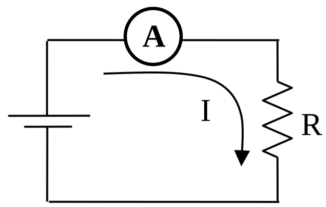
RC-1. A good ammeter has an internal resistance that is..

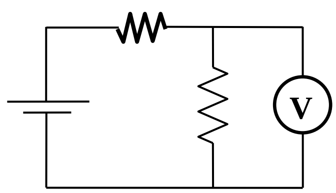
A) very low B) very high
C) the internal resistance of an ammeter does not affect its function.



Answer: very low An ideal ammeter has zero internal resistance, so that it does not affect the current it is measuring.

RC -2. A good voltmeter has an internal resistance that is..

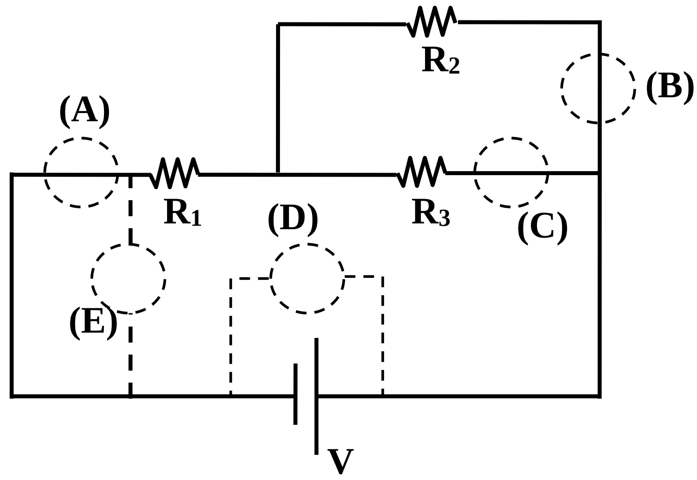
A) very low B) very high
C) the internal resistance of a voltmeter does not affect its function.



Answer: very high An ideal voltmeter has an infinite internal resistance, so that no current flows through the voltmeter. Otherwise, its presence would change the current through the resistor and that would affect the voltage across the resistor ($V_R = IR$).

RC -3. If you wanted to measure the current through the battery, where in the circuit would you place an ammeter?

(A), (B), (C), (D), (E).



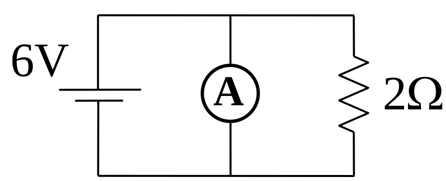
If you wanted to measure the voltage across resistor R_2, where would you place a voltmeter?
(A), (B), (C), (D), E) None of A-D would work

How many of the 5 locations are appropriate for a voltmeter
A) None B) 1 C) 2 D) 3 E) more than 3

Answers: To measure battery current, an ammeter can be placed in position A (in series with the battery). To measure the voltage across R_2, the voltmeter would have to be in parallel with R_2 and None of A-D is correct. Only 1 location (location D) is appropriate for a voltmeter. A voltmeter placed at location E would always read zero volts, since it would be measuring the voltage across a wire.

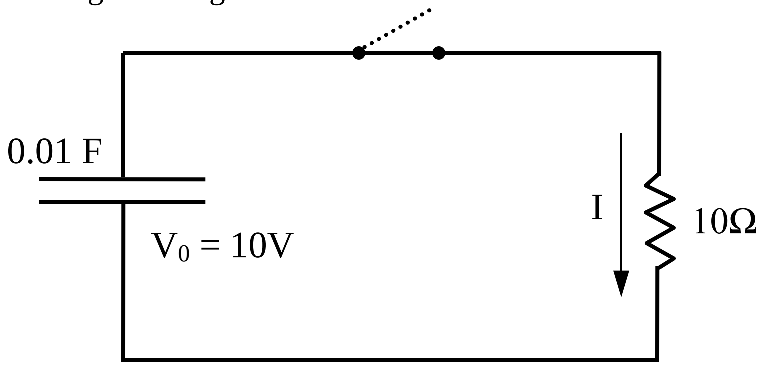
RC -4. What does the ideal ammeter read?

A) 6 A B) 3 A C) 2 A D) 0 A
E) the ammeter will break



Answer: The ammeter would break, because it would have infinite current.

RC -5. A capacitor in an RC circuit is initially charged up to a voltage of 10V and is then discharged through an R=10Ω resistor as shown. The switch is closed at time t=0.



What is the current through the resistor, immediately after the switch is closed, at time t = 0.0+ s?

A) 1A B) 0.5A C) 1/e A = 0.37A D) zero
E) None of these

What is the current through the resistor, a very long time after the switch is closed, at time t $\to \infty$?

A) 1A B) 0.5A C) 1/e A = 0.37A D) zero
E) None of these

Answers:

RC -6. Consider the function f(x) which obeys the differential equation

$$\frac{df}{dx} = -C \cdot f$$

, where C is a positive constant. Can f(x) be any of the following?

