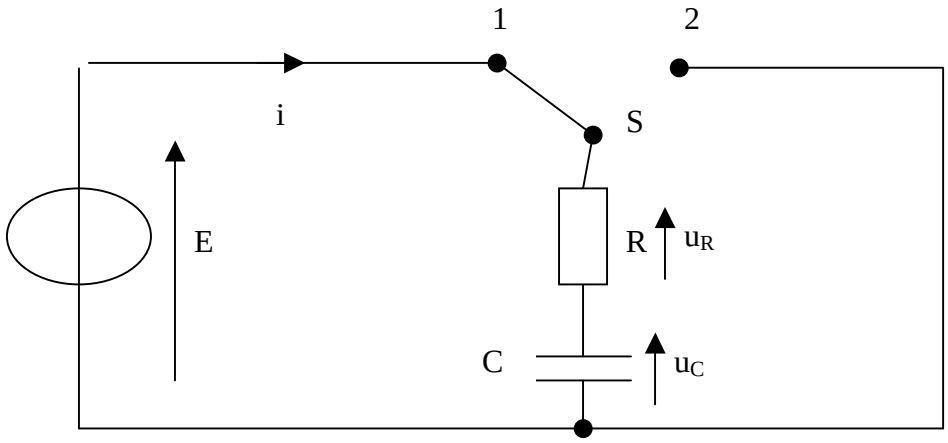
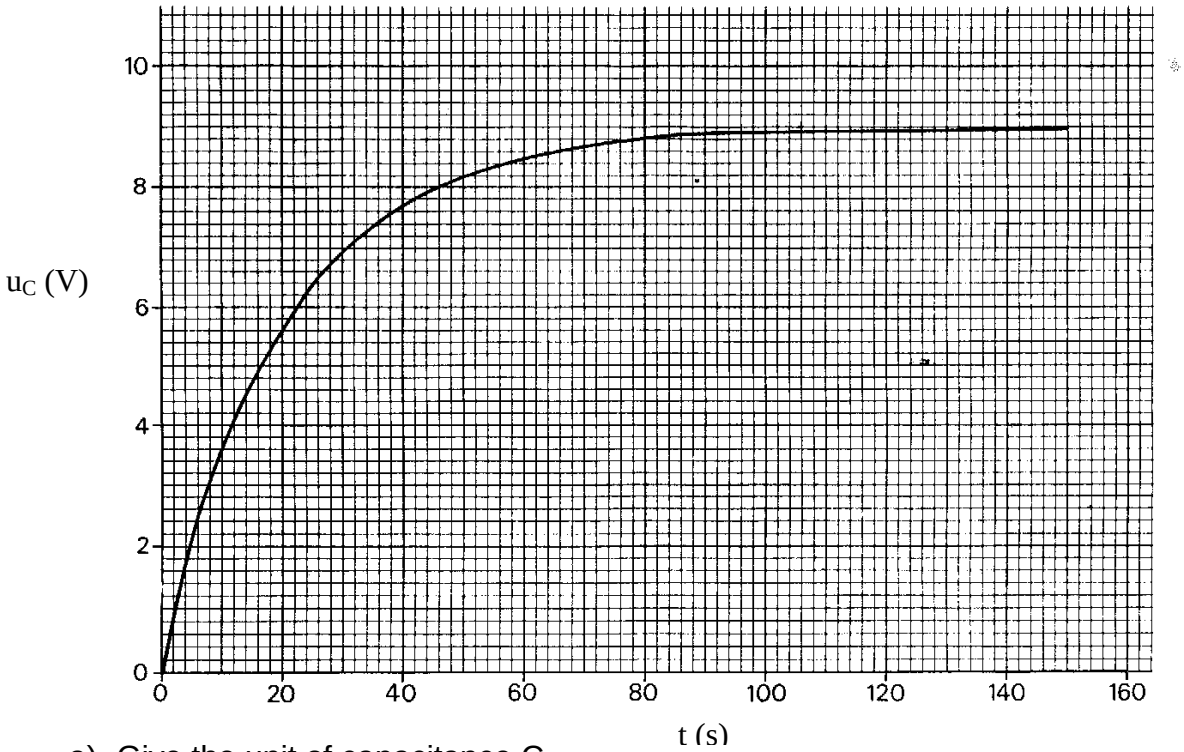
PART 1 : CHARGE AND DISCHARGE OF CAPACITOR ACROSS R

The following circuit is given:



E is a constant voltage source and R = 12 MΩ
By using switch S, the capacitor may be isolated from the voltage source and then discharged. Readings of the potential difference u_C across the capacitor are taken at regular intervals as the capacitor is charged and then discharged.
When the switch S is on the **position 1** the following graph is obtained:



a) Give the unit of capacitance C.
b) State whether the graph represents the charge or the discharge of the capacitor.
c) Is it a constant voltage charge across R or a constant current charge ?
d) From the graph, deduce the value of voltage E.
e) Express time constant τ in terms of R and C.
f) Give the % of charge after time t = τ and deduce the value of capacitance C.
g) What is the time taken by the capacitor to be charged at 95 %?

h) Apply KVL to show that the differential equation for the charge circuit is :

$$RC\ \frac{du_C}{dt} + u_C = E$$

i) We can show that the solution of the differential equation is :

