Final
EE40
Spring 2013

NAME:_____ **SSID:**_____

Instructions

Read all of the instructions and all of the questions before beginning the exam.

There are 6 problems in this exam. The total score is 150 points. Points are given next to each problem to help you allocate time. Do not spend all your time on one problem.

Unless otherwise noted on a particular problem, you must show your work in the space provided, on the back of the exam pages or in the extra pages provided at the back of the exam.

Be sure to provide units where necessary.

GOOD LUCK!

PROBLEM	POINTS	MAX
1		30
2		25
3		15
4		35
5		20
6		25

Fish to bird: *Bird, you are shameless: you fill the courtyard with your droppings.*

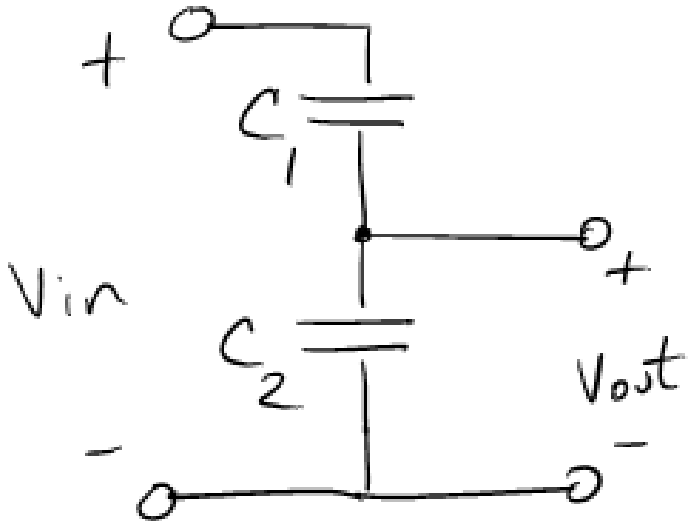
…

Bird to fish: *Your smell is awful; you make people throw-up; they sneer at you! ....*

- ***Debate between bird and fish****, 2100 BC, Sumerian text*

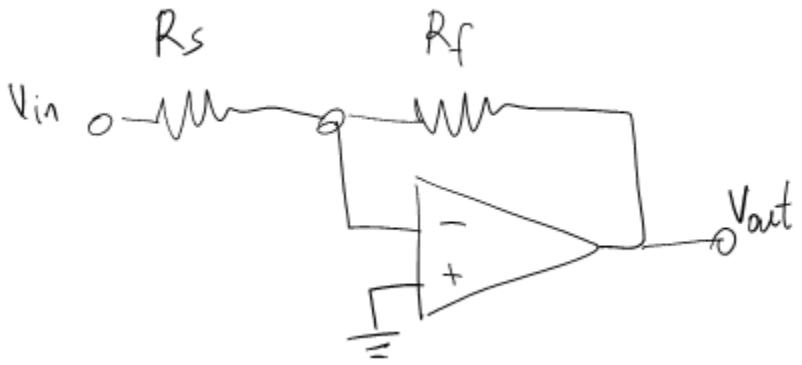
Problem 1 *Warm up*

a) Consider the circuit below. Provide an expression for the transfer function H(ω) = Vout/Vin for this circuit. *(7.5 points)*



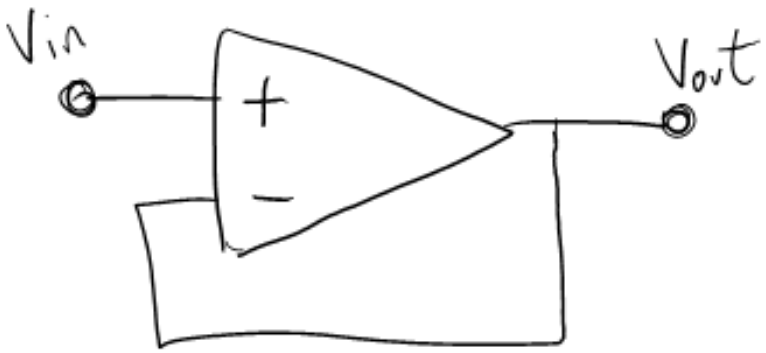
Solution:

b) Provide an expression for the DC gain of this op-amp circuit. *(5 points)*



Solution:

c) The op-amp in the circuit below is NOT ideal. Provide an expression for the DC gain of the op-amp circuit below as a function of the internal parameters of the amplifier. *(12.5 points)*



