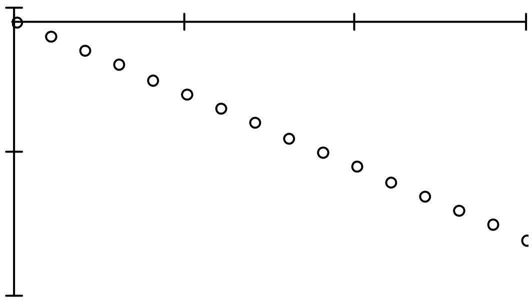
ECE 3510 Final given: Fall 22

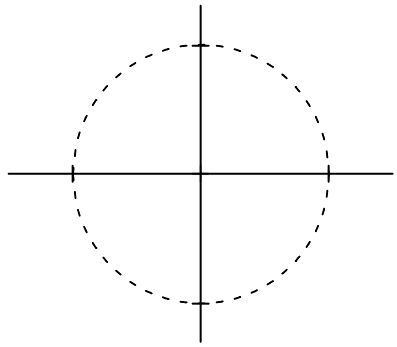
DO NOT use eraseable ink

Show all work to receive credit. Circle answers, show units, and round off reasonably

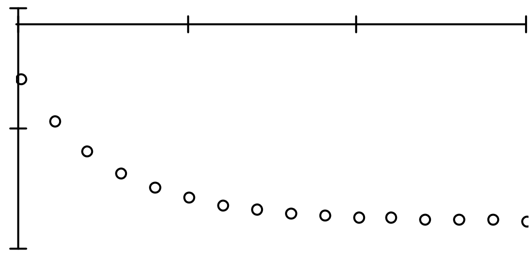
(16 pts) For each of the following discrete-time **signals**, draw the poles on the z-plane shown.
A unit circle is shown on each z-plane as a dotted line.

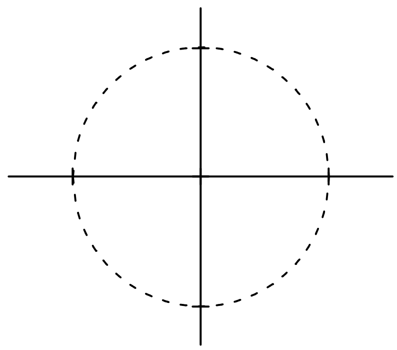
a)



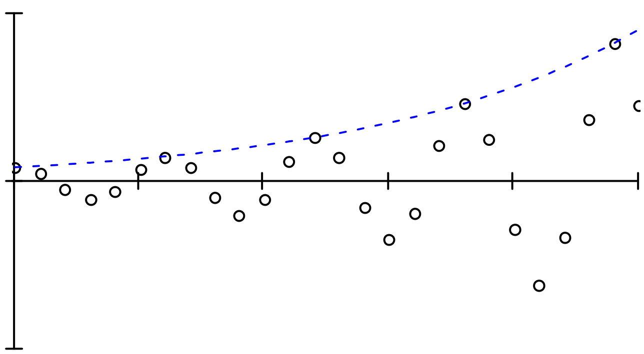


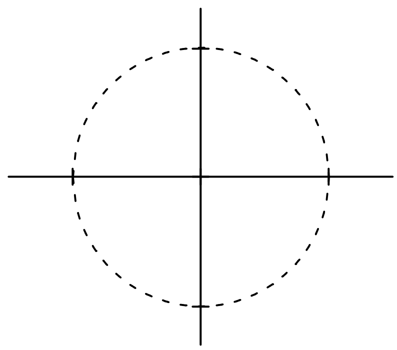
b)



