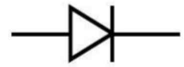
Rectification

Rectification:

Reason:

Rectifier:

Diode:

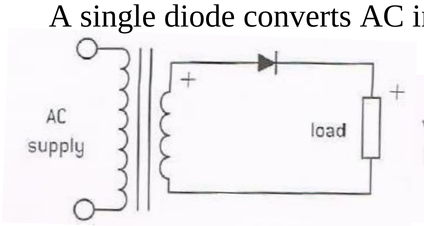


An ideal diode allows current to flow in the forward direction (negligible resistance with forward bias) but does not allow current to flow in the reverse direction (infinite resistance with reverse bias).

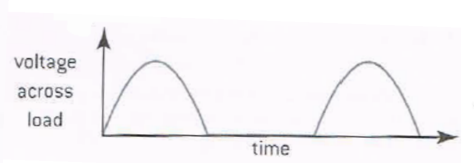
Types of rectification circuits (rectifiers)

a) **Half-wave rectification:** uses one diode - allows only the positive half of the AC wave to pass

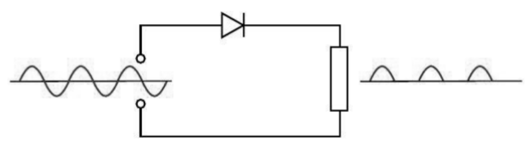
A single diode converts AC into pulsating DC.



Circuit

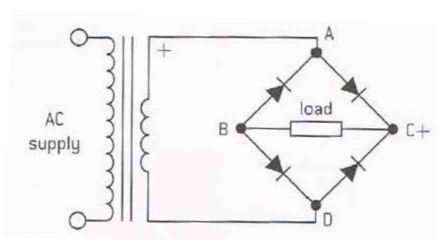


Voltage output

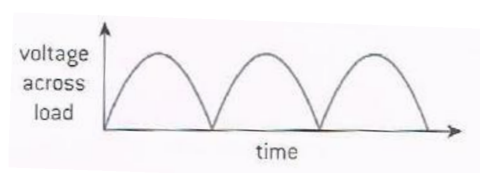


Another example

b) **Full-wave rectification:** uses a diode bridge (with four diodes) – allows both halves of the AC wave to pass but the negative half is inverted

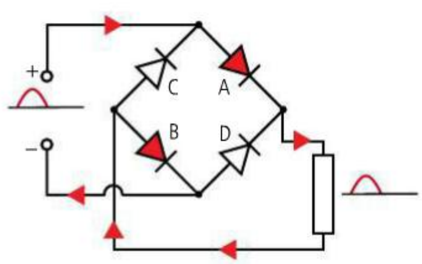


Circuit

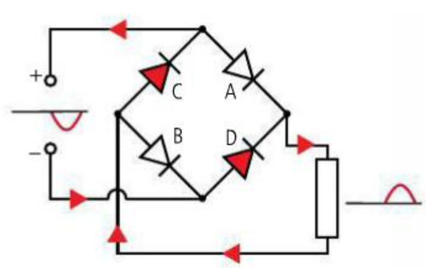


Voltage output

How does the full-wave rectification circuit work?



1st half of cycle

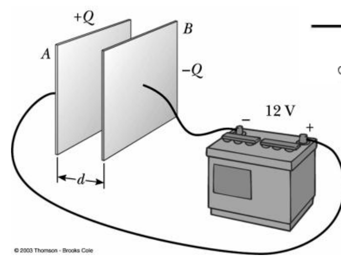


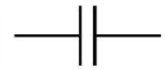
2nd half of cycle

a) Diode bridge is formed from two sets of parallel diodes. Diodes on parallel sides of the bridge point in the same directions.
b) During each half-cycle of AC, one set of parallel-side diodes conducts.
c) Output current always flows through the load resistor in the same direction (DC).
d) The output voltage and current are not constant or smooth. A capacitor may be used to "smooth" the output.

