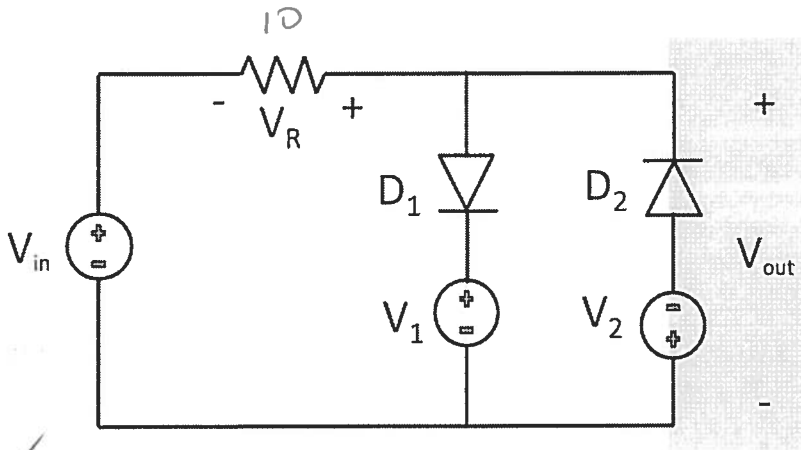
Week 5 Quiz Solutions

1. Consider a diode circuit shown below.

Assume that the diode can be modeled as an ideal diode in series with a voltage source, having $V_f = 0.7V$. The resistor has a value of $R1 = 10\Omega$. Check all statements that are true



- ☑ When Vin is in between the positive and negative limits of Vo, Vo=Vin
- ☒ When R1 is replaced with a resistor with higher resistance, the Voltage Transfer Characteristics (VTC) curve changes
- ☑ When any of the diodes are ON, the voltage across such diode is 0.7 V.
- ☑ If V1=2.3V and V2=2.3V, then Vo has a positive limit of 3 Volts and a negative limit of -3 Volts

D_1 ON for $V_{IN} > V_1 + V_f$

D_2 ON for $V_{IN} < (-V_2 - V_f)$

D_1 ON $\Rightarrow V_{out} = V_1 + V_f$

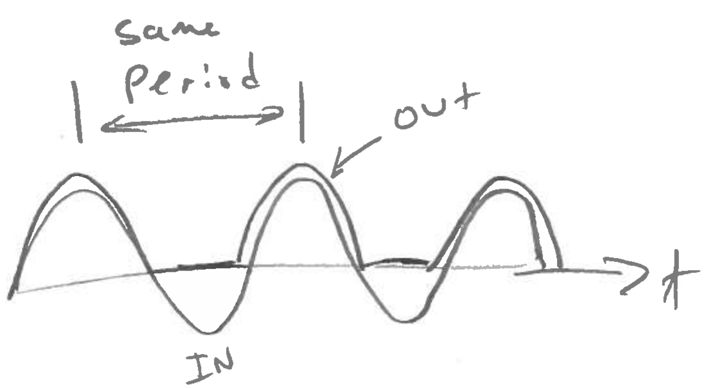
D2 ON $\Rightarrow V_{out} = -V_2 - V_f$

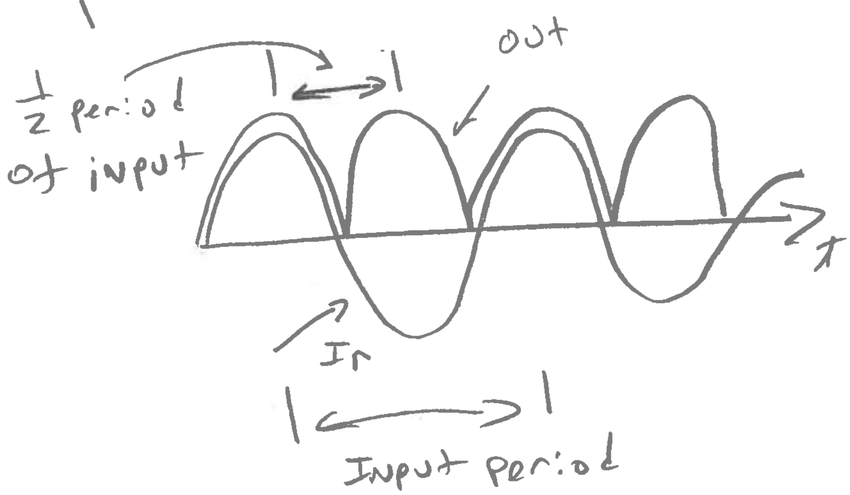
$D_1 + D_2$ OFF $\Rightarrow V_{out} = V_{IN}$

