Calculator Scope Report

1. Summary

This report lays out the scope of work required to design, build, test and document a calculator system as per client request. This calculator is limited to only integer power and integer square root functions. The product will provide the client with a fast, accurate computational device to be deployed in the specified office environment.

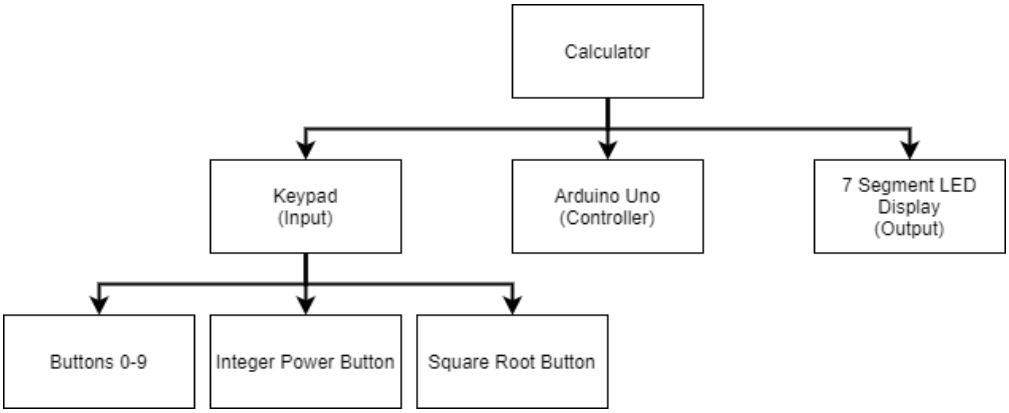


Figure 1: Hardware top-down breakdown.

As detailed in Figure 1 the calculator will consist of three major components. An Arduino Uno will control the calculator, while user inputs will be entered into a 3×4 keypad and a single digit 7-segment LED display will present the outputs.

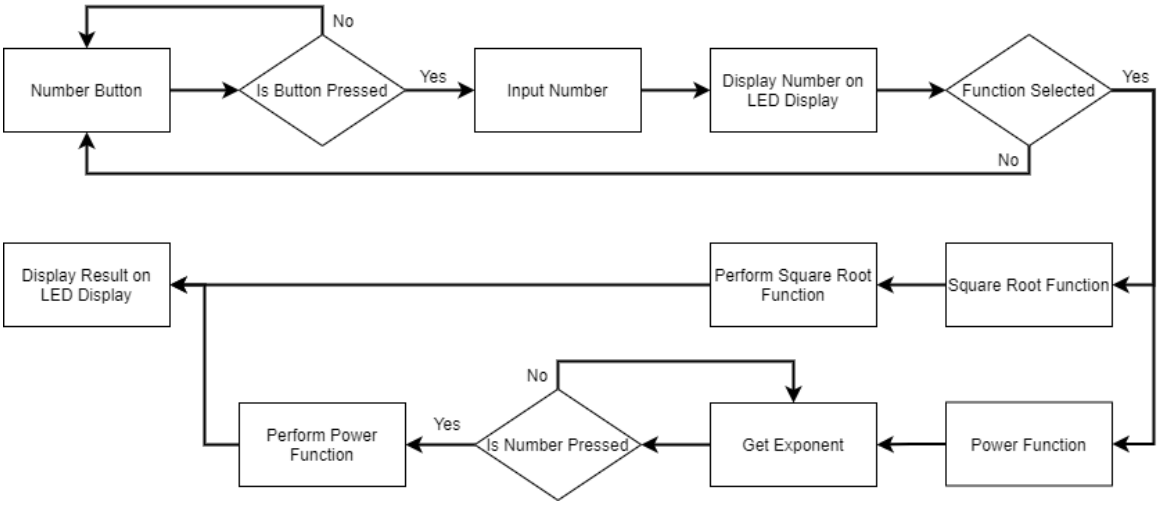


Figure 2: Operation algorithm overview.

The intended operation is depicted in Figure 2. As the user inputs numbers, these will be shown on the display. Upon selection of a function on the keypad, the Arduino will execute the selected function upon the inputted number (after asking for an exponent in the case of the power function) and output the result on the display. For results greater than a single digit the display will automatically scroll through the result on a 0.5 Hz cycle.

