**Affordable Learning Georgia Affordable Materials Grants  
Continuous Improvement Grants Final Report**

*(or Mini-Grants, for R17 and earlier)*

# General Information

Date: 1/20/2025

Grant Round: 24

Grant Number: M238

Institution Name(s): Kennesaw State University

Team Members (Name, Title, Department, Institutions if different, and email address for each):

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Title | Department | Email address |
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| Sandip Das | Associate Professor | ECE | [sdas2@kennesaw.edu](mailto:sdas2@kennesaw.edu) |
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Project Lead: Dr. Craig A. Chin

Course Name(s) and Course Numbers: EE 2301 – Circuit Analysis I

Final Semester of Project: Fall 2024

***If applicable to your project:***

Average Number of Students Per Course Section: 35

Number of Course Sections Affected by Implementation of Revised Resources: 3-4

Total Number of Students Affected by Implementation of Revised Resources: ~275 per year

# Project Narrative

Purpose

The purpose of the project is to design and develop an open access computer application (hereafter referred as the ‘App’) that auto-generates randomly varying questions that will assess major topics from Circuit Analysis arranged in three tiers of difficulty.

Description

The major topics assessed by the App include Series-Parallel DC Circuits, Complex DC Circuits (Nodal and Mesh Analysis), Linear Circuit Theorems (Thévenin, Norton, Superposition), 1st-order Transient Circuit Analysis, and AC (Sinusoidal) Circuit Analysis. Thirty base questions were designed under each topic which are organized into three tiers of difficulty – easy, medium and hard, with 10 questions at each level. The total number of base questions for all five topics is 150. Each of these base questions is programmed to randomly alter the value of certain components in the circuit over a predefined range. This results in auto-generated variants of a base question and along with the corresponding answers. This empowers the App to automatically generate thousands of question variations. The App provides instant feedback when an answer is entered for a given question, and it also includes real-time progress tracking of questions completed in the App. A chart on the main window displays the number of questions successfully completed in each difficulty level under each topic and tracks the number of attempts made to solve each problem. See Figure 1 below.

