ENGR 112 – Spring 2017

Semester-Long Pellet Sorter Project

This term, you will be involved in a semester-long design project. You and your design team will be responsible for designing, building, and testing a prototype machine for the delivery of water treatment pellets (AKA the Marble Sorter). As you will see in the project description below, this is part of a project headed by the World Health Organization (WHO) to stop an outbreak of Ebola hemorrhagic fever.

Project Organization.

The primary organization element will be the four-person team assigned by your instructor. These are the teams that we will use for all team-oriented work throughout the semester. Each four-person team will be assigned a Lego kit that is theirs for the semester. You will be able to take this Lego kit out of the classroom and use it at your convenience.

Due to the scope of the project, we will form taskforces (AKA megateams) by joining two four-person teams. You may organize your taskforce based on the original four-person teams or you may organize it based on interest- and skill level.

Only one graded demo is based on the work of the original four-person team. All other work for the project will be evaluated on a taskforce-level.

Your instructor will create the four-person teams. After the taskforces are formed, there will be assessment of team member performance. It is important that each team member contribute to the effort. Not all team members need to receive the same grade for the project assignments. Those that do not contribute as much as others should expect to receive less credit (a lower grade) for the team's work.

Project Deliverables and Schedule.

End-of-the-semester project deliverables include the working prototype and a team/taskforce oral presentation describing the prototype's performance in a demonstration. There are also project milestones along the way that involve demonstration of certain subsystems of the prototype. The taskforce's Design Notebook will also be submitted for review after each demonstration.

There are **three (3)** in-class demos scheduled prior to the final in-class demo. Your instructor may choose to substitute a "virtual demo" for one or more of the class subtasks. A virtual demo consists of the submission of a short video demonstrating a particular functionality of the prototype and the submission of the Design Notebook. Instructions on how to submit the video for the virtual demo will be provided. Your instructor may add additional "virtual demos" if he/she thinks your section would benefit from them.

The tentative project schedule organized by class period number is listed below. (This schedule is consistent with the class schedule from the syllabus.) Individual instructors may modify this schedule to fit their needs, so be sure to check with your instructor.

Class Period	Project Activity
6	Assign Teams/Distribute Lego kits/ Project Introduction/ Project Workday 1
9	Project Subtask 1 – Dispenser demo
16	Project Subtask 2 Corrected Dispenser
21	Project Work Day 2 (work on project in class)
22	Project Subtask 3 – Bar code and Pellet identifier Demo
24	Project work day 3/Matlab Project work day
25	Project Demo Day 1
26	Project Demo Day 2
28	Project Presentation Day 1
Final /29	Project Presentation Day 2

There are two days for final project demonstrations and two days final project presentations to allow adequate time for each team. The best projects from the demonstration days may be eligible to demonstrate their work in the Engineering Showcase, run by the College of Engineering.

REQUEST FOR PROTOTYPES

Project Overview

The goal of this project is the development of a proof-of-concept prototype for an antiviral delivery system. The prototype will, based on instructions on a series of cards, deliver a specified number of spherical pellets into a well. The detailed requirements are specified below.

Project Scenario

A new variant of the Reston strain of the Ebola hemorrhagic fever recently jumped from the destructively invasive crab-eating macaques (*Macaca fascicularis*) in rural Angaur Island in Palau to the human population. Unlike the strain responsible for the Paris, Texas outbreak in 1996, this variant is not only transmitted by contact with bodily fluids, such as blood, semen, and milk, but also has a significant airborne transmission component. Health workers have found that a combination of several antivirals is very effective at controlling the virus. Unfortunately, the airborne transmission mode requires that health workers wear full isolation suits to work with patients. This is extremely impractical due to the high summer temperatures combined with poor access to rural areas.

The World Health Organization (WHO) has proposed a three-pronged attack on the disease. The attack will consist of:

1. Quarantine of the impacted area to limit spread.
2. Introduction of antivirals into water wells.
3. Treatment of female macaques with the immunovaccine porcine zona pellucida to reduce their population over the long term.

Your engineering team has been tasked with providing the support technology for attack number two (2) above, namely the introduction of antivirals into water wells. WHO biomedical research teams have developed a stabilized form of the antivirals that will remain effective in water for a period of 24-hours, provided that certain water quality parameters are maintained. To make the antivirals universally available, they will be introduced into the local water supply. Unfortunately, local well water is of variable water quality and each well will require different treatment, depending on its location.

