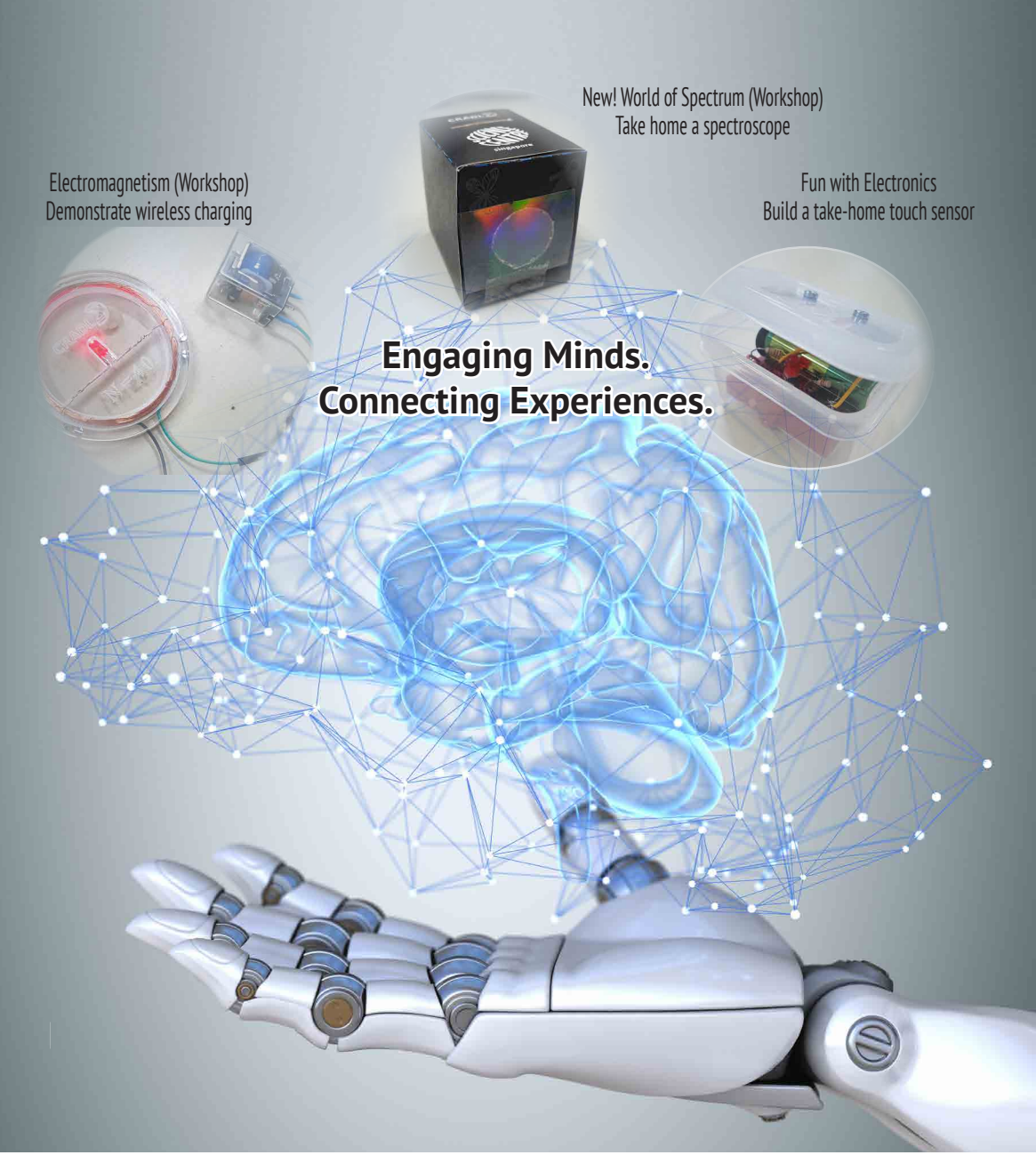


SCIENCE CENTRE singapore

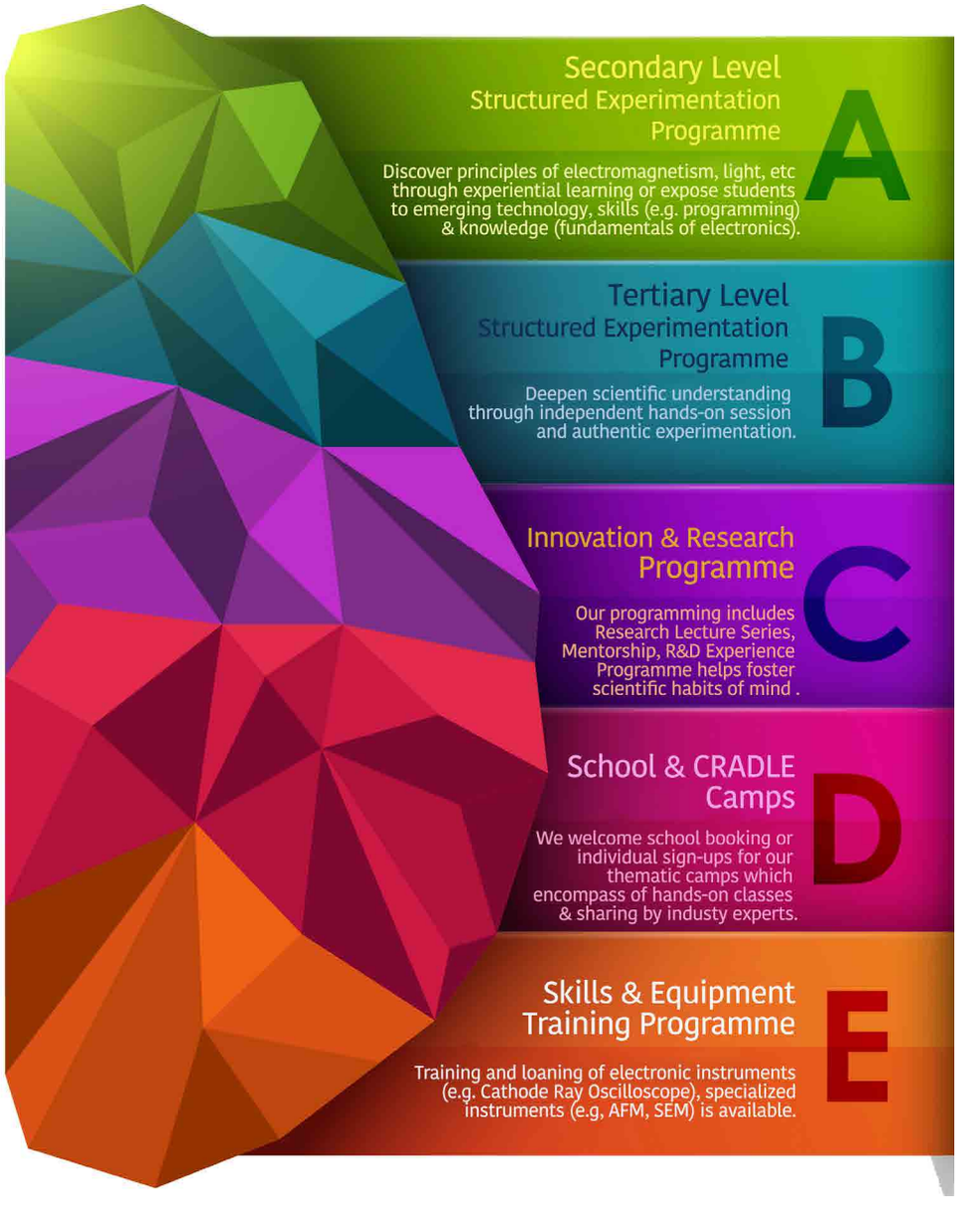
CRADLΣ

Centre for Research and Applied Learning in Science

PROGRAMME BOOKLET 2020

CONTENT PAGE

**The long edge of the booklet is colour-coded* *based on the different sections.*



Director's Message

When I first proposed the concept of CRADLΣ in 2008 possibly located in One North, the idea was to plug into the R&D ecosystem there to develop our future STEM talents. I envisaged it as a nurturing space where students would learn beyond classroom through research and hands-on / mind-on projects. Part of the bigger objective was also to build capacity for teachers in mentoring science research, to enhance scientific practices and design thinking in schools.

Now that CRADLΣ is a real unit operating in our Science Centre since 2012, I am very encouraged to see how it has and is fulfilling the mission of raising R&D culture in our schools. It has, over recent years, successfully rolled out many unique programmes for students to acquire beyond textbook knowledge and learn laboratory research skills not available in schools. CRADLΣ has since steadily established itself as a vibrant and effective centre where students are intrigued and challenged through starting-from-first principle workshops, science mentorship programmes, innovation camps, and work experience attachments. Our MOE teachers seconded to CRADLΣ have become competent research mentors, many of whom have supervised and guided student projects, winning recognitions in various science fairs and festivals.

A/Prof Lim Tit Meng
Chief Executive,
Science Centre Singapore
& Director, CRADLΣ

CRADLΣ strives to nurture students to grow the attributes and competence of a scientific mindset, with observation power, questioning with hypothesis, design and conduct experiments, use data acquisition with qualitative and quantitative analysis, reflect and discuss with critical thinking in science communication. We want our students to experience the power of STEM and be inspired and empowered through their engagements in CRADLΣ.

This programme booklet contains many useful information for teachers and students to appreciate what awaits them in their journey in scientific education and pursuits.

