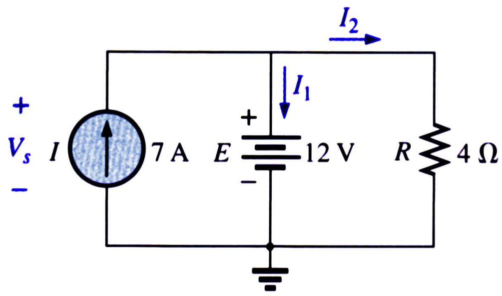
Practice problems for Lesson 3

Circuits with E, J and R

B11's Example 8.2

Determine the values of V_S, I_1 and I_2.



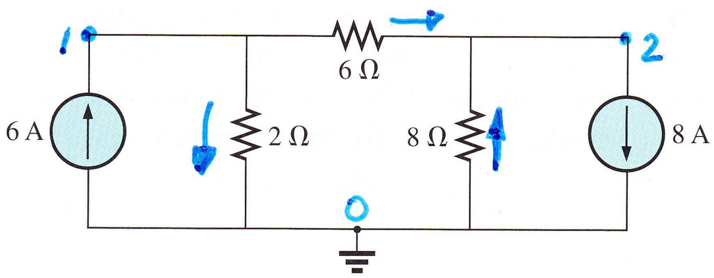
In the line below, we concatenate three commands using colons. The first stores the circuit's definition in a variable. The second asks Symbulator to run a DC simulation of the circuit described in that variable. The third asks the calculator to provide us the values of three variables that – given the circuit description – answer the questions.

```
s\dc("j,0,1,7:e,1,0,12:r1,1,0,4"):
{v1,ie,ir1}
```

The calculator returns **{12,4,3}**, meaning V_S is 12V, I_1 is 4A and I_2 is 3A. These are the correct answers. We will continue to use the single line instruction as we move on.

B11's Example 8.15

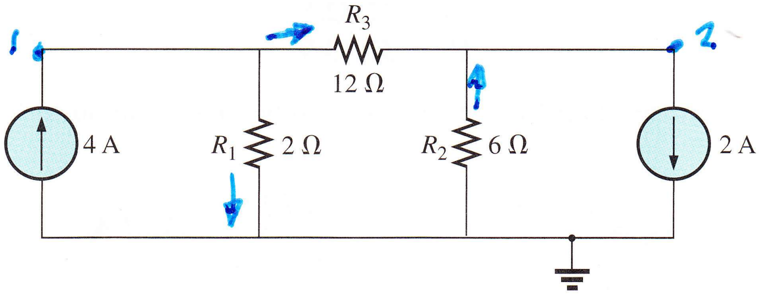
Determine the current through each resistor. My solution below, direction in blue:




```
s\dc("j6,0,1,6:r2,1,0,2:r6,1,2,6:r8,0,2,8:j8,2,0,8"):
approx({ir2,ir6,ir8})
```

We get these answers: **{1.25,4.75,3.25}**. So I_{R2} is 1.25A, I_{R6} is 4.75A, and I_{R8} is 3.25A.

B11's Example 8.21



Determine the voltage in each node and the current through each resistor.

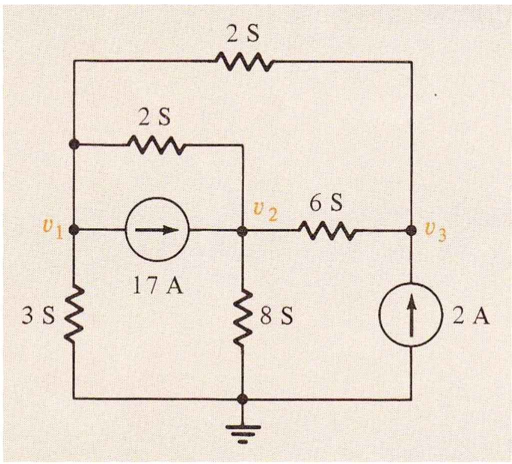
My solution below:

```
s\dc("j1,0,1,4:r1,1,0,2:r3,1,2,12:r2,0,2,6:j2,2,0,2"):
{v1,v2,ir1,ir2,ir3}
```

We get the following answers: **{6,-6,3,1,1}**. So V_1=6V, V_2=-6V, I_{R1}=3A, and I_{R2}=I_{R3}=1A.

Bo2's Drill Exercise 2.2 (Conductances)

Given the circuit below, determine the voltages in the nodes.



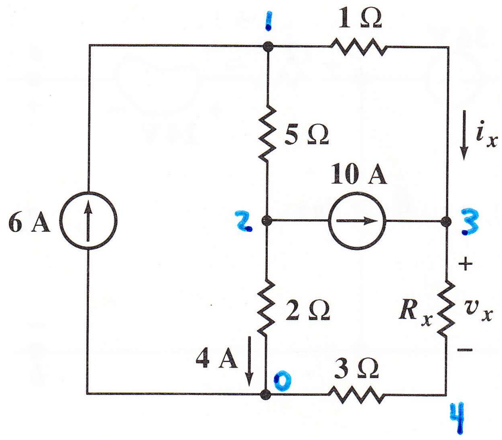
Below my solution:

```
s\dc("r10,1,0,1/3:r12,1,2,1/2:r13,1,3,1/2:r23,2,3,1/6:
r20,2,0,1/8:j12,1,2,17:j03,0,3,2"):approx({v1,v2,v3})
```

The answer, **{-2.,1.,.5}**, indicates v_1=-2V, v_2=1V, v_3=0.5V. This is correct.

HK5's Figure 1-24b (Expert)

Determine i_x and v_x in the following circuit.



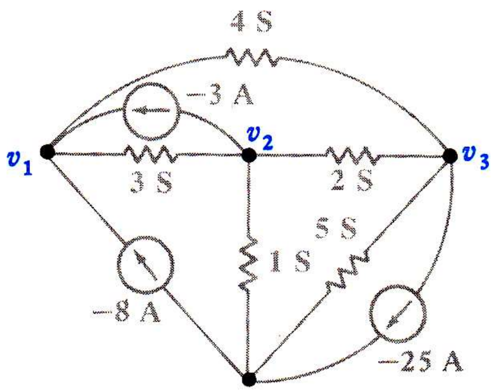
My solution below:

```
s\ex("j6,0,1,6:r5,1,2,5:r2,2,0,2:r1,1,3,1:
r3,0,4,3:j10,2,3,10:rx,3,4,rx"):{ir1,vrx}
```

Select DC. Add equation `ir2=4`. Add unknown `rx`. Run the simulation. The answer, **{-8,80}**, means that I_X is -8A and that V_X is 80V.