2. Which of the following are TRUE? Select all that apply.

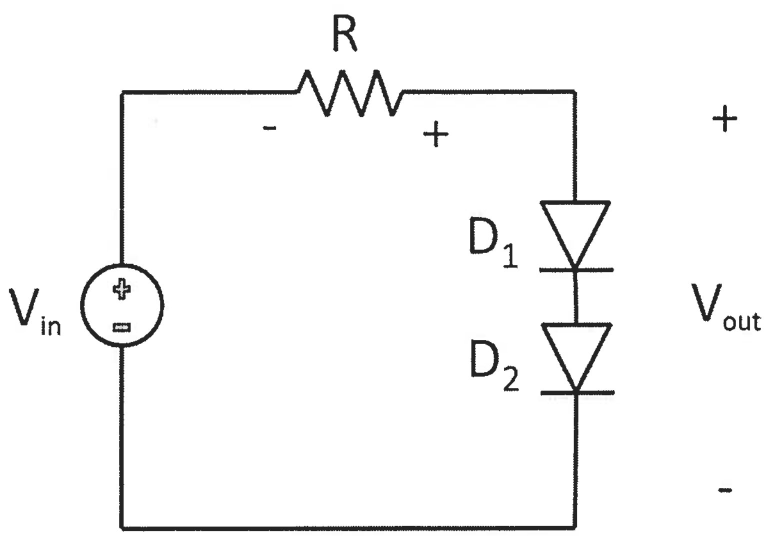
- [x] If the input to a rectifier is a sinusoid signal, the output of a half-wave rectifier will have the same frequency as the input.
- [x] ~~To have a smoother output voltage, one must use a~~ ~~smaller~~ larger filter capacitor.
- [x] If the input to a rectifier is a sinusoid signal, the output of a full-wave rectifier will have the same frequency as the input.
- [x] The order of stages in a DC power supply from input to output is a transformer, rectifier, then lastly a filter.
- [x] If diodes in rectifiers are non-ideal, the output voltage of a full-wave rectifier is smaller then that of a half-wave rectifier.

Have two diode drops for a full wave





3. A limiter is implemented using two non-ideal diodes, each modeled as an ideal diode in series with a voltage Vf volts. If the input voltage is a 5V amplitude sine wave, what is the minimum output voltage?



Non-Ideal Diodes

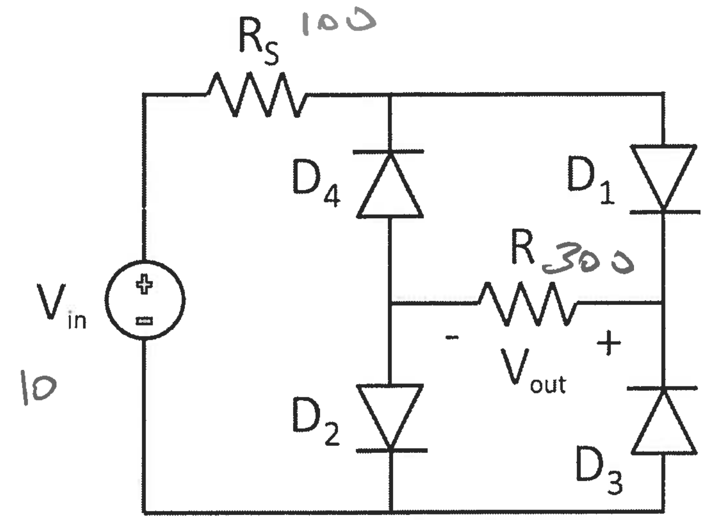
- ○ $-5 + 2V_f$
- ○ $2V_f$
- ○ V_f
- ● -5

Both diodes off for V_{IN} Negative. when both are off, $V_{out} = V_{IN}$

So, minimum V_{OUT} = minimum V_{IN} = -5

4. In the rectifier below, the resistance R_S of the voltage source has been included to see how it affects the output voltage. If $R = 300\Omega$, $R_S = 100\Omega$, and V_{in} is a sinusoidal voltage with amplitude 10V, what is the maximum output voltage V_{out} in volts?

