SASTA OLIPHANT SCIENCE AWARDS

South Australian Science Teachers Association

Prize Winner

Models & Inventions

Year 9-10

Regan Nelson

Prince Alfred College

Government of South Australia
Department for Education

SASTA South Australian Science Teachers Association

ROWE SCIENTIFIC PTY. LTD. www.rowe.com.au

THE SKYHOOK PROPULSION SYSTEM

Regan Finbarr Nelson

Prince Alfred College

Year 9 Chris Drew

11/10/2005

Age 14

0526-006

TSPS mk1

Humanities Ladder To The Stars

The theory behind this system is rather simple, instead of using chemical engines and literal tonnes of rocket fuel, we use the kinetic potential energy stored inside of a 1000 km tether in space, spinning around a counterweight.

Currently, a rocket needs to reach around 40,000 km/h to escape Earth. To achieve this, rockets are almost entirely fuel tanks, with only a tiny tip of payload. (NASA, n.d.)

Did you Know?

It currently costs around $20,000 to send a single kilogram of payload into space, although the SpaceX Falcon Heavy is hopeful to get this close to $1,000 in the near future. (Jones)

OSA RISK ASSESSMENT FORM

for all entries in (✓) ☑ Models & Inventions and ☐ Scientific Inquiry

This must be included with your report, log book or entry. One form per entry.

NAME: Regan Nelson ID: 0526-006

SCHOOL: Prince Alfred College

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

Build a model that explores the concept of a Skyhook (Space Tether) that would assist in space travel and supply of provisions to bases on the moon or Mars.

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 Risks	As I will use a soldering iron, I will ensure I do so under supervision and will wear glasses.
Sharps Risks	The use of power tools, drill and jigsaw and blades, will be completed under supervision and with the use of safety glasses
Chemical Risks	During the build, various chemical based items such as glues and paints will be used and appropriate glasses and masks will need to be worn.

(Attach another sheet if needed.) See other sheet

Risk Assessment indicates that this activity can be safely carried out

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

Regan Nelson

SIGNATURE(S): [signature]

☑ 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: [signature] DATE: 19/8/2020

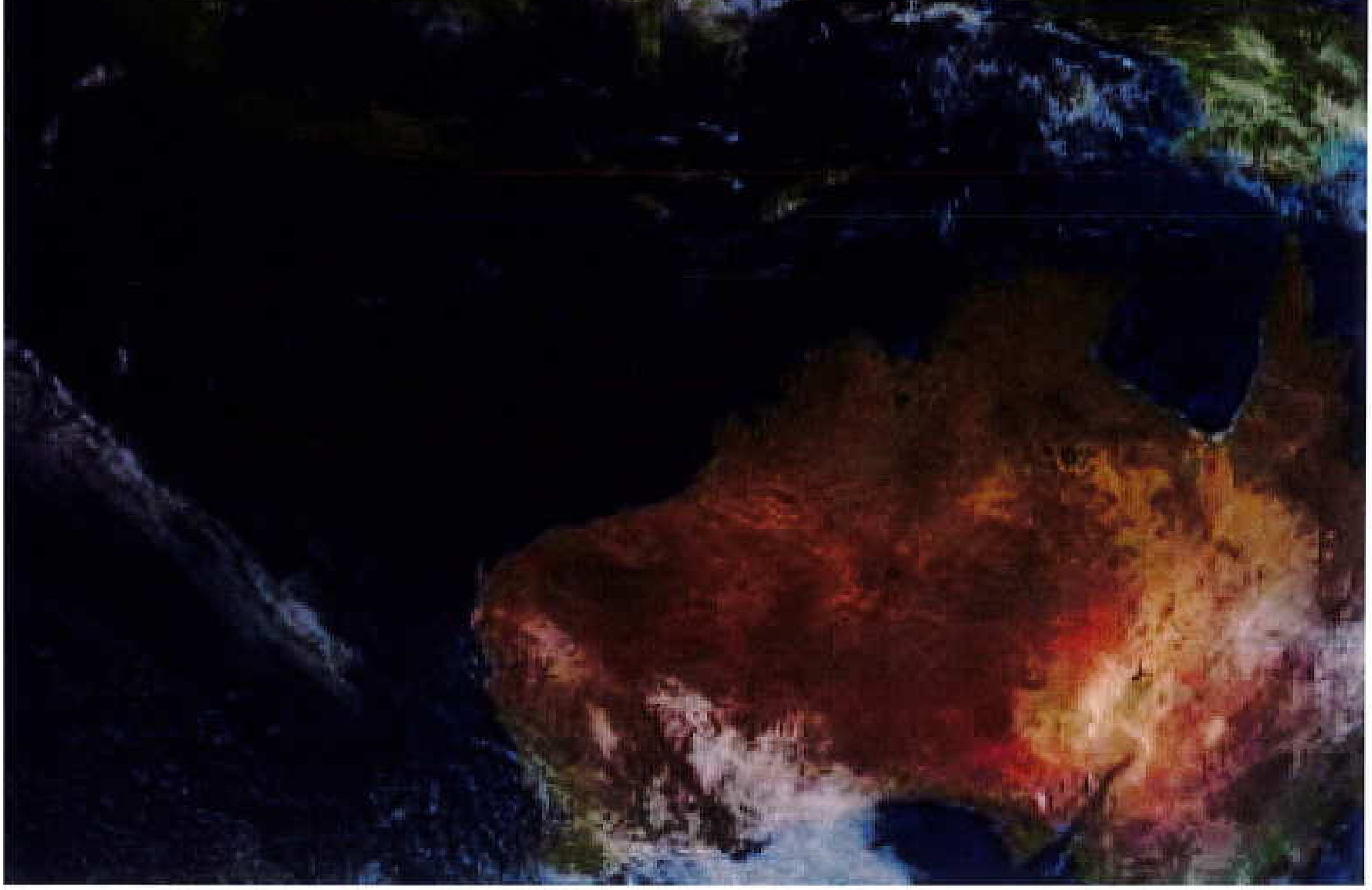
Contents

- Risk Assessment form "Models"
- Instructions on How to use The Skyhook Propulsion System.
- Scientific Report
- Original Design as per my initial drawing & the Tinker CAD drawings of my Design
- Pictures of the building and the making of the The Skyhook Propulsion System.
- Special Mention of Thanks including my Inspiration
- Bibliography

Instructions of how the TSPS mk1

- Press and Hold the start button
- Battery will power motor
- The Tether will start to rotate
- Watch it rotate and spin around the earth
- The skyhook picks up aircraft

- Imagine hopping into a space shuttle
- Brace yourself
- You will be catapulted off at incredible speed towards mars



THE SKYHOOK PROPULSION SYSTEM:

Humanities ladder to the stars

THE SCIENTIFIC CONCEPT

At its lowest point, the skyhook will be screeching through the upper atmosphere at around **32,600 km/h**, but if the tether spins in the opposite direction to the Earth's rotation, then it will technically slow at its lowest point to 28,249 km/h, which is equal to **orbital velocity** 7.847km/sec, giving small reusable spaceships a 60 to 90-second window to catch the tip of the tether.

The skyhook works like an orbital battery of **kinetic energy**, losing some momentum and imparting it on the craft that was attached to it when it is released into space.

To prevent the skyhook from just falling back into Earth's atmosphere, we would need to add energy back via incoming flights. When a ship is caught and slowed down by the hook, it would add the **kinetic energy** back to the skyhook, preventing it from slowing down and crashing into the Earth.

Sudden acceleration and deceleration experienced by the people inside of these space craft when they attach to the hook may be a problem.

Absolute velocity isn't the problem, but the increase of speed over time is. The G, is the most common measurement for this. 1G represents Earth's gravity and how fast things fall towards earth centre, which is 9.81 meters per second.

Accelerate or decelerate at twice this speed, and you'll be pulling 2 G's, so how many G's would our astronauts be pulling on the skyhook?

If our craft is already flying at **Orbital Velocity, 28,249 km/h**, and then it attaches to the skyhook, during the first few seconds our passengers will experience somewhere around **1.4 G's**, as they accelerate to **release velocity of 36,964 km/h**.

This means that the skyhook won't turn the people into marinara sauce.

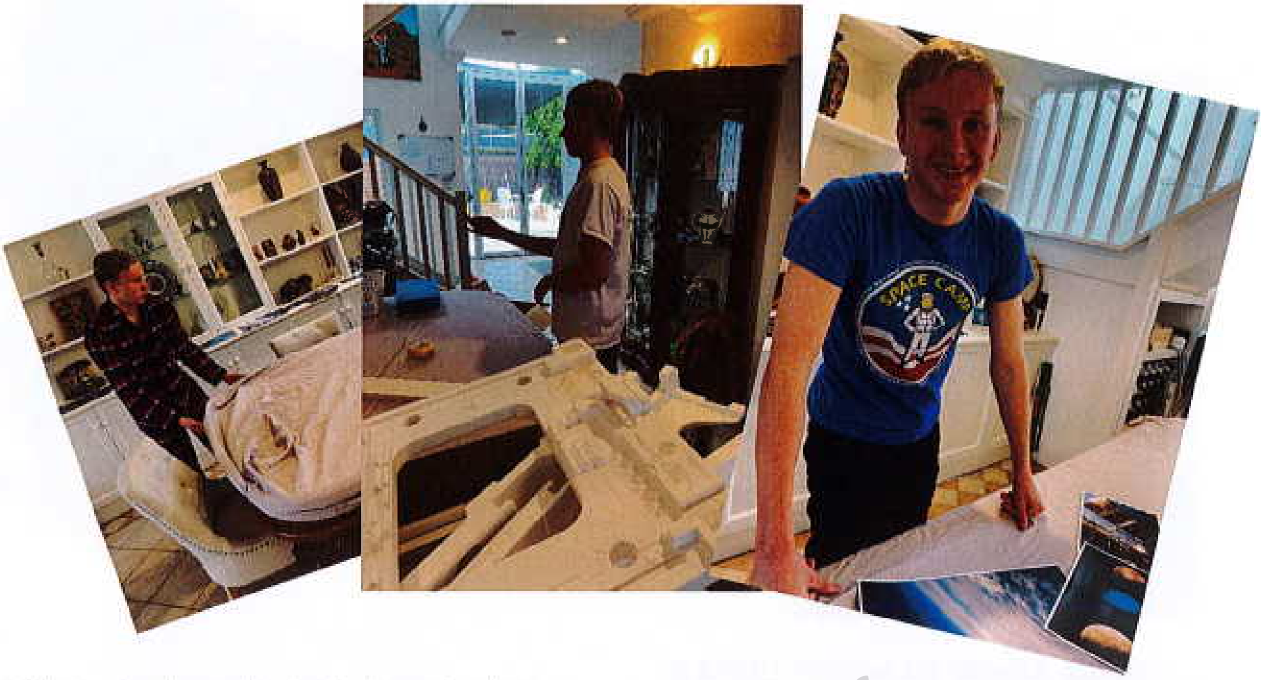
The effect of this release velocity is a trip of **97 days** instead of 210 days to reach Mars or a 2.2 fold improvement.