HK5's Example 2.2 (Conductances)

Determine the voltages in the nodes. My solution below:

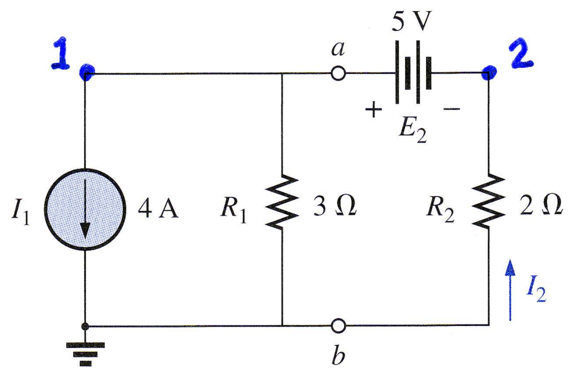



```
s\dc("j01,0,1,-8:j30,3,0,-25:j21,2,1,-3:r12,1,2,1/3:r23,2,3,1/2:r13,1,3,1/
4:r20,2,0,1:r30,3,0,1/5"):{v1,v2,v3}
```

The answer, **{1,2,3}**, is correct: v_1=1V, v_2=2V, v_3=3V.

B11's Example 8.5

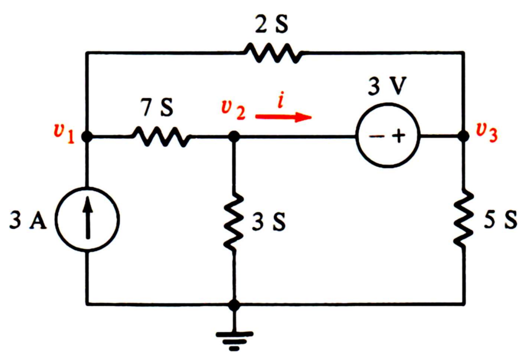
Determine the current I_2 in the circuit shown below. My solution is below the circuit.



s\dc("j1,1,0,4:r1,1,0,3:e2,1,2,5:r2,0,2,2"):approx(ir2)

This gives us a value for I_2 of **3.4** A. This is correct.

Bo2's Example 2.5 (Conductances)



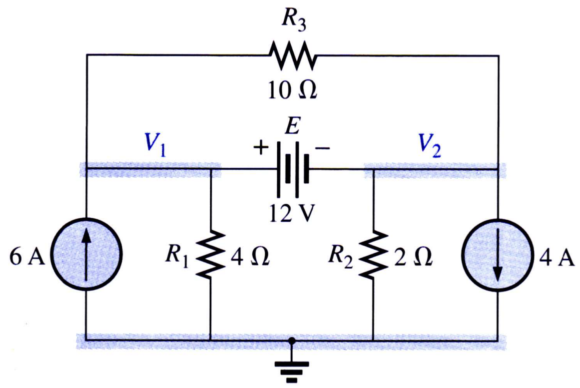
Determine the voltages in the nodes, and the current through the voltage source.

s\dc("j,0,1,3:e,3,2,3:r12,1,2,1/7:r20,2,0,1/3:r30,3,0,1/5:r13,1,3,1/2"):
approx({v1,v2,v3,-ie})

The answer, **{-.5,-1.5,1.5,11.5}**, is correct: v_1=-.5, v_2=-1.5, v_3=1.5, i=11.5

B11's Example 8.22

Determine V_1 and V_2. My solution below:

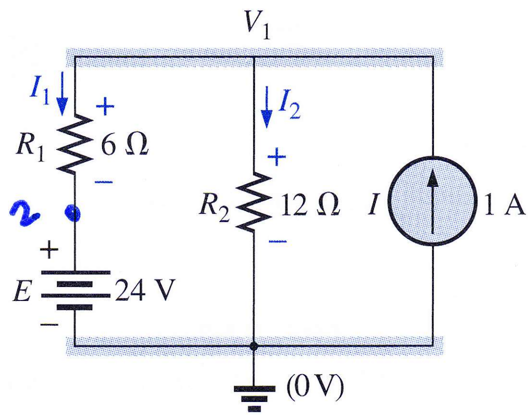


s\dc("j1,0,1,6:r1,1,0,4:e,1,2,12:r3,1,2,10:r2,2,0,2:j2,2,0,4"):
approx({v1,v2})

The answer, **{10.67,-1.33}**, tells us that V_1 is 10.67V and V_2 is -1.33V.

B11's Example 8.19

Determine V_1, I_1 and I_2, in the circuit below:

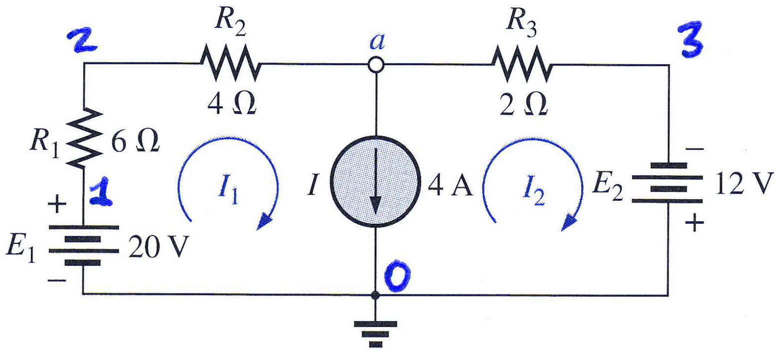


My solution below:

s\dc("e,2,0,24:r1,1,2,6:r2,1,0,12:j,0,1,1"):approx({v1,ir1,ir2})

The answer, **{20.,-.667,1.67}**, tells us that V_1 is 20V, I_1 is -.667A and I_2 is 1.67V.

B11's Example 8.14



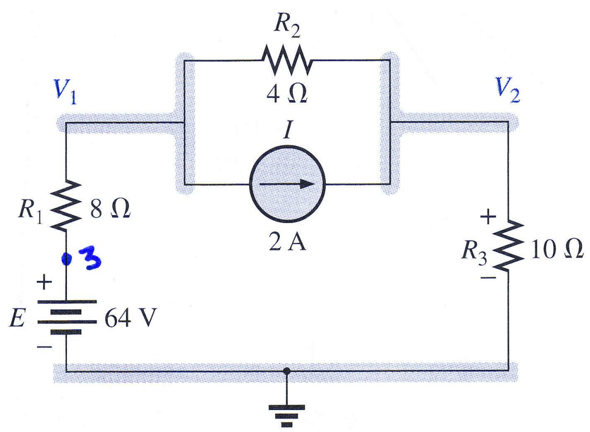
Determine I_2 and I_3.

```
s\dc("e1,1,0,20:r1,1,2,6:r2,2,a,4:j,a,0,4:r3,a,3,2:e2,0,3,12"):
approx({ir2,ir3})
```

Answer: **{3.33,-.666}**. This is correct.

