Electronics
EECE2412 — Spring 2018
Exam #1

Prof. Charles A. DiMarzio

Department of Electrical and Computer Engineering

Northeastern University

File:12262/exams/exam1

15 February 2018

Name: _____

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.

2.5

1   Short–Answer Questions

What is the ideal input impedance for a current amplifier?

0

What is the ideal output impedance for a transimpedance amplifier?

0

An amplifier has a voltage gain of $A_V = -50$. What is the gain in dB?

☐ 50 dB ☒ 34 dB ☐ -50 dB

An operational amplifier has some DC bias currents and voltages. These only need to be considered when using the amplifier for DC signals.

☒ True ☐ False

An amplifier has a uni–polar power supply at $+5$ Volts and is used in an inverting configuration with a gain of -5. This amplifier will only properly amplify input signals

☒ between -1 and 0 Volts
☐ between -1 and $+1$ Volts
☐ between 0 and 1 Volts

Increasing the donor concentration

☐ increases ☒ decreases

the hole concentration, p.

If a diode is reverse biased, the width of the depletion region is increased.

☒ True ☐ False

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

☐ True ☒ False

A full–wave rectifier circuit with a filtering capacitor will produce more ripple than a half–wave rectifier circuit with the same values of resistors and capacitors.

☐ True ☒ False

A circuit for a photodiode should provide reverse bias if the device is used for

☒ a high–speed communication device
☐ as part of a solar panel
☐ both of the above

Diode logic can be cascaded to any depth.

☐ True ☒ False

Donor–Doped semiconductor material has

☐ lower hole density than intrinsic
☐ higher electron density than intrinsic
☒ both of the above
☐ none of the above

2   Op Amps

Consider the op-Amp circuit in the figure below. Be careful about the signs on the inputs. The op–amp in this circuit has a gain–bandwidth product of 10 MHz.

For the circuit, $R_{in} = 1$ MOhm, $R_1 = 800$ Ohms, $R_2 = 4000$ Ohms.
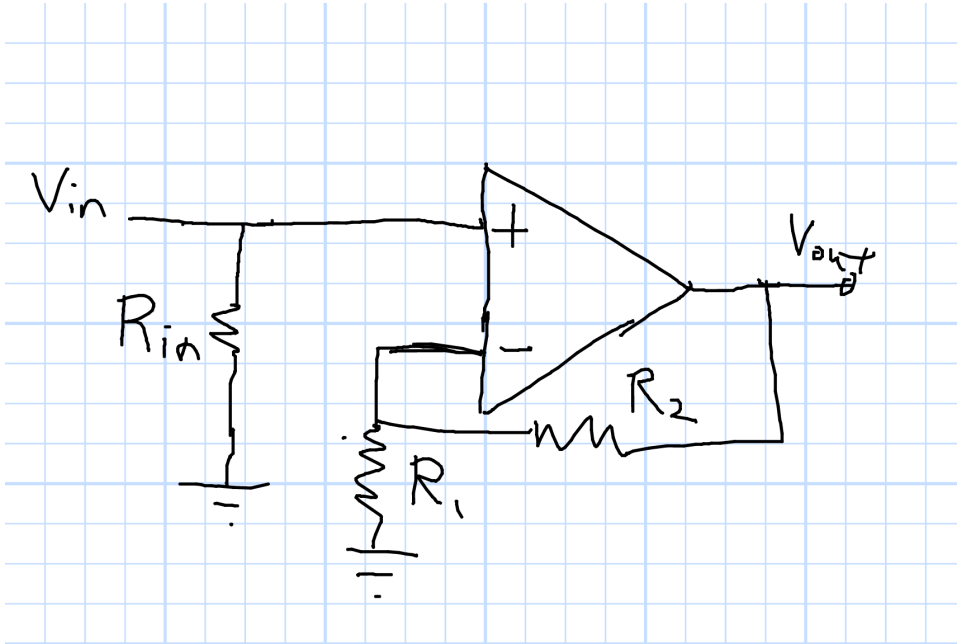
7.

2.1   DC Gain

What is the DC gain?

$$V_{out} \frac{R_1}{R_1 + R_2} = V_{in} \qquad A_v = 1 + \frac{R_2}{R_1}$$

$$20 \log_{10} 6 = 15.8$$

$A_v = \underline{\qquad 6 \qquad}$.

in dB? $\underline{\qquad 15.6 \qquad}$ dB.

6

2.2   Impedances

What is the input impedance? $\underline{\qquad 1M \qquad}$ Ohms

What is the output impedance? $\underline{\qquad 0 \qquad}$ Ohms

2.3 Bandwidth

What is the bandwidth of the amplifier circuit?

$$A_v \, f_b = 10 \, MHz \qquad A_v = 8$$

$$1.6 \, m$$

Hz.

