2015 Peterborough PEO/OACETT/IEEE

Engineering Month Challenge

Final Report

Overview:

The 2015 Engineering Month Challenge event, which is jointly planned and hosted by the Peterborough PEO/OACETT/IEEE chapters was held on March 4, 2015 in the multi-purpose room at the Evinrude Centre. This year's event challenged the students to build a mechanism to safely land a cell phone which was dropped from a height of 5m. This was a variation on the classic 'egg drop' style contest, which was presented as a 'Mars lander' competition, which introduced the students to the important aspects of lading a payload on a distant planet.

The Challenge:

Appendix B contains a copy of the handout that was provided to the students which outlines the objectives and constraints of the event. The students were provided with a wide variety of materials to build their landers, including:

- Garbage & recycling bags
- Sponges
- Egg cartons
- Bubble Wrap
- String & tape
- Popsicle sticks & straws
- Balloons

Total time given for construction was 2.5 hours, at which point all landers needed to be submitted for testing. Each team was given a wooden 'mock payload' which was a piece of wood approximately the same dimensions as an iPhone 3GS which needed to be able to be quickly installed and removed from their landers. The students were also provided with a rubber washer, approximately 2.5cm dia which needed to be installed at the top point of their device and which was used as the attachment point to the launch mechanism.

The launch mechanism consisted of a long wooden arm, hinged against a wall with a solenoid mechanism at one end which was actuated by a 12V car battery and switch. When the switch was engaged the solenoid retracted, and the plunger was placed tough the centre of the attachment washer. The arm was then raised up to 5m off the floor to drop the landers.

The goal of the challenge was for the students to design a lander which would protect the iPhone during landing (as measured by the accelerometers in the phone) and also kept the phone in the initial orientation and landed in the designated target area.

The main principle the challenge was trying to demonstrate was the transfer of energy during an impact. The lander + payload had a certain potential energy when lifted to the 5m height, and the students were challenged to design a lander which would 1) dissipate the energy as the lander fell (i.e. through a parachute) and would cushion the payload during the impact by having the energy absorbed in the lander.

There was a 'mock up' drop fixture available, which allowed the students to test their landers during construction.

Appendix A contains a number of photos from the event.

Attendance:

The event was attended by 113 students in grades 10-12 split into 29 teams from Lakefield College, St Peter's, Holy Cross, Adam Scott, Crestwood, and St Stephen's. Approximately 15 volunteers were in attendance to run the event.

There was also a special guest speaker at the event, Steven Morley - president of OACETT, who gave part of the opening address to the students.

Results:

For final testing, an iPhone 3GS was loaded into the landers, and the software to measure the peak 'g' force experience by the phone was reset. The lander was connected to the launch arm, raised to 5m and then dropped onto the floor in free fall. The phone was carefully removed and the maximum 'g' load was recorded.

Points were awarded for minimizing the 'g' load as measured by the iPhone, maintaining the orientation of the phone during the drop, landing in the designated target area, maintaining the total weight of the lander within the prescribed limits and also for written work. Full scoring details are given in appendix B.

Landers from all teams were tested, with the 5 highest scoring teams being re-tested in a final round.

The scores for the top placed teams were as follows:

1st Place: 101 Points: Adam Scott

Grace Duffey
Chris Preston
Damien Hill
Ayden Gibson

2nd Place: 90 Points: Adam Scott

Sebastian Kay
Aidan Hickie-Bentzen
Lydia Mills
Tristan Hilker

3rd Place: 89 Points: St Peter's

Will Trebbne
Greg Guinto
Theresa Kennedy
John Webster

The Subaru Peterborough Award for the most innovative design was awarded to a team from Lakefield College:

Greta Liu
Asic Chen
Mingze Lin
Edward Tian

Media Coverage:

The local media was contacted prior to the event, and representatives from the Peterborough Examiner, Peterborough This Week, CHEX TV all attended and covered the event.

