

Engineering Hands-On!

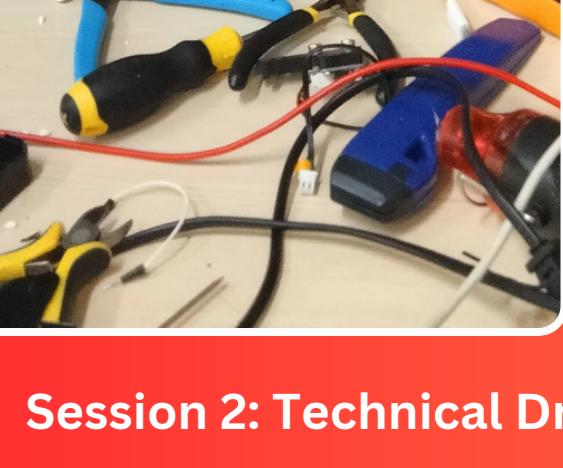
K-12 Engineering Education Curriculum



This curriculum is used by the Engineering Hands-On! CCA Club of SJI International, Singapore. This is fully created by students, for students, and aims to teach modern Engineering skills and mindset to Grade 7 - 12 through direct hands-on making. The intended group size is 15 - 25 students. The weekly sessions are 1 hour long & spread out over 24 weeks. The first 12 sessions in Term 1 focus on Mechanical & Structural Engineering topics, while the 12 sessions in Term 2 teach

Electrical & Electronics Engineering skills. The projects take into account the availability of common materials and equipment in a high school science lab. Emphasis is placed on keeping a low running budget to ensure the curriculum can be easily adopted and adapted to accommodate different learning environments.

Term 1



Session 1: Introduction to Engineering

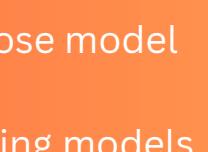
- Intro to Engineering & Engineering Design Process
- Safety & Guidelines
- Intro to tools of Engineering
- Common fabrication processes
- Hands-on Activities: How to use tape measure, read Vernier scale, making measurements of objects around the classroom & 3D printed small objects

Session 2: Technical Drawings

- Intro to isometric & orthographic projection
- How to take measurements, draw basic symbols, holes, hidden surfaces, threads, dimensions, etc.
- Hands on practice, can draw simple technical drawings of 3D printed parts

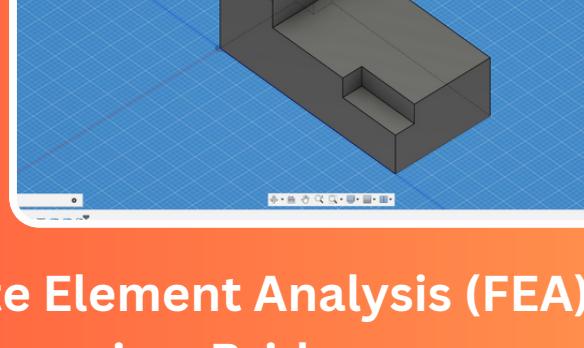


Session 3: Intro to Computer-Aided Design (CAD) & 3D Printing

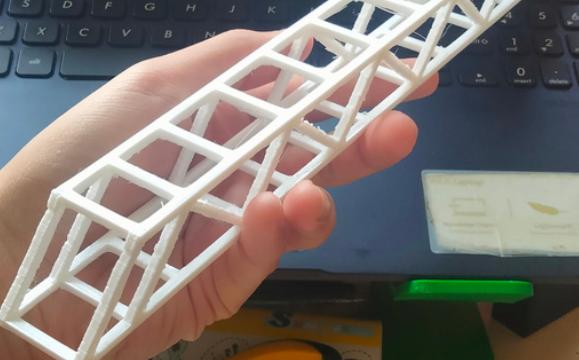


Session 4: CAD with Fusion360

- Introducing Product Design Process
- Introducing Fusion360
- Take measurements & model simple objects (can be 3D printed parts) with Fusion360, export file to 3D print prototype



Session 5: Finite Element Analysis (FEA). Structural Engineering. Bridges



- Introduction to forces.
- Basic bridge structures presentation. 5 main types of bridges
- Design basic truss bridge with Fusion360
- Structural analysis simulation on Fusion360 FEA to test bridge. Print bridges to test for next session



