Project Deliverable F: **Prototype I and Customer Feedback**

GNG 1103 – Engineering Design

Faculty of Engineering – University of Ottawa

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March 9th, 2021

Introduction

JAMZ delivery, a newly created drone delivery company, has been working with the Engineering students at the University of Ottawa in order to create various external additions to their drone system. Students in the group D2 have agreed to work with JAMZ to create an anti-theft module that is easily attachable to the drone and that will deter potential thieves using different coloured lights and an automated voice played through a speaker.

So far, with the previously identified client needs, students in our group have created a conceptual design for the module, along with an overall cost estimate for the parts required for testing and implementation. This anti-theft module will be implemented using red/yellow/green LEDs, connected to a motion sensor which will be directed and powered by an Arduino board. All of this will be contained in a small, low-profile case that will attach directly onto the drone.

This deliverable will outline a prototype test plan and will feature the first prototype which will be based on a proof of concept. This prototype will be a simple overview of some of the main components. As such, many of the components will not be as functional as would be expected in the final design. The components will also be analyzed using basic science and engineering concepts. Finally, we will include the feedback and general comments that were collected from the previous client meet on our proposed concept.

Prototype Test Plan

Why are we doing this test?

For this prototype, we will be attempting to test the basic functions that should be functioning by March 28 of 2021. To begin we must discover if we can program lights that turn on and off when given different values. This will be testing our circuit design knowledge and our coding abilities. Also, a 3D prototype of the speaker will be developed to check to see if the size of the speaker will fit on the drone.

Furthermore, we will design a protective case for the Arduino board in a 3D design software to be 3D printed later. On top of this, we must make sure that it fits on the drone. In addition, we will be testing our circuit design and coding abilities with the

motion sensor. This will assure that we are familiar with the motion sensor coding process to speed up testing in later prototypes.

What are the test objectives?

The initial test objective is to make sure that the prototypes are working as we intended.

First of all, we need to make sure that the light system can change colours based on the condition of the drone. Additionally we should become more familiar with the implementation of the motion sensor. Finally, we should make sure that we can determine the final size of the speakers that will fit into the drone.

What is being learned by this prototype?

This initial set of testing will teach us students how to code a light that will turn on in different situations as well as, setting up the Arduino board in the proper way. Next, we will learn the dimensions of the speaker to help decide the placement of the speaker on the drone. Similar testing will be done with the Arduino case to assure the placement of the board on the drone however, this test will be done in an online 3D design software. Finally, in TinkerCad, we will learn how to code a motion sensor to recognize the acceleration of the drone. This will communicate with the Arduino board when the drone's acceleration has reached the acceleration of gravity (free fall). Therefore we will know if the drone has crashed. Learning how the motion sensor must be coded and the layout for which it has to be designed with the Arduino is important to get an understanding of the motion sensor we will be using in the future.

What are the possible results?

To begin, we will discuss the results if every test fails. Since the students in this class have worked on the Arduino board with lights before, we will not fail at this test. However, if the test does fail, we would not be able to have a light ignite in different situations. The next test is the speaker size test. The worst case scenario, the speaker won't fit on the drone, in which case we will place the speaker on the Arduino case. The next test is to see if the Arduino case will fit on the drone. If it does not fit, we will have to redesign the case in an online design software such as OnShape. For the motion sensor, there is a chance that we could fail at the coding which will require a lot of trial and error.

Secondly, we will discuss if we succeed at every test. If the lights function properly, the light will turn on in three different situations. Next, the speaker would fit on the drone in any position and the same can be said for the Arduino case. Finally, the motion sensor will work properly and it can use its accelerometer to check if the acceleration of the drone reaches the acceleration of gravity.

How will these results be used to make decisions?

For the lights, we must be able to get the lights to work since this is the simplest part of our prototype. After testing the lights, we will decide to have three different coloured lights that will each turn on in different situations connected to the motion sensor. Next, if the speaker doesn't fit naturally on the drone we can place it on the Arduino board case. Finally, we will test the motion sensor, which is by far the most difficult part of this prototype, which will allow us to decide how the lights will function. For example, the light will turn a colour if the acceleration reaches the acceleration of gravity and then hits zero (indicating a crash).

What is the prototype and **how** is the test being done

What is the type of prototype?

