# Basic Elec. Engr. Lab

## ECS 204

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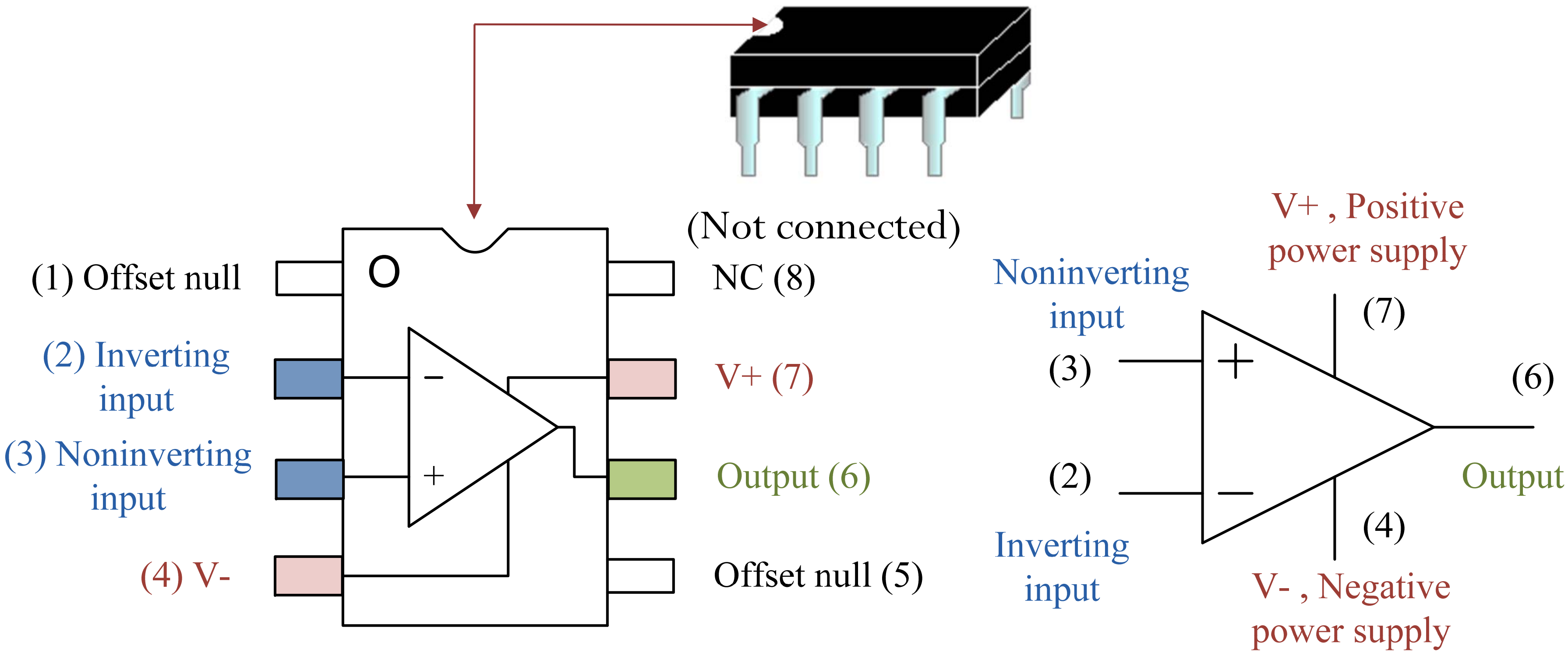
**Lab 7 & 8**

- Operational amplifier
- Inverting amplifier
- Summing Amplifier
- Inverting Integrator