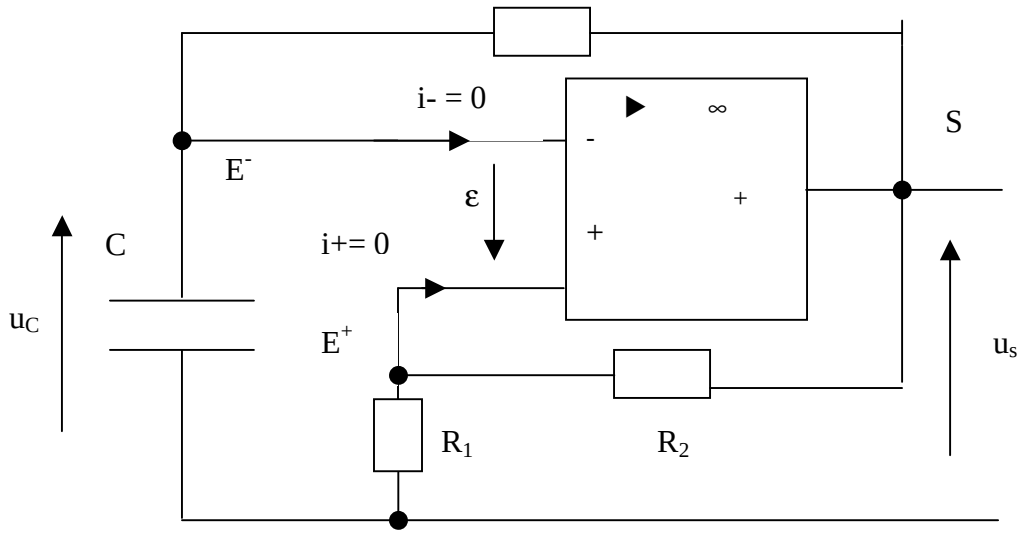
$$u_C = E(1 - e^{-\frac{t}{\tau}})$$

Give the value of u_C when t tends to infinity and what is the mathematical name for E on the charge graph.

j) Sketch the graph of uC against time when the switch is on **position 2.**

PART 2 : ASTABLE CIRCUIT

The following circuit is given :



$R_1 = R_2$
$= 10\ k\Omega$

$R = 4.7\ k\Omega$

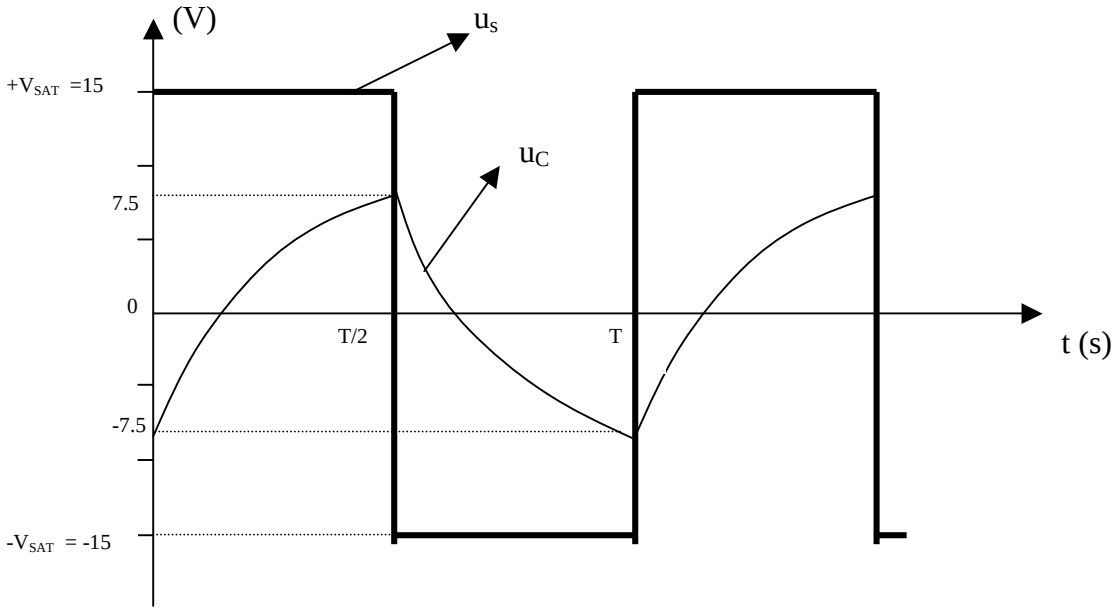
$C = 100\ nF$

$\pm V_{SAT} = \pm 15\ V$

The **op amp** is supposed to be **ideal** and **functioning non-linearly**. Voltage u_S is a periodic signal of period T.

a) What are the names of E^-, E^+ and S ?
b) Give the 2 possible values of u_S.
c) Apply the voltage divider formula to show that V_{E+} can take 2 values ± 7.5 V.
d) Express ε in terms of V_{E+} and u_C.
e) Give the value of us if $V_{E+} > u_C$.
f) Give the value of us if $V_{E+} < u_C$.

The waveforms of u_s and u_c are given.



g) $u_S = + V_{SAT}$ for $0 < t < T/2$. What happens to the capacitor during this time?
h) What is the maximum value of voltage u_C ?
i) At time $t = T/2$, $\varepsilon = 0$. What happens to voltage u_S ?
j) $u_S = - V_{SAT}$ for $T/2 < t < T$. What happens to the capacitor during this time?
k) What is the minimum value of voltage u_C ?
l) Give an application for the circuit.