# Impact of Step-Based Tutoring on Student Learning in Linear Circuit Courses

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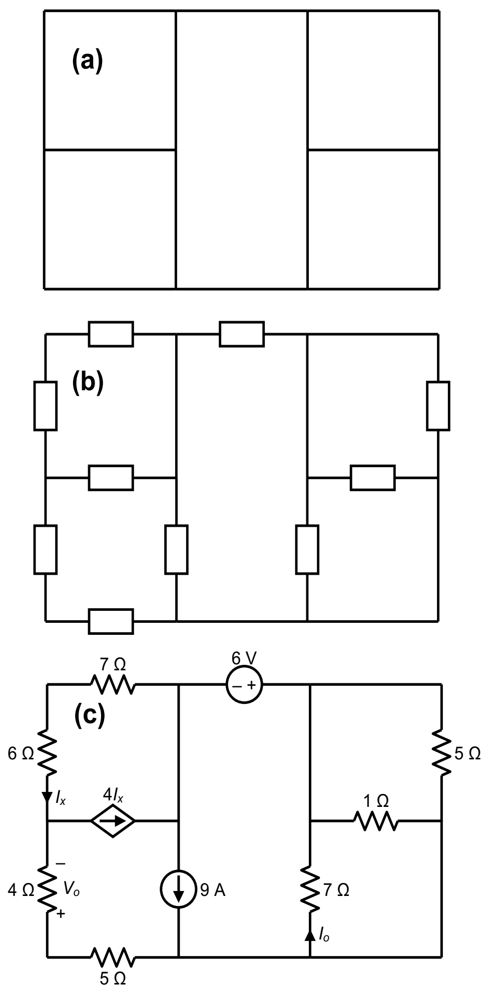
# Introduction

- Effective learning in key introductory classes such as linear circuit analysis is critical to improving student retention and graduation rates
- Our approach: Computer-based, adaptive instruction using step-based tutoring, in conjunction with example-based learning and automatic problem generation
- *Engaged examples*: Make fully explained solutions available any time a student gives up on a problem, with *no penalty for doing so*, to motivate their interest in learning from the examples
- Examples are isomorphic to problems students have to work (unlike many traditional textbook-based examples)
- Exploits our unique random problem generation algorithm, where an unlimited supply of problems of varying *topologies* at any desired level of complexity and difficulty can be generated on demand, giving every student a unique set of problems to work

# Random Circuit Generation Approach

**Three-step Process for Circuit Generation**




- Circuits randomly generated on square grids to avoid graphical interferences (can represent any planar circuit)

- A multi-step approach is used to create new circuits:
  - Step (a): Generate a “topology” consisting only of opens and shorts; must have correct number of meshes, be connected and not hinged
  - Step (b): Replace some of the shorts by generic circuits elements, placing at least two/mesh (including outer mesh) to avoid shorted elements; check that result is not hinged
  - Step (c): Find all or many trees of this network, and place required number of voltage sources and inductors on the twigs, and required # of current sources & capacitors on the links (resistors can be placed anywhere). Then choose random element values and pick control variables for dependent sources (following additional rules for latter)
  - Step (d): Choose “sought variable(s)” students are to find (currents, voltages, powers), following certain rules

# Single Loop/Single Node-Pair Tutorial (released Fall 2016)

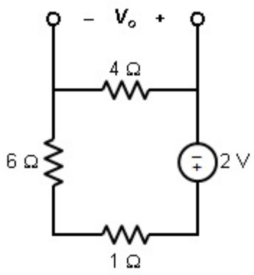
## Medium example:

Display DC Single Node-Pair/Single Loop Equations (Level 2) (Problem type #4)

Here are the correct equations. OK

Compute the following quantity for this circuit:

$V_o$




Sought variable equations:

In a series circuit, the voltage provided by the source is divided among the resistances. The voltage across each resistance is the current that flows through all of them multiplied by the resistance in question according to Ohm's law, V = IR or V = –IR, for the passive or active sign convention, respectively. The current is given by the source voltage divided by the total resistance seen by the source, which is the sum of all the resistances in series.

Because the polarities of the voltage source and the sought voltage have opposite senses (the positive side of the source is connected to the negative side of the sought voltage), the active sign convention applies and the sought voltage has a negative sign in this equation.

$$V_o = -2\ \text{V}\ \frac{4\ \Omega}{4\ \Omega + 6\ \Omega + 1\ \Omega} = -0.727\ \text{V}$$

# Single Loop/Single Node Pair Tutorial (released Fall 2016)(cont.)

## Hard example:

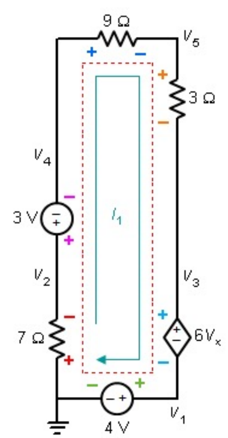
Display DC Single Node-Pair/Single Loop Equations (Level 3) (Problem type #3)

Explain Dependent Sources | Explain Control Variable Equations | Explain This KVL Equation | Here are the correct equations. | Next

Compute the following quantity for this circuit:

$V_{51}$

$V_{mn}$ is the voltage difference $V_m - V_n$, where m and n are node indices.




Sought variable equations:

Given that we have been asked to find a non–branch voltage in this circuit, we cannot simply use the normal voltage division formula. Instead, we apply KVL around the closed loop to solve for the unknown current $I_1$, which we define as that traveling in a clockwise direction around the circuit as indicated. We can then use that current in a second application of KVL to find the desired non–branch voltage(s).

