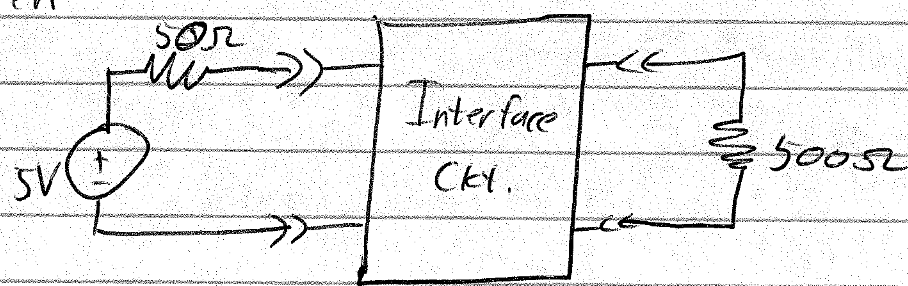
Make sure you read Section 4-5 on Op Amp Circuit Design.

Taking one example, Ex 4-22:

Given



Design an interface ckt so that 200mW of power is delivered to the 500Ω load.

1st - Do we need an interface other than a wire? - What maximum power could we get from 5V + 50Ω source? $P_{max} = \frac{1}{4}\frac{V_{oc}^2}{R_T}$

$$= \frac{1}{4}\frac{(5V)^2}{50\Omega} = \frac{1}{8}W$$

$$= 0.125W = 125\ mW$$

And this would be into a 50Ω load, less into a 500Ω load, so we need gain.

2.) Easiest to design for voltage gain, so let's think: To deliver 200mW power into 500Ω load, what must v_L be?

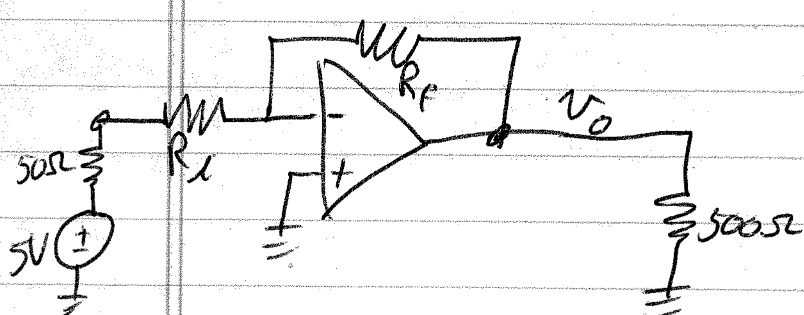
$$200\ mW = \frac{v_L^2}{500\Omega}$$

$$v_L^2 = (500\Omega)(0.2W) = 100\ V^2$$

$$\underline{\underline{v_L = \pm 10V}}$$

To get ±10V out from a 5V input we need a gain of $K = \frac{v_{out}}{v_{in}} = \frac{\pm 10V}{5V} = \pm 2.$

Can get this either inverting or non-inverting:



$$v_o = -\frac{R_f}{R_i(+50\Omega)} 5V$$

Such that $\frac{R_f}{R_i(+50\Omega)} = 2$

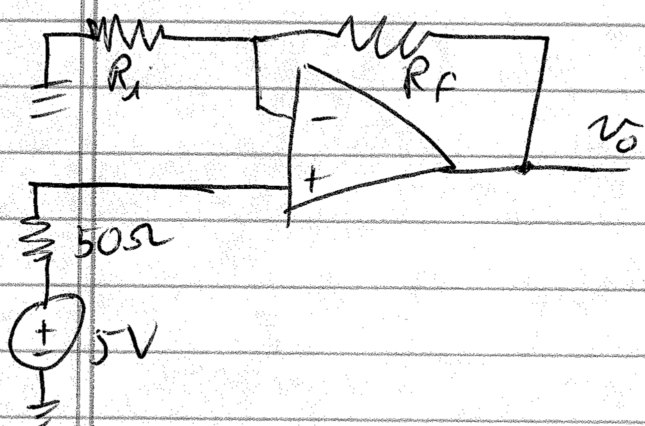
Choose R_i large compared to 50Ω, say 50kΩ, ignore 50Ω, and pick $R_f = 100k\Omega$, so

$$\underline{v_o = -\frac{100k\Omega}{50k\Omega} 5V = -10V}$$

Could use any other combination of

$R_f = 2R_i$ + $R_i \gg 50\Omega$

Non-inverting



$$G = \left(1 + \frac{R_f}{R_i}\right) = 2$$

or $\frac{R_f}{R_i} = 1$

or $R_f = R_i$

No restrictions, although to keep currents reasonable we should use $k\Omega$ range values.