Capacitance

Two identical metal plates, each with area A, are set a distance d apart. They are each charged by connecting them to a source of potential difference V like a battery, as shown in the diagram.





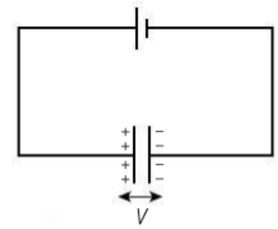
capacitor symbol

Capacitor:

Capacitance:

Definition -

Schematic



Formula:

Units:

1. What physical properties does the capacitance of a capacitor depend on?

Quantity	Variable	Unit

Permittivity of free space (vacuum):

General Formula:

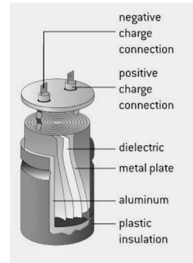
Formula for vacuum (air):

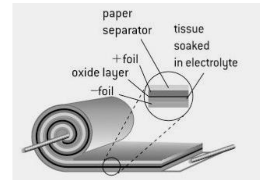
2. The square plates in the capacitor shown above are 32 mm apart and are 5.0 cm on each side.

   a) What is the capacitance?

   b) What is the amount of charge stored in the capacitor?

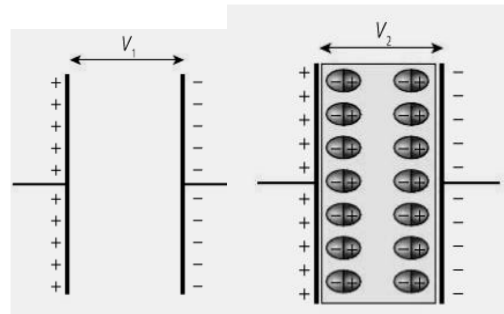
Dielectric material:





Examples: paper, mica, Teflon, plastics, ceramics, metal oxides

3. What is the effect of different dielectric materials on capacitance when the dielectric is placed between the parallel plates?

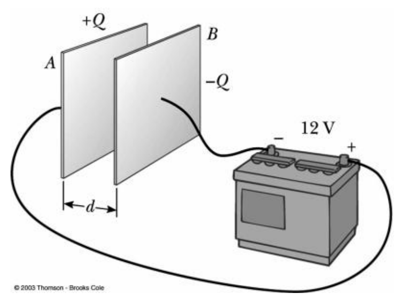


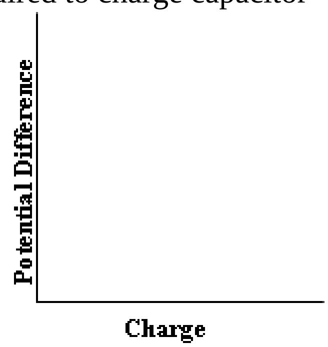
The insertion of the dielectric reduces the potential difference between the plates ($V_2 < V_1$) because some of the stored energy of the capacitor has been used to align the dielectric molecules. Because the overall charge stored is unchanged, the net effect is that the capacitance has increased.

Therefore, dielectrics increase the capacitance of a capacitor.

4. How much energy is stored in a capacitor, that is, how much work is required to charge capacitor to a final charge of q?

The plates are initially uncharged and their potential difference is zero. As charge builds up on the plates, the potential difference between them increases and more work is required to move additional charge onto the plates.

