Homeworks are due Tuesdays at noon.

- Each student must submit individual solution for each homework. You may discuss homework problems with other students registered in the course. If you use any source outside of class materials that we’ve provided, you must cite every source that you use.

- Write your name, netID, and section on each homework.

- Homework are to be turned in to homework boxes on 3rd floor of ECEB. Please put your homework into the appropriate box for the section you are registered in:
  - Section E - 1pm (Lynford Goddard): Box 29
  - Section X - 12 noon (Wei He): Box 30
  - Section P - 2pm (Dan Wasserman): Box 31
  - Section A - 9am (Arne Fliflet): Box 32
  - Section C - 11am (Zhi-Pei Liang): Box 33

- Unstapled homeworks will not be accepted.

- For each homework, a problem will be randomly selected and graded in detail, and will count for 20 points. The rest of the problems will be worth 10 points each, and will be graded on effort:
  - 10 points if excellent/good effort is made to solve the problem completely
  - 5 points if only fair effort is made to solve the problem
  - 0 points if it is clear that there was little or no effort to solve the problem.
1. A TL with characteristic impedance $Z_o = 50 \, \Omega$ and length $l = 0.4\lambda$ has an open termination at $d = 0$ and a $50 \, \Omega$ resistor connected between the TL conductors (a "shunt" connection) at $d = 0.1\lambda$. Use a SC to determine the input impedance and admittance of the line at the generator end, i.e., $Z(l)$ and $Y(l)$. Hand in your marked SC.

**Hint:** first move by $0.1\lambda$ from the load point (where you enter $z(0)$ or $y(0)$) toward generator on the SC, read off the corresponding $y(d)$, combine it in parallel with the shunt element, go back onto the SC with the normalized combined admittance, and move another $0.3\lambda$ toward the generator...

2. A lossless TL having a characteristic impedance of $50\, \Omega$ is terminated by a load of unknown impedance $Z_L$. Measurements of the voltage amplitude along the line reveal a "standing wave pattern" with a maximum of $6.3\, V$ and a minimum of $2.1\, V$. Hand in the marked SC you used to solve the problem.

   a) What is the voltage standing wave ratio (VSWR) on the line?
   
   b) A voltage minimum is observed at a distance $d = 2.192\lambda$ from the load. What is the distance $d_{min}$ between the load and the voltage minimum closest to the load?
   
   c) Determine the magnitude and phase angle of the load reflection coefficient $\Gamma_L$ using a SC and the results of (a) and (b). **Hint:** The constant $\Gamma$ circle passes through $z = VSWR + j0$ on the SC and moreover, this point corresponds to the location of a voltage maximum on the line.
   
   d) Determine $z_L$ using the SC and the value $Z_L$ in ohms.
   
   e) Determine $|V^+|$ and $|V^-|$, the traveling wave amplitudes on the line.
   
   f) What is the average power (in W) delivered to the load? **Hint:** the time averaged power satisfies $\langle P \rangle = \frac{1}{2} Re[\langle V(d)T(d) \rangle]$, very reminiscent of the time averaged Poynting vector $\langle S \rangle = \frac{1}{2} Re[E \times H^*]$. 

3. Two TL stubs of equal lengths $l = 0.3\lambda$ have unequal characteristic impedances of $Z_o = 50 \, \Omega$ and $100 \, \Omega$ and are each shorted at the load end. If the two stubs are connected in parallel at their input ports, what is the input admittance of the combined network. Use a SC to solve this problem and hand in your marked SC.

4. We wish to use a quarter wave transformer (QWT) in order to match a load $Z_L$ to a lossless TL having characteristic impedance $Z_0 = 100\, \Omega$. The QWT (having characteristic impedance $Z_Q$) is to be inserted in series at a distance $d_1$ from the load.

   a) Using a Smith Chart, determine the shortest possible $d_1$ (in units of $\lambda$) and $Z_Q$, if $Z_L = 60 - j80\, \Omega$.
   
   b) Repeat (a) for $Z_L = 100\, \Omega$.

5. We wish to use a "single-stub tuner" to match a load $Z_L$ to a TL with a characteristic impedance $Z_0 = 50\, \Omega$ by connecting a shorted-stub to the TL in parallel at a distance $d_1$ away from the load.

   a) Determine $d_1$ (in units of $\lambda$) and the length $d_s$ of the shorted stub if $Z_L = 100 - j100\, \Omega$ and the characteristic impedance of the stub is $50\, \Omega$.
   
   b) Repeat (a) if the characteristic impedance of the stub is $100\, \Omega$.

6. In this problem, you will combine several circuit concepts to analyze the TL system on next page. Using a SC, which you will hand in, determine the following for the circuit below:

   a) $z(0)$ and $\Gamma(0)$
b) $z(1.5\pi)$ and $\Gamma(1.5\pi)$ just to the left of the shunt resistor

c) $z(l)$ and $\Gamma(l)$

d) the $VSWR$ and the locations of $V_{\text{max}}$ on each transmission line

e) the voltage phasor, current phasor and time averaged power: $\bar{V}$, $\bar{I}$, and $\langle P \rangle$ across the shunt resistor.

7. (Bonus Problem) We wish to use a “double-stub tuner” to match a load $Z_L$ to a T.L. with a characteristic impedance $Z_0 = 50\Omega$ by connecting the first shorted-stub of length $l_1$ to the T.L. in parallel at a distance $d_1 = 0$ away from the load and the second shorted-stub of length $l_2$ to the T.L. in parallel at a distance $d_{12} = \frac{3}{8}\lambda$ from the first stub. Determine $l_1$ and $l_2$ (in units of $\lambda$) if $Z_L = 100 - j100\Omega$ and the characteristic impedance of the stub is 50\Omega.