



Integrating school curricula with the ATL



| Volume III |

Grades: 9–10



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Message from Samagra Shiksha, Andhra Pradesh



It is with immense pleasure and a deep sense of commitment to the future of our young learners that I present this handbook for teachers on using the Atal Tinkering Labs to provide a quality experiential learning for children. The ATLs, as we know, offer a unique opportunity for 'learning by doing', decisively moving away from rote-based learning. Learning by doing is the principle that is at the heart of STEM education. The ATLs, offering access to modern and conventional technology tools to young minds, have been established across the country at a pivotal moment, as we collectively strive to nurture a generation of innovators, problem-solvers and critical thinkers.

To the teacher, I would like to say that this handbook has been meticulously developed to serve as your invaluable companion on this exciting journey of exploration and learning. It is a practical guide that helps you to link the subject curriculum with the activities that can be done at the ATL. The integration of the ATL into your school timetable and routines is essential, and this will lead to an effective use of this innovative space. The handbook is designed to make this integration possible. At the same time, the handbook goes beyond the immediate needs of the syllabus, and offers a simple and powerful framework for identifying solutions to the myriad problems and challenges of daily life.

The handbook has two main parts – a section on Design Thinking, and a section on sample activity plans for grades 6-10 (40 of them, across the subjects of Physics, Chemistry, Mathematics and Biology), which offer clear guidance on how to integrate curricular concepts with ATL activities, using the tools available at the ATLs. As you implement the activity plans, you will understand how they help to bring key concepts alive, using a variety of tools available in your ATL. Also, use these activity plans to develop your own activity plans. Your aim should be to cover all the key concepts that you teach in science and mathematics.

A word or two must be said about the section on Design Thinking. This idea is at the heart of the Atal Tinkering Lab. It can be called a human centered process, a mindset or an approach to problem solving, with a focus on developing solutions. One can identify many challenges or problems that need to be solved in daily lives. Design thinking offers a framework that can be used by teachers and children to identify these problems and work towards their practical solutions. Increasingly, this is seen as an ability that needs to be developed through the educational

experiences that schools provide. The ATLs offer all the tools for design thinking. The handbook offers a simple and clear introduction to this powerful learning process, and we hope that the case studies presented here will motivate children and teachers to get on to this exciting journey.

Samagra Shiksha, Andhra Pradesh, is deeply committed to supporting all our teachers. The ATL handbook is a concrete step in that direction. We believe that by investing in the professional development of our teachers, we are directly investing in the future of our state.

I urge every teacher to thoroughly engage with this ATL handbook. Do share your experiences and continuously innovate within your labs. Let us collectively strive to transform our schools into hubs of innovation, where every child feels empowered to dream, design and create. Together, let us empower the next generation to be creators of solutions, not just consumers of knowledge and build a brighter, more innovative Andhra Pradesh.

With best wishes,

B. Srinivasa Rao (IAS)

State Project Director

Samagra Shiksha

Andhra Pradesh

Message from Samagra Shikshana, Karnataka



It is with immense pleasure and optimism that I present this *Atal Tinkering Lab Handbook for Teachers*. This is a thoughtfully crafted guide designed to bridge the gap between classroom learning and hands-on innovation. The Atal Tinkering Labs (ATLs) represent a transformative vision for education, fostering creativity, curiosity, and problem-solving among young minds. This handbook serves as a vital resource for teachers, empowering them to integrate core academic subjects—Physics, Chemistry, Biology, and Mathematics—with the dynamic, experiential activities of the ATL.

The activity plans included in this handbook are meticulously designed to be both detailed and are user-friendly, enriched with illustrations, video guidance through QR codes, and thought-provoking questions to spark meaningful discussions. By clearly mapping curricular linkages, these plans enable educators to seamlessly "bring the classroom to the ATL, and the ATL to the classroom." They are not just tools for teaching but invitations to explore, experiment, and connect theoretical knowledge with real-world applications.

Equally significant is the handbook's dedicated section on design thinking, a powerful framework for fostering innovation. ATLs are more than laboratories; they are vibrant spaces where ideas take flight. Design thinking, as outlined in this guide, equips teachers and students with a structured yet flexible approach to problem-solving, encouraging them to step beyond textbooks and embrace the world of innovation. Through engaging examples, this section illustrates how design thinking can ignite creativity and inspire solutions that are both practical and transformative.

This handbook is a testament to the belief that education thrives when it blends structure with imagination, discipline with exploration. It is our hope that teachers will find this resource an inspiring companion in their journey to nurture the next generation of innovators, thinkers, and changemakers. Let the Atal Tinkering Labs be the launchpad for ideas that shape a brighter future.

Dr. Vidya Kumari (IAS)

State Project Director

Samagra Shikshana

Karnataka

Message from Samagra Shiksha, Telangana



It gives me great joy to share with the teachers and students of Telangana the Atal Tinkering Lab Handbook for Teachers, as we take another meaningful step towards transforming education. Atal Tinkering Labs (ATLs), established in schools across the state, are redefining learning through a strong experiential and inquiry-driven approach. I truly believe this handbook will enable teachers to build the necessary skills to transform our schools into vibrant hubs of innovation.

The role of education has always been to nurture curiosity, encourage original thinking, and prepare students to face the challenges of a changing world. This is precisely what ATLs set out to do. They invite both teachers and students to return to the roots of discovery, by asking questions, exploring solutions and learning by doing. ATLs remind us of the true essence of education: a joyful, curious, and purpose-driven journey.

This handbook contains 40 carefully crafted activity plans across science subjects, serving as a reliable guide for teachers. Each activity plan includes detailed instructions, illustrations, and supplementary video explanations. These plans show how key curriculum concepts can be brought to life through hands-on projects. Teachers are encouraged to use these examples not only as blueprints but as inspiration to design their own activity plans tailored to their students' needs and interests.

The handbook also has a dedicated section on Design Thinking, a mindset and process that lies at the heart of the tinkering labs. Design Thinking rests on a fundamental belief: that everyone has the capacity to create change, regardless of how big the challenge, how small the budget, or how limited the time. I am especially proud to note that the handbook includes six inspiring case studies from ATL schools across Telangana, Andhra Pradesh, and Karnataka, where students have developed creative, practical solutions to everyday problems in their community. I hope these stories motivate our students to take on new challenges and turn their ideas into action.

I urge every teacher to engage deeply with this handbook. Encourage your students to experiment, question, and design solutions without restriction. Share your experiences, collaborate with peers, and also support your students to engage with this resource as the content in the handbook is accessible and

student-friendly, especially for those with the interest and curiosity to go further. I appreciate the hard work of all our teachers who played a key role in the design of the handbook, as well as Vigyan Ashram and UNICEF teams for their continuous support in this endeavour.

With our combined commitment and belief, let us make Telangana a model for transformative education - where every child is seen not just as a learner, but as a potential innovator, change-maker, and problem-solver. Let every school become a space where creativity, inquiry, and innovation take centre-stage.



Dr. E. Naveen Nicolas (IAS)

State Project Director

Samagra Shiksha

Telangana

Message from Atal Innovation Mission



It gives me great pride and enthusiasm to present this handbook for teachers—an essential resource developed to support the transformative work happening in Atal Tinkering Labs (ATLs) across India. At its core, the ATL initiative is not just about tools or technology—it is about cultivating a mindset. A mindset that encourages curiosity, creativity, critical thinking, and problem-solving among young learners.

This handbook is a step towards empowering teachers to seamlessly integrate the spirit of innovation into the fabric of everyday classroom learning. By linking theoretical concepts with ATL-based hands-on activities, this resource guides teachers to facilitate experiential learning that is both engaging and purposeful. With a clear structure that includes sample activity plans across STEM subjects and a foundational orientation to design thinking, the handbook equips educators to create vibrant learning experiences that go beyond textbooks.

The section on Design Thinking is particularly noteworthy—it introduces a human-centric approach to problem-solving that is essential in today's rapidly evolving world. Teachers are encouraged to use this section not just as a pedagogical tool, but as a way to inspire students to observe their surroundings, empathize with real-world problems, and develop innovative solutions with confidence and intent.

This handbook reflects our unwavering commitment to supporting educators on this journey. It is our belief that when equipped with the right tools and mindset, teachers can ignite in every child a lifelong passion for exploration and innovation.

Let this handbook be more than a guide—let it be an invitation to transform your ATL into a space where imagination thrives, questions lead to discovery, and every learner is empowered to be a change maker.

With warm regards and best wishes,

Deepali Upadhyay

Program Lead

Atal Innovation Mission, NITI Aayog

Message from UNICEF



The Atal Tinkering Laboratories (ATLs), established under the aegis of the Atal Innovation Mission (AIM) of NITI Aayog (National Institution for Transforming India Commission), represent a transformative initiative in reimagining the way children in middle and secondary grades learn. These innovative learning spaces provide students and teachers with opportunities to explore modern as well as traditional technological tools, engage in hands-on projects, and foster creativity through experiential learning. This aligns closely with the vision of the National Education Policy (NEP) 2020 and the 21st century skills framework, which are guiding schools across India in preparing children for the future.

The work done by the Departments of School Education in Andhra Pradesh, Karnataka, and Telangana to strengthen ATLs in partnership with UNICEF has yielded highly encouraging results. Teachers have responded positively to various capacity-building initiatives, delivered through both face-to-face and digital platforms, while students-girls and boys alike-have shown remarkable enthusiasm in utilizing these spaces. Several innovative ideas and examples of *design thinking in action*, some of which are presented in this handbook, have emerged from government schools in these states. A rigorous study to capture and analyse the outcomes of these initiatives is also being undertaken by UNICEF in collaboration with the respective state governments.

The Government of India's recent announcement to establish an additional 50,000 ATLs across the country is a welcome move which will help expand the reach of this innovative initiative, with one ATL catering to every three or four secondary schools and will also enable ATLs to serve as hubs for neighbouring schools that may not yet have such facilities.

This handbook has been developed as a practical resource for teachers, with the aim of supporting them in further advancing this exciting journey of tinkering, problem solving, discovery, and innovation. The handbook comprises two distinct sections:

- The first section introduces the principles and practice of *Design Thinking* in an accessible, illustrated format, enriched with case studies from government schools across Andhra Pradesh, Karnataka, and Telangana.

- The second section responds to a frequently expressed teacher concern-the need to meaningfully integrate ATL activities with the school curriculum. To this end, 40 sample activity plans are included, demonstrating how STEM (Science, Technology, Engineering, and Mathematics) concepts can be effectively reinforced through ATL resources and materials.

We believe that the implementation of these approaches and activity plans will not only provide children with engaging, but hands-on learning experiences that build their confidence, creativity, and problem-solving skills but also enhance the quality of education to enable better learning outcomes across the states.

It is my earnest hope that this handbook will complement the Government's efforts to make middle and secondary grades vibrant spaces of learning and innovation, equipping students with the skills and mindset required to contribute to the goals and aspirations of a developed nation by 2047.

With best regards,



Dr. Zelalem Birhanu Taffesse

Chief of Field Office

UNICEF Field Office for Andhra Pradesh, Karnataka and Telangana

Message from Vigyan Ashram



“Learning by doing” plays a vital role in nurturing understanding, creativity, and entrepreneurial skills in children. However, until recently, most schools lacked the necessary tools, equipment, and workshops to effectively implement this approach. The establishment of Atal Tinkering Labs (ATLs) has now made such opportunities accessible to schools.

Over the past three years, Vigyan Ashram, with the support of UNICEF and Samagra Shiksha, has conducted more than hundred online sessions for ATL teachers in Andhra Pradesh, Karnataka, and Telangana. In addition, several in-person training programs have been organized to help teachers effectively utilize ATL resources. Apart from this, we guided several schools in developing projects using the design thinking methodology to address challenges within their communities. During these programs, teachers developed projects that are useful for their classroom sessions and for their community, many of which form the basis of this manual. This manual is therefore a collaborative outcome, created in consultation with school teachers.

Tinkering extends far beyond electronics, 3D printing, coding, or mechanical projects—it is about fostering unstructured learning. Students are encouraged to explore ideas through experiments with food, waste materials, farming, biodiversity, and more. The projects compiled here are illustrative examples, intended to spark ideas and inspire teachers to guide students beyond the activities suggested. These projects serve as examples to inspire teachers about the many ways ATLs can be utilized.

In line with the National Education Policy (NEP) 2020, vocational education has been introduced from Grade 6 onwards. ATL labs provide the perfect platform for implementing vocational projects using the available tools and equipment. In fact, ATLs are not limited to STEM subjects; they are meant to support teachers across all disciplines in making their subjects more engaging and interactive.

We express our gratitude to UNICEF and the Samagra Shiksha teams of Andhra Pradesh, Karnataka, and Telangana for the continuous support they provided during the program. We look forward to many more innovative projects emerging from ATLs—projects that not only build on the examples provided here but also set new benchmarks in creativity and learning.

Dr Yogesh Kulkarni

Director

Vigyan Ashram

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Note for the Teacher

About the Handbook

This handbook has been thoughtfully designed to help you connect classroom learning with hands-on experiences for students. It enables them to visualise concepts taught in the classroom through tinkering, exploration, and innovation in the ATL.

The activity plans presented in this handbook focus on core academic subjects—Physics, Chemistry, Biology, and Mathematics—and include experiential activities.

The handbook is organised as a series of three volumes:

Volume 1: ‘Learning by Doing’ focuses on Design Thinking and equips students with problem-solving skills.

Volume 2: Provides you with activity plans for grades 6–8.

Volume 3: Provides you with activity plans for grades 9–10.

All activities are aligned with the curriculum and expected learning outcomes for each grade level.

Using the Activity Plans

The manual has been detailed in a user-friendly manner, enriched with illustrations, QR codes, web links, images, software programme codes and circuit diagrams to help you facilitate the activities at every step and guide you through the process of building and demonstrating the model. The explanation provided in the videos will help you understand how the model illustrating the concept needs to be built. This helps in reinforcing the concepts discussed in the classroom. Additionally, a glossary is provided in the Annexure to clarify key terms found within the activity plans.

Thought-provoking questions have also been provided to you at the end of each activity plan to spark meaningful discussions with your students. This will help you to assess their understanding of concepts and the project. To help you and your students explore the model further, ideas for modifications of the model have been provided to you in each activity plan. These ideas will help you and your students enhance the model and make it more interesting and applicable to everyday life situations.

Implementing the lesson plans needs to be seen as an activity involving students. This will initiate them to the world of the ATL and will help in developing the confidence needed to use the various technology tools (mechanical, electrical, electronic and software tools). This ‘learning by doing’ experience they will be valuable and is likely to contribute to their curiosity and creativity.

All activities require teamwork and coordination among students. We urge you to promote the spirit of collaboration and self-learning among students. Kindly discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner to motivate students. You could use the simple explanations given below to guide you in this activity. Each student can play these various roles as part of a team.



Safety Practices in the ATL

It is important that you and your students stay safe in the ATL. This calls for practicing safety measures that the outlined below. Kindly follow them diligently.

- Ensure the work area is clean and free from hazards.
- Keep all sharp tools and small parts out of reach of younger children
- Always wear safety gloves when cutting or soldering.
- Keep the soldering station well-ventilated and away from flammable materials.
- Supervise soldering and the use of hot glue gun to avoid burns or accidents
- Handle the drill machine carefully; adult supervision is recommended.
- You and your students must wear safety goggles while drilling.
- Handle electrical components like LEDs and resistors carefully to prevent damage.
- Ensure the wires are insulated to prevent electric shocks.
- Avoid touching the metallic parts of the Arduino board while powered.
- Handle the DC motor and battery connections carefully to avoid short circuits.
- Disconnect the battery after testing to avoid overheating.

Reflections for Improvement

Discussing the models you have built with the students - that is, looking more closely at the various components you have used and the role they play in the making of the model, will help students appreciate how various materials and facilities in the ATL can be used to develop

something useful. Most importantly, these discussions will help students to understand various concepts practically. This will go a long way in deepening their learning.

The activity plans aim to strengthen the linkage between the ATL and the classroom you have with your students while teaching Physics, Chemistry, Biology and mathematics. It also creates a more positive and engaging learning environment and ensures that you are using your time and resources in the ATL effectively.

At the same time, this experience prepares your students to identify challenges around them and do something about these daily life challenges. This is where the volume on Design Thinking will help you to undertake exciting journeys in innovation.

You could keep maintain a record your thoughts, observations, and reflections to help you motivate students to constantly modify the model and innovate.

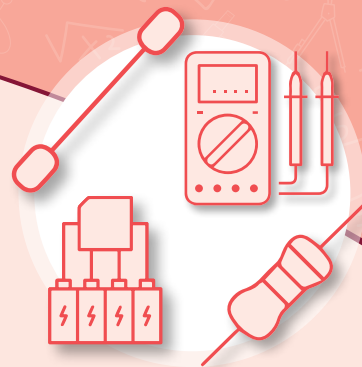
We hope that you will find these activity plans interesting and helpful in inspiring students to become innovators, thinkers, and changemakers.

Happy tinkering!!

Activity Plans

Activity 1

Learning Ohm's Law through Simulation and Hands-on Activities



Grade

9, 10



Subject

Physics



Topic/
Concept

Electricity
(Ohm's Law)

Objective

To help students understand Ohm's Law ($V = IR$) and its application in electrical circuits.

What will you help students learn?

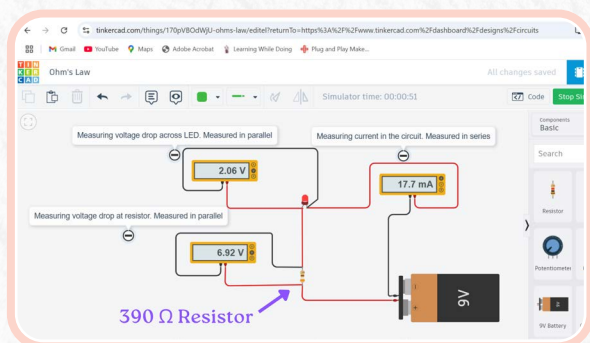
- To perform theoretical calculations, simulate circuits in Tinkercad and construct an actual circuit on a breadboard to verify Ohm's Law.
- Compare theoretical, simulated, and actual experimental results.
- Understand Ohm's Law ($V = IR$) and its significance in electrical circuits.
- To use simulations in Tinkercad to observe the effect of different resistances on current flow.

Sessions

- **Session 1:** Ohm's Law- introduction and basics through Tinkercad Simulation
- **Session 2:** Theoretical calculations and Simulation for the required value of a resistor
- **Session 3:** Hands on experiment with simulation using multiple resistors

What will you build/make?

You will build electrical circuits using a 9V battery, LED/LEDs and resistors of various resistance values (measured in Ω). You will also build these circuits using Tinkercad software and simulate them to verify the Ohm's Law.



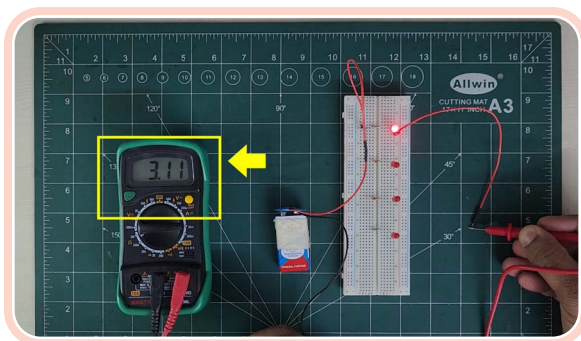
OHM'S LAW

Theoretical Value

1. $R = 330\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 330\Omega = 0.021A$
2. $R = 350\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 350\Omega = 0.02A$
3. $R = 390\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 390\Omega = 0.018A$

Tinkercad Readings

1. $R = 330\Omega$, $V = 7V$
 $I = 0.0209A$
3. $R = 350\Omega$, $V = 7V$,
 $I = 0.0197A$
3. $R = 390\Omega$, $V = 7V$,
 $I = 0.0177A$



Measured Vs Theoretical Vs Simulated Values of Current

Sr. No.	Rm = Resistance (Measured)	Vm = Voltage (Measured)	Im = Current (Measured)	It = Current (Theoretical) = V_m/R_m	Is = Current (Simulated)
1	2.148 K Ω	6.69 V	3.11 mA	$6.69 \text{ V}/2148 \Omega = 0.00311 \text{ A} = 3.11 \text{ mA}$	3.31 mA
2	4.58 K Ω	6.81 V	1.49 mA	$6.81 \text{ V}/4580 \Omega = 0.001486 \text{ A} = 1.49 \text{ mA}$	1.56 mA
3	21.64 K Ω	6.97 V	0.31 mA	$6.97 \text{ V}/21640 \Omega = 0.00032 \text{ A} = 0.32 \text{ mA}$	0.334 mA
4	46.4 K Ω	7.03 V	0.14 mA	$7.03 \text{ V}/46400 \Omega = 0.00015 \text{ A} = 0.15 \text{ mA}$	0.157 mA



<https://youtu.be/SzZB0KD99Wc>



<https://youtu.be/5c6-d1sf89k>



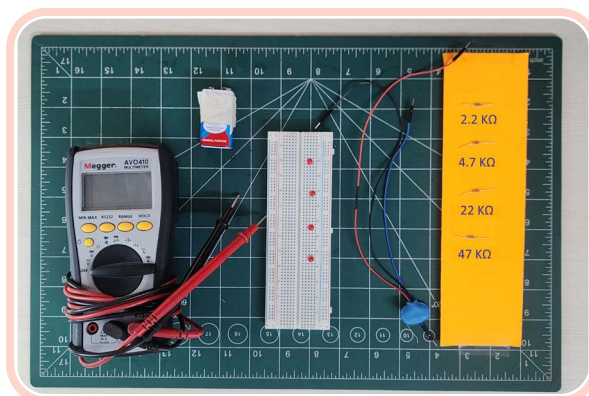
<https://youtu.be/g4KwcFHmUeo>

Click on the links or scan QR codes to watch DIY cum working videos of the project.

What will you need?

Materials Needed

- Breadboard
- 9V Battery with Clip
- Red LEDs (4)
- Resistors (2.2K Ω , 4.7K Ω , 22K Ω , 47K Ω)
- Multimeter
- Jumper Wires



ATL Tools/Equipment

- Digital Multimeter
- Calculator

Software/Application

- Tinkercad (to simulate circuits before implementing them practically)
- Spreadsheet Software (Excel/Google Sheets) - To compare theoretical, simulated, and actual values of current

Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

Introduction to Tinkercad:

Tinkercad is a web-based circuit simulation tool used for designing and testing electronic circuits. Students will create virtual circuits before building them physically.

Click the links or scan the QR codes to watch the video to learn the basics of Tinkercad circuits.



<https://www.tinkercad.com/learn/circuits>



<https://www.tinkercad.com/blog/official-guide-to-tinkercad-circuits>

Session 1: Understanding Ohm's Law through Theoretical and Simulated Circuits

Part 1: Theoretical Introduction to Ohm's Law

Click on the link or Scan the QR code to watch the video:
Introduction to Ohm's Law.

- Discuss the relationship between voltage (V), current (I), and resistance (R).



<https://youtu.be/SzZB0KD99Wc>

OHM'S LAW

Ohm's Law Statement:

Ohm's Law states that the current (I) flowing through a conductor is directly proportional to the voltage (V) applied across it and inversely proportional to the resistance (R), provided the temperature remains constant.

Mathematically, it is expressed as,

$$V = I \times R$$

OHM'S LAW

What is Voltage (V)?

Voltage is the potential difference between two points in a circuit that pushes the current to flow.

- Unit: Measured in volts (V).
- Key Points

Voltage is provided by a power source (like a battery).
Without voltage, there's no force to move the charges.

OHM'S LAW

What is Current (I)?

Current is the flow of electric charge through a conductor.

- Unit: Measured in amperes (A).
- Key Points :

Electrons are the moving charges.

A higher current means more electrons are flowing through the circuit.

OHM'S LAW

What is Resistance(R)?

Resistance is the opposition to the flow of current in a circuit

- Unit: Measured in ohms (Ω).
- Key Points:

Adding resistors in a circuit can control the amount of current.



- Solve simple Ohm's Law problems as shown below-
e.g. if Voltage = $V = 7\text{ V}$, Resistance = $R = 220\Omega$, what is the current (I) flowing in the circuit?
 As Ohm's Law state, $V=IR$, $7\text{ V} = I\text{ A} \times 220\ \Omega$
 Therefore, $I = 7\text{ V}/220\ \Omega = 0.0318\text{ A} = 31.8\text{ mA}$

Part 2: Simulating Ohm's Law in Tinkercad

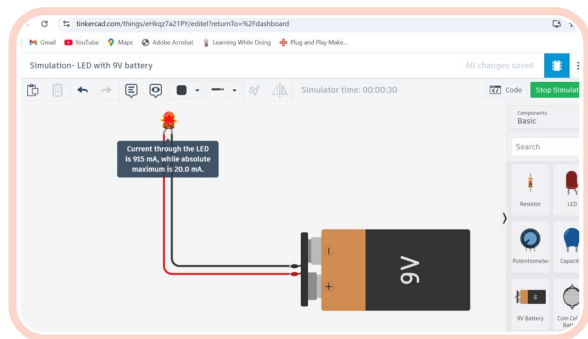
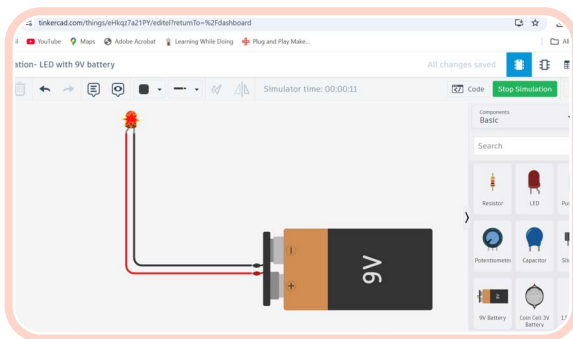
Click on the link or Scan the QR code to watch the video: Ohm's Law- Basics through Tinkercad Simulations.



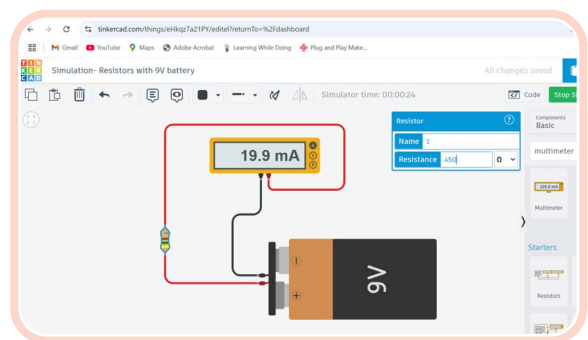
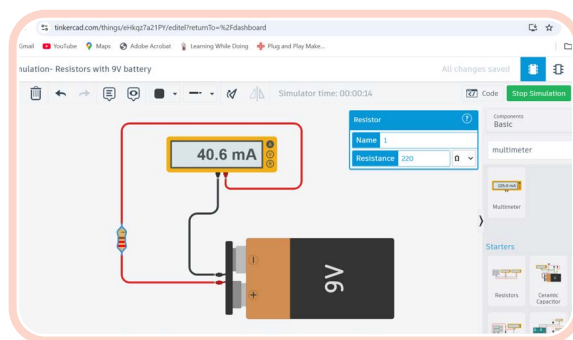
<https://youtu.be/5c6-d1sf89k>

- Perform two simulations:**

- First simulation:** Connect a 9V battery directly to a red LED without any resistor to observe the LED behaviour with higher current value.



- Second simulation:** Connect a 9V battery to a resistor and multimeter. Here, you will change the values of the resistor (220Ω , 360Ω , 470Ω , 580Ω) and simulate the circuit every time you change the value of resistor to measure current flowing through using a multimeter.
 - In the second simulation, try to find the ideal value of the resistor for an LED to work at an operating current of 20 mA.
 - Observe and analyse how increasing resistance decreases current, proving Ohm's Law.



Session 2: Calculating and Simulating the Right Resistor Value for an LED

Part 1: Theoretical Calculation of Resistor Value

Click on the link or Scan the QR code to watch the video: How to Calculate the Right Resistor for an LED theoretically



https://youtu.be/i1-ISBK78_w

- **Calculate the required resistor using:**

- **LED operating Voltage:** 2V
- **Battery Voltage:** 9V
- **Voltage across resistor:** 7V
- **LED operating current:** 20mA
- **Ohm's Law formula:** $V=I \times R$

$$R=V/I= 7V/0.02A = 350\Omega$$

OHM'S LAW

$$V = I \times R$$

Voltage from battery = 9V



Operating Voltage in LED (Voltage drop) = 2V
Current In LED = 20mA = 0.02 A



Voltage Drop in Resistor = 9V - 2V = 7V



OHM'S LAW

What's the Resistor Needed?

$$V = I \times R \Rightarrow R = V / I$$

So, We Know that,

$$R = ?, V = 7V, I = 20mA = 0.02 A$$

$$R = 7V / 0.02A = 350\Omega$$

$$R=350\Omega$$

- Discuss why resistors available in the lab (330Ω and 390Ω) need to be considered instead- As there is no resistor that comes with 350Ω value.

OHM'S LAW

But there is a problem:

We dont have a 350Ω Resistor

330 Ω



390 Ω



Which one will you use?

OHM'S LAW

Which one will you use?

$$V = I \times R \Rightarrow I = V / R$$

So, We Know that,

1. $R = 330\Omega, V = 7V, I = ?$

$$I = 7V / 330\Omega = 0.021A$$

2. $R = 390\Omega, V = 7V, I = ?$

$$I = 7V / 390\Omega = 0.018A$$

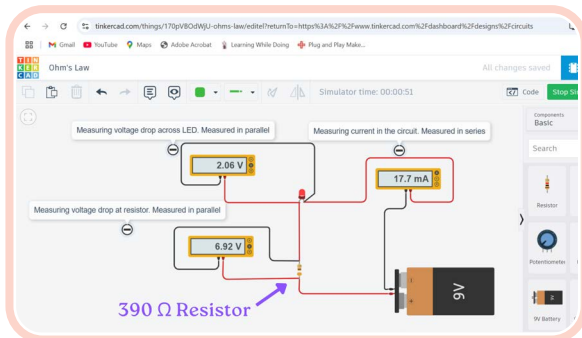
Part 2: Simulating the Resistor Selection in Tinkercad

Click on the link or Scan the QR code to watch the video: Tinkercad Simulation for selection of a right resistor.



<https://youtu.be/wYtpyX5Ye0k>

- Simulate the circuit with different resistors (330Ω, 350Ω, 390Ω) and measure current.
- Compare the simulated and theoretical values at the end of Part 2 activity of Session 2



OHM'S LAW

Theoretical Value

1. $R = 330\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 330\Omega = 0.021A$
2. $R = 350\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 350\Omega = 0.02A$
3. $R = 390\Omega$, $V = 7V$, $I = ?$
 $I = 7V / 390\Omega = 0.018A$

Tinkercad Readings

1. $R = 330\Omega$, $V = 7V$
 $I = 0.0209A$
3. $R = 350\Omega$, $V = 7V$,
 $I = 0.0197A$
3. $R = 390\Omega$, $V = 7V$,
 $I = 0.0177A$

Session 3: Hands-on DIY Activity and Simulation Comparison

Part 1: Practical Experiment with Real Components

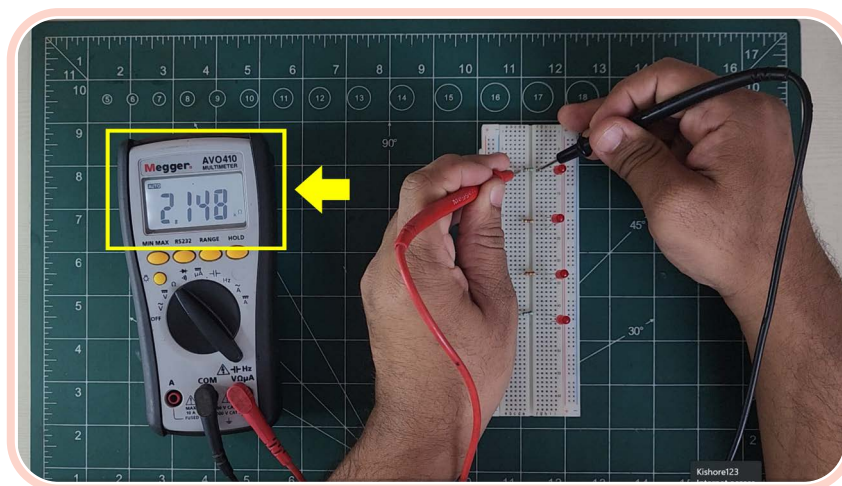
Click on the link or Scan the QR code to watch the video:
Ohm's Law Hands-on Experiment.



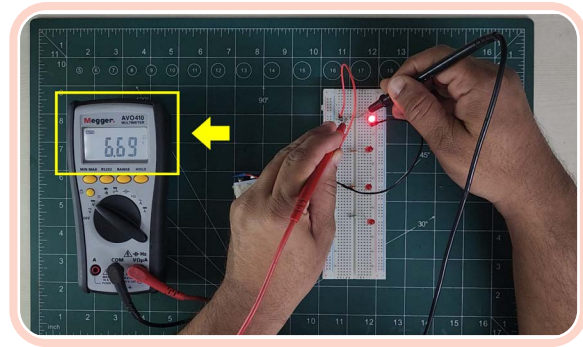
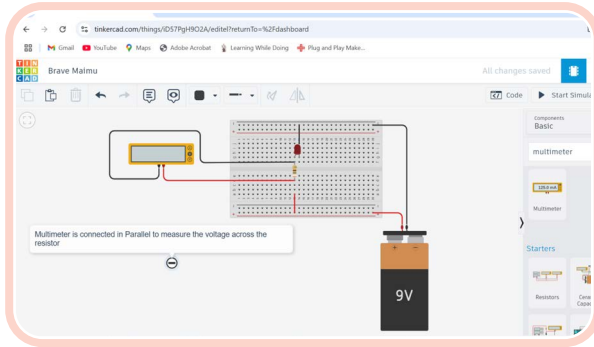
<https://youtu.be/g4KwcFHmUeo>

• Steps:

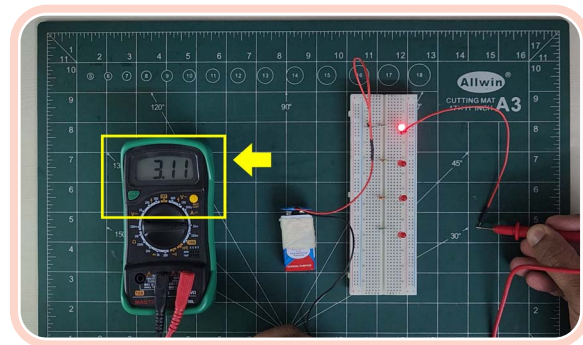
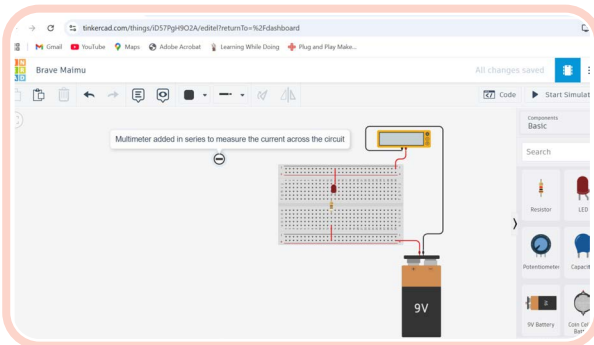
1. Measure actual resistor values using a multimeter.



2. Assemble a circuit with a 9V battery, different resistors (2.2KΩ, 4.7KΩ, 22KΩ, 47KΩ), and LEDs. The actual values of the resistors will be slightly different from the standard specified values provided by the resistor manufacturers because of the ambient conditions and tolerances.
3. For each resistor assembled in the circuit, measure and record:
 - o Voltage across resistors. Refer to the circuit diagram for measuring the voltage.



- o Current flowing through the circuit. Refer to the circuit diagram for measuring the current.



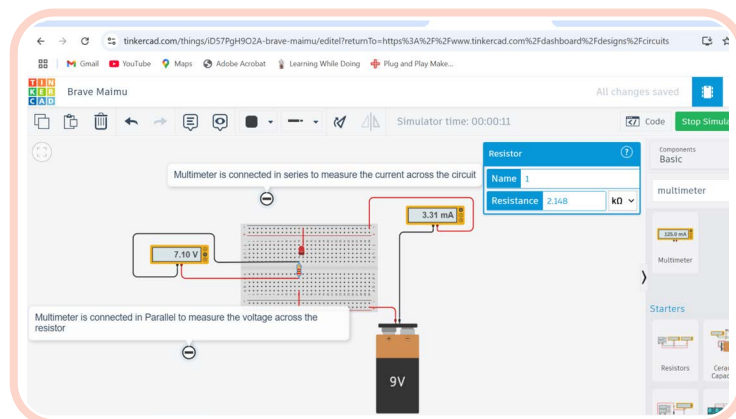
4. Compare the measured and theoretically calculated values of current. You can use a similar table for writing values from your hands-on project as shown here.

Sr. No.	R _m = Resistance (Measured)	V _m = Voltage (Measured)	I _m = Current (Measured)	I _t = Current (Theoretical) = V _m /R _m
1	2.148 K Ω	6.69 V	3.11 mA	6.69 V/2148 Ω = 0.00311 A = 3.11 mA
2	4.58 K Ω	6.81 V	1.49 mA	6.81 V/4580 Ω = 0.001486 A = 1.49 mA
3	21.64 K Ω	6.96 V	0.31 mA	6.96 V/21640 Ω = 0.00032 A = 0.32 mA
4	46.4 K Ω	7.03 V	0.14 mA	7.03 V/46400 Ω = 0.00015 A = 0.15 mA

Sr. No.	R _m = Resistance (Measured)	V _m = Voltage (Measured)	I _m = Current (Measured)	I _t = Current (Theoretical) = V _m /R _m
1				
2				
3				
4				

Part 2: Simulating the Hands-on Experiment in Tinkercad

- Create the same circuit in Tinkercad with different resistors.



- Measure and record simulated current and voltage values.
- Compare **theoretical, simulated, and measured** results.

Sr. No.	R_m = Resistance (Measured)	V_m = Voltage (Measured)	I_m = Current (Measured)	I_t = Current (Theoretical) = V_m/R_m	I_s = Current (Simulated)
1	2.148 K Ω	6.69 V	3.11 mA	$6.69 \text{ V} / 2148 \Omega = 0.00311 \text{ A} = 3.11 \text{ mA}$	3.31 mA
2	4.58 K Ω	6.81 V	1.49 mA	$6.81 \text{ V} / 4580 \Omega = 0.001486 \text{ A} = 1.49 \text{ mA}$	1.56 mA
3	21.64 K Ω	6.97 V	0.31 mA	$6.97 \text{ V} / 21640 \Omega = 0.00032 \text{ A} = 0.32 \text{ mA}$	0.334 mA
4	46.4 K Ω	7.03 V	0.14 mA	$7.03 \text{ V} / 46400 \Omega = 0.00015 \text{ A} = 0.15 \text{ mA}$	0.157 mA

Sr. No.	R_m = Resistance (Measured)	V_m = Voltage (Measured)	I_m = Current (Measured)	I_t = Current (Theoretical) = V_m/R_m	I_s = Current (Simulated)
1					
2					
3					
4					

How do the Ohm's Law Simulation Models work?

The Ohm's Law simulation models in **Tinkercad** work by allowing students to build and analyze virtual electrical circuits, measuring voltage, current, and resistance in real time. These models help visualize how changes in resistance affect current flow, demonstrating **Ohm's Law ($V = IR$)** practically.

How can you assess students' understanding?

