ID:	Sec:	Name:

Set: 01

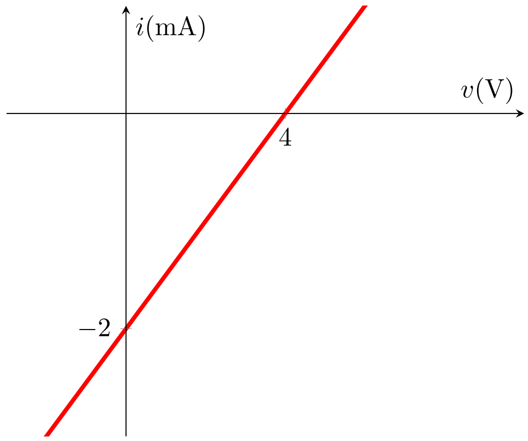
Brac University

Semester: Spring 2023
Course No: CSE251
Course Title: Electronic Devices and Circuits
Section: 1 to 13

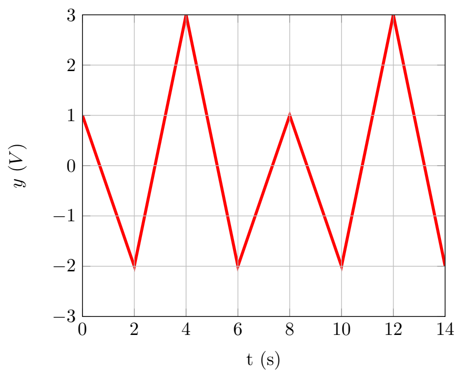
Final Exam
Full Marks: 30
Time: 1 hour 30 minutes
Date: March 1, 2023

Answer **any 3 questions**. All the questions carry equal marks.

Question 1 [CO1, CO2] **10**



(a) IV Characteristics of the PCB model



(b) Input of the FW rectifier

Part 1: Afia, an engineer at the INGNR company, is tasked to model a two terminal printed circuit board (PCB) with hundreds of linear circuit components. She plotted current I of the PCB as a function of the input voltage V. To her utter surprise, she found the simple IV graph shown in Figure 1(a), which she immediately recognized as the IV of a **(x)** source in series with a **(y)**.

(a) **What** is the equivalent model of the PCB, i.e., what is the name of (x) and (y)? [2]

(b) **Draw** the equivalent circuit of the model and find the model parameters, i.e., values of the (**x**) source and (**y**) [1]

(c) [**Bonus**] It's quite amazing that a circuit with hundreds of elements can be modeled using only two elements (**x**) and (**y**). What is the name of the theorem that supports this?

Part 2: A voltage waveform $V_i = 15\sin(2000\pi t)$ V is fed into a Half-wave rectifier with a load resistance $R = 5$ kΩ. Silicon diodes are used in this circuit for which the forward drop is $V_{D_0} = 0.7$ V.

(a) **Illustrate** the input and output waveforms in separate graphs. Label the graph and **indicate** the voltage levels properly. [2]

(b) **Calculate** the DC/Average value of the output. [1]

(c) A capacitor is now added to reduce the fluctuation of the output voltage, which makes the peak to peak ripple voltage **4%** of the maximum output voltage V_P. **Deduce** is the value of the capacitor from the given data. [2]

(d) The input of a Full-wave rectifier is shown in Figure 1(b) above and output load resistance is $R = 10$ kΩ. Germanium diodes are used in this circuit for which the forward drop is $V_{D_0} = 0.3$ V. **Show** the input and output waveforms [1]

Question 2 [CO1] **10**

Sherlock Holmes got a new case where he found a piece of paper from the pocket of a victim with the circuit shown below. The side of the paper is missing and the only available information was that the D1 diode is on. Sherlock needs to know the values of V_A, V_0, I_{D1} and I_{D2} as it generates a pass code for Professor Moriarty's safe. Sherlock knows nothing about diodes and asked for your help to solve the case.