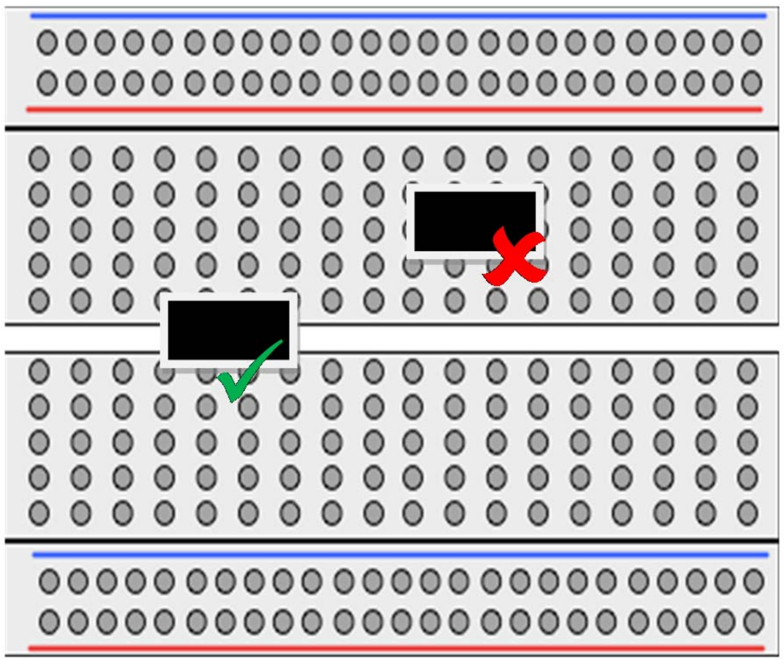
# Op-Amp 741

- **OP**erational **AMP**lifier



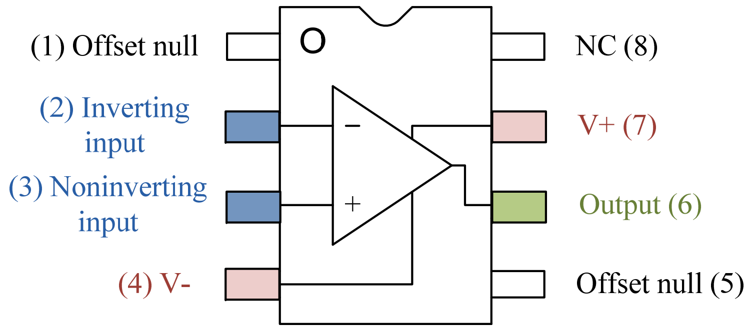
# Placing op amps on the proto-board

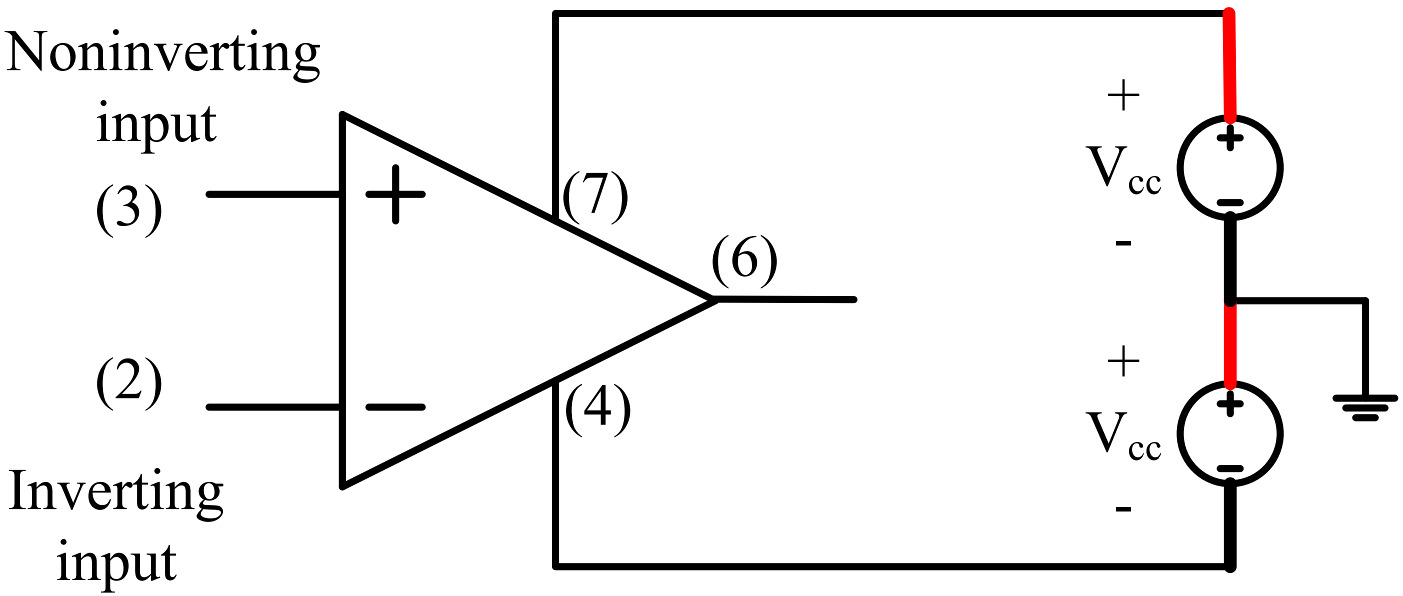
- Plug in op amp chips so that they straddle the troughs on the proto board.
- In this way, each pin is connected to a different hole set.