Assessment of Concept Understanding

- What is Ohm's Law, and how does it relate voltage, current, and resistance?
- What are the units for voltage, current, and resistance?
- How does a change in voltage affect the current in a circuit, assuming constant resistance?
- How does a change in resistance affect the current in a circuit, assuming constant voltage?
- Is Ohm's Law applicable to all electrical components? If not, why?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Evaluate students' understanding of Ohm's law and circuit design.
- Check for the functionality of the project during testing, creativity and accuracy in assembling the models.
- Conduct a quick Q&A session to evaluate their understanding of the working of the Ohm's Law Simulation Models.
 - o What happens if we use no resistor?
 - o Explain the importance of resistor selection in LED circuits.
 - o Why does the LED's brightness change with resistance?

- o How close were your theoretical, simulated, and actual values?
- o Compare theoretical, simulated, and measured results for accuracy.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

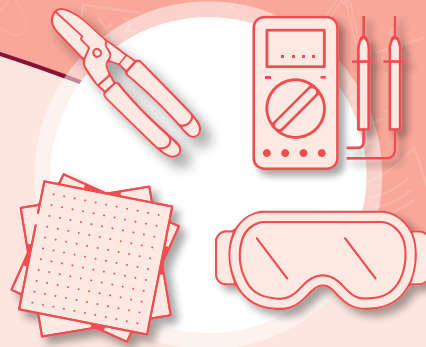
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Try different LED colors and note if their voltage drops vary.
 - Use a variable resistor (potentiometer) and observe real-time current changes.
 - Explore different battery voltages (6V, 12V) and their impact.

Activity 2

Building a Gyroscope to Demonstrate Centrifugal Force and Inertia



Grade

9



Subject

Physics



Topic/
Concept

**Inertia and mass
relation, Circular motion,
Centrifugal Force**

Objective

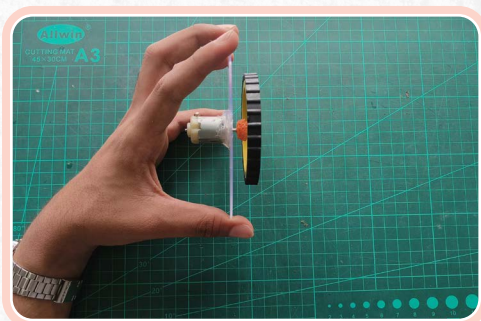
To reinforce understanding of Centrifugal Force and Inertia by constructing a Gyroscope.

What will you help students learn?

- The principle of gyroscope and its working.
- Explore the principles of centrifugal force and inertia as they apply to rotational motion of the gyroscope.
- Understand centrifugal force and its role in maintaining rotational stability.
- Understand practical applications of physics in technology and engineering.

What will you build/make?

A Gyroscope using mechanical and electronic components to demonstrate the scientific principles of centrifugal force and inertia.



<https://youtu.be/hfbm9vSeWWk>



<https://youtu.be/LvFRnD34dvk?si=yBU1mt9De2IaDfxc>

Click the links or scan QR codes to watch DIY cum working videos of the project.

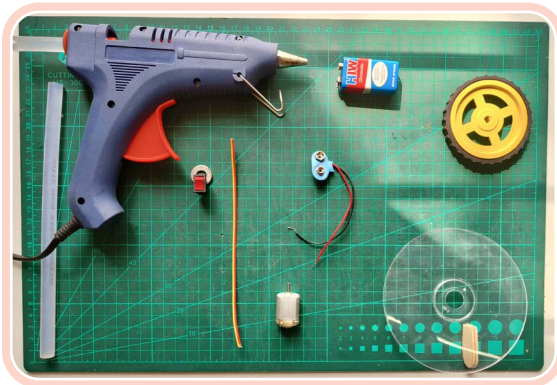
What will you need?

Materials Needed

- Plastic pulley (10 cm diameter, 3 mm thickness) (You can use old CD if you don't have the pulley)
- DC motor
- Mini rocker switch (SPST)
- BO motor wheel (68 mm diameter, 6 mm thickness) to support the plastic wheel and maintains balance
- 9V battery with battery clip
- Nuts and bolts (for balancing the wheel)

ATL Tools/Equipment

- Glue gun and glue stick
- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire stripper
- Spanners
- Sandpaper (Optional)
- Multimeter
- Gloves and safety goggles

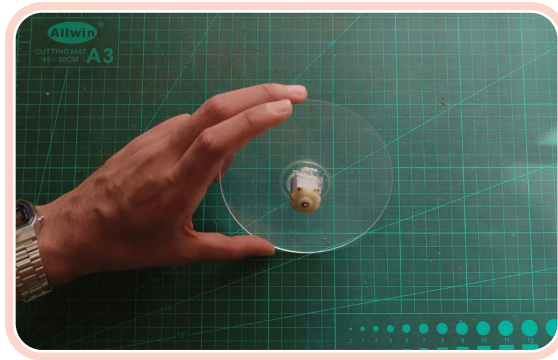


Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

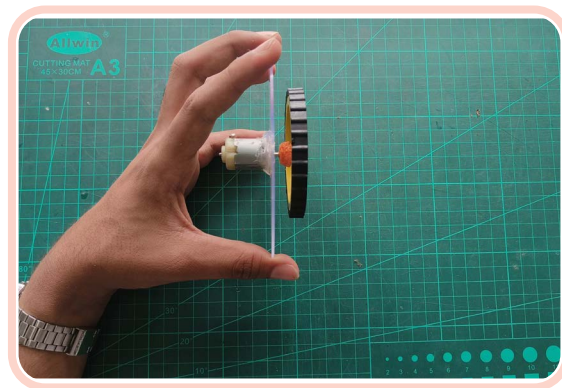
1. Mount the Motor on the CD:

- Mount the motor and rest of the assembly on the larger plastic pulley/old CD.
- Ensure that the motor shaft is exactly at the centre of the hole on pulley/old CD.



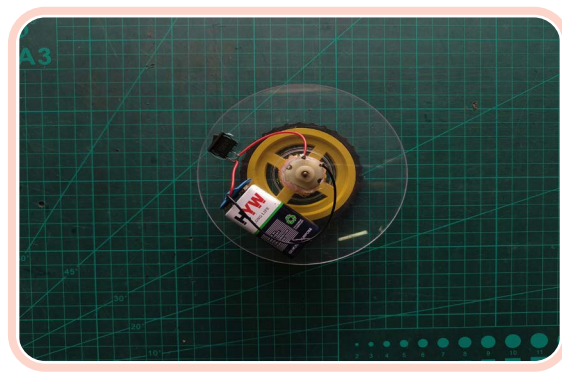
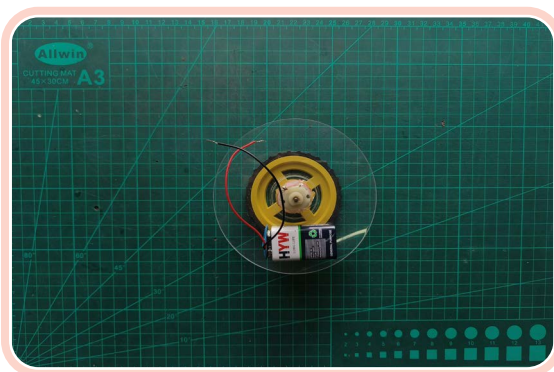
2. Attach the BO Motor Wheel:

- Fix the BO motor wheel securely to the shaft of the DC motor using glue.
- Check for any misalignment that could cause wobbling.
- Use nuts and bolts around the periphery of the BO motor wheel for precise balancing of the BO motor wheel. (Adjust the weight distribution for even rotation. Use spanners for this purpose.)



3. Prepare the Motor and Circuit:

- Strip the wires of the DC motor and solder them to the terminals of the mini rocker switch.
- Connect the switch terminals to the 9V battery clip to complete the circuit.



4. Secure Components and Conduct Trials:

- Use a hot glue gun to securely mount the DC motor, battery, switch, and other components firmly on the pulley/CD.
- Try spinning the BO motor wheel and see if it spins freely.



5. Testing the Gyroscope:

- Activate the switch to start the motor. Observe the spinning motion of the BO motor wheel.
- After spinning the BO motor wheel, try placing the gyroscope on to a flat surface to let it spin freely.
- Discuss how centrifugal force acts outward from the centre of rotation, stabilizing the system.

6. Demonstrate Inertia:

- Stop the gyroscope abruptly by switching off the battery connection and observe how the system resists sudden changes in its motion, demonstrating inertia.

7. Fine-Tuning:

- Adjust the number and positions of the balancing nuts and screws for optimal balancing and even weight distribution based on how you have mounted the 9V battery and switch on the other side of the pulley.
- Ensure the nuts are firmly tightened.

How does the Gyroscope model work?

This DIY gyroscope works based on the principles of rotational motion, centrifugal force, and inertia. When the DC motor is powered by the 9V battery, it spins the attached BO motor wheel and the larger plastic wheel/CD at high speed. As the wheel spins, the following physics principles come into play:

1. **Centrifugal Force** – As the wheel rotates, every point on it experiences a force that pushes outward from the center. This force helps maintain the balance and stability of the spinning system, making it resistant to external disturbances.

2. **Inertia** – According to Newton's First Law of Motion, an object in motion tends to stay in motion unless acted upon by an external force. This means that once the gyroscope is spinning, it resists changes in its orientation and direction.
3. **Gyroscopic Stability** – As the spinning wheel reaches a steady speed, the system becomes stable due to angular momentum. If you try to tilt or move the gyroscope, you will feel resistance, demonstrating the property of gyroscopic stability used in real-world applications like navigation systems in aircraft and spacecraft.

By experimenting with different wheel sizes, weights, and speeds, students can observe variations in the effects of centrifugal force and inertia, deepening their understanding of rotational motion in physics.

How can you assess students' understanding?

Assessment of Concept Understanding

- What is centrifugal force?
- What is inertia and how is centrifugal force related to inertia?
- What are some real-world examples of centrifugal force?
 - **Taking a Curve:** When a car turns, passengers feel an outward force, the centrifugal force, pushing them towards the outside of the curve.
 - **Washing Machines/Spin Dryers:** The spin cycle uses centrifugal force to spin clothes rapidly, flinging water out from the fabric and through the drum's holes.
 - **Merry-Go-Round:** Children on a merry-go-round feel an outward pull away from the center of rotation due to centrifugal force, which is resisted by friction.
 - **Rotating a Bucket of Water:** When you quickly rotate a bucket of water in a vertical circle, the centrifugal force acting on the water balances its weight, preventing it from falling out.
 - **Mud on Car Tires:** As a car's tires spin, mud clinging to the wheels is thrown outwards by centrifugal force, splattering onto the mudguards.
- Evaluate students' understanding of the principle of a Gyroscope.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Check for creativity and accuracy in assembling the model.
- Conduct a quick Q&A session to evaluate their understanding of the working of the Gyroscope.
 - How does centrifugal force help in maintaining the stability of the gyroscope?
 - How does inertia affect the behaviour of the gyroscope?

- o Discuss the role of gyroscopes in real-world applications such as drones and navigation systems by showing them this video:



<https://youtu.be/Zrsc-NeT-eo?si=4RvCuvGqngSsfXGe>

Click the link or scan QR code to know more.

- Observe the functionality of the gyroscope during testing and analyze its accuracy.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications like 'gesture-controlled robot, self balancing robots?
2. How can you modify this model?
 - Experiment with wheels of varying sizes and weights to observe changes in centrifugal force.
 - Investigate how increasing the rotational speed affects the gyroscope's stability.
 - Use the gyroscope to explain the concept of precession and how it counters external forces.

Activity 3

Building a Wired Remote-Controlled Car and Measuring Its Velocity and Acceleration Using a Mobile App



Grade

9



Subject

Physics



Topic/
Concept

Newton's Second
Law of Motion

Objective

To reinforce mechanics of motion, velocity and acceleration by building a wired remote-controlled car.

What will you help students learn?

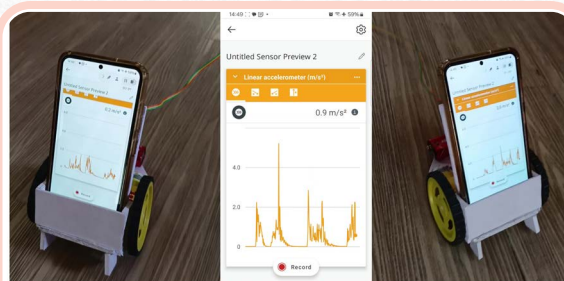
- To build a functional wired remote-controlled (RC) car using basic electronic components.
- Understand the relationship between velocity and acceleration.
- Understand how velocity and acceleration are measured in real-world applications.
- Measure the velocity and acceleration of the RC car using the 'Arduino Science Journal' or 'Phyphox' mobile app.

What will you build/make?

You will make a wired remote-controlled car and measure its performance by integrating technology (Arduino Science Journal or Phyphox app) and experimentation.



DIY Wired RC Car with
Arduino Science Journal App



Wired Remote-Controlled Car and Measuring Its Velocity and
Acceleration Using a Mobile App

Click on the link or scan QR code to watch the DIY and working video of the project.



<https://youtu.be/NO8ajEC7Xv4>

What will you need?

Materials Needed

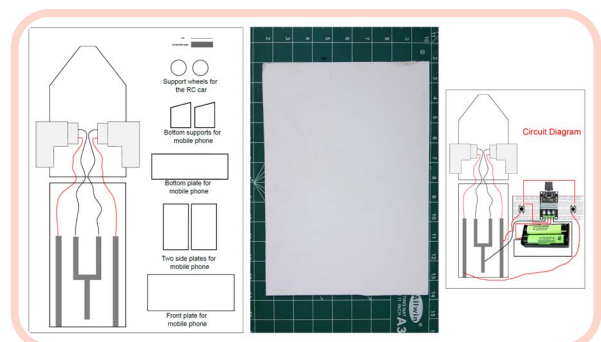
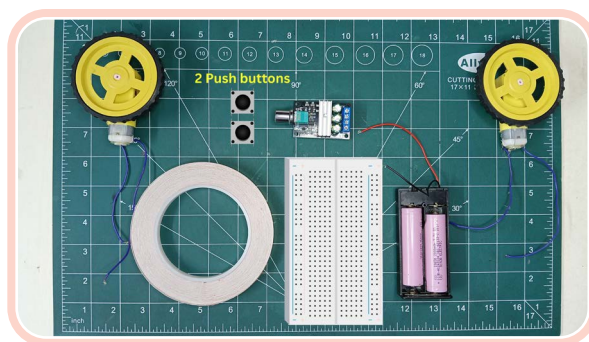
- Printable template for RC car chassis (Link to download the template is given in the procedure)
- Foam board
- Breadboard
- Wires and jumper cables
- Copper tape (for remote)
- Two 3.2V li-ion batteries with battery holder
- Two 300 RPM BO motors
- BO motor wheels
- PWM DC Motor Speed Controller
- Push Buttons
- Paper glue

ATL Tools/Equipment

- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire stripper
- Multimeter
- Screwdriver (Optional)
- Hot glue gun with sticks
- Scissors
- Paper cutter
- Cutting mat
- Hand gloves

Software/Application

- Mobile phone with 'Arduino Science Journal' or 'Phyphox' app installed



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction and Preparation:

- Explain the basic principles of an RC car: how motors work and how a PWM (Pulse Width Modulation) controller adjusts motor speed.
- Introduce the 'Arduino Science Journal' or 'Phyphox' app as a tool to measure velocity and acceleration.
- Click the links or scan QR codes to download the applications on your android mobile phones.
- Click the link or scan QR code to download and print the template on A4 size paper. This template is required for building this model.
- Gather all the materials and tools listed.
- Ensure the printed templates are ready and accessible to students.

Arduino Science Journal



<https://tinyurl.com/4pht6vjj>

Phyphox



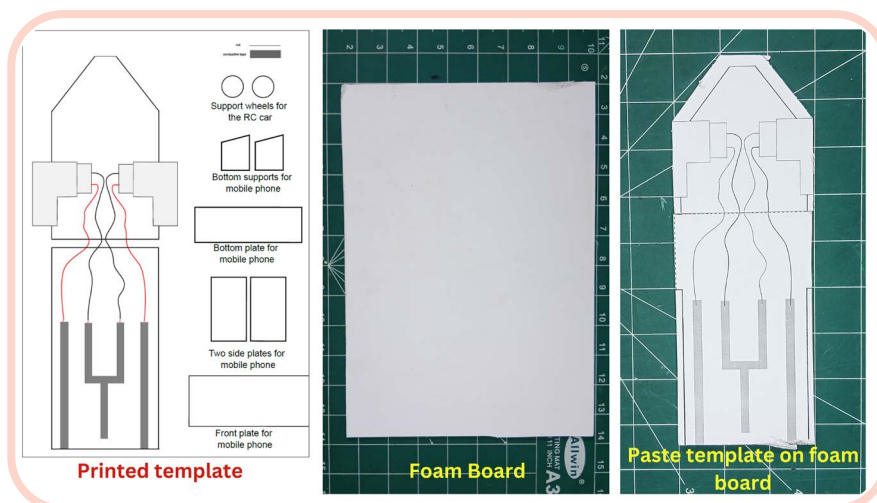
<https://tinyurl.com/yc72fdma>



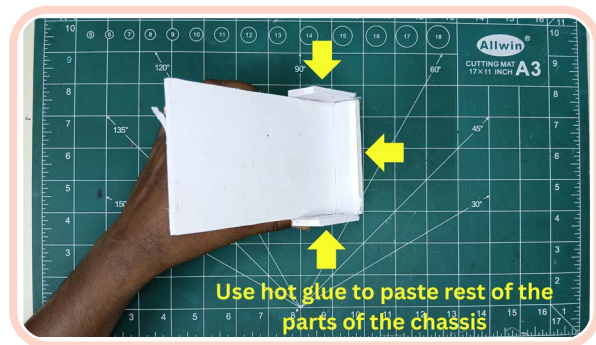
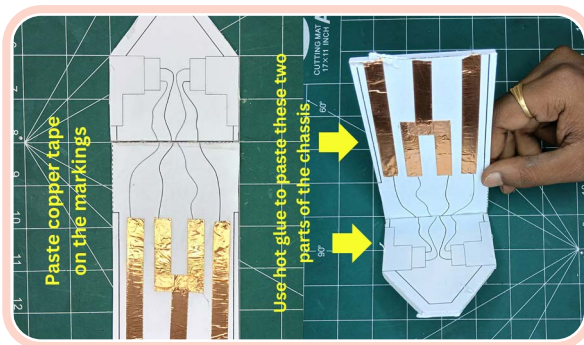
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2. Assemble the Chassis:

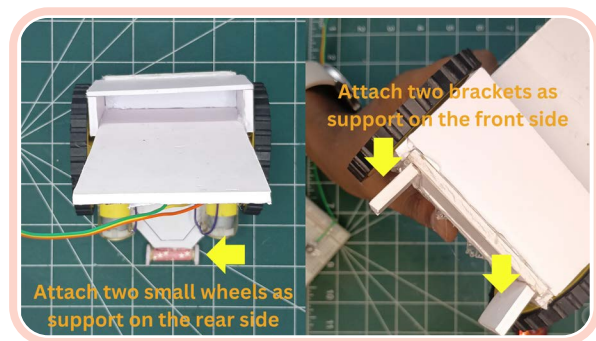
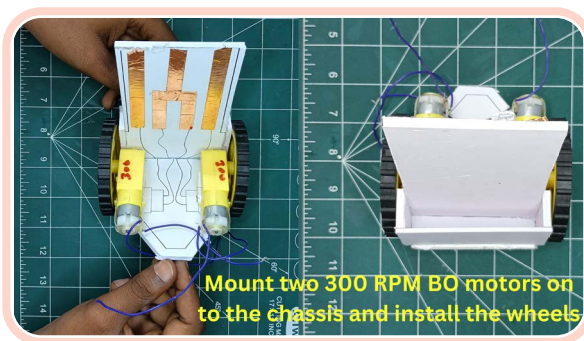
- Use scissors to cut the chassis parts from the printed template.
- Paste these parts on the foam board using paper glue and let the glue dry.
- Cut the foam board into required shapes to serve as the car chassis.



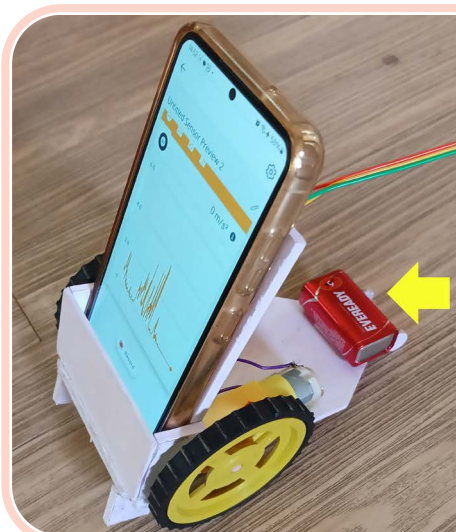
- Stick copper tape on the markings provided on the template.
- Use a hot glue gun to assemble other parts on the chassis.



- Mount the two 300 RPM BO motors on to the foam board chassis using hot glue. Ensure they are aligned correctly to allow the wheels to move properly.
- Secure BO motor wheels on to the motor shafts and test for smooth rotation.
- Attach small wheels at the rear and brackets at the front of the chassis (as supports) as shown in the image.



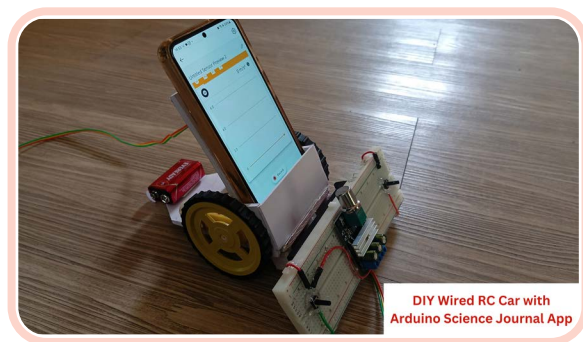
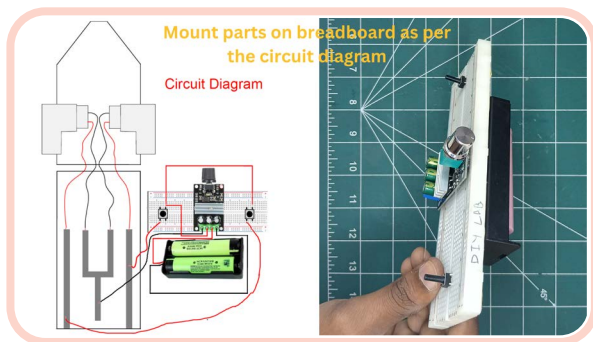
- Attach a dead weight at the rear end of the chassis. This helps in balancing the car when the mobile phone will be mounted on it while conducting the experiments later.



Mount some dead weight on the rear side (we have used a waste battery) for balancing the chassis.

3. Set Up the Remote Motor Control Circuit:

- Refer the circuit diagram provided below.
- Mount PWM DC Motor Speed Controller board on the breadboard.
- Use two 3.2V Li-ion batteries along with a battery holder to power the motors:
 - Connect the positive terminal of the battery to the push buttons through the PWM controller's positive terminal. These push buttons are ultimately connected to the exterior tracks of the circuit.
 - Connect the negative terminal of the battery to negative terminal of the PWM controller. This is ultimately connected to the common terminal of the circuit using cables.
- Solder motor terminal wires to the copper tape tracks after verifying the spinning direction of the motors. Both motors should spin in the forward direction.



4. Testing the Remote-Controlled Car:

- Adjust the control knob on the PWM controller and observe the speed of the RC car. Verify if turning the knob increases or decreases the motor speed.

5. Secure the Mobile Phone:

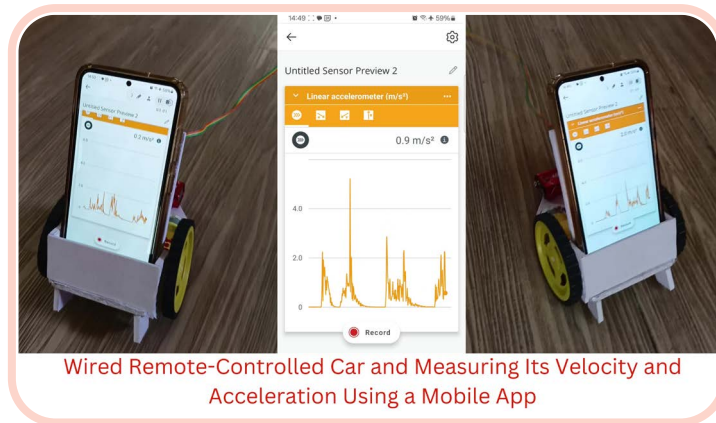
- Place the mobile phone securely into the small box type structure made at the front of the car.
- Turn the GPS location on.
- Open either of the two apps- 1. Arduino Science Journal or 2. Phyphox app and select the Location (GPS) module for measuring the velocity and Acceleration measurement module for recording the acceleration.

6. Conduct the Experiment:

- Run the RC car on a flat surface and observe the data recorded by the app.
- Measure and record the velocity and acceleration during different trials by varying the PWM settings.

7. Analyse the Data:

- Discuss how changes in motor speed affect velocity and acceleration.
- Plot the graph using data (optional) to visualize the relationship between velocity and acceleration.



How does the Remote-Controlled Car work?

The remote-controlled (RC) car in this project is built using a wired control system to regulate motor speed and direction. The Arduino Science Journal or Phyphox app is used to measure and analyze the car's velocity and acceleration.

Working Principle:

Two 3.7V batteries supply power to the motors. The RC unit controls the car's motion and direction. Pressing either or both buttons on the wired remote moves the car forward, left, or right. A smartphone with the Arduino Science Journal or Phyphox app is securely placed on the RC car. The app uses internal sensors (GPS, accelerometer & gyro-scope) to track motion. As the car moves, the app records speed and acceleration in real-time. Students can use the PWM motor speed controller to change the speed of the motor and thereby the acceleration. Data is displayed in graphical or numerical form, allowing students to analyze motion. Students can compare acceleration values under different motor speeds. The relationship between speed and acceleration can be studied. Changes in velocity help determine how the car responds to different surfaces.

Click on the link or scan QR code to watch the DIY and working video of the project.



<https://youtu.be/NO8ajEC7Xv4>

How Can You Assess Students' Understanding?

Assessment of Concept Understanding

- How does a remote-controlled car work?
- What is the relationship between velocity and acceleration?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the setup.
- Assess the functionality of the RC car and the clarity of the control system.
- Evaluate the accuracy and interpretation of data collected using the Arduino Science Journal or the Phyphox app.
- Observe creativity in remote design and problem-solving skills during assembly.
- Conduct a quick Q&A session to evaluate their understanding of the:
 - o Working of the remote-controlled car.
 - o Impact of PWM adjustments on speed and acceleration.
 - o Practical applications of measuring velocity and acceleration.
- Observe the functionality of the wired remote controlled car during testing and analyze its accuracy
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

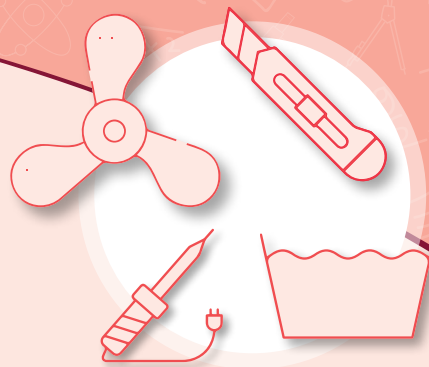
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Add an LED indicator on the remote to signal when the car is powered.
 - Experiment with different motor speeds or chassis designs to study their effects on performance.
 - Introduce an obstacle course to test acceleration and manoeuvrability.
 - Use the Arduino Science Journal or the Phyphox app to analyse additional parameters like angular velocity or displacement.

Activity 4

Making a Model of Newton's Boat



Grade



9, 10



Subject



Physics



Topic/
Concept



Newton's third
law of motion

Objective

To demonstrate Newton's 3rd Law of Motion using a model of Newton's Boat.

What will you help students learn?

- To design and construct a working model of a Newton's Boat using provided materials.
- To identify the function and importance of each part used in the model (battery, switch, motor, propeller, cables).
- Develop a foundational understanding of electrical conductivity, circuit logic, and mechanical force.
- To demonstrate Newton's Third Law of Motion and how it applies to propulsion systems in real-world scenarios (e.g., boats, rockets).
- Understand the cause-and-effect relationship between force application and motion in a physical system.
- Design and engineering principles in model-making.

What will you build/make?

A functional model of Newton's Boat to demonstrate the principle of action and reaction.



<https://youtu.be/AGYeKLNySG0>

Click on the link or scan QR code to watch DIY cum working video of the project.

What will you need?

Materials Needed

- Printable template for the boat (Link to download the template is given in the procedure)
- A4 size foam board
- Ribbon cables (as conductive medium for circuit)
- 9V battery
- Rocker switch
- DC motor
- Propeller
- Paper glue
- Water tub (small)- To test the boat's movement
- Double sided tape (Optional- you can use glue gun)

ATL Tools/Equipment

- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire stripper
- Multimeter
- Hot glue gun with glue sticks
- Scissors
- Paper cutter
- Cutting mat
- Hand gloves

Materials & Tools required



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction and Preparation:

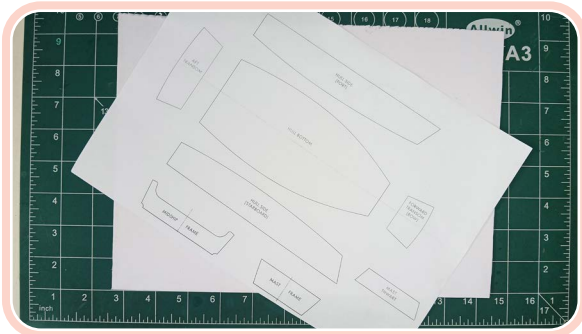
- Explain Newton's third law of motion.
- Click the link or scan QR code to download and print the template on A4 size paper. This template is required for building this model.
- Gather all materials and tools listed above.
- Ensure the printed templates are ready and accessible to students.



<https://tinyurl.com/3nvd67e3>

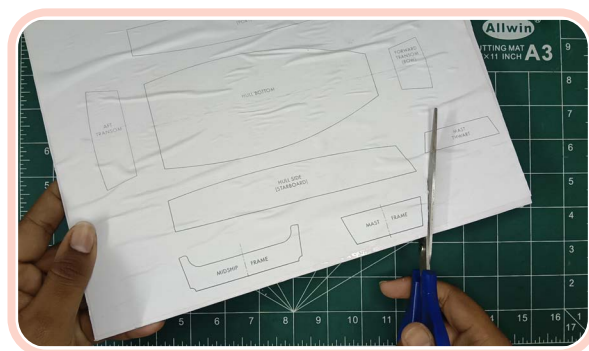
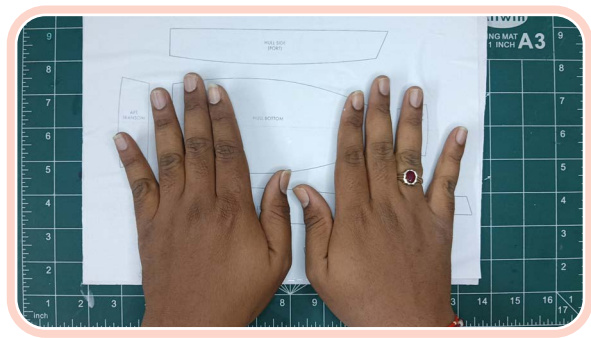
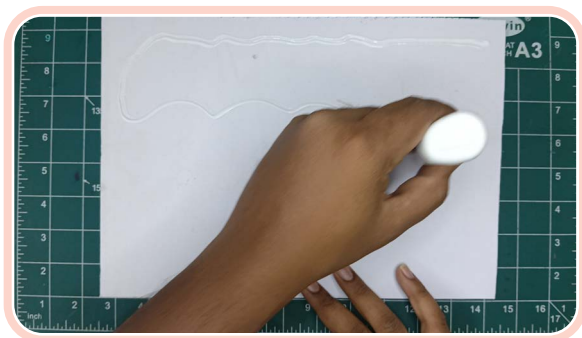
2. Prepare the Template:

- Distribute the printed templates of the boat design.
- Distribute the A4 size foam board as well.



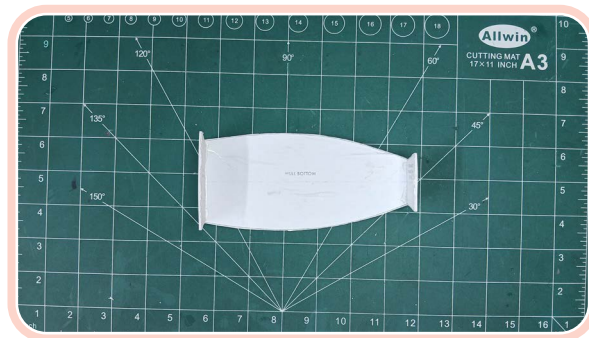
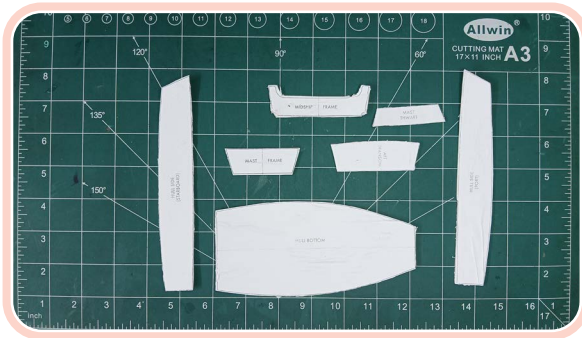
3. Transfer the Design:

- Paste the template over the foam sheet using paper glue. Do not use excess glue and spread it uniformly.
- Cut the foam sheet along the traced lines with a paper cutter or a scissors.



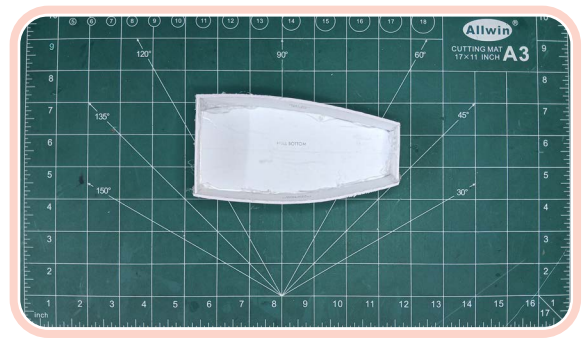
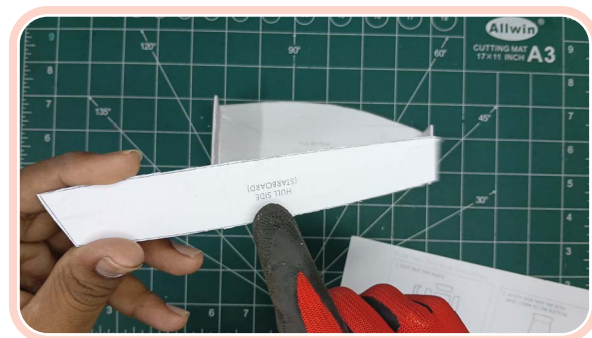
4. Assemble the Boat Base:

- Use a hot glue gun to assemble the foam pieces together as per the design to create the base of the boat.



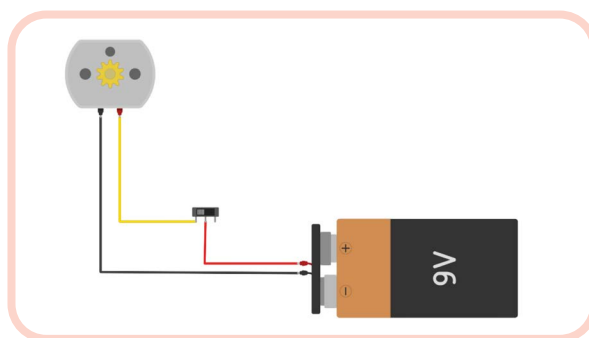
5. Assemble Remaining Parts on the Boat:

- Use hot glue gun to assemble the remaining parts of the boat.

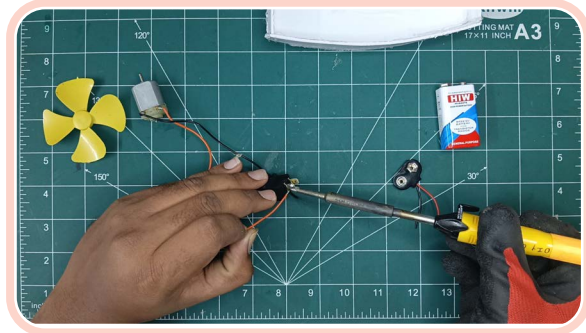
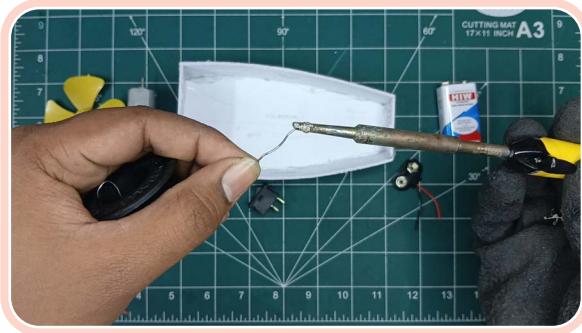


6. Set Up the Circuit:

- Refer to the circuit diagram and solder the components accordingly.

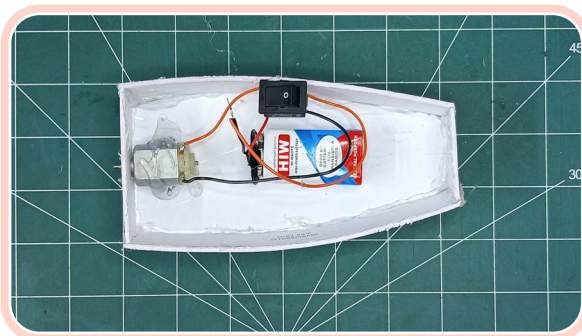


- Strip the ribbon cables/wires as needed using a wire stripper.
- Solder the ribbon cables to connect the 9V battery clip to the rocker switch and DC motor.
- Use soldering flux and soldering metal for secure connections.



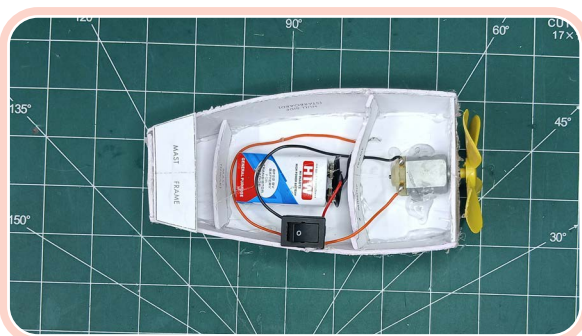
7. Install the circuit (Battery clip, Battery, Switch and DC motor) on the boat:

- Fix the DC motor at the rear end of the boat using a glue gun.
- Mount the battery and switch using a hot glue gun. Connect the battery clip to the battery.



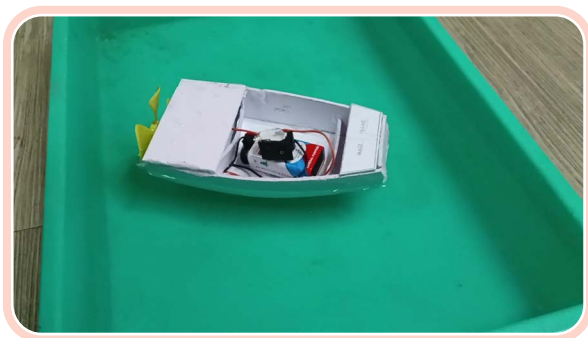
8. Final Assembly:

- Attach the propeller to the motor shaft.
- Secure all connections and remaining components on the boat structure.



9. Testing the Boat:

- Turn the motor on to check if the propellor rotates freely.
- Place the boat in a water tub and toggle the switch to power the motor and observe the propulsion. Relate it to Newton's Third Law.



How Does Newton's Boat Model Work?

