GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL of ELECTRICAL and COMPUTER ENGINEERING

ECE 2025 Fall 2003
Lab #12: Concept Maps-II

Date: 1–4 Dec. 2003

The Warm-up section of each lab must be completed **during your assigned Lab time** and the steps marked *Instructor Verification* must also be signed off **during the lab time**. After completing the warm-up section, turn in the verification sheet to your TA.

Forgeries and plagiarism are a violation of the honor code and will be referred to the Dean of Students for disciplinary action. You are allowed to discuss lab exercises with other students and you are allowed to consult old lab reports but the submitted work should be original and it should be your own work.

NO lab report is required for this lab.
This second part of Lab #12 is worth 50 points; the first part of Lab #12 (last week) was also 50 pts.

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1 Introduction

After completing the previous laboratory assignment, you should have a feel for using ***Conceptor*** and generating concept maps. In this laboratory assignment, you are to use your knowledge of poles and zeros to generate detailed concept maps. Since **PeZ** deals with poles and zeros, experience using **PeZ**— should be helpful when generating these concept maps. Detailed instructions for generating concept maps have been given in the previous laboratory assignment. You may refer to the previous laboratory write up to refresh your memory. Remember that there is no one truly correct concept map. Thus there is a lot of freedom in creating concept maps as long as the relationships between various concepts are correct.

This lab will also deal with the addition of resources to concept maps with the use of appropriate keywords. ***Conceptor*** is connected to a database of *SP-First* resources. This database contains problem sets and solutions, sample problems, old quizzes, etc. from the *SP-First* CDROM. Meta information for all resources contains keywords, which are names of concepts that are relevant to that particular resource. If a concept map is created and appropriate keywords are entered for each node, then the concept map can be populated with resources. Resources relevant to a node can be accessed by clicking on that particular node.

2 PreLab: Software Used

2.1 Conceptor

Concept maps in ECE-2025 have been created using the ***Conceptor*** Concept Map Software.[1] This software allows the user to create concept maps with ease and when a concept map is complete, it can be exported to XML. This XML code can be opened in ***Conceptor*** for the purpose of editing or viewing the map. A screenshot of ***Conceptor*** is shown in Fig. 1. ***Conceptor*** can be downloaded from

`http://dml-wpm.ece.gatech.edu/cnt.exe.`

A web based version is available at `http://awarehome.ece.gatech.edu/extra/cnt.html.`

On running the software, one can see three tabs at the top left. The `Workspace` is where concept maps can be created and modified. The `Preview` window displays the current map in a printer friendly format. `Options` allows one to set various options such as fonts, colors and meta information. At the top right of the workspace sits a toolbar. Various buttons in the toolbar allow one to open maps, create new maps, save

[1] Authored by Chris Scheibe of Georgia Tech, using Macromedia Flash.

