ECE Class Kit Vending Machine  
Project Proposal

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# Introduction

Every year hundreds of students require devices for their ECE classes. These specific devices are provided by the College of Engineering and are rented out to students through the ECE office. Typically, in the first month of a semester, a significant number of students attempt to check out devices from the office. This capstone project will focus on designing and implementing a vending machine that can check devices out to students while recording which students have checked out a device.

The finished product will be a vending machine that is able to vend devices to students. A student can enter their information and the machine will record who has checked out the device. The machine will include a clear front panel, which allows students to see and determine which board they need. A platform will lift to the desired device and vend it to the student.

The ECE office will benefit from having this machine because it will reduce traffic in the ECE office. It will also ease the process for the students because they will not have to fill out paperwork. Instead, the vending machine will allow the office to view the data submitted by the students. Because of this, the office associates will have to fill out paperwork on students less frequently, and the machine will remember the data students enter.

The first prototype will have the ability to prevent boards from getting stuck, have a touch interface for students to enter information on, have a locked door to enable associates to refill the machine, and have memory in the event of a fault or power loss to remember its functionality. The machine will also be fitted with a method of communication in order for the associates to pull student information from it. Security will be implemented in order to prevent boards from being stolen and to protect the database.

The objective of this capstone project is to make the process of checking out devices for ECE courses simpler by utilizing a vending machine, while also recording all information given by a student through a database.

# Formulating the Problem

This section will introduce the background information needed for the project. This includes the constraints and

specifications of the machine and the standards we will be bound to when working on the project. A survey of possible solutions to the problem will also be given so the project can be further improved in the future.

## Background

Much of the project relies on the background information of the systems in vending machines, and how they operate. The project will require knowledge in the areas of controls, programming, embedded, power, databases, and others.

Vending machines are used throughout many businesses and are a great source of convenience for the customers who use them. Maintenance on well-made vending machines is also low, saving time for the business as well [1]. A vending machine for the class kits in the ECE office would be of great convenience to students who can come by and pick up a device. It would eliminate the need to fill out paperwork in the office to obtain a board, as well as allow the office associates to do their own work without worrying about the students.

The project that is desired is difficult enough to allow for multiple people to assist in the creation of the machine. The machine requires its own control and power system to operate correctly. It must also have a computing system to control the platform and motors to dispense the board for the student. For the office to know who has retrieved a board, the machine must also have an onboard database system that is able to keep track of students and communicate with the office associates. The machine also requires some type of security to avoid student information being stolen, as well as physical security such as a lock to protect the devices. The reason we do not require a machine that is “off the shelf” is that all current vending machines drop the items to the bottom. The devices in the ECE office are sensitive and prone to breaking if dropped from a height. Also, most vending machines are paid services requiring the customer to buy the product whereas ours is for renting the product without a charge. Our team of engineers is in charge of the design of electrical and computer systems, and the mechanical team is in charge of the actual machine. Our part of the project cannot be bought and requires design.

The objective of the class kit vending machine is to have a machine that is capable of recording student and class information and using that information to know which device is required for the student. Then the machine can properly retrieve and distribute the device to the student and record that the student has the device for the department. In order for the machine to accomplish its given task, a power system, microcontroller, sensors, motors, student database, controls, interface, and possibly PLC systems.

The proposed power system for the machine would utilize a 120 W AC to DC converter as its source. The converters can range in output from 12 volts DC to 54 volts DC and need to be high efficiency to avoid overconsumption [2]. A benefit of a high-efficiency power supply is the machine remains cooler, increasing the machine’s lifetime [2]. Extra Fuses will be included to ensure the voltages of the devices are not exceeded as another protection layer. If needed, the team may also include a backup supply in case the system fails.



*Figure 1: 120W Power Supply*

The machine requires a microcontroller/computer to control the electronics inside and to hold a database that keeps track of each student who has obtained a board. The computer will also control the interface on the machine that the student needs to be able to take a device and possibly control a card reading device.

For vending the devices, the team has ideas on what type of motor to use. One option is to use normal vending machine parts such as the coils with stepper motors. Another is a belt and gate which moves only the device that has its gate opened. Either option will require the team to use a platform that can raise and lower to retrieve the device for the student.

## Specifications

The class kit vending machine must follow several specifications to achieve the customers’ desired objectives. First, the team must prevent the devices from getting stuck in the machine. However, normal machines are prone to having products become stuck, which results in people shaking and possibly damaging the machine [3]. The machine must be large enough to accommodate any device the department must put into the machine as well.

Secondly, the customer requires that the machine have some form of communication so the information can be retrieved from the machine. Most vending machines communicate through telemetry, which allows the machine to connect to the internet [4]. Some machines that are connected to the internet are vulnerable to hacking and can cause issues with other devices, which is why the team is considering alternate methods [5].