A) f(x) = sin(C x)

B) f(x) = sin(–C x)

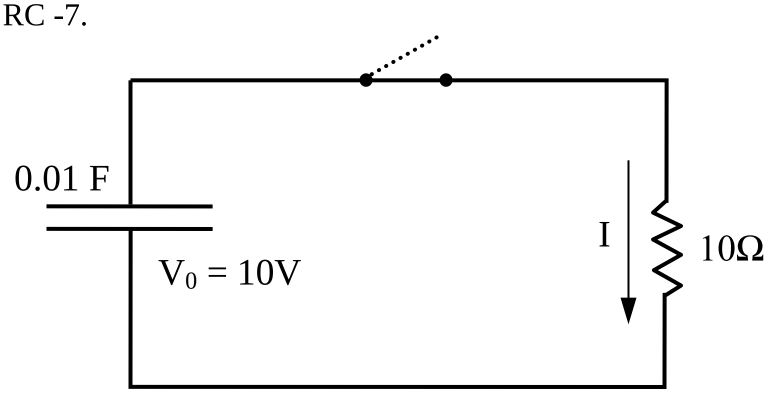
C) D) f(x) = exp(+C x)

D) f(x) = exp(–C x)

E) More than one of these is a solution.

Answer: Only exp(–C x) solves the differential equation.

RC -7.

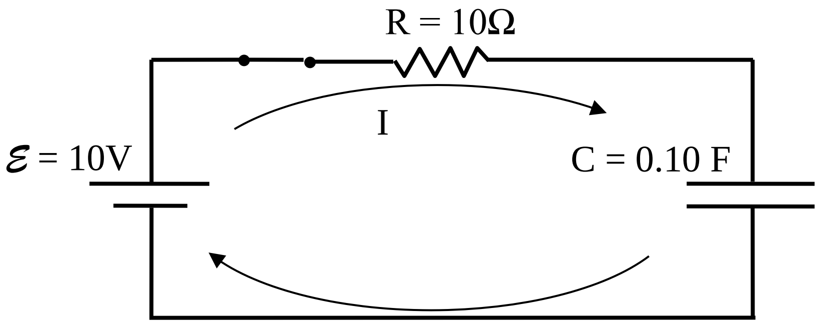


What is the time constant for this circuit?
A) 0.01 s B) 0.1 s C) 1 s D) 10 s
D) None of these.

What is the current through the resistor at time t = 0.2 s?
A) 1A B) 0.5A C) 1/e A = 0.37A D) None of these.

Answers: Right after the switch is closed, the current thru R is I = V/R = 10V/10ohm = 1A. The time constant for this circuit is RC=10Ω ·0.010F = 0.10 sec. So at time t=0.2 sec, two time constants have passed. After one time constant, the voltage, charge, and current have all decreased by a factor of e. After two time constants, everything has fallen by e^2. The initial current is 1A. So after two time constants, the current is $1/e^2$ A = 0.135A. So the answer is none of these.

RC -8. Consider the RC circuit shown. Before the switch was closed the charge Q on the capacitor was zero.



The switch has just been closed and the charge Q is still increasing.
The voltage across the capacitor V_C is..

A) increasing B) decreasing C) remaining constant

The voltage across the resistor V_R is ..

A) increasing B) decreasing C) remaining constant

The current I through the resistor is ..

A) increasing B) decreasing C) remaining constant

What is the initial current through the capacitor?

A) 1 A B) 0.5 A C) zero D) None of these

After a long time (t >> RC), what is the current through the capacitor?

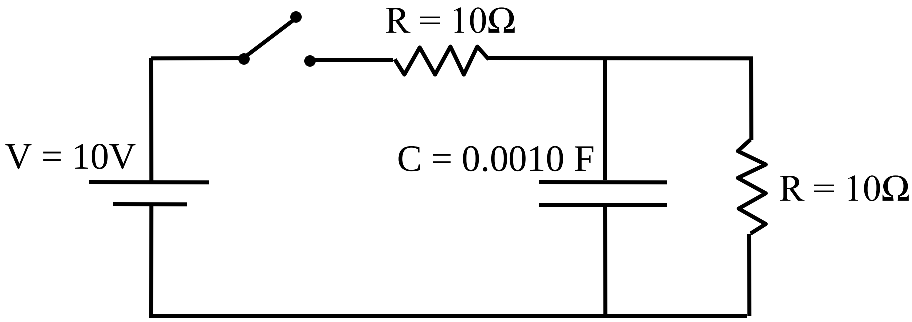
A) 1 A B) 0.5 A C) zero D) None of these

After a long time, what is the voltage across the capacitor?

A) 10 V B) 5 V C) zero D) None of these

Answers: Notice that by the Loop Law, $\mathcal{E} = V_R + V_C$
Initially, at t = 0+, $V_C = 0$ (since $Q_0 = 0$) and $V_R = 10$ V (since $\mathcal{E} = V_R$, initially).
As time increases, V_C increases (since Q is increasing), V_R decreases (since $\mathcal{E} = V_C + V_R$), and the current I decreases (since $V_R = IR$ is decreasing).
The initial current is $I_0 = \mathcal{E}/R = 10V/10\Omega = 1A$ (since $\mathcal{E} = V_R$, initially). After a long time, the current must be zero (because if the current continues indefinitely, the charge on the capacitor increases to infinity). After a long time, when the current I = 0, then $V_R = 0$, and $\mathcal{E} = V_C$. So $V_C = 10V$ (in the limit $t \to \infty$).

