Electronics
EECE2412 — Fall 2018
Exam #1

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Name: Solutions

General Rules:

- You may make use of two sheets of notes, 8.5–by–11 inches, using both sides of the page.
- You may use a calculator.
- Present your work as clearly as possible. I give partial credit if I can figure out that you know what you are doing. I do not give credit for putting down everything you know and hoping I will find something correct in it.
- Each question has a vertical black bar providing space for your work and a line for numerical answers or box for plots or drawings. Please write your answer to each question clearly. If it happens to be correct, I give you points quickly and move on to the next problem. Please show your work in the space provided, or on extra pages, clearly labeled with the problem number. If the answer is wrong, this will make it easy for me to find ways to give you partial credit.
- Avoid any appearance of academic dishonesty. Do not talk to other students during the exam. Keep phones, computers, and other electronic devices other than calculators secured and out of reach.

1 Short–Answer Questions

2 each x 5 for 25 total

What is the ideal output impedance for a transconductance amplifier?

∞ Ω

What is the ideal input impedance for a voltage amplifier?

∞ Ω

An amplifier has a voltage gain of $A_V = -20$. What is the gain in dB?

☒ 26 dB ☐ 40 dB ☐ 13 dB

A typical intrinsic carrier concentration in silicon is

☒ 10^{10} /cm^3
☐ 10^{12} /cm^3
☐ 10^{8} /cm^3

The gain–bandwidth product of an amplifier is a property of the op–amp.

☒ True ☐ False

In a photodiode, light that is absorbed contributes to a reverse current.

☒ True ☐ False

In a diode, forward current flows from the n–type material to the p–type material.

☐ True ☒ False

The ripple voltage in a typical rectifier circuit with a diode and capacitor increases with load current.

☒ True ☐ False

An "or" circuit for diode logic usually requires a pull–up resistor.

☐ True ☒ False

Doped semiconductor material has

☐ lower total carrier density than intrinsic
☒ higher total carrier density than intrinsic

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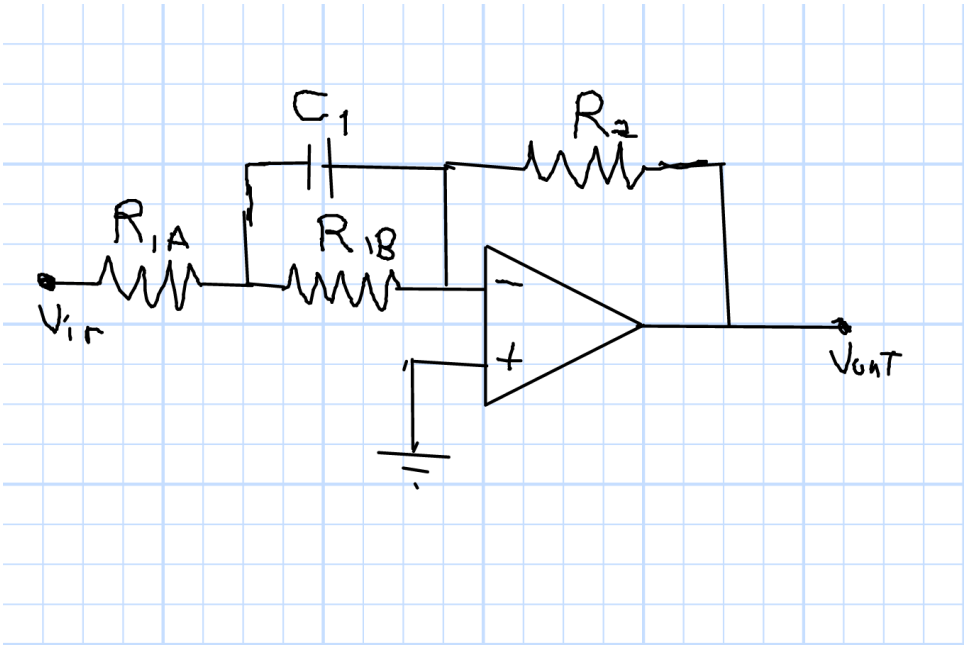
2 Op Amps

The op–amp in this circuit has an open–loop gain of 10^6 and a gain–bandwidth product of 10 MHz.