To do this, we add the voltage DROPS across each element, traveling in a clockwise direction. As this direction is the same as that of $I_1$, we are automatically using the passive sign convention for each passive element, so that those terms have positive coefficients. Further, the voltage drop across each voltage source we encounter is just the value of the source if we encounter its positive side first, or the negative of its value if we encounter its negative side first:

$$I_1(7\ \Omega) + 3\ \text{V} + I_1(9\ \Omega) + I_1(3\ \Omega) + 6V_x + 4\ \text{V} = 0$$

Further, we need to write equations for the control variables for each dependent voltage source, because those variables appear in the KVL equation above.

The value of the control voltage $V_x$ that controls the $6V_x$ source must be found by writing an equation for it using Ohm's Law. Note that in this case, $I_1$ points into the positive side of the control voltage, which is the passive sign convention, so Ohm's law has a positive sign:

$$V_x = I_1(7\ \Omega)$$

Now, substituting each the expression for each relevant control variable in terms of $I_1$ into the KVL equation above, we can easily solve for the current $I_1$, yielding $I_1 = -0.115$ A. Substituting this value yields $V_x = -0.803$ V. Next, we use these values to find each desired quantity:

Finding the non–branch voltage $V_{51}$ requires that we sum all voltage rises from node 1 to node 5, using a path that does NOT go through any DC capacitors or current sources, whose voltages would be unknown. Each voltage source along this path (if any) contributes a positive voltage rise if we encounter its negative terminal first, or a negative voltage "rise" (really a drop) if we encounter its positive terminal first. The voltage rise across each resistance is $I_1$ times that resistance if the direction of $I_1$ is opposite to our direction of travel along the path, as the passive sign convention implies a positive rise in that case, or negative $I_1$ times that resistance if $I_1$ is directed along the chosen path. We choose to do this using the path where the resulting expression will be the simplest:

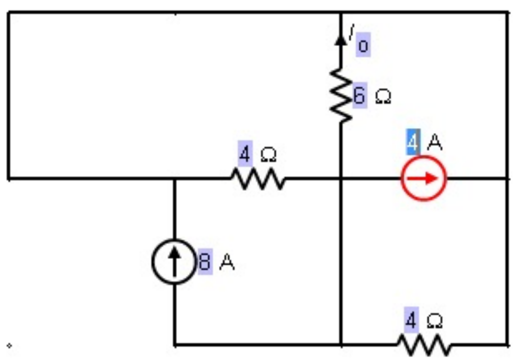
$$V_{51} = I_1(3\ \Omega) + 6V_x = -5.16\ \text{V}$$

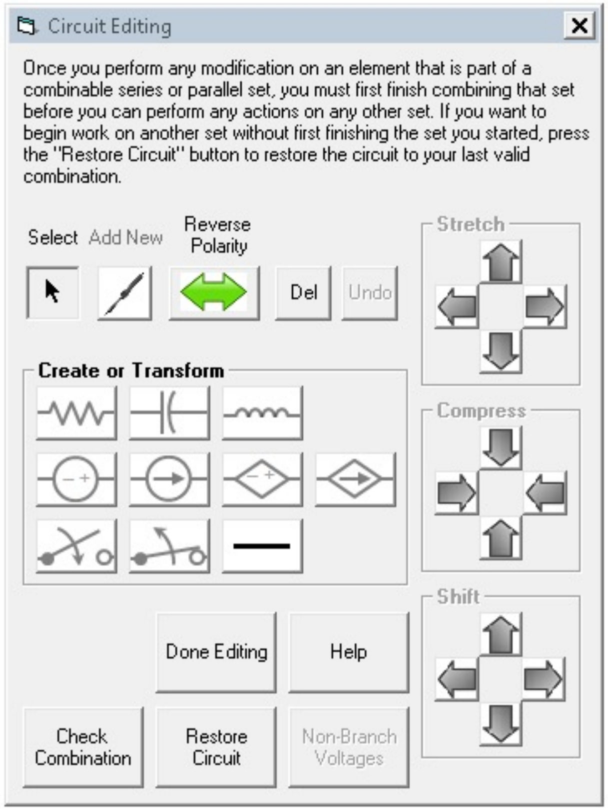
# Single Loop/Single Node Pair Tutorial (released Fall 2016)(cont.)

Compute the following quantity for this circuit:

