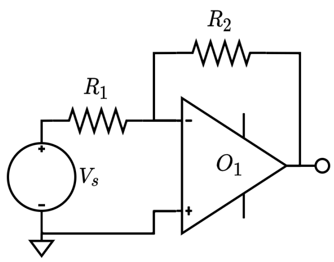
Operational amplifier circuits

1. Simple inverting op-amp

The ideal operational amplifier is supported as a 3-terminal element. Let's see how the program handles circuits with OpAmps included. The analysis is done as with any other circuit.

```
circuit = Circuit('circuits/r_op_amp.txt');
circuit.list
```

```
ans =
    'Vs 1 0 AC Vs
     R1 1 2 R1
     R2 2 3 R2
     O1 0 2 3
     '
```




```
ELAB.analyze(circuit)
```

```
Symbolic analysis successful (0.261925 sec).
```

```
circuit.symbolic_node_voltages
```

ans =

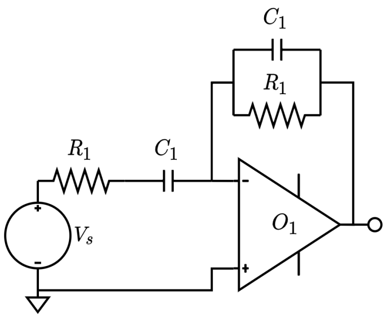
$$\begin{pmatrix} v_1 = \mathrm{Vs} \\ v_2 = 0 \\ v_3 = -\dfrac{R_2\,\mathrm{Vs}}{R_1} \end{pmatrix}$$

2. Inverting op-amp with additional reactive elements.

This is a slightly more complex example. We are still dealing with an inverting amplifier configuration.

```
circuit = Circuit('circuits/rc_op_amp.txt');
circuit.list
```

```
ans =
    'Vs 1 0 AC Vs
     R1 1 2 20000
     R2 3 4 20000
     C1 2 3 C1
     C2 3 4 C2
     O1 0 3 4
     '
```



Suppose we want to know what values for the capacitors, we need to choose, to achieve poles at $p_1 = -1000\,\mathrm{rad}/s$ and $p_2 = -5000\,\mathrm{rad}/s$.

```
ELAB.ec2sd(circuit,1,4)
```

```
Symbolic analysis successful (0.549786 sec).
Symbolic transfer function calculated successfully (5.603227e-01 sec).
ans =
```

$$\frac{v_4}{v_1} = -\frac{C_1\,R_2\,s}{(C_1\,R_1\,s+1)\ (C_2\,R_2\,s+1)}$$

From this transfer function, it is immediately apparent, that if $R_1 = R_2 = 20k\Omega$, then $C_1 = 1/1000R_1 = 0.05\mu F$ and $C_2 = 1/5000 = 0.01\mu F$.