# Analog Electronics

## FOR EC/EE ESE & GATE

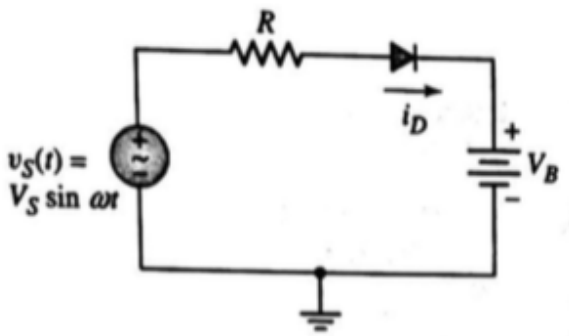
## WORK BOOK PART 2

Q1

**Objective:** Determine the currents and voltages in a half-wave rectifier circuit.

Consider the circuit shown in Figure  Assume $V_B = 12$ V, $R = 100\ \Omega$, and $V_\gamma = 0.6$ V. Also assume $v_S(t) = 24 \sin \omega t$. Determine the peak diode current, maximum reverse-bias diode voltage, and the fraction of the cycle over which the diode is conducting.

Ans 32.4%.




Q2

Repeat above Q if the peak sinusoidal voltage is $V_S = 30$ V and the resistor is $R = 200\ \Omega$. All other parameters are the same.

Ans 36.2%.

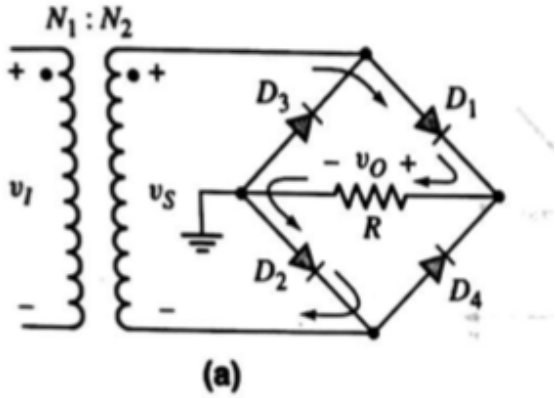
Q3

Consider the bridge circuit shown in Figure  with an input voltage $v_S = V_M \sin \omega t$. Assume a diode cut-in voltage of $V_\gamma = 0.7$ V. Determine the fraction (percent) of time that the diode $D_1$ is conducting for peak sinusoidal voltages of (a) $V_M = 12$ V and (b) $V_M = 4$ V.

Ans

(a) 46.3%

(b) 38.3%




(a)

Q4

**Objective:** Determine the capacitance required to yield a particular ripple voltage.

Consider a full-wave rectifier circuit with a 60 Hz input signal and a peak output voltage of $V_M = 10$ V. Assume the output load resistance is $R = 10$ kΩ and the ripple voltage is to be limited to $V_r = 0.2$ V.

Ans 41.7μF

Q5

Assume the input signal to a full-wave rectifier has a peak value of $V_M = 24$ V and is at a frequency of 60 Hz. Assume the output load resistance is $R = 1$ kΩ and the ripple voltage is to be limited to $V_r = 0.4$ V. Determine the capacitance required to yield this specification.

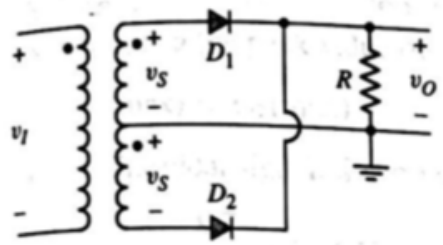
Ans 500μF

**Q6** The circuit in Figure (a) is used to rectify a sinusoidal input signal with a peak voltage of 120 V and a frequency of 60 Hz. A filter capacitor is connected in parallel with $R$. If the output voltage cannot drop below 100 V, determine the required value of the capacitance $C$. The transformer has a turns ratio of $N_1 : N_2 = 1 : 1$, where $N_2$ is the number of turns on each of the secondary windings. Assume the diode cut-in voltage is 0.7 V and the output resistance is 2.5 kΩ.