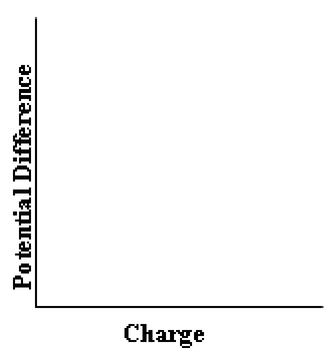




Derivation:

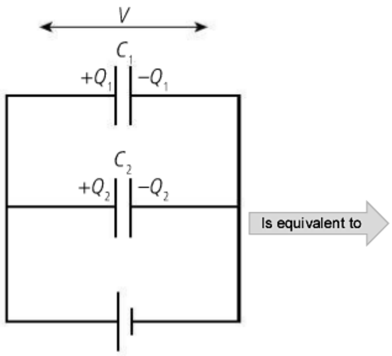
Formula:

5. What do the slope and area of the graph represent?



Capacitors in Series and Parallel

Parallel Capacitors

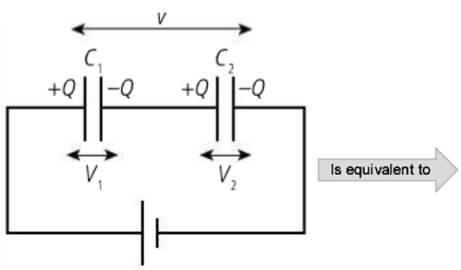


Control variable:

Conservation of . . .

Derivations:

Series Capacitors



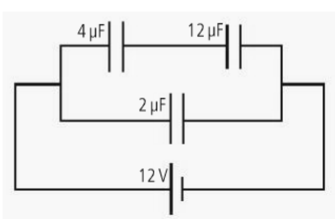
Control variable:

Conservation of . . .

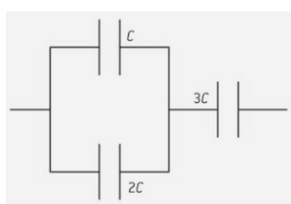
Derivations:

1. Calculate the equivalent capacitance of each network below.

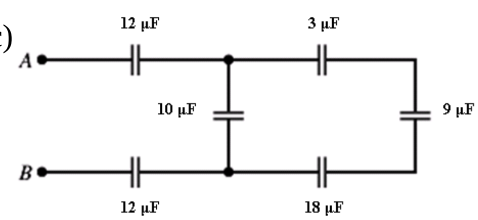
a)



b)

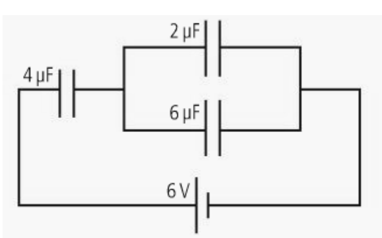


c)

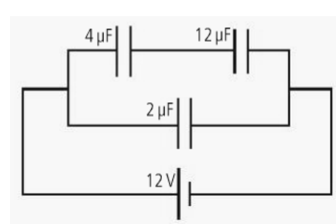


2. In each circuit, calculate the potential difference across the 4μF capacitor.

a)

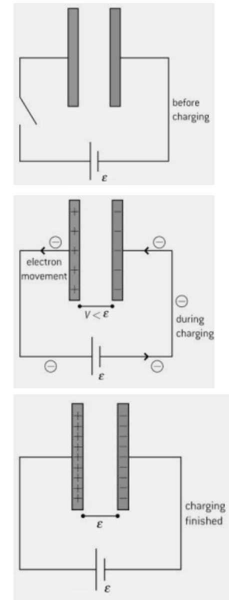


b)



Charging a Capacitor

A capacitor which is initially uncharged is connected to a cell in order to be charged, as shown.



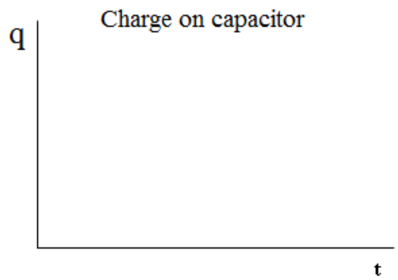
a)

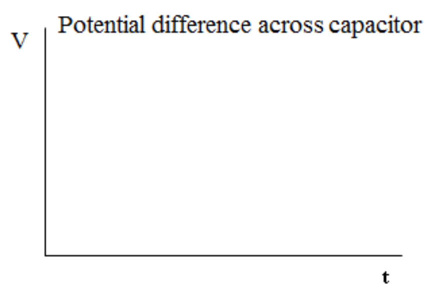
b)