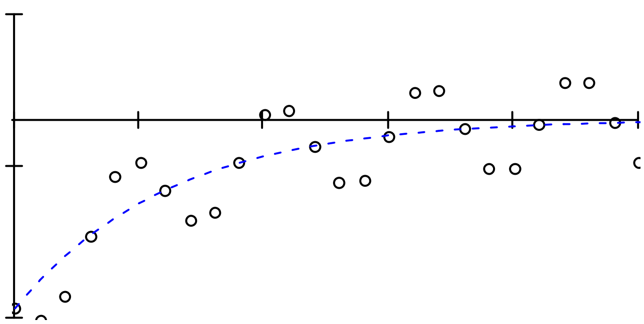


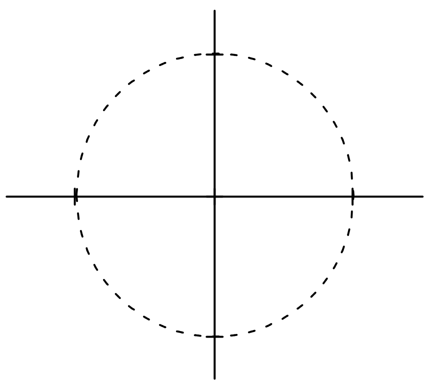
c)





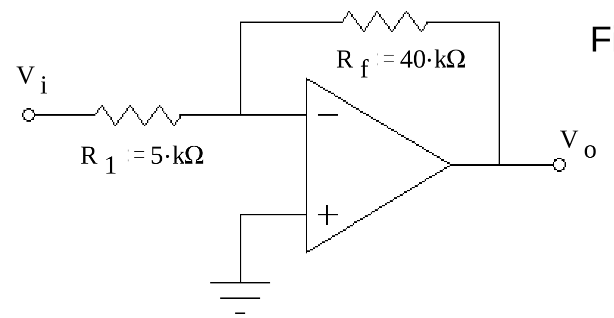
d)





Fin F22

1. (15pts) The op-amp in the circuit shown has a gain bandwidth product of 1.6MHz, an open-loop DC gain of 90dB, an input resistance of 80MΩ, and an output resistance of 100Ω.



a) What is the feedback factor (B) and the gain of the circuit shown at right.

b) What is the 3dB roll-off point of this circuit?

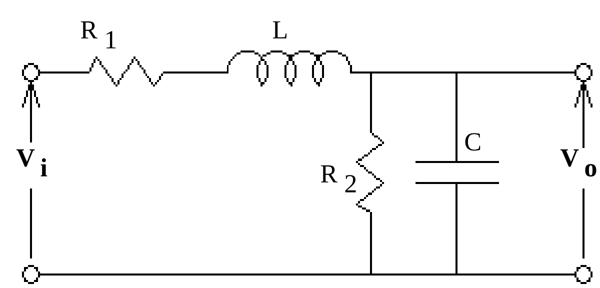
c) What is the input resistance of this circuit?

d) What is the output resistance of this circuit?

e) What does "compensation" mean when refering to op-amps, and why are op-amps compensated?

2. (32 pts) a) Find the transfer function of this circuit.

$$\mathbf{H}(s) = \frac{\mathbf{V_o}(s)}{\mathbf{V_i}(s)} = ?$$



b) What load does this circuit place on the source of $\mathbf{V_i}$? In other words, what is the input impedance?

c) Find the output impedance of this circuit, assuming the output impedance of the preceeding circuit is negligible.

d) Find the output impedance if this circuit is preceded by another circuit with an output impedance of: $\mathbf{Z_{out0}}(s)$