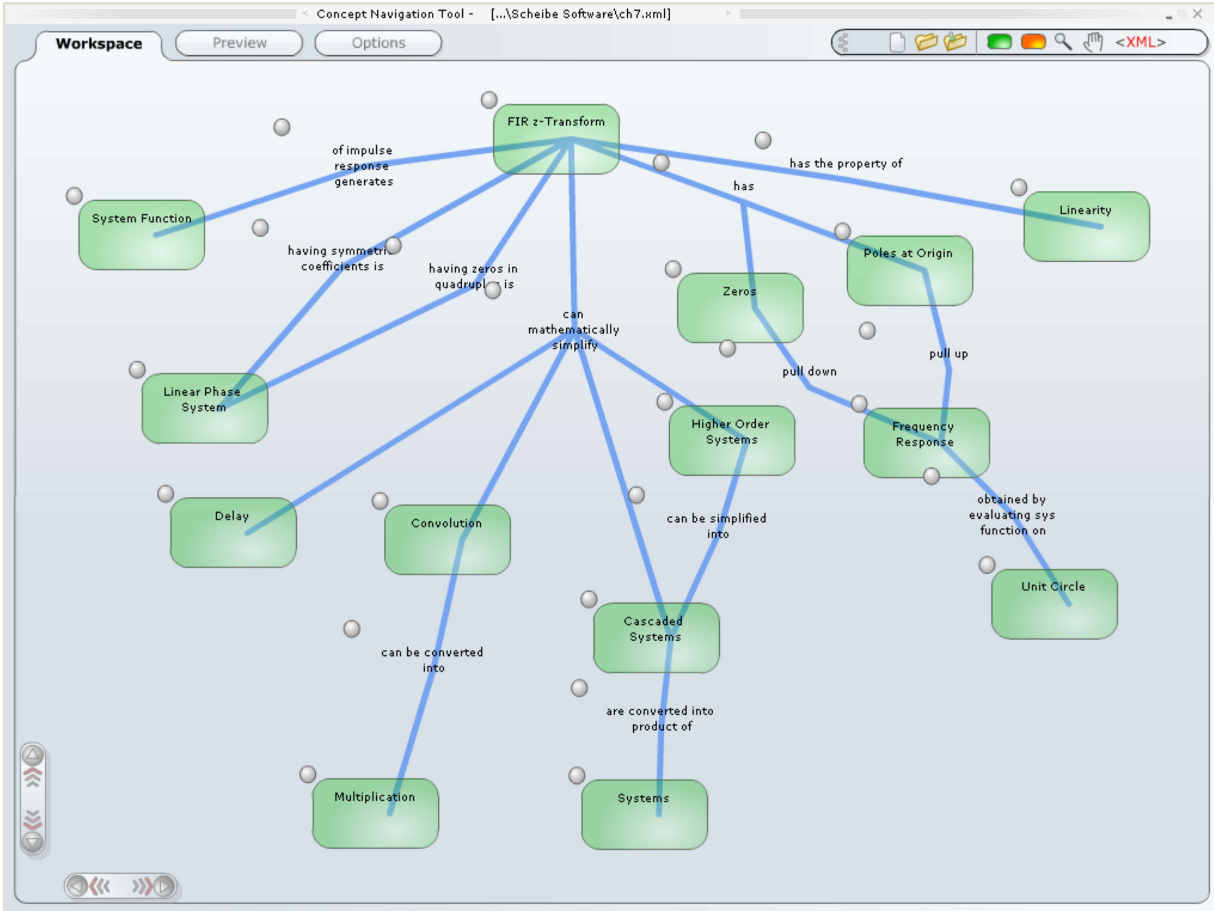

Figure 1: The ***Conceptor*** Concept Map Software

maps, zoom in or out of maps, move maps and generate XML code. Using these functions one can easily create and modify concept maps. The options menu allows the user to change the appearance of the concept map as well as enter important meta information. ***Conceptor*** will not let you save your concept maps unless all the meta information has been entered. Nodes and links can be modified by changing their colors and their skins. Currently two skins are available; `Default` and `Clarity`, shown in Fig. 2. Both skins have their advantages and disadvantages. The Clarity skin shows just the concept name and thus the information carried by the node has a strong impact on the user. However, in order to modify any attributes of the node or link it to other nodes, the user needs to navigate through the menu by clicking the button to the top left of the node. The Default skin has shortcuts in the body of the node for modifying the concept name and linking the node to other nodes. Thus the Default skin is more user friendly when constructing the map.

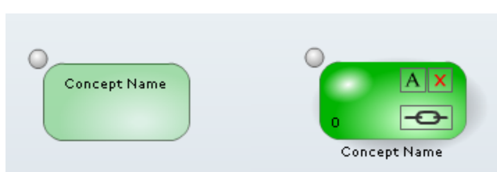

Figure 2: Node Skins: Clarity (Left) and Default (Right).

2.1.1 Adding Resources to Concepts

With ***Conceptor*** it is also possible to add various resources (such as pictures, movies, .pdf files, other concept maps, etc.) to each concept. The addition of resources to concept maps could become very tedious. The maps that we are creating are based on concepts in *SP First*. Thus, concepts throughout the book are interrelated and related resources appear in various locations throughout the book. It would be humanly impossible to be able to read through the whole book and add relevant resources to each concept. ***Conceptor*** solves this problem of adding resources. Each concept in a map has two fields associated with it. The first field holds the concept name that is displayed on the map in the viewer. The second field contains a list of keywords. Once a concept is created and keywords are entered, ***Conceptor*** searches through a database of resources (such as homework solutions, test solutions, lecture videos, etc.) and those resources that have matching keywords are automatically added to the concept. This eliminates the tedious process of manually adding resources. All the map creator has to do is include the relevant keywords in each node of the map, and then the resources will be automatically added.

