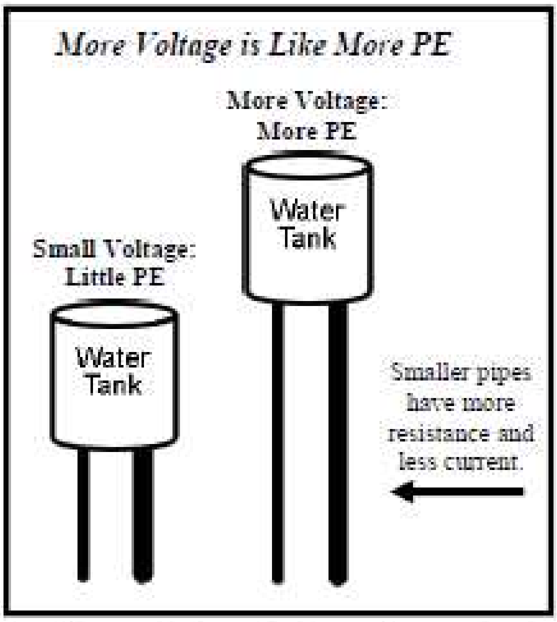
Name:______________________

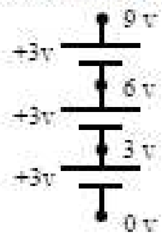
Voltage in Circuits

8.4

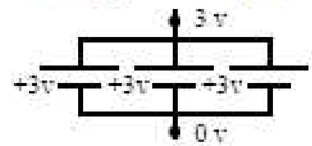
Batteries add voltage: as you move over a battery you gain voltage. The voltage at the bottom of the first battery is always 0 volts. *Think of batteries as lifting water up: adding electrical potential energy.*



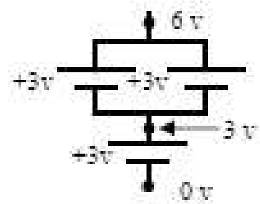
Batteries in series add voltage (raising electrical potential energy).



Batteries in parallel share the same voltage. (They just last longer.)

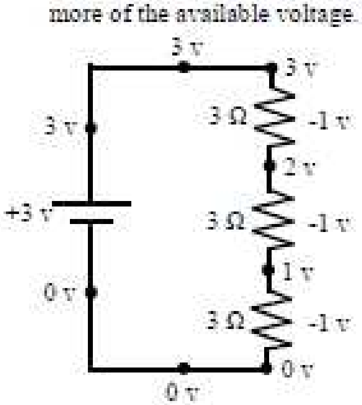


Remember: there can never be a change of voltage on a wire.

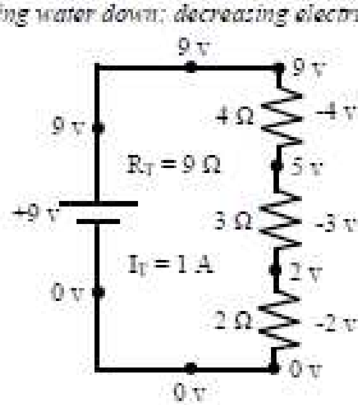


Notice here that the two batteries in parallel add only 3 volts, giving 6 volts total.

Resistors use (subtract) voltage: Every resistor in a circuit uses voltage. Think of it as a negative voltage: subtract the voltage it uses from the voltage at the top of the resistor. Resistors in series SHARE voltage, with bigger resistors using more of the available voltage. *Think of resistors as lowering water down: decreasing electrical potential energy.*



In this circuit we don't need to calculate the voltage drops. Since there are three resistors of equal resistance, each will use one-third the available voltage.



To find the voltage drops, we must first find the total current.

$$I_T = \frac{V_T}{R_T} = \frac{9v}{9\Omega} = 1A$$

$V_{4\Omega} = IR = 1(4) = 4v$

$V_{3\Omega} = 3v$

$V_{2\Omega} = 2\ v$

Notice that the biggest resistor used the most voltage.

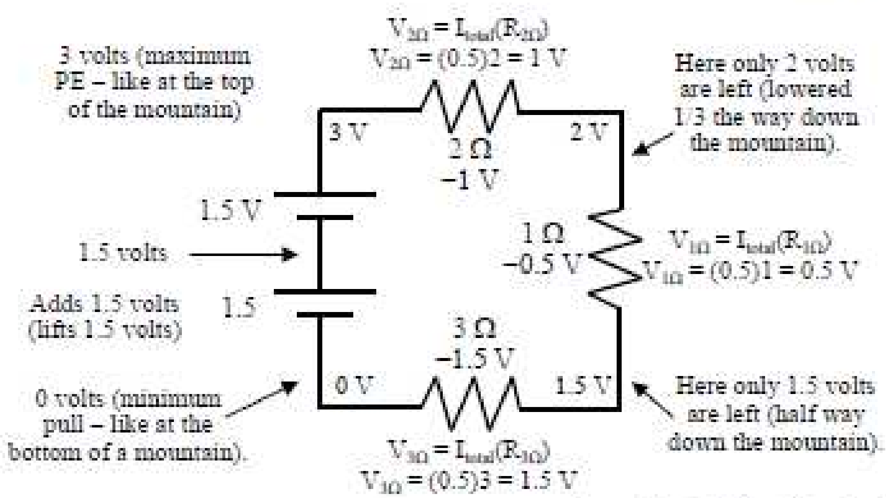
Each battery raises voltage (the electrical potential energy) and each resistor uses part of the voltage (lowering the electrical potential). Since the three resistors are in series, they have the same current (since there is only one path for the current).