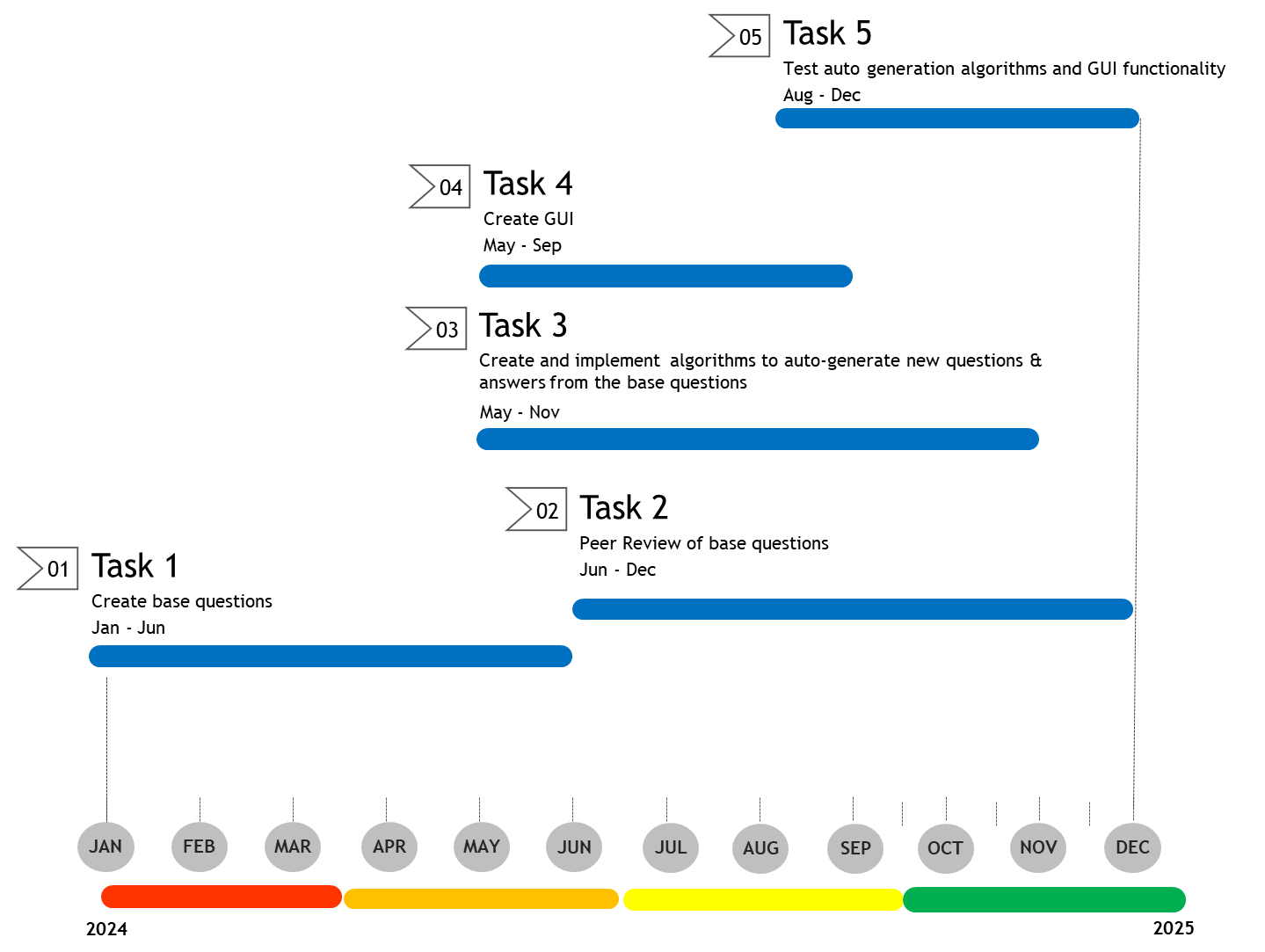
A screenshot of a computer

AI-generated content may be incorrect.

Figure 1 - App's Graphical Interface

Design and Development Plan

The design and development of the App included five major tasks, which are displayed in the timeline below.



**Task 1.** *Create the base questions (Jan 2024 – Jun 2024).* Three instructors (Chin, Hill and Lee) created the base questions within each of the five categories previously specified and within each of three difficulty levels: easy, medium, hard. This resulted in a total of 150 base questions. Question creation involved writing the question text; drawing the circuit schematic (if required); assigning the problem parameters, including those that will be varied randomly; writing the solution steps to answer the base question; and providing 2 sample answers.

**Task 2.** *Peer review of the base questions (Jun 2024 – Dec 2024).* Each base question was reviewed by an instructor other than the creator. A review included checking the question for clarity, checking the solution steps for errors and verifying the 2 sample answers. The review schedule was distributed amongst instructors Chin, Hill and Lee. Note: The Series-Parallel DC Circuits topic was not reviewed because additional work was added to Task 1 due to the limited computational capabilities of the App related to matrix and complex number computations.

**Task 3.** *Create and implement algorithms to auto-generate new questions & answers from the base questions (May 2024 – Nov 2024).* Dr. Das worked along with a student assistant to create and implement the code that will auto-generate new questions from each base question. Questions are auto generated by randomly varying select circuit parameters over a pre-defined range of values.

**Task 4.** *Create GUI.* Dr. Das and the student assistant created a GUI that supported the following features:

1. Main Navigation Bar – Supports topic (Chapter) and difficulty level selection.
2. Question Information Display Bar – Displays the chapter, difficulty level and number of the current question.
3. Problem Navigation – ‘Next’ and ‘Previous’ buttons allow user to navigate to different questions within the same chapter and difficulty tier.
4. Problem Display Area - Displays the question statement and the associated circuit diagram (if any).
5. Answer Input Section: This is the text box(s) provided on the right-hand side of the App GUI window for students to enter their calculated answers for the given problem. Only accepts numerical answers.
6. Immediate Feedback Section: Upon submitting the answer for a given question, the App’s internal solution calculation algorithm/codes are activated which provide instant feedback.
7. Error Display Area: In case of an incorrect answer, the App might highlight the error and may be able to provide suggestions or hints on how to fix it (e.g., “Please check your calculation and final answer units. You may have entered the answer in wrong units”). This helps students reflect on their mistakes and learn the correct approach. This functionality is currently limited to wrong units when the algorithm detects entered numbers with wrong decimal points.
8. Progress Chart Area: The real-time progress tracker, which provides visual feedback on the student’s performance over time

**Task 5.** *Test auto-generation algorithms and GUI functionality*. Dr. Das and the student assistant performed trials of the auto-generation algorithm to validate that it was generating the correct answer given a set of input parameters. Also, the various GUI items were tested.

Lessons Learned

The primary lesson learned was to perform a more thorough assessment of the development environment that will be used for this type of software-based project. The limitations of the development environment resulted in a reduction in scope of the project because of the time-consuming nature of developing auto-generation algorithms for problems involving matrix-type or complex number solution methods.

# Materials Description

This application auto-generates randomly varying questions that assess the Circuit Analysis topics of Complex DC Circuits (Nodal and Mesh Analysis), Linear Circuit Theorems (Thévenin, Norton, Superposition), 1st-order Transient Circuit Analysis, and AC (Sinusoidal) Circuit Analysis. For each topic, questions are arranged in three tiers of difficulty (Easy, Medium and Hard). The App also features immediate feedback to a submitted answer as well as a progress chart to track learner performance over time.

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# Materials Links

Link to App Installation File and Manual

<https://tinyurl.com/ydx8psw3>

# Future Plans

Future plans include conducting a mixed methods study of the App that will encompass student perceptions of the impact of the App on their learning as well as the usability of the App. The study will also assess the impact of App usage on students’ academic performance.

Future App development will include adding the omitted Series-Parallel DC topic to the app and improving the immediate feedback to include step-by-step solutions.