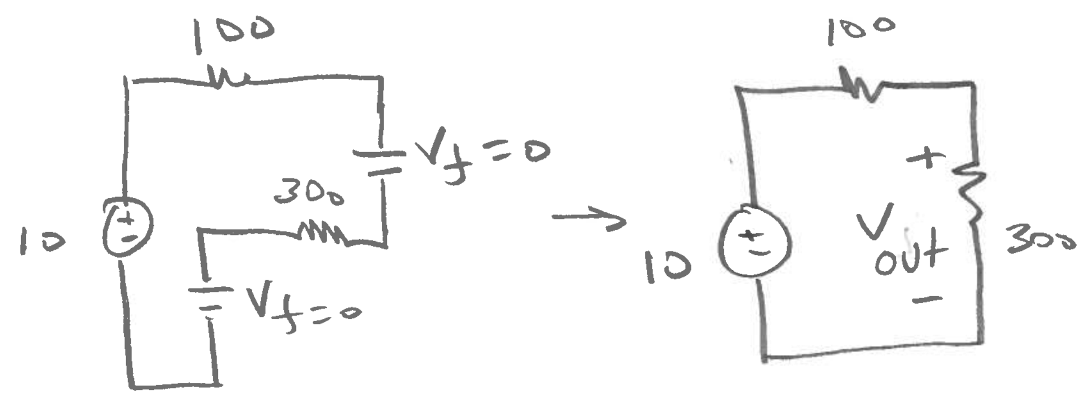
(It may help to redraw the circuit with diodes replaced by short and open circuits as appropriate)



Ideal Diodes

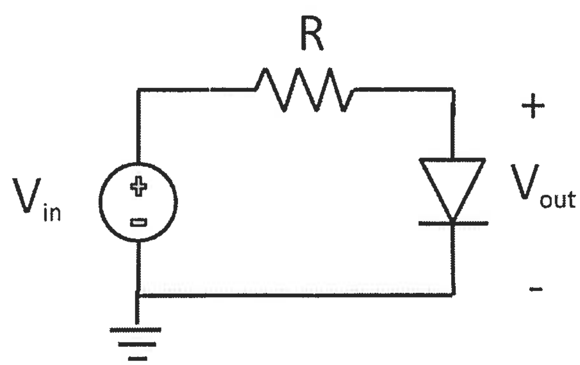
V_{out} max for $V_{IN} = 10V$ or $-10V$.

For $V_{IN} = 10V$, D_1 + D_2 ON. Ideal diodes.



$$V_{out} = 10 \frac{300}{300+100} = \boxed{7.5V}$$

5. For the circuit shown and the given input voltage, which of the following plots is the correct output voltage versus time? The diode in the circuit is modeled as an ideal diode in series with a voltage source $V_f = 0.65V$.

