Le Fevre High School
The Maritime School of South Australia

STEM in SACE Integration
Through Project Based Learning

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PROGRAM :

1) SACE Platforms usable for developing STEM learning.

2) Examples of STEM programs
   Naval Engineering courses at Le Fevre High School.

3) Challenges in using and integrating new technologies in Schools.

4) Students' outcomes.

5) Having a STEM Mind Set - Involvement with Relevant Industries.

6) Having a STEM Mind Set using an "augmented reality" set of eyes.

7) Projects examples not directly related to Naval Engineering.

8) Key Points and Summary.

9) Discussion – Questions.

STEM SACE platforms and integration of new technologies in Schools

There are two main vehicles to incorporate STEM learning within the SACE framework :

- Scientific studies
- Integrated Learning

If the Scientific studies framework is used, there a risk of shutting out students that are not very academic.

I have chosen to use Integrated Learning as a vehicle for STEM learning because :

1) As there is an externally assessed component (Project), Students can get an ATAR score from this subject and use it to go on studying at University level, in particular in Engineering courses.

2) Thanks to the Integrated Learning structure, my courses are project based learning. It allows me to welcome both academic and more hands-on students…

In fact, this mix is crucial for the success of the program. Academic minded students help more hands-on students when it comes to use Mathematics, Science and ICT skills to design the various parts of their project.
In return VET students offer their expertise to their more academic minded friends and show them how to use machines to produce parts for their common project.

The courses are structured in such a way that students operate as if they were already working in an Engineering company.

Students are asked to chose their team. Typically in Naval Engineering we have four teams per project :

- Buoyancy Systems / Hull Team
- Superstructures and Navigation Systems Team
- Propulsion Systems Team
- Control Systems Team

The need for cooperative work also develops their communication, problem solving and negotiation skills.

From an assessment point of view, Integrated Learning at year 12 level gives students 20 SACE points for a full year.

30 % Practical
20 % Group work
20 % Portfolio

30 % External assessment – Project

The great thing about this structure is that I can show students high level Mathematics, Physics and Engineering principles, through various associated activities, but I do not have to assess their performance in Mathematics, Physics, etc.

What they have to be able to do though, is to explain what these different techniques/principles are and how they are used in their project.

In the end, students that want to go on studying Engineering gain very strong STEM foundations for their future studies and at the same time, less academic students still can pass this subject with flying coulours.

Former students have even taken their portfolio with them when they went for jobs or apprenticeship interviews, allowing them to showcase their skills in a very concrete way. The feedback from future employers was very positive.

Examples of STEM programs

Naval Engineering courses at
Le Fevre High School.

Le Fevre High School
The Maritime School of South Australia

LE FEVRE HIGH SCHOOL

NAVAL ENGINEERING

T. HERMAN

STEM Integration
Project Based Learning

with a focus on Science, Mathematics and Technology

Naval Engineering at Le Fevre High School

Naval Engineering

Integrated Learning
Stage 1 and Stage 2

T. Herman

Naval Engineering Program STEM Themes

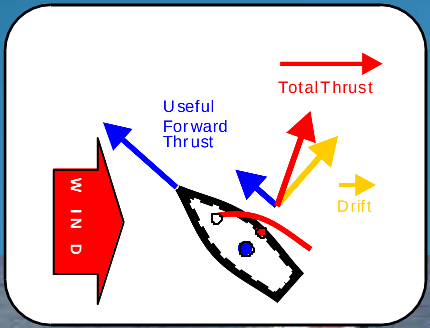
- *Use of Scales and scale representation (plan)*
- *Archimedes Principle and Displacement*
- *Electro-chemical zinc anode steel hull protection*
- *Density and buoyancy (Boats / Submarines)*
- *Notion of Relative wind*
- *Righting Moment / Torque*
- *Stable / Unstable designs*
- *Propulsion Systems and Electronics*
- *Hydrodynamics (Winged keel)*
- *Navigation and Angles / Trigonometry*
- *Triangulation, GPS Technology*
- *Radar technology / Doppler effect*
- *Rope and Cable making / Tensile strength*
- *Chemistry (Epoxy / Polyester Resins)*
- *Carbon fiber technology , etc …*

Naval Engineering Program

Year 11 Naval Engineering

Semester 1

The Science and Engineering of Sailing and Racing Machines

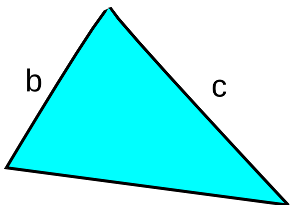


Naval Engineering Program

Boat Building as a pedagogical vehicle for Mathematics, Physics and Technology

Hero's Formula

Calculations of the surface area of triangles

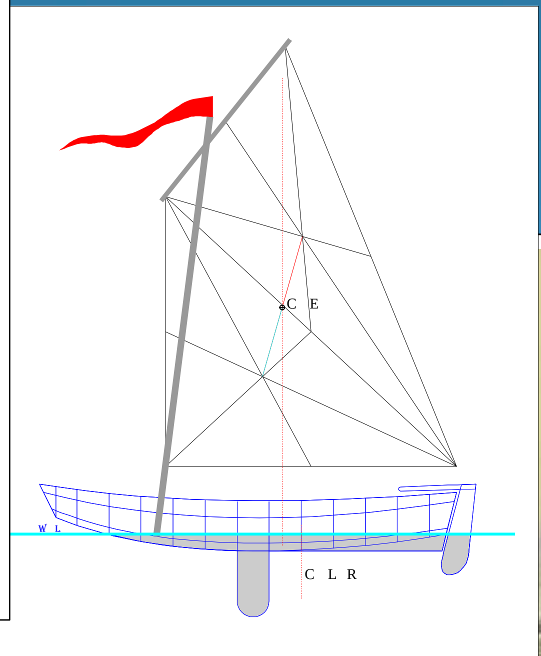


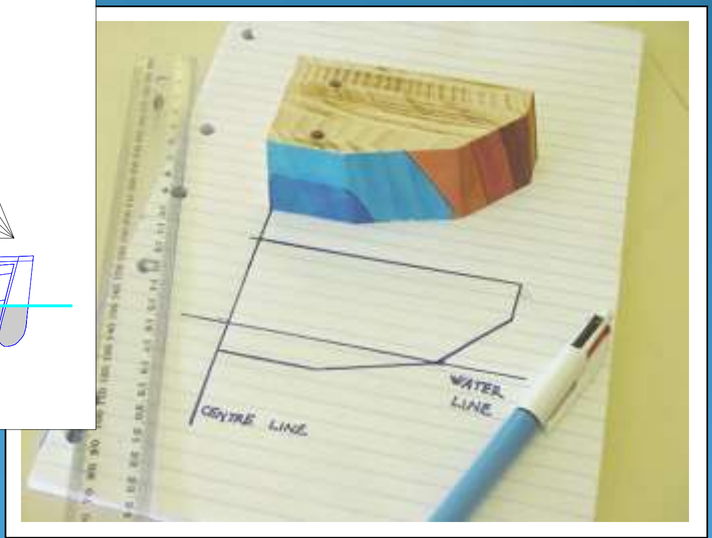
If $s = 1/2$ perimeter

ie $s = \dfrac{a+b+c}{2}$

Then,

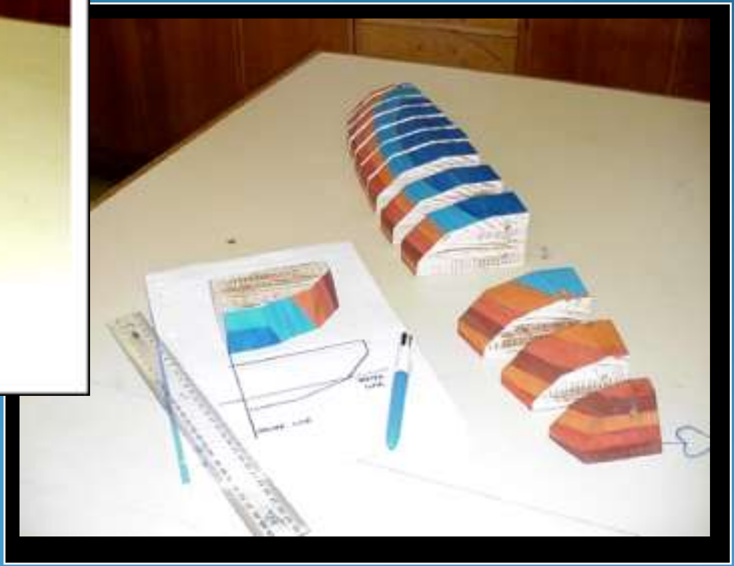
$$\boxed{\text{Surface Area } A = \sqrt{s(s-a)(s-b)(s-c)}}$$





Naval Engineering Program

Getting the profile of the frames (stations) from a half hull



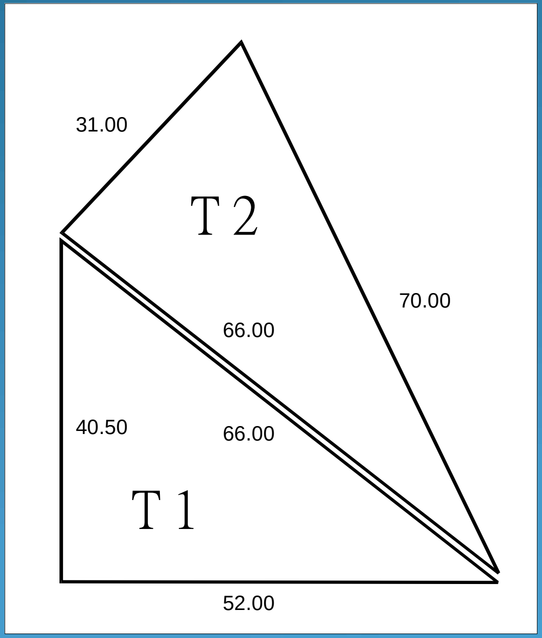
Half hull machined, taken apart to paint water line levels and finally sliced transversally to gain access to the profile of the frames

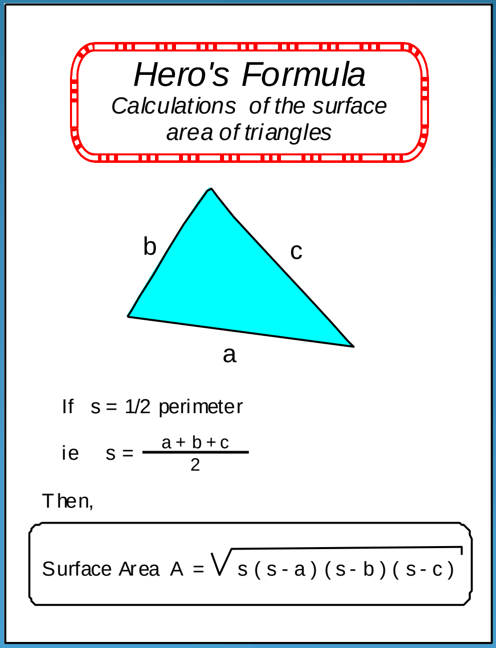
Mathematics and Physics as design tools for Boat Building

B) Theory relating to the Centre of Effort :

Determination of CE by using Mathematics :

- ***Then by using Hero's formula to calculate the surface areas A1 and A2 of T1 and T2***

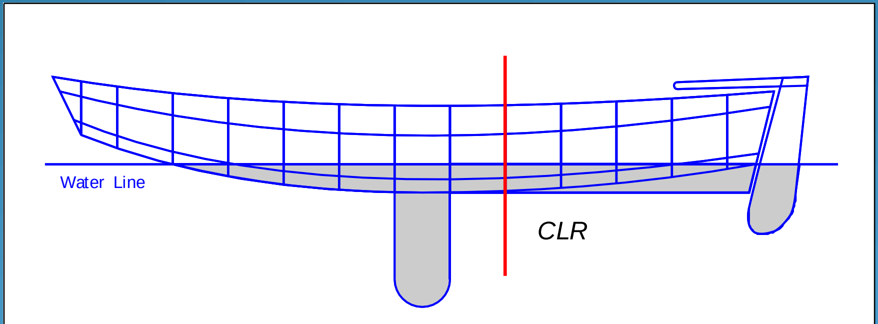




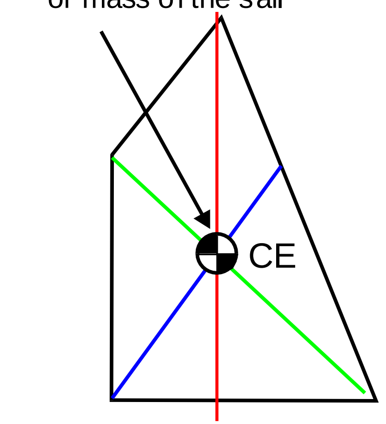
CE = Pivot point of the Sail plan in the air

Naval Engineering Program

Since the position of the CLR is set from the geometry of the hull, fin, keel and rudder, the only way to align CLR and CE is to shift the sail plan and therefore the position of the mast along the longitudinal axis of the boat until the CE is just above the CLR.

