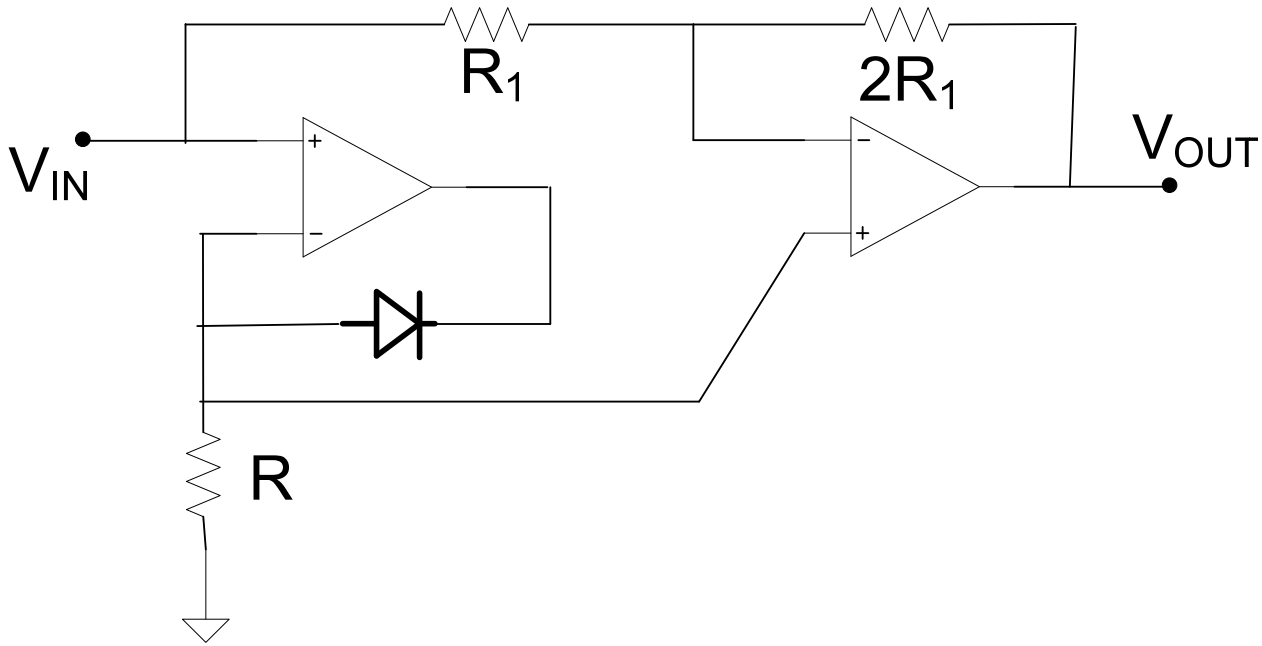
EE 230
Lecture 29

Nonlinear Circuits and Nonlinear Devices

- Diode
- BJT
- MOSFET

Quiz 19

Obtain the transfer characteristics of the following circuit and plot the output if V_{IN}= -5sinωt. Assume the diode is ideal.



And the number is ?