Centre for Research & Applied Learning in Science

CRADLΣ has built a reputation for excellence in serious hands-on science education. "Serious" means that we see hands-on classes not as an entertaining magic show, but try to plan and interpret measurements or observations within the frameworks of mathematics and scientific theories/models. "Hands-on" means that we build and do experiments, which requires practical problem solving (engineering) using available tools (technology) to make them work.

Around 30 years ago, the acronym STEM had been coined for this approach, and much more recently, "STEM fever" has gripped policymakers worldwide. But acronyms and buzzwords aside, this approach has been a staple in science and engineering education for centuries, with a stellar track record in moving humanity ahead. Whatever you choose to call it, CRADLΣ is honoured to help continue this long tradition by offering hands-on classes, opportunities for project work, and research skill lectures to pass the skills for exploring, learning, and doing to the next generation. And since learning never stops, we are also happy to conduct professional development for teachers.

"CRADLΣ has since steadily established itself as a vibrant and effective centre where students are intrigued and challenged through starting-from-first principle workshops, science mentorship programmes…"

Our Sponsor

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

DSO NATIONAL LABORATORIES

KURVE Automation

ROHDE&SCHWARZ

SHIMADZU
Excellence in Science

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)

Partnerships

School Partners for 2019

ANDERSON JUNIOR COLLEGE

ANG MO KIO Secondary School

BUKIT PANJANG GOVT HIGH SCHOOL SINGAPORE

CHUA CHU KANG SECONDARY SCHOOL

DUNMAN SECONDARY SCHOOL

華僑中學 HWA CHONG INSTITUTION

HILLGROVE SECONDARY SCHOOL

SCGS

ZHONGHUA SECONDARY SCHOOL

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 microcontrollers 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)

Incentives for CRADLΣ School Partners*

- Waiver of transportation cost for ONE off-site workshop per year.
- 5% discount for usage of research and prototyping facilities as part of students' science research projects. Equipment includes Scanning Electron Microscope, Optical Microscope, Atomic Force Microscope and Laser Cutter.
- 10% discount for ONE New-Workshop[1] booked per year.
- 15% discount for additional cohort-based programmes[2] (on top of existing programs with CRADLΣ) booked per year.
- Priority for School-Partnered R&D Experience Programme[3] / consultation of projects (chargeable) given an advance notice of 4 months.
- Cluster school teachers' workshops – By hosting CRADLΣ teachers' workshop for their cluster schools, CRADLΣ partner-school teachers will get 20% discount on workshop fees with a minimum of 10 sign ups from cluster schools.

[1] New-workshop refers to a workshop that is within its first year of commencement and is reflected in print for that year.

[2] Cohort-based programmes refer to CRADLΣ workshops (excluding lectures) catered for ⩾80 students and are booked on one particular instance. Workshops can be conducted off-site or onsite on different days for different workshops.

[3] School-Partnered R&D Experience Programme (R&D EP) refer to collaboration with schools to provide opportunities for science research for its students. The nature of school-partnered R&D EP can be similar to CRADLΣ R&D EP or otherwise proposed by schools.

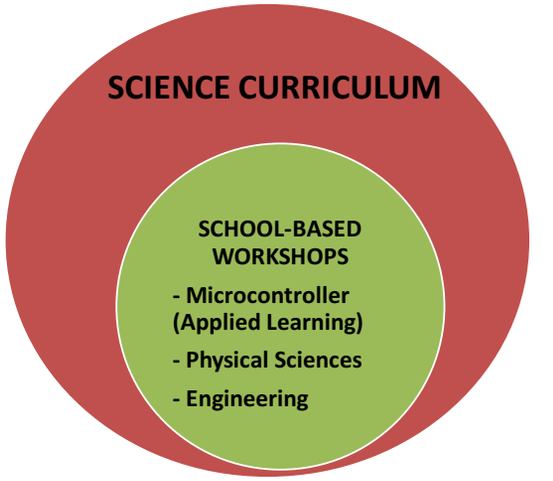
*CRADLΣ retains the right to amend the incentives at any point without approval of its partners. CRADLΣ School Partners will be notified if changes are made.

The above incentives are subjected to availability of venue, date and trainers/mentors.

Partnerships

School-Based Workshops (SBW)

Our School-Based Workshop (SBW) scheme aims to support curriculum innovation in schools. Through this scheme, schools have the option to incorporate CRADLΣ's equipment and kits in the classrooms in line with curriculum teaching. With our in-house kits, students can 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 next page, the generic overview of SBW is shown. The full details will have to be discussed and finalised on an individual basis with CRADLΣ.

Outline of SBW Implementation Process

Confirmation of SBW

- School decides on a workshop, preferred scheme & teacher training period.
- CRADLΣ sends an official quotation to school. (Lead time about 3 months)
- School accepts quotation and CRADLΣ to invoice school accordingly as stated in PO.

Training

- Teacher training conducted at least 1 month before the lesson.

Logistics

- Equipment / kits will be set up at least 3 hours prior to the first lesson and will be removed within 1 week after the last workshop. (rentals only)
- School staff to inspect equipment / kits upon arrival for faults. After hand-over, any damage due to negligence will be chargeable.

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.

Please contact us to find out more about this exciting mode of workshop delivery or CRADLΣ partnership opportunities.

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.

Making History: Redefining the Kilogramme: - "Creating" the new kilogramme based on electromagnetic forces.

Open-Dated Professional Development

Making History: Redefining the Kilogramme: - "Creating" the new kilogramme based on electromagnetic forces.

- 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.

Teachers Professional Development Programme

Courses Recommended for Science Teachers (Secondary & Tertiary)

Title of Workshop	Duration (hrs)	Page
AC Circuit Analysis	2	33
Balmer Series & Bohr's Atomic Model	3	27
Diffraction as a Metrology Tool		31
Diffusion Cloud Chamber	2	26
Digital Oscilloscopes		62
Electromagnetism	2.5	32
Electronic Structure of Semiconductors	3	27
Electronics I & II	6	37
Fuel Cells	3	25
Fun with Electronics (Option 1)		36
Investigating Linear Motion & Collisions		34
Making History: Redefining the Kilogramme		23
Measuring Magnetic Field Strength		32
Measuring Speed of Light (Advanced)		24
Modern Microscopes	2	34
Navigating with Waves		30
Optical Spectroscopy	3	30
Organic Solar Cells		25
Physics Modelling & Simulation Using Python		44
Properties of Waves	2	25
Superconductivity	3	33
Speed of Sound (Advanced)		24

Note: All teacher workshops are priced at $50 per pax with the exception of Electronics Workshop which is priced at $80 per pax

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

Title of Workshop	Duration (hrs)	Page
Microcontrollers for Beginners (Scratch)	3	38
Understanding Corals with STEM		39
Introduction to Sense HAT (Raspberry Pi) Using Scratch		38
Game Programming with Sense HAT (Raspberry Pi) Using Scratch*		39
Introduction to Microcontrollers 1 & 2 Abridged Version (Arduino C++)	5	40, 42
ISM Radio Robotic Vehicle (Arduino C++)*	3	41
Datalogging (Arduino C++)*		43
Robot Arm*		42
Distance & Motion Sensing (Arduino C++)*		43
Urban Farming*		43
Introduction to Microcontrollers 3 (Arduino C++)*		44
Introduction to Python with Raspberry Pi & Sense HAT		44

Note: All teacher workshops are priced at $50 per pax with the exception of Introduction to Microcontrollers 1 & 2 (abridged version) & ISM Radio Robotic Vehicle which are priced at $80 per pax

* There are pre-requisites for this workshop. Please refer to the relevant page for more details.

Teachers Professional Development Programme

Specialised Instruments Under our Skills & Equipment Training Programme

Title of Workshop	Duration (hours)	Page
Modern Microscopes: - Scanning Electron Microscope (SEM) - Atomic Force Microscope (AFM)	2	61
2D CAD Design & Laser Cutting - Laser Cutting Machine	3	63

Courses Recommended for Teachers Mentoring Students' Research

How to Effectively Mentor Your Students?

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

Choosing a good problem and being resourceful can help in the facilitation of research in a school lab. Good teacher mentors are invaluable guides for 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, sourcing for cheap (or even free) and valuable resources that schools may already have without knowing, and where to find advice.

STRUCTURED EXPERIMENTATION PROGRAMME

Secondary and Tertiary Level Workshops

STEM (Science, Technology, Engineering and Mathematics) is vital to our future - it is everywhere and inevitably shapes our everyday experiences.

Physical Sciences

CRADLΣ offers a series of structured workshops designed to allow students to discover science concepts through experiential learning. The workshops feature independent hands-on components that allow 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.

Engineering

CRADLΣ 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. They tie in with the Applied Learning Programme (ALP) that integrate concepts usually taught as separate subjects.

