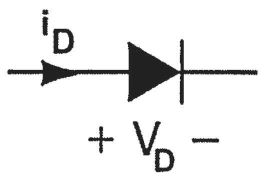
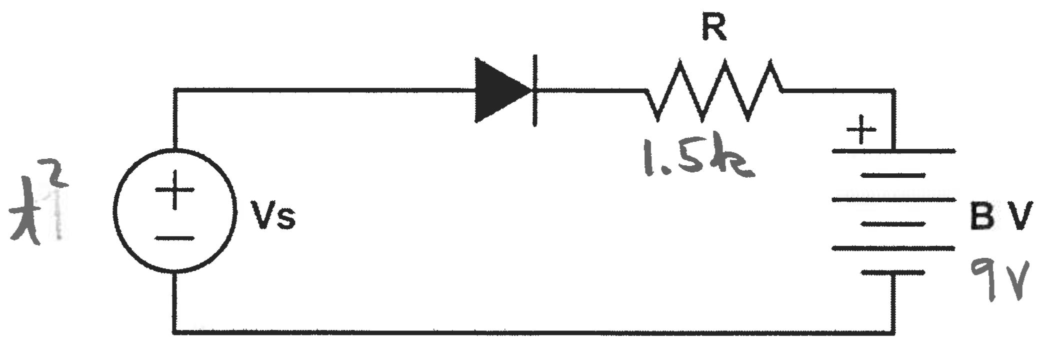
# Week 4 Quiz Solutions

1. Consider a standard diode shown below. Check all that statements that are true for diodes and diode circuits.




- [x] An ideal diode in forward bias can be thought of as a short circuit.
- [ ] The diode voltage, $V_D$, of an ideal diode in forward bias is a positive value larger than 0. For IDEAL, $V_D = 0$
- [x] Diodes are used in rectifier circuits, in voltage regulator circuits, in limiter circuits, and as light emitting diodes (LEDs).
- [ ] A diode cannot be used to block current flow in a specific direction. It can be and often is.
- [x] Diodes have three operation regions: one is forward bias, one is reverse bias, and one is reverse breakdown.

2. For the following circuit with an ideal diode, determine at what time the diode starts conducting (goes into the "ON" state). Assume that the resistor is R = 1500Ω, the battery has a constant voltage of B = 9V, and the varying source is $V_s = t^2$ volts, where $t > 0$. Enter the value of time (in seconds) without the units.

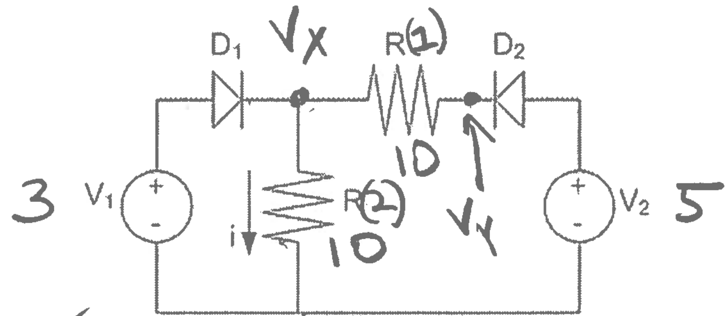



Diode conducts when $V_s > 9V$

$t^2 = 9 \Rightarrow t = \boxed{3s}$

Diode is ON for $t \geq 3s$

3. The following circuit has ideal diodes. The parameters are $V_1 = 3V$, $V_2 = 5V$, and R = 10Ω. If a diode is conducting, we say that it is "ON". If a diode is not conducting, we say that it is "OFF". Select which answer is correct.