Session 6 & 7: Simple Machines

- Bridge testing from previous session
- Introduction to mechanical advantage
- Simple machines & mechanisms demo with printed models (pulley systems, worm gears, bevel gears, rack & pinion, lead screw, 4 bar linkage, slider crank, cam)
- More complicated mechanisms (clock escapement, harmonic drive, etc.)
- Hands-on designing & making simple machines, using basic materials or CAD.



slider crank mechanism



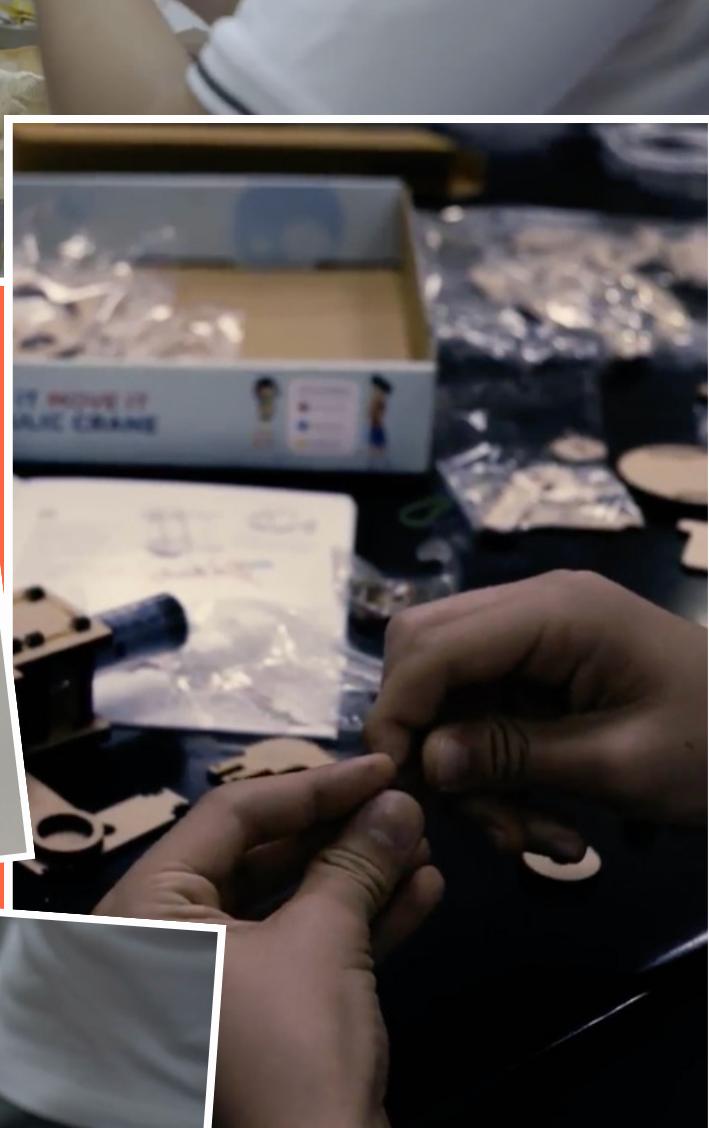
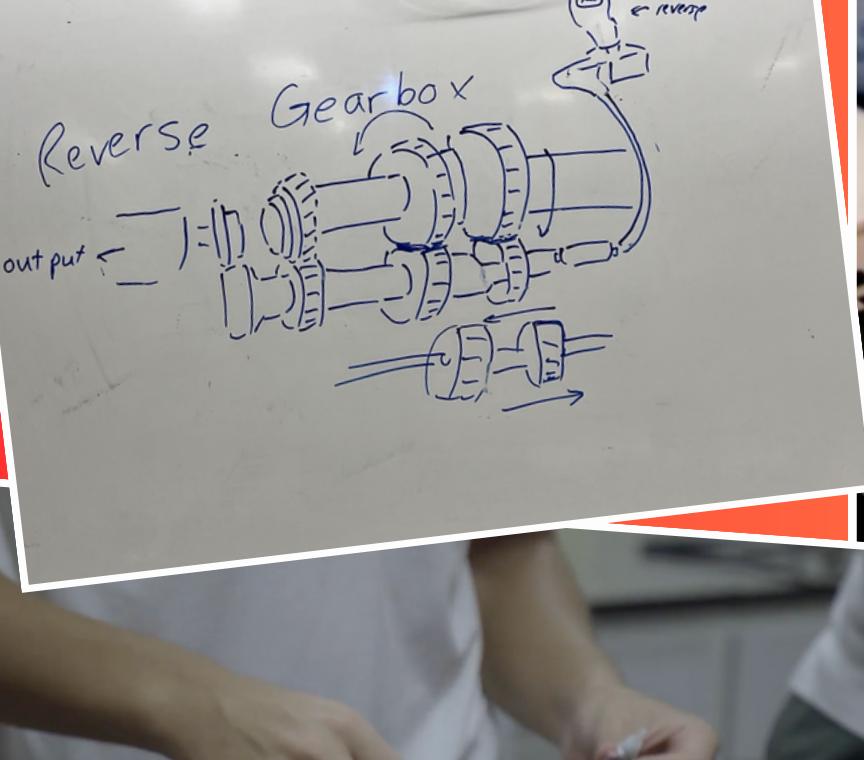
Session 8 & 9: Complex systems breakdown. Cars

