Resistors and Capacitors in Series and Parallel Circuits

Series Circuits

Parallel Circuits

Mixed Circuits

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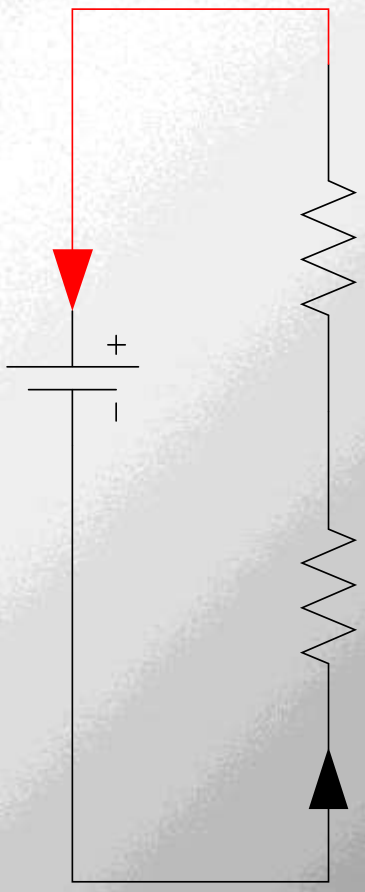
Resistors in Series Circuits

If there is only one current path, the components are in series.

Current is the same at all points.

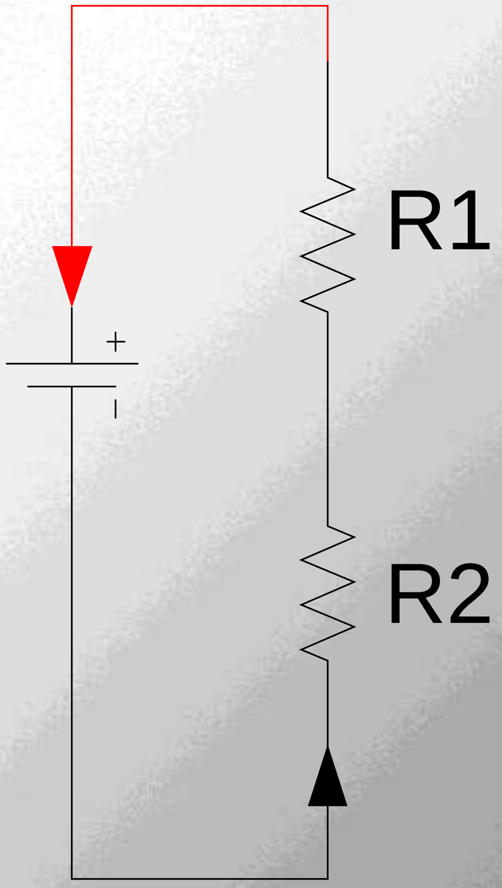


Resistors in Series Circuits

Think of the equivalent resistor broken into two or more resistors.

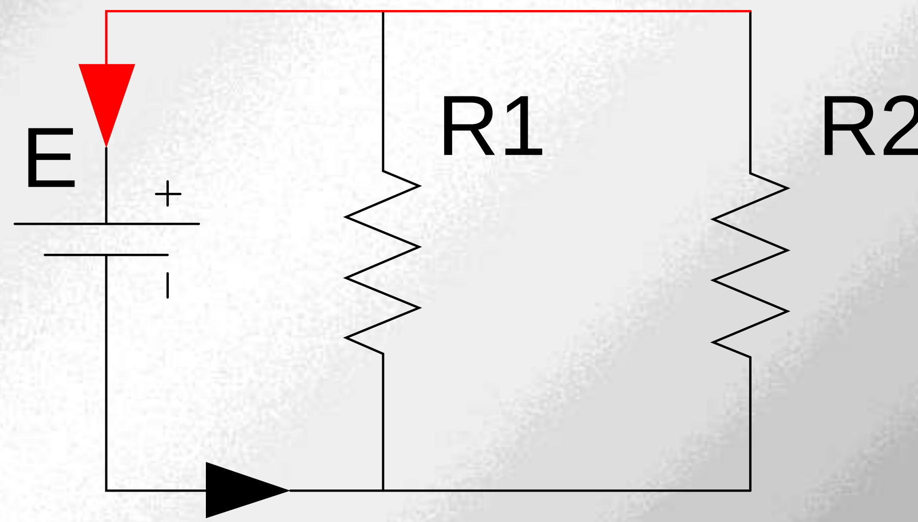
Just add up the parts to get the equivalent, R_E.