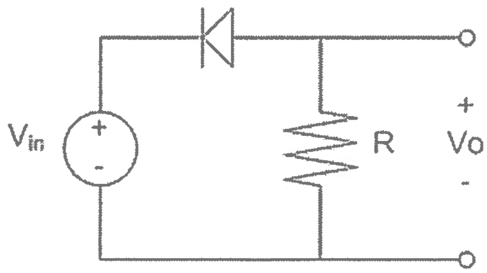

- Both diodes are ON
- Diode 1 is OFF and diode 2 is ON
- Diode 1 is ON and diode 2 is OFF
- Both diodes are OFF

Assume D1 ON. Then $V_x = 3V$. If $V_x = 3V$, then D2 is also ON because $(V_2 = 5) > 3$. Then $V_y = 5V$. The current through R(1) = $\frac{5-3}{10} = \frac{2}{10}$ A. The current through R(2) = $\frac{3}{10}$ A. So the current supplied by $V_1$ must be $\frac{1}{10}$ A. No contradictions.

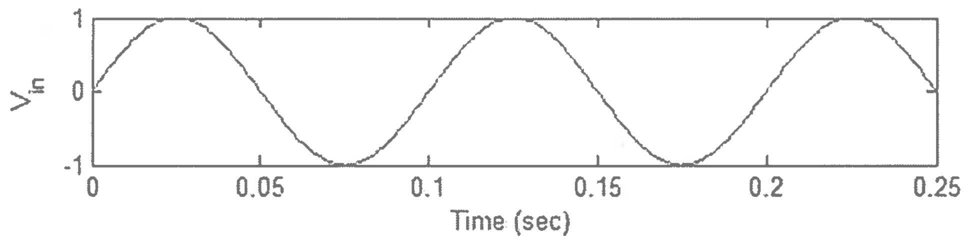
4. For the circuit in question 3, solve for the current i, in amps. Enter your answer in the box below without units.

$$i = \frac{V_x}{10} = \frac{3}{10} = 0.3A$$

5. Consider the following circuit, where the diode is ideal:



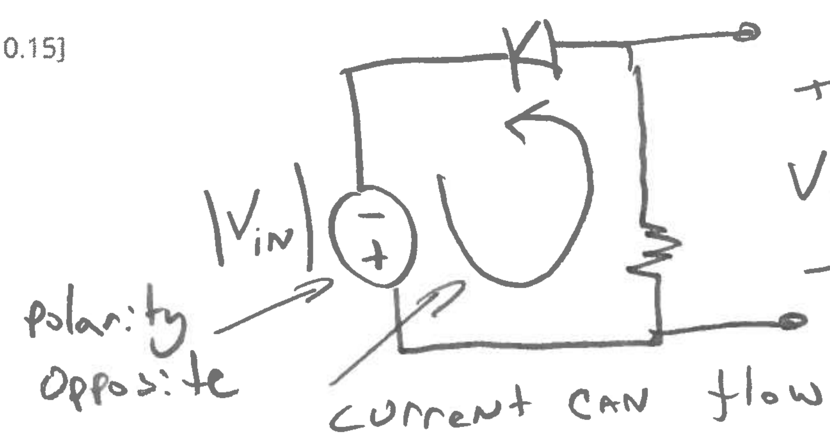

The input to the circuit is shown below. Determine the time periods for which the output waveform equals the input, that is, when $V_o = V_{in}$. Select all that apply.




- [x] t = [0.05, 0.1]
- [ ] t = [0.2, 0.25]
- [x] t = [0.15, 0.2]
- [ ] t = [0, 0.05]
- [ ] t = [0.1, 0.15]

The diode is forward biased when $V_{in} < 0$

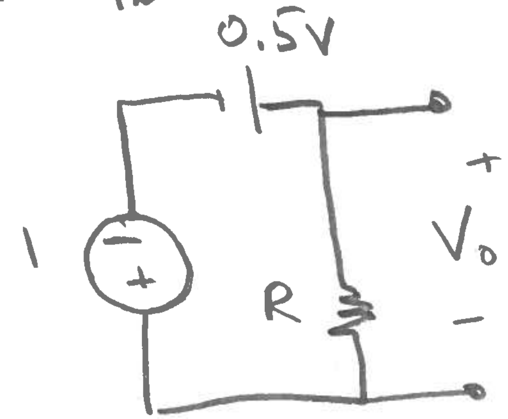
For $V_{in} < 0$, can redraw circuit as



6. With the same circuit and input as in question 5 except using the ideal diode plus voltage source model with $V_f$ = 0.5V, determine minimum voltage of $V_o$.

