SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Models & Inventions

Year 9-10

Regan Nelson

Prince Alfred College

RISK ASSESSMENT FORM
Models & Inventions

This must be included with your report, log book or entry

NAME: Regan Nelson ID: 0526-005

SCHOOL: Prince Alfred College

Activity: Give a brief outline of what you are planning to do.

Engineering the galaxy. Build a model of a Dyson sphere that would assist in generating energy for the earth and planets int he solar system.

Are there possible risks? Consider the following:

- Chemical Risks: are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Thermal Risks: are you heating things? Could you be burnt?
- Biological Risks: are you working with micro-organisms such as mould and bacteria?
- Sharps Risks: are you cutting things, and is there a risk of injury from sharp objects?
- Electrical Risks: are you using mains (240 volt) electricity? How will you make sure that this is safe? Could you use a battery instead?
- Radiation Risks: does your entry use potentially harmful radiation such as UV or lasers?
- Other hazards.

Also, if you are using other people as subjects in an investigation you must get them to sign a note consenting to be part of your experiment.

Risks	How I will control / manage the risk
Thermal Sharps Chemical Risks	-As i will use a soldering Iron I will ensure i do so under supervision and will wear safety glasses. -The use of power tools drill and jigsaw and blades will be completed under supervision and with the use of saftey glasses. -During the build various chemical based items such as paints and glues will be used and appropriate glasses and masks will need to be worn.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out