2.2 PeZ: Introduction

In order to build an intuitive understanding of the relationship between the location of poles and zeros in the z-domain, the impulse response $h[n]$ in the n-domain, and the frequency response $H(e^{j\hat{\omega}})$ (the $\hat{\omega}$-domain), A graphical user interface (GUI) called **PeZ** was written in MATLAB for doing interactive explorations of the three domains.[2] **PeZ** is based on the system function, represented as a ratio of polynomials in z^{-1}, which can be expressed in either factored or expanded form as:

$$H(z) = \frac{B(z)}{A(z)} = G\,\frac{\prod_{k=1}^{M}(1 - z_k z^{-1})}{\prod_{\ell=1}^{N}(1 - p_\ell z^{-1})} = \frac{\sum_{k=0}^{M} b_k z^{-k}}{1 - \sum_{\ell=1}^{N} a_\ell z^{-\ell}} \tag{1}$$

There are two version of the **PeZ** GUI: the original one written for versions 4 and 5 of MATLAB; and a newer one for version 6. Both versions are contained in the *SP-First* toolbox. To run **PeZ**, type `pezdemo` at the command prompt and you will see the GUI shown in Fig. 3.[3]

2.2.1 Controls for PeZ using `pezdemo`

The **PeZ** GUI is controlled by the `Pole-Zero Plot` where the user can add (or delete) poles and zeros, as well as move them around with the pointing device. For example, Fig. 3 shows a case where two (complex-conjugate) poles have been added, along with single zeros at $z = 1$ and $z = -1$. The buttons named `PP` and `ZZ` were used to add these poles and zeros. By default, the `Add with Conjugate` property is turned on, so poles and zeros are typically added in pairs to satisfy the complex-conjugate property:

> A polynomial with real coefficients has roots that are real, or occur in complex-conjugate pairs.

To learn about the other controls in `pezdemo`, access the menu item called "Help" for extensive information about all the **PeZ** controls and menus.

Here are a few things to try. You can use the `Pole-Zero Plot` to selectively place poles and zeros in the z-plane, and then observe (in the other plots) how their placement affects the impulse and frequency responses. In **PeZ** an individual pole/zero pair can be moved around and the corresponding $H(e^{j\hat{\omega}})$ and $h[n]$ plots will be updated as you drag the pole (or zero). Since exact placement of poles and zeros with the mouse is difficult, an `Edit` button is provided for numerical entry of the real and imaginary parts. Before you can

[2] The original **PeZ** was written by Craig Ulmer; a later version by Koon Kong is the one that we will use in this lab.

[3] The command `pez` will invoke the older version of **PeZ** which is distinguished by a black background in all the plot regions.