2. Requirements

Consultation with the clients and the initial client request has yielded the following requirements:

- Calculator is controlled by an Arduino Uno, use keypad inputs and output to a single digit 7-segment LED display.
- Keypad with digits 0-9 and capacity to select the integer square root and integer power functions.
- $10AUD budget (excluding Arduino Uno as this is provided).
- Performs only power and square root functions using positive integer inputs.
- Up to 4-digit input for power function base and square root function radicand.
- Single digit exponent only for power function.
- Full precision output for power function. All digits displayed with no rounding.
- Square root function will round any non-integer output down to the nearest integer.
- Digits of any output longer a single digit will scroll through the LED display on a 0.5 Hz cycle.
- LED display brightness will be a minimum of 6.3 mcd [1].
- Maximum power consumption of 350 mW (Arduino processor (ATmega328) consumes 4.5 mW, LED with all 7 segments fully illuminated consumes 245 mW, keypad power consumption is negligible, and contingency).

3. Assumptions/Specifications

- Mounting and housing of the calculator is outside the scope of work.
- Users will record outputted digits as they are displayed. Method of recording is typing.
- Users are not professional typists, hence the 0.5 Hz display cycle.
- Power supply to the calculator will be provided on site in the office.
- Calculator will not be mounted directly in front of a light source including direct sunlight.
- Calculator will be viewed directly from less than 1m away.
- Office background light intensity is no greater than 750 Lux [2].
- Calculator will be mounted in normal room temperature conditions (10°C – 35°C).

4. Deliverables

Calculator

A fully functional prototype of the calculator constructed to the above requirements and specifications ready to be installed on site with the program installed and operational.

Documentation

Main report containing:

- Hardware research, evaluation, and selection for both the keypad and LED display, and bill of materials.
- Wiring schematics for keypad and LED display.
- Power supply recommendation.
- User instructions and calculator limitations
- A copy of the fully annotated, uncompiled program files.
- Comprehensive testing reports including documentation of issues and relevant solutions.

5. Milestones

See Appendix – Gantt Chart for Gantt chart and task dependencies. Timeline set to finish end of semester week 13. Table 1 details the major milestones entailed in the development of the calculator and their due dates.

Table 1: Milestone chart for duration of project.

Milestone	Description	Date
Complete LED Design Report	Full design layout, wiring schematics, hardware research, evaluation, and selection for LED display.	28/03/2021
Complete Keypad Design Report	Full design layout, wiring schematics, hardware research, evaluation, and selection for keypad.	11/04/2021
Order List Submitted	Hardware component order list complete and submitted.	12/04/2021
Components Arrived	Hardware components delivered and ready for assembly.	19/04/2021
Hardware Assembled	Hardware completely assembled, tested, and working.	22/04/2021
Complete Power Function	Power function is operational, tested and displaying in IDE.	24/04/2021
Complete Square Root Function	Square root function is operational, tested, and displaying in IDE.	26/04/2021
Operational Keypad	Keypad firmware complete, fully operational, and tested.	13/05/2021
Operational Display	Display firmware complete, fully operational, and tested.	18/05/2021
Complete Calculator	Hardware and software fully tested and configured in accordance with test sheets. All issues resolved and recorded.	25/05/2021
Finished Preliminary Report	Draft of all documents completed. Document list to be confirmed.	26/05/2021
Submitted Final Report	All documents finalized and submitted.	30/05/2021

6. Estimates

There are two main categories of estimates relevant to the production of the calculator, time, and cost. Table 2 details the time estimates to complete all the major tasks throughout the project. The expected time to complete each task is given in the final column. This has been calculated using PERT time analysis, in which a weighted average has been taken of the optimistic, pessimistic, and likely time to complete each task. One standard deviation of the estimated time has been added for contingency.

Table 2: PERT time analysis for major project tasks Estimate with contingency calculation: $X = \frac{A+4B+C}{6} + \frac{(C-A)}{6}$

Task	Optimistic A (Days)	Likely B (Days)	Pessimistic C (Days)	Estimate with Contingency (Days)
Design and document LED display	5	14	21	17
Design and document keypad	5	14	21	17
Order components	2	4	14	8
Assemble the hardware	1	2	5	3
Develop the power function	5	10	15	12
Test and configure the power function	4	7	10	8
Develop the square root function	5	10	15	12
Test and configure the square root function	4	7	10	8
Integrate the LED display	5	10	15	12
Test and configure the LED display	4	7	10	8
Integrate the keypad	5	10	15	12
Test and integrate the keypad	4	7	10	8
Final testing and configuring on complete unit	2	5	10	7
Finalize report and supporting documents	2	3	7	5

The cost estimates must be kept within $10AUD as per client requirements. These price estimates are based upon constructing a single unit and do not account for bulk pricing. Should bulk quantities be required proceeding successful prototyping, costs will be reevaluated. The price estimates observed in Table 3 are based upon Digikey's product listings. The remainder of the $10AUD budget is contingency reserved for any currently unforeseen components (e.g. resistors, diodes, etc).