Diode ON when $V_{IN}$ more negative than $V_f$. The most negative value of $V_{IN}$ is $-1$ V.

For $V_{IN} = -1$ V have

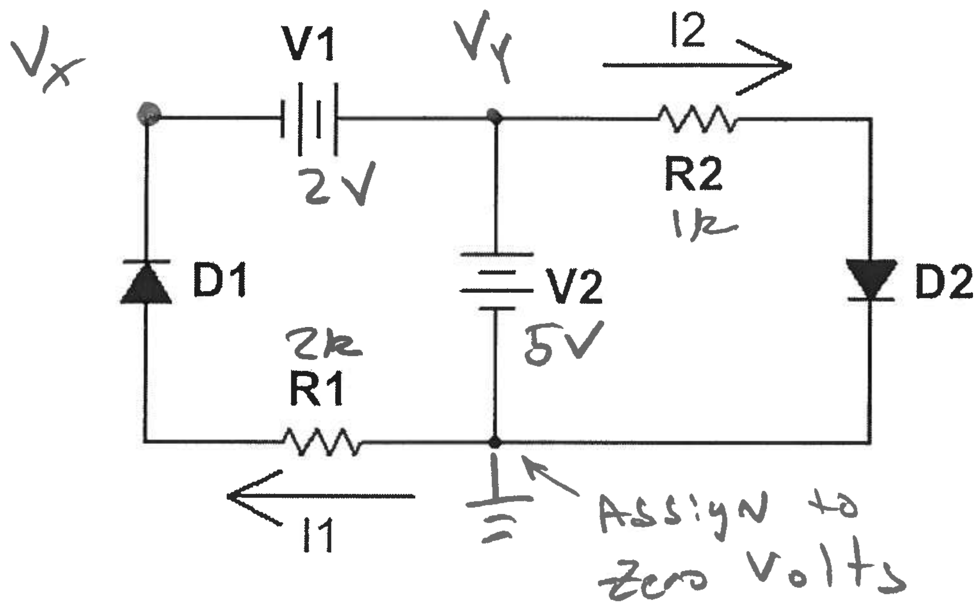



$1 + V_o - 0.5 = 0$ ← loop equation

$\Rightarrow V_o = 0.5 - 1 = -0.5$ V

7. In the circuit shown, the diodes are ideal.

For $V1 = 2V$, $V2 = 5V$, $R1 = 2k\Omega$, $R2 = 1k\Omega$, what is $I1$ in amps?




$V_Y = 5V$ $\quad V_x = V_Y - 2 = 3V$ so D1 is reverse biased or OFF. $\Rightarrow I_1 = 0A$

8. For the circuit and values of question 7, what is $I2$? Enter your answer in mA.

Because $V_Y = 5V$, D2 is ON.