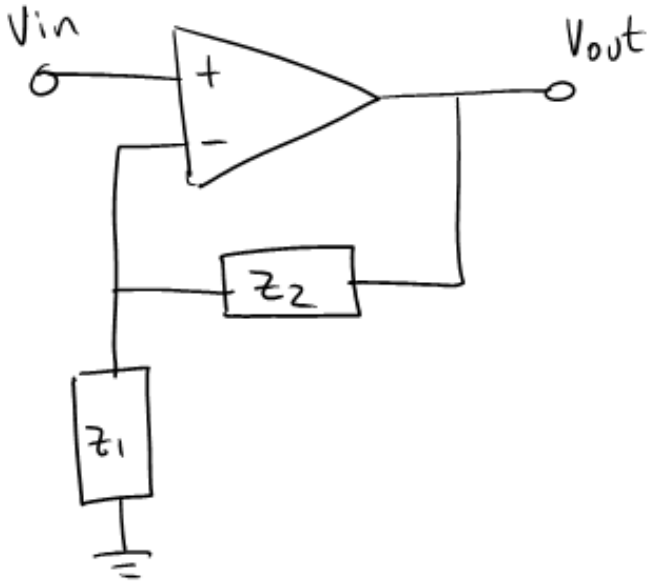
Solution:

d) For the circuit above, what is the DC gain as A → ∞, Ri → ∞, Ro → 0? *(5 points)*

Solution:

Driver: *If there's no room at the Hotel Genius, I'll take a room at the Hotel Imbecile.*
- Night on Earth

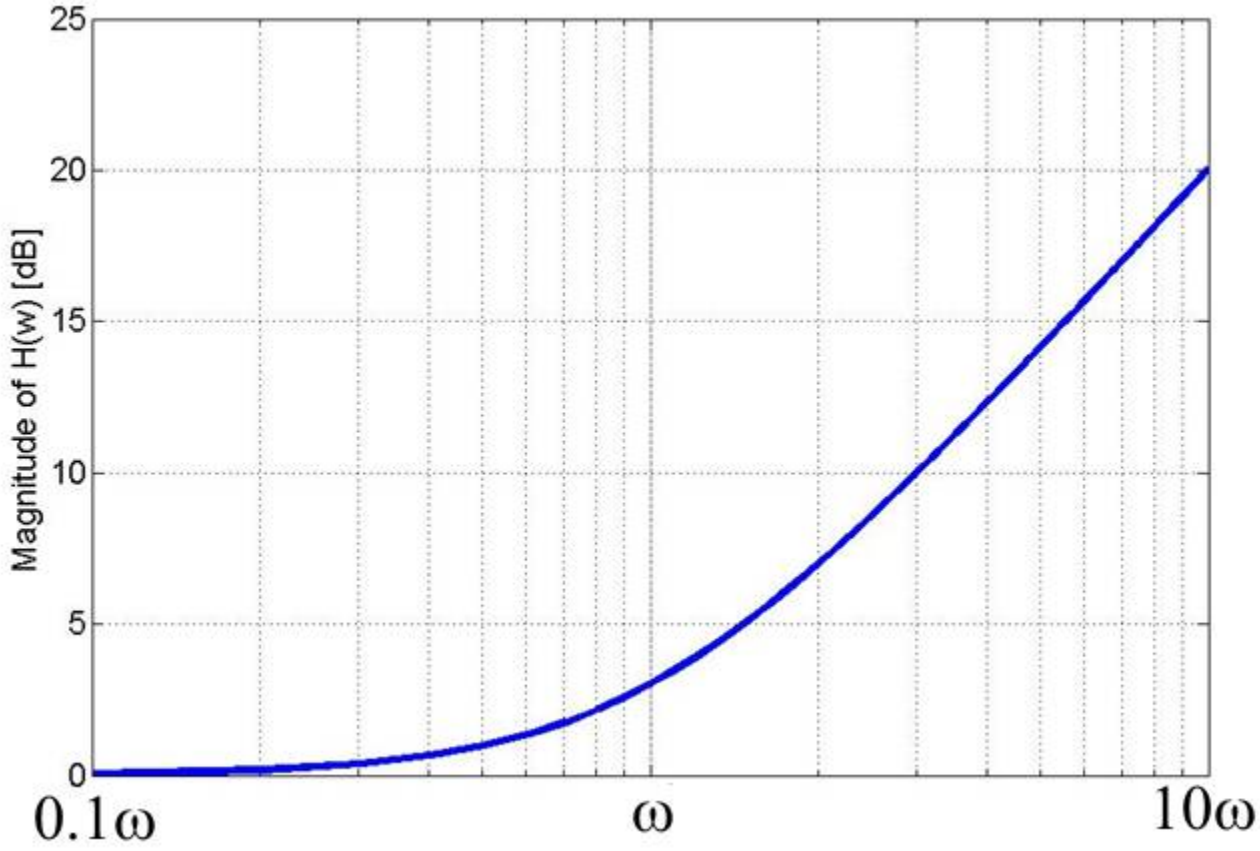
Problem 2 *Impedances and Op-amps*
Consider the circuit below.