2.4 Frequency Response

What is the value of the transfer function at

100 kHz $\underline{15.5}$ dB at $\underline{-3}$ Degrees.

200 kHz $\underline{15.5}$ dB at $\underline{-7}$ Degrees.

2 MHz $\underline{11.7}$ dB at $\underline{-50}$ Degrees.

$$A_v(f) = A_v(0) \, \frac{1}{1 + f/f_b}$$

3   Rectifier Circuit

Consider the simple rectifier in the figure below.
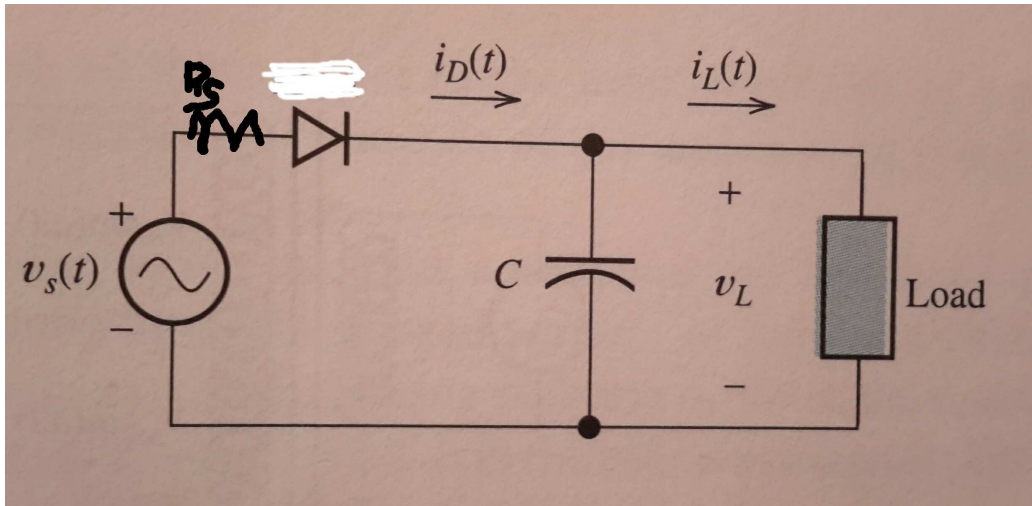

Figure from Hambley, *Electronics, 2nd Ed.*

This circuit is a simple rectifier circuit with a filter capacitor. The capacitor is said to be "charging" when the diode is "on" and "discharging" when it is "off." The diode has a forward voltage drop of 0.7 V (CVD Model). The source has an internal series resistance of $R_s = 1$ ohms. The load, R_L, can be anything from an open circuit to 500 Ohms.

The input is at 50 Hz with an amplitude of 40 Volts peak–to–peak.

3.1   Charging

Draw the circuit model for the "charging" state. Reduce it to a Thevenin equivalent circuit for everything but the capacitor, and add the capacitor at the output of that circuit.
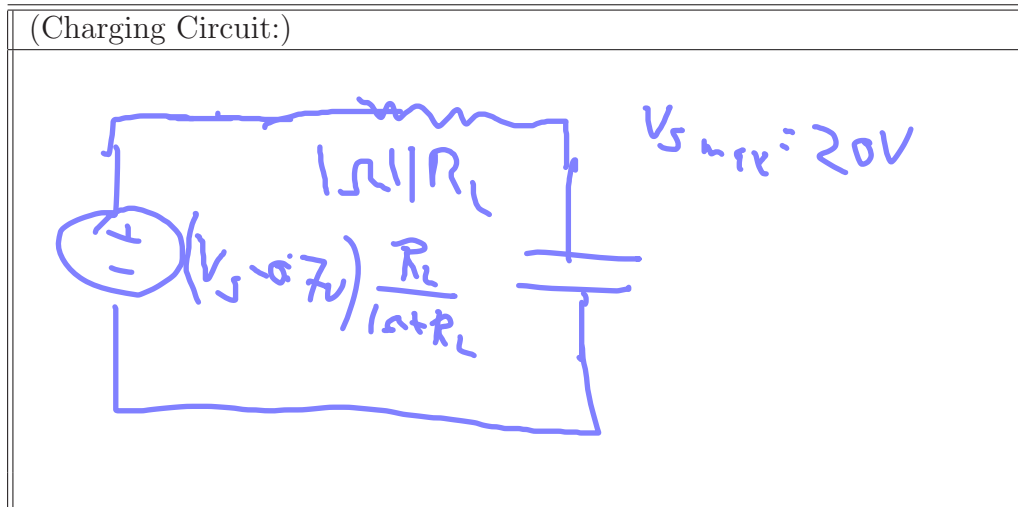
(Charging Circuit:)