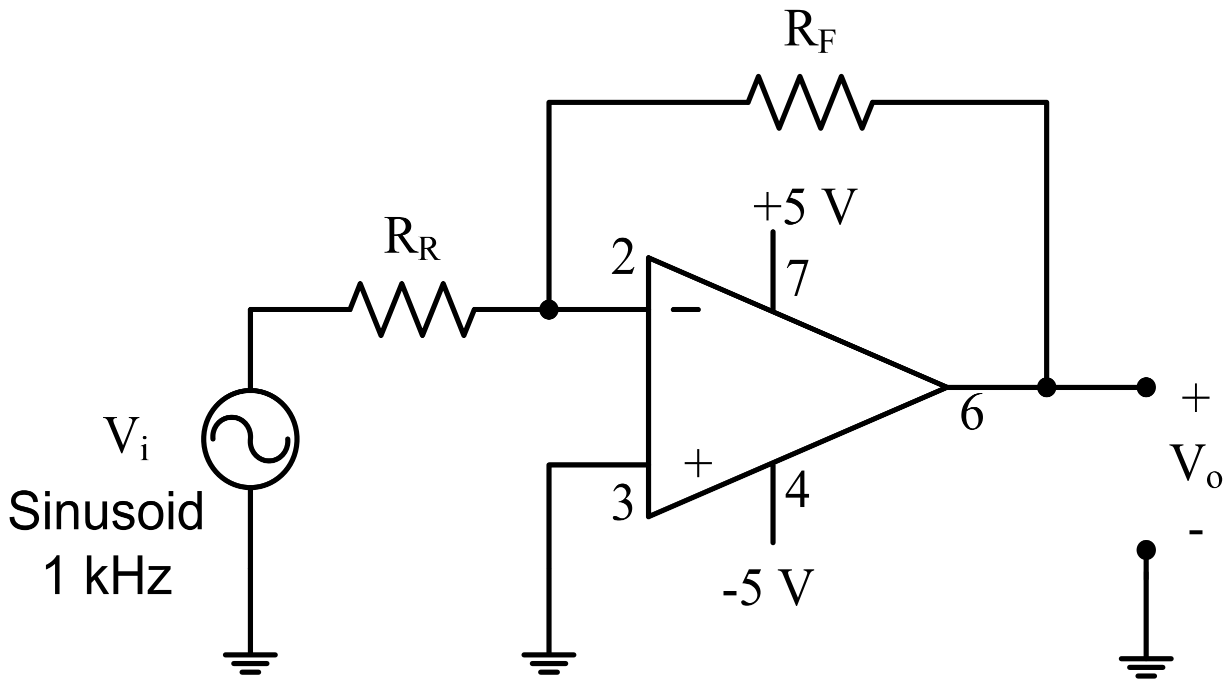
# Powering the op amp

- The op amp must be powered by voltage supplies.
- These supplies are often ignored in op amp circuit diagrams for the sake of simplicity.