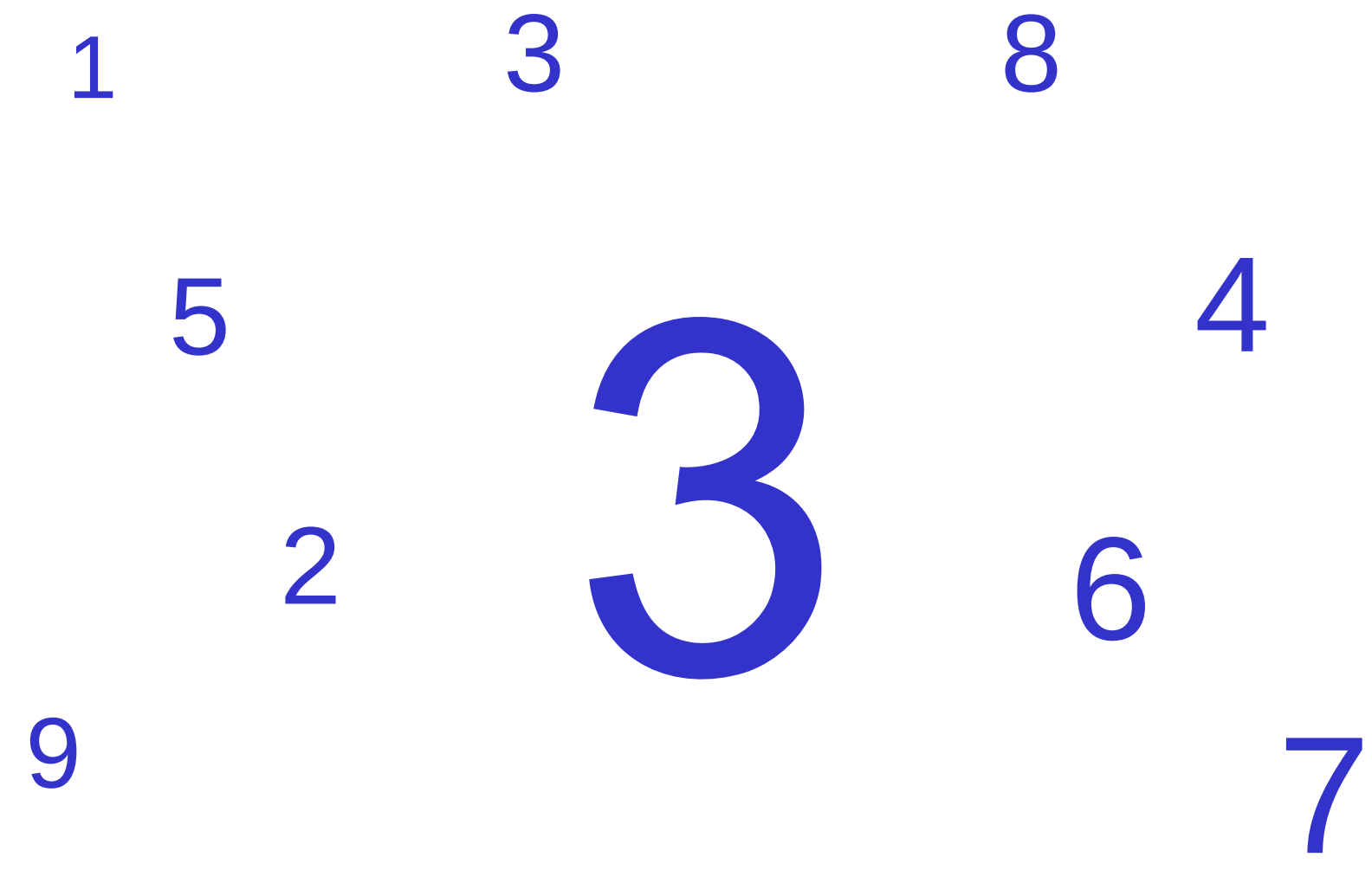
1 3 8

5 4

2 6

9 7

And the number is ?



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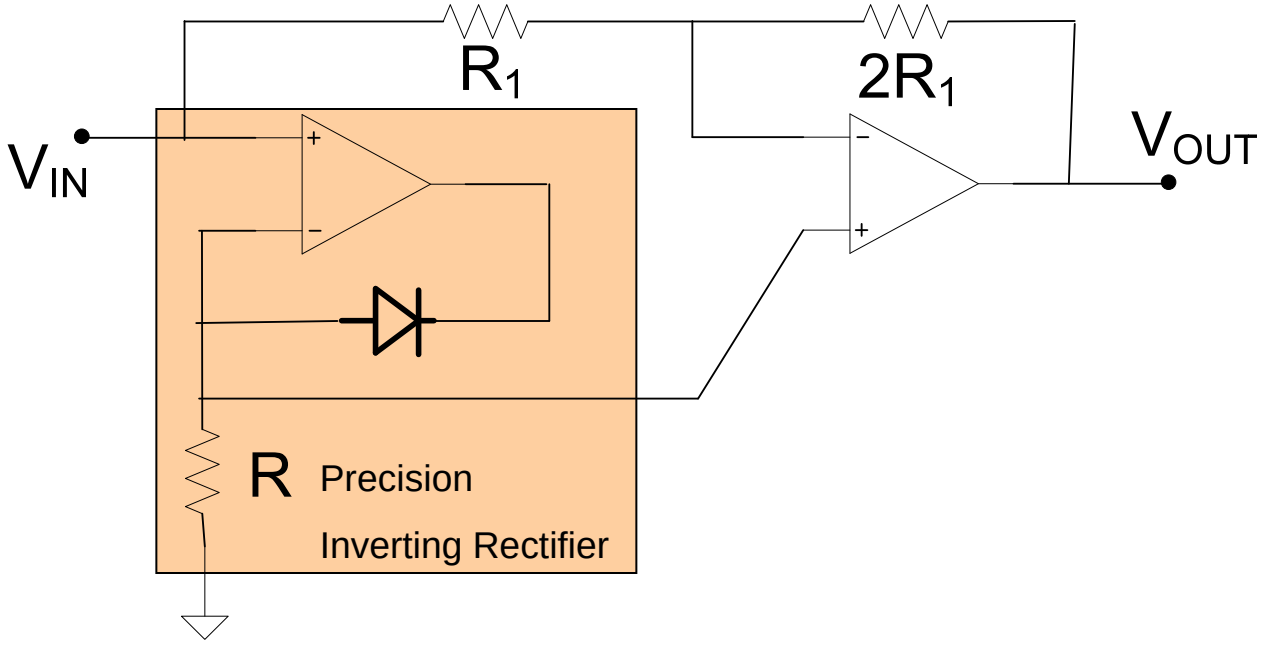
Obtain the transfer characteristics of the following circuit and plot the output if $V_{IN}=5\sin\omega t$. Assume the diode is ideal.