Newton's Boat demonstrates Newton's Third Law of Motion: For every action, there is an equal and opposite reaction. As the motor spins the propeller, the water is pushed backwards and in response, the boat moves forward.

Click on the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/AGYeKLNysG0>

How can you assess students' understanding?

Assessment of Concept Understanding

- Conduct a quick Q&A session to evaluate their understanding of Newton's Third Law, the boat's functionality, and the role of the electrical components.
 - o State Newton's 3rd Law of Motion
 - o How does the recoil of a gun illustrate this law?

- Discuss how Newton's principles apply to the day-to-day life examples and also to real-world engineering, such as in rocket propulsion by showing them this video.



<https://youtu.be/mO1qtmFee-k?si=JmEPt0PWs2Qf6ps>

Click the link or scan QR code to know more.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the setup.
- Assess the functionality of the boat (Does it move as expected?).
- Ask students
 - o How does the boat's movement demonstrate Newton's Third Law?
 - o What could be done to increase the boat's speed?
- Reflect on the importance of precision in engineering and design.
- Check for creativity and accuracy in assembling the model.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher)

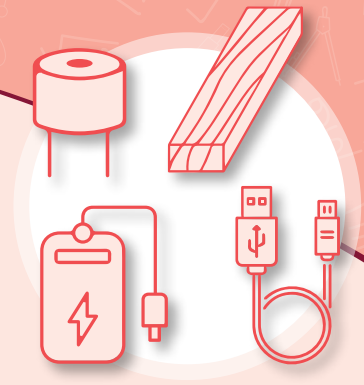
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Experiment with different propeller designs and sizes to test efficiency.
 - Use a solar panel as an alternative power source.
 - Design a larger boat with multiple motors and propellers.

Activity 5

Vehicle speed detection system using IR sensors



Grade



9, 10



Subject



Physics



Topic/
Concept



Motion, Speed

Objective

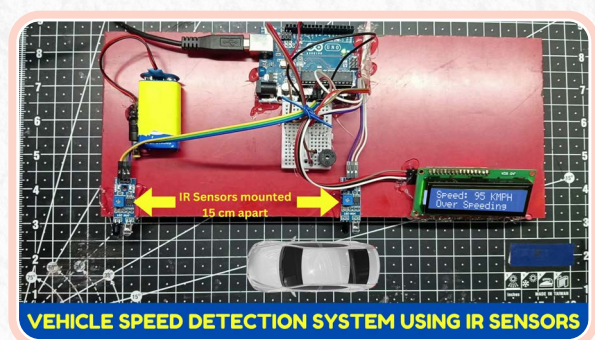
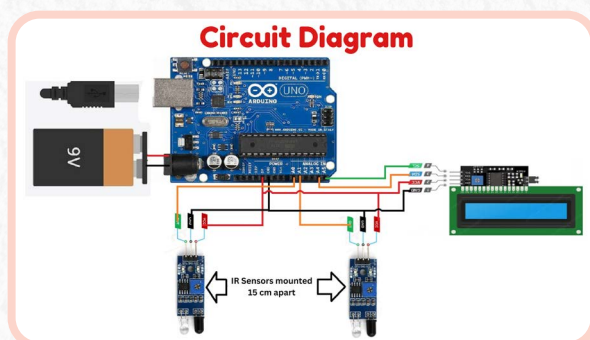
To apply understanding of Speed, Distance and Velocity and build a vehicle speed detection system.

What will you help students learn?

- The principles of speed measurement by calculating distance and time using sensor-based detection systems.
- How digital sensors like IR sensors detect motion and interact with a microcontroller like Arduino by providing input signals to it.
- How Arduino collects, processes, and displays real-time data.
- Learn to interface an LCD display with Arduino using I2C communication module, which simplifies wiring and Arduino program.
- Develop skills in assembling, programming, and troubleshooting electronic circuits.
- Test and calibrate a working prototype and refine it for accuracy.
- Interpret real-time data and make design-based decisions for improvement

What will you build/make?

A speed detecting device that can measure the speed of any moving object using IR sensors.



Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/mYAhYnqvWGo>

What will you need?

Material and components

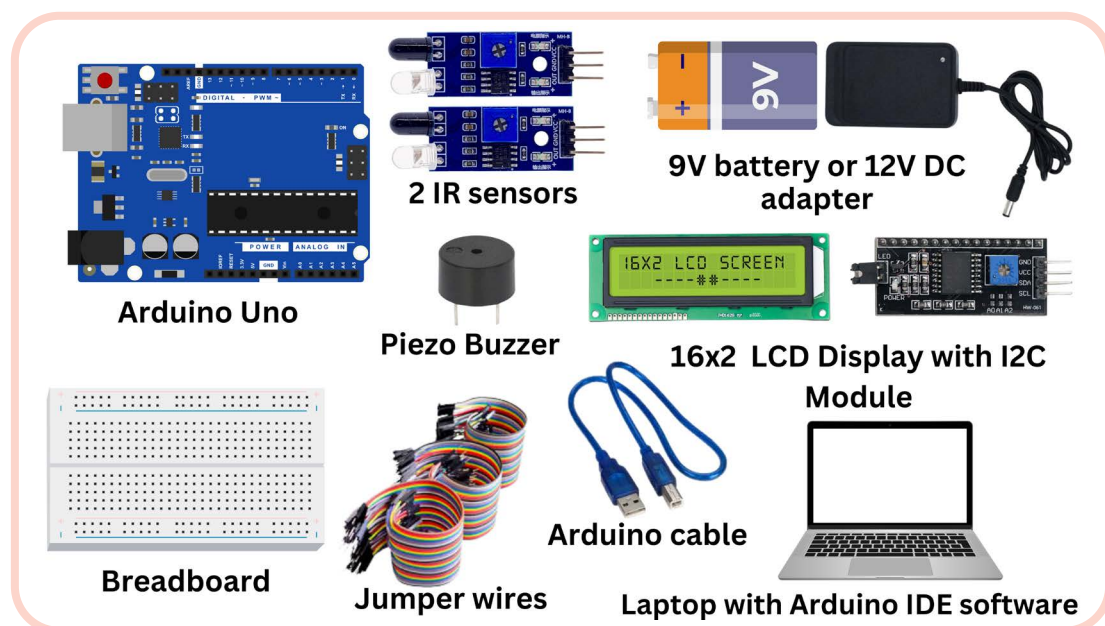
- Arduino Uno
- IR sensor (x2)
- Breadboard
- 16x2 LCD Display
- I2C Connector (for LCD)
- 5V piezo buzzer
- 9V Battery
- 9V Battery Clip
- Jumper Cables
- Wooden Plank/Board
- USB Cable
- Power Supply (USB Power Bank)

ATL Tools/Equipment

- Hot glue gun with hot glue sticks
- Computer with Arduino IDE
- Multimeter (Optional)
- Precision screw driver

Software/Application

- Arduino IDE software



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

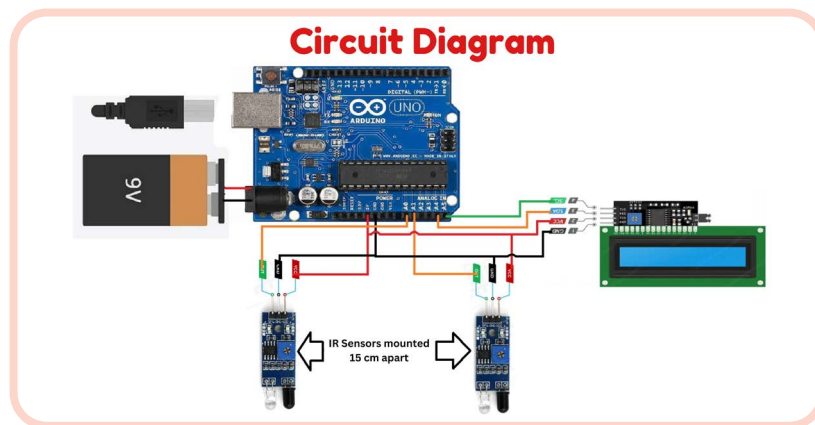
- Discuss the concept of speed: $\text{Speed} = \text{Distance} / \text{Time}$
- Explain how IR sensors detect objects based on the reflected infrared light and trigger signals. Click the link or scan QR code to watch the video to learn how IR sensors work.



<https://www.youtube.com/watch?v=LTWOa-Hbm8Q>

2. Hardware Setup:

- Refer to the circuit diagram for setting up the components.



- **IR Sensors:** Connect two IR sensors to the breadboard and Arduino. They will be positioned apart at a known distance (15 cm in this case) to detect the moving object after all the hardware connections are complete.
- **Connect two IR sensors to the Arduino:**
 - o VCC to 5V, GND to GND
 - o Output pin of IR sensor on the left – A0
 - o Output pin of IR sensor on the right – A1
- **LCD Display with I2C:**
 - o Connect the I2C module to the back of the LCD display.
 - » VCC to 5V, GND to GND
 - » SDA to A4, SCL to A5

3. Programming the Arduino:

- Open Arduino IDE and upload the code given to detect the speed of the moving object as it crosses their paths. Click the link or scan QR code to download the code (.ino file).
- You can also copy the code given here and paste in the Arduino IDE.



<https://tinyurl.com/5n94v4t4>

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
#include <Wire.h>
int timer1;
int timer2;
float Time;
int flag1 = 0;
int flag2 = 0;
float distance = 0.15; \\IR sensors are placed 15 cm or 0.15 m apart
float speed;
int ir_s1 = A0;
int ir_s2 = A1;
int buzzer = 13;
void setup(){
    Serial.begin(9600);
    pinMode(ir_s1, INPUT);
    pinMode(ir_s2, INPUT);
    pinMode(buzzer, OUTPUT);
    lcd.init();
    lcd.backlight();
    lcd.setCursor(0,0);
    lcd.print("Speed detector");
    lcd.setCursor(0,1);
    lcd.print(" ");
    delay(2000);
```

Continue...

Continue...

```
    lcd.clear();
}

void loop() {
    if(digitalRead (ir_s1) == LOW && flag1==0){timer1 = millis(); flag1=1;}
    if(digitalRead (ir_s2) == LOW && flag2==0){timer2 = millis(); flag2=1;}
    if (flag1==1 && flag2==1){
        if(timer1 > timer2){Time = timer1 - timer2;}

        else if(timer2 > timer1){Time = timer2 - timer1;}
        Time=Time/1000;//convert millisecond to second
        speed=(distance/Time);//v=d/t
        speed=speed*3600;// multiplied by 3600 for speed m per hr
        speed=speed/1000;//division by 1000 for speed km/hr
    }
    if(speed==0){
        lcd.setCursor(0, 1);
        if(flag1==0 && flag2==0){
            lcd.print("No car detected");
            else{lcd.print("Searching... ");}
        }
    }
    else{
        lcd.clear();
        lcd.setCursor(0, 0);
        lcd.print("Speed:");
        lcd.print(speed,1);
        lcd.print(" Km/Hr ");
        lcd.setCursor(0, 1);
        if(speed > 50)
        {
            lcd.print(" Over Speeding ");
            digitalWrite(buzzer, HIGH);
        }
    }
}
```

Continue...

Continue...

```
        else{lcd.print("  Normal Speed  "); }  
        delay(3000);  
        digitalWrite(buzzer, LOW);  
        speed = 0;  
        flag1 = 0;  
        flag2 = 0;  
    }  
}
```

- Install the required Arduino library for LCD Display if you do not have this library installed on your computer.
- To install this library, first click the link or scan QR code to download this library on your computer.
- Then, click the link or scan the QR code to watch the video to learn how to install the library on your computer.
- Write or upload an Arduino sketch to the Arduino board.



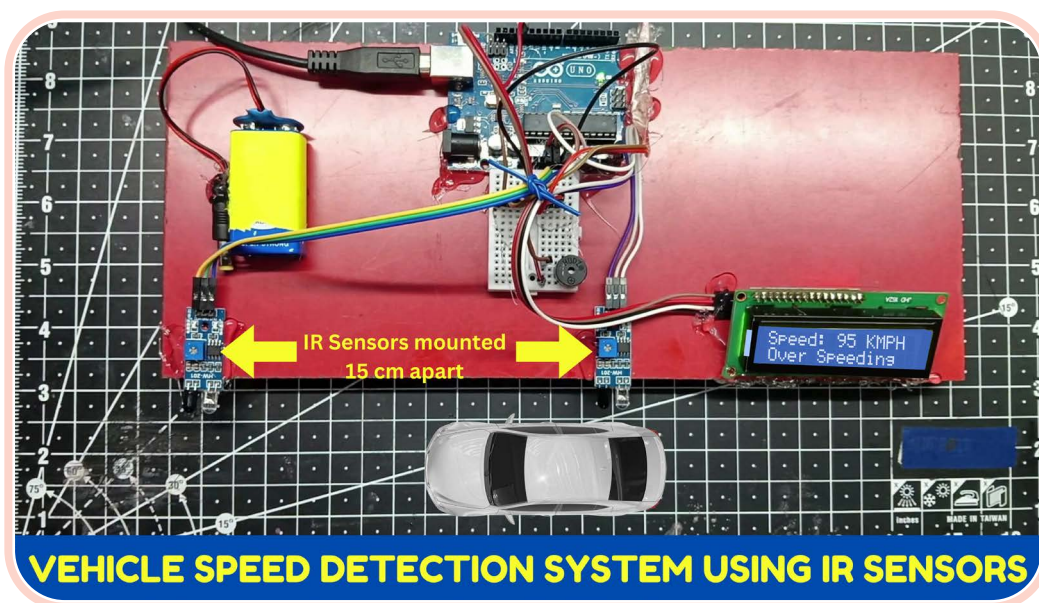
<https://tinyurl.com/2fryhwnb>



https://youtu.be/33NPxEUJ_Y4

4. Mounting the Components:

- Once the code is uploaded to the board, arrange the project set-up as shown in the image.



- Secure the IR sensors, LCD with I2C module, Arduino uno, breadboard with piezo buzzer, and battery with the battery clip onto the wooden plank using hot glue.
- Make sure to mount the IR sensors 15 cm apart.

5. Testing the Speed Detecting Device:

- Connect the Arduino board to a power source (either a 9V battery or 12V DC adapter).
- Place a toy car or any other object in the path of the sensors.
- Push or move the car across the sensors, ensuring it passes each IR sensor sequentially.
- The LCD screen will display the calculated speed using I2C communicator.
- Observe the calculated speed on the LCD display.

How does the Vehicle Speed Detection System work?

The vehicle speed detection system uses two IR (Infrared) sensors placed at a known fixed distance apart. As a vehicle (or toy car) passes in front of the first sensor, it triggers a signal which the Arduino registers as the start time. When the vehicle passes the second sensor, it triggers another signal which is recorded as the stop time. The Arduino calculates the time taken for the vehicle to travel between the two sensors using these timestamps. By applying the basic speed formula, the Arduino computes the speed of the vehicle.

Speed = Distance/Time

This value is then displayed on the 16x2 LCD screen. If the speed exceeds a predefined safe limit, a piezo buzzer is activated to provide an audible warning.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/mYAhYnqvWGo>

How can you assess students' understanding?

Assessment of Concept Understanding

- Conduct a quick Q&A session to evaluate their understanding of 'Speed and Velocity'.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Test the circuit's functionality and observe whether the LCD displays the correct speed.

- Check if students have assembled the circuit and loaded the code successfully.
- Conduct a quick Q&A session to evaluate their understanding of the working of the speed detecting device.
 - o How do IR sensors detect the object's motion?
 - o Why is I2C communication advantageous for the LCD connection?
- Evaluate their understanding through questions about the working principles and code logic.
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Discuss how sensors and cameras are used for speed detection in real-world applications by showing them this video:



<https://youtu.be/Vz5pMBLHyMI?si=46DrXNu7nESxcP8W>

Click the link or scan QR code to know more.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. *(Rubric for this is provided in the note for the teacher)*

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

How can you modify this model?

- Increase the number of sensors to measure acceleration.
- Use a Bluetooth module to send speed data to a smartphone app.
- You can adapt the setup for larger objects or real vehicles.

Activity 6

Making a Model for Autonomous Emergency Braking System



Grade

9, 10



Subject

Physics



Topic/
Concept

**Motion and Measurement
of Distance, Sound-
Applications of Ultrasound**

Objective

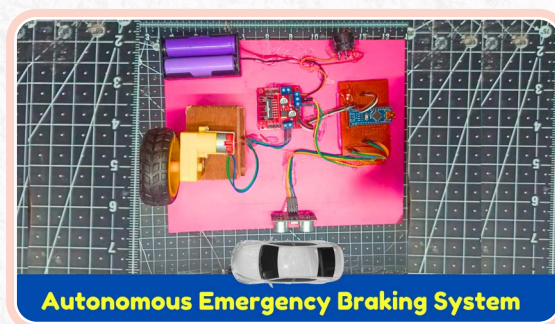
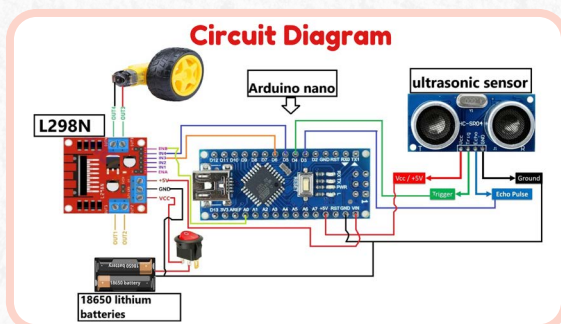
To apply the knowledge of distance and speed in making a model of Autonomous Emergency braking system.

What will you help students learn?

- How distance measurement systems in the real world
- The working of ultrasonic sensors and motor drivers.
- Basic soldering techniques and Arduino programming.
- Design and build a functional model of an Autonomous Emergency Braking (AEB) system using Arduino Nano, ultrasonic sensor and other electronic components.
- Understand the role of automation and sensor-based systems in modern safety technologies in automobiles.
- Application of engineering concepts in a real-world scenario.
- Critical thinking and problem-solving skills through debugging and iterative testing.

What will you build/make?

A model of an Autonomous Emergency Braking System.



Click the link or scan QR code to watch
DIY cum working video of the project.



<https://youtu.be/4pR4i4Qb8nA>

What will you need?

Materials Needed

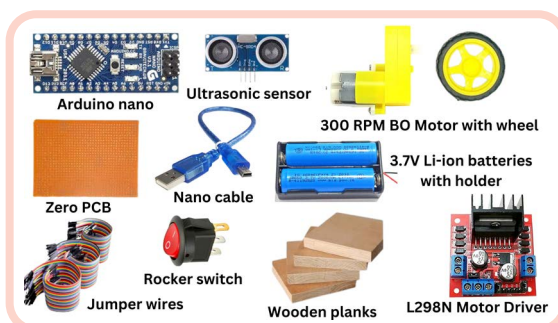
- Arduino Nano
- Zero PCB
- Ultrasonic Sensor (HC-SR04)
- 3.7V 3000 mAh Li-ion Batteries (2x)
- Battery Holder
- Rocker ON/OFF Switch
- 300 RPM BO Motor
- BO Motor Wheel
- L298N Motor Driver- To control motor speed and direction using Arduino signals
- Wooden Plank/Board
- Wooden Block - to elevate the motor and align with the wheel
- Jumper/Connecting Wires
- Arduino Nano USB Cable
- Power Supply (USB Battery Bank)

ATL Tools/Equipment

- Hot glue gun with hot glue
- Computer with Arduino IDE
- Multimeter (Optional)
- Precision screw driver (Optional)
- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire Cutter/Stripper
- Hand gloves
- Cutting mat

Software/Application

- Arduino IDE software



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

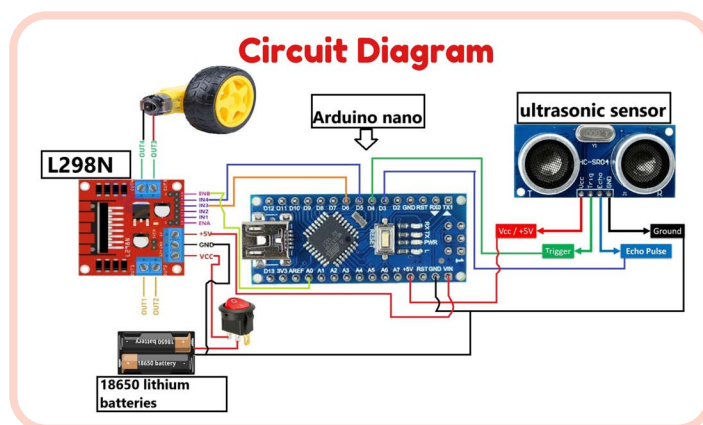
- Discuss the concept of speed: $\text{Speed} = \text{Distance} / \text{Time}$
- Explain how the ultrasonic sensor, when connected to the microcontroller boards like Arduino, emits high-frequency sound waves and calculates the distance to an object by measuring the time it takes for the sound to reflect back, using the speed of sound. Click the link or scan QR code to watch the video to learn how ultrasonic sensors work.



<https://www.youtube.com/watch?v=GexkGfRSTec>

2. Assembling the Circuit as per the Circuit Diagram:

- Refer to the circuit diagram for setting up the components.



- Solder the Arduino Nano to the zero PCB using a soldering gun, metal, and flux.
- Connect the ultrasonic sensor to the Arduino Nano (VCC, GND, Trig, Echo pins).
 - o VCC to 5V of Arduino, GND to GND
 - o Trig – D4
 - o Echo – D3
- Connect the BO motor to the L298N motor driver through-
 - o Out3 and Out4
- Mount the battery holder and wire the L298N motor driver to the Arduino Nano for speed and direction control.
 - o VCC to Battery Positive, GND to GND

- o 5V of L298N to Arduino Vin
- o IN3 to D6
- o IN4 to D5 and
- o ENB to A0
- Connect the rocker ON/OFF switch between the battery positive and the 5V of L298N.

3. Programming the Arduino:

- Open the Arduino IDE and upload the provided code to enable the sensor to detect approaching objects, calculate the distance to the object, and control the motor accordingly by turning it on or off based on that distance. Click the link or scan QR code to download the code (.ino file).



<https://tinyurl.com/3f4f43b7>

- You can also copy the code given here and paste in the Arduino IDE.

```
#include <NewPing.h>
NewPing mySensor(4,3,400);
const int IN3=6;
const int IN4=5;
const int ENB=A0;
void setup() {
  Serial.begin(9600);
  pinMode(IN3,OUTPUT);
  pinMode(IN4,OUTPUT);
  pinMode(ENB,OUTPUT);
}
void loop() {
  int distance = mySensor.ping_cm();
  int y = map(distance, 3, 30, 0, 260);
  Serial.print("y=");
  Serial.print(y);
```

```

Serial.print(" distance=");
Serial.println(distance);