B11's Example 8.20

Determine V_1, V_2, , I_1, I_2 and I_3. My solution is found below the circuit schematic:

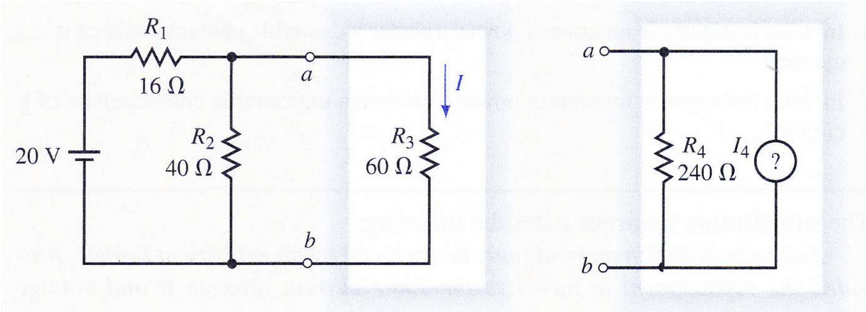



```
s\dc("e,3,0,64:r1,3,1,8:r2,1,2,4:j,1,2,2:r3,2,0,10"):
approx({v1,v2,ir1,ir2,ir3})
```

Answer: **{37.82,32.73,3.27,1.27,3.27}**. You should know how to read these by now, but here it is just in case: V_1 = 37.82V, V_2 = 32.73V, I_1 = 3.27A, I_2 = 1.27A, I_3 = 3.27A.

RM3's Example 9-12 (*solve*)

If R_3 is to be replaced with R_4 and I_4, determine the value and direction of the source.



So that we can keep the name of node b, we will use the top left node as reference.

First, make sure you understand what this problem is asking you to do. The idea is that, despite the change, we keep the same voltage drop and current flow between nodes ***a*** and ***b***. We must first know what they are. So we simulate the original circuit:

```
s\dc("e,0,b,20:r1,0,a,16:r2,a,b,40:r3,a,b,60"):{va-vb,ir3}
```

We find that the voltage drop is 12V and the current is 0.2A. These are the currents and voltages that we have to keep once we do the replacement. Simulate the circuit now replacing R_3 with a resistor R_4 of 240Ω and a source **j** with value I_4. Run this:

```
s\dc("e,0,b,20:r1,0,a,16:r2,a,b,40:r4,a,b,240:j,a,b,i4")
```

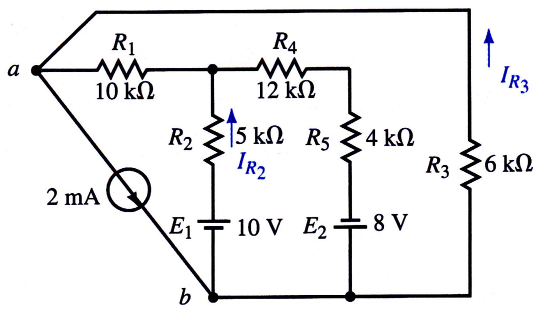
Notice that both the voltage drop (given by `va-vb`) and the current (given by `ir4+ij`) are algebraic functions in terms of i4. Now you can find i4 solving by voltage drop:

`solve(va-vb=12.,i4)` …or by current flow… `solve(ir4+ij=0.2,i4)`

The result is the same: i4 = **.15** A The required current source is .15A from ***a*** to ***b***.

RM3's Example 8-13

Solve for the currents through R_2 and R_3 in the circuit shown. My solution is below:

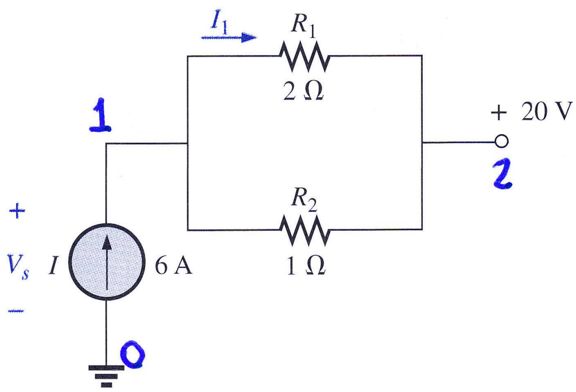


```
s\dc("r1,a,0,10'k:r2,1,0,5'k:r3,b,a,6'k:r4,0,2,16'k:
j,a,b,2'm:e1,1,b,10:e2,b,2,8"):approx({ir2,ir3})
```

The answer, **{.00154,.00111}** is correct: I_{R2} = 1.54 mA and I_{R3} = 1.11 mA.

B11's Example 6.3 (Hidden source)

Determine V_S and I_1.



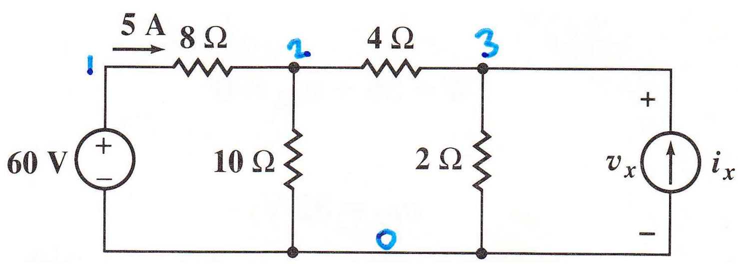
The problem presents a seemingly 'hanging' node with 20V. To simulate this, imagine a 'hidden' 20V voltage source connected to the node.

```
s\dc("j,0,1,6:r1,1,2,2:r2,1,2,1:e,2,0,20"):
{v1,ir1}
```

We get the answer: **{24,2}**, which is correct. V_S is **24**V and I_1 is **2**A.

HK5's Figure 1-24c (Expert)

Determine i_x and v_x in the following circuit.

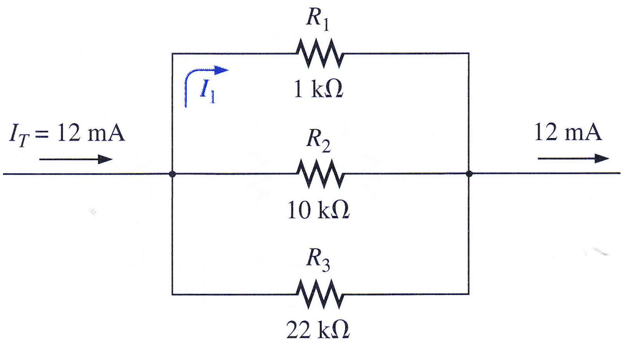



```
s\ex("e,1,0,60:r8,1,2,8:r10,2,0,10:r4,2,3,4:r2,3,0,2:j,0,3,ix"):
{ix,v3}
```

Select DC. Add equation ir8=5. Add unknown ix. Run the simulation, and you will get: **{1,8}**. This is correct: I_X is 1A and that V_X is 8V.

