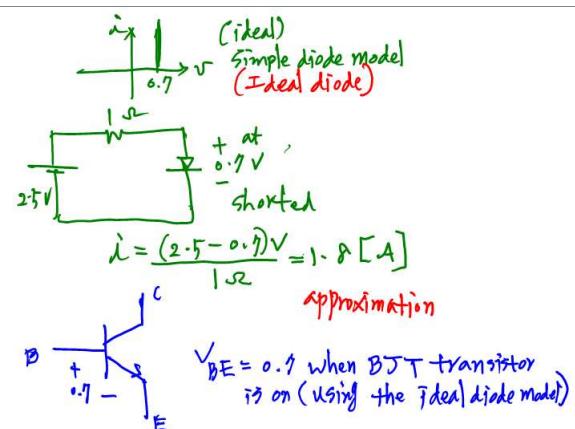
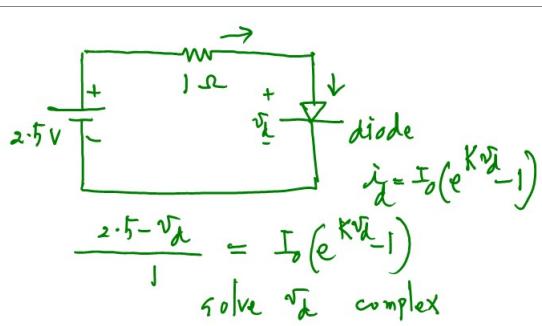
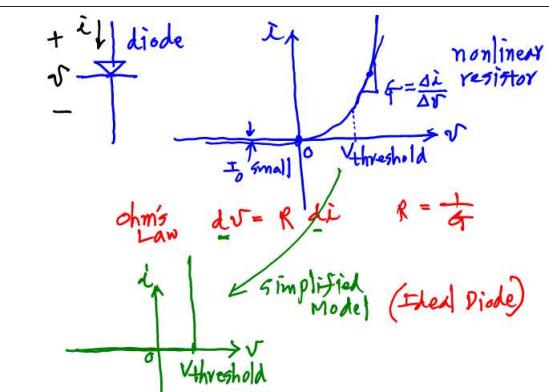
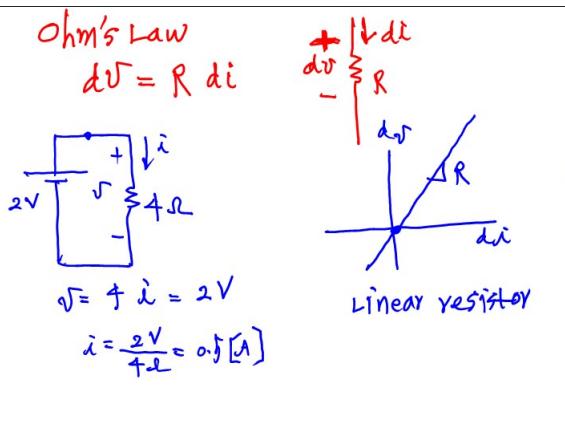
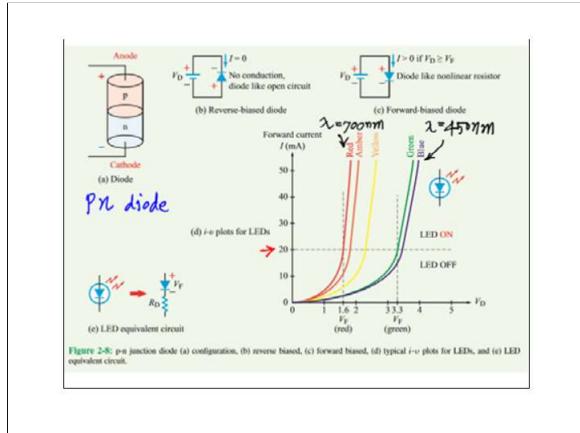


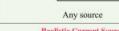
HW #1 ( $\rightarrow$  Quiz #1 on Oct 3 Th)  
 $2 = 50 - 3 = 0.5 \text{ pm}$ .