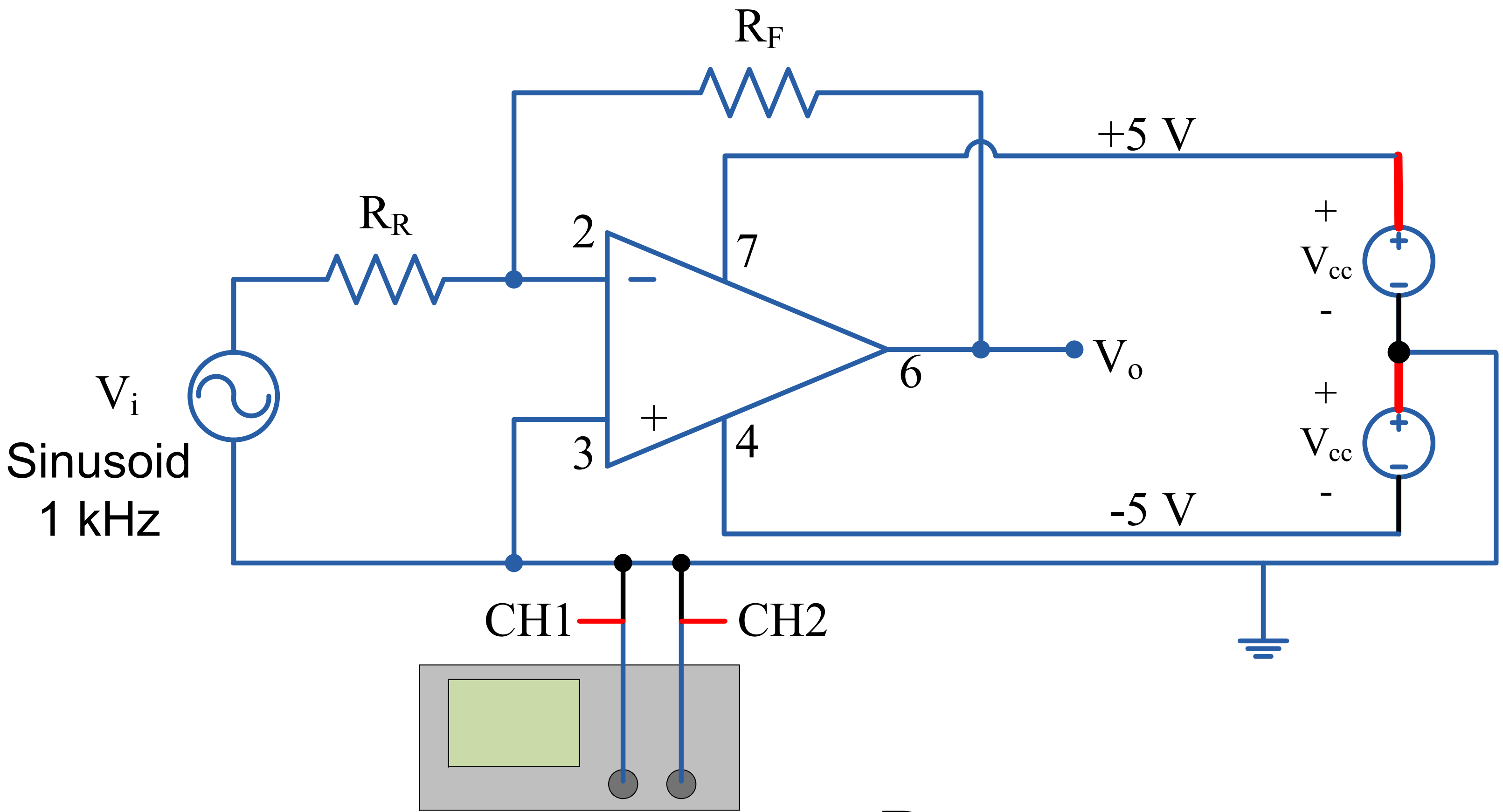



# Part A: Inverting Amplifier




$$V_o = -\frac{R_F}{R_R} V_i.$$

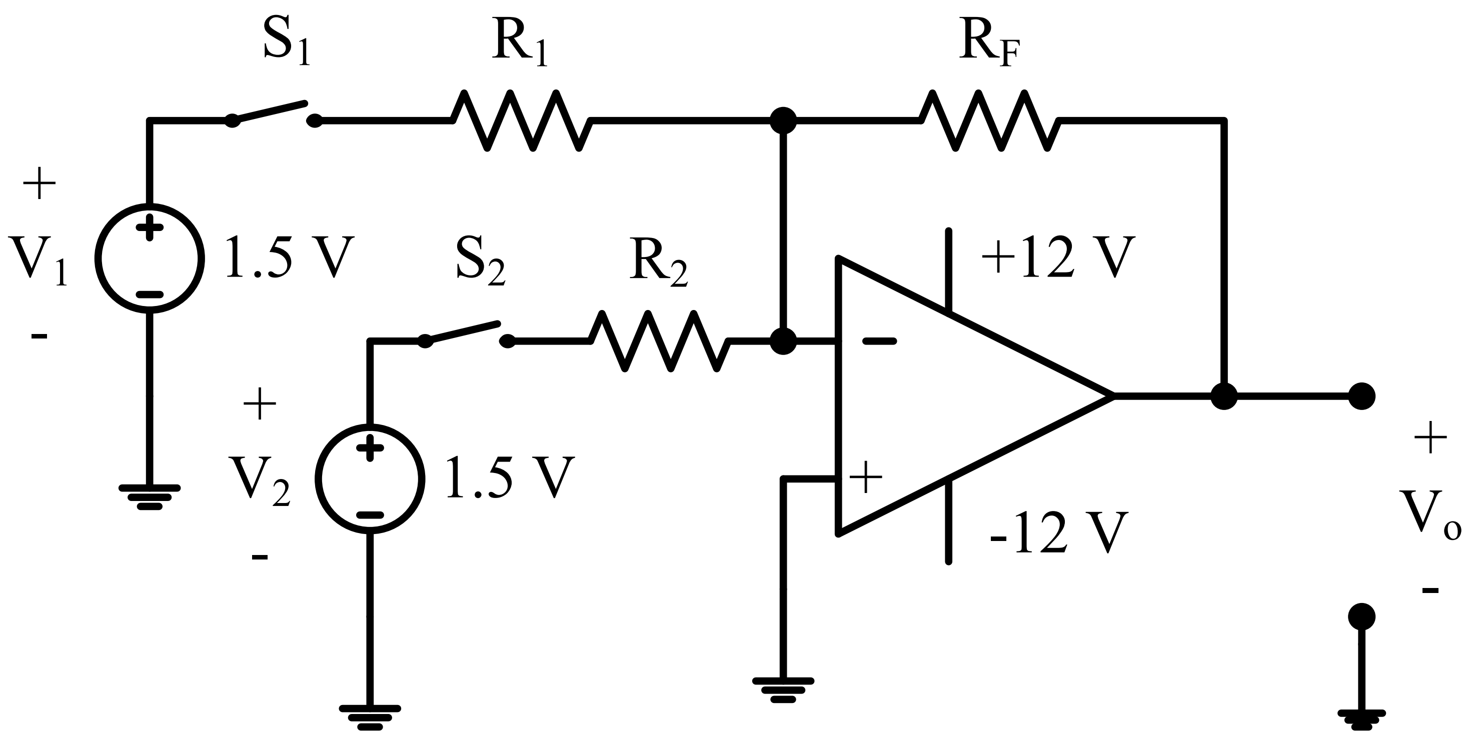
# Part A: Inverting