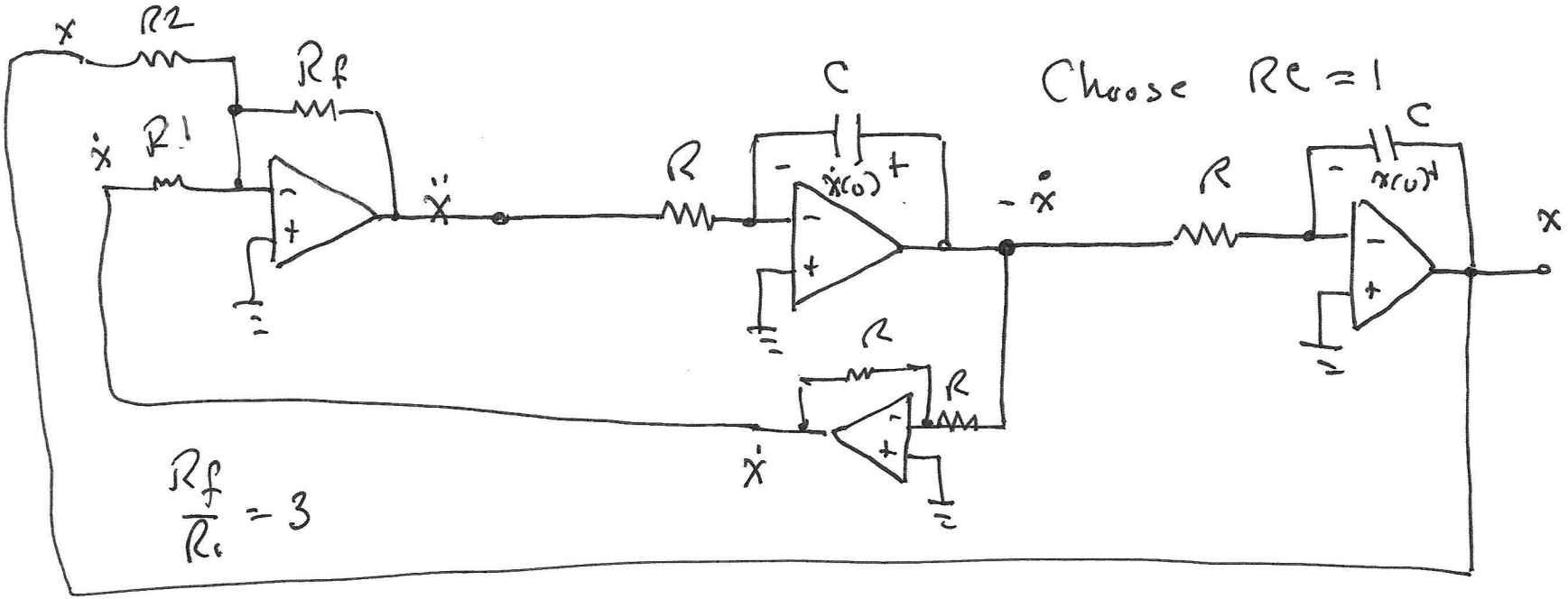
$$\ddot{x} + 3\dot{x} + 2x = 0$$

$$\ddot{x} = -3\dot{x} - 2x$$

Design an analog computer to solve for x.



$$\frac{R_f}{R_1} = 3$$

$$\frac{R_f}{R_2} = 2$$

Exam #2 will be available next Thursday, November 4, and due the following Tuesday, November 9.

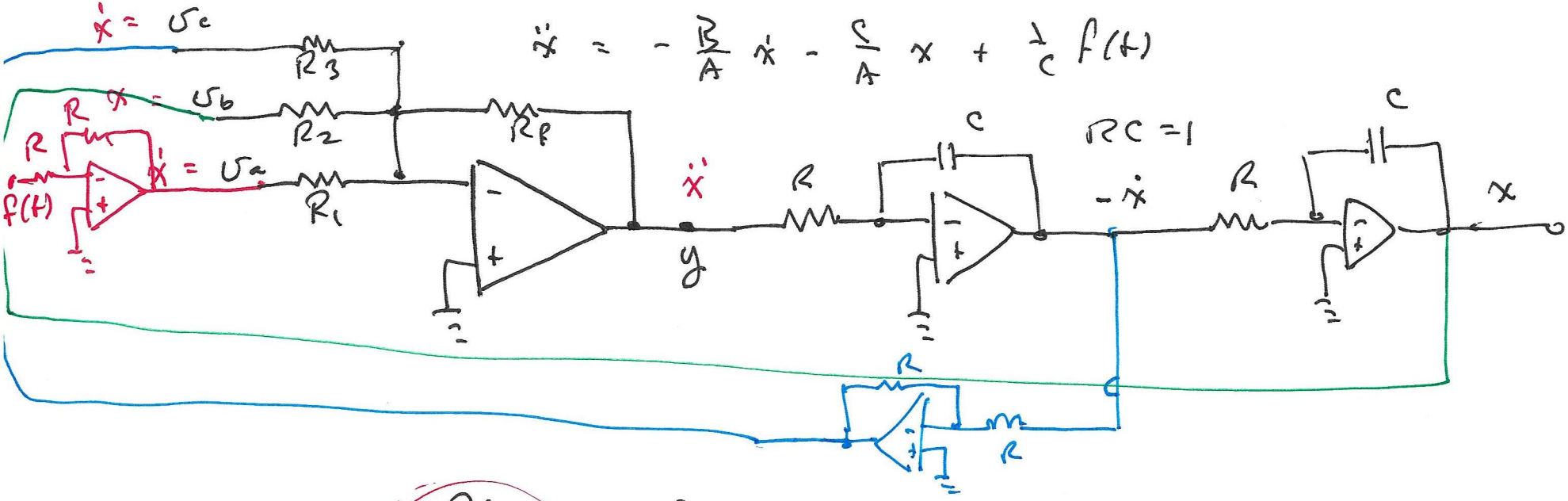
No class on Thursday, November 4.

Homework	20%
Exam 1	20%
Exam 2	20%
Final Exam	40%
	100%

$$A\ddot{x} + B\dot{x} + Cx = f(t)$$

$$\Rightarrow \quad \ddot{x} + \frac{B}{A}\dot{x} + \frac{C}{A}x = \frac{1}{C}f(t)$$

$$\ddot{x} = -\frac{B}{A}\dot{x} - \frac{C}{A}x + \frac{1}{C}f(t)$$



$$y = -\frac{R_f}{R_3}v_c - \frac{R_f}{R_2}v_b - \frac{R_f}{R_1}v_a$$

$$\frac{R_f}{R_3} = \frac{B}{A} \qquad \frac{R_f}{R_2} = \frac{C}{A} \qquad \frac{R_f}{R_1} = \frac{1}{C}$$

For example, $A = 2$, $B = 6$, $C = 1$

$$\frac{R_f}{R_3} = \frac{6}{2} = \frac{B}{A} \qquad \frac{R_f}{R_2} = \frac{C}{A} = \frac{1}{2} \qquad \frac{R_f}{R_1} = \frac{1}{C} = 1$$

$$\frac{R_f}{R_3} = \frac{6}{2} = 3$$

$$\frac{R_f}{R_2} = \frac{1}{2}$$

$$\frac{R_f}{R_1} = 1$$

Choose $R_f = 10\,k\Omega$

$$\frac{10\,k\Omega}{R_3} = 3 \Rightarrow R_3 = \frac{10}{3}\,k\Omega$$

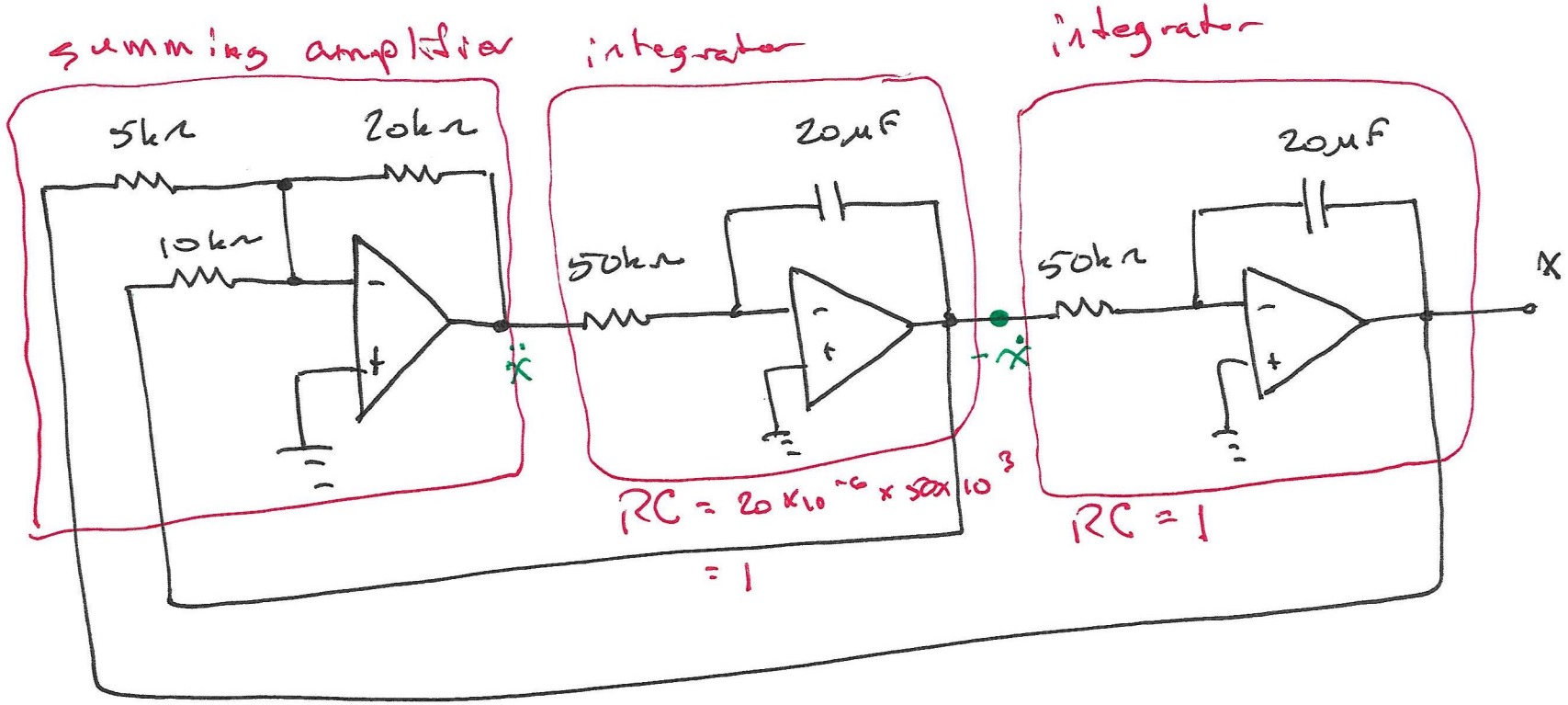
$$\frac{10\,k\Omega}{R_2} = \frac{1}{2} \Rightarrow R_2 = 20\,k\Omega$$

