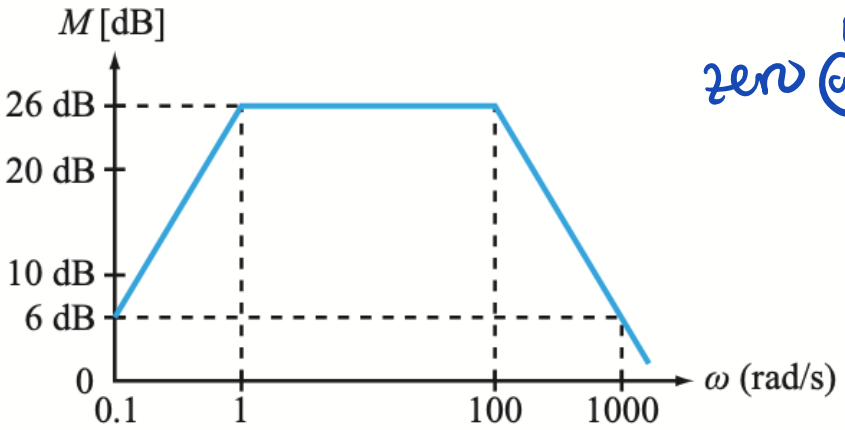
Last Class…

What is the gain K for the bode plots below



start with slope

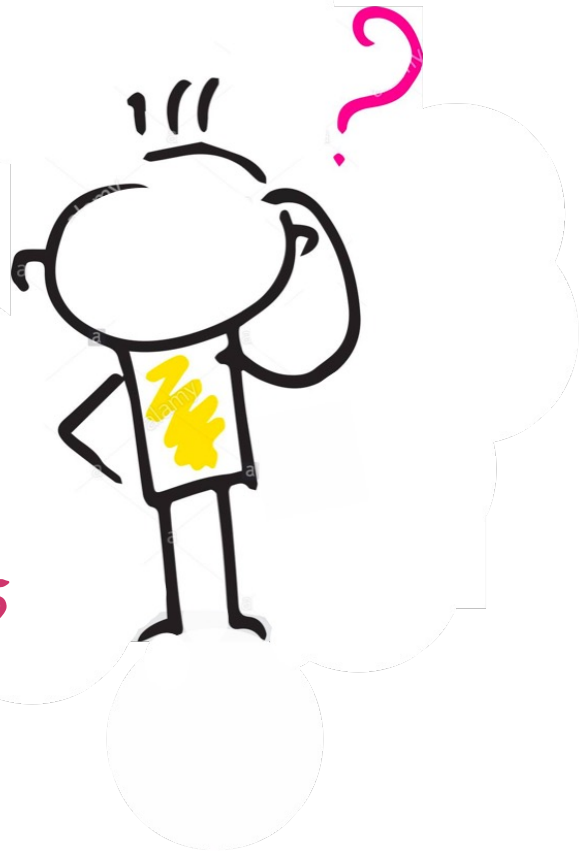
zero @ 0 ↘ pole @ 0 ↙

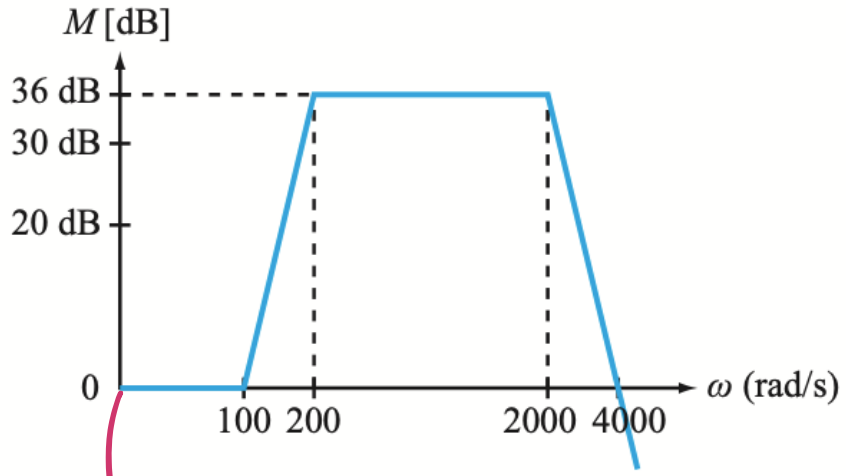
$w = 1 \Rightarrow 0\,dB$

$26dB = 20\log_{10}(K)$

$\frac{26}{20} = \log_{10}(K)$

$K = 10^{26/20} = 19.95$