For the circuit, $R_{1A} = 1$ kΩ, $R_{1B} = 2$ kΩ, $C_1 = 5$ μF, and $R_2 = 15$ kΩ.



2.1 The Op–Amp

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What is the open–loop bandwidth of the Op–Amp (by itself).

$10^7 / 10^6 =$

10

_____ Hz

2.2 Circuit Gain

What is the mid–band gain of the circuit?

$-\frac{R_2}{R_{1A}}$

Midband Gain: -15

in dB? 23.5 dB.

What is the DC gain of the circuit?

$-\frac{R_2}{R_{1A}+R_{1b}}$

DC Gain: -5

in dB? 14.0 dB.

What is the bandwidth of the complete amplifier circuit?

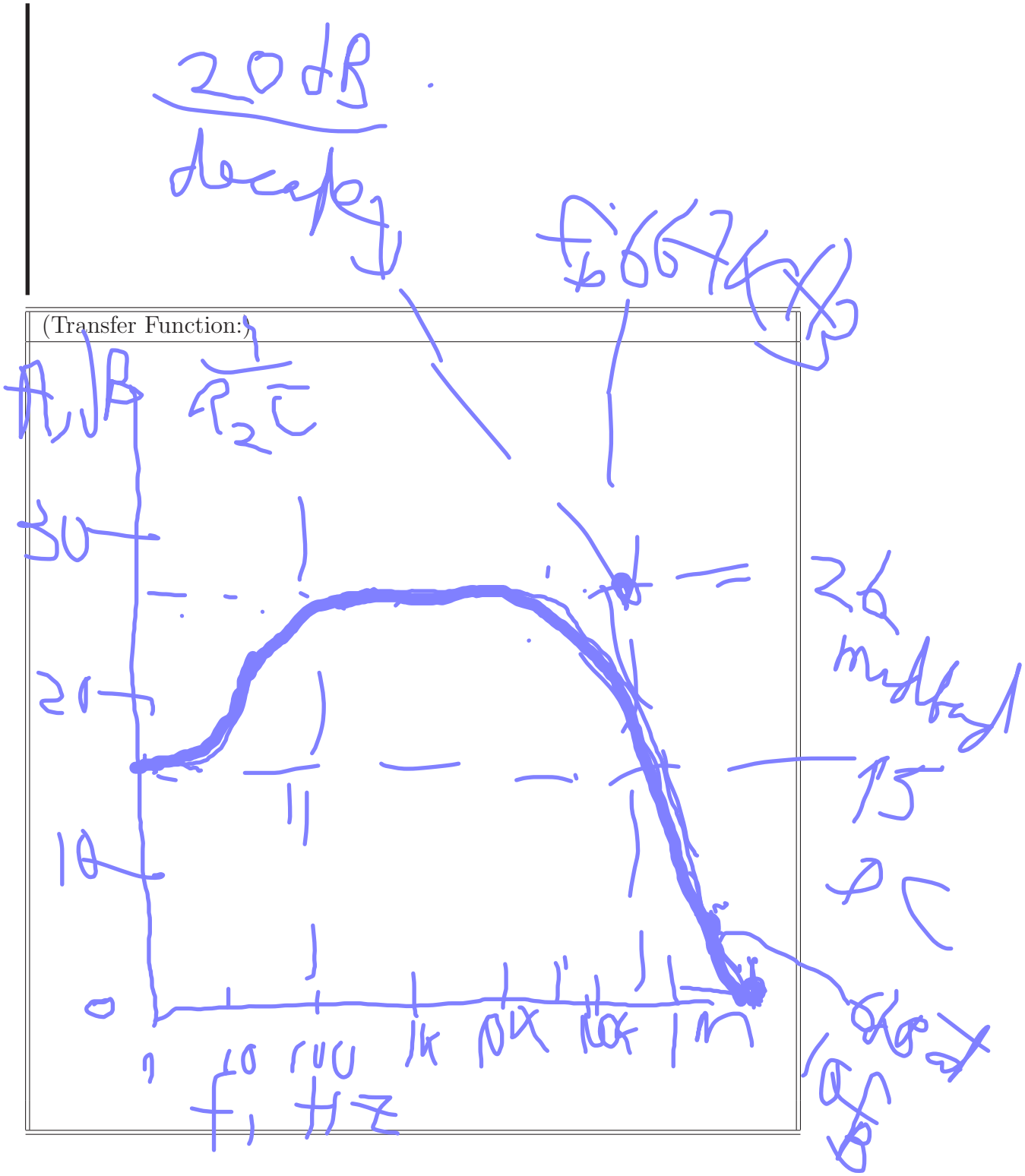
$10^7 \text{ Hz} / 15$

667 kHz.

2.3 Frequency Response