Pick $R_f = R_i = 10k\Omega$ and get

$$v_o = \left(1 + \frac{10k}{10k}\right)5V = 2(5V) = \underline{\underline{10V}}$$

Pick from the 2?

1.) Noninverting draws no current from source, and uses same R values for R_f + R_i (no possibility of mixing them up)

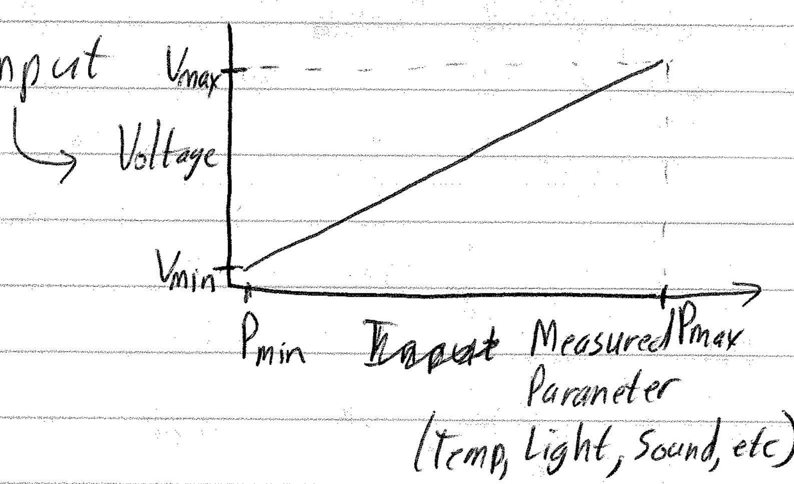
2.) Inverting draws current from source (small) + has different values for R_f + R_i.

Be sure to read the sections on
OP AMP Ckt. Design - (4-5)
Design + Evaluation Examples 4-22 + 4-23

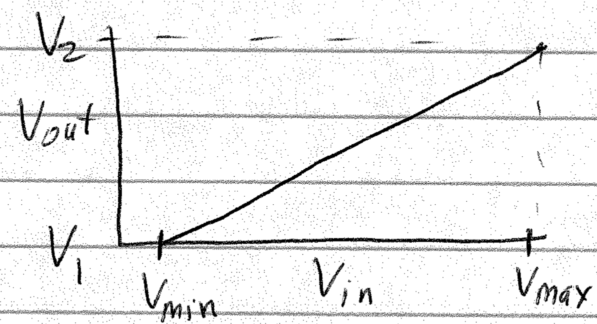
and 4-6, OpAmp Circuit Applications

An example there is for "Instrumentation," a common use of Op Amps, taking a signal from a sensor of some sort and changing it to meet the needs of an input device like an Analog to Digital Converter, or A/D Converter, or ADC.

The text shows examples of how to take a linear input



and convert it to the desired range:

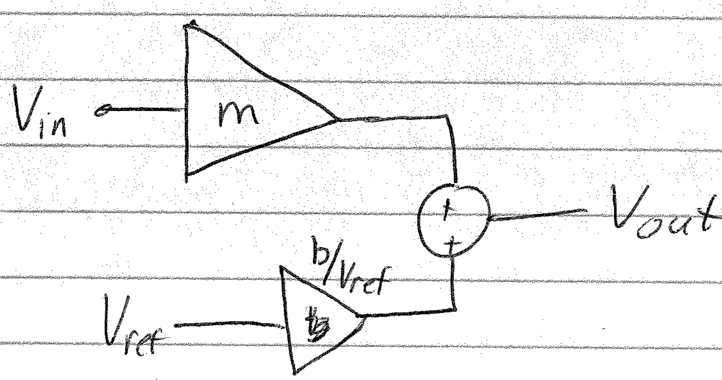


$$V_{out} = m\,V_{in} + b$$

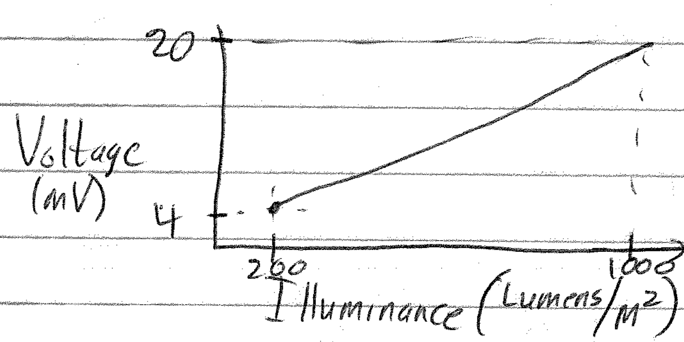
$$m = \frac{V_2 - V_1}{V_{max} - V_{min}}$$

$$b = V_2 - m\,V_{max}$$

You can construct this using:



Example from text: Light meter



We want to scale this to fit an ADC that accepts 0-5V input.

Using our formulas:

$$m = \frac{5V - 0V}{20mV - 4mV} = \frac{5V}{16mV} = 312.5$$

$$b = 5V - (312.5)(20mV) = -1.25V$$

So our desired output will be

$$V_{out} = 312.5\, V_{in} - 1.25V$$

312.5 is a little big to do in 1 step.

Factor it, choose an easy thing like

25: $\frac{312.5}{25} = 12.5$ (exactly ½ of 25, good)

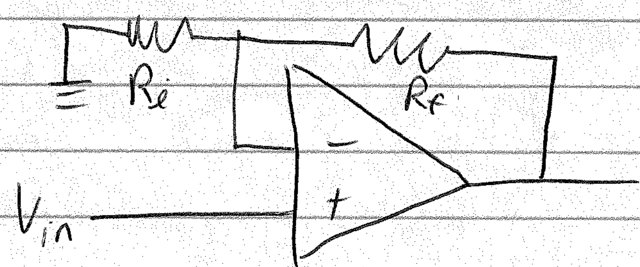
In the text, they chose to set the slope with two inverting stages, $312.5 = (-25)(-12.5)$

Let me do it as two noninverting stages

$$312.5 = (25)(12.5)$$

I will then subtract the intercept by scaling a standard voltage I can get in my circuit, say a regulated 5 V, or scale by $\frac{1.25\text{ V}}{5\text{ V}} = \underline{0.25} = \frac{1}{4}$

Use a non inverting op amp to get the 25:

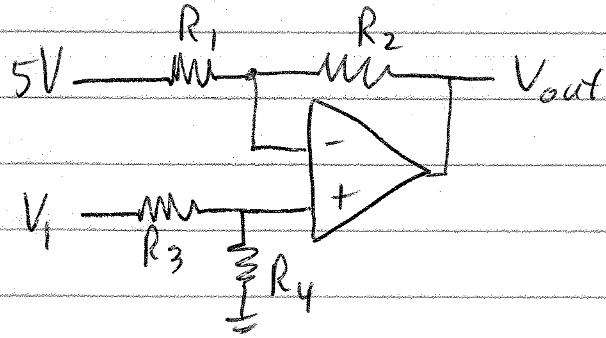


$V_1 = \left(1 + \frac{R_f}{R_i}\right) V_{in}$

want 25, so $\frac{R_f}{R_i} = 24$.

Pick $R_i = 10\text{k}\Omega$, so $\underline{R_f = 240\text{k}\Omega}$

Then use a subtractor to get 12.5 + −0.25:



$V_{out} = -\underbrace{\frac{R_2}{R_1}}_{=1/4}(5V) + \underbrace{\left(\frac{R_1+R_2}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right)}_{=12.5} V_1$

Pick $R_1 = 100\text{k}\Omega$ so $\frac{R_2}{R_1} = \frac{1}{4} \Rightarrow R_2 = \frac{100\text{k}\Omega}{4} = 25\text{k}\Omega$

So $\frac{R_1+R_2}{R_1} = \frac{100k\Omega + 25k\Omega}{100k\Omega} = \frac{125k\Omega}{100k\Omega} = \underline{1.25}$

and we want $(1.25)\left(\frac{R_4}{R_3+R_4}\right) = 12.5$

or $\frac{R_4}{R_3+R_4} = 10$

Pick $R_3 = 100k\Omega$ (as a trial)

$$R_4 = 10(100k\Omega + R_4)$$
$$-9R_4 = 1000k\Omega$$
$$R_4 = -111.1k\Omega$$

!!! cannot do this !!!