B11's Example 6.22 (Hidden source)

Determine I_1.



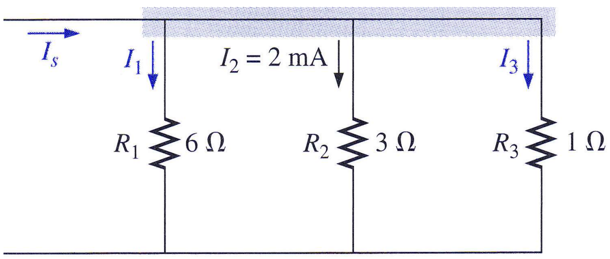
Although no source is shown, the circuit has a current. I use a 'hidden' current source.

```
s\dc("jt,0,1,12'm:r1,1,0,1'k:r2,1,0,10'k:r3,1,0,22'k"):approx(ir1)
```

We get I1 = **10.48** mA, which is correct.

B11's Example 6.21 (Hidden source, Expert)

Determine I_S, I_1 and I_3.



This 'hidden source' problem is perfect for Expert. My solution:

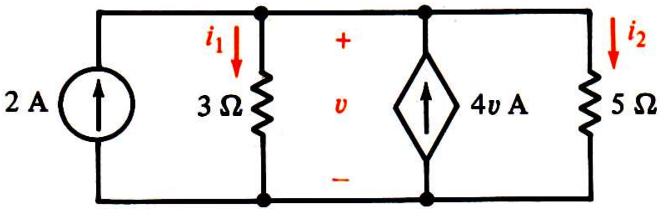
```
s\ex("js,0,1,is:r1,1,0,6:r2,1,0,3:r3,1,0,1"):approx({is,ir1,ir3})
```

Select DC, and press Enter. Add equation ir2=2'm. Add unknown is. Run the simulation. The answer, **{.009,.001,.006}**, is correct, since the currents are as follows: I_S is 9mA, I_1 is 1mA and I_3 is 6mA.

Circuits with dependent sources

Bo2's Example 1.9

Determine I_1, I_2 and v.



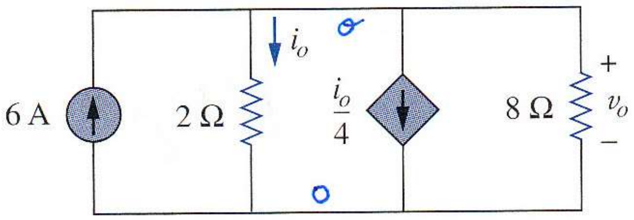
This is my solution.

```
s\dc("ji,0,1,2:r1,1,0,3:jd,0,1,4v1:r2,1,0,5"):{ir1,v1,ir2}
```

The answer, **{-5/26,-15/26,-3/26},** is correct: I_1=-5/26, I_2=-3/26 and v=-15/26.

AS2's Practice Problem 2.7

Find v_o and i_o in the circuit. My solution below:

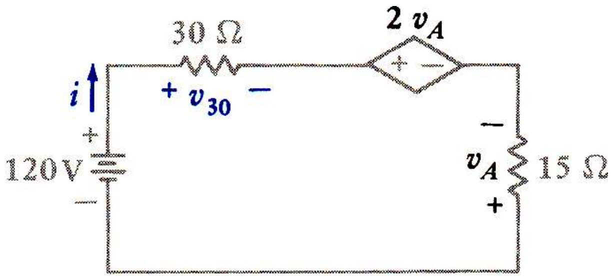



```
s\dc("ji,0,o,6:ro,o,0,2:jd,o,0,iro/4:r8,o,0,8"):{vo,iro}
```

The answer, **{8,4}**, is correct: v_o = 8 and i_o = 4.

HK5's Example 1-3

Determine the power delivered by each source and consumed by both resistors.

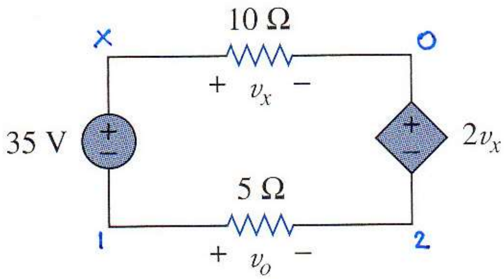


s\dc("ei,1,0,120:r1,1,2,30:ed,2,3,2vra:ra,0,3,15"):{-pei,-ped,pr1+pra}

The answer, **{960,1920,2880}**, is right: the independent source delivers 960W, the dependent source delivers 1920W, and the resistors consume 2880W together.

AS2's Practice Problem 2.6

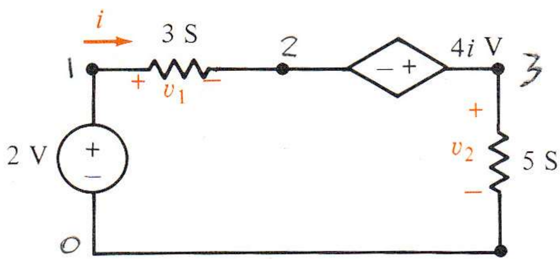
Find v_x and v_o in the circuit. My solution below:



s\dc("ei,x,1,35:rx,x,0,10:ed,0,2,2vx:ro,1,2,5"):{vx,vro}

The answer, **{10,-5}**, is correct: v_x =10 and v_o =-5.

Bo2's Example 1.10

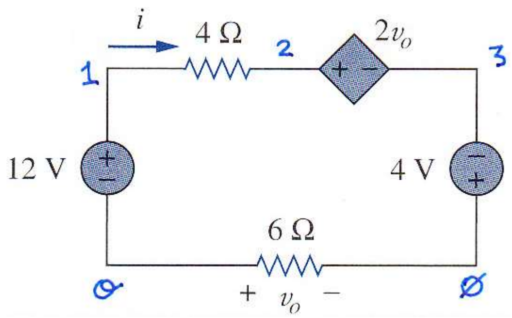


Determine v_1, v_2 and i. My solution below. The simulation took 14 seconds.

s\dc("ei,1,0,2:r1,1,2,1/3:ed,3,2,4*ir1:r2,3,0,1/5"):{ir1,vr1,vr2}

The answers, **{-15/26,-5/26,-3/26}**, is correct: v_1=-5/26, v_2=-3/26 and i=-15/26.

