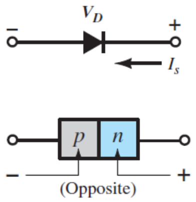
# ECN 101

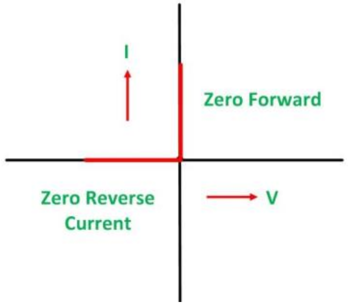
**Introduction to Electronics and Communication Engineering**

# Review

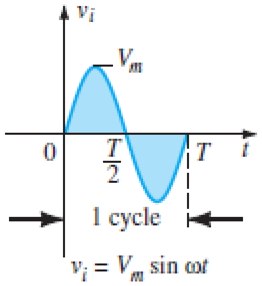
**Integration crucial for modern technological development.**

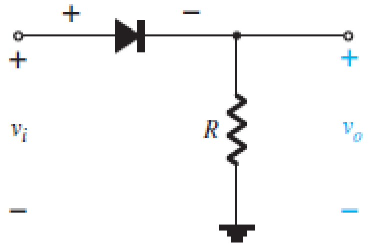
## Diode circuits



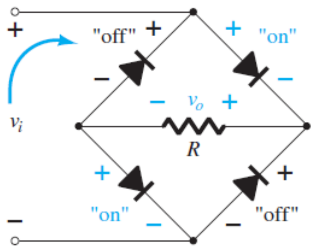



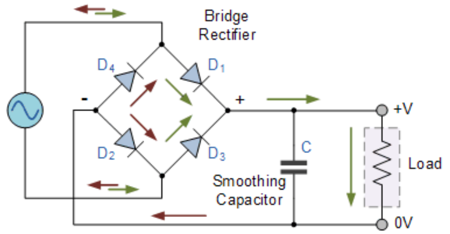

## Half wave rectifier

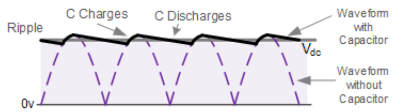



## Full wave rectifier

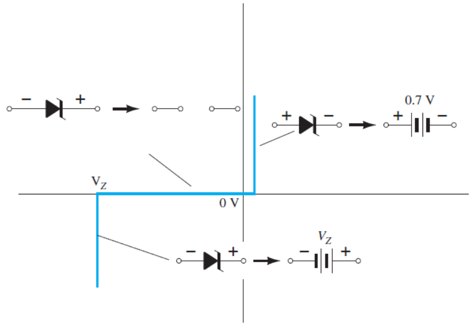



## Diode as clipper and clamper

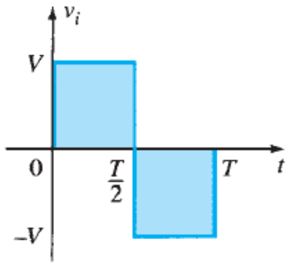
## Diode as voltage regulator

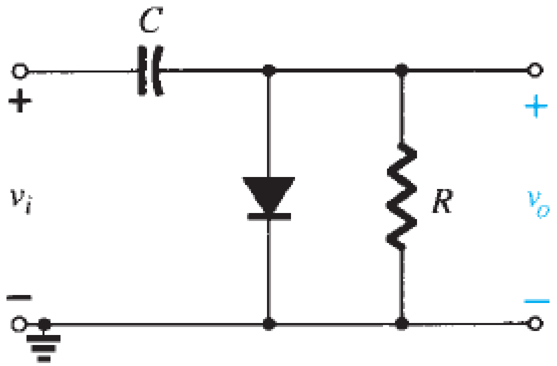


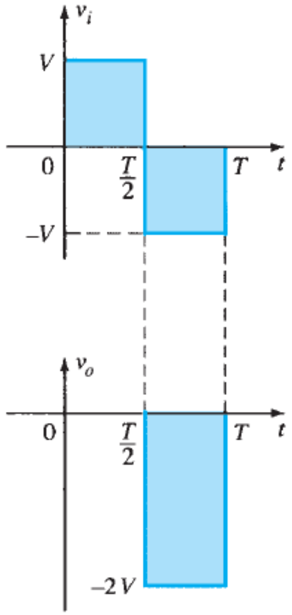