Sketch on a single graph with values clearly labelled on the axes, the actual transfer function of the amplfier circuit. Use a logarthmic axis for frequency and plot the gain in dB. With arrows, show the DC gain, Mid–Band gain, and bandwidth.

(Transfer Function:)



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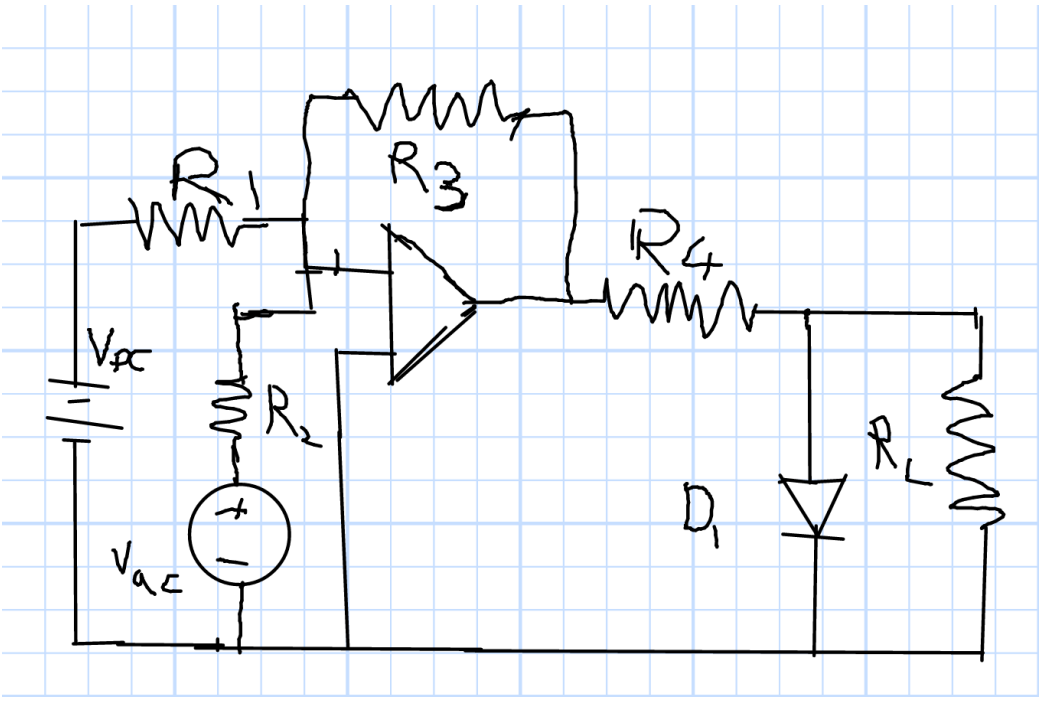
3 Diode Circuit

Consider the diode circuit in the figure below. In the circuit, $R_1 = 2$ kΩ, $R_2 = 1$ kΩ, $R_3 = 4$ kΩ, $R_4 = 500$ Ω, and $R_L = 2$ kΩ. The DC voltage is $V_{DC} = -1$ V.



3.1 DC Solution

Consider only the DC part of the problem. You may use the Constant–Voltage–Drop model for the diode.

What is the DC current through R_L?