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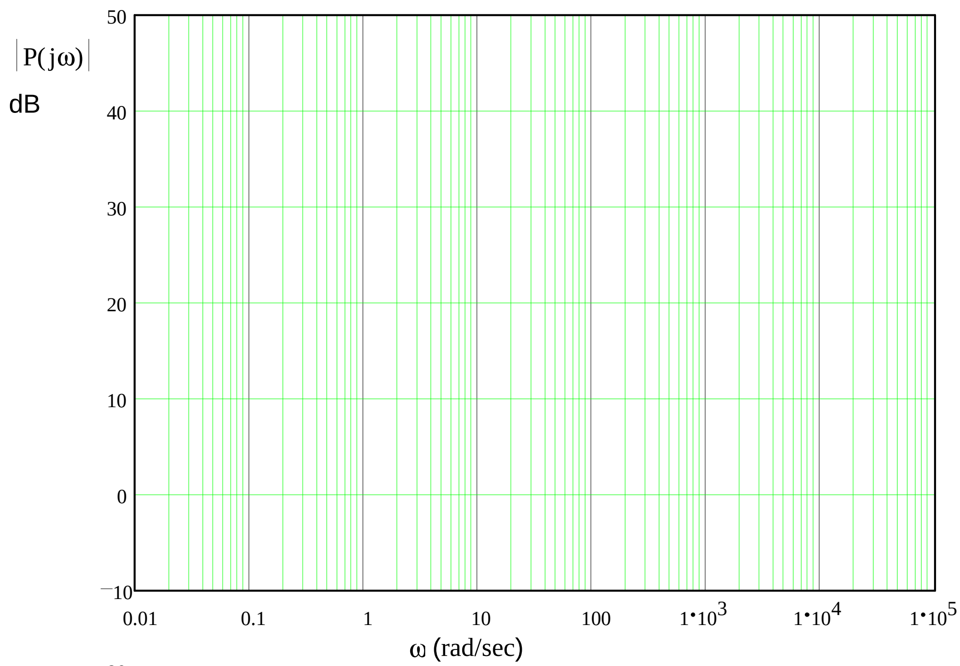
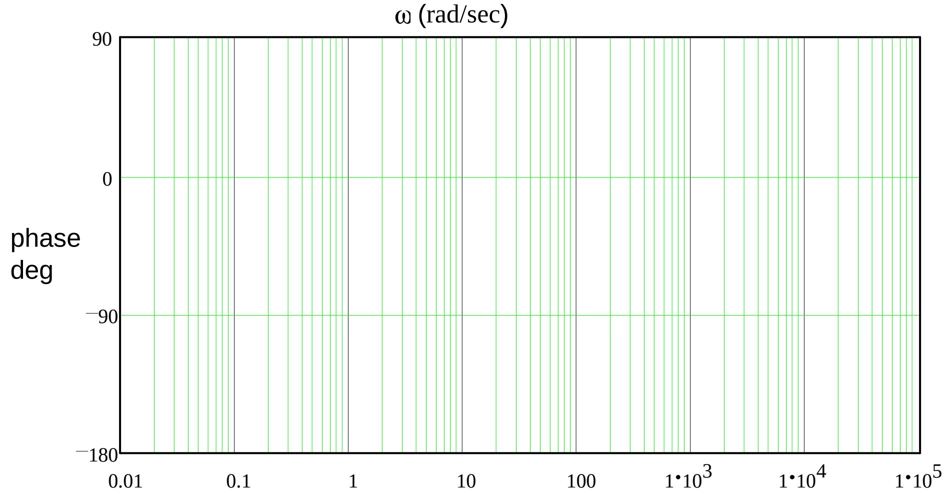
Fin F22

3. (30 pts) Sketch the Bode plot for the following transfer functions. Use the method I taught in class to find magnitudes, slopes and angles and to check yourself. Also accurately draw the "smooth" lines.