if (y <=80 )
{
    analogWrite(ENB, 0);
    digitalWrite(IN3,LOW);
    digitalWrite(IN4,LOW);
}
else
{
    analogWrite(ENB, y);
    digitalWrite(IN3,HIGH);
    digitalWrite(IN4,LOW);
}
delay(100);
}

```

- Install the required Arduino library for ultrasonic sensor if you do not have this library installed on your computer.
- To install this library, first click the link or scan QR code to download this library on your computer.
- Then, click the link or scan the QR code to watch the video to learn how to install the library on your computer.
- Write or upload an Arduino sketch to the Arduino board.



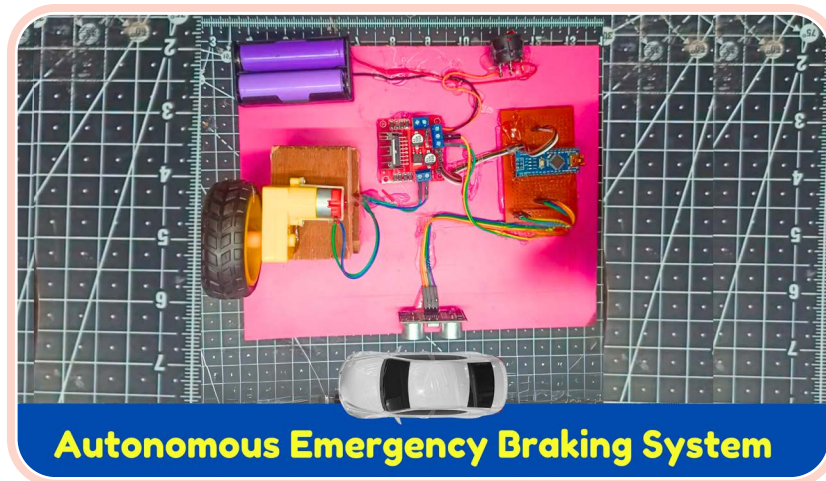
<https://tinyurl.com/mps5y3y6>



<https://youtu.be/z7ikS4Za7O8>

4. Mounting the Components:

- Once the code is uploaded to the board, arrange the project set-up as shown in the image.



- Secure the L298N motor driver, battery holder, Zero PCB with Arduino Nano, ultrasonic sensor and the rocker switch onto the wooden plank using hot glue.
- Fix the wooden block onto the wooden plank at the desired position.
- Attach the BO motor to the wooden block using hot glue. This is required to elevate the motor to align with the wheel.

5. Testing the Autonomous Emergency Braking System:

- Connect the Arduino board to a power source (9V battery).
- Bring a toy car or any other object in the path of the sensor.
- Ensure the motor stops when an object is detected within a certain range.
- Adjust the code or connections if the system doesn't function as expected.
- Use a multimeter to check continuity and voltage levels for troubleshooting.

How does the Autonomous Emergency Braking Model work?

The model uses an ultrasonic sensor mounted at the front to continuously measure the distance between the vehicle and any obstacle ahead. This sensor sends distance data to the Arduino Nano, which processes the input in real time. If an object is detected within a predefined minimum distance, the Arduino signals the L298N motor driver to stop the DC motor, simulating an autonomous braking action. This mimics the real-life working of an emergency braking system in modern vehicles, where braking is triggered without human intervention to avoid collisions.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/4pR4i4Qb8nA>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate student's understanding of speed, distance and time and their relationship.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Check for creativity and accuracy in assembling the model.
- Check if the model stops the motor when an obstacle is detected within the defined range.
- Evaluate the soldering and assembly quality.
- Assess the understanding of each component's functionality.
- Conduct a quick Q&A session to evaluate their understanding of the working of the Autonomous Emergency Braking System.
 - o How does the ultrasonic sensor detect obstacles?
 - o How can we improve the accuracy and response time of the system?
- Evaluate their understanding through questions about the working principles and code logic.
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Discuss how sensors are used for autonomous emergency braking system in real-world applications by showing them this video:



https://youtu.be/Xet1_Rl12Ig?si=1rJj50AaFGDmhsIt

Click the link or scan QR code to know more.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

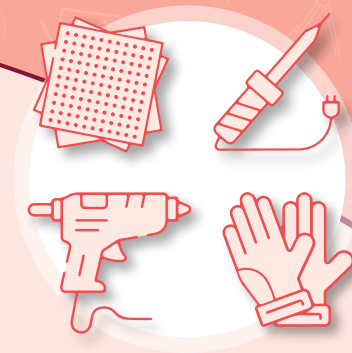
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Add an LCD to display the distance of the obstacle.
 - Use a rechargeable battery with a charging module for sustainability.
 - Incorporate a buzzer or red LED to alert the user when the object detected is within a predefined minimum distance.

Activity 7

DIY Paper Speaker: Exploring Sound Waves and Electromagnetism



Grade



9, 10



Subject



Physics



Topic/
Concept



**Electromagnetism,
Electromagnetic
Induction**

Objective

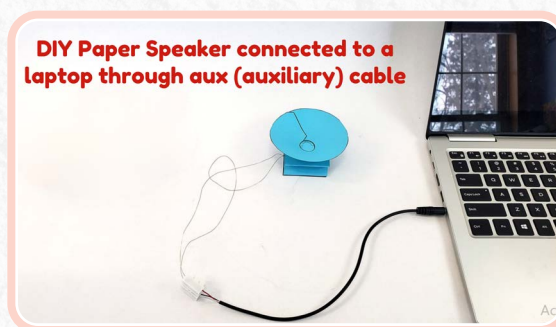
To demonstrate the production and amplification of sound using the principles of electromagnetism.

What will you help students learn?

- The principles of sound production and how speakers convert electrical signals into mechanical vibrations and finally to acoustic forms.
- To identify key components of speaker systems (coil, magnet, diaphragm) and describe their functions.
- To explain the working principle of a speaker using electromagnetic induction.
- To identify the key components of speaker systems (coil, magnet, diaphragm) and describe their functions
- Importance of precision in design and assembly when creating functional electronic devices.

What will you build/make?

A Paper Speaker using scientific principles of electromagnetism and sound.



Click the link or scan QR code to watch
DIY cum working video of the project.



<https://www.youtube.com/watch?v=liEwqdq7aA>

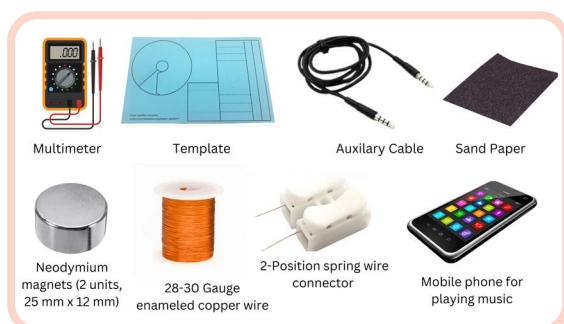
What will you need?

Materials Needed

- Cardstock paper (thick)
- Speaker Template (Link to download the template is given in the procedure)
- Neodymium magnets (2 units, 25 mm x 12 mm) - To create a strong magnetic field essential for electromagnetic interaction with the coil.
- 28 to 30 gauge enameled copper wire (5 meters) - to create a magnetic field when current passes through it.
- AUX (Auxiliary) cable
- 2-Position spring wire connector (Optional)

ATL Tools/Equipment

- Scissors
- Tape
- Sandpaper
- Ruler (Optional)
- Compass (Optional)
- Wire stripper
- Soldering kit- gun, stand, metal, flux, fume extractor
- Multimeter
- Hot glue gun with sticks
- Cutting mat
- Hand gloves

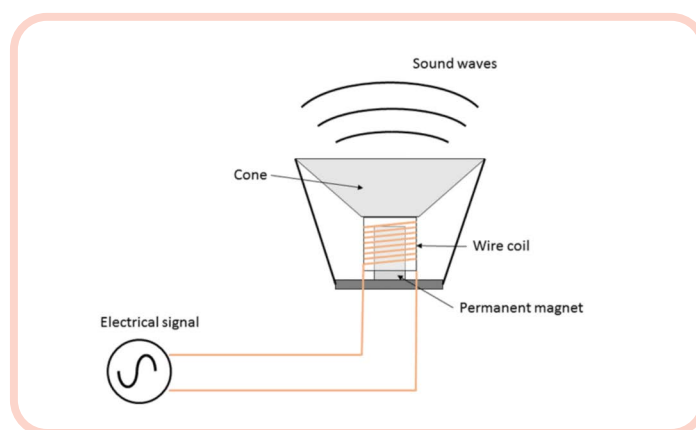


Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

- Discuss the basics of how speakers work: sound is produced when an electromagnetic coil interacts with a magnet, causing a diaphragm to vibrate.
- Show an example or diagram of a speaker to explain its components.

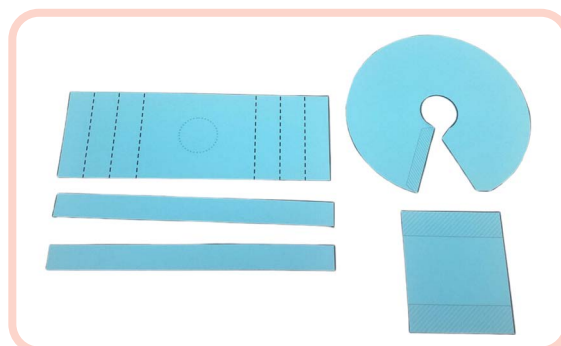
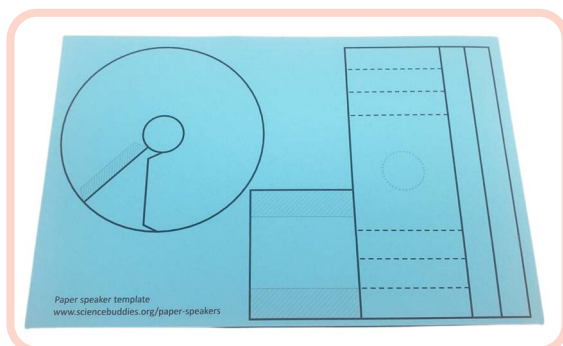


2. Prepare the Speaker Structure using Cardstock Paper:

- Click the link or scan QR code to download and print the 'paper speaker' template on A4 size cardstock paper. Your speaker will work with regular printer paper, but it will not be as sturdy and loud.
- This template is required for developing the project model.
- Cut out the template using scissors.



<https://tinyurl.com/bdews5uv>

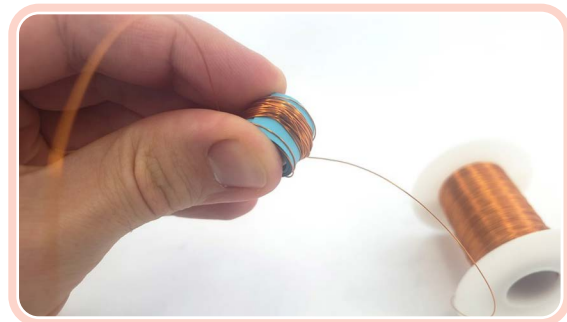


3. Create the Voice Coil:

- Wrap one of the long, narrow strips of paper tightly around the magnet.
- As you hold the paper-wrapped magnet firmly in place, begin wrapping the second long, narrow strip of paper around the first strip.
- Now use very little hot glue to hold the outer strip of paper in place so it does not unwind when you remove the magnet later.



- Wrap the enameled copper wire (~50–100 turns) around the outer strip of paper to form a coil approximately 4 cm in diameter.
- Leave about 15–20 cm of wire at each end for connections.
- If needed, you may leave a little extra length of the wire at each end, which you can cut later depending on the length of your auxiliary cable.

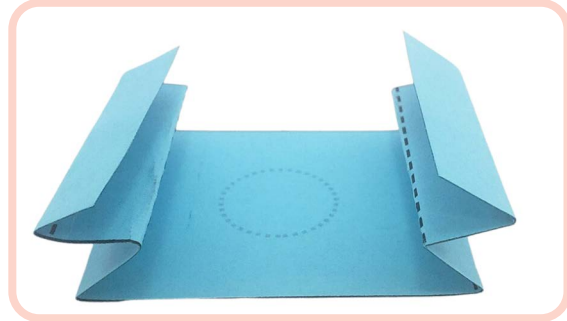
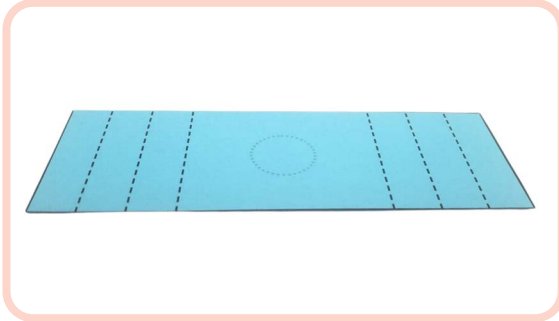


- After the glue has dried, push the magnet and the inner tube (first layer) of paper out of the coil. This will create a gap between the coil and the magnet to allow the coil to move up and down freely at the later stage of the assembly.

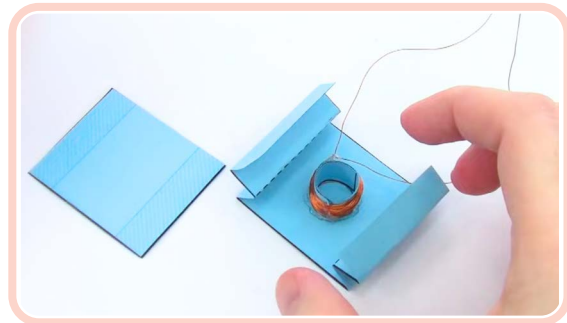
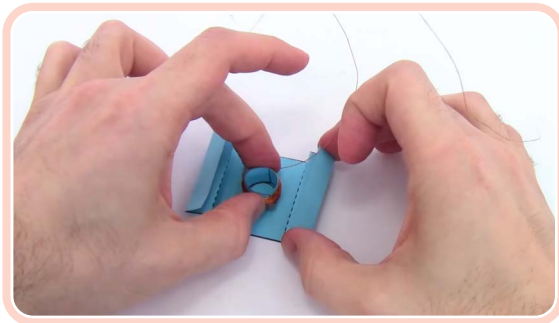


4. Create the Base Structure and Attach the Coil:

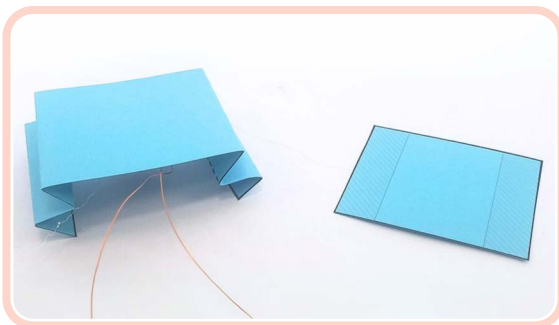
- Fold the large rectangular piece from the template along the dashed lines. Begin by folding the edges of the paper inwards and continue back and forth to form an accordion shape.



- Glue the coil to the dashed circle marked on the accordion piece. Allow the glue to dry.

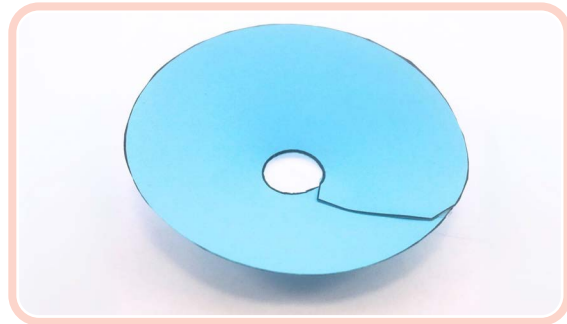
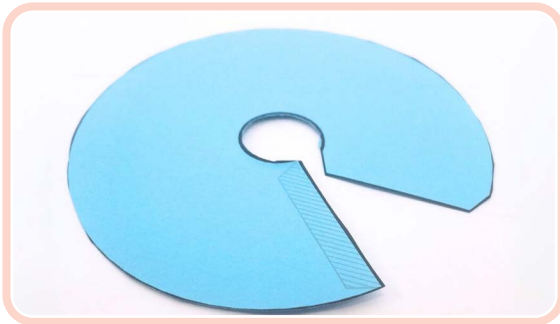


- Flip the accordion piece upside down. Using the small rectangle of the template as a base, glue the two accordion legs to the shaded areas on the rectangle.
- This completed piece will be the main body of the speaker.

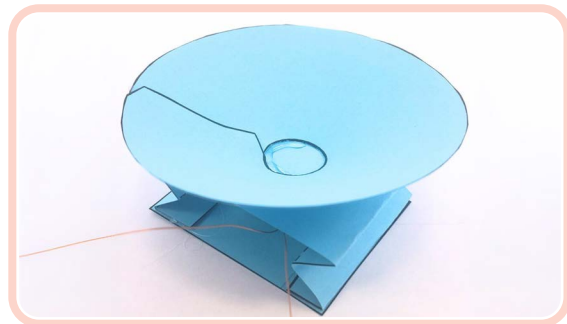
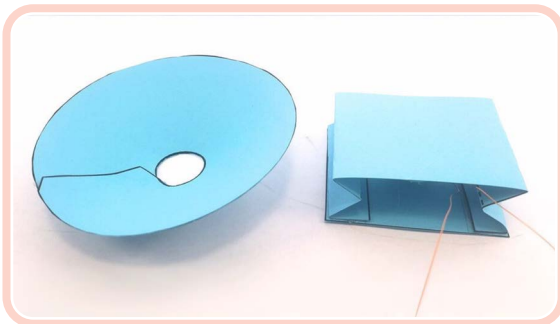


5. Create the Cone and Attach it to the Body of the Speaker:

- Bend the cone slightly to glue the angled tab onto the shaded area. Allow the glue to dry.

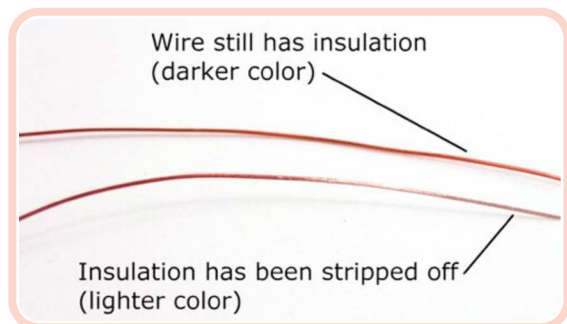
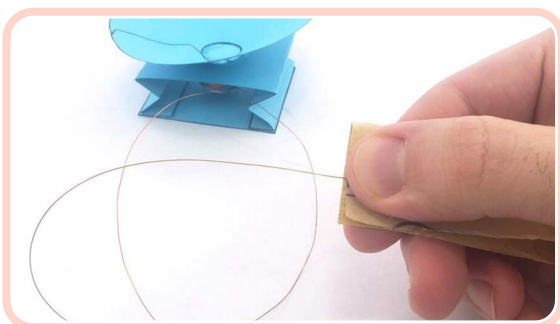


- Glue the smaller opening of the cone on the bottom side to the top of the speaker's body.



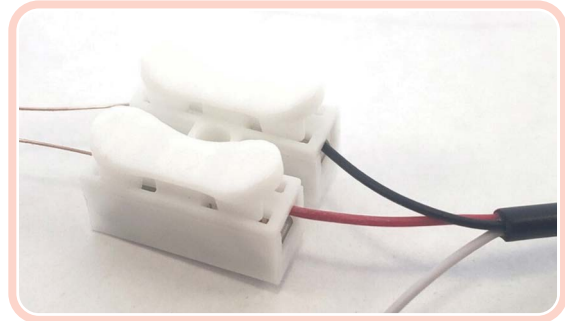
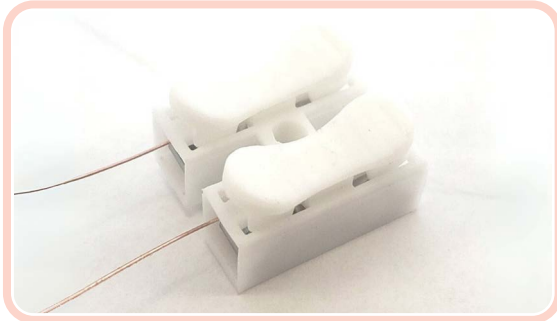
6. Connect the AUX cable to the copper wire:

- Use sandpaper to strip the insulation from about 1 cm of each end of the wire. Fold the sandpaper in half, pinch the wire between the sides of the sandpaper with your fingers, and pull along the wire.



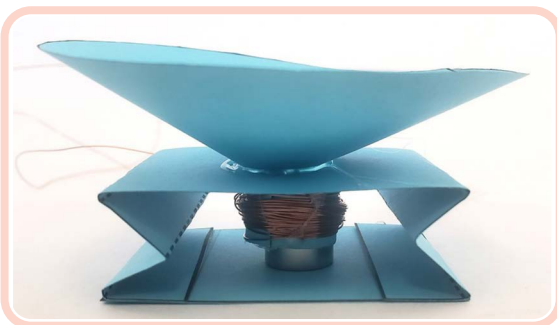
- Insert one end of the magnet wire into the 2-position spring wire connector. Repeat the same with the other wire so they are next to each other.
- Cut the AUX cable to expose the inner wires. Connect the loose wire ends of the AUX cable to the other end of the 2-position spring wire connector.

- An audio cable has 3 wires inside it – black (ground), red (left audio channel), and white (right audio channel). You need to connect the ground wire and one of the audio channels (red or white wire). Select the black wire and either the red or white wires, and connect them to the 2-position spring wire connectors.



7. Position the Magnets:

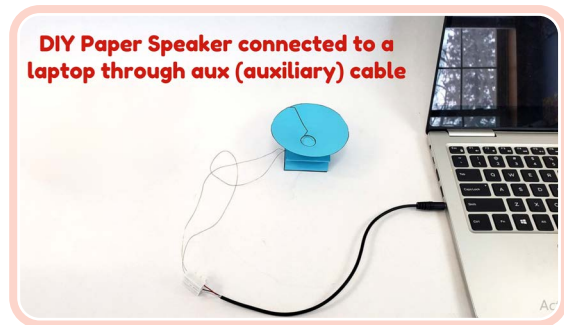
- Stack two neodymium magnets together. Gently pull the top and bottom parts of the speaker apart, far enough that you can slide the stacked magnets inside the coil.
- There should be a small gap between the coil and the magnets to allow the coil to move up and down freely. We have ensured this while creating the voice coil in one of the earlier steps.
- The magnets will be resting on the base of the speaker. You do not need to glue the magnets in place. They are heavy enough to be held in place by their own weight. This allows you to easily remove them if needed.
- Plug the 3.5 mm cable into the headphone jack of your phone, tablet, or computer to test the speaker.



8. Test the Speaker:

- After plugging the AUX cable into a mobile phone or music player, play the music.
- Make sure the volume on your device is all the way up.

- Observe the coil and magnets interacting to produce sound. The cardstock surface area below the cone and above the magnet acts as the diaphragm.



9. Fine-Tuning and Troubleshooting:

- If you do not hear any music, try these troubleshooting steps:
 - Make sure you have the correct sound source selected on your phone or computer. For example, make sure you are not connected to a Bluetooth headset or speakers.
 - Check that the volume on your device is turned all the way up.
 - Check that the 3.5 mm cable is firmly plugged into the headphone jack.
 - Make sure the spring clips are gripping the exposed metal parts of the 3.5 mm cable, not the insulated parts.
 - Make sure you have fully stripped the insulation off of the ends of the magnet wire.
 - Make sure the exposed parts of the two magnet wires are not touching each other. This will create a short circuit.
 - Make sure the coil is not glued too tightly to allow for vibrations.
 - Make sure the magnet is not rubbing against the inside of the paper tube, as this will add friction and decrease the speaker's vibrations.
 - Align the wire coil so it is just around the top of the magnet. Magnetic fields quickly get much weaker with distance. If the coil and the magnet are too far away from each other, your speaker will not work.
 - In these cases, adjust the position of the magnets or the tightness of the coil for optimal sound quality.



https://www.youtube.com/watch?v=UupWNWZPR_Y

Click the link or scan QR code to watch the video for troubleshooting.

How does the Paper Speaker work?

The working of a paper speaker can be explained using an electromagnetic induction principle. An audio signal (music in this case) is sent through the wire coil. The electrical current flowing through the coil creates a changing magnetic field. This changing magnetic field causes the coil to be attracted and repelled by the permanent magnet, making it move back and forth. The movement of the coil is transferred to the attached paper cone, causing it to vibrate. These vibrations create sound waves that are audible to the human ear.

This is how the speakers convert electrical signals into mechanical vibrations and finally to acoustic forms.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://www.youtube.com/watch?v=liSEwqdq7aA>

How can you assess students' understanding?

Assessment of Concept Understanding

Ask students the following questions

- What is electromagnetic induction?
- How do speakers work?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Observe and assess the functionality of the speaker by checking if it produces sound.
- Observe the students' ability to explain the science behind their creation.
- Evaluate creativity and troubleshooting skills during assembly.
- Conduct a quick Q&A session to evaluate their understanding of the working of the paper speaker.
 - o How does the interaction between the magnetic field and electric current produce sound?
 - o What role does the diaphragm (cardstock) play in amplifying the sound?
- Ask- Where have you seen this application being used around you?
e.g. Real-world applications like speakers in devices like headphones and loudspeakers.
- Discuss how principles of electromagnetism are used in motors, wind-mill/hydroelectric power plants generating electricity, micro-wave ovens in real-world applications by showing them this video:



<https://youtu.be/nllCgjlWAF4?si=PYHMonMEPzy8Raz>

Click the link or scan QR code to know more.

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

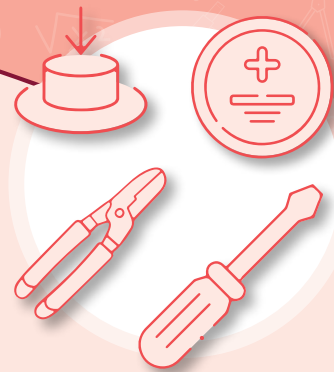
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Use a larger diaphragm (e.g., a plastic plate) to observe changes in sound quality and volume.
 - Experiment with different magnet sizes or coil thicknesses to explore their impact on performance.
 - Integrate a sound amplifier circuit (BC-547 and a capacitor) to boost the sound output. You can also use the sound amplifier module to boost the sound output.

Activity 8

Blood Donor and Receiver Compatibility Model



Grade

9



Subject

Biology



Topic/
Concept

Blood Groups

Objective

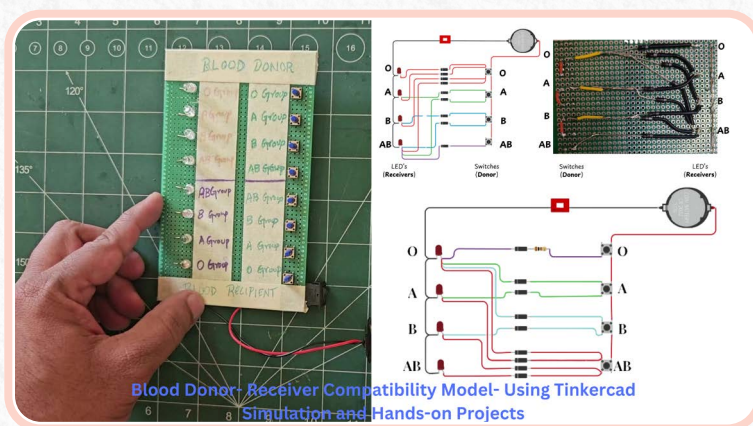
To reinforce understanding of blood group compatibility between donor and receiver.

What will you help students learn?

- Understand the concept of blood group compatibility for donation and reception.
- Understand basic circuit design and soldering techniques
- Create a functional model that visually represents the relationship between donor and receiver blood groups.

What will you build/make?

A Blood Donor and Receiver Compatibility Model using LEDs and Push Buttons



Click on to the link or scan QR code to know the working of the blood donor and receiver compatibility model.



https://youtu.be/LyV_kK_5w9I

What will you need?

Materials Needed

- LEDs (Light Emitting Diodes)
- Diodes (IN4007)
- Push Buttons
- 3V Coin Battery
- Wires
- Switch
- Zero PCB

ATL Tools/Equipment

- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire stripper
- Multimeter
- Screwdriver (Optional)
- Hot glue gun with sticks



Software/Application

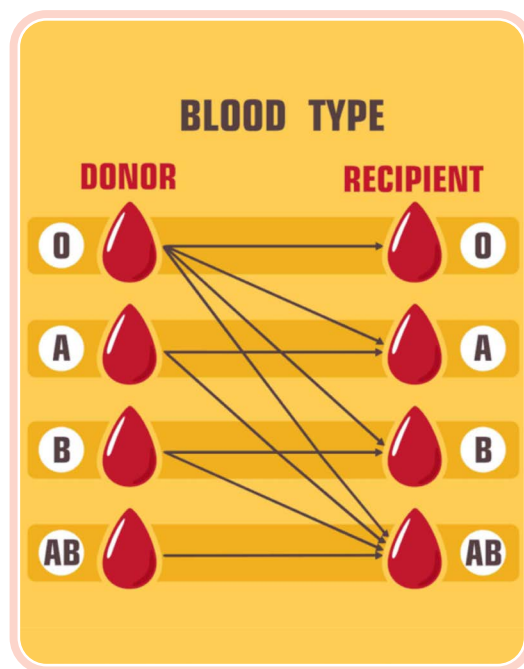
- Tinkercad

Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

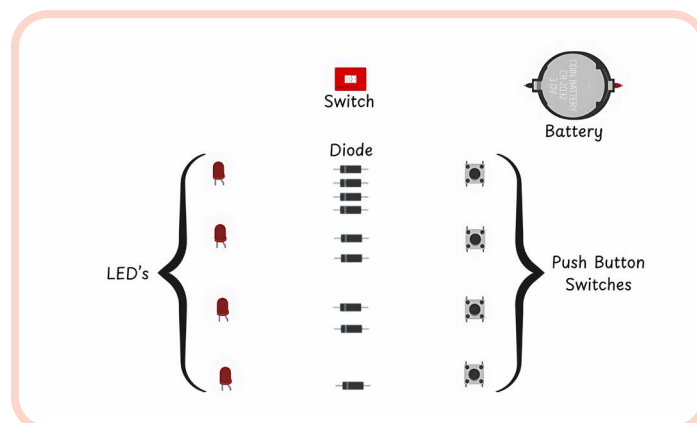
- Explain the concept of blood group compatibility:
 - o Donor Blood Groups: O, A, B, AB
 - o Receiver Blood Groups: Same as donor groups.
 - o O is a universal donor; AB is a universal receiver.
 - o Outline the logic of the circuit: When one presses a button corresponding to a donor group, the LED/LEDs corresponding to the compatible receiver blood group will light up and vice versa.



2. Simulate the Circuits in Tinkercad

A. Model#1- Blood Donor-to-Receiver compatibility:

- Open Tinkercad and create a new circuit project.
- Add these components to the virtual workspace: Push buttons, LEDs, Diodes, 3V coin battery and wires for connections



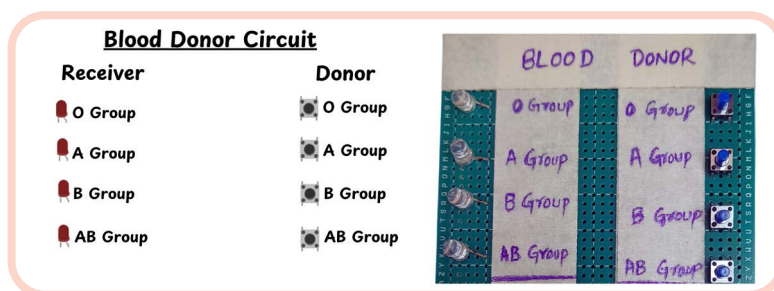
- Arrange the components based on the provided circuit diagram.
- Connect the components:
 - Link the push buttons to the LEDs through diodes.
 - Connect the LEDs to the battery terminals.
 - Ensure diodes are oriented correctly (stripe toward the LED).
- Simulate the circuit by pressing the buttons to test compatibility.
- Observe how LEDs light up based on the blood group compatibility.
- Click on the link or scan QR code to learn the circuit connection and simulation of blood donor and receiver compatibility in detail.



https://youtu.be/wC3P_zYEaWo

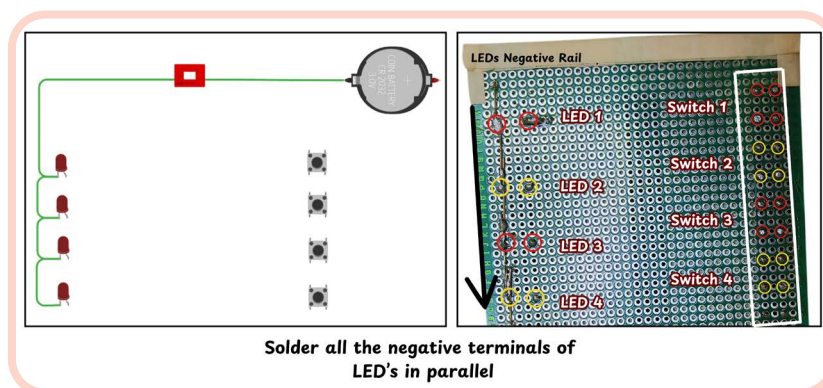
Note: Encourage students to troubleshoot any issues they see in the simulation before moving to the practical assembly.

3. Prepare the Zero PCB:



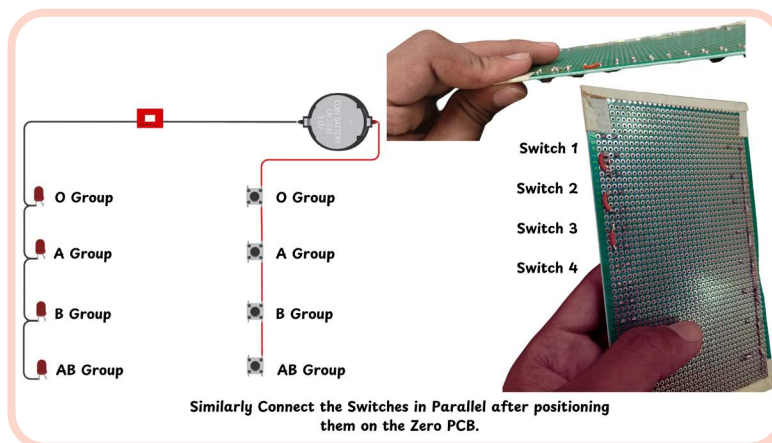
- Place the push buttons in one column to represent donor groups.
- Place the LEDs in another column to represent receiver groups.
- Label the buttons and LEDs with blood group names (e.g., A+, A-, etc.).

4. Connect the LEDs:



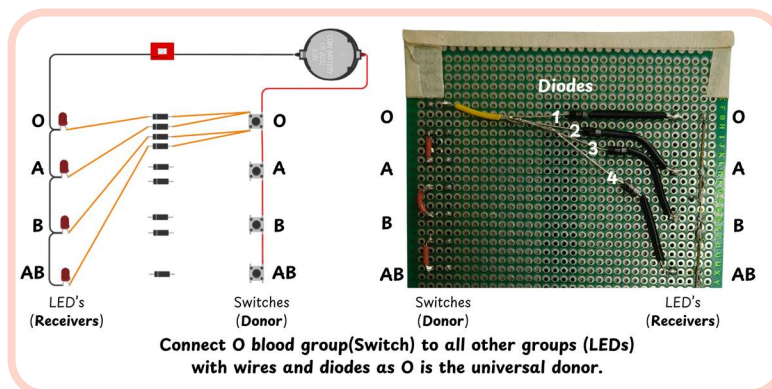
- Solder all the cathode (-) terminals of LEDs together in parallel as shown in the above image.
- Connect the cathode (-) of each LED to the ground rail of the PCB.

5. Wire the Push Buttons:



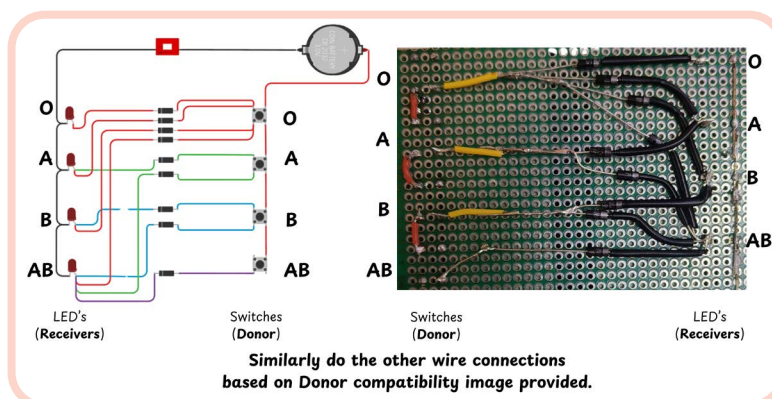
- Solder the push buttons to the PCB.
- Connect one side of each push button to a common 9V power supply rail (+) via the slide switch.
- Connect the other side of each push button to corresponding LEDs through diodes.

6. Add Diodes for Reverse Current Protection:



- Solder a diode (IN4007) between each push button and its respective LED, with the cathode (stripe) pointing towards the LED.

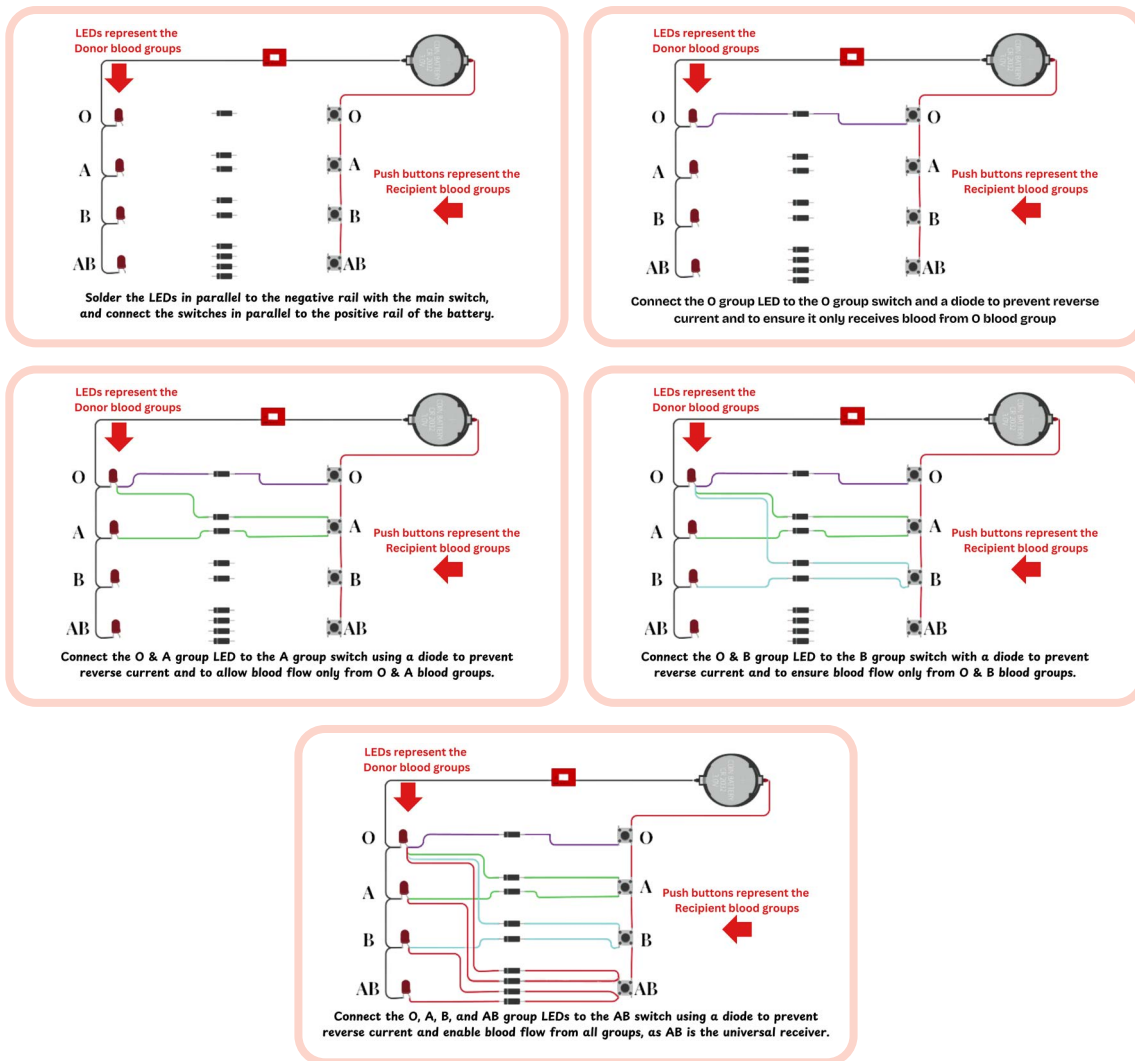
7. Complete the Circuit:



- Ensure the positive terminals of all the LEDs are connected to the power rail (via the slide switch).
- And the negative terminals of all the LEDs are connected to the ground rail.

B. Model#2- Blood Receiver-to-donor compatibility:

- Similar to Model#1 (Blood Donor to Recipient compatibility circuit), for Model#2 (Blood-Recipient to Donor compatibility circuit) make connections in Tinkercad and also using PCB as per the steps shown:



8. Testing the Models:

- Flip the slide switch to power on the circuit.
- Press each push button to ensure that the appropriate LEDs light up, representing compatible blood groups in both the models.

9. Finalize the Models:

- Secure all components with hot glue for stability.
- Label the donor and receiver sides clearly for easy understanding.

How do the models work?

Model#1: Blood Donor to Receiver Compatibility-

- In the 'Blood Donor to Receiver Compatibility' model, when the user presses any push button that represents the donor blood group, the LEDs representing corresponding compatible receiver blood groups will turn on.

Model#2: Blood Receiver to Donor Compatibility-

- In the 'Blood Receiver to Donor Compatibility' model, when the user presses any push button that represents the receiver blood group, the LEDs representing corresponding compatible donor blood groups will turn on.

Click on to the link or scan QR code to know the working of the 'blood donor to receiver' and 'blood receiver to donor' compatibility models.



https://youtu.be/LyV_kK_5w9I

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of blood groups and blood group compatibility between donor and receiver.
- What makes O a universal donor and AB a universal receiver?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Evaluate students' understanding of blood group compatibility and the circuit designed for the same.
- Check for creativity and accuracy in assembling the model.
- Assess whether the circuit correctly lights up compatible LEDs for each button press.
- Observe the functionality of the project during testing and analyse its accuracy
- Conduct a quick Q&A session to evaluate their understanding of the working of the Blood Donor and Receiver Compatibility Model.
 - o How do diodes ensure that current flows only in one direction in this circuit?
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. *(Rubric for this is provided in the note for the teacher).*

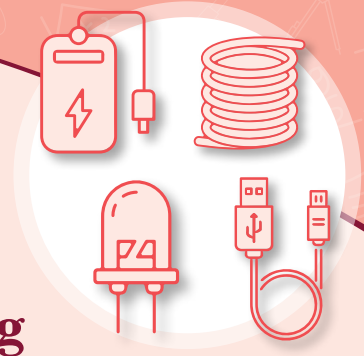
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can use an Arduino to automate compatibility checks and display results on an LCD.
 - Extend the model to include the Rh factor or create a digital version using sensors.

Activity 9

Blood Donor and Receiver Compatibility Model Using Arduino Uno and Block Coding



Grade

9



Subject

Biology



Topic/
Concept

Blood Groups

Objective

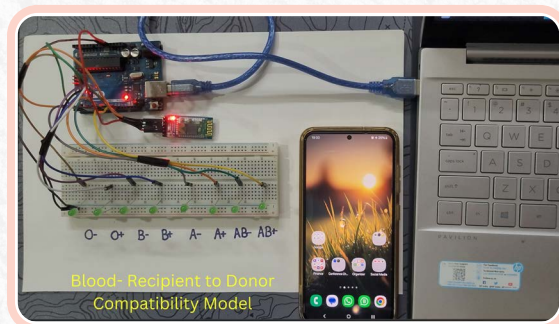
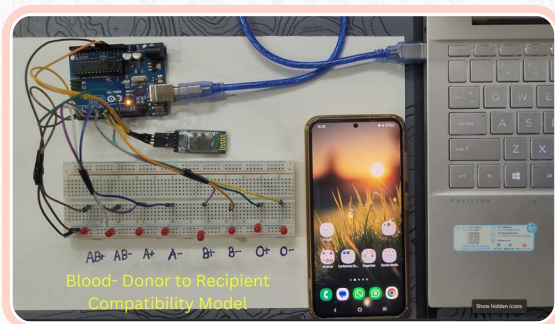
To reinforce understanding of blood group compatibility between donor and receiver by building a working digital model to check compatibility using PictoBlox (a block coding software).

What will you help students learn?

- Develop an understanding of blood donor and receiver compatibility based on the standard blood donor-recipient chart.
- Block coding using Pictoblox (Scratch-based environment).
- Familiarize themselves with serial communication between hardware and mobile applications.
- Problem-solving and debugging skills

What will you build/make?

A DIY Project for Blood Donor-Receiver Compatibility Using Arduino Uno, Pictoblox, and Dabble Mobile Application



<https://youtu.be/3LEJlIjGMuQ>



https://youtu.be/_V8teGXQ4M

Click on to the links or scan QR codes to know the working of the blood donor and receiver compatibility model.

What will you need?

Material and components

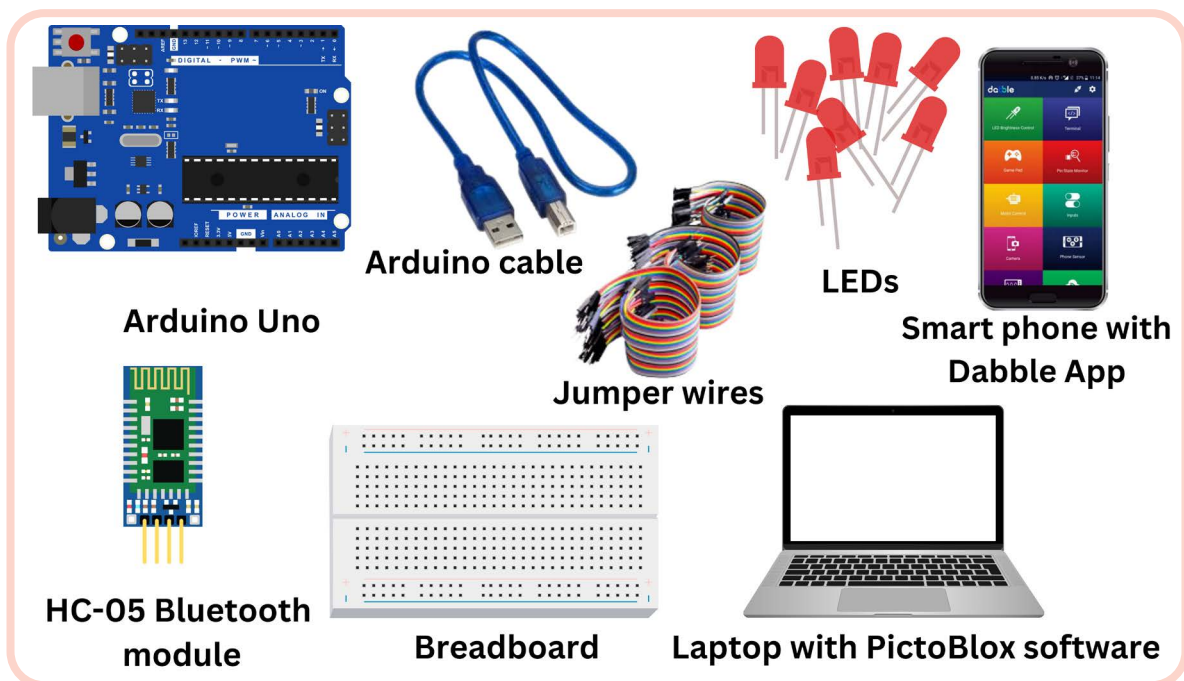
- Arduino Uno
- HC-05 Bluetooth Module
- 8 LEDs representing blood groups O-, O+, B-, B+, A-, A+, AB-, AB+)
- Breadboard
- Jumper Wires

ATL Tools/Equipment

- Mobile Phone with Dabble Application installed
- Computer with Pictoblox software installed
- USB Cable for Arduino
- Power Bank / Battery Pack (Optional)

Software/Application

- Pictoblox (a scratch-based programming environment)
- Dabble Mobile Application



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introducing the Concepts of Blood Donor-Receiver Compatibility:

- Explain the standard blood donor-recipient chart.
- Discuss universal donors (O-) and universal recipients (AB+).
- Show compatibility using a table or visual aids.

	DONOR BLOOD TYPES							
	O-	O+	B-	B+	A-	A+	AB-	AB+
AB+								
AB-								
A+								
A-								
B+								
B-								
O+								
O-								

2. Introducing Pictoblox Software, Arduino and Dabble mobile application:

- **What is PictoBlox?**
 - o A visual programming software based on Scratch 3.0 used for coding Arduino.
- **Why use PictoBlox?**
 - o Makes coding easier through drag-and-drop blocks instead of complex text-based programming.
- Install Pictoblox software. Click the link or scan QR code to download the software.
- Briefly explain what Scratch-based programming PictoBlox is. Click the link or scan QR code to learn more on Pictoblox software.



<https://tinyurl.com/2jemya36>



<https://tinyurl.com/4uufjhfa>

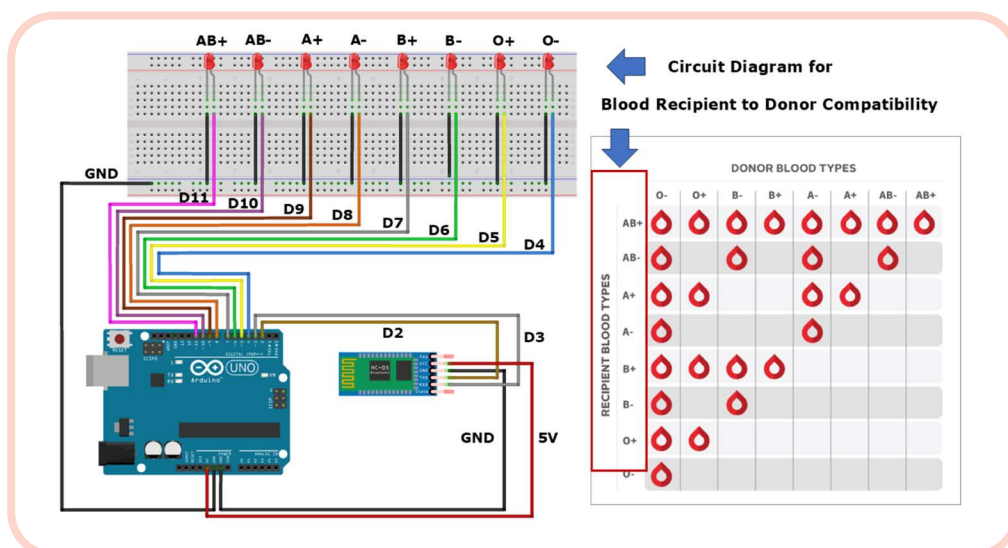
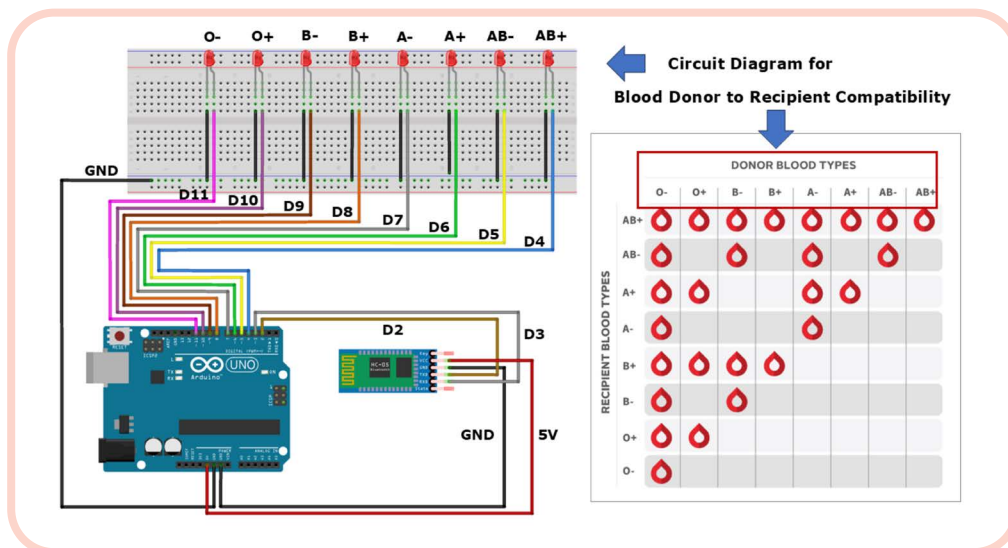
- Explain how Arduino communicates with external devices using serial communication.
- Install Dabble application on mobile phone. Click on the link or scan QR code to download the software.
- Demonstrate the use of Dabble mobile application and its serial terminal feature.



<https://tinyurl.com/yjt24f6x>

3. Circuit Setup:

- Refer the circuit diagrams given separately below for donor-to-recipient and recipient-to-donor compatibility projects.
- You can build these two circuits separately if you want to demonstrate both the projects simultaneously or you can build them using the same components one after another.
- We have provided the list of components required, circuit diagrams and step-by-step instructions to develop both the projects in the activity plan.



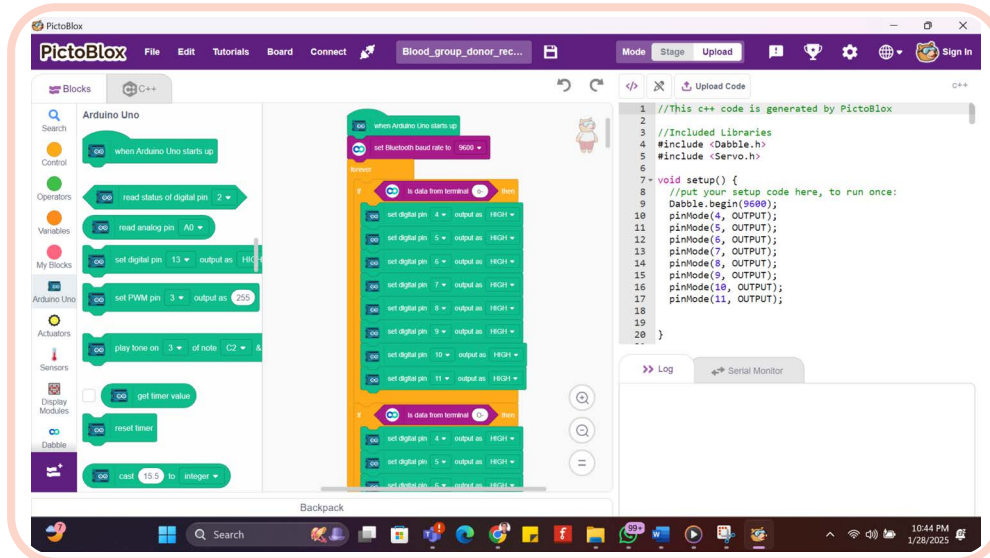
- #### 4. Writing and Uploading Programs:

- [illegible]

-
- The screenshot shows the PictoBlox IDE interface. On the left, the 'My Blocks' palette is visible, with the 'enable LED control' block highlighted by a magnifying glass. The main workspace contains a Scratch script with a 'when green flag clicked' event, a 'say Hello World! for 2 secs' speech bubble, and a 'say Hello World! for 2 secs' speech bubble. The right side of the interface shows a C++ code editor with a simple LED control program using digitalWrite and delay functions.

Program 1: Blood Donor to Recipient compatibility:

- Develop Program 1 first and upload it before you develop program 2 for Blood Recipient to Donor compatibility if you are not going to design two separate circuits for these two programs.

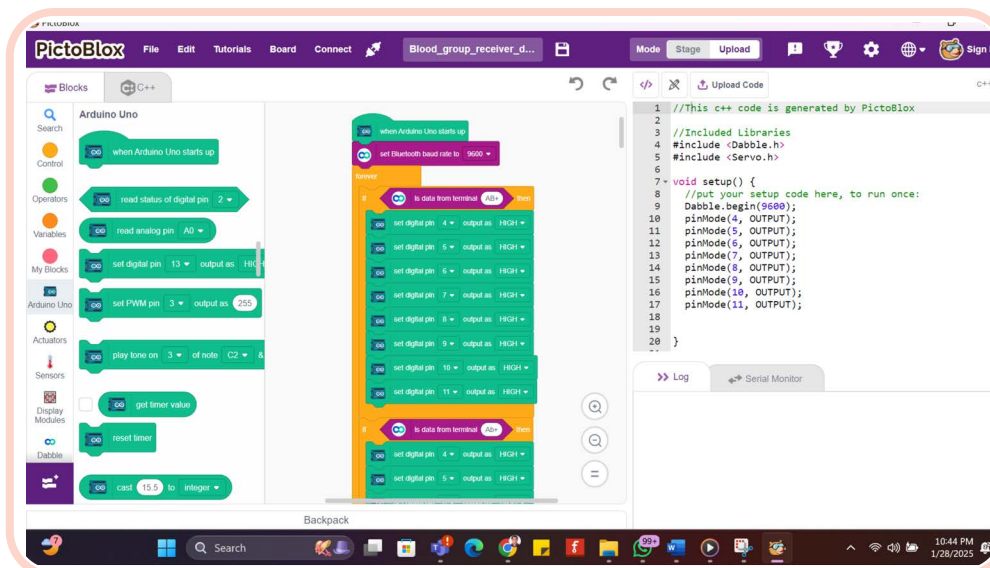


- Click on the link or scan the QR codes below to follow the DIY video for developing the block coding program for blood donor to recipient compatibility project.
- Refer to the circuit diagram and build the code in such a way that-
 - o The user enters a donor blood group in the serial terminal of the Dabble application.
 - o The corresponding compatible recipient LEDs turn ON.



<https://youtu.be/amejpi1Y48>

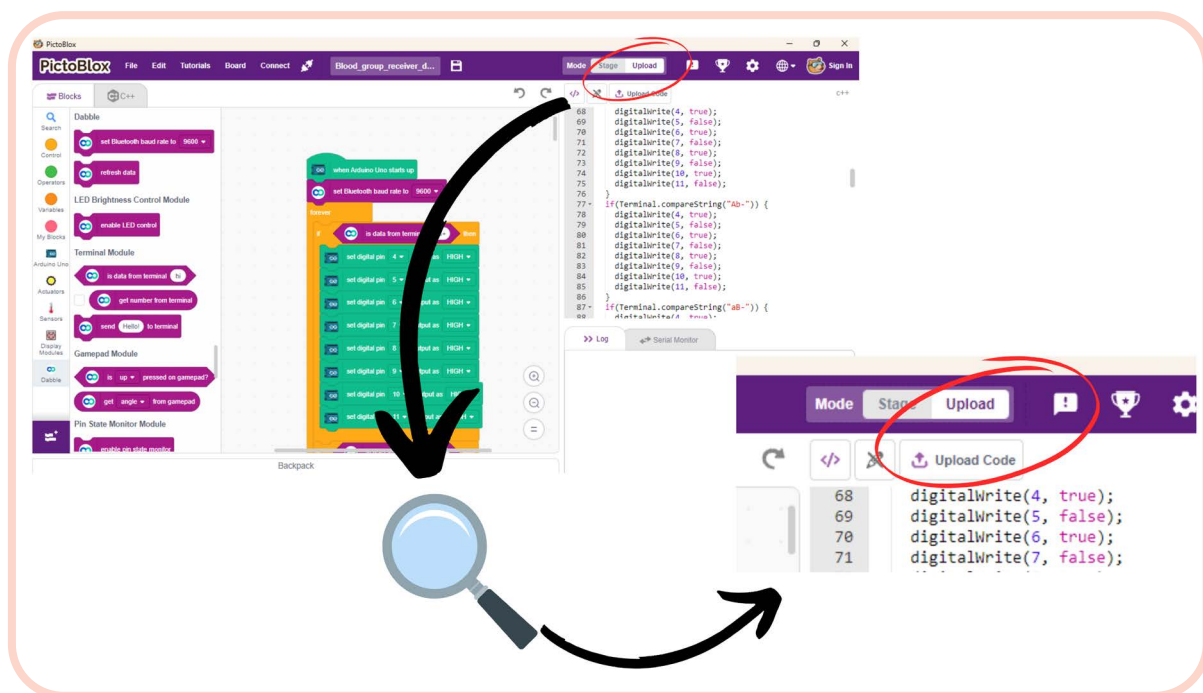
Program 2: Blood Recipient to Donor Compatibility



- Click on the link or scan the QR codes below to follow the DIY video for developing the block coding program for blood recipient to donor compatibility project
- Refer to the circuit diagram and build the code in such a way that-
 - o The user enters a recipient blood group in the serial terminal of the Dabble application.
 - o The LEDs corresponding to compatible donors turn ON.
- **Upload the program to Arduino Uno through Pictoblox software:** Develop Program 1 first and upload it before you develop program 2 for Blood Recipient to Donor compatibility if you are not going to design two separate circuits for these two programs. If you are going to design two separate circuits, upload them separately.
- Upload the program to Arduino Uno through 'Upload' mode in Pictoblox as shown in the image below.



<https://youtu.be/A0M9y08DI4g>



5. Testing and Debugging:

- Run the programs individually.
- Verify compatibility logic by entering different blood groups.
- Check LED responses for both donor and receiver inputs.

How does the model work?

- Once the program is uploaded, switch on Bluetooth in your mobile phone and do not select the Bluetooth module as a Bluetooth device here.
- Open Dabble application and select Bluetooth module name inside the application to connect Bluetooth module with your mobile phone as explained in the video (scan the QR codes below to learn this).
- If the program is for donor to recipient compatibility, write any donor blood group name in the serial terminal inside the dabble application. The LEDs corresponding to compatible receivers for that donor blood group will turn ON.
- If the program is for recipient to donor compatibility, write any receiver blood group name in the serial terminal inside the dabble application. The LEDs corresponding to compatible donor blood groups for that receiver blood group will turn ON.
- Click on the links or scan QR codes to follow the working videos to learn how to use these projects to verify the blood compatibility
- Working video of blood donor to recipient compatibility project using PictoBlox:
- Working video for of blood recipient to donor compatibility project using PictoBlox:



<https://youtu.be/3LEJIjGMuQ>



https://youtu.be/_VW8teGXQ4M

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of blood groups.
- Why are some blood groups compatible with others?
- How does the universal donor and universal recipient concept work in real-life transfusion scenarios?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Check for creativity and accuracy in assembling the model.
- Evaluate the correctness of compatibility logic and LED responses.
- Discuss the importance of accurate programming and debugging.

- Allow students to demonstrate their working models.
- Conduct a quick Q&A session to evaluate their understanding of working of the model.
 - o Why do we use a breadboard instead of directly connecting components to Arduino?
 - o How does the Arduino know which LEDs to turn ON when a user enters a blood group in the Dabble app?
 - o What is the function of the serial terminal in the Dabble app?
 - o Why do we need two separate programs for donor-to-receiver and receiver-to-donor compatibility?
 - o How does Arduino receive input from the Dabble app?
 - o How can Bluetooth be used in real-life applications?
- Discuss how well they integrated hardware and software.
- Ask- where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

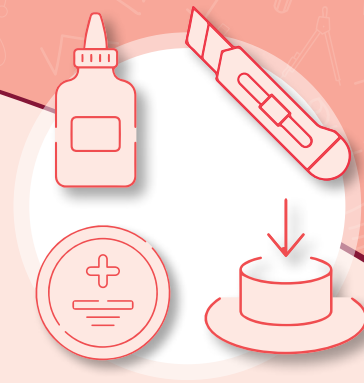
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Develop a graphical interface in Pictoblox for better visualization.
 - Expand the project to include Rh factor compatibility.
 - Modify the project using Raspberry Pi Processor
 - Extend the project to display text output using an LCD screen.
 - Experiment with other Bluetooth-controlled projects using Dabble's multiple functions.

Activity 10

DIY model that demonstrates the Five Stages of Blood Circulation using Tinkercad Simulation and Electronics



Grade



10



Subject



Biology



Topic/
Concept



Transportation in Human Beings- Human Circulatory System/Double Circulation

Objective

To reinforce the understanding of blood circulation in human beings by building an electronic model to demonstrate different stages in the human circulatory system.

What will you help students learn?

- To understand and visualize the five stages of blood circulation in humans.
- Construct a functional DIY model of blood circulation with LEDs in parallel.
- To learn basic circuit design using Tinkercad simulation.
- To understand the human circulatory system stages and their functions.
- To integrate biology concepts with basic electronics and simulation tools.
- Develop soldering and circuit assembly skills.
- Troubleshoot and solve problems.

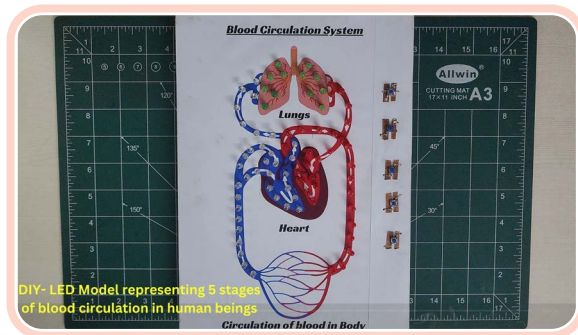
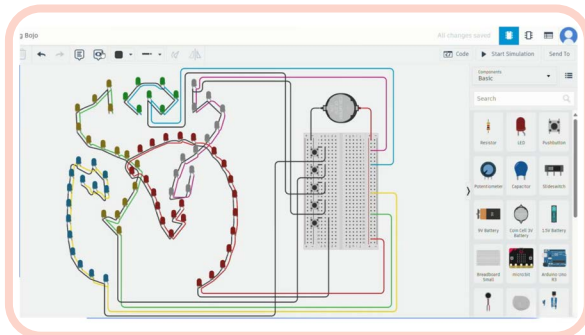
Sessions

The process of building the model is divided into 2 focused sessions:

- **Session 1:** Tinkercad simulation and discussion.
- **Session 2:** DIY model construction and testing.

What will you build/make?

A functional model simulating the five stages of blood circulation using Tinkercad for simulation and a DIY electronic model.



<https://youtu.be/3QpK6hfOWt8>



https://youtu.be/_f5anja3YmM

Click on the links or scan QR codes to watch DIY cum working videos of the project.

What will you need?

Materials Needed

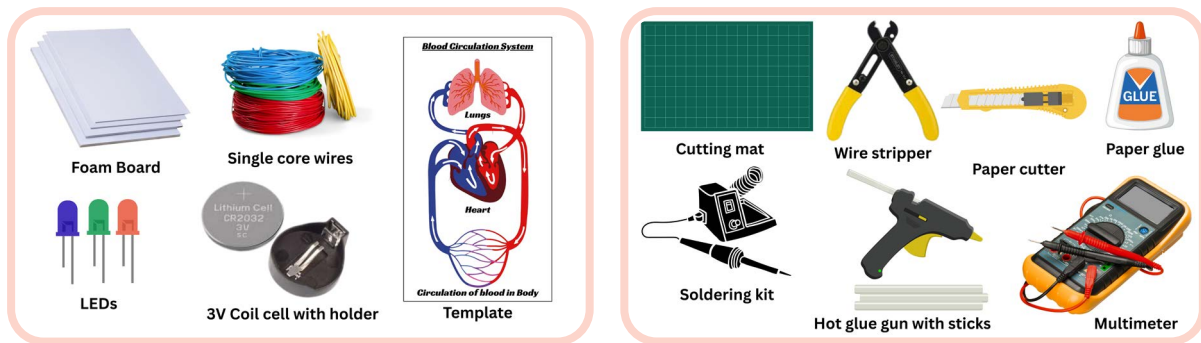
- Blue LEDs (18-20)
- Blue LEDs (15-16)
- Green LEDs (12)
- Red LEDs (10-12)
- Red LEDs (20)
- Push buttons (5)
- 3V coin cell battery with holder
- Single-core wires
- Printable blood circulation template (Link to download the template is given in the procedure)
- Foam board (A4 size)
- Paper glue

ATL Tools/Equipment

- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire cutter/stripper
- Multimeter (optional)
- Paper cutter
- Cutting mat

Software/Application

- Tinkercad simulation platform



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

Session 1: Tinkercad simulation and discussion

1. Introduction:

- Briefly explain the stages of blood circulation:
 - o Deoxygenated blood from body to heart.
 - o Deoxygenated blood from heart to lungs.
 - o Purification in lungs.
 - o Oxygenated blood from lungs to heart.
 - o Oxygenated blood from heart to body.

2. Tinkercad Setup:

- Log in to [Tinkercad](https://www.tinkercad.com) and create a new circuit.
- Click on the links or scan the QR codes to watch the videos to learn the basics of Tinkercad circuits.



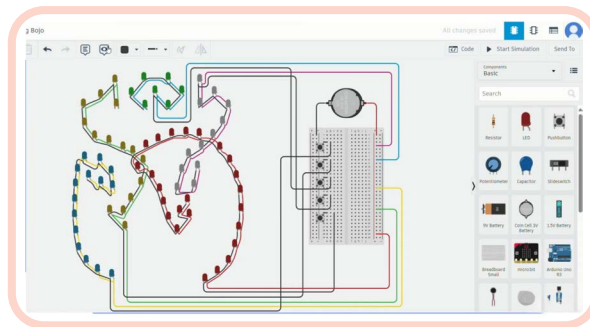
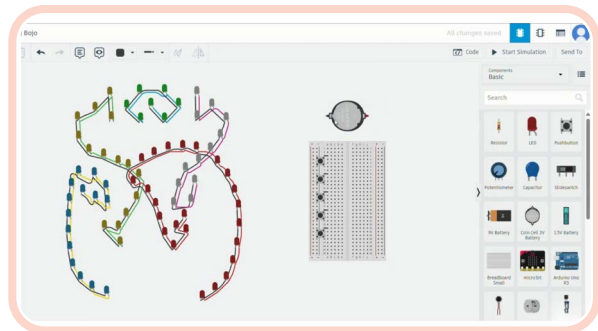
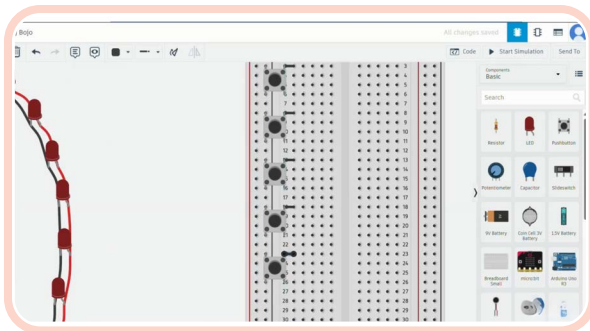
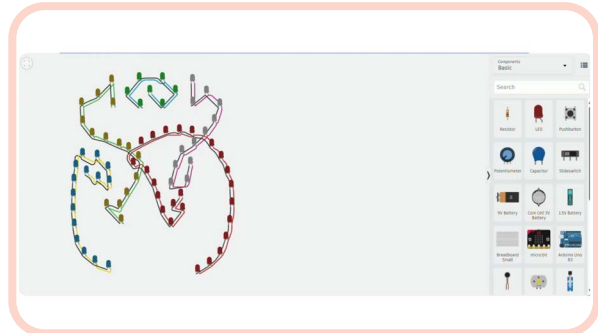
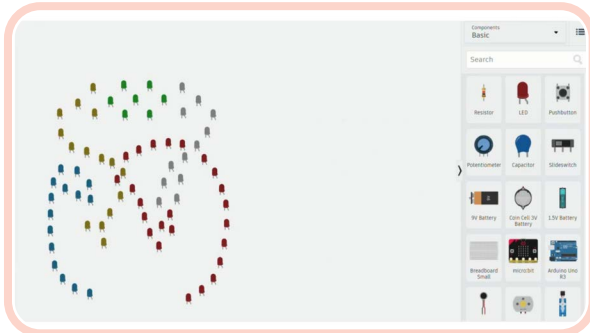
<https://www.tinkercad.com/learn/circuits>



<https://www.tinkercad.com/blog/official-guide-to-tinkercad-circuits>

- Add blue, green and red LEDs in the required numbers (as suggested in material list) to the workspace.

- Place 5 push buttons corresponding to the 5 paths of blood flow.
- Design a parallel circuit where:
 - o Each LED is connected to a push button.
 - o All LEDs share a common power source (3V coin cell battery).
- Simulate the circuit, pressing each button to ensure the LEDs light up as intended.



3. Discussion:

- Discuss how the Tinkercad simulation relates to the actual blood circulation process.
- Troubleshoot and make necessary adjustments to the circuit in Tinkercad.

Session 2: DIY Model Construction

4. Preparation:

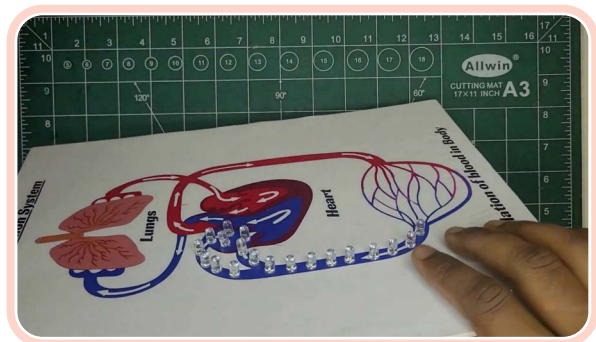
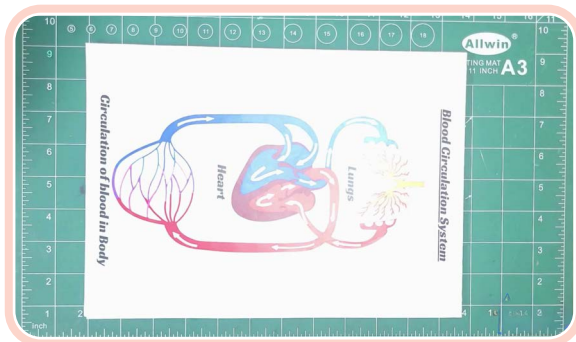
- Click on the link or scan the QR code to download and print the blood circulation template in A4 sheet paper. Color printing is recommended.
- Cut the foam sheet as per the size of the blood circulation template (A4 size)
- Paste the template onto a foam sheet for a sturdy base.
- Use a needle to make holes on the board for mounting LEDs as per the stages of blood flow.



<https://tinyurl.com/yr7jnkss>

5. Setting up the LEDs:

- Insert blue LEDs for deoxygenated blood flow, a green LED for the purification stage, and red LEDs for oxygenated blood flow.
- Ensure correct orientation (long leg = positive terminal) for all LEDs

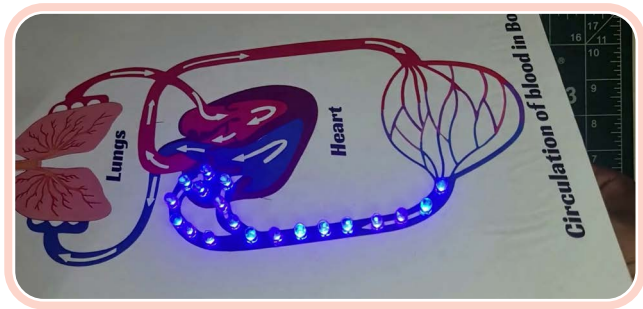


6. Wiring the Circuit:

- Connect the LEDs in parallel using single core wires.
- Use push buttons to control the flow of electricity in each path.
- Attach the coin cell battery and holder to the circuit.

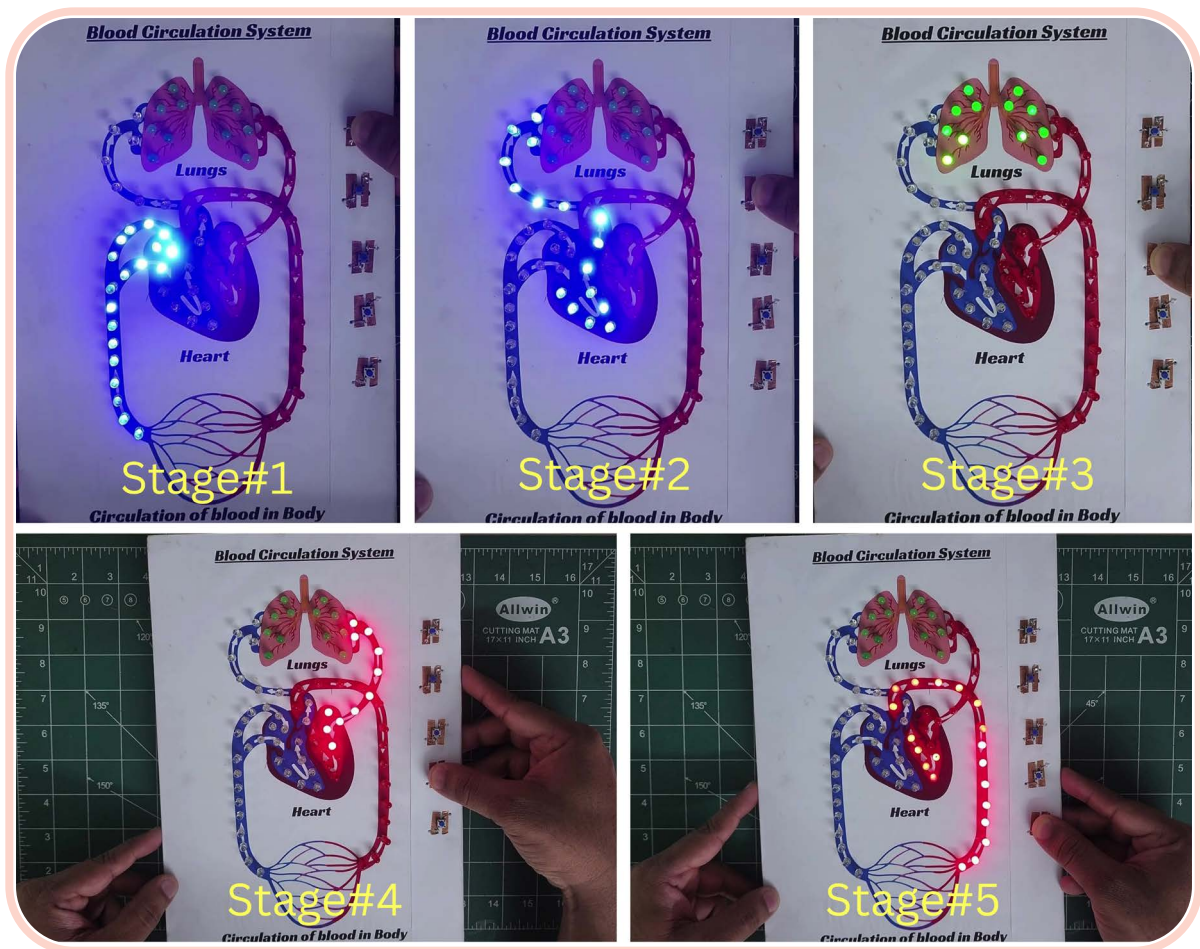
7. Soldering:

- Secure all connections with solder, ensuring clean and strong joints.
- Use a fume extractor and take precautions during soldering.



8. Final assembly and testing the model simulating the five stages of blood circulation:

- Neatly arrange the wires and secure the components to the foam sheet.
- Press each push button to test if the corresponding LED lights up.
- Troubleshoot any issues and finalize the circuit.



How do the models work?

Both the models (Simulation model and DIY model) represent the five stages of blood circulation in human beings. The different sets of LEDs are assembled in both the models to represent the stages of blood flow. LEDs in each stage are connected in a parallel circuit and they are powered with a coin battery of 3V. Each set of LEDs also has a push button connected to switch the power on and off. When a push button is pressed, the corresponding set of LEDs will turn on representing the blood flow in that particular stage of the circulation.

- Click on the links or scan QR codes to watch working videos of the project.



<https://youtu.be/3QpK6hfOwT8>



https://youtu.be/_f5anja3YmM

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding human circulatory system.
- Explain the blood circulation process using the model.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Assess students based on:
 - o Accuracy of the Tinkercad simulation.
 - o Functionality and neatness of the DIY model.
- Conduct a quick Q&A session to evaluate their understanding of the working of the model
 - o How does this model help in visualizing blood circulation?
 - o What challenges were faced in simulation and real-life assembly?
 - o How does this activity integrate biology and technology?
- Ask- where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

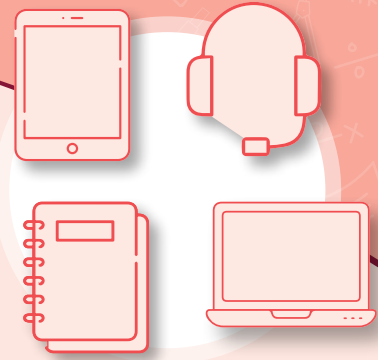
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. You can use this model be used in real-life applications?
2. How can you modify this model?
 - You can use an Arduino board to automate the LED switching process.
 - Incorporate a buzzer for each stage to indicate proper functionality.
 - You can use RGB LEDs to represent dynamic blood oxygen levels.

Activity 11

Creating an Animation of the Five Stages of Blood Circulation Using Scratch or PictoBlox



Grade

10



Subject

Biology



Topic/
Concept

**Transportation in
Human Beings- Human
Circulatory System/
Double Circulation**

Objective

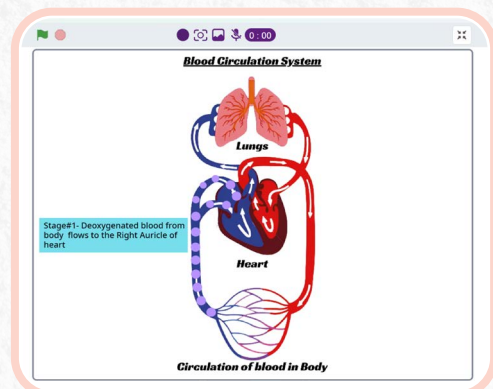
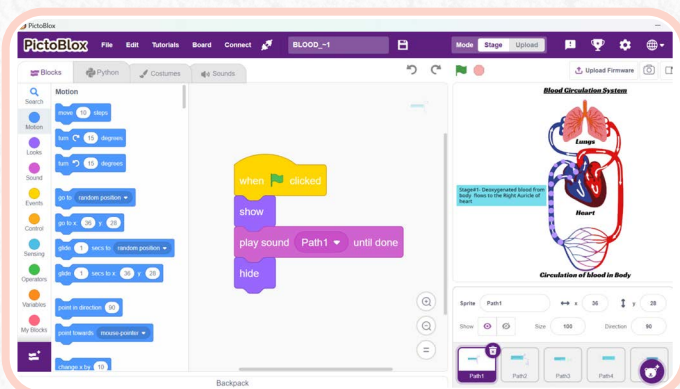
To reinforce the understanding of blood circulation in human beings by creating an animation to demonstrate different stages in the human circulatory system.

What will you help students learn?

- Understand the 5 stages of blood circulation in the human body.
- Visualize and animate the flow of deoxygenated and oxygenated blood through different circulatory pathways.
- Create a basic animation using programming software.
- Skills in Scratch or Pictoblox programming.
- Problem-solving and presentation skills.
- How to use costumes and sprites for animation.
- Computational thinking through programming.

What will you build/make?

An Animation Showing the 5 Stages of Blood Circulation Using Scratch or PictoBlox.



Click on the link or scan QR code to watch DIY cum working videos of the project.



<https://youtu.be/FKFQuFA-sLE>

What will you need?

Materials Needed

- Notebook and Pen

ATL Tools/Equipment

- Computer/Laptop
- Speakers/Headphones
- Microphone (Optional)

Software/Application

- Scratch Software (Offline/Online) OR Pictoblox Software
- Diagram of Human Blood Circulatory System. (Link to download the image is given in the procedure)
- Internet Connection

Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction to Scratch/Pictoblox Programming:

Click on the link or scan QR code to download the PictoBlox software.



<https://tinyurl.com/yc7f436f>

Click on the link or scan QR code to learn more about the PictoBlox software.



<https://tinyurl.com/4uufjhfa>

- Explain Scratch/Pictoblox as a block-based programming tool.
- Demonstrate how to create a new project.
- Introduce sprites, backdrops, event, sound, and sound blocks.
- Show an example of simple animations using motion blocks.

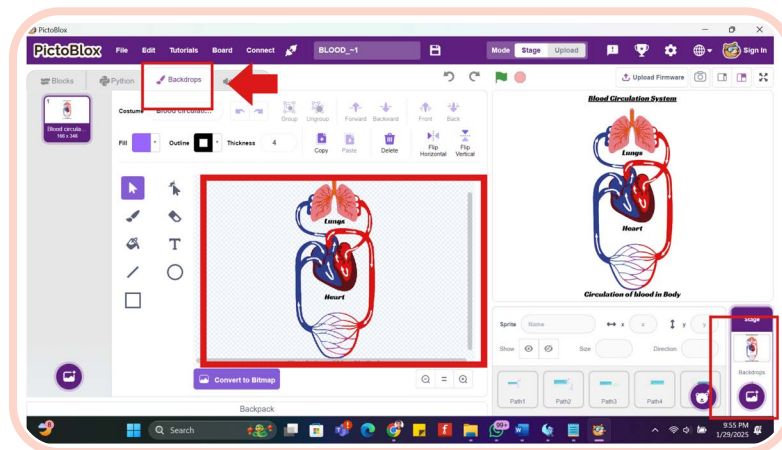
2. Setting Up the Animation Components:

- **Set the Backdrop:**

- Click on the link or scan QR code to download the blood circulatory system diagram.
- Upload this human circulatory system diagram as the backdrop in PictoBlox.



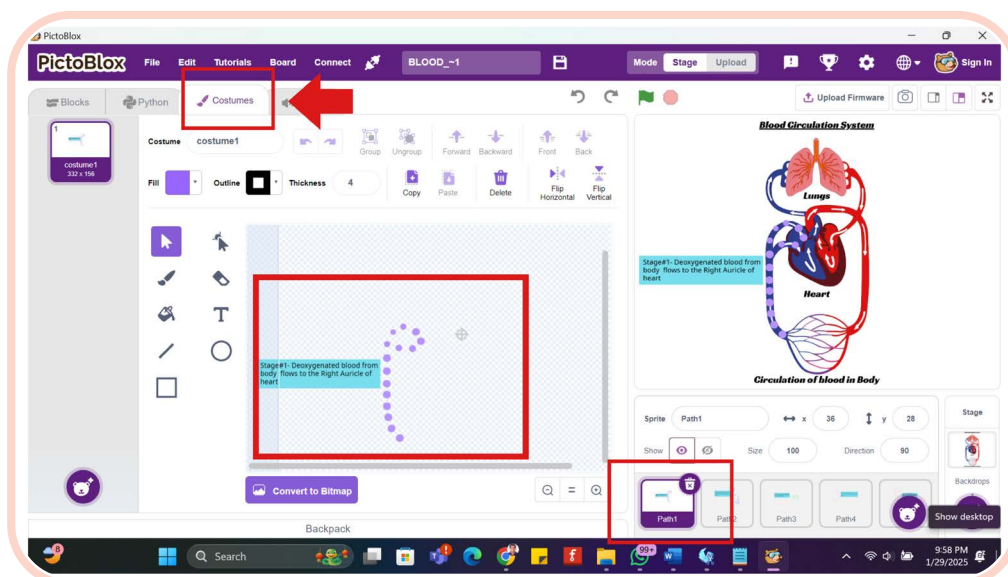
<https://tinyurl.com/4fu99b7d>



- Label the heart, lungs, arteries, and veins (Optional).

- **Create 5 Blood Flow Sprites as shown below:**

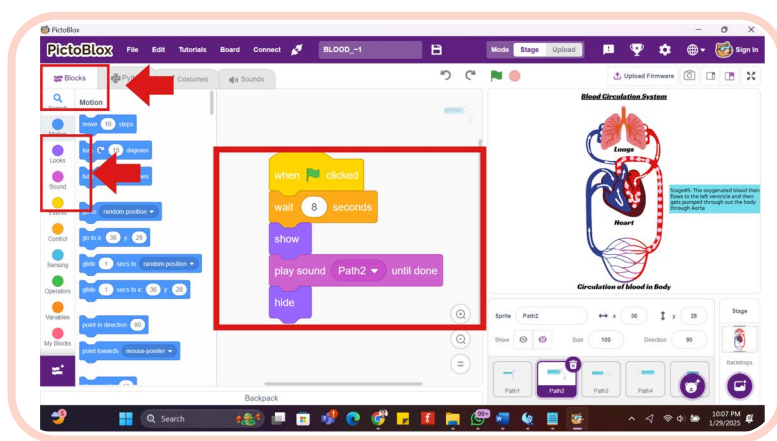
- **Sprite 1:** Represents deoxygenated blood from body to heart.
- **Sprite 2:** Represents deoxygenated blood from heart to lungs.
- **Sprite 3:** Represents purification stage in lungs.
- **Sprite 4:** Represents oxygenated blood from lungs to heart.
- **Sprite 5:** Represents oxygenated blood from heart to body.



3. Coding the Blood Flow Animation:

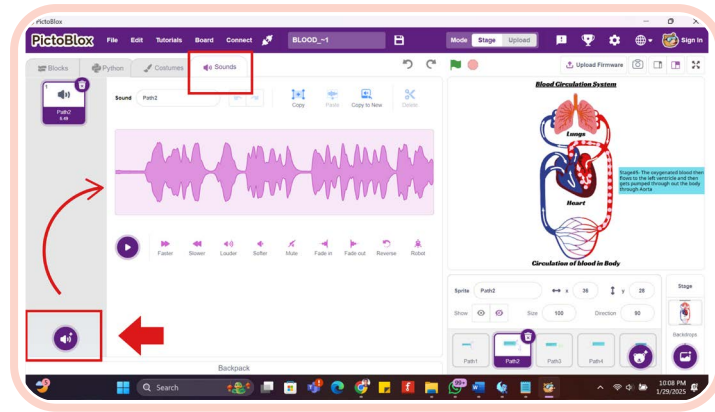
- **Show or Hide the Sprites:**

- o Use 'Looks' blocks to show and hide sprites along predefined paths.
- o Adjust speed to show the sprite using a 'wait' block.
- o The wait time of a particular sprite can be increased or decreased depending upon the time it is required for animation of the earlier sprite.
- o The wait time should be calculated based on the amount of time the sprite should be there on the screen and the time it requires for narration of the information regarding the sprite. In this case, the narration is about the information regarding that particular path of the blood circulation.
- o One can preview the animation as you develop the code by clicking the green flag that is seen on the top left corner of the stage window.



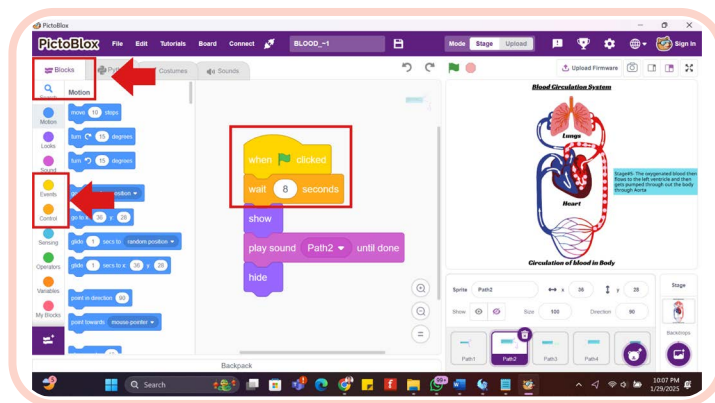
- **Add Sound Effects & Narration:**

- o Use 'Sound' blocks to narrate the path of blood flow and record the narration.
- o Example: " Stage#1- Deoxygenated blood from the body the flows to the Right Auricle of the heart.."
- o One needs to use the 'Record sound' button inside the sound menu to record their own sound required for the narration.
- o The user can edit the sound by using tools like trimming the sound file, slowing down or increasing the speed of the sound.
- o One can play the sound to test it before they save and use it in the program.
- o You may record the sound outside this tool as an mp3 file and upload it here. However, it is recommended to record the sound inside the application.



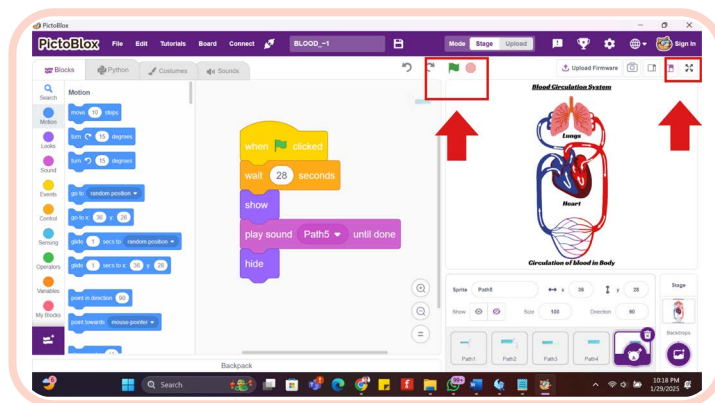
- **Control Animation Sequence:**

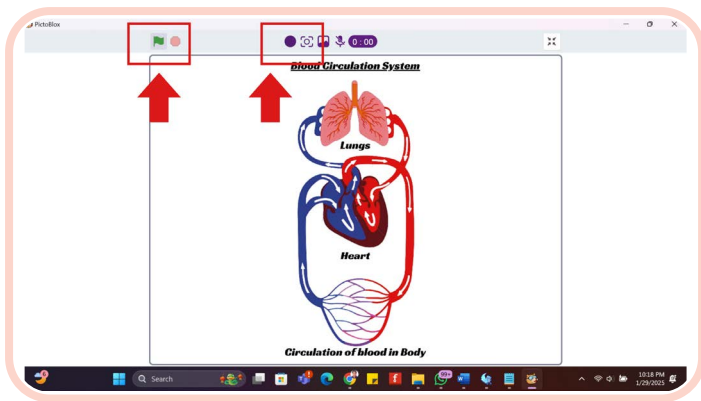
- o Use 'Event' blocks to trigger each sprite's movement.
- o Apply 'wait' blocks to synchronize animations.
- o Wait blocks help in completion of animation of one sprite before the next sprite appears



4. Finalizing and Presenting the Animation:

- Debug and test the animation for smooth transitions.
- Present animations to the class and discuss findings.





<https://youtu.be/FKFQuFA-sLE>

Click on the link or scan QR code to watch DIY cum working videos of the project.

How does the model work?

The animation simulates the five stages of blood circulation by using backdrops, sprites, and coding in Scratch or Pictoblox. The model visually represents the sequential movement of blood through the body, heart, and lungs. After completing the coding part, as the user clicks on the green flag, the simulation progresses through following five key stages showing the flow of the blood in human blood circulatory system:

1. **Flow of Deoxygenated Blood from the Body to the Heart:** A sprite representing deoxygenated blood moves through veins towards the heart.
2. **Flow of Deoxygenated Blood from the Heart to the Lungs:** The sprite transitions to show the blood moving from the right ventricle of the heart to the lungs for oxygenation.
3. **Blood Purification in the Lungs:** The sprite changes color or costume to indicate oxygenation, showing that the blood is now carrying oxygen.
4. **Flow of Oxygenated Blood from the Lungs to the Heart:** The oxygenated blood moves from the lungs back to the left atrium and left ventricle of the heart.
5. **Flow of Oxygenated Blood from the Heart to the Body:** The sprite representing oxygen-rich blood moves through arteries to supply oxygen to different parts of the body.

In this model, multiple sprites represent different blood flow paths, and sound narration is added to describe each stage. The coding uses the 'Looks' block to show and hide the sprites and their corresponding costumes to distinguish between the different stages of the blood flow. The animation provides a dynamic, interactive way to understand human circulation.

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of blood circulation in human beings.
- Conduct a quick Q&A session to evaluate their understanding of concepts and the working of the model:
 - o Why is oxygenated blood red and deoxygenated blood blue?

- o How does the heart act as a pump in blood circulation?
- o What happens if blood flow is blocked?
- o Can we use this animation to explain heart diseases?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Assess students based on:
 - o Did students correctly animate the 5 stages of blood circulation?
 - o Did they use appropriate sprites, backdrops, and sound effects?
 - o Were they able to explain the function of each stage clearly?
 - o Did students demonstrate logical sequencing in their animation?
 - o Were they able to debug and improve their project?
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

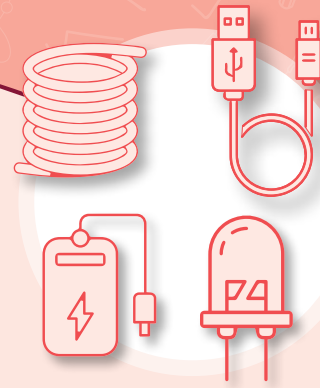
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Add move blocks to show movement of blood as sprites (Advanced Animation).
 - Create a quiz feature where students identify blood flow stages. (User Interaction).
 - Instead of 2D animation, use 3D simulation tools like Unity.

Activity 12

Sex Determination Model using Arduino, PictoBlox, and Dabble Application



Grade

9, 10



Subject

Biology



Topic/
Concept

Human Reproduction-
Sex Determination

Objective

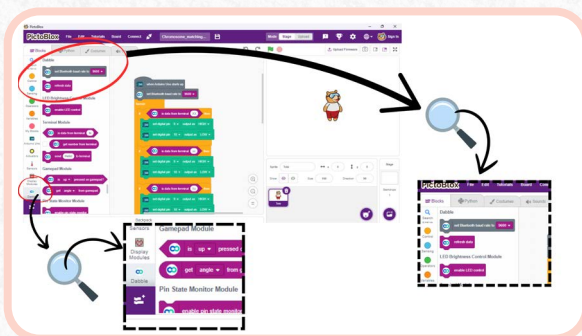
To understand the concept of sex determination in Human Genetics by building a functional digital model.

What will you help students learn?

- The concept of gender determination in human beings by observing XX and XY chromosome combinations.
- Basics of programming in PictoBlox (Scratch-based coding).
- To use the Dabble mobile application for wireless data transmission.
- Understand serial communication between hardware and software using Bluetooth.

What will you build/make?

A Sex Determination Model using Arduino, PictoBlox, and Dabble Application



Sex Determination Model using Arduino, Bluetooth module, PictoBlox, and Dabble Application

Click the links or scan QR codes to watch the DIY and working videos of the project.



<https://youtu.be/8lZqdF-3MUg>



<https://youtu.be/ASgSL5Vu0is>

What will you need?

Materials Needed

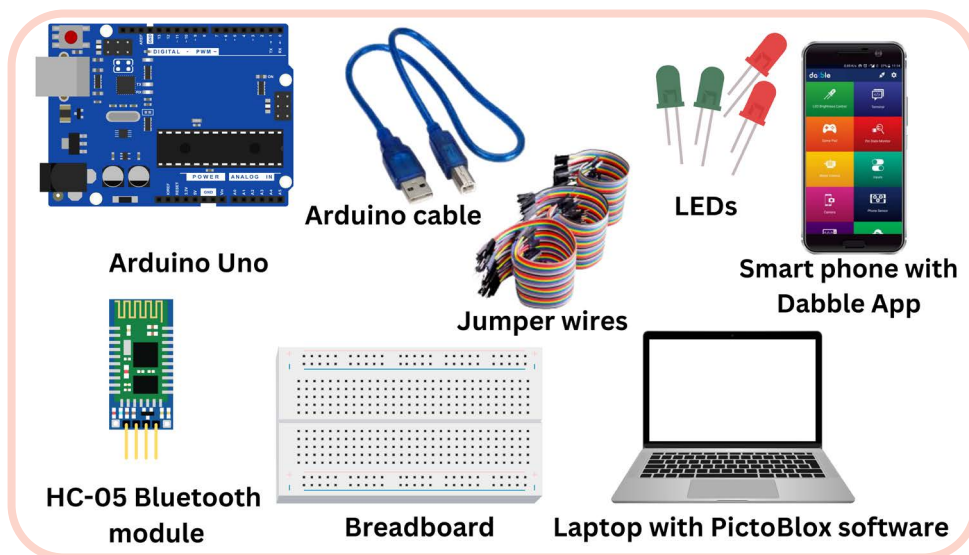
- Arduino Uno
- HC-05 Bluetooth Module
- Red LEDs
- Green LED
- Breadboard
- Jumper Wires

ATL Tools/Equipment

- Mobile Phone with Dabble Application installed
- Computer with Pictoblox software installed
- USB Cable for Arduino
- Power Bank / Battery Pack (Optional)

Software/Application

- Pictoblox (a scratch-based programming environment)
- Dabble Mobile Application



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction to Gender Determination:

- Explain the concept of genetic inheritance and gender determination in humans.