RISK ASSESSMENT COMPLETED BY (student name(s)): Regan Nelson

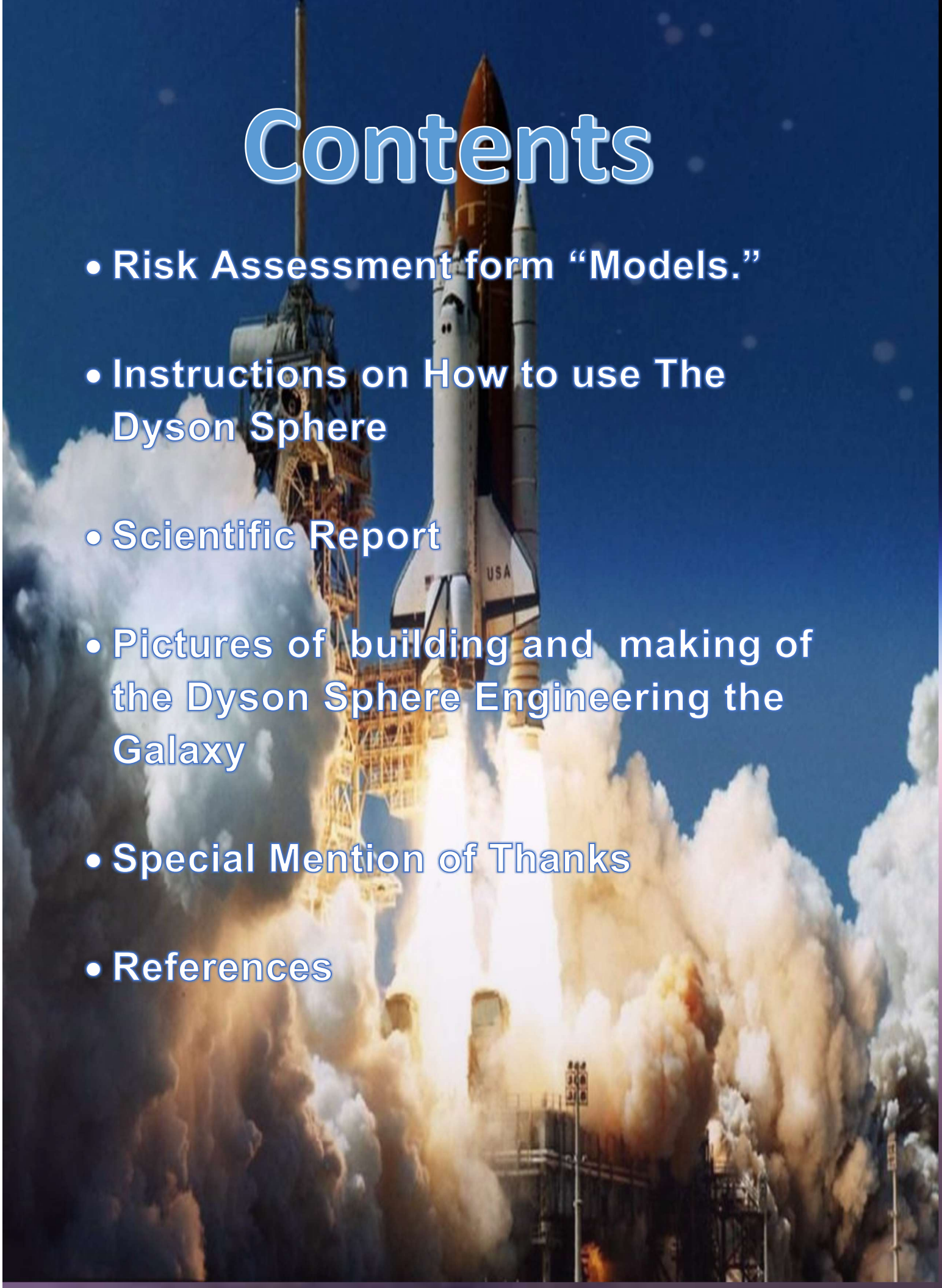
SIGNATURE(S): _____

☑ **by ticking this box, I / we state that my / our project adheres to the listed criteria for this Category.**

TEACHER'S NAME: Peter Hopkins SIGNATURE: _____

DATE: 17/8/2021

Contents



Instructions of how the Model Dyson Sphere works

3 buttons

- Press **Operate The Dyson Sphere** Hold the red start button down to see the rotation of the Dyson Sphere and the Sun.

- Press the **Release The Energy** button to show sending the power back to Earth. This will light up

- Press the **Surprise** button for a surprise Sci-Fi or Reality

.

- The Battery will Run 2 motors independently

- Now imagine Earth being Powered by the Sun. When the model comes alive watch Renewable Energy in its greatest form. Solar Panels, or mirrors Collecting energy from the Stars . Ask yourself is it Sci-Fi or a Possibility?

Regan Finbarr Nelson

Prince Alfred College

Year 10 Regan Nelson

11/10/2005

Age 15

Engineering the Galaxy

The Dyson Sphere & Unlimited Power

As young emerging scientists, how do we plan to get energy from outer space to the Earth from solar panels? Bringing energy from outer space is science fiction now, but did you know it has been discussed since the late 1950s.

We cannot sustain the speed of using fossil fuels and plundering the Earth's natural resources indefinitely, and it will be exhausted.

The need to cope with climate change is driving tremendous changes in the global power system.

Of course, we can continue using solar energy to run things on Earth, but why not get closer to the source?

Is it possible to have a site that can obtain energy directly from the sun, At any time of the day without seasonal or weather-related interference risks?

In the future, can a Dyson Sphere or Dyson Swarm be possible to provide a steady stream of renewable energy for the Earth? Or any other planet in our universe. Just thinking about this possibility excites me to figure out a way to save our planet.

Engineering The Galaxy

The Dyson Sphere and Unlimited Power

The Dyson sphere is an incredibly intricate, yet simple project proposed by Freeman Dyson, a man before his time. Freeman was a legendary theoretical physicist. His idea was to use an extensive array of solar panels or mirrors around the Sun to produce infinite energy for civilisation by harnessing the solar radiation output and redirecting it towards the Earth.

The Big Idea:

Energy is the defining limit on humanity and is how we tell our human history. In the beginning, we used the kinetic energy of our muscles; then, we harnessed the energy of fire. Then soon after, we industrialised the world by burning coal and oil to produce electricity. Shortly after that, we discovered splitting the atom and harnessed nuclear energy for good and evil.

Now we are at a turning point of finding *new green solutions to the world's energy*. At every step of this ladder, humanity has increased its energy output drastically. It has advanced to new heights never seen, and as we begin to make our way into space, it will take an amount of energy never before seen to power humanities expansion into the rest of the solar system.

If humanity were to use all the fossil fuels and uranium on Earth to launch as much mass as possible into space, we would only be able to launch roughly the mass of Mount Everest into space. The *Dyson Sphere would be able to replace the fossil fuel industry* thousands of times over.

Currently, humanity uses roughly 580 million terajoules or 580 trillion joules of power every year. However, according to Dyson Spheres and the New Age of Energy (wondergressive.com) (Singh, 2021), "By using a Dyson sphere, we would have access to a colossal 400 septillion watts of solar energy. That is a trillion times more power than what the entire Earth consumes today."

Using a Dyson Sphere, humanity would never have to worry about having the energy to power society. However, due to the sheer scale of this project, we almost need the power output of a Dyson sphere to build a Dyson Sphere.