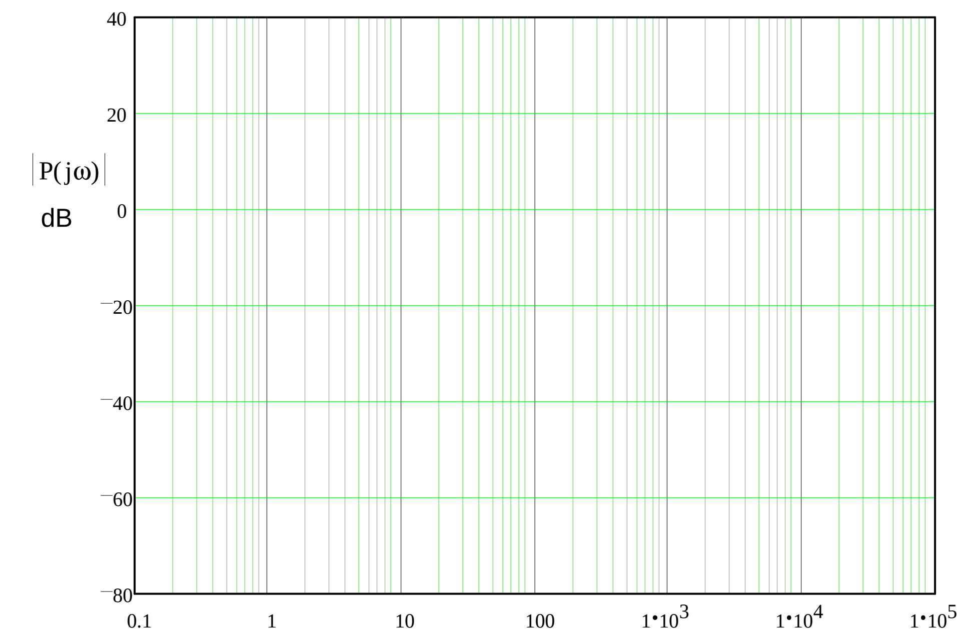
a) $P(s) = \dfrac{20000\cdot(s+0.1)\cdot(s+80)}{(s+2)^2\cdot(s+5000)}$

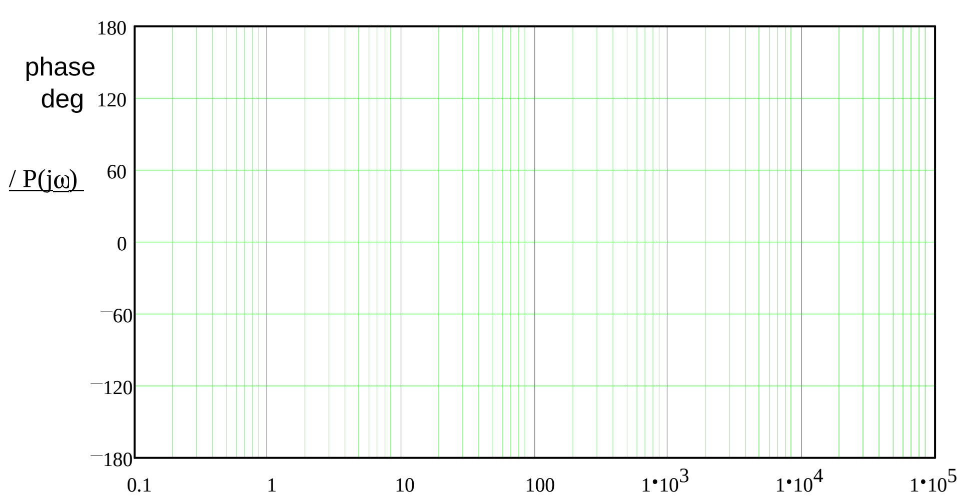




b) $P(s) = \dfrac{18000\cdot\left(s^2 + 0.3\cdot s + 9\right)}{\left[(s+20)^2 + 9600\right]\cdot(s+5000)}$