$0dB = 20\log_{10}(K) \Rightarrow K = 1$

THE OHIO STATE UNIVERSITY

COLLEGE OF ENGINEERING

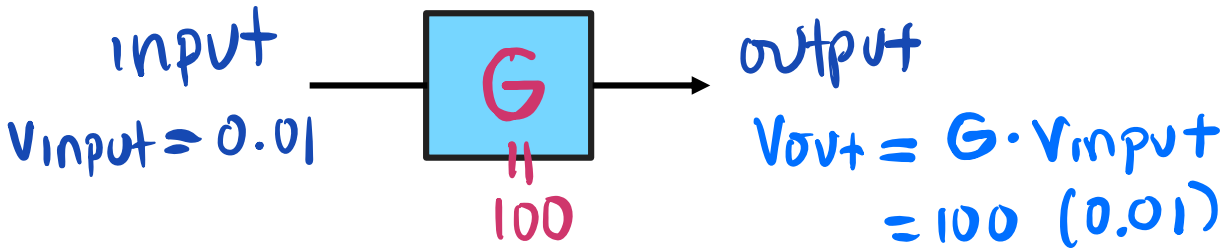
Intro to Operational Amplifiers

This Lecture…

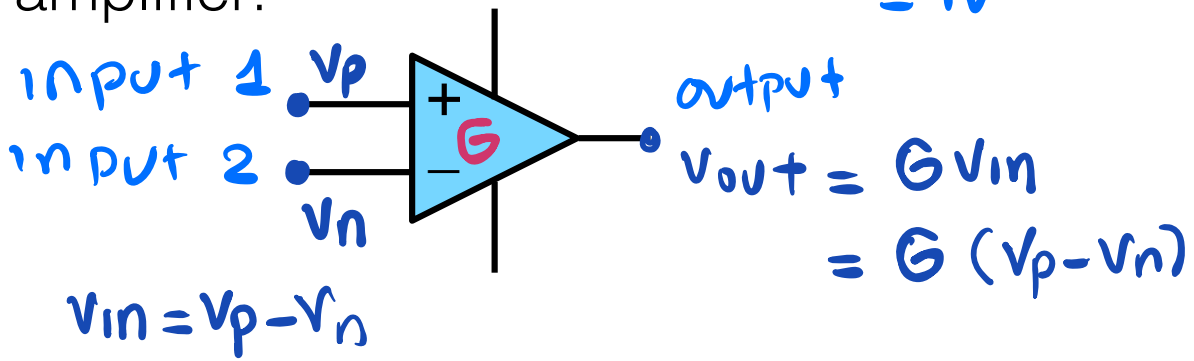
- Learning Objectives:
  - Describe the basic properties of an op amp and state the constraints of the ideal op-amp model.