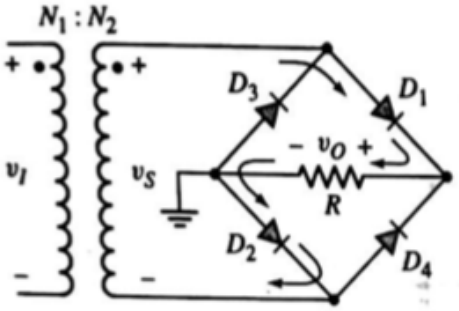
Ans C = 20.6uF

**Q7** The secondary transformer voltage of the rectifier circuit shown in Figure (b) is $v_S = 50 \sin[2\pi(60)t]$ V. Each diode has a cut-in voltage of $V_\gamma = 0.7$ V, and the load resistance is $R = 10$ kΩ. Determine the value of the filter capacitor that must be connected in parallel with $R$ such that the ripple voltage is no greater than $V_r = 2$ V

Ans 20.34F



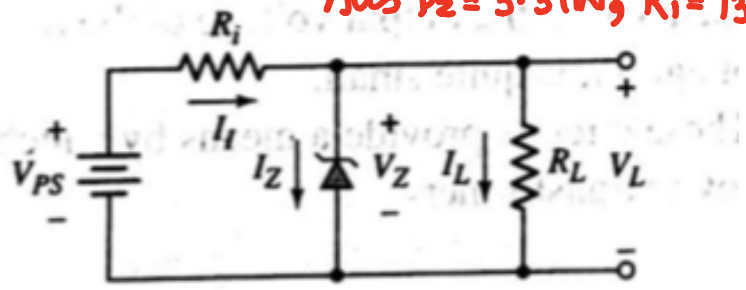

(a)




(b)

**Q8** The Zener diode regulator circuit shown in Figure 2.18 has an input voltage that varies between 10 and 14 V, and a load resistance that varies between $R_L = 20$ and 100 Ω. Assume a 5.6 Zener diode is used, and assume $I_Z(\text{min}) = 0.1 I_Z(\text{max})$. Find the value of $R_i$ required and the minimum power rating of the diode.

Ans $P_Z = 3.31W$, $R_i = 13\Omega$




**Q9**

**Objective:** Determine the source regulation and load regulation of a voltage regulator circuit. Consider the circuit described in above Q8 and assume a Zener resistance of $r_z = 2\ \Omega$.

$$\text{Source Reg} = \frac{\Delta V_L}{\Delta V_{source}} \times 100\%$$

Ans 11.6% - SourceReg

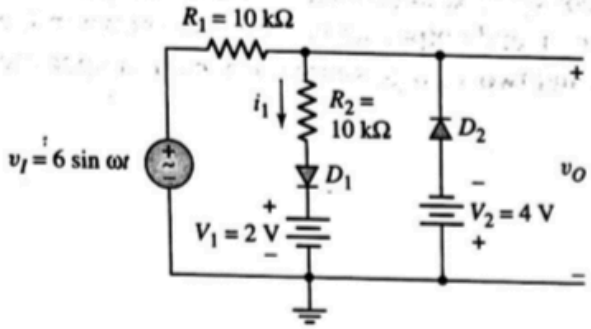
1.89 - loadReg

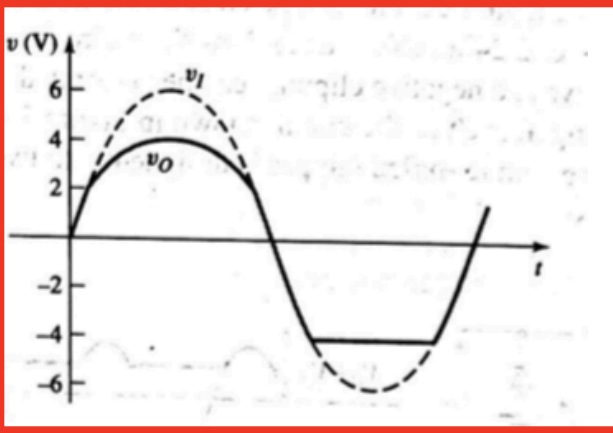
$$\text{load Reg} = \frac{V_{NL} - V_{FL}}{V_{FL}}$$

## Q10

**Objective:** Find the output of the parallel-based clipper in Figure
For simplicity, assume that $V_\gamma = 0$ and $r_f = 0$ for both diodes.