a) Assuming Vin is a DC signal and Z_1 and Z_2 are real, what is the DC gain (Vout/Vin) of the circuit? *(5 points)*

Solution:

b) Now assuming Z_1 is real and V_{in} is an AC signal, what must Z_2 be for the frequency response of the transfer function [$H(\omega) = V_{out}/V_{in}$] magnitude to look like the plot below? *(10 points)*



Solution:

c) Assume $Z_1 = j\ \Omega$ and $Z_2 = 1\ \Omega$. What is $V_{out}(t)$ if $V_{in}(t)$ is $\cos\omega t$ at $\omega = 2\pi$ kHz ? *(10 points)*

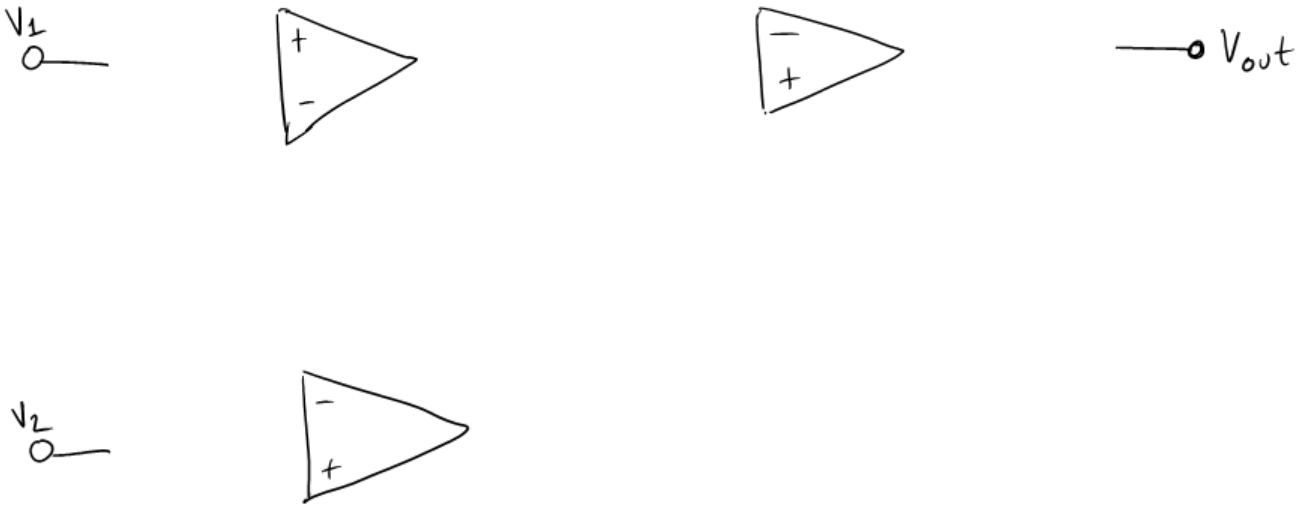
Solution:

What? What? What?

