ece231 Midterm 2025

The midterm test has been graded. Please follow the instructions to be posted in the announcement regarding remark requests.

Class scores distribution Show

My score

46.4% (16.7/36)

Q1 6

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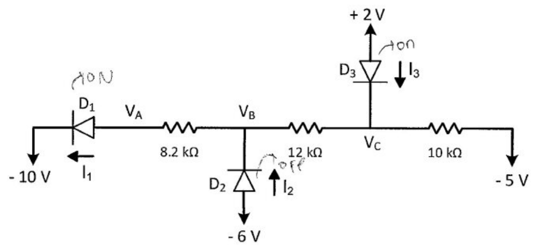
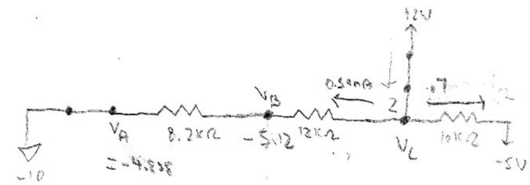
Question 1 [6 marks]

The diodes in the circuit shown below are ideal. Determine the node voltages, V_A, V_B and V_C, and the currents, I_1, I_2 and I_3.



$V_A =$ -4.838	(V)
$V_B =$ -5.13	(V)
$V_C =$ 2	(V)
$I_1 =$ 0.59	(mA)
$I_2 =$ 0	(mA)
$I_3 =$ 1.29	(mA)

Assume D_1 and D_3 on, D_2 is off.



$V_C = 2$

$\frac{2-(-5)}{10} = \underline{0.7mA}$

$i_2 = \frac{2-(-10)}{8.2+12}$

$= \underline{\underline{0.594059405\ mA}}$

$\frac{2-V_B}{12} = 0.59$

$2 - V_B = 7.128$

$-5.128712871 = \underline{\underline{V_B}}$

$-0.7 - 0.59 + i = 0$

$i = 1.29405\,9405\ mA$

Question 1 *(blank page for solution)*

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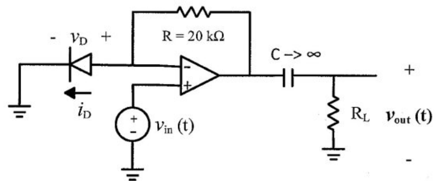
Q2 3.7

Question 2 [5 marks]

For the circuit shown below, $i_D = I_S\left(e^{v_D/V_T} - 1\right)$ where I_S = 0.1 μA and V_T = 25 mV, and the input is

$v_{in}(t) = 0.15 + 5 \times 10^{-3}\sin(\omega t)$ V. (Q-point) (small-signal)



a) Find the small-signal resistance of the diode.
b) Find the expression for v_{out} **(t)**.

no change

r_d = 621 Ω

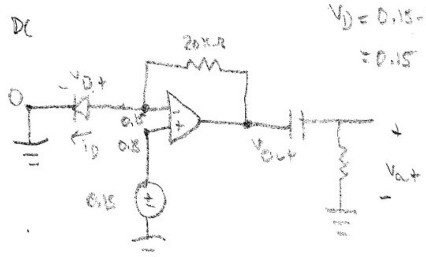
$v_{out}(t)$ = − 0.65 − 0.156 sin (ωt) V

0

−1

a)

DC



$V_D = 0.15 - 0$
$= 0.15$

$I_D = 0.1\mu A\left(e^{+0.15/25mV} - 1\right)$
$= 0.1 \times 10^{-6}(402.4287935)$
$= 4.024287935 \times 10^{-5}$
$= 0.04024287 9$ mA

$r_d = \frac{V_T}{I_D} = \frac{25mV}{0.04} = 621.2279146\ \Omega$

2

Part b next page →

$\frac{0.15 - V_{out}}{20} = 0.04 \rightarrow 0.15 - V_{out} = 0.8$ (use DC)

$V_{out} = -0.65485 758$ V

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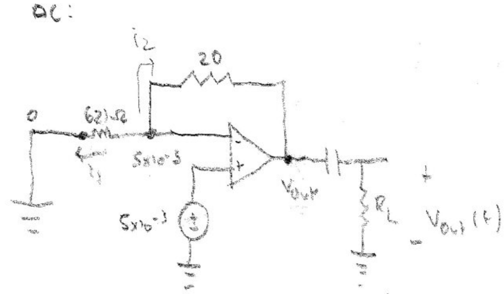
Question 2 *(blank page for solution)*

b)

ac:



$i = \frac{5\times10^{-3} - 0}{621}$

$= 8.0515\times10^{-6}$

$= 8.0515\times10^{-3}$ mA

$\frac{5\times10^{-3} - V_{out}}{20} = 8.0515\times10^{-3}$

$5\times10^{-3} - V_{out} = 0.16103035$

$\underline{-0.1560305035} = V_{out}$

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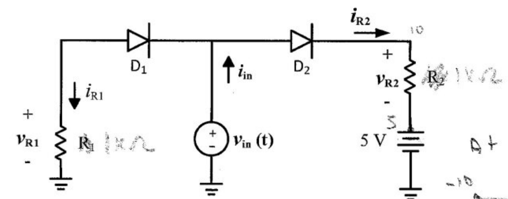
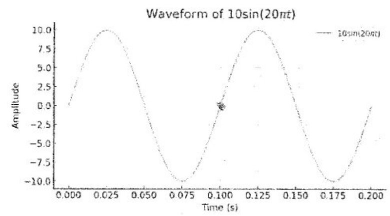
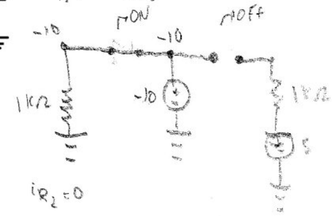
Question 3 [7 marks]

In the circuit shown below, the diodes are ideal and the input signal is $v_{in}(t) = 10\sin(20\pi t)$ V, and $R_1 = R_2 = 1$ kΩ. Sketch the waveforms of v_{R1}, i_{R1}, v_{R2}, i_{R2} and i_{in} for one period $(0 \le t \le 0.1s)$ on the next page. Clearly label the maximum and minimum signal values on the graphs.





At -10:



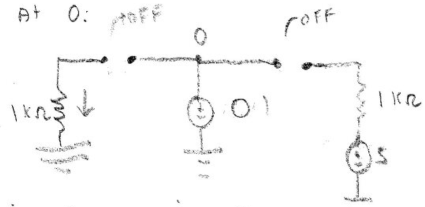
$i_{R_2} = 0$

$V_{R_2} = \frac{-10+5}{1} = -5$

$i_{R_1} = \frac{-10-0}{1} = -10mA$

$V_{R_1} = -10(1) = -10V$

At 0:



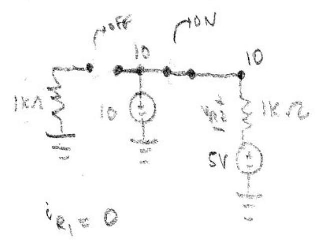
$i_{R_1} = 0$

$V_{R_1} = 0$

$i_{R_2} = 0$

$V_{R_2} = \frac{0-5}{1} = -5V$

At 10:



$i_{R_1} = 0$

$V_{R_1} = 10V$

$i_{R_2} = \frac{10-5}{1} = 5mA$

$V_{R_2} = 5(1) = 5V$

Q3 3

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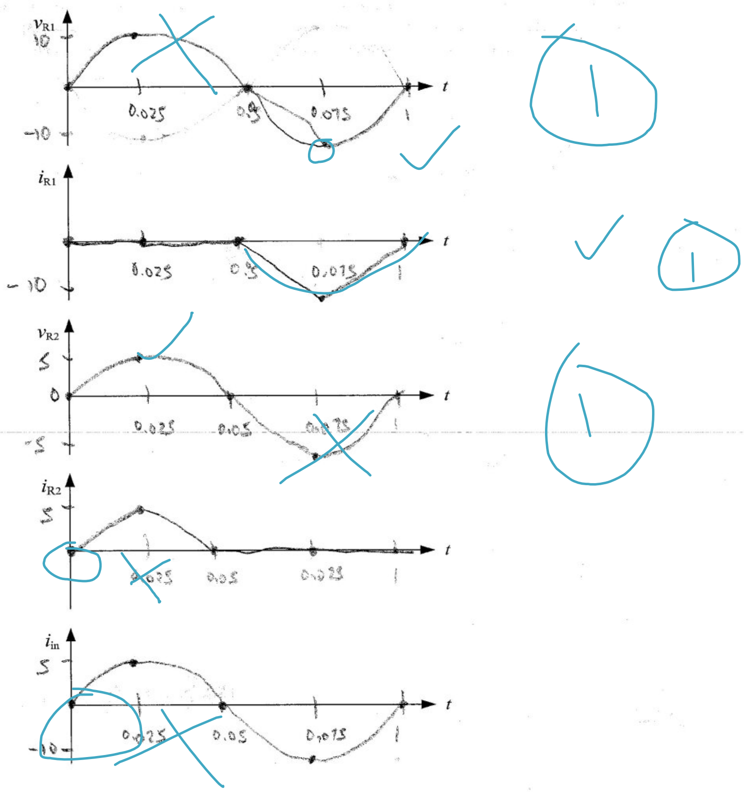
Question 3 (*solution*)



Q4 1

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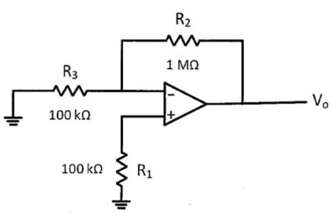
Question 4 [8 marks]

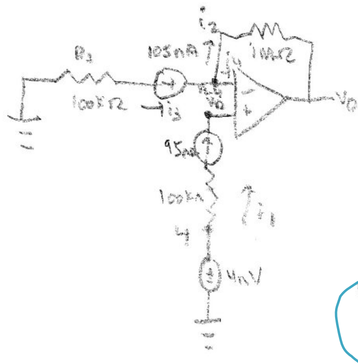
The Op Amp in the circuit shown below has V_{OS} = 4 mV, I_{B1} = 105 nA and I_{B2} = 95 nA. Calculate the worst-case output voltage, and find the new value of R_1 to achieve a zero-output voltage according to the worst-case scenario. Hint: worst-case means that V_o has the largest positive value.