Ans

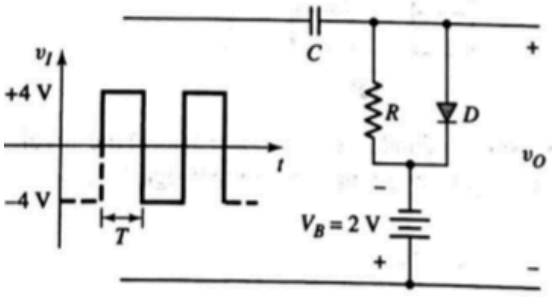



## Q11

Sketch the steady-state output voltage for the input signal given for the circuit in Figure
Assume $V_\gamma = r_f = 0$.

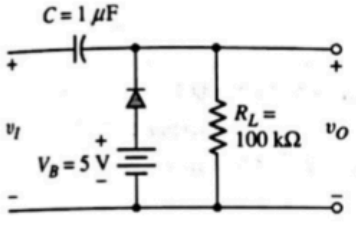
Ans square b/w -2 to 10



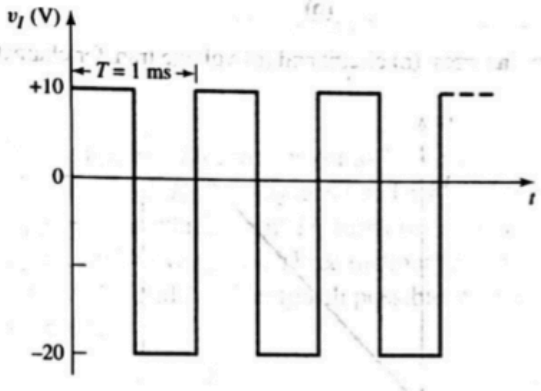

## Q12

Determine the steady-state output voltage $v_O$ for the circuit in Figure (a), if the input is as shown in Figure (b). Assume the diode cut-in voltage is $V_\gamma = 0$.

Ans square b/w +5 and +35




(a)

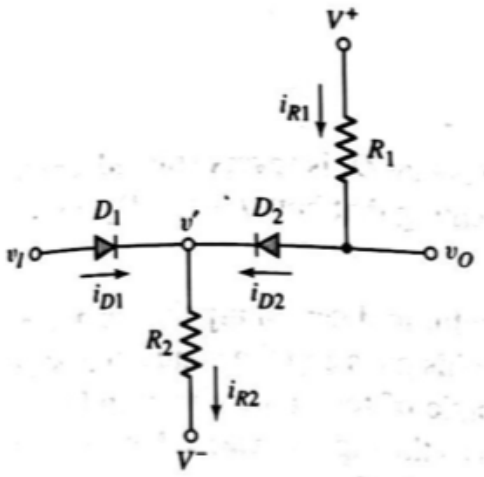



(b)

# Q13

**Objective:** Determine the output voltage and diode currents for the circuit shown in Figure , for two values of input voltage.

Assume the circuit parameters are $R_1 = 5\ \text{k}\Omega$, $R_2 = 10\ \text{k}\Omega$, $V_\gamma = 0.7\ \text{V}$, $V^+ = +5\ \text{V}$, and $V^- = -5\ \text{V}$. Determine $v_O$, $i_{D1}$, and $i_{D2}$ for $v_I = 0$ and $v_I = 4\ \text{V}$.

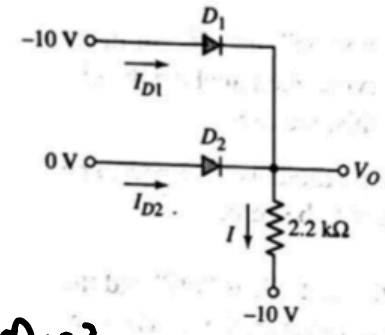



Ans $V_i = 0$ $i_{D1} = 0$, $i_{D2} = 0.62\text{mA}$, $V_O = 1.9\text{V}$

$V_i = 4$ $i_{D1} = 0.63\text{mA}$ $i_{D2} = 0.2\text{mA}$ $V_O = V_i$

# Q14

Determine $V_O$, $I_{D1}$, $I_{D2}$, and $I$ in the circuit shown in Figure . Assume $V_\gamma = 0.6\ \text{V}$ for each diode.