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

Online Booking @ https://obs.science.edu.sg/OBS2020/WebApp/Login

cradle@science.edu.sg

www.science.edu.sg/for-schools/cradle

Physical Sciences

1. Measurement of Physical Quantities

2. Energy

3. Atomic & Molecular Structures

4. Waves

5. Electricity & Magnetism

6. Others

NEW! New Workshop
Chemistry Concepts Included
* Requires Pre-requiste
LS Recommended for Lower Sec & Above

Engineering

1. Electronics

2. Programming

Using Scratch

Fundamentals	Application-Based Workshops
Microcontrollers for Beginners LS Pg 38 ($20 /pax | 3 hrs)	Understanding Corals with STEM * LS Pg 39 ($25 /pax | 3 hrs)
Introduction to Sense HAT (Raspberry Pi) LS Pg 38 ($20 /pax | 3 hrs)	Game Programming with Sense HAT (Raspberry Pi) * LS Pg 39 ($20 /pax | 3 hrs)

Using Arduino C++

Introduction to Microcontrollers 1 LS
Pg 40 ($20 /pax | 3 hrs)

Introduction to Microcontrollers 2*
Pg 42 ($20 /pax | 3 hrs)

Introduction to Microcontrollers 3*
Pg 44 ($20 /pax | 3 hrs)

ISM Radio Robotic Vehicle* LS NEW!
Pg 41 ($30 /pax | 3 hrs)
Laser Piano (Revamped!)* NEW!
Pg 41 ($30 /pax | 3 hrs)
Understanding Corals with STEM* LS
Pg 41 ($25 /pax | 3 hrs)

Robot Arm* Pg 42 ($40 /pax | 3 hrs)
Datalogging* Pg 43 ($30 /pax | 3 hrs)
Distance & Motion Sensing* Pg 43 ($30 /pax | 3 hrs)
Urban Farming* Pg 43 ($20 /pax | 3 hrs)

Using Python

Introduction to Python with Raspberry Pi & Sense HAT LS Pg 44 ($25 /pax | 3 hrs)

* Requires Pre-requiste
NEW! New Workshop
LS Recommended for Lower Sec & Above

Physical Sciences

1. Measurement of Physical Quantities

Making History: Redefining the Kilogramme NEW!	Pg 23 ($20 /pax | 2.5 hrs)
Speed of Sound (Basic) LS	Pg 22 ($15 /pax | 2 hrs)
Speed of Sound (Advanced)	Pg 24 ($20 /pax | 3 hrs)
Measuring the Speed of Light (Basic)	Pg 22 ($15 /pax | 2 hrs)
Measuring the Speed of Light (Advanced)	Pg 24 ($20 /pax | 3 hrs)

2. Energy

Fuel Cells
Pg 25 ($20 /pax | 3 hrs)
Organic Solar Cells
Pg 25 ($20 /pax | 3 hrs)

3. Atomic & Molecular Structures

Diffusion Cloud Chamber
Pg 26 ($15 /pax | 2 hrs)
Electronic Structure of Semiconductors
Pg 27 ($20 /pax | 3 hrs)
Balmer's Series & Bohr's Atomic Model
Pg 27 ($20 /pax | 3 hrs)

4. Waves

Navigating with Waves LS	Pg 30 ($15 /pax | 2 hrs)
Optical Spectroscopy	Pg 30 ($30 /pax | 3 hrs)
Diffraction as a Metrology Tool	Pg 31 ($20 /pax | 3 hrs)

5. Electricity & Magnetism

Electromagnetism LS	Pg 32 ($20 /pax | 2.5 hrs)
Measuring Magnetic Field Strength	Pg 32 ($20 /pax | 3 hrs)
Superconductivity	Pg 33 ($20 /pax | 3 hrs)
AC Circuit Analysis	Pg 33 ($15/pax | 2 hrs)

6. Others

Modern Microscopy	Pg 34 ($12 /pax | 2 hrs)
Investigating Linear Motion & Collisions	Pg 35 ($20 /pax | 2.5 hrs)
Physics Modelling & Simulation using Python	Pg 35 ($15 /pax | 3 hrs)

* Requires Pre-requiste Chemistry Concepts Included NEW! New Workshop

Online Booking @ https://obs.science.edu.sg/OBS2020/WebApp/Login

Engineering

1. Electronics

Electronics I	Pg 37 ($25 /pax | 3 hrs)
Electronics II*	Pg 37 ($25 /pax | 3 hrs)

2. Programming

Using Scratch

Fundamentals	Application-Based Workshops
Microcontrollers for Beginners LS Pg 38 ($20 /pax | 3 hrs)	Understanding Corals with STEM * LS Pg 39 ($25 /pax | 3 hrs)
Introduction to Sense HAT (Raspberry Pi) LS Pg 38 ($20 /pax | 3 hrs)	Game Programming with Sense HAT (Raspberry Pi) * LS Pg 39 ($20 /pax | 3 hrs)

Using Arduino C++

Introduction to Microcontrollers 1 LS
Pg 40 ($20 /pax | 3 hrs)

Introduction to Microcontrollers 2*
Pg 42 ($20 /pax | 3 hrs)

Introduction to Microcontrollers 3*
Pg 44 ($20 /pax | 3 hrs)

ISM Radio Robotic Vehicle* LS NEW!
Pg 41 ($30 /pax | 3 hrs)
Laser Piano (Revamped!)* NEW!
Pg 41 ($30 /pax | 3 hrs)
Understanding Corals with STEM* LS
Pg 42 ($25 /pax | 3 hrs)

Robot Arm*	Pg 42 ($40 /pax | 3 hrs)
Datalogging*	Pg 43 ($30 /pax | 3 hrs)
Distance & Motion Sensing*	Pg 43 ($30 /pax | 3 hrs)
Urban Farming*	Pg 43 ($20 /pax | 3 hrs)

Using Python

Introduction to Python with Raspberry Pi & Sense HAT LS Pg 44 ($25 /pax | 3 hrs)

* Requires Pre-requiste NEW! New Workshop

Workshops (Tertiary)

ment of Physical Quantities

Theme: Measurement of Physical Quantities - Intermediate Level

Speed of Sound (Basic)

$15 /pax | 2 hours | recommended for Sec 2 to Tertiary | 10⩽ pax ⩽30

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

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).

Measuring Speed of Light (Basic)

$15 /pax | 2 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽30

Syllabus Links:; Physics O-Level: Wave motion, Light, Reflections, DC circuits, Interpretation of oscilloscope waveforms, Physics A-Level: Wave motion, Use of oscilloscope

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.

Structured Experimentation Programme (Secondary Level)

Workshops (Secondary)

Workshops (Tertiary)

Making History: Redefining the Kilogramme

new

$20 /pax | 2.5 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽15

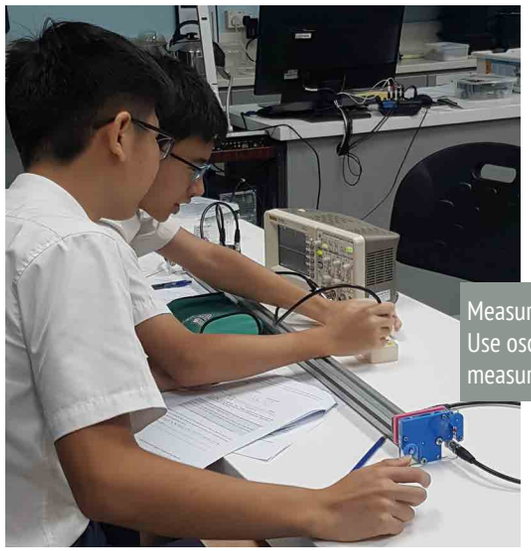
Syllabus Links: Physics O-Level: Measurement – Physical quantities, units and measurement, Electricity and magnetism – current of electricity, electromagnetism, electromagnetic induction

(students should have been exposed to electromagnetic force and induction)

Since May 2019, our units of measurement have been defined in terms of stable and experimentally reproducible constants of nature rather than arbitrary and fragile artefacts. This required a completely different experimental approach for defining the unit of mass, the kilogram. The key that made this redefinition practical is the development of precision measurement methods linking quantum phenomena with macroscopic behaviour.

One of the officially recognised methods to implement the new kilogramme is a balance based on electromagnetic forces – the Kibble balance. Workshop participants will use a Kibble balance to measure currents and emf (voltage induced by motion in a magnetic field), and calculate weight and mass of an unknown object.

The Kibble balance is a showcase for the practical application of basic principles of mechanics and electromagnetism. Students will also practise the use of an oscilloscope for acquiring data.



Measuring Speed of Light (Basic): Use oscilloscope to perform high- speed measurements.

Theme: Measurement of Physical Quantities - Advanced Level

Measuring Speed of Light (Advanced)

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

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

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.

Speed of Sound (Advanced)

$20 /pax | 3 hours | recommended for JC to Tertiary | 10⩽ pax ⩽30

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

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

(The session) was really enriching as i (have gained) knowledge (on) organic solar cells. (It is surprising that to understand the) small object (would require) so many disciplines of science.

-Student in Upper Secondary
(Comments for Organic Solar Cells Workshop)

The concepts taught is very well-related to the H2 Chemistry. Personally, I find it very useful & fun. It helps me to relook at the environmental aspect of Electrochemistry.

-Teacher from a Junior College
(Comments for Fuel Cell Workshop)

Structured Experimentation Programme (Secondary Level)

Theme: Energy - Intermediate Level

Fuel Cells

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽26

Syllabus Links: Physics O-Level: Energy, Work & power, States of matter, Current of electricity, DC circuits, Chemistry O-Level: Chemistry of reactions (electrolysis, energy from chemicals), Stoichiometry and mole concept, Air, Chemistry A-Level: Electrochemistry

Fuel cells hold great promise in today's global relentless search for new demand and supply of clean energy. In this workshop, participants will learn about the different fuel cell technologies and gain insight into the working principles of Alkaline and Proton Exchange Membrane (PEM) fuel cells. Participants will get hands-on experience to perform electrolysis of water using solar energy (weather permitted) and store the hydrogen gas obtained to be used in a PEM fuel cell. Participants will also conduct experiments to find out the minimum voltage required to

Organic Solar Cells

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 20⩽ pax ⩽30

Syllabus Links: Physics O-level: Current of Electricity (I-V graph), Chemistry O-level: Redox Reaction

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 in-house kit, students will perform characterization of their solar cell and plot a graph to identify the maximum power of the solar cell.