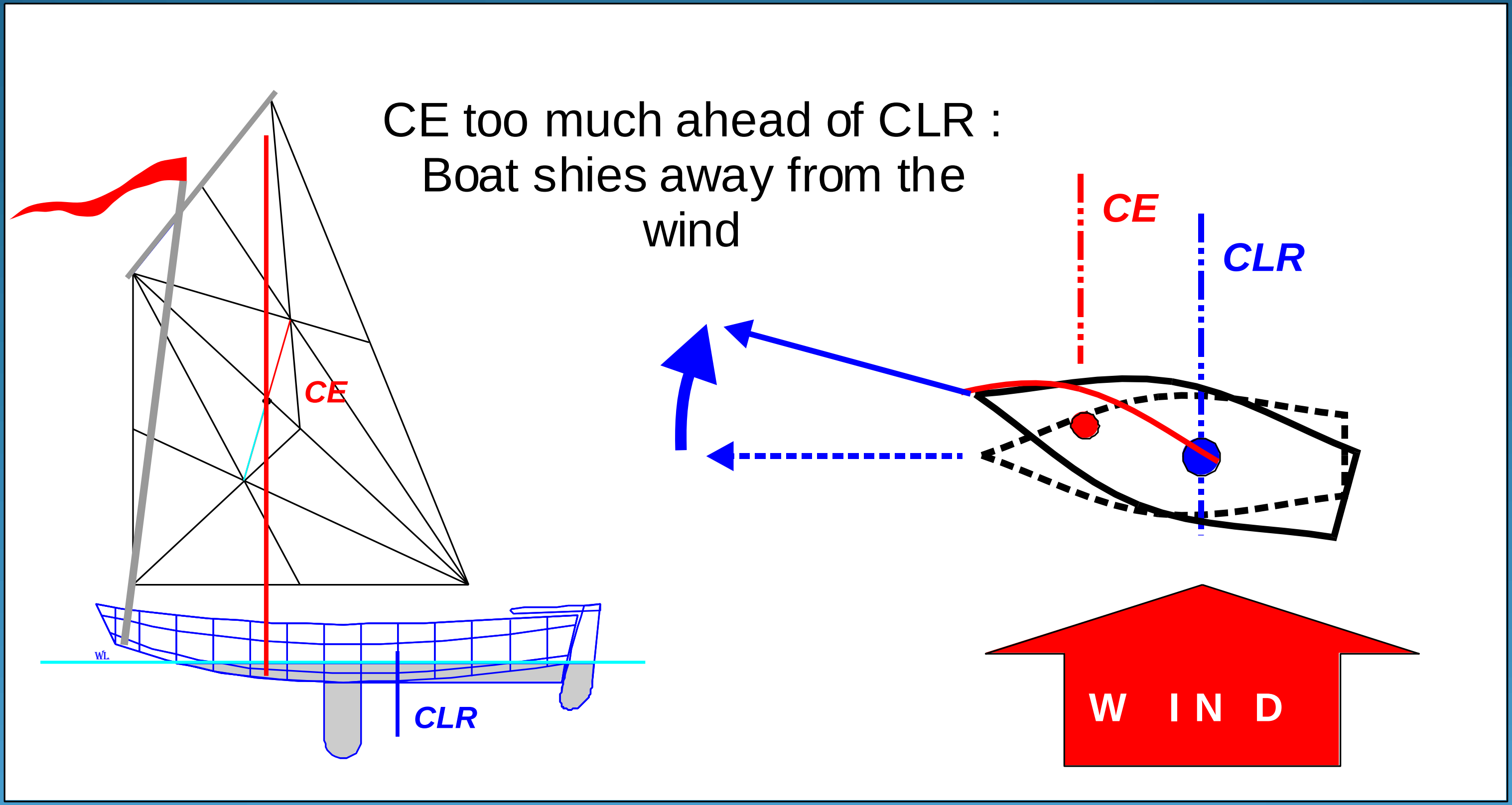


CLR : Centre of Lateral Resistance in the water

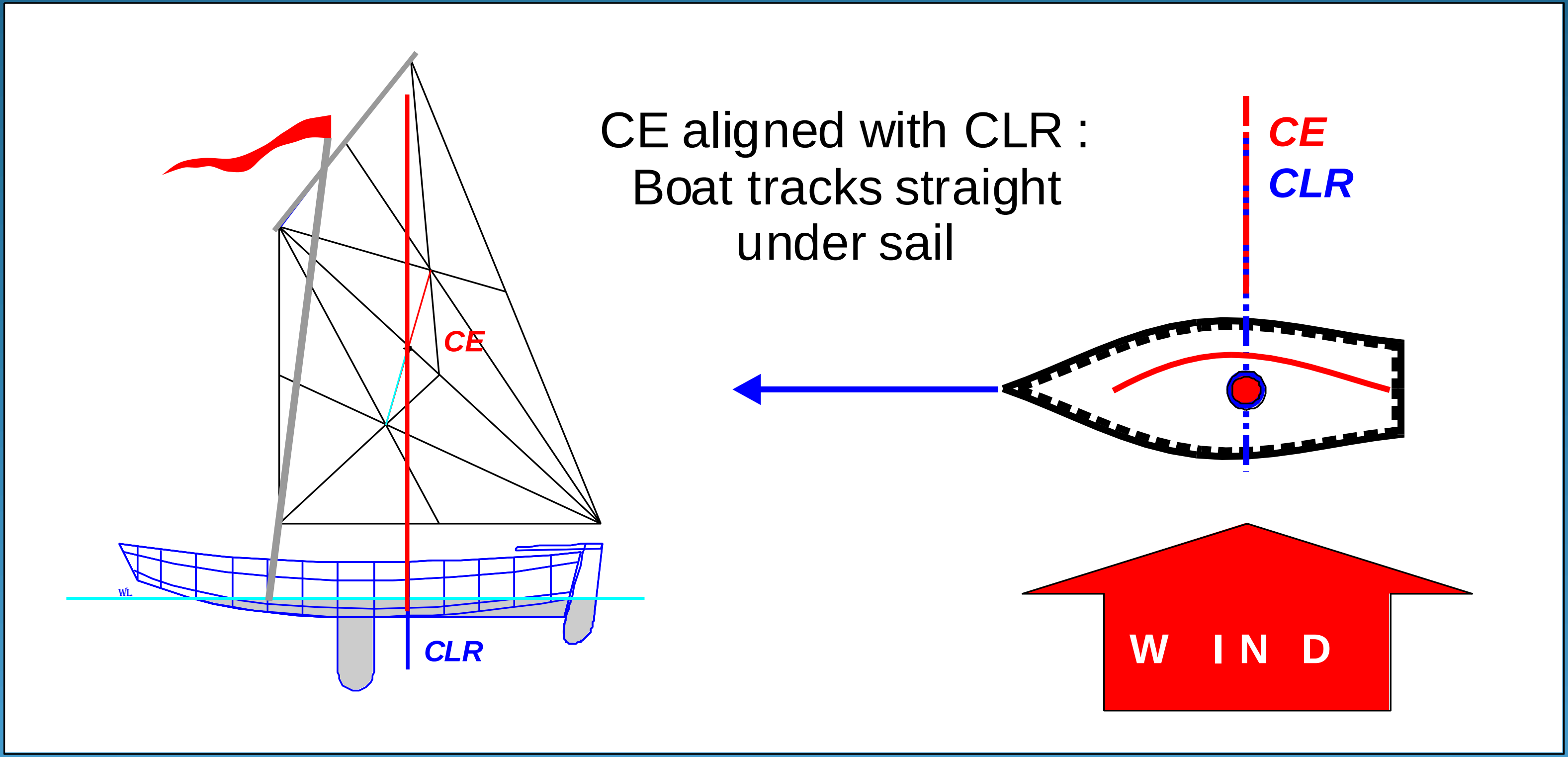


also called Centre of Effort CE

Naval Engineering Program



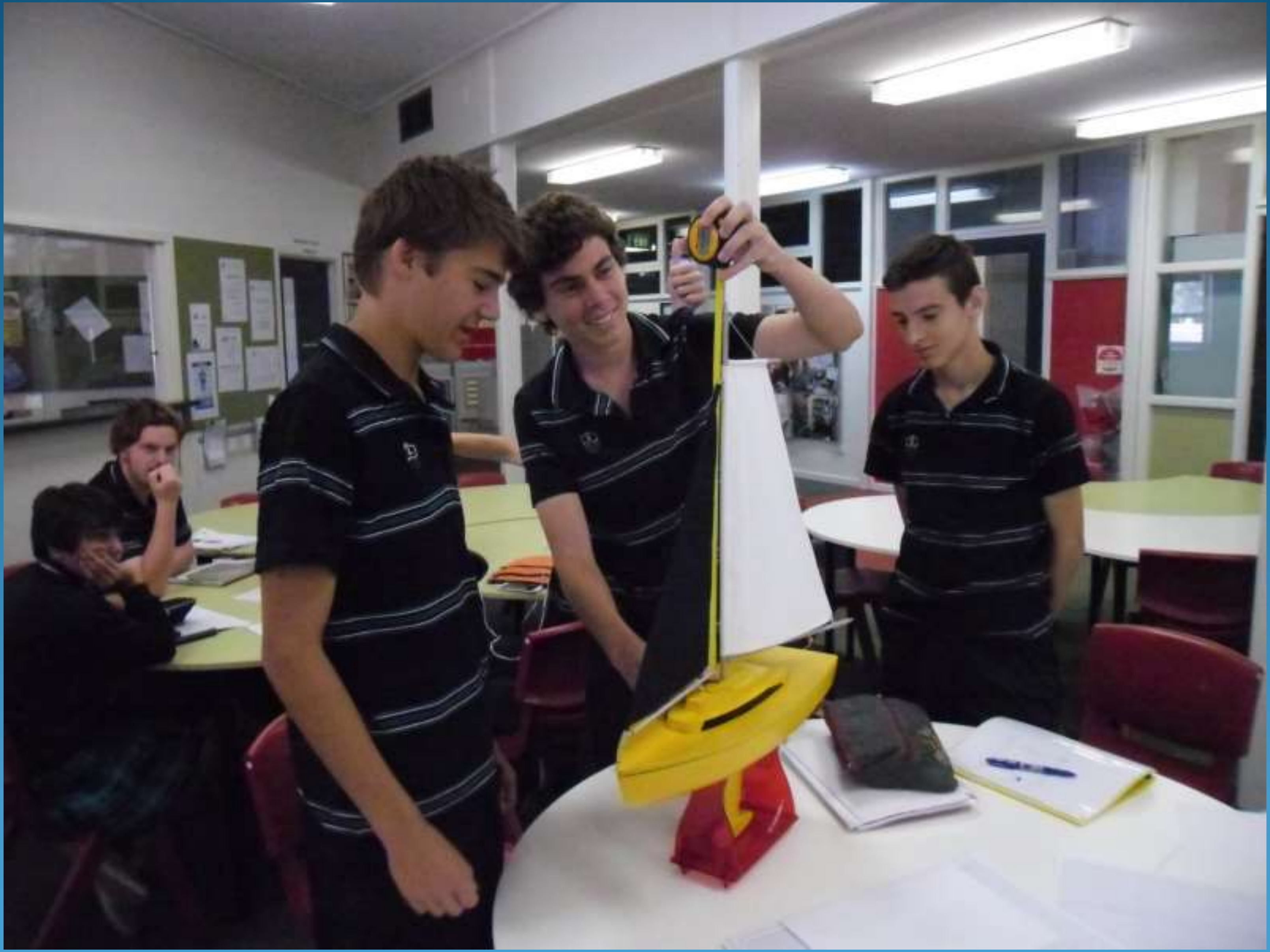
Naval Engineering Program



Naval Engineering Program

Naval Engineering Program

Naval Engineering Program



Naval Engineering Program

Naval Engineering Program

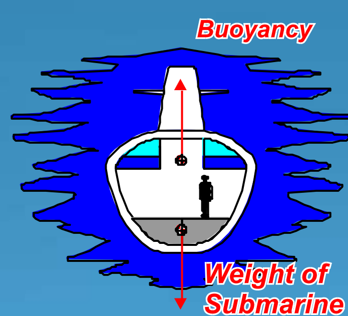
Naval Engineering Program

Year 11 Naval Engineering

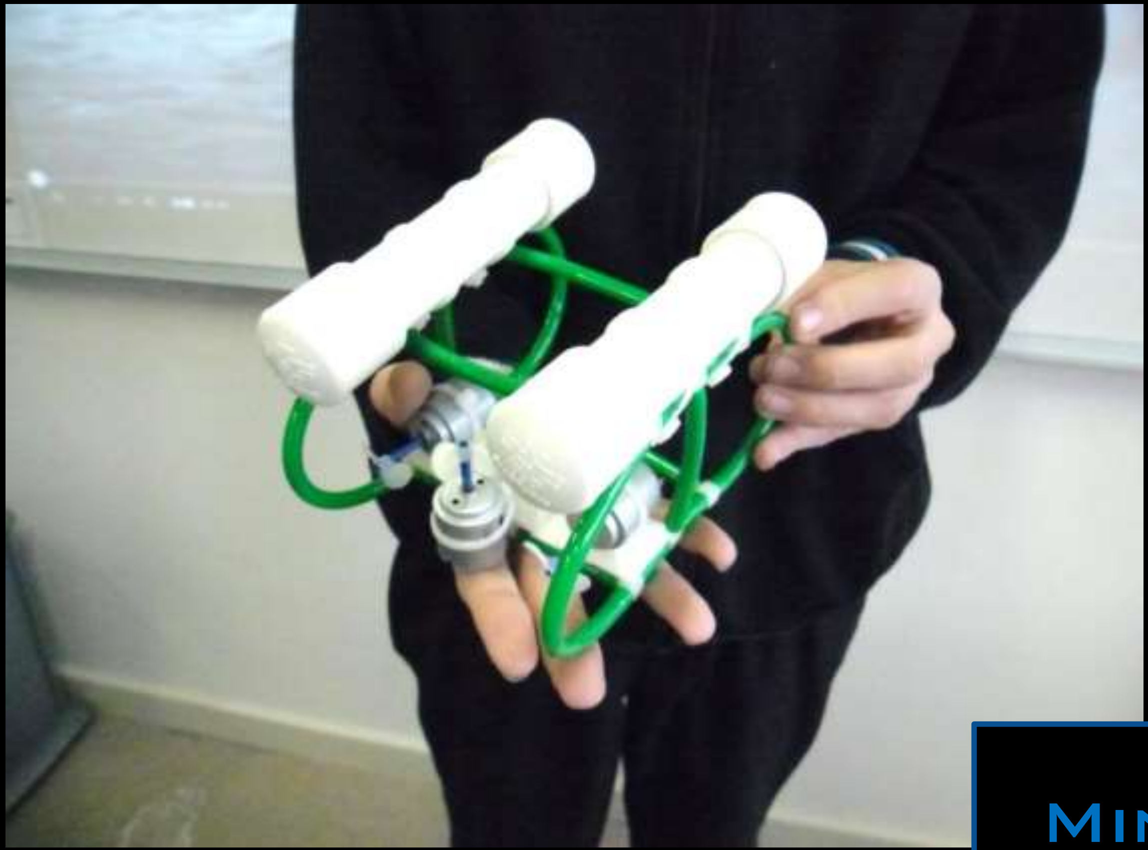
Semester 2

The Science and Engineering of Submarines and Submarine technologies

In Partnership with ASC and F1 in Schools

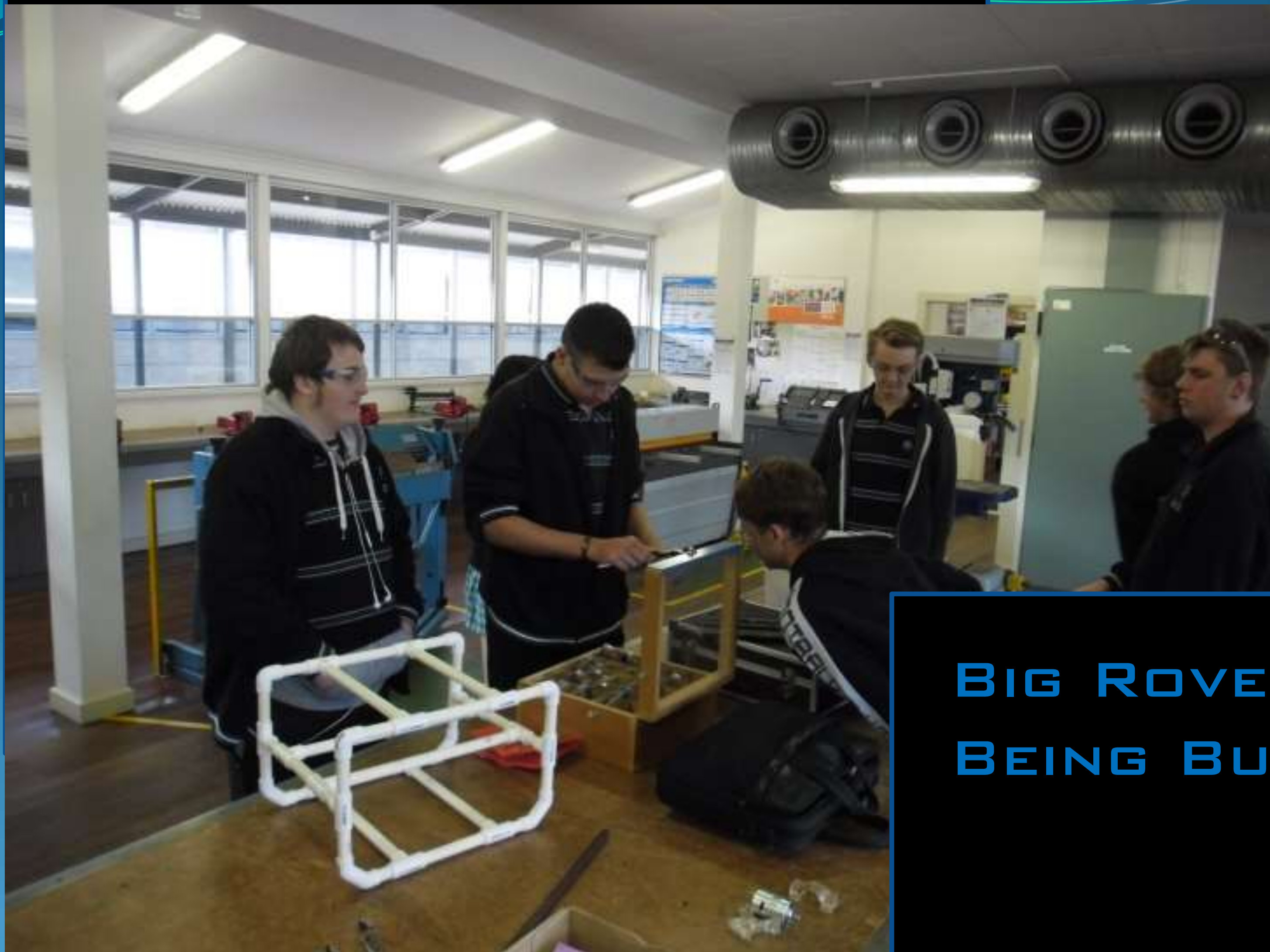


Buoyancy
=
Weight



Mini Rover finished

Mini rover in its natural element ...



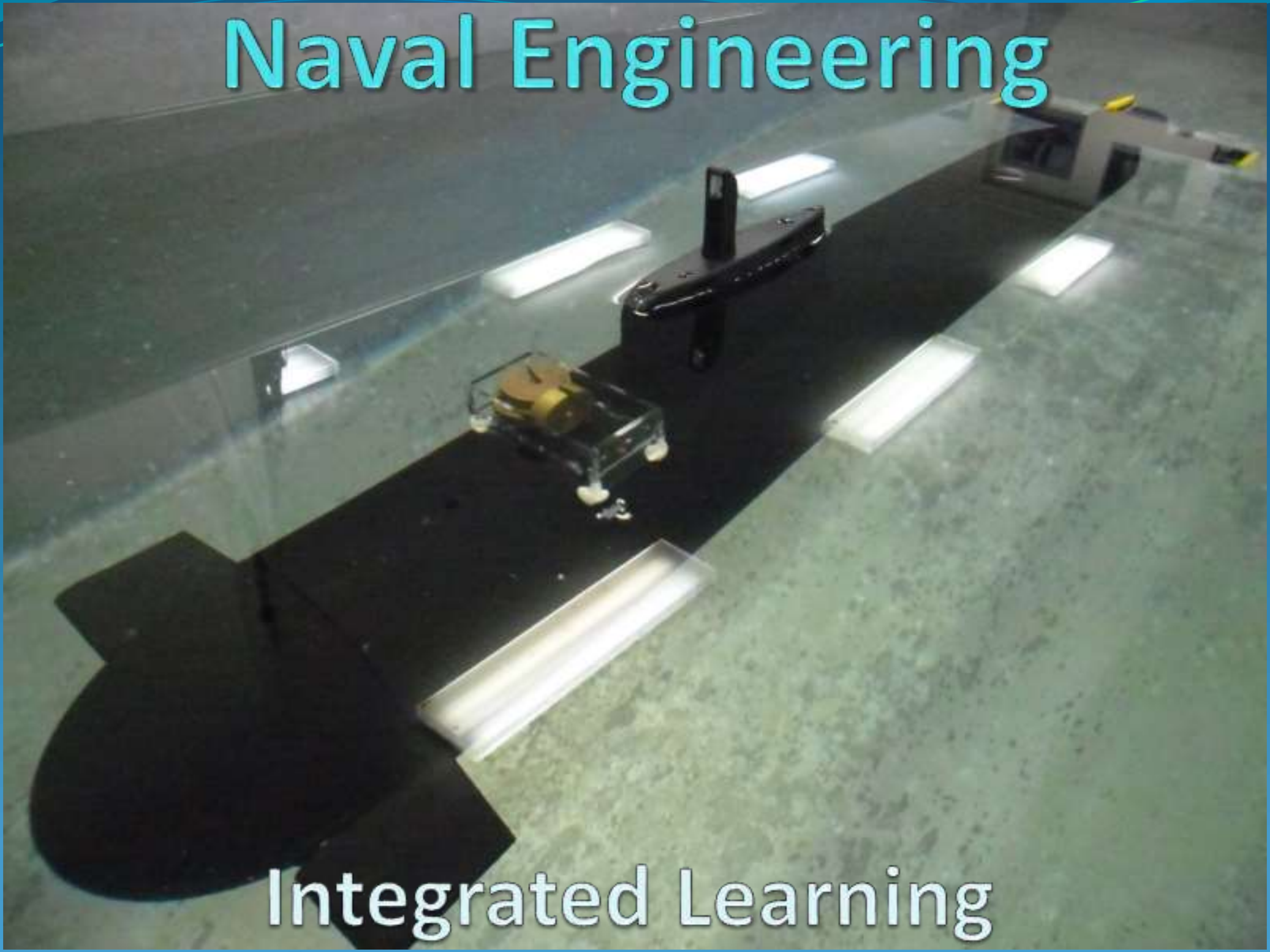
Big Rover Being Built

Big Rover Being Built

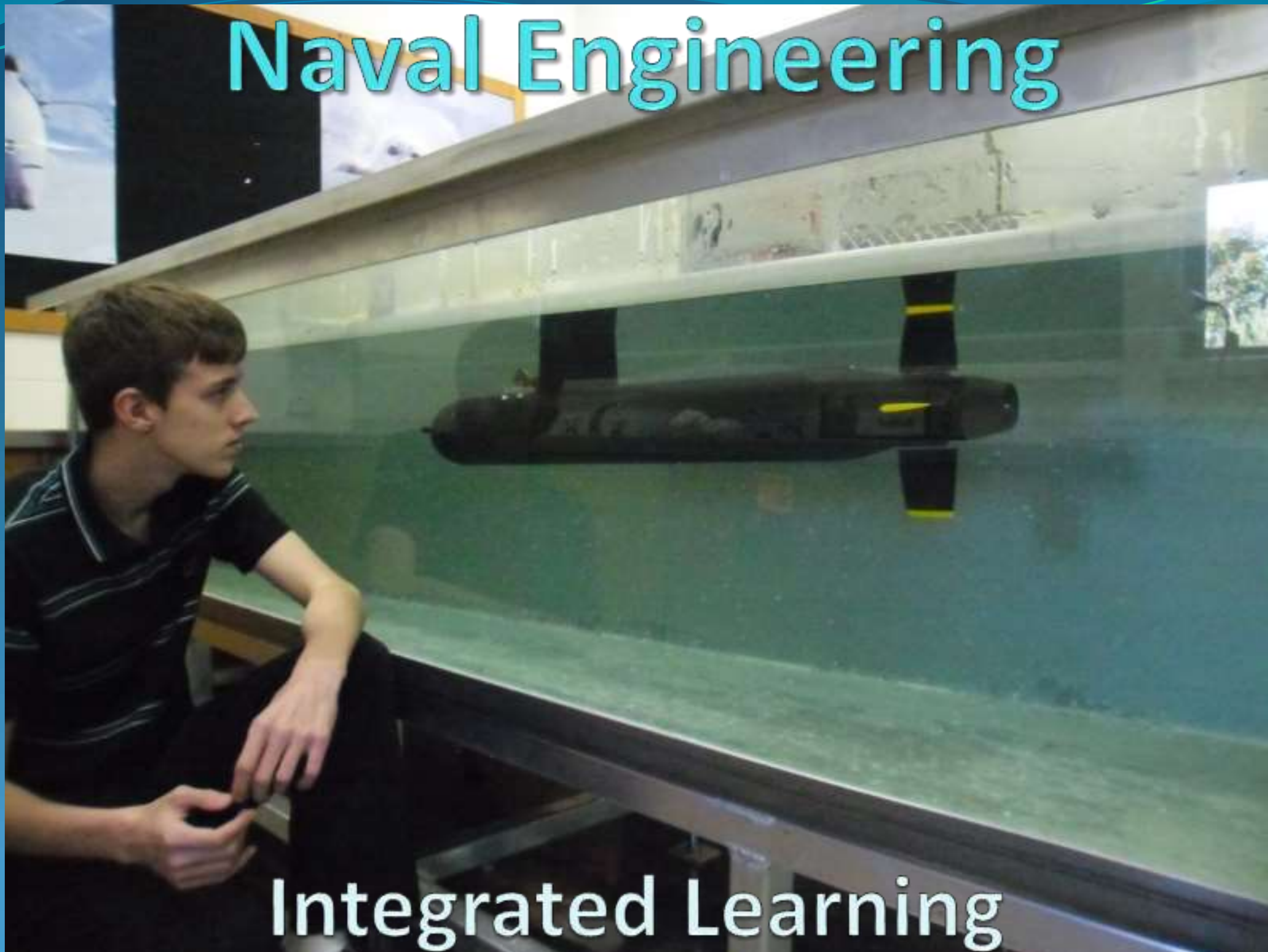

Naval Engineering
Submarine Prototype
Propulsion System
Integrated Learning

Stage 1

Stage 1



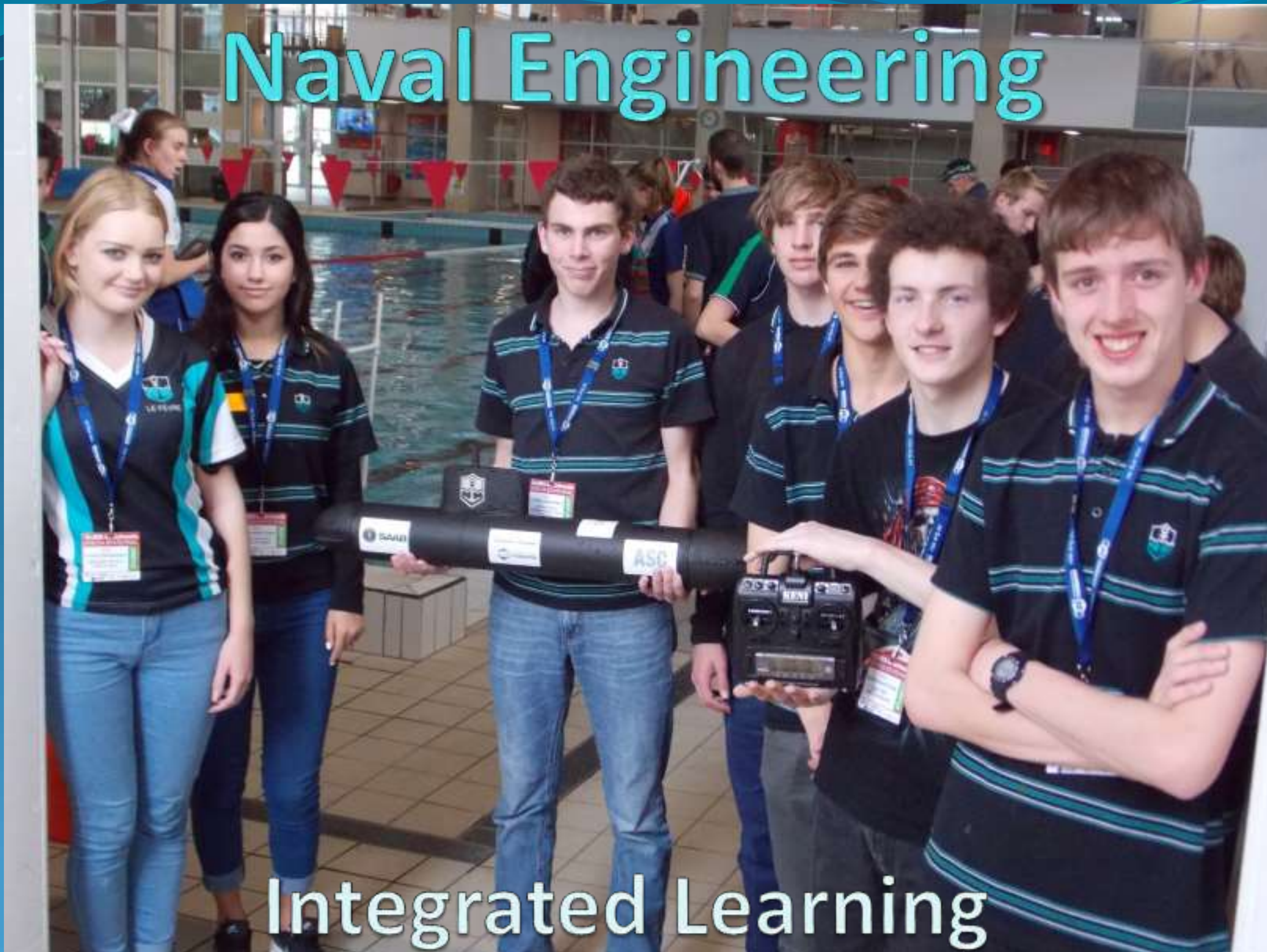
Stage 1



Stage 1

Naval Engineering

Integrated Learning
Stage 1



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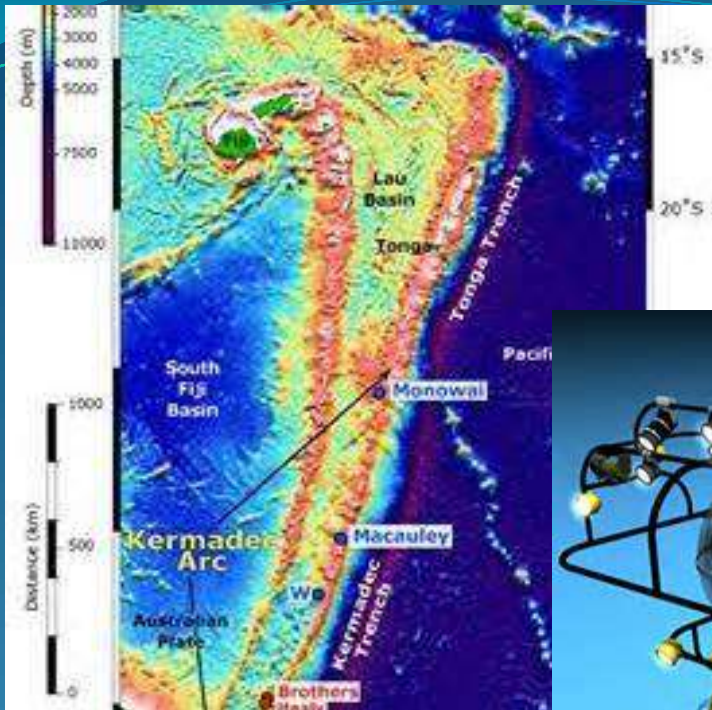
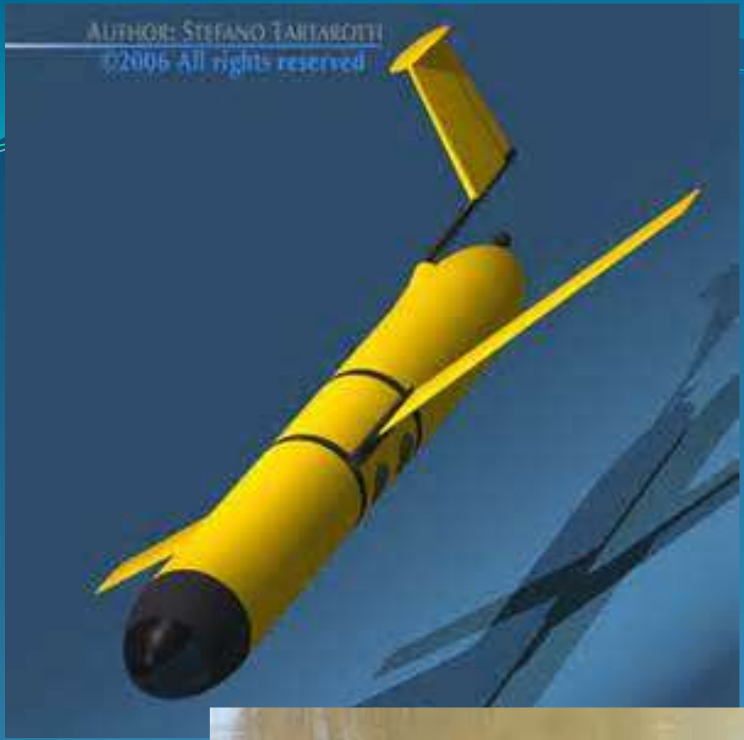


Civilian Applications
ROVs and Manned Submarines

Civilian Applications
ROVs and Manned Submarines



Military Applications ROVs, Drones and Manned Submarines

ASC

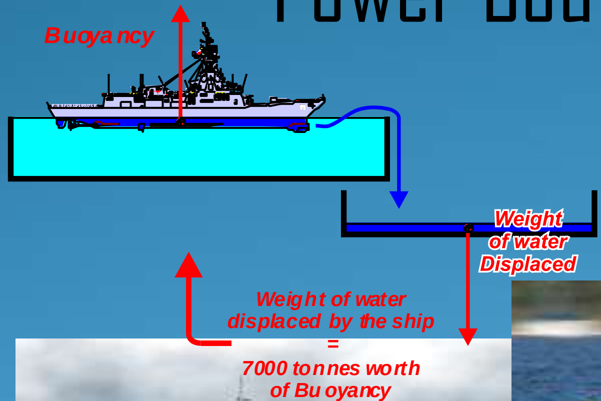
Military Applications ROVs, Drones and Manned Submarines