Look back: $V_{out} = -\frac{R_2}{R_1}(5V) + \left(1+\frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3+R_4}\right)$

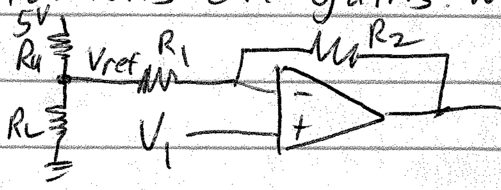
if this $= \frac{1}{4}$, then this $= 1\frac{1}{4}$,

requiring the $\left(\frac{R_4}{R_3+R_4}\right)$ to be

>1, but that is

impossible!!

So, we find out that this ~~method~~ proposed solution will not work, because of limitations on gains we can achieve.



Let's go ~~the~~ another way: Pick ~~$\frac{R_4}{R_3+R_4}$ to be~~

$R_4 = \infty$ (leave it out entirely) then R_3 can be 0 and $\frac{R_4}{R_3+R_4} = 1$. $\left(\frac{\infty}{\infty}\right)$

Now pick $\frac{R_1+R_2}{R_1} = 12.5$, using $R_2 = 100k\Omega$

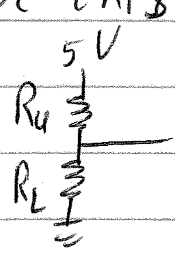
$$R_1 + 100k\Omega = 12.5\,R_1$$
$$100k\Omega = 11.5\,R_1$$

$$R_1 = \frac{100k\Omega}{11.5} = 8.7\,k\Omega$$ (This will be $R_1 + R_u // R_L$)

Now $\frac{R_2}{R_1} = \frac{100k\Omega}{8.7k\Omega} = 11.5$, so to get

$(11.5)(V_{ref}) = 1.25V$ we need $V_{ref} = \frac{1.25V}{11.5} = 0.1087V$

I can achieve this from 5V using a voltage divider:



$$0.1087V = \frac{R_L}{R_u + R_L} 5V$$

Pick $R_L = 1k\Omega$, and get:

$$\left(\frac{1k\Omega}{R_u+1k\Omega}\right)5V = 0.1087V$$

$$\frac{1k\Omega}{R_u+1k\Omega} = \frac{0.1087}{5} = 0.02174$$

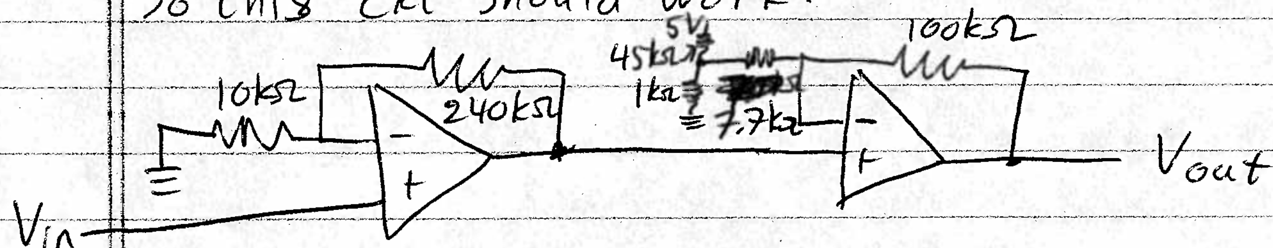
$$1k\Omega = 0.02174\, R_u + 1k\Omega(0.02174)$$

$$1k\Omega - 21.74\Omega = 0.02174\, R_u$$

$$\frac{978.26\,\Omega}{0.02174} = \underline{R_u = 45\,k\Omega}$$

So $R_1 = 8.7k\Omega - (1k\Omega \| 45k\Omega) = 7.7k\Omega$

So this ckt should work:



The text example came up with: