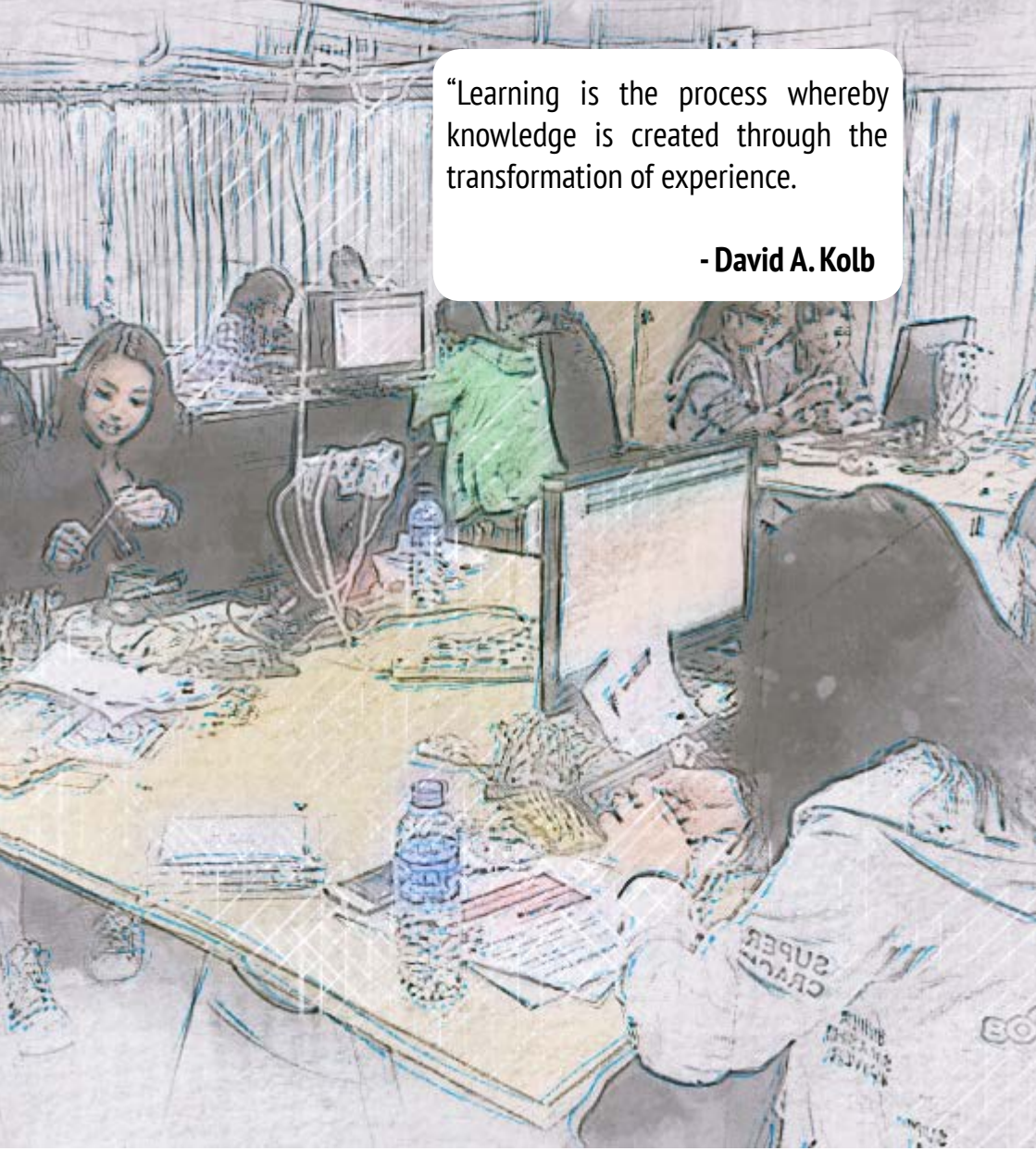

CRADLΣ

PROGRAMME BOOKLET 2018

Engaging Minds. Creating Experiences.

CONTENT

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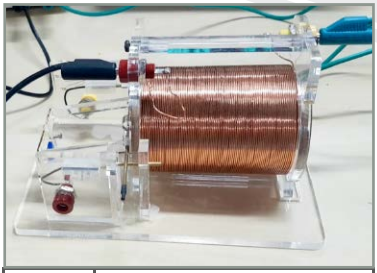

PAGE

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About Us

Director's Message

A/Prof Lim Tit Meng

CRADLΣ Director &
Chief Executive
Science Centre Singapore

"An effective way to nurture students' interest and curiosity is to make them see the relevance and impact of science and technology in real world through research and applied learning."

Students are linked to many information platforms and their learning is no longer confined to a school classroom setting. They intrinsically want to know the what, how and why of subject matters because curiosity is inborn with them. An effective way to nurture students' interest and curiosity is to make them see the relevance and impact of science and technology in real world through research and applied learning.

Students enjoy learning with hands-on minds-on activities. They also learn well through project collaboration. They should be encouraged to ask questions often and where possible try to explore and experiment to investigate topic of their interest and even innovate solutions to solve problems they identify as worthy pursuits. The ability to ask the right questions is key to good scientific research. Questions can come from observation, reading or simply imagination. The questions should lead to a hypothesis or a proposed solution that can be tested or developed within the constraints of resources available. They should learn to be resourceful and not be afraid of using instruments to help gather data or design and make gadgets for experiment or investigation. Our students are generally good in gathering known information but they have much to learn about how to deal with the grey areas and the unknown. I guess too much examination-oriented learning have made them to always look for model answers of known knowledge instead of creating new knowledge. To find a novel answer or invention is the purpose of research and development in science.

All the above involve desirable attributes we strive to develop in all the students touched by us through CRADLΣ. I am proud of my colleagues who have worked relentlessly over the past years, serving with the conviction to help students grow their innate curiosity, investigative nature and innovation power through research and applied learning in science. I am also grateful to our sponsors and partners from the corporate and education sectors for their strong support and faith in us.

Many have benefited from our programmes and mentorship, and we look forward to many more coming through our doors!

Centre for Research & Applied Learning in Science

CRADLΣ is staffed by a team of experienced scientists, educators and support staff who share a vision of making science concepts meaningful and showing their relevance through hands-on experimentation and engineering design.

Conceptualised in 2008 and established in 2012, CRADLΣ has quickly earned a reputation for its high-quality programmes. We develop workshops as well as design, test and build experimental setups in-house, practising ourselves the applied learning approach that we are promoting. This forces us to develop expertise and subject authority that we hope shows in our teaching and mentoring.

At our prototyping and research lab at Science Centre, we offer hands-on science, engineering and mathematics workshops to students and teachers. We also mentor students in research projects. Beyond Science Centre, we support hands-on teaching of science at schools by conducting on-site workshops as well as providing experimental setups and teacher training for school-owned workshop delivery. To help school-based research, we offer a series of research skills lectures, consultation for teams and provide access (including training) to specialised R&D equipment in our lab.

While our principal target is the secondary school and junior college community, we also work with students and educators from universities, polytechnics and technical institutes. In the spirit of self-initiated and life-long learning, we are further expanding our scope by offering programmes for interested individuals and non-traditional audiences – students and non-students alike.

Partnerships

Our Sponsors

Singapore's national defence R&D organisation, DSO National Laboratories create the critical edge in defence technology to multiply the SAF's combat capabilities.

Ministry of Education
SINGAPORE

The Ministry of Education directs the formulation and implementation of education policies. It has control of the development and administration of the Government and Government-aided primary schools, secondary schools, junior colleges, and a centralised institute.

Industry Partners

Together with CRADLΣ , industrial partners create authentic programmes and experiences for students. With industrial partners on board, we can draw on their expertise to allow students to view knowledge through different lenses. Such partnerships make syllabus links explicit, allow real-world applications and at the same time develop interests into possible career paths.

*Sections of the booklet are colour-coded (as illustrated on the content page)

cradle@science.edu.sg
15 Science Centre Road, Singapore 609081.

Partnerships

School Partners

ANDERSON JUNIOR COLLEGE

BUKIT PANJANG GOVT HIGH SCHOOL SINGAPORE

圣尼各拉女校
CHIJ ST NICHOLAS GIRLS' SCHOOL

華僑中學
HWA CHONG INSTITUTION

NATIONAL Junior College

CRADLΣ collaborates with schools to support curriculum innovation under our school-based workshop scheme. Partnered schools infuse STEM-based workshops into their curriculum creating more opportunities to allow experiential learning in the classroom. An example is the use of CRADLΣ's home-built diffraction kits for a cohort to measure microscopic distances. With the push for applied learning, we also support schools to provide professional development on microcontroller as well as student workshops under our school-based workshop scheme.

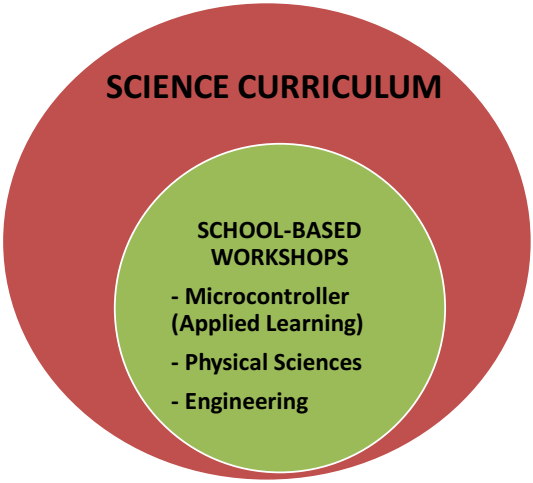
For more information on our school or industrial partnerships, please contact CRADLΣ.

**Sections of the booklet are colour-coded (as illustrated on the content page)*

Partnerships

School-Based Workshops (SBW)

Our School-Based Workshop (SBW) scheme aims to support curriculum innovation in schools. Through this scheme, schools would have the free play to incorporate the usage of CRADLΣ's equipment and kits in the classrooms in line with curriculum teaching. With our homebuilt kits, students would be able to experience authentic experimentation, allowing knowledge building through experiential learning.



The School-Based Workshop (SBW) scheme was conceived to bypass many of the logistical issues commonly encountered by schools - time constraint, transport arrangement and cost. Schools can choose to purchase or rent the kits for two weeks. The latter lessens the inventory overhead while enabling the school to conduct multiple workshops for its students at a very reasonable price.

On the facing page, the generic overview of SBW is shown. The full details will still have to be discussed and finalised on an individual basis (with CRADLΣ) prior to implementation.