Solution:

Observe D_1 is ON for $V_{IN}<0$ and OFF for $V_{IN}>0$

$\therefore$ for $V_{IN}>0$, $V_{OUT}=-2V_{IN}$

for $V_{IN}\leq 0$, $V_{OUT}=(1+2)V_{IN}-2V_{IN}=V_{IN}$

Quiz 19

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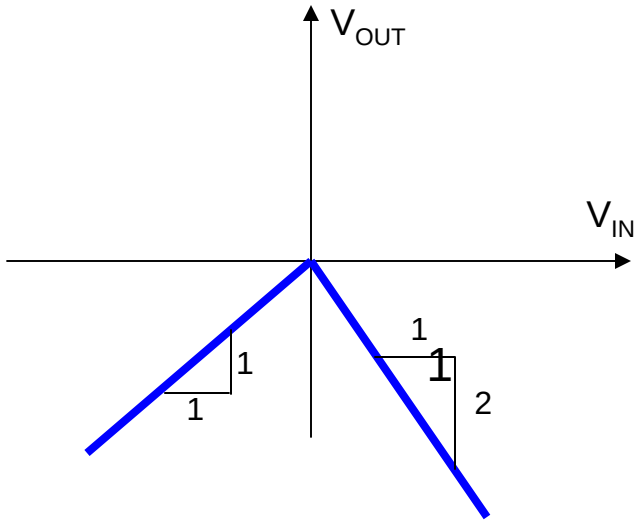
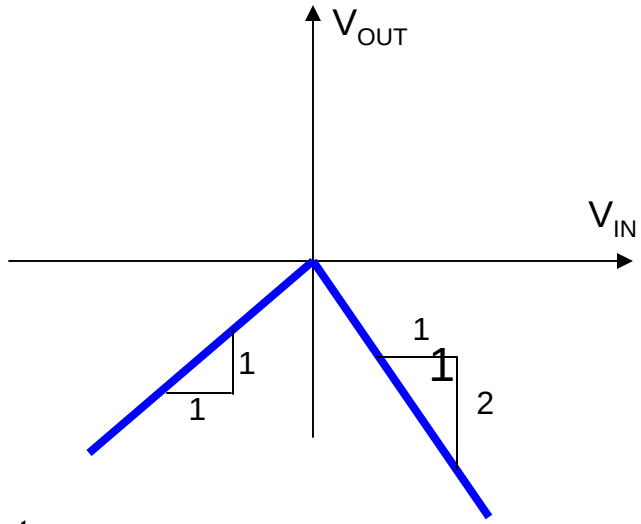
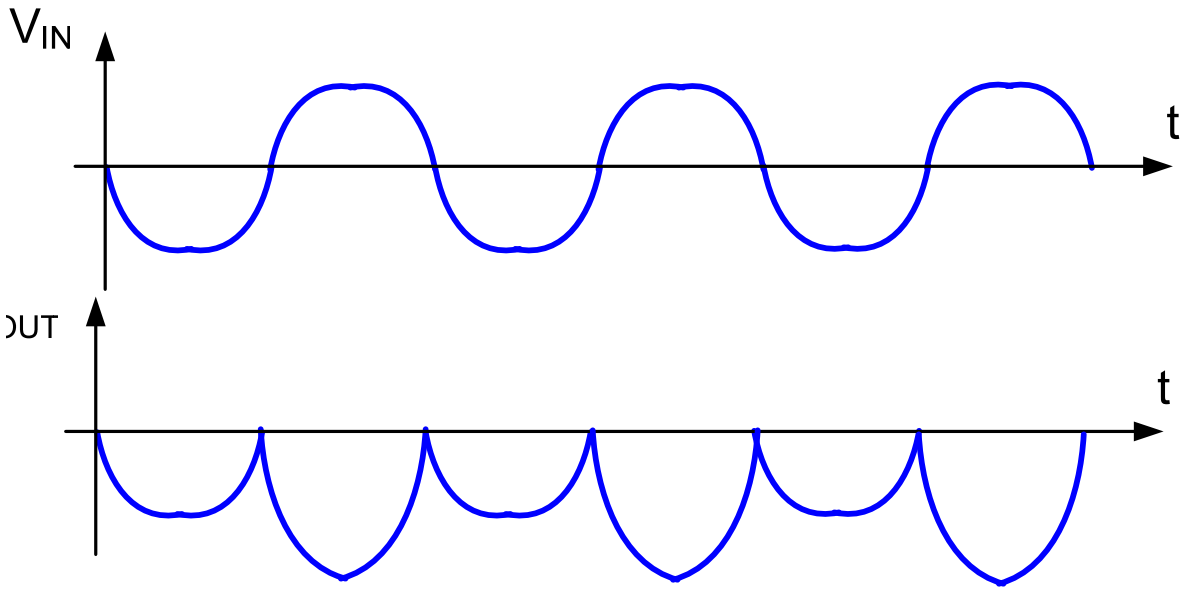