-The 10th Doctor

Problem 3 *Amplifiers, more amplifiers (15 points)*

You are provided with 3 op-amps and any number of resistors. Wire up the three op-amps below into a working circuit so that the output voltage, $V_{out}(t) = 11(v_2 - v_1)$. You can insert any number of resistors (you must specify their value) and you can use ground wherever you want. Supply rails are assumed.



Brian: *You have to be different!*
The Crowd: *Yes, we are all different!*
- **Life of Brian**, Monty Python

Problem 4 *Fun, fun*

Design a passive voltage bandpass filter with the following characteristics:

- The center frequency, ω_o, is 100 MHz.
- The bandwidth is 1 MHz.
- Any L used must satisfy 1 μH < L < 1 mH
- Any C used must satisfy 1 pF < C < 1 μF
- Any inductor has a series resistance (just add a resistor in series with the inductor) of 1 Ω.

a) Draw your circuit and label V_{in}, V_{out} and component values. *(10 points)*

Solution:

b) What are the two corner frequencies? *(5 points)*

Solution:

c) What is the phase shift between the input and output for the input Vin = $\cos\omega_0 t$? *(5 points)*

Solution:

d) How much power does the circuit consume in one period of oscillation when given Vin = $\cos\omega_0 t$? *(10 points)*

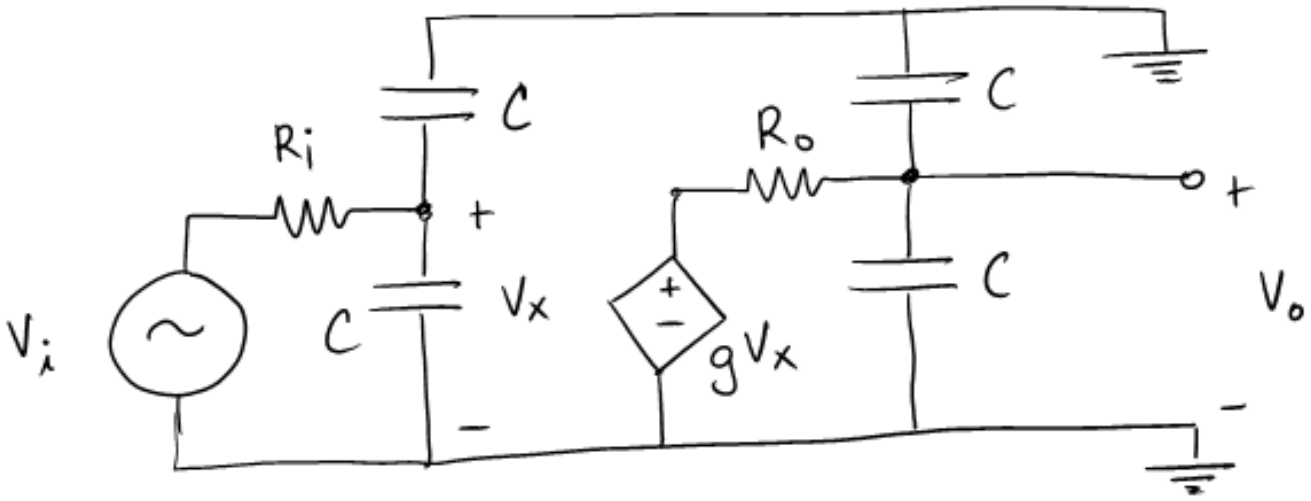
Solution:

e) When looking at transient behavior in the time domain, is your circuit **over-**, **under-**, or **critically-damped**? *(5 points)*

Solution:

Dave, stop. Stop, will you? Stop, Dave. Will you stop Dave? Stop, Dave.
-HAL 9000, **2001: A Space Odyssey**

Problem 5 *Bzzzz…. (20 points)*
Consider the circuit below.
$\mathbf{V_i}$ is an AC signal with a 1 V amplitude at $(1/2\pi)$ MHz;
C = 1 μF; g = 100; Ri = Ro = 1 Ω.
What is $V_O(t)$?



