Kah Seng Cheong

Cosc 3p98 Term Project

"Rube Goldberg Machine"

A short animation following a ball as it moves down a rube goldberg machine.

Inspiration

For this project I wanted to make a simple animation that would have me explore certain techniques that I had yet to learn or be comfortable with. So picking up from the last project (Assignment 3) where I realised the complexity of making realistic collision between non static objects I wanted this to be more of a case study were in I would do my best to try and replicate a real life machine and then pick up what that means behind the scenes after I have got it as close as I could.

The focus ended up being less on the visuals especially since my computer is very old and struggles to render high quality images/videos (explored further down below). So when thinking of what physics interaction to mimic that wouldn't be too taxing on my device, the idea of the rube goldberg machine came to mind. A bunch of simple primitives colliding with each other to make a fun reaction would be the perfect piece to learn from.

Research

Looking into what to create, I was fixated on the idea of a ball traversing a course for some reason, so reading to youtube I found a couple projects made by other people that all provided much inspiration and served as a reference for physics interaction even if it was not the final piece that i modelled after.
Rainbow Ball Adventure 🌈
75 Rube Goldberg Ideas & Inventions
Automatic Ball Lift - Rube Goldberg Tips & Tricks - #9
World's largest Rube Goldberg machine lights up Christmas tree

All of the above aided in the creation of the project either through inspiration or aiding in developing a scene. The one below was the one ultimately chosen to be the piece for the case study.

Red Ball Adventure 🔴

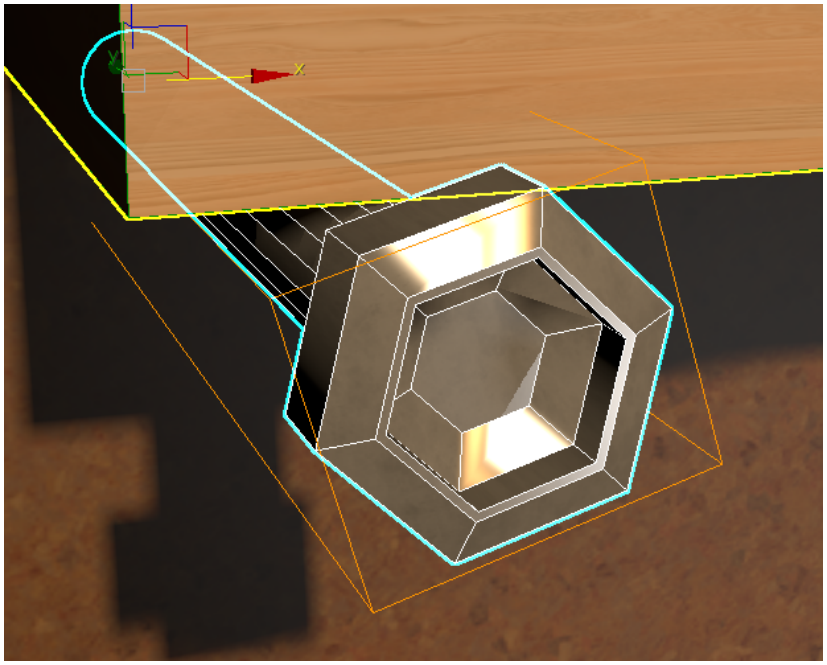
I picked this piece because of the steady camera angle that makes the constant observation of the ball's movement a lot easier. Additionally it had enough interactions I wanted to attempt to mimic in on itself.

Software

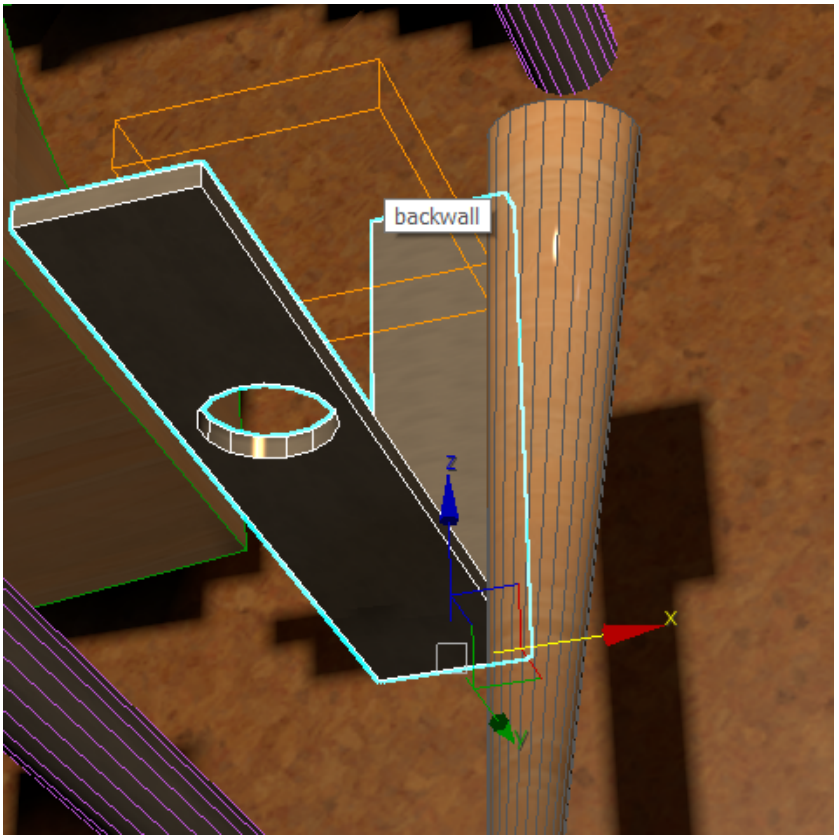
For the majority of the project, the modelling, texturing, and animation were all performed on 3DS Max. It had the simplest UI of the suggested programs alongside the fact that I had previous experience with it in some 1st year courses. The final touches were made on app.clipchamp.com, as I only needed a way to compile the separate videos, there was no need for more in depth tools.

Modelling

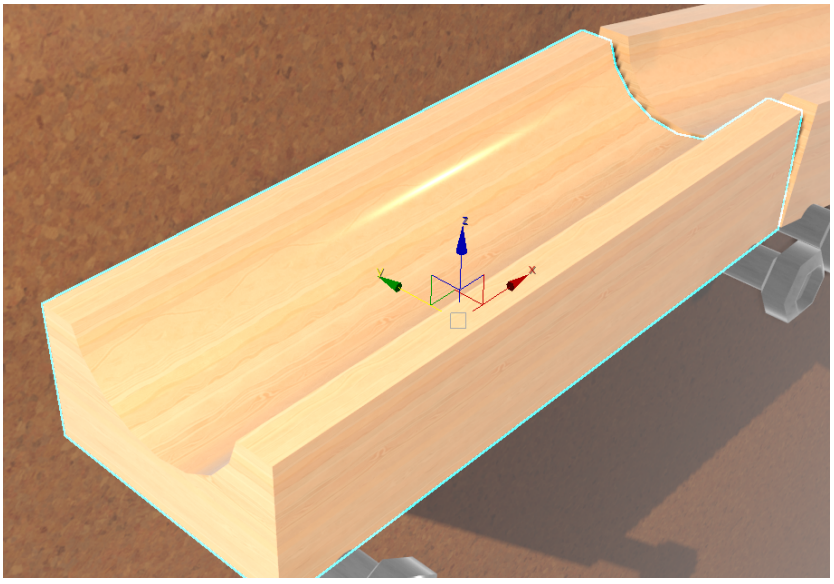
Quite a few pieces for the project were easel handled by the default shapes provided by 3DS Max, the sphere for the ball and a cube for the back drop. Others took some combining of several altered shapes either through merging or using as a way to cut from.
Such as the screw that is used in most of the animation.



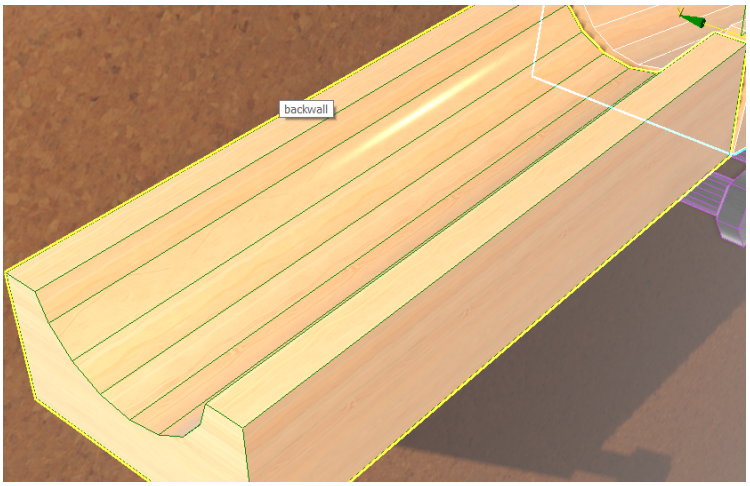
And the metal hanger that holds up the golf pin.



Coming back to the issue of my computer inability to render high quality images at a reasonable rate, I had to do some tricks to lower poly counts to ease up on rendering time.



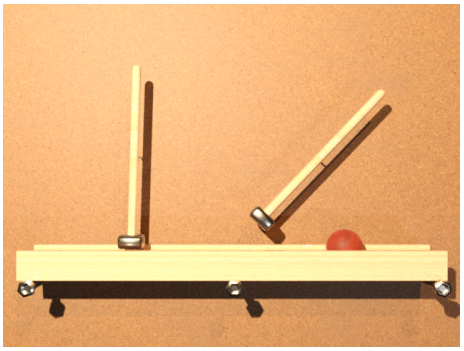
Like this piece of wood over here. It looks a lot smoother and round than it actually is. With the help of the gloss and normal maps I could mimic that property with a relatively low poly count.

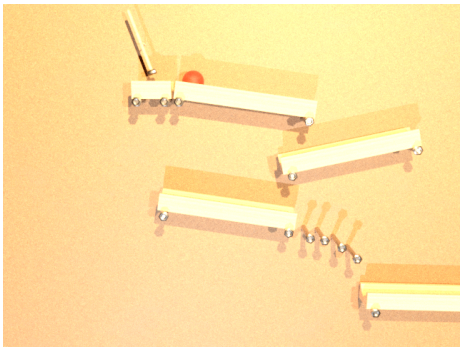


Unfortunately it proved to be harder to do the same for the ball, and so it remained as a high poly object. In hindsight it may have been a better idea to just let it look worse in the final product rather than keep the high fidelity as that was not the focus.

Lighting

I Initially wanted to use the 3 point light system used in photography to best capture the animation. Knowing the camera stays on a fixed spot makes it so that this technique should be quite effective. The main light is there to dictate the overall scene, the back light to reduce the amount of dark surfaces on the subject, and a fill light with a separate colour to set a tone.



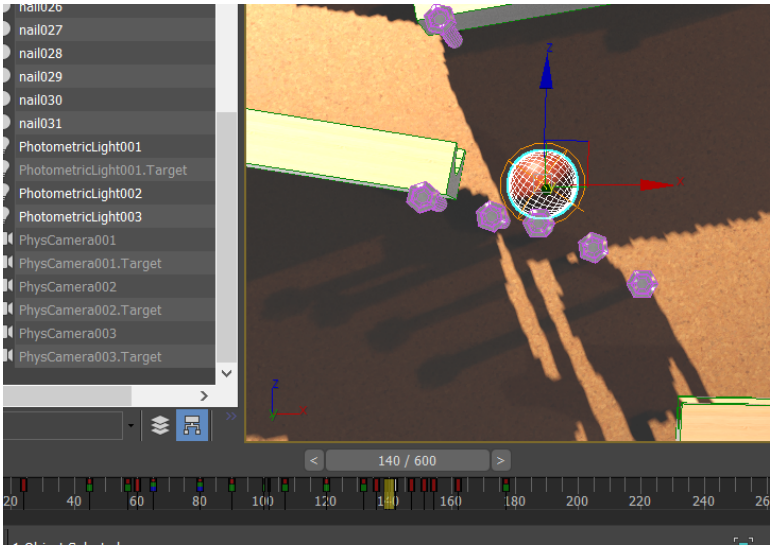


Unfortunately, this was where the issue of my computer's specs came into play. Each of the above images took 5 minutes to render. So for a short 24 second animation, it would take 48 hours at minimum to fully render barring any issues. Unfortunately, with other responsibilities, that was not something I could attempt especially with the risk of it failing mid way, so I had to drop it to 1 light and reduce the overall quality to a pretty disappointing state. Ultimately that was not the focus of the exercise, so I scrapped it and moved on to the next step.

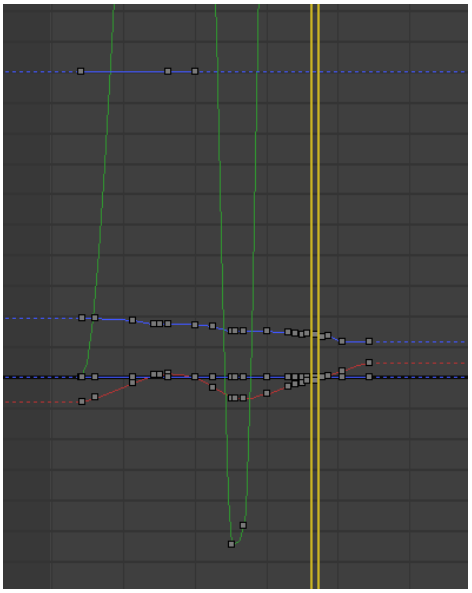
Animation

When I picked the specific video there were 3 aspects that I wanted to explore in this project. The ball bouncing, colliding with a restricted object, and acceleration/deceleration of objects from friction.

The first quickly proved to be the hardest among the 3 to mimic as the additional force of gravity accelerating the ball consistently was not something I could easily manage like in assignment 3 where the Y speed just decreased globally without a care for its other movement.



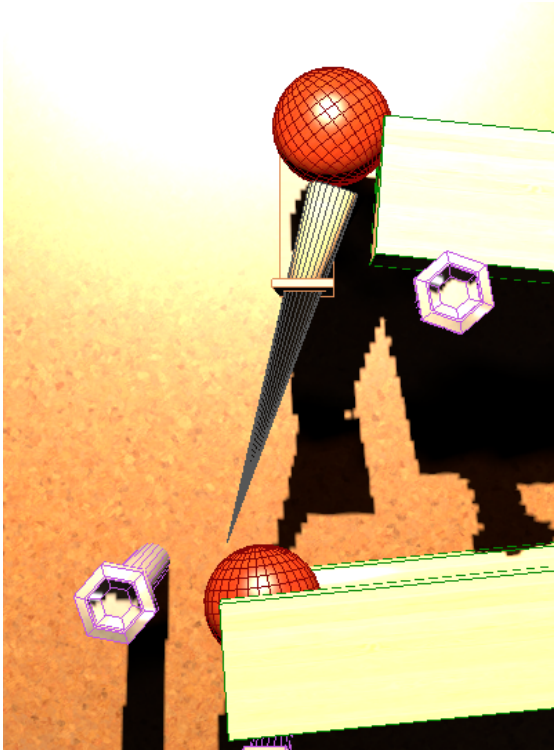
Starting from just the time keys it made the general movement of the ball there. However, it lacked a lot of impact and quick descent a ball would have in real life. So I had to learn about 3DS Max's curve editor.



Which would look a little like this, you might be able to see that the time keys above matches the graph, with the addition of some details. The very first thing I picked up was that 3DS Max automatically handles smoothing between 2 time keys. By that I

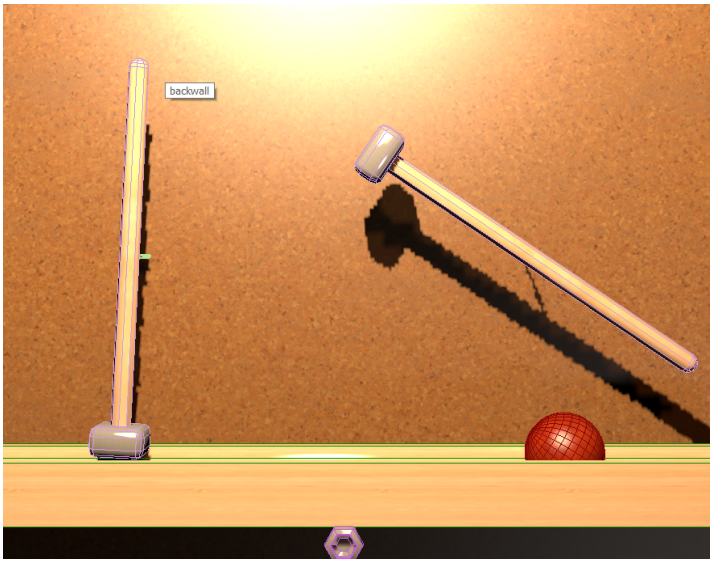
mean, you can imagine that the amount of movement between 2 time keys would look like a bell curve. Where the majority is in the middle, with a ramp at the start that diminishes toward the end. This was very handy for simple things like the ball just rolling down a ramp. However, when I needed to mimic impulses, it was actively detrimental. Messing with the graph a little, I was able to make it mimic the real life video a little better, but I was not able to perfectly replicate it. I would deem this overall a failure in learning to mimic impulse reaction, even if I learned a good bit about animation curves.

The 2nd aspect of collision with a semi restricted object, is to see how the held object would react with its own reaction, and due to the fact of it being acted on by an additional force, how would the moving react when colliding into it. This is quite similar to accounting for normal force in physics, where it only exists when a force is applied in the opposite direction.



The golf pin in the metal cup holder like this was used for this experiment. This one proved to be a bit boring and not much was there to pick, but that the resistance would be increased proportionally to how tightly the pin is held. However, a fun thing that I had to account for that was not in the video was the cone shape of my pin. As Mine had a different design than the video, it reacted differently to the impact, it had to slide upwards due to the different radius along the length of the pin.

For the 3rd one, attempting to mimic acceleration and deceleration was where I picked up another animation trick I'm sure would be simple for those more familiar, but was quite interesting for me.



The pendulum like hammers had to react to the impulse of the collision, accelerate from gravity, and decelerate due to friction all in one. Following the mindset I have when programming, I had time keys every 5 frames similar to how code would update each iteration, I had it moving less and less when decelerating. However, When it did not match up exactly, I went to edit it on the bar. For ease I just moved the time key to a later step, which was much easier than clicking on a key and then inputting a location. What I found was that instead of having set frames to act on (even if everything was predetermined, ie gravity/friction, and that you did not have to react to any new forces) if I knew where it had to end up, I could instead alter where in the bar each event occurs. Where in each key would have the hammer rotate the same amount, but the time between would be altered. This was much simpler to implement, and I later used it for the acceleration component when working on the second hammer.

Lessons

Impulse is hard to implement when you can't type up a formula to accommodate all the forces at play. At the same time, smoothing out starting and ending points was a lot more impactful than I realised. Collision to a held object takes into account redirecting the force, and how the object is shaped can alter the velocity a good bit. Ultimately it only reaffirms lessons learned in year 1 physics class, but it's nice to see it physically rather than on equations. The last test, albeit being the most interesting when working in 3DS Max, would seem to be not that applicable when it comes to coding. Altering the time step rather than move amount seems to be a harder way to implement consistent change in a value. However, I will have that on my mind now if a situation ever comes up that might utilise it.

Sources

Albedos for textures acquired from Textures.com
(Normal/gloss/metallic maps where made utilising the albedos downloaded from the site)

Stainless Steel Texture

Glue Laminated Beam

Bakelite Plastic 1

Galvanised Metal 2

Cork