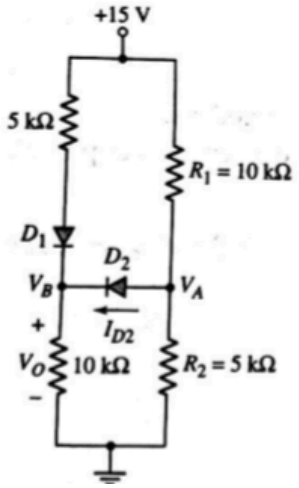

Ans $V_O = -0.6\text{V}$

$I_{D1} = 0$

$I_{D2} = I = 4.27\text{mA}$

# Q15

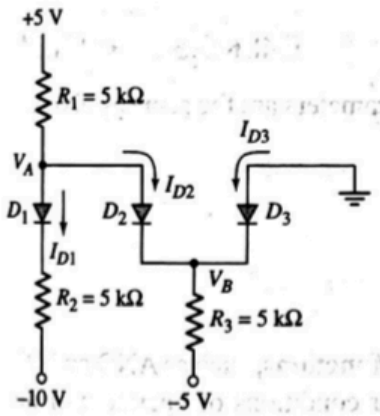
**Objective:** Determine the current $I_{D2}$ and the voltage $V_O$ in the multidiode circuit shown in Figure . Assume $V_\gamma = 0.7\ \text{V}$ for each diode.




Ans $I_{D2} = -7.86\text{mA}$

## Q16

**Objective:** Determine the current in each diode and the voltages $V_A$ and $V_B$ in the multidiode circuit shown in Figure  Let $V_\gamma = 0.7$ V for each diode.




Aus

$I_{D1} = 1.43$ $I_{D2} = 0$

$I_{D3} = 0.86$mA

## Q17

Consider the half-wave rectifier circuit in Figure . The input voltage is $v_I = 80\sin[2\pi(60)t]$ V and the transformer turns ratio is $N_1/N_2 = 6$. If $V_\gamma = 0$ and $r_f = 0$, determine (a) the peak diode current, (b) the value of PIV, (c) the average value of the output voltage, and (d) the fraction (per cent) of a cycle that $v_O > 0$.

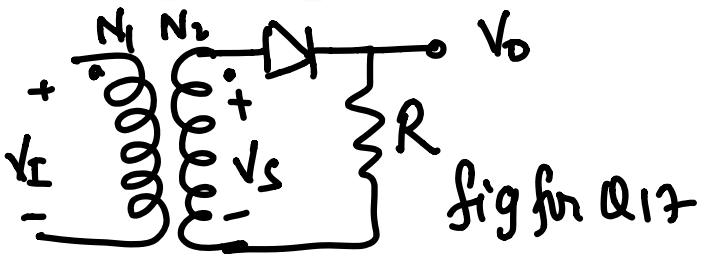



fig for Q17

Aus a) $i_{dmax} = 13.3/R$

b) PIV = 13.3 V

c) $V_{O(avg)} = 4.24$ V

d) 50%

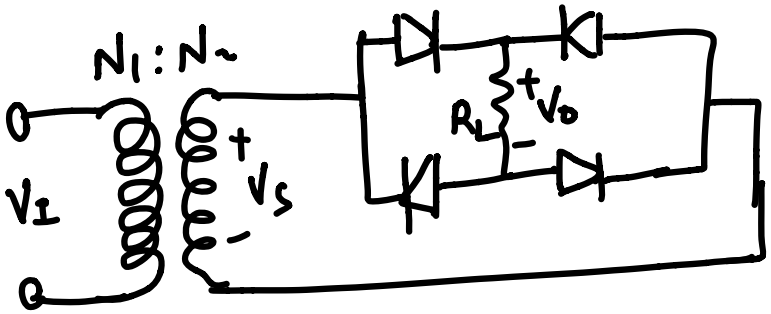
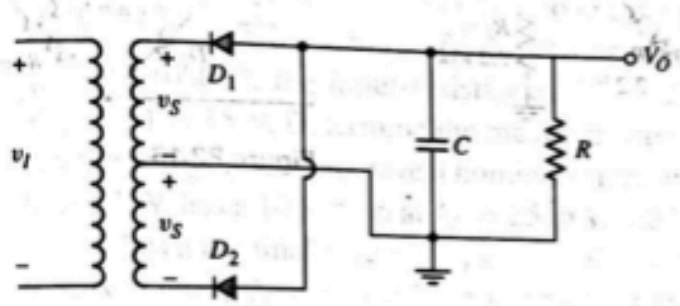