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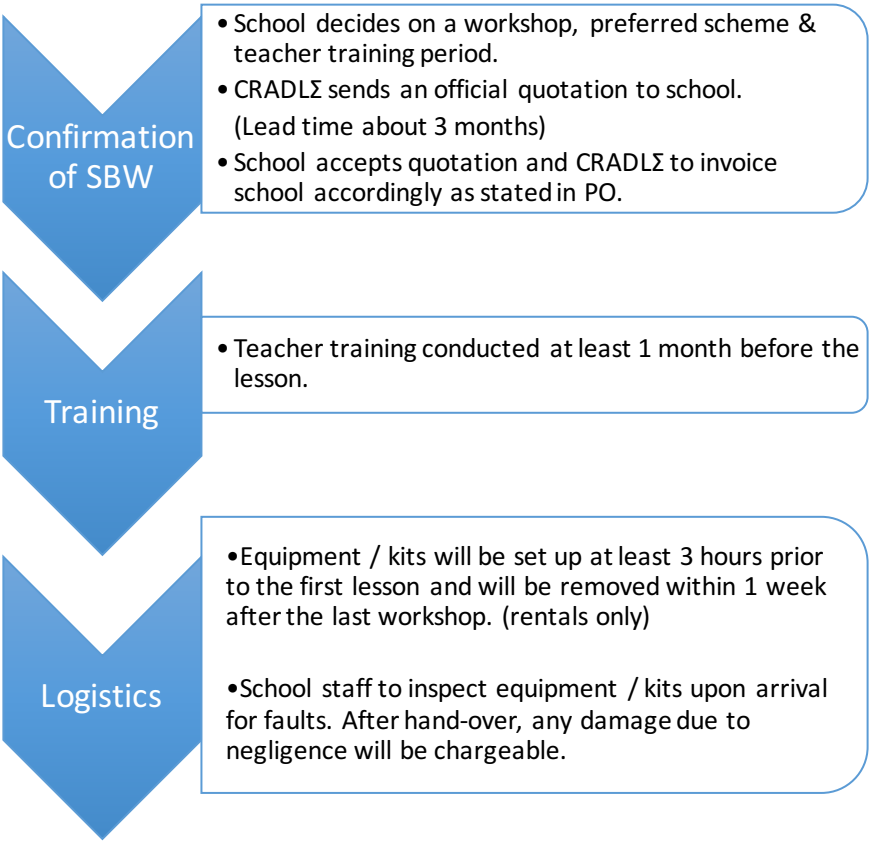
Outline of SBW Implementation Process



Other Considerations

CRADLΣ staff may observe a few lessons for internal evaluation to aid with continued improvements.
School will need to furnish a certified report of the number of participants yearly.
Pictures may be taken for documentation & publicity purposes.

To find out more about this exciting mode of workshop delivery or CRADLΣ partnership opportunities, please contact CRADLΣ for more information.

STRUCTURED

Engineering

Science, Technology, Engineering and Mathematics (STEM) is vital to our future - it is everywhere and inevitably shapes our everyday experiences. Here at CRADLΣ, the Engineering Workshops are designed to convey the concept of **logical & computational thinking** (programming), **design thinking** (prototyping) as well as the integration of subjects from various fields. It ties in with Applied Learning Programme (ALP) that **integrate concepts** usually taught as separate subjects and emphasises the **application of knowledge to real-life situations**.

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EXPERIMENTATION PROGRAMME

Physical Sciences

CRADLΣ offers a series of structured workshops designed to allow students to discover science concepts through **Experiential Learning**. The workshops feature an **independent hands-on** component that **allows students to explore and draw conclusions from the data set obtained**. These sessions demonstrate how systematic application of science concepts, not the cost of the equipment, is the key to successful and often quite sophisticated experimentation.

Sections of the booklet are colour-coded (as illustrated on the content page)

Structured Experimentation Programme (Secondary Level)

Fun with Electronics ..... Pg 15
$15 /pax (Option 1) or
$20 /pax (Option 2)
| 2 hours

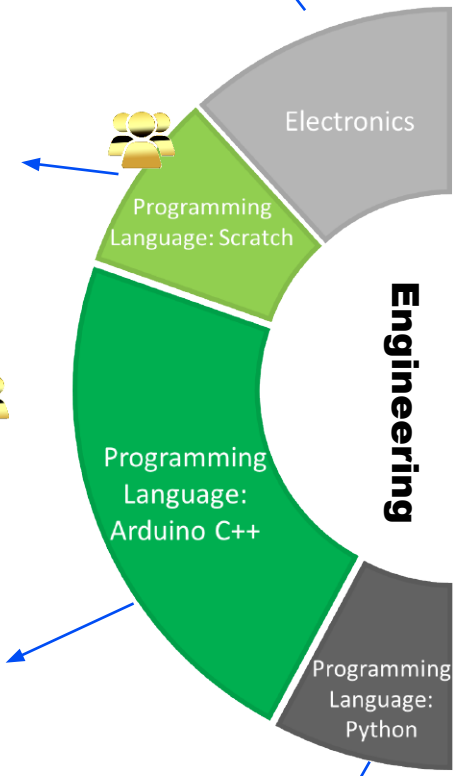
Electronics I ..... Pg 27
($25 /pax | 3 hours)

Electronics II* ..... Pg 27
($25 /pax | 3 hours)

Microcontrollers for Beginners .....
Pg 14 ($20 /pax | 3 hours)

Introduction to Sense HAT (Raspberry Pi) ..... Pg 14 ($20 /pax | 3 hours)

Game Programming with Sense HAT (Raspberry Pi)* ..... Pg 31
($20 /pax | 3 hours)



Introduction to Microcontrollers I ..... Pg 15 ($20 /pax | 3 hours)

Bluetooth Robotic Vehicle* ..... Pg 28
($80 /pax | 3 hours)

Introduction to Microcontrollers II* ..... Pg 28 ($20 /pax | 3 hours)

Datalogging* ..... Pg 27
($30 /pax | 3 hours)

Distance & Motion Sensing* ..... Pg 30
($30 /pax | 3 hours)

Smart Fan* .....Pg 29
($20 /pax| 3 hours)

Robot Arm* ..... Pg 30
($40 /pax | 3 hours)

Introduction to Python with Raspberry Pi and Sense HAT ..... Pg 16 ($25 /pax | 2.5)

Physics Modelling & Simulation .....
Pg 26 ($15 /pax | 3 hours)

* **Requires Pre-requiste**

Recommended for Lower Sec & Above

**Sections of the booklet are colour-coded (as illustrated on the content page)*

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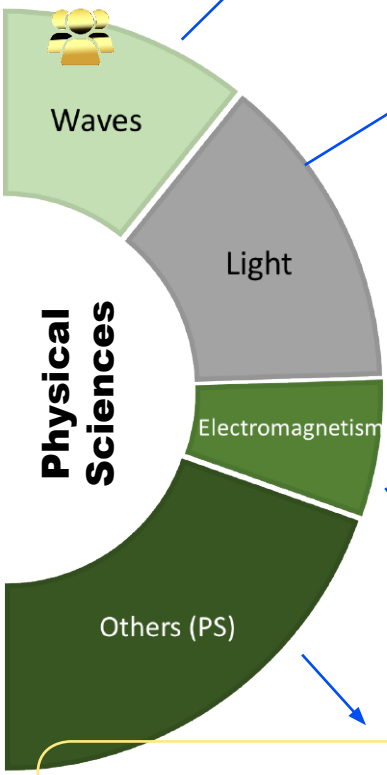
Structured Experimentation Programme (Secondary Level)

Properties of Waves ..... Pg 16
($15 /pax | 2.5 hours)

Navigating with Waves ..... Pg 18
($15 /pax | 2 hours)

Speed of Sound (Basic) ..... Pg 18
($15 /pax | 2 hours)



Microscopy in Motion ..... Pg 23
(15 /pax | 2.5 hours)

Measuring the Speed of Light (Basic) ..... Pg 19 (15 /pax | 2 hours)

Measuring the Speed of Light (Advanced) ..... Pg 20 (20 /pax | 3 hours)

Optical Spectroscopy ..... Pg 21
($30 /pax | 3 hours)

Polarised Light..... Pg 31
($15 /pax | 2 hours)

Electromagnetism..... Pg 17
($20 /pax | 2.5 hours)

Measuring Magnetic Field Strength ..... Pg 19 (20 /pax | 3 hours)

Diffusion Cloud Chamber ..... Pg 17 ($15 /pax | 2 hours)

Modern Microscopy ..... Pg 20
($15 /pax | 2 hours)

Organic Solar Cells ..... Pg 25 ($20 /pax | 3 hours)

Investigating Linear Motion & Collisions..... Pg 25
($20 /pax | 2.5 hours)

Fuel Cells ..... Pg 22
($20 /pax | 3 hours)

Superconductivity ..... Pg 24
($20 /pax | 3 hours)

Chemistry Concepts Included **Biology Concepts Included**

*Sections of the booklet are colour-coded (as illustrated on the content page)

Structured Experimentation Programme (Secondary Level)

Microcontrollers for Beginners (Scratch)

new

$20 /pax | 3 hours | recommended for Sec 1 to Sec 5 | 10⩽ pax ⩽40

Through simple block programming (Scratch), students are able to learn programming without the prior need to know the intricacies of the programming language. On top of that, block programming eliminates the confusion that may arise due to syntax errors. Students can hence focus on the logical and systematic approach to solving the problems encountered.

Furthermore, students will be taught the basic working concepts of electronic components and gain deeper understanding of microcontrollers by programming simple circuits using Scratch.

Syllabus Links:
- Physics O-level - DC Circuits (Potential divider circuit)

Introduction to Sense HAT (Raspberry Pi) using Scratch

new

$20 /pax | 3 hours | recommended for Sec 1 to Sec 5 | 20⩽ pax ⩽40

Consider a simple, portable device in the International Space Station (ISS) to monitor and indicate acceptable environmental conditions for astronauts. With the use of the environmental sensors in the Raspberry Pi Sense HAT, students can easily use Scratch to replicate the program used by the crew of ISS.

In this workshop, students will learn to use Scratch to program the Sense HAT to display messages as well as to use the environmental sensors to display the temperature, pressure and humidity and to program a Red Alert system.

Syllabus Link:
- Suitable for Applied Learning Program

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Structured Experimentation Programme (Secondary Level)

Fun with Electronics

$15 /pax (Option 1) or $20 /pax (Option 2)* | 2 hours | recommended for Sec 2 to Sec 5 | 20≤ pax ≤40

Electronics is the science of controlling electrical energy in the form of electrons by circuits that are built with electrical components. These smart gadgets play a vital role in building our 21st century technology.

In this workshop, students will be introduced to several basic electronic components (resistors, LEDs, switch, capacitors, potentiometer, transistors) and build electronic circuits utilising their properties on a breadboard (prototyping board). They will also get to assemble and bring home their own touch sensor box based on concepts learnt (option 2 only).