## Op-Amp basics

# Diode as clamper

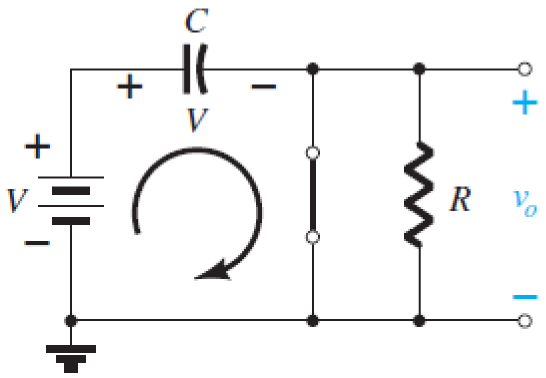
Clamper is a circuit that changes the dc level of a waveform without changing its appearance.



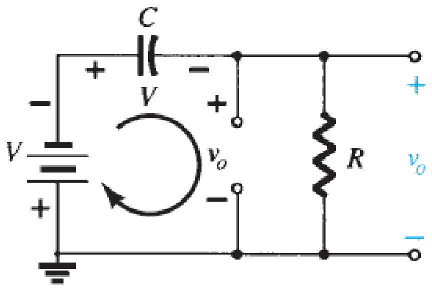




During the period that the diode is in the 'on' state, assume that the capacitor will charge up instantaneously to a voltage level determined by the surrounding network.



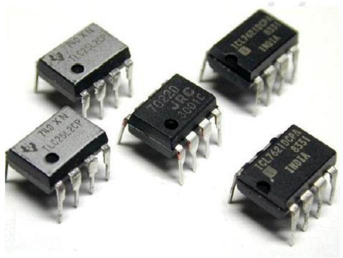

Assume that during the period when the diode is in the 'off' state the capacitor holds on to its established voltage level.

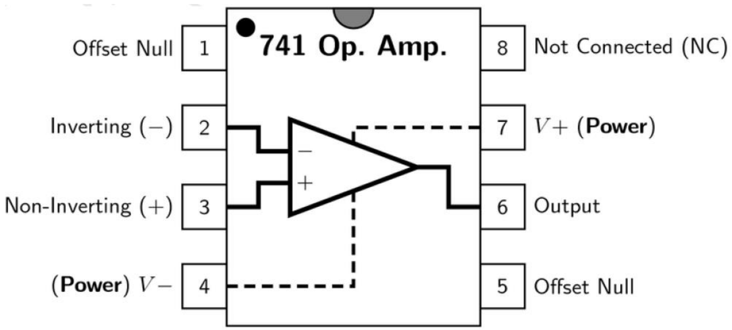


# Op-Amp: LM 741

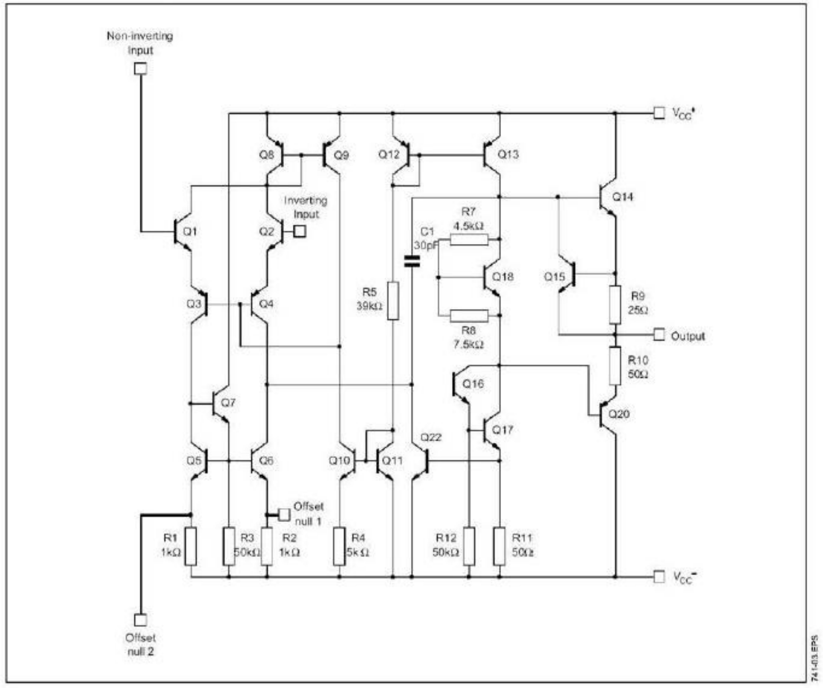
- One of the most commonly used Op-Amp.