Some ideas for a Dyson sphere propose a solid shell around the Sun as written by TJ Wright from Harvard University in 2020 (2020SerAJ.200....1W Page 1, 2021). However, this could be incredibly disastrous as not only would it block light from reaching Earth, but it would also be highly susceptible to a catastrophic failure that would cause the sphere to fall into the Sun. Instead, a much more efficient and safe proposal is a Dyson Swarm. A Dyson Swarm is a massive swarm of mirror panels deployed around the Sun to redirect and concentrate light.

The intent would be to collect and harness energy from central nodes before being sent back to Earth and potentially around the solar system to aid in colonising the energy-poor Mars. The panels would not need to be complicated, just a simple one-kilometre sheet of aluminium a few millimetres thick which could be mined and constructed from nearby Mercury by robots. (See appendix "top 5 elements on the surface of mercury") to use like the mirrors of a solar collector back on Earth, making the whole process much cheaper and more efficient.

Based on this size, it would take roughly thirty quadrillion panels to surround the whole Sun at 5 million kilometres from the Sun to keep the aluminium panels from melting. This is based on the temperature of Mercury at 450-degrees Celsius, 46 million kilometres from the Sun. NASA has done the maths for their new Parker Solar Probe (PSP), concluding 5 million kilometres from the Sun to be roughly 120 degrees Celsius. (Solar System Temperatures | NASA Solar System Exploration, 2021) This would make the Aluminium panels easily capable of surviving at that distance.

Scientific Formulas

Force x velocity/time is to find out how much force is needed to launch panels.

The mathematical formula for gravitational force is **F=GMmr2 F = G Mm r 2**, where G is the gravitational constant. The gravity of the Sun is 274 m/s² or 28 G's

Orbital Velocity, The mathematical formula for gravitational force is **F=GMmr2 F = G Mm r 2** , where G is the gravitational constant. The gravity of the Sun is 274 m/s² or 28 G's

Orbital Velocity = $\sqrt{\frac{(Gravitational\ Constant)(mass\ of\ Sun)}{distance from\ object\ to\ center\ of\ the\ Sun}}$

Used to calculate the relative Velocity of the orbiting panels based on distances from the Sun.

Considered in estimating the newtons force needed to launch the panels.

The way heat is transferred in space is radiation, so it will take a long time for heat to move from the Sun to the panels.

Einsteinian Gravity. He theorised that a mass can prod space plenty. It can warp it, bend it, push it, or pull it. **Gravity was just a natural outcome of a mass's existence in space** (Einstein had, with his 1905 Special Theory of Relativity, added time as the fourth dimension to space, calling the result spacetime.

The critical difference is that Newtonian gravity has a privileged separation of spacetime into space and time, whereas **Einsteinian gravity just has spacetime**.

$E^2=pc^2$
The equation for light in motion, in this case, the laser

On the other hand, if the particle in question is mass-less like light, then the mass is **0**, and we get **E** equals **p** times **c.** This tells us that the energy of a mass-less particle like a photon of light is the same as its momentum, up to a factor of the speed of light. In fact, the closer the energy of something is to, **p** times c, the closer that something is to behaving like light.
(Know about the complete formula for energy in the theory of relativity, 2021)

$E=Mc^2$
The equation for energy of an object at rest

The **Einstein gravitational constant, how suns gravity influences the celestial around it, such as the panels and the planets in the solar system**

$$\kappa = \frac{8\pi G}{c^4} \approx 2.077 \times 10^{-43} N^{-1}, \qquad \textbf{the bodies}$$

Where *G* is the Newtonian constant of gravitation and *c* is the speed of light in a vacuum. The Einstein Field Equation can thus also be written as

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \kappa T_{\mu\nu}.$$

In standard units, each term above has units of 1/length². This calculates the effect of the suns field of gravity
(Einstein field equations - Wikipedia, 2021)

Problems that occurred

- From the initial design, I decided to add side panels to protect people from the rotating Dyson sphere in case it flys off as it moves pretty fast
- Getting the cables into the Motor

- Electronics connecting the shaft onto the Motor to rotate
- I had to recut the cable several times to get it to fit

- Wrapping the mesh around the frame was tricky than first thought
- Keeping the weight under 8 kg

- The electronic process of getting the right connections
- Forgetting about the aliens' eyes
- Light beam fibre optic cable and to get it to glow, my dad suggested to notch it with a Stanley blade this was very time consuming