Amplifiers

- Amplifier:

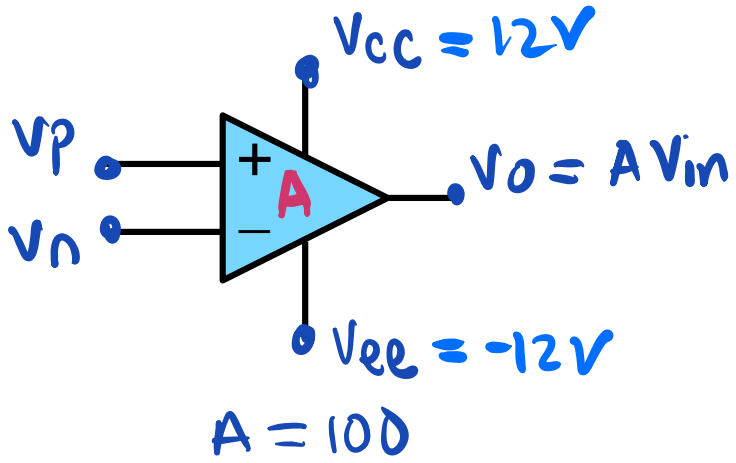


- Operational amplifier:



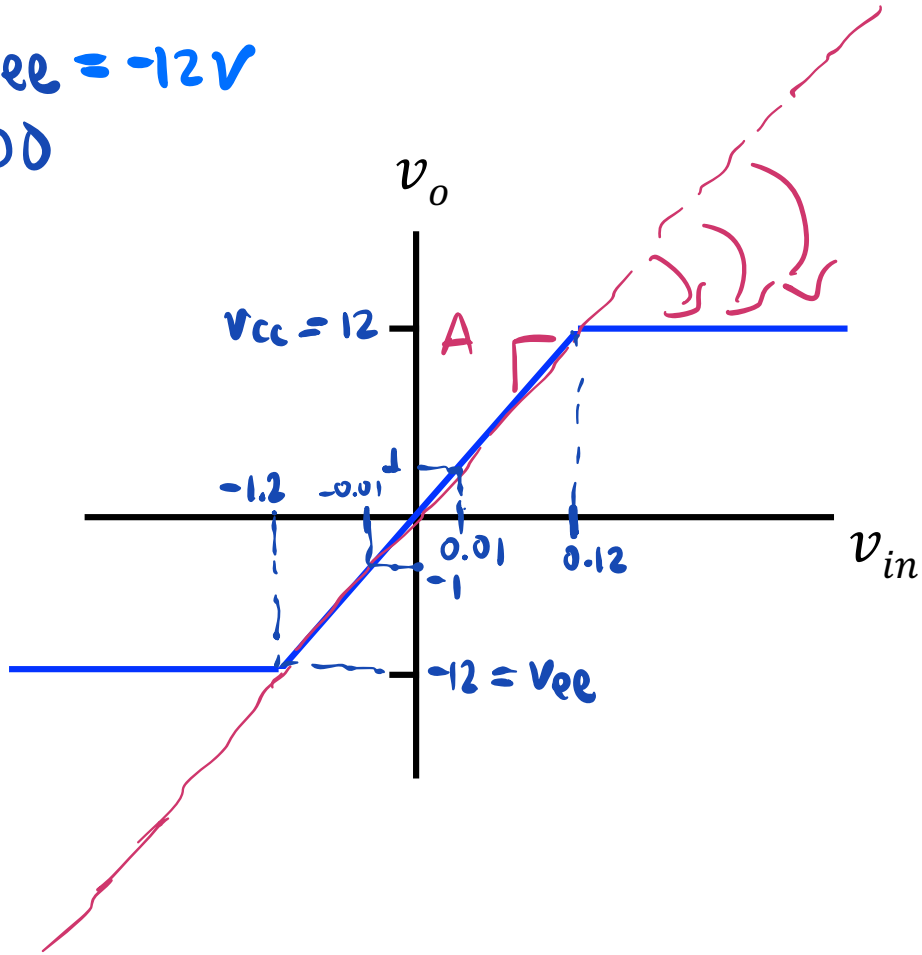
- It acquired the adjective operational because it is a versatile device capable not only of amplifying a signal but also inverting it (reversing its polarity), integrating it, or differentiating it.