figure for Q18

Q18 The output resistance of the full-wave rectifier in Figure in the text is $R = 150\,\Omega$. A filter capacitor is connected in parallel with $R$. Assume $V_\gamma = 0.7$ V. The peak output voltage is to be 12 V and the ripple voltage is to be no more than 0.3 V. The input frequency is 60 Hz. (a) Determine the required rms value of $v_S$. (b) Determine the required filter capacitance value. (c) Determine the peak current through each diode.

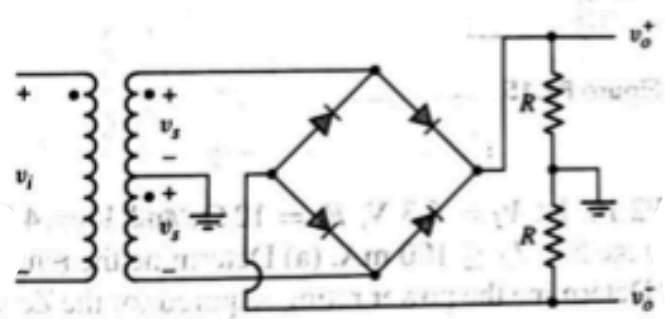
Ans (a) 9.48V (b) 22224F (c) 2.33A

Q19 The full-wave rectifier circuit shown in Figure has an input signal whose frequency is 60 Hz. The rms value of $v_S = 8.5$ V. Assume each diode cut-in voltage is $V_\gamma = 0.7$ V. (a) What is the maximum value of $V_O$? (b) If $R = 10\,\Omega$, determine the value of $C$ such that the ripple voltage is no larger than 0.25 V. (c) What must be the PIV rating of each diode?



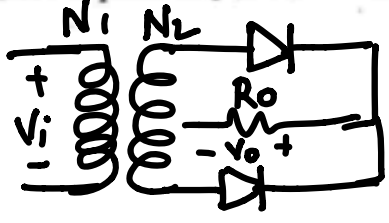

Ans (a) 11.3V
(b) C = .03767F
(c) 23.3V

Q20 The circuit in Figure is a complementary output rectifier. If $v_s = 26 \sin[2\pi(60)t]$ V, sketch the output waveforms $v_o^+$ and $v_o^-$ versus time, assuming $V_\gamma = 0.6$ V for each diode.




Ans $V_o^+ = |V_i|$
$V_o^- = -|V_i|$

Q21 The full-wave rectifier in Figure is to deliver 0.1 A and 15 V (peak values) to a load. The ripple voltage is to be no larger than 0.4 V peak-to-peak. The input signal is 120 V (rms) at 60 Hz.

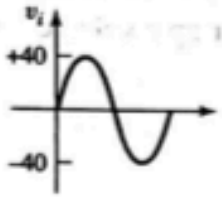


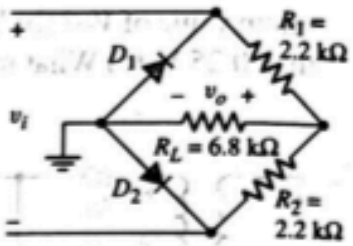
Assume diode cut-in voltages of 0.7 V. (a) Determine the required turns ratio, (b) the filter capacitance value, and (c) the diode PIV rating.

Ans (a) $N_1/N_2 = 10{\cdot}8$
(b) 20.34μF (c) 30.7V

Q22

Sketch $v_o$ versus time for the circuit in Figure The input is a sine wave given by $v_i = 10 \sin \omega t$ V. Assume $V_\gamma = 0$. (b) Determine the rms value of the output voltage.