Quiz 19

Obtain the transfer characteristics of the following circuit and plot the output if V_{IN}= - 5sinωt. Assume the diode is ideal.

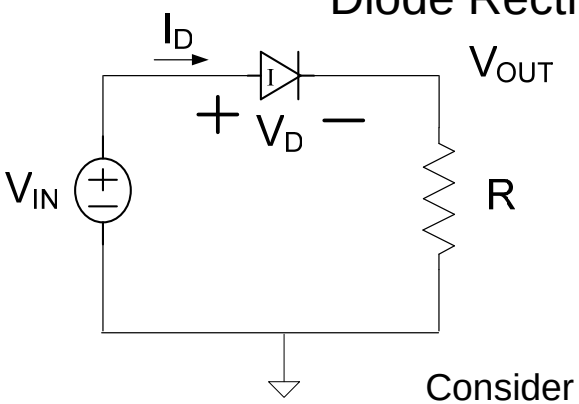
Solution:

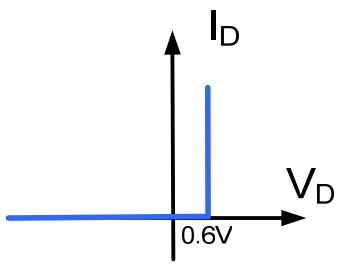




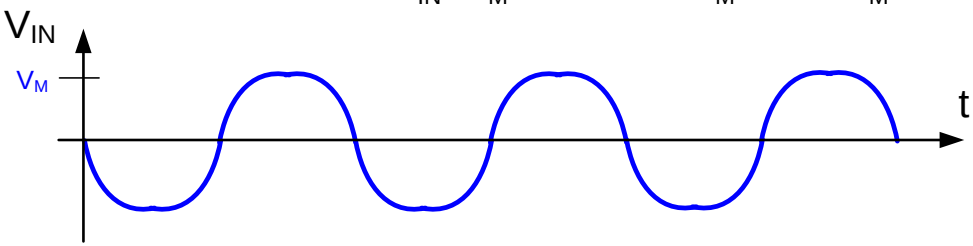
Review from Last Time:

Diode Rectifier Circuit

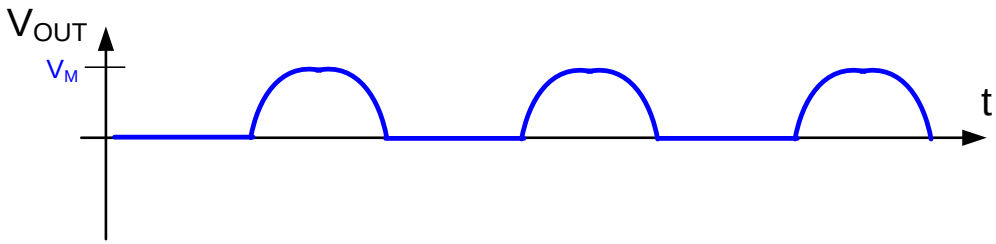


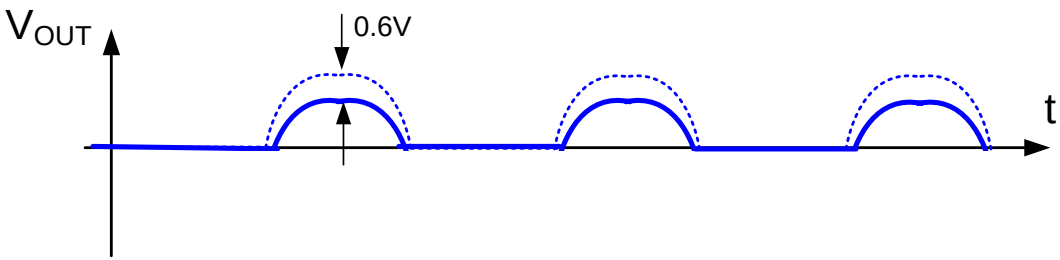


Consider $V_{IN}=V_M \sin\omega t$ for $V_M=50V$, $V_M=1V$ and $V_M=0.5V$



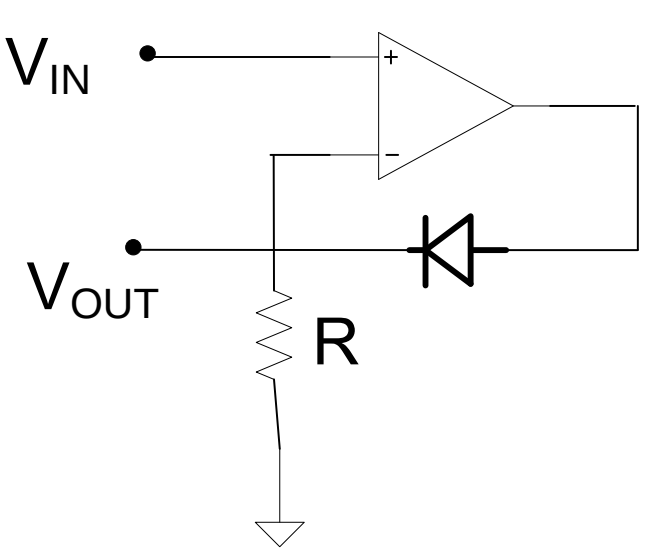
Desired output:

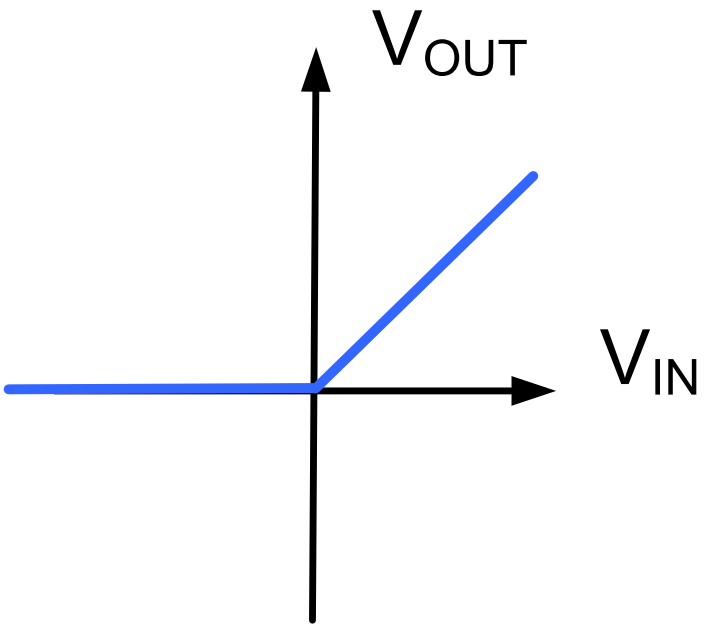




Review from Last Time:

Precision Rectifier Circuit

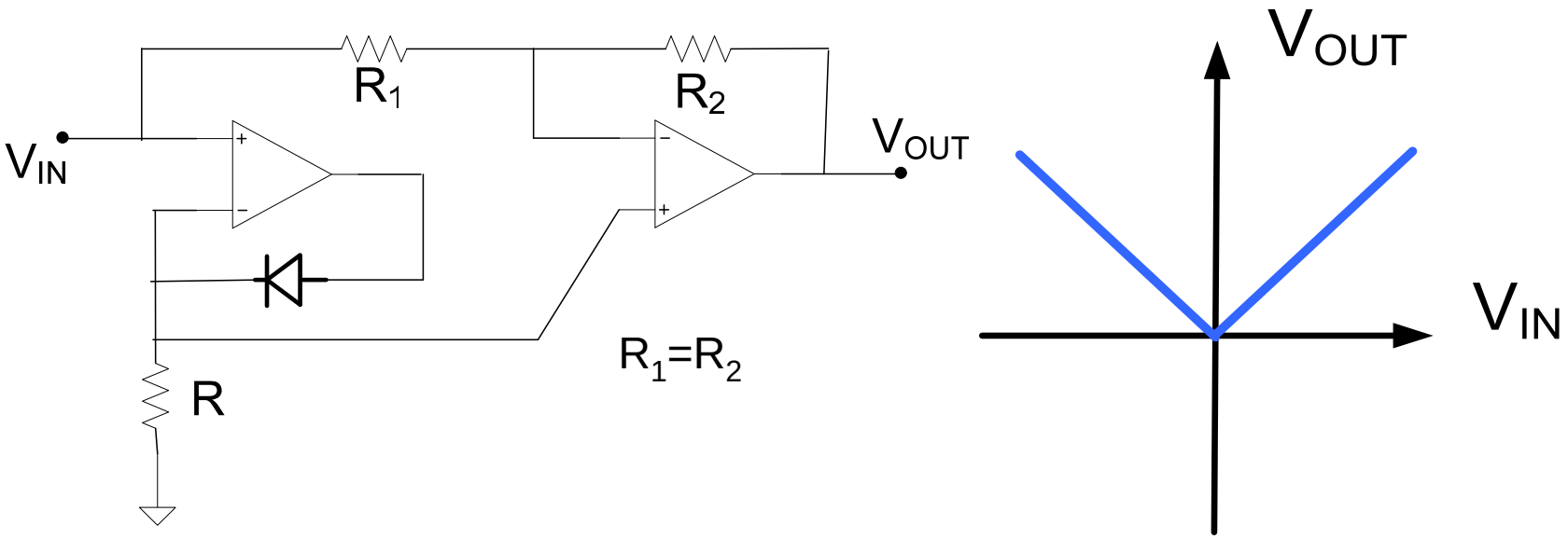




- Buffer may be needed on V_{OUT}
- SR of op amp limits speed of this circuit

Review from Last Time:

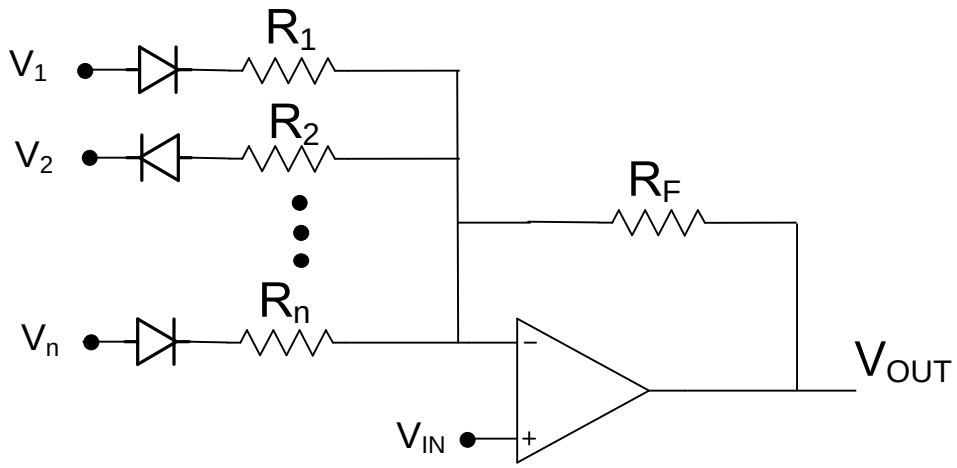
Precision Full-Wave Rectifier Circuit



- SR on first op amp limits speed of this circuit

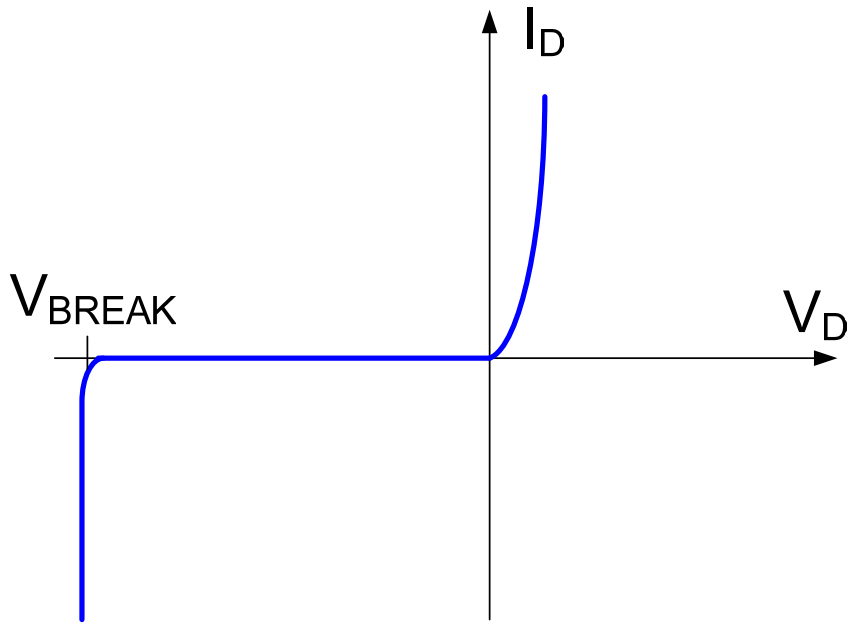
Review from Last Time:

Nonlinear Function Generation



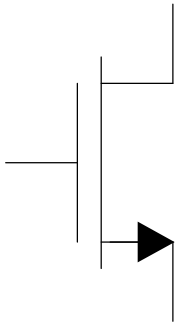
Variants of this approach can be used to generate arbitrary nonlinear functions

Diode Limitations

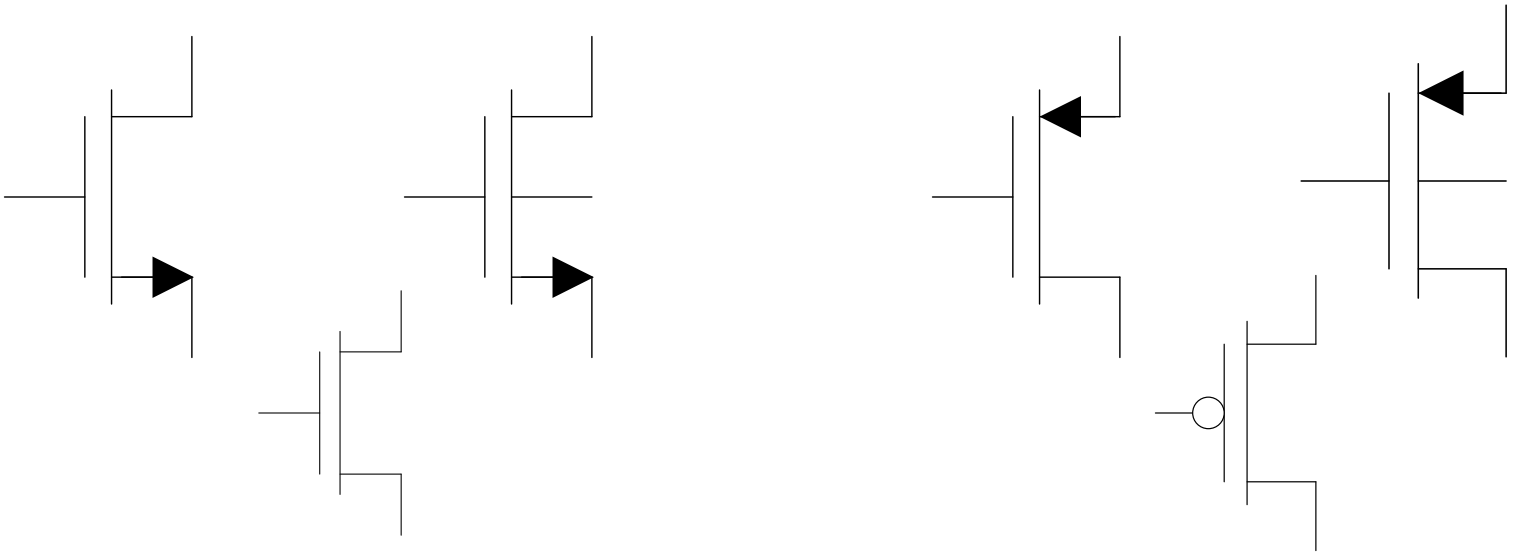


- All diodes will break down if too much reverse bias is applied
- V_{BREAK} can range from a few volts to over 1000V depending upon diode type
- Some are designed to work with modest breakdown voltages (zener diodes)
- Most are not and will be destroyed if allowed to breakdown due to excessive power dissipation