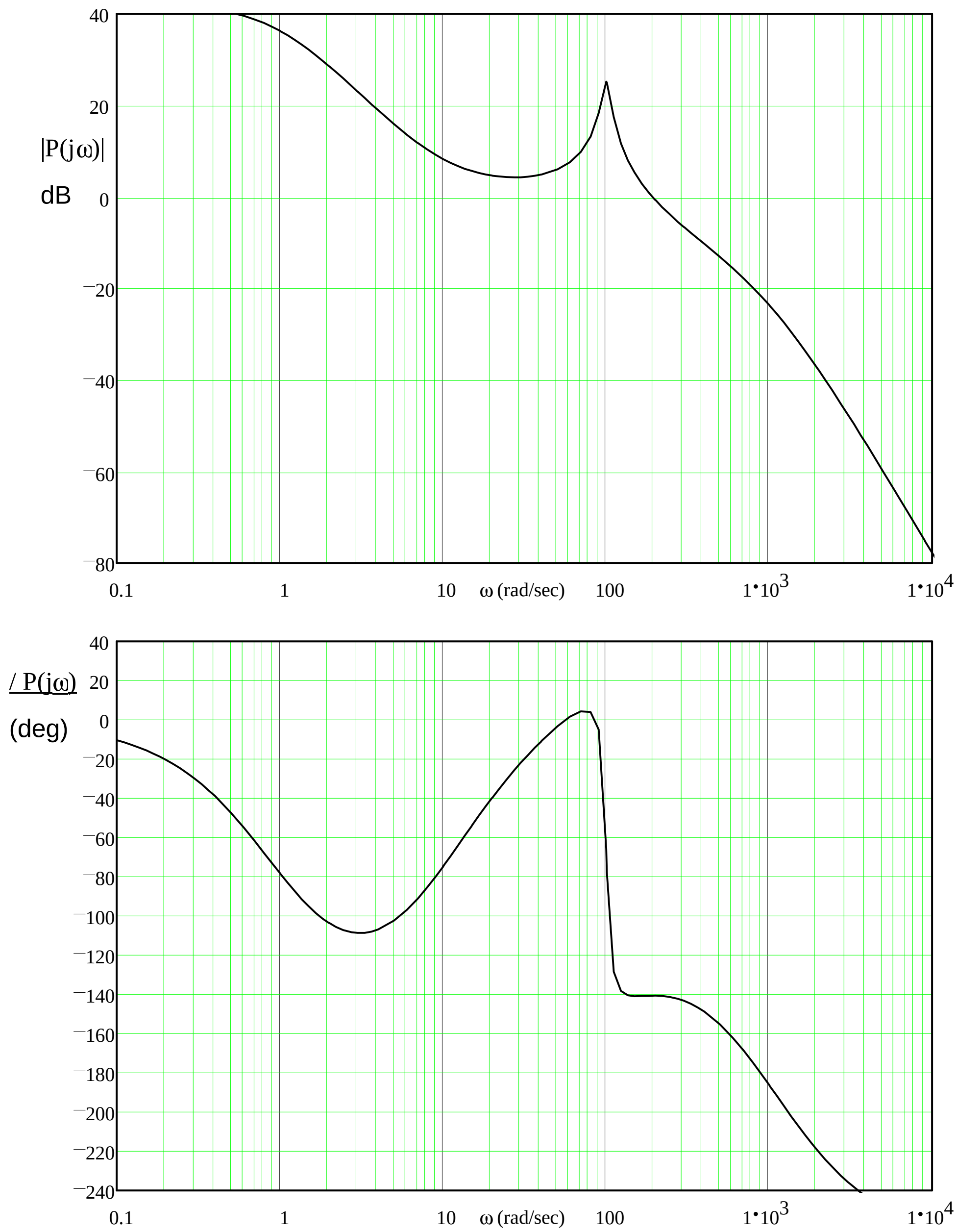
Fin F22





_____ / 30 pts

4. (18 pts) The open-loop Bode plots of a system are given at right.
   a) Find the gain margin and phase margin of the closed-loop system. Show your work on the drawings.



   b) Find the delay margin.

   c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 7\cos(4t+30^o)$.
   express the answer in the time-domain. $y_{ss}(t)$ = ?