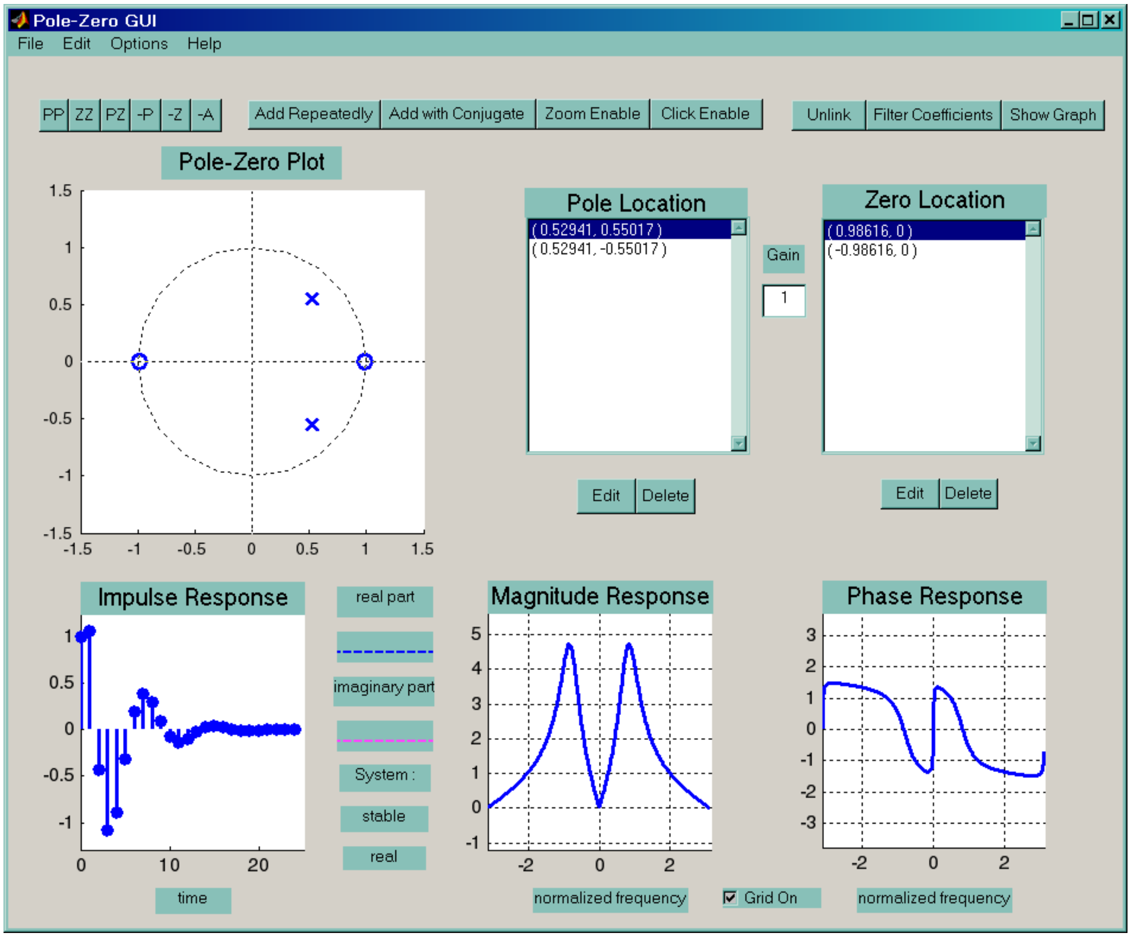

Figure 3: GUI interface for `pezdemo` running in MATLAB version 6. A 2nd-order bandpass filter is shown. Pole and zero locations are given in rectangular coordinates.

edit a pole or zero, however, you must first select it in the list of `Pole Locations` or `Zero Locations`. Removal of individual poles or zeros can also be performed by using the `-P` or `-Z` buttons, or with the `Delete` button. Note that all poles and/or zeros can be easily cleared by clicking on the `-A` button.

2.2.2 Create an IIR Filter with PeZ

Play around with **PeZ** for a few minutes to gain some familiarity with the interface. Implement the following first-order system:

$$H(z) = \frac{1 - z^{-1}}{1 + 0.9z^{-1}}$$

by placing its pole and zero at the correct locations in the z-plane. First try placing the pole and zero with the mouse, and then use the `Edit` feature to get exact locations. Since **PeZ** wants to add complex-conjugate pairs, you might have to delete one of the poles/zeros that were added; or you can turn off the `Add with Conjugate` feature. Look at the frequency response and determine what kind of filter you have.

Now, use the mouse to "grab" the pole and move it from $z = -0.9$ to $z = +0.8$. Observe how the frequency response changes. Describe the type of filter that you have created.

3 Warm-up

3.1 Relationships between z, n, and $\hat{\omega}$ domains

The lab verification requires that you write down your observations on the verification sheet when using the PeZ GUI. These written observations will be graded.

Work through the following exercises and keep track of your observations by filling in the worksheet at the end of this assignment. In general, you want to make note of the following quantities:

- How does $h[n]$ change with respect to its rate of decay? For example, when $h[n] = a^n u[n]$, the impulse response will fall off more rapidly when a is smaller.
- If $h[n]$ exhibits an oscillating component, what is the period of oscillation? Also, estimate the decay rate of the "envelope" that overlays the oscillation. How are the period and decay rate related to the pole location?
- How does $|H(e^{j\hat{\omega}})|$ change with respect to peak location and peak width?