Syllabus Links:
- Physics O-level - Current of electricity, D.C. Circuits
- Electronics O-level - Fundamentals of electronics

**Option 2 would include a take-home touch sensor kit.*

****Arrangements can be made to deliver this workshop for a large group of students (up to 200).***


Touch Sensor Kit

Introduction to Microcontrollers 1 (Arduino C++)

MOST POPULAR

$20 /pax | 3 hours | recommended for Sec 2 to Tertiary | 10< pax <24

Microcontrollers are integrated circuits (IC) chips that are able to process input and control machines and devices based on their written program. One example is the rice cooker. A microcontroller in the cooker controls the heating coil and with its array of sensors, emulates the manual cooking of rice on a stove. In our current lifestyle, it is rare to find a product that does not involve a microcontroller at some stage of its operation. In this part, participants will have a deeper understanding of microcontrollers by programming simple circuits.

Syllabus Links:
- Physics O-level - DC Circuits (Potential divider circuit)
- Suitable for Applied Learning Program

Structured Experimentation Programme (Secondary Level)

Properties of Waves

new

$15 /pax | 2.5 hours | recommended for Sec 2 to Sec 5 | 15⩽ pax ⩽40

Waves are everywhere around us. A disturbance in a calm pond distorts the image reflected on the water surface and sends ripples outwards. The pitch of the siren of an ambulance changes as it approaches us. The way we see, hear and communicate is due to the way waves travel and transfer energy. Waves can transfer energy with little displacement of the medium [sound and water waves], or no medium at all [light waves].

In this workshop, learn about transverse and longitudinal waves, observe waves in action and how they interact with each other. Gain an understanding of the properties of waves, such as wavelength, frequency and amplitude.

Syllabus Links:

- Physics O-level: General Wave Properties

Introduction to Python with Raspberry Pi and Sense HAT

new

$25 /pax | 2.5 hours | recommended for Sec 2 to Tertiary | 20⩽ pax ⩽40

Python is a powerful programming language that is used by many tech companies such as Google, Walt Disney and NASA while the SenseHat is an add-on to the popular Raspberry Pi mini computer and comes with a suite of sensors and actuators such as temperature/humidity sensors, accelerometers and an 8x8 LED screen.

In this workshop, participants will be introduced to basic Python commands and data structures to access and control the various elements on a SenseHat as well as learn to use the Rapsberry Pi as a datalogger. This course serves as a gateway to beginners who are interested in learning this powerful programming language.

Syllabus Links:

Computing syllabus for O-level and A-Level

Suitable for Applied Learning Program

Structured Experimentation Programme (Secondary Level)

Electromagnetism

new

$20 /pax | 2.5 hours | recommended for Sec 2 to Tertiary | 15≤ pax ≤40

Electromagnetism is responsible for many phenomena encountered in our daily lives. While it was first discovered by Hans Christian Ørsted, it was Michael Faraday's breakthrough in 1821 that propelled electromagnetism into modern applications. He successfully built two devices to produce "electromagnetic rotation", one of which is now known as the homopolar motor. He further discovered electromagnetic induction and all these led to the foundation of modern electromagnetic technology, i.e. DC motors and AC generators.

In this workshop, students will learn the basics of electromagnetism, make their own homopolar motor and experience the phenomenon of electromagnetic induction. Students will be able to observe and investigate the turning effect on a current-carrying coil and the effects of a changing magnetic field on a conductor.

Syllabus Links:

- Physics O-level: Electromagnetism, Electromagnetic Induction

Diffusion Cloud Chamber

$15 /pax | 2 hours | recommended for Sec 2 to Tertiary | 10≤ pax ≤24

What does meteorology have to do with particle physics? In this workshop, participants will learn how a serendipitous observation led to the development of the cloud chamber particle detector by Charles Wilson (Nobel prize 1927), according to Lord Rutherford the "most wonderful and original instrument in scientific history". Exploiting concepts such as condensation, evaporation, and super-saturation, participants will build their own cloud chambers and observe some of the natural ionising radiation surrounding us.

Syllabus Links:

- Physics O-level: Pressure, States of matter, Evaporation/condensation, Electromagnetic spectrum

- Chemistry O-level: Particulate nature of matter

- Physics A-Level: Energy, Thermal physics, Nuclear physics

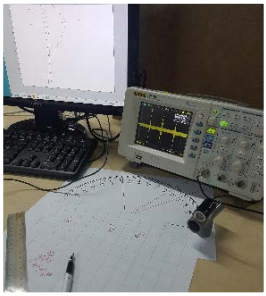
Structured Experimentation Programme (Secondary Level)

Navigating with Waves

$15 /pax | 2 hours | recommended for Sec 2 to Tertiary | 10⩽ pax ⩽20

How can planes navigate in fog? How can a GPS (global positioning system) receiver determine its position (and why is it sometimes considerably off the mark)? Radio waves penetrate fog and clouds and have mostly obsoleted the lighthouses of old.

In this workshop, we use ultrasonic waves as a model for radio waves. Students use ultrasonic receivers and an oscilloscope to determine their position in the lab using direction (angulation) and time (lateration) measurements.



Syllabus Links:
- Physics O-Level: Waves, Interpretation of oscilloscope waveforms
- Physics A-Level: Wave motion, Use of oscilloscope
- Mathematics O-Level: Geometry and measurement

Speed of Sound (Basic)

$15 /pax | 2 hours | recommended for Sec 2 to Tertiary | 10⩽ pax ⩽24

We use sound for numerous purposes such as to communicate with people, for entertainment (music and movies) and even as a second form of sight. In physics, sound is an excellent model for introducing wave phenomena in general.

In this workshop, students will learn to use an oscilloscope to measure the time it takes sound to travel for a given distance, and accurately determine the speed of sound. They will also be able to observe the phenomenon of sound reflection (echos).

Syllabus Links:
- Physics O-Level: Waves (general properties, sound), Interpretation of oscilloscope waveforms

Structured Experimentation Programme (Secondary Level)

Measuring Magnetic Field Strength

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Besides gravity, electromagnetism is the next most encountered force in our everyday life. It is of immense practical importance and underlies numerous innovations that propelled humanity into the modern age – e.g. electricity generation (motors and transformers), modern communications and optics.

In this workshop, participants will re-enact Ørsted's experiment that shows that an electric current gives rise to a magnetic field. They will measure magnetic forces using a current balance, derive the magnetic field constant μ_0 and use it to determine the strength of Earth's magnetic field.

Syllabus Links:

- Physics O-Level: Turning effect of forces, Mass and weight, Magnetism, Electromagnetism

- Physics A-Level: Forces, Electromagnetism

Measuring Speed of Light (Basic)

$15 /pax | 2 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

The speed of light is one of the most important constants in science and technology. It is so large that historically, it was argued whether light is moving at all! In this workshop, participants will learn to use an oscilloscope to perform high-speed measurements and determine the time it takes a laser beam to travel across an optical setup.

Syllabus Links:

- Physics O-Level: Wave motion, Light, Reflections, DC circuits, Interpretation of oscilloscope waveforms

- Physics A-Level: Wave motion, Use of oscilloscope

Structured Experimentation Programme (Secondary Level)

Workshops (Sec)

Measuring Speed of Light (Advanced)

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

In the advanced version of the workshop, participants will get additional exposure to laboratory equipment (signal generator) and not just measure the speed of light, but also investigate some of the difficulties (and solutions) in achieving sufficiently fast response of the optoelectronic detector registering the laser beam. Participants thus gain an appreciation how multiple scientific concepts/phenomena (in this case not just light, but also the wave nature of electric signals traveling in cables and electrostatic capacitance) show up in any real scenario and need to be taken into account.

Syllabus Links:

- Physics O-Level: Wave motion, Light, Reflections, DC circuits, Interpretation of oscilloscope waveforms

- Physics A-Level: Wave motion, Use of oscilloscope, Photoelectric effect

Workshops (Tertiary)

Modern Microscopes

$12 /pax | 2 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽30

The power to make tiny objects or structures visible has greatly expanded our understanding of nature, and has made micro- and nanotechnology possible. Today, it is even possible to observe individual atoms and molecules! In this interactive session, students will learn about the principles of projective vs. scanning microscopy and experience live demonstrations of common microscope types used in research laboratories – an optical microscope, an atomic force microscope, and a scanning electron microscope.

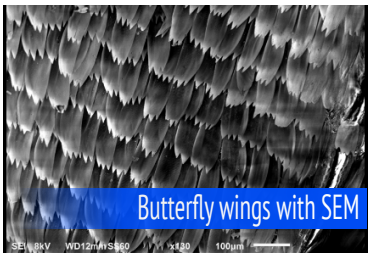
Syllabus Links:

- Physics (O-level): Newtonian mechanics, light, electromagnetic spectrum, electromagnetism

- Chemistry (O-level): atomic structure

- Physics (A-level): Forces, electromagnetism, nuclear physics

- Chemistry (A-level): atomic structure, nanomaterials



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Structured Experimentation Programme (Secondary Level)

Optical Spectroscopy

MOST POPULAR

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Spectroscopy is a class of techniques that investigates how radiation (such as, but not limited to light) is affected by interactions with matter. Our understanding of the world is largely based on spectroscopy – for example, many chemical elements were first discovered through their spectra, and our knowledge how atoms and molecules are built has been almost entirely derived from spectroscopic observations.

In this non-mathematical workshop, students build their own spectroscopes (which they can keep and use for further investigations) and use them to observe spectra of various light sources, culminating in the observation of Fraunhofer spectral lines in daylight. The characteristic properties of different types of spectra (atomic, molecular and solid-state origin) are qualitatively explained.

Syllabus Links:

- Physics O-Level: Light, Thin lens, Real & virtual images, Electromagnetic spectrum

- Physics A-Level: Waves, Superposition (diffraction), Energy levels, Line spectra

- Chemistry O-Level: Atomic structure, Covalent bonding, Chemical elements/periodic table

- Chemistry A-Level: Atomic structure, Orbitals, Chemical bonding

"Learnt a lot about optical spectroscopy and even built my own spectroscope! Amazing workshop and I can use the spectroscope when at home or anywhere else to learn more about light sources around us."

-Upper Secondary Student

Structured Experimentation Programme (Secondary Level)

Fuel Cells

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Fuel cells hold great promise in today's global relentless search for the demand and supply of clean energy. In this workshop, participants will learn about different fuel cell technologies. They will experiment with a Proton Exchange Membrane (PEM) fuel cell and determine how efficient it is in converting hydrogen fuel into electrical energy, and how efficiently hydrogen fuel is generated by electrolysis.

