point and direction are chosen for a path around loop.

Path around loop passes through this emf in backward direction.



What is correct equation?

a. $\mathcal{E}_1 + IR_1 + \mathcal{E}_2 + IR_2 = 0$

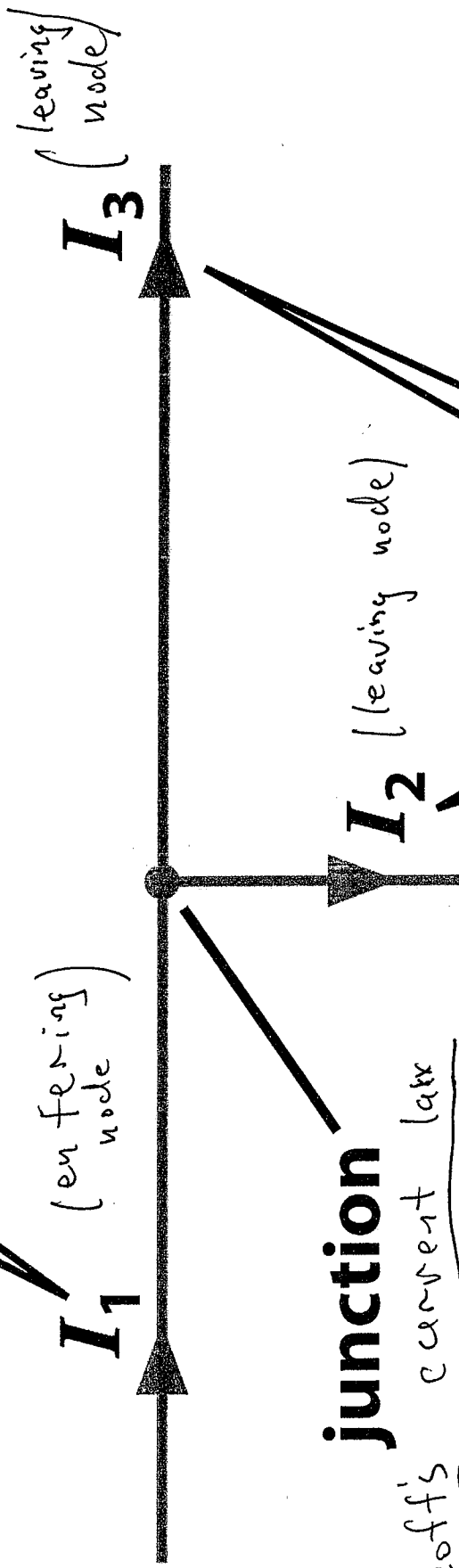
b. $-\mathcal{E}_1 + IR_1 - \mathcal{E}_2 + IR_2 = 0$

c. $-\mathcal{E}_1 + IR_1 + \mathcal{E}_2 + IR_2 = 0$

Assumed current direction here is parallel to path chosen around loop.

Figure 28-10b Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

When current I_1 encounters a junction...



junction

Kirchoff's current law

Total current into a node is zero

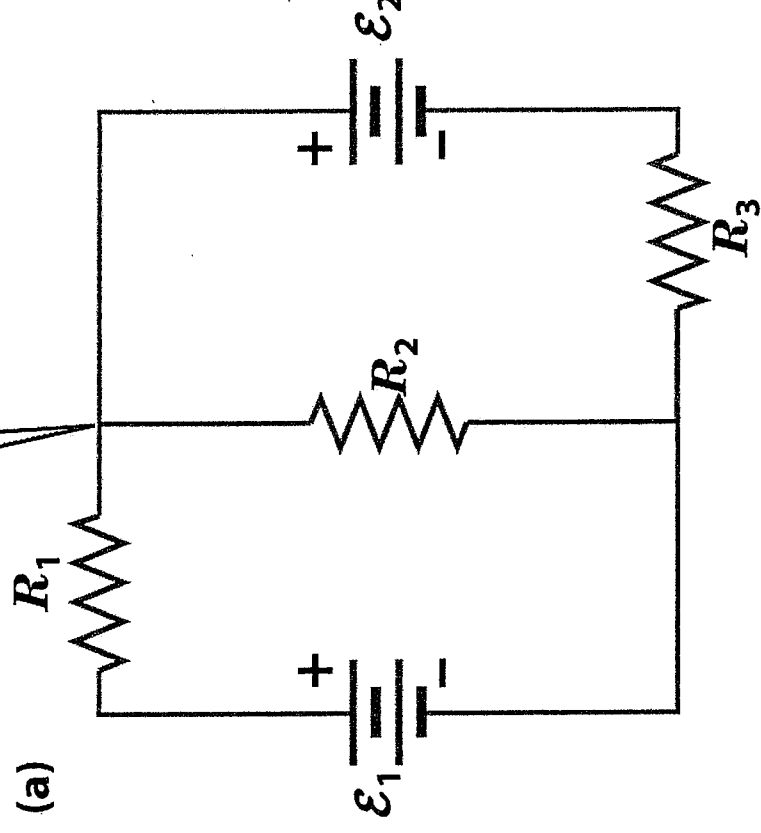
...it splits into two separate currents, I_2 and I_3 .