Note: review the "Three-Domains - FIR" under the Demos link for Chapter 7 and "Three-Domains - IIR" under the Demos link for Chapter 8 for movies and examples of these relationships.

3.2 Complex Poles and Zeros

PeZ assumes real coefficients for the numerator and denominator polynomials when the `Add with Conjugate` mode is on (which it is by default). Therefore, if we enter a complex pole or zero, **PeZ** will automatically insert second root at the conjugate location. For example, if we place a root at $z = \frac{1}{3} + j\frac{1}{2}$, then we will also get one at $z = \frac{1}{3} - j\frac{1}{2}$.

(a) What property of the polynomial coefficients of $A(z) = 1 - a_1 z^{-1} - a_2 z^{-2}$ will guarantee that the roots of $A(z)$ are complex conjugates of each other?

(b) Clear all the poles and zeros from **PeZ**. Now place a pole pair with magnitude 0.85 at angles of $\pm 45°$ (two zeros should appear at $z = 0$). Note that **PeZ** automatically places a conjugate pole in the z-domain. The frequency response has a peak—record the frequency (location) of this peak.

(c) Change the angle of the pole: move the pole to 90°, then 135°. Describe the changes in $|H(e^{j\hat{\omega}})|$. Concentrate on the location of the peak versus frequency $\hat{\omega}$.

(d) Start again with the pole pair at $0.85e^{\pm j\pi/4}$. Increase the magnitude of the pole: first try 0.9, then 0.95, and then go outside the unit circle. Describe the changes in both $h[n]$ and $|H(e^{j\hat{\omega}})|$.

Next, we will put complex zeros on the unit circle to see the effect on $|H(e^{j\hat{\omega}})|$. **PeZ** will automatically put poles at the origin to keep the filter causal.[4]

(e) Clear all poles and zeros from **PeZ**. Now place zeros at the following three locations: $z_1 = +1$, $z_2 = (1 - j)/\sqrt{2}$ and $z_3 = (1 + j)/\sqrt{2}$; remember that conjugate pairs such as z_2 and z_3 will be entered simultaneously. Judging from the impulse and frequency responses what type of filter have you just implemented? Is the system IIR or FIR?

[4]Recall that a length-L FIR filter whose impulse response extends from $n = 0$ to $N = L - 1$ will have $L - 1$ poles at $z = 0$.

3.3 Exercise C1a: Finishing a Concept Map

In the laboratory material, you will find two `.xml` files: `Map1.xml` and `Map2.xml`. Run ***Conceptor*** and open the concept map `Map1.xml` for this exercise. You should see the map in Fig. 4 which is an incomplete