Atomic & Molecular Structure

Theme: Atomic & Molecular Structure - Beginner to Intermediate Level

Diffusion Cloud Chamber

MOST POPULAR

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

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

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.

"Very interesting to see ionization which is usually only taught as a concept, but now we can see what is really happening. I've learnt about cosmic rays and muon particles and how they can travel to sea level."

-Student in Upper Secondary
(Comments for Diffusion Cloud Chamber)

View alpha particles in a self-made cloud chamber

Structured Experimentation Programme (Tertiary Level)

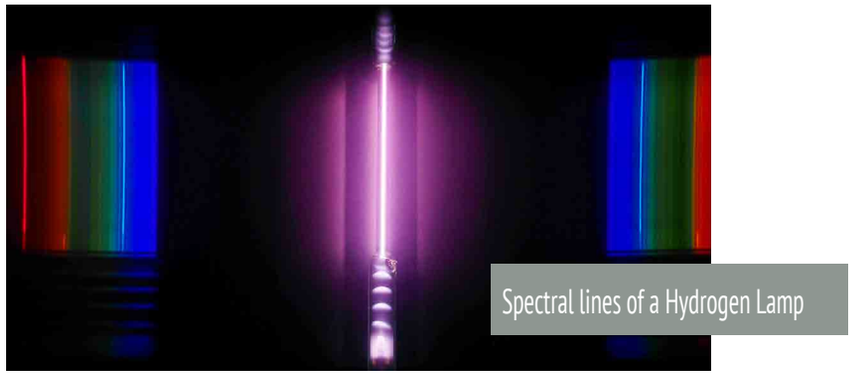
Theme: Atomic & Molecular Structure - Advanced Level

Balmer Series & Bohr's Atomic Model

$20 /pax | 3 hours | recommended for JC to Tertiary | 10⩽ pax ⩽30

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)

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. Bohr's atomic model introduces key characteristics of quantum physics (e.g. de Broglie waves) at a level that is easy for students to comprehend.
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.



Spectral lines of a Hydrogen Lamp

Electronic Structure of Semiconductors

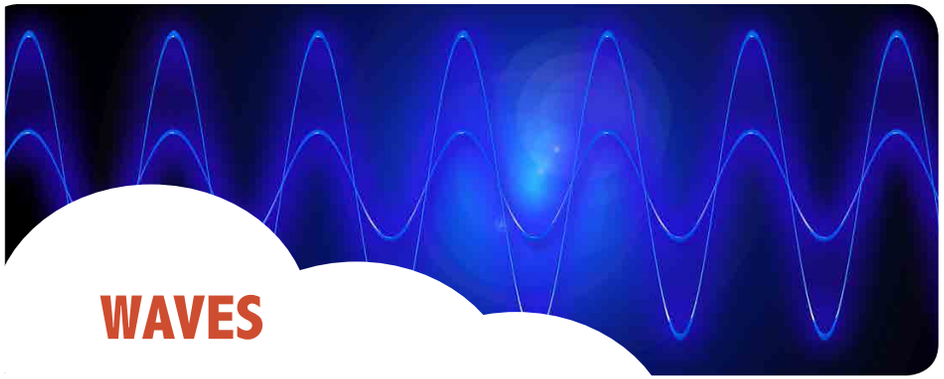
$20 /pax | 3 hours | recommended for JC to Tertiary | 10⩽ pax ⩽30

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

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.

Workshops (Tertiary)

Structured Experimentation Programme (Secondary Level)



Theme: Waves - Basic Level

Properties of Waves

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

Syllabus Links: Physics O-level: General Wave Properties

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!

Properties of Waves: View waves in action and how they interact

Online Booking @ https://obs.science.edu.sg/OBS2020/WebApp/Login

Structured Experimentation Programme (Secondary Level)

World of Spectrum new

$20 /pax | 2 hours | recommended for Sec 1 to Sec 2 | 20⩽ pax ⩽40

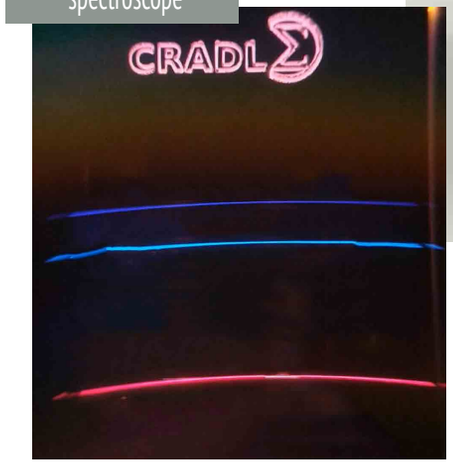
Syllabus Links: Lower Secondary: Model of Matter - Atoms and Molecules, Ray Model of Light

Much of our understanding of the world originates from investigating visible light. In this workshop, students assemble take-home cardboard spectroscopes and use them to explore the surprising variety in the composition of light (i.e. different colours/ wavelengths) from common sources.

This workshop is targeted at lower secondary students and aims to cultivate their interest in using basic physical phenomena as tools for scientific exploration.

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

View the spectrum of hydrogen using a spectroscope



Construct a take-home paper spectroscope

Structured Experimentation Programme (Secondary Level)

Theme: Waves - Intermediate Level

Navigating with Waves

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

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

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.

Navigating with Waves: Locate position using angulation and time measurements

Optical Spectroscopy

MOST POPULAR

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽40

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

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.

Structured Experimentation Programme (Secondary Level)

Theme: Waves - Advanced Level

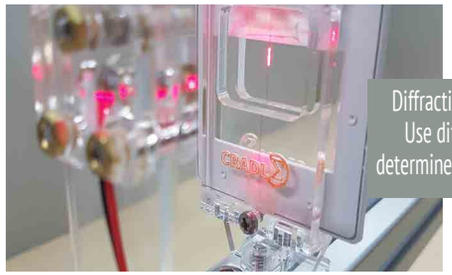
Diffraction as a Metrology Tool

$20 /pax | 3 hours | recommended for JC to Tertiary | 10⩽ pax ⩽30

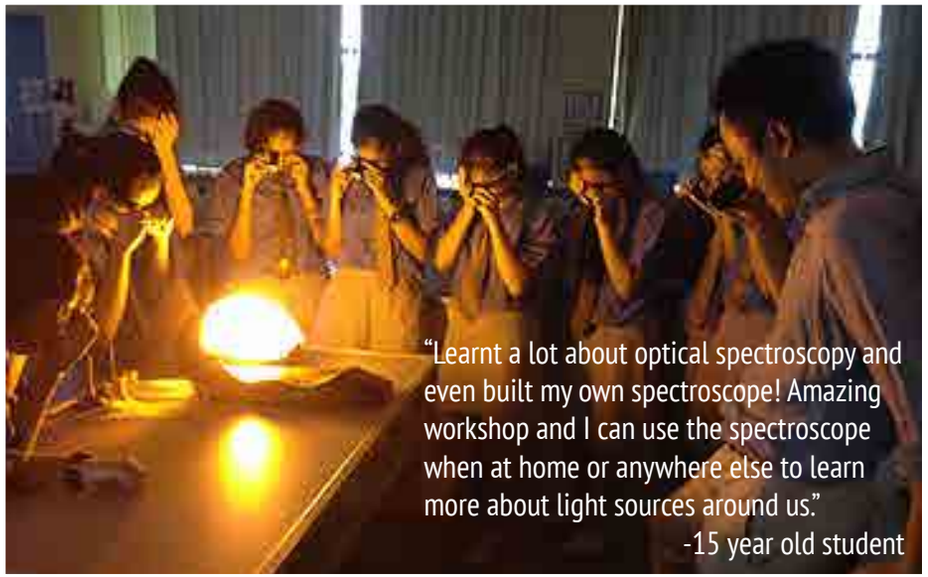
Syllabus Link: Physics A-Level: Superposition (diffraction)

In the 17th 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.

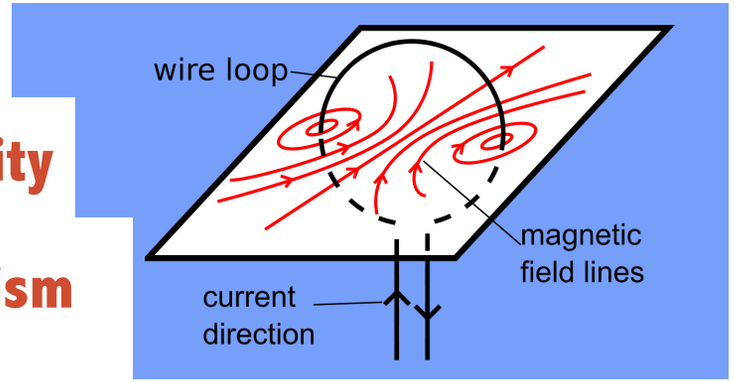
In the workshop, students will explore the diffraction patterns generated by gratings and single slits, and use them to determine the wavelength of light or the size of microscopic structures.



Diffraction as Metrology Tool: Use diffraction paterns to determine size of a strand of hair



Electricity & Magnetism



Theme: Electricity & Magnetism - Intermediate Level

Electromagnetism

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

Syllabus Links: Physics O-level: Electromagnetism, Electromagnetic Induction

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. motors and 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.

Measuring Magnetic Field Strength

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

Syllabus Links: Physics O-Level: Turning effect of forces, Mass and weight, Magnetism, Electromagnetism, Physics A-Level: Forces, Electromagnetism

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.