ISSUE TO OVERCOME TO BUILD A REAL SKYHOOK

- Getting materials into space to build a 1,000 km long piece of Infrastructure.
- Getting the SkyHook spinning
- Building specialised spacecraft
- Space Junk may get in the way of the cable, such as old & New Satellites.
- Getting a Craft to hook on at massive speed

HOW THE MODEL WAS MADE

DESIGN PHASE

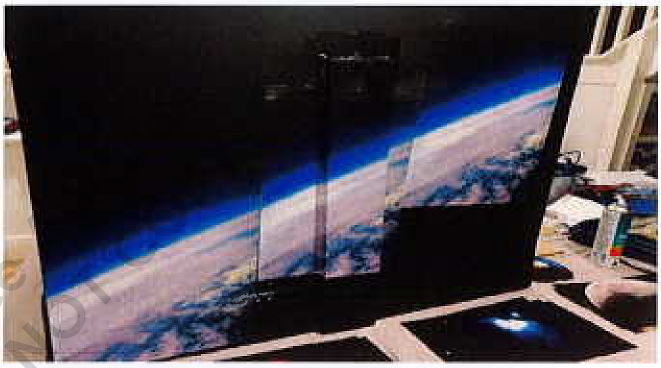


PREPARING THE BUILDING SITE

THE INITIAL STRUCTURE, A BIT OF HELP FROM DAD TO STABILISE AND EVEN THE DOGS GOT INVOLVED.

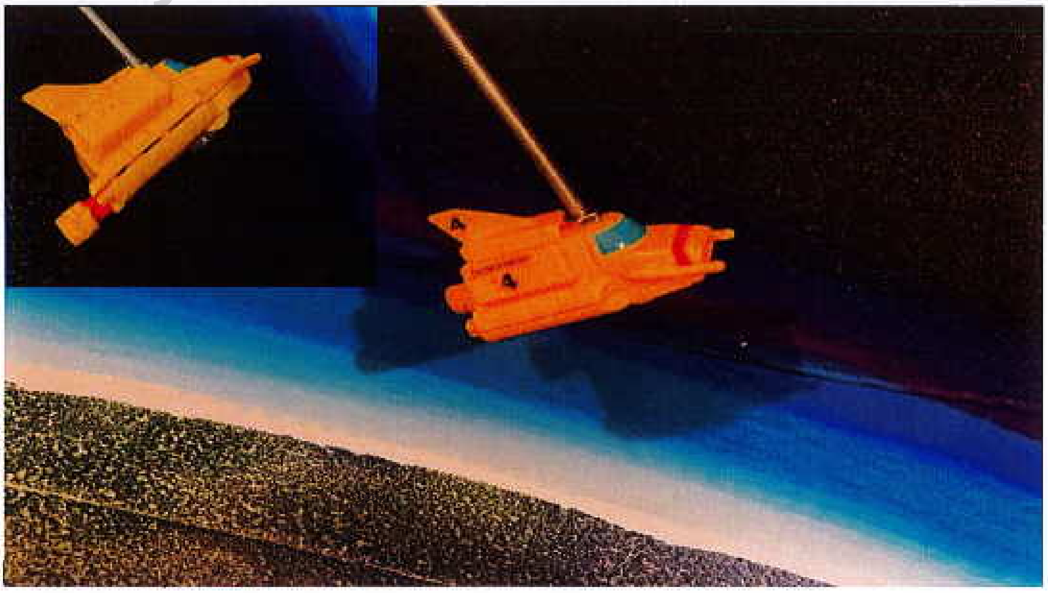
STYROFOAM WAS INTEGRAL IN BUILDING LANDSCAPE AND ADDING SUPPORT

SHAPING STYROFOAM TAKES PATIENCE AND LOTS OF PVA GLUE



ADDING COLOUR AND STYLE HARD WORK ON CRUTCHES

RAIDING
THE TOY CUPBOARD WHAT IS SPACE WITH OUT THUNDERBIRDS



ALMOST
LABELS.

ACKNOWLEDGEMENTS

Regan Nelson:	Model Builder/Scientist/Report writer/Editor
David Nelson:	Regan's Dad, Assistant Builder, Parts Holder Safety Officer Assistant Editor
Eileen Nelson	Photographer/Videographer and Morale Builder

"Thank you to my parents who spent a lot of time with me as I put together the SkyHook." ☺ Especially when I tore my Ligament

Equipment needed

- Wood
- Bolsar 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 Tinker CADD program
- Jig Saw
- Sandpaper
- Drill
- Duct Taper
- Scissors
- Glitter
- Glitter Paint
- Printer

SKILLS AQUIRED

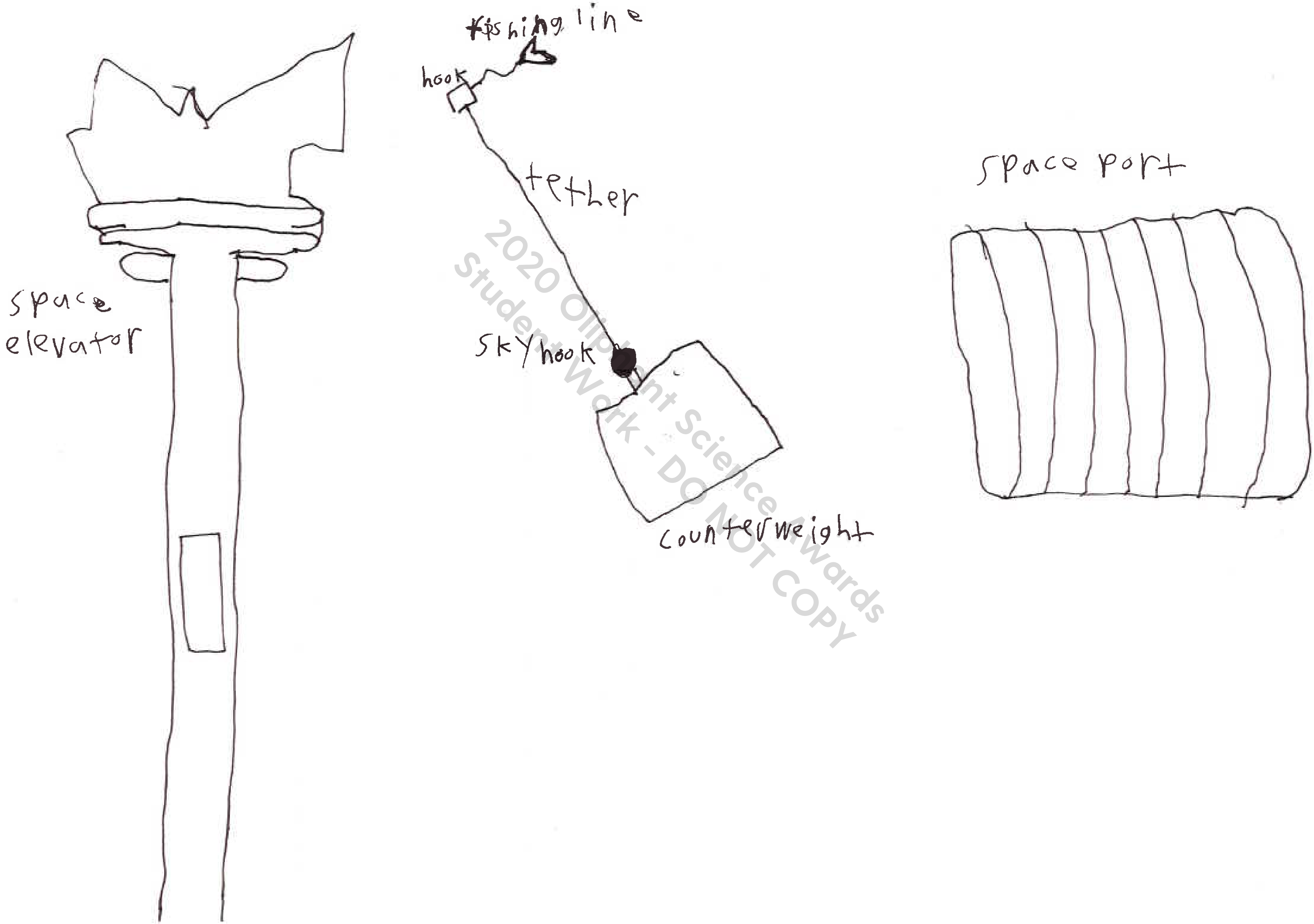
- Tinker Cad Program
- soldiering Iron
- Jig saw
- Knowledge

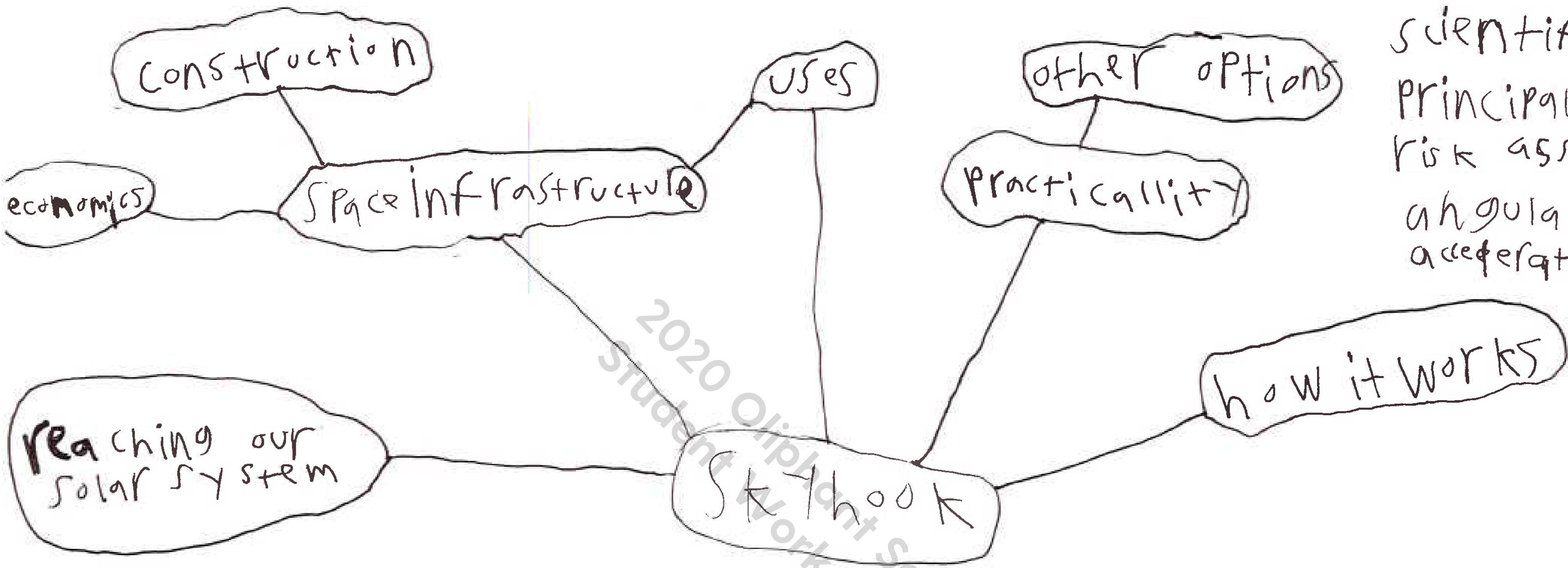
Protection Gear:

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

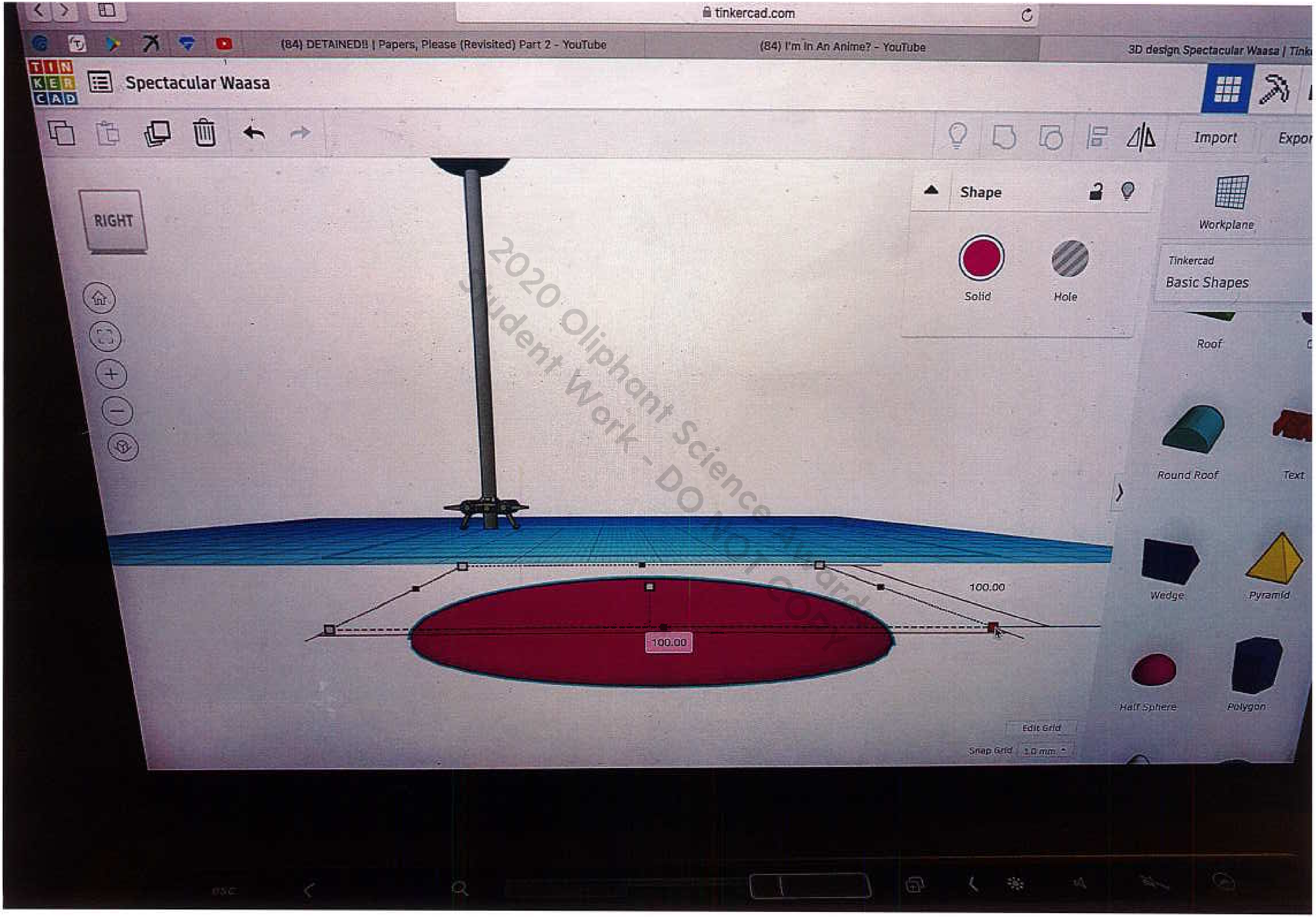
Hazards

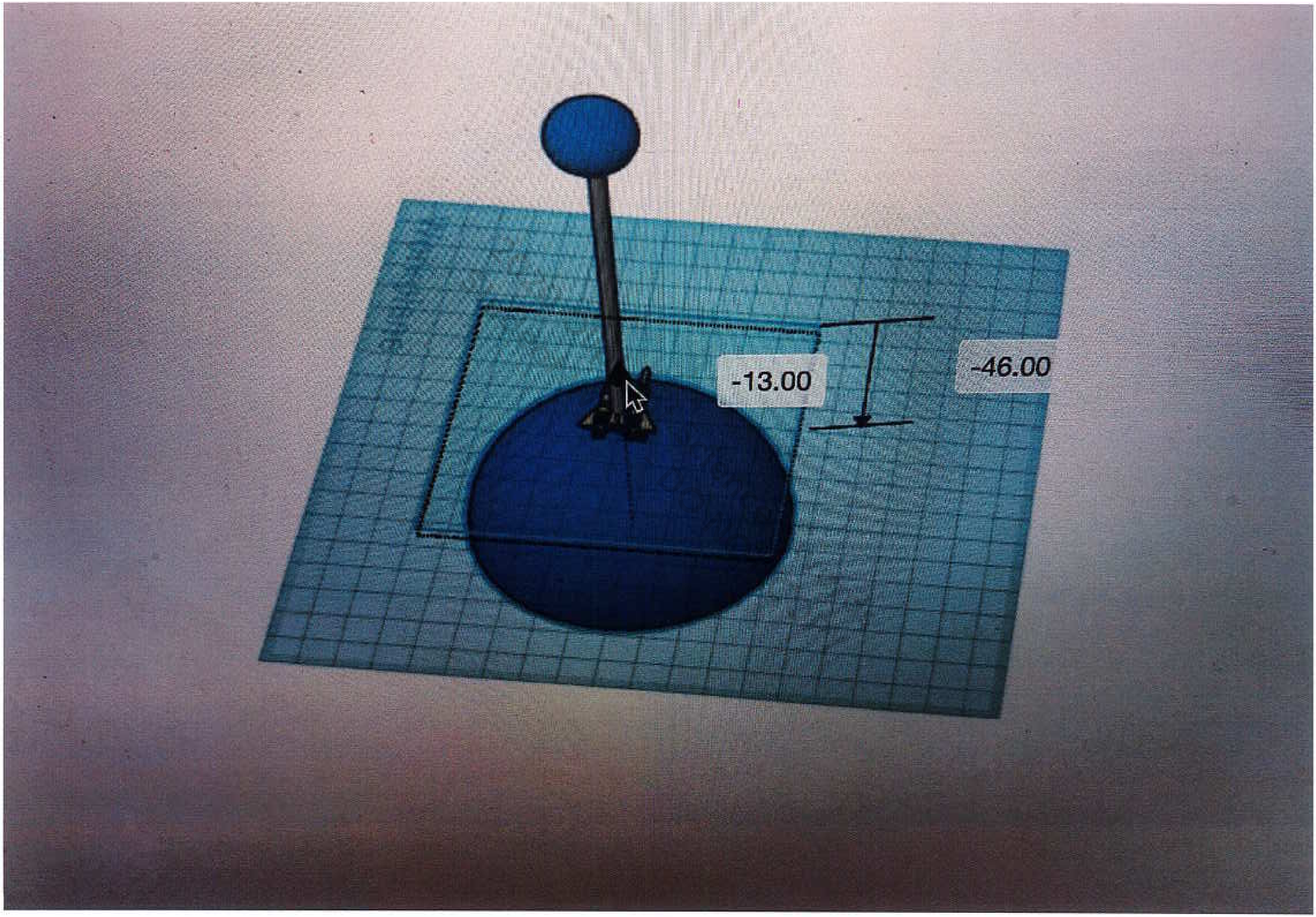
- Soldering iron
- Drill
- Screwdrivers
- screws
- Drill
- Hammer
- Use Glue
- Hot Glue Gun
- Power Equipment
- Spray Paints
- Working on Crutches
- Jigsaw
- Stanley Knife
- Large Kitchen knife
- Electric Knife