Operational Amplifiers



Properties:

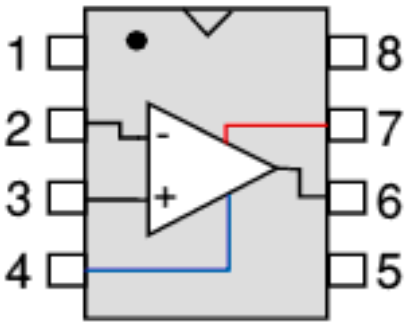
- High Gain: $A = 10^5 - 10^6$
- Differential input: $v_{in} = v_p - v_n$
- Linear operating range:
- Saturated by $+v_{cc}$ and $-v_{ee}$
- Usually $v_{ee} = -v_{cc}$



Operational Amplifiers

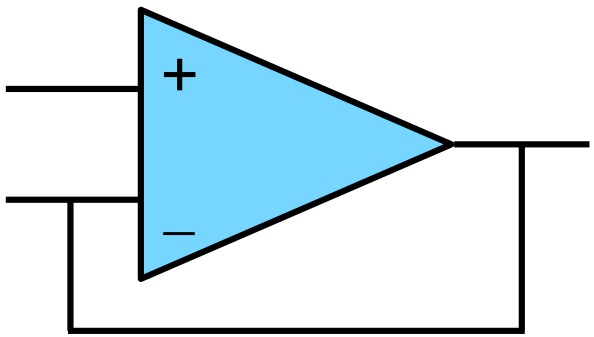
- Amplifier functions:
  - Signal Amplification.
  - Filtering.
  - Add, Subtract, Integrate, Differentiate.

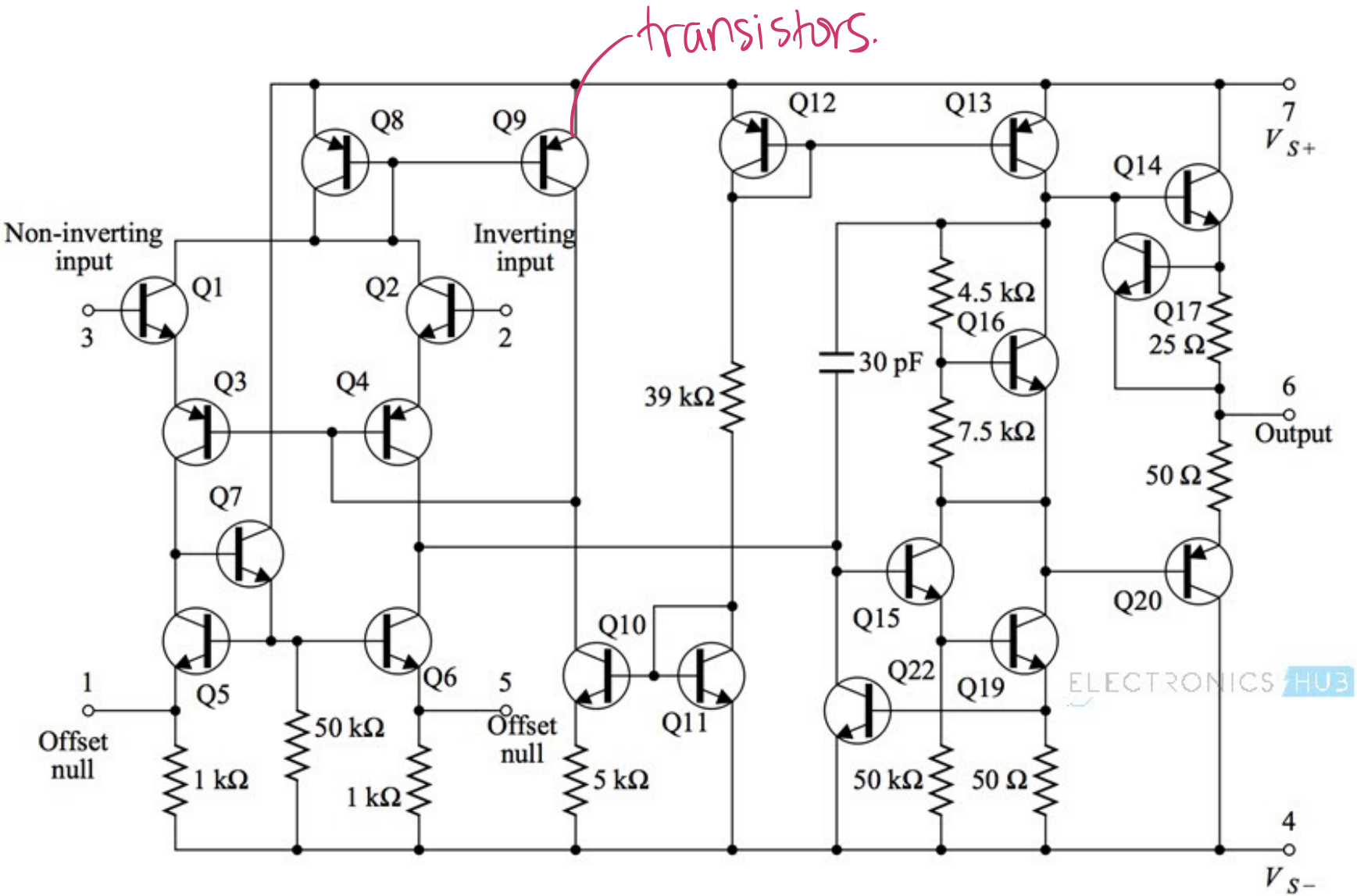
- Example amplifier applications:
  - Digital audio player.
  - Measurement sensors.
  - Feedback.