- Discuss that:
 - XX combination leads to a female child.
 - XY combination leads to a male child.
- Introduce the idea of representing chromosomes using LED lights.

2. Introducing Pictoblox Software, Arduino and Dabble mobile application

- **What is PictoBlox?**

- o A visual programming software based on Scratch 3.0 used for coding Arduino.

- **Why use PictoBlox?**

- o Makes coding easier through drag-and-drop blocks instead of complex text-based programming.

- Install Pictoblox software. Click the link or scan QR code to download the software.



<https://tinyurl.com/2jemya36>

- Briefly explain what Scratch-based programming PictoBlox is. Click the link or scan QR code to learn more on Pictoblox software



<https://tinyurl.com/4uufjhfa>

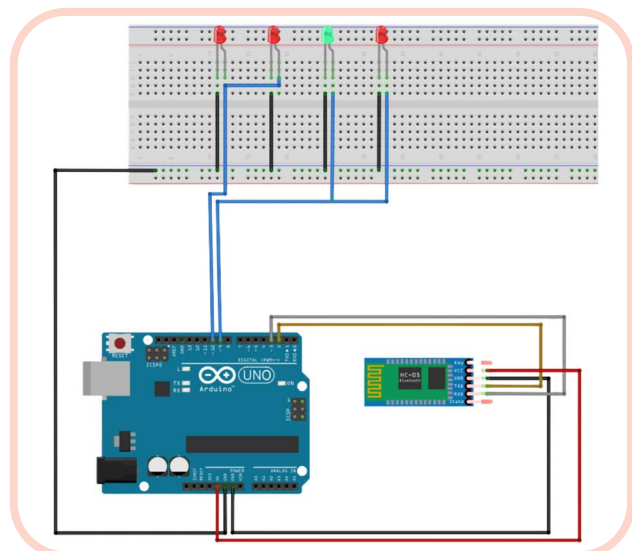
- Explain how Arduino communicates with external devices using serial communication.
- Install Dabble application on mobile phone. Click on the link or scan QR code to download the software.
- Demonstrate the use of Dabble mobile application and its serial terminal feature.



<https://tinyurl.com/yjt24f6x>

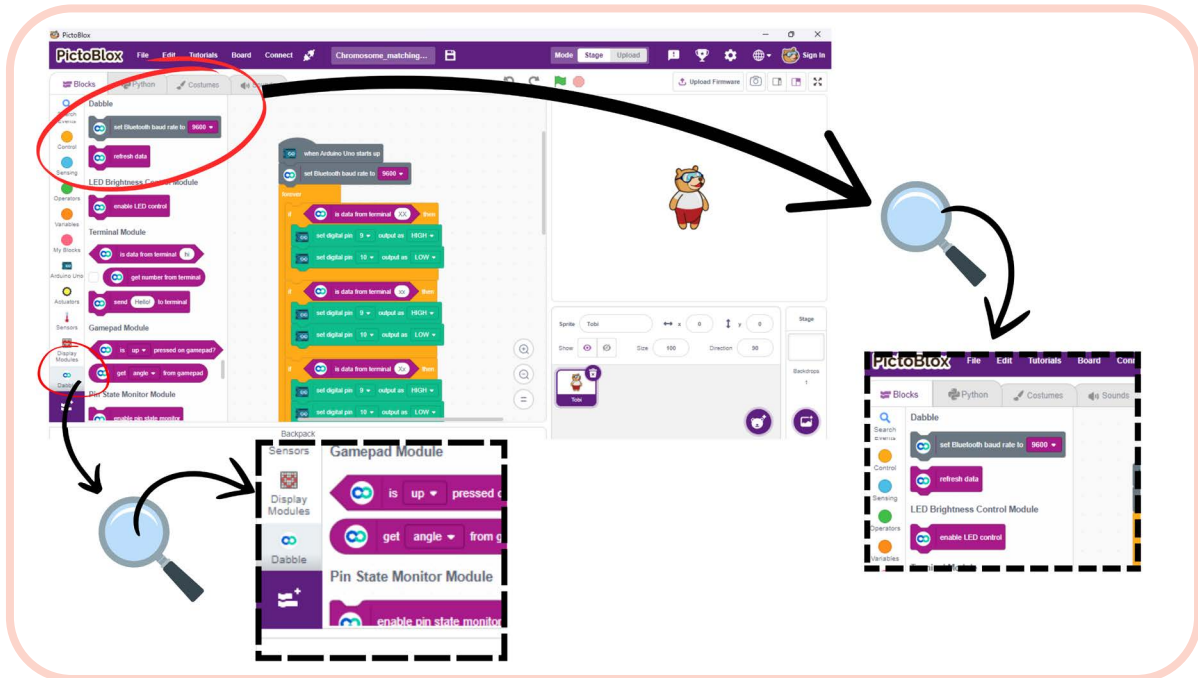
3. Circuit Assembly

- Refer to the circuit diagram for this project.
- Connect the HC-05 Bluetooth module to Arduino Uno:
 - o VCC → 5V on Arduino
 - o GND → GND on Arduino
 - o TX → Digital Pin 2 on Arduino
 - o RX → Digital Pin 3 on Arduino
- Connect LEDs and Resistors:
 - o XX Combination (Female): Two red LEDs in parallel to Digital Pin 9.
 - o XY Combination (Male): One red and one green LED in parallel to Digital Pin 10.

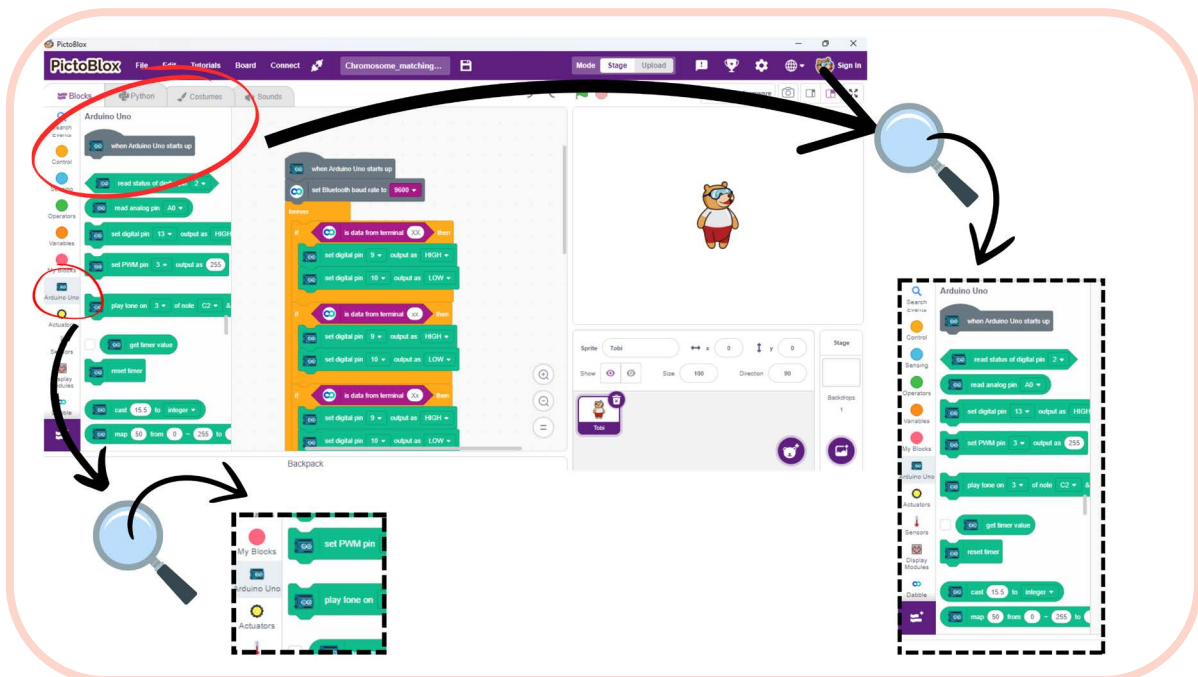


4. Writing the Code in PictoBlox:

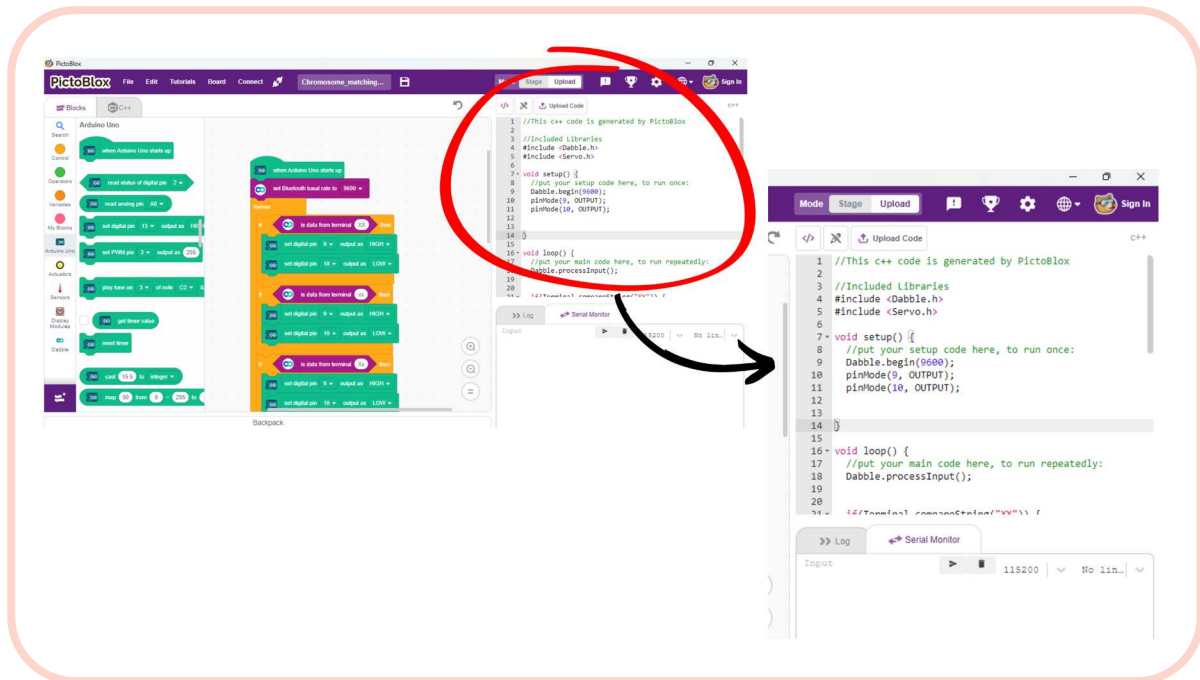
- Open PictoBlox and select Arduino Uno as the board.
- Refer to the Dabble extension in Pictoblox software as shown in the image below.



- Use blocks from Dabble and Arduino Uno in Pictoblox to develop the code as shown in the image below.



- Write a program that:
 - o Reads XX or XY input from Dabble's Terminal module.
 - o Turns on two red LEDs for XX (female).
 - o Turns on one red and one green LED for XY (male).
- Upload the code to Arduino Uno in 'Upload' mode.



- Click the link or scan QR code to follow the DIY video for developing the block coding program for chromosome matching project.



<https://youtu.be/8IZqdF-3MUg>

5. Using the Dabble Application:

- Switch on the mobile phone Bluetooth but do not pair the HC-05 Bluetooth module here.
- Open the Terminal module in Dabble.
- Pair the mobile phone with HC-05 Bluetooth module through a 'Bluetooth device connect' button inside the Dabble application.
- Send "XX" (Develop a program in such a way that this does not become case sensitive) → Observe two red LEDs turn on (female).

- Send "XY" (Develop a program in such a way that this does not become case sensitive) → Observe one red LED and one green LED turn on (male).
- Click the link or scan QR code to watch the working video of the project.



<https://youtu.be/ASgSL5Vu0is>

How does the model work?

The project uses Arduino Uno, PictoBlox, and the Dabble mobile application for wireless communication and LED-based representation.

- The user enters "XX" (for a female child) or "XY" (for a male child) in the Terminal module of the Dabble application.
- This input is sent via Bluetooth to the HC-05 Bluetooth module connected to Arduino Uno.
- The Arduino Uno receives the chromosome input through serial communication.
- If "XX" is received, the Arduino turns on two red LEDs connected in parallel, representing female gender.
- If "XY" is received, the Arduino turns on one red LED and one green LED in parallel, representing male gender.

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of sex determination in human genetics, the XX and XY chromosomes.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Assess the accuracy of circuit connections and functionality of the LED response to XX and XY input.
- Assess their ability to troubleshoot and debug the project.
- Conduct a quick Q&A session to evaluate their understanding of gender determination and serial communication:
 - o What did you observe when different chromosome pairs were entered?
 - o How can this model be used to demonstrate other genetic traits?

- o How can Bluetooth be used in real-life applications?
- o Why do we use a breadboard instead of directly connecting components to Arduino?
- o How does the Arduino know which LEDs to turn ON when a user enters either 'XX' or 'XY' in the Dabble app?
- o What is the function of the serial terminal in the Dabble app?
- o How does Arduino receive input from the Dabble app?
- Discuss how well they integrated hardware and software.
- Ask- where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

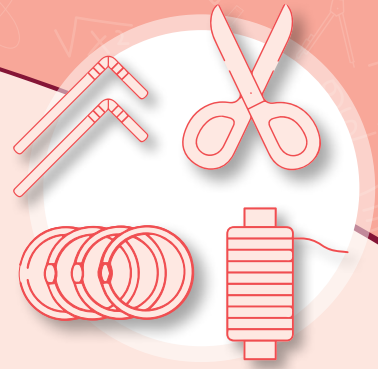
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can modify the project using Raspberry Pi Processor
 - Develop a graphical interface in Pictoblox for better visualization.
 - You can extend the project to display text output using an LCD screen.
 - Experiment with other Bluetooth-controlled projects using Dabble's multiple functions.

Activity 13

Building a Functional Gripper using Cardboard



Grade

9



Subject

Biology



Topic/
Concept

Animal Tissue-
Tendon

Objective

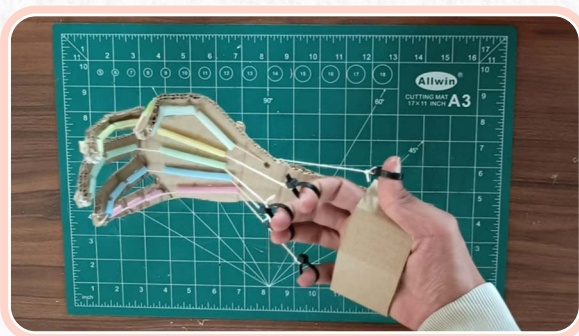
To create a working prototype of robotic hand applying concepts of tension, compression and movement to understand movement of muscles and joints in a human hand.

What will you help students learn?

- Basics of simple mechanisms and engineering principles.
- Basic muscle movements in joints of animals (specifically the hand).
- An understanding of biomimicry by examining how machines can mimic human anatomy.
- To apply concepts like tension, compression, and movement.
- To connect the learning with the functionality of simple machines and mechanisms.
- An understanding of the engineering design process, including ideation, prototyping, testing, and iteration.
- Enhance creativity, problem-solving, and motor skills.

What will you build/make?

A Functional Gripper using Cardboard.





<https://youtu.be/dpU8hCH1MtE>



<https://www.youtube.com/watch?v=jjjRsVHEOLU>

Click on the links or scan QR codes to watch DIY cum working video of the project.

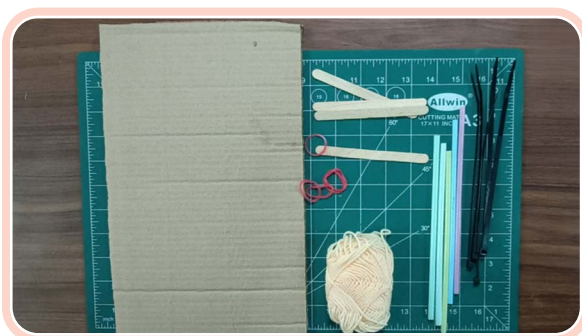
What will you need?

Materials Needed

- Cardboard sheet
- Plastic straws
- Strings or thin ropes
- Rubber bands
- Ice cream sticks
- Zip ties / Cable ties
- Markers or pencils

ATL Tools/Equipment

- Hot glue gun with sticks
- Scissors
- Paper cutter/Craft knife
- Ruler
- Hole puncher (optional)
- Cutting mat
- Hand gloves



Procedure

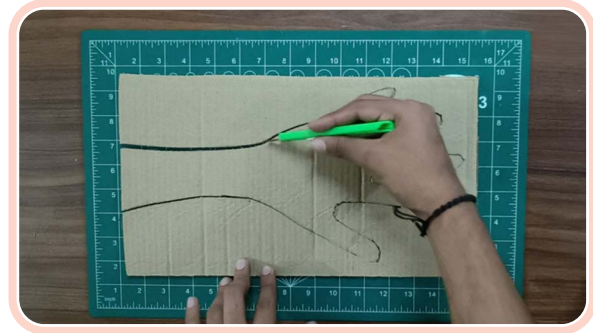
Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction and Template Preparation:

- Begin with a discussion on grippers and their applications (e.g., robotic hands).
- Distribute cardboard sheets big enough to enable students to trace their palm on it.

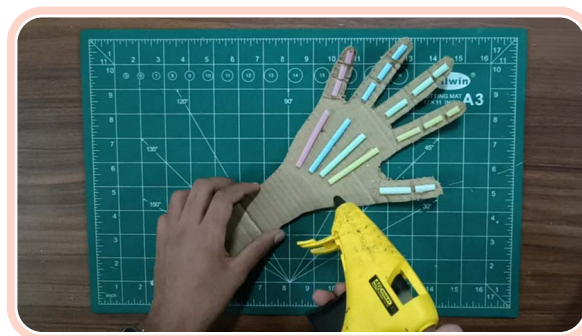
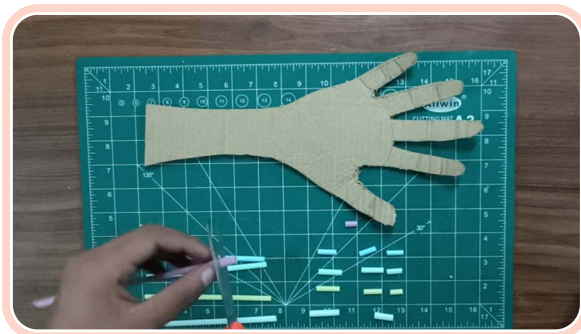
2. Drawing and Cutting:

- Place the palm on the cardboard sheet and trace it.
- Carefully cut out the traced shape from the cardboard using scissors or a craft knife.



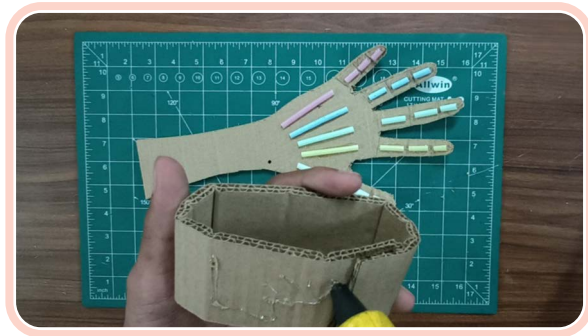
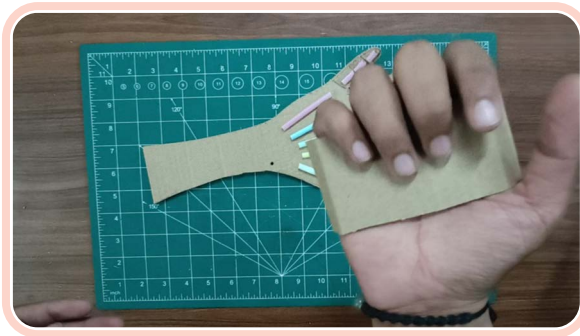
3. Adding Straws:

- Cut straws into 14 small pieces (around 2 cm each) and 5 longer pieces (6-7 cm long).
- Glue the small straw pieces along each "finger" segment.
- Glue the long straw pieces along each "finger" on the cardboard palm.
- Ensure the pieces are aligned to allow string movement through them.

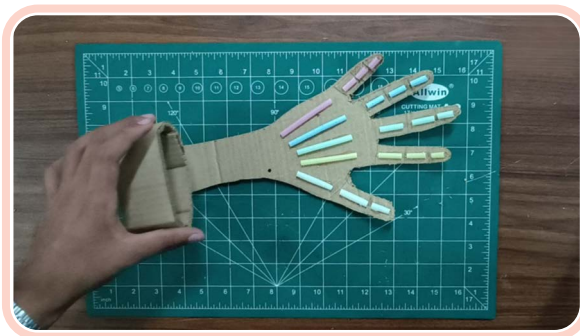


4. Building a Handle:

- Use an additional piece of cardboard (5-6 cm wide) to create a handle for the gripper.
- Wrap this cardboard piece around your palm to find its required length. The handle should fit in your palm comfortably (Not too tight and not too loose).
- Use a hot glue gun to join the two ends of this cardboard piece to make a handle.

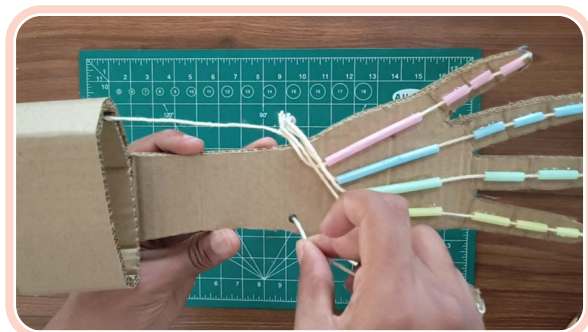
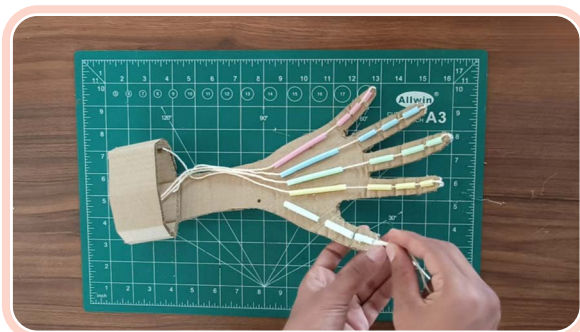
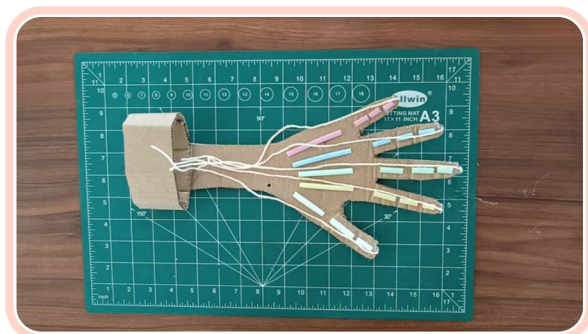
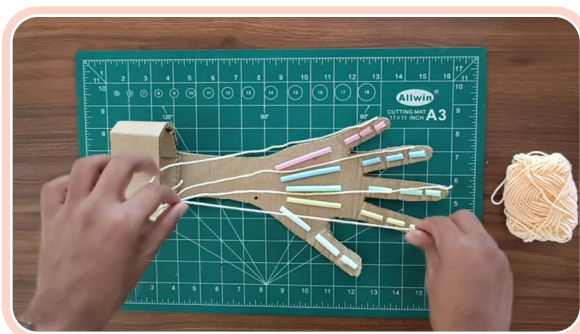


- Attach the handle securely to the base of the palm using hot glue.
- Keep the handle pressed on to the palm until the glue is completely dry.



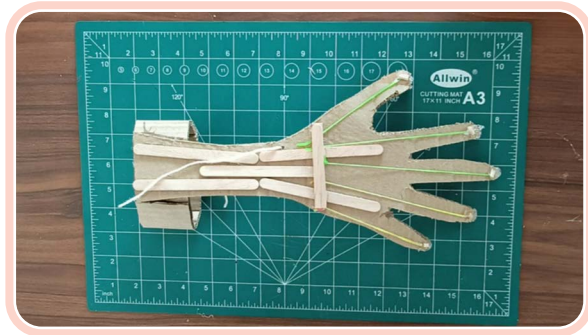
5. Inserting Strings:

- Cut strings according to the lengths of the fingers.
- Thread strings through the straw pieces, leaving excess string at both ends.
- Secure one end of each string to the fingertip using glue or tape.
- Make a small hole near the thumb to insert the string through later.
- Insert the string for the thumb finger through the hole made in the gripper.

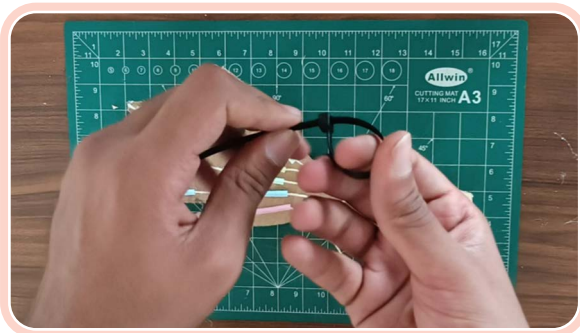


6. Creating Finger Movement:

- Glue a few ice cream sticks at the backside of the hand gripper (just below the palm level) in order to build strength to the structure. Make sure, they do not restrict the bending action of the palm.
- Cut a few rubber bands and glue them at the backside of the cardboard fingers (at the joints) to help the fingers return to a straight position after bending.
- Keep moderate tension in the rubber bands. Make sure, they do not restrict the bending action of the fingers.



- Make rings using zip-tags and tie them to the end of the strings so that they can be controlled with the right amount of tension.



7. Testing the Gripper:

- Hold the gripper in your hand and pull on the strings to observe the fingers moving. Adjust tension and alignment if needed.

- Try grabbing some object using the gripper to test its functionality.



8. Optional Enhancements:

- Add foam sheet pieces for padding inside the handle for a more ergonomic grip.
- Decorate the gripper with markers or stickers.

How does the Gripper work?

The cardboard functional gripper works by mimicking the movement of a human hand using a simple mechanical system. Each finger of the gripper is made from cardboard and supported with ice cream sticks for stability. Plastic straws are attached along the length of each finger, acting as guides for strings threaded through them.

When a user pulls the zip ties or cable ties attached to the ends of the strings, tension is created, causing the cardboard fingers to bend inward—similar to how real fingers curl. The strings function like tendons and muscles in the human hand, where pulling them creates movement, just as muscles contract to pull on tendons and bend the fingers. Rubber bands attached to the back of the fingers act as return mechanisms, pulling the fingers back to their original position when the strings are released. This push-pull system enables the gripper to grasp and release light objects, demonstrating basic principles of tension, motion, and mechanical design.

Click on the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/dpU8hCH1MtE>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of movement of the human hand.
- What joints in the human hand are used while gripping an object.
- Can you demonstrate the gripping action of a human hand?
- Compare the gripper you have created with the human hand.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Observe and assess the functionality of the gripper based on its ability to pick up objects.
- Observe students' understanding of the engineering concepts discussed.
- Encourage reflection on the activity and suggestions for improvement.
- Conduct a quick Q&A session to evaluate their understanding of the functional gripper.
 - o How does the gripper mimic the movement of a human hand?
 - o What challenges did you face while making the gripper, and how did you solve them?
 - o How can this design be improved for better functionality?
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can experiment with different materials for the fingers (e.g., foam, thin plastic or 3D printed parts).
 - Modify the design to include opposable thumb functionality.
 - You can explore applications of similar grippers in robotics and assistive devices.

Activity 14

Demonstration of Electrolysis of Water using Pencil Electrodes



Grade

8

10



Subject

Chemistry

Chemistry



Topic/
Concept

Decomposition
of Water

Electrolysis
of water

Objective

To reinforce concepts such as chemical decomposition, role of electrolyte and formation of end products in an electrochemical reaction.

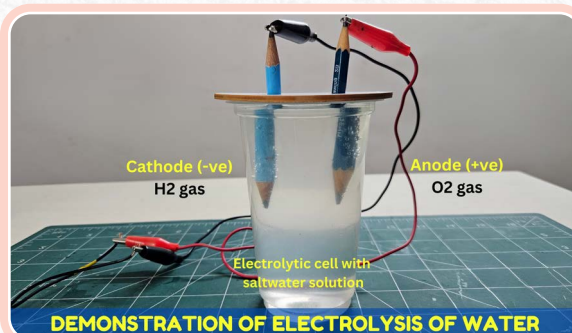
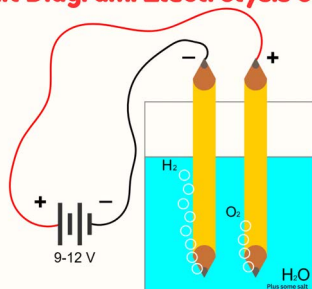
What will you help students learn?

- Understand the concept of electrolysis and its role in breaking down compounds.
- Build a simple setup to demonstrate electrolysis of water using pencils as electrodes.
- Recognize that water is a compound made of hydrogen and oxygen.
- The role of electrolytes in conducting electricity in water.
- To identify the formation of gases at different electrodes (hydrogen at cathode, oxygen at anode).
- Relate real-life applications of electrolysis in industries.

What will you build/make?

A simple working electrolysis setup using a plastic cup, saltwater solution, and pencil electrodes powered by a 9V battery or DC power adapter to visibly demonstrate the decomposition of water into hydrogen and oxygen gases.

Circuit Diagram: Electrolysis of Water



Click the link or scan QR code to watch
DIY cum working video of the project.



https://youtu.be/nft_nBCXQc

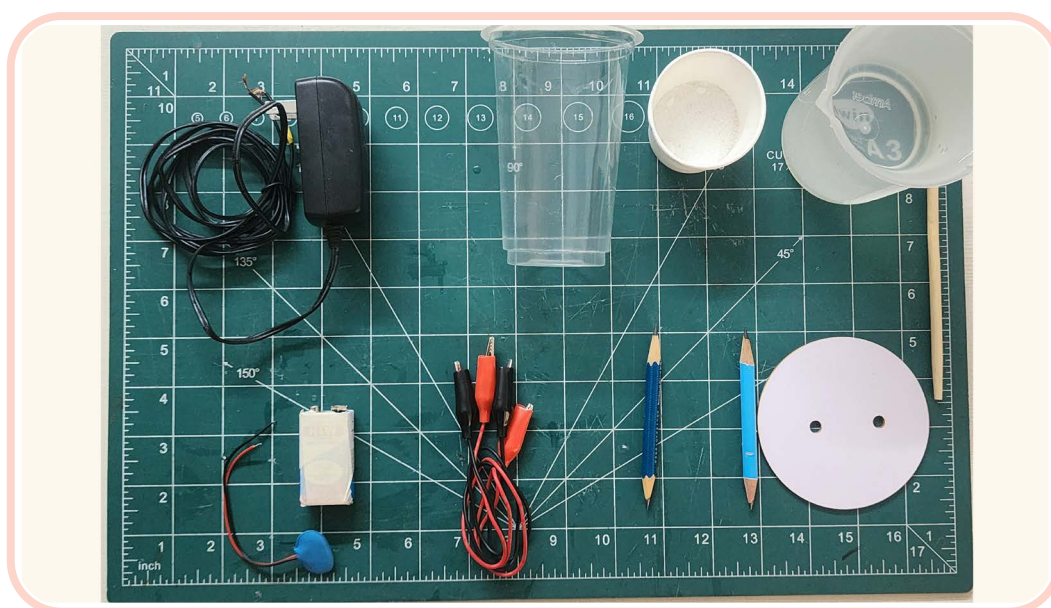
What will you need?

Materials Needed

- Plastic cup/jar
- Common salt (Acts as an electrolyte to help water conduct electricity.)
- 2 graphite pencils (sharpened)- Act as electrodes (anode and cathode)
- WaterMedium for electrolysis (to be decomposed)
- Foam board
- Stirrer
- 9V Battery + Battery clip
- 9V DC Power Adapter (Optional)
- Crocodile clips (red and black)

ATL Tools/Equipment

- Paper cutter/knife
- Wire stripper
- Sharpener



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction to Electrolysis of Water:

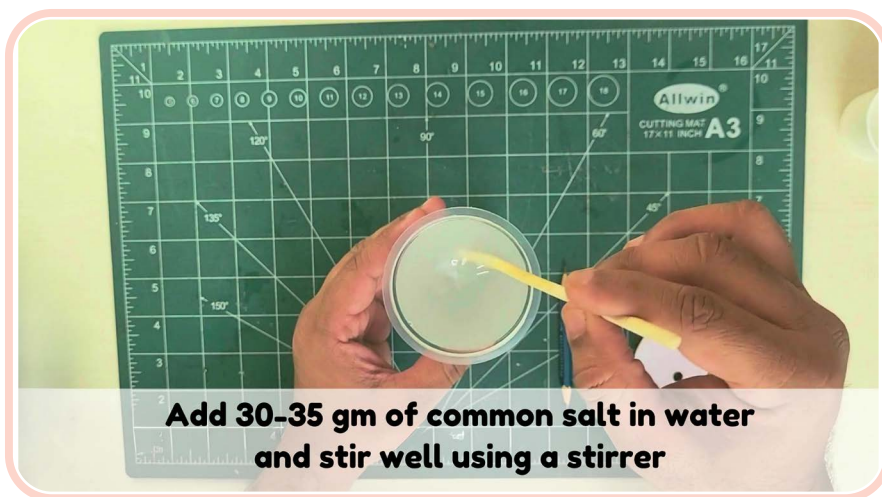
- Begin by explaining to students that electrolysis is a process where an electric current is passed through a liquid (in this case, water) to cause a chemical change. In water electrolysis, the water molecules (H_2O) are broken down into hydrogen and oxygen gases. Since pure water is a poor conductor of electricity, an electrolyte like salt is added to facilitate the flow of electric current. Click the link or scan the QR code to watch the video on Electrolysis of water.



<https://www.youtube.com/watch?v=WmtaMq36jaE&t=126s>

2. Prepare the Electrolyte Solution:

- Fill a plastic cup or jar with water (approximately 300-350 ml). Add 30-35 gm of common salt into the water (The salt added should not exceed 10 percent of the volume of water) and stir well using a stirrer to dissolve the salt completely. This creates a saltwater electrolytic solution that can conduct electricity. The plastic cup/jar with saltwater solution is known as 'electrolytic cell'.



3. Prepare the Electrode Holder:

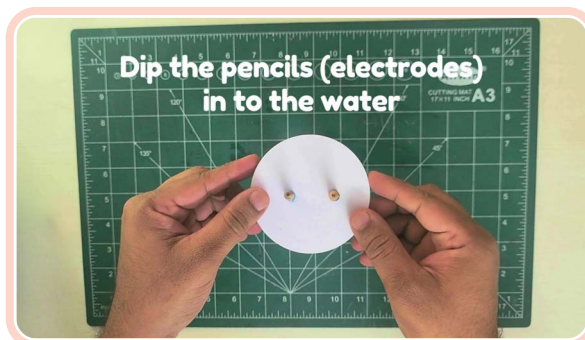
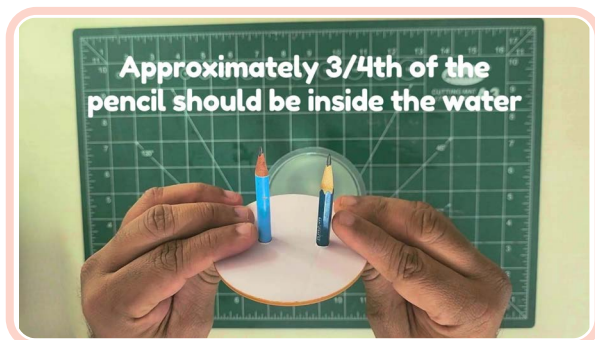
- Take a foam board and cut it using a paper cutter so that it works as a lid over the plastic cup. This will also act as a holder for the pencil electrodes.

4. Prepare the Electrodes:

- Use a sharpener to sharpen both ends of two graphite pencils. These pencils will serve as the electrodes—one will act as the anode (positive) and the other as the cathode (negative).

5. Insert Electrodes into the Holder:

- Make two holes in the foam board lid, spaced a few centimetres apart. Insert the pencils vertically through these holes so that both sharpened tips are submerged in the saltwater.

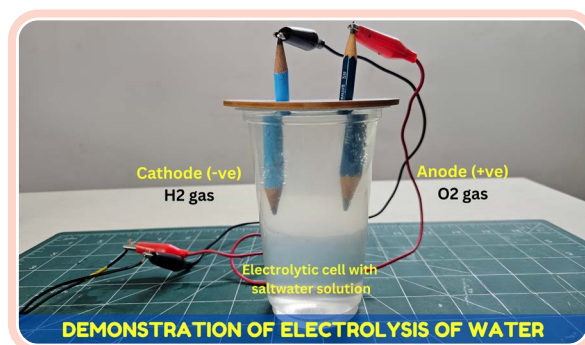
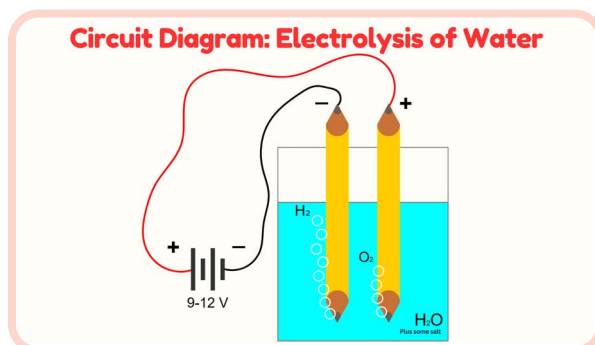


6. Connect the Electrical Components:

- Use a red crocodile clip to connect the top end of one pencil to the positive terminal of the 9V battery (or adapter)- this will be the anode. Use a black crocodile clip to connect the other pencil to the negative terminal of the 9V battery (or adapter)- this will be the cathode.

7. Power the Setup:

- Attach the battery clip to the 9V battery or plug in the 9V DC adapter. Once powered, electricity will start flowing through the saltwater between the two electrodes.

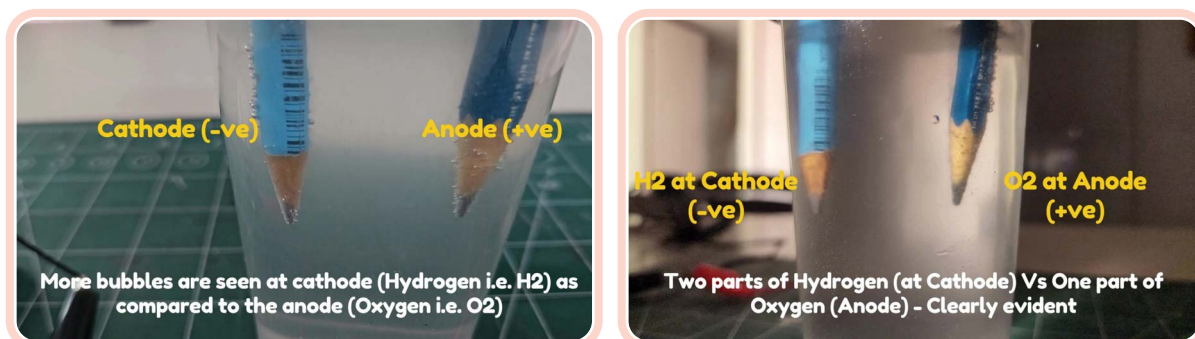


Please note:

- Do not use high voltage sources. Use only 9V power sources to avoid electric shocks.
- Do not allow wires to touch each other directly.
- Do not leave the setup unattended when connected to power.
- Do not use broken or uninsulated wires.
- The salt added should not exceed 10 percent of the volume of water.
- Do not taste or ingest the saltwater or gases produced.

8. Observe the Electrolysis Reaction:

- Bubbles will start to form at both pencil tips under the water. You'll notice more bubbles at the cathode (hydrogen gas) and fewer bubbles at the anode (oxygen gas), demonstrating the 2:1 ratio of hydrogen to oxygen in water (H_2O).



9. Discussion and Analysis:

- Ask students to observe and record which electrode forms more bubbles. Discuss why this happens based on the chemical composition of water and the electrolysis process.

10. Turn Off and Disassemble:

- After the observation, disconnect the power source before handling any part of the setup. Dispose of the saltwater safely and store materials for future use.

How does the model work?

In this demonstration, electrical energy is used to decompose water into its basic components- hydrogen and oxygen gases. The added salt helps in conducting electricity through water. Pencils made of graphite act as electrodes. When connected to a 9V DC power source, water undergoes electrolysis:

- Cathode (-):** Attracts positive hydrogen ions → releases hydrogen gas (more bubbles)
- Anode (+):** Attracts negative oxygen ions → releases oxygen gas (fewer bubbles)

The observable bubbles represent the gases released during the process.

Click the link or scan QR code to watch DIY cum working video of the project.



https://youtu.be/nft_-nBCXQc

How can you assess students' understanding?

Assessment of Concept Understanding

- Check if the students can explain what electrolysis is.

- What are anode and cathode?
- What is an electrolyte? What is the electrolyte used in this project?
- What chemical changes take place during electrolysis of water?
- What is the chemical formula of water and how is it split?
- Why do we use graphite pencils?
- What real-world processes use electrolysis?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Assess the understanding of each component's functionality.
- Conduct a quick Q&A session to evaluate their understanding of the working of the 'Model for Demonstrating Electrolysis of Water'.
 - o Why is salt added to the water?
 - o Which electrode produces more gas and why?
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can use baking soda instead of salt as the electrolyte.
 - Collect the gas produced using test tubes (advanced).
 - You can connect a small buzzer or LED in the circuit to show current flow.
 - Try using carbon rods from batteries or metallic pins/long screws instead of pencils.

Activity 15

Building a Model to Detect and Measure CO₂ Generated from an Acid-Base Reaction using Arduino and MQ-135 Sensor



Grade



9, 10



Subject



Chemistry



Topic/
Concept



Acid, Bases
and salts

Objective

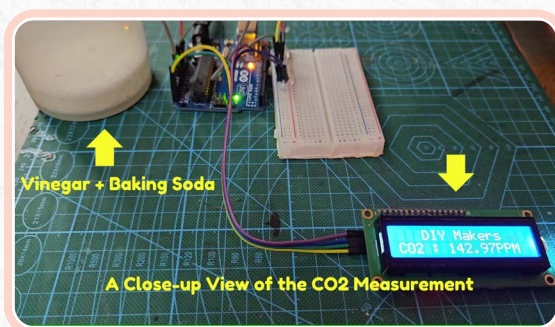
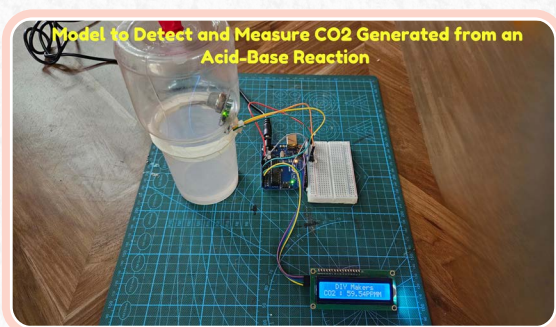
To understand an acid-base reaction and measure CO₂ released as a byproduct using a CO₂ detection and measurement system.

What will you help students learn?

- Understand and demonstrate the chemical reaction between vinegar (acid) and baking soda (base) that produces carbon dioxide (CO₂).
- To build a basic CO₂ detection and measurement system that reacts to real-time changes in gas concentration using electronics.
- To Explain how analog sensor values are processed by a microcontroller and translated into meaningful measurements (e.g., ppm).
- To interpret experimental data, identify patterns, and relate gas concentration changes to chemical processes.
- To appreciate the real-world relevance of sensor technology in areas like air quality, environmental science, and IoT (Internet of Things).

What will you build/make?

A device that will measure CO₂ as an outcome of an Acid-Base Reaction, using Arduino, MQ-135 Sensor and an LCD display.





<https://youtu.be/w4OnaGBifd4>



https://youtu.be/yozs__dV-r0

Click on the links or scan QR codes to watch DIY cum working videos of the project.

What will you need?

Materials Needed

- Arduino Uno
- MQ-135 Gas Sensor (Detects and measures CO₂ concentration from the acid-base reaction)
- 16x2 LCD Display with I2C Connector (Displays real-time CO₂ concentration readings)
- Breadboard
- Jumper Cables
- USB Cable
- Power Supply (USB Power Bank)
- Vinegar (Acetic Acid)
- Baking Soda (Sodium Bicarbonate)
- Old Plastic Jar
- Glass/Plastic Beaker
- Plastic Pipe and Funnel
- Paper tape

ATL Tools/Equipment

- Hot glue gun with glue sticks
- Computer with Arduino IDE
- Battery-Operated Drill Machine
- Drill Bits
- Precision screwdriver
- Multimeter (Optional)
- Cutting mat
- Hand gloves

Software/Application

- Arduino IDE software



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

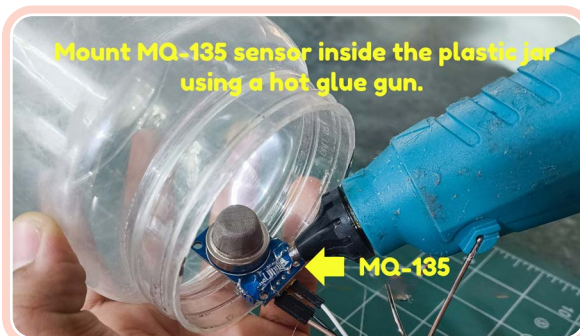
- Explain the chemical reaction: CH_3COOH (vinegar) + NaHCO_3 (baking soda) $\rightarrow$ $\text{NaCH}_3\text{COO} + \text{H}_2\text{O} + \text{CO}_2$
- Introduce the MQ-135 gas sensor and how it detects CO_2 concentration. Click the link or scan QR code to watch the working video of the gas sensors.



<https://www.youtube.com/watch?v=4C-uibzUIts>

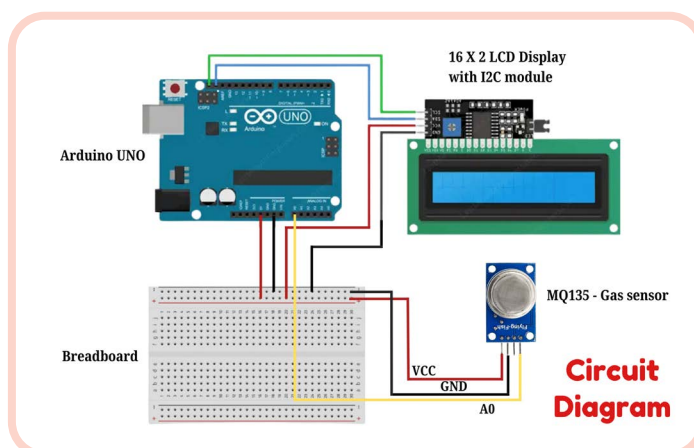
2. Prepare the Plastic Jar:

- Drill one hole at the centre of the bottom of the plastic jar. The plastic pipe will be inserted through this hole for adding baking soda to vinegar. Secure the jar tightly to prevent gas leakage.
- Mount the MQ-135 sensor inside the jar, securing it with hot glue. Place the sensor only at the suggested location to avoid short-circuiting of wires and/or the sensor inside the jar.



3. Set up the Electronic Components:

- Refer to the circuit diagram for setting up the components.



- Connect the MQ-135 sensor to the Arduino:
 - o VCC to 5V
 - o GND to GND
 - o AO (Analog Output) to A0 pin on the Arduino.
- Connect the LCD Display with I2C module to the Arduino:
 - o VCC to 5V
 - o GND to GND
 - o SDA to A4
 - o SCL to A5
- **Important Note-** Test the sensor connections before starting the experiment. Do not expose the MQ-135 sensor to extreme temperatures and also avoid its direct contact with the chemicals.

4. Write the Arduino Code:

- Open Arduino IDE and upload the code given to read and display CO₂ concentration. Click the link or scan QR code to download the code (.ino file).
- You can also copy the code given here and paste in the Arduino IDE.



<https://tinyurl.com/mrywkvjv>

Arduino Program

