Build Your Own Glider: Physics IIU Culminating Activity

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SPH 3UI - Ms.Patel
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Worksheet A: Investigation: Factors Affecting Range of a Projectile

Reflection:
After investing using the online applet and see how projectile motion works in calculation method (as opposed to experimental), I reflected on the facts and see how that may help me build a glider that works well.

Hypothesis

In this section, I will be doing an investigation of factors that will affect the range of a projectile. This knowledge will help me understand what I have to do in order to create a successful flight with my glider in the final presentation.

Hypotheses:
I will be hypothesizing variables of projectile motion from previous knowledge that I've gained in class.

Following a thorough investigation using the online applet given, I was then able to confirm whether my hypotheses regarding the causes of a projectile motion's range were correct or not. I checked using the same settings with only one different variable each test.

I started out by testing with the applet using initial velocity as the variable and kept the value of other aspects constant for every test. It appeared that as you alter the initial velocity, the range of the projectile motion would also increase. The fact that the range may increase as you alter the velocity to have a higher value proves that my hypotheses was correct. This also tells me that Vi can give an effect to a projectile motion by increasing the range as its own value increased. This is so because a larger value of Vi allows an object to go through larger distance in the same amount of time with an object with the same mass and Δt but a lower Vi.

Following up this step, I returned the initial velocity to the original value and make it become a constant value like the others. This will allow me to make another value be the variable, I chose launch angle and compare and contrast it to the hypothesis I made beforehand. As I finished testing it out, I remembered that I've observed motions that were similar to what I predicted. The change of launch angle does determine the range of a projectile motion, but it has boundaries. As the launch angle is increased from 0°, the object is able to be in air for a longer period of time and causes a larger horizontal displacement to be made. In my tests using the online applet, this was the case until the angle hits 43°. Following 43° + until 90°, the range decreases until it reaches 0m again like what 0° did. This is cause because if the velocity is constant but the angle is increased, as the Vy increases the Vx will be decreased instead, making the object have less possible horizontal displacement in a given time period. The fact that a projectile motion's range can be increased by increasing the launch angle and has a limit proves that the hypothesis I made beforehand was correct.

Another value of variable was to be chosen for the next step. This time I kept everything constant except for the mass of the object that's undergoing the projectile motion. I also made sure tht air resistance is at a constant value of zero, meaning that it is absent for these particular experiments. I realized that no matter what the mass is, the range of the projectile would be constant as long as the other aspects of variables are kept the same. This contradicts my hypothesis, so now I know that mass itself (not counting air resistance) would not affect the range of the projectile since the force of gravity is kept at a constant of 9.8N by nature.

I concluded the testing period by using air resistance as the variable for this set of tests. Like the tests I've mentioned above, I kept the rest of the aspects of the projectile motion constant. Air resistance is connected to mass, so I had to keep that in mind to understand more about projectile motion. First I compared the projectile motion with the absence of air resistance to one that included air resistance in it. I know that air resistance will naturally occur in real life, so I kept an eye for the one that included the air resistance factor. As I have hypothesized in the first section of this worksheet, the presence of air resistance reduced the range of the projectile motion. Air resistance is a type of force and since it acts in an opposite direction of the object undergoing projectile motion, the object will have a shorter range as the force of air resistance gets stronger. This all ties back to mass due to the fact that fair resistance gets stronger as the object possess more mass as I have tested in the simulator. Mass will only affect the length of a projectile motion's range if air resistance is present, t does not affect it directly by itself.

Describe how you will use the results of this investigation to help design your glider.

The results from this investigation from the previous section have aided me to give me a clearer understanding towards projectile motion, which will then help me design the glider I was required to build for the final test at the end of the semester. Now that I know what factors affect a projectile motion's range and how it works, I will know how to make my design with factors that make its projectile motion have a great value of range. From what I've written on the tests from the simulator, the variables that could be changed in order to maximize the value of horizontal displacement include a large enough initial velocity, a medium launch angle of around 43°, and a minimum amount of air resistance which can be received by decreasing the mass.

The first two things that I've mentioned were; a large enough initial velocity and a moderate (~43°) launch angle. These can't be deciphered into a design of the glider, so I will have to make sure I do this while practicing for the glider's flights.

The last two things on the list were the mass and amount of air resistance present. From what I've just learned previously, I know that these two are interlinked to each other and cannot be calculated separately since the amount of air resistance present is dependent on the mass of the object (in this case my glider). To make sure my glider can go through a large range, I should design it so that the glider isn't too heavy and cause a large amount of air resistance to be received. This is why I'll be using 3mm thick foamcore as the main material and have each of the glider's part only have one layer of the material in order to have a light glider that can go through a large range.