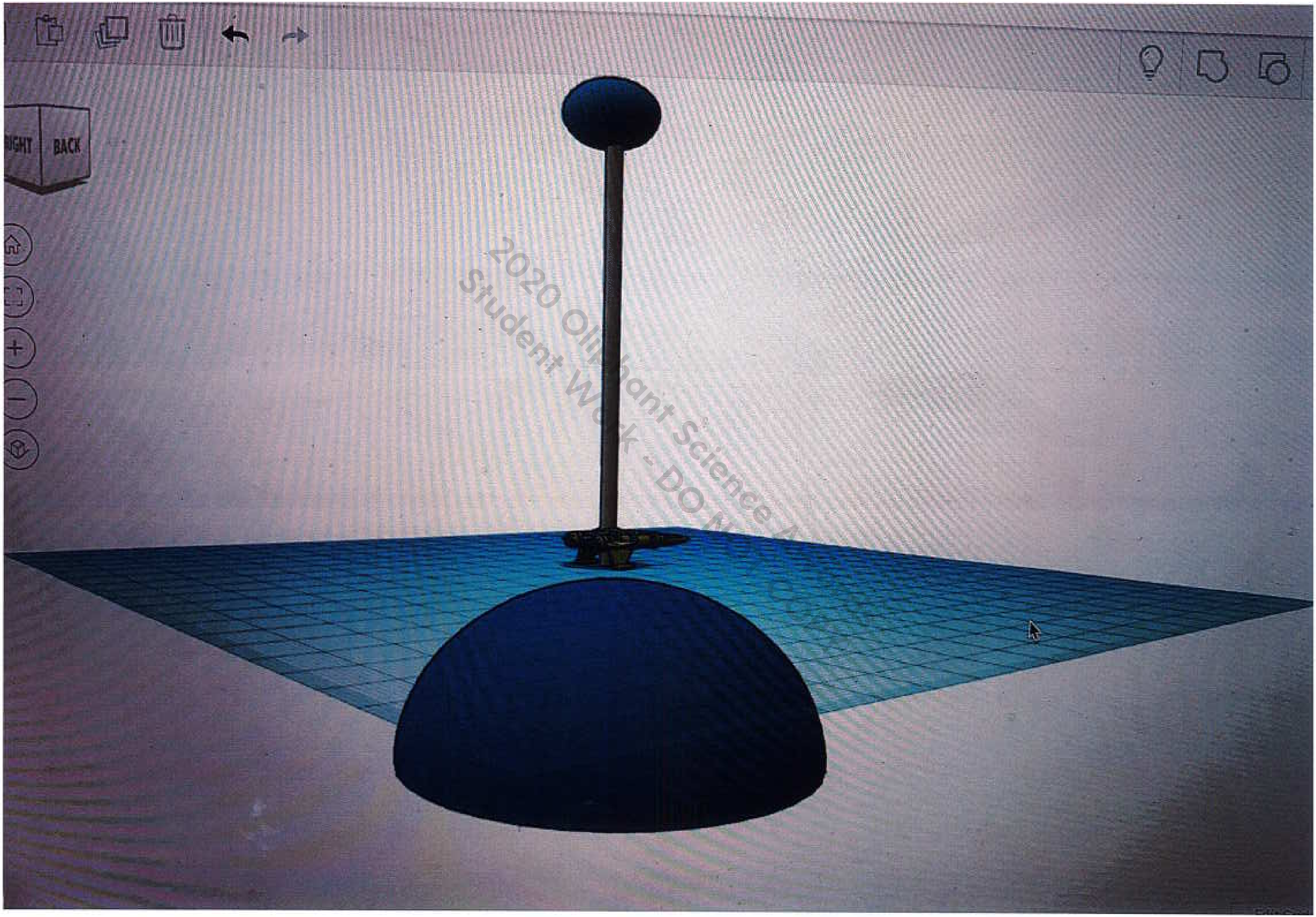

fishing line
hook
tether
skyhook
counterweight
space elevator
space port

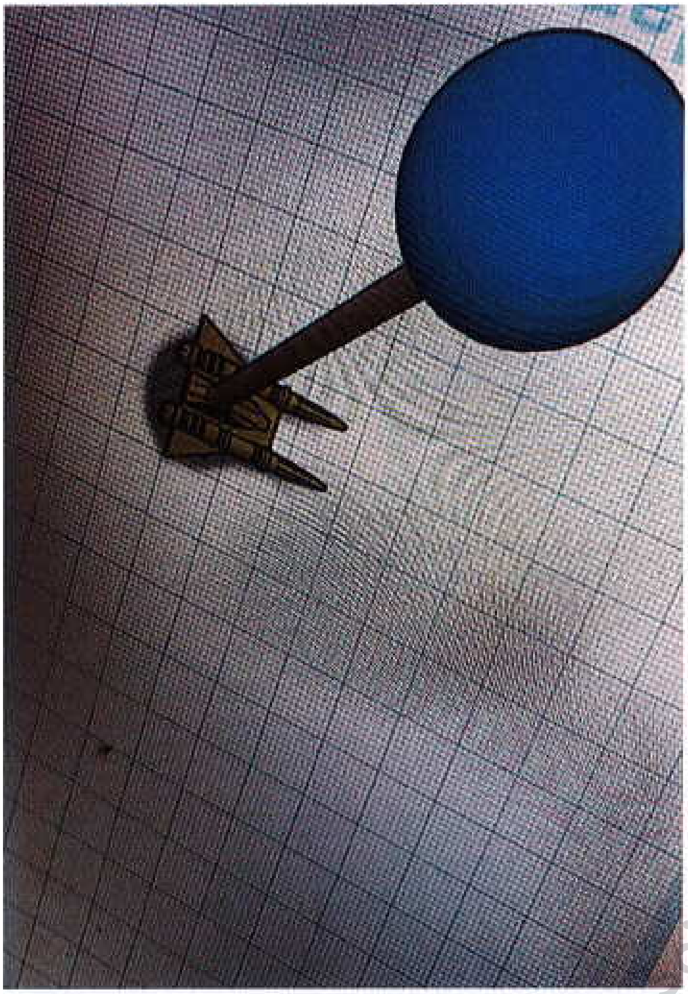
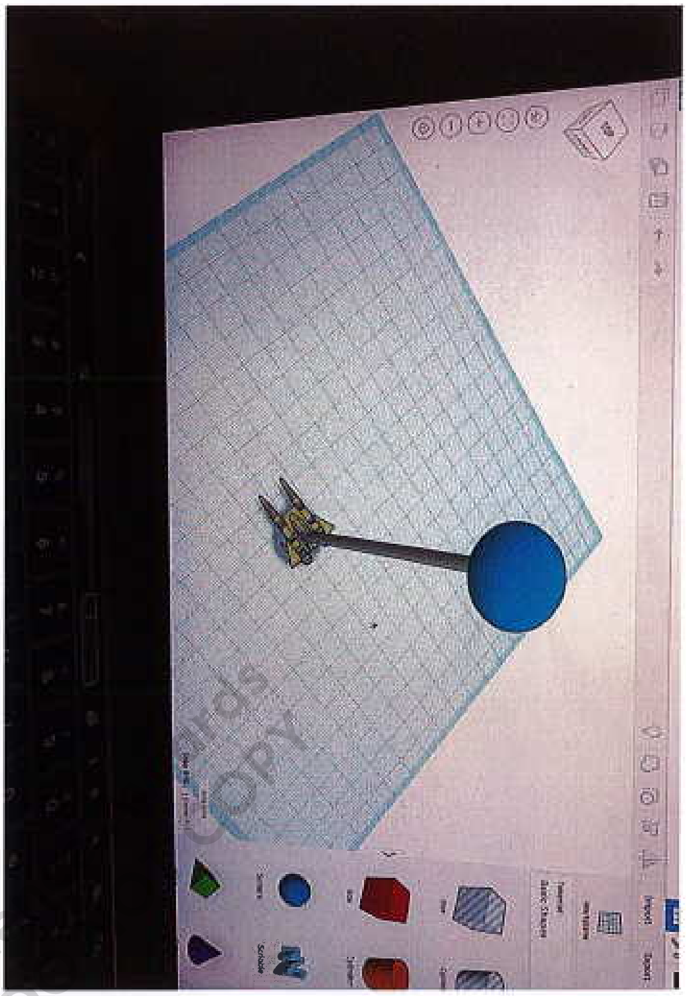
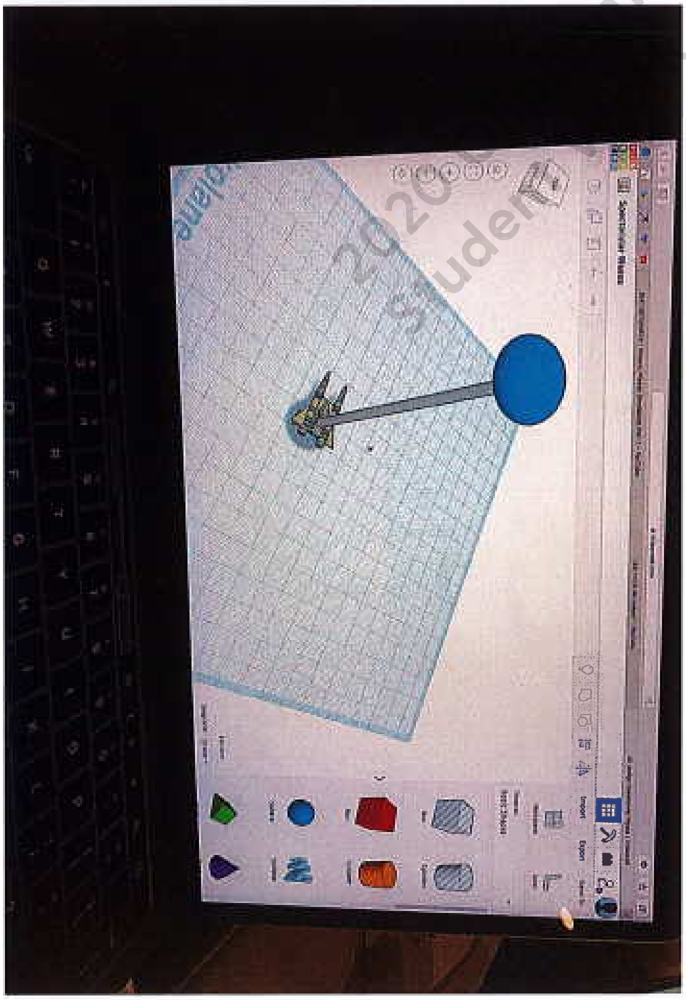
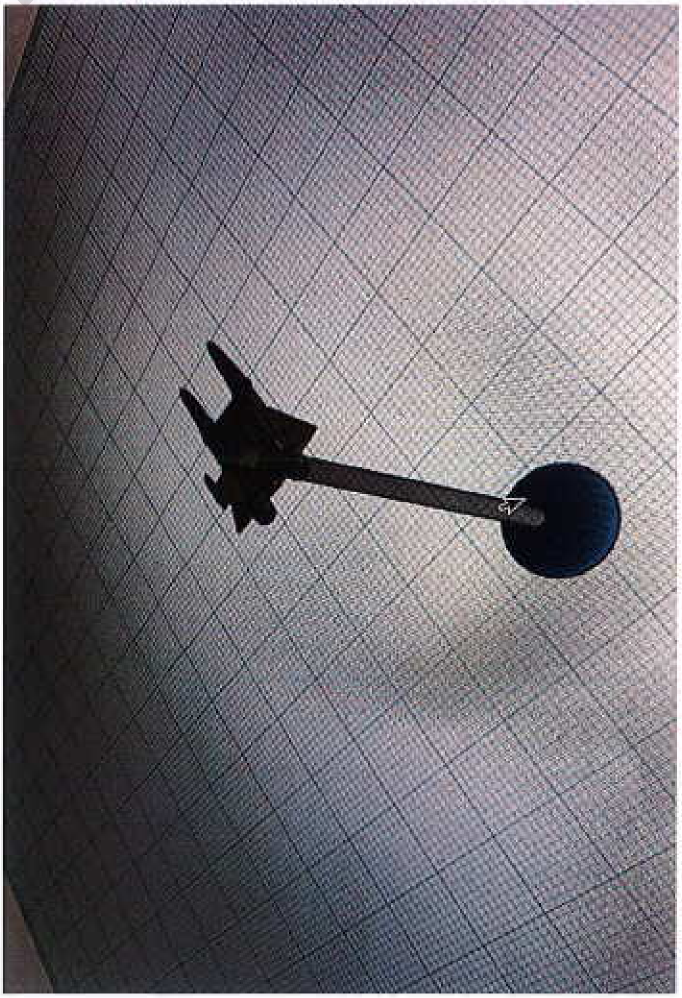


scientific principal:
risk assesment
angular acceleration

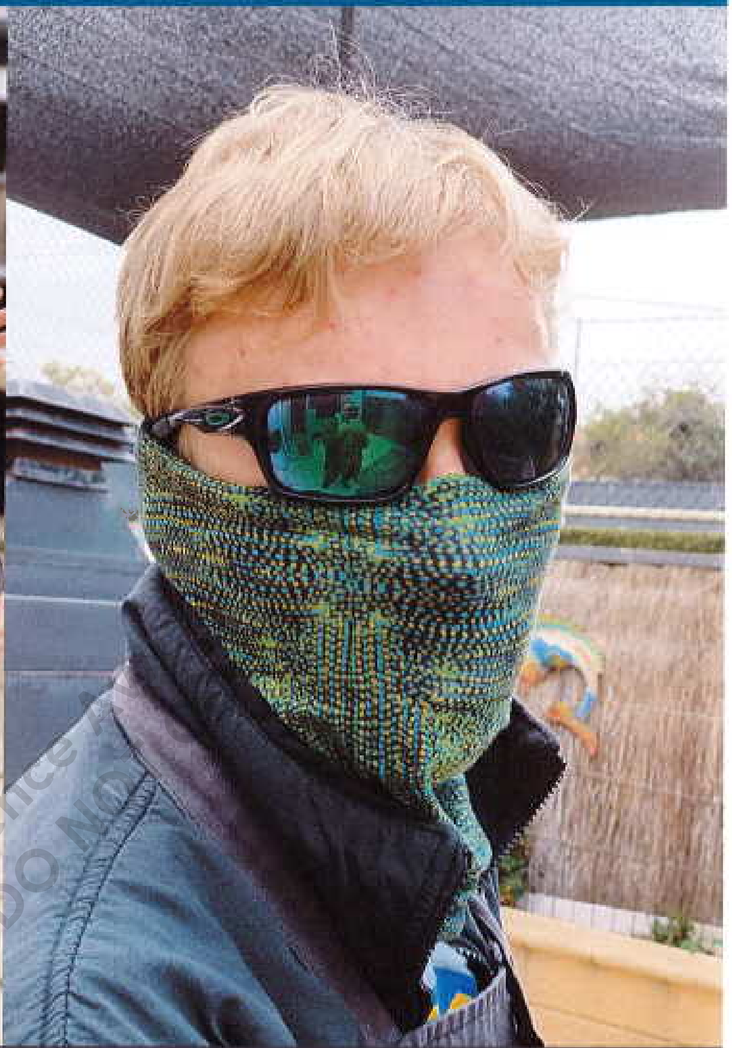

tinkercad.com
(84) DETAINED!! | Papers, Please (Revisited) Part 2 - YouTube
(84) I'm In An Anime? - YouTube
3D design Spectacular Waasa | Tink
Spectacular Waasa
Import
RIGHT
Shape
Solid
Hole
Workplane
Tinkercad
Basic Shapes
Roof
Round Roof
Text
Wedge
Pyramid
Half Sphere
Polygon
100.00
100.00
Edit Grid
Snap Grid


-13.00
-46.00


BACK

Year 9: Regan Nelson : Prince Alfred College



Appendix

Additional Information and Images

APPENDIX:
ADDITIONAL READING:

THE SKYHOOK PROPULSION SYSTEM:
HUMANITIES LADDER TO THE STARS

The theory behind this system is rather simple, instead of using chemical engines and literal tonnes of rocket fuel, we use the kinetic potential energy stored inside of a 1000 km tether in space, spinning around a counterweight.