$V_{out} = -2V_{DC} = 2$ V

$V_{Drop} = 0.7$ V

$i = \frac{V_D}{R_L}$

$I_L =$ 950 μ Amperes

What is the DC current through R_4?

$$\frac{2\,V - 0.7\,V}{500\,\Omega}$$

$I_4 =$ 2.6 m Amperes

3.2 Small–Signal Model

Now determine the small signal model for the diode.

$$i_d = 2.6\,mA - 0.35\,mA$$

$$= 2.25\,mA$$

$$r_d = \frac{25\,mV}{2.25\,mA}$$

$r_d =$ 11.1 Ω

3.3 AC Analysis

Now determine the AC gain of the circuit, $A_V = v_{load}/v_{ac}$.

AC Gain: $-8.6 \| 11 - 2$ Ω

$$-\frac{R_3}{R_2}\,\frac{R_L \| r_d}{R_4 + (R_L \| r_d)}$$

$$= -\frac{5k}{1k}\,\frac{11}{5 \| 11}$$

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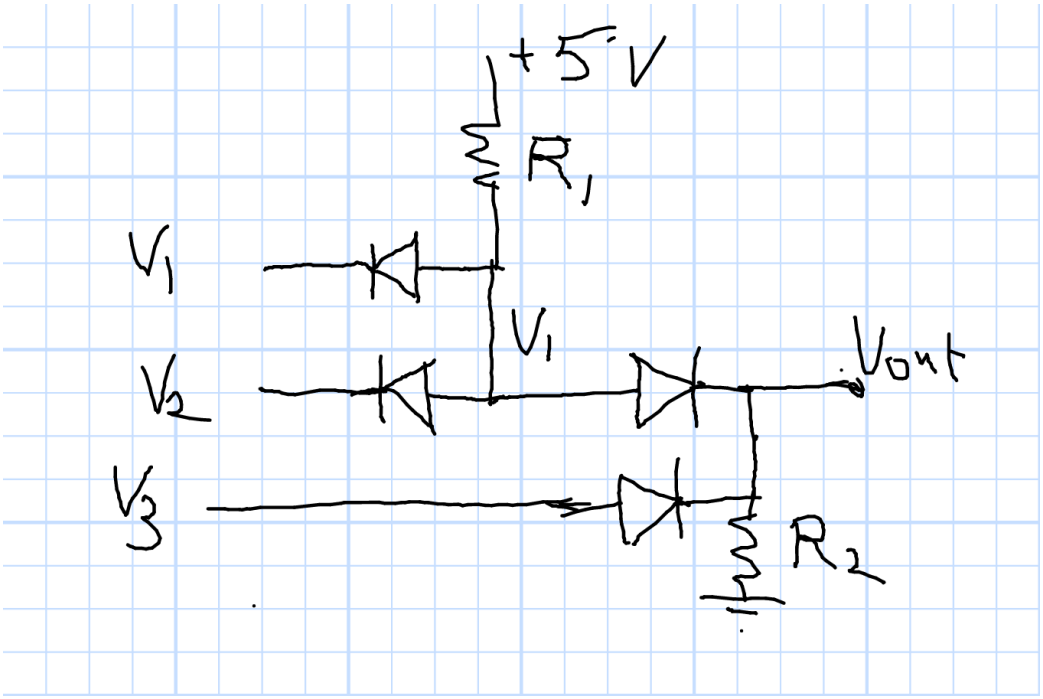
4 Diode Logic Circuit

Consider the circuit shown in the figure. Use the Constant–Voltage–Drop model for the diodes. There are three logic inputs, V_1, V_2, and V_3. Each can be $T = 5$ V for "True" or $F = 0$ for "False."



What is the intended function of this logic circuit? Express your answer in words with appropriate parentheses.

(V1 and V2) or V3

If the inputs, $[V_1, V_2, V_3]$ are $[F, F, F]$, what is the intermediate voltage at the bottom of R_1, and what is the output voltage?

$V_1 =$ 0.7 Volts and $V_{out} =$ 0 Volts

What are the answers for inputs of $[T, T, F]$?

$V_1 =$ 5 Volts and $V_{out} =$ 4.3 Volts

What are the answers for inputs of $[T, F, T]$?

$V_1 =$ 0.7 Volts and $V_{out} =$ 4.3 Volts