

# ECE231 – Introductory Electronics

## Midterm Test

Instructors – B. Wang, A. Prodic, K. Phang

Date – October 23, 2025

**Duration: 90 minutes**

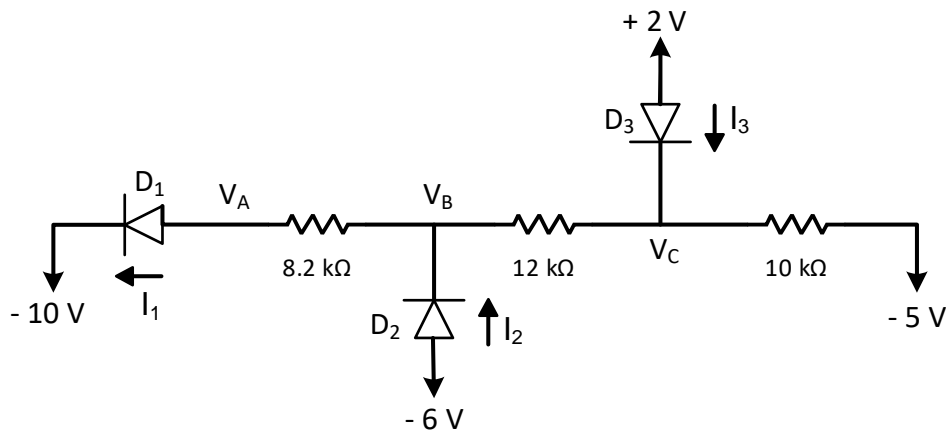
---

- 
1. Print your name and student number clearly in the boxes above. Your name should be exactly as it appears on Quercus. It is okay to overflow past the boxes if your name is long.
  2. The test is printed **double-sided**. Avoid writing on the QR codes found on each page.
  3. You may write in pencil but make sure it is dark enough to come out clearly when scanned.
  4. The marks for each question are indicated within brackets [ ].
  5. **Place your final answers in the boxes where given.**
  6. **Show your work**, answers without justification may not receive full marks.
  7. **Aids:** Any non-programmable calculator, the **key diode equations**, no other aids.

Question	Q1	Q2	Q3	Q4	Q5	Q6	TOTAL
Marks	6	5	7	8	7	3	36

### 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  $I_3$ .

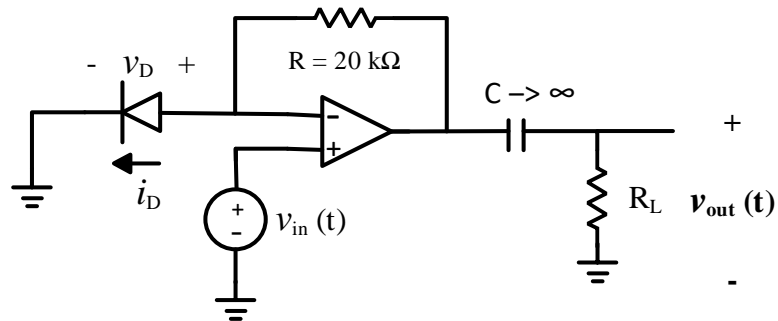


$V_A =$	-10	(V)
$V_B =$	-5.2	(V)
$V_C =$	2	(V)
$I_1 =$	0.6	(mA)
$I_2 =$	0	(mA)
$I_3 =$	1.3	(mA)