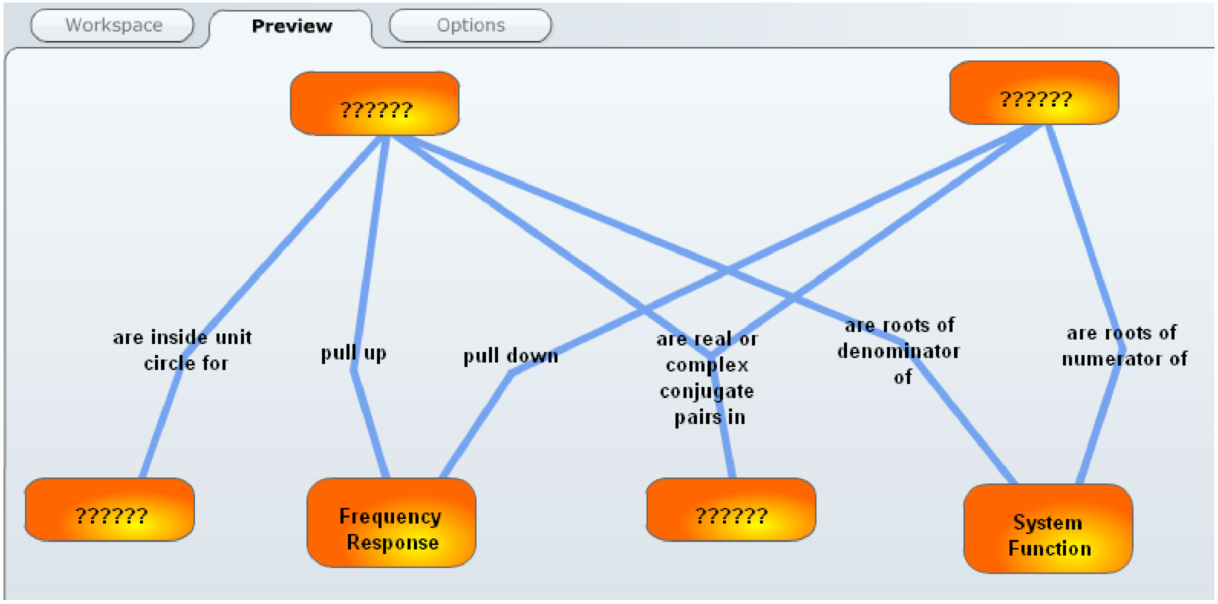

Figure 4: Map to be completed in Exercise C1a. Missing concepts are denoted by **??????**.

map with nodes that must be completed. Using your knowledge of poles and zeros, fill in the four missing concepts from the restricted list below. You may leave the `Keywords` field of the nodes blank. The list of choices is:

Imaginary Systems	Poles	Stable Systems
Real Systems	Zeros	Unstable Systems
Unit Circle		Sinusoids

Note that not all the choices above will be used. When you are done and want to save the file, you need to update the meta information associated with the concept map. Click on the `Options` tab, then click on the `Global` button, and then enter the following information:

1. Under `Name` enter your name.
2. Under `Lecture` enter `CMAP_Lab12_MapC1`
3. Under `Class` enter `ECE2025`
4. Under `Date` enter today's date.

To save the concept map, click on `Save` in the toolbar and choose the `Save to Web` option. You should also save a copy on the drive for your records using the `Save to Drive` option.
Print the concept map from the Preview window. Hand the printout to the TA.

Instructor Verification (separate page)

3.4 Exercise C1b: Resources for Concept Maps

In this exercise you will take the concept map from Exercise C1a and populate it with resources. Open up the concept map you just created in Exercise C1a. You now need to add *Keywords* to each node so that

Conceptor will be able to search the *SP-First* database for relevant resources. A list of keywords can be entered under each node. Individual keywords should be delimited by a comma.

Open each node and add its concept name as the first keyword. You may add additional keywords if you want a broader search. Additional keywords should be synonyms for the concept name. An example of synonyms would be *delta* and *impulse*, which are two different names for the same concept. Such synonyms should be added to the keyword list because some resources may have only one of the synonyms as a keyword, and these would not be linked to the concept map unless that particular synonym is entered as a keyword. Before saving this concept map, you need to update the meta information:

1. Under `Name` enter your name.
2. Under `Lecture` enter `CMAP_Lab12_MapC1_Resources`
3. Under `Class` enter `ECE2025`
4. Under `Date` enter today's date.

Then save the file to the drive and to the web.

When you change to `Preview` mode in ***Conceptor***, and then left click on a node, a drop-down list will appear. This list is connected to various *SP-First* resources such as solved problems. Demonstrate to your TA that you can navigate to some of the resources.

Instructor Verification (separate page)

3.5 Exercise C2: Building a Concept Map

In the laboratory material, you will find two `.xml` files: `Map1.xml` and `Map2.xml`. Run ***Conceptor*** and open the concept map in `Map2.xml` for this exercise. You will see a layout of nodes as shown in Fig. 5.