AS2's Example 2.6



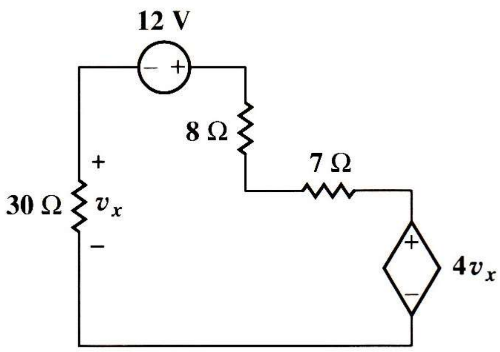
Determine v_o and *i* in the circuit. My solution is shown below:

```
s\dc("e12,1,o,12:ri,1,2,4:ed,2,3,2vo:e4,0,3,4:ro,o,0,6"):{vo,iri}
```

The answer, **{48,-8}**, is correct: v_o =48 and *i* = -8.

HK5's Drill Problem 1.11

Find the power absorbed by each element in the circuit. My solution below:

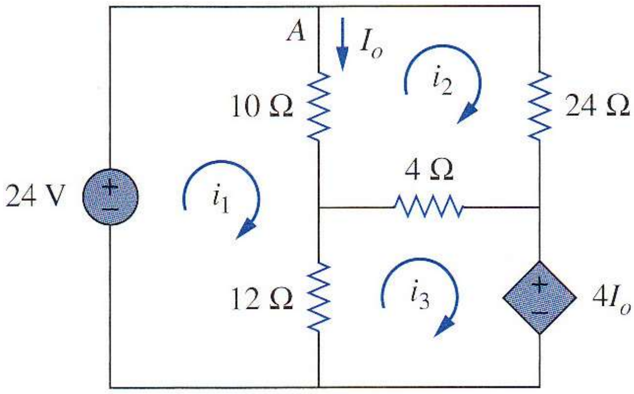



```
s\dc("r1,x,0,30:ei,1,x,12:r2,1,2,8:r3,2,3,7:ed,3,0,4vx"):
approx({pr1,pei,pr2,pr3,ped})
```

The answer, **{.768,1.92,.2048,.1792,-3.072}**, is correct.

AS2's Example 3.6

Determine the value of I_o in the circuit. My solution below:

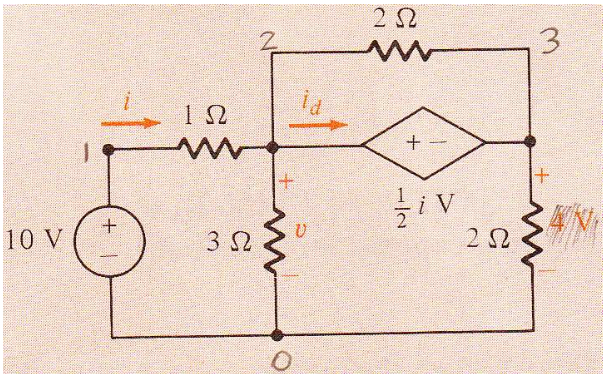


s\dc("ei,a,0,24:ro,a,b,10:r12,b,0,12:r4,b,c,4:r24,a,c,24:ed,c,0,4iro"):
approx(iro)

The answer, **1.5** A, is correct.

Bo2's Drill Exercise 1.12

Determine i, v and i_d.



We are given an unnecessary piece of information: the 4V drop in the 2Ω resistor.

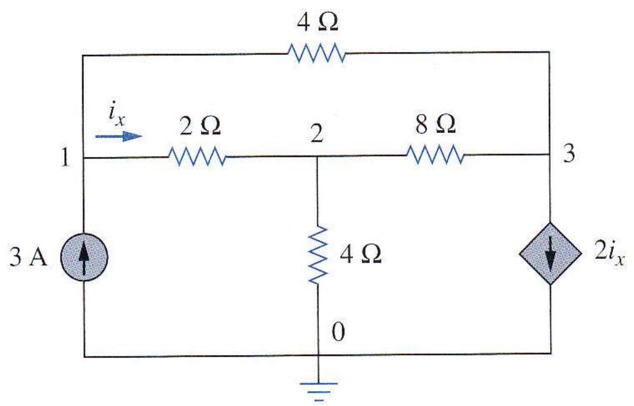
My solution is shown below the schematic.

s\dc("ei,1,0,10:r1,1,2,1:r2,2,3,2:r3,2,0,3:
r4,3,0,2:ed,2,3,ir1/2"):{ir1,vr3,ied}

The answer, **{4,6,1}**, is correct: i=4, v=6 and i_d=1.

AS2's Example 3.2

Determine the voltages at the nodes.



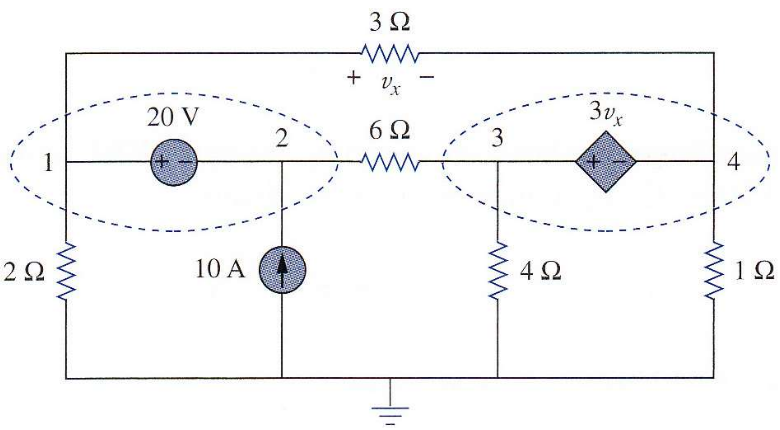
My solution below:

```
s\dc("ji,0,1,3:jd,3,0,2ir2:r2,1,2,2:r4a,1,3,4:r8,2,3,8:r4b,2,0,4"):
approx({v1,v2,v3})
```

The answer, **{4.8,2.4,-2.4}**, is correct.