$V = IR$, so $I = V/R$

$R_{total} = 6\ \Omega$ and $V_{total} = 3\ v$

So, $I = 3v/6\Omega = 0.5$ amps.

Then use $V = IR$ for each resistor to find how much voltage it uses.

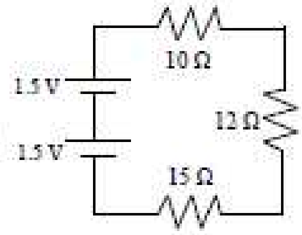


Equivalent Resistance

Resistors in Series

$$R_{total} = R_1 + R_2 + R_3 \ldots$$

As you add resistors in series, you increase resistance. Simply add the amounts together.

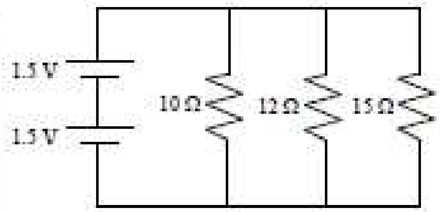


Example: Calculate the total resistance of this circuit.

$R_T = R_1 + R_2 + R_3 \ldots$
$R_T = 10 + 12 + 15$
$R_T = 37\Omega$

Resistors in Parallel

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$$



Example: Calculate the total resistance of this circuit.

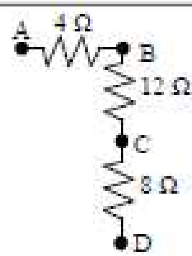
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

$$\frac{1}{R_T} = \frac{1}{10} + \frac{1}{12} + \frac{1}{15} = .1 + .083 + .067$$

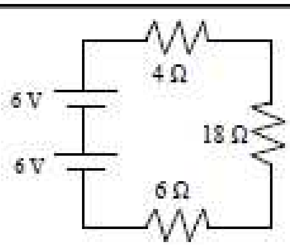
$$\frac{1}{R_T} = .25 \qquad R_T = \frac{1}{.25} = 4\Omega$$

As you add resistors in parallel, you open more paths for the electricity to flow, increasing total current, and decreasing total resistance. For resistors in parallel, the total resistance is always less than the smallest resistor.

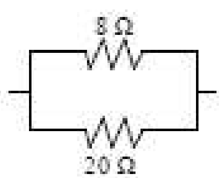
1. These resistors are in:
2. What is R_{total} from A to C?
3. What is R_{total} from B to D?
4. What is R_{total} from A to D?



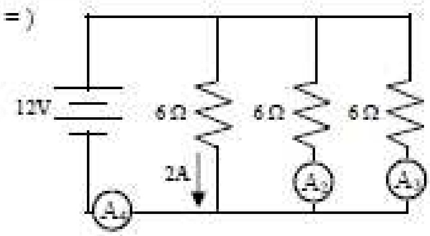
5. Calculate the total resistance.
6. Calculate total voltage.
7. Calculate total current.



8. Calculate the total resistance.
9. How does R_{total} compare with the individual resistors?
10. Why?



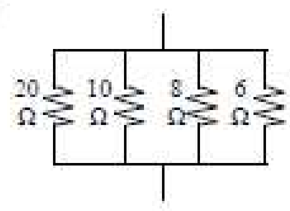
11. A_2 reads (current 2 =)
12. A_3 =
13. A_4 =
14. Since V = IR and R = V/I, R_{total} =



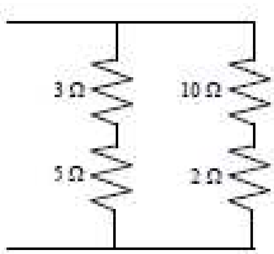
15. If one of the resistors is removed, R_{total} =

16. You are given four 100 Ω resistors.
    A. If in series R_{total} =
    B. If in parallel R_{total} =

17. Without calculating, you know that R_{total} must be less than:
18. Calculate R_{total}.



19. Calculate and label the total resistance for each pair of resistors in series.
20. Calculate the total resistance for the two parallel branches.



21. What is the equivalent resistance of the parallel resistors?
22. Calculate R_{total} for all three resistors.