Figure 28-15 Physics for Engineers and Scientists 3/e
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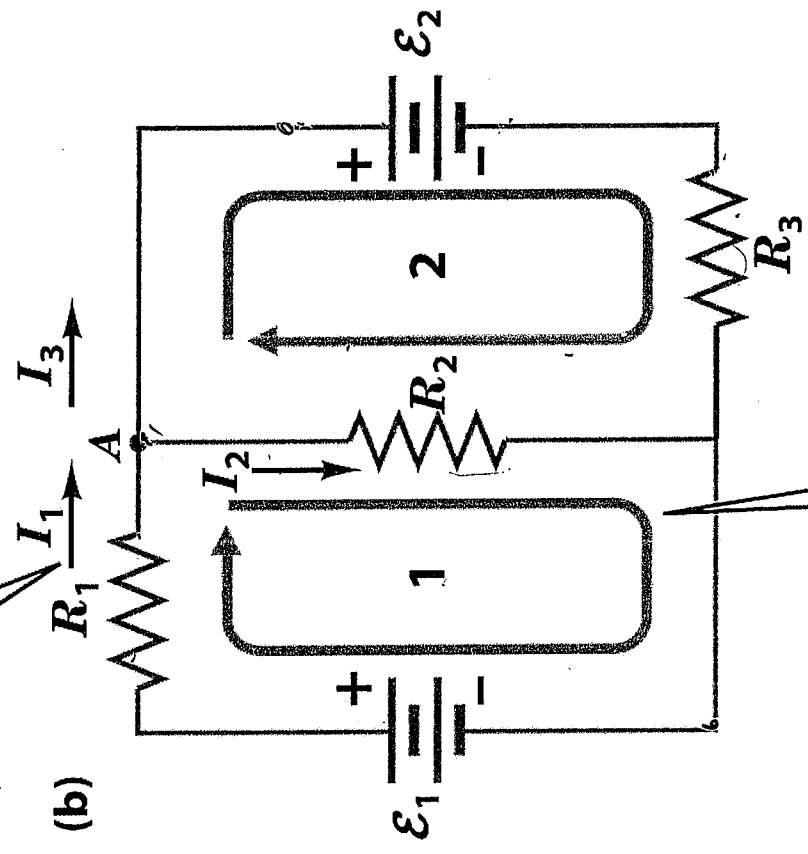
$$I_1 - I_2 - I_3 = 0$$
$$\text{or } I_1 = I_2 + I_3$$

Write equations for circuit
 3 unknowns I_1, I_2, I_3

For this two-loop circuit...



...we first label and draw arrows for the three separate branch currents...



...and then choose a starting point and direction to go around each loop.

$$I_1 - I_2 - I_3 = 0 \quad \text{K Cur}$$

$$I_2 = I_1 - I_3$$

$$-E_1 + I_1 R_1 + I_2 R_2 = 0$$

$$+E_1 - I_2 R_2 + I_3 R_3 = 0$$

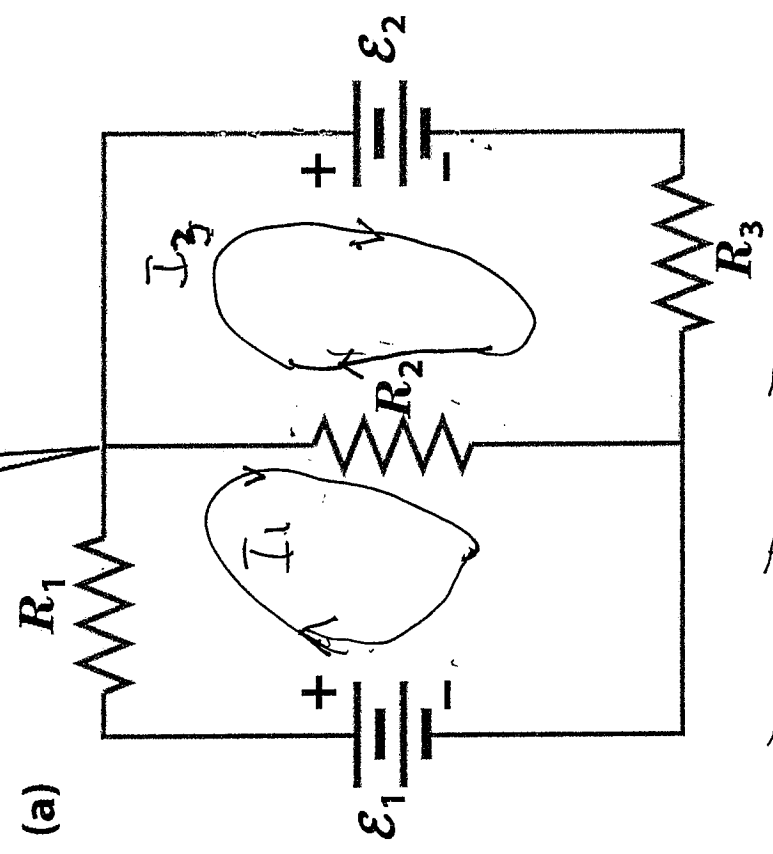
Figure 28-17 Physics for Engineers and Scientists 3/e
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Write Equation for circuit