```
#include <LiquidCrystal_I2C.h>
#include "MQ135.h"
#define ANALOGPIN A0    // Define Analog PIN on Arduino Board
#define RZERO 206.85    // Define RZERO Calibration Value
MQ135 gasSensor = MQ135(ANALOGPIN);
LiquidCrystal_I2C lcd(0x27, 16,2);
void setup()
{
  lcd.init();
  lcd.begin(16,2); //Defining 16 columns and 2 rows of lcd display
  lcd.backlight();
  Serial.begin(9600);
```

Continue...

Continue...

```
float rzero = gasSensor.getRZero();
delay(3000);
Serial.print("MQ135 RZERO Calibration Value : ");
Serial.println(rzero);
}

void loop() {
  float ppm = gasSensor.getPPM();
  delay(1000);
  long time = millis() / 1000;
  Serial.print("CO2 ppm value : ");
  Serial.println(ppm);

  Serial.print(" ppm | time since the launch of the Arduino: ");
  Serial.print(time / 60);
  Serial.print(" m");
  Serial.print(time % 60);
  Serial.println(" s.");
  lcd.setCursor(0,0);
  lcd.print(" CO2 Detector ");
  lcd.setCursor(0,1);
  lcd.print("CO2 : ");
  lcd.print(ppm);
  lcd.print(" PPM");
}
```

- Install the required Arduino libraries for MQ-135 sensor and LCD I2C module if you do not have these libraries installed on your computer.
- To install these libraries, first click the link or scan QR code to download these libraries on your computer.
- Then, click the link or scan QR code to watch the video to learn how to install libraries on your computer.



<https://tinyurl.com/469stvu6>



https://youtu.be/akkPtvDnk_4

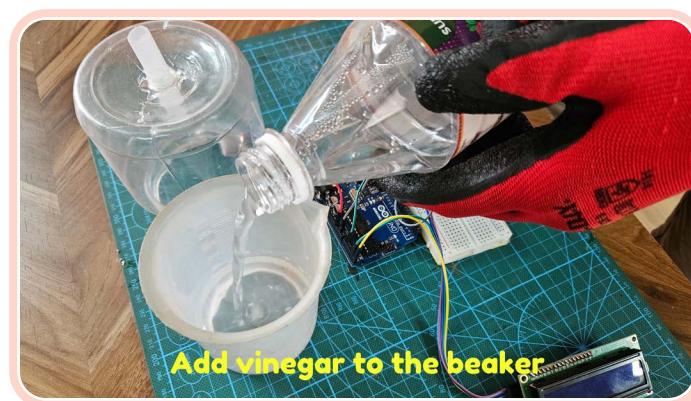
5. Assemble the pipe in plastic jar:

- Insert the plastic pipe through the drilled hole made on the plastic jar to add baking soda gradually into the vinegar. Use a hot glue gun to properly secure the pipe to the jar. Be careful with the hot glue gun nozzle while operating the gun. Hold it carefully and make sure it does not touch any of the plastic parts. Secure the pipe tightly to prevent CO₂ gas leakage.

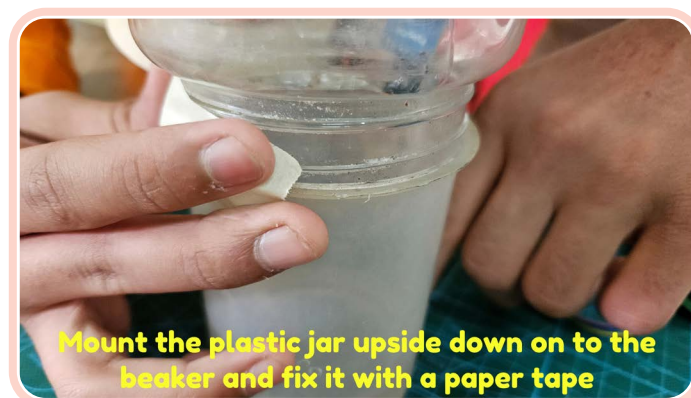


6. Set up the beaker:

- Add vinegar in a beaker as shown in the image. Avoid overfilling the beaker with vinegar to prevent overflow.

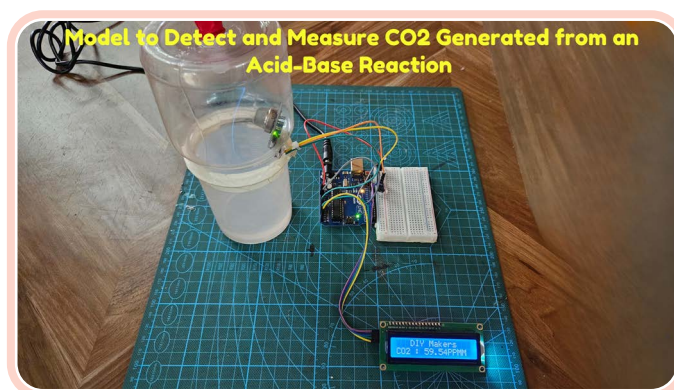


- Now, carefully turn the plastic jar with MQ-135 sensor in it upside down and place it on to the beaker. Secure both the jar and the beaker tightly by using a paper tape to prevent leakage of CO₂ gas.

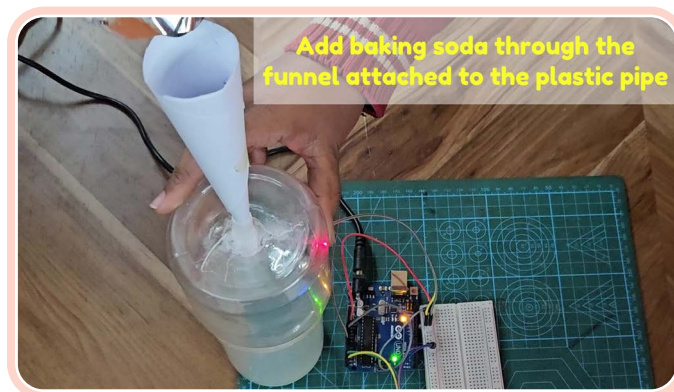


7. Conduct the Reaction:

- Attach a funnel (you can make one with the help of a paper) onto the top end of the pipe attached to the plastic jar as shown in the image.
- Fix the funnel onto the pipe using a paper tape.
- Connect the Arduino to a 12V DC adapter to power it on. The LCD display along with the sensor will not work properly when you power the Arduino using your laptop as the display needs higher voltage to work properly.
- **Important Note-** Check the set-up once again before you start the experiment to avoid short-circuiting of wires and/or sensor inside the jar..
- The entire project set-up will look like this-



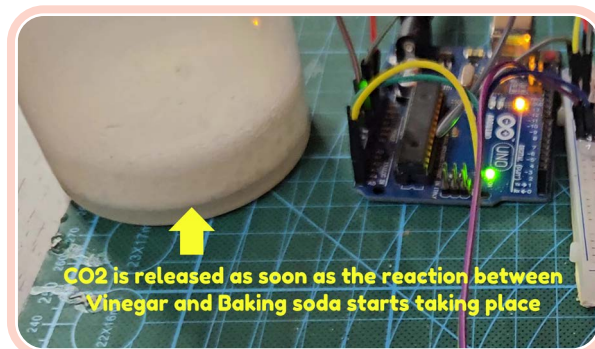
- Start the experiment by adding baking soda through the funnel into the vinegar, which is already present into the beaker. Add baking soda slowly to control the reaction rate.



- As the baking soda starts reacting with the vinegar, the CO_2 will be released as a product of their chemical reaction. Avoid inhaling concentrated CO_2 in enclosed spaces.
- Click the link or scan QR code to observe the behaviour of CO_2 Gas.

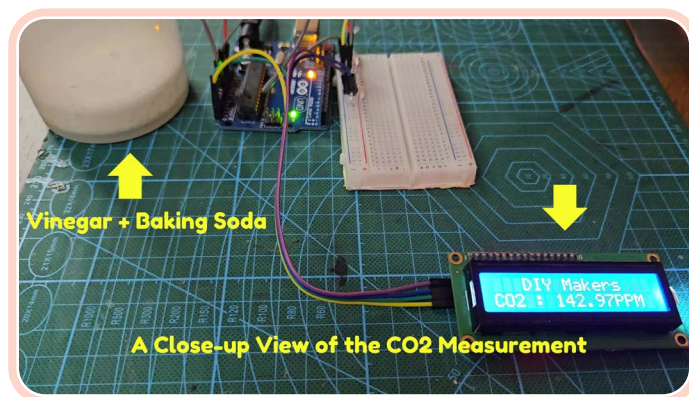


<https://youtu.be/w4OnaGBifd4>



8. Analyse Results:

- Record the CO₂ concentration over a period of time.
- Observe how the CO₂ gas concentration rises, stabilizes and then decreases gradually as the reaction progresses.
- Monitor the readings on the LCD display to know the changes in CO₂ concentration (PPM) over time.



- Click the link or scan QR code to watch the video to see the changes in CO₂ concentration on the LCD display as the chemical reaction progresses.



https://youtu.be/yozs_dV-r0

How does the device work?

As we slowly add baking soda into the plastic jar through a funnel, it reacts with the vinegar (acetic acid) inside the beaker. The reaction produces CO₂, which is collected in the plastic jar and surrounds the MQ135 gas sensor. The MQ135 sensor detects the concentration of CO₂ and sends the data to the Arduino. The LCD screen then displays the CO₂ value in terms of PPM (Parts Per Million). As the CO₂ level inside the jar gradually decreases, the LCD updates the CO₂ value to show the change in CO₂ concentration.

Note: The other byproducts of this reaction, water and sodium acetate, are also collected inside the glass container.

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of chemical reactions.
- What are reactants used in this reaction?
- What are the products formed?

- How does the chemical reaction between vinegar (acid) and baking soda (base) produce carbon dioxide (CO₂)?
- What is the relationship between the reaction rate and CO₂ concentration?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Observe and assess the functionality of the setup and the clarity of data displayed on the LCD.
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Conduct a quick Q&A session to evaluate their understanding of the working of the CO₂ Detecting and Measuring Device.
 - o How does the MQ-135 sensor detect CO₂?
 - o Explain the set up, the acid-base reaction and its relationship to CO₂ production.
- Ask- Where have you seen this application being used around you?
- Discuss real-world applications of CO₂ sensors (e.g., air quality monitoring)

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can use a larger jar to study the effect of volume on CO₂ concentration.
 - Try adding a buzzer to alert when CO₂ concentration exceeds a certain threshold.
 - Calibrate the MQ-135 sensor for more accurate PPM readings using a known gas sample.

Activity 16

Making a Model for Detecting Heat Generated During Exothermic Chemical Reactions using Arduino



Grade



10



Subject



Chemistry



Topic/
Concept



Chemical Reaction
and Equations

Objective

To enable understanding of exothermic reactions and measure the heat generated during the reaction using sensors and microcontrollers.

What will you help students learn?

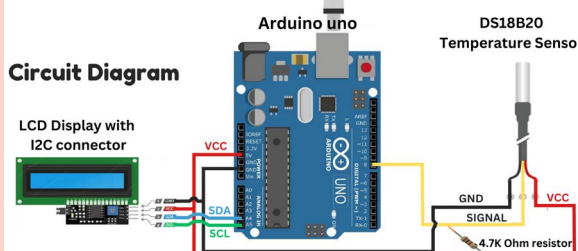
- Understand the concept of exothermic chemical reactions.
- Understand how energy in the form of heat is released during such reactions.
- Learn how temperature changes can indicate the release of energy.
- How to integrate chemistry with physics and electronics by using an Arduino and a temperature sensor in a practical application.
- Interpret data from real-time temperature monitoring.
- Develop skills in safe handling of chemicals and electronics.

What will you build/make?

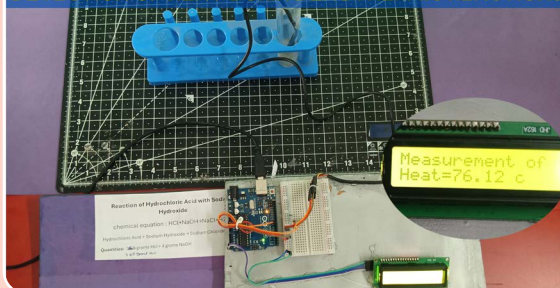
A DIY experimental setup that uses an Arduino Uno, DS18B20 waterproof temperature sensor, and an LCD display to detect and display the rise in temperature during exothermic chemical reactions.

Detection of Heat Produced During Chemical Reactions

Circuit Diagram



DETECTION OF HEAT DURING EXOTHERMIC REACTIONS



Click the link or scan QR code to watch
DIY cum working video of the project.



<https://youtu.be/Mev58X967eU>

What will you need?

Materials Needed

- Arduino Uno
- DS18B20 Waterproof Temperature Sensor
- 4.7K ohm Resistor
- 16x2 LCD with I2C Module
- Small Breadboard
- Wooden Plank/Board
- Jumper/Connecting Wires
- Arduino USB Cable
- 9V battery or 9V DC adapter

ATL Tools/Equipment

- Hot glue gun with hot glue sticks
- Computer with Arduino IDE
- Multimeter (Optional)
- Precision screw driver
- Soldering kit- gun, stand, metal, flux, fume extractor
- Wire Cutter/Stripper
- Hand gloves
- Cutting mat

Chemicals

- Zinc metal (2g)
- Hydrochloric Acid (HCl) (1.44g + 3.65g)
- Sodium Hydroxide (NaOH) (4g)
- Concentrated Sulfuric Acid (8–10 drops)
- Distilled Water (20 ml)

Lab Items

- Test Tubes & Test Tube Stand
- Dropper
- Gloves, Goggles, Apron (Safety gear for handling chemicals safely)
- Weighing scale

Software/Application

- Arduino IDE software



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

- Begin with a short discussion or presentation on chemical reactions, focusing on exothermic reactions.
- Explain how exothermic reactions release energy in the form of heat. Click the link of scan QR code to watch the video. (**Please note:** The default language of this video is Hindi. You can switch to the English audio track by selecting it from the settings menu on YouTube.)
- Introduce the three reactions that will be conducted in the activity and highlight their exothermic nature.
- Show the students the chemical equations and discuss the expected temperature changes.

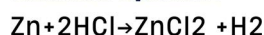


<https://www.youtube.com/watch?v=ejXL0IrbtqE>

Experiment# 1

Reaction of Zinc with Hydrochloric Acid

Chemical equation :



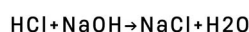
Zinc + Dil. Hydrochloric Acid → Zinc Chloride + Hydrogen

Quantities: 2 grams of Zn + 1.44 grams HCl

Experiment# 2

REACTION OF HYDROCHLORIC ACID WITH SODIUM HYDROXIDE

Chemical equation :



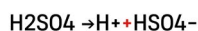
Hydrochloric Acid + Sodium Hydroxide → Sodium Chloride + Water

Quantities: 3.65 grams HCl + 4 grams NaOH

Experiment# 3

DISSOLVING CONCENTRATED SULFURIC ACID IN WATER

Chemical equation :



Sulfuric Acid → Hydrogen ion + Hydrogen Sulfate ion

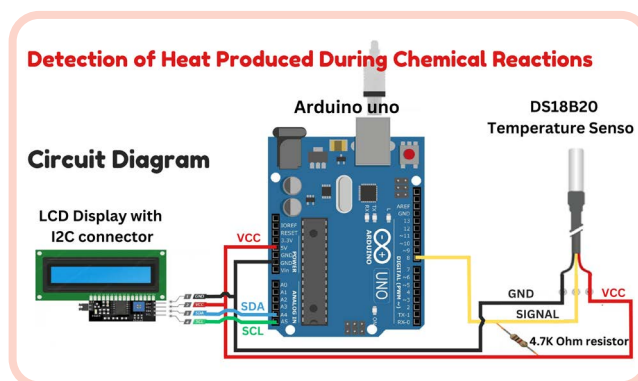
Quantities: Add a few drops of H₂SO₄ in to 20ml water

- Explain how we can detect and measure the heat produced during these reactions using digital tools.
- Introduce the DS18B20 temperature sensor, explaining that it is a digital sensor that measures temperature and sends data to a microcontroller.
- The DS18B20 communicates using a 1-Wire digital protocol, which allows it to send temperature readings with high precision over a single data wire. When connected to Arduino Uno, the Arduino reads the digital temperature signal from the sensor, processes it, and can then display it in real-time on an LCD screen.
- This setup allows for accurate and live monitoring of temperature changes during chemical reactions, helping students visualize the energy released in exothermic processes.
- Click the link to scan QR code to watch the video to learn how the DS18B20 sensor works with Arduino.
- **Do not dip the DS18B20 sensor in chemicals beyond its metallic probe.**
- **Do not connect the DS18B20 sensor without a pull-up resistor.**



<https://www.youtube.com/watch?v=qxEclOy6jpI>

2. Assembling the Circuit as per the Circuit Diagram:



- Refer to the circuit diagram for setting up the components.
 - o Connect the DS18B20 sensor to the Arduino Uno using jumper wires and a 4.7K resistor between the sensor's data (Signal) and VCC pins. **Do not connect the DS18B20 sensor without a pull-up resistor.**
 - » VCC to 5V, GND to GND

- » Data (Signal) Pin to D8
- o Connect the I2C LCD display to the Arduino.
 - » VCC to 5V, GND to GND
 - » SDA to A4, SCL to A5
- o Ensure connections are secure using the breadboard. Double-check connections with the circuit diagram before powering the Arduino.

3. Programming the Arduino:

- Open the Arduino IDE and upload the program that reads temperature from the DS18B20 sensor and displays it on the LCD.
- Adjust LCD brightness using the precision screwdriver if needed. Adjust LCD contrast before starting the experiment. Click the link or scan QR code to download the code (.ino file).
- You can also copy the code given here and paste in the Arduino IDE.



<https://tinyurl.com/mw4bfx5y>

```
#include <OneWire.h>
#include <DallasTemperature.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,20,4);
#define ONE_WIRE_BUS 8
OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature
sensors(&oneWire);

void setup()
{
  Serial.begin(9600);
  sensors.begin();
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0,0);
  lcd.print("Measurement of");
}
```

```
void loop(){
  //lcd.clear();
  lcd.setCursor(0, 1);
  lcd.print(" Heat=");
  lcd.setCursor(5, 1);
  lcd.print(sensors.
    getTempCByIndex(0));
  lcd.setCursor(11, 1);
  lcd.print(" c");