Feedback

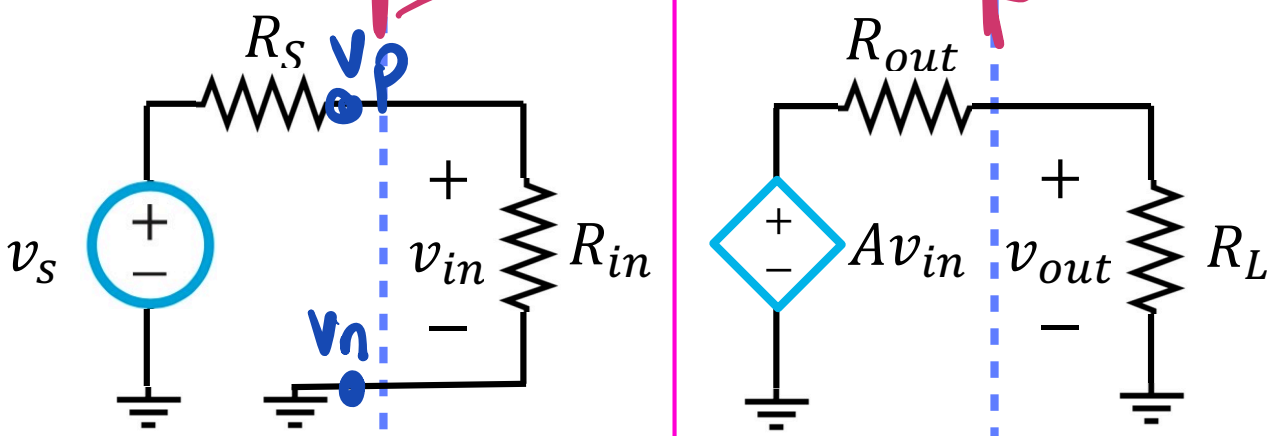
- Process of using the output to reinforce (positive feedback) or inhibit (negative feedback) its input.
  - Open-loop mode if feedback is not used.
  - Closed-loop if feedback is used.
- Key benefits:
  - Decreased sensitivity to signal variations.
  - Increased bandwidth and linearity.
  - Increased signal-to-noise ratio.