Table 3: Estimated costs for all major components required for calculator construction.

Component	Digikey Product Code	QTY	Price (AUD)
Arduino Uno	N/A	1	Provided
3 X 4 Keypad	1528-1136-ND	1	5.22
7 Segment LED Display	1830-1155-ND	1	1.49
Solderable Breadboard	SBBTH1506-1-ND	1	1.584
Connections	N/A	N/A	Negligible for prototype
		TOTAL	**8.294**

7. Design Test Cases

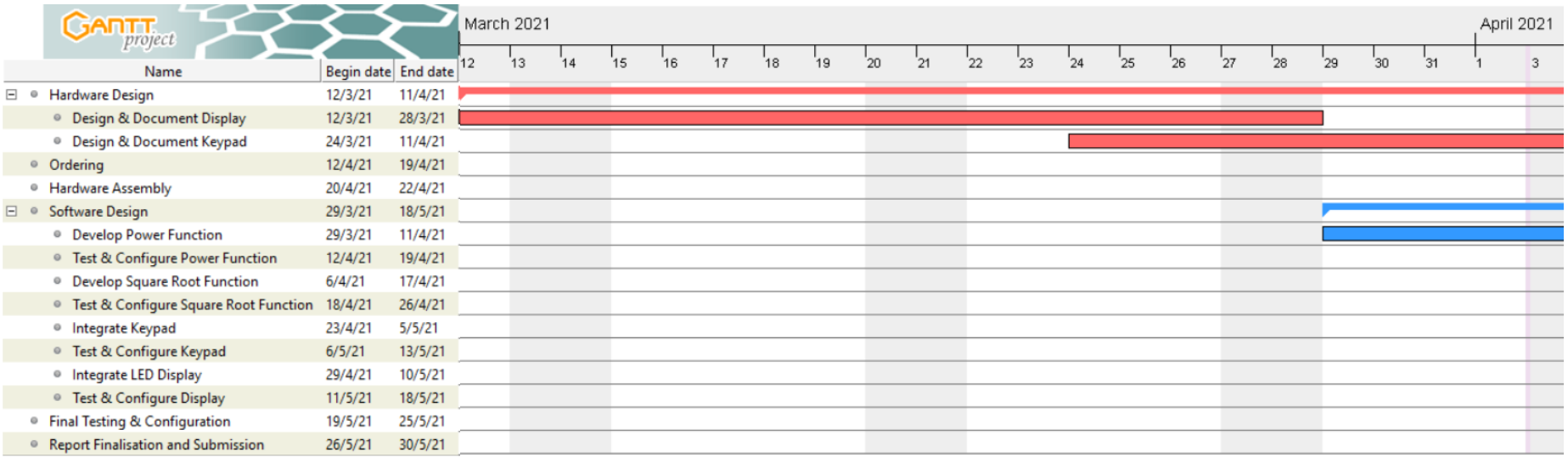
1. Test square root and power functions are outputting the correct results against Table 4 in Arduino IDE.

Table 4: Function test cases.

Integer Square Root Table			Integer Power Table	
Input	**Output**		**Input**	**output**
27	5		9999^9	9991003599160125987400839964000089999
25	5		541^3	158340421
9999	99		0^5	0
0	0		9^0	1

2. Test the keypad integrates fully into the calculator function.
   - Pressed buttons register correctly in Arduino IDE.
   - Able to correctly input number, select function and output result in IDE (test against Table 4).
   - Keypad robust to multiple input cases (holding button down, pressing multiple simultaneously, etc).
   - Test system does not accept more than the maximum allowable digits.
3. Test LED display integrates fully into calculator function.
   - Outputted result displays correctly.
   - Digits of results cycle through display on a suitable time cycle (research and experiment to find suitable timings).
   - Brightness of LED's kept to minimum value that is clearly visible in user environment.
4. Test entire system
   - Digits of user input and selected function displayed on LED as they are entered.
   - User inputs register into functions correctly and output the correct answer (test against Table 4)
   - Use a multimeter to determine power consumption across each major component under maximum operations (LED all segments full brightness, Arduino calculating 9999^9, etc).