- Packaged device look like:



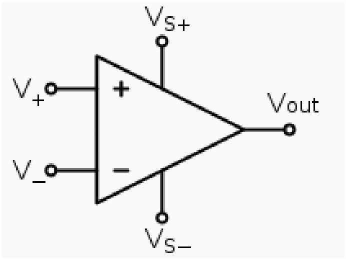



SCHEMATIC DIAGRAM




- An Op-Amp contains several transistors, resistors, and a few capacitors and diodes.

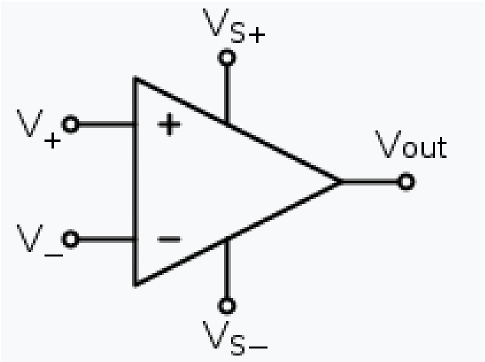
- More simply, an Op-Amp is depicted as:



# Op-Amp in a nutshell

- The internal circuitry in the op-amp tries to force the voltage at the inverting input to be equal to the non-inverting input.

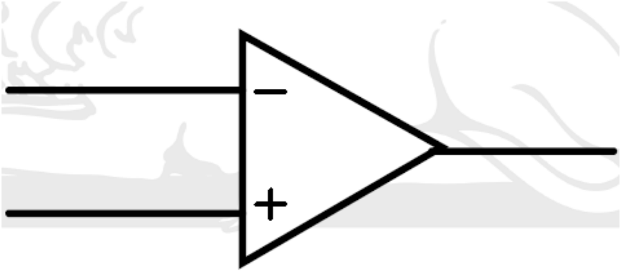
- While analyzing an Op-Amp circuit
  - Assume no current flows into either input terminal
  - Assume no current flows out of the output terminal



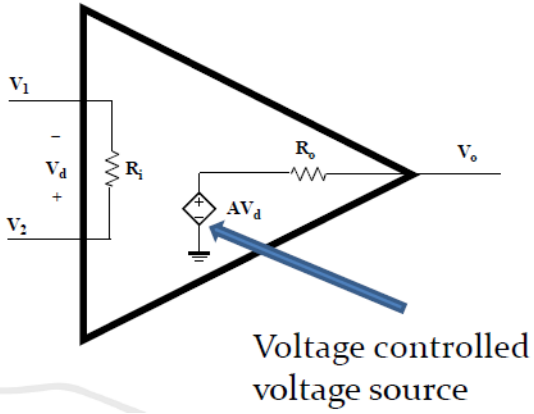

The output voltage is limited by the supply voltage.

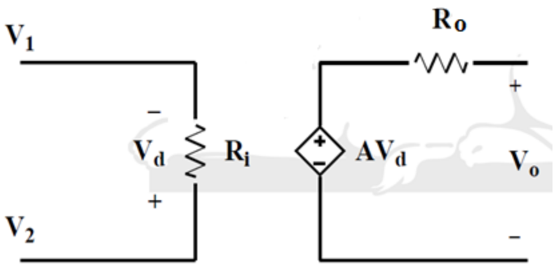
# Op-Amp contd..