The Idea: Space Infrastructure
Currently, a rocket needs to reach around 40,000 km/h to escape Earth. To achieve this, rockets are almost entirely fuel tanks, with only a tiny tip of payload. (NASA, n.d.)

It currently costs around $20,000 to send a single kilogram of payload into space, although the SpaceX Falcon Heavy is hopeful to get this close to $1,000 in the near future. (Jones, n.d.)

A solution to further reduce this cost and increase the speed and efficiency would be to build infrastructure in space. This would make space flight drastically cheaper and faster, and although it would still be challenging to establish this skyhook system, it is much easier than strapping a few kilos to over 400 tonnes of explosives going at 40,000 km/h. (Wikipedia, n.d.)

At its lowest point, the skyhook will be screeching through the upper atmosphere at around 32,600 km/h, but if the tether spins in the opposite direction to the Earth's rotation, then it will technically slow at its lowest point to 28,249 km/h, which is equal to orbital velocity 7.847km/sec, giving small reusable spaceships a 60 to 90-second window to catch the tip of the tether.

There would be three main parts to the skyhook, the counterweight, the tip and the cable that hold the 2 points together. The skyhook works like an orbital battery of kinetic energy, losing some momentum and imparting it on the craft that was attached to it when it is released into space.

To prevent the skyhook from just falling back into Earth's atmosphere as a result of the loss of energy, we would need to add energy back via incoming flights. When a ship is caught and slowed down by the hook, it would add the kinetic energy back to the skyhook, preventing it from slowing down and crashing into the Earth. But the sudden acceleration and deceleration experienced by the people inside of these space craft's when they attach to the hook may be a problem, so let's do the math.

50,000 x 3.142 = 157,100 m/sec or 565,560 KM/hr

This would be 328x faster than the current estimated speed to Mars and would take 6.38 days.

So, if the cable was 1,000 km long like what I have seen on documentaries (Kurzgesagt, 2019), this model would have the rocket moving at 1,000,000 x 3.142 = 3,142,000 m/sec approximately 1% the speed of light and could travel to Mars in just 7.66 hours.

But of course, the real thing won't swing once every 2 seconds, most likely once every 2 hours at the fastest.

Absolute velocity isn't the problem, but the increase of speed over time is. G Force is the most common measurement for this. 1G represents Earth's gravity and how fast things fall towards earth centre, which is 9.81 meters per second.

Accelerate or decelerate at twice this speed, and you'll be pulling 2 G's. The average person can handle around 9 G's, so how many G's would our astronauts be pulling on the skyhook?

Well, if our craft is already flying at Orbital Velocity, 28,249 km/h, and then it attaches to the skyhook, during the first few seconds our passengers will experience somewhere around 1.4 G's, as they accelerate to release velocity of 36,964 km/H, which isn't all that bad.

This means that the skyhook won't turn the people inside of our shuttle into marinara sauce. But what about other satellites and space junk in the way of our hook. Well, there are so few satellites in low earth orbit, so they likely won't be a problem. Plus, many satellites in that area of space are out of date, and due for removal anyways.

The effect of this release velocity is a trip of 97 days instead of 210 days to reach Mars or a 3 fold improvement.

https://www.softschools.com/formulas/physics/orbital_velocity_formula/76/

Orbital Velocity Formula

Objects that travel in a uniform circular motion around the Earth are said to be "in orbit". The velocity of this orbit depends on the distance from the object to the centre of the Earth. The velocity has to be just right so that the distance to the centre of the Earth is always the same. The orbital velocity formula contains a constant, G, which is called the "universal gravitational constant". Its value is = 6.673 x 10-11 N·m2/kg2 .The radius of the Earth is 6.38 x 106 m.

$$\text{orbitalvelocity} = \sqrt{\frac{(\text{gravitational constant})(\text{mass of earth})}{\text{distance from object to center of the Earth}}}$$

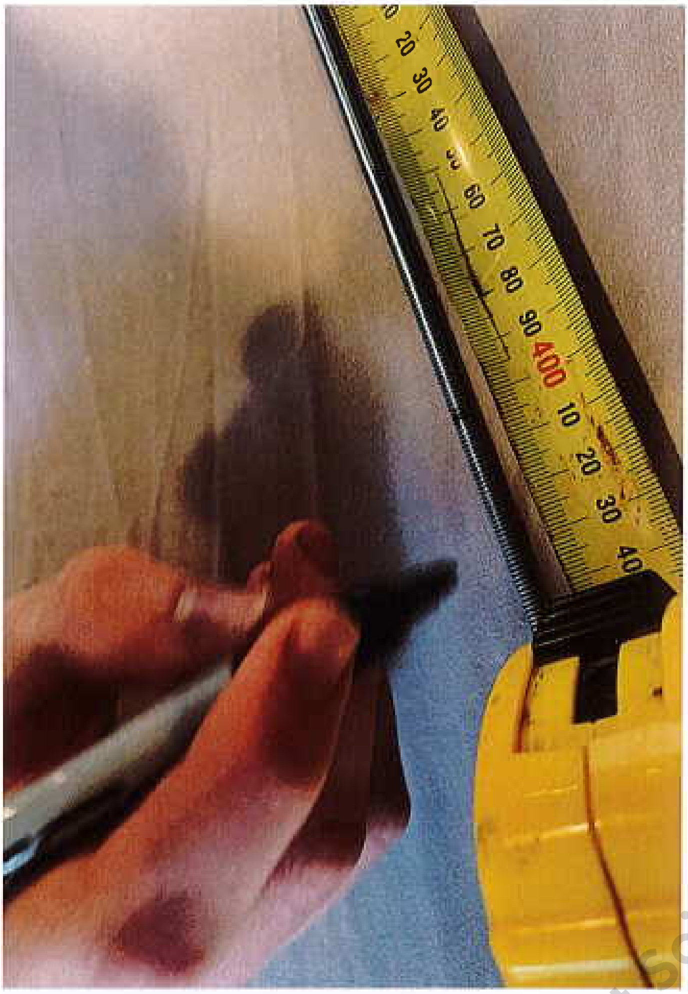
$$v = \sqrt{\frac{Gm_E}{r}}$$

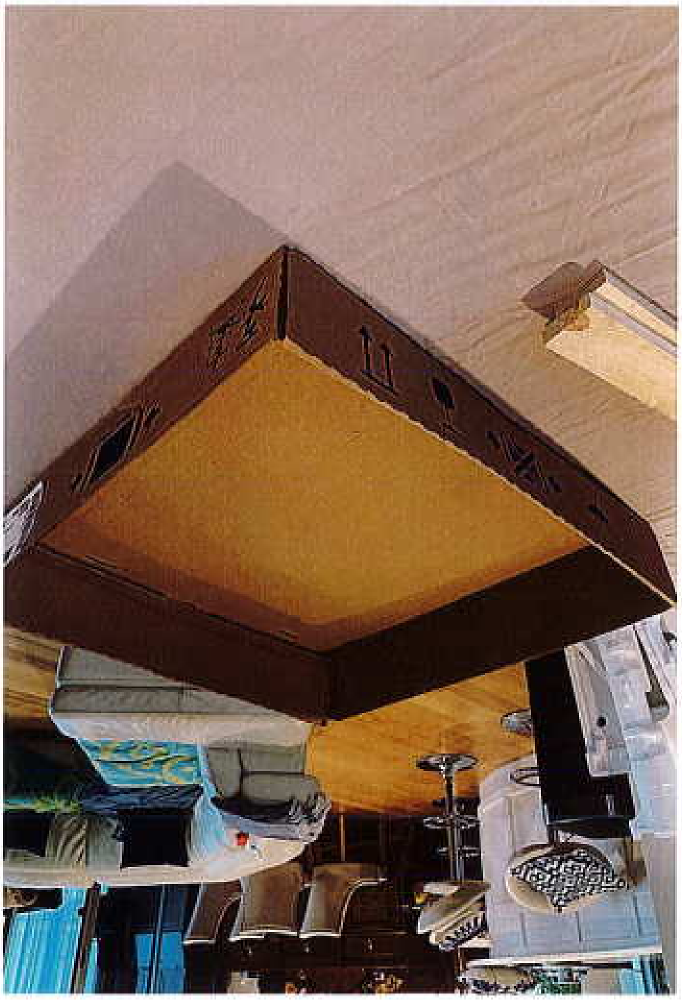
v = the orbital velocity of an object (m/s)

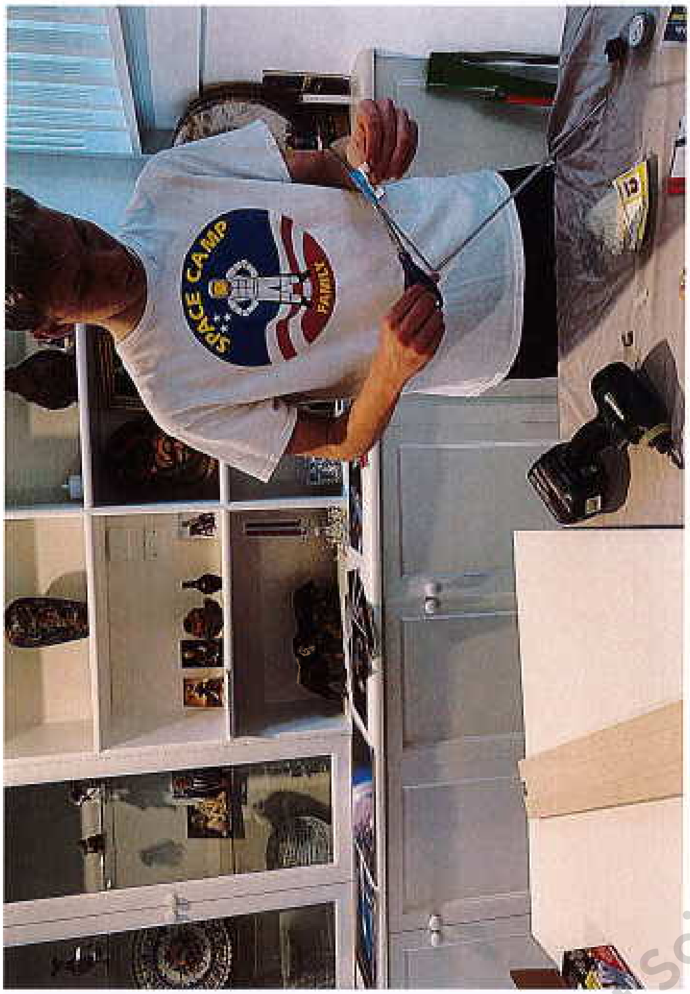
G = the universal gravitational constant, G = 6.673x10(-11) N·m2/kg2