- Painting the backboard before getting it right. I am not good at art, so I printed the sheets and then lightly painted over parts to get them to blend in.
- Cutting the Styrofoam was difficult, but because I have built lots of models, I am getting good at it; and this year, dad bought a multitool nibbler, and this made the cutting so much easier

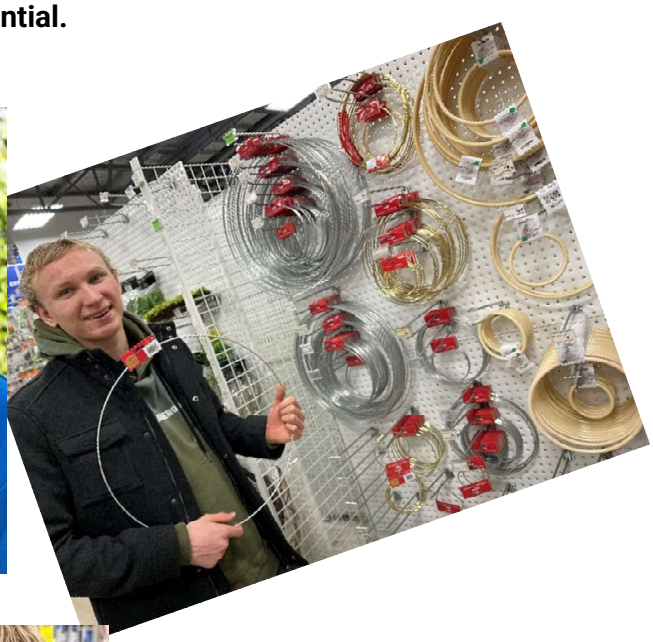
- The integrity of Styrofoam had to stiffen the bottom section with balsa wood as dad thought it was too flimsy
- When we tried to move the model, we noticed that it was very wide and hard to move, so I added handles to make it easier to transport.

The issue to overcome to build a real Dyson Sphere

- Getting materials into space to build a mega Infrastructure.
- Getting the Dyson Sphere spinning
- Linking the Dyson Panels together
- Space Junk may get in the way
- Building Robots to mine Elements of Mercury
- Robots building Robots
- Mining Mercury
- Transfer of Energy back to Earth or other planets
- Money who will fund it
- Time as it may take hundreds of years to build
- Needs to be a Whole World Approach
- Who will own it?
- Politics and so much more

How the Model was Made

Making sure Protection is used Safety is essential.



Buying Materials

Getting inspiration: Some research, YouTube, papers and documentaries. The picture above of the Scientist who has inspired the thoughts of the Dyson Sphere Freeman Dyson

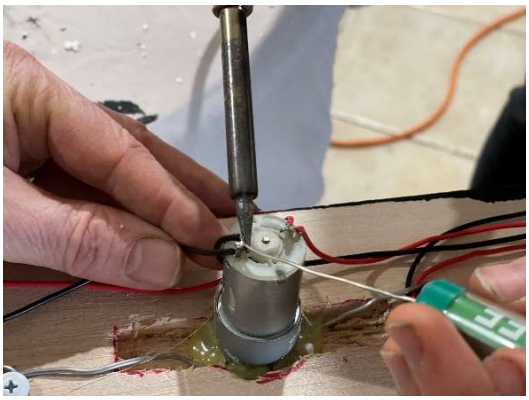
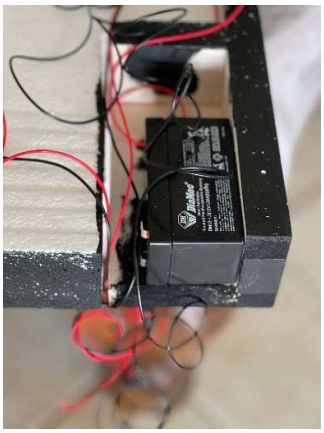
Preparing the building Site

The initial Structure, a bit of help from Dad to stabilise.