$$R_E = R_1 + R_2 + \ldots + R_n$$



Resistors in Parallel Circuits

- If there is more than one path for the current, the circuit is a parallel circuit.
- The currents add together.
- I = E/R1 + E/R2
- Use R = E/I.
- Cancel the E's.



$$R_E = \frac{\cancel{E}\;1}{\frac{\cancel{E}\;1}{R_1} + \frac{\cancel{E}\;1}{R_2}}$$

Formulas for Resistors in Parallel

For three or more resistors:

$$R_E = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}}$$

For two resistors:

$$R_E = \frac{R_1 R_2}{R_1 + R_2}$$

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Resistors in Series: $R_E = R_1 + R_2$

Use a proto board or clip leads to set up this circuit using the resistance values indicated on the next slide.

Calculate the equivalent resistant R_E and measure the resistance with your Ohmeter.

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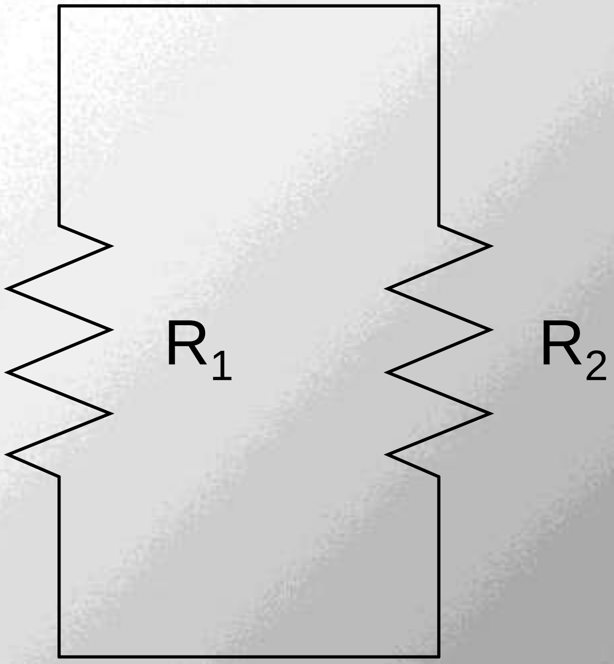
Resistors in Series: $R_E = R_1 + R_2$

R_1	R_2	Calculated R_E	Measured R_E
100	100		
100 k	10 k		
4.7 k	4.7 k		
330	4.7 k		

Resistors in Parallel: $R_E = 1/(1/R_1 + 1/R_2)$

Use a proto board or clip leads to set up this circuit using the resistance values indicated on the next slide.

Calculate the equivalent resistant R_E and measure the resistance with your Ohmeter.



Resistors in Parallel: $R_E = 1/(1/R_1 + 1/R_2)$ or: $R_E = R_1 * R_2 /(R_1 + R_2)$ (Try using both methods.)