$$\frac{10\,k\Omega}{R_1} = 1 \Rightarrow R_1 = 10\,k\Omega$$

For the integrators, $RC = 1$

Arbitrarily Choose $R = 10k\Omega$

$$C = \frac{1}{10000} = 100\mu F$$

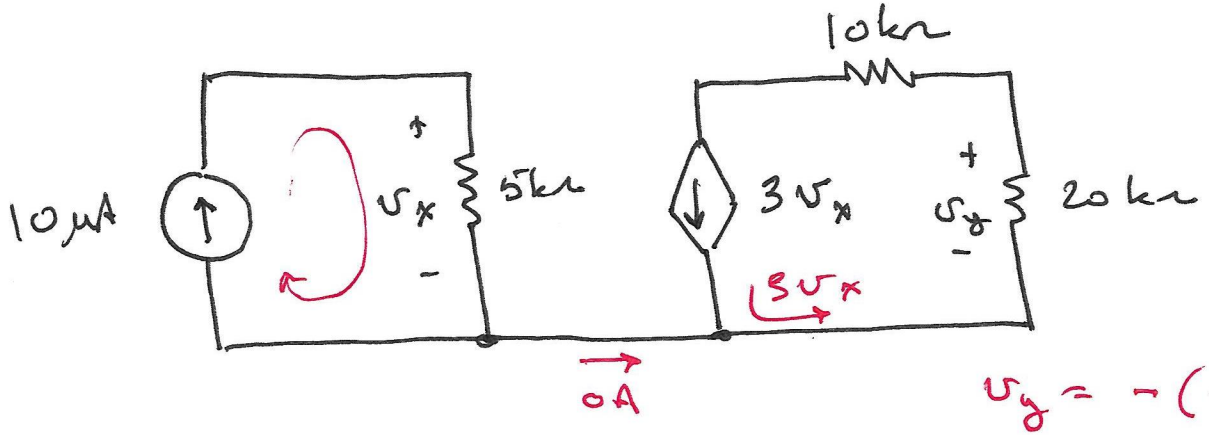


2nd order because there are 2 integrators

$$\ddot{x} = -\frac{20k\Omega}{5k\Omega}x - \frac{20k\Omega}{10k\Omega}(-\dot{x})$$

$$= -4x + 2\dot{x}$$

$$\boxed{\ddot{x} - 2\dot{x} + 4x = 0}$$



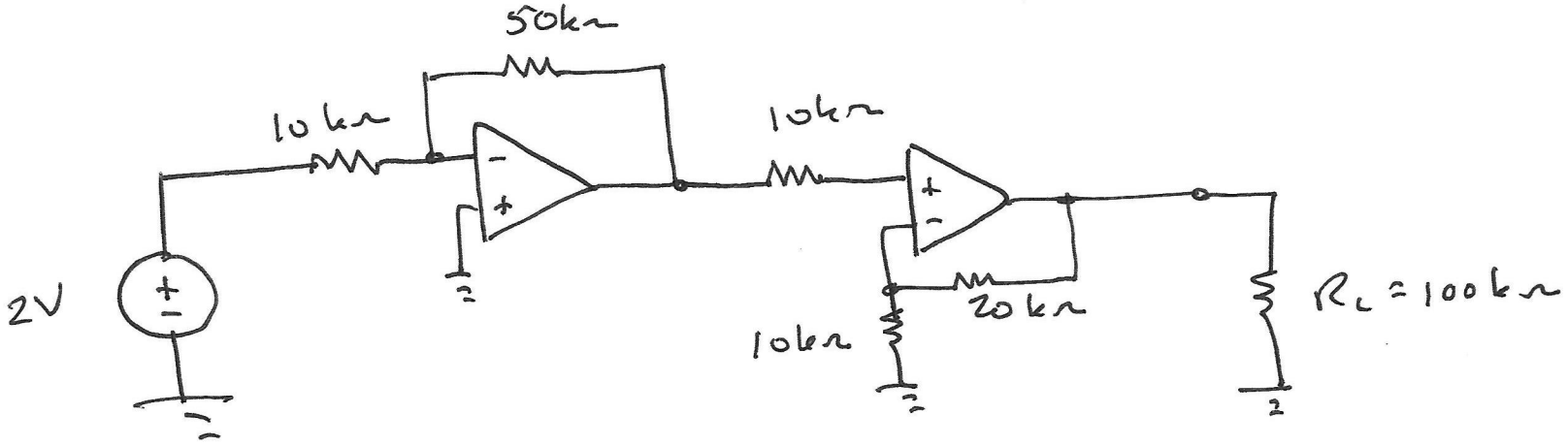
Find v_y.