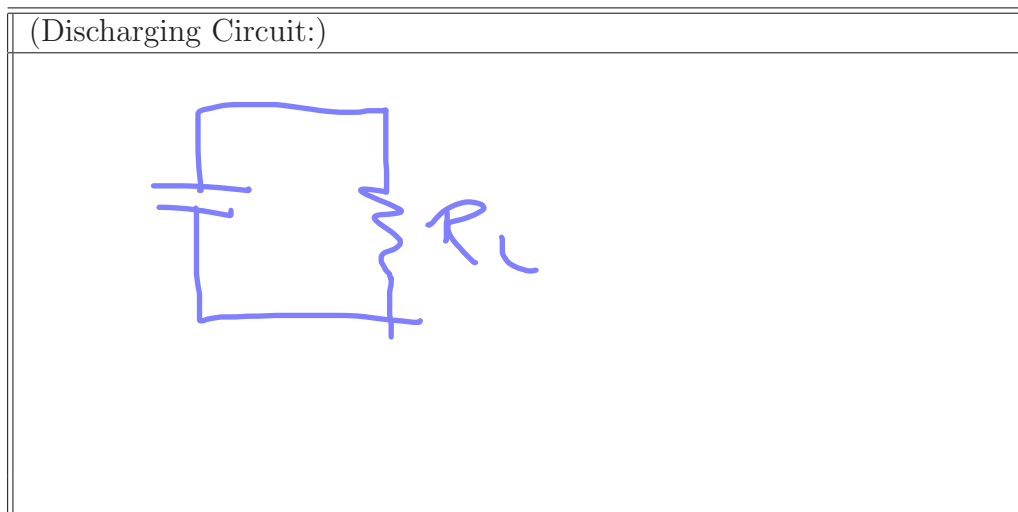What is the equation for the time constant of the charging circuit?

Time Constant: $(1 || R_L)C = 1\Omega C$

3.2   Discharging

Draw the circuit model for the "discharging" state.

(Discharging Circuit:)

What is the equation for the time constant of the discharging circuit?

Time Constant: $R_L C$

What capacitance is needed to ensure that the ripple is less than 0.5 Volts?

$$19.3V \, e^{-t/\tau} = 18.7$$

$$\tau = R_L C \qquad \frac{t}{\tau} = -\ln \frac{18.7}{19.3}$$

$$\tau = \frac{(1/50) \, sec}{-\ln(18.7/19.3)} = 0.63 \, sec$$
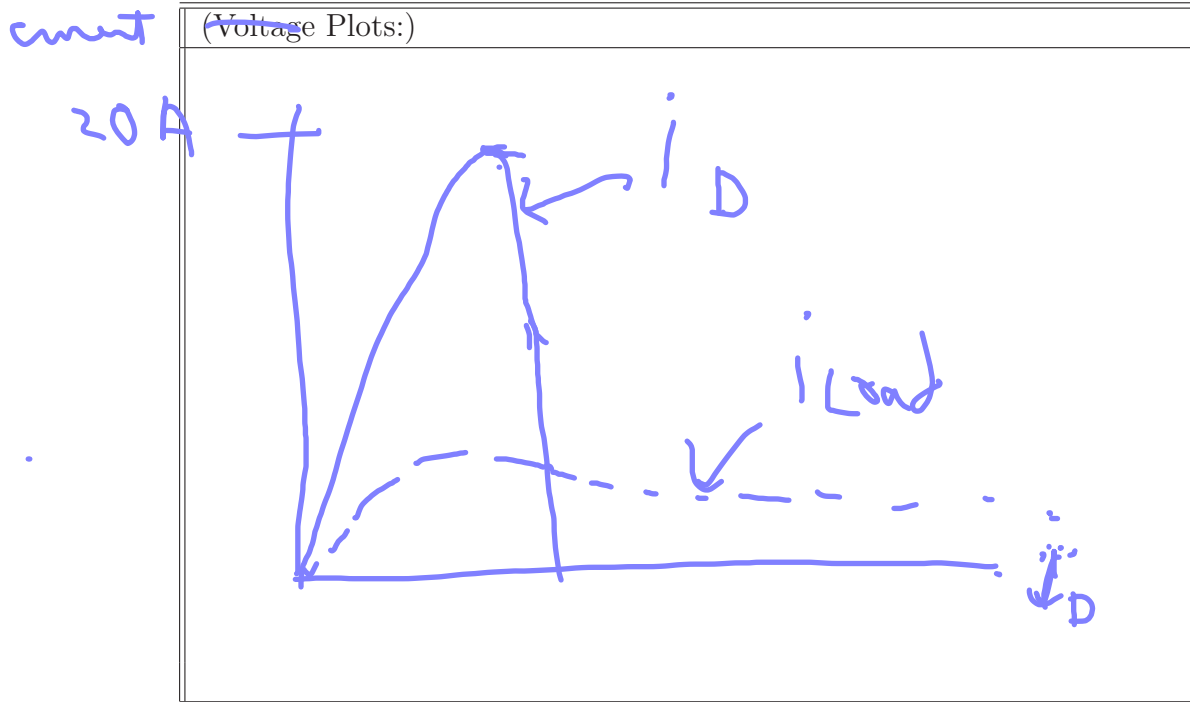
$$C = \frac{t}{R_L} = \frac{0.63s}{500\Omega}$$