Naval Engineering Program

Year 12 Naval Engineering

Full Year

The Science and Engineering of Power Boats and Racing Machines



Naval Engineering Program

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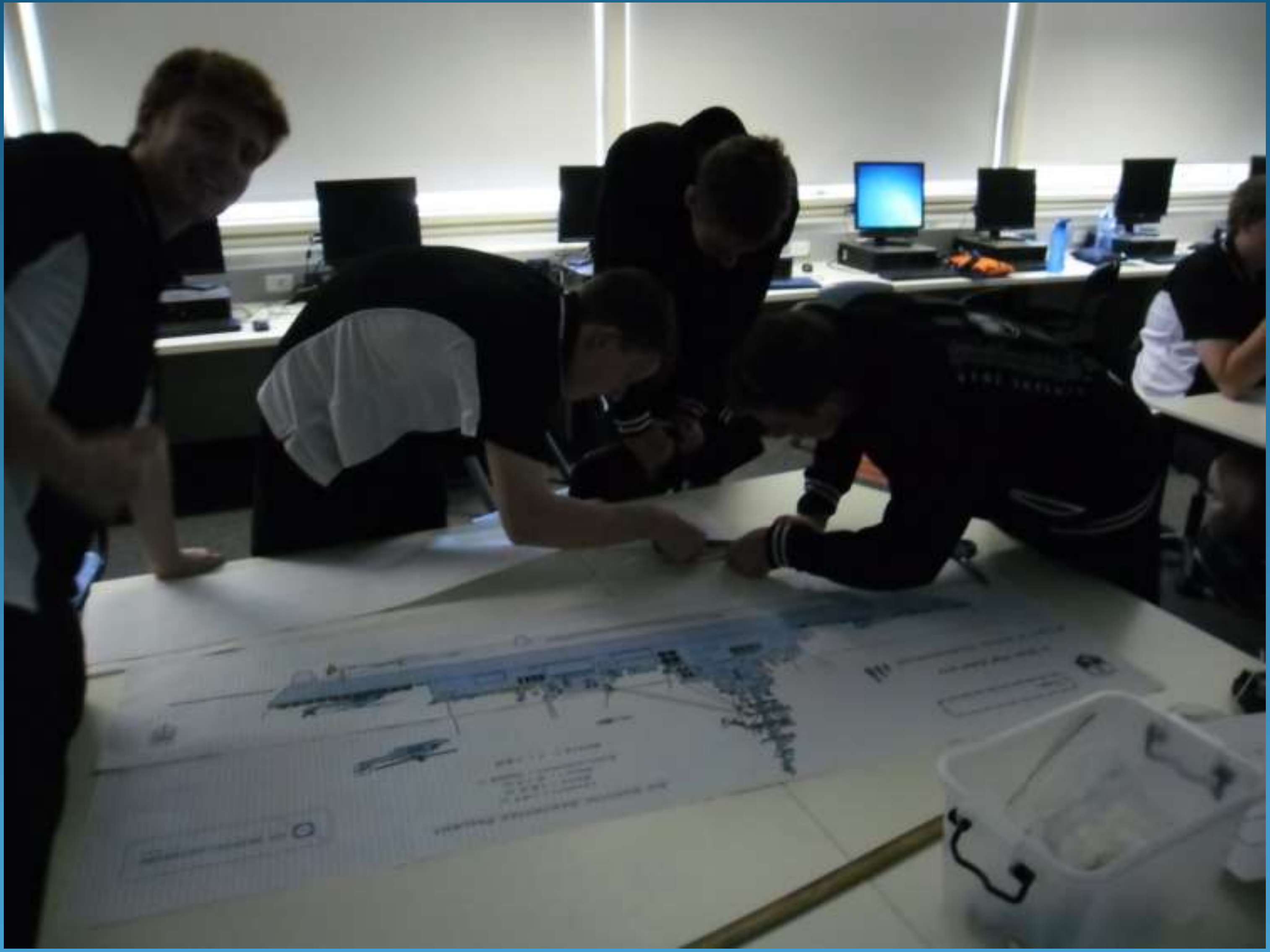
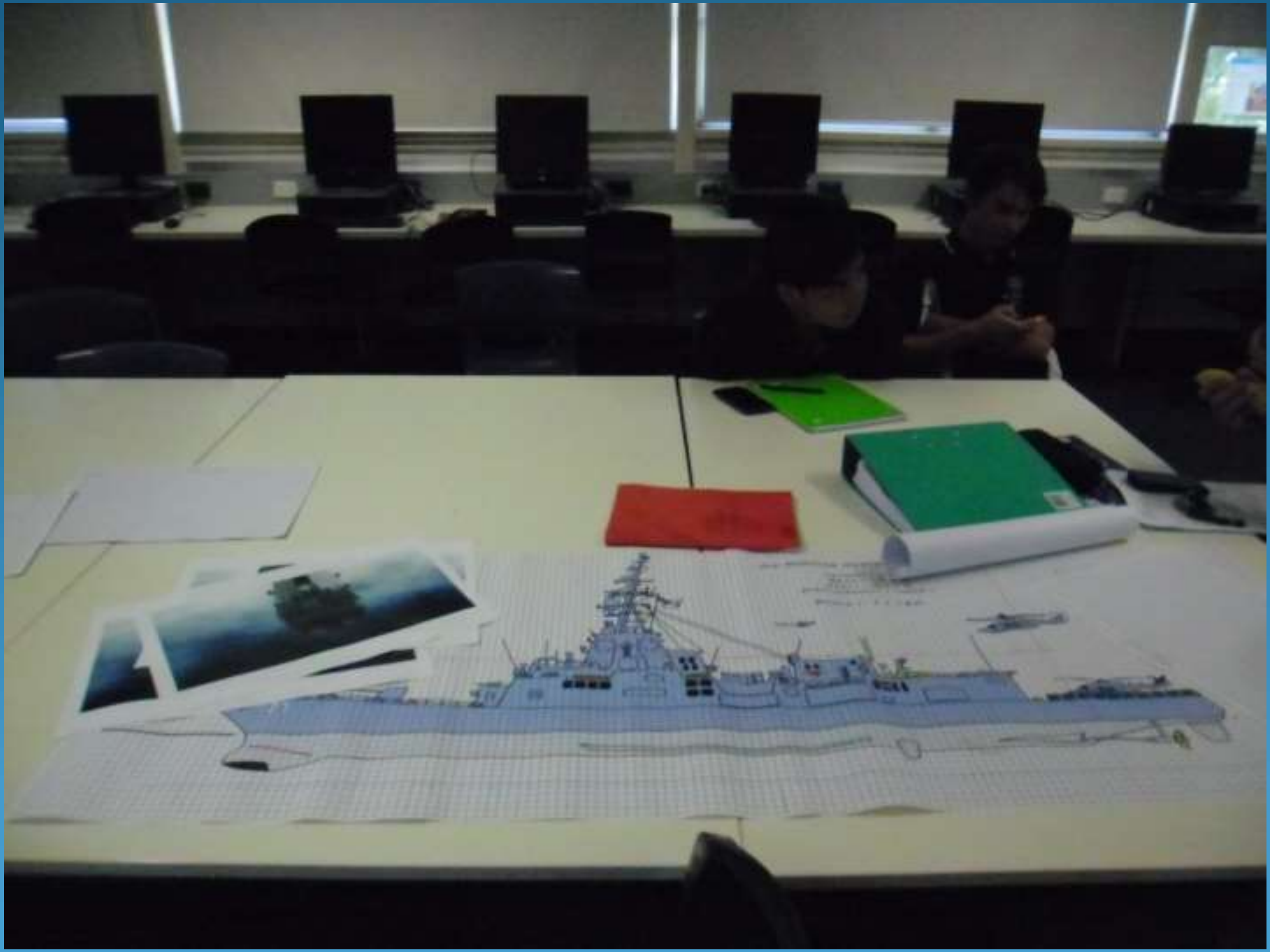


Naval Engineering Program



Naval Engineering Program

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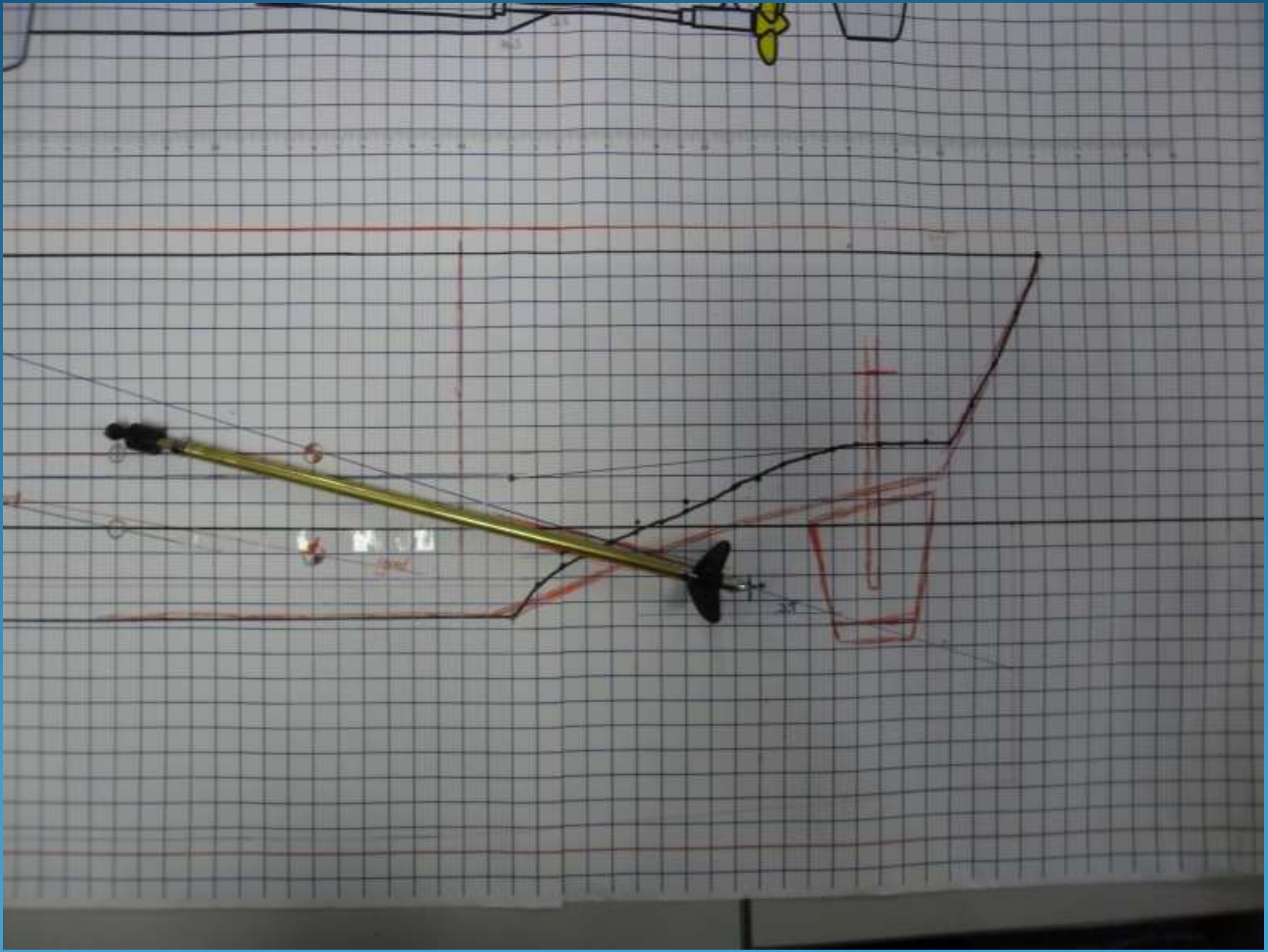

Naval Engineering Program

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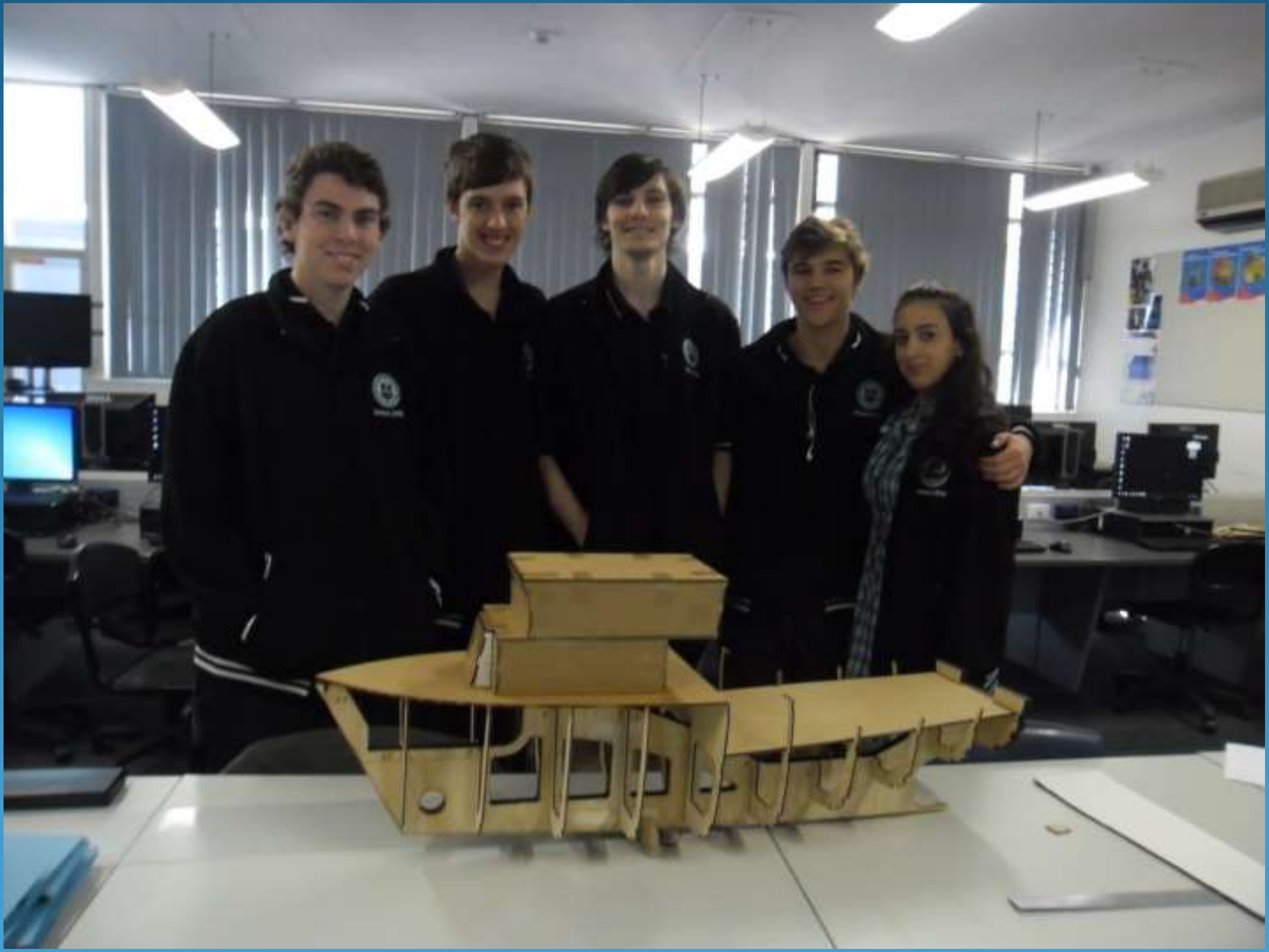


Naval Engineering Program

Naval Engineering Program

Challenges in using and integrating new technologies in Schools

Such as Laser Cutting and 3D Printing

Key requirements are needed :

Self evident, nonetheless, you need machines such as Laser Cutting and 3D Printing machines.

Students willing to learn how to use new software.

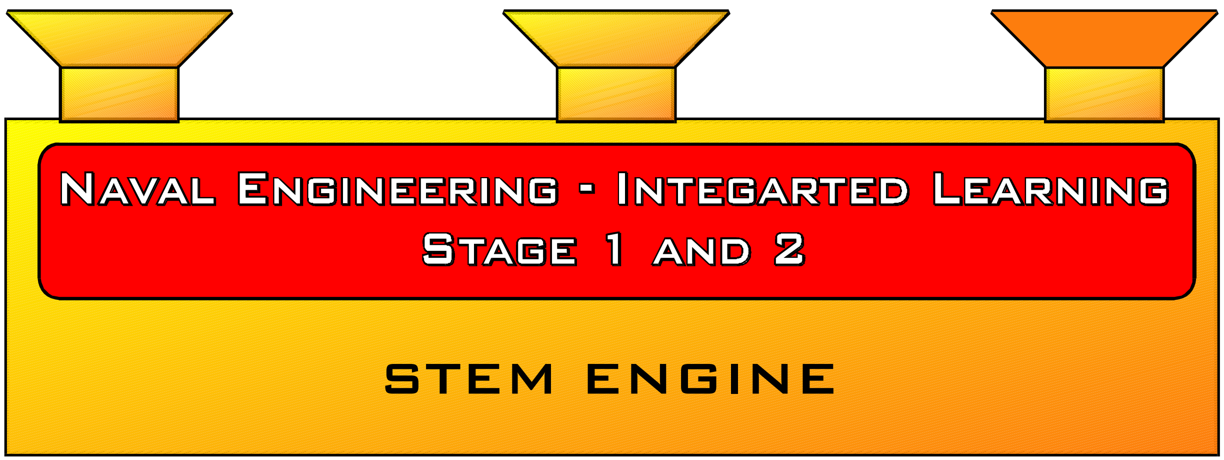
A team of teachers willing to upgrade their skills and work together

Thierry Herman

Mathematics
Physics
Science
Chemistry
Naval Engineering

Designer Software
(CorelDraw)

Laser Cutting
Manufacturing



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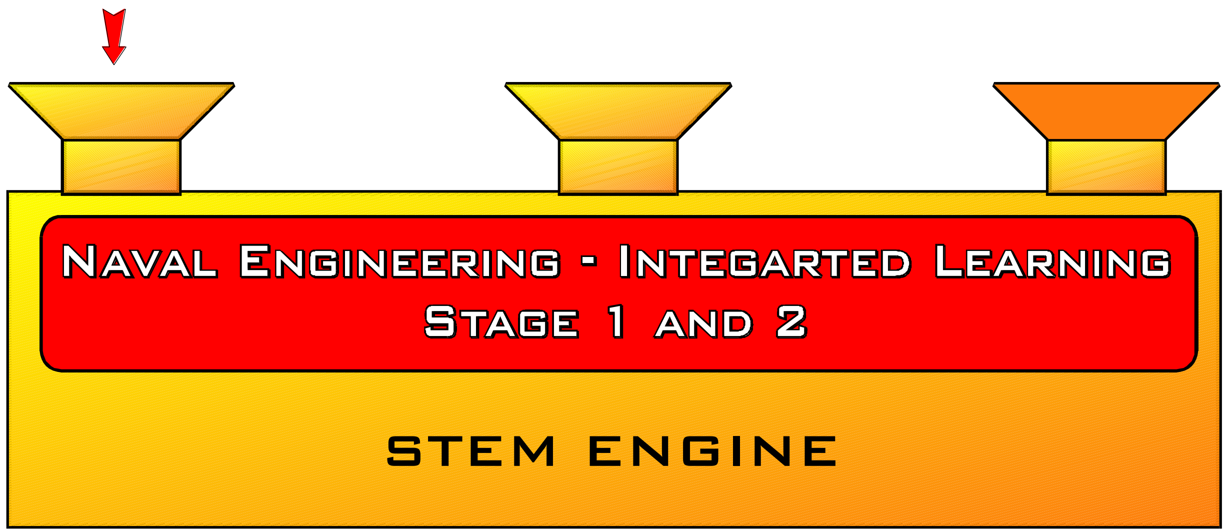

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Eddie Grzeskowiack

Design Tech

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(CorelDraw
Inventor)

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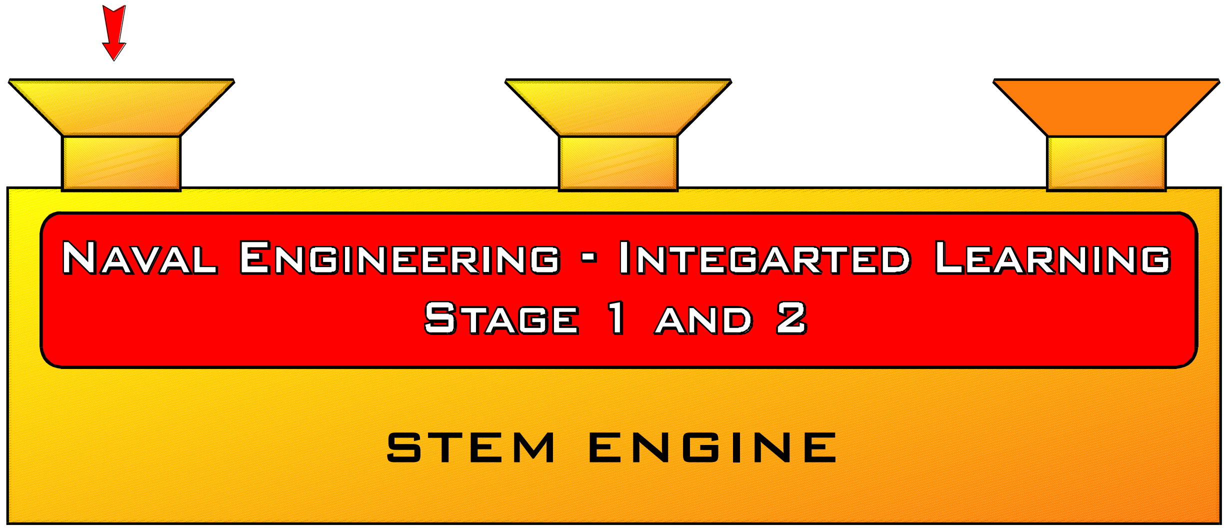
3D Printing



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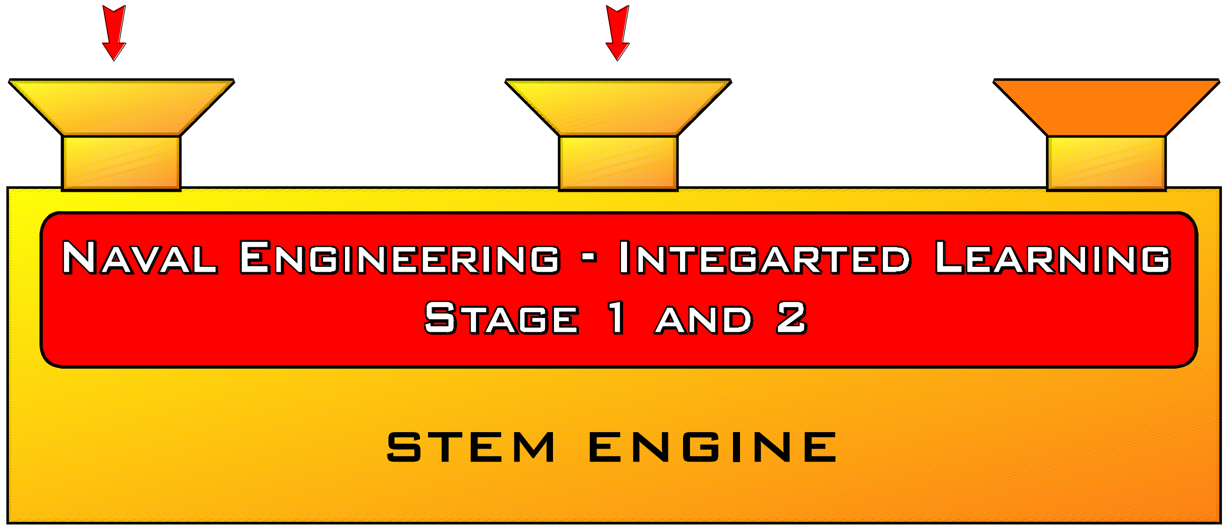