R_1	R_2	Calculated R_E	Measured R_E
100	100		
100 k	10 k		
4.7 k	10 k		
330	4.7 k		

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Resistors in Parallel Challenge

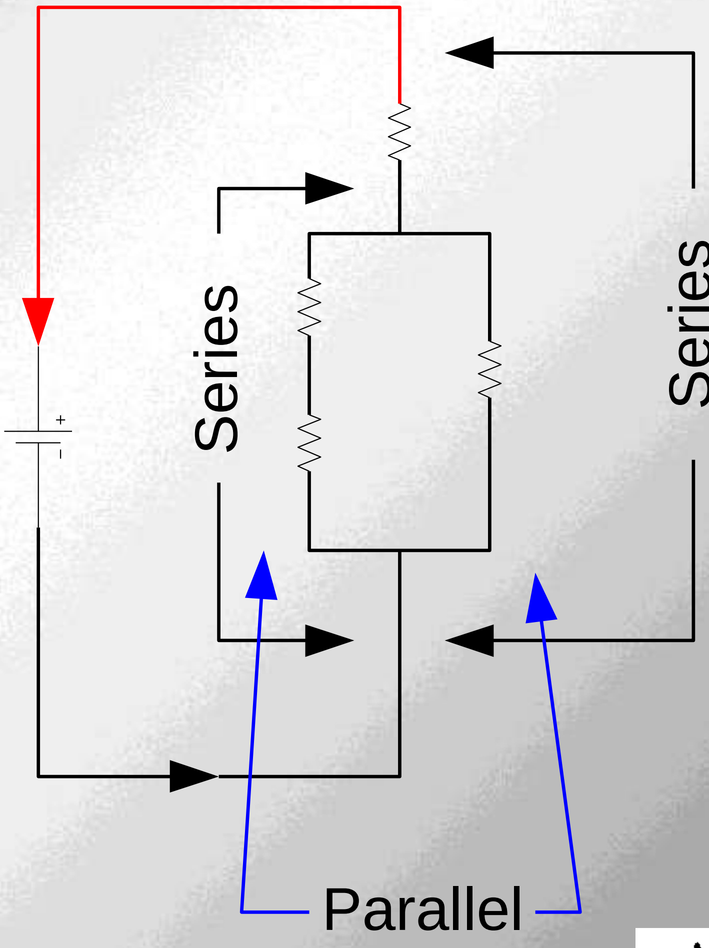
Make a circuit with 3 resistors in parallel, calculate the equivalent resistance then measure it.

- R_1 = 330 ohm
- R_2 = 10 k-ohm
- R_3 = 4.7 k-ohm

R_E = 300 ohm

Resistors in Series-Parallel

- Sometimes resistors are in series with other resistors which are in parallel with resistors.
- You can solve the individual branches to get to one equivalent resistance.



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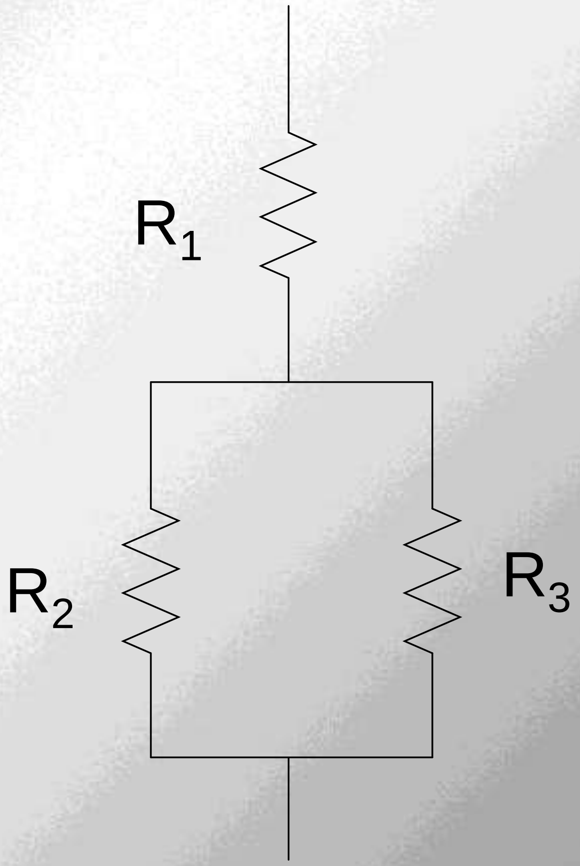
Resistors in Series-Parallel