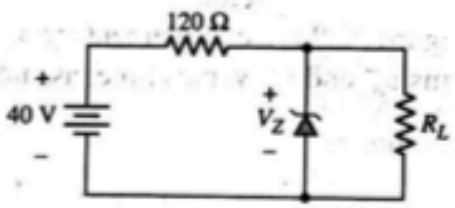



Ans 3.04V.

Q23

Consider the Zener diode circuit shown in Figure P2.15. Assume $V_Z = 12$ V and $r_z = 0$. (a) Calculate the Zener diode current and the power dissipated in the Zener diode for $R_L = \infty$. (b) What is the value of $R_L$ such that the current in the Zener diode is one-tenth of the current supplied by the 40 V source?




Ans
(a) 0.233A, 2.8Ω
(b) $R_L = 57.1\Omega$

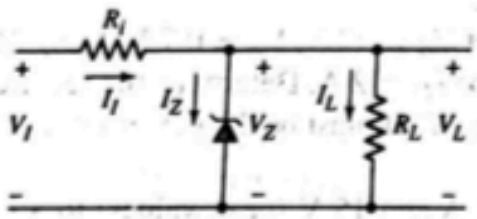



fig for Q24

Q24 In the voltage regulator circuit in Figure P2.16, $V_I = 20$ V, $V_Z = 10$ V, $R_i = 222\,\Omega$, and $P_Z(\max) = 400$ mW. (a) Determine $I_L$, $I_Z$, and $I_I$, if $R_L = 380\,\Omega$. (b) Determine the value of $R_L$ that will establish $P_Z(\max)$ in the diode.

Ans (a) $I_L = 26.3$ mA, $I_Z = 18.7$ mA, $I_I = 45$ mA
(b) $R_L = 2\,k\Omega$

Q25 A voltage regulator is to have a nominal output voltage of 10 V. The specified Zener diode has a rating of 1 W, has a 10 V drop at $I_Z = 25$ mA, and has a Zener resistance of $r_z = 5\,\Omega$. The input power supply has a nominal value of $V_{PS} = 20$ V and can vary by ±25 percent. The output load current is to vary between $I_L = 0$ and 20 mA. (a) If the minimum Zener current is to be $I_Z = 5$ mA, determine the required $R_i$. (b) Determine the maximum variation in output voltage. (c) Determine the percent regulation.

Ans 200Ω, 0.35 V, 3.5%

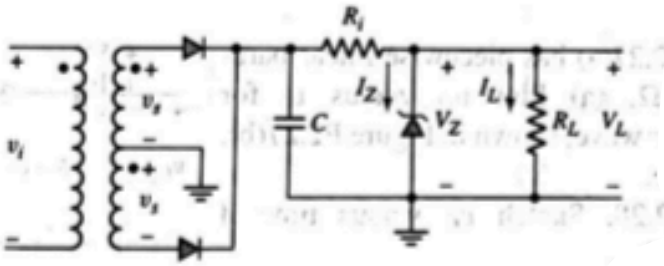



fig for Q26

Q26 The secondary voltage in the circuit in Figure is $v_s = 12 \sin \omega t$ V. The Zener diode has parameters $V_Z = 8$ V at $I_Z = 100$ mA and $r_z = 0.5\,\Omega$. Let $V_\gamma = 0$ and $R_i = 3\,\Omega$. Determine the percent regulation for load currents between $I_L = 0.2$ and 1 A. Find $C$ such that the ripple voltage is no larger than 0.8 V.

Ans 5%, $C = 0.0357$ F

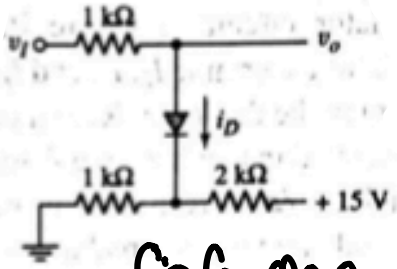



fig for Q27

Q27

For the circuit in Figure , plot $v_O$ versus $v_I$ for $0 \le v_I \le 15$ V. Assume $V_\gamma = 0.7$ V. Indicate all breakpoints. (b) Plot $i_D$ over the same range of input voltage.