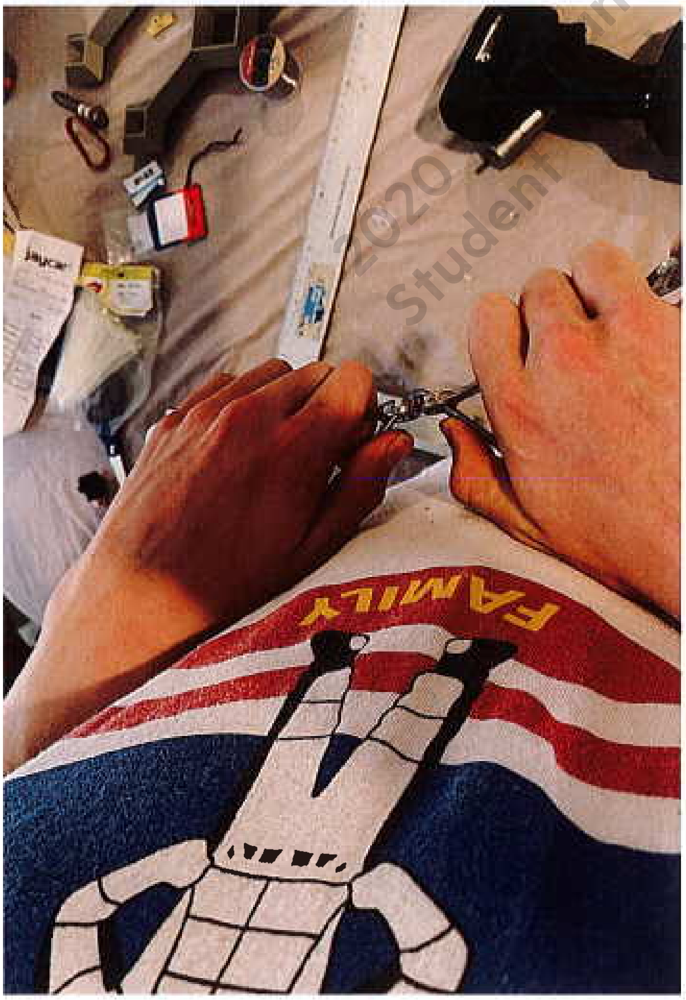

BEYOND • LAUNCHING DREAMS • INSPIRING
SPACE CAMP

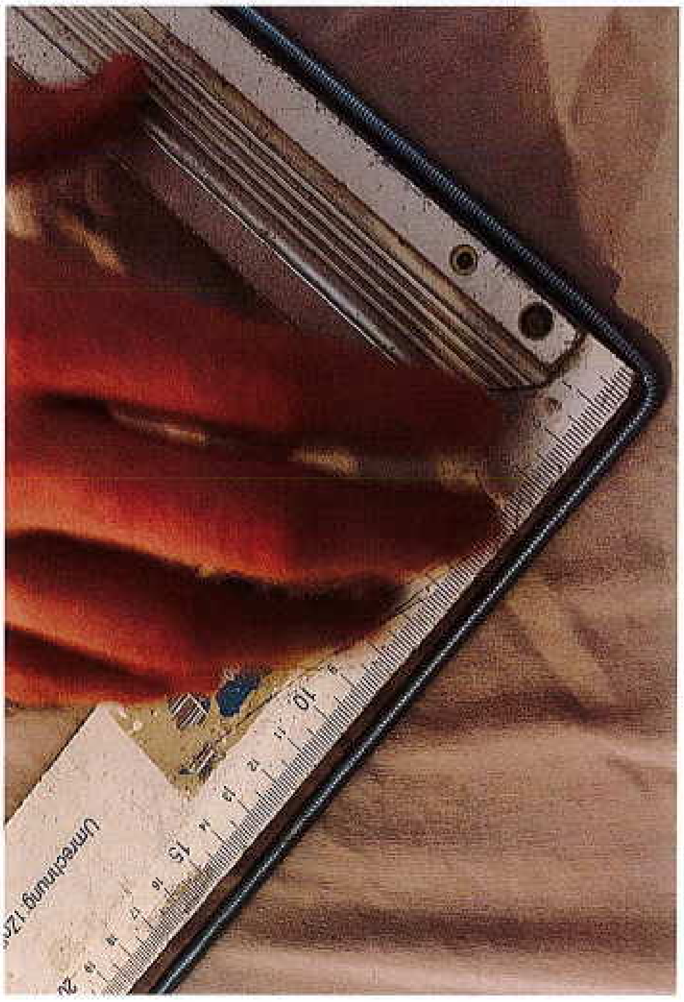

SPACE CAMP






SPACE CAMP
FAMILY


FAMILY

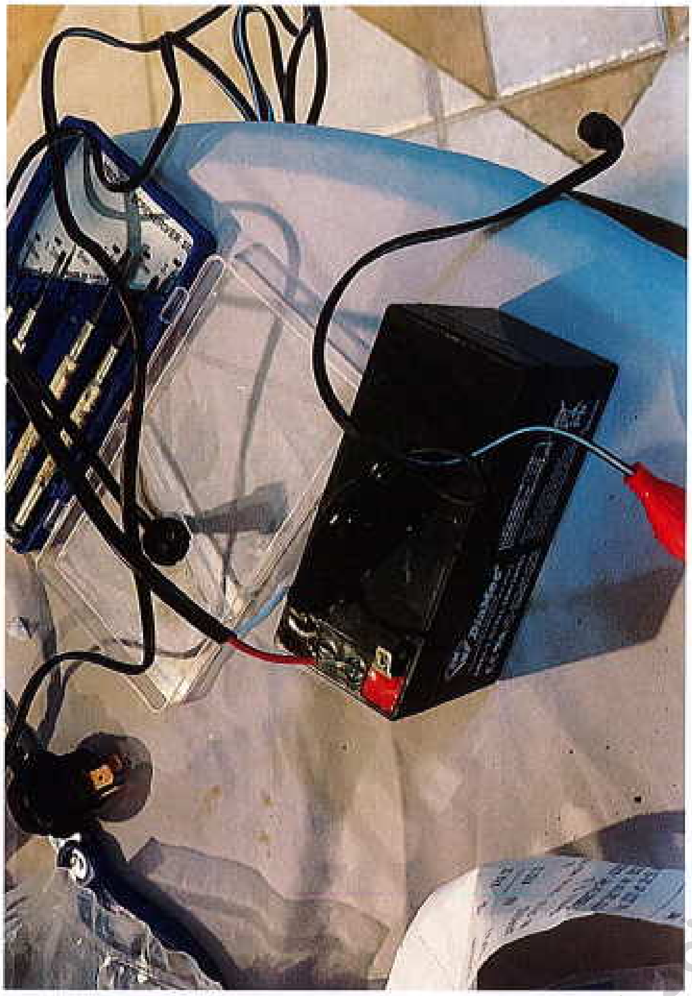



SPACE CAMP
BOSCH

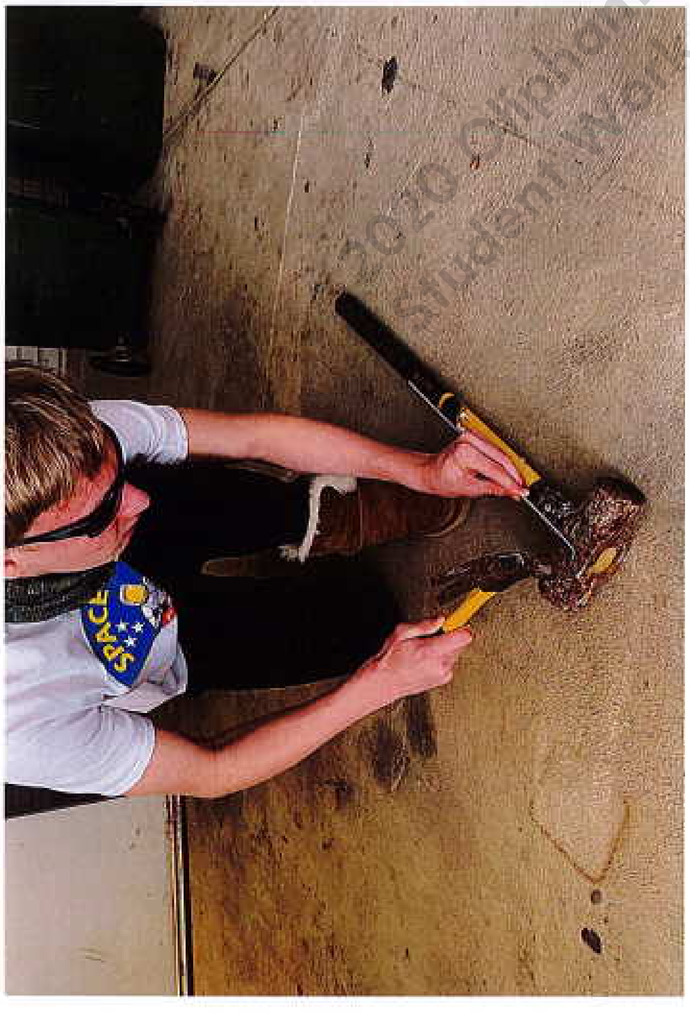

SPACE CAMP

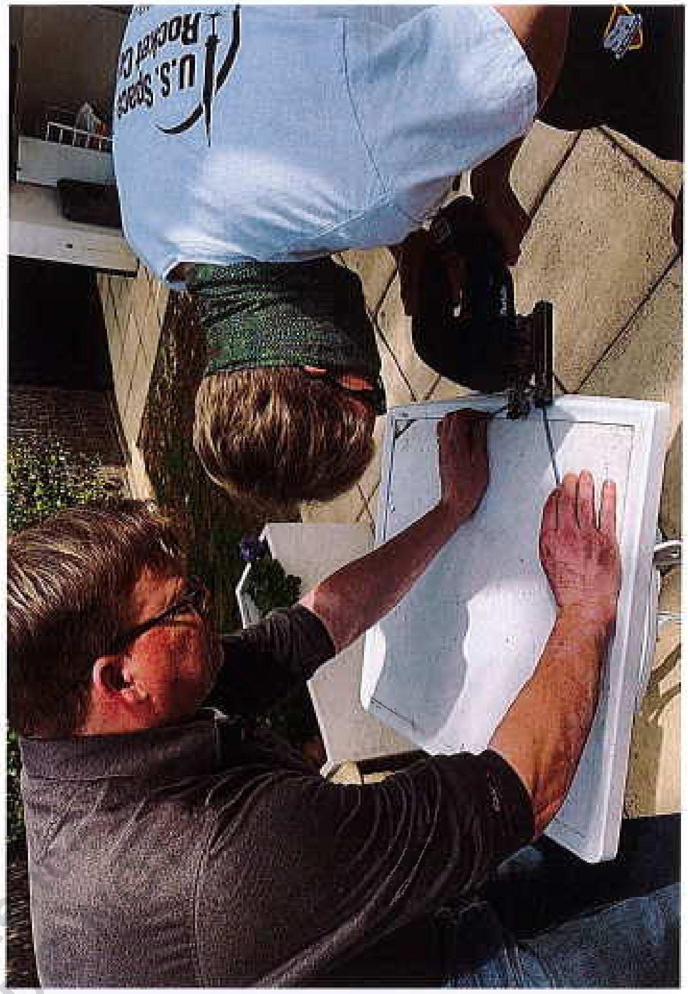

SPACE CAMP
FAMILY