Use a proto board or clip leads to build this circuit using:

- R_1 = 330
- R_2 = 4.7 k
- R_3 = 2.2 k

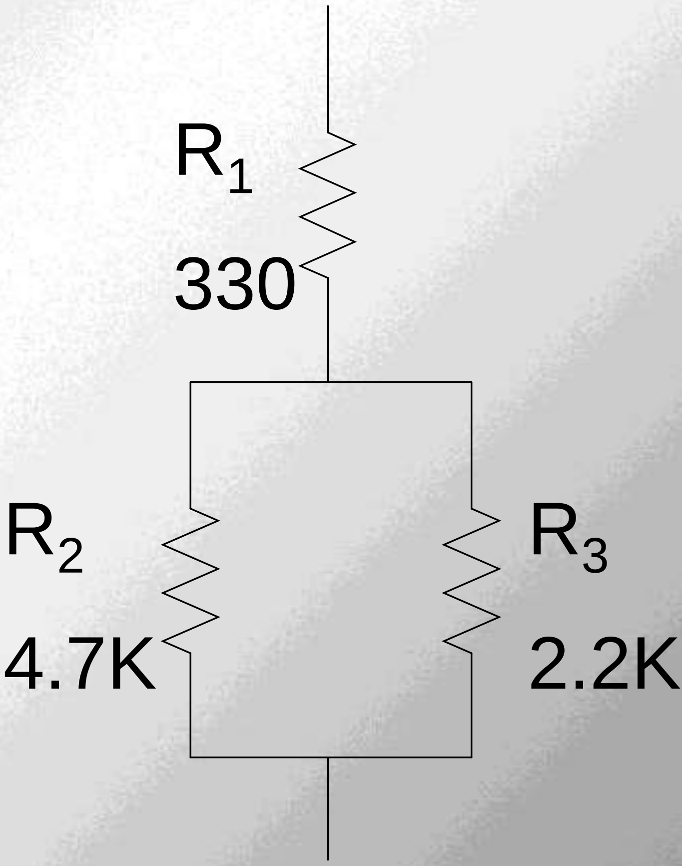


Resistors in Series-Parallel

Take the parallel segment of the circuit and calculate the equivalent resistance:

$$R_E = \frac{R_2 R_3}{R_2 + R_3}$$

$R_E = 1498$



Resistors in Series-Parallel

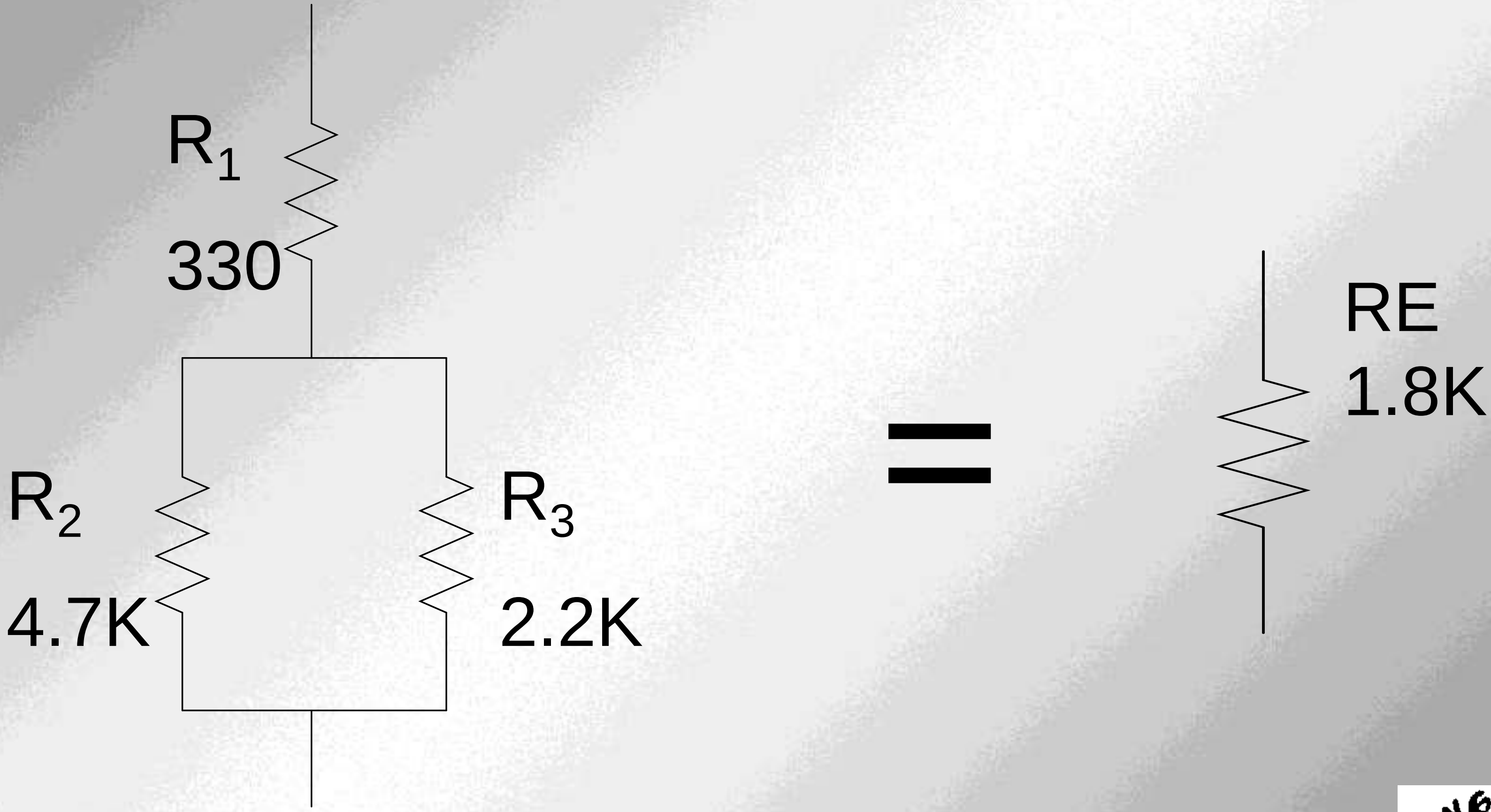
We now can look at the simplified circuit as shown here. The parallel resistors have been replaced by a single resistor with a value of 1498 ohms.

- Calculate the resistance of this series circuit:

$$R_E = 330 + 1498$$

$R_E = 1828$

Resistors in Series-Parallel



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Inductors in Series or Parallel

Inductors in series, parallel, and mixed circuits combine the same way as resistors mathematically so the same formulas and techniques may be used.

- Inductors in series are like resistors in series.
- Inductors in parallel are like resistors in parallel.
- Inductors may have inductance from mutual coupling, which must be included.

Capacitors in Circuits

The amount of capacitance depends on:

- Surface area of parallel conductive plates.
- Space between plates.
- Dielectric (material between plates).

The math for finding equivalent capacitance is opposite from the math for resistors.

- Capacitors in parallel have more surface area.
- Capacitors in series have more space between plates.

Capacitors in Parallel

When capacitors are connected in parallel, the top plates are connected together and the bottom plates are connected together.

- This means that the top surface areas are combined (added) and the bottom surfaces are combined (added).
- Greater surface area means greater capacitance.