Structured Experimentation Programme (Secondary Level)

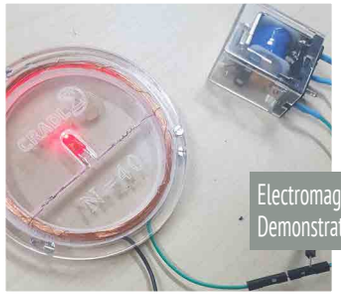
Superconductivity

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

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

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.



Electromagnetism: Demonstrate wireless charging

Superconductivity: Measuring resistance of superconducting ceramics

Theme: Electricity & Magnetism - Advanced Level

AC Circuit Analysis (for Mathematics & Mathematically inclined students)

$15 /pax | 2 hours | recommended for JC to Tertiary | 12⩽ pax ⩽30

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.

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

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.

Structured Experimentation Programme (Secondary Level)

Investigating Linear Motion & Collisions

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

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

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.

Modern Microscopes

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

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

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.

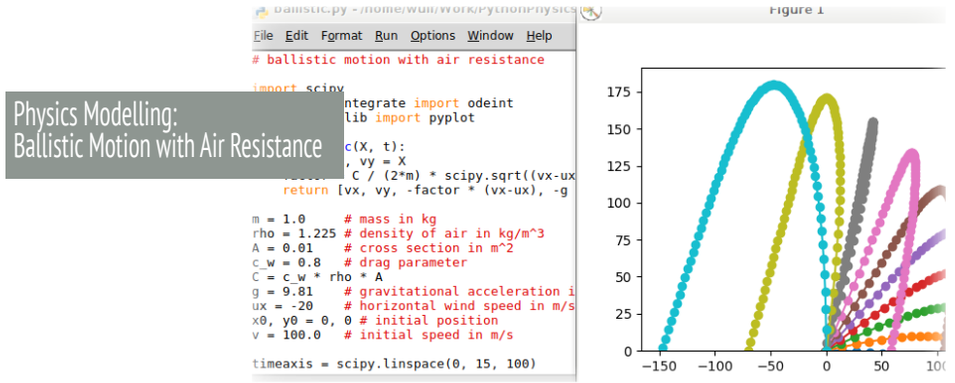
Structured Experimentation Programme (Secondary Level)

Physics Modelling and Simulation using Python

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

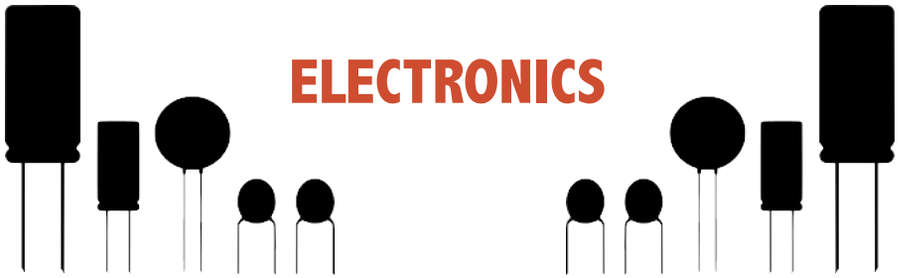
Syllabus Links: Physics O-Level: Kinematics, Dynamics, Newton's law , Physics A-Level: Forces, Dynamics, Energy, Gravitational field, Motion in a circle, Oscillations, Computing O-Level: Algorithms, Programming, Mathematics O-Level: Rate and speed, Functions and graphs, Problems in real-world contexts, Geometry and measurement Mathematics A-Level: Functions and graphs, Vectors, Sequences and series, Calculus, Numerical methods

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.



Interesting experiments to validate current laws of physics.

-15 year old student,
Participant of Linear Motion Workshop



Theme: Electronics - Beginner Level

Fun with Electronics

MOST POPULAR

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

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

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, capacitors, 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*).

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


Touch Sensor Kit

Mass Programme on Fun with Electronics

Theme: Electronics - Intermediate Level

Electronics Workshop I

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

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 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.

Theme: Electronics - Advanced Level

Electronics Workshop II

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

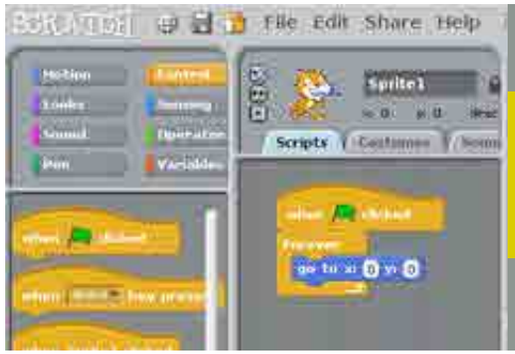
Pre-requisite: Electronics Workshop I

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)

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


Electronics I & II

Structured Experimentation Programme (Secondary Level)



PROGRAMMING USING SCRATCH

Theme: Programming Using Scratch - Fundamentals

Introduction to Sense HAT (Raspberry Pi) using Scratch

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

Syllabus Link: Suitable for Applied Learning Programme, Mathematics O-level: Algebra, Inequality

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.

Microcontrollers for Beginners (Scratch)

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

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

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.

Structured Experimentation Programme (Secondary Level)

Theme: Programming Using Scratch - Application Workshops

Game Programming with Sense HAT (Raspberry Pi) using Scratch

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

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

Syllabus Link: Suitable for Applied Learning Programme

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.

Understanding Corals with STEM

$25 /pax | 3 hours | recommended for Sec 2 to Tertiary | 10⩽ pax ⩽24

Option 1: Programming using Scratch Option 2: Programming using Arduino (C++)

Pre-requisite: Microcontrollers for Beginners / Microcontroller 1 or equivalent

Coral reefs around the world are in distress and are on the brink of destruction due to environmental changes. Increase in sea temperature and pH changes are some of the threats that corals face. By programming and designing a system that can detect these changes in the environment, intervention and rescue works can be carried out before it's too late.

In this workshop, students will learn about corals and the conditions required for their survival and reproduction. Students will also learn how to build simple circuits and program a microcontroller to detect changes in the water conditions that are essential to the survival of corals. Students will be able to calibrate and test their circuits on actual sea water samples.

Microcontrollers for Beginners: Build simple circuitry on breadboard

Introduction to Sense HAT: Program the Sense HAT using Scratch

PROGRAMMING USING ARDUINO C++ (Level 1)

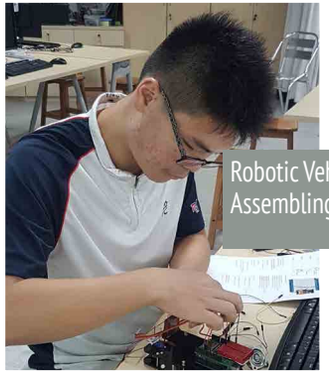
Theme: Programming Using Arduino C++ Level 1

Introduction to Microcontrollers 1 (Arduino C++)

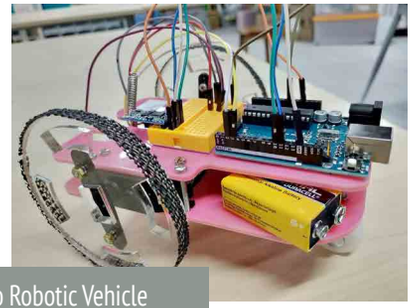
$20 /pax | 3 hours | recommended for Sec 1 to Tertiary | 10< pax <40

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

Microcontrollers are integrated circuit (IC) chips that are able to process input and control machines and devices based on their written program. In our current lifestyle, we can find microcontrollers used in devices such as rice cookers, washing machines, remote controls, etc. In this workshop, participants will get to understand the different components of a development board used for prototyping. They will also get exposed to the C++ programming language and write simple programs using Arduino's Integrated Development Environment (IDE). They will build circuitry on a breadboard using simple components such as buzzer, light-emitting diodes (LEDs) and light dependent resistor (LDR). Mini projects will also be given during the session to enhance participants' understanding of the various components and programming skills taught in the workshop.



Robotic Vehicle: Assembling the Vehicle



ISM Radio Robotic Vehicle

Theme: Programming Using Arduino C++ Level 1 - Application Workshops

ISM Radio Robotic Vehicle (Arduino C++) new

$30 /pax | 3 hours | recommended for Sec 2 to Tertiary | 10≤ pax ≤24

Pre-requisite: Introduction to Microcontrollers 1 or equivalent

Syllabus Link: Suitable for Applied Learning Programme

Robotics is a fast growing industry that is estimated to be worth tens of billions of dollars. Using the Arduino Uno and the Radio Communication Module, participants will learn to send messages between two microcontrollers wirelessly. This technique can be used in many applications such as datalogging, robotics and telecommunications. In this workshop, participants will self-assemble a robotic vehicle and control the vehicle via radio communications. Computational and systems thinking will be required to assemble and program the final prototype from its constituent components.

Understanding Corals with STEM

$25 /pax | 3 hours | recommended for Sec 2 to Tertiary | 10≤ pax ≤24

Option 1: Programming using Scratch Option 2: Programming using Arduino (C++)

Pre-requisite: Microcontrollers for Beginners / Microcontroller 1 or equivalent

Syllabus Link: Suitable for Applied Learning Programme

Coral reefs around the world are in distress and are on the brink of destruction due to environmental changes. Increase in sea temperature and pH changes are some of the threats that corals face. By programming and designing a system that can detect these changes in the environment, intervention and rescue works can be carried out before it's too late.