Internal Circuitry of 741 Op-Amp IC

Amplifier Behavioral Model



Voltage Division

$$V_{in} = \frac{R_{in}}{R_S + R_{in}} V_S$$

Voltage Division:

$$V_{out} = \frac{R_L}{R_{out} + R_L} \cdot A V_{in}$$

$$V_{out} = \frac{R_L}{R_{out} + R_L} \cdot A \cdot \frac{R_{in}}{R_S + R_{in}} V_S$$

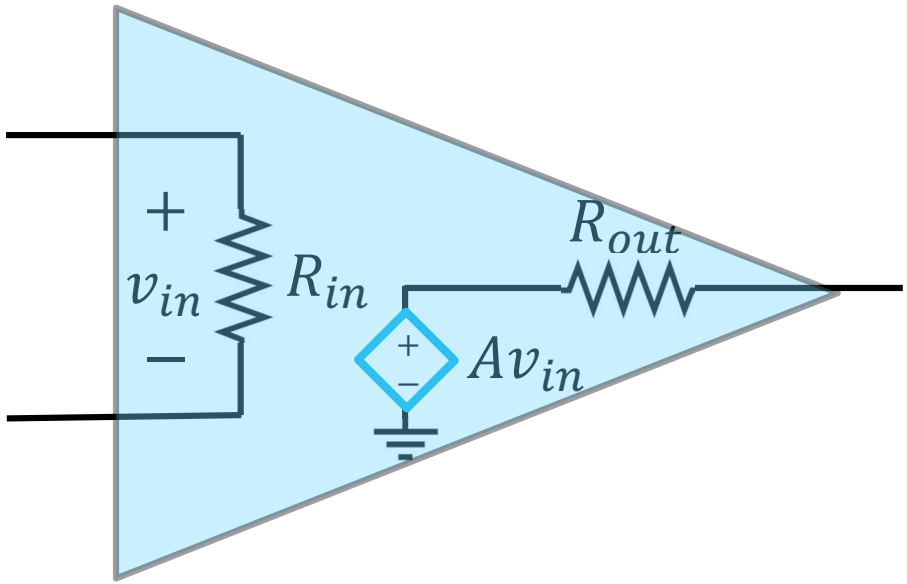
$$V_{out} = A V_S \frac{R_L}{R_{out} + R_L} \cdot \frac{R_{in}}{R_S + R_{in}}$$