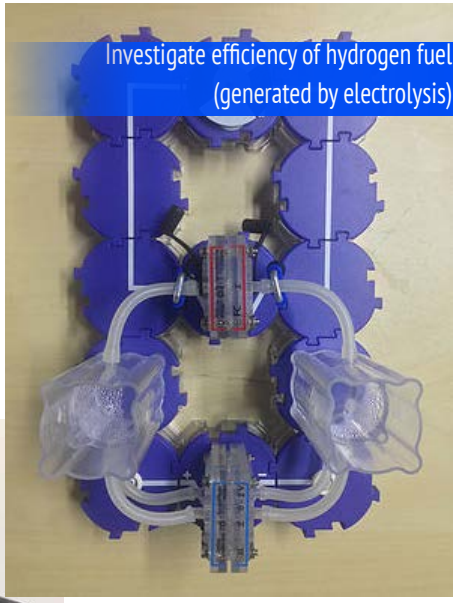
Syllabus Links:

- Physics O-Level: Energy, Work & power, States of matter, Current of electricity, DC circuits

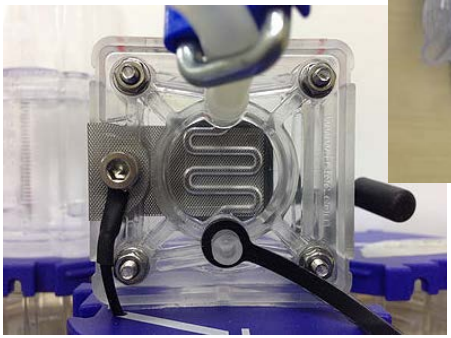
- Physics A-Level: DC circuits, Efficiency

- Chemistry O-Level: Chemistry of reactions (electrolysis, energy), Stoichiometry and mole concept, Air

- Chemistry A-Level: Electrochemistry



Investigate efficiency of hydrogen fuel (generated by electrolysis)



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Microscopy in Motion

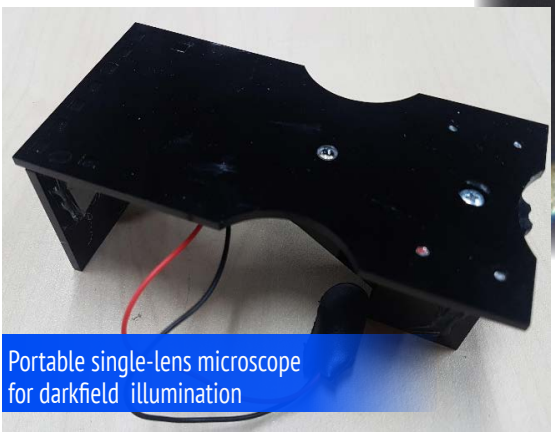
new

$15 /pax | 3 hours | recommended for Sec 3 to Sec 5 | 20⩽ pax ⩽40

Darkfield & Differential Interference Contrast (DIC) Microscopy are popular techniques to study unstained transparent cells and motile cells. The illumination techniques create good contrast between samples and the background, making fine details more pronounced. Commonly these techniques are used to observe pond organisms e.g. protozoas, algae.

Through group exploration and reasoning, participants will understand the principles of light microscopy. The workshop will have students carry out slides preparation and observation of biological samples under dark-field microscopy. Participants will also appreciate the complexity of DIC Microscopy through simple activities and demonstrations.

Syllabus Links:
- Physics O-level: Light (Ray diagrams, focal length)
- Biology O-level: Reproduction in Plants (Observing female & male structures)
- Elementary Mathematics O-level: Trigonometric Ratio



Portable single-lens microscope for darkfield illumination

View stamen using darkfield illumination

Structured Experimentation Programme (Secondary Level)

Superconductivity

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

The electrical conductivity of certain materials changes dramatically as they are cooled to sufficiently low temperatures. In 1911, Heike Kamerlingh-Onnes found that some materials might enter a state where electrical resistance completely disappears.

In this workshop, students will apply Ohm's law and the 4-wire (Kelvin) technique to accurately measure small resistances. They will observe the resistance of a ceramic superconductor material diminish – and suddenly disappear completely – as the material is cooled down using liquid nitrogen.

Syllabus Links:

- Physics O-Level: Thermal properties of matter, Current of electricity, DC circuits

- Physics A-Level: DC circuits, Modern physics, Temperature and ideal gases

Superconductivity - Measuring resistance of superconducting ceramics

Organic Solar Cell

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15 Science Centre Road, Singapore 609081.

Structured Experimentation Programme (Secondary Level)

Organic Solar Cells

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 20≤ pax ≤40

The advent of solar cells in 1883 by Charles Fritts was the beginning of the vast advancement of methods to harness the renewable energy as a form of clean energy. In the 1990s, the notion to mimic photosynthesis has led to the development of Organic Solar Cells. This technology replaces chlorophyll in green plants with organic dyes (such as blueberry extract) and uses other electrolytes and catalysts to simulate the internal environment of a leaf.

In this workshop, students will fabricate and assemble an organic solar cell. Using our homebuilt kit, students will perform characterization of their solar cell and plot a graph to identify the maximum power of the solar cell.

Syllabus Links:

- Physics O-level: Current of Electricity (I-V graph)

- Chemistry O-level: Redox Reaction

Investigating Linear Motion & Collisions

$20 /pax | 2.5 hours | recommended for Sec 3 to Tertiary | 15≤ pax ≤30

Everything moves in our universe. In 1687, Sir Isaac Newton's published his three laws of motion, establishing the foundation of classical mechanics. Quantities that describe motion can be calculated precisely. Motion leads to collision, where two or more bodies exert forces on each other for a relatively short time.

Through this workshop, students will be able to investigate the relationship between a body and the forces acting upon it, and its motion in response to those forces. Students will also observe and compare between elastic and inelastic collisions and determine momentum as a conserved physical quantity.

Syllabus Links:

- Physics O-level & A-Level: Dynamics (Newton's Laws of Motion, Linear Momentum)

"Interesting experiments to validate current laws of physics"
-Upper Secondary Student

Structured Experimentation Programme (Secondary Level)

Physics Modelling and Simulation using Python

$15 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Science makes extensive use of models to describe reality. The predictive powers of models are also the foundation of technology/engineering. However, even the application of simple models can quickly result in challenging mathematical problems. Numerical simulations on computers are a much easier way to understand the behavior of a model.

In this workshop, students formulate mathematical models of simple mechanical systems such as the motion of projectiles including air drag, the non-harmonic motion of a physical pendulum, or the motion of a planet. They get introduced to the principles of solving the equations of motion by numerical integration and program computers using the Python language accordingly.

Syllabus Links:

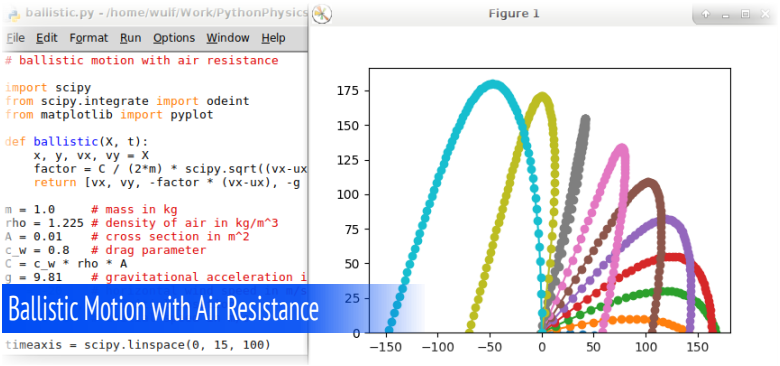
- Physics O-Level: Kinematics, Dynamics, Newton's law

- Physics A-Level: Forces, Dynamics, Energy, Gravitational field, Motion in a circle, Oscillations

- Computing O-Level: Algorithms, Programming

- Mathematics O-Level: Rate and speed, Functions and graphs, Problems in real-world contexts, Geometry and measurement

- Mathematics A-Level: Functions and graphs, Vectors, Sequences and series, Calculus, Numerical methods



cradle@science.edu.sg

15 Science Centre Road, Singapore 609081.

Structured Experimentation Programme (Secondary Level)

Electronics Workshop I

new

$25 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Electronics is not just a key enabling technology of the modern age – it can also be a fascinating hobby that has led many to a fulfilling high-tech career. In part I of this workshop, participants will learn about discrete components – resistors, capacitors, diodes and transistors – and build/investigate basic analogue circuits (high/low pass filters, rectifiers, amplifiers, and flip-flops) with the help of multimeters, signal generators and oscilloscopes.

Syllabus Links:

- Physics O-Level: Current of electricity, DC circuits

- Physics A-Level: Current of electricity, DC circuits, AC circuits

- Electronics O-Level: Systems, Fundamentals of electricity, Analogue electronics

Electronics Workshop II

$25 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

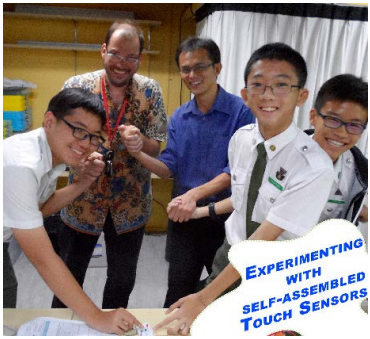
Pre-requisite: Electronics Workshop I

In this follow up workshop, participants make the transition to the use of standard integrated circuits (operational amplifiers and 555 timer chip) and how their behaviour can be custom-configured via external components to suit a wide range of applications.

Syllabus Links:

- Physics (A-level): Current of electricity, DC circuits, AC circuits

- Electronics (O-level): Systems, Fundamentals of electricity, Analogue electronics, Digital electronics (comparator, timing and counting circuits)

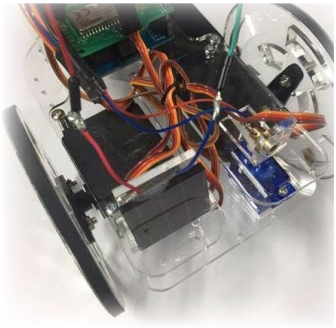


Structured Experimentation Programme (Secondary Level)

Bluetooth Robotic Vehicle (Arduino C++)

$80 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽18
Pre-requisite: Introduction to Microcontrollers 1

Robotics is a fast growing industry that is estimated to be worth tens of billions of dollars. Using the Arduino Uno and the Annikken Andee, participants will learn to program a graphical user interface (GUI) for an Android device. The GUI will subsequently be used to control a self-assembled robotic vehicle via Bluetooth communications. Computational and systems thinking will be required to assemble and program the final prototype from its constituent components.



Syllabus Link:

- Suitable for Applied Learning Program

Introduction to Microcontrollers 2 (Arduino C++)

MOST POPULAR

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24
Pre-requisite: Introduction to Microcontrollers 1

Building on the previous workshop, Microcontrollers 1, participants will be introduced to more electronic components and programming syntax. They will learn more advanced methods of controlling the new components to achieve more complex results.