- Op-Amp is represented as:



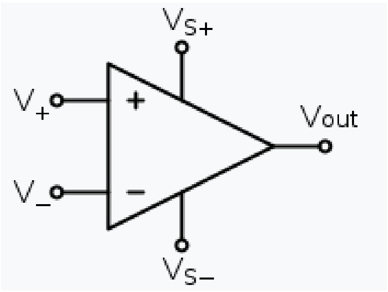

Op-Amp functional model

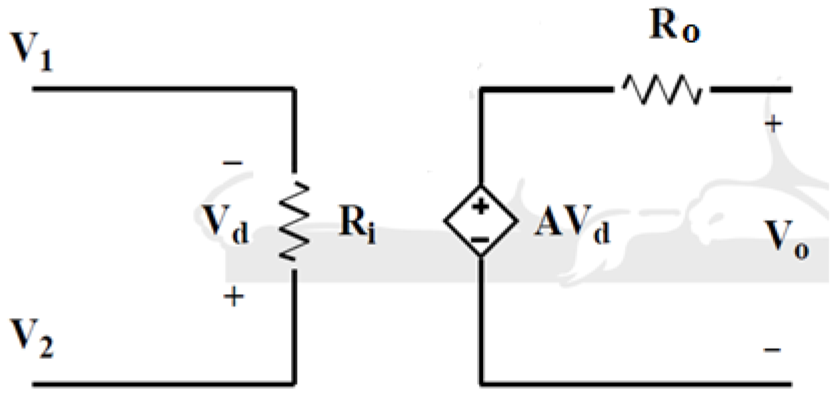



$$V_d = V_2 - V_1$$

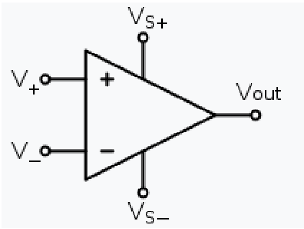
**A** is the open loop gain.

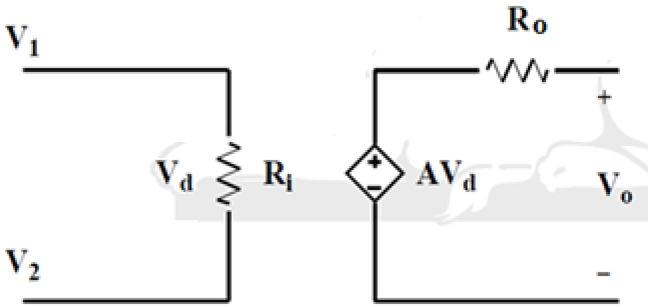


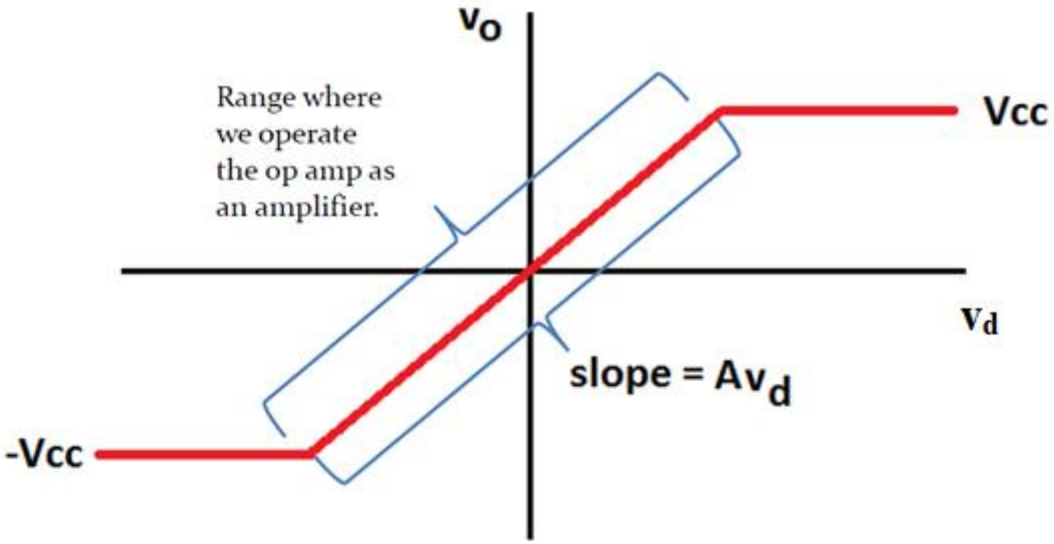




| Parameter | Variable | Ideal Values | Typical Ranges |
|---|---|---|---|
| Open-Loop Voltage Gain | A | $\infty$ | $10^5$ to $10^8$ |
| Input Resistance | Ri | $\infty$ Ω | $10^5$ to $10^{13}$ Ω |
| Output Resistance | Ro | 0 Ω | 10 to 100 Ω |
| Supply Voltage | Vcc/$V^+$<br>-Vcc/$V^-$ | N/A<br>N/A | 5 to 30 V<br>-30V to 0V |