Other engineering teams are building robots that automatically perform water quality analyses and, based on those analyses, print out a series of four cards containing a black and white bar codes. These cards will specify the combination of pellets to be delivered into a specific well. For convenience, all of the components to be delivered into the wells have been pelletized into hard spheres ranging from ~14 mm to ~19 mm.

Goals

The research teams have requested that your team develop a proof-of-concept unit that will introduce the antivirals along with appropriate chemical treatments to improve the water quality into a well at regular intervals. To reduce exposure time to the disease, mixtures of pellets will be delivered in a single container.

Your prototype should perform the following actions:

1. Read the bar code from each of four cards and determine the pellet mix specified by those four cards. All four cards should be read and the pellet mix determined before any pellets are delivered into the well.
2. Receive an unsorted mixture of approximately 75 pellets.
3. Sort the pellets by size, color, and material, storing each pellet type in its own and separate bin.
4. Gather the correct dosage as specified by the bar codes. This involves gathering the needed pellets from the pre-sorted pellet bins.
5. If a complete correct dosage can be gathered, deliver the mix of pellets into the well. A complete set of the pellet mix must be introduced into the well three times over a ten minute period with a minimum of a twenty second gap between deliveries.
6. If there are insufficient pellets available for the specified mix, no pellets should be dispensed, and an alarm signal provided.
7. The final unit is expected to be solar powered. Therefore, you should be as energy efficient in your design as possible, running motors only as required.
8. As these agents are expensive, the only pellets that should be intentionally directed to a waste stream are those pellets that do not meet the current specification for the antiviral pellets or the water quality treatment pellets.

Taskforce, Team, and Individual Contributions

The primary organizational element will be the four-person team. Due to the scope of the project, we will form taskforces by joining two four-person teams. You may organize your taskforce based on the original four-person teams or you may organize it based on interest- and skill- level. Each taskforce shall be responsible for developing a prototype pellet dispenser and fully documenting the design and design process throughout the semester.

Pellet Description:

To assist in the sorting process, the manufacturers have agreed to add a non-toxic colorant to their products based on their role in the process. The colors have been assigned along with their material for use in your prototype's development. Because the pellet compositions are still under development, the pellet sizes have yet to be determined. Note that, as products in development, these preliminary materials, sizes, and colors are subject to alteration. However, your design should be able to identify and sort based on all three parameters. As we receive feedback from our development partners, the information will be made available.

Prototype development pellets, of these specified sizes, materials, and colors, will selected for the table below:

Role	Color/Transparency	Size (Approximate)	Simulant Material
Water Quality Pellet: Type I	Metallic	14 mm	Low-Carbon Steel or Hollow Aluminum
Water Quality Pellet: Type II	Blue, Opaque	14 mm or 18-20 mm	Glass
Water Quality Pellet: Type III	Red, Opaque	14 mm or 18-20 mm	Glass
Water Quality Pellet: Type IV	White, Opaque	14 mm or 18-20 mm	Glass
Antiviral Pellet	Translucent White	14 mm	Polyethylene (HDPE)

Please note that pellets of other materials, sizes, and colors may be provided for prototype testing. Your prototype should be able to detect and reject these pellets as they do not need to be sorted like the pellets listed above. In other words, these extra pellets will never be specified on a bar code for delivery into a well.

Design Components Available to Each Team

- Lego Mind Storms Kit
- Additional materials such as magnets and wooden strips for framework and pellet movement will be provided. You may use them as you see fit in the project.

- Up to $40 of additional materials per 4 member team. You will be asked to provide receipts for all purchases and reasonable cost estimates for all donated materials in your final report. However, you will not be reimbursed by the university.
- You may (but are not required to do so) use the EIC for 3D printing of parts for you device. This will not cost you anything at the EIC. But to preserve fairness, you will be "charged" $0.25/gram of your parts against your $40 limit; i.e., if you have a 100 gram part from the EIC, you will be allowed to spend only $15 on other stuff (if you so choose).
- Samples of the various pellets and some of the product stabilization pellets will be provided for measurements. Note that the aluminum pellets are not currently available, they may or may not be available for prototype development.

Deliverables

This project will have two major deliverables at the end of the semester: a design notebook, and a final presentation. Each of these items are to be completed by every taskforce. There will also be subtask activities throughout the semester. What follows is a brief description of each of these deliverable items.