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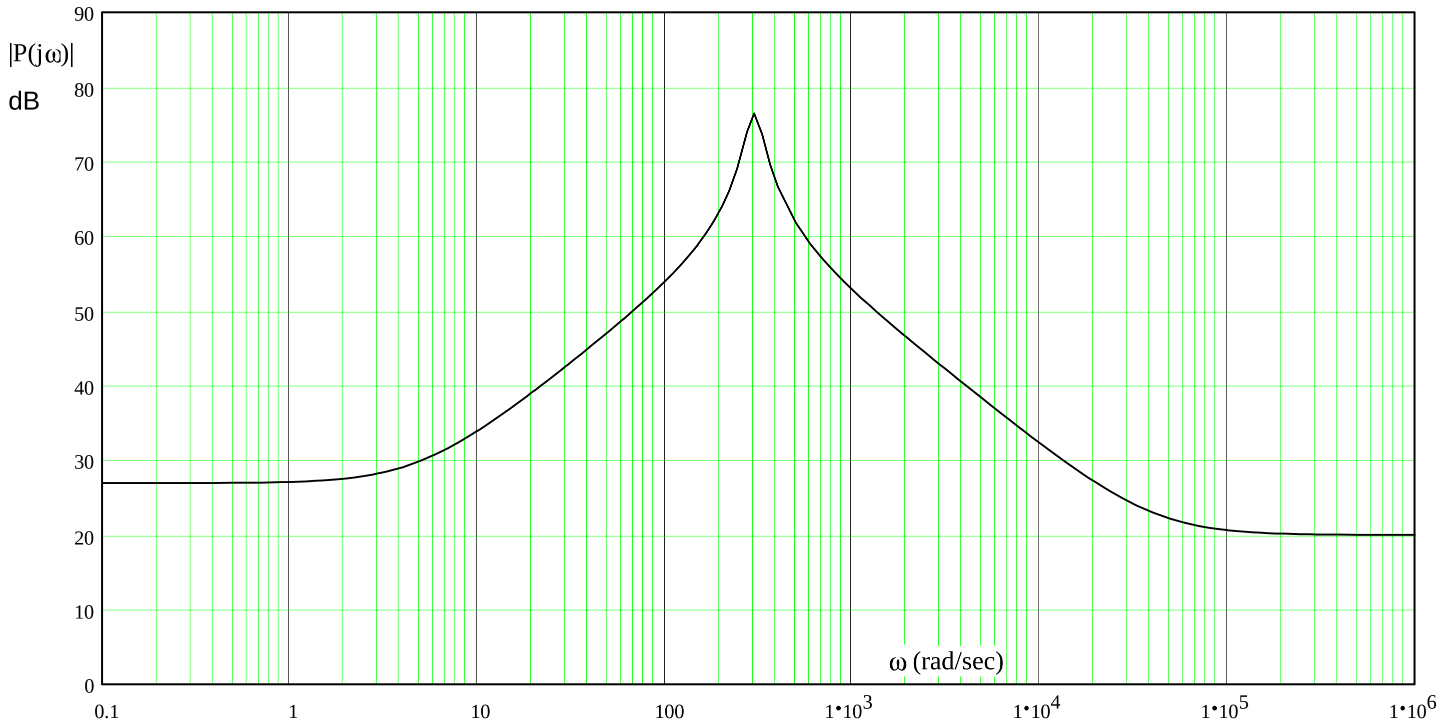
5. (20 pts) Given the magnitude frequency plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Use a straight edge and show your work (how you made your estimate).

Fin F22



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6. (27 pts) Use partial fraction expansion to find $x(k)$ for the following z-transform:

Fin F22

$$X(z) = \frac{z^2}{(z+1)\cdot\left(z^2 - 1.4\cdot z + 0.98\right)}$$

b) Is the signal represented by part b) bounded?

Does it converge?

If yes, to what value?

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7. (22 pts) a) Draw the block diagram of a simple direct implementation of the difference equation.

Fin F22

$$y(k) = 2\cdot x(k) + \frac{1}{2}\cdot x(k-2) - \frac{1}{3}\cdot x(k-3) + \frac{1}{4}\cdot y(k-1) - \frac{1}{5}\cdot y(k-2)$$

b) Find the **H(z)** corresponding to the difference equation above. Show your work.

c) List the poles of **H(z)**. Indicate multiple poles if there are any.

d) Is this system BIBO stable? Yes No How do you know?

e) Is this an FIR system? Yes No
If not, which terms in the difference equation are to blame?