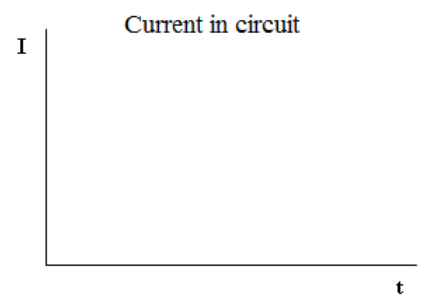
c)

d)

1. Sketch the following graphs for the charging circuit shown.

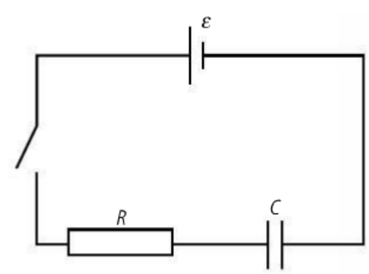






Type of relationships:

R-C circuit:



Effect of adding resistor:

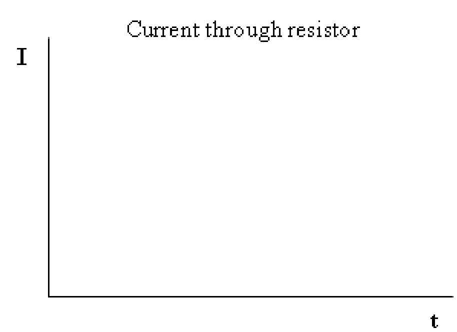
Common use:

2. What determines the amount of time it takes the capacitor to charge?

Time constant:

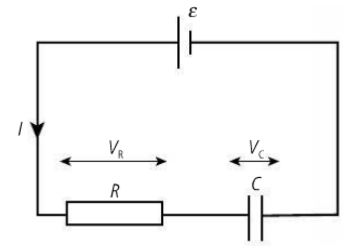
Units:

3. On the axes at right, sketch a graph of the charging current for a circuit with a large time constant and one with a small time constant. Label each.



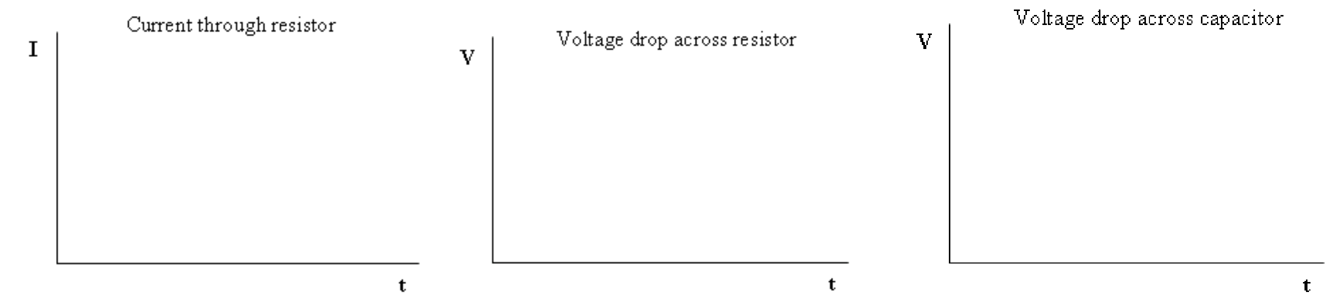
Maximum current:

4. What are the steady state values?



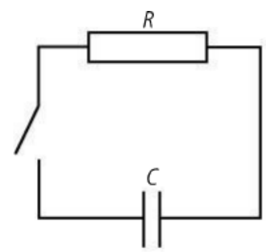
Steady State:

5. Sketch the following graphs for the R-C charging circuit above.

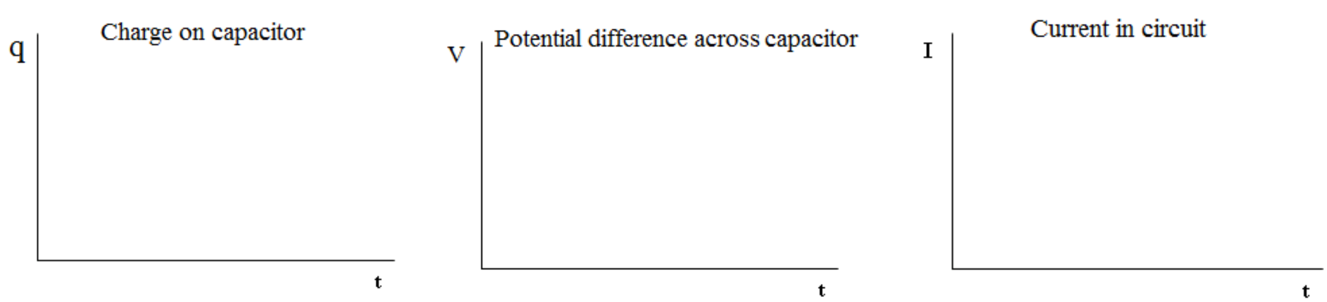


Discharging a Capacitor

6. What happens when the switch is closed in the circuit at right?



7. Sketch the following graphs for the R-C discharging circuit above.

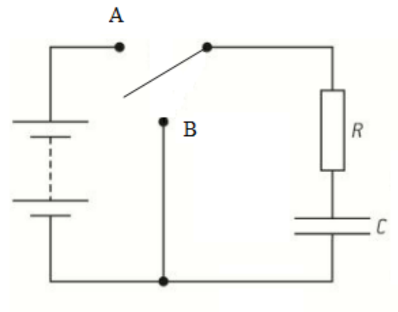


Derivation:

Time constant:

Math Models:

8. A circuit is shown at right that can be used to both charge and discharge a 220 μF capacitor through a 330 kΩ resistor.



a) In which position should the switch be to:

i) charge the capacitor? ii) discharge the capacitor?

b) Calculate the time constant for this circuit.

c) If the capacitor has been charged to 30 V, what will be the potential difference across it after discharging for 20 seconds?

d) How long will it take the capacitor to discharge to 10 V?

e) Calculate the amount of charge that has passed through the circuit in the time it takes to discharge to 10 V.

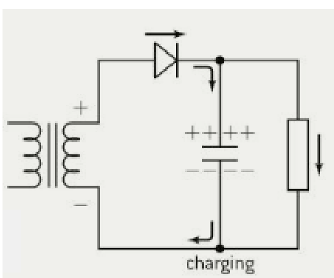
f) How much time will it take the capacitor to lose 90% of its charge?

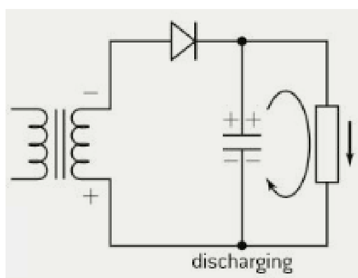
9. The discharge current of a 470 μF capacitor through an unknown resistance falls from 87 mA to 12 mA in two minutes. Determine the unknown resistance.

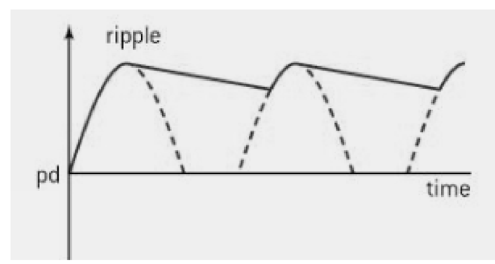
Effect of adding a capacitor on diode bridge rectification circuits

Effect:

a) Half-wave rectification







b) Full-wave rectification