We will have a physical prototype of the LED light that will be connected to a circuit and programmed to turn on at different settings in TinkerCad. The next prototype will be the speaker prototype made out of cardboard that will give us an idea of the space needed for the speaker system. Following these, we will have an online design of an Arduino board case that will give us an idea of the amount of space needed for the case compared to the drone. Finally, the motion sensor will be programmed and modelled in TinkerCad as an early modelling view.

What information is being measured?

First off, the acceleration of the drone is being constantly measured by the motion sensor's accelerometer. This will allow us to detect if the drone has crashed and therefore send signals to the lights and the speaker. Next, the dimensions of the speaker and the Arduino board case are being measured to make sure there's room on the face of the drone to fit all the components.

What is being observed?

The lights will be observed to turn on at the right times. As well, the motion sensor program will be observed in reaction to changing accelerations. Also, we will observe the sizes of the physical components in comparison to one of the sides of the JAMZ drone.

What are the required materials and cost?

We require an Arduino board and everything else in the Arduino kit purchased at the start of the semester. Each student has spent $20 on the kit which includes all the supplies needed for this first prototype.

How is the prototype used? Does it match the objectives?

This prototype has multiple small sub-systems that work together to ensure the objectives are met. For instance the speaker prototype and the arduino case that we are designing both have the same purpose to see if they will fit on the JAMZ drone. Another thing is that the led lights and motion sensor will be set up and see if we can code it properly in order to make different lights appear at different situations and see if it is working in general. If these prototypes are used on the drone successfully then our objectives will have indeed matched as we built our prototype properly.

What work needs to be done?/ Prototyping process

First off, Yusuf and Geoffrey will build, program and test a single LED light that will need to turn on in three different situations. This will simulate the process in the later prototypes. Next, Zakkai and Steven will design an Arduino cover in OnShape to protect the Arduino board when the JAMZ drone is flying or crashes. After this, Steven will make a model of the speaker out of cardboard to help visualise the space needed for it. And finally, Andy will code and design a circuit for the motion sensor.

When is the testing happening / How long will it take?

The testing of the overall prototype will happen after we have finished all of the individual prototypes. The most difficult part of testing the prototypes will be programming the light system since the lights will need to change color depending on the status of the drone. Programming the lights should take up to one day. Testing the

speakers will be easier since we just need to fit it onto the drone properly and record a message for the speakers to play out when delivering. For the arduino case, the only testing we need to do is to make sure that an Arduino board will fit into the case. This will be done by using Arduino board measurements (from the previous Arduino lab) when designing the CAD model. Lastly, we will test the PIR motion sensor on TinkerCad and eventually configure the sensor with the Arduino board.

How long is the test estimated to take and what are the dependencies (i.e. what needs to happen before the testing can occur)?

Before we can even start with the testing, a basic version of the prototype needs to be designed using CAD for the case and Tinkercad for the arduino simulation. An understanding of the principles of circuits is also needed to make sure the arduino works and is connected properly. This will ensure that testing will go smoothly and results will be easy to obtain.

The tests should only take a few hours over 1-3 days. And because the prototype is still in a very early stage, the results should be fairly reachable and simple.

The following Gantt chart roughs out the test plan over the allocated period and other time constraints.