Design Notebook

Documentation is an important part of the Design Process. Your team/taskforce's efforts will be documented via a Design Notebook. (A thorough description of the requirements for the Design Notebook may be found in on the eCommunity page along with several examples of good Design Notebook entries and not-so-good Design Notebook entries.) Briefly, the Design Notebook is a living document where the team/taskforce enters Gantt charts, WBS charts, schedules, project meeting minutes and attendance, design ideas, schedule entries, work task assignments and due dates, and anything else associated with the project. Inclusion of drawings and photos is encouraged. It is kept in digital format (a pdf file) and should be available to all team/taskforce members at all times. It should also be available for upload to eCampus for grading at all times.

The Design Notebooks will be graded after each project demo. Therefore, another item to include would be an after-demo assessment of how the prototype performed and ideas on how to proceed.

Final Demonstration

The final demonstration is designed to test your prototype's ability to satisfy the project goals listed above. Here, with slight repetition, is an outline of the final demonstration process.

1. Provide the means to accept a load of approximately 75 pellets into the prototype's hopper or storage bin without structural failure or deformation that would hinder performance.
2. Provide the means to release the pellets from the hopper in a controlled fashion.
   a. Control implies on/off and perhaps speed control.
3. Provide the means of identifying each pellet and directing it toward the appropriate storage bin or waste bin.
4. Provide the means of reading four bar code from cards and storing the data.
5. Provide the means of converting the bar code data to a number of pellets of each type that is required for the dosage.
6. Provide the means to retrieve or dispense the needed number of each type of pellet from the storage bins and deliver to the well.
7. Provide the means to detect that a full dosage is not available and sound an alarm rather than deliver an incomplete dosage to the well.
8. Energy efficiency, and zero intentional direction of valuable pellets to the well are expected.
9. As pictures and videos of your prototype demonstration will be shared with WHO officials, the quality of your prototype's construction is important. However, you must stay within your cost limits.

At no time during the test can the team unjam or otherwise interfere with their machine's operation except between trials. Accuracy in dispensing the pellets is of primary importance. Speed of operation is not an issue as long as the three sets of pellets are dispensed within 10 minutes. Incorrect pellet mixture or inclusion of an out-of-specification pellet is disastrous and will be so reflected in credit for this project.

Subtask 1: Dispenser Demo (In-Class)

This subtask is for each four-person team. Each Team of each Taskforce will complete this demo separately.

The deliverable for this subtask is a pellet dispenser that is capable of dispensing one pellet at a time in a controlled manner. By "controlled manner" we mean that only one pellet is dispensed at time, that the process can be easily turned on and off, and that the rate of dispensing may be changed.

After demonstrating each Team's prototype, the two teams forming each taskforce should get together and compare design characteristics and performance from the two prototypes.

Subtask 2: Fix Your Dispenser Demo

This subtask is for each taskforce.

The deliverable is your taskforce's dispenser. This should represent (in most cases) an improvement in performance over the previous dispenser demos. The same criteria as Subtask 1 will be used to evaluate performance.

Subtask 3a: Bar Code Reader (In-Class)

This subtask is for each taskforce.

For this demo, the prototype should accept four bar code cards, one at a time, and read and store the bar code. Internally, the bar code should be decoded and the required numbers of each of the eight types of pellets should be displayed on the Lego brick or a computer screen.

Your instructor may add two additional virtual (video) subtasks, to insure your progress towards the final demonstration. This will decided on a section basis, and may reflect the amount of progress (or lack thereof) towards the final demonstration. (We really do want every taskforce to have a successful final demonstration, and know that students often put off work on the project until the end. We reserve the right to make sure you don't make the same mistakes as your predecessors.)

Subtask 3b.: Pellet Identifier. (In class or Virtual)

This subtask is for each taskforce.

For this demo, the prototype should be able to accept a single pellet, placed by hand, and indicate the material, color, and size of the pellet. This data should be displayed on the Lego brick, a computer screen, or by the pellet arriving in the correctly labeled bin.

Possible Subtask 4: Dosage Dispenser (Virtual)

This subtask is for each taskforce.

For this video demo, the design team may manually sort pellets into the proper bins prior to the demo. Next, a valid dosage will be entered into the system in some way. It may be done manually or via the barcode reader. The dosage dispenser should then demonstrate the ability to gather the specified number of each type of pellet and, when the complete dosage has been gathered, simulate delivery into a water well