$I_o$

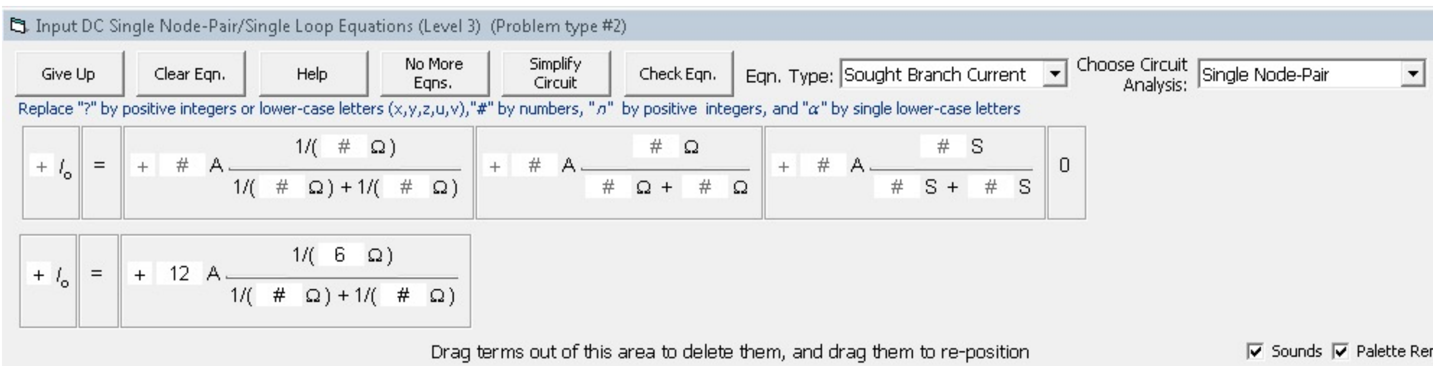
Using the interactive circuit editor to pre-simplify the circuit to where it can be solved using current division by combining sources:



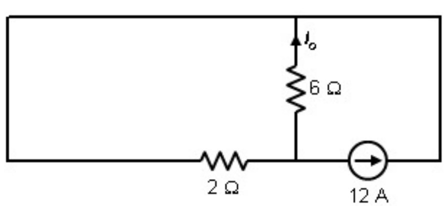
# Single Loop/Single Node Pair Tutorial (released Fall 2016)(cont.)

Entering the current division equation after pre-simplification has been completed in the circuit editor (template-based interface):




Compute the following quantity for this circuit:

$I_o$



ARIZONA STATE UNIVERSITY

# Web-based Tutorial on Bode Plots

## Bode Plots

Question 1.5.3

**Section 1 of 2**

**Problem**

Given a transfer function

$$\mathbf{H}(j\omega) = \frac{1000\,(j\omega+4)}{(j\omega)^2 + 50.8 j\omega + 40}.$$

A. Find the limits of $\mathbf{H}(j\omega)$ when $\omega \to 0$ and $\omega \to \infty$.

B. Identify the type and order of the filter corresponding to the above transfer function.

C. Draw a Bode magnitude plot for the above transfer function.

**Solution to Part A:**

$$\lim_{\omega\to 0} \mathbf{H}(j\omega) = \frac{1000\,(0+4)}{0^2 + 50.8\cdot 0 + 40} = 100,$$

$$\lim_{\omega\to\infty} \mathbf{H}(j\omega) = \lim_{\omega\to\infty} \frac{1000\left(j\omega + \cancel{4}\right)}{(j\omega)^2 + \cancel{50.8 j\omega} + \cancel{40}} = \lim_{\omega\to\infty} \frac{1000 j\omega}{(j\omega)^2} = \lim_{\omega\to\infty} \frac{1000}{j\omega} = \frac{1000}{\infty} = 0.$$

**Solution to Part B:**

The magnitude is a constant (100) at low frequencies, and is attenuated at higher frequencies. Therefore this is a **low-pass** filter.

The order of a filter is simply the number of poles in the transfer function. This filter has two poles, so it is a second order filter.

**Solution to Part C:**

***Step 1*: Rewrite the transfer function in standard form.**

Note: In standard form, the constant of each term is unity.

$$\mathbf{H}(j\omega) = \frac{1000\,(j\omega+4)}{(j\omega+50)\,(j\omega+0.8)}$$

# Currently Released Tutorials (19)

## Grades

When a game is completed it will be shown in green. If it is not green, it has not been marked as completed.

Click on a game's title in the first column to start it.

| | | |
|---|---|---|
| Concept Pre-Test | **Not Completed** | |
| Basic Electrical Waveforms | Completed | |
| Series/Parallel | 0 / 4 Levels Completed | Next step: Level 1 |
| DC Single Node-Pair/Single Loop | 0 / 3 Levels Completed | Next step: Pre-Test |
| Series/Parallel with Terminals | 0 / 2 Levels Completed | Next step: Level 1 |
| Resistor Simplification | Not Started | |
| DC Node Equations | 1 / 4 Levels Completed | Next step: Level 2 |
| DC Node Solutions | Not Started | |
| DC Mesh Equations | Not Started | |
| DC Mesh Solutions | Completed | |
| L/C Waveforms | Completed | |
| L/C Simplification | 0 / 3 Levels Completed | Next step: Pre-Test |
| Impedance Simplification | Not Started | |
| AC Node Equations | Not Started | |
| AC Node Solutions | Not Started | |
| AC Mesh Equations | Not Started | |
| AC Mesh Solutions | Not Started | |
| Bode Plots | 0 / 2 Levels Completed | Next step: Level 1 |
| Laplace Transforms | Completed | |
| Inverse Laplace Transforms | Not Started | |
| Concept Post-Test | **Not Completed** | |
| Circuits Survey | **Not Completed** | |

# Summary of Previously Reported Evaluation Results

## Fall 2012

- Laboratory-based study covering series-parallel identification and nodal analysis
- Compared Circuit Tutor to conventional paper homework; controlled study with random assignment, used pre-test & post-test to assess learning gains and a motivational survey
- Effect size of $d = 1.21\ \sigma$ ($p < 0.05$) on learning gain; $d = 0.91\ \sigma$ on survey (IMMS)