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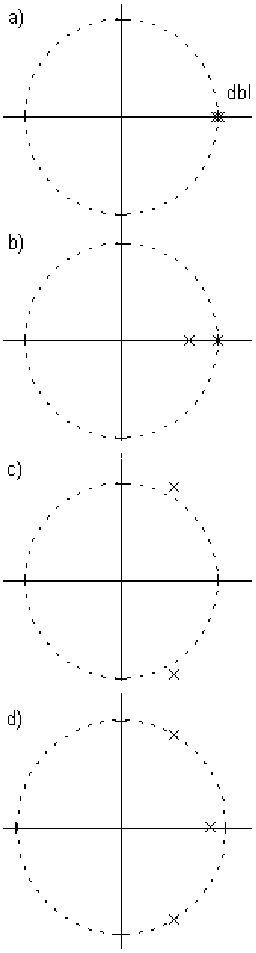
CB _____ / 16 _____ / 180 pts

Answers

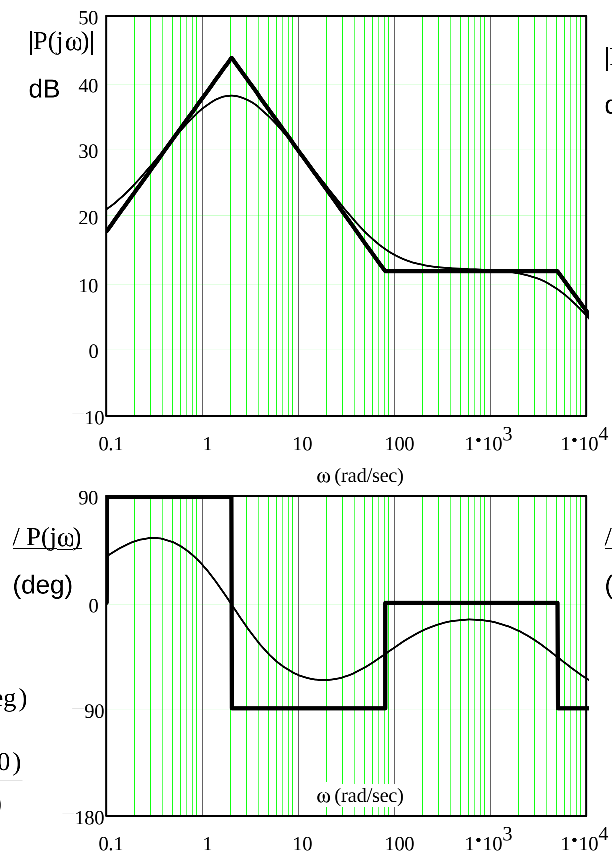
Closed everything



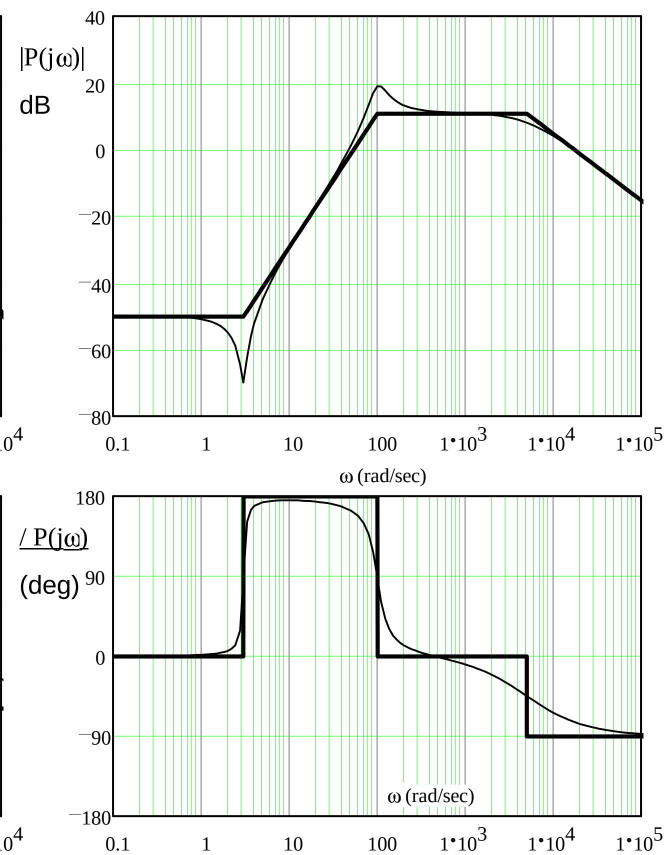
1. a) 8
   c) $5 \cdot k\Omega$
   b) $200 \cdot kHz$
   d) $0.025 \cdot \Omega$
   e) Limit the bandwidth with a simple single-pole low-pass filter. Done so that the op-amp circuit will still have a decent phase margin, even with a feedback factor of 1.