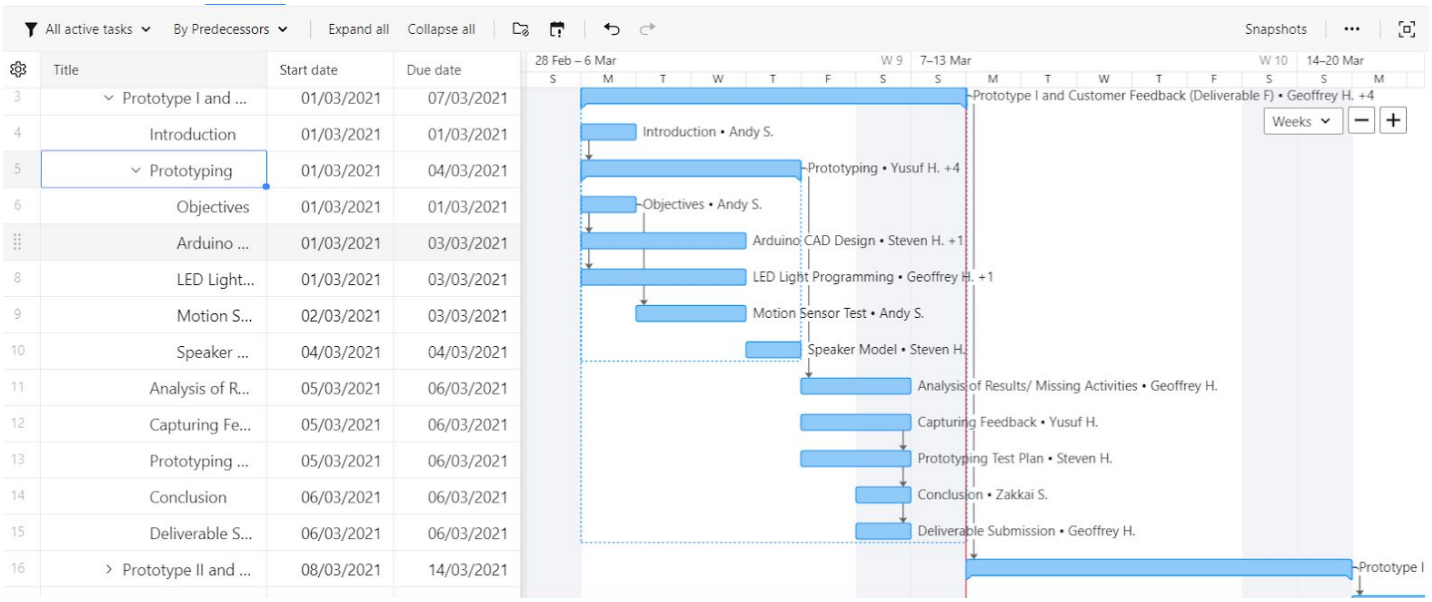

Figure 1: Project Gantt Chart (Prototype 1 Test Plan)

When are the results required and what depends on the results of the tests in the project plan?

The results from the Prototype 1 will be used to modify objectives and improve the testing in Prototype 2. Therefore, they are needed by March 7th which also is shown in the Gantt Chart. The results are also needed to move on to the next phase of the task plan. Without them, our team will have issues in the next stages and will find it very hard to connect the different aspects of the projects (i.e. connecting the lights to the motion sensor and speaker).

Client Feedback

During our client meet on February 22nd, 2021, we proposed our initial idea of having both a motion and a proximity sensor in the **anti-theft module**. The JAMZ representative, Mohammad Abu-Shaaban indicated that including only a motion sensor would be enough for the module, and that having two sensors would be overly complicated for the scope of the project and would push the limits of our budget.

When we proposed to have various colours of lights to deter thieves from stealing the drone, JAMZ mentioned that the drone would already have red and green LEDs and that they would like an additional yellow LED to be attached with the module. JAMZ wanted the module to display different coloured lights based on the condition of the drone. Green would represent everything working as usual, yellow would represent that the drone is in an intermediate state (loading another operation), and red would indicate that the drone is not acting as it should be (this condition would activate the anti-theft measures). JAMZ also told the group that a good way to detect if the drone is acting abnormally would be if the drone's acceleration was exactly the acceleration due to gravity ($-9.81 m/s^2$) and then reaches an acceleration of zero. After, if the acceleration rises past zero, JAMZ will know the drone was picked up and moved.

When asked about the approximate range of the automated voice, Mohammed said that the voice should be able to be heard from around 10 meters away. Additionally the automated voice should be looping a message that will make the thief aware that the drone is being tracked.

Since Mohammed also indicated that the drone has a height determining sensor, it would be a good addition if the module could use the sensor's data to predict when the drone has crashed. If the drone's height is below 5 meters, the module should recognize the drone as having crashed and activate the red lights and the corresponding anti-theft precautions.