2 unknowns

I_1 and I_3

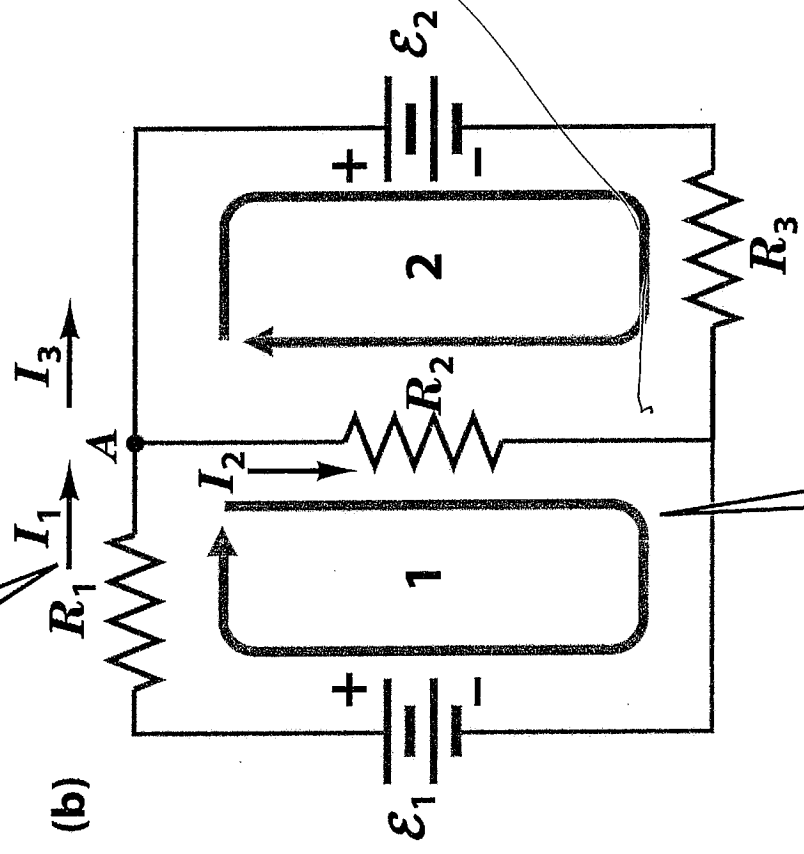
For this two-loop circuit...



$$I_2 = I_1 - I_3$$

$$-\mathcal{E}_1 + I_1 R_1 + R_2(I_1 - I_3) = 0$$

...we first label and draw arrows for the three separate branch currents...



...and then choose a starting point and direction to go around each loop.

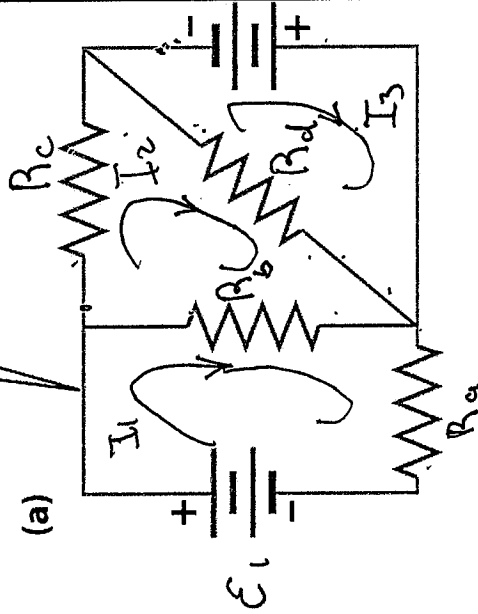
Figure 28-17 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

$$\mathcal{E}_2 + I_3 R_3 + R_2(I_3 - I_1) = 0$$

Write

equation for circuit

For a complicated circuit with several loops and branches...



$$-E_1 + R_1(I_1 - I_2) + R_9 I_1 = 0$$

$$I_2 R_2 + R_3(I_2 - I_3) + R_4(I_2 - I_1) = 0$$

$$-E_2 + R_5(I_3 - I_2) = 0$$

additional HW

Solve for $I_1, I_2, I_3!$

Figure 28-16 Physics for Engineers and Scientists 3/e
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