

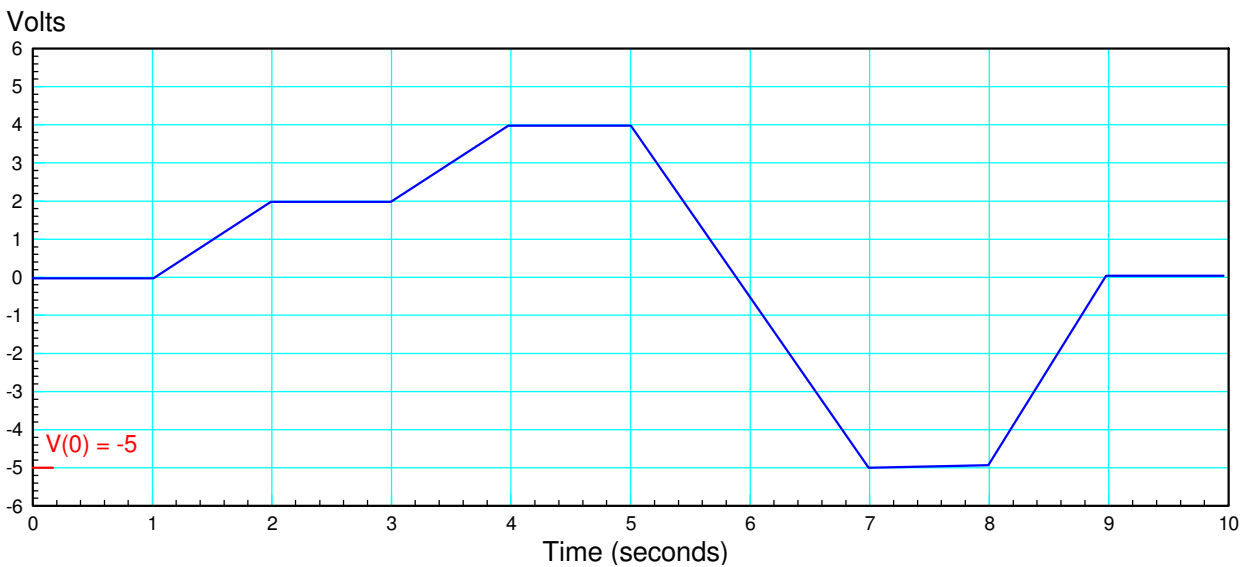
# ECE 111 - Make-Up Homework #10

ECE 311 Circuits II - Capacitors & the Heat Equation

1) Assume the current flowing through a one Farad capacitor is shown below. Sketch the voltage. Assume  $V(0) = 0$ . The voltage is the integral of the current (capacitors are integrators)

$$V = \frac{1}{C} \int I \cdot dt$$

Assume the initial voltage on the capacitor is -5V.



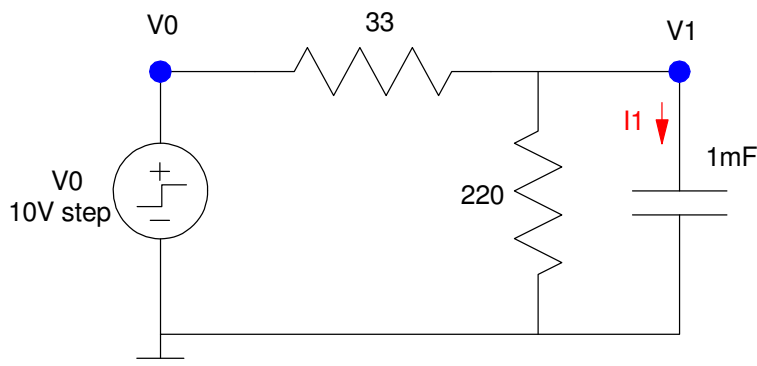
## 1-Stage RC filter:

2) Write the differential equation that describe this circuit. Note:

$$I_1 = C \frac{dV_1}{dt} = \sum(\text{current to node } V_1)$$

3) Find and plot  $V_1(t)$  for two seconds using Matlab.