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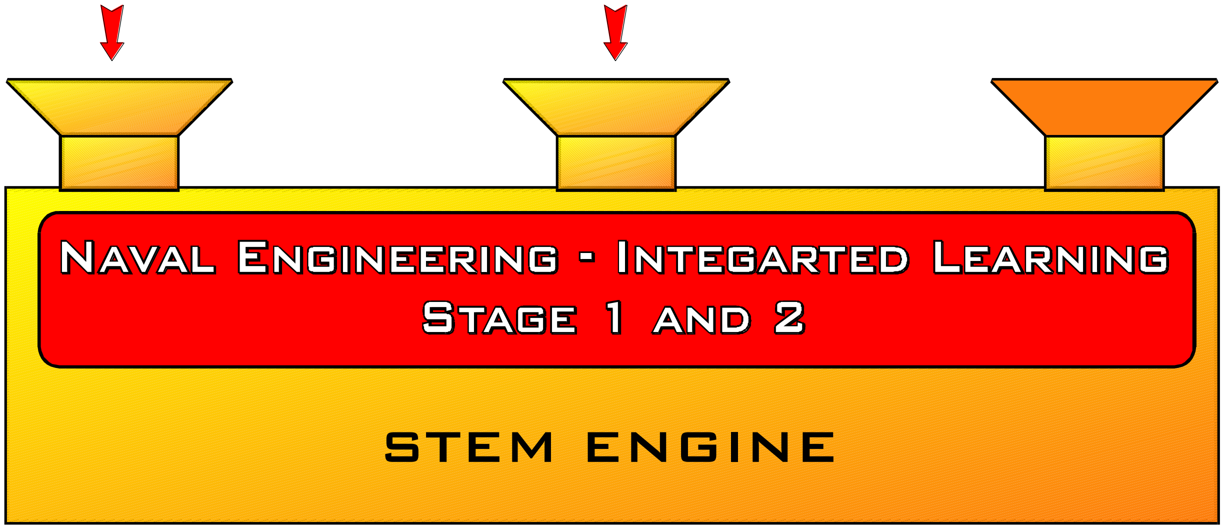
3D Printing

Chris Chrisakis

VET Engineering

Drafting Skills
CAD

Practical Engineering
Machining



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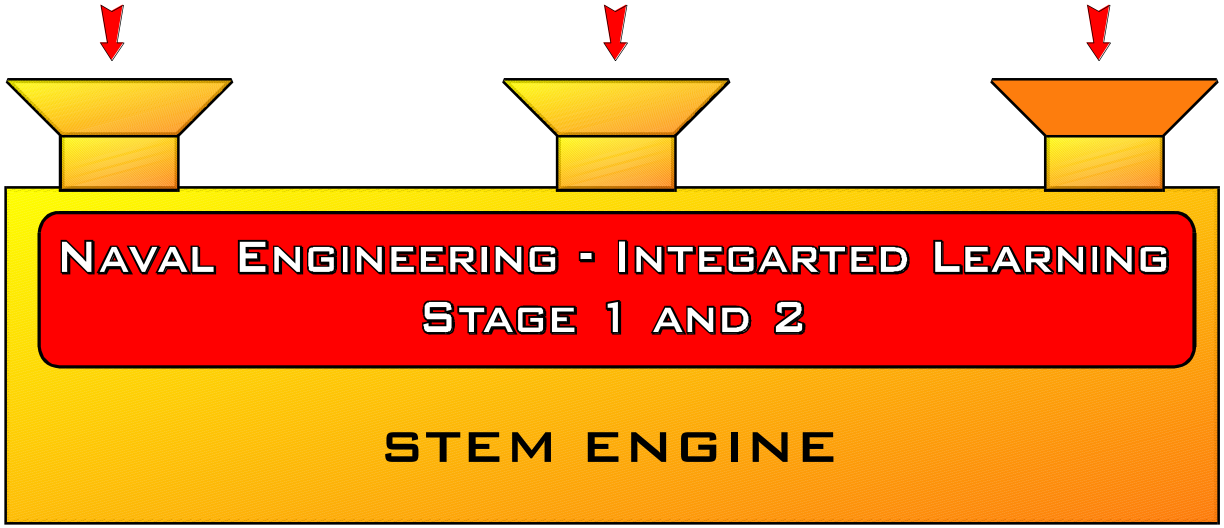

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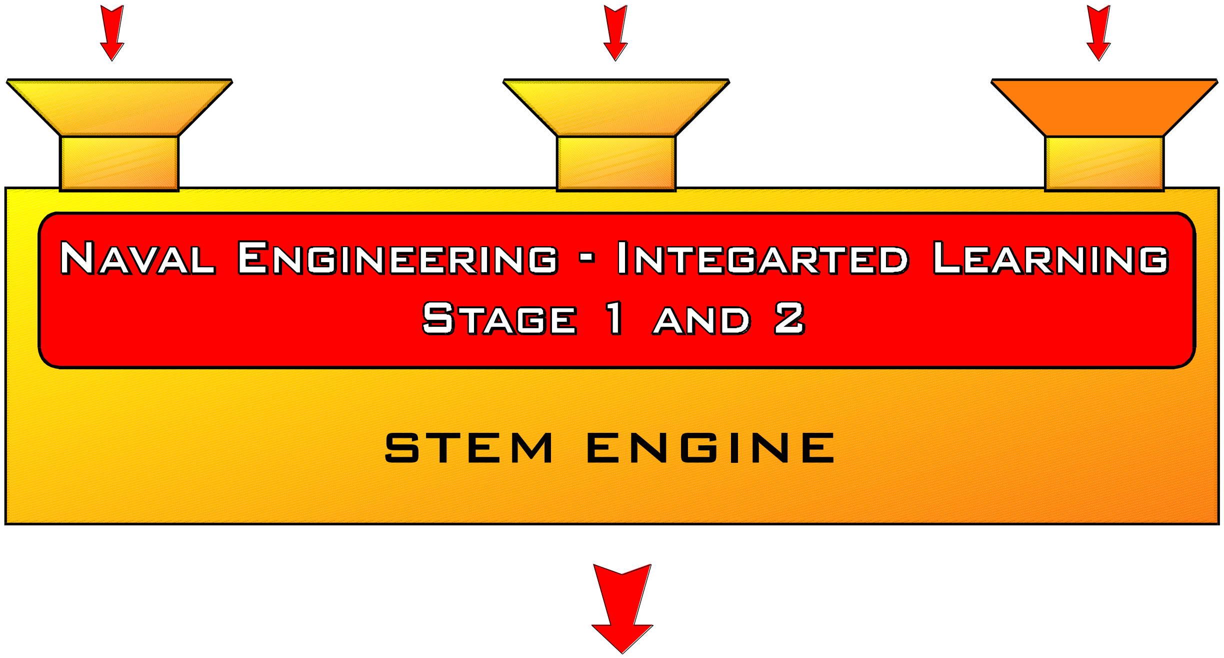


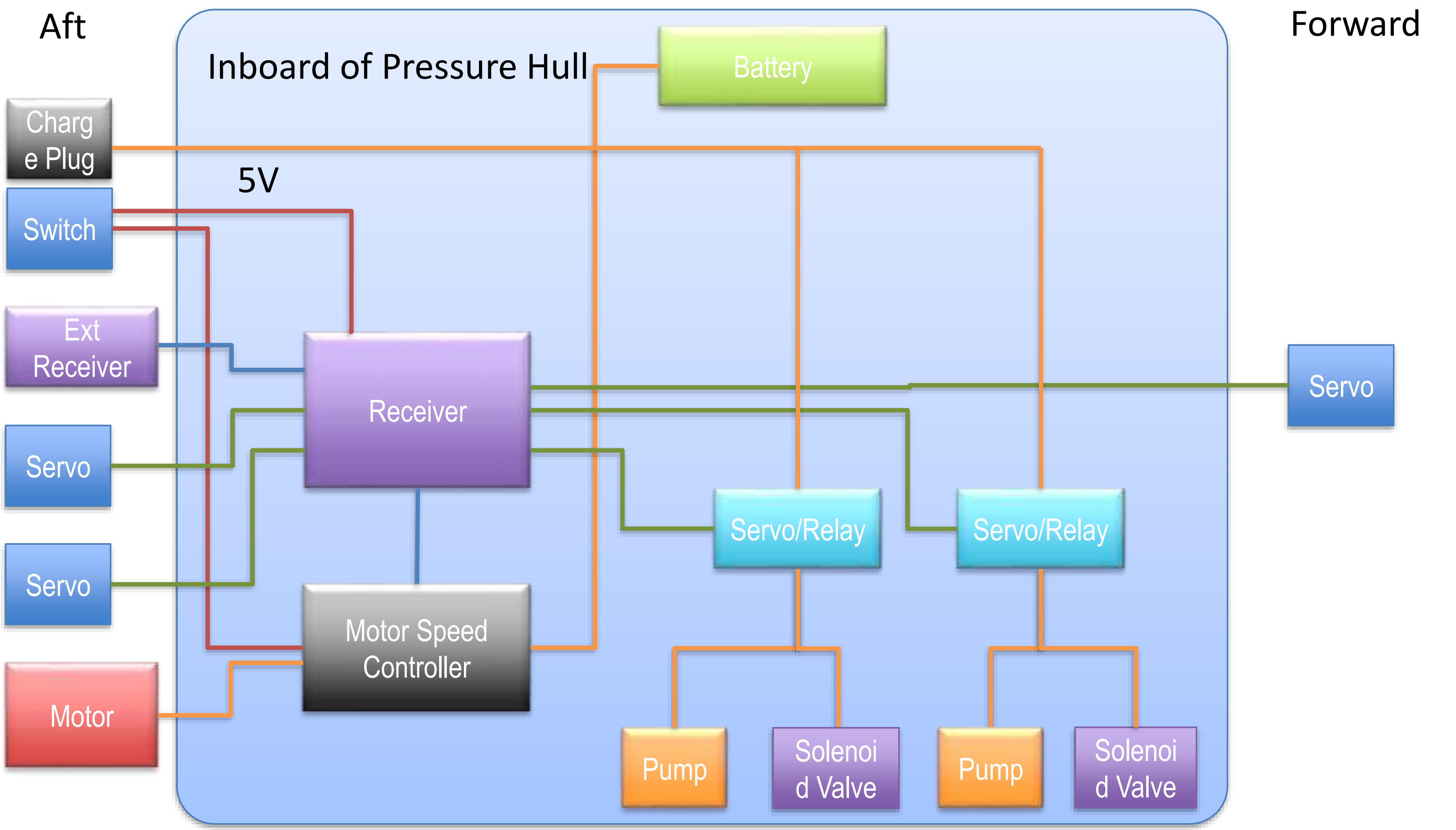
What do we get from this process?

STUDENTS' OUTCOMES

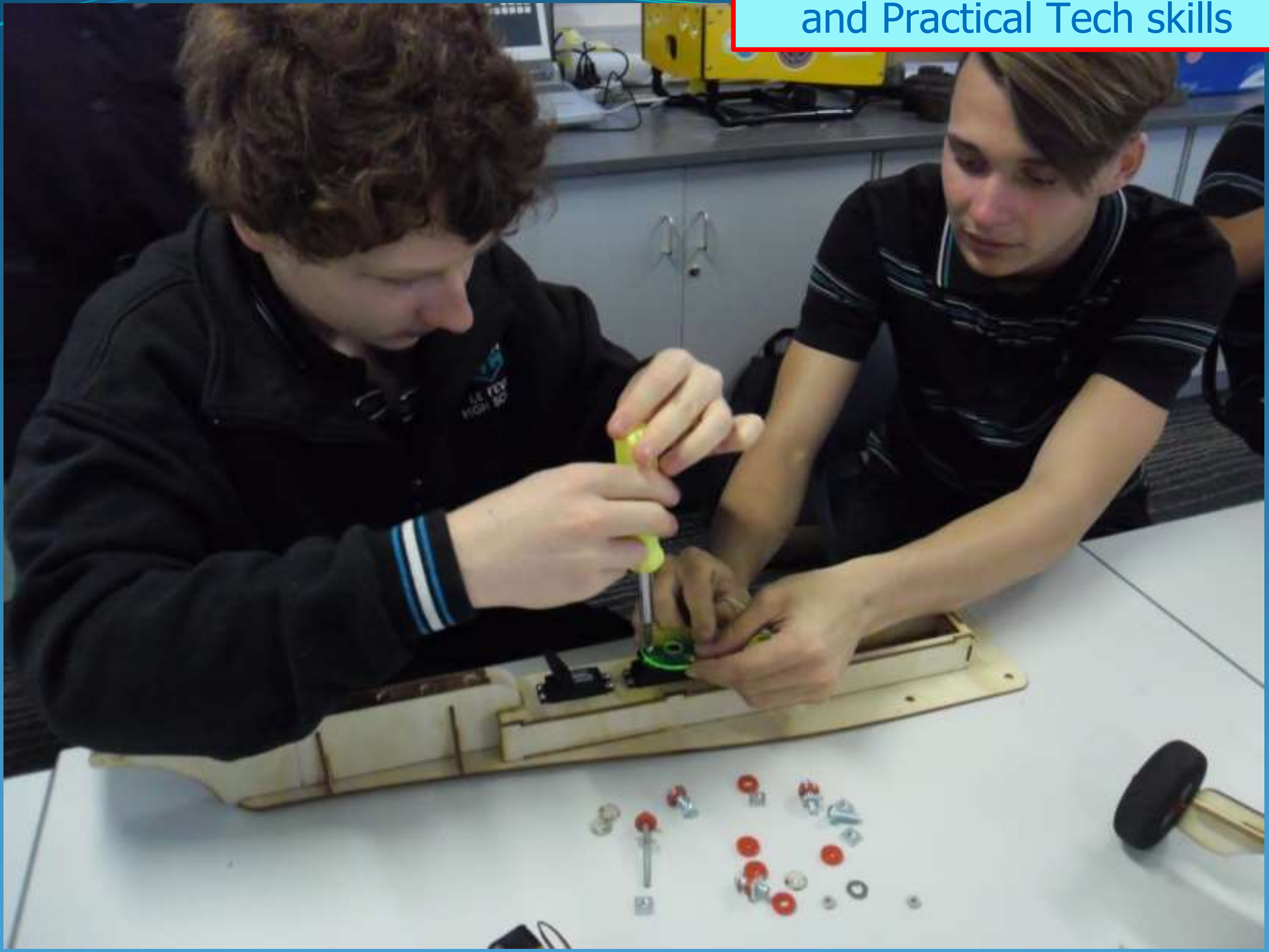
Safe use of a number of traditional tools

Development of drafting, 3D vision and Scaling skills

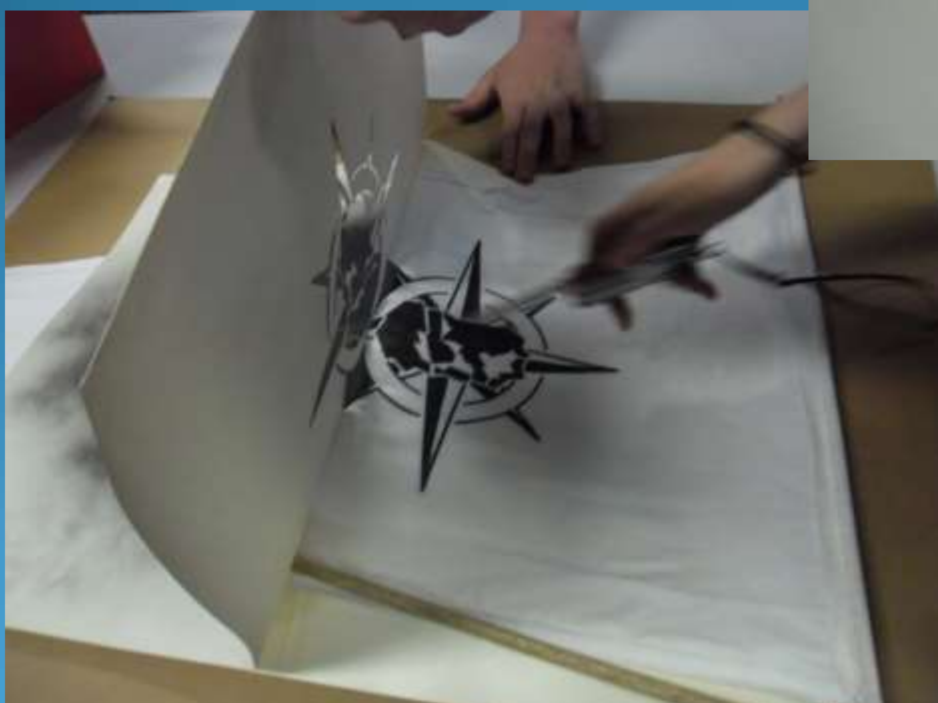
Development of Electronics and diagrams reading skills



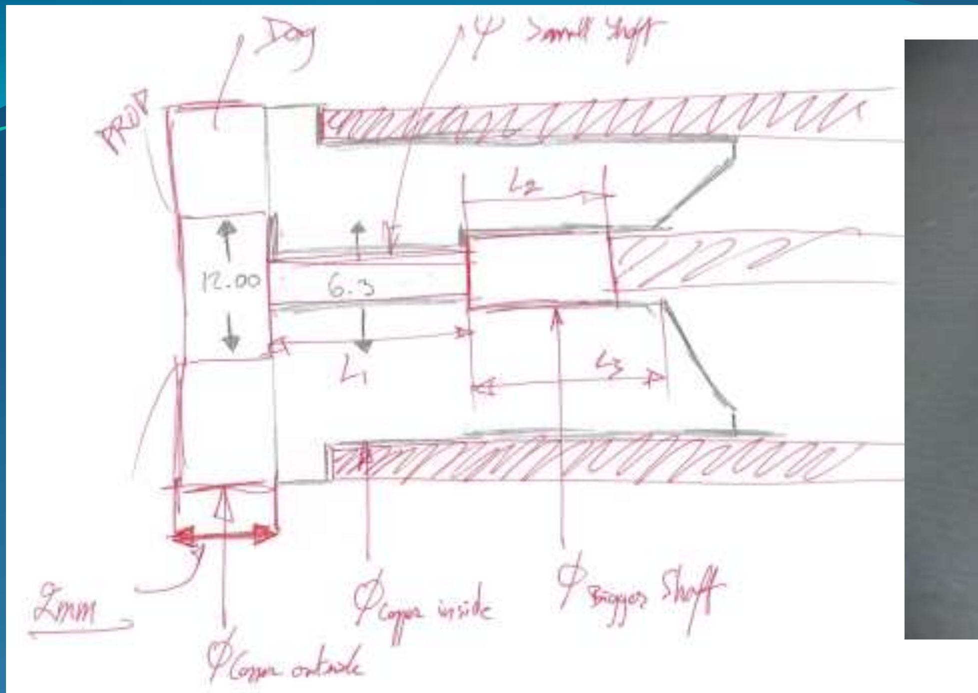
Development of Team work and Practical Tech skills



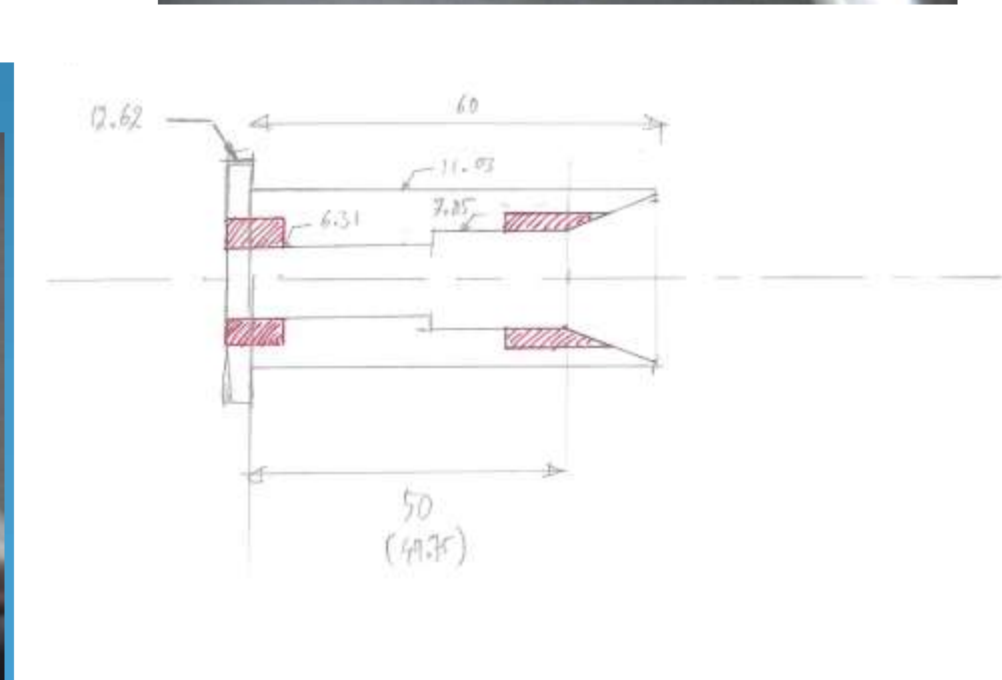
Development of Practical and Artistic skills through the use of Technology



Team Spirit Development

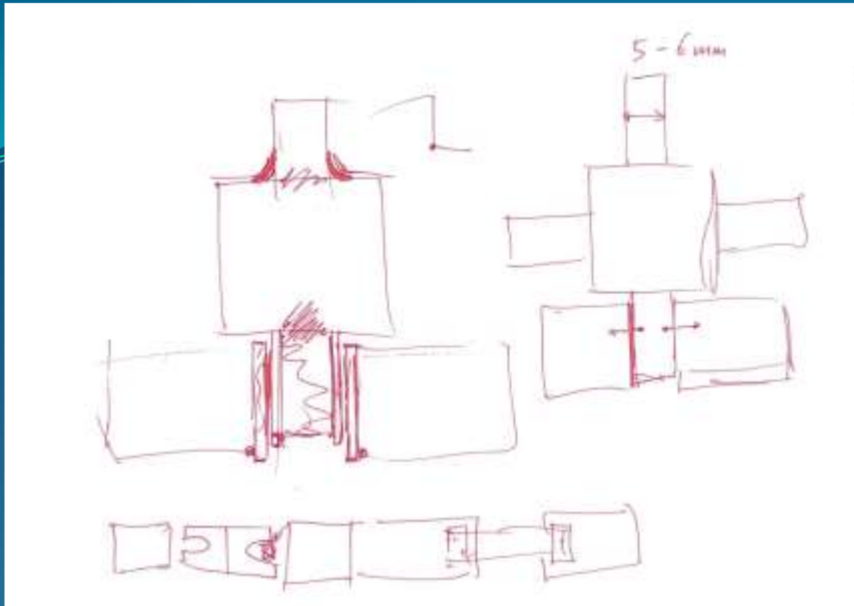


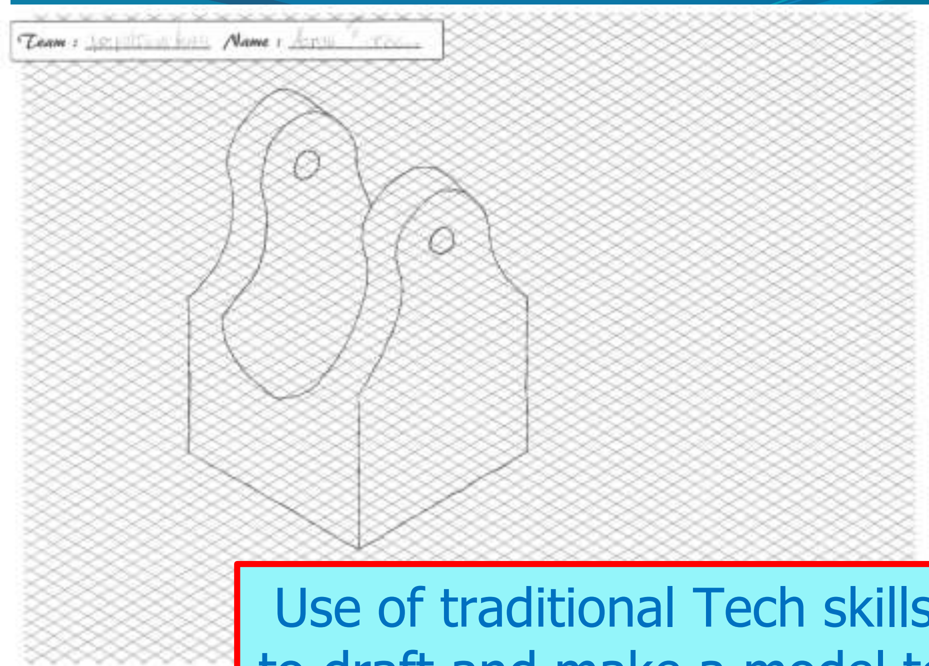
Drafting skills development and 3 D Printing