Syllabus Link:

- Suitable for Applied Learning Program

Structured Experimentation Programme (Secondary Level)

Datalogging (Arduino C++)

MOST POPULAR

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽20
Pre-requisite: Introduction to Microcontrollers 1 & 2

Data logging is a common application in many science laboratories. In this workshop, participants will learn how to integrate micro-controllers, sensors and data storage devices to make their very own data loggers. The final activity will see participants designing and building their own air quality monitoring system that logs data as well as sound an alarm once the threshold values of certain variables are crossed.

Syllabus Link:

- Suitable for Applied Learning Program

Smart Fan (Arduino C++)

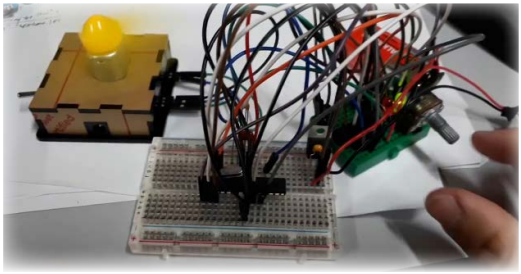
$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24
Pre-requisite: Introduction to Microcontrollers 1 & 2

Ever wondered how an automated venting system works? Imagine yourself building a smart fan that can sense the temperature and control the motor accordingly. In this workshop, participants will learn the necessary components to do just that, while learning about physics concepts such as convection and fan blade aerodynamics.

Syllabus Links:

- Physics O-level and A-Level - Electromagnetism (DC Motors)

- Suitable for Applied Learning Program

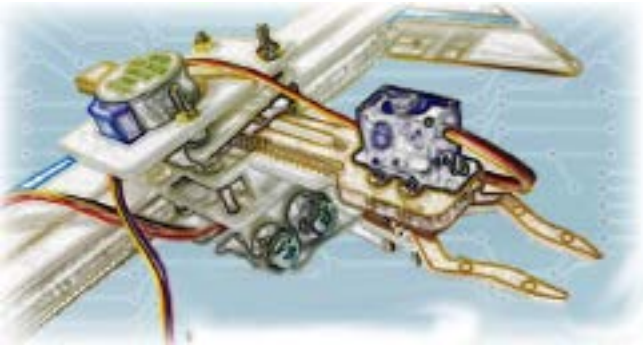


Structured Experimentation Programme (Secondary Level)

Robot Arm (Arduino C++)

$40 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽18
Pre-requisite: Introduction to Microcontrollers 1 &2, Smart Fan

In this workshop, participants will assemble a simple XY Cartesian robot arm using stepper and servo motors. Participants will learn about Darlington arrays, stepper motors and write functions to control the direction and speed of rotation. Serial communications between the computer and the Arduino will be used, to establish manual control over the robot arm.
Syllabus Link:
- Suitable for Applied Learning Program



Distance & Motion Sensing (Arduino C++)

MOST POPULAR

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽20
Pre-requisite: Introduction to Microcontrollers 1 & 2

In this workshop, participants will learn about the science behind the different distance and motion sensors and integrate them with components learnt in the Introduction series to come up with real life applications. Further applications to these sensors can be found in the field of robotics.
Syllabus Link:
- Suitable for Applied Learning Program

Structured Experimentation Programme (Secondary Level)

Game Programming with Sense HAT (Raspberry Pi) using Scratch

new

$20 /pax | 3 hours | recommended for Sec 1 to Sec 5 | 10⩽ pax ⩽40

Pre-requisite: Introduction to Sense HAT (Raspberry Pi) using Scratch

Remember Pong or Snake? These may be simple games to play but is the programming behind these simple games really that straight-forward? Game programming, even for the simplest of games, requires careful planning and logical thinking. In this workshop, participants will be required to use their logical thinking skills to create an interactive game on the Sense HAT's LED display using Scratch to program the joystick and accelerometer function in the Sense HAT.

Syllabus Links:

-Suitable for Applied Learning Program

Polarised Light – (planned for 3rd quarter 2018)

new

$15 /pax | 2 hours | recommended for Sec 3 to Tertiary | 15⩽ pax ⩽30

Light, being a transverse wave, can assume two distinct polarisation states which are commonly exploited by sunglasses, agricultural/chemical/food science instruments, optical measurement instruments, liquid crystal displays, photographic filters, and many more. In the workshop, students will use linear polarisers, analysers, and optoelectronic equipment to test Malus' law, investigate the degree of polarisation of specular reflected light (Brewster angle and Fresnel formulas), and explore the effect of birefringent and optically active (chiral) materials on polarisation.

Syllabus Links:

- Physics O-Level: General wave properties, Light (reflection/refraction)

- Physics A-Level: Oscillations and waves

- Chemistry A-Level: Isomerism (chiral centres, optically active substances)

Structured Experimentation Programme (Tertiary Level)

Electronics I ..... Pg 27
($25 /pax | 3 hours)

Electronics II* ..... Pg 27
($25 /pax | 3 hours)

Introduction to Microcontrollers I ..... Pg 15 ($20 /pax | 3 hours)

Bluetooth Robotic Vehicle* ..... Pg 28
($80 /pax | 3 hours)

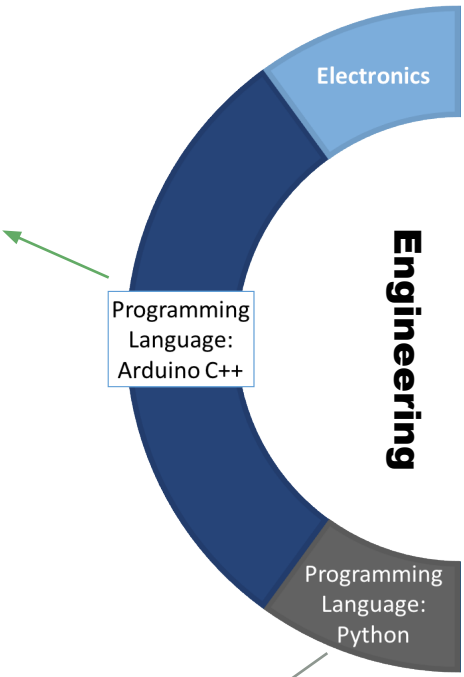
Introduction to Microcontrollers II* ..... Pg 28
($20 /pax | 3 hours)

Datalogging* ..... Pg 29
($30 /pax | 3 hours)

Distance & Motion Sensing* ..... Pg 30
($30 /pax | 3 hours)

Smart Fan* .....Pg 30
($20 /pax| 3 hours)

Robot Arm* ..... Pg 30
($40 /pax | 12 hours)



Introduction to Python with Raspberry Pi and Sense HAT ..... Pg 16 ($25 /pax | 2.5 hours)

Physics Modelling & Simulation ..... Pg 26
($15 /pax | 3 hours)

* **Requires Pre-requiste**

Chemistry Concepts Included

**Sections of the booklet are colour-coded (as illustrated on the content page)*

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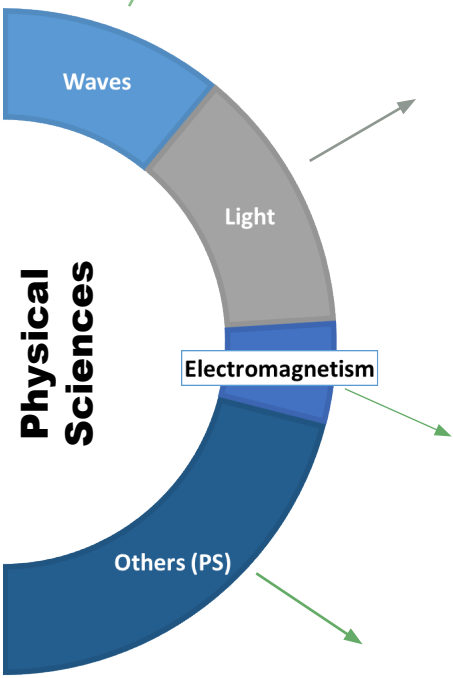
Structured Experimentation Programme (Tertiary Level)

Navigating with Waves ..... Pg 18
($15 /pax | 2 hours)

Speed of Sound (Basic) .....
Pg 18 ($15 /pax | 2 hours)

Speed of Sound (Advanced) .....
Pg 34 ($20 /pax | 3 hours)



Measuring the Speed of Light (Basic) ..... Pg 19
(15 /pax | 2 hours)

Measuring the Speed of Light (Advanced) ..... Pg 20
(20 /pax | 3 hours)

Optical Spectroscopy .....
Pg 21 ($30 /pax | 3 hours)

Diffraction as a Metrology Tool.....
Pg 34 ($20 /pax | 3 hours)

Polarised Light..... Pg 31
($15 /pax | 2 hours)

Electromagnetism..... Pg 17
($20 /pax | 2.5 hours)

Measuring Magnetic Field Strength
..... Pg 19 (20 /pax | 3 hours)

Diffusion Cloud Chamber .....
Pg 17 ($15 /pax | 2 hours)

Modern Microscopy .....
Pg 20 ($15 /pax | 2 hours)

Organic Solar Cells ..... Pg 25
($20 /pax | 3 hours)

Investigating Linear Motion & Collisions..... Pg 25
($20 /pax | 2.5 hours)

Fuel Cells ..... Pg 22
($20 /pax | 3 hours)

Superconductivity ..... Pg 23
($20 /pax | 3 hours)

Electronic Structure of Semiconductors..... Pg 36
($20 /pax | 3 hours)

Balmer's Series & Bohr's Atomic Model..... Pg 35 ($20 /pax | 3 hours)

AC Circuit Analysis..... Pg 36
($15 /pax | 2 hours)

Sections of the booklet are colour-coded (as illustrated on the content page)

Structured Experimentation Programme (Tertiary Level)

Diffraction as a Metrology Tool

MOST POPULAR

$20 /pax | 3 hours | recommended for Tertiary only | 10≤ pax ≤24

In early 18th century, Sir Isaac Newton proposed that light must be made up of particles to explain its straight-line propagation. It wasn't until the early 19th century that the wave theory of light gained popularity when Thomas Young demonstrated diffraction effects using two closely spaced slits. This laid the foundation for a modern understanding of optics, including breakthrough applications like crystal/molecular structure analysis using X-ray diffraction.

In the workshop, students will explore the diffraction patterns generated by gratings and single slits, and use them to determine the wavelength of light or the size of microscopic structures.

Syllabus Link:
- Physics A-Level: Superposition (diffraction)


Diffraction as Metrology Tool

Speed of Sound (Advanced)

$20 /pax | 3 hours | recommended for Tertiary only | 10≤ pax ≤24

In physics, sound is an excellent model for demonstrating wave phenomena in general. In this workshop, students will use a signal generator and oscilloscope to generate/investigate both traveling and standing (stationary) waves.