8. Appendix – Gantt Chart



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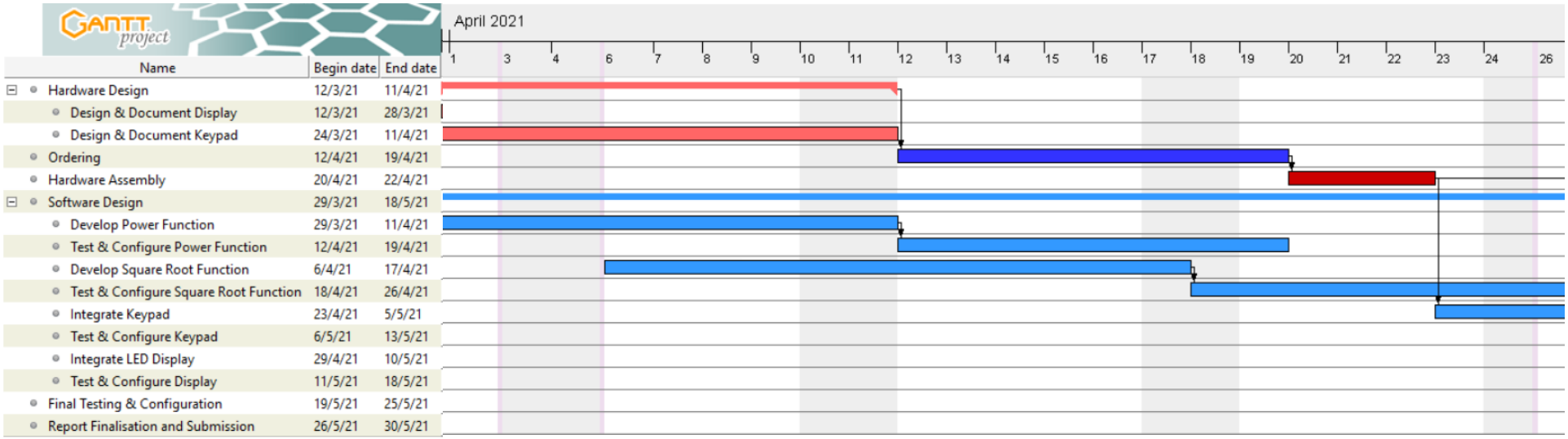
Hardware Design	12/3/21	11/4/21
Design & Document Display	12/3/21	28/3/21
Design & Document Keypad	24/3/21	11/4/21
Ordering	12/4/21	19/4/21
Hardware Assembly	20/4/21	22/4/21
Software Design	29/3/21	18/5/21
Develop Power Function	29/3/21	11/4/21
Test & Configure Power Function	12/4/21	19/4/21
Develop Square Root Function	6/4/21	17/4/21
Test & Configure Square Root Function	18/4/21	26/4/21
Integrate Keypad	23/4/21	5/5/21
Test & Configure Keypad	6/5/21	13/5/21
Integrate LED Display	29/4/21	10/5/21
Test & Configure Display	11/5/21	18/5/21
Final Testing & Configuration	19/5/21	25/5/21
Report Finalisation and Submission	26/5/21	30/5/21