AS2's Example 3.4

Find the node voltages in the circuit. My solution below:



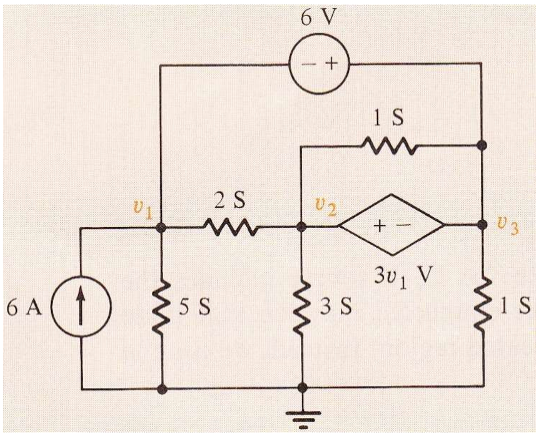

```
s\dc("r2,1,0,2:e,1,2,20:j,0,2,10:r6,2,3,6:rx,1,4,3:r4,3,0,4:
ed,3,4,3vrx:r1,4,0,1"):approx({v1,v2,v3,v4})
```

The answer, **{26.67,6.67,173.33,-46.67}**, is correct.

Bo2's Drill Exercise 2.6

Determine the voltage in each node.

Notice that in the schematic, the resistors' values are given in siemens. Symbulator has to be fed the resistors with values in ohms. This means that, when we simulate them, we have to convert them from siemens to ohms by dividing 1 over the siemens value.



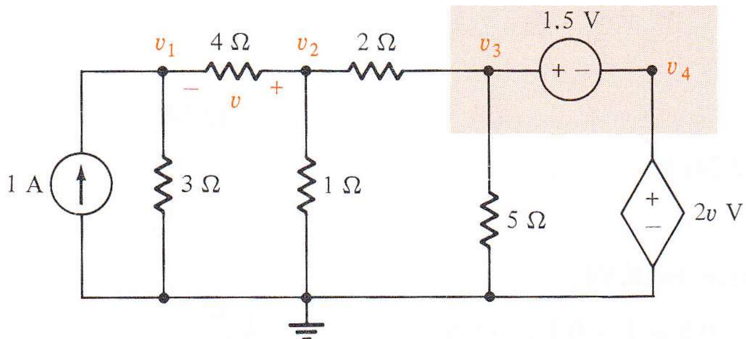
My solution below:

```
s\dc("j,0,1,6:ei,3,1,6:ed,2,3,3v1:r5,1,0,1/5:r2,1,2,1/2:
r3,2,0,1/3:r1,2,3,1:r4,3,0,1"):{v1,v2,v3}
```

The answer, **{-1,2,5}**, is correct.

Bo2's Example 2.7

Determine the voltages in all nodes. My solution below the schematic:

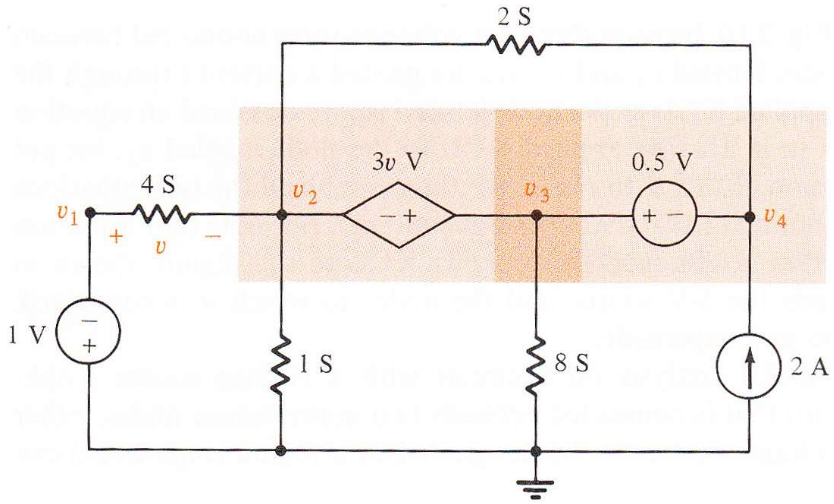



```
s\dc("j,0,1,1:r3,0,1,3:r4,2,1,4:r1,2,0,1:r2,2,3,2:
r5,3,0,5:ei,3,4,1.5:ed,4,0,2vr4"):{v1,v2,v3,v4}
```

The answer, **{1.5,-.5,-2.5,-4.}**, is correct.

Bo2's Example 2.6

Determine the voltages in all nodes.



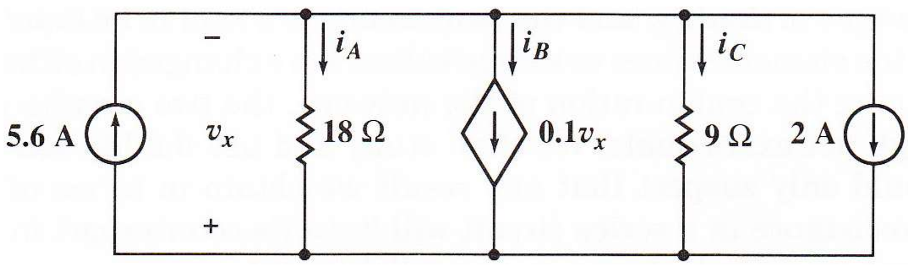
My solution below:

```
s\dc("e1,0,1,1:e2,3,4,.5:ed,3,2,3vr4:j,0,4,2:r4,1,2,1/4:
r1,2,0,1:r8,3,0,1/8:r2,2,4,1/2"):{v1,v2,v3,v4}
```

The answer, **{-1,-2.,1.,.5}**, is correct.

HK5's Drill Problem 1-12

Find i_A, i_B and i_C.



My solution below:

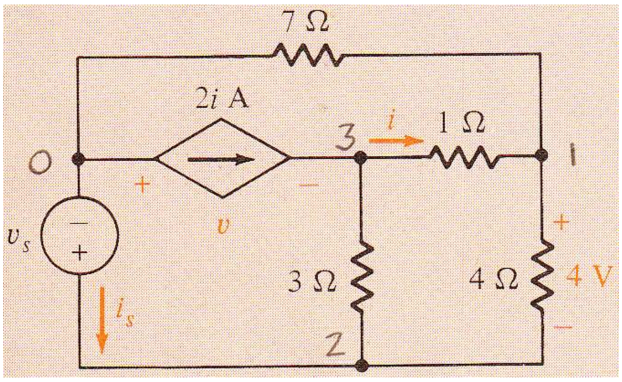
```
s\dc("jl,x,0,5.6:ra,0,x,18:jb,0,x,.1vx:r9,0,x,9:jr,0,x,2"):
approx({ira,ijb,ir9})
```

The answer, **{3.,-5.4,6.}**, is correct.

Numerical-from-symbolic examples

Bo2's Drill Exercise 1.10

Determine i, v, i_s and v_s.



With one unknown value and one known solution, this problem is a job for Expert.