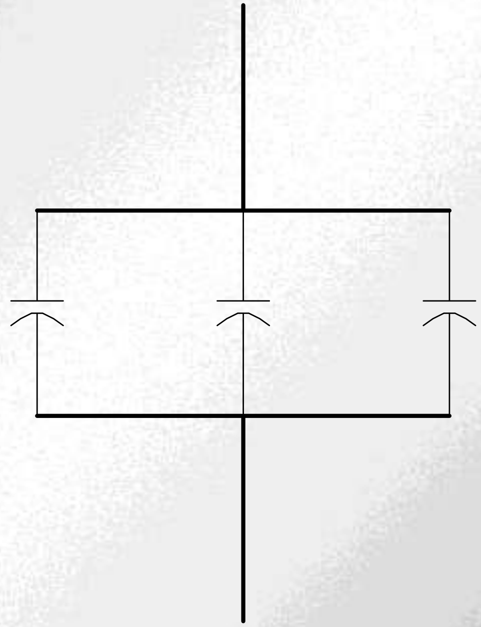
Capacitors in Series

When capacitors are connected in series, the top plates are connected to the bottom plates of the adjacent capacitor.

- This means that the top plate of the first capacitor is further away from the bottom plate of the last capacitor.
- The greater the distance between the plates in a capacitor the lower the capacitance.

Capacitors in Parallel

$$C_T = C_1 + C_2 + C_3 + ... + C_N$$



Calculating Capacitors in Parallel

Change all values to same units, pF, nF, uF.

C_1	C_2	Calculated C_E
5 nF	750 pF	pF
100 pF	100 pF	pF
0.01 uF	0.047 uF	uF
100 uF	50 uF	uF

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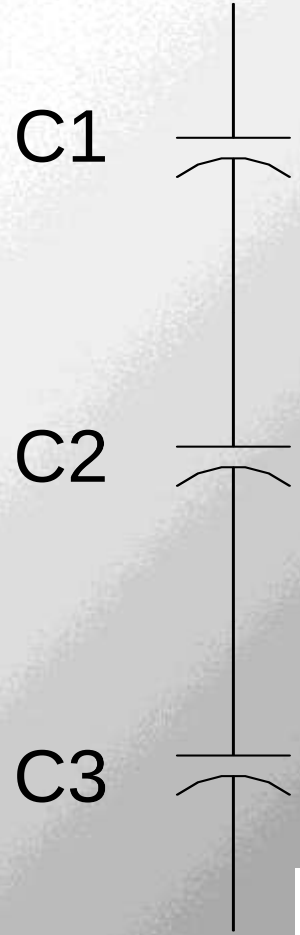
Calculating Capacitors in Series

$$C_E = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_N}}$$

For two capacitors:

$$C_E = \frac{C_1 C_2}{C_1 + C_2}$$



Calculating Equivalent Capacitance

Series circuit of two or three capacitors:

C_1	C_2	C_3	C_E
5000 pF	750 pF	-	
100 pF	100 pF	-	
0.01 uF	0.047 uF	100nF	
100 uF	50 uF	8uF	

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Resistors in Parallel vs. Series

R_1	R_2	Parallel	Series
100	100	50	200
100 k	10 k	9.09 k	110 k
4.7 k	4.7 k	2.35 k	9.4 k
330	4.7 k	308	5.03 k

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Capacitors in Parallel vs. Series

C1	C2	Parallel	Series
5000 pF	750 pF	5750 pF	652 pF
100 pF	100 pF	200 pF	50 pF
0.01 uF	0.047 uF	0.057 uF	0.008 uF
100 uF	50 uF	150 uF	33 uF

Comparing Resistors and Capacitors

Compare the results:

- **Resistors** in **series** are equivalent to a resistance which is larger than any of the resistors.
- **Resistors** in **parallel** are equivalent to a resistance which is smaller than the smallest of the resistors.
- **Capacitors** in **paralle**l are equivalent to a capacitance which is larger than any of the capacitors.
- **Capacitors** in **series** are equivalent to a capacitance which is smaller than the smallest of the capacitors

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Conclusion

You can learn one set of formulas (for resistance), and just remember that capacitors are the opposite (mathematically) of resistors.

Series R, Parallel C:

$$R_E = R_1 + R_2 + ... + R_n$$

Parallel R, Series C:

$$R_E = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}}$$

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