1. The natural responses of a third order circuit for the two sets of initial conditions are given below.

| The response to a set of initial conditions. | $v_C(t) = 2 e^{-3t}$ V  
$i_{L1}(t) = e^{-3t}$ A  
$i_{L2}(t) = -1 e^{-3t}$ A |
|------------------------------------------------|------------------------------------------------|
| The response to another set of initial conditions. | $v_C(t) = - \cos(2t+30^\circ)$ V  
$i_{L1}(t) = 3 \cos(2t+82^\circ)$ A  
$i_{L2}(t) = 2 \cos(2t-130^\circ)$ A |

a) For some voltage or current in the circuit, write the general form of the complete response to the input $10 \sin(3t+35^\circ)$ for an arbitrary set of initial conditions.

b) Can you find a bounded input so that the response will be unbounded as $t \to \infty$ in the circuit considered above?

2. Find a set of initial conditions so that only one mode will be excited in the natural response.

![Circuit Diagram]

3. The opamp is ideal and operating in the linear region.

a. For $R = 1 \, \Omega$ and $C = 1 \, \text{F}$ find the value of $R_f$ so that the circuit has a natural frequency at $s = -1/6$. What are the other natural frequencies of the circuit? Is the circuit stable? Discuss.

b. For $R = 1 \, \Omega$ and $C = 1 \, \text{F}$ find the value of $R_f$ so that $v(t)$ is a sinusoid. What is the frequency of this sinusoid?

c. Suppose that $R_f$ is such that $v(t)$ is a sinusoid at the frequency $f_o = 4 \, \text{KHz}$ and $R = 10 \, \text{K}\Omega$. Find the values of $R_f$ and $C$. 
4) Write the node, mesh and modified node equations for the following circuit.

5) Obtain the state equations in matrix form for the following circuit.