**Question 2 [5 marks]**

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

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



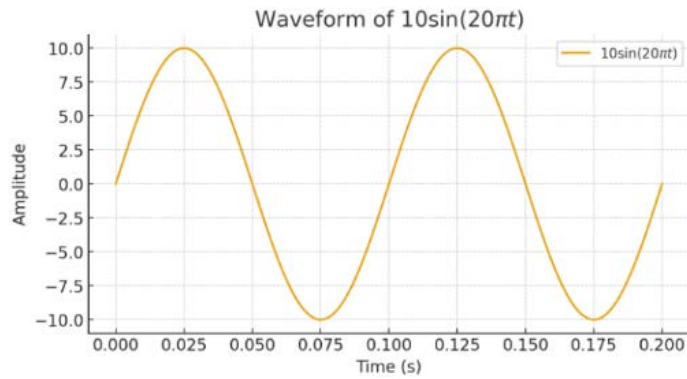
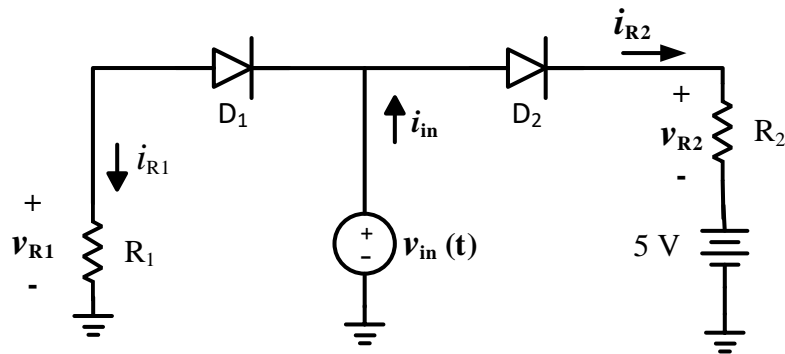
- Find the small-signal resistance of the diode.
- Find the expression for  $v_{out}(t)$ .

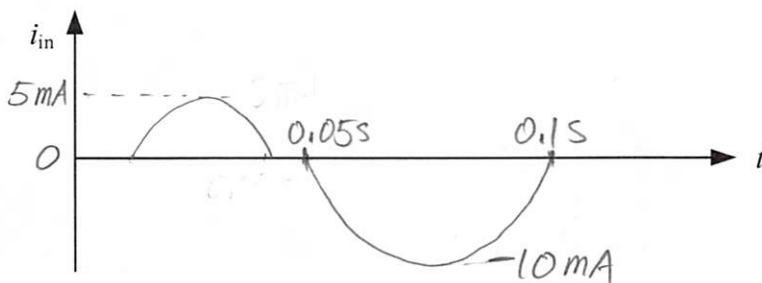
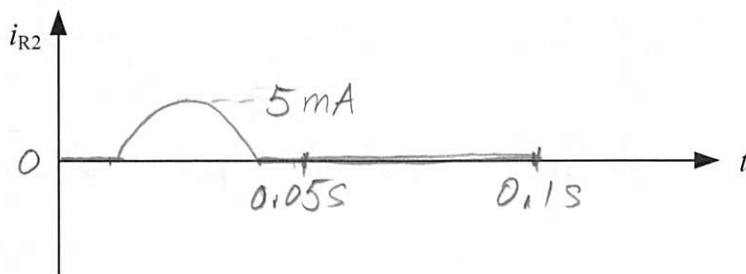
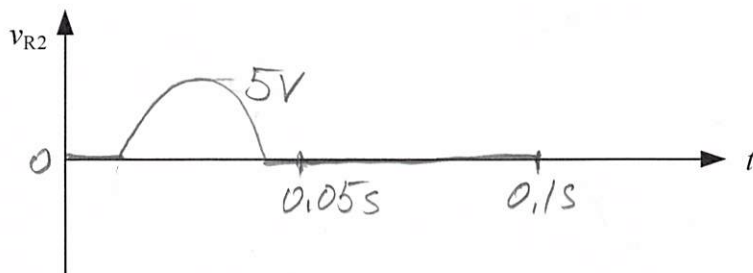
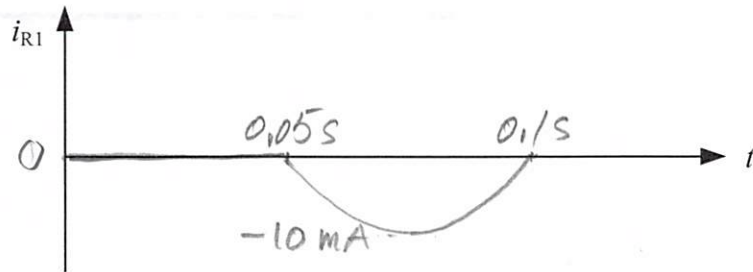
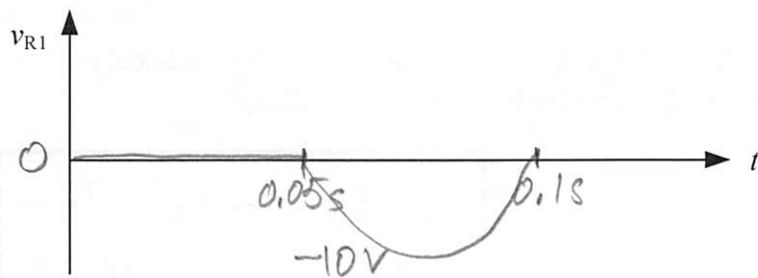
$$r_d = 622 \text{ Ohm}$$