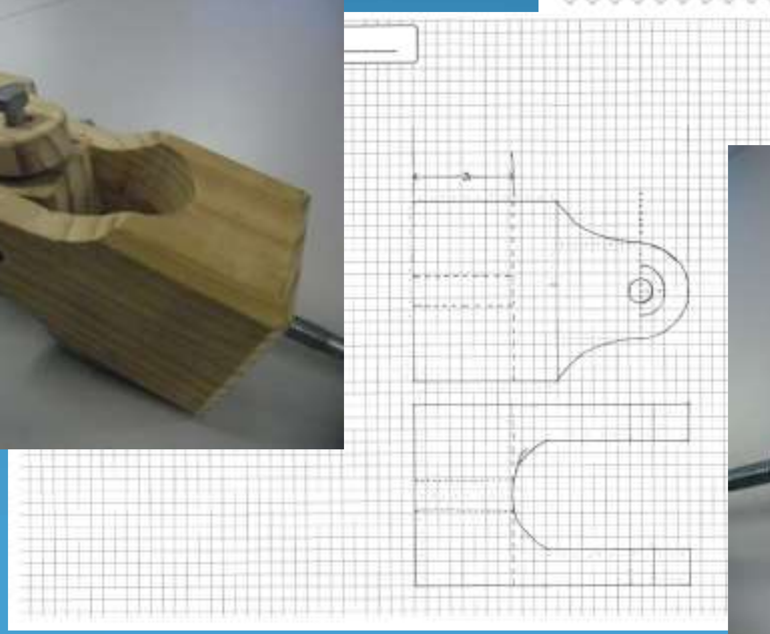


Use of traditional Tech skills to manufacture metal parts

Use of traditional Tech skills to manufacture metal parts

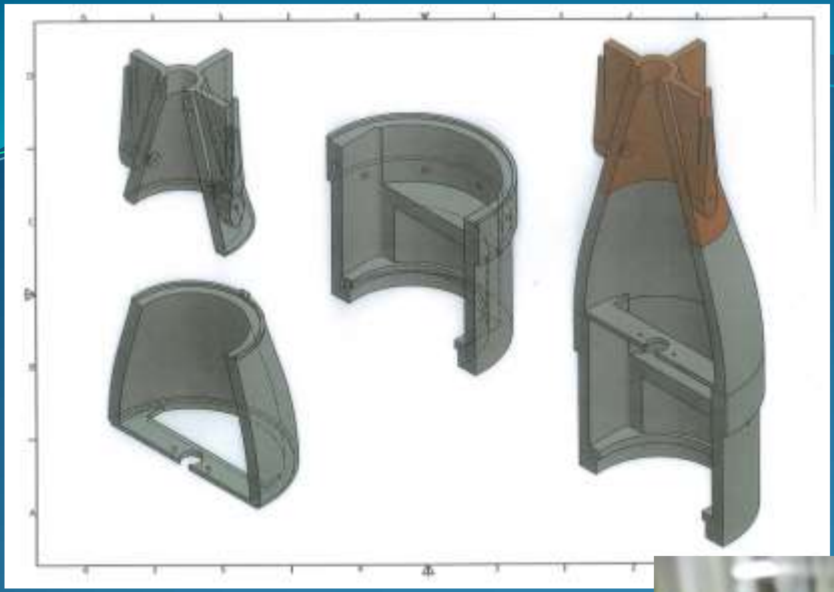


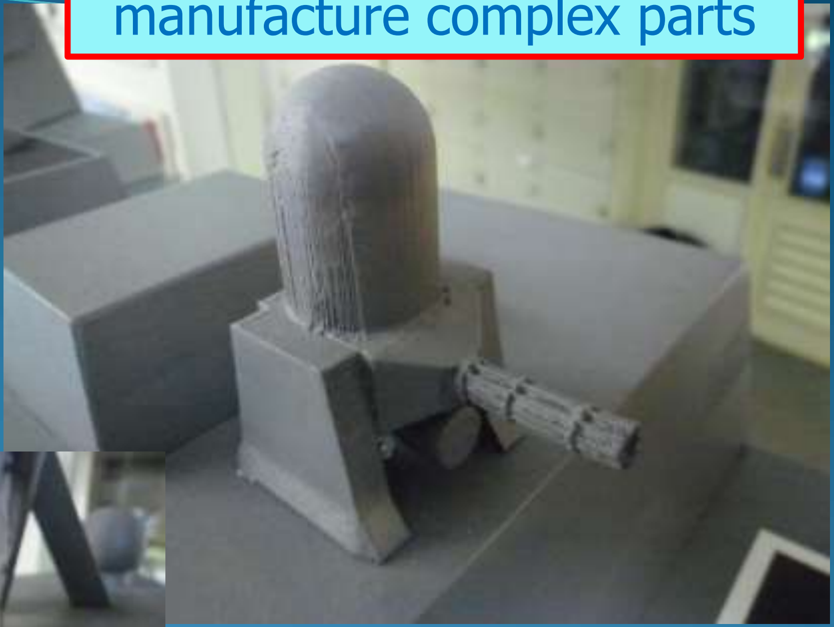


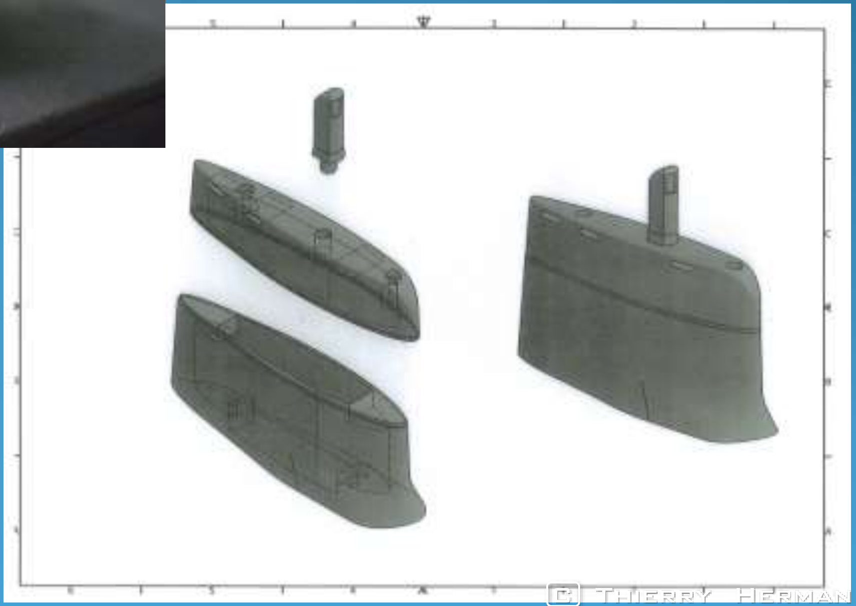


Use of traditional Tech skills to draft and make a model to understand the properties of CV Joints

Use of 3D Printing to manufacture complex parts







Having a STEM Mind Set

Involvement with Relevant Industries

Consider working / teaming up with local industries:

What are their products and expertise, do they use machines such as Laser Cutting, 3D Printing or other CNC machines ?

Can you organise relevant industry visits for students ?

Maybe consider taking part in programs such as the Advanced Tech Program to increase your Industry awareness and take advantage of Industry placement programs for Teachers in Universities and Manufacturing Industries.

Personal example : Placement at AWD/ASC

I did a half year one day a week industry placement at the Air Warfare Destroyer Systems Centre at Osborne.

Benefits : This placement gave me access to Navy personal as well as Engineers to gain insight into the different aspects of this projects, not only from an Engineering point of view but also from a Scholarly point of view which allowed me to match various aspects of the AWD project with our school Curriculum.

Outcome : Through our collaboration, I produced a number of STEM units of work where Naval Engineering topics where used as springboards to cover Maths, Physics, Chemistry and Technology points across Year 8 to Year 12.

AIR WARFARE DESTROYER
ALLIANCE

Educational material related to the Hobart Class DDGs (Air Warfare Destroyers) built at Techport, Adelaide South Australia

AWD ALLIANCE / DECD
STEM Program –
Science Technology Engineering Mathematics

Life with the light of knowledge
VITAI LAMPADA
LE FEVRE HIGH SCHOOL

LE FEVRE HIGH SCHOOL - THE MARITIME SCHOOL OF SOUTH AUSTRALIA

AIR WARFARE DESTROYER ALLIANCE

The Maritime School of South Australia

VITAI LAMPADA Life with the light of knowledge LE FEVRE HIGH SCHOOL

ALLIANCE / DECD
STEM PROGRAM –
SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS

Author / Developer : Thierry Herman Mathematics and Maritime Science Teacher - Le Fevre High School
The Maritime School of South Australia

AWD Personnel - Contributors / Advisors :

Alliance

Michael Clements – Platform Systems Activation
Nigel Agars – ILS (Integrated Logistics Support) Principal
Mark Eglinton – Project Manager - transportation
Matt Sinnett – Jones – Sonar
Paul Shinks – Sonar
Tom Robinson – Ship Production
David Gonzales- Propulsion
Ronnie Watt - Sonar
Nick Fletcher – ISS Lead system engineer
Craig Schwartz - Sonar
Ruben Spyker – Technical Director
Mike Lorenzo - Training
Anna Jackson – AWD Communications Manager

CoA

CAPT Shane Casboult – Trails and Acceptance (Engineering)
CAPT James Nash – Ballistics
Roger Duffield – Construction Design Acceptance (Engineering)
LEUT Peter Shirley – Top side Lead Engineer – Radar
Lee Rigano – FMS (Foreign Military Sales) Manager
Terry Foster - Staff Officer - Projects
Tracey Guest – Administration Coordinator
Terri George - Business Support Officer (HR)

AIR WARFARE DESTROYER ALLIANCE

MISSIONS

Theme	Mathematics	Physics	Science / Chem	VET
HULL	Year 8 Hull volume calculations	Year 10 Why does it Float ?	Year 11 Hull protection Electrochem.	CERT II Welding Techniques
PROPULSION SYSTEMS	Year 9 Propeller Geometry	Year 11 / 12 How Fast does it turn ?	Year 11 /12 Which metal for which use ?	CERT I Pitch
RADAR COMMUNICATIONS	Year 10 / 11 Quadratics Applications	Year 11 What is a focal point ?	Year 9 Microwaves Energy Transfer	CERT III Building a Parabolic BBQ
BALLISTICS / RAS Replenishment At Sea	Year 10 Total Surface Area of Propellant	Year 12 Parabolic Trajectories	Year 10 Propellant Combustion	CERT II Machining Tolerances

AIR WARFARE DESTROYER ALLIANCE

Theme	Subject	Topic	Year level
HULL	Mathematics	Measurement & Volume	Year 8

***ACARA* / SACE / VET Reference :** ACMMG 198

Develop the formulas for volumes of rectangular and triangular prisms and prisms in general. Use formulas to solve problems involving volume (ACMMG198)
investigating the relationship between volumes of rectangular and triangular prisms

VITAI LAMPADA Life with the light of knowledge LEFEVRE HIGH SCHOOL

The Maritime School of South Australia

AIR WARFARE DESTROYER ALLIANCE

Description of Unit :

This unit is related to the geometry of ship hulls and in particular to the calculation of the volume of prismatic solids.

This unit will enable students to calculate the immersed volume of simplified ship hulls and therefore, the displacement of a ship.

A ship hull can be modelled and broken down into three parts :

Front (Prow):	***Triangular prism,***
Mid-ship :	***Rectangular prism***
Rear (Stern) :	***Trapezoidal Prism***

Each of these volumes are calculated separately and added together to find the overall volume.

AIR WARFARE DESTROYER ALLIANCE

UNIT :

(To access Hyperlinks, left click on them)

Prior knowledge : *See*

- *Prismatic Volumes*
- *Calculator for calculating the surface of a Triangle*
- *Calculator for calculating the surface of a Rectangle*
- *Calculator for calculating the surface of a Trapezium*

Example :

- Calculations for the volume of prisms (Video)

-

STUDENT RESOURCE : Worksheet on the calculation of the immersed volume of AWD hull

AIR WARFARE DESTROYER ALLIANCE

RELATED TOPICS : (HULL)

PHYSICS tab : Archimedes Principle (Why does it float ?)

CHEMISTRY tab : Hull Protection and Electrochemistry

VET tab : Welding techniques

AWD Alliance Resources : *AWD Home Page*

AIR WARFARE DESTROYER ALLIANCE

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VITAI LAMPADA Life with the light of knowledge

EXTENSION / POSSIBLE RESEARCH TOPICS

You might want to investigate :

Platonic Solids

Who developed the first understanding of how to calculate volumes ?

Check out the volume in cubic metres of the Great Pyramid. How was it calculated ?

What is Calculus and how is it related to the calculation of volumes ?
(even if you are in year 8, you can get the basic facts about calculus and understand its application regarding the calculation of volumes without going into too many details).

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OTHER INTERESTING WEB SITES

- **Archimedean Solids**
- ***Archimedes and his work***

Further considerations

Having a STEM Mind Set

By using
an “augmented reality” like
set of eyes

STEM MINDSET

A DIFFERENT WAY
TO LOOK
AT THE WORLD

Chrome reflective surface

Tech / Engineering :

How is this surface obtained ?
Industrial processes

Science :

Reflection law in Optics

Maths :

Angles and Trigonometry

Possible Students research Topics :

Why do polished metals reflect light ?
Wave/particle Theory of light
Nano surfaces
Mirrors and reflecting surfaces
Satellite dish and Radar Technology

etc ...

Transparent Plastic Part

Tech / Engineering :

How is this part made ?
Industrial processes

Science :

Refraction laws in Optics

Maths :

Use of refraction formula and sinus

Possible Students research Topics :

Why are some materials transparent and not others ?
Lens technology
Polarising lenses
Optic Filters
Electromagnetic spectrum
Redefine transparent - X rays > applications in checking the quality of welds
Optic fibers technology

etc ...

Molded Plastic Parts

Tech / Engineering :

How is this part made ?
Industrial processes / injection molds
Various plastics: Thermoset, Thermo-softening plastics rubbers, silicone, etc …

Science :

Polymer Properties

Maths :

Calculations of pressures and use of conversion calculations (PSI, Pascals, kg/cm2, Atmospheres, etc …)

Possible Students research Topics :

What are polymers ?
Different polymer structures ?
Why are some plastics hard and some supple ?
Tyre technology / vulcanisation

etc …

Ink

Tech / Engineering :

How is this ink made ?
Industrial processes
Pigments industries

Science :

Ink composition
Colour Theory
Chromatic Wheel
Chromatographic analysis of inks
etc ...

Maths :

Concentration calculations
Ratios
Rate of displacement of pigments in Chromatography

Possible Students research Topics :

What were the first inks used by humans ?
Anti Theft UV inks
How does an inkjet printer work ?

etc ...

Ball Point

Tech / Engineering :

How is this tiny sphere made ?
Industrial processes
Metallurgy of Steel and Alloys
clearance between ball and body - matching ink viscosity
Manufacturing tolerance

Science :

Structure of Steel
What are alloys ?
etc ...

Maths :

Calculations of volume of spheres
Tolerance and clearance calculations
Units - Conversion tables

Possible Students research Topics :

What are alloys and when was the first one produced ?
Steel Metallurgy in Australia
Cubic Centre Face and Cubic Centre crystalline structure of Steel
etc ...

Spring

Tech / Engineering :

How are springs manufactured?
Industrial processes - Shock absorbers Technology
Metallurgy of Steel and Alloys
How to evaluate the temperature of Steel by its colour ?

Science :

Hooks' Law
Different types of springs (Compression, Extension)
etc ...

Maths :

Calculations using Hooks' law ($F = k\ x$)
Linear relationships
Determination of the stiffness coefficient k of the spring

Possible Students research Topics :

What makes a metal part springy ?
Metallurgy of Steel
Damascus steel and Japanese sword-smiths
Quenching and Tempering

etc ...

STEM Projects examples not directly related to Naval Engineering.

Year 8
The STEM in Medieval Siege Engines

STEM / YEAR 8
TREBUCHETS

Australian Government
Department of Defence

ADVANCED TECHNOLOGY PROJECT

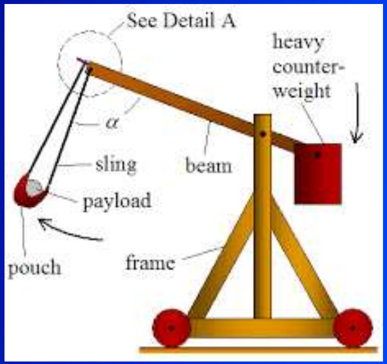
HISTORY, ETHNOLOGY, MATHEMATICS PHYSICS AND BALLISTICS

T . Herman

Content

1) Historical Background :

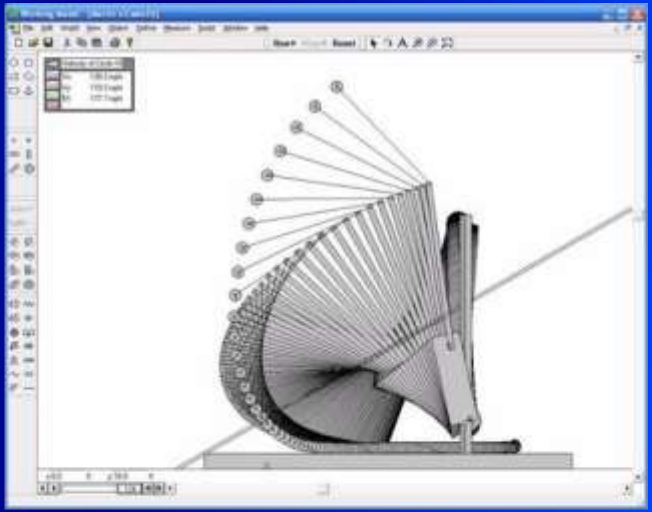
Enters the Trebuchet. The name derives from the French word still in use today " Trebucher " meaning : to stumble.
This is because the original trebuchets used to rock back and forth as a drunk person stumbling on an obstacle in their path.



They store Potential energy of gravitation which is NOT dependent on the humidity in the air, is very reliable and can store tremendous amounts of energy released when the projectile is fired.

2) Physics of Trebuchets

2.1) Transfer of Energy



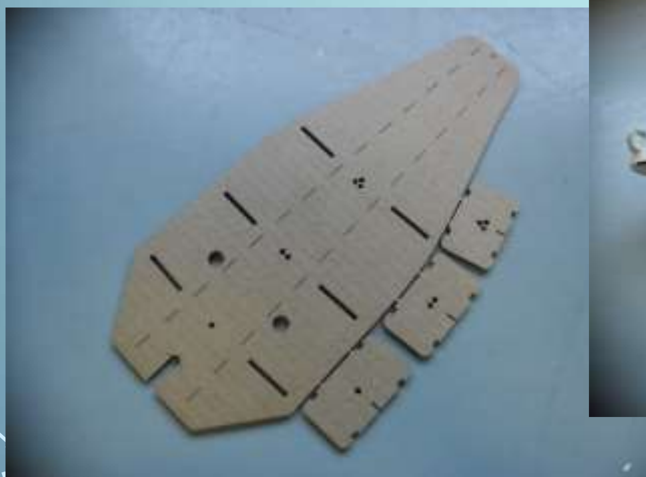
As the counter weight falls, it loses potential Energy of Gravitation which is simultaneously transferred to the sling and payload in the form of Kinetic Energy of motion.

The payload accelerates faster and faster until the sling is released at the top of the trajectory and allows the payload to fly away.