The speed of sound will be determined in 3 different ways: 1) based on the time of travel; 2) by determining the wavelength of a standing (stationary) wave; and 3) by determining the resonance frequencies of a waveguide.

Syllabus Links:
- Physics O-Level: Waves (general properties, sound), Interpretation of oscilloscope waveforms
- Physics A-Level: Oscillations and waves (resonance, frequency/wavelength determination), Superposition (stationary waves), Use of oscilloscope

Balmer Series & Bohr's Atomic Model

MOST POPULAR

$20 /pax | 3 hours | recommended for Tertiary only | 10⩽ pax ⩽24

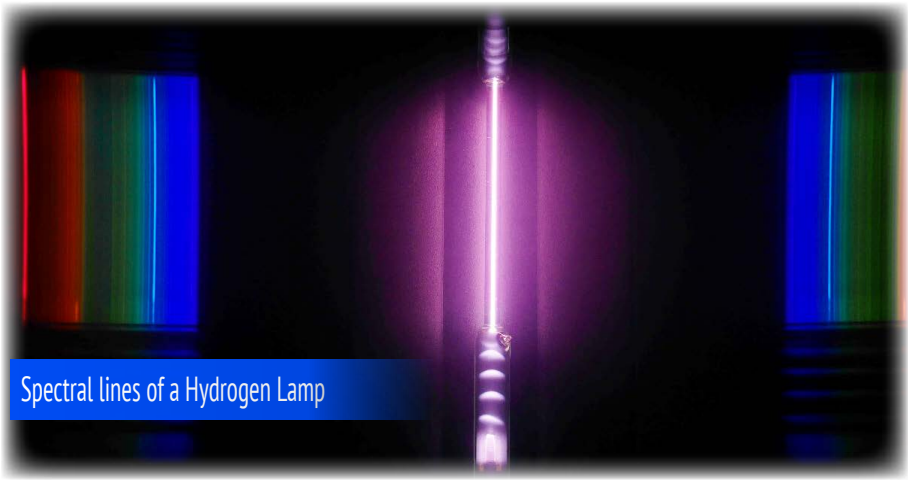
Soon after the introduction of spectral analysis in the 19th century, an empirical relation for the wavelengths of spectral lines of hydrogen atoms was found (Rydberg formula). The physical reason for this relation only became clear with the introduction of a hydrogen atom model by Niels Bohr. While Bohr's atomic model is not quite right from today's perspective, it introduces key characteristics of quantum physics (e.g. de Broglie waves) at a level that is easily within students' reach.

In the workshop, students will use a diffraction grating to measure the wavelengths emitted by a hydrogen lamp. Through careful analysis, they will not only derive the Rydberg constant but also identify the quantum numbers (electron shells) associated with each spectral line.

Syllabus Links:

- Physics A-Level: Motion in a circle, Electric field, Energy, Quantum physics (energy levels, line spectra, wave-particle duality, photons), Superposition (diffraction)

- Chemistry A-Level: Atomic structure (energy levels, principal quantum numbers)



Spectral lines of a Hydrogen Lamp

Structured Experimentation Programme (Tertiary Level)

Electronic Structure of Semiconductors

$20 /pax | 3 hours | recommended for Tertiary only | 10⩽ pax ⩽24

Semiconductors are the basis for all the electronic gadgets we use in our everyday lives. This workshop introduces the valence / conduction band model and how it explains the rectifying characteristics of p-n junctions. Students will use temperature dependent measurements of the current-voltage relationships of diodes to determine the size of the semiconductor band gap (forbidden zone) as well as the charge of an electron.

Syllabus Links:

- Physics A-Level: Quantum physics (energy levels), Thermal physics, Current of electricity and DC circuits

AC Circuit Analysis (for Mathematics & Mathematically inclined students)

$15 /pax | 2 hours | recommended for JC to Tertiary | 12⩽ pax ⩽24

Aside from its technological relevance, the analysis of AC circuits is a model showcase for the application of mathematical techniques to science/engineering problems that is specifically listed as a possible context for exam questions in the A-level mathematics syllabi.

Participants should have some familiarity with calculus, complex numbers, and linear algebra (vectors and matrices); special physics knowledge is not required. They will use calculus to formulate equations describing AC circuits, transform them to matrix form, and solve them in terms of (complex) eigenvalues and –vectors. They will build the circuits on a breadboard and, using oscilloscopes, compare observed behaviour with their mathematical predictions.

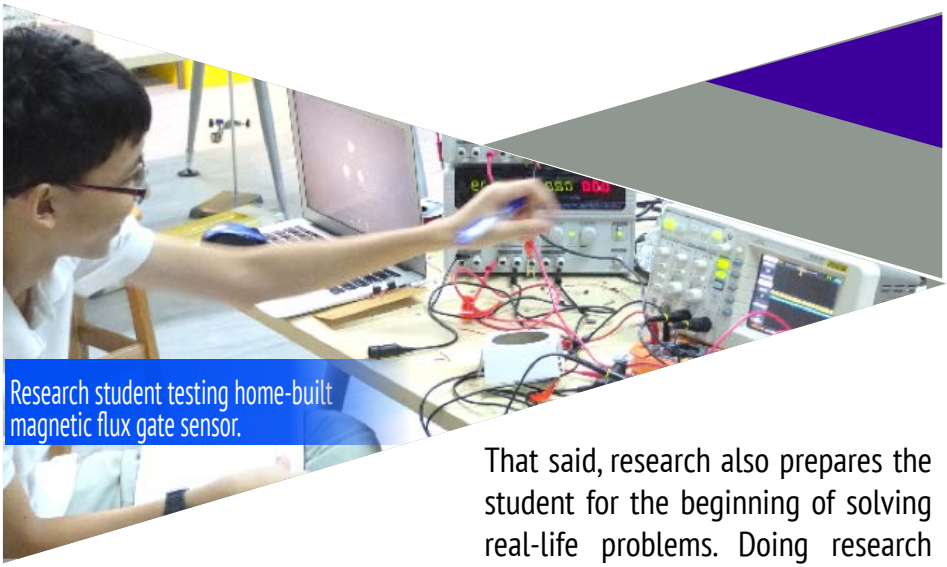
Syllabus links:

Mathematics (A-level): Functions, vectors, Complex numbers, Calculus, Differential equations

Further Mathematics (A-level): Complex numbers, Differential equations, Matrices and Linear spaces

Physics (A-level): Damped and forced oscillations, Current of electricity, Electromagnetic induction, Alternating current. Content is also closely related to quantum mechanics.

INNOVATION & RESEARCH PROGRAMME



Research student testing home-built magnetic flux gate sensor.

Exposing students to the research process gives them a different perspective than simply presenting theories from textbooks, or even research from academic journals. Furthermore, involving classes or student projects in industry research exposes students to real world environments and expectations.

That said, research also prepares the student for the beginning of solving real-life problems. Doing research creates life-long & resilient learners, learning that involves making mistakes while pursuing the joy of discovery.

Our programmes (including our Work Experience Programme (WEP), Research Lecture Series and collaborations with school including School-based Research Projects, School-Partnered WEP) help foster scientific habits of mind through science reseach.

Sections of the booklet are colour-coded (as illustrated on the content page)

School-Based Research Projects

Introduction

Schools looking to embark on student projects can tap on CRADLΣ's expertise in mentoring student projects. At CRADLΣ, we are staffed with Research Mentors who can mentor your students and provide the advice for their projects. There is also a suite of prototyping and measurement equipment available at CRADLΣ to support the needs of the project.

Our team of Research Mentors has extensive experience in mentoring students for projects, events and competitions such as the Singapore Science and Engineering Challenge (SSEF), MOE's Science Mentorship Programme (SMP), the National Science Challenge (NSC), the Singapore International Science Challenge (SISC) and more. Do refer to the facing page for a list of past projects.

Do contact CRADLΣ if you would like to explore student research opportunities with us.

Award-winning project on
Semi-Autonomous Pond Cleaner

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15 Science Centre Road, Singapore 609081.

Past Projects

Engineering

- The development of an open-source low cost bioprinter and standard protocol for bioprinting
- Investigation of Aerogel properties
- Investigation and fabrication of superhydrophobic surfaces
- Design, characterisation and optimization of a human-motion-based renewable energy harvesting system
- Absorbance/Fluorescence Spectrometer

Physics & Mathematics Related

- To investigate electrical power generation from a solid-state heat pump
- New piezoelectric energy harvester design to produce high power at low frequency
- Energy harvester design to produce high power output from composite PFCB cantilever at low frequency for the same magnitude of external vibration
- Development of a fluxgate magnetometer
- Acoustic modes and resonances
- Radio Direction Finding
- Investigating Piezoelectricity as future power source
- Reconstruction of a surface grid using laser assisted image analysis
- Detection of water bodies using computer vision
- SONAR applications
- Characterization of gold nanoparticles generated from a sputter-coat machine

Chemistry / Environmental Science

- The effectiveness of an organic anti-bacterial spray as a repellent to common bacteria found on table-tops
- Investigation of chitosan graphene oxide composite in water filtration
- To investigate common materials that can be re-used / recycled as effective oil sorbents
- Recycling natural organics into useful bio-materials
- Investigate the effectiveness of titanium dioxide coated photocatalytic filter
- Electrochemical Energy of Fruits and Vegetables
- To investigate the strength and water resistance of paper made from fibres of different fruits

Lectures

What Makes a Good Science & Engineering Project?

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40≤ pax ≤200

Aerospace engineer and scientist Theodore von Kármán, who directed the Guggenheim Aeronautical Laboratory at Caltech and was involved in founding NASA's Jet Propulsion Laboratory, is credited with formulating a simple distinction between science and engineering, which is "science seeks to understand what is, while engineering seeks to create what never was". While the goal of science is fundamentally different from that of engineering, they both depend on each other in order for scientists and engineers to come up with new useful applications. In this talk, the speaker will share his/her view on the qualities that increase the chances of a project to result in good science and successful engineering.

Literature Review

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40≤ pax ≤200

How often have you embarked on a research project in earnest before discovering that it is fundamentally flawed? Or try to decipher a scientific journal but are unable to make any sense of it? Good research builds on previous findings in order not to waste resources and cleverly avoid past mistakes. Hence Literature Review is a vital skill for all budding researchers. This lecture will also cover some search engine key phrases to help sift through that mountain of online information.

Methodology & Data Collection

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40⩽ pax ⩽200

A well thought action plan for your research is half the battle won. Just as important are the types of data collected, how the right type of data will give your solution more depth and credibility. Learn the ways to plan your research as well as the types of data that can / should be collected.