- Introduction to complex system of cars. Models of some mechanisms (gearbox, engine)
- Group work: Designing & modelling working prototype of cars parts (windshield wiper, car window, steering mechanism, differential, basic reverse wheel for gearbox, etc.)
- Presentation of work



Session 10, 11 & 12: Final Engineering Project

- Group brainstorming, designing and creating a final project, using skills acquired throughout the course.
- Presentation of projects.



Session 13: Introduction, Basic Circuit Elements & Design

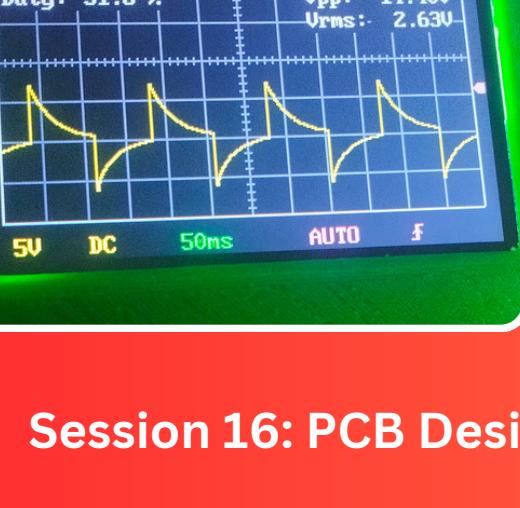
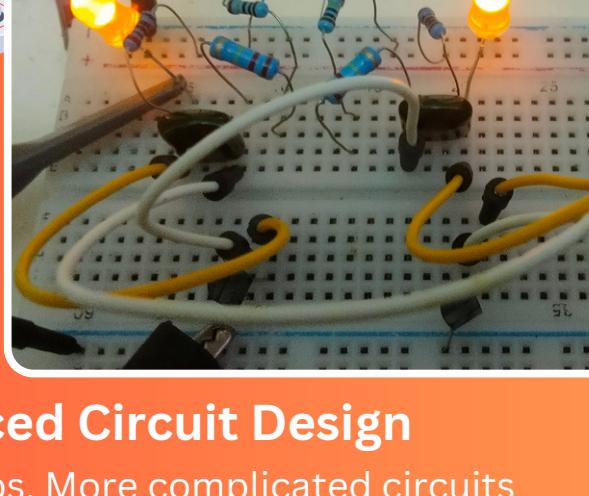
- Electrical Safety & Guidelines
- Current and Voltage - Basic Components (power supply, breadboard, resistors, caps, inductors, diodes, LED, switches, multimeter, oscilloscope, etc.)
- Hydraulic Analogy
- Color codes, Circuit Symbols & Wiring Diagrams
- Practice measuring components, power supply, using oscilloscope, etc.