# Voltage transfer characteristics



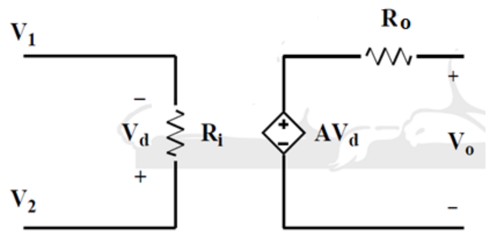



# Op-Amp analysis

$R_i = \infty\ \Omega$

– Therefore, $i_1 = i_2 = 0A$

$R_o = 0\ \Omega$

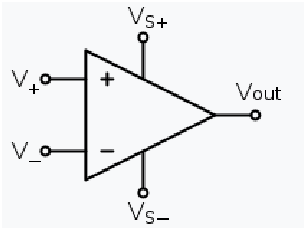



Rarely is the op amp limited to $-V_{cc} < V_o < +V_{cc}$

$V_d = 0V$ and so $V_1 = V_2$

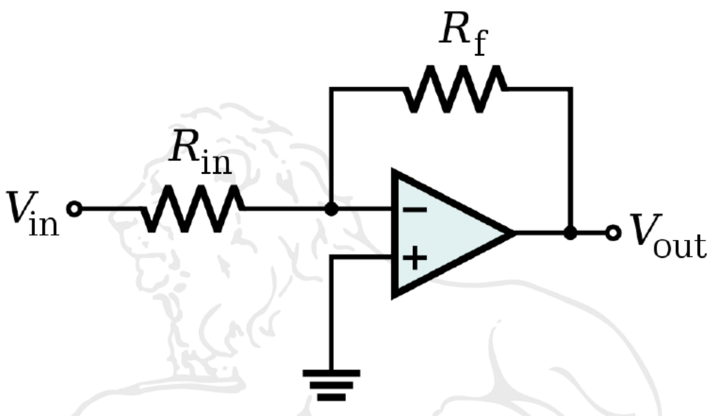
- **The internal circuitry in the op-amp tries to force the voltage at the inverting input to be equal to the non-inverting input.**

- **While analyzing an Op-Amp circuit**
    - **Assume no current flows into either input terminal**
    - **Assume no current flows out of the output terminal**