How will initial velocity affect the range of a projectile?

The range of a projectile will be varied depending on many different aspects of the experimental diversity of each trial. I do believe that initial velocity (Vi) is one of the aspects that will affect the range of a projectile. From my prior knowledge of objects' motion in a/c I have several hypotheses of why initial velocity may greatly affect the range of a particular object's motion. If Δt is kept constant, the range of the projectile motion will be larger if one increases Vi of the object, assuming that the initial velocity affects the horizontal velocity.

How will launch angle affect the range of a projectile?

As I have previously mentioned, there are more than one aspect to change in order to have varying the range of a projectile. From my prior knowledge of projectile motion, it is clear that changing the launch angle of an object about to go through projectile motion will affect its horizontal range. Altering the initial angle will also alter the initial velocities for both vertical (Viy) and horizontal (Vix) displacement. If Vix is kept constant, increasing the Δt that the object is in the air can increase the range of the projectile motion. One of the ways to do so is to launch the object in the air is to change the Viy which is tied up to changing the object's initial launch angle. There would be a limit to how much Viy should be before it decreases the projectile's range instead of increasing it.

How will mass affect the range of a projectile?

Mass is also one of the aspects that could change the object's range of a projectile. I have enough prior knowledge to make this hypothesis about how altering the object's mass will also affect its projectile motions and explain how my predictions make sense in terms of the laws of physics. Since the time duration (Δt) for vertical and horizontal displacement are always the same, even if only one is altered then the other will also be affected. When the mass of an object is increased, it will directly affect the object's initial Eg, which in turn will also increase the positive acceleration towards the ground. This will create shorter Δt for the vertical displacement, and will also shorten the Δt of horizontal displacement. The range of the horizontal movement will be reduced when the horizontal displacement possesses a lower Δt and a constant velocity as before,.

How will air resistance affect the range of a projectile?

Knowing the effects that air resistance have on free-falling objects, this will help me understand how air resistance could also affect the range of a projectile motion. Air resistance is a type of force that will occur naturally when an object is under a type of motion in air; one can describe it as 'friction in air' because the direction of air resistance is opposite to that of the moving object. When the force of air resistance takes an effect on an object, it cancels out as much Fg as possible so ΔY of the object's vertical displacement will be lengthened. I've stated above that Δt of the vertical and horizontal displacement will always be the same, so if the Δt of the vertical displacement is lengthened and cause the Δt of horizontal displacement to also be expanded, it will give a chance for the object to cover additional horizontal Δd.

Worksheet B: Wing Shapes and Functions

In this section, I will be doing a research-based investigation of wing shapes and how they contribute to the object's movement in the air. [Worksheet B]

Since its invention, the wings of an airplane have gone through many different designs in order to have a great lift efficiency. The wings of an airplane must be functional to its uses, in which one of the uses is to allow the aircraft itself to be lifter upwards. There are many different aspects to the model that can be varied to change the efficiency of its lift.

1. How angle of attack have an effect on the lift of a plane:

The first variable that I will investigate/research through is how angle of attacks of the wings could affect the amount of lift. Angle of attacks refers to how deep the wings are in relation to the wind going the opposite direction to the plane's movement. Starting from 0°, the airplane can be lifted upwards as the angle of attack is increased. This is true until it reaches its limit. At around 10° and up, the air in front of the wings will circulate in a motion that will not help the plane to be lifted up; the wings act as barrier that will hinder the plane's movement as opposed to the helpful lift that can be achieved if the angle of the wings are set from 0° - 10°.

2. How thickness of wings have an effect on the lift of a plane:

One of the other factors of the wings that would alter the lift of an airplane is the thickness of the wings themselves. From the research that I have performed, I then understood that as the thickness of the wings decrease, it would also create a decreased amount of lift for the airplane; however, one must also know that the front tips of the wings would also have to be thin in order for the lift to be at its highest. If it would be helpful to thin out the tip. This would work best because when the wings are thickened up for a greater lift, the tip should be thin to cut or else they would act as a barrier that won't let the air they're hitting to pass easily, which would hinder the airplane back.

3. How curviness of wings have an effect on the lift of a plane:

Another variable that would affect an airplane's lift is the curvature of the wings. This can also be called: alteration of the camber (measure of how long the distance between minimum point to maximum point of the wings). Research has proved that an airplane is able to gain more lift as the camber is stretched, even when other variables stay constant at their minimum.