Amplifier




$$V_o = -\frac{R_F}{R_R} V_i.$$

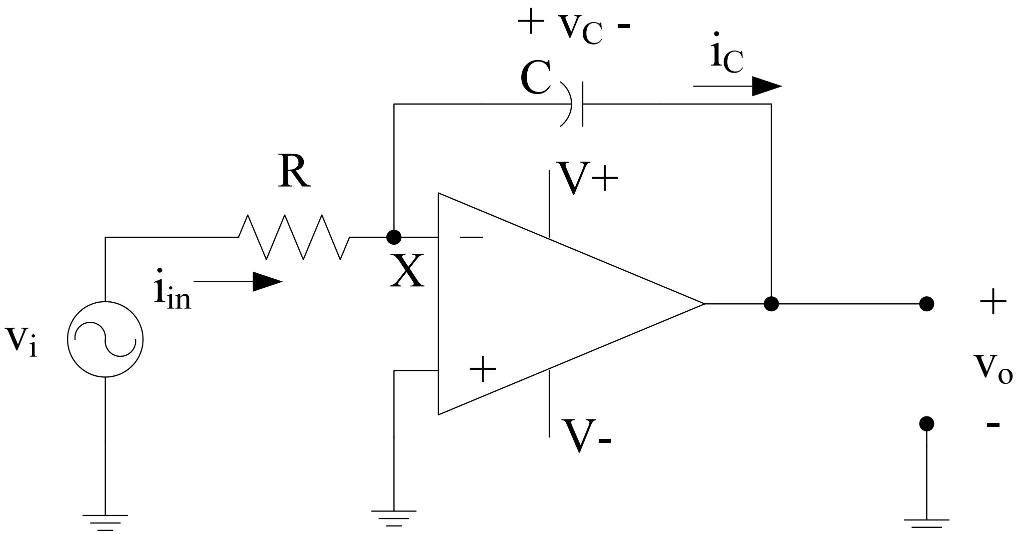
# Part b: Summing Amplifier

- Note that you will **need 4 DC Voltage Sources** in this part.