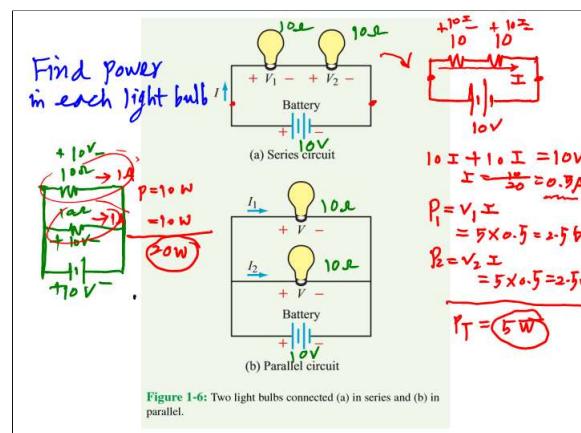
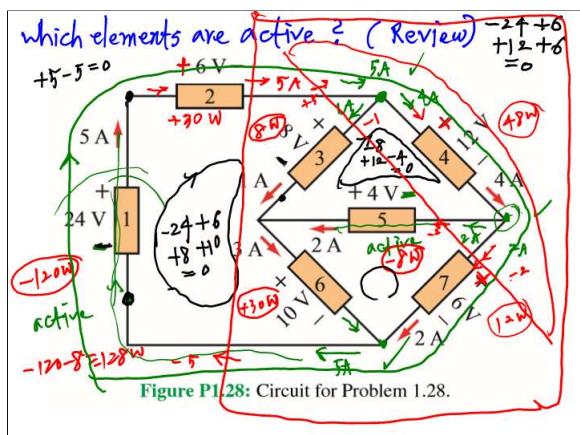
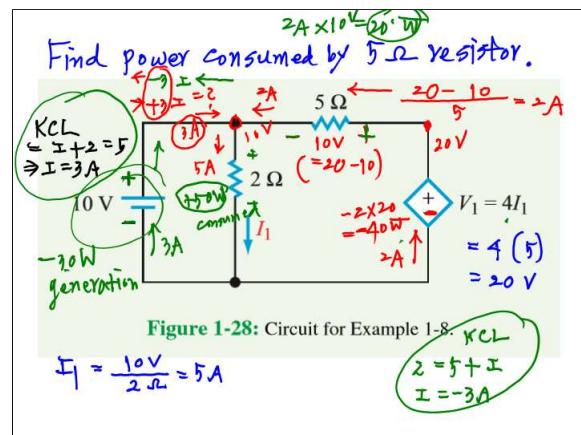
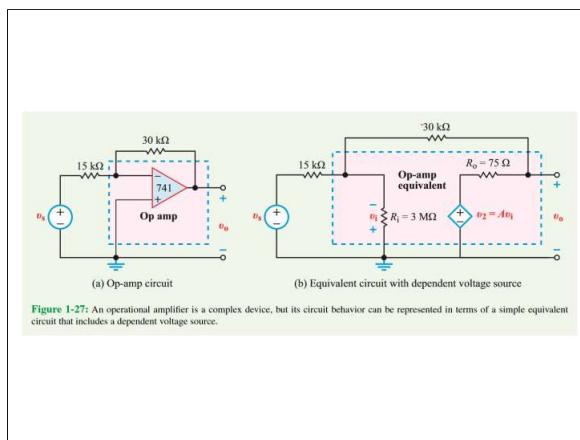
- 1) 1-1  
 2) 1-5  
 3) 1-14  
 4) 1-16 (b) + (c)  
 5) 1-25  
 6) 1-29  
 7) 1-31

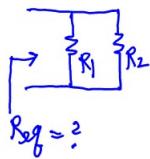
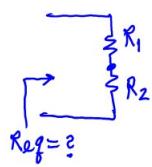
$\Rightarrow$  Qz 1  
 (15 minutes)  
 no calculator.





Independent Sources		Dependent Sources	
	or		
Battery	dc source	$v_s$	Any source*
	de source		
$I_s$	Any source	$I_s$	Any source
Dependent Sources			
	$I_x = aV_x$		$I_x = gV_x$
	$V_x = \alpha I_x$		$I_x = \beta I_x$





$$V = \frac{I}{R_1} + \frac{I}{R_2} + \dots + \frac{I}{R_N}$$

$$R_{eq} = R_1 + R_2 + R_3 + \dots + R_N$$

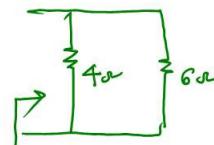
$$V = (R_1 + R_2 + \dots + R_N) I$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \dots + \frac{V}{R_N}$$

$$R_{eq} = \frac{V}{I} = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}\right)}$$