2. a) $$\frac{\frac{1}{L \cdot C}}{s^2 + \left(\frac{R_1}{L} + \frac{1}{R_2 \cdot C}\right) \cdot s + \left(1 + \frac{R_1}{R_2}\right) \cdot \frac{1}{L \cdot C}}$$
   b) $$R_1 + L \cdot s + \frac{1}{\frac{1}{R_2} + C \cdot s}$$
   c) $$\frac{\frac{1}{C} \cdot s + \frac{R_1}{L \cdot C}}{s^2 + \left(\frac{1}{C \cdot R_2} + \frac{R_1}{L}\right) \cdot s + \frac{1}{L \cdot C} \cdot \left(1 + \frac{R_1}{R_2}\right)}$$
   d) $$\frac{1}{\frac{1}{\mathbf{Z_{out0}} + R_1 + L \cdot s} + \frac{1}{R_2} + C \cdot s}$$

3. a)



b)

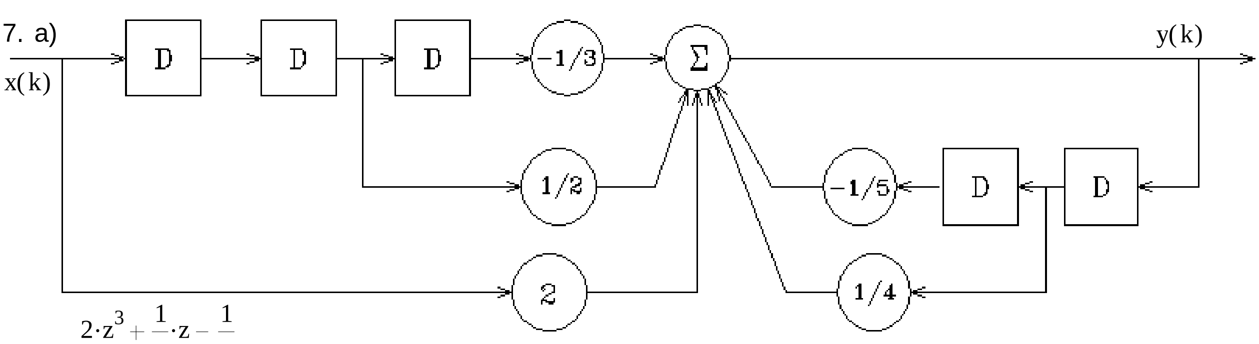


4. a) $GM := 22 \cdot dB$
   $40 \cdot deg$
   b) $3.5 \cdot ms$
   c) $70 \cdot \cos(4 \cdot t - 79 \cdot deg)$

5. $$\frac{10 \cdot (s+5) \cdot (s+40000)}{\left(s^2 + 60 \cdot s + 90000\right)}$$

6. a) $x(k) := \left[-0.296 \cdot (-1)^k + 0.98^{\frac{k}{2}} \cdot \left(0.296 \cdot \cos\left(\frac{\pi}{4} \cdot k\right) + 0.71 \cdot \sin\left(\frac{\pi}{4} \cdot k\right)\right)\right] \cdot u(k)$
   b) Yes No N/A

7. a)



   b) $$\frac{2 \cdot z^3 + \frac{1}{2} \cdot z - \frac{1}{3}}{z \cdot \left(z^2 - \frac{1}{4} \cdot z + \frac{1}{5}\right)}$$
   c) $0.125 + 0.429 \cdot j$ $\quad 0.125 - 0.429 \cdot j$ $\quad$ & $\quad 0$
   d) Yes, All poles are inside the unit circle
   e) No $\quad \frac{1}{4} \cdot y(k-1)$ and $-\frac{1}{5} \cdot y(k-2)$