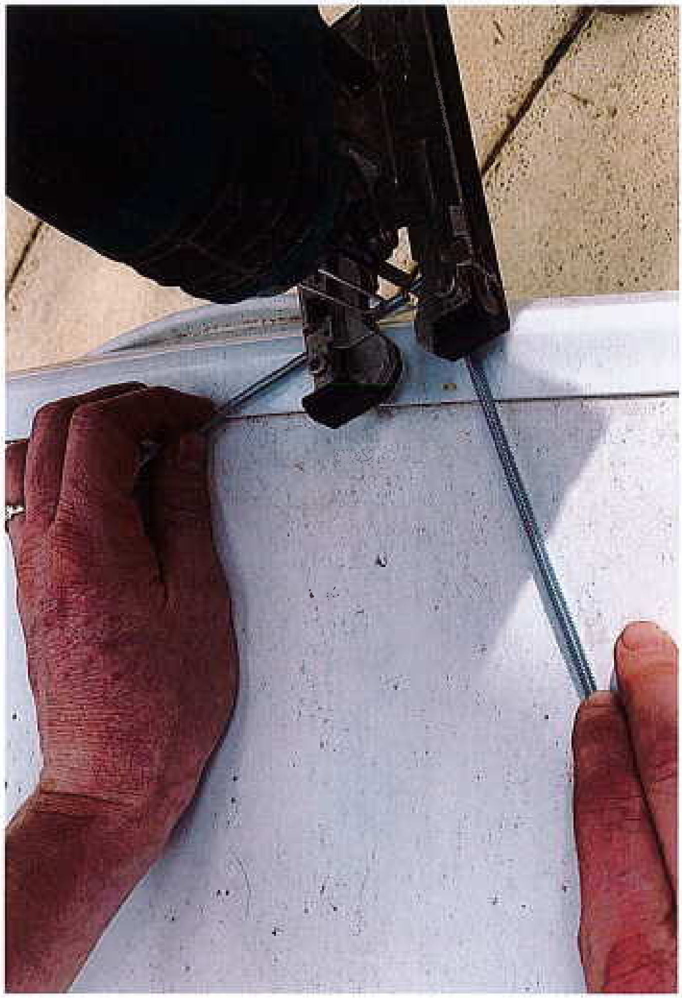

FAMILY




SPACE CAMP


SPACE







FAMILY RULES
SHARE
Be Thankful
BE HAPPY
Dream Big
Hug Often

















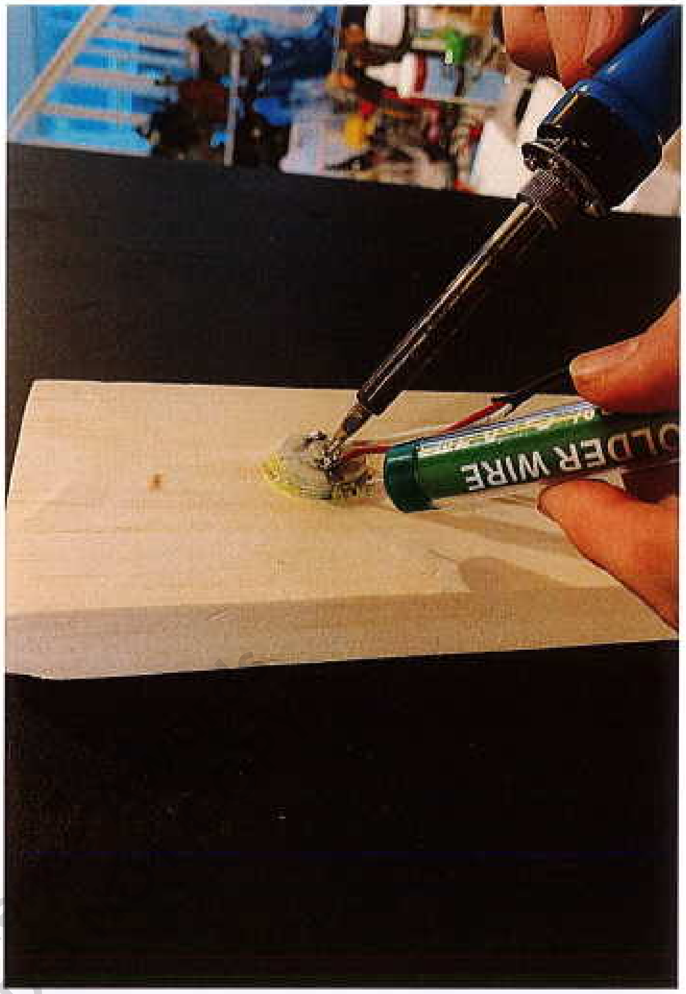
FAMILY RULES
SHARE

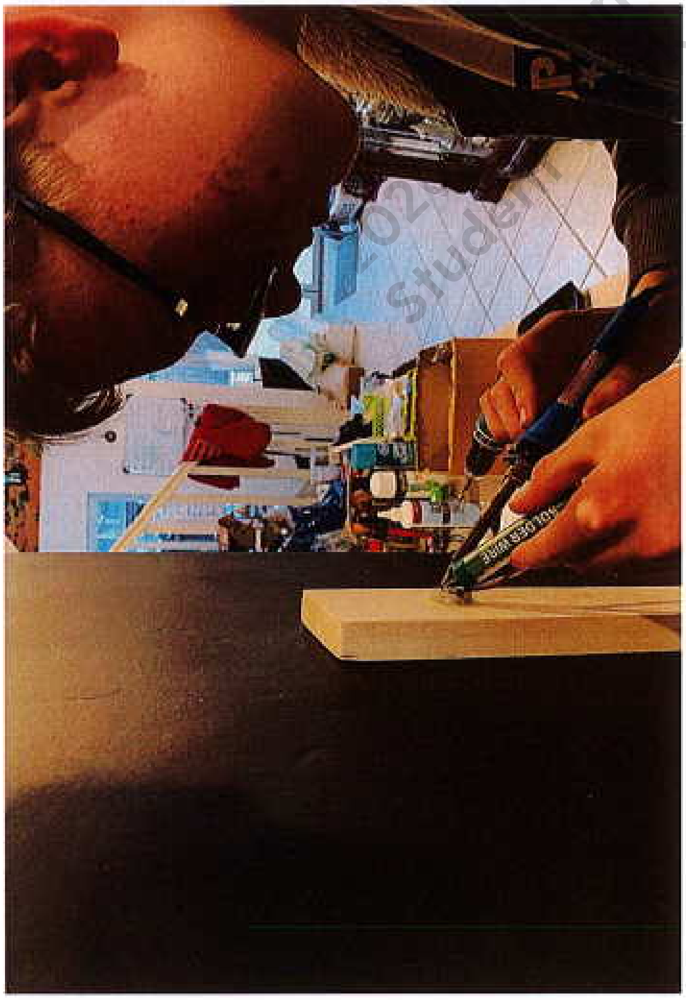

Hug

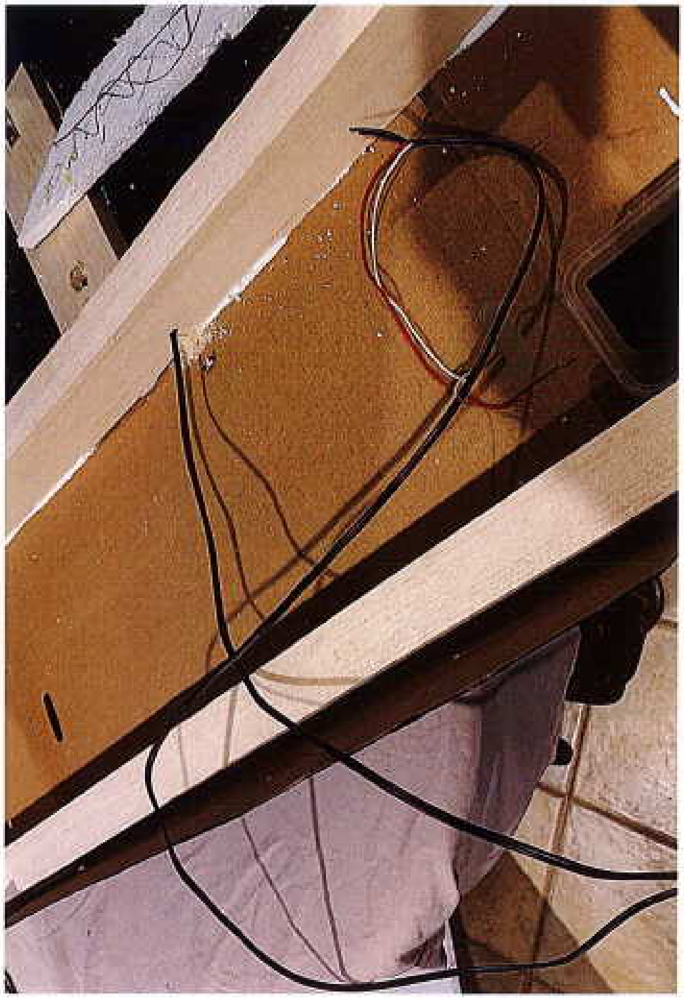




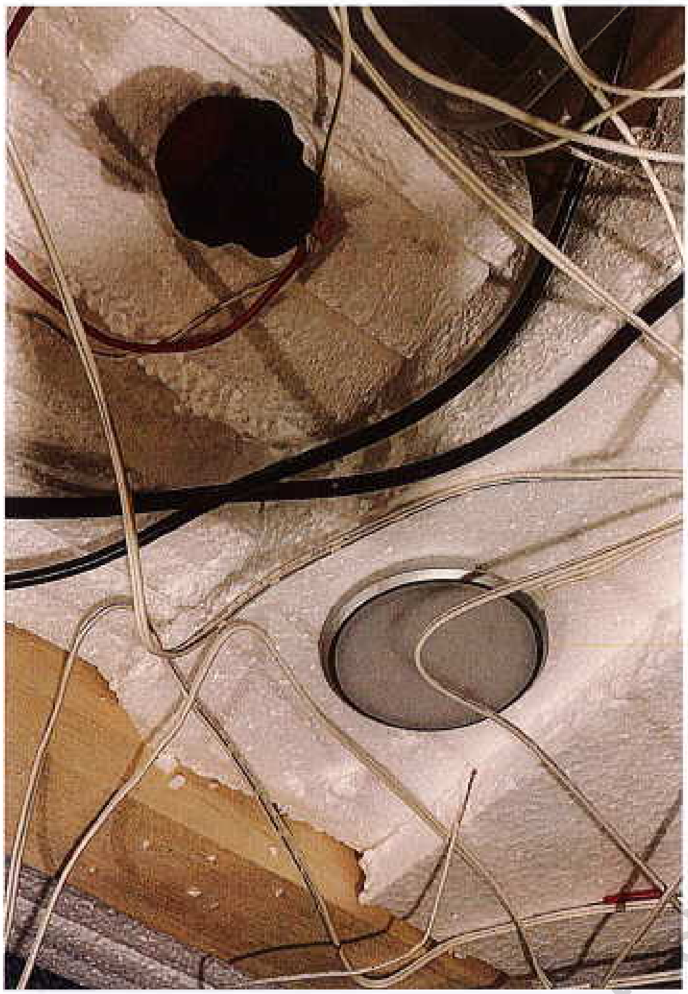


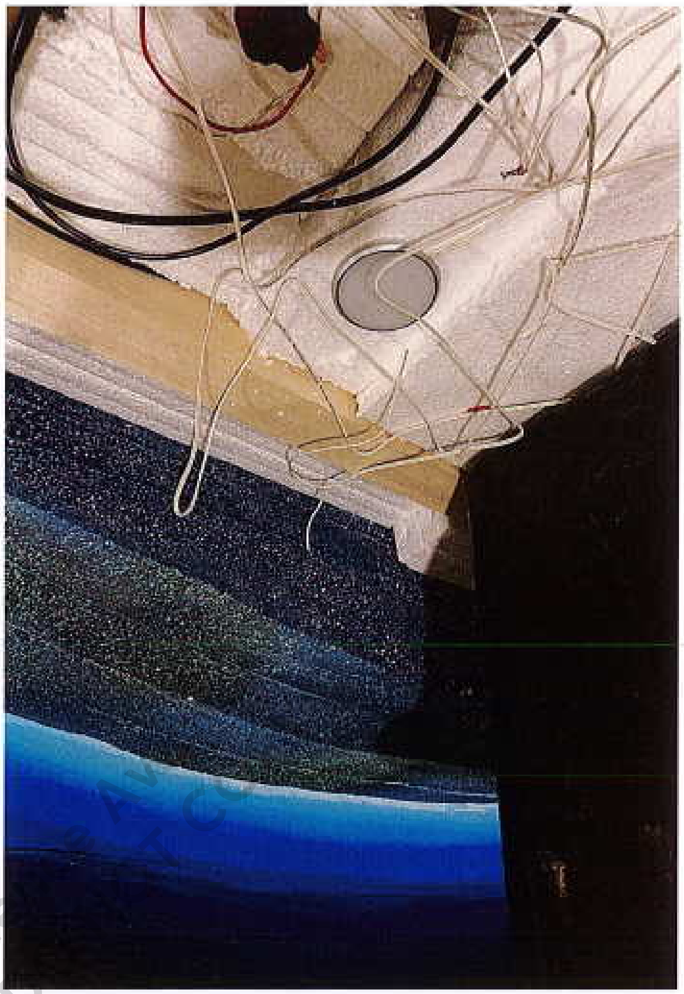