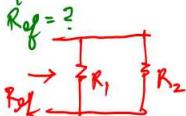
$$q = q_1 + q_2 + \dots + q_N$$

$$R = \frac{1}{q} = \frac{1}{q_1 + q_2 + \dots + q_N}$$



$$R_{eq} = \frac{1}{\left(\frac{1}{R_1} + \frac{1}{R_2}\right)}$$

$$= \frac{1}{\frac{4+6}{10}} = \frac{10}{10} = 1 \Omega$$



$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{R_1 R_2}{R_1 + R_2}} = \frac{R_1 + R_2}{R_1 R_2}$$

$$= \frac{4+6}{4 \cdot 6} = \frac{10}{24} = \frac{5}{12} \Omega \checkmark$$

Voltage Reference

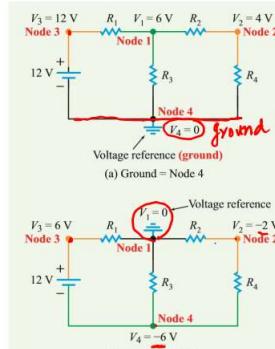
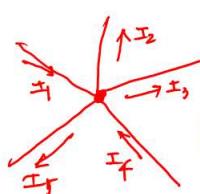


Figure 1-17: Ground is any point in the circuit selected to serve as a reference point for all points in the circuit.



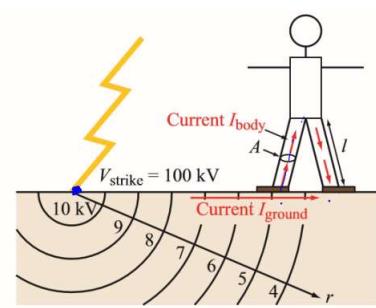
$$\sum \text{into a node} = \sum \text{out of a node}$$

$$I_1 + I_4 = I_2 + I_3 + I_5$$

$$I_1 - I_2 - I_3 + I_4 - I_5 = 0$$

$\sum I_k = 0$   
(entering +)  
leaving -

Algebraic sum of currents entering a node = 0  
Algebraic sum of currents leaving a node = 0



$$\text{Voltage} = \frac{V_{\text{strike}}}{2 \left( \frac{4}{3} \pi r^3 \right)}$$

Figure TF2-4: Current path from a lightning strike.

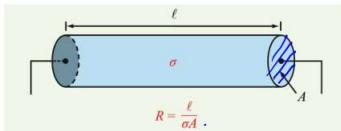


Figure 2-1: Longitudinal resistor of conductivity  $\sigma$ , length  $l$ , and cross-sectional area  $A$ .

### 2-1.1 Resistance

► The **resistance**  $R$  of a device incorporates two factors:  
(a) the inherent bulk property of its material to conduct (or impede) current, represented by the conductivity  $\sigma$  (or resistivity  $\rho$ ), and (b) the shape and size of the device. ◀

For a longitudinal resistor (Fig. 2-1),  $R$  is given by

$$R = \frac{\ell}{\sigma A} = \rho \frac{\ell}{A} \quad (\Omega), \quad (2.2)$$

$$R = \rho \frac{\ell}{A}$$

$\ell = 35'$

$2\pi r = 14'' = 14 \times 2.54 \text{ cm} = 35.6 \text{ cm} = 0.36 \text{ m}$

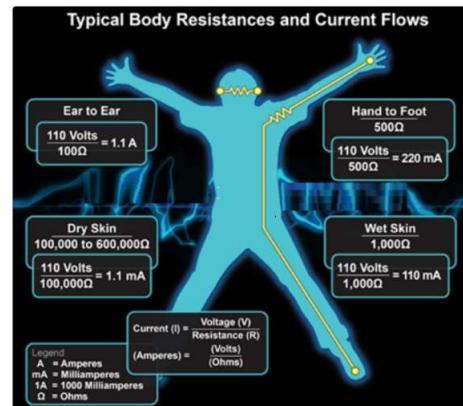
$\ell = 35' = 35 \times 2.54 \text{ cm} = 88.9 \text{ cm} = 0.89 \text{ m}$

$$\begin{aligned} \frac{\ell}{A} &= \frac{0.89 \text{ m}}{\pi r^2} = \frac{0.89}{\pi \left(\frac{0.36 \text{ m}}{2\pi}\right)^2} \\ &= \frac{0.89 \text{ m}}{\pi \frac{0.13 \text{ m}^2}{4\pi^2}} = \frac{0.89 \times 4 \times 3.14}{0.13} \left[\frac{1}{\text{m}}\right] \\ &= 86 \left[\frac{1}{\text{m}}\right] \end{aligned}$$