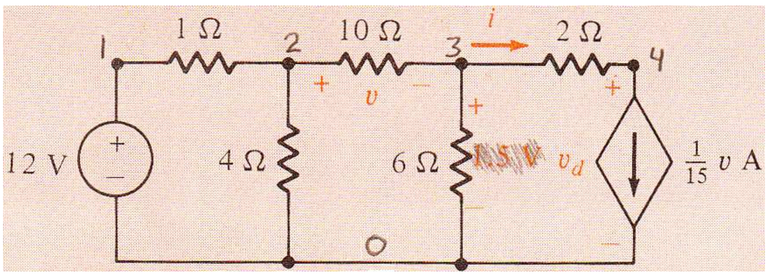
Determine i, v, i_s and v_s.

```
s\ex("es,2,0,vs:jd,0,3,2ir1:r7,0,1,7:r1,3,1,1:r3,3,2,3:r4,1,2,4"):
{ir1,vjd,-ies,vs}
```

Select DC, Add `vr4=4` to the equations and `vs` to the unknowns. Run the simulation. The answer, **{2,-9,-3,3}**, is correct: i=2, v=-9, i_s=-3 and v_s=3.

Bo2's Drill Exercise 1.11

Determine i, v and v_d. (Since all element values are known, the tip we are given by the book – namely, that the voltage drop in the 6Ω resistor is 1.5V – is totally superfluous.)



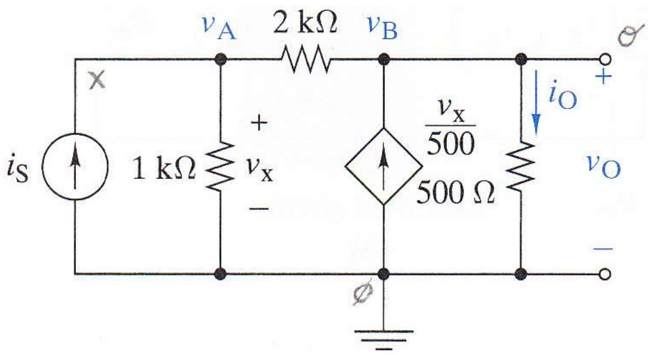

```
s\dc("e,1,0,12:r1,1,2,1:r4,2,0,4:r10,2,3,10:r6,3,0,6:
r2,3,4,2:j,4,0,vr10/15"):approx({vr10,ir2,vj})
```

The answer, **{7.5,.5,.5}** is correct: i=.5, v=7.5 and v_d=.5.

Symbolic examples

TR5's Exercise 4.2

Find v_O and i_O in terms of i_S.



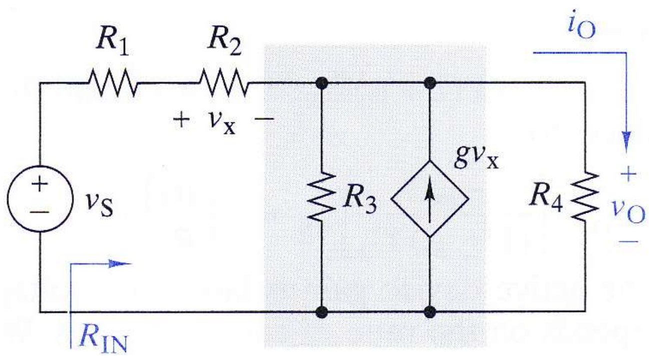
This is my solution. The simulation took 14 seconds.

```
s\dc("ji,0,x,is:r1,x,0,1'k:r2,x,o,2'k:jd,0,o,vx/500:ro,o,0,500"):
{vo,iro}
```

The answer, **{1000*is,2*is}**, is correct: v_O=1000 i_S and i_O=2 i_S.

TR5's Example 4.4

Find v_O and the equivalent resistance R_{IN}, in terms of v_S, when R_1 is 50, R_2 is 1'k, R_3 is 100, R_4 is 5'k and g is 100mA (e.g. 100'm).



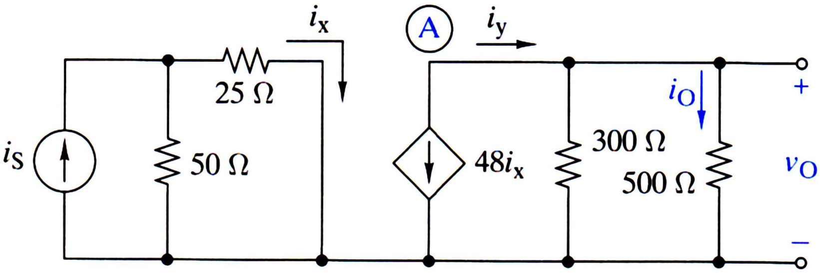
This is my solution. The simulation took 18 seconds.

```
s\dc("e,1,0,vs:r1,1,2,50:r2,2,o,1'k:r3,o,0,100:
r4,o,0,5'k:j,0,o,100'm*vr2"):approx({vo,re})
```

The answer, **{.904*vs,10951.}**, is correct: v_O=.904 v_S and R_{IN}=10.95'kΩ.

TR5's Figure 4-4

Find the voltage drop, current, and power consumed by the 500Ω resistor, and the ratio of that power to that delivered by the independent source, all in terms of i_S.



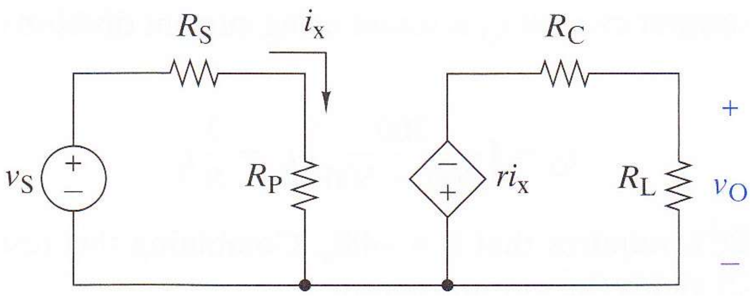
I have not labeled the nodes in the figure, so you can practice doing it. My solution:

```
s\dc("js,0,1,is:r50,1,0,50:rx,1,0,25:jd,o,0,48irx:
r3,o,0,300:ro,o,0,500"):{iro,vo,pro,pro/(-pjs)}
```

The answers we get are correct: i_O=**-12is**, v_O=**-6000is**, p_O=**72000is^2**, and p_O/p_S=**4320**.

TR5's Example 4.1 (Symbolic)

Find v_O.



I did not label the nodes, so you can practice. Remember not using **rc**: it is reserved.