## Fall 2014

- Classroom-based study covering nodal and mesh analysis (~70 students)
- Compared Circuit Tutor to publisher-based electronic homework system (“System X”)
- Students randomly assigned to use Circuit Tutor for nodal analysis, and System X for mesh analysis (Group A); or System X for nodal analysis, and Circuit Tutor for mesh analysis (Group B); problems selected in System X to be very similar to those in Circuit Tutor, with four allowed attempts (only numerical answers checked)
- Voluntary use of the opposite system permitted after assignment due date
- No post-test given prior to crossover, so learning gains could not be compared
- Higher assignment scores on Circuit Tutor exercises ($d = 0.41\ \sigma$, $p < 0.008$)
- ~33% of System X users *voluntarily* used Circuit Tutor on same topic, completing average of 6.5/10 additional exercises for *no credit whatsoever*; <u>no</u> student did the reverse
- 7/7 unsolicited comments comparing the two systems favored Circuit Tutor over System X

# Evaluation Results: Controlled Classroom-Based Study (F'15)

- Essentially repeated the A/B study of Fall 2014, comparing Circuit Tutor to publisher-based System X for nodal & mesh analysis; again involved ~70 students
- This time, a post-test (in-class quiz) was used to compare actual student learning for each group, and students were specifically surveyed on which system they preferred, and why

| Comparison Item | Circuit Tutor | System X |
|---|---|---|
| Avg. post-test score on nodal analysis* | 72% | 49% |
| Avg. post-test score on mesh analysis** | 71% | 65% |
| Students who preferred each system | 86% | 9% |
| Students who feel the system taught them more effectively than the other one | 94% | 3% |

*Effect size of Cohen $d = 0.72\ \sigma$, statistically significant with $p < 0.05$
**Difference not statistically significant ($p = 0.38$)

## Evaluation Results: Controlled Classroom-Based Study at Notre Dame (F'14)

- Compared Circuit Tutor to textbook and paper-based exercise
- Experimental section of course assigned to complete Series-Parallel and Series-Parallel with Terminals tutorials in Circuit Tutor
- Control section of course assigned to read textbook discussion, do assessment problem in book, and complete a paper-based exercise to identify series and parallel elements in about 20 circuit problems selected from the book
- Did not use random assignment
- Same pre-test and post-test given to both sections
- One-way analysis of variance on the post-test scores using pre-test scores as a covariate
- $F(1.62) = 16.76$, MSE = 36.3, $p < 0.001$:

| Comparison Item | Circuit Tutor | Paper Exercise |
|---|---|---|
| Adjusted mean score | 36.68 | 30.49 |

- Effect size $d = 0.97\ \sigma$ (large effect)

- Similar experiment on nodal and mesh analysis did not yield reliable comparison due to large differences in pre-test scores between the two sections

## Usage Statistics & Survey Results

- So far, Circuit Tutor has been used by over 3290 students in 81 class sections taught by 37 different instructors at 10 different colleges and universities
- Diverse set of institutions have used system:
  - Arizona State University, University of Notre Dame, University of the Pacific, Morgan State University, North Carolina A&T State University, Messiah College, Auburn University, University of Virginia, South Mountain Community College, Chandler-Gilbert Community College, and Glendale Community College
- Short survey at end of each tutorial: How useful was the system to learn the material? 92-96% rate as "very useful" or "somewhat useful"; 65-74% say "very"
- More detailed 12-question survey at end of semester in three categories:

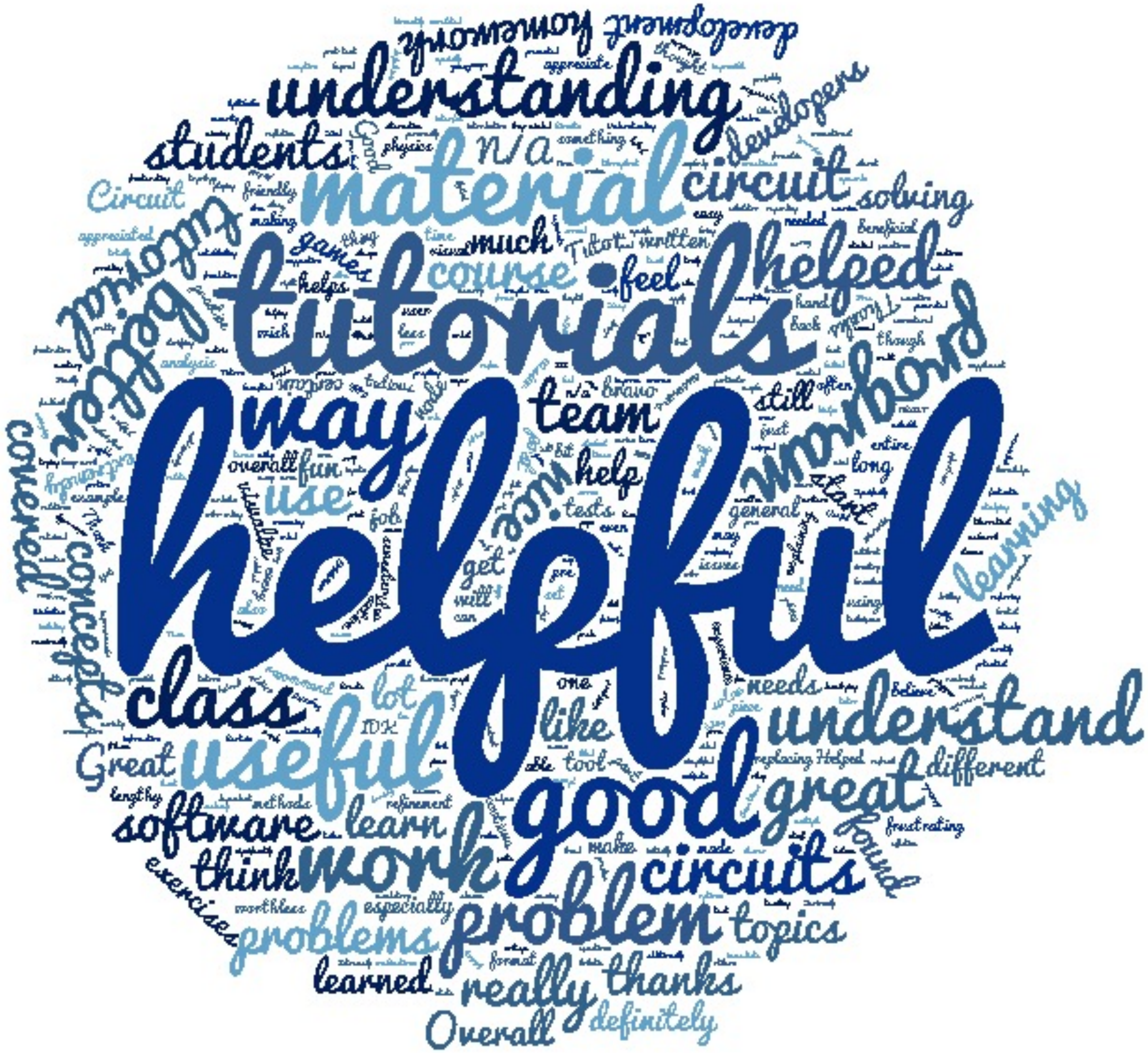
| Institution | Useful & well designed* | Approp. difficulty & coverage* | Prefer to conventional HW* | Overall* | N |
|---|---|---|---|---|---|
| All (combined) | 76.1% | 75.3% | 73.4% | 74.9% | 518 |
| Arizona State Univ. | 74.9% | 73.2% | 72.4% | 73.5% | 363 |
| Morgan State Univ. | 62.2% | 66.3% | 59.3% | 62.6% | 43 |
| Messiah College | 85.9% | 89.6% | 77.1% | 84.2% | 48 |
| North Carolina A & T | 90.4% | 94.2% | 92.3% | 92.3% | 13 |
| Glendale Commun. Coll. | 88.3% | 86.7% | 88.3% | 87.8% | 15 |
| Auburn University | 81.5% | 75.9% | 84.3% | 80.6% | 27 |
| Univ. of the Pacific | 83.3% | 77.8% | 77.8% | 79.6% | 9 |

*Favorable percentages for Fall 2015-Spring 2016 school year

# Student Comments (Comparing Circuit Tutor to System X)

- Simple, Circuit Tutor actually gives you examples and shows you want to do before making you do it. [System X] does not.
- Circuit tutor walks you through problems clearly and one step at a time. It also allows you infinite attempts so you can attempt the problem repeatedly with less stress about losing points. Circuit tutor's explanations for problems are also easier to follow.
- I liked Circuit Tutor more because I could do a ton of problems. I liked that even if I couldn't figure it out, I  could ‘give up’ and it would thoroughly explain how to do everything so I could understand what I did wrong and then do a new problem and try to get that right. I seem to retain more of the content when I am doing this one.  I have trouble with [System X] because, if I have trouble with a problem, the hints do not explain what I am doing wrong. It's really frustrating because I could be 2 or 3 wrong attempts in and I do not know what I'm doing wrong.
- I preferred Circuit Tutor because it was more forgiving in the aspect of not just showing that your answer was wrong like [System X], it helped guide you to the solution. I felt it was a more effective learning tool, while [System X] would be better as a quiz tool after using Circuit Tutor. When it came to the quiz I felt much more confident on the node questions vs the mesh questions because of Circuit Tutor. I plan to use Circuit Tutor some more to prepare for the upcoming test.
- Circuit Tutor is far better. [System X] is not only more difficult, but only allows 4 attempts. [System X] discourages me while Circuit Tutor teaches me.

# Word Cloud—Spring 2016 End-of-Semester Survey (General Comments)



# Conclusions

- Our step-based tutoring system for linear circuit analysis uses random problem generation, varying both circuit topology and element values for every student, and exploits *engaged examples* (fully worked solutions to problems already attempted by students) as well as traditional examples
- The system accepts many forms of student input, such as re-drawn (edited) circuit diagrams, equations (using template-based interfaces), simplified and matrix equations, waveform sketches, and numerical and short answers; designed to minimize student frustration and wasted time
- Three separate evaluations (all controlled, two of them using random assignment) have established statistically significant improvements in learning with substantial effect sizes ($d$ = 1.21 $\sigma$, 0.97 $\sigma$, and 0.72 $\sigma$) and strong evidence for student preference for our system over both paper homework and a publisher-based electronic homework system
- Preliminary integration of our system with a publisher-based electronic homework system is in progress this fall, to facilitate wide dissemination

