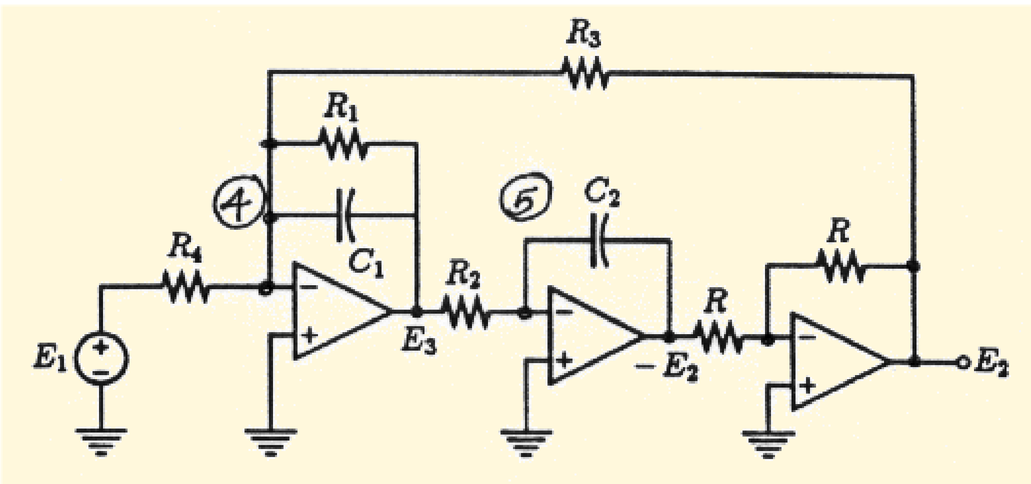
Matlab Symbolically Solving for Voltage Transfer Functions:

E2/E1 and E3/E1

Step1: Identify proper nodes whereby Nodal Analysis can be applied successfully.

(Idea): Node (4) and node (5) are proper nodes, that is at the "input" side of the OA. Because the output impedance of an OA is very very small compared to external R C's, thus nodal equations can not be written there. Another way of saying, the node voltage will be multiplied by a very large admittance values. Not practical at all.

Step2: Use knowledge of Nodal Analysis (basically apply Ohms Law), write down the node (4) and node (5) equations. Call it **eq4** and **eq5**.(they are shown in Matlab code below)




```
% TTbiquad2.m

syms s R1 R2 R3 R4 R C1 C2 E1 E2 E3 E4
eq4= -E1/R4 - (1/R1+s*C1)*E3 - E2/R3;
eq5= -E3/R2 + s*C2*E2;
[E2,E3]=solve(eq4,eq5,E2,E3);

[n,d]=numden(E2/E1);
pretty(sort(n)/sort(d))

[n,d]=numden(E3/E1);
pretty(sort(n)/sort(d))
```

Execution Results,

```
>> TTbiquad2

                     R1 R3
      - ----------------------------------------
                2
        R4 (s  R1 C1 R3 R2 C2 + s R3 R2 C2 + R1)
```

$$-\frac{s\,C2\,R1\,R3\,R2}{R4\,(s^2\,R1\,C1\,R3\,R2\,C2 + s\,R3\,R2\,C2 + R1)}$$

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These voltages transfer function results, E2/E1 and E3/E1, agrees with Su's textbook, ANALOG FILTER page 243 and also demonstrated by MapleV symbolic CAD at http://faculty.capitol-college.edu/~andresho/tutor/mapleV/TUTsolve1.htm)