Ideally I want

$V_{out} = G \cdot V_{in}$

$R_{out} = 0\,\Omega$ $\quad$ $R_{in} = \infty$

Ideal Amplifier



Ideally

$R_{out} = 0\ \Omega$

$R_{in} = \infty$

$A = \infty$

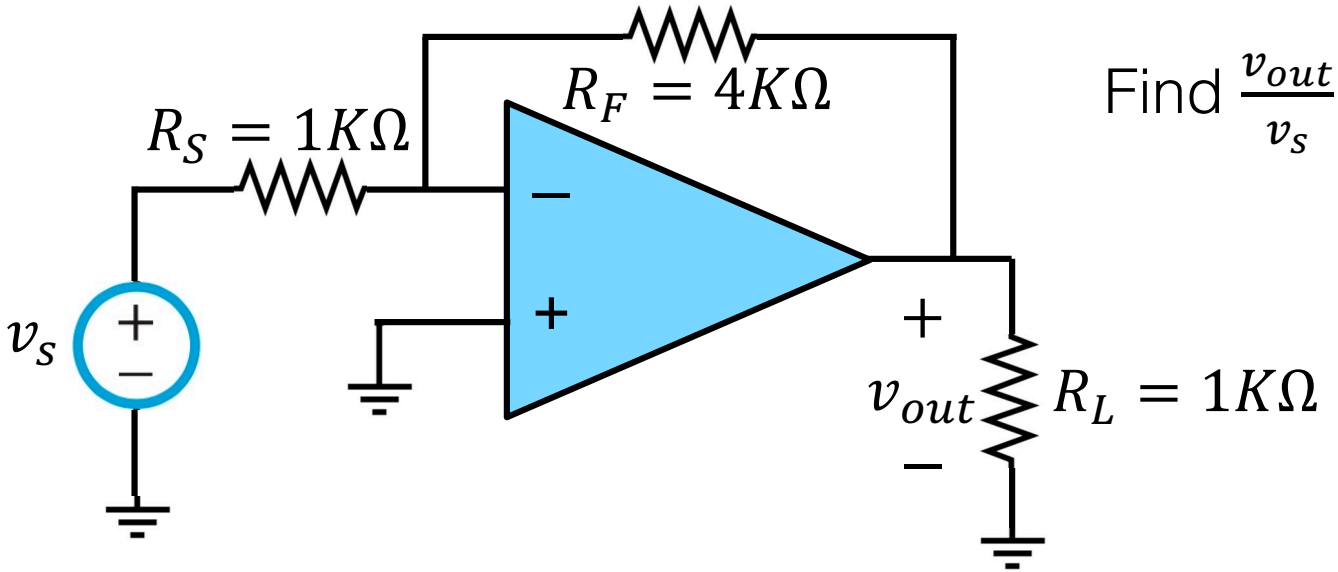
Realistically

$R_{out} = 10 - 100$

$R_{in} = 10^6 - 10^{13}$

$A = 10^6$

Example



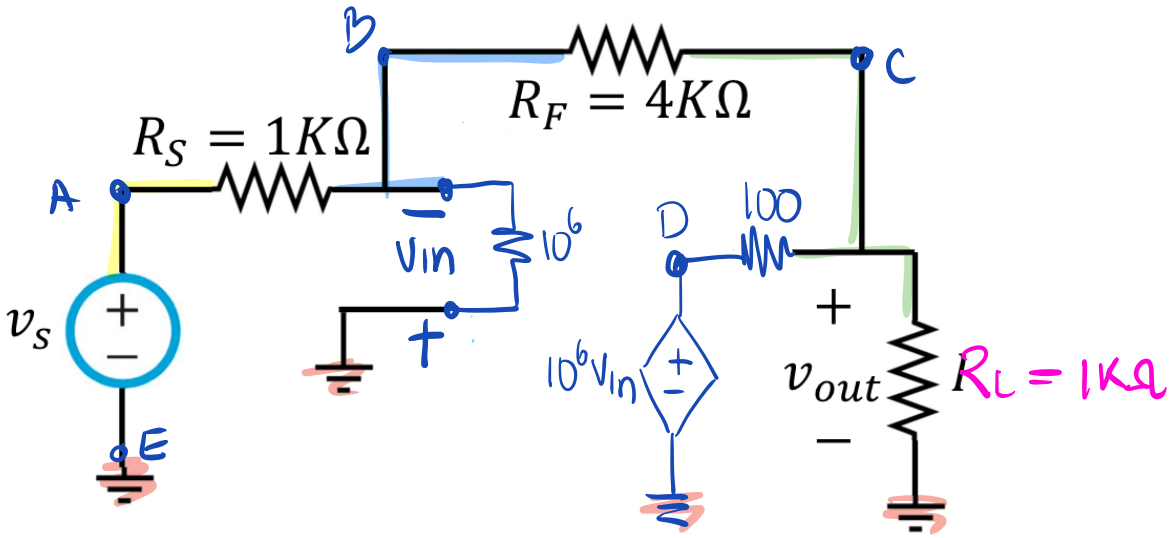
Find $\frac{v_{out}}{v_s}$ given that:

$R_{in} = 10^6\Omega$

$R_{out} = 100\Omega$

$A_{vol} = 10^6$

Behavioral Model



Node Voltage Analysis 5 nodes

$V_E = 0V$ $\quad V_D = 10^6 V_{in} = 10^6 (V_E^{0} - V_B) = -10^6 V_B$

$V_A = V_S$

KCL @ B: $\quad$ KCL @ C

we will finish on Wednesday.