Prototype I

TinkerCad PIR Motion Tester

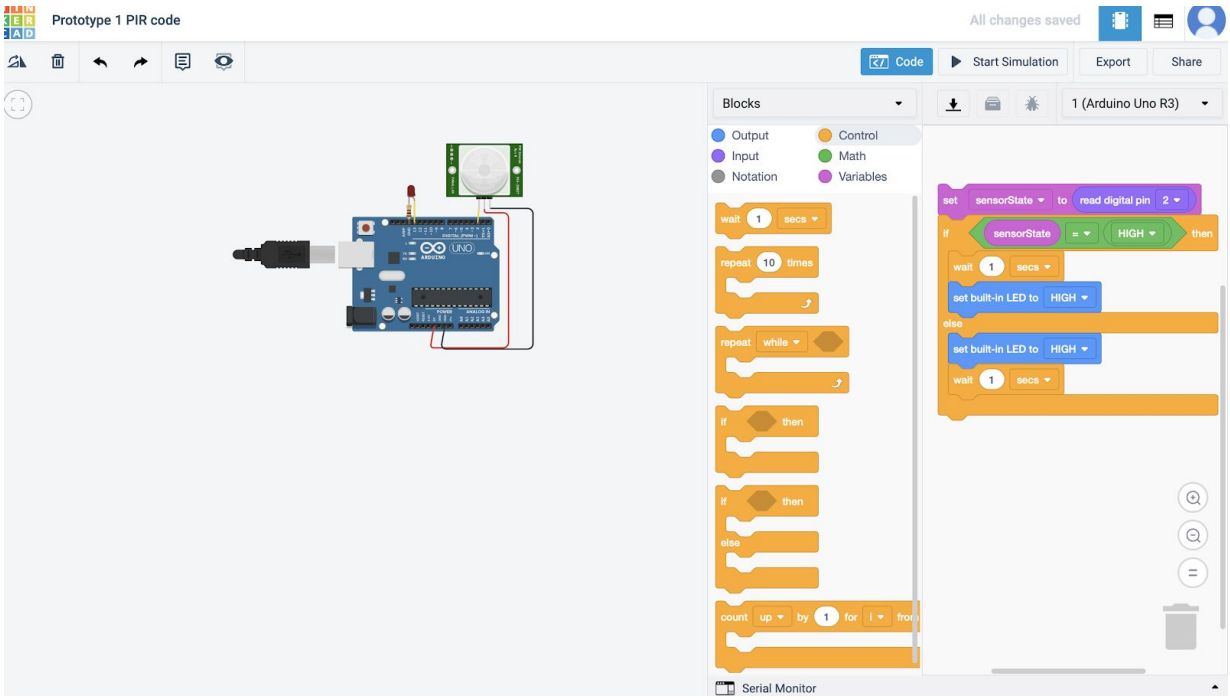

Figure 2: TinkerCad PIR Motion Tester OFF

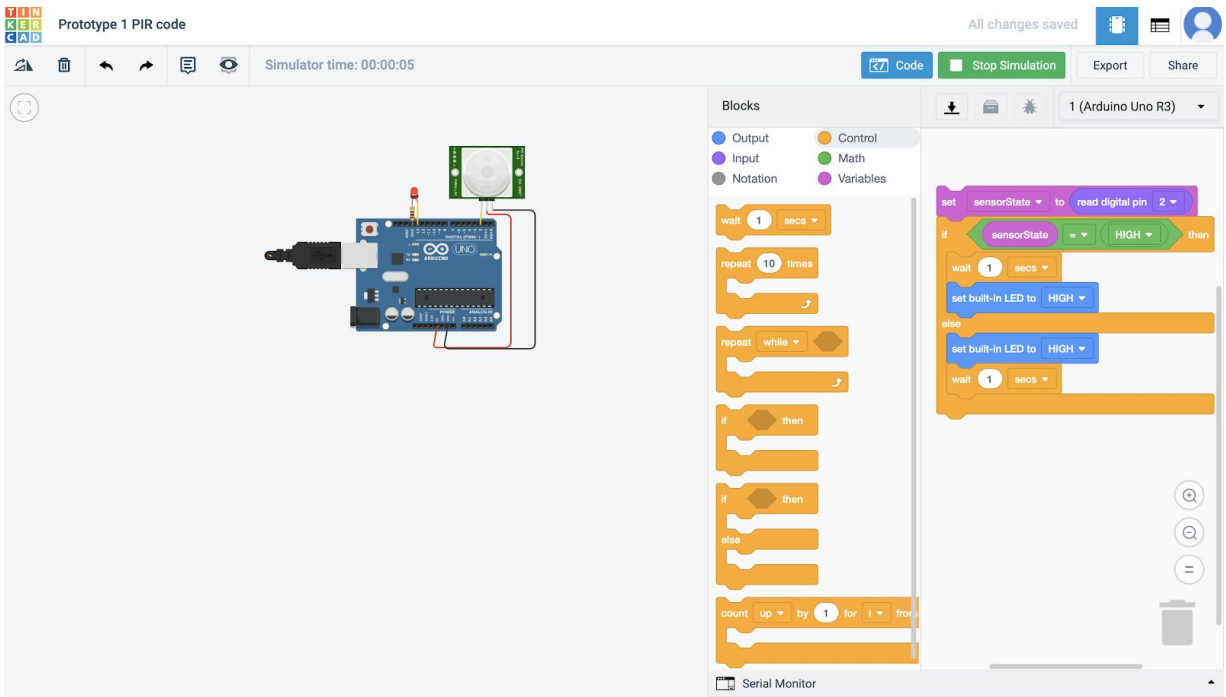

Figure 3: TinkerCad PIR Motion Tester ON

Light Simulation Under different conditions

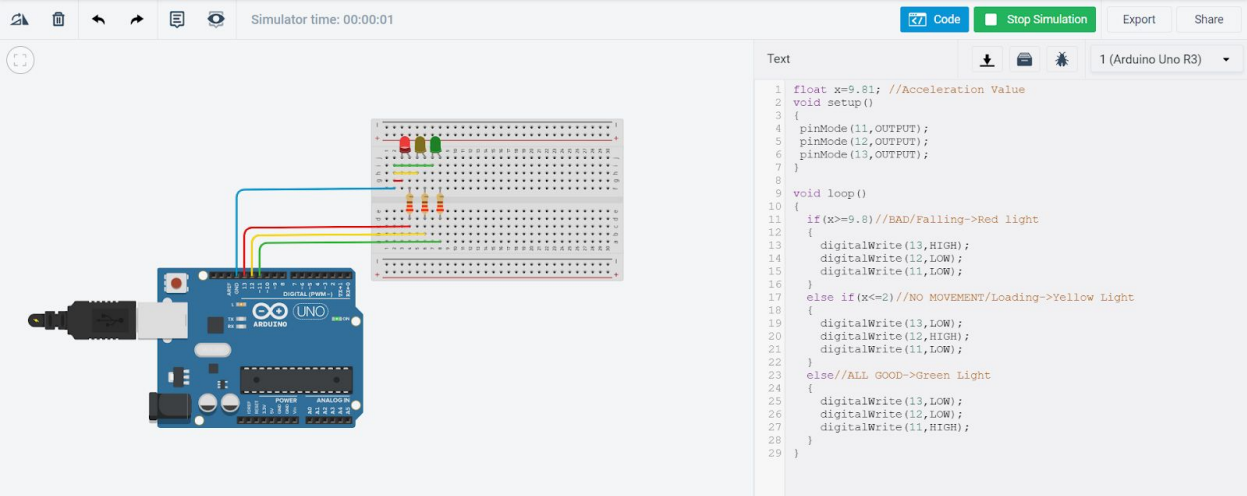

Figure 4: TinkerCad Light Simulation Using Red/Yellow/Green LEDs

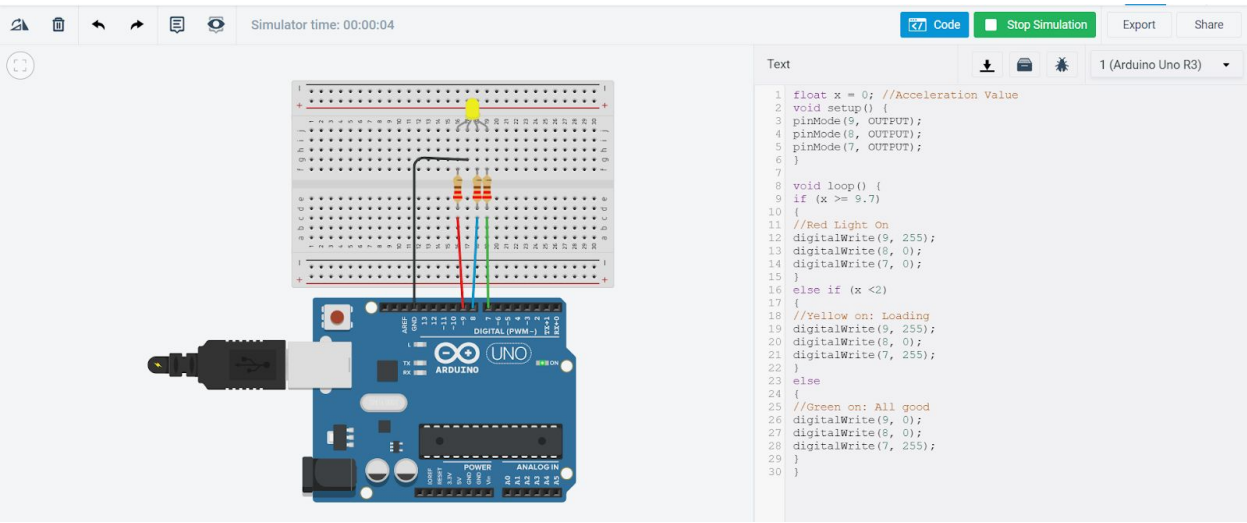

Figure 5: TinkerCad Light Simulation using an RGB LED

Model for the Arduino Case:

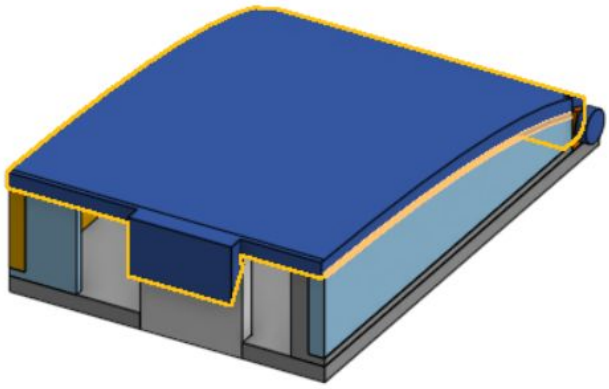