http://www.mykawartha.com/community-story/5459653-give-our-teenagers-a-bag-sponges-and-some-popsicle-sticks-and-they-can-build-some-amazing-things/

http://www.chextv.com/2015/03/04/it-all-comes-down-to-the-landing/

http://www.thepeterboroughexaminer.com/2015/03/05/adam-scott-st-peter-teams-win-mars-lander-challenge-at-annual-high-school-engineering-championship

We were also contacted by CBC radio, and a student who participated in the event was interviewed the following morning on the CBC radio "Ontario Morning" show. The interview is near the end of the following podcast:

http://podcast.cbc.ca/mp3/podcasts/ontariomorning_20150305_17682.mp3

Funding & Donations

As in past years, we had many generous sponsors who donated towards the event:

- Peterborough IEEE Chapter (trophies – approx. $350)
- Costco (snacks and drinks for students, garbage and recycling bags for building landers)
- Peterborough Subaru (design innovation trophy)
- Tim Horton's (coffee and snacks for volunteers)
- PrimaIP (juice boxes for students)

NEMOC also provided subsidized T-shirts for the volunteers, as well as Engineering Month posters and some small prizes for the students.

NEM 2015 Income & Expense Summary

Expenses

Evinrude Centre Rental	$	618.11
Trophies	$	367.08
Food (Kenner)	$	500.00
Building Supplies	$	288.60
iPhone & Sensor Costs	$	270.45
Debrief Meeting	$	214.42
Total Expenses	**$**	**2,258.66**

Funding

NEMOC	$	750.00
PVNCCDSB	$	500.00
IEEE	$	367.08
OACETT	$	200.00
Total Funding	**$**	**1,817.08**

Appendix A: Event Photos

Figure 1: Steven Morley – OACETT President - Giving Opening Address

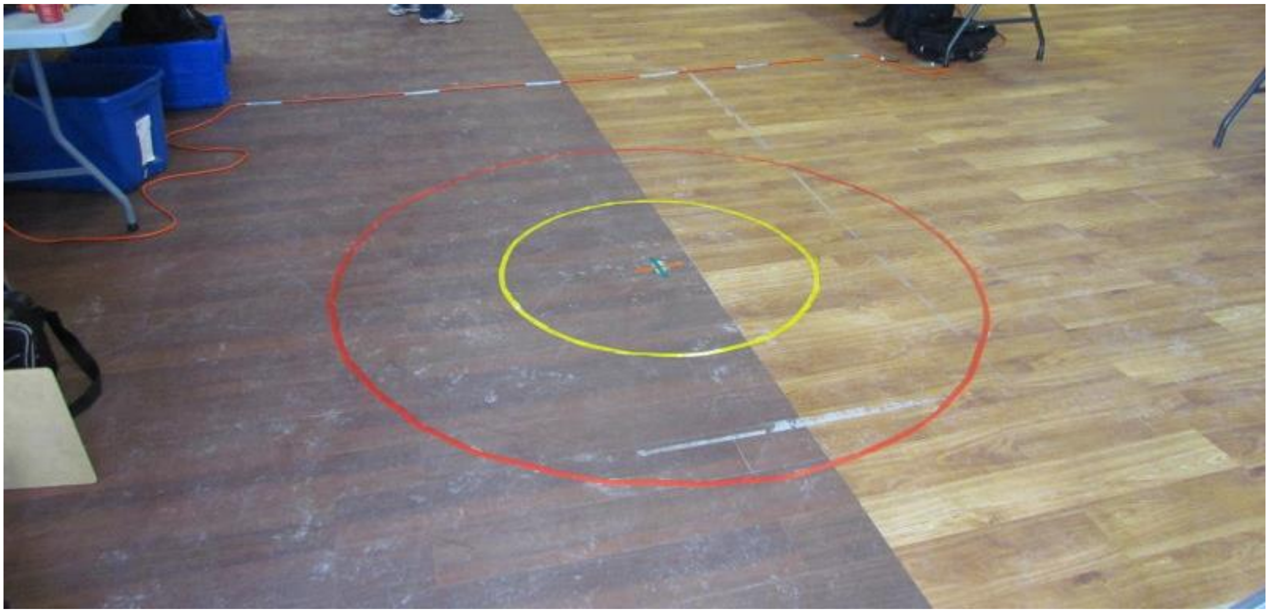

Figure 2: The Final Landing Zone Under The Drop Mechanism

Figure 3: A Lander Under Construction

Figure 4: A Chute Being Tested

Figure 5: A Lander Being Loaded

Figure 6: A Lander Ready to Launch (Launch Arm is Not Yet Raised)