$$\nwarrow$$

worst case

Capacitance: ___1.3 mF___

3.3   Summary

Sketch the input current, $i_D(t)$ and the load current, $i_L(t)$ both on the same axis.

current

20 A

(Voltage Plots:)

i_D

i_{Load}

i_D

4   Laser Diode Driver

The circuit below shows a laser diode and its driver circuit. The idea is to present a particular DC current and AC current to the diode.

This laser diode is not silicon and so the CVD model voltage drop is not 0.7 but 2.0 Volts. However, other than that it behaves like the diodes with which we are familiar.
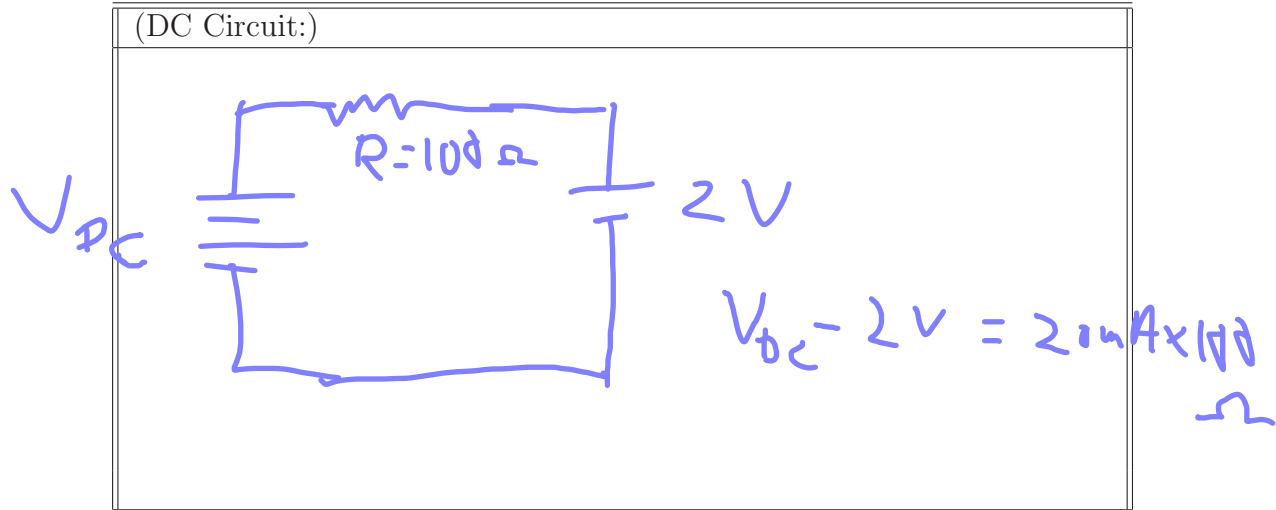
Our goal is to set the light output to some constant value determined by the DC current and then introduce a "modulation" AC signal on that to carry information. We'd like the DC current to be about 120 mA and the AC current to have a peak value of about 20 mA.
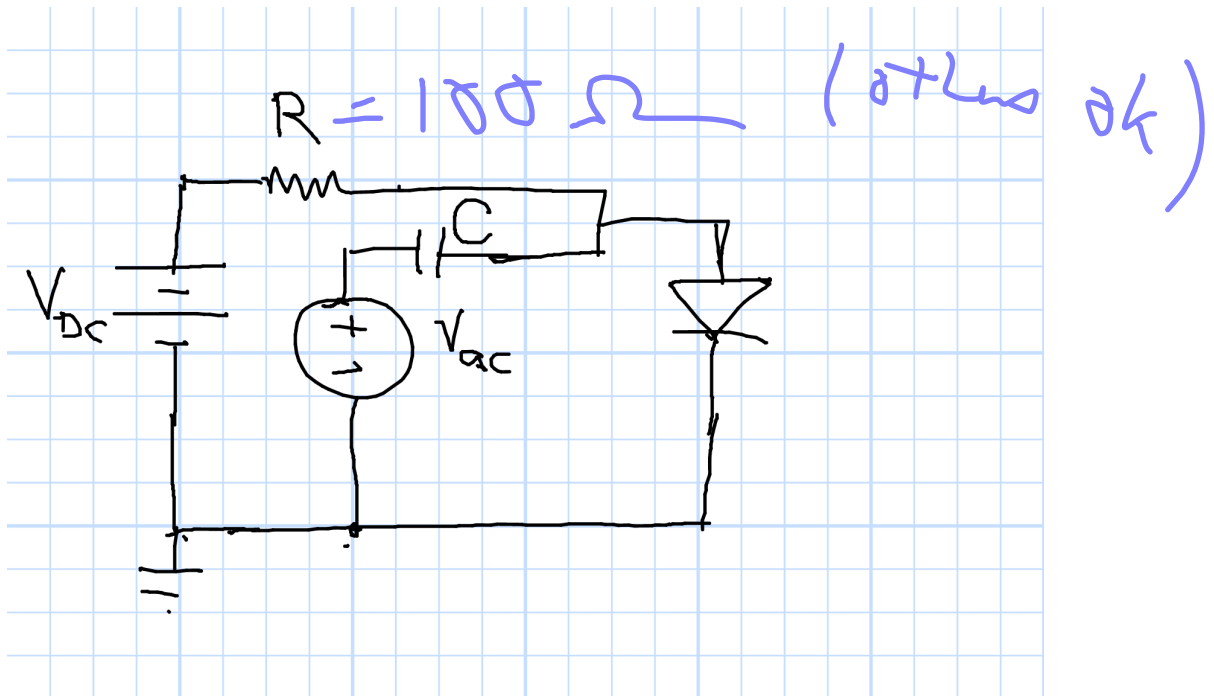
4.1   DC Circuit