$$v_{out}(t) = 166 \sin(\omega t) \text{ mV}$$

### Question 3 [7 marks]

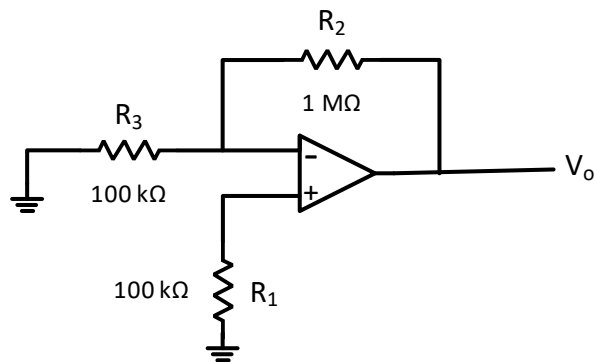
In the circuit shown below, the diodes are ideal and the input signal is  $v_{in}(t) = 10 \sin(20\pi t)$  V, and  $R_1 = R_2 = 1 \text{ k}\Omega$ . Sketch the waveforms of  $v_{R1}$ ,  $i_{R1}$ ,  $v_{R2}$ ,  $i_{R2}$  and  $i_{in}$  for one period ( $0 \leq t \leq 0.1 \text{ s}$ ) on the next page.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





#### Question 4 [8 marks]

The Op Amp in the circuit shown below has  $V_{OS} = 4 \text{ mV}$ ,  $I_{B1} = 105 \text{ nA}$  and  $I_{B2} = 95 \text{ nA}$ . 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.



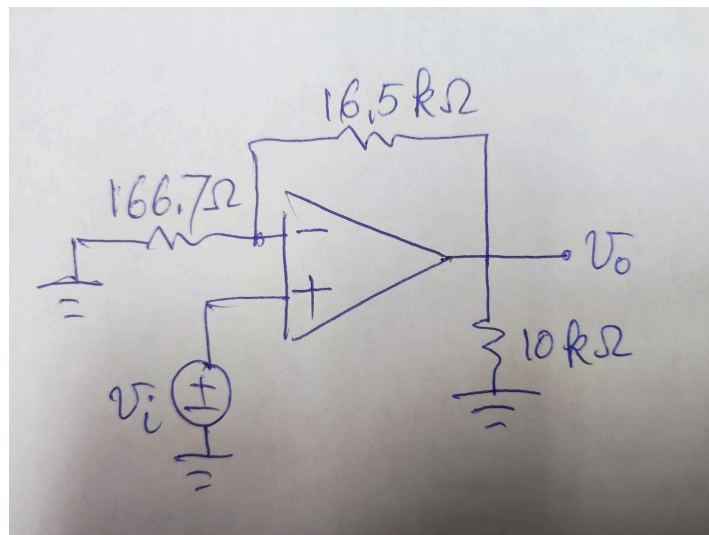
$$V_{o \text{ worst-case}} = 44.5 \text{ mV}$$

$$R_{1 \text{ new}} = 142.6 \text{ k}\Omega$$

**Question 5 [7 marks]**

Design a noninverting amplifier with a gain of 100 that can deliver a 10 V signal to a 10 k $\Omega$  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.

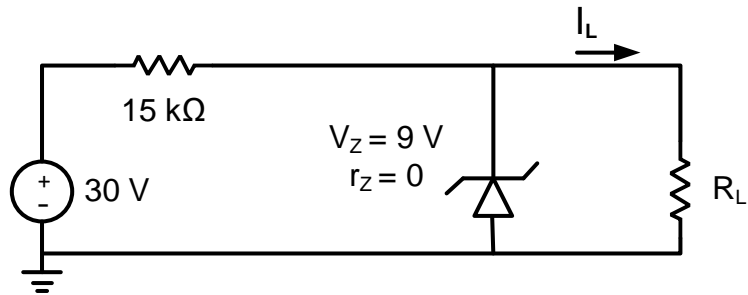
Draw your circuit here



**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?



$$I_L \text{ maximum} = 1.4 \text{ mA}$$

$$R_L \text{ minimum} = 6.43 \text{ k}\Omega$$