Experiment 2: Z-Transform - Answer Book

• **Name:**	**Lab Date:**
• **Student No.:**	**Day of the week:** **Time:**
• **Name:**	**TA Signature:**
• **Student No.:**	**Grade:**

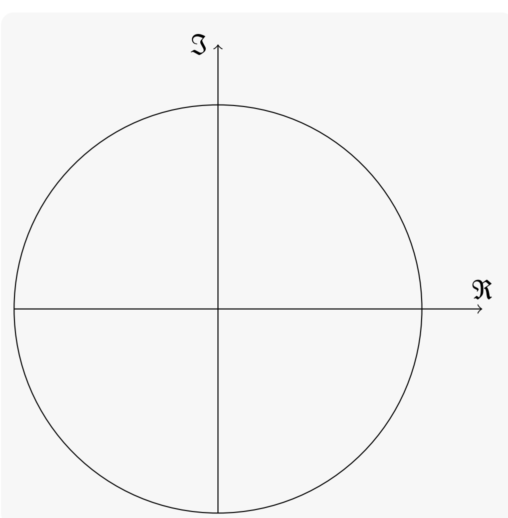
1. Experiment

1.1 Differentiator

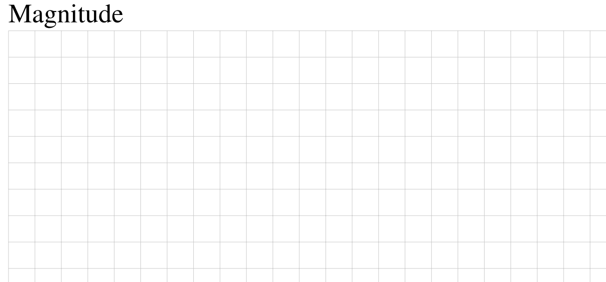
- *Write the difference equation corresponding to the given transfer function.* [0.5 pts]

- *Assuming* $b = 0.9$*, draw the z-domain pole-zero diagram for that case, as well as the magnitude and phase responses of the system (we even give you the unit circle and the grid!). Be sure to express frequency in radians per sample, magnitude in dB, and phase in degrees. Show how to convert the normalized frequency to the continuous time frequency in Hz (label it on the graph).* [1 pt]

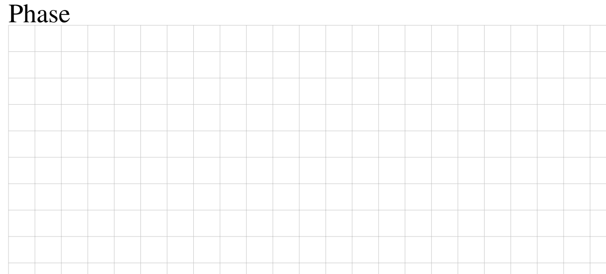
Unit Circle



Magnitude



Phase



- *Based on the transfer function or the difference equation, draw a block diagram for this system. It should contain one unit delay block, one adder and one gain. Explain with words how this system works.* [0.5 pts]

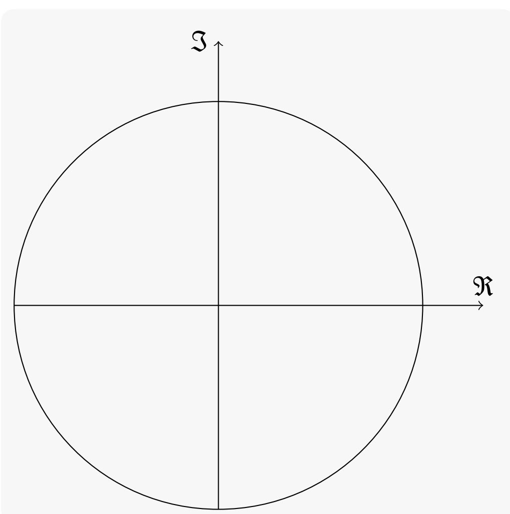
- *Will this system ever become unstable? Explain why it will or not.* [0.5 pts]

1.2 Integrator

- *Write the difference equation corresponding to the given transfer function.* [0.5 pts]

- *Assuming $a = 0.5$, draw the z-domain pole-zero diagram for that case, as well as the magnitude and phase responses of the system. Again, express frequency in radians per sample, magnitude in dB, and phase in degrees. Show how to convert the normalized frequency to the continuous time frequency in Hz (label it on the graph).* [1 pts]