Draw the DC circuit and determine the required source, V_{DC}.

(DC Circuit:)

V_{DC}

$R = 100\ \Omega$

$2V$

$V_{DC} - 2V = 20mA \times 100\ \Omega$

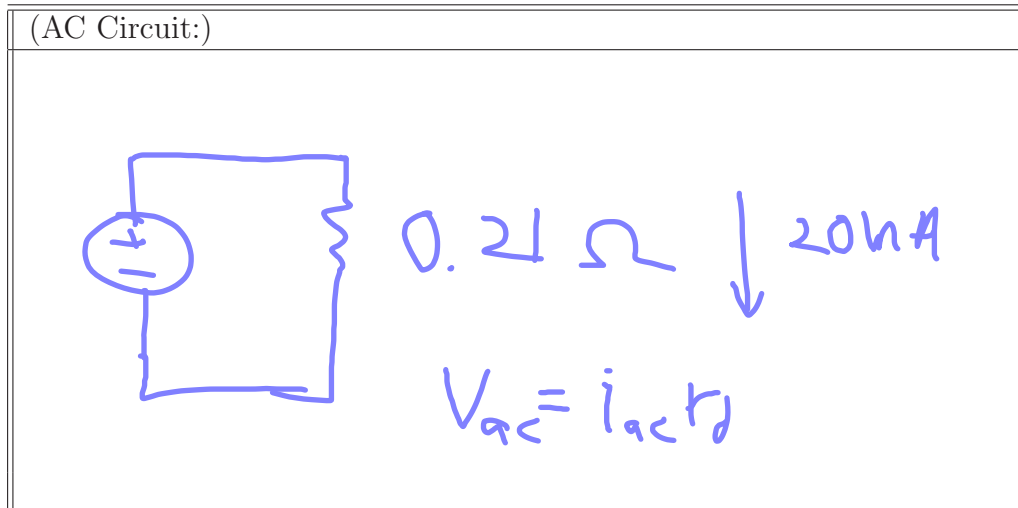$V_{DC} =$ ____14V____ Volts.

4.2   Small–Signal Diode Model

What is the diode small–signal model? Specifically, what is r_d?

$r_d = \dfrac{V_T}{I_{DC}} =$ ____0.21____ Ohms.

4.3   AC Circuit

Draw the AC circuit and calculate the peak value of the AC voltage source, v_{ac}.

(AC Circuit:)

$0.21\ \Omega$ $20mA$

$V_{ac} = i_{ac} r_d$

$v_{ac} =$ ____4.2 m____ Volts.