# Classification of Qualitative Responses Comparing Circuit Tutor to System X

| Category | Responses | Favorable* | Unfavorable* |
|---|---|---|---|
| 1. Overall opinions | 9 | 89% | 0% |
| 2. Effect on motivation or attitude | 13 | 100% | 0% |
| 3. Appropriate level of difficulty and coverage | 10 | 60% | 40% |
| 4. Facilitation of learning | 54 | 96% | 4% |
| 5. Repeated testing/retrieval practice/mastery | 12 | 100% | 0% |
| 6. Providing useful examples | 16 | 88% | 13% |
| 7. Providing useful feedback | 10 | 90% | 10% |
| 8. Technical problems and user interface | 9 | 33% | 44% |
| 9. System cost | 2 | 100% | 0% |
| Combined | 135 | 88% | 10% |

# Comparison to Previous Work

- We provide an unlimited supply of topologically different circuit diagrams, generated on demand. Commercial publisher-based systems typically vary only the element values, making different versions of a problem essentially the same. Other systems have used limited, pre-defined problem banks. In our system, every student gets completely different, error-free problems!
- Unlike other systems, if a student gives up on a problem or fails to solve it correctly in a certain number of attempts, we provide a fully explained solution, and then present another problem of the same type (as many times as needed!)
- We generate full (error-free) solutions to problems using the methods typically used in textbooks (voltage/current division, node analysis, superposition, etc.) rather than the numerical approaches used in software like PSPICE
- We accept a wide variety of student inputs such as interactively redrawn circuit diagrams, equations (using a template-based interface), simplified equations, matrix equations, interactively sketched waveforms, Bode plots, numerical answers, and traditional multiple choice or short answers. Most existing systems are limited to numerical answers and short answers, providing no feedback on intermediate steps

# Comparison to Previous Work (cont.)

- We use special pedagogical devices, such as color coding of nodes (very popular with students!), color coding of currents or voltage drops and the corresponding terms in KCL or KVL equations, etc. No other software implements these methods
- An unlimited supply of fully worked and explained examples is always provided that are exactly isomorphic to the exercises, which is known to be important to learning, particularly in the early stages (see, e.g., J. Sweller, J. J. G. Van Merrienboer, and F. Paas, “Cognitive architecture and instructional design,” Educ. Psychol. Rev., vol. 10, pp. 251-296, 1998)
- We aim to cover the full content of a typical linear circuits course, whereas many other systems have been more limited in scope
- Very importantly, we are conducting rigorous, controlled, randomized evaluations of our software both in laboratory and classroom-based settings, as well as collecting quantitative and qualitative survey data from students, unlike many previous studies

Problem #1

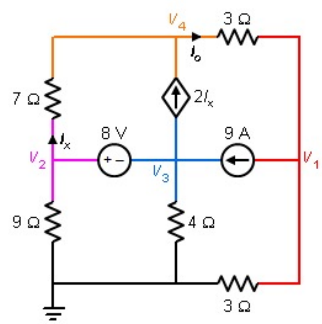
Circuit Diagram with Node Analysis

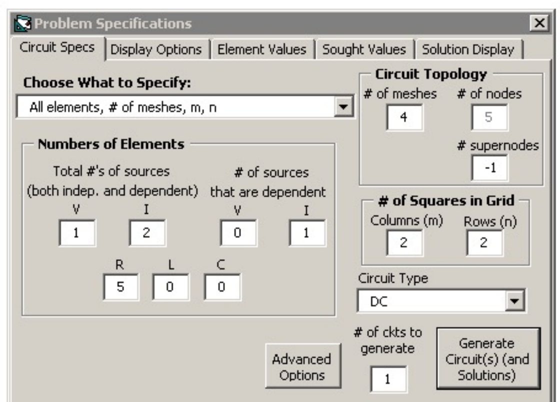
Compute the following quantity for this circuit:

$I_o$

# Example DC Circuit & Solution

Note color coding of nodes; pedagogical feature




Voltage constraint equations:

$V_2 - V_3 = 8\text{ V}$

KCL equations for each node or supernode:

$$\frac{V_1}{3\,\Omega} + 9\text{ A} + \frac{V_1 - V_4}{3\,\Omega} = 0$$

$$\frac{V_2}{9\,\Omega} + \frac{V_3}{4\,\Omega} + \frac{V_2 - V_4}{7\,\Omega} + 2I_x - 9\text{ A} = 0$$

$$\frac{V_4 - V_2}{7\,\Omega} - 2I_x + \frac{V_4 - V_1}{3\,\Omega} = 0$$

Equations for control variables of dependent sources:

$$I_x = \frac{V_2 - V_4}{7\,\Omega}$$

Simplified node equations:

$$\begin{array}{rrrrrcr}
0V_1 & +V_2 & -V_3 & +0V_4 & +0I_x & = & 8 \\
0.667V_1 & +0V_2 & +0V_3 & -0.333V_4 & +0I_x & = & -9 \\
0V_1 & +0.254V_2 & +0.25V_3 & -0.143V_4 & +2I_x & = & 9 \\
-0.333V_1 & -0.143V_2 & +0V_3 & +0.476V_4 & -2I_x & = & 0 \\
0V_1 & -0.143V_2 & +0V_3 & +0.143V_4 & +I_x & = & 0
\end{array}$$

Matrix form of node equations:

$$\begin{array}{c}
\begin{array}{ccccc} V_1 & V_2 & V_3 & V_4 & I_x \end{array} \\
\begin{bmatrix} 0 & 1 & -1 & 0 & 0 \\ 0.667 & 0 & 0 & -0.333 & 0 \\ 0 & 0.254 & 0.25 & -0.143 & 2 \\ -0.333 & -0.143 & 0 & 0.476 & -2 \\ 0 & -0.143 & 0 & 0.143 & 1 \end{bmatrix}
\end{array}
\begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ I_x \end{bmatrix} = \begin{bmatrix} 8 \\ -9 \\ 9 \\ 0 \\ 0 \end{bmatrix}$$