In this workshop, students will learn about corals and the conditions required for their survival and reproduction. Students will also learn how to build simple circuits and program a microcontroller to detect changes in the water conditions that are essential to the survival of corals. Students will be able to calibrate and test their circuits on actual sea water samples.

Laser Piano (Revamped!) new

$30 /pax | 3 hours | recommended for Sec 2 to Tertiary | 10≤ pax ≤24

Pre-requisite: Microcontroller 1 or equivalent

Syllabus Link: Suitable for Applied Learning Programme

Using lasers as triggers, this simple yet exotic piano teaches participants how interactive elecronics can be used to produce musical notes. Participants will be able to apply their knowledge from the previous microcontroller workshop to learn, build and bring home their handcrafted pianos after the workshop, allowing for further enhancements and refinements.

PROGRAMMING USING ARDUINO C++ (Level 2)

Theme: Programming Using Arduino C++ Level 2 - Fundamentals

Introduction to Microcontrollers 2 (Arduino C++)

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽40
Pre-requisite: Introduction to Microcontrollers 1 or equivalent
Syllabus Link: Suitable for Applied Learning Programme

Building on the previous workshop, Microcontroller 1, participants will be introduced to more electronic components. For example, they will learn how to use a potentiometer to control a RGB LED to create a home mood lighting system. Participants will also be expose to more advanced programming syntax such as conditional loops and map function.

Theme: Programming Using Arduino C++ Level 2 - Application Workshops

Robot Arm (Arduino C++)

$40 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽18
Pre-requisite: Introduction to Microcontrollers 1 &2 or equivalent
Syllabus Link: Suitable for Applied Learning Programme

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.

Structured Experimentation Programme (Secondary Level)

Workshops (Secondary)

Workshops (Tertiary)

Datalogging (Arduino C++)

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽20
Pre-requisite: Introduction to Microcontrollers 1 & 2 or equivalent
Syllabus Link: Suitable for Applied Learning Programme

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.

Distance & Motion Sensing (Arduino C++)

$30 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽20
Pre-requisite: Introduction to Microcontrollers 1 & 2 or equivalent
Syllabus Link: Suitable for Applied Learning Programme

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.

Urban Farming (Arduino C++)

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽20
Pre-requisite: Introduction to Microcontrollers 1 & 2 or equivalent
Syllabus Link: Suitable for Applied Learning Programme

Urban farming is gaining popularity in land scarces Singapore which depends primarily on imported food. Such farms use high-tech and high-yield methods to overcome the limitations of traditional farming. Many urban farmers use drip or underground irrigation system which will trickle a measured amount of water where and when it is needed instead of spraying too much water over the crops.
In this workshop, participants will learn how to build a simple plant watering system using different sensors, and use an Arduino-based microcontroller to program the automation process. Participants will build on their programming knowledge acquired in Microcontrollers 1 and 2, and learn how a microcontroller system can be applied to solve a real-life situation.

PROGRAMMING USING ARDUINO C++ (Level 3)

Theme: Programming Using Arduino C++ Level 3

Introduction to Microcontroller 3 (Arduino C++)

$20 /pax | 3 hours | recommended for Sec 3 to Tertiary | 10≤ pax ≤18

Pre-requisite: Introduction to Microcontrollers 1 & 2 or equivalent

Syllabus Links: Physics O-level and A-Level - Electromagnetism (DC Motors), Suitable for Applied Learning Programme

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.

PROGRAMMING USING PYTHON

Introduction to Python with Raspberry Pi and Sense HAT

$25 /pax | 3 hours | recommended for Sec 2 to Tertiary | 20≤ pax ≤40

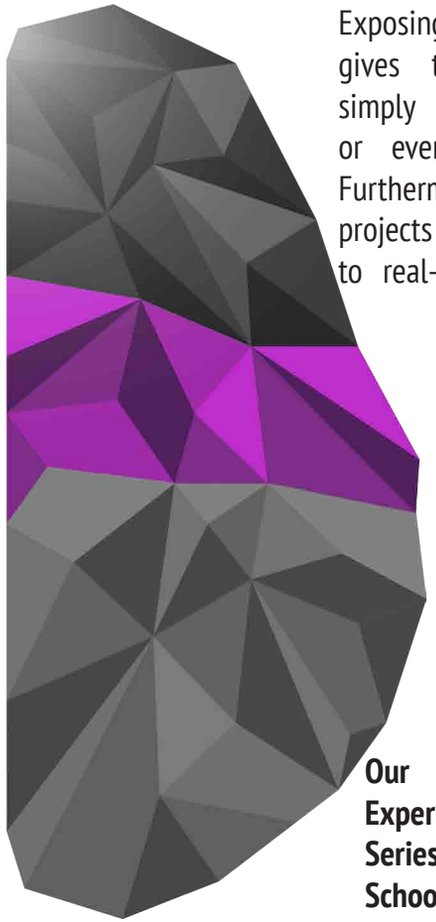
Syllabus Links: Computing syllabus for O-level and A-Level, Suitable for ALP

"It was amazing and it aroused my interest in coding."

Zechariah Singh (13 year old), Student participant of Introduction to Python

Python is a powerful programming language that is used by many tech companies such as Google, Walt Disney and NASA while the Sense Hat 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 starting point for beginners who are interested in learning this powerful programming language.

INNOVATION & RESEARCH PROGRAMME



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 R&D Experience Programme, Research Lecture Series and collaborations with school including School-Partnered Research Projects, School-Partnered R&D Experience Programme) help foster scientific habits of mind through science research.

Mentorship (School-Partnered)

Cluster West
Science Mentoring Programme 2019,
Four groups received High Distinction

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 advice for their projects. There is also a suite of prototyping and measurement equipment available at CRADLΣ to support the needs of their projects.

Our team of Research Mentors has extensive experience in mentoring students for projects, events and competitions such as the Singapore Science and Engineering Fair (SSEF), Youth Science Conference (YSF), 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 and our track record.

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

Innovation & Research Programme

Research Programme

Past Projects

Physics & Mathematics Related

- SONAR applications
- Characterization of gold nanoparticles generated from a sputter-coat machine
- White light communication
- Acoustic beaconing

Chemistry / Environmental Science

- Electrochemical energy of fruits and vegetables
- Investigating the densities, viscosities & refractive indexes of biodiesel-diesel fuel blends
- Microbial Fuel Cell
- Co-sensitisation of Betalain and Chlorophyll Pigments on Dye-Sensitised Solar Cells
- Effect of polystrene on the growth and movement of *Oxyrrhis marina*.

Engineering

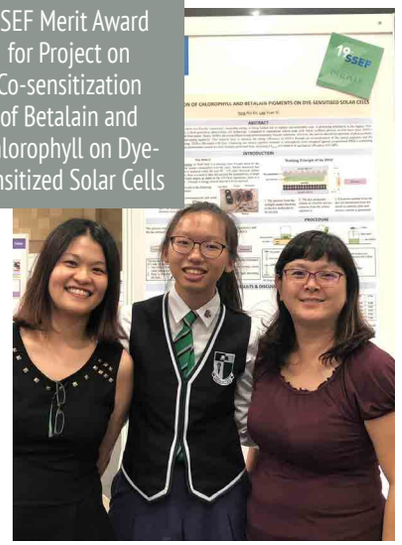
- Investigation of Aerogel properties
- Investigation and fabrication of superhydrophobic surfaces
- Design, characterisation and optimization of a human-motion-based renewable energy harvesting system
- Absorbance/Fluorescence spectrometer
- Long range cell phone signal detector

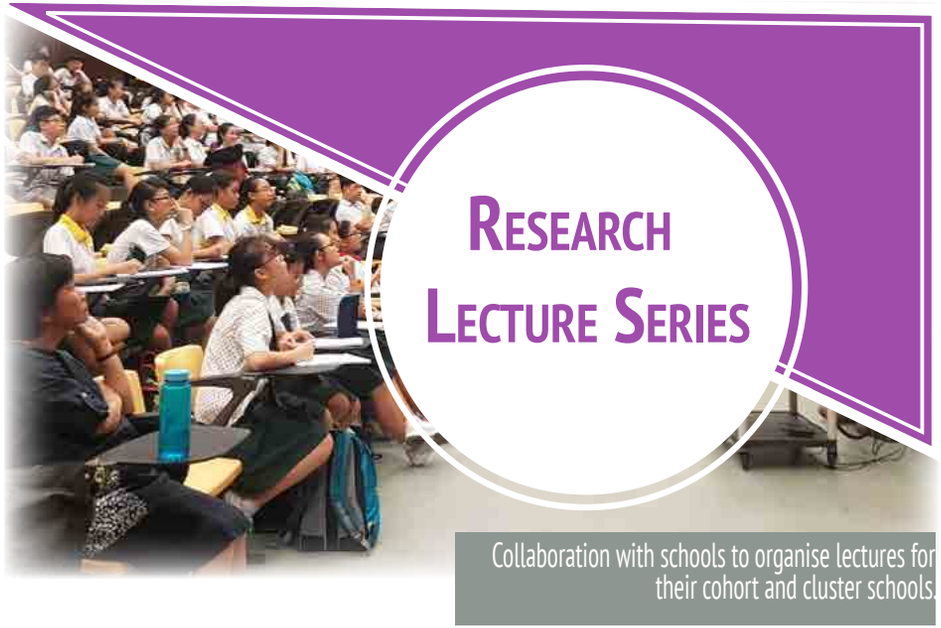
Our Recent Track Record

2018
YSF: One 3M Best Project Award, Three Distinction Awards, One Merit Award, Two Outstanding Mentor Awards
SSEF: One Silver Award, One Merit Award & One Special Award (IEEE)

2019
YSF: Three 3M Best Project Awards, Two Distinction Awards, One Merit Award, One Outstanding Mentor Award
SSEF: One Merit Award

SSEF Merit Award for Project on Co-sensitization of Betalain and Chlorophyll on Dye-sensitized Solar Cells





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 that "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 to result in good science and successful engineering project.

