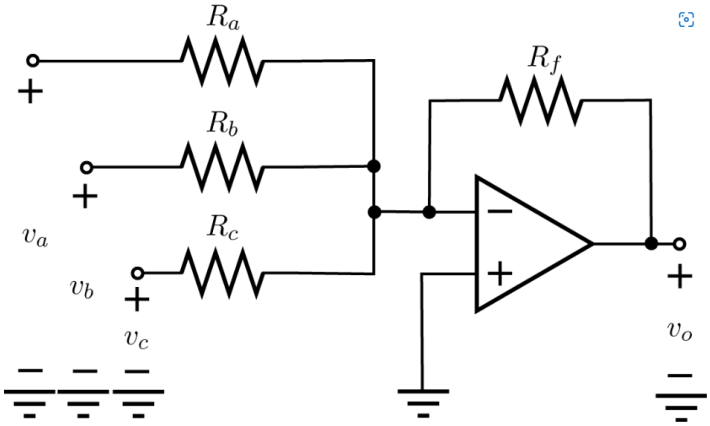
# Problem 2.3.3




Given the above circuit, where:

- $R_a = 1k\Omega$
- $R_b = 2k\Omega$
- $R_c = 3k\Omega$
- $R_f = 12k\Omega$
- $v_a = -4V$
- $v_b = +2V$
- $v_c = 1V$

The power supplies for the op-amp are +15V and −15V. What is the value of $v_o$?

While

$$v_o = G_1 v_a + G_2 v_b + G_3 v_c$$

$$G_1 = -\frac{R_f}{R_a},\ G_2 = -\frac{R_f}{R_b},\ G_3 = -\frac{R_f}{R_c}.$$

Therefore

```
Ra = 1e3;
Rb = 2e3;
Rc = 3e3;
Rf = 12e3;
va = -4;
vb = 2;
vc = 1;
v_o = (-Rf/Ra)*va ...
      + (-Rf/Rb)*vb ...
      + (-Rf/Rc)*vc
```

```
v_o = 32
```

$v_o = 32V$

The calculated output voltage is greater than 15 so saturation occurs and $v_o$ is equal to the power supply voltage of 15 volts.

What must be $R_a$ be changed to so that $v_o = 13V$?

```
syms Ra
f(Ra) = (-Rf/Ra)*va ...
      + (-Rf/Rb)*vb ...
      + (-Rf/Rc)*vc == 13;
% Compute analytic solution of a symbolic equation
solution = solve(f,Ra);
% Display symbolic solution returned by solve
displaySymSolution(solution);
```

```
solution =
```

$$\frac{48000}{29}$$

$R_a = 1.6552k\Omega$