$$V_o = -\left(\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2\right).$$

# Part C: Inverting Integrator

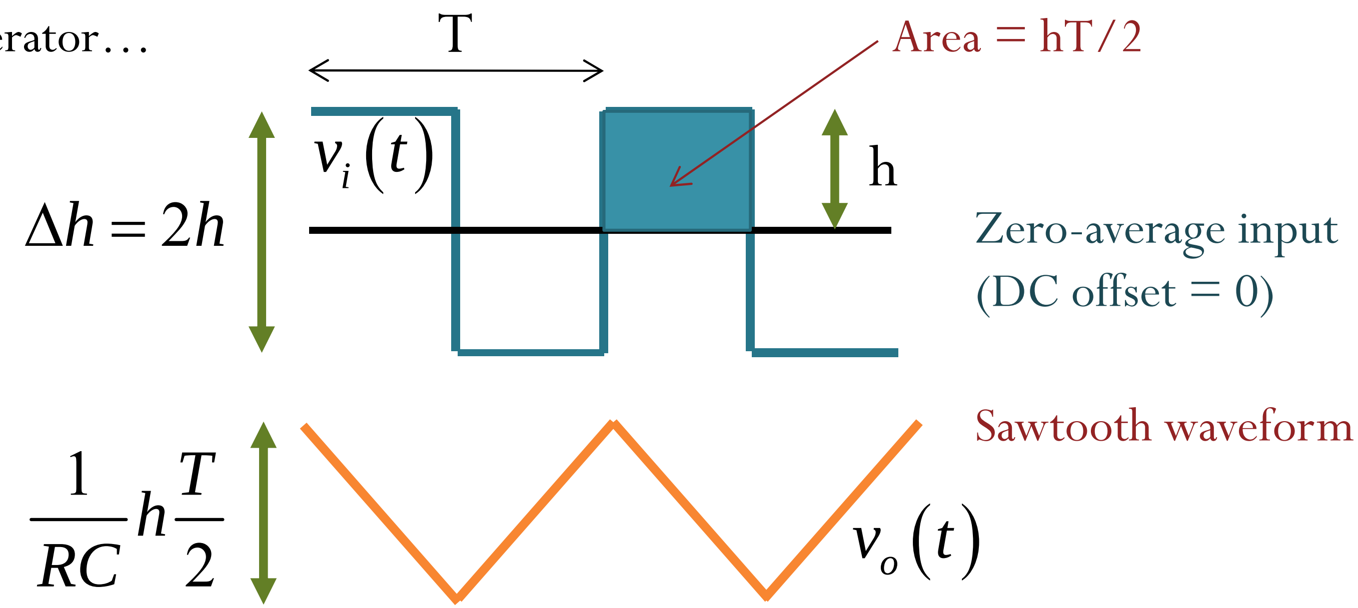



$$i_i(t) = i_C(t)$$

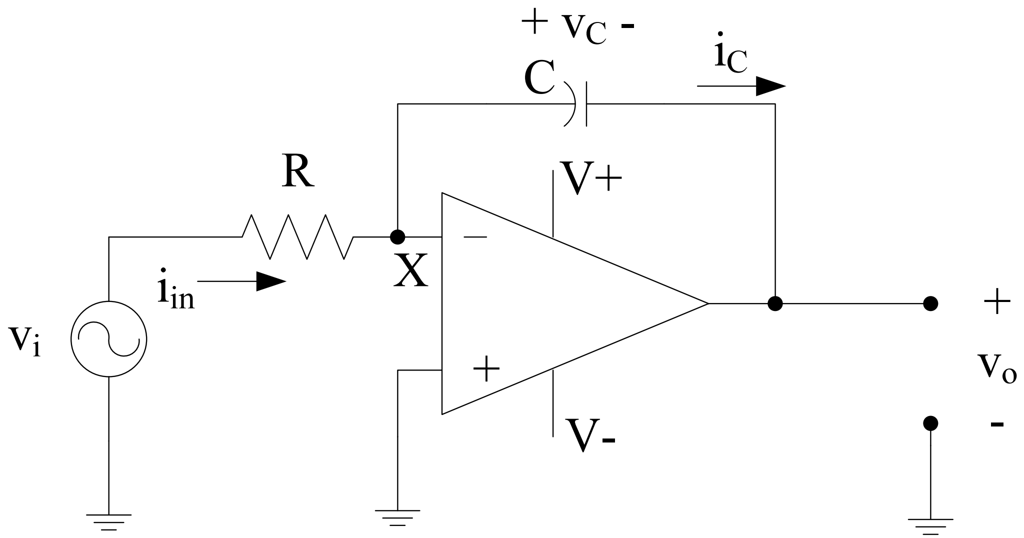
$$\frac{v_i(t)}{R} = -C\frac{d}{dt}v_o(t)$$