Figure 7: Event Day Volunteers

Appendix B: Instruction Sheet

Engineering Challenge 2015 – Questions and Evaluation

March 4, 2015

Objective: Design and build the payload delivery mechanism to safely land a payload on a surface, the floor. You will be required to launch your payload (a cellphone) from a height of 5m (16ft.) to a landing area on the floor. You will be provided with various construction materials including a "template block" to represent the payload (cellphone). You will be marked on the weight (more marks for using less weight) and the accuracy of your landed payload staying upright. You will be marked on your calculations. You will be marked for your diagram and answering some multiple choice questions. Marks can be earned for partial success and for your calculations.

Assignment:
Today you are building a payload delivery mechanism designed to safely land (minimum g-force) a payload on a surface.

1. Landers are not built with unlimited resources.
    - Your structure will be marked based on its overall weight. Points will be given for lesser weight. 20 marks will be given for a weight of 100g or less(without cellphone). 1 point deduction for every 2g over 100g.
    - Landers also must hang a maximum of 0.75m below the launch point.
    - Landers are allowed a maximum footprint of 1 (one) sq. ft. (900 cm^2).

2. Landers are designed to land a payload at a target
    - You will be marked on how accurate your lander is at maintain its original orientation on landing. 10 points keeping the payload in the same orientation. Also points will be given for landing within a designated target area on the floor. You will get 1 landing attempt from the 4.9 m height once your design is finalized. Your score will be based on the g-force achieved in the landing attempt (points based on a sliding scale).

Use the equations to calculate the velocity and time of the fall at the floor.

Draw a diagram of your structure showing dimensions.

Answer the multiple choice questions related to the physics of the landers on the reporting sheets. (See reading material included in these instructions)

Competition Rules

- Only one lander may be launched at a time
- Only the provided cellphone payload may be launched – no modifications to the cellphones are allowed
- The landers must provide sufficient protection to the cellphone as determined by the judges. If there is a question about this the test area will be used to verify it.
- In the final competition each team will get one launch attempt. The score will be based on the orientation, hitting the target area and g-force on landing.
- After the first launch attempts the top 5 (five) teams based on **TOTAL** score will be given a second attempt to improve their score for the landing part only. The remainder of their score will not be changed. The best result of these second attempts will be declared the winner.

General Safety Rules

- The payload (cellphone) must be easily installed and removed from your lander.
- An eye-hook (provided) must be used to attach the lander to the release point. Keep well clear of the test area when testing is going on.
- No one is allowed near the target area while a lander is falling.

Marking:

#	**Description**	**Points**
1	Weight of lander (100g or less)	20
2	G-force measurement	30 (on a scale)
	Points for Orientation	10
3	Points for hitting target area	10
4	Velocity and time Calculations	10
5	Diagram	10
6	Multiple Choice questions	20
	Total	110

Timeline:

Activity	**Start Time**
Introduction and Overview	10:00am
Construction Begins	10:30am
Lunch Arrives	12:00pm
Testing Begins	12:30pm
Written Work Submitted – Designs To Be Finalized	12:30pm
Testing ends and Results Announced	2:15pm

How does a parachute work in theory?

Throw a ball up in the air and, sooner or later, it always falls back to the ground. That's because Earth pulls everything toward it with a force called gravity. You've probably learned in school that the strength of Earth's gravity is roughly the same all over the world (it does vary a little bit, but not that much) and that if you drop a heavy stone and a light feather from the top of a skyscraper, gravity pulls them toward the ground at exactly the same rate.