Data Analysis

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40⩽ pax ⩽200

How can we make use of data to gain insight on what is happening in our experiment? The answer is data analysis. In this lecture, students will have a better understanding of how to discover important patterns in the data collected, how to interpret and then communicate your results to have the biggest possible impact. Students will also learn some of the basic statistical methods like mean, standard deviation and t-test, which will be useful when discussing their research project.

Writing a Scientific Report

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40⩽ pax ⩽200

Scientific reports can serve to both document and communicate research. The quality of writing can greatly affect the perception and reader response towards the underlying research – and a poorly written article may even be rejected for publication in reputable journals. Good scientific writing also follows a somewhat different set of rules than literary prose. This talk will highlight what information needs to be captured in a report, and how it can be presented to meet the expectations of potential readers and reviewers alike.

Lectures

Scientific Poster & Presentation Skills

MOST POPULAR

FREE **or** $150 @ school | 1 hour | recommended for Sec 3 to Tertiary | 40≤ pax ≤200

Scientific presentations are sometimes referred to as "oral papers" – yet anyone who had to suffer watching a presenter read out her latest publication to an audience can attest that requirements for an oral presentation are different from a written report. This talk will provide some pointers on how to get the essential science across while keeping the audience alert.

Collaboration with schools to organise lectures for their cohort and cluster schools.

RESEARCH PROGRAMME

For all bookings for lectures to be conducted at Science Centre Singapore, please login to **https://obs.science.edu.sg.** #

For all bookings for lectures to be conducted at schools, please email us at **cradle@science.edu.sg** to make arrangements.

Your patronage is important to us. If you cannot find a suitable timeslot in the online booking system, please contact us at cradle@science.edu.sg and we may be able to make special arrangements.

Introduction

CRADLΣ's Work Experience Programme (WEP) has grown from strength to strength. Piloted in 2014, the objective of the short 2-week stint is to expose students to real life applications, utilizing what they have learnt in school as well as for them to pick up skills that are difficult to achieve in a school setting. The work attachments are also meant to be catalysts for students' interest in STEM-related fields, possibly cumulating into full-fledged research projects. For the tenacious students, innovative solutions to existing problems might be borne from further efforts.

Over the past 3 years, we've conducted 10 cycles of WEP, mentoring students from a variety of institutions. We have successfully mentored more than 80 students, over more than 25 projects.

A nominal fee per student will be charged.

Participants of WEP 2016

Work Experience Programme

Our Work Experience is split into 2 main categories:

Engineering Projects:

- Students will work on a pre-determined engineering project and submit a deliverable at the end of the attachment.
- Basic workshops will be provided but students will be given opportunities to research on the project and suggest alternatives.

Research Projects:

- Students will assist in a section of a pre-determined research project and submit a deliverable at the end of the attachment.
- Basic conceptual underpinnings will be taught but additional rigorous research and multiple experimentation will be expected of students.

Past Projects

Engineering Projects

- Developing Wave Machine
- Hand-cranked Generator
- Laserphone
- Investigating an Efficient Pest Rodent Trap
- 3D scanner
- Robotic Vehicle
- DIY Tea Mixer
- Laser Firing Training Ground
- LDR Curtain Slider
- Ultrasound Doppler Anemometer
- Mini Robotic Vehicle
- Facial Recognition Door Lock

Research Projects

- Create Vegetable-Based Batteries
- Investigating Forces
- Stereo Imaging and Analysis
- Ultrasonic Imaging
- Novel Solar Traps for Dye Sensitised Solar Cells
- Investigate and Prototype a Brightfield & Darkfield Microscope
- Investigating Different Habitats
- Investigating Plant Electrophysiology

Testimonials

"It is important to have an open mind when experimenting, so as not to miss any potential options. Never underestimate everyday things as they may bear so much more potential that meets the eye."

Chanell Ng (Veggie Power)

"I enjoyed the process of creative thinking and analysis to develop a suitable, manageable and ultimately successful design of generator, as well as the process of bringing our generator designs to life and building the various components."

-Yeo Soon Yii (Hand-cranked Generator)

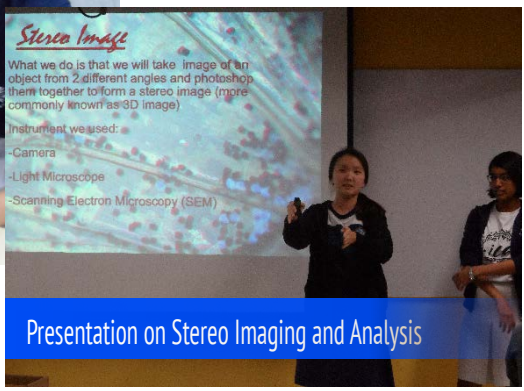
"Most importantly, I learnt to be more confident in my own abilities, as well as that of others. Of course, I also learnt the value of persistence, but what is also equally valuable is the painful lesson we learnt to never assume that nothing will go wrong... when we had to rebuild the entire robot..."

Ng Huai Ling (Mini Robotic Vehicle)

"I enjoyed my project the most when the results of our project met our expectations, or when the experiments were successful, as it feels as if our hard work had paid off."

Foo Xin Yue (Dye-sensitised Solar Cells)

Prototyping a Rodent Trap



Presentation on Stereo Imaging and Analysis

Work Experience Programme

Workflow 2018

Period of **Work Experience Programme 1**: 12th Nov 2018 to 23th Nov 2018
Period of **Work Experience Programme 2**: 3rd Dec 2018 to 14th Dec 2018

Deadline	Action
by 13 Aug 2018	Work Experience offerings (Phase 1) is open for application. Schools to advertise and get student sign-ups.
by 27 Aug 2018	Schools to email scanned application forms to CRADLΣ. If a project is oversubscribed, a selection interview will be conducted.
by 6 Sep 2018	CRADLΣ to email Work Experience results (Phase 1) to schools.
by 17 Sep 2018	Work Experience offerings (Phase 2) is open for application. Students to choose from remaining projects.
by 28 Sep 2018	Schools to email scanned application forms to CRADLΣ.
by 5 Oct 2018	CRADLΣ to email Work Experience results (Phase 2) to schools.
12 Nov 2018	Start of WEP 1.
23 Nov 2018	End of WEP 1.
by 23 Nov 2018	Submission of written report and interview questionnaire to CRADLΣ.
3 Dec 2018	Start of WEP 2.
14 Dec 2018	End of WEP 2.
by 14 Dec 2018	Submission of written report and interview questionnaire to CRADLΣ.

Things to note:

1. Application for the Work Experience does not guarantee acceptance.
2. Incomplete application forms will not be considered.
3. There is no compensation / pay during the period of the program.
4. Applicants are to read the Code of Conduct and adhere to the conditions stated.

School-Partnered Work Experience Programme

Introduction

School-Partnered WEP is a customised WEP (chargeable) for interested schools to expose students to the research process. Similar to apprenticeship, students will be mentored by CRADLΣ mentors to develop science research literacy and perform an investigation to test the hypothesis. Students will be required to do a presentation, submit a technical report and summary report of their work at the end of the attachment. Schools interested will need to inform us six months before the intended start date of the School-Partnered WEP to check for mentors' availability as well as discussion of other details.

Project Ideation Options

1. Open-ended - As per CRADLΣ WEP, the mentors will come up with the project ideas and students can apply for it.
2. Thematic - The school can choose a theme or an area for development, then either CRADLΣ mentors or the students can come up with the project ideas.

Venue

Held at Science Centre, CRADLΣ Lab

Suggested Duration

1. 4 weeks at 4 hours per day OR
2. Once a week, over a course of the entire term.

Maximum intake: 30 students

To find out more about our School-Partnered WEP, please contact CRADLΣ for more information.

SKILLS & EQUIPMENT TRAINING PROGRAMME

Prototying using a Laser Cutting Machine

CRADLΣ has a collection of basic to advanced test & measurement equipment used in research & development in science and engineering.

Electronic instruments are versatile building blocks for experimental research and participants of our workshops will know how they can make advanced experiments almost child's play. Mechanical designs complemented by electronic control systems are an important enabling technology for experimental science and engineering.

CRADLΣ has electronic tools and components to prototype and build both simple and advanced circuits – from basic voltage dividers through precision analogue signal processing circuits to microprocessor-controlled scientific equipment! CRADLΣ also has a variety of mechanical tools to create engineering prototypes and experimental apparatuses for scientific research. In our line up, the mill, lathe and laser cutting machine, together with other power tools allow us to quickly & accurately create a plethora of prototypes. There is also a chemical etch tank and UV exposure unit for Printed Circuit Board manufacture.

Contact us if you are interested in loaning our equipment for research projects, lessons or demonstration purposes.

cradle@science.edu.sg

15 Science Centre Road, Singapore 609081.

Equipment list

Electronic Instrumentation:

- Arbitrary Waveform Generator
- Cathode Ray Oscilloscope
- Current and Voltage Preamplifiers
- Digital Multimeter
- Digital Oscilloscope
- High Voltage Power Supply
- Lock-In Amplifier
- Power Supply
- RF (Radio Frequency) Signal Generator
- Spectrum Analyzer

Mechanical Tools:

- 3D Printer
- Benchtop Lathe
- Chemical Etch Tank
- Dremel Rotary Tool
- Glue Guns
- Cutting Plotter
- Hot Air Gun
- Laser Cutting Machine
- Benchtop Mill Machine
- Portable Jigsaw
- Power Drill
- Solder Station
- Stone Grinder
- UV Exposure Unit

Specialized Instrumentation:

- Atomic Force Microscope
- Optical Microscope
- Scanning Electron Microscope
- Sputter Coater
- Hydrogen Discharge Lamps
- Sodium Vapor Lamps
- Ultrasonic Cleaner

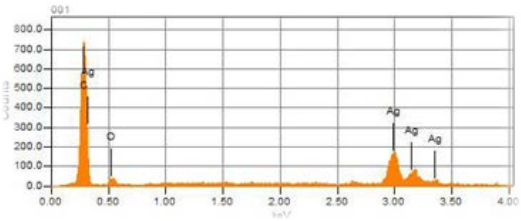
Things to note:

- Email us at cradle@science.edu.sg to book the equipment.
- Charges apply for the use of some equipment.
- Terms and conditions for purposes of loan or use of equipment apply.

Skills & Equipment Training Programme

Scanning Electron Microscope (SEM)

CRADLΣ's research-grade scanning electron microscope is available for student research use (including school-based projects) at highly subsidised rates. Capabilities include high vacuum and low vacuum modes, secondary and backscattered electron detection, and elemental analysis by energy-dispersive X-ray spectroscopy (EDX). The SEM is a fast and extremely useful micro-characterization tool for dry samples.



