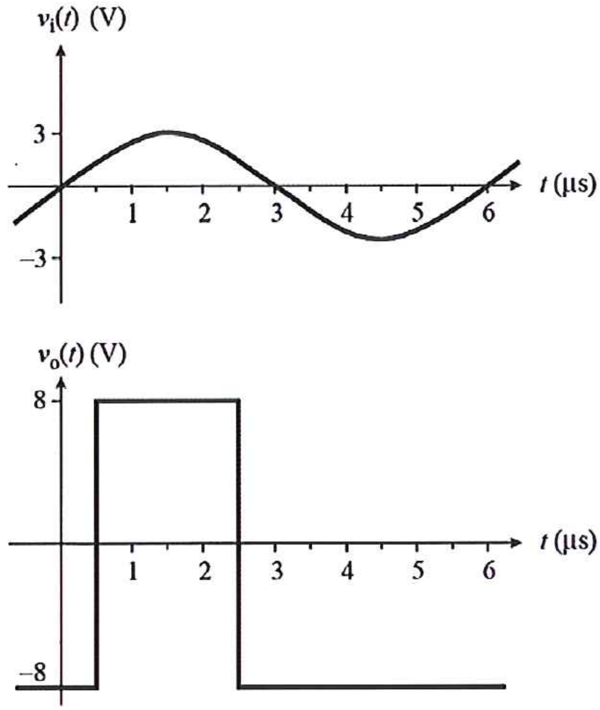
Ex:



Using op-amps, power supplies, and resistors, draw a circuit to produce $v_o(t)$ from $v_i(t)$. (Assume you have a function generator that produces $v_i(t)$ for you to use.) Show all relevant information in your circuit, including positive and negative power supply voltages for op-amps. You may use only two power supplies in your design. You must generate other voltages you need from those two power supplies, (for example by using a voltage-divider).

Note: Both signals repeat every 6 μs.

sol'n: The response is nonlinear, otherwise $v_o(t)$ would be a sinusoid. Thus, we use a comparator circuit. The output voltages are rail voltages, one volt away from the power supply voltages. Thus, the power supply voltages are ±9 V.

The trigger voltage for the comparator is the value of $v_i(t)$ at times $t = 0.5\,\mu s$ and $t = 2.5\,\mu s$. Assuming the input waveform is sinusoidal (as it appears to be), the trigger points occur at $\theta = 2\pi\,(0.5\,\mu s / 6\,\mu s)$, which is 1/12 of a cycle of sine( ), and at $\theta = 2\pi\,(2.5\,\mu s / 6\,\mu s)$, which is 5/12 of a cycle of sine( ).

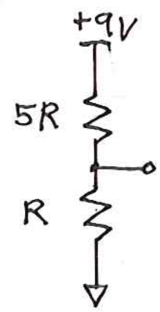
$$\sin\left(\frac{2\pi}{12}\right) = \sin\left(\frac{\pi}{6}\right) = \sin(30°) = \frac{1}{2}$$

$$\sin\left(\frac{2\pi \cdot 5}{12}\right) = \sin\left(\frac{5\pi}{6}\right) = \sin(150°) = \frac{1}{2}$$

Multiplying $\frac{1}{2}$ by the height of the sinusoid, 3V, gives the trigger voltage:

$$v_{Trig} = 3V\left(\frac{1}{2}\right) = 1.5\,V$$

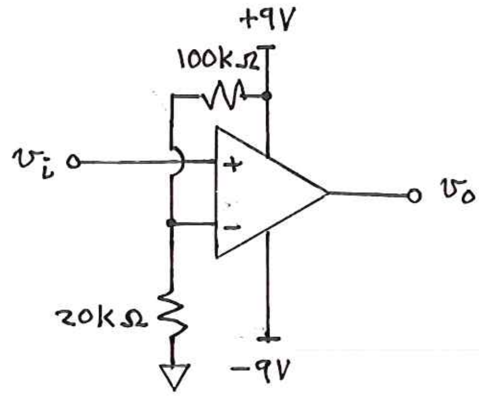
Given a power supply voltage of 9V, a voltage divider with resistances R and 5R gives a voltage of 1.5V.



$$1.5\,V = 9V \cdot \frac{R}{R + 5R} = 9V\left(\frac{1}{6}\right) = 1.5\,V$$

$R = 20k$ and $5R = 100\,k\Omega$ are acceptable (but not unique) resistance values.

Finally, the $v_i(t)$ will be connected to the + input of the comparator since the comparator output is positive when $v_i(t) > 1.5V$.



+9V
100kΩ
v_i
+
−
v_o
20kΩ
−9V