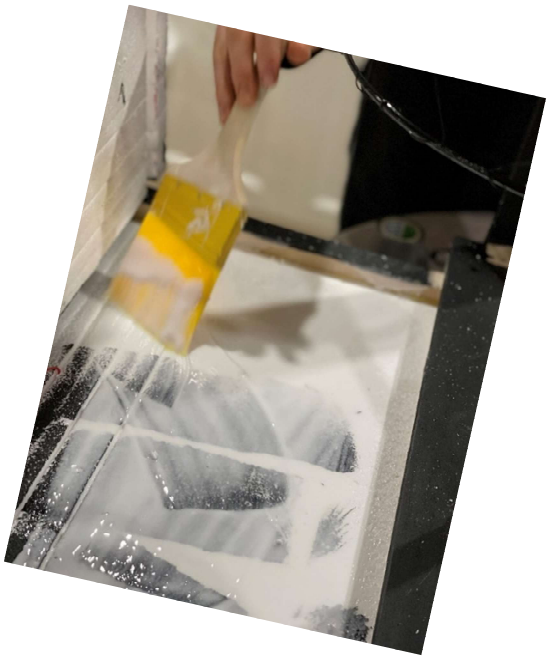
Adding some paint for the base



Balsa Wood and Styrofoam: trying to make the model stable but light

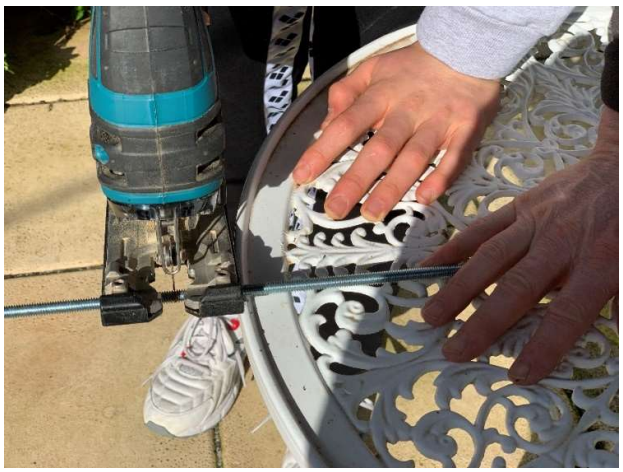




Soldering: 12v Motor Installation, Battery

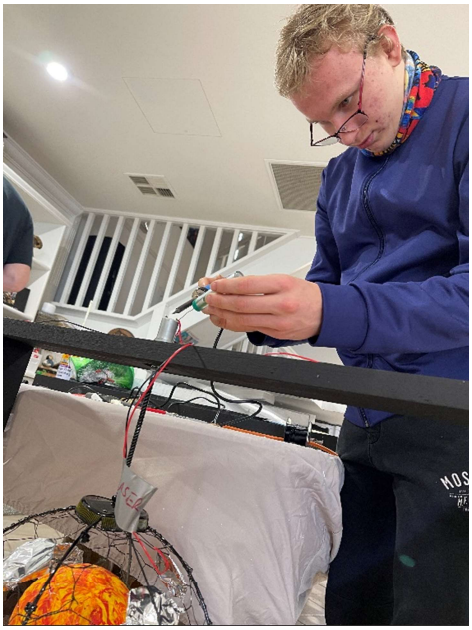



Styrofoam was integral in building the model and adding support
Shaping Styrofoam takes patience and lots of PVA glue

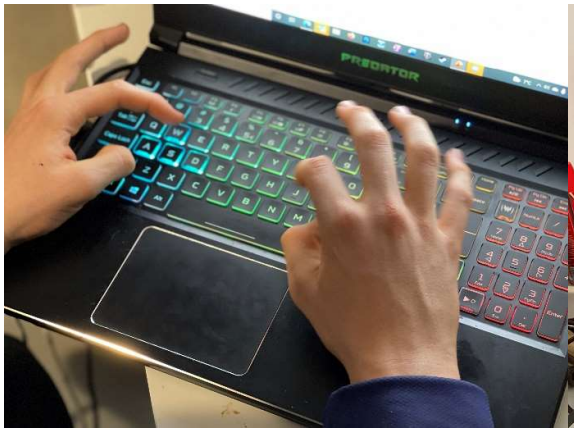
Connecting the Motor to the Rods needed a bit of thinking and lots of Hot Glue.



What else needs to be done??



Almost finished,



Acknowledgements

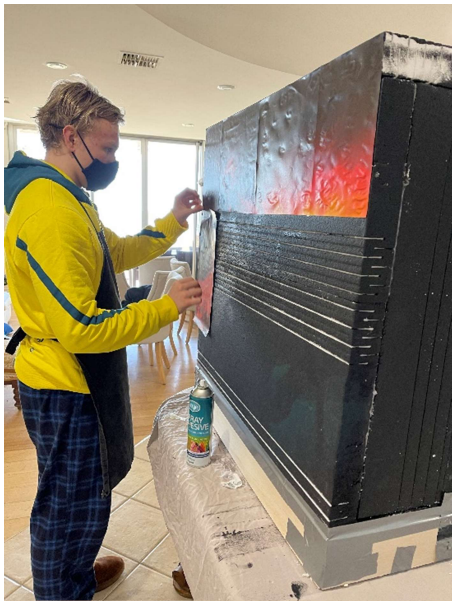
Regan Nelson:
Model Builder/Scientist/Report Writer/Editor