$$v_o(t) = v_o(0) - \frac{1}{RC}\int_0^t v_i(t)\,dt$$

As a Ramp Generator…



# Inverting Integrator (2)

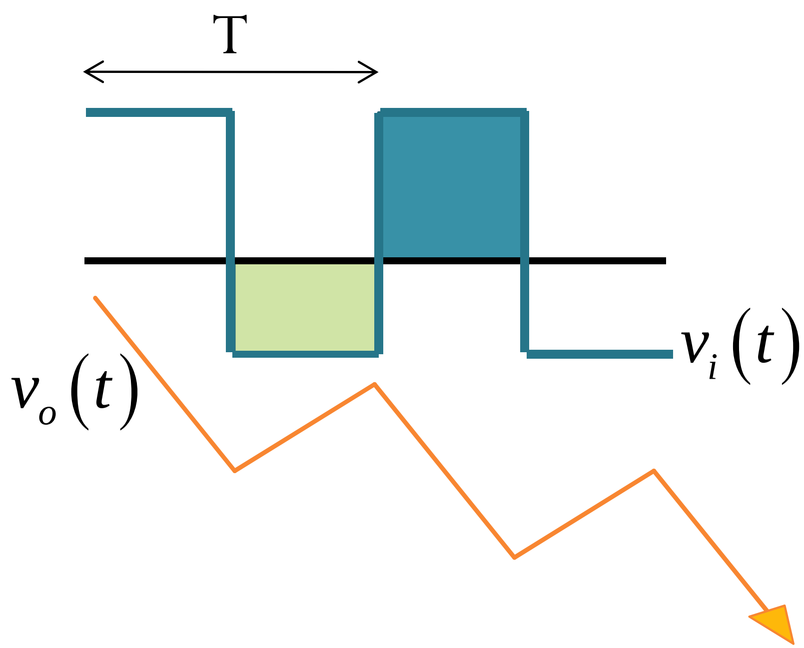



$$i_i(t) = i_C(t)$$

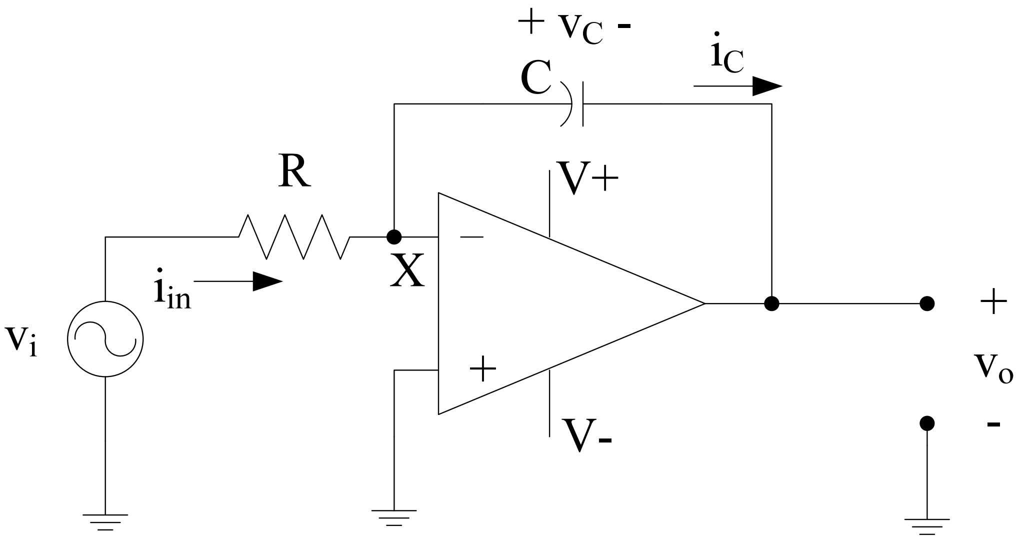
$$\frac{v_i(t)}{R} = -C\frac{d}{dt}v_o(t)$$

$$v_o(t) = v_o(0) - \frac{1}{RC}\int_0^t v_i(t)\,dt$$

- An input with nonzero mean (DC offset) can saturate the op amp.



# Inverting Integrator: AC SS Analysis




$$V_o = -\left(\frac{Z_C}{R}\right)V_i$$

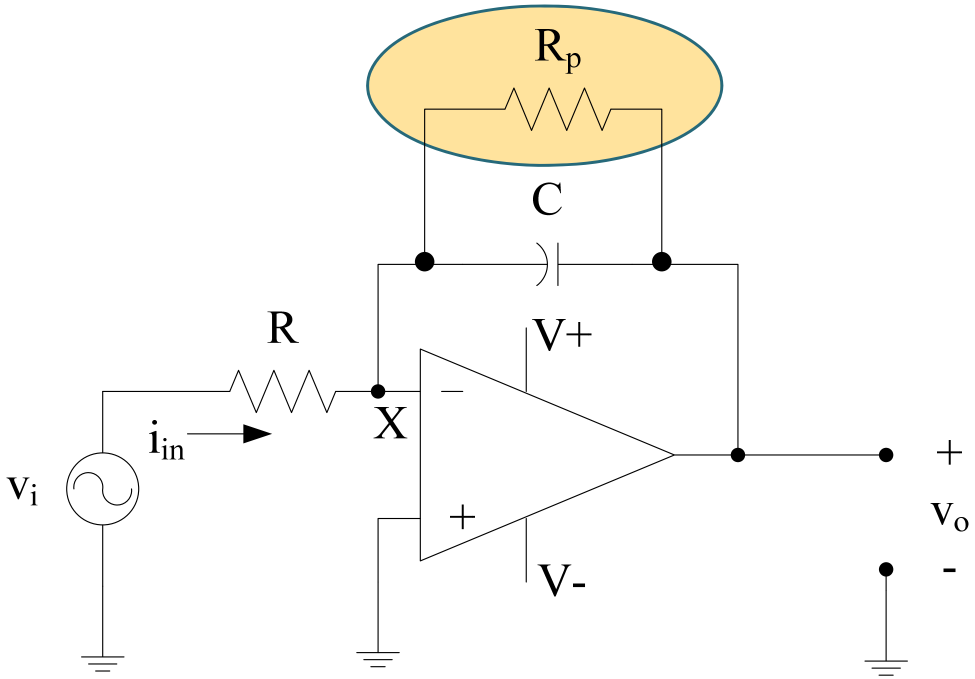
$$= -\left(\frac{V_i}{R}\right) \times \frac{1}{j\omega C}$$

- The gain at $f = 0$ is unbounded.
- Act like an **active low pass filter**, passing low frequency signals while attenuating the high frequencies.

