Ex:

A function generator outputs the following signal, $v_i(t)$.

Design op-amp circuits to output each of the following waveforms when $v_i(t)$ is the input. You may use either one or two op-amps in each case.
sol(n: a) We need an inverting amplifier with a gain of 0.5. We have \( v_o = -v_i \frac{R_2}{R_1} \). So \( R_2/R_1 = 1/2 \).

We use \( R_1 > 10 \text{k}\Omega \) and \( R_5 < 1 \text{M}\Omega \), and we use supply voltages of at least 6V and less than or equal to ±15V, which is a typical maximum supply voltage.

b) We need a non-inverting amplifier with a gain of one. We use supply voltages of \( +9V \) and \( -9V \) to get clipping at ±8V.

For a gain of one, we use a buffer.

c) To get a PWM wave, we use a comparator. We use supply voltages ±10V to get ±9V output. We now determine the input voltage where \( v_o \) switches.

\( v_i \) is time when \( v_o \) switches

\( v_i = -8V \) when \( v_o \) switches
So we need a reference voltage going into the comparator of -8V. To avoid using an additional $v$-source, we use a $v$-divider for the -8V reference.

$$v_{\text{ref}} = -10V \cdot \frac{R_1}{R_1 + R_2} = -8V$$

One solution is 120kΩ and 30kΩ. The key is to have a ratio of four to one.

Finally, $v_o$ is high when $v_i > -8V$. So we want $v_i$ to go into the + input of the comparator.