Key Ideas, Formulas, Procedures in EECS 42

I. Lectures 1-11

Lecture 1: Electrical Engineering, signals as voltages and currents, energy flow. Devices and integrated circuits. Analog and digital representations. Electronic building blocks.

Lecture 2: Concepts of charge, electric field, energy, potential, flow (flux or fluence), electric current, power. Scalars and vectors. Ground as reference potential.

Important electrical quantities	SI prefixes	Constants
Electric Field ξ (V/m)	femto f 10^{-15}	q=1.6 X e^{-19}
Charge Q (C)	pico p 10^{-12}	$\in_o$= 8.85 X 10^{-12} F/m
Force QXξ (N)	nano n 10^{-9}	
Current I or i (A)	micro μ 10^{-6}	
Potential V or v (V)	milli m 10^{-3}	
P=IXV (W) Power flows in for associated signs	kilo k 10^{3}	
ForceX distance (QV)= Energy (J)	mega M 10^{6}	
Resistance (Ω) Ω = V/A	giga G 10^{9}	
Capacitance (F) F=Q/V		
Inductance (H) H= (V-sec)/A		

Lecture 3: Resistors and Ohms law. Associated and unassociated sign conventions. Voltage and current sources. Series and parallel combinations of resistors. Wires.

V = I X R (ohms law)	V and I are associated (I into +V terminal)
$R_1 \parallel R_2$ R= R_1 X R_2 / (R_1 + R_2)	Parallel resistors
R_1 in series with R_2 R = R_1 + R_2	Series resistors
P = V X I (power flow into element)	V and I are associated (I into +V terminal)

Lecture 4: I-V graphs of two-terminal elements. IV graphs of combinations of elements. Nonlinear circuit elements, Method of Load Lines for solving for I and V.

Lecture 5: Circuits, Nodes, and branches. Kirchoff's Laws (KVL, KCL), Voltage drops, Voltage rises, Node voltages.

Lecture 6: P=VI (positive for power absorbed if signs are associated). Time averaged power is integral of power divided by the interval over which the power is integrated. Computationally, we just sum the area under the P(t) curve and divide by the time interval. For periodic time varying power it is important to integrate over a complete period. For resistors P(t) = v(t) X i(t) (dissipated as heat). Thus from ohms law $P=V^2/R$ or equivalently I^2R. For a capacitor we know that the energy stored is 1/2QV or $1/2CV^2$ since Q=CV. We also note that in charging a capacitor from a voltage source (through a resistor) exactly half the energy is wasted (because the Energy delivered by the source is QV).

Lecture 7: All linear single capacitor circuits with resistors have a simple solution for the capacitor voltage: $A + Be^{-t/RC}$. Here R is the effective resistance seen from the terminals of the capacitor (which we will learn how to compute in lectures 8-12). Of course A+B is the initial value and A is the final value. The capacitor voltage cannot jump, that is it cannot change instantaneously.

Lecture 8: The easy method to find the transient waveform is to solve the two DC problems (before and after the transient), and note that the transient is 63% completed after one time constant RC. We sketch the waveform and simply write down the equation. We can shift the time axis of waveforms when the switching event does not occur at t=0. Thus if the switch moves at some time t1, we plot the transient versus t-t1, rendering the problem identical to the simple case in which the event occurs at t=0.

Lectures 9 and 10: Nodal analysis provides a rigorous method of solving circuit problems of arbitrary complexity. An algorithm is used in which the reference and unknown nodes are defined, and KCL is applied at each node and the constitutive relationship of the branch is used to relate the currents in the branches to the node voltages. In the case of floating voltage sources we use a "supernode" enclosing the voltage source and express KCL at this supernode. The simple relationship between the voltages at the two nodes of the supernode provides and auxilliary equation.We can use Nodal analysis to quickly prove the voltage divider formula: V2 (across R2) = Vtot X R2/(R1+R2) where Vtot is the total voltage across the two resistors in series.. Similarly we can prove the current divider:I2 (current through R2) = Itot X R1/(R1+R2) where Itot is the total current through the two resistors in parallel.

Lecture 11: All linear circuits can be reduced to their Thevenin or Norton Equivalents. If we test the circuit and find its open circuit voltage V_{OC} and short circuit current I_{SC} (associated signs) then the Thevenin voltage source $V_T = V_{OC}$ and the Thevenin resistance R_T equals $-V_{OC}/I_{SC}$. The Norton current source equals $-I_{SC}$ and the Norton resistance is the same as the Thevenin resistance. The resistance may also be found by turning off all the sources and measuring the resistance at the terminals.