$v_y = -(20k\Omega)\, 3v_x$

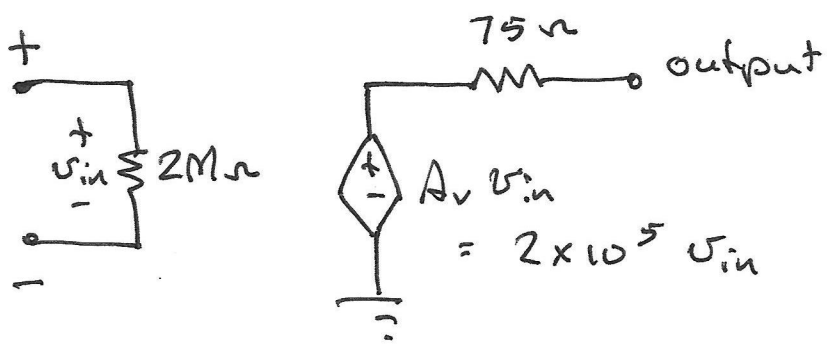
$v_x = (5k\Omega)(10\mu A) = 50mV$

$v_y = -(20k\Omega)\boxed{3(50mV)}$ amperes

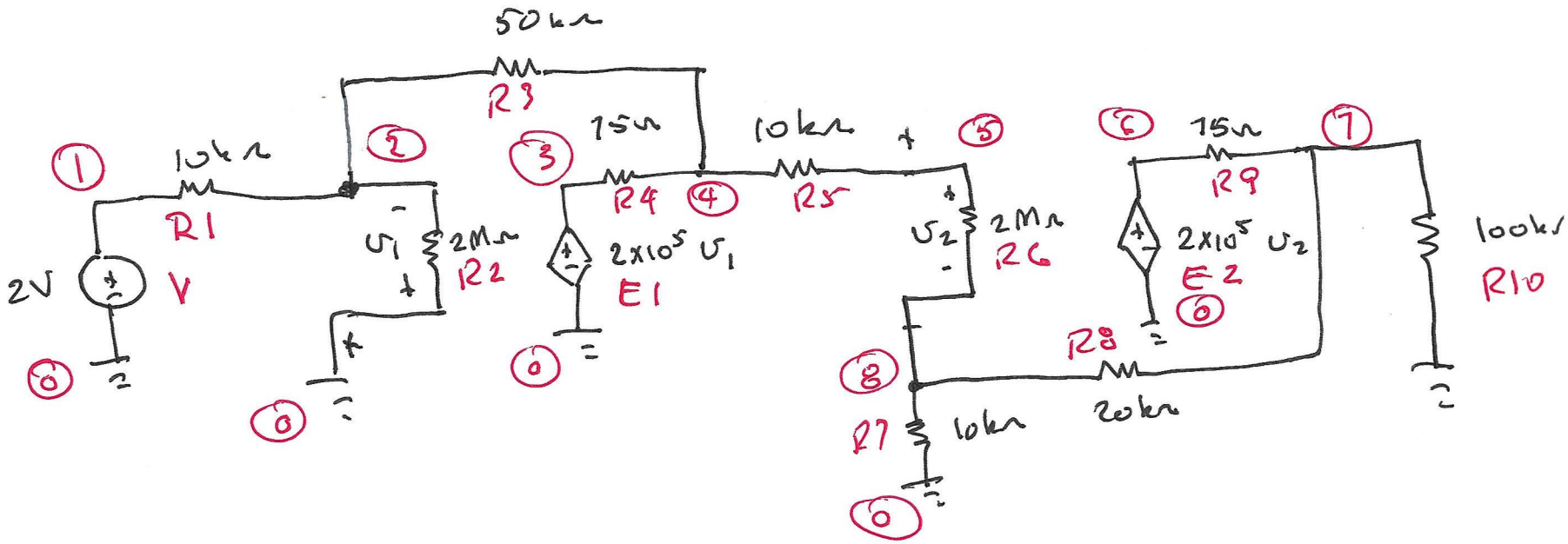
$= -3kV$



The opamps are ideal.



Close Model for an "ideal" Op Amp



```
V     1     0     DC     2
R1    1     2     10k
R2    2     0     2MEG
R3    2     4     50k
R4    3     4     75
E1    3     0     0      2     2E5
R5    4     5     10k
R6    5     8     2MEG
R7    8     0     10k
R8    8     7     20k
R9    6     7     75
E2    6     0     5      8     2E5
R10   7     0     100k
.OP
```