The vending machine must be able to keep track of a student’s Tech email, name, ID, and class according to the customer. In order to know what device is checked out, it must also know which board number is taken, which the student must enter after getting the device. An interface is required on the machine for the student to enter board numbers into the database as well after vending.

The machine requires a fault option if power is lost, and must remember what was entered before power loss. Security must also be applied to avoid any student stealing a board out of the machine after power loss, which will most likely be a type of lock. Lastly, the machine must be large enough to fit a decent number of devices before requiring the office associates to refill the machine.

## Constraints

The vending machine must follow certain constraints in order to be properly designed for the ECE office. The machine will be plugged into the wall, and must, therefore, follow the national electric code in order to be allowed to be used. The national electric code of the United States is the NFPA 70, which is the benchmark for the safe design and installation of electric devices [6].

The machine must not be as large as a normal vending machine because it must fit inside of the ECE office without obstructing the work environment. Also, for communication purposes, if Bluetooth is used, it can only operate on a 2.4 GHz frequency in order to avoid conflict with wireless networks [7].

The team must also adhere to student data privacy regulations from the school and apply measures to the machine in order to prevent any name or ID leaks.

## Standards

To ensure our team can successfully and safely implement our vending machine, we must understand the standards under which the machine will have to comply. These standards come from both IEEE and the government, and we must comply with both.

One of the most important standards we must hold to is the National Fire Protection Association 70 (NFPA 70), also known as the National Electric Code (NEC). This standard covers a large portion of our safety regulations; installations of connections, circuit protection, wiring, and general-purpose equipment such as cords, receptacles, and switches. This standard also covers the installation of electrical conductors and equipment “…used by the electric utility, such as office buildings…that are not an integral part of the generation plant…” [8]. These regulations are just the surface of the NFPA 70 standard. Our team must familiarize ourselves with this standard, above all, in order to successfully implement our vending machine.

Another standard similar to the NFPA 70 that we must comply with is the IEEE C2-2023 code. This code is similar to the NFPA 70, in that it involves standards related to those covered in the NFPA 70. IEEE C2-2023 is the National Electrical Safety Code(R) (NESC(R)) that “…includes the work rules for the operation of electric supply and communication lines and equipment,” [9]. This is a standard that covers more specific elements of working with the electrical communication and wiring rather than being an overall standard for all things electrical, like the NFPA 70.

Finally, one more standard we must comply with is IEEE Policy 7.8. This is the Code of Ethics that any electrical and computer engineer must comply with in order to conduct any professional work. This code of conduct requires that all engineers “uphold to the highest standard of integrity, responsible behavior, and ethical conduct in professional activities,” and “[To] treat all persons fairly and with respect, to avoid harassment or discrimination, and to avoid injuring others,” [10]. While IEEE Policy 7.8 does not cover anything involving electrical work specifically, it is a crucial standard we much adhere to. Without this policy, there is no guarantee that a project will be ethical or safe for the public. It also helps our team members keep each other accountable for upholding good ethics.

## Units

* Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
* Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
* Do not mix complete spellings and abbreviations of units: “Wb/m2” or “webers per square meter”, not “webers/m2”. Spell out units when they appear in text: “. . . a few henries”, not “. . . a few H”.

Identify applicable funding agency here. If none, delete this text box.

* Use a zero before decimal points: “0.25”, not “.25”. Use “cm3”, not “cc”. (*bullet list*)

## Equations

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

*a**b* 

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

## Some Common Mistakes

* The word “data” is plural, not singular.
* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
* In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
* A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
* Do not use the word “essentially” to mean “approximately” or “effectively”.
* In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
* Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
* Do not confuse “imply” and “infer”.
* The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
* There is no period after the “et” in the Latin abbreviation “et al.”.
* The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

# Using the Template

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

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### For papers with more than six authors: Add author names horizontally, moving to a third row if needed for more than 8 authors.

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#### Selection: Highlight all author and affiliation lines.

#### Change number of columns: Select the Columns icon from the MS Word Standard toolbar and then select the correct number of columns from the selection palette.

#### Deletion: Delete the author and affiliation lines for the extra authors.

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Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named “Heading 1”, “Heading 2”, “Heading 3”, and “Heading 4” are prescribed.

## Figures and Tables

#### Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

1. Table Type Styles

| Table Head | Table Column Head | | |
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| copy | More table copya |  |  |

1. Sample of a Table footnote. (*Table footnote*)
2. Example of a figure caption. (*figure caption*)

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

##### Acknowledgment *(Heading 5)*

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

##### References

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence: “Reference [3] was the first ...”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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10. <https://www.ieee.org/content/dam/ieee-org/ieee/web/org/about/corporate/ieee-policies.pdf>

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