Ans (a) $V_o = V_i$ for $V_i \le 5.7$

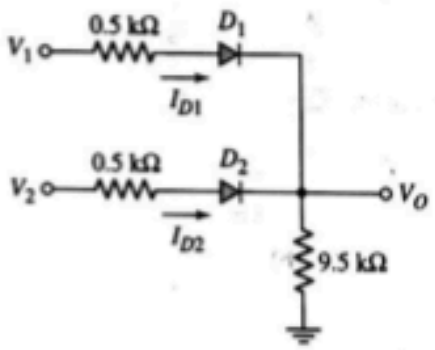
$V_o = \frac{V_i}{2.5} + 3.42$ $5.7 \le V_i \le 15$

(b) $i_D = 0$ for $V_i \le 5.7$

$i_D = \frac{0.6V_i - 3.42}{1}$ for $5.7 \le V_i \le 15$

Q28

The diodes in the circuit in Figure have piecewise linear parameters of $V_\gamma = 0.6$ V and $r_f = 0$. Determine the output voltage $V_O$ and the diode currents $I_{D1}$ and $I_{D2}$ for the following input conditions: (a) $V_1 = 10$ V, $V_2 = 0$; (b) $V_1 = 5$ V, $V_2 = 0$; (c) $V_1 = 10$ V, $V_2 = 5$ V; and (d) $V_1 = V_2 = 10$ V.




Aus

(a) $I_{D1} = 0.94$ $I_{D2} = 0$

$V_O = 8.93$

(b) $I_{D1} = 0.44$mA, $I_{D2} = 0$

$V_O = 4.18$

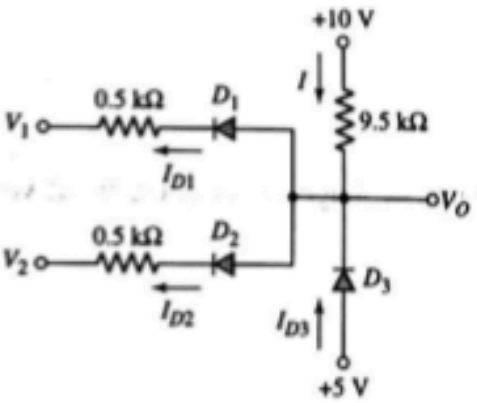
(c) Same as (a)

(d) $I_{D1} = I_{D2} = 0.482$ mA

$V_O = 9.16$V

Q29

The diodes in the circuit in Figure have the same piecewise linear parameters as described in Problem Q28. Determine the output voltage $V_O$ and the currents $I_{D1}$, $I_{D2}$, $I_{D3}$, and $I$ for the following input conditions: (a) $V_1 = V_2 = 0$; (b) $V_1 = V_2 = 5$ V; (c) $V_1 = 5$ V, $V_2 = 0$; and (d) $V_1 = 5$ V, $V_2 = 2$ V.

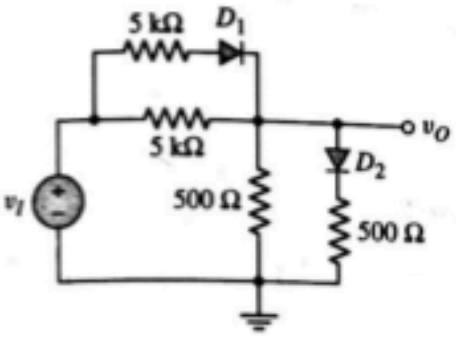



Aus

| | $I_{D1}$ | $I_{D2}$ | $I_{D3}$ |
|---|---|---|---|
| (a) | 7.6 mA | 7.6mA | 14.6mA |
| (b) | 0.2255 | 0.2255mA | 0 |
| (c) | 0 | 7.6mA | 7.01mA |
| (d) | 0 | 3.6mA | 3.01 mA |

Q30

(a) For the circuit in Figure each diode has $V_\gamma = 0.6$ V. Plot $v_O$ versus $v_I$ over the range $0 \le v_I \le 10$ V.