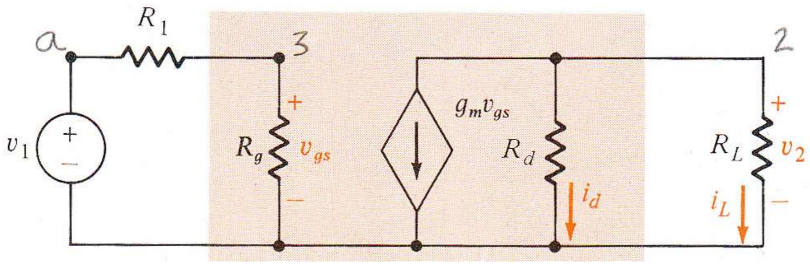
```
s\dc("ei,1,0,vs:rs,1,2,rs:rx,2,0,rp:ed,0,3,r*irx:rrc,3,o,rrc:rl,o,0,rl"):vo
```

The answer, shown left, is correct. The textbook's answer is shown right.

$$\frac{-rl\cdot vs\cdot r}{(rl+rrc)\cdot(rp+rs)} \qquad v_O = \left[\frac{-R_L r}{(R_S+R_P)(R_C+R_L)}\right] v_S$$

Bo2's Example 1.11 (Symbolic)

Determine v_2.



My solution below. In my solution I named the value of the source v_1, to keep it similar to the book. This required avoiding naming any node as **1**: if there was a node 1, Symbulator would store in **v1** the voltage of the node, creating trouble. There is no problem with using r1 as a value, since nothing will be stored in that r1 value.

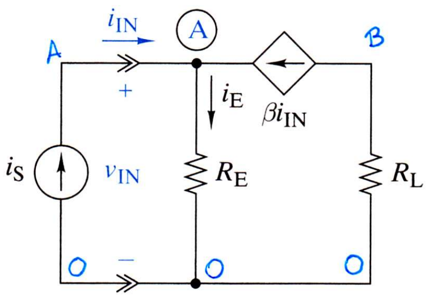
```
s\dc("e,a,0,v1:r1,a,3,r1:rg,3,0,rg:j,2,0,gm*vrg:rd,2,0,rd:rl,2,0,rl"):v2
```

The simulation took 25 seconds. The answer I got is shown left (the textbook's right.)

$$\frac{-gm\cdot rd\cdot rg\cdot rl\cdot v1}{(r1+rg)\cdot(rd+rl)} \qquad v_2 = \frac{-g_m R_d R_g R_L v_1}{(R_g + R_1)(R_L + R_d)}$$

TR5's Example 4-7 (Symbolic)

Find R_{IN}, e.g. the resistance as seen by the current source. My solution below.



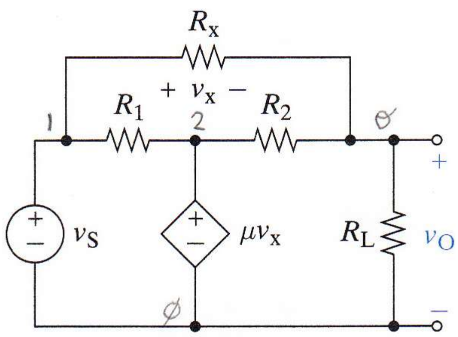

```
s\dc("ji,0,a,is:re,a,0,re:jd,b,a,β*is:rl,b,0,rl"):rji
```

The answer we get, re*(β+1), is correct, as can be seen by comparing it to the textbook's answer, shown below.

$$R_{IN} = (\beta + 1)R_E$$

TR5's Exercise 4.3 (Symbolic)

Find v_O, in terms of the value in the circuit. For resistors, use their conductance value.



This is my solution. We use **µ** as a constant in the dependent source. It is not confused with the SI prefix for micro because the prefix has an apostrophe.

```
s\dc("ei,1,0,vs:ed,2,0,µ*(vrx):r1,1,2,1/g1:
r2,2,o,1/g2:rx,1,o,1/gx:rl,o,0,1/gl"):vo
```

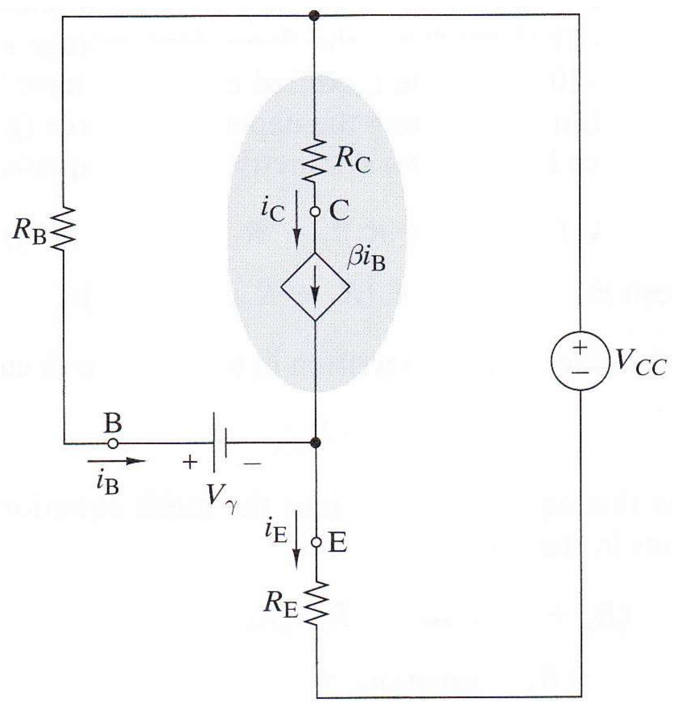
This is the answer we get. It is correct. Compare it with the textbook's answer.

$$\frac{(g2 \cdot \mu + gx) \cdot vs}{g2 \cdot (\mu + 1) + gl + gx} \qquad v_O = \frac{G_x + \mu G_2}{G_x + G_L + (\mu + 1) G_2} v_S$$

The last four problems show Symbulator at its DC best. I don't know of any calculator-based program that was able to provide this kind of purely symbolic answer to a circuit simulator back in 1999 when I made Symbulator. As a matter of fact, even today – a quarter of a century later - I know of no other calculator-based simulator that can do this.

TR5's Example 4.5 (Symbolic)

Find i_B.



My solution is shown below. Be patient. This simulation takes more than one minute.

```
s\dc("e1,1,0,vcc:rb,1,b,rb:e2,e,b,vγ:re,e,0,re:rrc,1,c,rrc:j,c,e,β*irb"):irb
```

Compare my answer, left, to the book's answer, right.

$$\frac{vcc + v\gamma}{rb + re \cdot (\beta + 1)} \qquad\qquad i_B = \frac{V_{CC} - V_\gamma}{R_B + (\beta + 1)R_E}$$