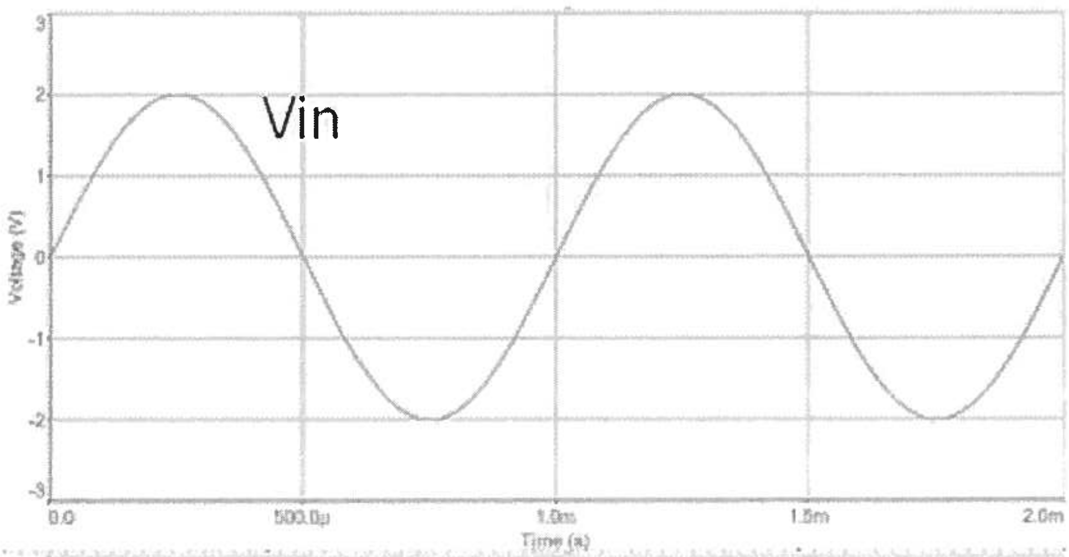


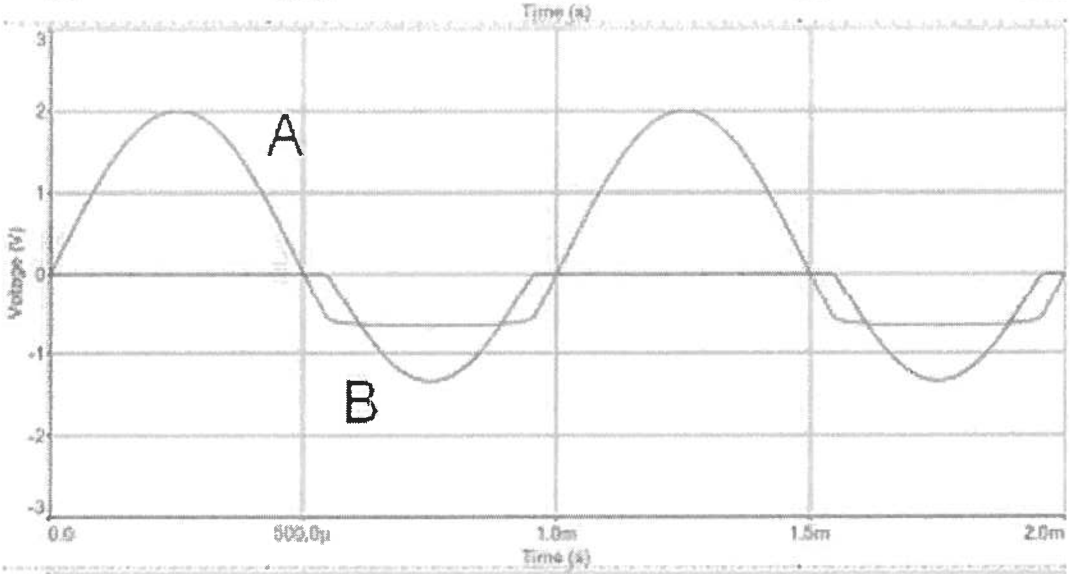
$V_{out} = V_{IN}$ for $V_{IN} < 0.65$

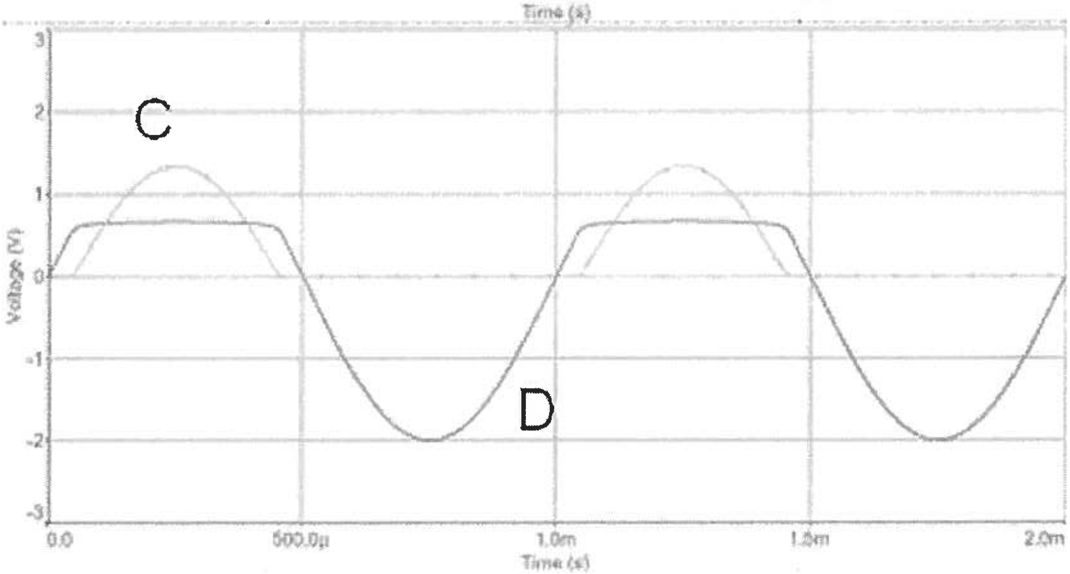
$V_{out} = 0.65$ for $V_{IN} \geq 0.65$

$\Rightarrow D$

- A
- B
- C
- D

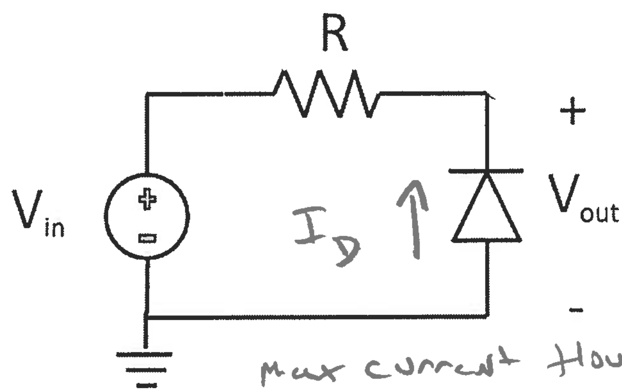

Vin
Voltage (V)
Time (s)
0.0
500.0µ
1.0m
1.5m
2.0m


A
B
Voltage (V)
Time (s)
0.0
500.0µ
1.0m
1.5m
2.0m


C
D
Voltage (V)
Time (s)
0.0
500.0µ
1.0m
1.5m
2.0m

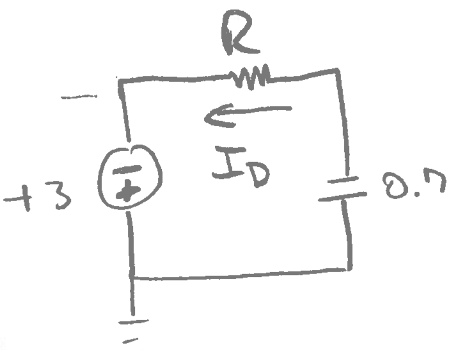
6. A diode circuit and sinusoidal input signal are shown. The diode is modeled as an ideal diode in series with a voltage source $V_f = 0.7V$.

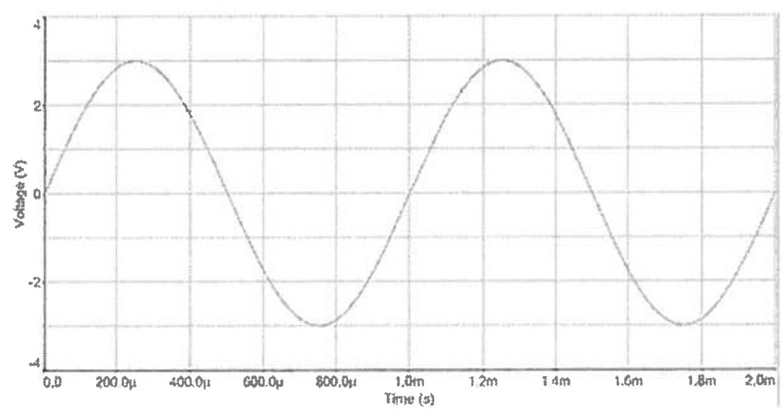
What value resistor should be used so that the maximum diode current is 10 mA? Give your answer in ohms to the nearest ohm.



$I_D > 0$ for $V_{IN} < -0.7V$

Max current flows for $V_{in} = -3$





$$I_D = \frac{-0.7 - -3}{R}$$

$$10 = \frac{2.3}{R}$$

$$\Rightarrow \boxed{R = 230\,\Omega}$$

7. For the circuit and input of problem 6,

If R = 510 Ω, what is the magnitude of the diode current at t = 400μs? Give your answer in milliamps.

$V_{in} = A \sin(2\pi f t)$

From plot $A = 3$ $f = \frac{1}{T} = \frac{1}{1ms} = 1kHz$

$V_{IN} = 3 \sin(2\pi 1000 t)$

$V_{in}\Big|_{t=400\mu} = 3 \sin(2\pi\, 1000\, 400 \times 10^{-6})$

$= 1.763$

This is greater than $-0.7V$ so diode OFF. $\Rightarrow I_D = 0$

(OR, from plot $V_{in} > -0.7V$)

8. For the circuit and input of problem 6,

If R = 510 Ω, what is the magnitude of the diode current at t = 700μs? Give your answer in milliamps.

