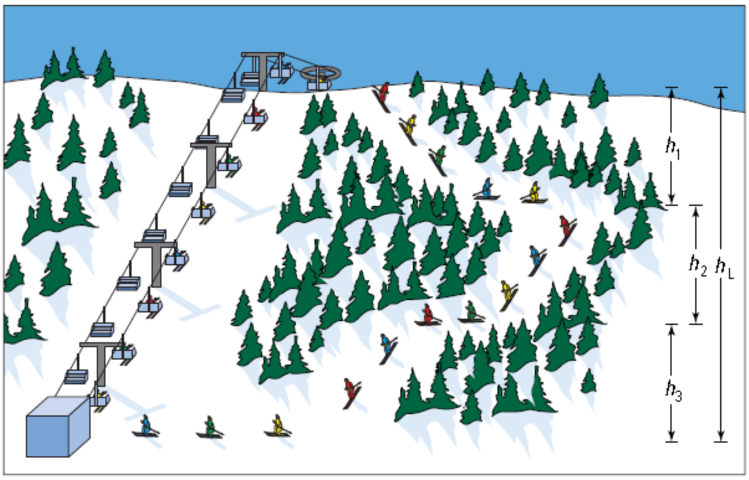
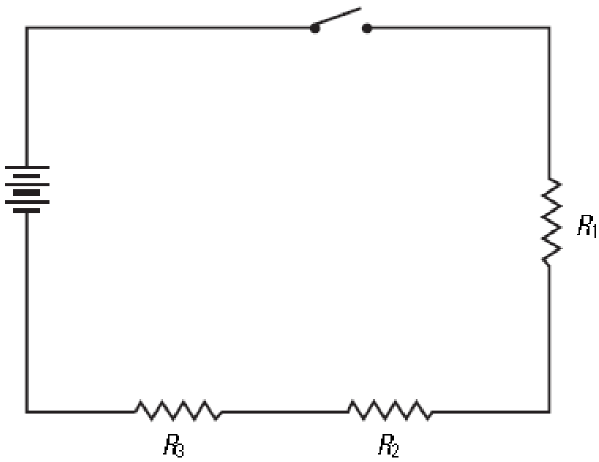
15.4 Series and Parallel Circuits

Series Circuits



- all the skiers leaving the lift MUST follow the same path down the hill
- the number of skiers past any given point in a specific amount of time would be the same
- the change in E_g would be shared between the three runs, therefore the total E_g is the sum of all three



- all the current leaving the battery MUST follow the same path through the circuit
- the number of electrons past any given point in a specific amount of time would be the same
- the change in electric potential (voltage) would be shared between the three loads, therefore the total electric potential is the sum of all three

EQUIVALENT RESISTANCE OF LOADS IN SERIES

The equivalent resistance of loads in series is the sum of the resistances of the individual loads.

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

Quantity	Symbol	SI unit
equivalent resistance	R_{eq}	Ω (ohm)
resistance of individual loads	$R_{1,2,3,\cdots N}$	Ω (ohm)

Resistances in Series

Four loads (3.0 Ω, 5.0 Ω, 7.0 Ω, and 9.0 Ω) are connected in series to a 12 V battery. Find

(a) the equivalent resistance of the circuit

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

(b) the total current in the circuit

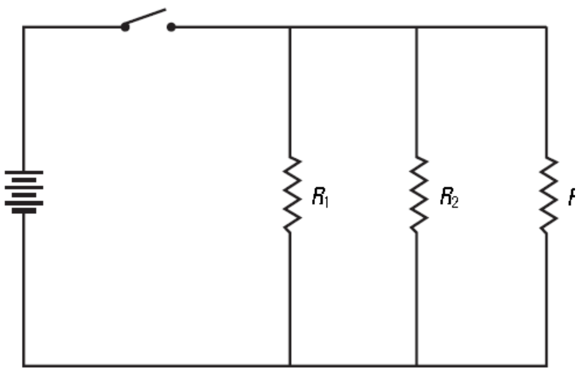
$$V = IR$$

(c) the potential difference across the 7.0 Ω load

$$V = IR$$

Parallel Circuits

- Skiers gain the same Eg, but now have a choice of paths to follow to the bottom
- the change in Eg for all skiers is the same
- the harder the run, the fewer skiers might pass by a given point at any time, but the SUM of the skiers arriving at the bottom is the same as those that got to the top



- Electrons gain the same electric potential but now have a choice of paths to follow
- the change in electric potential for electrons is the same, and is equal to that provided by the battery
- the current splits at each junction and recombines at the other side
- the total of the currents in each of the paths is equal to that leaving the battery

RESISTORS IN PARALLEL

For resistors connected in parallel, the inverse of the equivalent resistance is the sum of the inverses of the individual resistances.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

Quantity	Symbol	SI unit
equivalent resistance	R_{eq}	Ω (ohm)
resistance of the individual loads	$R_1, R_2, R_3, \ldots, R_N$	Ω (ohm)

Resistors in Parallel

A 60 V battery is connected to four loads of 3.0 Ω, 5.0 Ω, 12.0 Ω, and 15.0 Ω in parallel.

(a) Find the equivalent resistance of the four combined loads.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

(b) Find the total current leaving the battery.

$V = IR$

(c) Find the current through the 12.0 Ω load.

$V = IR$