Innovation & Research Programme

Literature Review

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

Have you embarked on a research project in earnest before discovering that it is fundamentally flawed? Or tried 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 the mountain of online information.

Methodology & Data Collection

MOST POPULAR

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, as well as 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

MOST POPULAR

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 about basic statistical methods like mean, standard deviation and t-test, which will be useful when discussing their research project.

Data Analysis (Practical)

new

$20 /pax | 2.5 hour | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽40
Pre-requisite: Data Analysis Lecture

An add-on to the data analysis lecture, this practical session allows students to work on actual data and interpret the data accordingly. Students will be able to perform basic descriptive statistics (mean, median, standard deviation), plot charts and carry out inferential analysis (hypothesis testing, t-test) by just using Microsoft Excel.

Research Programme

Writing a Scientific Report

MOST POPULAR

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 as compared to 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.

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 has 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.

"The experience was amazing. I like the instructor because he (shared with us) a lot of experiences and the knowledge (could be used) in the near future."
- Umariah, 15 year old

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 time slot in the online booking system, please contact us at cradle@science.edu.sg and we may be able to make special arrangements.

R&D Experience Programme

R&D EP 2019 Period 1

Introduction

CRADLΣ's Work Experience Programme (WEP) has been renamed to Research & Development Experience Programme in 2018 to give a more accurate indication to the programme that the students will attend here at CRADLΣ.

Piloted in 2014, CRADLΣ's WEP has grown from strength to strength. 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 projects are also meant to be a catalyst for students' interest in STEM-related fields, possibly cumulating into full-fledged research projects. For tenacious students, innovative solutions to existing problems might be borne from further efforts.

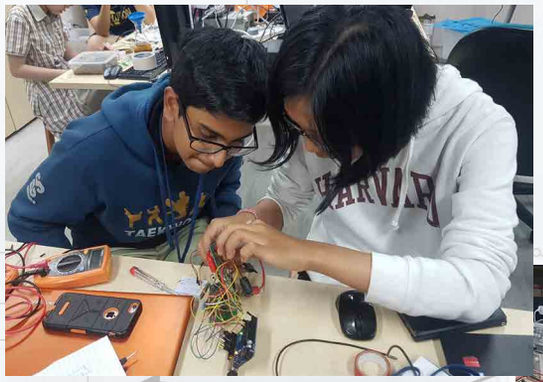
In the new R&D Experience Programme, we will see students being given more time to read up and design and develop their projects. A nominal fee per student will be charged.

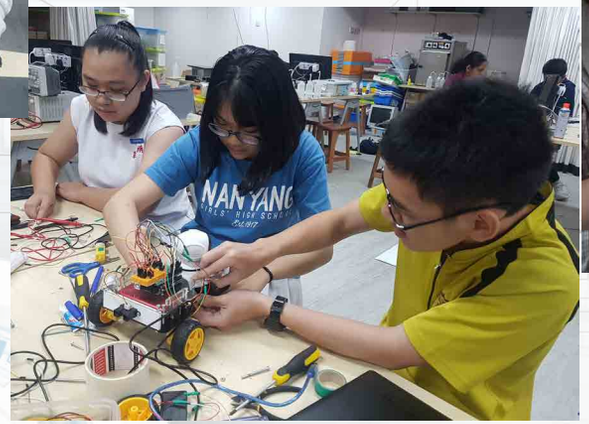
Innovation & Research Programme

Our R&D Experience Programme is split into 2 main categories:

1. 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.





"I had a lot of learning various skills such as LibreCAD and soldering, and applying them on the spot. Although the learning curve was a bit steep, I like how we were constantly challenged to improve our prototype."

By Teo Ji Xin (Project: Solar Pyranometer)

Past Engineering Projects

- Line Tracking Robotic Vehicle
- Inductive Metal Detector
- Wi-Fi Vision Robotic Vehicle
- Email Arduino Communication
- MMPT Solar Charge Controller
- Remote Controlled Tank Chassis
- Wireless Controlled Robotic Hand
- DIY Electric Diffuser
- Polarimeter
- Theremin
- Arduino Titrator
- Automated Plant Watering System
- Water Quality Sensor

2. 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.

"What I enjoyed most about the project is to be able to design my own prototypeas there are minimal opportunities (in school) to think creatively and really create what we have designed."

By Cheryl Lee (Project: Solar Tracker)

Past Research Projects

- Investigating Plant Electrophysiology
- Create Vegetable-based Batteries
- Microfluidics in Biology, Chemistry and Diagnostic
- Atmospheric Attenuation of Solar Radiation
- Neurophysiology of Earthworms

Research Programme

Research & Development Experience Programme

Workflow 2020

R&D Experience Programme **Period 1**: 19th Nov 2020 to 30th Nov 2020

R&D Experience Programme **Period 2**: 3rd Dec 2020 to 14th Dec 2020

Deadline	Action
by 17 Aug 2020	R&D Experience Programme Application Phase 1 opens. Schools to advertise and get student sign-ups. **ALL** project offerings are open for application (regardless of period of attachment).
by 3 Sep 2020	Schools to email completed application forms to CRADLΣ. If a project is oversubscribed, a selection process will be conducted (by the respective mentors).
by 10 Sep 2020	CRADLΣ to email R&D Experience Programme (Phase 1) results to schools.
by 16 Sep 2020	R&D Experience Programme Application Phase 2 opens. Students to apply for any remaining projects or newly listed projects.
by 28 Sep 2020	Schools to email completed application forms to CRADLΣ.
by 1 Oct 2020	CRADLΣ to email R&D Experience Programme (Phase 2) results to schools.
19 Nov 2020	Start of R&D Experience Programme Period 1.
30 Nov 2020	End of R&D Experience Programme Period 1.
by 30 Nov 2020	Submission of written report and review questionnaire to CRADLΣ.
3 Dec 2020	Start of R&D Experience Programme Period 2.
14 Dec 2020	End of R&D Experience Programme Period 2.
by 14 Dec 2020	Submission of written report and review questionnaire to CRADLΣ.

Things to note:

1. Application for the R&D Experience Programme does not guarantee acceptance.
2. Application forms are the first point of selection.
3. Incomplete / illegible application forms will not be considered.
4. There is no compensation / pay during the period of the programme.
5. Applicants are to read the Code of Conduct and adhere to the conditions stated.

Innovation & Research Programme

Research Programme

SchoolPartnered R&D Experience Programme

Introduction

School-Partnered R&D Experience Programme is a customised programme (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. Schools interested will need to inform us six months before the intended start date of the School-Partnered R&D Experience Programme to check for mentors' availability as well as discussion of other details.

Project Ideation Options

1. Open-ended - As per CRADLΣ R&D Experience Programme, the mentors will come up with the project ideas and students can apply for it.
2. Thematic - The school can choose a theme (Eg. Robot Arm) 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: 5 to 10 days
Maximum intake: 25 students

To find out more about our School-Partnered R&D Experience Programme, please contact CRADLΣ for more information.

Research Programme

Innovation & Research Programme

Choa Chu Kang Secondary School R&D EP for Tier 2 ALP in 2019

Kranji Secondary School R&D Experience Programme 2019

Zhonghua Secondary School R&D Experience Programme 2019

Online Booking @ https://obs.science.edu.sg/OBS2020/WebApp/Login

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

CRADLΣ & SCHOOL CAMPS

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. S.M.A.R.T. encompass lectures, hands-on classes and sharing by industry experts on a respective theme.

Starting from 2019, schools will be able book for our thematic camps (as shown below) and have it conducted to your students.

2019 SMART Camp: Robotic Vehicles

Interested in S.M.A.R.T. camps to be conducted for your school? Contact us now!

cradle@science.edu.sg

www.science.edu.sg/for-schools/cradle

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 2020.

March Holidays: **17th - 18th March 2020**
Nov-Dec Holidays: **1st - 2nd December 2020**

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.

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

2019 Overseas Jakarta Group

Online Booking @ https://obs.science.edu.sg/OBS2020/WebApp/Login

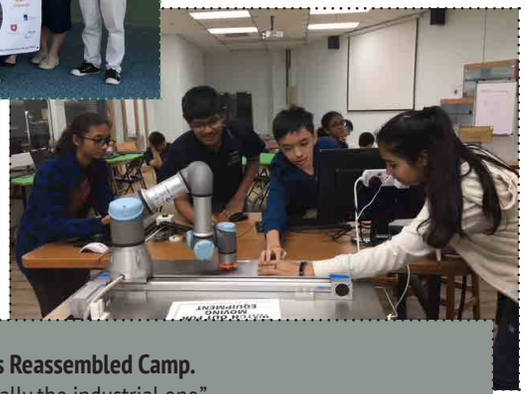
School Camps

Starting from 2019, schools will be able book for our thematic camps (as shown below) and have it conducted to your students. The camp could be arranged to fit into the school's schedule but subjected to trainer's availability.