$V_{iN} = 3\sin(2\pi 1000\ 700\times10^{-6})$

$= -2.853\ V \leftarrow$ diode ON

$-0.7 - {}^{-}2.853 = 2.15\ V$

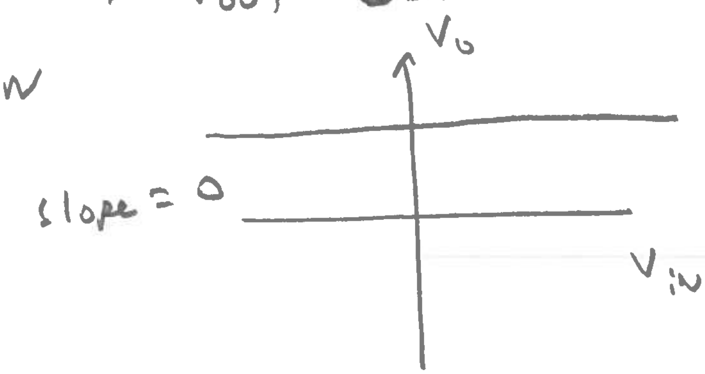
$\frac{2.15}{510} = 4.2\ mA$

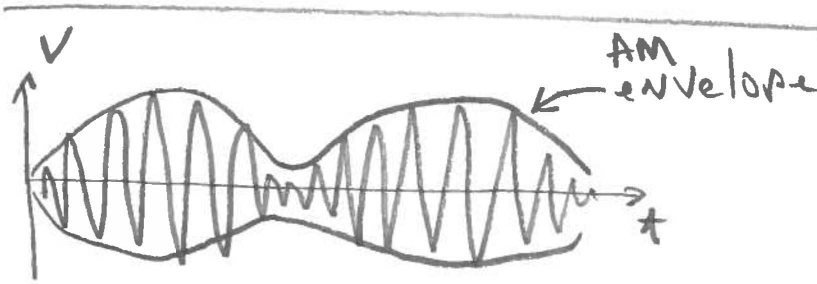
9. Select all of the statements that are **NOT** true.

- T — A diode envelope detector with a relatively large time constant can act as a peak detector. Large τ ⇒ C holds charge between peaks.
- F — The voltage transfer characteristic of an ideal voltage regulator is a line of slope 1.
- F — The envelope of an AM voltage waveform is a plot of the peak voltage of the carrier signal versus frequency.
- T — Loading of a source may be reduced by lowering the source resistance. If $R_s = 0$, load doesn't affect voltage source.
- F — A diode circuit with three regions of operation (three states) has three corners on its VTC plot. 3 states ⇒ 2 corners

---

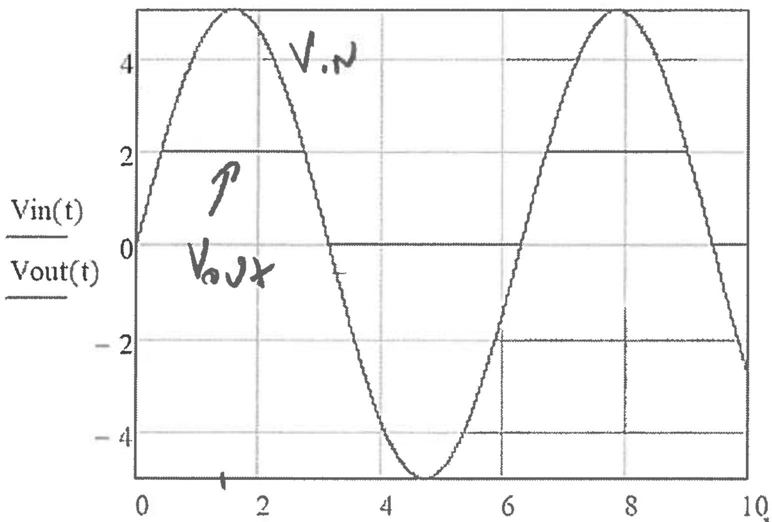
Ideal regulator ⇒ V_{out} constant for any V_{in}





---

10. For the input and output waveforms shown, which of these sets of (Vin, Vout) points contains only points that are on the VTC?



Vout never greater than 2

- (0.5,2) (3,3) (-2,0)
- (1.5,5) (0.5,0.5) (3,2)

when Vin = 0.5, Vout = 2

- (0,0) (5,2) (-0.5,0)
- (-2,-1) (0,0) (4,2)

Vin = -2 ⇒ Vout = 0