Sought variable equations:

$$I_o = \frac{V_4 - V_1}{3\,\Omega}$$

Solution:

$V_1 = -11.5\text{ V};\ V_2 = 16.1\text{ V};\ V_3 = 8.13\text{ V};\ V_4 = 4.05\text{ V};\ I_x = 1.73\text{ A}$

$I_o = 5.18\text{ A}$

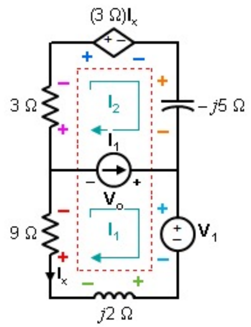
# Example AC Circuit (Phasor Analysis)

ay Equations: Level 4

Explain Constraint Equations | Explain This KVL Equation | Here are the correct equations. | Next

Compute the following quantity for this circuit:

$\mathbf{V}_o$




$\mathbf{V}_1(j\omega) = 2\angle 0°$ V

$\mathbf{I}_1(j\omega) = 3\angle 0°$ A

Each colored +/– symbol pair corresponds to a term in KVL equation #1 of 1.

Current constraint equations:

$\mathbf{I}_1 - \mathbf{I}_2 = 3\angle 0°$ A

KVL equations for each mesh or supermesh:

$\mathbf{I}_1(9\ \Omega) + \mathbf{I}_2(3\ \Omega) + (3\ \Omega)\mathbf{I}_x + \mathbf{I}_2(-j5\ \Omega) + 2\angle 0°\ \text{V} + \mathbf{I}_1(j2\ \Omega) = \mathbf{0}$

Equations for control variables of dependent sources:

$\mathbf{I}_x = -\mathbf{I}_1$

Simplified mesh equations:

$$\begin{array}{rrrcl} 1\,\mathbf{I}_1 & -1\,\mathbf{I}_2 & +0\,\mathbf{I}_x & = & 3\angle 0° \\ (9+j2)\,\mathbf{I}_1 & +(3-j5)\,\mathbf{I}_2 & +3\,\mathbf{I}_x & = & 2\angle 180° \\ 1\,\mathbf{I}_1 & +0\,\mathbf{I}_2 & +1\,\mathbf{I}_x & = & 0 \end{array}$$

Matrix form of mesh equations:

$$\begin{bmatrix} 1 & -1 & 0 \\ 9+j2 & 3-j5 & 3 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \\ \mathbf{I}_x \end{bmatrix} = \begin{bmatrix} 3\angle 0° \\ 2\angle 180° \\ 0 \end{bmatrix}$$

Sought variable equations:

Finding the voltage $\mathbf{V}_o$ across the $\mathbf{I}_1$ current source is tricky, because the voltage across a current source is whatever it needs to be. Therefore, we need to sum all voltage drops from one end of this source to the other using a path that does NOT go through the current source, and use KVL.
The drops are considered positive if they have the same polarity as the desired voltage, or negative if they are reversed.
We choose to do this on the side where the resulting expression will be the simplest, using mesh # 1.

$\mathbf{V}_o = \mathbf{I}_1(9\ \Omega) + 2\angle 0°\ \text{V} + \mathbf{I}_1(j2\ \Omega)$

Solution:

$\mathbf{V}_o = 17.78\angle -30.41°$ V

$\mathbf{I}_1 = 1.745\angle -46.55°$ A; $\mathbf{I}_2 = 2.201\angle -144.9°$ A; $\mathbf{I}_x = 1.745\angle 133.5°$ A

# Matrix Equation Entry Interface

Problem #1

Circuit Diagram with Node Analysis

Compute the following quantity for this circuit:

$V_o$

Voltage constraint equations:

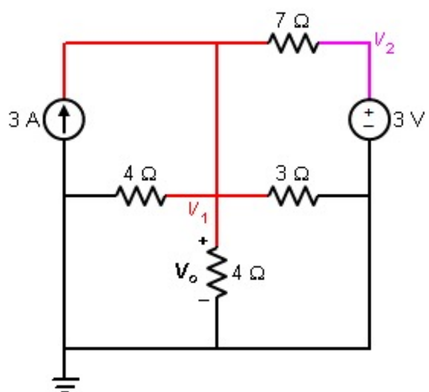
$V_2 = 3\ \text{V}$

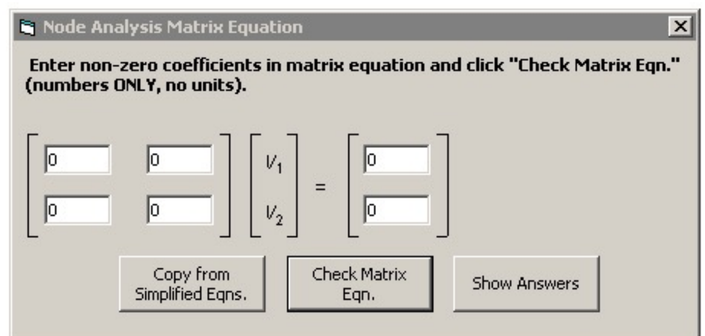
KCL equations for each node or supernode:

$$\frac{V_1}{4\ \Omega} - 3\ \text{A} + \frac{V_1}{4\ \Omega} + \frac{V_1}{3\ \Omega} + \frac{V_1 - V_2}{7\ \Omega} = 0$$