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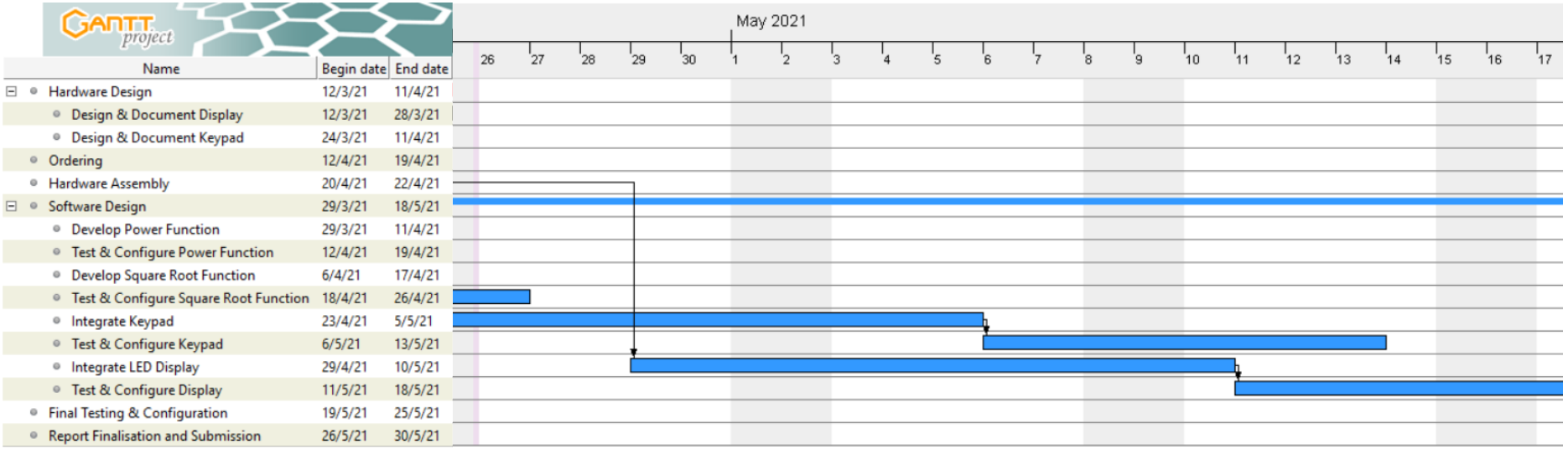

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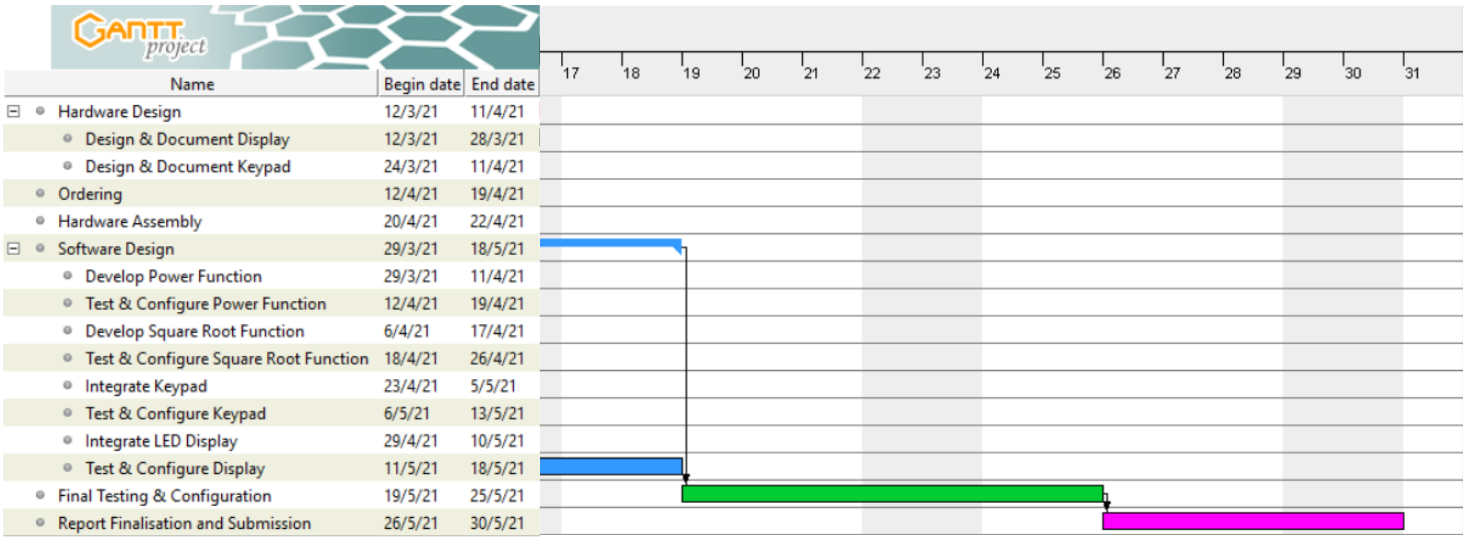

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9. Bibliography

[1] J. Wachtel, "Report on Digital Sign Brightness," The Veridian Group, November 2014. [Online]. Available: https://scenicnevada.org/wp-content/uploads/Condensed-Verstion-Part-I-Wachtel-Study-1.pdf. [Accessed 27 March 2021].

[2] Airfal International, "Recommended lighting levels for offices," Airfal International, [Online]. Available: https://www.airfal.com/en/residential-lighting-news/recommended-lighting-levels-for-offices-4265/. [Accessed 27 March 2021].