If there were no air, the feather and the stone would hit the ground at the same time. In practice, the stone reaches the ground much faster, not because it weighs more but because the feather fans out and catches in the air as it falls. Air resistance (also called drag) slows it down.

What causes air resistance?

Just because the air's invisible, doesn't mean it's not there. Earth's atmosphere is packed full of gas molecules, so if you want to move through air—by walking, in a car, in a plane, or dangling from a parachute—you have to push them out of the way. We only really notice this when we're moving at speed.

Air resistance is a bit like the way water pushes against your body when you're in a swimming pool—except that air is invisible! If you jump off a diving board or do a belly flop, the awkward shape of your body will create a lot of resistance and bring you rapidly to a halt when you crash into the water. But if you make a sharp pointed shape with your arms and dive in gracefully, your body will part the water cleanly and you'll continue to move quickly as you enter it. When you jump or belly flop, your body slows down quickly because the water can't get out of the way fast enough. When you dive, you part the water smoothly in front of you so your body can glide through it quickly. With parachutes, it's the slowing-down effect that we want.

If you fall from a plane without a parachute, your relatively compact body zooms through the air like a stone; open your parachute and you create more air resistance, drifting to the ground more slowly and safely—much more like a feather. Simply speaking, then, a parachute works by increasing your air resistance as you fall.

Terminal velocity

When a force pulls on something, it makes that object move more quickly, causing it to gain speed. In other words, it causes the object to accelerate. Like any other force, gravity makes falling objects accelerate—but only up to a point.

If you jump off a skyscraper, your body ought to speed up by 10 meters per second (32ft per second) every single second you're falling. We call that an acceleration of 10 meters per second per second (or 10 meters per second squared, for short, and write it like this: 10m/s/s or 10m/s2). If you were high enough off the ground, then after about a minute and a half (let's say 100 seconds), you'd theoretically be falling at about 1000 meters per second (3600km/h or 2200 mph), which is about as fast as the fastest jet fighters have ever flown!

In practice, that simply doesn't happen. After about five seconds, you reach a speed where the force of air resistance (pushing you upward) increases so much that it balances the force of gravity (pulling you downward). At that point, there is no net acceleration and you keep on falling at a steady speed called your terminal velocity. Unfortunately, the terminal velocity for a falling person (with arms stretched out in the classic freefall position) is about 55 meters per second (200km/h or 125 mph), which is still plenty fast enough to kill you—especially if you're falling from a plane!

How much does a parachute slow you down?

Feathers fall more slowly than stones because their terminal velocity is lower. So another way of understanding how a parachute works is to realize that it dramatically lowers your terminal velocity by increasing your air resistance as you fall. It does that by opening out behind you and creating a large surface area of material with a huge amount of drag. Parachutes are designed to reduce your terminal velocity by about 90 percent so you hit the ground at a relatively low speed of maybe 5–6 meters per second (roughly 20 km/h or 12 mph)—ideally, so you can land on your feet and walk away unharmed.

Other factors to consider is the distance over which an object stops (de-accelerates) when it hits a surface such as the Earth, another planet or a comet (or a floor). This called shock and can be measured as a force in "g" units as described in the following sentence.

After a free fall from a height $h$the shock on an object during impact is h/dg, where $d$is the distance covered during the impact. For example, a stiff and compact object dropped from 1 m that impacts over a distance of 1 mm is subjected to a 1000 g deceleration.

Equations for free fall without air resistance:

The following equations calculates the free fall time and velocity ignoring air resistance (for simplicity) from the free fall distance.

Equation 1: $d = v_i \bullet t + 1/2 \bullet g \bullet t^2$

Equation 2: $v_f = v_i + g \bullet t$

Equation 3: $v_f^{\,2} = v_i^2 + 2 \bullet g \bullet d$

Variables:

g = acceleration due to gravity = 9.8 m/s^2
d= distance of drop, [d = 5 m (16 ft.)]
t = time (in sec, s)
v_i = initial velocity (in m/s)
v_f = final velocity (in m/s)

<u>Note:</u>
The above equations do not account for air resistance so the actual results your lander experiences will be different from the calculated numbers.