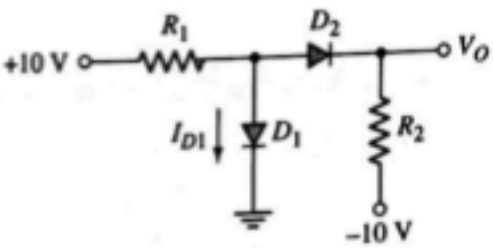

$V_O = 0.0909\, V_I \quad 0 \le V_i \le 0.66V$

$V_O = \frac{2V_I - 0.6}{12} \quad 0.66 \le V_i \le 3.9V$

$V_O = \frac{2V_I + 5.4}{22} \quad 3.9 \le V_i \le 10V.$

Q31

Let $V_\gamma = 0.7$ V for each diode in the circuit in Figure Find $I_{D1}$ and $V_O$ for $R_1 = 5\,k\Omega$ and $R_2 = 10\,k\Omega$. (b) Repeat part (a) for $R_1 = 10\,k\Omega$ and $R_2 = 5\,k\Omega$.



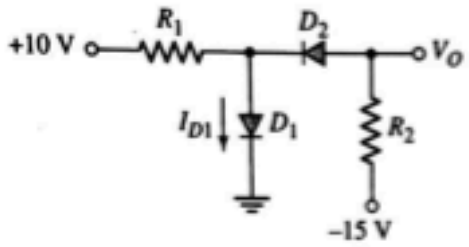

Ans

(a) $V_O = 0$ $I_{D1} = 0.86mA$

(b) $I_{D1} = 0$, $V_O = -3.57$ mA

## Q32

Assume each diode cut-in voltage is $V_\gamma = 0.7$ V for the circuit in Figure . Determine $I_{D1}$ and $V_O$ for (a) $R_1 = 10\,k\Omega$, $R_2 = 5\,k\Omega$ and (b) $R_1 = 5\,k\Omega$, $R_2 = 10\,k\Omega$.



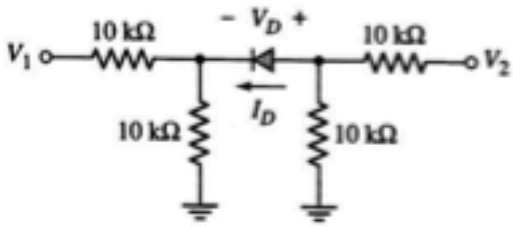

Ans

(a) $I_{D1} = 0.93$mA $V_O = -15$V

(b) $I_{D1} = 1.86$mA $V_O = -15$V

## Q33

Let $V_\gamma = 0.6$ V for the diode in the circuit in Figure . Determine $I_D$ and $V_D$ if: (a) $V_1 = 15$ V, $V_2 = 10$ V; and (b) $V_1 = 10$ V, $V_2 = 15$ V.



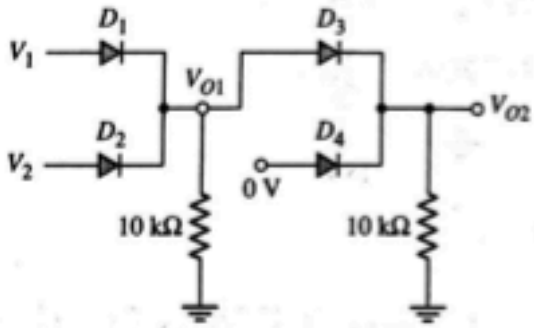

Ans

(a) $I_D = 0$, $V_D = -2.5$V

(b) $V_D = 0.6$V, $I_D = 0.19$mA

## Q34

Consider the circuit in Figure . The output of a diode OR logic gate is connected to the input of a second diode OR logic gate. Assume $V_\gamma = 0.6$ V for each diode. Determine the outputs $V_{O1}$ and $V_{O2}$ for: (a) $V_1 = V_2 = 0$; (b) $V_1 = 5$ V, $V_2 = 0$; and (c) $V_1 = V_2 = 5$ V. What can be said about the relative values of $V_{O1}$ and $V_{O2}$ in their "high" state?




Ans

(a) $V_{O1} = V_{O2} = 0$

(b) $V_{O1} = 4.4$V, $V_{O1} = 3.8$V

(c) $V_{O1} = 4.4$V, $V_{O2} = 3.8$V.