$$I2 = \frac{V_Y - 0}{R_2} = \frac{5}{1k} = 5\,mA$$

9. For the circuit of question 7, $V2 = 5V$, $R1 = 2k\Omega$, $R2 = 1k\Omega$, and $I1 = 1mA$, what is $V1$ in volts?

$I_1 \neq 0 \Rightarrow$ D1 Now ON

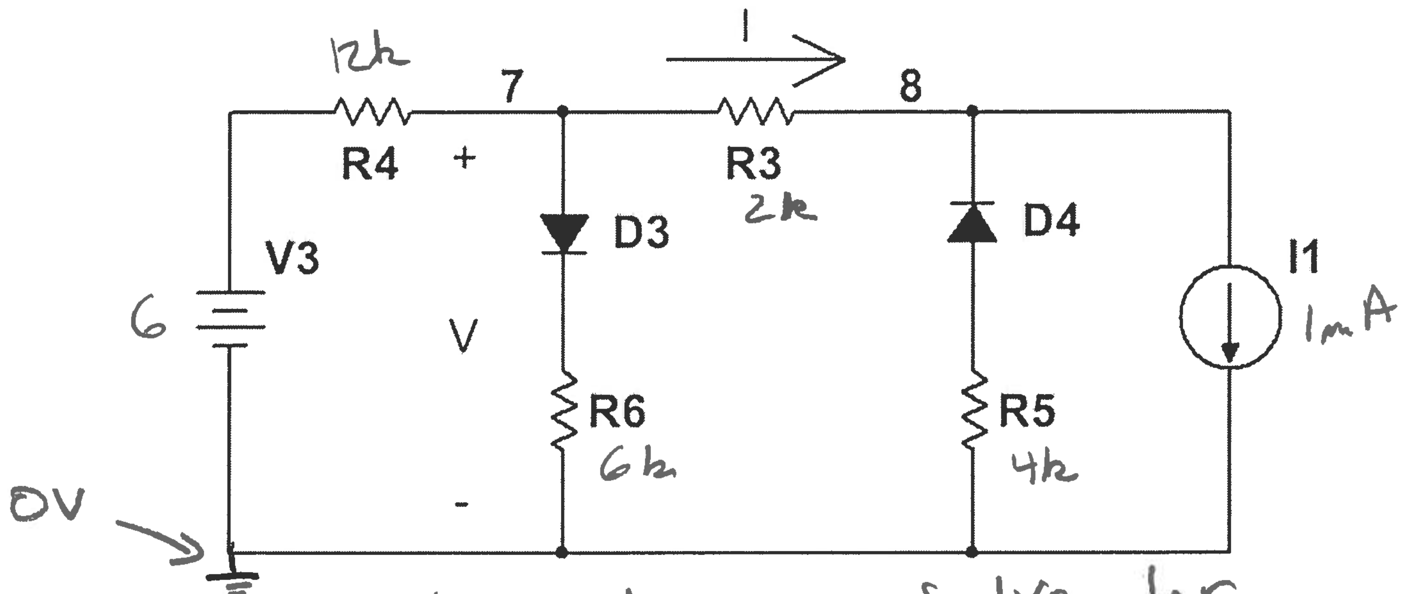
For D1 ON $V_x$ must be greater than the zero volts on the anode of D1.

$$0 - I_1 R_1 + V_1 = V_Y$$

$$0 - (1)(2) + V_1 = 5$$

$$V_1 = 7V$$

10. For the circuit shown, $V3 = 6V$, $I1 = 1mA$, $R3 = 2k\Omega$, $R4 = 12k\Omega$, $R5 = 4k\Omega$, and $R6 = 6k\Omega$. Solve for the current I in milliamps, assuming that the diodes are ideal.




Assume both diodes ON. Solve for voltages at Nodes 7 + 8 to check

By superposition

$$V7 = 6\,\frac{(4+2)\|6}{(4+2)\|6+12} - 1\,\frac{4}{4+(12\|6+2)}\,6\|12 = -0.4V$$

$$V8 = 6\,\frac{(4+2)\|6}{(4+2)\|6+12}\,\frac{4}{2+4} - 1\,\frac{4}{4+(12\|6+2)}\cdot(12\|6+2)$$

$$= -1.6V$$

$V7 < 0 \Rightarrow$ D3 OFF Not ON.

Now assume D3 OFF, D4 ON.

Node equation at 8

$$\frac{6 - V_8}{12+2} + \frac{0 - V_8}{4} - 1\text{mA} = 0$$

$$\frac{6}{14} - \frac{V_8}{14} - \frac{V_8}{4} = 1\text{mA}$$

$$-\frac{2V_8}{28} - \frac{7V_8}{28} = 1 - \frac{6}{14}$$

$$\frac{-9V_8}{28} = 1 - \frac{6}{14} \Rightarrow V_8 = {}^{-}1.778\text{V} \quad \left(\begin{array}{c}\text{So D4 is}\\ \text{ON}\end{array}\right)$$

$$I = \frac{6 - V_8}{12+2} = \frac{6 - {}^{-}1.778}{14} = \boxed{0.556\text{ mA}}$$

$$V_7 = 6 - IR_4 = 6 - (.556\text{m})(12\text{k}) = {}^{-}0.667\text{V}$$

$\Rightarrow$ (D3 is OFF)