# Op-Amp usages

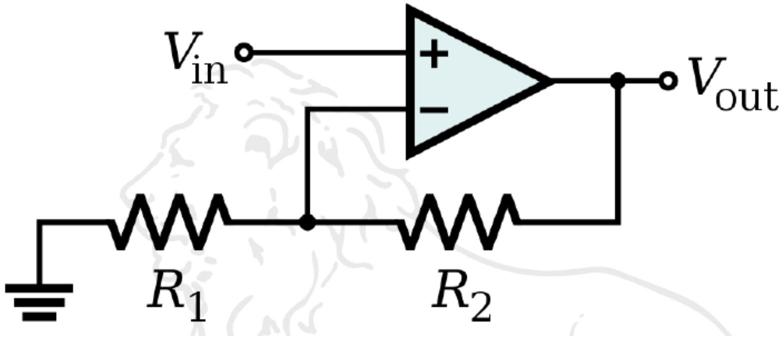
**Inverting Amplifier**




$$V_{out} = -\frac{R_f}{R_{in}} V_{in}$$

# Op-Amp usages

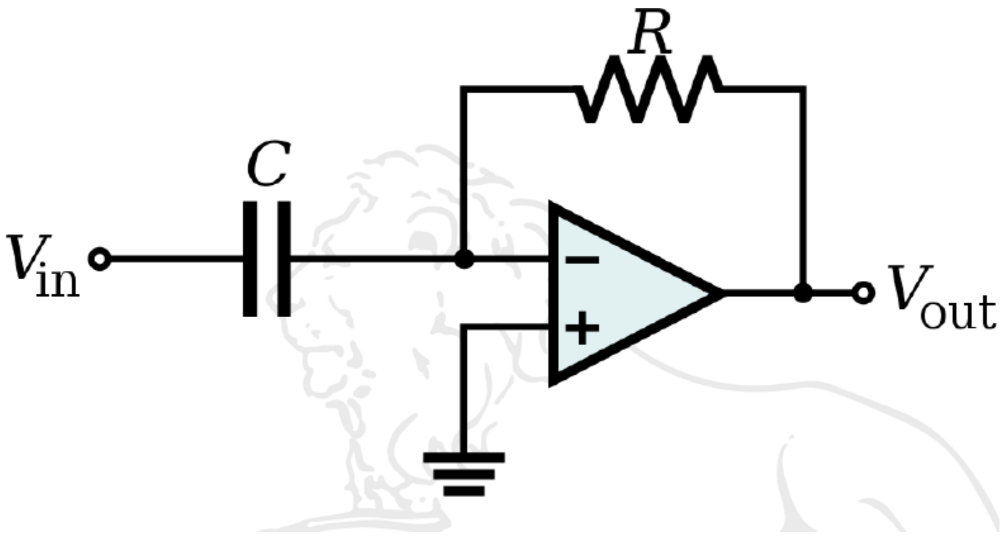
**Non-inverting Amplifier**




$$V_{out} = V_{in}\left(1 + \frac{R_2}{R_1}\right)$$

# Op-Amp usages

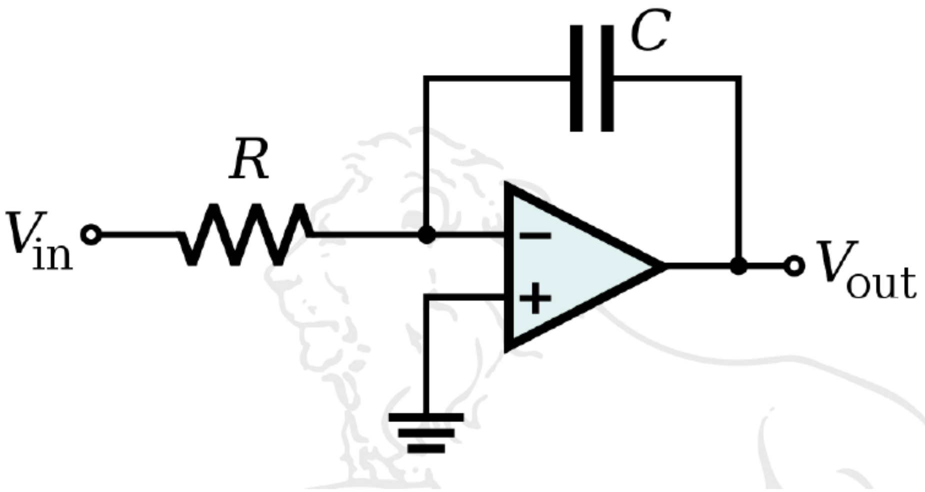
**Differentiator**




$$V_{out} = -RC\,\frac{dV_{in}}{dt}$$

# Op-Amp usages

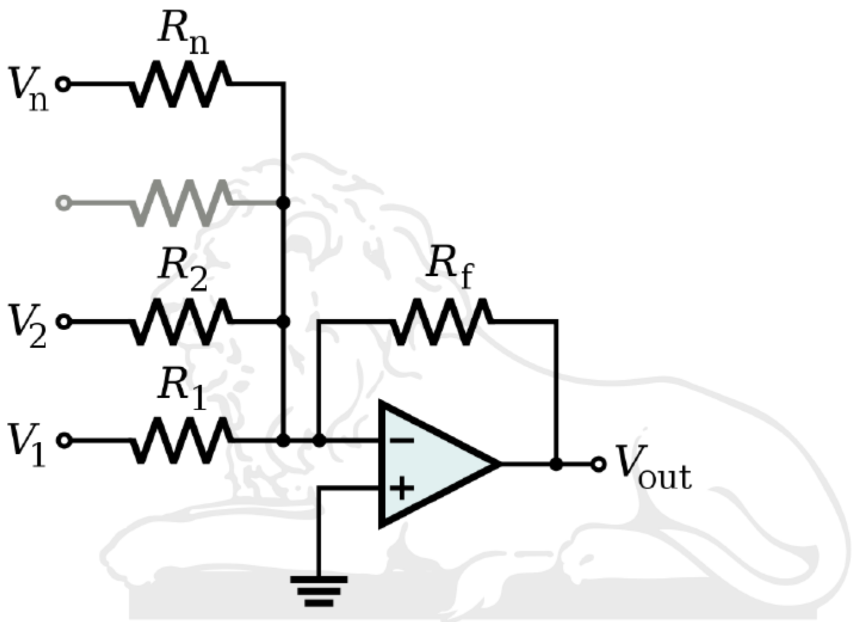
## Integrator




$$V_{out} = -\int_0^t \frac{V_{in}}{RC}\,dt + V_{initial}$$