ATP – STEM LFHS Trebuchet Project Initiative

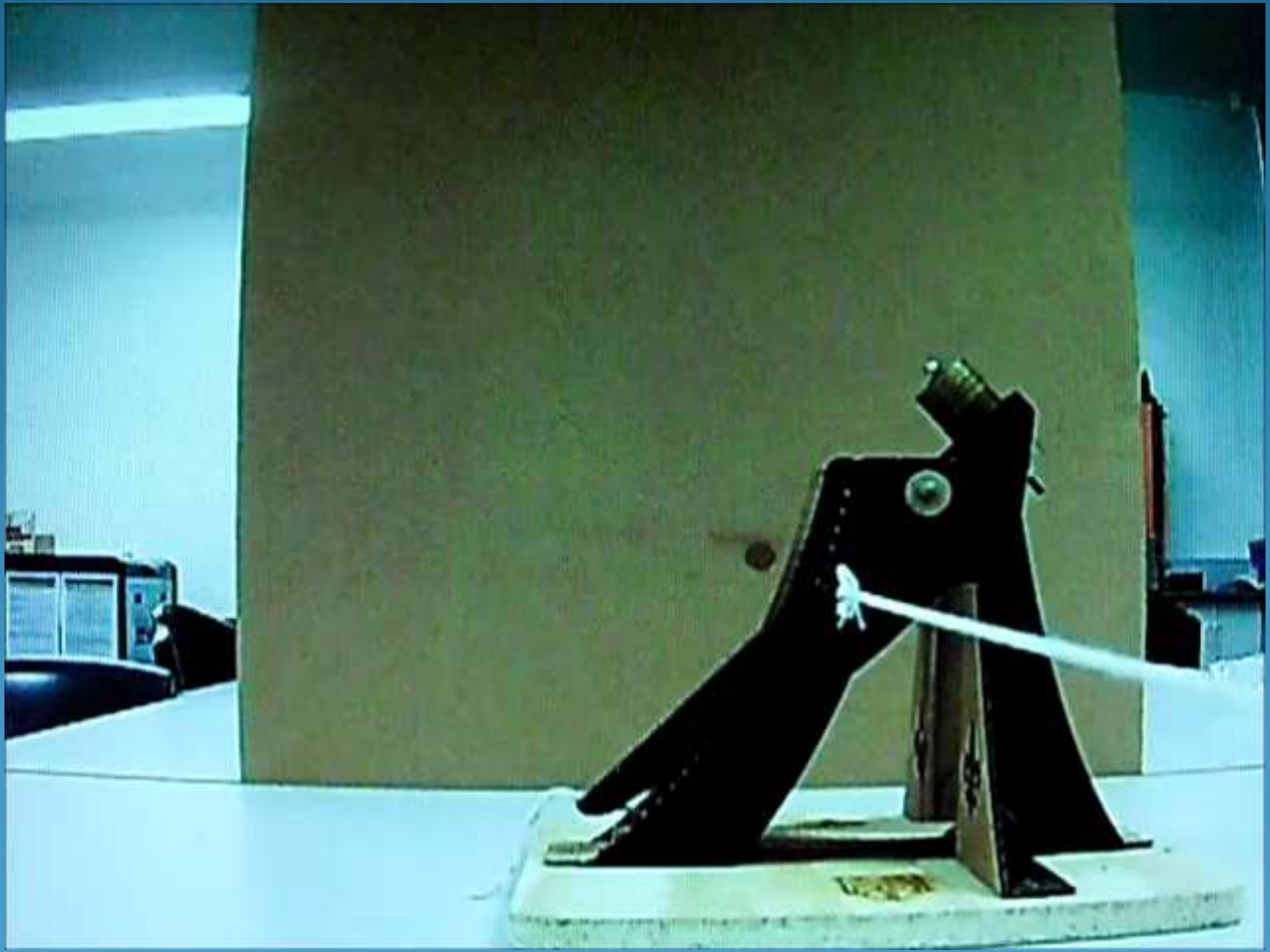
Trebuchet Building and Set up

ADVANCED TECHNOLOGY PROJECT

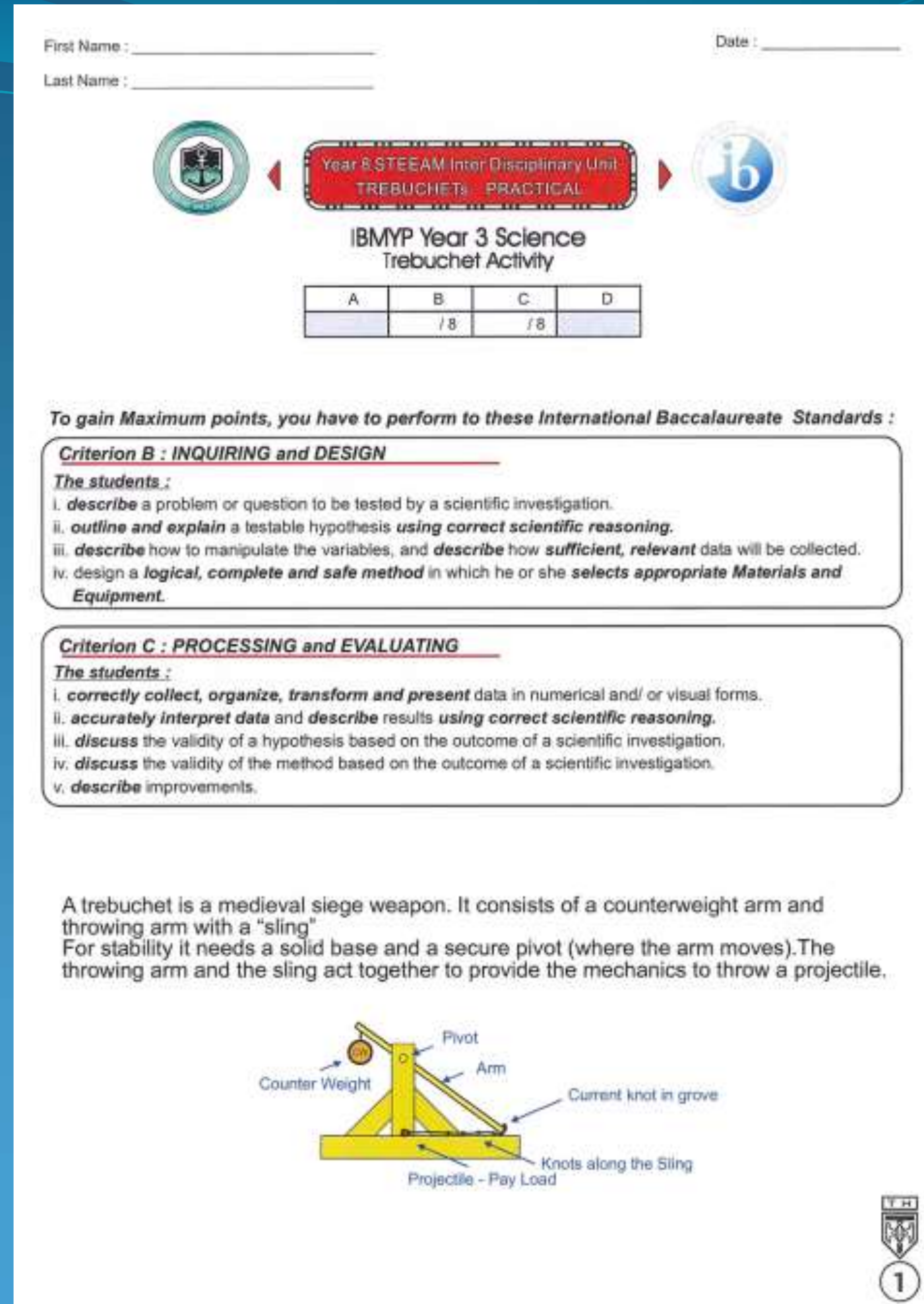


Year 8 (and Year 12)
The STEM in Medieval Siege Engines

Year 8
Trebuchet in action



Year 8 Trebuchet in action


First Name : ______________________ Date : ____________

Last Name : ______________________

Year 8 STEEAM Inter Disciplinary Unit
TREBUCHETs PRACTICAL

IBMYP Year 3 Science
Trebuchet Activity

A	B	C	D
	/ 8	/ 8	

To gain Maximum points, you have to perform to these International Baccalaureate Standards :

Criterion B : INQUIRING and DESIGN

The students :

i. ***describe*** a problem or question to be tested by a scientific investigation.
ii. ***outline and explain*** a testable hypothesis ***using correct scientific reasoning.***
iii. ***describe*** how to manipulate the variables, and ***describe*** how ***sufficient, relevant*** data will be collected.
iv. design a ***logical, complete and safe method*** in which he or she ***selects appropriate Materials and Equipment.***

Criterion C : PROCESSING and EVALUATING

The students :

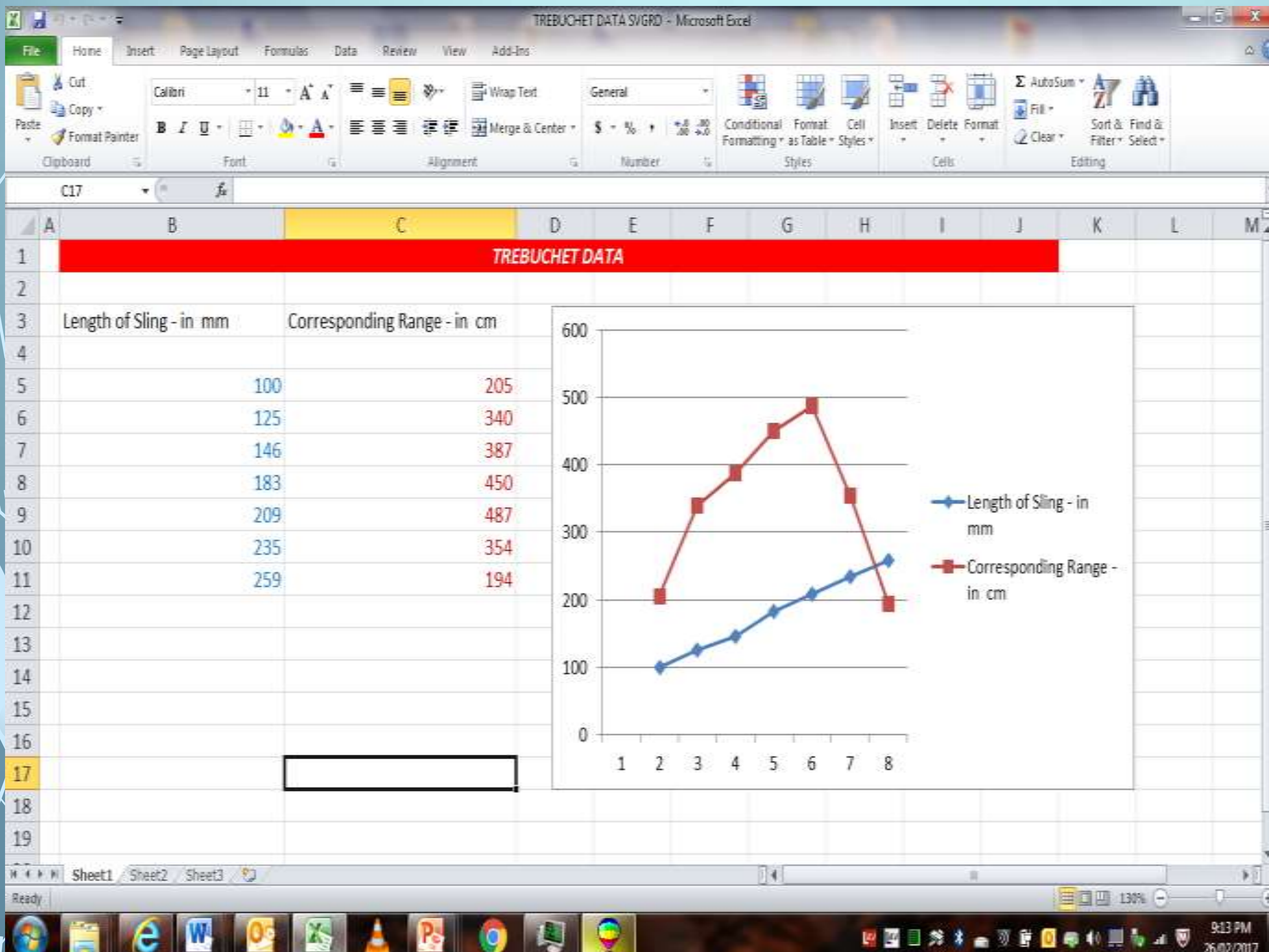
i. ***correctly collect, organize, transform and present*** data in numerical and/ or visual forms.
ii. ***accurately interpret data*** and ***describe*** results ***using correct scientific reasoning.***
iii. ***discuss*** the validity of a hypothesis based on the outcome of a scientific investigation.
iv. ***discuss*** the validity of the method based on the outcome of a scientific investigation.
v. ***describe*** improvements.

A trebuchet is a medieval siege weapon. It consists of a counterweight arm and throwing arm with a "sling"
For stability it needs a solid base and a secure pivot (where the arm moves).The throwing arm and the sling act together to provide the mechanics to throw a projectile.

1

ATP – STEM LFHS Trebuchet Project Initiative

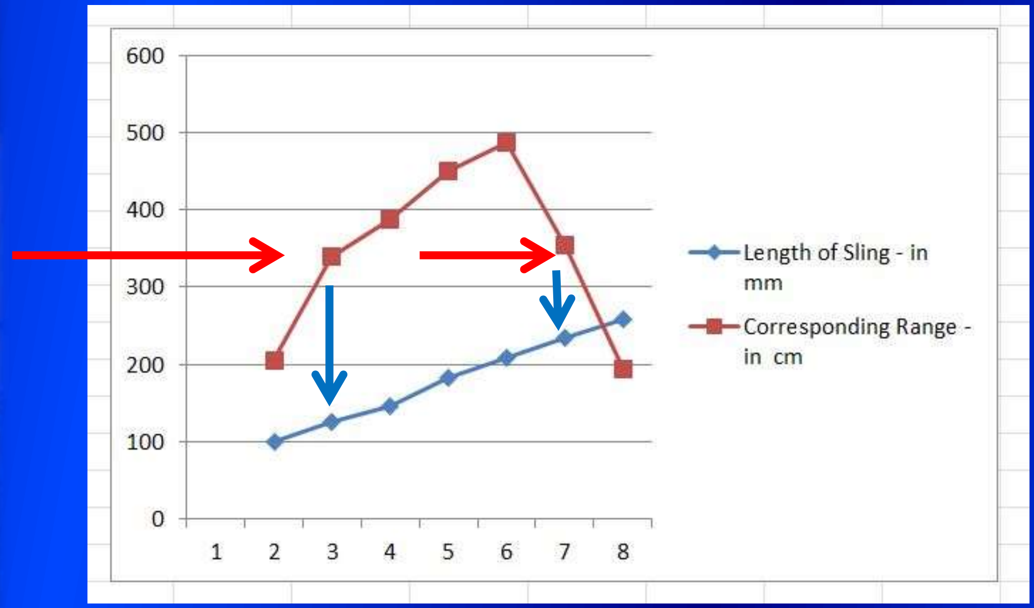
Trebuchet Data Exploitation - Range vs Length of Sling



Students use the graph of Range vs Length of Sling to reverse engineer the length of sling they need to reach a target at a given distance.

3) Using the Data–Maths of Trebuchets

3.2) Using the graph to get your target



On the day of the competition, you will be given a distance to the target (Castle). Use your graph to find the best length for the sling, to hit the castle and win the competition.

Year 10
Rocket Science

Water Rocket Project

Water Rocket in action

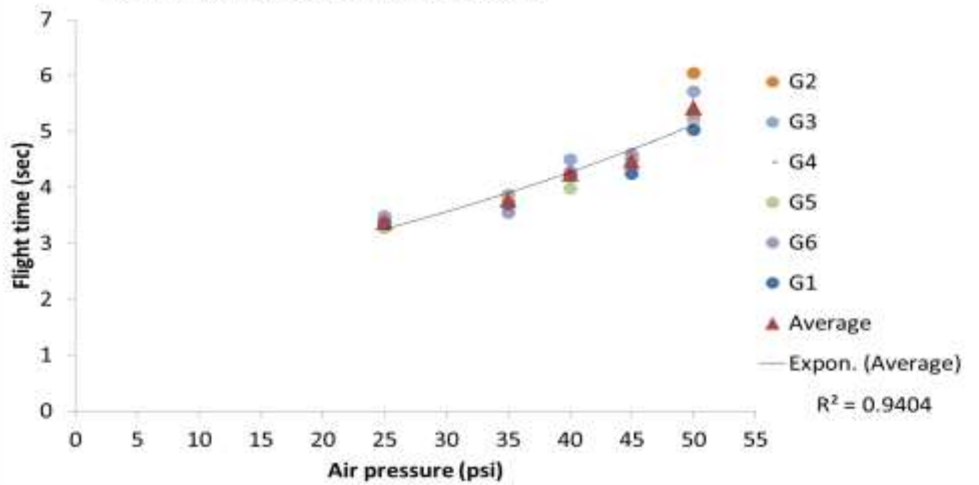
Water Rocket flight analysis

Results

Table 1. Trial 1: Total flight times (sec.) recorded by each group and the average flight time (±SD), for each air pressures (psi), using a 2 litre bottle with a water volume of 900ml.

Air pressure (psi)	G1	G2	G3	G4	G5	G6	Average	SD	n	Min	Max	Range
50	5.03	6.05	5.72	5.2	5.2	5.31	5.42	0.39	6	5.03	6.05	1.02
45	4.25	4.5	4.6	4.5	4.45	4.54	4.47	0.12	6	4.25	4.6	0.35
40	4.2		4.5	4.21	3.98	4.28	4.23	0.19	5	3.98	4.5	0.52
35	3.7	3.83	3.86	3.86	3.8	3.55	3.77	0.12	6	3.55	3.86	0.31
25	3.37	3.3	3.4	3.4	3.27	3.48	3.37	0.08	6	3.27	3.48	0.21

Figure 1. The relationship between air pressure (psi) and total flight duration (sec.), when water volume is set at 900ml, using a 2 litre bottle (Trial 1). Trend line based on average times (red triangles).

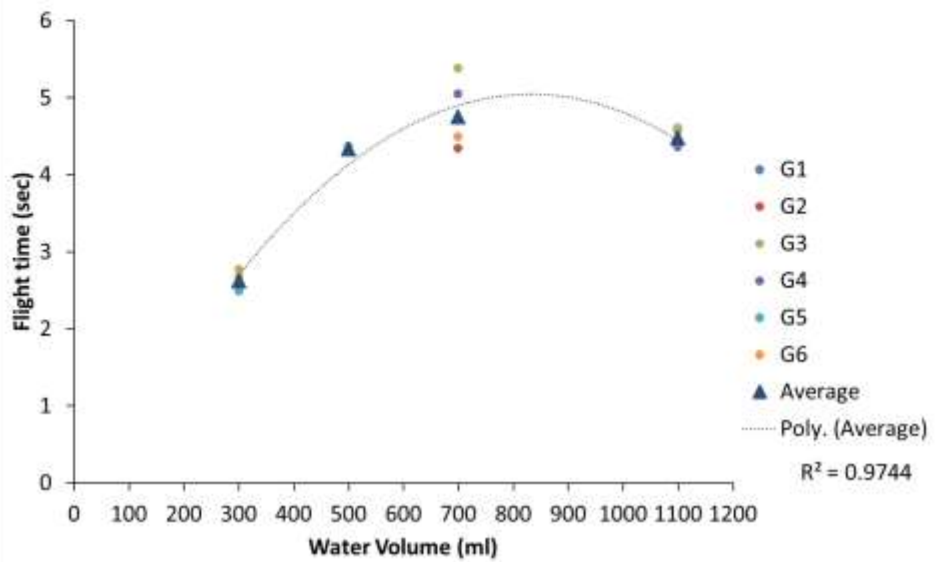


Water Rocket flight analysis

Table 2. Trial 2: Total flight times (sec.) recorded by each group and the average flight time (±SD), for different water volumes (ml), using a 2 litre bottle with air pressure set at 50psi.

Water volume (ml)	G1	G2	G3	G4	G5	G6	Average (sec.)	SD	n	Min	Max	Range
1100	4.39	4.58	4.61	4.36	4.42	4.47	4.47	0.10	6	4.36	4.61	0.25
700		4.34	5.38	5.05	4.49	4.49	4.75	0.44	5	4.34	5.38	1.04
500	4.29		3.1	4.37	4.37	4.32	4.09	0.55	5	3.1	4.37	1.27
300	2.55	1.66	2.77	4.28	2.49	2.68	2.74	0.85	6	1.66	4.28	2.62

Figure 3. The relationship between water volume (ml) and total flight duration (sec.), with air pressure set at 50 psi, using a 2 litre bottle (Trial 2, outliers removed). Trend line based on average times (blue triangles) after outliers removed.



Water Rocket flight analysis

Maximum altitude

In this experiment we used total flight time as an indicator of altitude, based on the idea that if the rocket was launched vertically the maximum height attained should correlate closely to the total flight time.

The approximate altitude attained can be estimated using Littlewood's Law.

J.E. Littlewood was a mathematician who worked with the British army in WW1, in Ballistics. He developed a formula to approximate the altitude attained by projectiles. The water rocket is similar to a projectile because it looses most of its water soon after take-off.

Approximation of peak height (m) using Littlewood's Law

$$h_{approx} = \frac{g}{8}\, t^2$$

Where h_{appox} = approximate height (m) g = gravity force (9.81 m/s^2) t = total flight time (sec)

Ignoring air friction and using the average flight time for 900 mL at 50 psi :

Max Height = 1/8 g t^2 = 1/8 x 9.81 x (5.42)^2 = 36.02 m

Water Rocket further enquiries

Extensions, variations and cross curriculum integration:

- Convert all flight times to approximate altitudes and draw up additional graph.
- Convert water volume to % capacity and draw up additional graph.
- Use data in maths classes – discuss fitting of trend lines, variation, SD, outliers influence on fitting trend lines.
- Tech & engineering – design of rockets. Various simulation programs online – can change elements of the design of the rocket and simulate flight.
- Use duel timers or two stopwatches to measure ascent and total flight time.
- Test Littlewood's Law – use an altitude tracker and geometry to measure the altitude of the rocket during the practical. Compare the two methods. Which is easier for students to perform? Do they give similar estimates? Design and construction of an altitude tracker: https://spaceflightsystems.grc.nasa.gov/education/rocket/TRCRocket/altitude_tracking2.html

Water Rocket further enquiries

- Use food colouring in the water – may make it easier to see the pattern and timing of the water expulsion. Could time point of full water expulsion. Compare for different pressures and water volumes.
- Change density of liquid used.
- Change nozzle size – different bottle.
- Change mass or length of rocket.
- Measure initial velocity – use upright measuring stick, camera on a tripod and slow motion in QuickTime media player to estimate initial velocity.

Useful web links:

Lots of additional information on the web – best site NASA

Water rockets

https://spaceflightsystems.grc.nasa.gov/education/rocket/BottleRocket/index.htm

Other rocket projects for education

https://spaceflightsystems.grc.nasa.gov/education/rocket/TRCRocket/Intro.html

Year 11 General Mathematics STEM Event
Simpson's Rule in 3D
and displacement of Hulls

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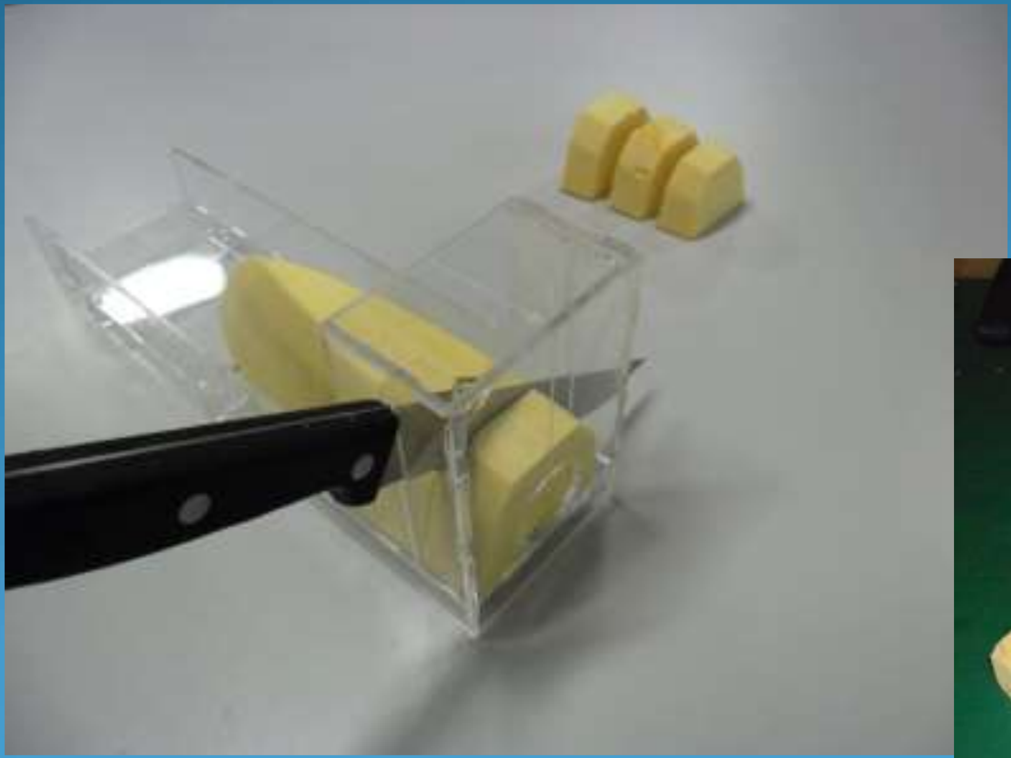
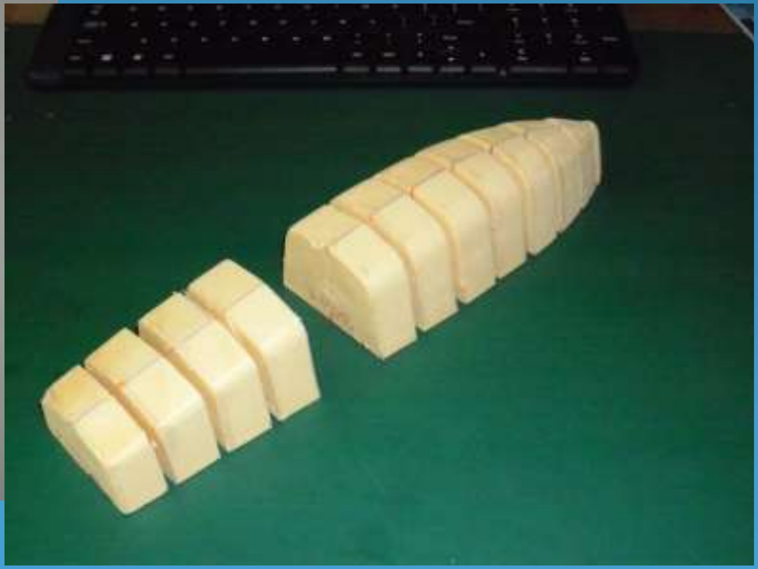
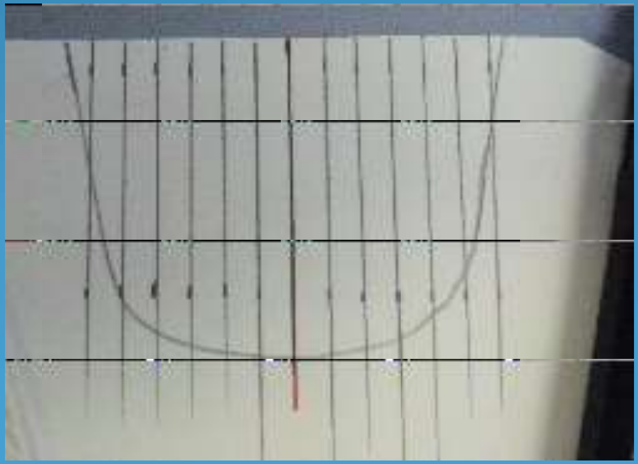
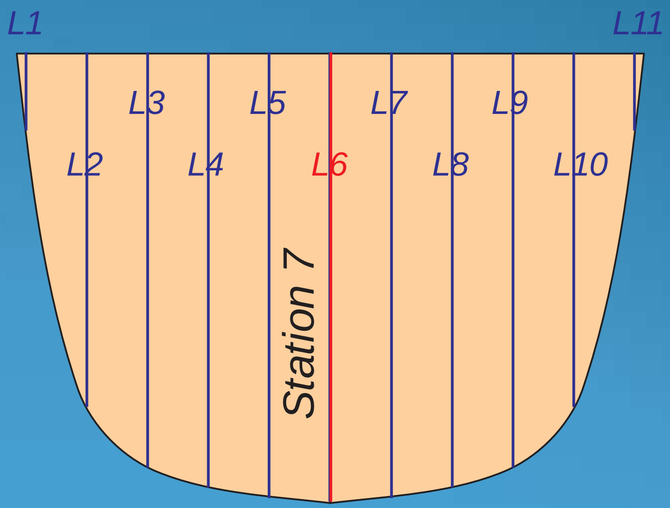




Year 11 General Mathematics STEM Event

Simpson's Rule in 3D
and displacement of Hulls





Year 11 General Mathematics

STEM Event Simpson's Rule in 3D

and displacement of Hulls

Stations (Frames) Areas
Electronic Scales method -

Teacher's Notes

Consider Station 7 : $m_7 = 0.43\ g$

Benchmark : 100 cm^2 have a mass of 1,69 g.