(w/ DC Gain Control)

# Inverting Integrator w/ Shunt Resistor

- In practical circuit, a large resistor $R_p$ is usually shunted across the capacitor

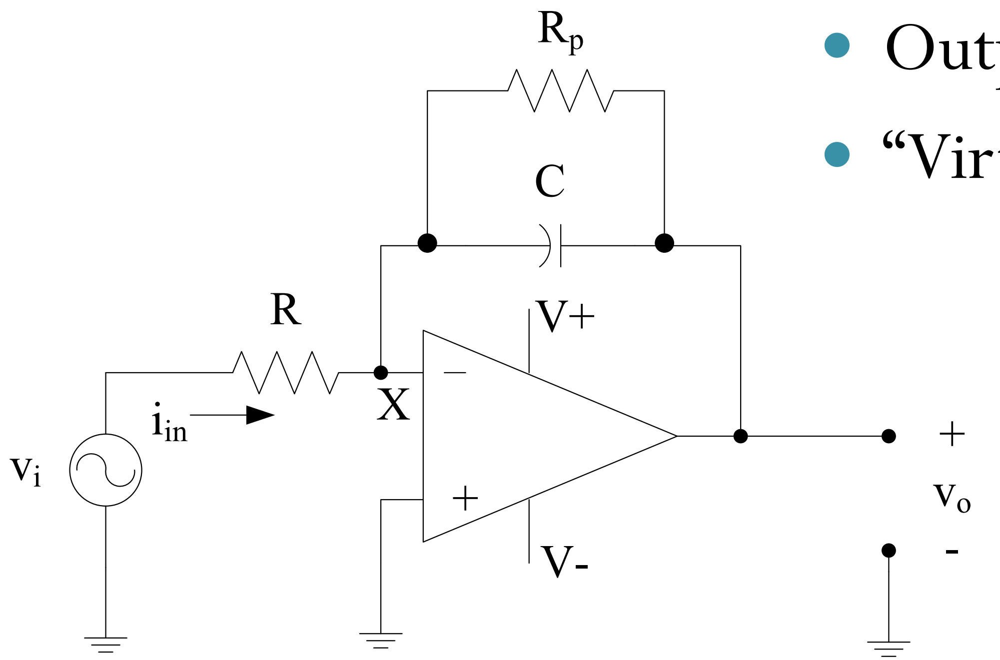



$$V_o = -\left(\frac{Z_C // R_p}{R}\right) V_i$$

$$= -\left(\frac{V_i}{R}\right) \times \frac{R_p}{j\omega R_p C + 1}$$

- Observe that at $f = 0$, the gain is finite.

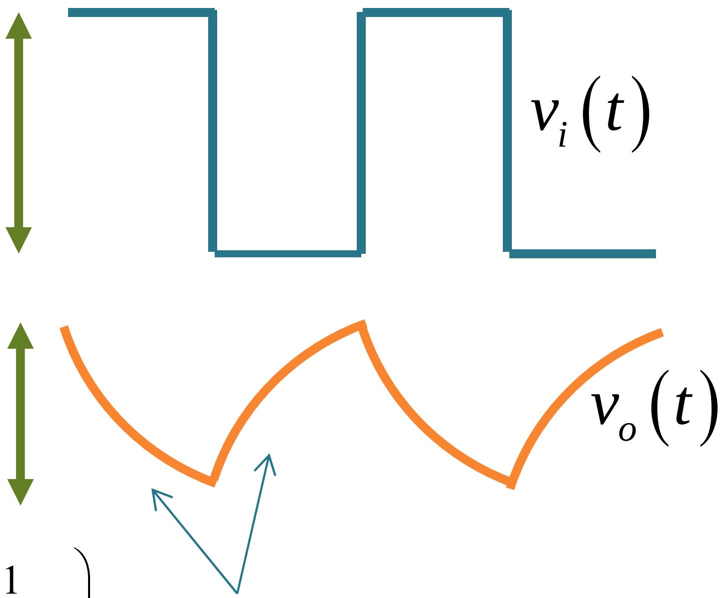
# Inverting Integrator w/ Shunt Resistor




- Output is <u>*not*</u> triangular.
- "Virtually triangular" if $R_p C \gg \frac{T}{2}$

$$R_p \gg \frac{1}{2fC} \qquad C \gg \frac{1}{2fR_p}$$

$$\Delta h$$




$$\Delta h \frac{Rp}{R}\frac{1-r}{1+r}$$

$$r = \exp\left(-\frac{1}{2fR_p C}\right)$$

$$\tau = R_p C$$