David Nelson:
Regan's Dad, Assistant Builder, Parts Holder, Safety Office,r Assistant Editor of the build and compliance

Mr Peter Hopkins Science Teacher Reviewed

Eileen Nelson
Photographer/Videographer and Morale Builder

"Thank you to my parents, who spend a lot of time with me as I put together, they are always there to give a hand and constructive suggestions. I hope you have enjoyed learning about the Dyson Sphere Engineering The Galaxy.



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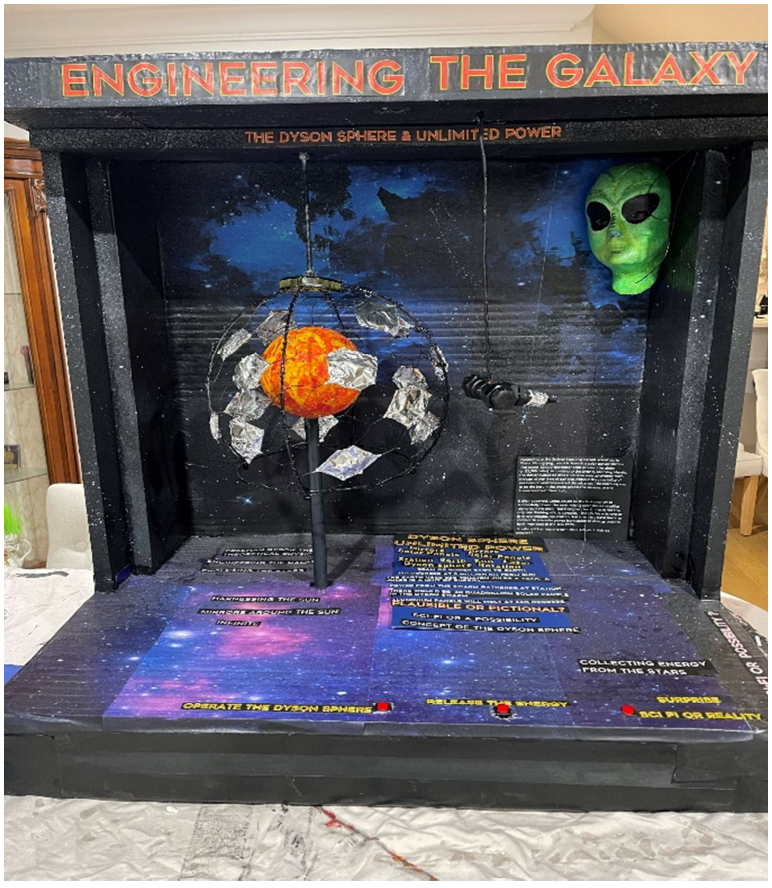
ENGINEERING THE GALAXY
The Dyson Sphere & Unlimited Power
ENGINEERING THE GALAXY


ENGINEERING THE GALAXY
THE DYSON SPHERE & UNLIMITED POWER


ENGINEERING THE GALAXY
THE DYSON SPHERE & UNLIMITED POWER
OPERATE THE DYSON SPHERE
RELEASE THE ENERGY
SCI FI OR REALITY

EQUIPMENT NEEDED

- Wood
- Bolsa Wood
- Bright light Magnifying glass
- Protractor Ruler
- Tape measure
- Scales Lead pencils
- Solder
- Soldering Iron
- Plyers to strip wires
- Paint Spray can and normal brush paint
- Roller
- Paint Brushes
- Drop Sheets
- Glue & Glue Gun
- Lithium Battery
- Styrofoam Markers
- Jig Saw
- Multitool
- Sandpaper
- Drill
- Duct Taper
- Scissors
- Glitter
- Glitter Paint
- Printer

SKILLS AQUIRED

- Soldering Iron
- Jig saw
- Knowledge

PROTECTION GEAR:

- Mask/Buff
- Apron
- Safety Glass
- Closed in Shoes
- Long Trousers

HAZARDS

- Soldering iron
- Drill
- Screwdrivers
- screws
- Drill
- Hammer
- Use Glue
- Hot Glue Gun
- Power Equipment
- Spray Paints
- Working on Crutches
- Jigsaw
- Multitool
- Stanley Knife
- Large Kitchen knife
- Electric Knife