Proportional Table :

A_7	0.43 g
100 cm^2	1.69 g

$$\frac{A_7}{100} = \frac{0.43}{1.69} \Rightarrow A_7 = \frac{0.43 \times 100}{1.69} = 25.44\ cm^2$$

Absolute Error : m_7 Upper $= 0.435\ g \rightarrow A_7$ upper $= 25.74\ cm^2$
m_7 Lower $= 0.425\ g \rightarrow A_7$ Lower $= 25.15\ cm^2$

Absolute error on $A_7 = \frac{25.74 - 25.15}{2} = 0.30\ cm^2$

Relative (%) error $A_7 = \frac{0.30}{25.44} = 0.012 = 1.2\ \%$

This method is quite accurate and precise, so when comparing with the value calculated with Simpson's method, the value found with the electronic scale method will be used as the benchmark (exact value of the area of the frames) -

Year 11 Aerodynamics Unit

Y 11 Aerodynamics Unit

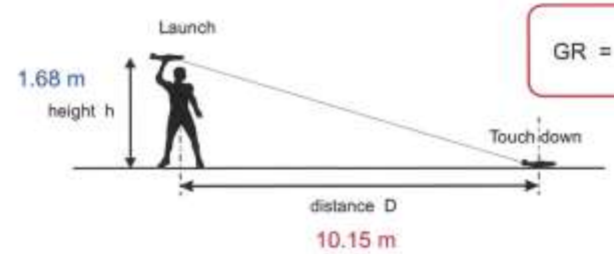
Y 11 Aerodynamics Unit

Mathematics activity : **Mathematics : Gliding Ratio (Finesse)**

Definition : The gliding Ratio (Finesse) of an aircraft is equal to the horizontal distance covered divided by the altitude lost while traveling this distance.

Unit : No unit.

Example : If a glider covers a distance of 6.75 m while dropping from a height of 1.68 m, its finesse " F " (or Gliding Ratio GR) is equal to 10.15 / 1.68 = 6.04



$$GR = F = \frac{D}{h}$$

Exercise 1 : a) On the previous example, calculate the angle of depression corresponding to this finesse of 6.04

b) If another glider is used but this time covers a distance of 12.87 m, calculate the finesse of this second type of glider.

Y 11 Aerodynamics Unit

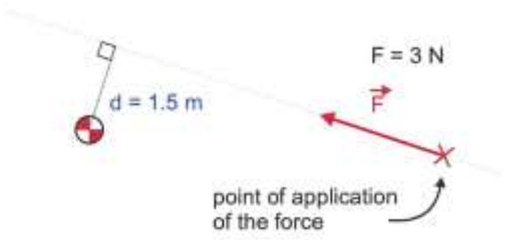
Physics activity :

Physics : Moment (also called Torque)

Definition : The moment of a force with respect to a pivot point is equal to the magnitude of this force (in Newton) multiplied by the right angle distance between the pivot point and the direction of the force (in meters).

Unit : The unit is Nm. You may have heard it about Torque wrenches or about the Torque of an engine. Typically four wheel drives have higher torque than normal car and therefore can tow bigger loads.

Example : A force of 3 N which direction is 1.5 meters away from a pivot point generates a torque of 4.5 Nm



$$T = F \times d$$
$$= 3 \times 1.5$$
$$= 4.5 \text{ Nm}$$

Property : Let two forces generate a global torque on an object around a pivot point. If the object does not rotate, it means that the respective torques generated by these two forces are ***equal***. In the case of an aircraft flying level, it does not mean that the object is not moving, it simply means that it is not rotating around its Centre of Gravity.

This is called ***DYNAMIC EQUILIBRIUM***.

Here, things are simpler than in the previous general example, because we assume that the aircraft has to fly level (horizontal) and because the weights of the front and the back part of the glider are vertical , we can easily have access to d1 and d2.

Y 11 Aerodynamics Unit

LFHS

Y 11 Aerodynamics Unit

Launch Height = 1.8 m

Distance covered = 17.0 m

Finesse or Gliding Ratio :

D/h = 17.0 / 1.8 = 9.4

ie a 1 in 9.4 gliding ratio,

or expressed differently, for every foot of altitude lost, the glider is capable of covering a horizontal distance of 9.4 feet.

Year 12 Woomera Project

SSATA Integrated Learning

and NAVAL ENGINEERING

LE FEVRE HIGH SCHOOL

2017

THE WOOMERA PROJECT

An Advanced Technology Program Initiative
For the Promotion of STEM and Advanced Technologies
For ATSI Students.

ADVANCED TECHNOLOGY PROJECT

Government of South Australia

Australian Government
Department of Defence

LE FEVRE HIGH SCHOOL NAVAL ENGINEERING

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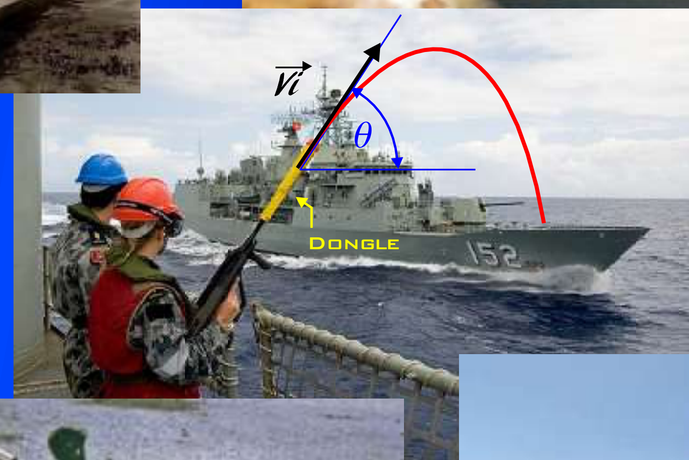


From Woomeras to AWD RAS and Harpoon Missiles Weapon Systems

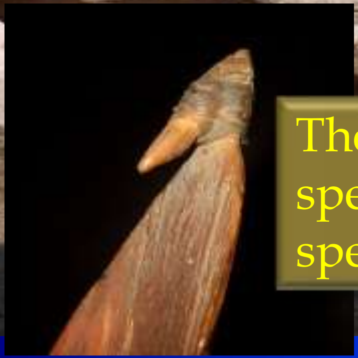
WOOMERAS

WOOMERAS

1 Historical Background

1.1 Australia

A 30,000 year old
Heritage



The people of New Guinea and Australian Aborigines also use spear-throwers. In the mid Holocene, Australians developed spear-throwers, known as woomeras.

WOOMERAS

1 Historical Background

1.2 Europe

The spearthrower is believed to have been in use by Humankind since the Upper Paleolithic (around 30,000 years ago).

WOOMERAS

1 Historical Background

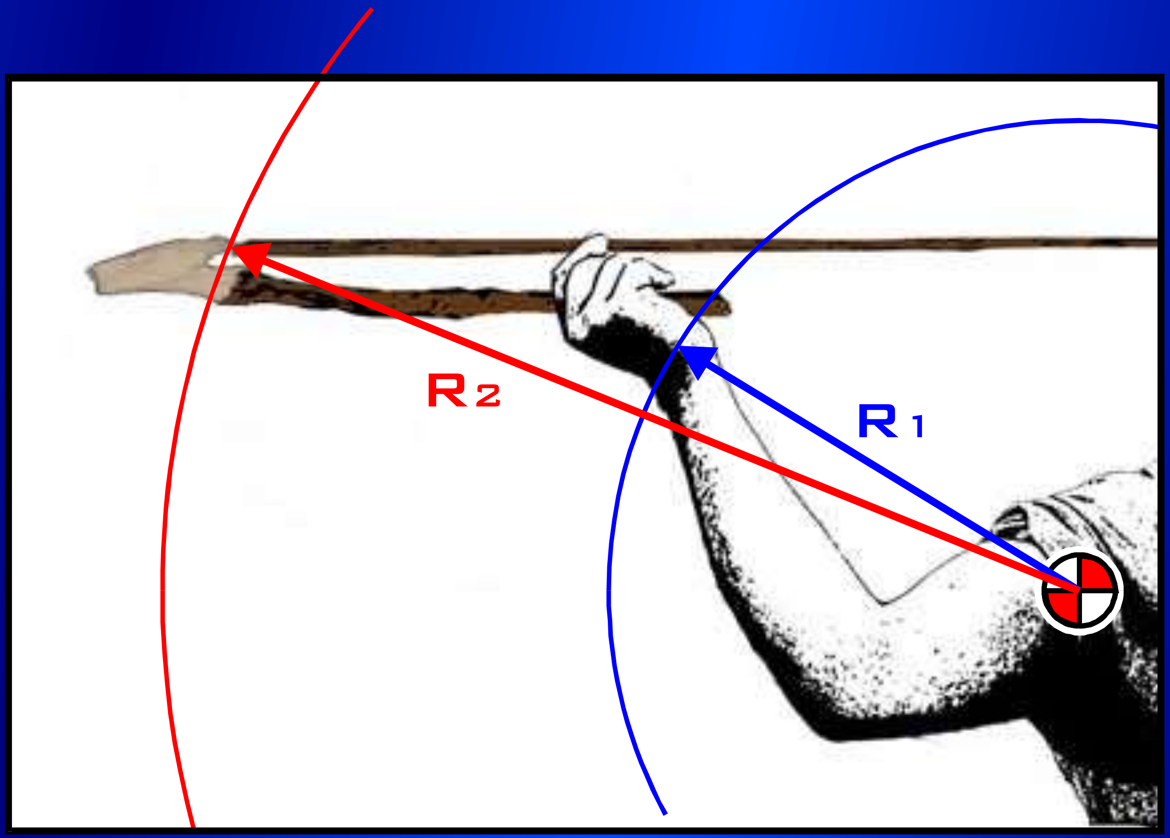
1.3 North and South American Atlatls

South American Tarairiu warriors, equipped with their atlatl, could hurl their long darts from a great distance with accuracy, speed, and such deadly force that these easily pierced through the protective armor of the Portuguese or any other enemy.

WOOMERAS

2 The Physics of Woomeras

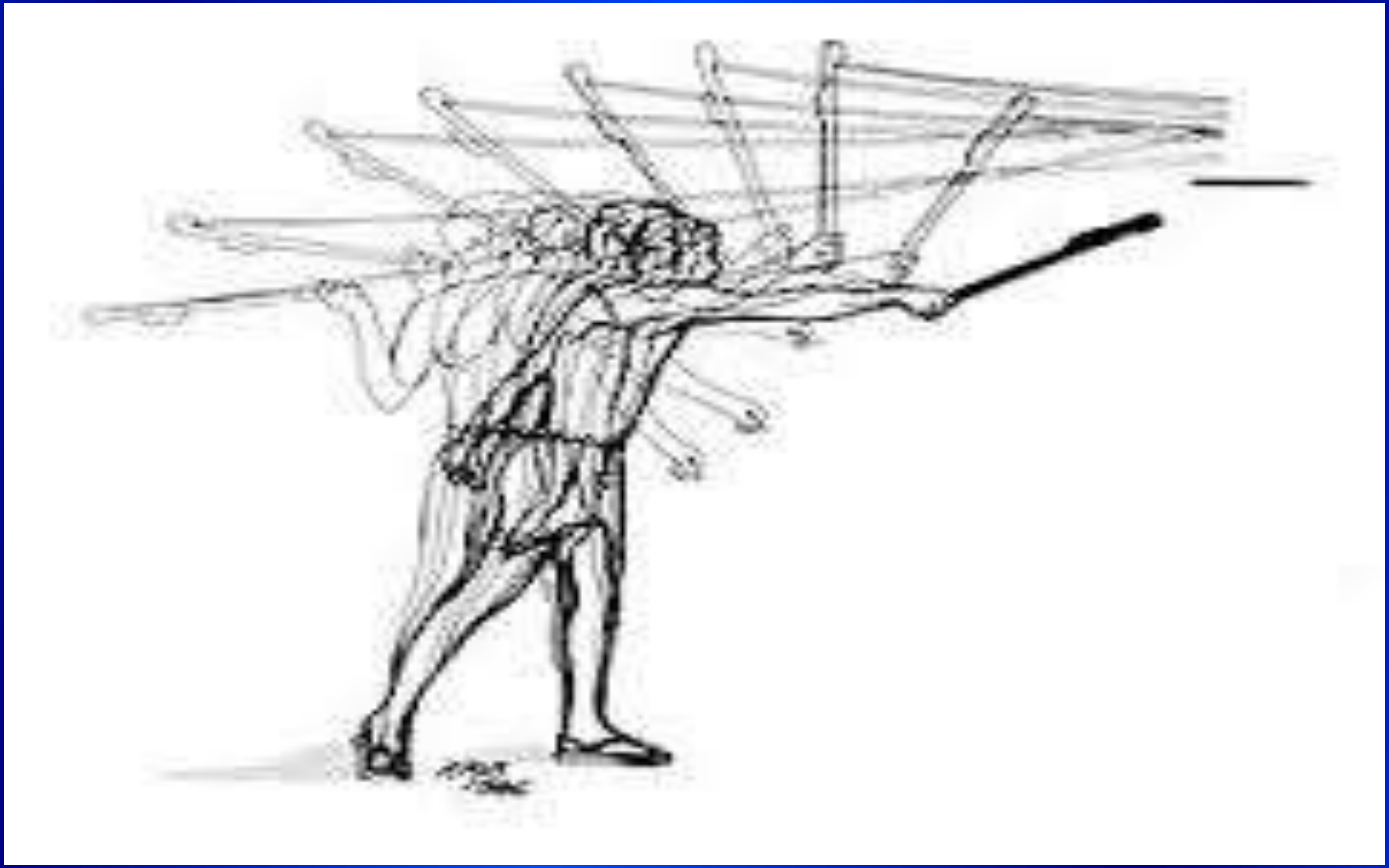
2.2 Simplified Circular Theory



WOOMERAS

2 The Physics of Woomeras

3.3 Refined Rail Theory



WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

WOOMERAS

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3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

$V_i = D_i / 2\,\Delta t$
(in m/s)

$\Delta t = 0.0083$ s

$a_i = \Delta V_i / 2\,\Delta t$
$= (V_{i+1} - V_{i-1}) / 2\,\Delta t$
(in m/s^2)

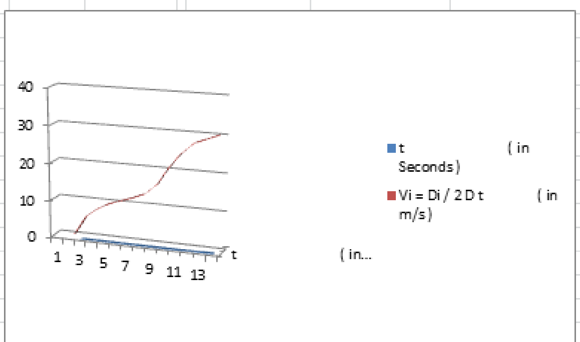
WOOMERAS

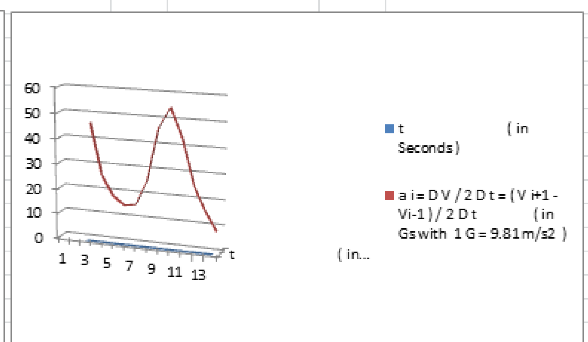
3 Ballistics applied to Woomeras and Spears

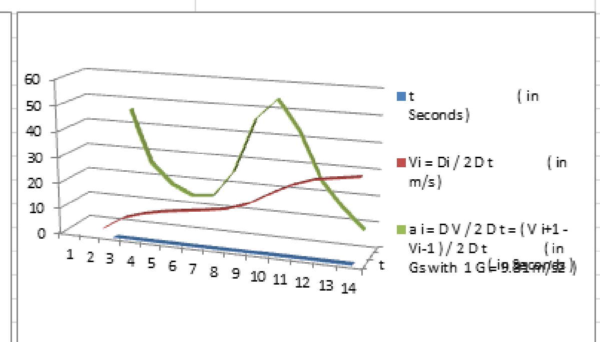
3.1 Applied Physics and Mathematics

WOOMERA DATA and GRAPHS

ΔD	ΔD	ΔD (m)	t (in Seconds)	Δt = (1 / 120 fps)		Vi = Di / 2 Δt (in m/s)		a i = ΔV / 2 Δt = (V i+1 - V i-1) / 2 Δt (in m/s^2)	a i = ΔV / 2 Δt = (V i+1 - V i-1) / 2 Δt (in Gs with 1 G = 9.81 m/s^2)
					V 0	0	a 0		
D1	A0 A2	0.085	0.00833	0.008333333	V 1	5.10	a 1	453.60	46.24
D2	A1 A3	0.126	0.01667	0.008333333	V 2	7.56	a 2	252.00	25.69
D3	A2 A4	0.155	0.02500	0.008333333	V 3	9.30	a 3	176.40	17.98
D4	A3 A5	0.175	0.03333	0.008333333	V 4	10.50	a 4	140.40	14.31
D5	A4 A6	0.194	0.04167	0.008333333	V 5	11.64	a 5	147.60	15.05
D6	A5 A7	0.216	0.05000	0.008333333	V 6	12.96	a 6	248.40	25.32
D7	A6 A8	0.263	0.05833	0.008333333	V 7	15.78	a 7	453.60	46.24
D8	A7 A9	0.342	0.06667	0.008333333	V 8	20.52	a 8	532.80	54.31
D9	A8 A10	0.411	0.07500	0.008333333	V 9	24.66	a 9	421.20	42.94
D10	A9 A11	0.459	0.08333	0.008333333	V 10	27.54	a 10	248.40	25.32
D11	A10 A12	0.48	0.09167	0.008333333	V 11	28.80	a 11	151.20	15.41
D12	A12 A13	0.501	0.10000	0.008333333	V 12	30.06	a 12	75.60	7.71
					V 13	30.06			







WOOMERAS

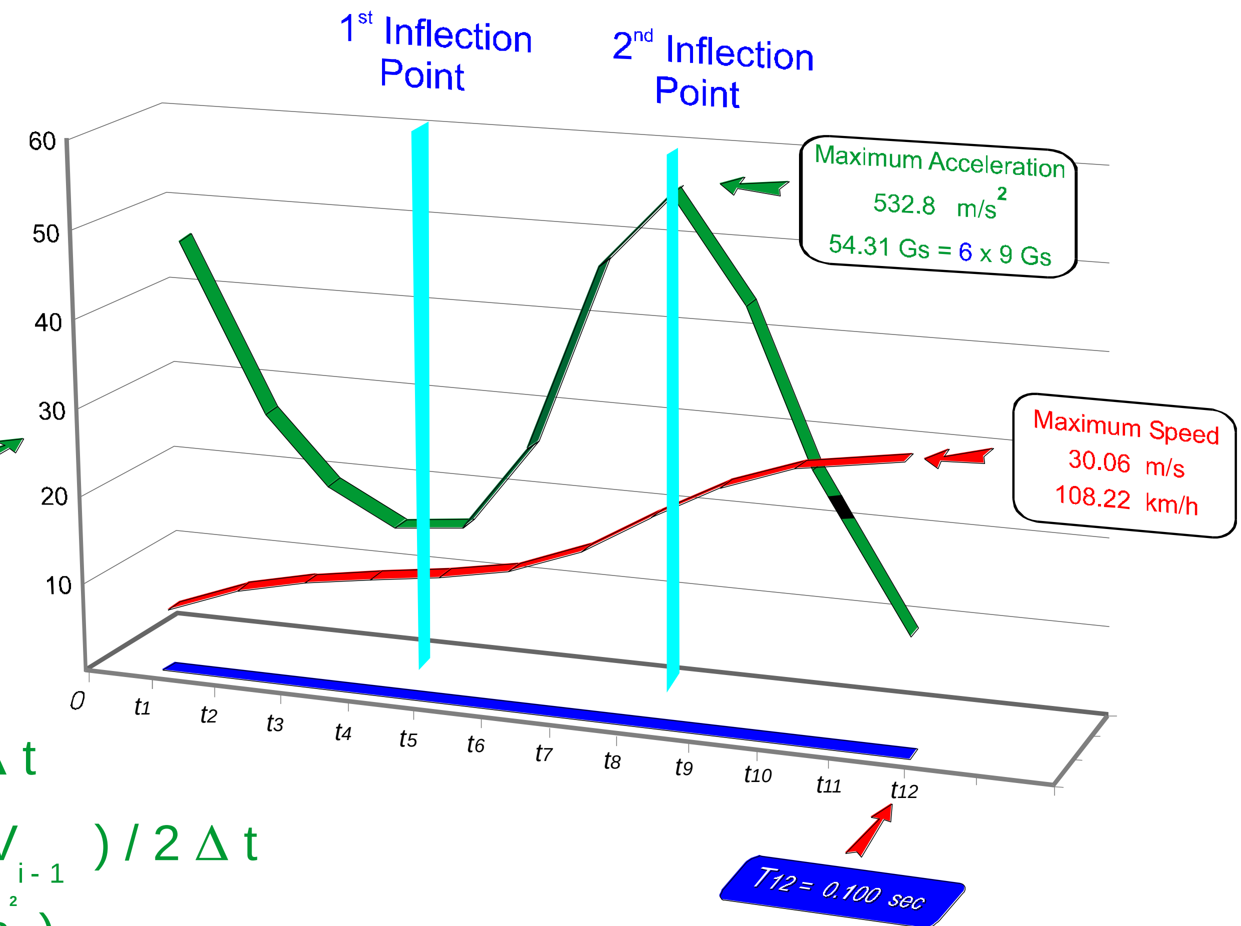
3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