# Op-Amp usages

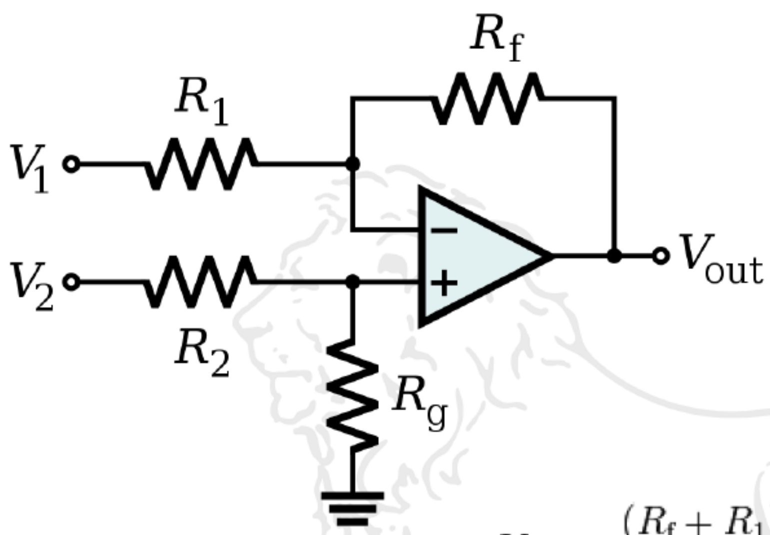
## Summing amplifier




$$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots + \frac{V_n}{R_n}\right)$$

# Op-Amp usages

## Difference amplifier

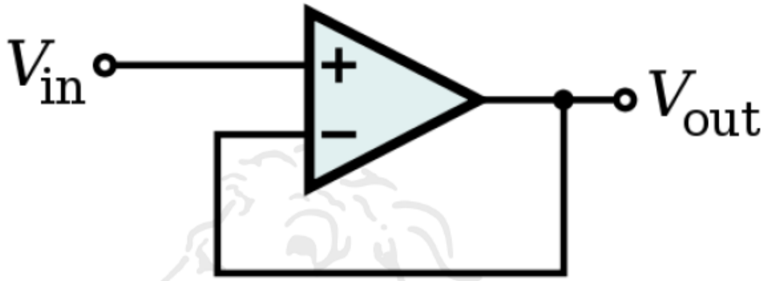


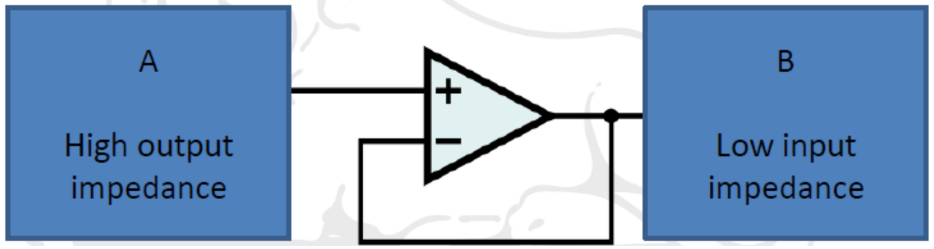

$$V_{out} = \frac{(R_f + R_1)\,R_g}{(R_g + R_2)\,R_1} V_2 - \frac{R_f}{R_1} V_1$$

If $R_1 = R_2$ and $R_f = R_g$: $V_{out} = \frac{R_f}{R_1}(V_2 - V_1)$

# Op-Amp usages

**Buffer/Voltage follower**



# Question