Material	Conductivity $\sigma$ (S/m)	Resistivity $\rho$ (Ω-m)
<b>Conductors</b>		
Silver	$6.17 \times 10^7$	$1.62 \times 10^{-8}$
Copper	$5.81 \times 10^7$	$1.72 \times 10^{-8}$
Gold	$4.10 \times 10^7$	$2.44 \times 10^{-8}$
Aluminum	$3.82 \times 10^7$	$2.62 \times 10^{-8}$
Iron	$1.03 \times 10^7$	$9.71 \times 10^{-8}$
Mercury (liquid)	$1.04 \times 10^6$	$9.58 \times 10^{-7}$
<b>Semiconductors</b>		
Carbon (graphite)	$7.14 \times 10^4$	$1.40 \times 10^{-5}$
Pure germanium	2.13	0.47
Pure silicon	$4.35 \times 10^{-4}$	$2.30 \times 10^3$
<b>Insulators</b>		
Paper	$\sim 10^{-10}$	$\sim 10^{10}$
Glass	$\sim 10^{-12}$	$\sim 10^{12}$
Teflon	$\sim 3.3 \times 10^{-13}$	$\sim 3 \times 10^{12}$
Porcelain	$\sim 10^{-14}$	$\sim 10^{14}$
Mica	$\sim 10^{-15}$	$\sim 10^{15}$
Polystyrene	$\sim 10^{-16}$	$\sim 10^{16}$
Fused quartz	$\sim 10^{-17}$	$\sim 10^{17}$
<b>Common materials</b>		
Distilled water	$5.5 \times 10^{-6}$	$1.8 \times 10^5$
Drinking water	$\sim 5 \times 10^{-3}$	$\sim 200$
Sea water	4.8	0.2
Graphite	$1.4 \times 10^{-5}$	$71.4 \times 10^3$
Rubber	$1 \times 10^{-13}$	$1 \times 10^{13}$
<b>Biological tissues</b>		
Blood	$\sim 1.5$	$\sim 0.67$
Muscle	$\sim 1.5$	$\sim 0.67$
Fat	$\sim 0.1$	10

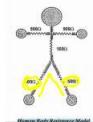
$$\begin{aligned} R &= \rho \frac{\ell}{A} \\ &= 6 \left[ \Omega \cdot \text{m} \right] \\ &\times 86 \left[ \frac{1}{\text{m}} \right] \\ &\approx 516 \left[ \Omega \right] \\ &\approx 500 \left[ \Omega \right] \\ &\text{mmmm} \end{aligned}$$

$$\begin{cases} \log \rho = \text{say} \\ 6 \left[ \Omega \cdot \text{m} \right] \end{cases}$$



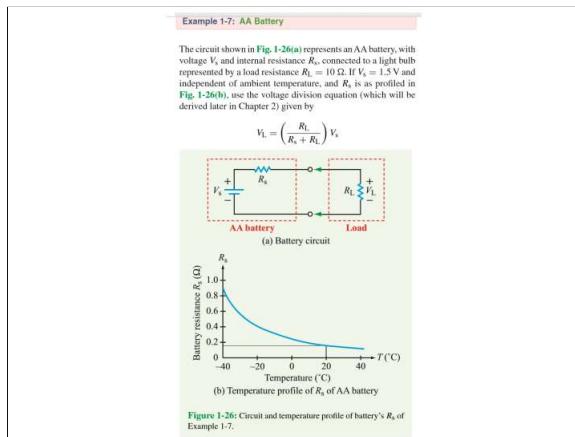
### Human body resistance ohms

Resistance and the Human Body. Dry skin resistance can be **100,000 ohms** or more depending on several factors including skin thickness, dryness levels, calluses. Do whatever you can to raise your body's resistance. The key to survival is to decrease exposure. The typical body has a contact resistance of 500 ohms at the point of contact with the electrical source.



Reference: [www.msamc.org/arclight/Arc\\_Flash\\_Overview15.html](http://www.msamc.org/arclight/Arc_Flash_Overview15.html)

$$\begin{aligned} V(r_1) &= \frac{50k}{(3\pi r_1^3)} \approx 1 \\ r_1 &= 5 \text{ m} \\ \frac{50k}{5^3} &= 50kV [0.008] \\ r_2 &= 5.5 \text{ m} \\ \frac{50k}{5.5^3} &= 50kV [0.006] \\ V(r_1) - V(r_2) &= 50kV [0.002] = 100V \\ I &= \frac{100V}{5K} = 20 \text{ mA} \end{aligned}$$