4. How speed have an effect on the lift of a plane:

The lift that an airplane could get during its flight doesn't come only from the design/structure of the wings; nature also plays a big part of the gain/loss of lift. One aspect of the environment that one should consider is the airspeed, which refers to how fast the wing moves through the air surrounding them. It is a fact that in the case where the airspeed is increased to a higher value, it will result in the increase of the airplane's lift.

5. How altitude have an effect on the lift of a plane:

The altitude of the plane's flight is another variable that occurs naturally that would also affect the amount of lift generated by the plane. As a plane increases the altitude of its flight from the ground, the efficiency of lift will be decreased. This would mean that the amount of lift generated by the plane would be less than when it is in a position closer to the ground. I believe this would happen since the amount of potential gravitational energy (Eg) increases as the plane reaches a greater altitude, and would require a larger amount of energy of lift to go against Eg and be lifted up.

6. How much effect thickness of airfoil has on an airplane's lift:

As I have mentioned before, thickness is one of the variables that would give an effect to the amount of lift an airplane would generate. When the airfoil of an aircraft is mentioned, they are referring to the general shape of the wings. When it is thickened, it is also known as increasing the airfoil camber. One has to keep in mind that the camber is calculated by referring the thickness to the wing in relation to the longest straight line of the wing. It is true that as the wings' airfoil camber increases, the lift that can be generated; furthermore, the main function of these airfoil cambers is to increase the amount of lift generated by the plane. This shows that altering the airfoil camber would cause a great amount of change to a plane's lift.

7. How a negative airfoil camber value has an effect to the lift of the plane:

Not only can it be increased, the wings' airfoil camber can also be decreased. This will result in a concave shape on the wing, creating a feature that is called negative airfoil camber. This feature is the exact thing that will have the exact effect the lift of an airplane by creating a negative lift to the plane. A negative lift indicates that it goes downwards instead of upwards (as we want it for this particular project's purpose) which could be helpful if it was used as the plane is landing.

Worksheet C: Free Body Diagram Practice

1. A book is at rest on a tabletop. Diagram the forces acting on the book.

2. A girl is suspended motionless from the ceiling by two ropes. Diagram the forces acting on the combination of girl and bar.

3. An egg is free-falling from a nest in a tree. Neglect air resistance.

4. A flying squirrel is gliding (no wing flaps) from a tree to the ground at constant velocity. Consider air resistance. Diagram the forces acting on the squirrel.

5. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

6. A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

7. A college student rests a backpack upon his shoulder. The pack is suspended motionless by one strap from one shoulder. Diagram the vertical forces acting on the backpack.

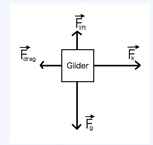
8. A skydiver is descending with a constant velocity. Consider air resistance. Diagram the forces acting upon the skydiver.

9. A force is applied to the right to drag a sled across loosely packed snow with a rightward acceleration. Diagram the forces acting upon the sled.

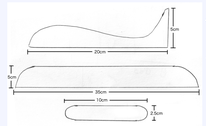
10. A football is moving upwards towards its peak after having been booted by the punter. Diagram the forces acting upon the football as it rises upward towards its peak.

11. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.

Visuals



FBD of the glider



Pre-Build plans

Post-build Reflection

The sizes are quite different from the preliminary design due to material limitations and human error.

Knowledge/Understanding

As a follow-up of our understanding of grade 11 Physics from the knowledge we've acquired from the rest of the semester, we were to conclude it with a glider research/building project before wrapping it all up with our final exam. It was a spot-on choice of a culminating project due to the fact that it had to make us think in a wider range from many different lessons that we've had throughout the semester. We were then to apply all that into a project to show how we would've think, inquire, and apply our knowledge and understanding of Physics in our level.

As an introduction to grade 11U Physics course, we were first faced with the concept of scalar and vector measurements. Our studies repeated and stressed on one particular vector measurement, which happened to be velocity. Velocity is a vector measurement that is used to determine the magnitude and direction of the rate in which an object could travel a certain distance to a specific direction. We applied this knowledge into our gliders since we now know how velocity plays a big role in any moving objects. Considering the fact that I've mentioned velocity would've affected a projectile motion in Worksheet A, we should consider and think through that a just-right launching velocity was important to our project since it would affect the final results.

Expanding our knowledge of velocity, we were then introduced to the more detailed concept of another vector measure, acceleration. With it being a vector measurement of the rate of change of speed in a certain direction, it is considered related to velocity. As we went on to learn more about this concept more in the class, we understood more such as gravitational acceleration. Gravity is a one-way forceful pull towards the earth's centre and cannot be avoided as long as you're in its field, so we understood the fact that it would affect our gliders. Using our knowledge of acceleration was considered quite important in or culminating activity.