Solution:

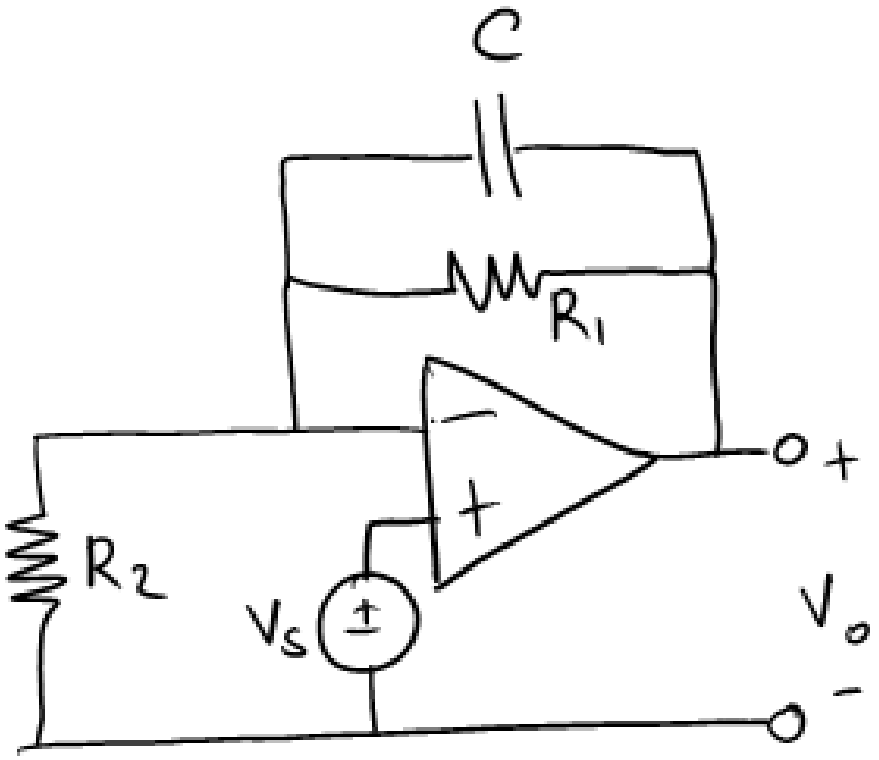
Life itself is a quotation.
- Jorge Luis Borges

Problem 6

Consider the circuit below.