(Left) Scanning Electron Microscope JEOL JSM-6100LA (Right) The EDX spectrum of this sample shows that the reflective metal film is made from silver (Ag). The carbon (C) and oxygen (O) peaks arise from the polycarbonate plastic substrate beneath the thin metal film.

Atomic Force Microscope (AFM)

Atomic force microscopy obtains ultra-high resolution images of surfaces by mechanically scanning an ultra-sharp tip across the sample. CRADLΣ's AFM allows operation both in static and dynamic modes, and in ambient as well as in liquid. AFM work requires patience, but can provide unique information about the nano-scale properties of a sample.

Laser Cutting Machine

Our computer-controlled laser cutter is able to cut and/or engrave both simple and complex 2-dimensional shapes, with a precision of a fraction of a millimetre. The shapes to be cut are described by files generated using computer aided design (CAD) software. Since cutting does not involve powerful motors or sharp tools, the laser cutter is very safe to use.

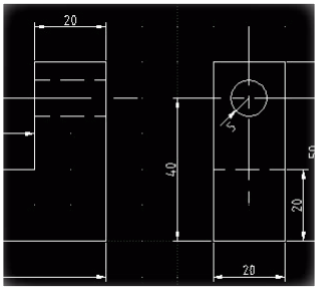
3-dimensional structures can be built by assembling 2-dimensional parts. Compared to 3D printing, laser cutting is typically much faster, precise and reliable, and learning to use 2D design software is much easier than 3D design software.

Our laser cutter has a bed size of 45 by 60 cm. The preferred material to be cut is acrylic sheet (up to about 8 mm thickness); some other materials such as corrugated cardboard are also suitable. Please enquire regarding other materials.

2D CAD Design & Laser Cutting

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Laser cutting machines are fairly common quick-prototyping tools, allowing researchers and engineers the capability to try out multiple designs in a short time. However, in order to create meaningful and customized designs, users must know how to create and manipulate the .dxf files.



In this workshop, users will be taught the skills to kick-start their creative designing and output the essential files.

Skills & Equipment Training Programme

Digital Oscilloscopes

$15 /pax | 2 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

Karl Ferdinand Braun pioneered the science and engineering of wireless communications using early oscilloscopes (Nobel prize 1909), and ever since oscilloscopes have been among the most important measurement instruments. Over the last decade, traditional cathode ray oscilloscopes have largely given way to digital oscilloscopes, which offer a plethora of advanced functions that widen their versatility.

In this workshop, participants will explore the basic functions of a digital oscilloscope.

Basic Soldering

$15 /pax | 2 hours | recommended for Sec 2 to Tertiary | 10⩽ pax ⩽20

A staple in electronics, Basic Soldering aim to equip participants with skills that allow them to transfer their electronic prototypes from a breadboard onto a strip board. This is necessary if the circuit is to be made smaller and more rugged. Participants will be exposed to the different types of IC chip packages so as to make informed choices when designing their PCB circuits.

Do note that this workshop is a prerequisite for some of the Engineering Workshops.

PROFESSIONAL DEVELOPMENT PROGRAMME

With the transition to more rigorous achievement standards and better student assessments, there has been an increased focus on the use of technology to personalise learning. This emerging era of teaching and learning demands more engaging lessons, creativity and innovation.

CRADLΣ has developed itself into a strong resource for teachers seeking to deepen their content knowledge as well as broaden their outlook

In order to further minimise logistical constraints:

- Workshops can be conducted at schools for an extra admin fee.
- Packaged price for bundle workshops are also possible, just email us to inquire.
- Teachers who are keen to co-create teaching and learning content, conduct their own experiments or simply use the equipment at CRADLΣ for resource building, can email us to inquire.

Email us now to find out more!

*Sections of the booklet are colour-coded (as illustrated on the content page)

Professional Development Programme

Courses for Teachers Mentoring Students' Research Projects

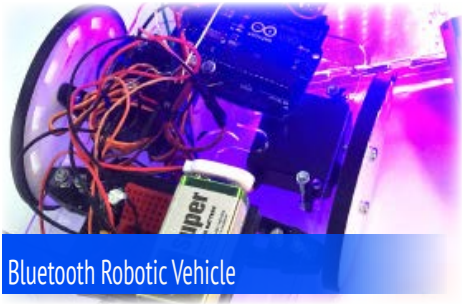
How to Effectively Mentor Your Students?

FREE **or** $150 @ school | 1 hour | recommended for Secondary to Tertiary Science Teachers

A careful choice of a problem and some resourcefulness allow solid research to be conducted in a school lab. Good teacher mentors are invaluable to guide students on this journey of discovery – from the planning stage to final write-up. This talk for teachers discusses scoping and planning realistic school-based research projects, finding resources cheap (or even free), valuable resources that schools may already have without knowing, and where to find advice.

Specialised Instruments Under our Skills & Equipment Training Programme

Title of Workshop	Cost (/pax)	Duration (hours)	Page
Modern Microscopes: **- Scanning Electron Microscope (SEM)** **- Atomic Force Microscope (AFM)**	$50	2	20, 50
2D CAD Design & Laser Cutting **- Laser Cutting Machine**		3	51



Bluetooth Robotic Vehicle

cradle@science.edu.sg

15 Science Centre Road, Singapore 609081.

Courses for Teachers in Applied Learning Programme (ALP), Project Work, STEM related programmes

Title of Workshop	Cost (/pax)	Duration (hours)	Page
Microcontrollers for Beginners (Scratch)	$50	3	14
Introduction to Sense HAT (Raspberry Pi) Using Scratch			
Game Programming with Sense HAT (Raspberry Pi) Using Scratch*			31
Introduction to Microcontrollers I & II Abridged Version (Arduino C++)	$80	5	15, 28
Bluetooth Robotic Vehicle (Arduino C++)*		3	28
Datalogging (Arduino C++)*	$50		29
Smart Fan (Arduino C++)*			29
Distance & Motion Sensing (Arduino C++)*			30
Robot Arm*			30
Introduction to Python with Raspberry Pi and Sense HAT	$50	3	17
2D CAD Design & Laser Cutting			51
Basic Soldering			52

* Pre-requisites are needed for the workshop. See the relevant page for more details.

Professional Development Programme

Courses for Science Teachers (Sceondary & Tertiary)

Title of Workshop	Cost (/pax)	Duration (hours)	Page
AC Circuit Analysis	$50	2	36
Balmer Series & Bohr's Atomic Model		3	35
Diffraction as a Metrology Tool			34
Diffusion Cloud Chamber		2	17
Digital Oscilloscopes			52
Electromagnetism		2.5	17
Electronic Structure of Semiconductors		3	36
Electronics Workshop	$80	6	27
Fuel Cells	$50	3	22
Fun with Electronics (Option 1)			15
Investigating Linear Motion & Collisions			25
Measuring Speed of Light			19
Measuring Magnetic Field Strength			19
Microscopy in Motion			23
Modern Microscopes		2	20
Navigating with Waves			18

* Pre-requisites are needed for the workshop. See the relevant page for more details.

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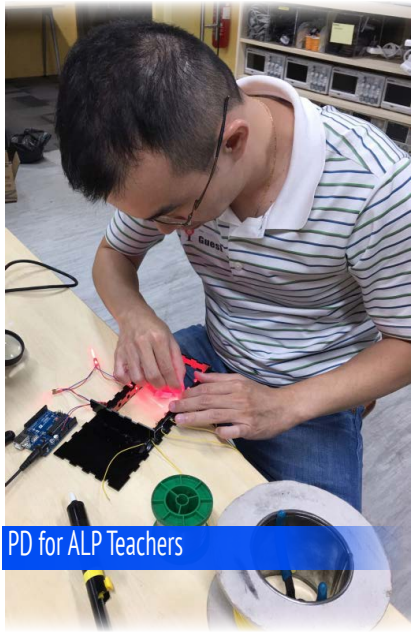
Title of Workshop	Cost (/pax)	Duration (hours)	Page
Optical Spectroscopy	$50	3	21
Organic Solar Cells			25
Physics Modelling & Simulation Using Python			26
Polarised Light			31
Properties of Waves			16
Superconductivity			24
Speed of Sound			34



PD for ALP Teachers

S.M.A.R.T CAMP

Introduction

A smart nation depends on smart technology – and the smart people who can create it. Be one of them - join our CRADLΣ S.M.A.R.T. camps.

Starting with its inaugural instalment in December 2016, CRADLΣ is proud to offer two runs of S.M.A.R.T camp in 2018.

June Holidays: **5th - 6th June 2018**
Nov-Dec Holidays: **27th - 28th November 2018**

S.M.A.R.T. camps are for individuals (age 15 years and above) who are interested to learn more about the science & technology that are the foundation for creating the smart cities and societies of tomorrow. S.M.A.R.T. camps are scheduled during school breaks to cater to sign ups by highly motivated students.

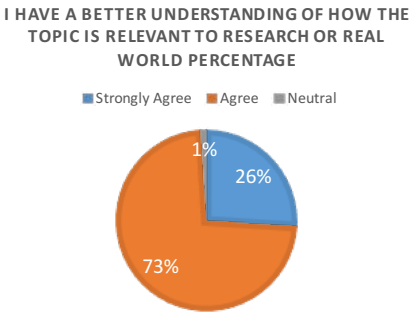
S.M.A.R.T. Camp

S.M.A.R.T. camps offer themed tracks on varying topics and encompass lectures, hands-on classes and sharing by industry experts.

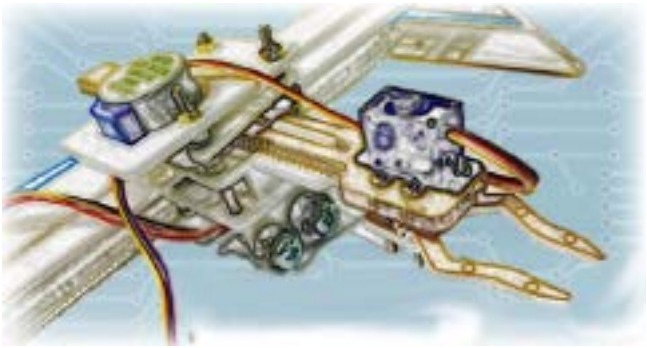
November 2016 & June 2017 (Electronics S.M.A.R.T CAMP)

Testimonials & Feedback

"Learnt how to build circuits that teach us practical uses of components."
"It was very fun and is memorable. I enjoyed building circuits and solving problems."
- Upper Secondary Students from 2017 S.M.A.R.T Camp



November 2017 (Computer Vision Aided Robot Arm S.M.A.R.T CAMP)



Watch out for announcements of future S.M.A.R.T. camps or inquire via cradle@science.edu.sg!

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All information in this booklet is believed to be correct at time of print. Please enquire with us for latest updates.

All prices quoted are per pax and inclusive of GST unless otherwise stated.