Session 14: Simple circuits. Semiconductor. Integrated Circuits



- Basic Introduction to Semiconductors (Transistors), basic ICs (555 Timer, 78x). How to read data sheet
- Building Simple Circuits (LED with switch, Blinking with 555 Timer / BJT, RC/LR Filters, LC Oscillator). Observe with Oscilloscope



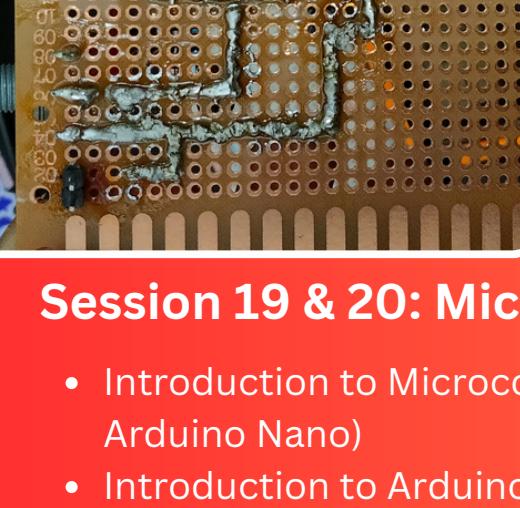
Session 15: Advanced Circuit Design

- Introduction to op-amps. More complicated circuits (Rectifier, Amplifier circuits, etc.)
- Basic AC circuits (discussion on Inductance, Impedance, Household power supply)
- Introduction to Transformers, relays.
- Hands-on making Amplifier Circuit, DIY Bench Power Supply, etc. Testing with Oscilloscope.

Session 16: PCB Design



- Introducing PCB & design software (KiCAD)
- Design PCB & send for printing
- Possible designs: Amplifier circuit, Guitar Filter pedal, Blinking LED, etc.

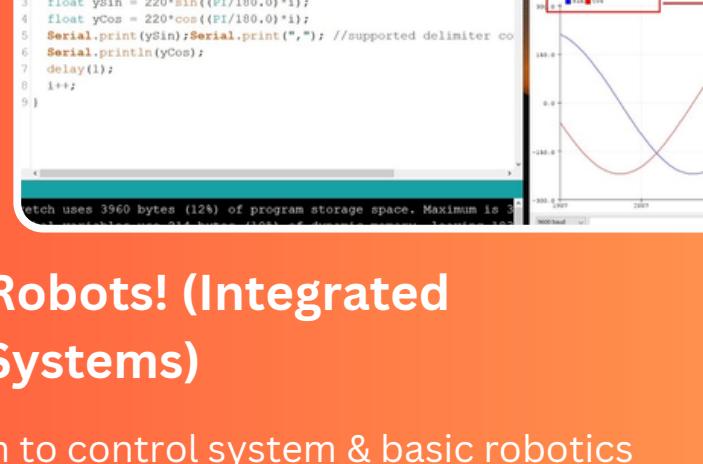


Session 17 & 18: Soldering & Perfboard

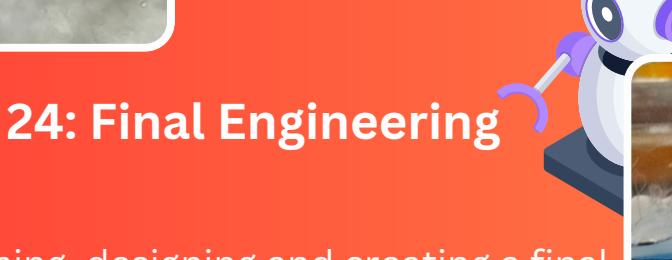
- Introduction to soldering equipment & process
- Demonstration by mentors
- Practice soldering (Analog Transistor blinker circuit with Perfboard)
- Practice soldering components on the designed PCB.

Session 19 & 20: Microcontrollers

- Introduction to Microcontrollers (Arduino, Arduino Nano)
- Introduction to Arduino programming (basic LED blinker)
- Introduction to sensors & motors (motor driver, DC, stepper, servo)
- Practice: using potentiometers, light, range sensor, motors,...



Session 21: Robots! (Integrated Embedded Systems)



- Introduction to control system & basic robotics control. Integration of mechatronics engineering
- Activity: making small moving robot with motors & joystick control



Session 22, 23 & 24: Final Engineering Project

- Group brainstorming, designing and creating a final project, using skills acquired throughout the course.
- Presentation of projects.