Figure 6: Arduino case closed

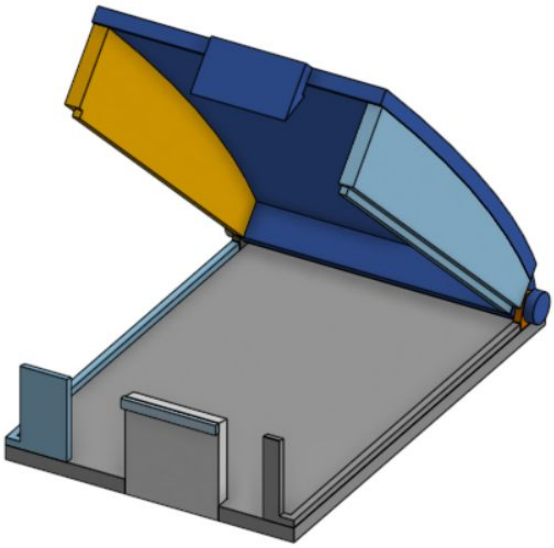

Figure 7: Arduino case opened

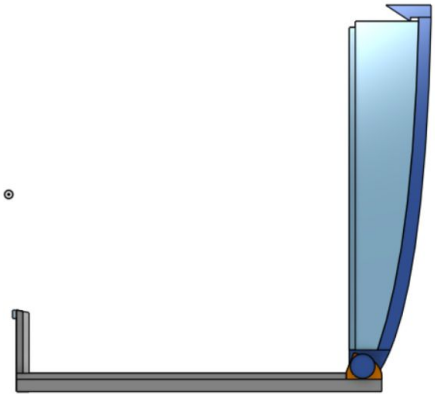

Figure 8: Arduino case opened (side view)

Model for the Speaker:

Figure 8: Speakers with logo (front view)

Conclusion

In this deliverable, students in GNG1103 group D2 designed and tested our first prototype for the JAMZ delivery anti-theft module based on criteria that was developed in previous deliverables. This prototype included a basic code to program LED lights with an Arduino board, figuring out the basics of programming a motion sensor in TinkerCAD, and finally figuring out the dimensions of the Arduino Case and sensor to make sure that they both fit on the drone.

Using the prototyping steps completed in this deliverable, the group will be able to move onto creating our next prototype using this one as a foundation. Many of the prototyping planned for prototype II will include the combination of a few of the components created in prototype I.