We were able to extend our understanding by applying our knowledge in different problem-solving exercises starting with linear motion situations and moved on to 2D paths and expanded into projectile motion situations. Being able to solve these problems would help us understand how the glider would be able to glide.

Understanding the concepts of physics would help us not only build, but the purpose and how a glider would work.

Pre-build Planning:
Before even starting to physically build the glider that I was supposed to present to the class with a BANG!, I made sure to have the basics planned out in the form of a drawing along with the size, materials, and consider the steps upon constructing the glider. I have to make sure to include my knowledge of physics laws and how aerodynamics apply to gliders (Worksheet B) to make a glider that's supposedly glide well as the name implies.

Measurements:
Following thorough research of handmade glider designs, I decided to add some elements of a glider that could have a large horizontal range. For this, I decided to make the wings the largest component of the 3 parts I proposed: The body, the wings, and the tail airfoil. I made sure the size wasn't too small that it wouldn't be able to glide 5m or too big that the longer parts would be prone to damage. I tried to keep it handheld so I decided that the body should be a bit shorter than a 30cm ruler and the wings should be longer than a 30cm ruler since I have already decided that the wings would be the longest component. As for the tail airfoil, I didn't want it to be longer than half of the body because I didn't want it to act too much like the wing.

Materials:
Given what I know about projectile motion from class and personal research, I tried to use materials that would help increase its lift. Since mass has a great effect on lift, I decided that I should use a light material that I would be able to cut into shape and is readily available such as foamcore. I felt like foam-core was a great option since it's able to be cut and hold its shape while being light-weight enough to not create a large amount of fg. I will also try to use leftover clumps of the foamcore to use as weight on the front so the glider would still be light enough to not cause too much air resistance.

Construction:
A step that should be done precedent to the actual building is an investigation of how one must go around to building it; therefore, I visualized methods for building the final glider. I made sure that I was able to smoothly cut foamcore and flatten the tips of the airfoils that would be attacking the air directly in front of them. Once I made sure these were possible to be done, I thought that I was sure to continue on to the next step.

Materials:
Until the end, I stuck with my original plan of using foamcore, it was durable enough to hold its shape despite being a light enough material. For the weight that was added to the front of the glider, I decided to use two watch batteries for the final copy after testing the glider with multiple different weights. Since I had two of them I was able to stick them using cellotape, one on either side of the glider to keep its balance. I changed it from my original plan of using clumps of foamcore because the batteries were working better as weight, the foamcore clumps were too light. When I used the foamcore clumps the glider flipped and the nose was up in the air because it was the lightest part of the glider, indicating the need of material change for the weight.

Procedure:
Since I knew the shape, parts, and size of the glider I was making I went on and drew the template on the foamcore directly and cut out the shapes and holes using a precision cutting tool. Once I had all three parts cute out I flatten the front parts of each airfoil to increase lift like the information I was able to get on airfoils. Before putting all the parts together I taped one watch battery on either side of the glider body's nose as the weight. Once that was done, all I had to do was to mark the mid-way point of each airfoil and stick the wings/tail airfoil into the holes I had cut out on the body. Once it's all set, I folded the wings upwards from the body because I realized this was able to give the glider more range as it glides.

Flight Test Log

Observations/Results
Prior to the final testing, I had to make sure that the glider that I have designed and constructed was functional.

During my personal glide tests, I knew that my glider was quite inconsistent in a way, with the fact that my flights kept turning to the left side while my sister kept making the glider fly to the right side. I kept adjusting the wings and tried to keep it consistent, but I was able to get from 4m-6m range. It never went past the 6m mark but I was able to go past the goal, 5m, and since that goal was achieved I tried to make my glider's flights go straight. I have tried 3 different wings of similar shape but my flights kept going to the left. I tried to balance it since the wings and tail airfoil were adjustable, but I didn't know exactly what was making it to the left. When my sister tried, she kept making the glider glide to the left even though she didn't adjust the wings and kept it the same as mine. This told me that there was something wrong with the way I threw it, and I knew my glider was far from perfect. Before this error test, I tried to make it go past the 5m range and was able to when I bent the wings so that it goes upward from the wing midpoint.

The final flight tests (2 tries) at school was quite different from at home, but it was just as inconsistent. My throw made it go slanted and less than 5m. It was about 3.2m and the second one was about 3.1m, with it being slanted over 6cm from the middle flight line.

Challenge Day Analysis
January 12, 2016

As a class, we have agreed to a mass-testing on Tuesday, January 12th 2016. There were a total of
12 groups.

Observations/Results
I hereby apologize for any mistakes of the group members' names and classification.

Emily, Shirley, Jun

This group was successfully able to make a glider that glides >5m without it slanting too much, though if I recall correctly, there were some imbalances that might've been to human error while physically building it.
The glider itself looked pretty sturdy in my own opinion.

This group's glider looked bulky and heavy, but it was able to glide 5m. I think that inside all that voluminous body it was actually air, so it wasn't that heavy. The nose of it kept hitting the ground first, so it might be that the front weight is a bit too much and could be taken a bit. It had an interesting design for a glider; the wings were apparently big enough to support its already large body.

Yara

Jaxin, Fanny, Rui, Guanyi

The first two flights were able to show
how the glider was able to glide smoothly through the air for >7m without slanting to the sides. The third flight were off by >30cm to the side, showing that the launch
of the glider is a very important aspect of its range.
The first two flights were already enough to show how well-constructed and thought up it was.

Mashaal

This glider was made out of all cardboard, which I find interesting because they used extra cardbord bits as weight. Since I tried doing the same with foamcore, I was interested how it would work in this glider. The glider was able to glide farther than 5m, so the weight worked well and wasn't too light that would flip the glider upside-down. There were also two strings attached to the wings that I think are supposed to represent the outline of a delta wing such as Anson&Tahmina's glider.

Samira

At first sight, the glider seemed very small, light, and delicate but it was able to glide past the 5m marks and make its way to go into the 6m range. I was later told by the creator herself that it was made out of styrofoam and a straw. Mass would increase air resistance which in turn will create drag and shorten the range, so it was well thought-out that the glider's final design was light enough.

Anson, Tahmina

This group's glider had a very distinct wing form from the rest of our class, since it was the only one who had delta wings. It looked light at first sight, since the wings were made of tissue paper. I really liked their idea of using playdoh as weight because they can easily adjust them. It looked light and quite different from the rest of the class, but it was able to glide ~7m during test and over 10m in their previous tests (I was told by the members) and in the little class contest that many people participated in for fun. It seemed that some groups mentioned how they were able to get better results in the competition due to the lack of pressure, it was fun to watch and see others' reactions..

Saadia

Natasya
(Self-Evaluation)

I was able to talk to the creator of this glider, she was able to use balsa wood and superglue to construct her glider. It was very light and felt delicate, but it was able to go as far as ~8m. Its lightness was able to glide smoothly without a lot of air resistance.

Arbab, Shanukh

This was another group that had a pretty large-in-volume glider. They were able to use balsa wood as their main material and still keep them in tact for a large glider. They were able to go past 5m but a bit off in accuracy, which I think was the cause of construction. It was large enough but it was well-thought that they still managed to make it light enough for the glider to be able to glide. It might be a bit too light as it kept lifting up to the ceiling.

Khalid, Rafay

Khusanbek, Tasin, Kevin

The glider that this group managed to make was clearly larger than most, it also looked pretty thick. Wing thickness could be a good thing since it can increase lift. The glider was able to succeed its two tests and for-fun flight competition at the end. It was a successful glider, I was told by one of the members that
it was made by foamcore so I know it was still light even
though it was huge. This was able to let them make a glider that could glide over 10m.

Tim, Krishna, Fatari, Omid

I was impressed by this team's successful glider, the visuals were also great but there were some unbalances that made the flight path not so straight, I think that it was the cause of human error in building. I feel like changes should be made after each test until flights are consistent.

This group's glider looked like it was able to glide straight, but it was slanted to the left. It was able to go past the 5m range and was able to go straight but not too far away from the 5m line, it might be too heavy but it was well-constructed overall.

Self-Reflection:
Looking back at my glider's design and performance, I was able to reflect its successes and failures I should consider in order to understand more about aerodynamics and how I could've made it better. My glider wasn't able to go past 5m in the final testing for both tries, so I know there were flaws that should've been fixed. The balance of the glider was off because it wasn't able to go in a straight line, so I should've kept it in place instead of making detachable parts that I quickly put together right before the testing. I also have a feeling that the watch batteries were too light, the orientation of the glider while it was gliding was not stable. Another source of error I think I did horribly was my shaky launching. I was aware of how inconsistent my launches can be as explained in my Flight Test Log follow-up. Despite all these failures, I do think that it was actually quite successful because I actually built something that could glide in a way.