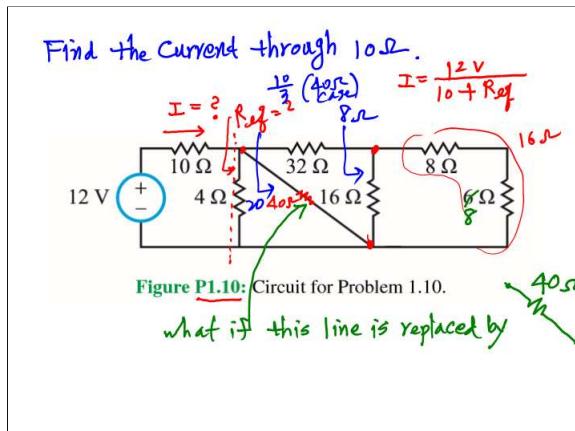
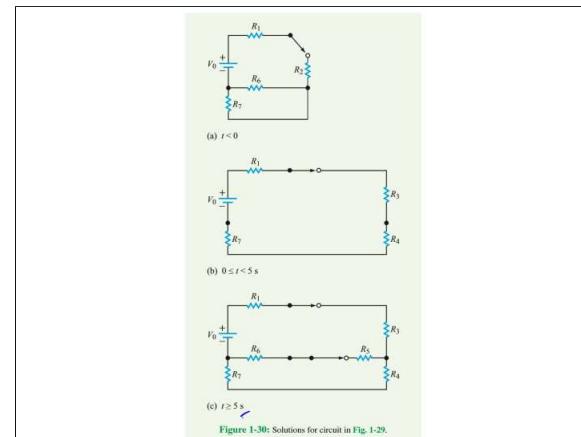
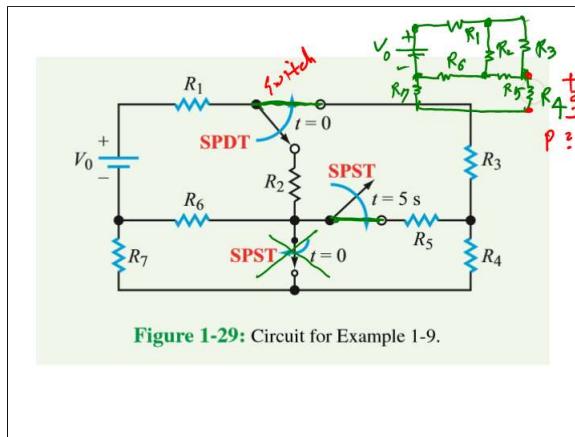
$$V_s \xrightarrow{R_s} V_L = \frac{R_L}{R_s + R_L} V_s$$

$$P_L = V_L I = \frac{R_L}{R_s + R_L} V_s I$$

$$P_L = I^2 R_L = \frac{(V_s)^2}{(R_s + R_L)^2} R_L$$

$$\frac{\partial P_L}{\partial R_L} = 0 \Rightarrow R_L^* = R_s$$

$$R_L^* = R_s$$



$$\frac{R_1 R_2}{R_1 + R_2} \parallel \frac{R^2}{2R} = \left( \frac{R}{2} \right)$$

$$\frac{4 \times 20}{20 + 4} = \frac{16 \times 20}{34 \times 2} = \frac{10}{3} \Omega$$

$$I = \frac{12}{10 + \frac{10}{3}} = \frac{12 \times 3}{30 + 10} = \frac{36}{40} = 0.9 \text{ A}$$

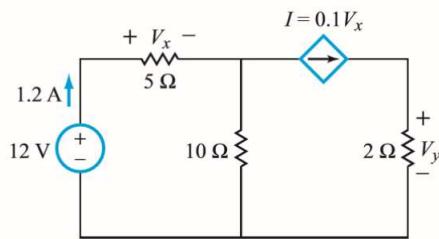


Figure P1.38: Circuit for Problem 1.38.

1.42 For the circuit in Fig. P1.42, generate circuit diagrams that include only those elements that have current flowing through them for

- (a)  $t < 0$
- (b)  $0 < t < 2 \text{ s}$
- (c)  $t > 2 \text{ s}$

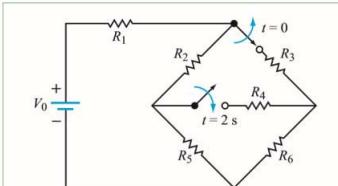


Figure P1.42: Circuit for Problem 1.42.

Find  $V_x, V_z$

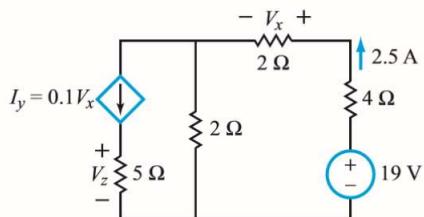


Figure P1.40: Circuit for Problem 1.40.