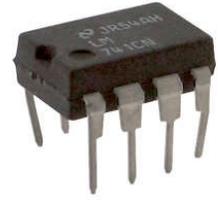


Lesson 9: Operational Amplifiers 1

Operational amplifier

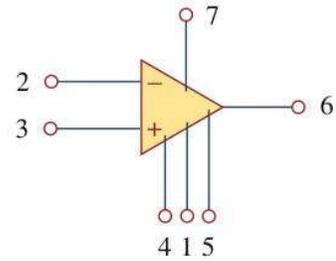
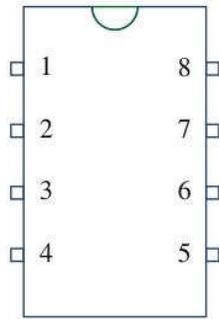
An operational amplifier (op amp) is an active circuit element designed to perform _____ of addition, subtraction, multiplication, division differentiation, and integration.



Although the design of an op amp is complex, we can model it as a _____.

Typical op amp layout

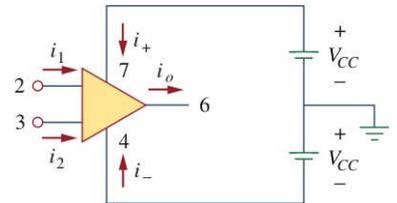
- Inverting input (-), pin 2
- Non-inverting input (+), pin 3
- Output, pin 6
- Positive supply power V^+ , pin 7
- Negative supply power V^- , pin 4



Powering the op amp

Op amps require both a positive and negative power supply voltages (V_{CC}). Applying KCL, we can see $i_o =$

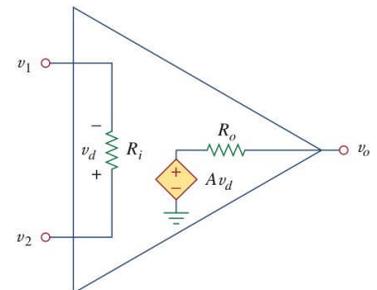
In working problems, we can often ignore the power supplies.



Equivalent circuit model (non-ideal)

We can model an op amp using a voltage-controlled voltage source.

- R_i is the input resistance
- R_o is the output resistance
- A is the _____ voltage gain.
- v_d is the _____ input voltage where $v_d =$



Open-loop gain

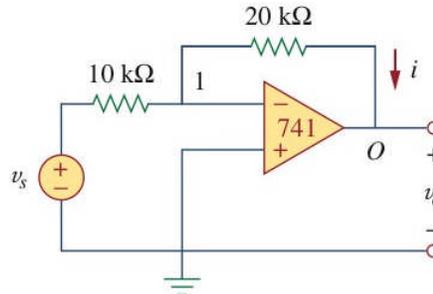
The open-loop voltage gain implies that there is no _____ from output to input.

In this case, the output v_o is given $v_o =$

Feedback

Negative feedback is achieved when the _____ of the op amp is fed back to the _____ input.

The ratio of output voltage to input voltage is called the _____ gain.

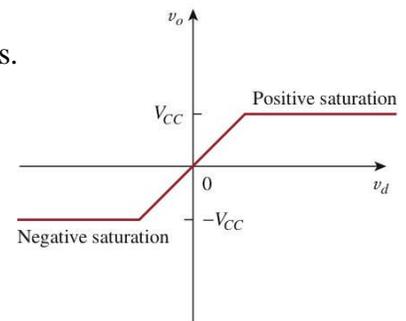


Practical limits

Op amp output voltages are bound by the _____ voltages.

An op amp can operate in three regions

- Positive saturation, $v_o =$
- _____ region, $\leq v_o = Av_d \leq$
- Negative saturation, $v_o =$



Ideal op amp

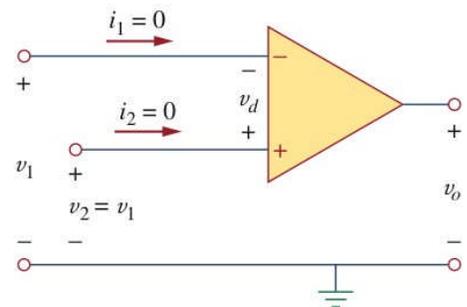
We can simplify the analysis of op amp circuit by using an ideal op amp model.

An ideal op amp has the following characteristics

- _____ open-loop gain, $A \cong$
- _____ input resistance, $R_i \cong$
- _____ output resistance, $R_o =$

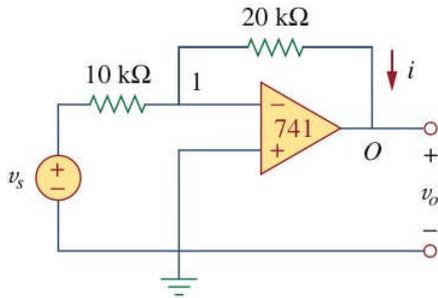
Ideal op amp characteristics

- Input currents (i_1, i_2) are _____.
- The voltage across the input terminals is _____.



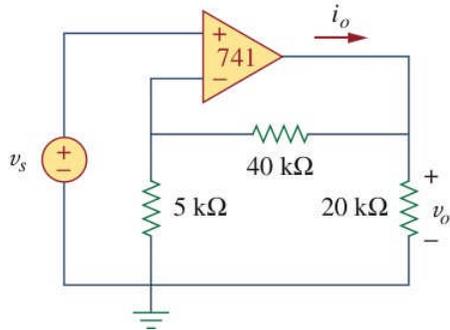
Example Problem 1

A 741 op amp has an open-loop voltage gain of 2×10^5 , input resistance of $2 \text{ M}\Omega$, and output resistance of 50Ω . The op amp is used in the circuit below. Find the closed-loop voltage gain v_o/v_s . Determine the current i when $v_s = 2 \text{ V}$.



Example Problem 2

A 741 op amp has an open-loop voltage gain of 2×10^5 , input resistance of $2 \text{ M}\Omega$, and output resistance of 50Ω . The op amp is used in the circuit below. Find the closed-loop voltage gain v_o/v_s . Determine the current i_o when $v_s = 1 \text{ V}$.



Example Problem 3

Using ideal op amp assumptions, calculate the closed loop gain v_o/v_s . Find i_o when $v_s = 1 \text{ V}$.