Themes available:
1) Electronics Camp (2-day)
2) Robotics Reassembled Camp (2-day)
3) Robotic Vehicles (2-day)

"It was a very fun experience and I could learn a lot of things about electronics"

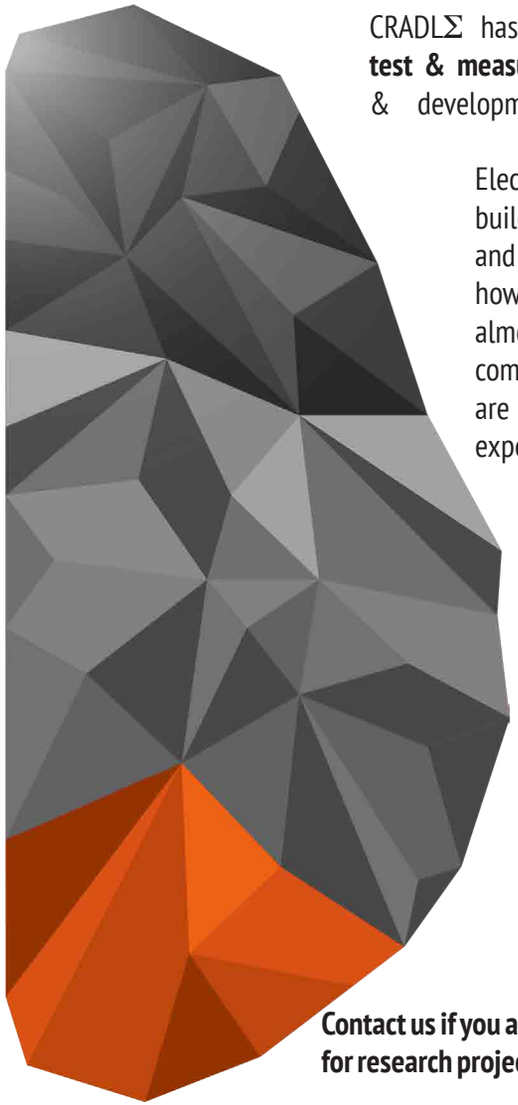
By 16-year old female participant of Electronics Camp



Describe your fun moments of the Robotics Reassembled Camp.
"Building & programming the robots especially the industrial one."
"Handling the 6-axis robot gives a good understanding of the real world applications."
By 16-year old participants

To find out more, please contact CRADLΣ for more information.

SKILLS & EQUIPMENT TRAINING PROGRAMME



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

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

Skills & Equipment Training Programme

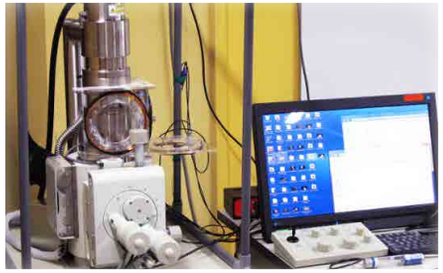
Equipment List

1. Specialized Instrumentation

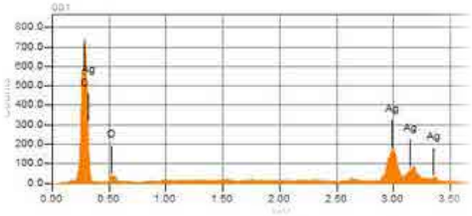
- Optical Microscope
- Sputter Coater
- Hydrogen Discharge Lamps
- Sodium Vapor Lamps
- Ultrasonic Cleaner
- Scanning Electron Microscope with X-ray Elemental Analysis Capability

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 (Bottom) The EDX spectrum of the sample below 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.

Equipment Training Programme

2. Electronic Instrumentation

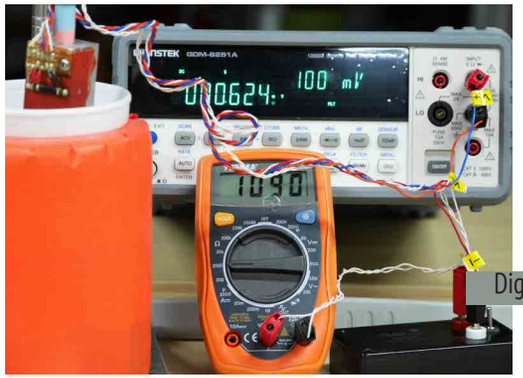
- Arbitrary Waveform Generator
- Cathode Ray Oscilloscope
- Current and Voltage Preamplifiers
- Digital Multimeter
- Digital Oscilloscope
- Lock-In Amplifier
- Power Supply
- RF (Radio Frequency) Signal Generator
- Spectrum Analyzer
- High Voltage Power Supply

Digital Oscilloscopes

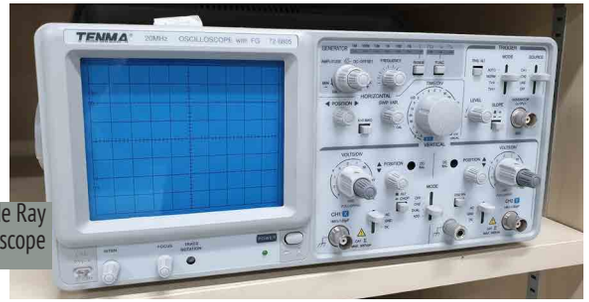
$15 /pax | 2 hours | recommended for Sec 3 to Tertiary | 10⩽ pax ⩽24

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.



Digital Multimeter



Cathode Ray Oscilloscope

Skills & Equipment Training Programme

Equipment Training Programme

3. Mechanical Tools

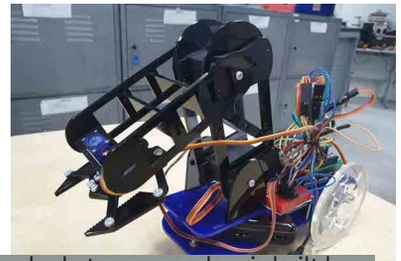
- 3D Printer
- Benchtop Lathe
- Chemical Etch Tank
- Dremel Rotary Tool
- Stone Grinder
- Laser Cutting Machine
- Benchtop Mill Machine
- Portable Jigsaw
- Power Drill
- Solder Station
- Glue Guns
- Cutting Plotter
- Hot Air Gun
- UV Exposure Unit

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.

Engrave and cut two-dimensional structures using a laser cutter



Three-dimensional robot arm on a chassis built by assembling two-dimensional parts

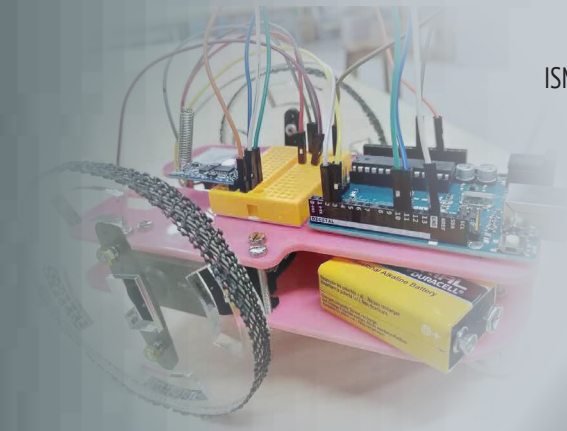
Basic Soldering

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

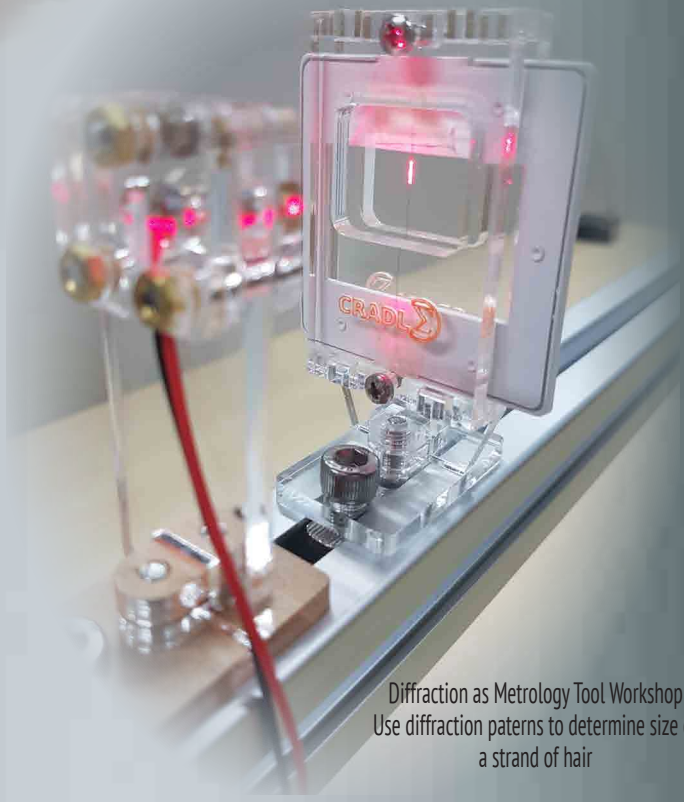
A staple in electronics, Basic Soldering aim to equip participants with skills that allow them to transfer their electronic prototypes from a breadboard onto a strip board. This is necessary if the circuit is to be made smaller and more rugged. Participants will be exposed to the different types of IC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

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.



ISM Radio Robotic Vehicle Workshop



Diffraction as Metrology Tool Workshop: Use diffraction paterns to determine size of a strand of hair

www.science.edu.sg/for-schools/cradle

cradle@science.edu.sg

www.facebook.com/CRADLEsci

15 Science Centre Road, Singapore 609081

All information in this booklet is correct at time of print. Please enquire with us for latest updates. SCB reserves the right to adjust programme price.

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