Unit Circle



Magnitude

Phase

- *Based on the transfer function or the difference equation, draw a block diagram for this system. It should contain one unit delay block, one adder and one gain. Explain with words how this system works.* [0.5 pts]

- *Will this system ever become unstable? Explain why it will or not.* [0.5 pts]

- *Write a piece of C code to implement this integrator. Remember, this is a sampled (i.e., discrete-time) system, with a fixed sampling rate. Integration happens over a limit, and has a "differential" component in it. (this is really a question about numerical methods...)* [Bonus 1 pt]

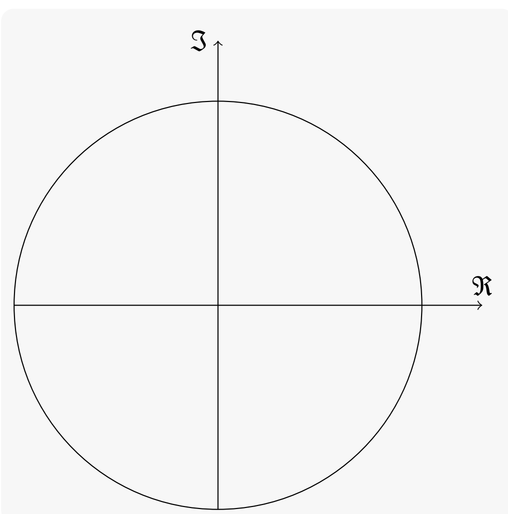
1.3 Two More Complex Systems

1.3.1 Creating Notches

- *This part refers to the setup in Figure 1 on the experiment outline. You are trying to design an electrocardiograph, which samples your heart signals using f_s =1.2 kHz. You find out that your system is really suffering from the 60 Hz signal and its harmonics coming from the power line. Moreover, there is a DC that really should not be there. At what angles would you place the zeros of $H(z)$ to get rid of such undesired features? (the diagnosis depends on it!)* [1 pt] Hint: Let $x_c(t)$ be a sinusoid of frequency 60 Hz, for example $x_c(t) = \mathrm{e}^{j2\pi 60t}$. Then $x[n]$ is the discrete-time sinusoid $\mathrm{e}^{j2\pi 60nT}$, where $T = 1/f_s$. Then $y[n]$ is a sinusoid of the same frequency as $x[n]$, and you want $y[n]$ to be zero.

- *Write the transfer function $H(z)$ of such system below. Draw the pole-zero map and obtain the difference equation.* [0.5 pt]

Unit Circle



- *If you added poles at the same angles and very near your zeros, what would be the effect on the frequency response? Any advantage in doing that? Any disadvantage?* [0.5 pts]

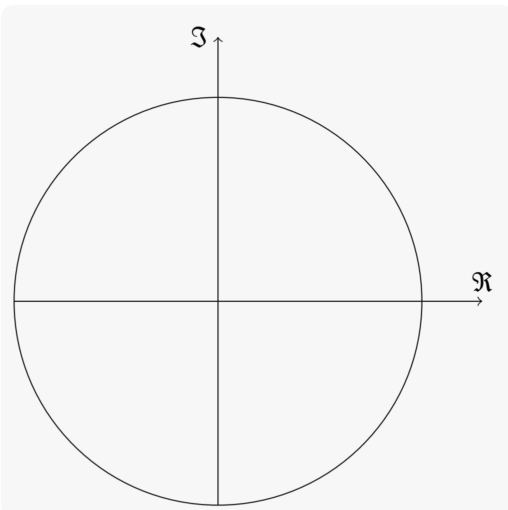
1.3.2 Generating a Sine Wave

Using `Code Composer Studio`, look at the oscillator program given for the DSP platform and run it.

- *You want to generate a 6 kHz sine wave with some programmable processor, which takes samples at the rate of 48 kHz. The transfer function of your system is given to you in Equation 6 on the experiment outline. Write below the difference equation that characterizes that system. Use the number values for scale, angle, frequency, etc.* [0.5 pts]

- *You do not want your system to blow up. Based on the transfer function, place the poles and zeros appropriately on the unit circle below, and indicate their position with magnitude and phase. Then draw what you expect to be the magnitude and phase response of your system.* [1 pt]

Unit Circle



Magnitude

Phase

- *Make your system run, and when it displays a sinusoid on the oscilloscope have the TA initial the box.*

- *Say you want to change the frequency and magnitude of this sine wave you have just generated. For example, you need to make it 5KHz and attenuate it by 3dB (power). What would you change and how would you change it?* [1 pts]

- *Finally, draw a block diagram with unit delays, gains and adders to represent the system you just implemented.*