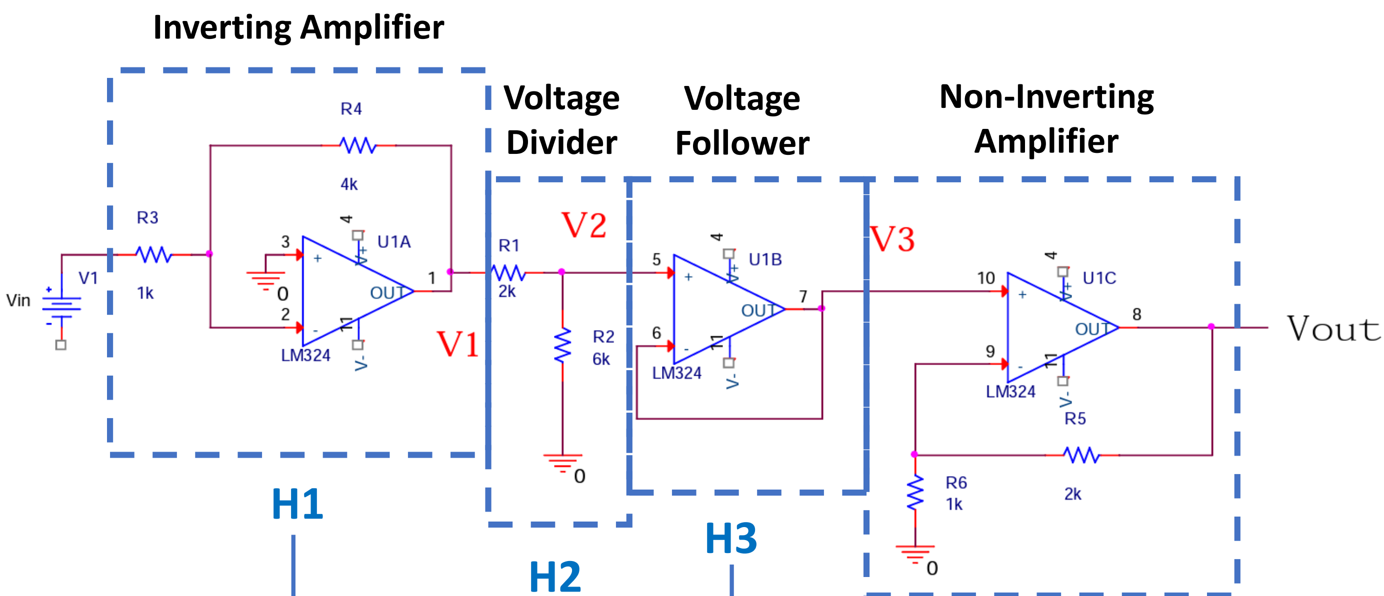
Cascading Op-Amps

$V_{supply+}$ = +9V
$V_{supply-}$ = -9V

What is V_{out} in terms of V_{in}?



H4

$$H_1 = -\frac{R_4}{R_3} = -\frac{4k}{1k} = -4$$

$$H_3 = 1$$

$$H_2 = \frac{R2}{R1 + R2} = \frac{6k}{8k} = \frac{3}{4}$$

$$H_4 = 1 + \frac{R5}{R6} = 1 + \frac{2k}{1k} = 3$$

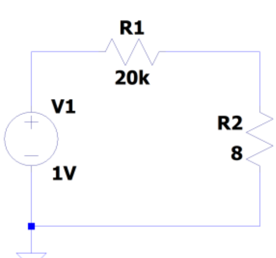
$$H_{total} = H_1 H_2 H_3 H_4 = (-4)\left(\frac{3}{4}\right)(1)(3) = -9 \longrightarrow V_{out} = -9V_{in}$$

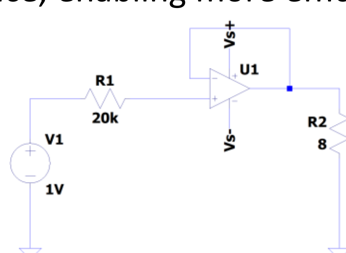
Example: If V_{in} = 3V, what is V1?

- Mathematically, V1 = (3V)(-4) = -12, however the supply voltages are +/- 9V, meaning that the signal will saturate at either +9V or -9V, so V1 = -9V

Why use a voltage follower?

1. It stops any current from flowing from the right side of the voltage follower to the left side of the voltage follower (no current enters the terminals of ideal op-amps); it isolates one circuit from another
2. It can transform impedance, enabling more efficient voltage transfer





- Op-amp has input impedance of about 2M ohm (in series with R1)
- Op-amp has output impedance of about 5 ohm (in series with R2)
- Voltage follower greatly improves voltage transfer from V1 to VR2

$$V_{R2} = 1V\frac{8\Omega}{20k\Omega + 8\Omega} = 0.4mV$$

$$V_{+} = 1V\frac{2M\Omega}{2M\Omega + 20k\Omega} = 990mV$$

$$V_{R2} = 990mV\frac{8\Omega}{5\Omega + 8\Omega} = 609mV$$