Simplified node equations:

$$\begin{aligned} 0V_1 \quad & + V_2 &= 3 \\ 0.976V_1 \quad & - 0.143V_2 &= 3 \end{aligned}$$




- Used to put simplified equations into matrix form prior to solving

# Instructor Web Site

## Circuit Tutor

Administrator
Account
Logout

Home | Documentation | Logs | Server Info | View

Home > Courses > EEE 202: Circuits I > Students

### Students

School: Arizona State University (Tempe campus)
Instructor: Meng Tao

Course: EEE 202: Circuits I
Term: 2015 Spring

Students Registered: 79 out of 81 (97.5%)

Export as CSV | New Student(s)

| ID | Registered | User Code | Pre-Test | Post-Test | Ser/Par | Terminals | Combine R | DC Node Eq | DC Node Sol | DC Mesh Eq | DC Mesh Sol | Combine C & L | Combine Z | AC Node Eq | AC Node Sol | AC Mesh Eq | AC Mesh Sol | Survey | Actions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2824 | Yes | STTN5M-KK66-HPPY | 20 / 30 | 0 / 30 | 0 / 4 | 0 / 2 | 0 / 4 | 5 / 5 | 0 / 5 | 0 / 5 | 0 / 5 | 4 / 4 | 0 / 3 | 0 / 5 | 0 / 4 | 0 / 5 | 0 / 4 | No | View Log |
| 2832 | Yes | STTN5M-KK66-J2PE | 24 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 2 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2799 | Yes | STTN5M-KK66-J9MD | 15 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 4 / 5 | 5 / 5 | 4 / 5 | 4 / 4 | 0 / 3 | 5 / 5 | 0 / 4 | 5 / 5 | 0 / 4 | No | View Log |
| 2817 | Yes | STTN5M-KK66-JGK5 | 24 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 0 / 5 | 0 / 5 | 0 / 5 | 0 / 5 | 0 / 4 | 0 / 3 | 0 / 5 | 0 / 4 | 0 / 5 | 0 / 4 | No | View Log |
| 2823 | Yes | STTN5M-KK66-JSNF | 11 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 0 / 5 | 0 / 5 | 5 / 5 | 0 / 5 | 4 / 4 | 0 / 3 | 0 / 5 | 0 / 4 | 5 / 5 | 0 / 4 | No | View Log |
| 2860 | Yes | STTN5M-KK66-L282 | 8 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 3 / 5 | 0 / 5 | 0 / 5 | 4 / 4 | 0 / 3 | 0 / 5 | 0 / 4 | 0 / 5 | 0 / 4 | No | View Log |
| 2850 | Yes | STTN5M-KK66-LP9Y | 11 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 4 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2821 | Yes | STTN5M-KK66-LPE7 | 11 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 4 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2795 | Yes | STTN5M-KK66-LR7G | 26 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 4 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2794 | Yes | STTN5M-KK66-MUEA | 12 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 4 / 5 | 0 / 5 | 0 / 5 | 0 / 4 | 0 / 3 | 0 / 5 | 0 / 4 | 0 / 5 | 0 / 4 | No | View Log |
| 2818 | Yes | STTN5M-KK66-N6CA | 28 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 3 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2856 | Yes | STTN5M-KK66-NYUK | 9 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 4 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| 2807 | Yes | STTN5M-KK66-PFFR | 7 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 2 / 4 | 5 / 5 | 2 / 4 | No | View Log |
| 2820 | Yes | STTN5M-KK66-PNHB | 11 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 5 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 0 / 4 | 5 / 5 | 2 / 4 | No | View Log |
| 2790 | Yes | STTN5M-KK66-PS3G | 9 / 30 | 0 / 30 | 4 / 4 | 2 / 2 | 4 / 4 | 5 / 5 | 3 / 5 | 5 / 5 | 5 / 5 | 4 / 4 | 3 / 3 | 5 / 5 | 4 / 4 | 5 / 5 | 4 / 4 | No | View Log |
| | | Completed | 79 | 0 | 76 | 75 | 75 | 75 | 55 | 73 | 66 | 73 | 61 | 65 | 40 | 63 | 42 | 0 | |
| | | % Completed | 98% | 0% | 94% | 93% | 93% | 93% | 68% | 90% | 81% | 90% | 75% | 80% | 49% | 78% | 52% | 0% | |

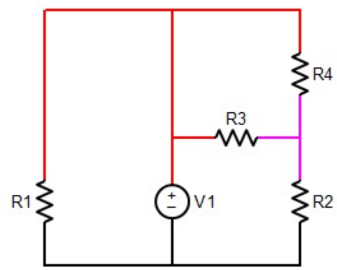
- Students identified only by codes to be FERPA-compliant (only instructor knows actual student identities)
- Can monitor progress in each tutorial, or bore down to detailed logs for each student

Arizona State University

Frontiers in Education

## Series/Parallel Tutorial

**Section 6 of 12**




Now, let's study series connections. In this circuit, are R2 and R4 in series?

- Yes
- No

Submit

# Web-Based Tutorial Engine

- Used to give tutorial instruction prior to exercises, using multiple choice and similar short-answer questions
- Authoring interface under development to facilitate easy writing of tutorials by developers and instructors
- Can allow branching depending on multiple student answers
- Questions stored in human-readable JSON format

# Series-Parallel Identification Game