MOS Transistors



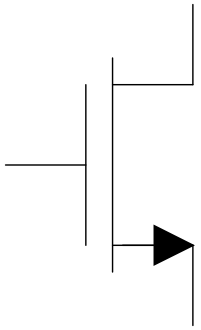
MOSFET



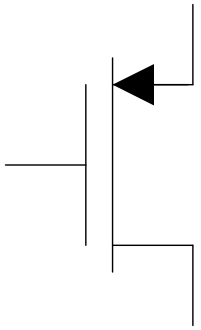
n-channel

p-channel

MOS Transistors



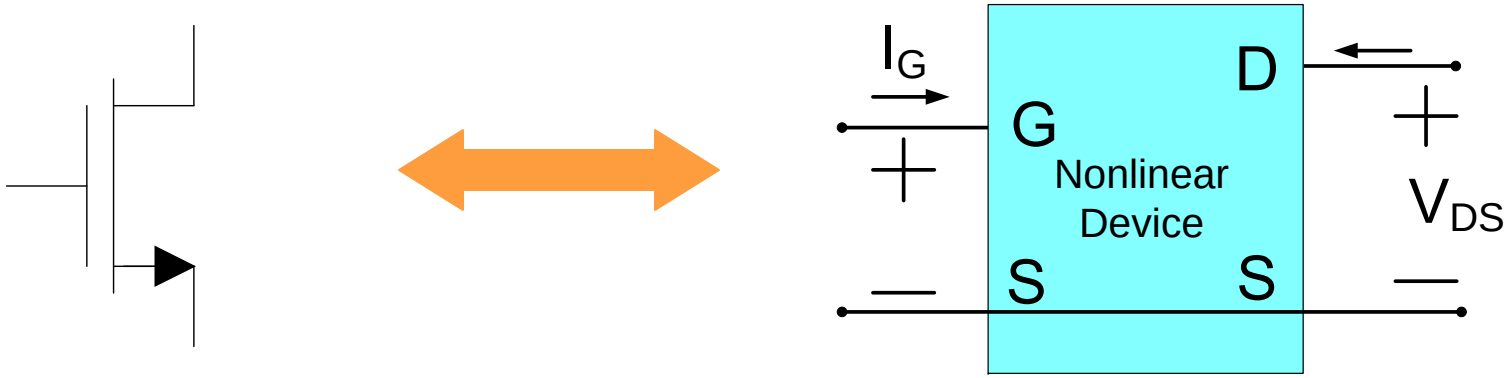
n-channel



p-channel

- Operation very similar
- Model parameters differ modestly
- Direction of current flow differs

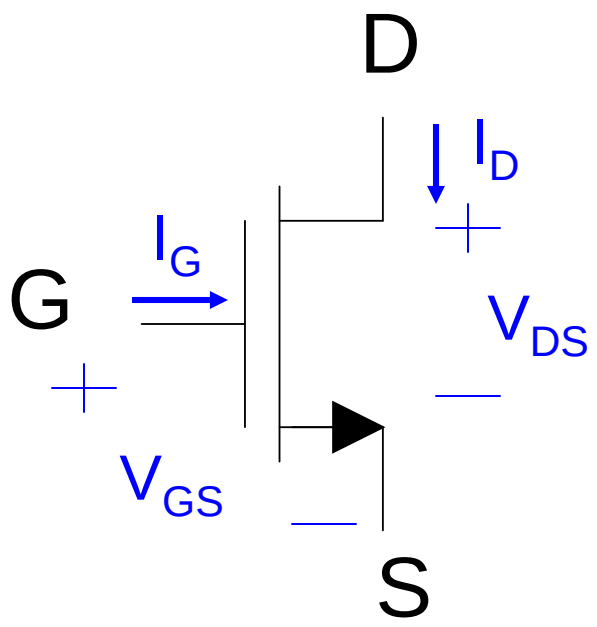
MOS Transistors



$$I_G = 0$$

$$I_D = \begin{cases} 0 & V_{GS} < 1V \\ 10^{-4}\left(V_{GS} - 1 - \frac{V_{DS}}{2}\right) V_{DS} & V_{GS} > 1V,\ V_{DS} < V_{GS} - 1V \\ \frac{10^{-4}}{2}(V_{GS} - 1)^2 & V_{GS} > 1V,\ V_{DS} > V_{GS} - 1V \end{cases}$$

MOS Transistors



Model:

$$I_G = 0$$

$$I_D = f_1(V_{GS}, V_{DS})$$

the two-variable function
f_1 is quite nonlinear

D: Drain
G: Gate
S: Source

End of Lecture 29