$Vi = Di / 2\,\Delta t$
(in m/s)

$\Delta t = 0.0083$ s

Average Acceleration
281.27 m/s^2
28.67 Gs = 3.2 x 9 Gs



$a_i = \Delta V_i / 2\,\Delta t$

$= (V_{i+1} - V_{i-1}) / 2\,\Delta t$

(in m/s^2)

3 Ballistics applied to Woomeras and Spears

3.1 Applied Physics and Mathematics

Maximum Speed

30.06 m/s

108.22 km/h

Maximum Acceleration

532.8 m/s^2

54.31 Gs = 6 x 9 Gs

Average Acceleration

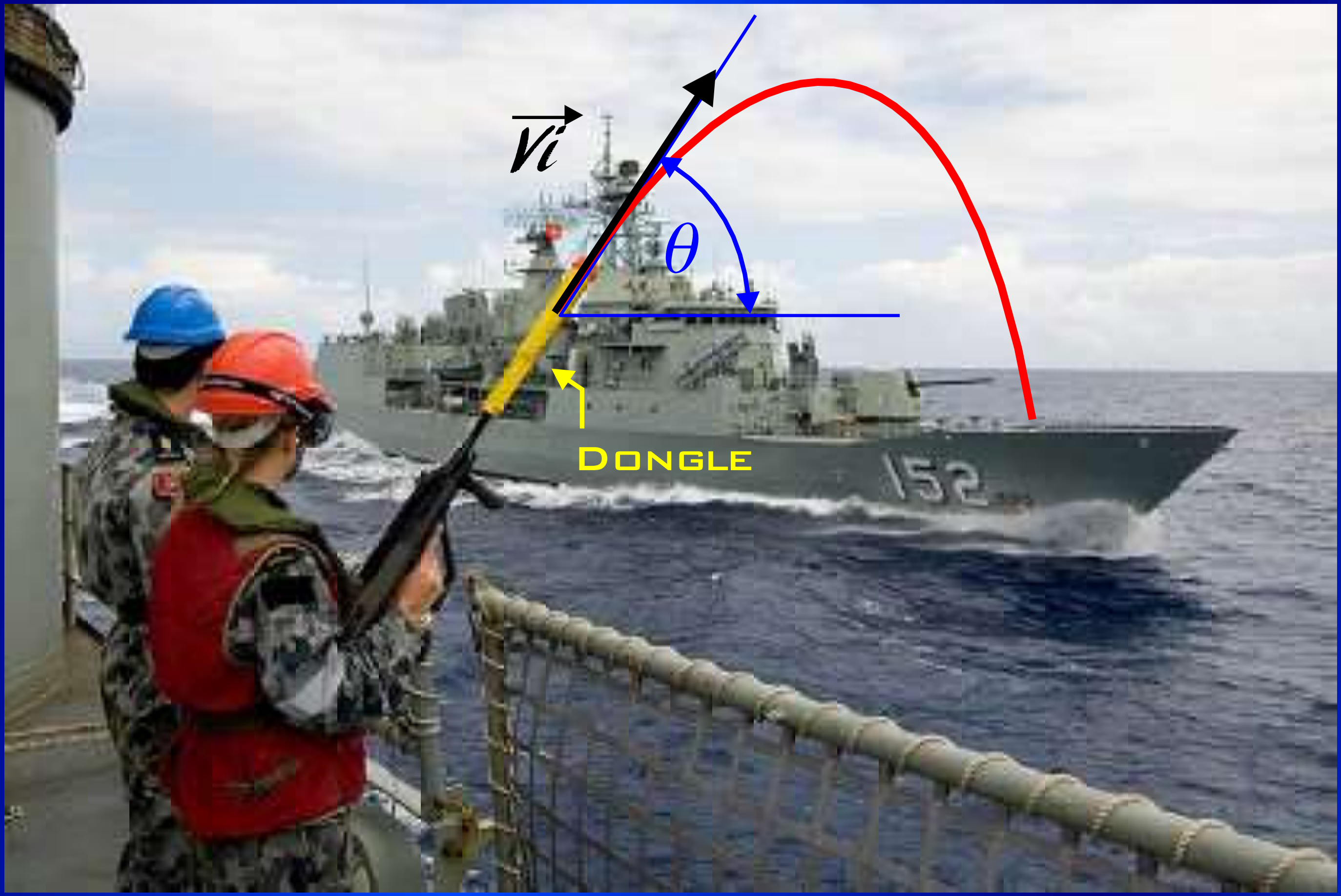
281.27 m/s^2

28.67 Gs = 3.2 x 9 Gs

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea And Harpoon Missiles Systems



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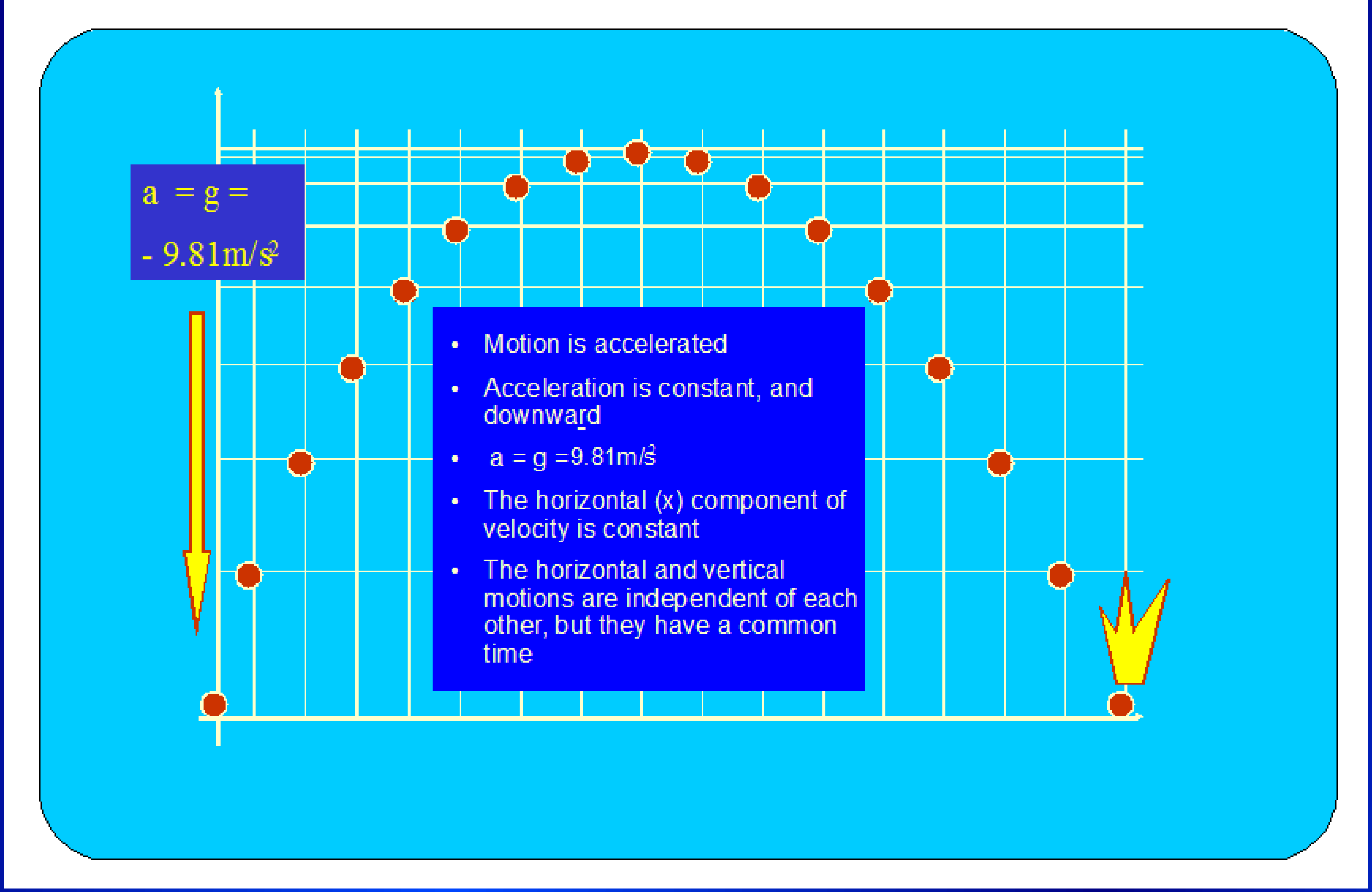

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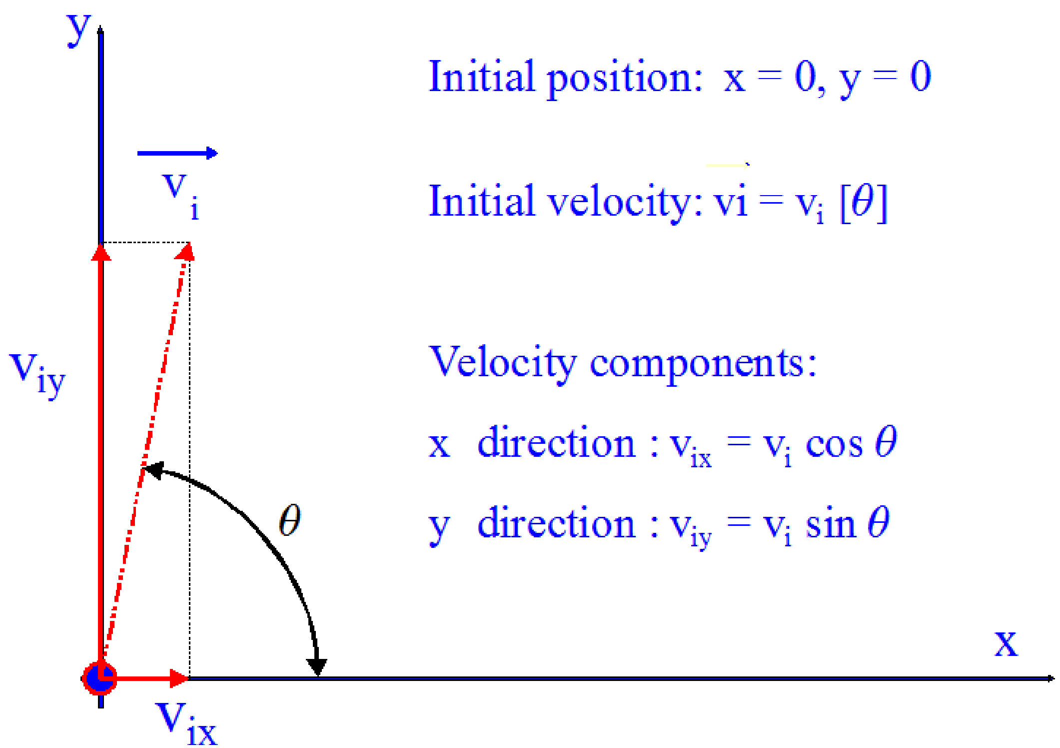


Initial position: $x = 0, y = 0$

Initial velocity: $\vec{vi} = v_i\ [\theta]$

Velocity components:

x direction : $v_{ix} = v_i \cos\theta$

y direction : $v_{iy} = v_i \sin\theta$

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea And Harpoon Missiles Systems

Equations of motion:

	X Uniform motion	Y Accelerated motion
ACCELERATION	$a_x = 0$	$a_y = g = -\ 9.81\ m/s^2$
VELOCITY	$v_x = v_i \cos\theta$	$v_y = v_i \sin\theta + g\,t$
DISPLACEMENT	$x = v_i\, t \cos\theta$	$y = v_i\, t \sin\theta + ½\, g\, t^2$

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea And Harpoon Missiles Systems

Initial Conditions :

Distance between firing point (sending ship) and point of impact (receiving ship) : 55 m

Initial velocity of the dongle : 30 m/s

ACTIVITIES

QUESTION 1: Flight time

By using the following formula, find an expression for the total flight time Δt as a function of the initial velocity Vi and the initial angle θ.
(Remember that after a span of time Δt, the altitude y will be zero again)

$$\boxed{y = v_i t \sin\theta + \tfrac{1}{2} g t^2}$$

After a time Δ t, y = 0 again (Touchdown)

Therefore :

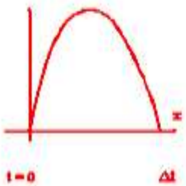
$$0 = v_i \Delta t \sin\theta + \tfrac{1}{2} g (\Delta t)^2$$

Solve for Δt :

$$0 = v_i \sin\theta + \tfrac{1}{2} g \Delta t$$

$$\boxed{\Delta t = \frac{2 v_i \sin\theta}{(-g)}}$$

with $g = -9.81\ m/s^2$



QUESTION 2 : Range

By using the formula for x as a function of the time t and the angle , as well as the formula you found in Question 1, find an expression of the range Δx (which is the total horizontal distance travelled during the span of time Δt), as a function of the initial velocity Vi and the initial angle θ , that is to say a formula independent from the travel time t.

$$\boxed{x = v_i t \cos\theta} \qquad \boxed{\Delta t = \frac{2 v_i \sin\theta}{(-g)}}$$ **(From Question 1)**

After a time Δt, x = Δx
Therefore :

$$x = v_i\ t \cos\theta$$

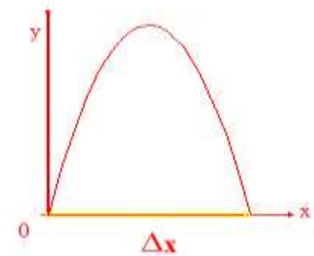
$$\Delta x = v_i \Delta t \cos\theta$$

and, according to Question 1 :

$$\Delta t = \frac{2 v_i \sin\theta}{(-g)}$$

So, $$\Delta x = \frac{2 v_i^2 \sin\theta \cos\theta}{(-g)}$$

but : $2 \sin\theta \cos\theta = \sin(2\theta)$



Therefore

$$\boxed{\Delta x = \frac{v_i^2 \sin(2\theta)}{(-g)}}$$

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea And Harpoon Missiles Systems

Initial Conditions :

Vi = 30.06 m/s

$\theta = 31.6^{o}$

$$\boxed{\Delta t = \frac{2\, v_i \sin\theta}{(-g)}}$$

$$\boxed{\Delta x = \frac{v_i^{\,2} \sin(2\theta)}{(-g)}}$$

with g = - 9.81 m/s^2

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea And Harpoon Missiles Systems

$$\Delta t = \frac{2 \times 30.06 \ \sin 31.6}{9.81}$$

$$\Delta t = 3.21 \ \text{sec}$$

Flight Time = 3.21 sec

WOOMERAS

3 Ballistics applied to Woomeras and Spears

3.2 Modern application in the Royal Australian Navy : Replenishment at Sea and Harpoon Missiles Systems

$$\text{Range} = \Delta X = \frac{(30.06)^2 \sin(2 \times 31.6)}{9.81}$$

$$\Delta X = \mathbf{82.21\ m}$$

Theoretical Range = 82.21 m which tallies with the ground observations of 70 to 80 m, taking into account air friction.

WOOMERAS

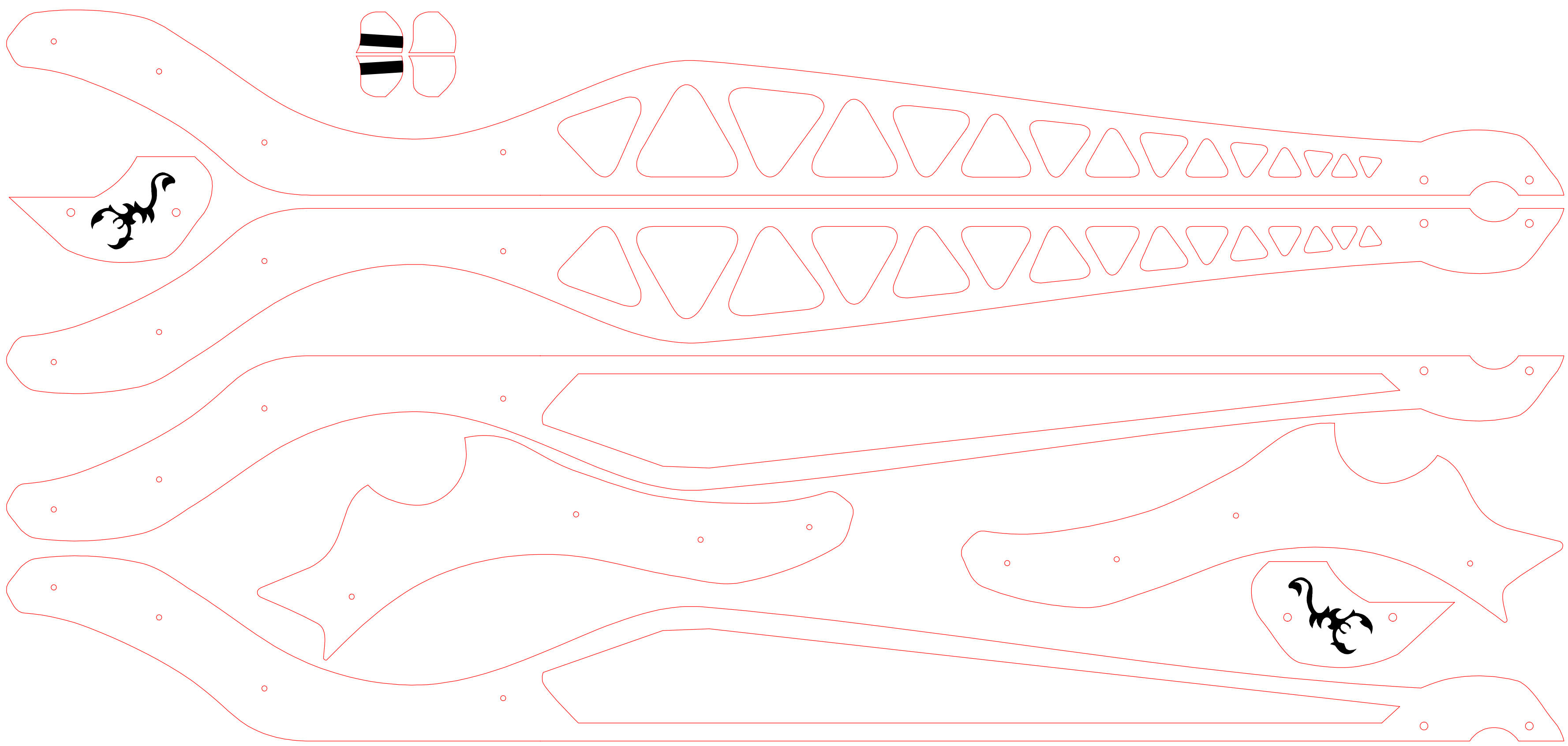
4 Making woomeras with students

4.1 Elements of Design

WOOMERAS

4 Making woomeras with students

4.2 Software

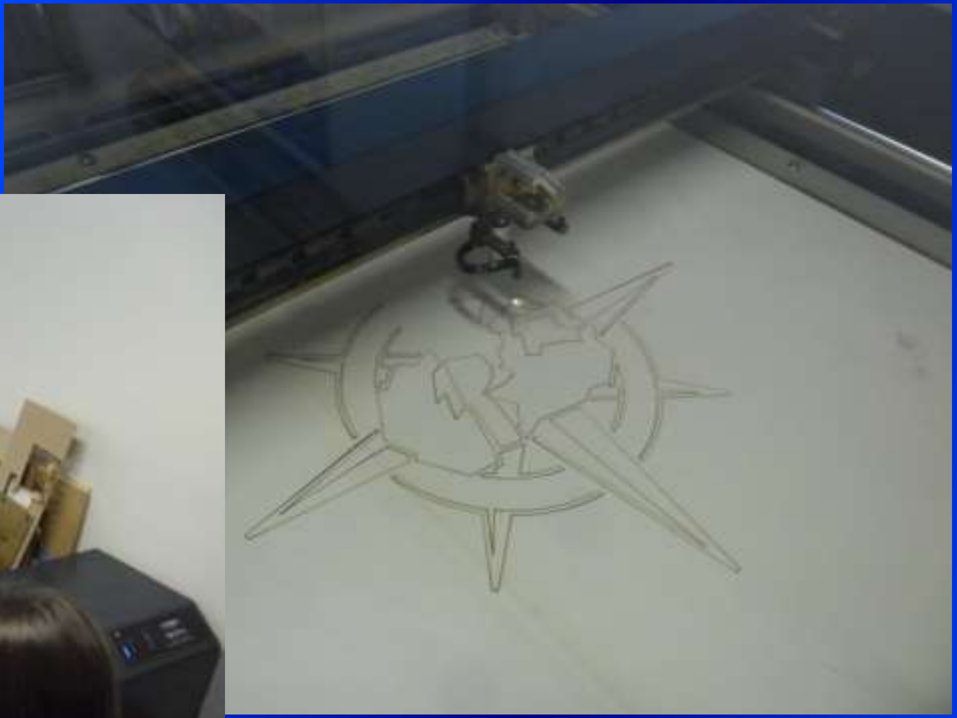


Corel Draw or Inventor

WOOMERAS

4 Making woomeras with students

4.3 CNC Laser Cutter



STEM in SACE
Key Points and Summary

STEM Project Based Learning allows students to :

- Become aware that in the Real World, Mathematics, Science, Technology and Engineering are always interconnected.

- Gain confidence in trying new things and in particular using their current knowledge to solve their project R & D challenges.

- It also encourages students TO SEEK NEW KNOWLEDGE on a needs to do and relevant basis, in order to make their project a success.

- Finally, STEM Project Based Learning allows students to make mistakes, to go back to their "drawing boards" , improve on their design by using any tools at their disposal, intellectual and physical, and finally experience a great feeling of pride when they successfully finish their project.

See our Education Minister Susan Close interviewing STEM Naval Engineering Le Fevre students about their experience as STEM Learners. This interview will soon be uploaded to the DECD website.

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STEM in SACE
Key Points and Summary

SUMMARY

There is no doubt that, without neglecting the Arts and Humanities, the future of Education, anywhere in the world will be centred on STEM skills – for a very simple reason : most of the jobs that our current students will occupy will have one way or another some STEM components.

It is therefore our duty to prepare them, and try to equip them to the best of our capabilities to successfully negotiate the challenges they will face in their professional life.

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STEM in SACE
Key Points and Summary

SUMMARY

A few quotes …

STEM Spirit

STEM in SACE
Key Points and Summary

SUMMARY

A few quotes …

STEM Spirit

STEM Education Challenge

STEM in SACE
Key Points and Summary

SUMMARY

A few quotes …

STEM Spirit

STEM Education Challenge

Reality Check

STEM in SACE
Key Points and Summary

And remember, like Rock and Roll in the 50s',

STEM is here to stay ☺

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Key Points and Summary

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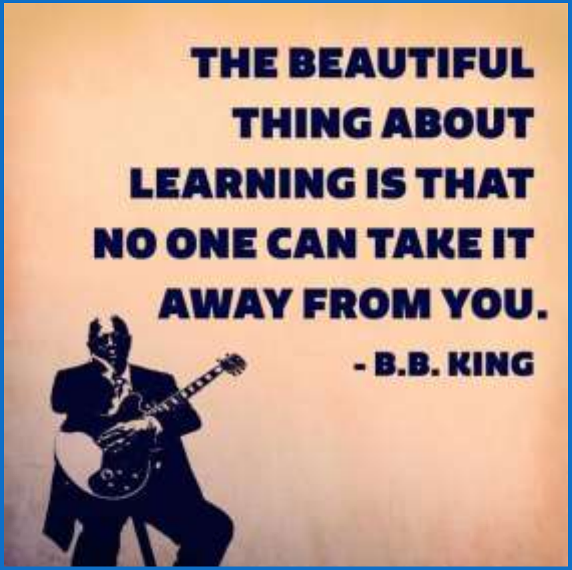

Le Fevre High School

The Maritime School of South Australia

STEM in SACE Integration

Through Project Based Learning

Thierry.Herman885@schools.sa.edu.au

Discussion / Questions

Le Fevre High School
Naval Engineering

Le Fevre High School
The Maritime School of South Australia

T. Herman

End of Presentation