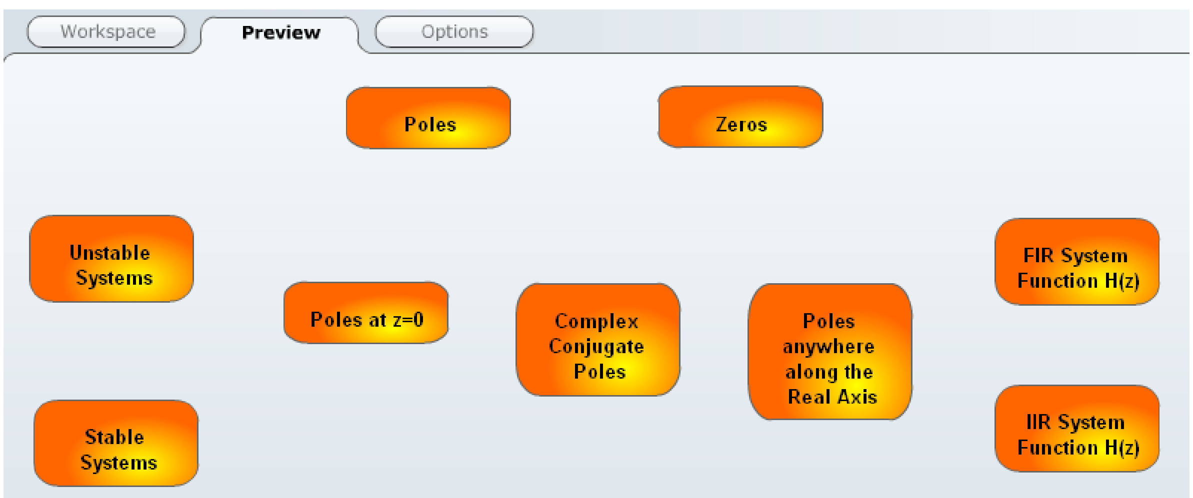

Figure 5: Concepts to be linked in Exercise C2. Links will have to added between various concepts.

Here you are given several concepts, but there are no links between them. Generate a concept map with the hierarchy starting with the concepts *Poles* and *Zeros*. These concept nodes have been placed at the top of Fig. 5. The other concepts are placed below. Similar to the concept maps that you have already encountered, the relationships in this concept map should propagate *downward*. Using your knowledge of poles and zeros gained from using **PeZ**, link the given concept nodes together. You will need to move nodes around so that they can be connected together appropriately. Add cross links wherever necessary. A cross link is a link that connects together nodes from different branches of the concept map. A list of possible linking phrases is given below:

Are always	Can be	Only have	Are inside the unit circle for
Are found in	Can have	Are roots of	Are outside the unit circle for

Note that some of these linking phrases may be used more than once. The use of these linking phrases will allow you to generate a good concept map, but you are not restricted to using phrases from this list. Furthermore, there is not one correct answer for the concept map, so let the map reflect your own individual knowledge. It is said that the more expert you are in a topic area, the more links you can make between concepts, so if your map ends up looking like a "string map" you should try to add more links.

Once you get the nodes linked together according to your understanding of the concepts, you should rearrange the nodes so that the map layout will be neat. It is important that the information contained within the map should be easily visible, and that the links should not be crowded together. When you are done and want to save the file, you need to update the meta information again.

1. Under `Name` enter your name.
2. Under `Lecture` enter `CMAP_Lab12_MapC2`
3. Under `Class` enter `ECE2025`
4. Under `Date` enter today's date.

Save the concept map to the web and to the local drive.
Print the concept map in the `Preview` window. Give the printout to the TA as part of the lab verification.

Instructor Verification (separate page)

Lab #12 (part two)
ECE-2025 Fall-2003
WORKSHEET & VERIFICATION PAGE

For each verification, be prepared to explain your answer and respond to other related questions that the lab TA's or professors might ask. Turn this page in at the end of your lab period.

Name: ____________________________________ Date of Lab: _________

Evaluation: Completed the on-line survey in Web-CT, and the GT surveys.

Verified:__________________ Date/Time:__________

Part	Observations from **PeZ**
3.2(a)	
3.2(b)	
3.2(c)	
3.2(d)	
3.2(e)	
3.2(f)	

Verified:__________________ Date/Time:__________

Part 3.3 Add links to the given concept map. Print a copy for your TA.

Verified:__________________ Date/Time:__________

Part 3.4 Demonstrate that you can access various *SP-First* resources from your concept map.

Verified:__________________ Date/Time:__________

Part 3.5 Create a concept from minimal information. Print a copy for your TA.

Verified:__________________ Date/Time:__________