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Passcode

V_a	V_O	I_{D1}	I_{D2}

(a) **Show** the alternate circuit representation of the given circuit. **[1.5]**

(b) **Analyze** the circuit drawn in part-(a) to **calculate** the values of V_A, V_0, I_{D1} and I_{D2}. You must **validate** your assumption. Use the Constant-Voltage Drop model with a forward voltage drop, $V_{D0} = 0.5$ V. **[5+2]**

Question 3 [CO6] **10**

Part 1

Farhan is building a water level indicator for an overhead tank. For this, he has placed three sensors at three different levels of the tank. The voltage outputs of the three sensors are denoted as V_1 (lowest level), V_2 (mid level), and V_3 (highest level). Farhan decided that the indicator for the water level would be

$$V_{\text{indicator}} = \frac{1}{k}\left(V_1 + V_2 + V_3\right).$$

(a) Assuming $k = 1$, **design** the circuit using op-amps that will take V_1, V_2, and V_3 as *input* and will produce $V_{\text{indicator}}$ as *output*. [3]

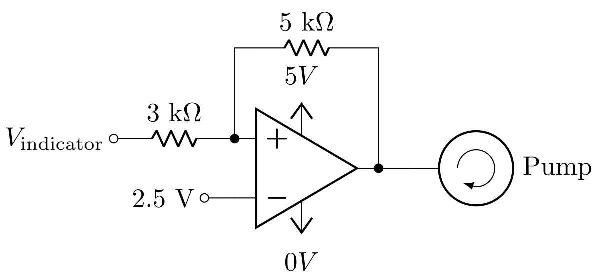
Upon further experimentation, Farhan realized that the maximum of V_1, V_2, and V_3 is 5V. Hence, the maximum value of the $V_1 + V_2 + V_3$ is 15V. However, Farhan only has access to +5 V and −5 V as power supplies, meaning the output cannot be greater than +5 V or less than −5 V.

(b) **Calculate** the value of k such that maximum value of $V_{\text{indicator}}$ is within the given range. [1]

(c) **Design** the circuit in part (a) again using this new value of k. [2]

Part 2

Now Farhan wants to control a pump based on $V_{\text{indicator}}$. He observed that the voltage of $V_{\text{indicator}}$ increases when water level decreases, and vice-versa. He wants the pump to **turn on** when the water level is below a threshold, i.e., when $V_{\text{indicator}}$ **greater than** V_{TH}, and **turn off** when the water level is above a threshold, i.e., $V_{\text{indicator}}$ **less than** V_{TL}. Based on this, he built the following two-threshold comparator (Schmitt Trigger).



(d) **Calculate** the thresholds V_{TH} and V_{TL} and show the voltage transfer characteristic . [2 + 2]

Question 4 [CO1, CO5] **10**

(a) **Analyze** the Ckt - 2 to find i_C and v_{O_1} using the Method of Assumed State. **Validate** your assumptions. [5]

(b) **Analyze** the Ckt - 3 to find i_D and v_{O_2} using the Method of Assumed State. Here, the input of the MOSFET is the output of Ckt - 2 from part (a), *i.e.*, v_{O_1}. You must **validate** your assumptions. [5]

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Question 5 [CO6] **10**

Consider a BJT Common Emitter amplifier with $\beta = 150, R_I = 100$ kΩ, $R_L = 5$ kΩ and $V_S = 12$ V. The input has a DC bias of 1 V with a small sinusoidal signal of 0.2 V amplitude, *i.e.*, $v_{IN} = 1 + 0.2 \sin(\omega t)$

(a) **Determine** the valid input range for which the BJT of the amplifier will remain in the active mode. [3]

(b) **Calculate** the small signal gain k of the amplifier. [1]

(c) **Calculate** the DC operating point $(V_X,\ V_Y)$ of the amplifier. [2]

(d) **Determine** the operating bias point $(V_X,\ V_Y)$ to get the maximum input swing. [2]

(e) **Discuss** two main differences between BJT and MOSFET. [2]