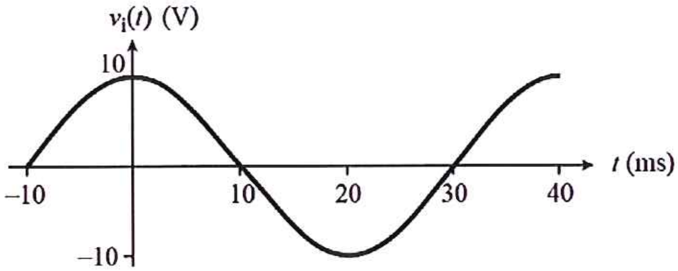
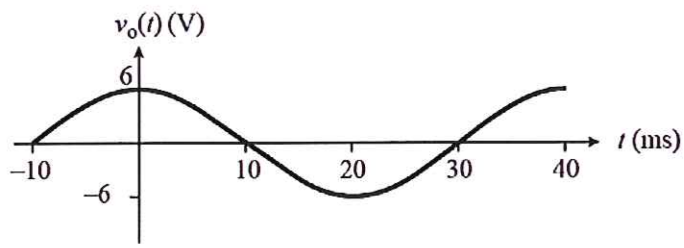
Ex: A function generator outputs the following signal, $v_i(t)$.

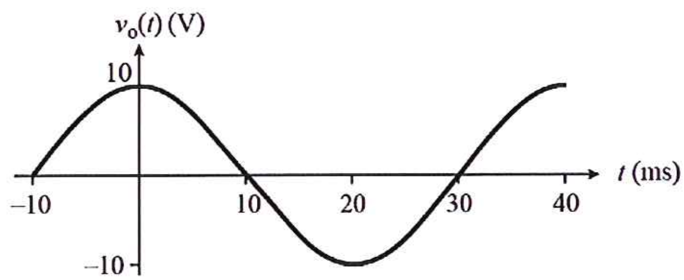


Design op-amp circuits to output each of the following waveforms when $v_i(t)$ is the input. You may use either one or two op-amps in each case.

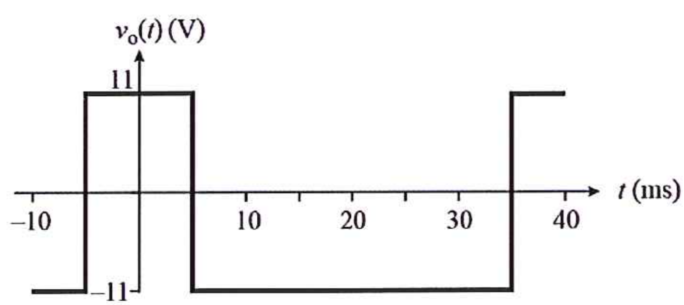
a)



b)



c)



sol'n: a) We have $\frac{v_o}{v_i} = 0.6$. Since this gain is less than 1, we cannot use a standard non-inverting configuration, which has gain $1 + \frac{R_f}{R_s} > 1$.

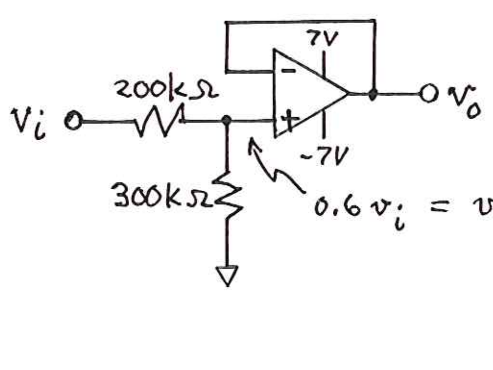
Three possible solutions address this issue in diffent ways:

1) Use two inverting amplifiers with the product of their "gains" equal to 0.6. For example, $R_{f1} = 120\,k\Omega$, $R_{s1} = 200\,k\Omega$, $R_{f2} = 100\,k\Omega$, $R_{s2} = 100\,k\Omega$ gives:

$$\frac{v_o}{v_i} = \left(-\frac{R_{f1}}{R_{s1}}\right)\left(-\frac{R_{f2}}{R_{s2}}\right) = (-0.6)(-1.0) = 0.6$$

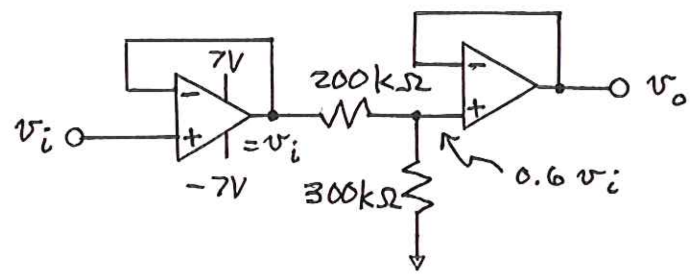
For the power supply, we use a voltage greater than 7V. (This is true for the following two cases as well.)

2) Use a non-inverting amplifier with a V-divider on the + input to reduce the gain. If the voltage divider outputs $0.6\,v_i$, we can use a buffer amp.

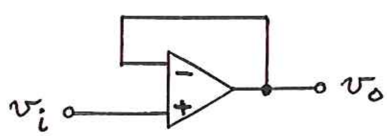


$$0.6\,v_i = v_i \cdot \frac{300\,k\Omega}{300\,k\Omega + 200\,k\Omega}$$

3) The previous solutions have a drawback: they draw current from the v_i source. If v_i is a weak signal, it is better to add a buffer stage that draws little to no current.



b) A unity-gain buffer gives $v_o = v_i$.



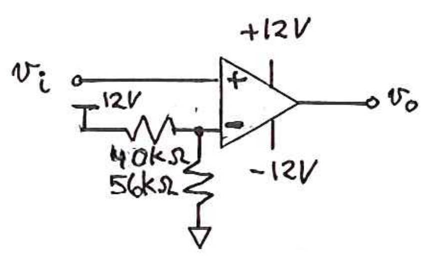
c) We use a comparator with power supplies of ± 12V to give $v_{rail} = 11V$ $\quad -v_{rail} = -11V$.

If we assume our waveform is a cosine, we have

$$v_i(t) = 10 \cos\left(2\pi\left(t/40ms\right)\right)$$

The comparator should trip when $t = 5ms$.

$$v_i(5\,ms) = 10 \cos\left(2\pi(5ms/40ms)\right) \doteq \frac{10}{\sqrt{2}} \approx 7.07$$



We want $v_- \doteq 7V$. Use V-divider: $v_- = 12V \cdot \frac{56k\Omega}{96k\Omega}$

or $v_- = 7V$