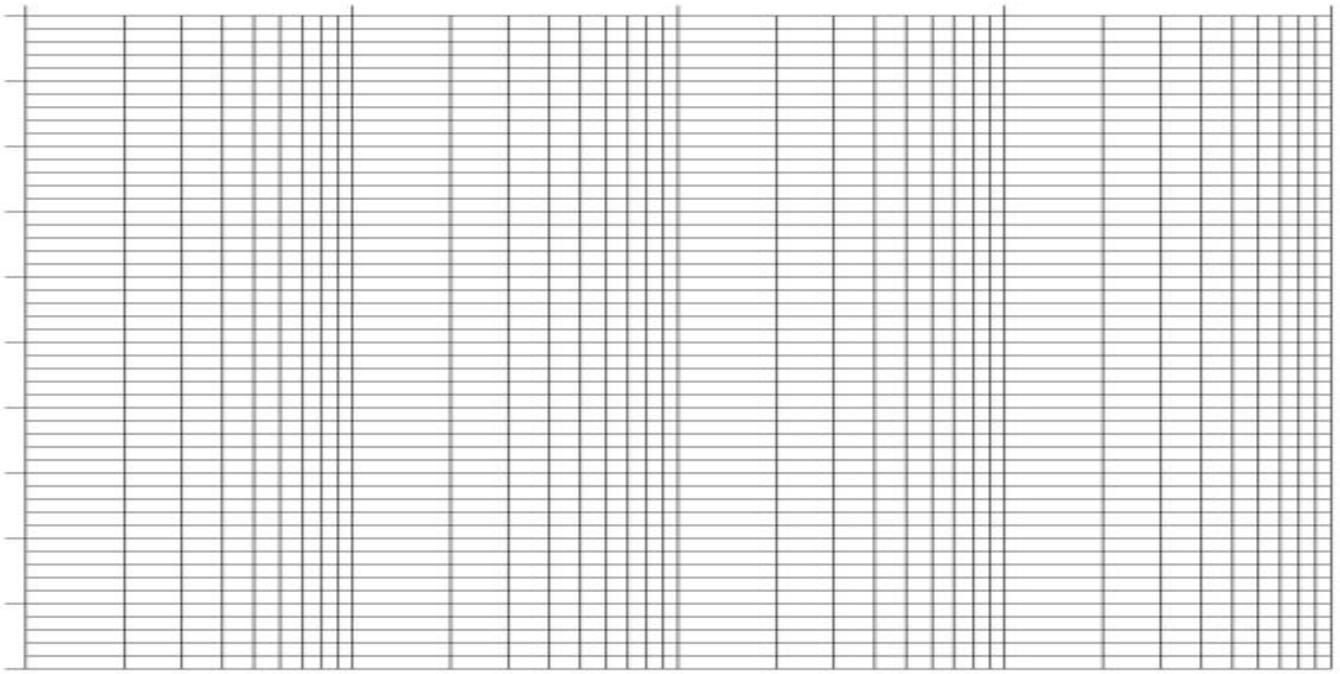
a) Provide an expression for the transfer function $H(\omega) = V_o/V_S$. *(10 points)*

Solution:

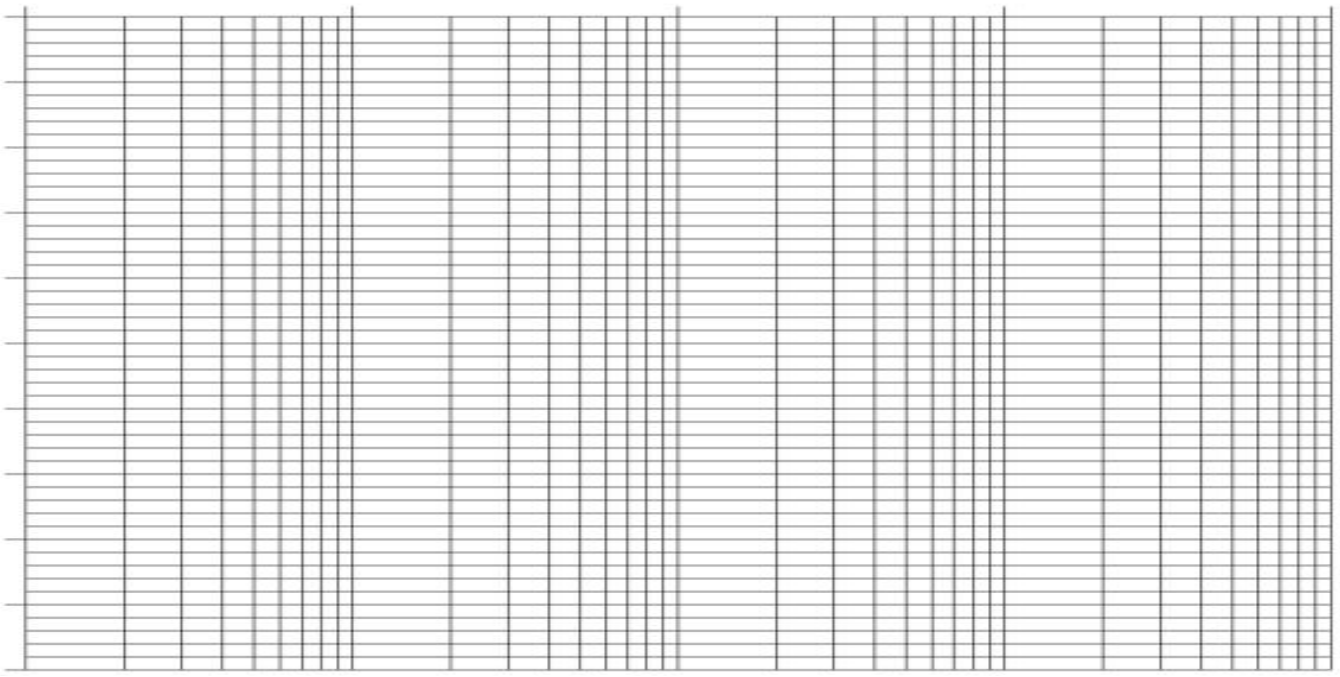


b) Produce Bode plots for magnitude and phase of H(ω), given that R1 = 99 kΩ, R2 = 1 kΩ, and C = 0.1 μF. *(10 points)*

Magnitude Bode plot for left circuit



Phase Bode plot for left circuit

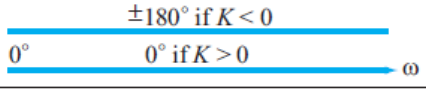
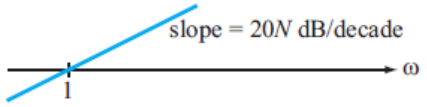
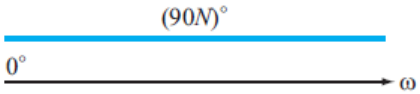
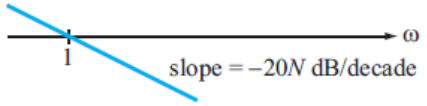
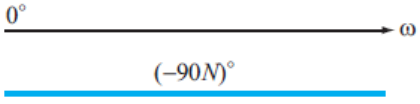
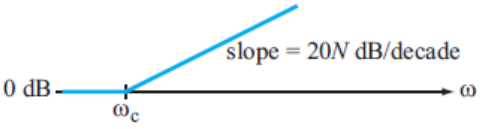
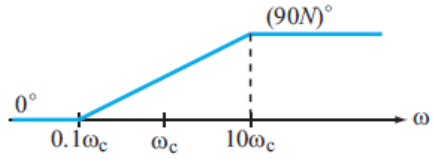
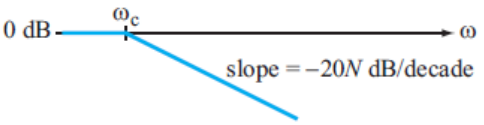
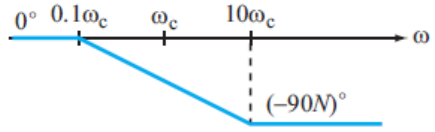
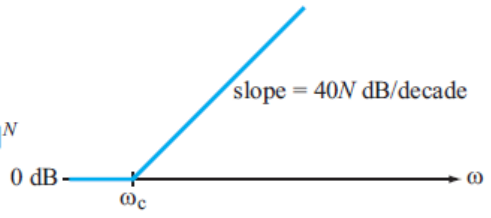
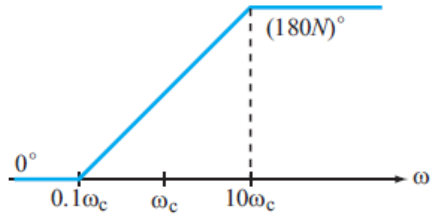


c) What type of filter is this? What is the maximum gain? *(5 points)*

Solution:

Scratch

Scratch

Factor	Bode Magnitude	Bode Phase
Constant K		
Zero @ Origin $(j\omega)^N$		
Pole @ Origin $(j\omega)^{-N}$		
Simple Zero $(1 + j\omega/\omega_c)^N$		
Simple Pole $\left(\frac{1}{1 + j\omega/\omega_c}\right)^N$		
Quadratic Zero $[1 + j2\xi\omega/\omega_c + (j\omega/\omega_c)^2]^N$		
Quadratic Pole $\frac{1}{[1 + j2\xi\omega/\omega_c + (j\omega/\omega_c)^2]^N}$