RC -9. An RC circuit is shown below. Initially the switch is open and the capacitor has no charge. At time t=0, the switch is closed. What is the voltage across the capacitor immediately after the switch is closed (time t = 0+)?



A) Zero B) 10 V C) 5V D) None of these.

What is the voltage across the resistor on the far right (in parallel with the capacitor) at time = 0+?
A) Zero B) 10 V C) 5V D) None of these.

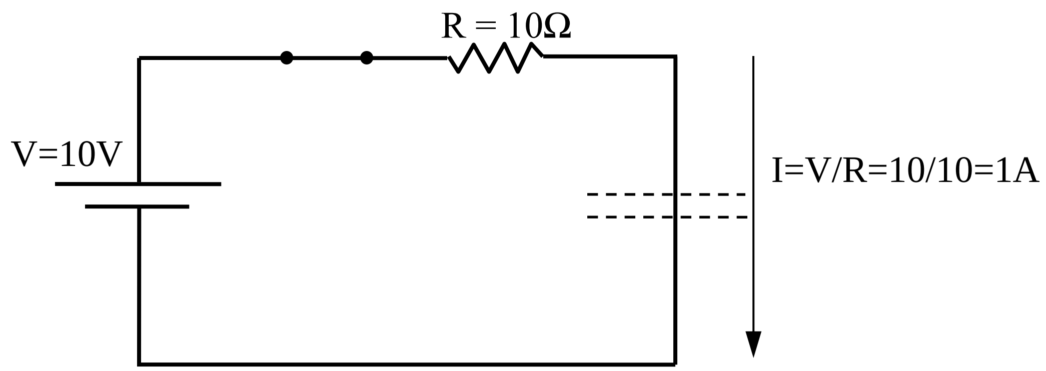
What is the initial current "through" the capacitor (immediately after the switch is closed)?
A) 1A B) zero C) 0.5A D) None of these.

A long time after the switch has been closed, what is the voltage across the capacitor?
A) 5V B) 10 V C) zero D) None of these.

Answer: A) Initially, $V_C = 0$, since $Q_0 = 0$. Before the switch is closed, the charge Q on the capacitor is zero and the voltage across the capacitor = V = Q/C = 0. Right after the switch is closed, the charge has not had time to build up on the capacitor and the charge and voltage are still zero.

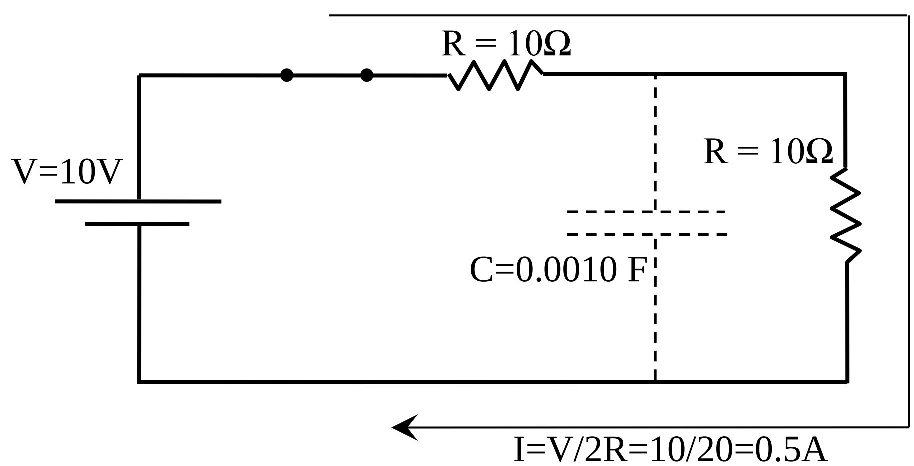
The initial voltage across the resistor on the right is zero. The capacitor and the resistor on the right are in parallel and therefore have the same voltage drop across them. Since the capacitor is acting like a wire there is no voltage drop across it, which is the same for the resistor on the right.

The initial current through the capacitor is 1A. Initially, when the capacitor has zero charge, it behaves like a short-circuit (zero resistance) because it is easy to put charge on an uncharged capacitor. The circuit is then, effectively...



The capacitor acts like a zero resistance wire which all the current flows through (initially). The other resistor in parallel with the capacitor is not involved in the (initial) current flow.

After a long time, the voltage across the capacitor is 5V. After a long time, the capacitor becomes fully charged, and current stops flowing through it. When this happens it behaves like an infinite resistor, and the circuit is effectively..



As far as current flow is concerned, the capacitor is gone. The voltage across the capacitor is the same as the voltage across the resistor on the right, since they are in parallel. The voltage across each resistor is 5V. Same R's, same I in each, so the voltage across each R must be the same, and they must add up to 10V.