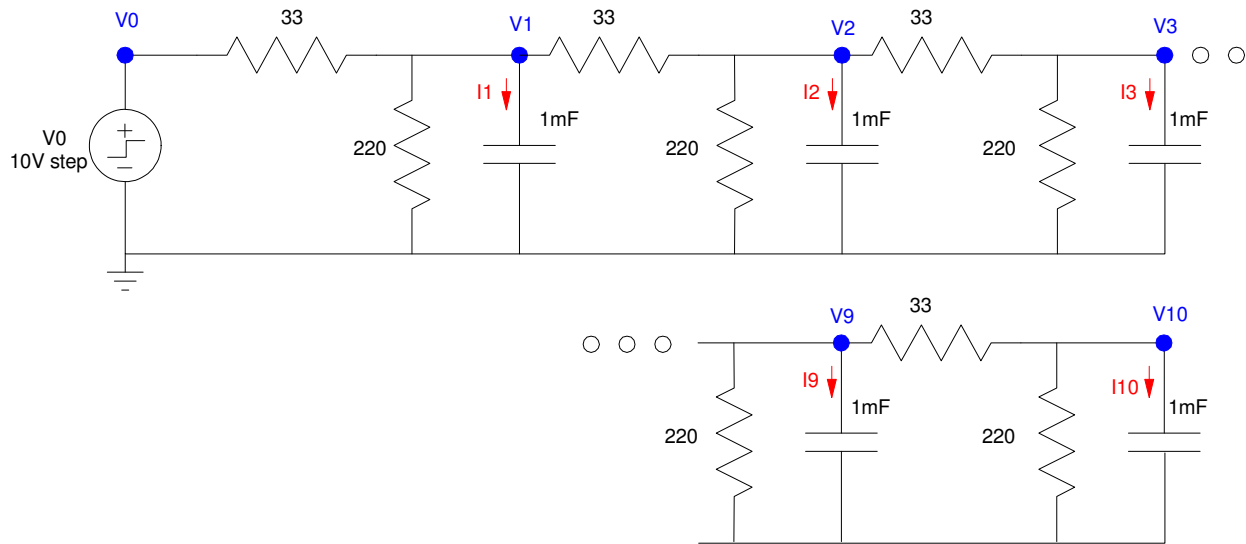
4) Find and plot  $V_1(t)$  for two seconds using CircuitLab



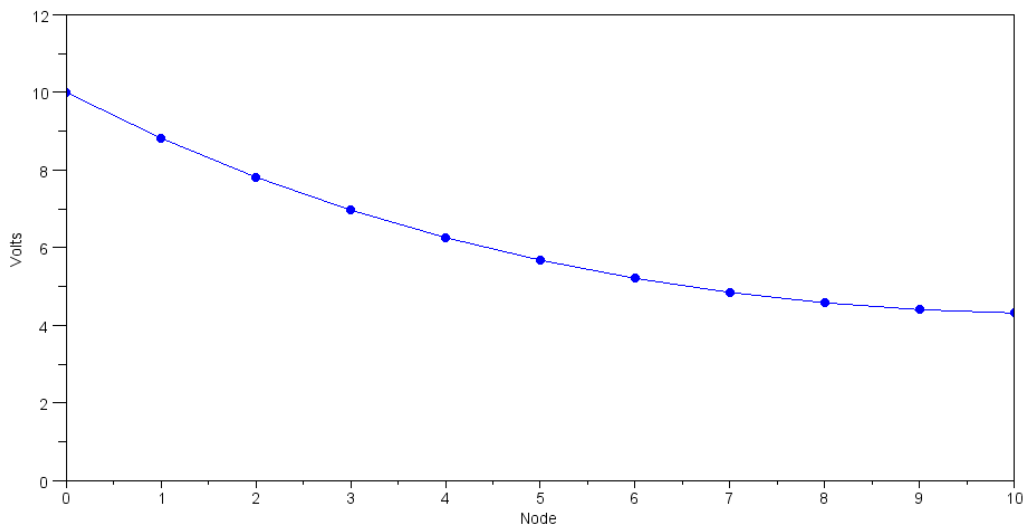
## 10-Stage RC Filter

5) Write the dynamics for a 10-stage RC filter (repeat for ten stages) as ten coupled differential equations:

$$I_1 = C \frac{dV_1}{dt} = \sum(\text{current to node } V_1)$$



**Forced Response for a 10-Node RC Filter (heat.m):**



6) Using Matlab, solve these ten differential equations for  $0 < t < 5$  s assuming

- The initial voltages are zero, and
- $V_0 = 10V$ .

7) Using CircuitLab, find the response of this circuit to a 10V step input. *note: It's OK if you only build this circuit to 3 nodes...*

### **Natural Response: Eigenvectors and Eigenvalues**

8) Assume  $V_0 = 0V$ . Determine the initial conditions of  $V_1..V_{10}$  so that

- The maximum voltage is 10V and
- 5a) The voltages go to zero as slow as possible
- 5b) The voltages go to zero as fast as possible.

Simulate the response for these initial conditions in Matlab.

9) Assume  $V_{in} = 0V$ . Pick random voltages for  $V_1 .. V_{10}$  in the range of (0V, 10V):

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V = 10 * rand(10,1)
```

Plot the voltages at  $t = 2$ . Which eigenvector does it look like?