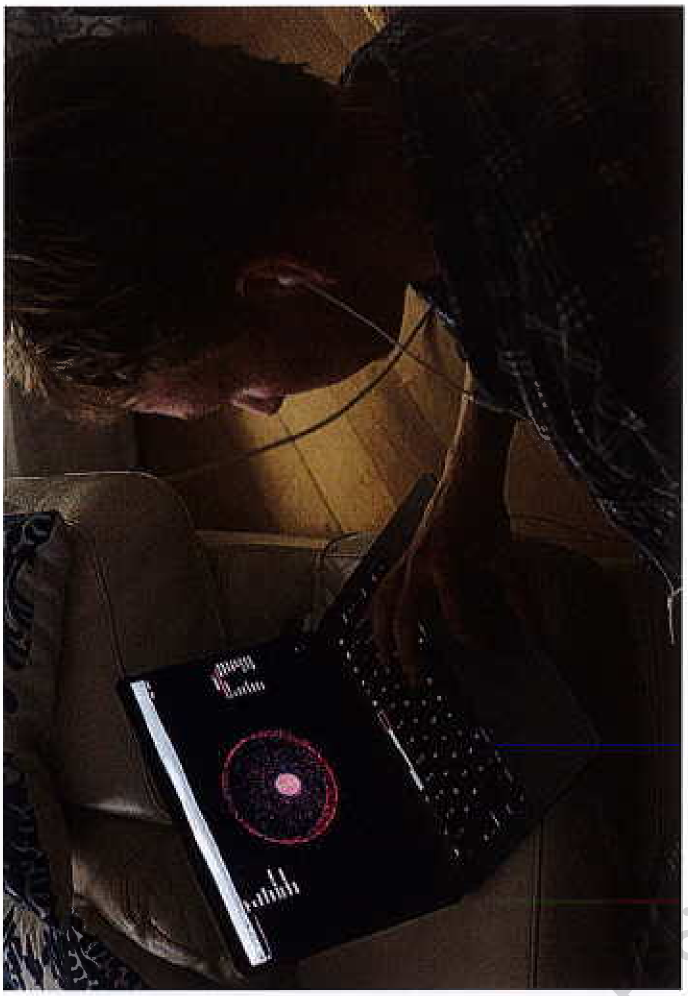



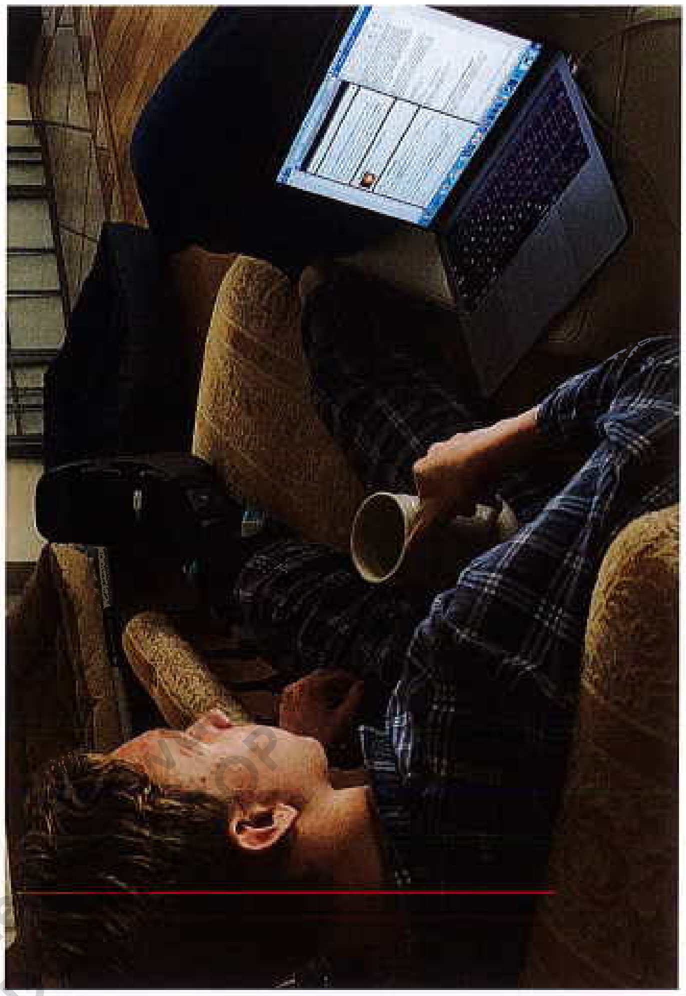


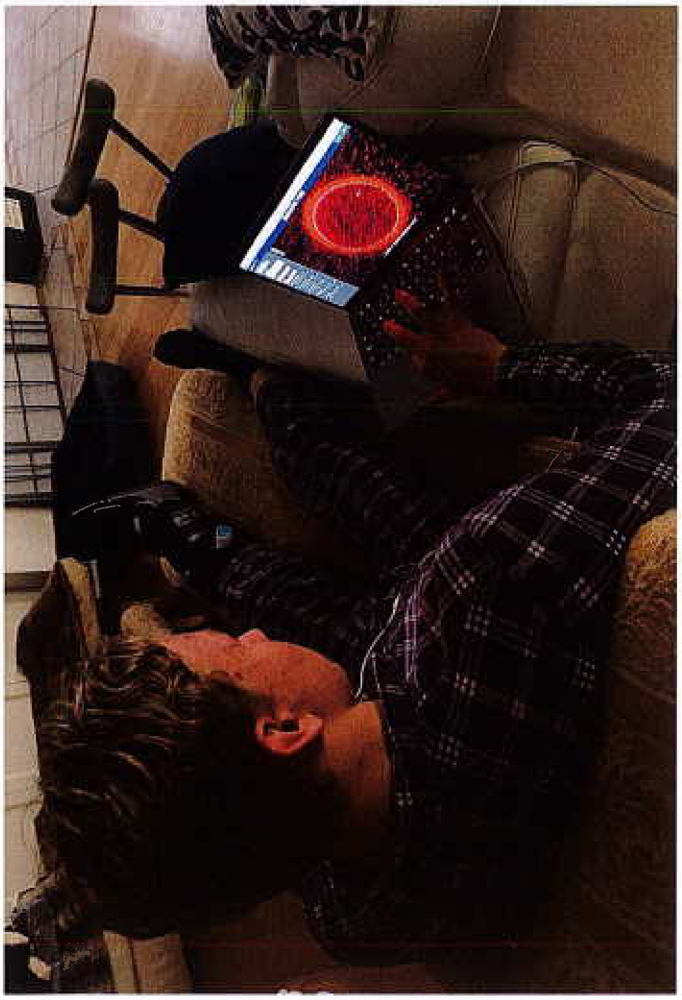

THUNDERBIRD
4
4
4


SOLDER WIRE

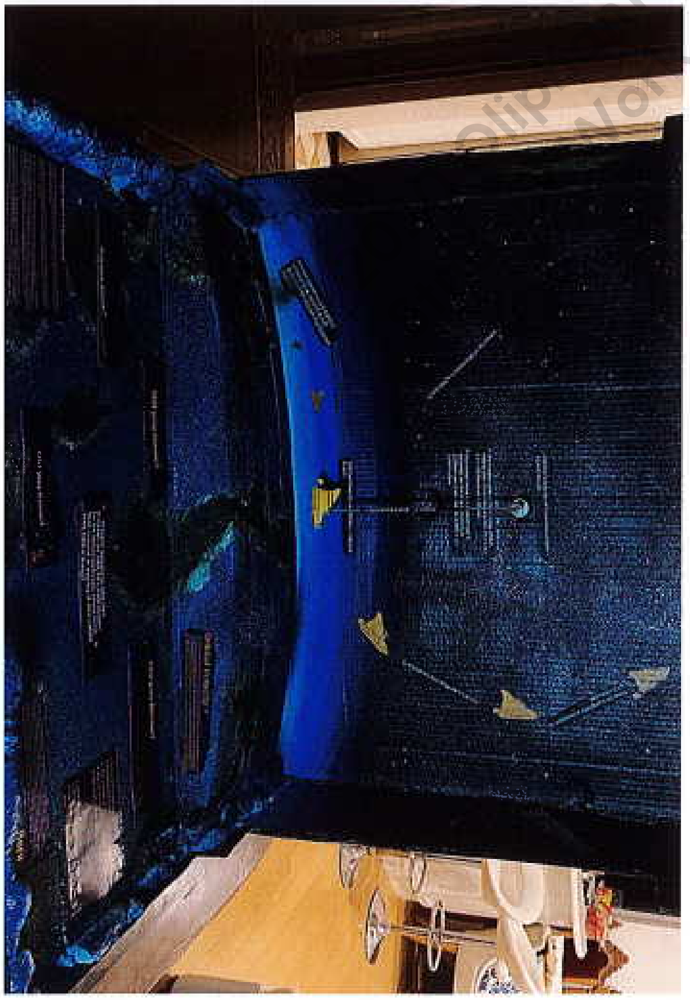












FOAM FILL


FOAM FILL


hugo


THE SKYHOOK PROPULSIONS
T.S.P.S. mk1


THE SKYHOOK PROPULSIONS
T.S.P.S. mk1


THE SKYHOOK PROPULSIONS
T.S.P.S. mk1