$V_{o\ worst\text{-}case}$ = 42.4 mV

$R_{1\ new}$ = 68.4 kΩ

→ R_1 new on. next page



$V = 95\times10^{-9}(100\times10^{3})$

$= 9.5\times10^{-3}$ V

$= 9.5$ mV

$V_A = 9.5+4 = 13.4$ V

$\frac{13.4^{mV}-0}{100\,k\Omega} = 1.34\times10^{-4}$ mA

$i_2 = 1.3\cancel{4\times10^{-4}}$ mA $-$ 105 nA

$i_2 = 2.9\times10^{-8}$ A

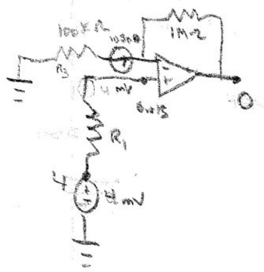
$\frac{V_0 - 13.4mV_0}{1M\Omega} = 2.9\times10^{-8}$ A

$V_0 - 13.4$ mV $= 0.029$

$V_0 = 0.0424$ V

$V_0 = 42.4$ mV

Question 4 *(blank page for solution)*



$V_3 = 100\,(105 \times 10^{-9})$

$= 0.0105\ V$

$\dfrac{4_{mV} - 0.0105}{R_1} = 95\,nA$

$4mV - 0.0105 = 95 \times 10^{-9} R_1$

$\underline{68.4210526} = R_1$
$k\Omega$

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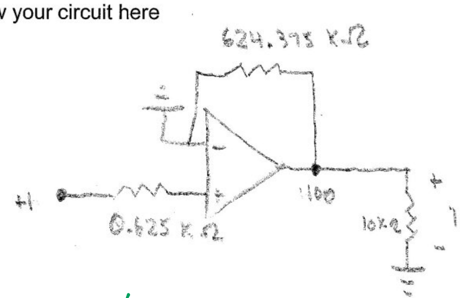
Q5 0

Question 5 [7 marks]

Design a noninverting amplifier with a gain of 100 that can deliver a 10 V signal to a 10 kΩ load resistor. Your Op Amp can supply only 1.6 mA of output current, and we want to draw the maximum current from the Op Amp. Draw your circuit, clearly indicate the input and output ports and all the resistor values.

Draw your circuit here



Work for circuit shown on next page →

wrong circuit diagram

I am assuming that by delivering a 10V signal, the question means that the load voltage is 10V rather than input voltage ✓

$A_V = +100$ Non-inverting

max output current = 1.6mA

Load = 10 kΩ

Signal = 10 (input)

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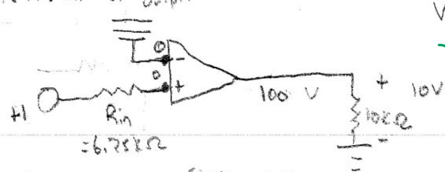
Question 5 *(blank page for solution)*

$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_{in}}$$

$A_V = \frac{V_{out}}{V_{in}}$ $100 = \frac{V_{out}}{1}$

$V_{out} = 100V$?

max current = 1.6 mA of output



V_+: $\frac{1 - 0}{R_{in}} = 1.6mA$

Since we want maximum current, use all 1.6 mA of output

$1 = 1.6R_{in}$

$0.625k\Omega = R_{in}$

$\frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_{in}}$

$1000 = 1 + \frac{R_F}{0.625}$

$999 = \frac{R_F}{0.625}$

$R_F = 624.375 \, k\Omega$

Q6 3

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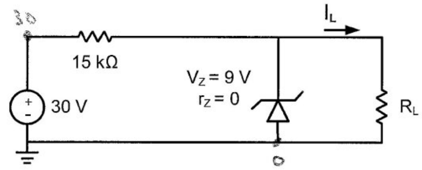
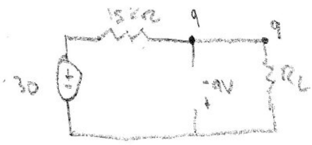
Question 6 [3 marks]

What is the maximum load current I_L that can be drawn from the Zener regulator as shown below?
What is the minimum value of R_L that can be used and still have a regulated output voltage?



$I_{L\ maximum}$ = 1.4 mA
$R_{L\ minimum}$ = 6.43 kΩ

Since reverse is 0, we have:



$\frac{30-9}{15} = i$ $\qquad$ $\frac{9-0}{R_L} = 1.4$

$1.4 = i$ $\qquad$ $9 = 1.4R_L$

$6.42857 = R_L$ kΩ