  sensors.requestTemperatures();
  Serial.print(" Celsius temperature:
    ");
  Serial.print(sensors.
    getTempCByIndex(0));
  Serial.print(" - Fahrenheit
    temperature: ");
  Serial.println(sensors.
    getTempFByIndex(0));
  delay(1000);
}
```

- Install the required Arduino libraries for this project if you do not have these libraries installed on your computer.
- To install these libraries, first click the link or scan QR code to download these libraries on your computer.
- Then, click the link or scan QR code to watch the video to learn how to install these libraries on your computer.
- Write or upload an Arduino sketch to the Arduino board.



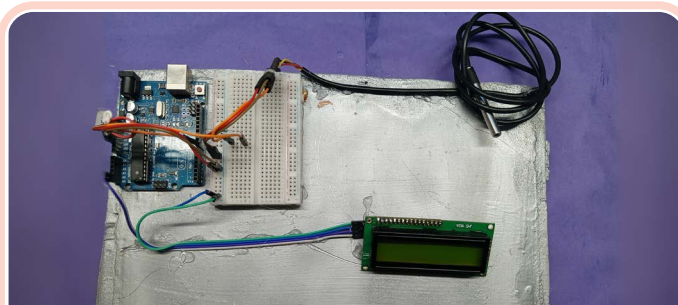
<https://tinyurl.com/8sxtbcpk>



<https://youtu.be/UBeAfdhrmbI>

4. Mounting the Components:

- Once the code is uploaded to the board, arrange the project set-up as shown in the image.

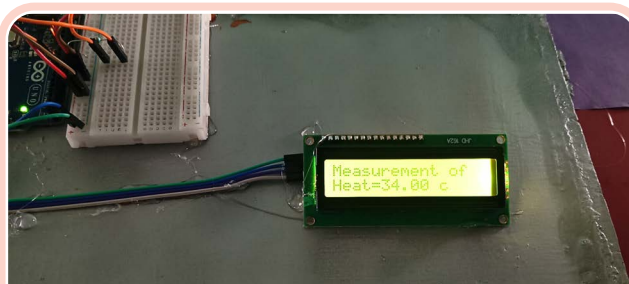


Detection of heat during exothermic reactions using Arduino Uno, DS18B20 sensor & LCD display

- Use a hot glue gun to secure the Arduino, breadboard, LCD, and sensor wires onto the wooden mounting board.
- Position the sensor so that its metal probe can be dipped into test tubes for readings.

5. Test the Circuit:

- Use a multimeter to check for continuity and proper voltage at sensor and display connections.
- Measure the ambient temperature and compare it with the recorded temperature on any authenticated website to verify that the temperature readings appearing on the LCD screen are correct.



Test the circuit by measuring the ambient temperature and compare with the recorded temperature.

6. Conduct Experiments (Watch the DIY video for complete instructions):

- Prepare the chemical reactions in test tubes:

Please note:

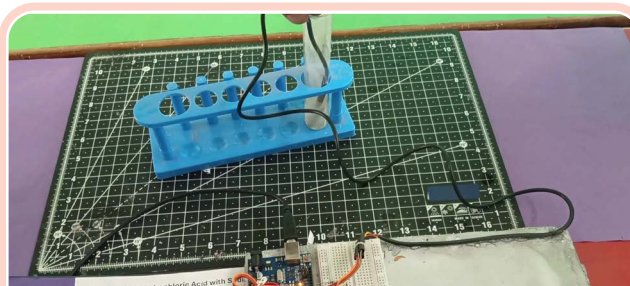
- **Add acid to water, never the other way around (especially sulfuric acid).**
- **Do not leave chemicals and chemical reactions unattended.**
- **Do not allow students to directly smell or touch chemicals.**
- **Do not mix up chemical quantities or reactions.**

- **Experiment 1:** Zinc + Hydrochloric Acid



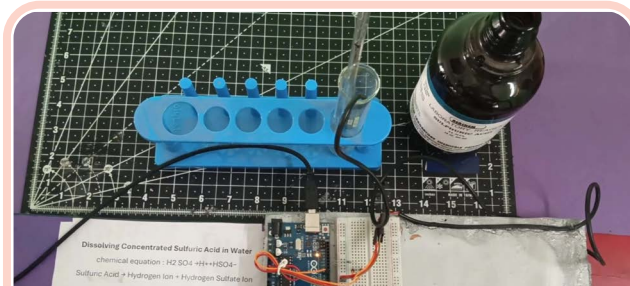
Mix Zinc with Hydrochloric acid and carefully dip the DS18B20 sensor's metal part in the test tube.

- **Experiment 2:** Hydrochloric Acid + Sodium Hydroxide



Carefully dip the DS18B20 sensor's metal part into the test tube.

- **Experiment 3:** Sulfuric Acid + Water (add the acid drop by drop)



Continuously add a few drops of Sulphuric acid into the water.

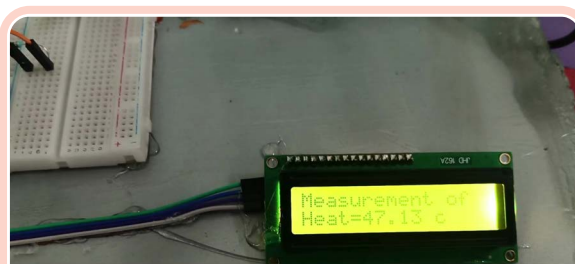
- o Carefully dip the sensor probe into each test tube during the reaction.
- o Don't dip the DS18B20 sensor in chemicals beyond its metallic probe.

7. Observe and Record:

- Monitor the temperature readings on the LCD during each reaction (before and after).
- Note the starting temperature, peak temperature, and time taken for temperature to stabilize.
- Use proper labels and document temperature data accurately.



Note the initial temperature before the reaction.



Temperature rises after the chemical reaction indicating the heat generation.



The temperature is still rising indicating the heat generation during the reaction.

8. Cleanup and Disposal:

- Once all reactions are complete, safely dispose of the chemical contents as per lab protocols.
- Clean the sensor probe with distilled water and dry thoroughly.

9. Discussion and Analysis:

- Compare temperature data from each reaction.
- Discuss which reaction produced the most heat and why.
- Link observations to the concept of energy change in exothermic reactions.

How does the model work?

When certain chemical reactions take place—like the ones in this activity—they release energy in the form of heat. These are called exothermic reactions. For example, when Zinc reacts with hydrochloric acid, or when sulfuric acid is added to water, heat is generated as a product of the reaction.

To detect and quantify this heat, we are using a DS18B20 digital temperature sensor. The metallic probe of the sensor is waterproof and safe to dip into the reaction mixtures. It detects the rise in temperature during and after the reaction.

The sensor sends this temperature data in digital form to the Arduino Uno microcontroller using a 1-Wire protocol. The Arduino reads this data, processes it, and then sends it to a 16x2 LCD display with I2C module, which shows the live temperature.

This setup allows students to visually monitor how much heat is being generated during each chemical reaction, turning invisible thermal energy into quantifiable, real-time data.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/Mev58X967eU>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of Chemical Reactions (exothermic and endothermic reactions).
- Ask:
 - What is an exothermic reaction?
 - Why does temperature increase during these reactions?/ Why was heat released in each reaction?
 - Which reaction released the most heat?
 - What are real-life applications of monitoring exothermic reactions?
 - Which of the 3 reactions conducted generated maximum heat?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Check if the students were able to follow the circuit and safely complete experiments?
- Observe if they accurately recorded temperature changes?

- Did they demonstrate proper chemical handling and Arduino usage?
- Assess the understanding of each component's functionality.
- Conduct a quick Q&A session to evaluate their understanding of the working of the 'Model for Detecting Heat Generated During Exothermic Chemical Reactions using Arduino'.
 - o Present your findings on the heat generated during each of the reactions that you have conducted using the model.
 - o How can automation like Arduino improve safety and precision in labs?
- Evaluate their understanding through questions about the working principles and code logic.
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Add data logging using an SD card module to record temperature trends.
 - Use multiple sensors to compare reactions side-by-side.
 - Design a mobile app or use Bluetooth to send data to a smartphone.
 - Construct a similar model for endothermic reactions and observe cooling trends.

Activity 17

Making Machine Learning based pH Card Recognition System



Grade



9, 10



Subject



Chemistry



Topic/
Concept



Acids, Bases
and Salts

Objective

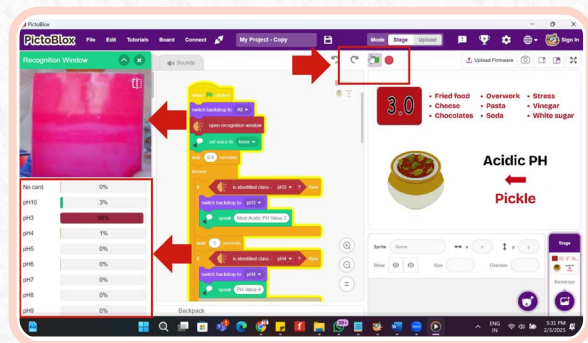
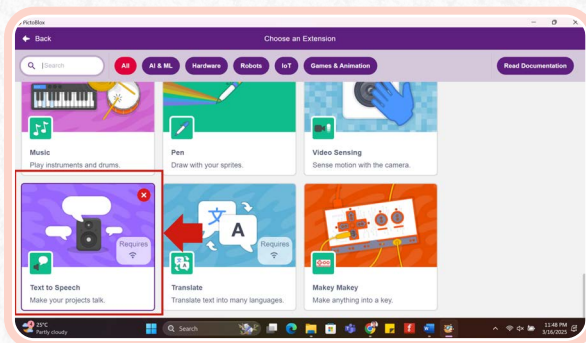
To enable understanding of the concept of pH and classification of substances as acid, base or salt based on their pH value.

What will you help students learn?

- The concept of pH and how substances are classified as acids, neutral, or bases.
- Develop an machine learning (ML) model in PictoBlox to classify pH indicator cards based on their colors.
- Understand how machine learning (ML) can be used for image classification using PictoBlox's Machine Learning Environment.
- Apply block coding in PictoBlox to recognize pH cards through integration of image recognition, display information using backdrops, and generate text-to-speech output.
- Develop problem-solving and computational thinking skills.

What you will build/make

A Machine Learning model to identify and interpret a pH Card.



Click the link or scan QR code to watch
DIY cum working video of the project.



https://youtu.be/8tMYJC_P1Vo

What will you need?

Materials Needed

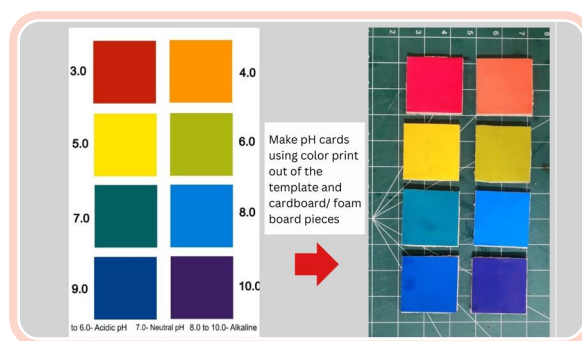
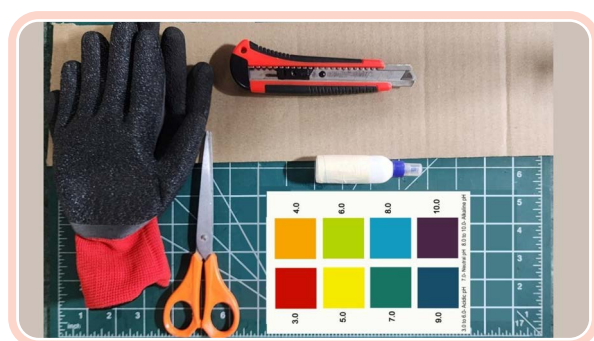
- 8 Printed pH indicator cards (pH 3 to 10)-
Used for image classification and training
the ML model
- Standard images related to each pH value-
Used as backdrops in PictoBlox to visually
display information.
- Cardboard/Foam Board
- Pencil/Marker
- Scissors
- Paper Glue

ATL Tools/Equipment

- Scissors and paper cutter
- Cutting Mat
- Computer with internet access and
webcam- Required for running PictoBlox,
accessing the ML model, and capturing
images for training.
- Color printer
- External webcam- Captures real-
time images of pH cards for training
and recognition. (Optional- in case
the computer does not have in-built
camera)

Software/Application

- PictoBlox software with login credentials
- PictoBlox's Machine Learning Environment
- PictoBlox's Text-to-Speech extension



Procedure

The process of building the model is divided into 3 focused sessions:

- **Session 1:** Introduction to pH and PictoBlox
- **Session 2:** Developing the ML Model Using Image Classifier in PictoBlox
- **Session 3:** Developing Block Coding for Image Recognition in PictoBlox

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

Session 1: Introduction to pH and PictoBlox

1. Understanding the Concept of pH:

- Introduce the **pH scale** (0-14) and classify substances as:
 - **Acidic (pH < 7):** Lemon juice, vinegar.
 - **Neutral (pH = 7):** Pure water.
 - **Basic (pH > 7):** Baking soda solution, soap.
- Discuss the importance of pH in real life (e.g., food, medicine, agriculture).

2. Introduction to PictoBlox and Machine Learning Environment:

- Click the link or scan QR code to download and install the PictoBlox software.
- Briefly explain what Scratch or PictoBlox is. Click the link or scan QR code to learn more on Pictoblox software.



<https://tinyurl.com/2jemya36>



<https://tinyurl.com/4uufjhfa>

- Explain what machine learning is and its applications in image classification.
- Open PictoBlox and go to the Machine Learning Environment (MLE).
- Select "Create New Project" → Choose "Image Classifier Module".
- Click the link or scan QR code to learn the basics of the ML environment in PictoBlox.



<https://tinyurl.com/4dzb5nyx>

Session 2: Developing the ML Model Using Image Classifier in PictoBlox

1. Preparation: Create pH cards:

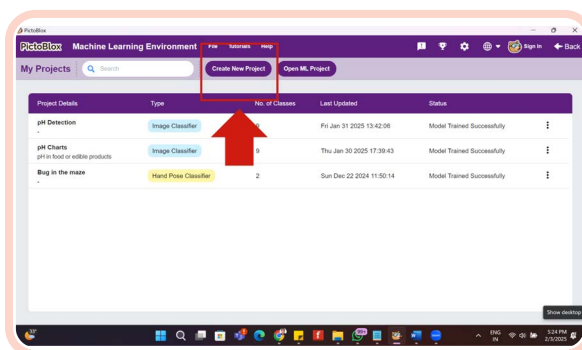
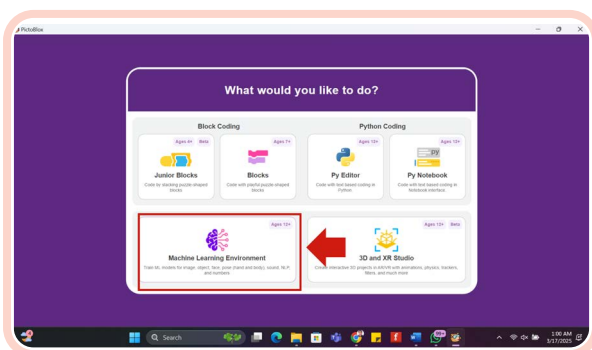
- Click the link or scan QR code to download the pH card template and color print it on a good quality photo paper. This template is required for developing an ML model.
- Use paper glue to paste the color template of pH cards on A4 size cardboard/foam board. Let the glue dry.
- Use scissors or paper cutter to cut the pH cards pasted on the cardboard/foam board.



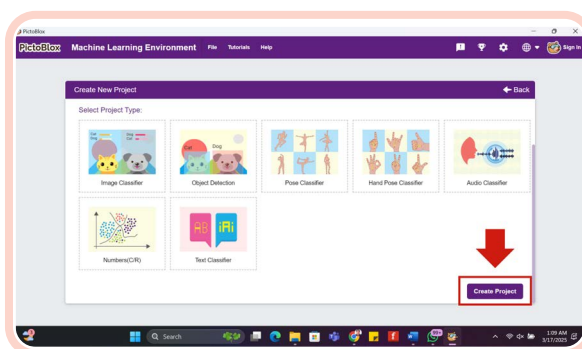
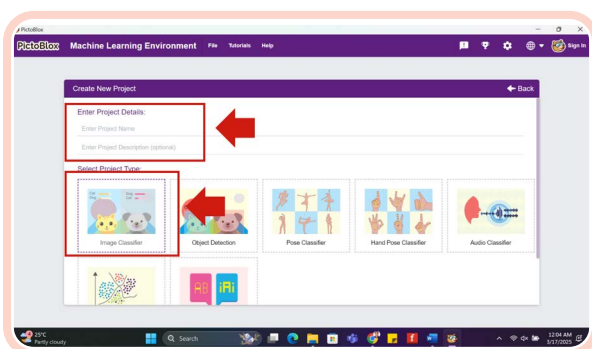
<https://tinyurl.com/4az4u2ej>

2. Setting Up the Image Classifier in PictoBlox's ML Environment:

- Open PictoBlox's Machine Learning Environment and click on the 'Create New Project' button.



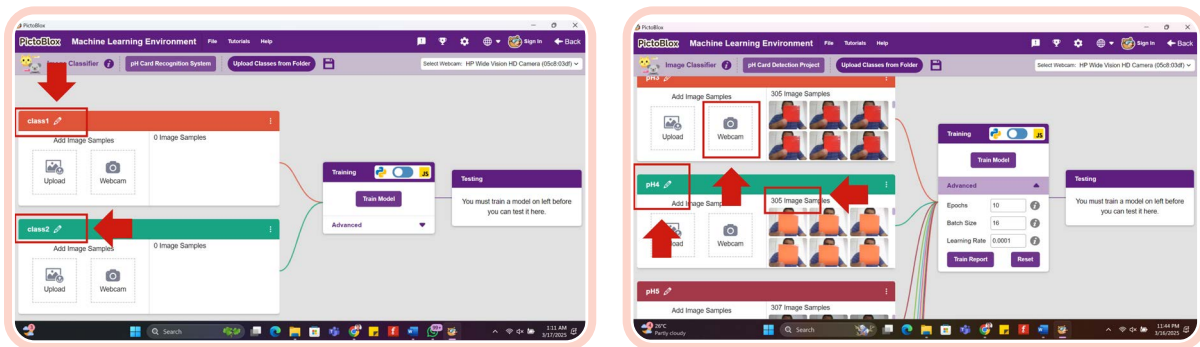
- Create a new image classifier project. Enter Project Name and Description and click on the 'Create Project' button.



3. Creating new classes and collecting Image Data:

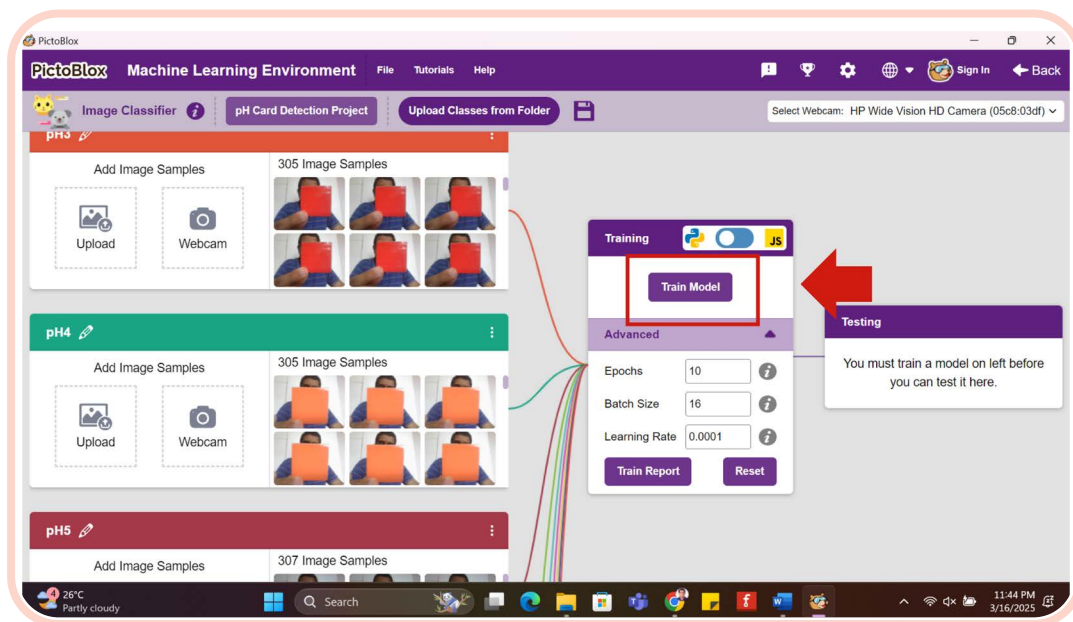
- Create new classes. Rename each class according to the pH values (pH 3 - pH 10).
- Capture at least 200 images per pH card class using a webcam. Avoid using blurry or low-resolution images for developing the model.
- Ensure images are clear, well-lit, and taken from different angles for better accuracy of the model.

- Avoid reflections or obstructions when capturing images.



4. Training the Model:

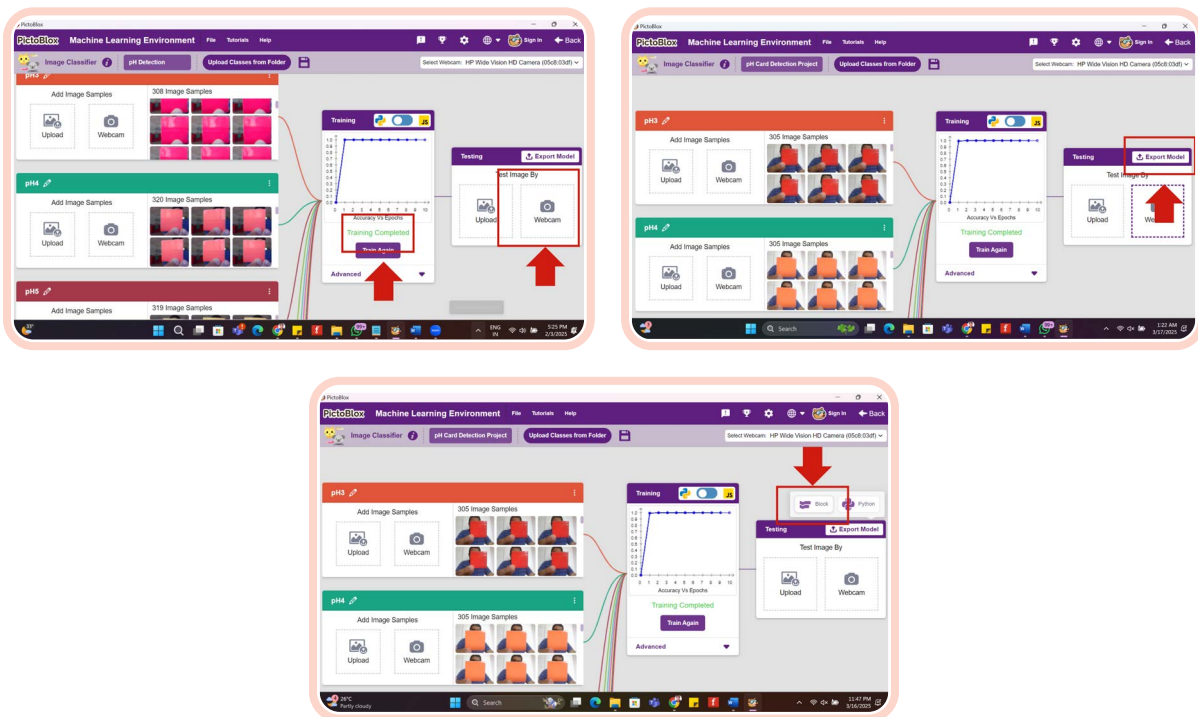
- Once image collection is complete for all the classes (From pH<=3 to pH=10), start the ML training process.
- Check internet connectivity before training the model.



5. Testing and Exporting the Model:

- Monitor accuracy levels and adjust by adding more images if needed.
- Test the trained model by showing different pH cards to the camera. Do not place multiple pH cards at once in front of the camera.
- Ensure pH cards are well-lit during the training. Avoid using similar-colored backgrounds behind the pH cards during testing of the model.

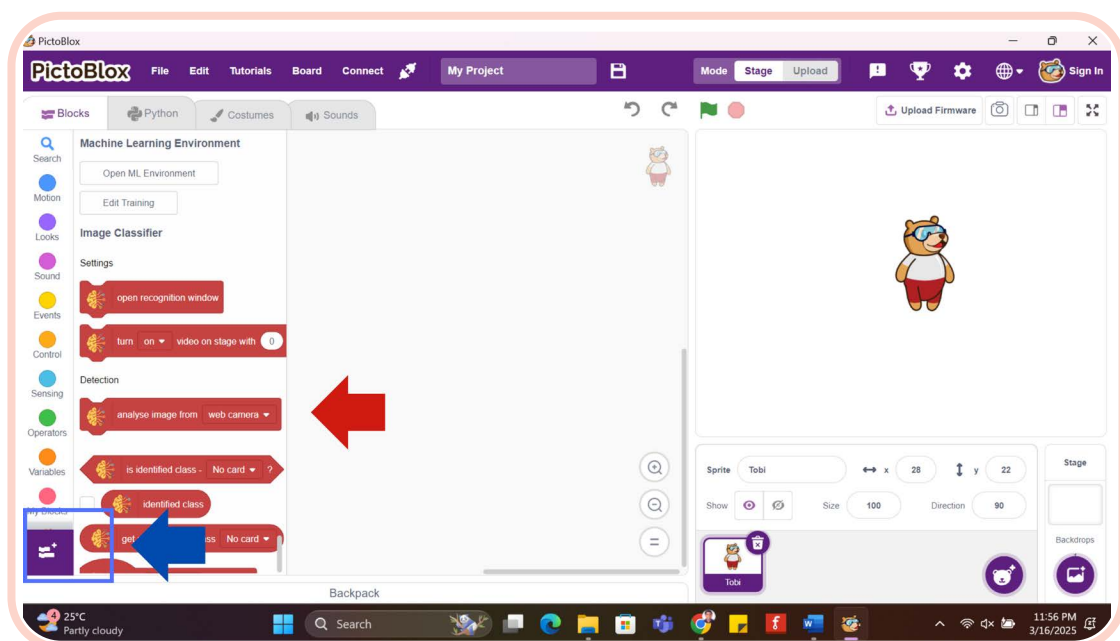
- If the model is accurate, export it for block coding in PictoBlox.



Session 3: Developing Block Coding for Image Recognition in PictoBlox

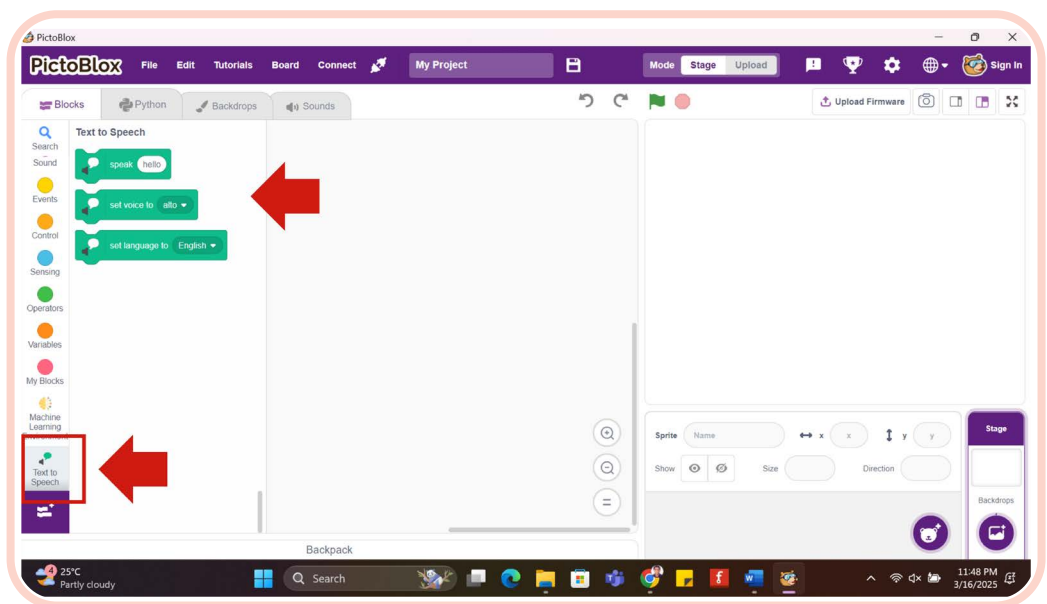
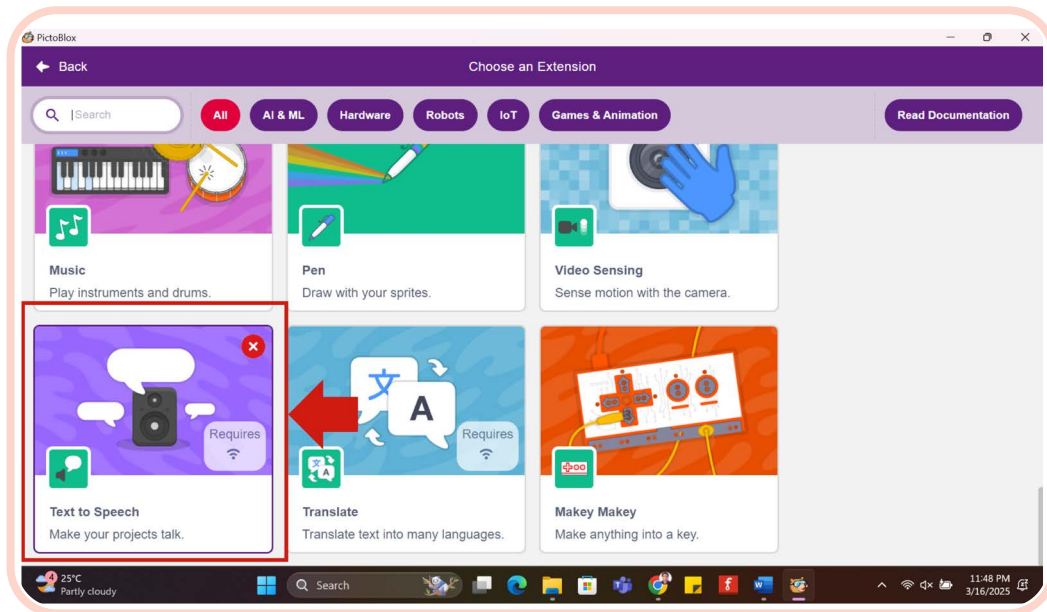
1. Importing the ML Model into PictoBlox:

- PictoBlox Block coding environment will be opened to create a new project.
- The ML blocks seen in the 'Blocks' section in the left-hand side of the software window ensures that the trained ML model has been imported successfully into the project.



2. Adding Extensions:

- Add the Machine Learning Environment and Text-to-Speech modules as shown in the image.

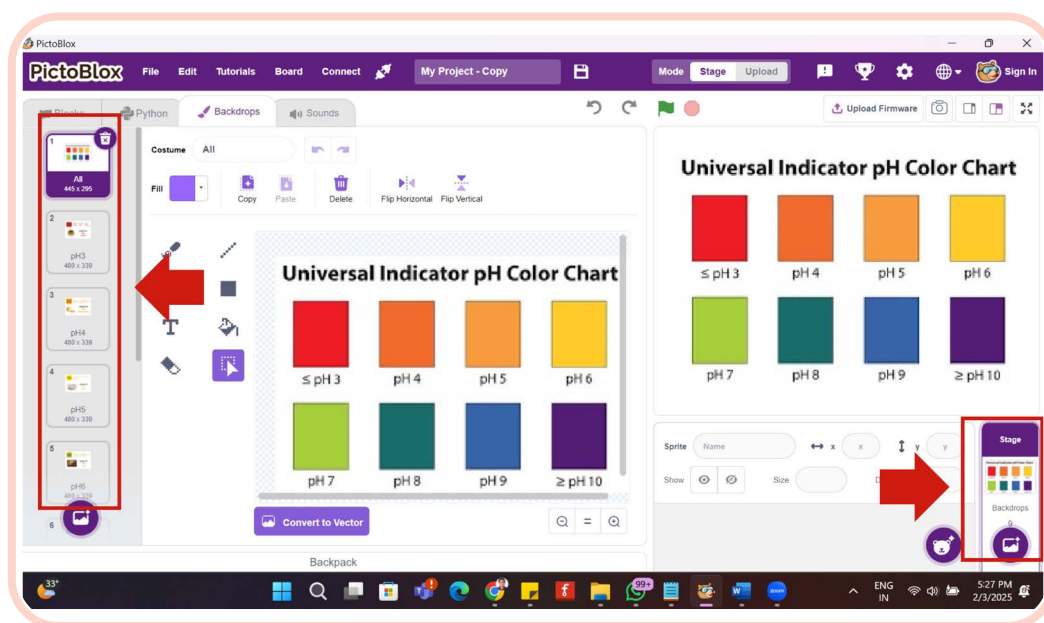


3. Setting Up Backdrops:

- Click the link or scan QR code to download the standard backdrop images we have provided for you. You may design your own backdrop images.
- In case you are designing your own backdrops, add the standard information related to pH values as visual representations on the backdrops. You can use bold labels for pH values on the backdrops for better effects.



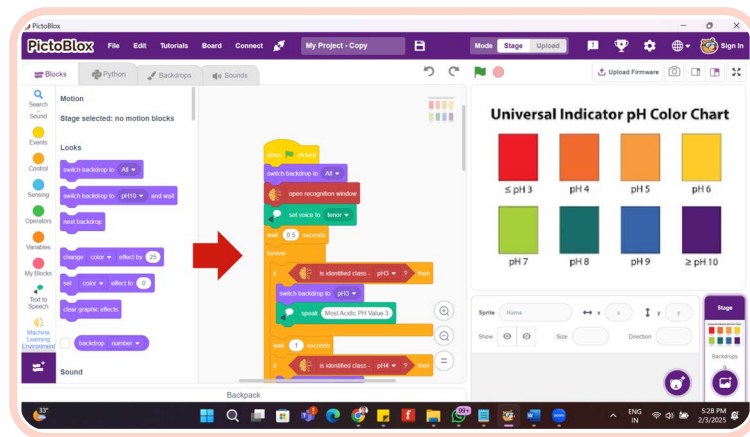
<https://tinyurl.com/5n6zvhdn>



4. Developing the Image Recognition Program:

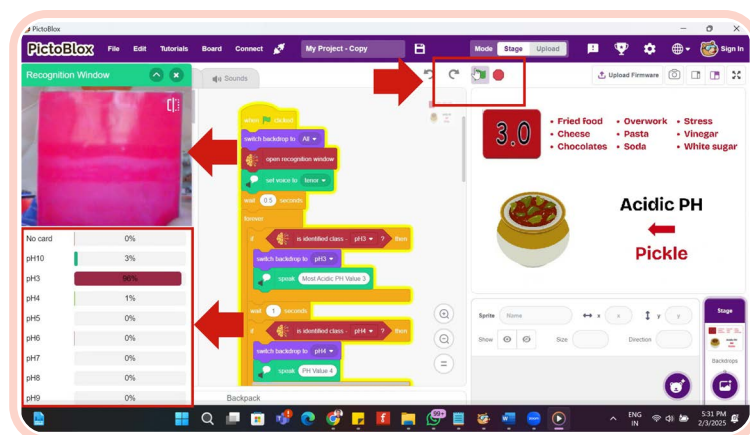
- Use the following blocks to create the recognition script:

Block Category	Block Used	Purpose
Machine Learning Environment	open recognition window	Opens the ML-based recognition window.
Machine Learning Environment	is identified class	Detects the pH value of the displayed card through image recognition
Looks	switch backdrop to	Changes the background (backdrop) based on the detected pH card.
Text to Speech	set voice to	Setting up the background voice generated from text.
Text to Speech	speak	Reads out the detected pH value and related information.



5. Running and Testing the Project:

- Show different pH cards to the camera.
- Observe if PictoBlox correctly identifies the pH and updates the backdrop.
- Ensure the text-to-speech module provides accurate information.



How does the Machine Learning model work?

The Machine Learning (ML) model for pH card identification in PictoBlox is designed to recognize different pH values based on color variations in pH indicator cards. This model is trained using image classification within the Machine Learning Environment (MLE) module in PictoBlox. When a user shows a pH card in front of the webcam, the ML model:

- Recognizes the pH value based on the color of the card.
- Switches the backdrop in PictoBlox to display information related to that pH card.
- Uses Text-to-Speech to announce the detected pH level and provide educational facts about it.
- Click the link or scan QR code to watch DIY cum working video of the project.



https://youtu.be/8tMYJC_P1Vo

How can you assess students' understanding?

Assessment of Concept Understanding

- Assess students' understanding of the pH scale (0-14) and classify substances as:
 - **Acidic (pH < 7):** Lemon juice, vinegar.
 - **Neutral (pH = 7):** Pure water.
 - **Basic (pH > 7):** Baking soda solution, soap.
- Ask- How can pH classification be used in real-world applications?
- Discuss the importance of pH in real life (e.g., food, medicine, agriculture).

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and train and export ML models.
- Ensure that ML model correctly classifies pH cards.
- Check if the execution of block coding is correct: Does the program change backdrops and read information correctly?
- Conduct a quick Q&A session to evaluate their understanding of the workflow of ML integration in PictoBlox.
 - How does machine learning recognize objects?
 - What factors affect the accuracy of an ML model?
 - How can this ML model be improved further?
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

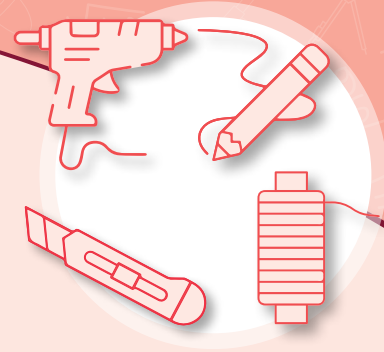
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can expand the dataset to include more pH values (1-14).
 - Use real-life substances instead of printed pH cards for classification.
 - You can try implementing a confidence score system to measure accuracy.

Activity 18

Building Models of Clinometers for Measuring Height



Grade



10



Subject



Mathematics



Topic/
Concept



Trigonometry and
Pythagorean Theorem

Objective

To apply trigonometric principles in the construction and use of Clinometer models in measuring heights of buildings and tall structures.

What will you help students learn?

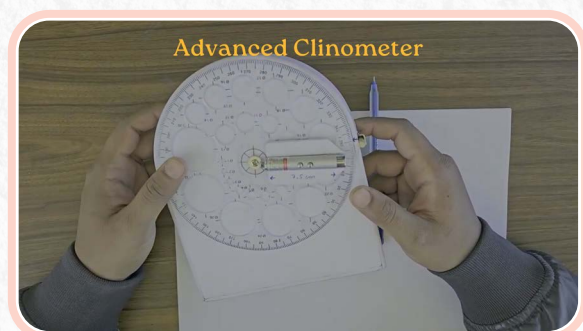
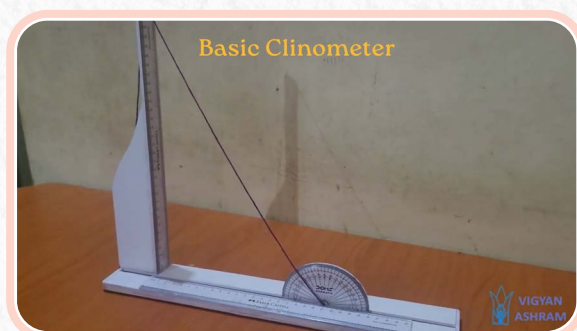
- Understand the principles of trigonometry and its practical application in height measurement.
- To construct and use both basic and advanced clinometers for measuring height.
- To calculate height using $\tan(\theta) = \text{opposite/adjacent}$ and Pythagorean theorem.
- To apply the formula $\tan(\theta) = \text{opposite/adjacent}$ and the Pythagorean theorem to measure heights

Sessions

- **Session 1:** Building and using a basic clinometer.
- **Session 2:** Building and using an advanced clinometer.

What will you build/make?

Functional models of a Clinometer (basic and advanced) for Measuring Height.





<https://youtu.be/BlizUOgY7x0>



<https://youtu.be/7iSwRNrw7JI>



<https://youtu.be/58NMPZ5kXqo>

Click on the links or scan QR codes to watch DIY cum working videos of the project.

Session#1: To build a model of a 'Basic Clinometer'

What will you need?

Materials Needed

- 180-degree protractor
- Two 30 cm rulers
- Foam board
- Thread
- Paper cutter
- Hand gloves
- Marker pen or pencil
- Separate ruler

ATL Tools/Equipment

- Paper cutter
- Hand gloves
- Marker pen or pencil
- Hot glue gun with glue sticks

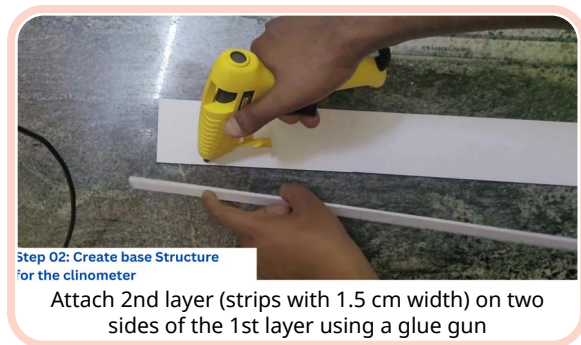
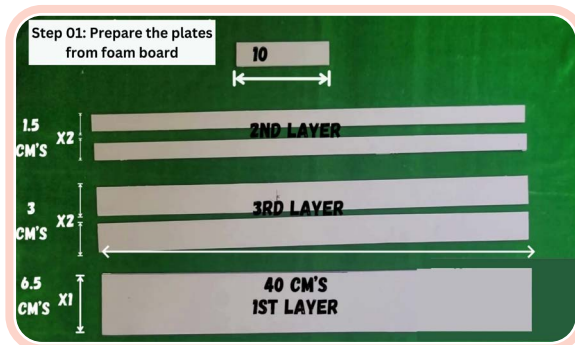


Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

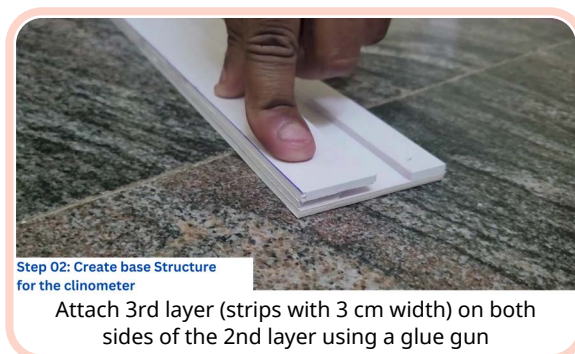
1. Use foam board to create a base structure:

- Mark and cut plates from a foam board as per the given dimensions.
- Create a base structure for the project using these plates as shown in the image.



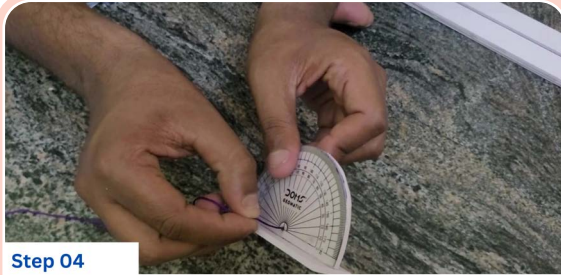
2. Build a structure for mounting protractor:

- Attach the 3rd layer on top of the 2nd layer of the base structure.
- Mark and cut foam board into a semi-circular shape as per the size of the protractor.
- Create a structure to mount the protractor for measurement of the angle.



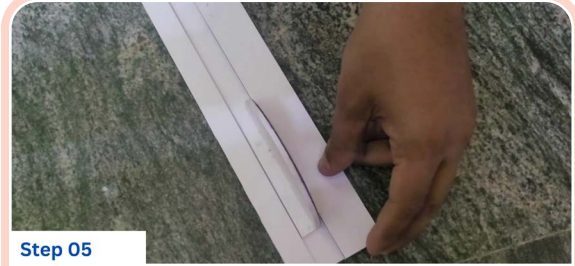
3. Mount protractor on the semi-circular shape:

- Use a hot glue gun to mount the protractor on the semi-circular shape.
- Make a hole exactly at the origin of the protractor and insert a thread through it. Tie a knot on the thread from the opposite side.
- Create a sliding mechanism to insert and slide the structure with a protractor mounted on it.



Step 04

Make a hole exactly at the center of the protractor and insert a thread. Put a knot on the thread from opposite side



Step 05

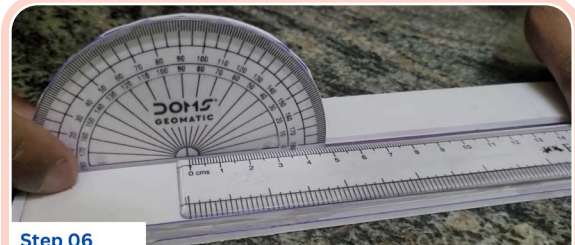
The Protractor mounted on a base will be sandwiched in between the 1st and 3rd layer. Use second layer as a stopper for the protractor base from both the sides

4. Mount ruler/scale on the base plate:

- Use a hot glue gun to mount a ruler/scale (as X- axis) on the base plate.
- Ensure that the protractor mechanism slides freely after this scale is mounted.



The slider mechanism for protractor is ready



Step 06

Mount one ruler/scale as X-axis and fix it on the foam board using glue gun. Ensure that the protractor mechanism slides freely after the scale is mounted

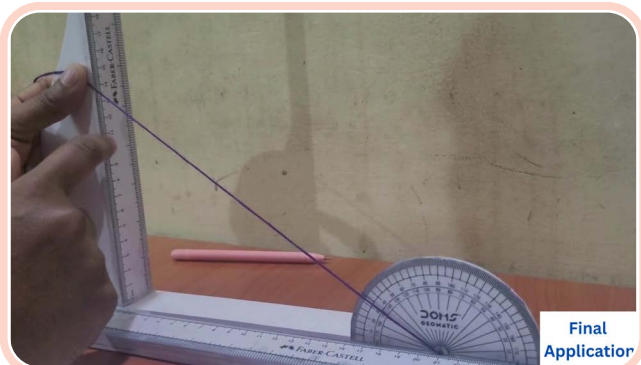
5. Mount ruler/scale on the vertical plate:

- Affix an additional ruler/scale to the foam board using a glue gun. It will act as a Y-axis.
- Ensure it is mounted perpendicular to the base and it is aligned with 'zero' mark on the scale/ruler mounted on X-axis.



Step 07

Affix an additional ruler/scale (as Y-axis) to the foam board using a glue gun. Ensure it is mounted perpendicular to the base and aligned with the 'Zero' mark on the X-axis



Final Application

How does the 'Basic Clinometer' model work?

Testing the Basic Clinometer

- Slide the protractor mechanism to align its origin at a certain distance along the X-axis.
- Measure the distance of the origin from the 'zero' mark on the X-axis. Note it down as 'base' (b).
- Point the thread at a certain height along the Y-axis. Note this height (h_{measured}) and read the angle (θ) of projection on the protractor.
- Apply the $\tan(\theta)$ formula to calculate height ($h_{\text{theoretical}}$), i.e. $\tan(\theta) = (h_{\text{theoretical}})/b$.
- Compare the $h_{\text{theoretical}}$ with that of the h_{measured} .
- Click on the link or scan QR code to watch DIY cum working video of the Basic Clinometer.



<https://youtu.be/BlizUOgY7x0>

Session#2: To build a model of an Advanced Clinometer

What will you need?

Materials Needed

- Two 360-degree protractors
- 5m retractable measuring tape
- Two laser pointers
- Foam board
- Bamboo stick

ATL Tools/Equipment

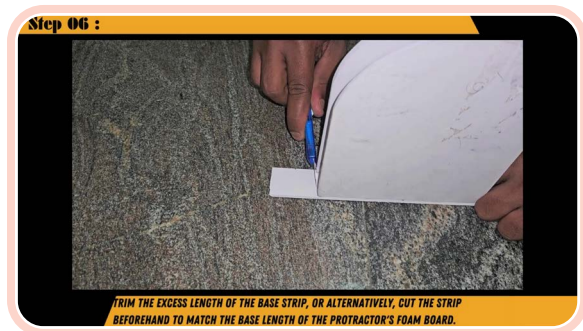
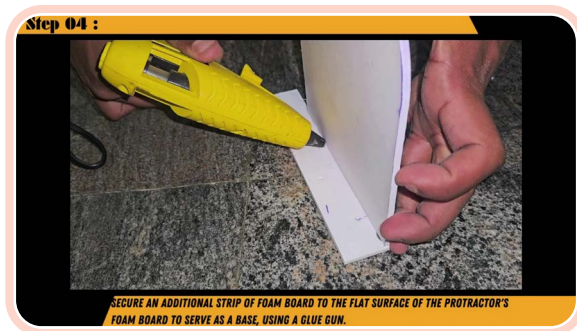
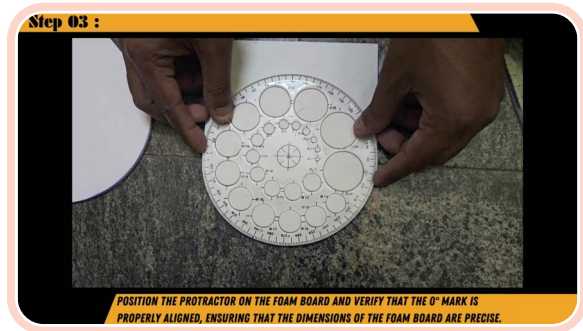
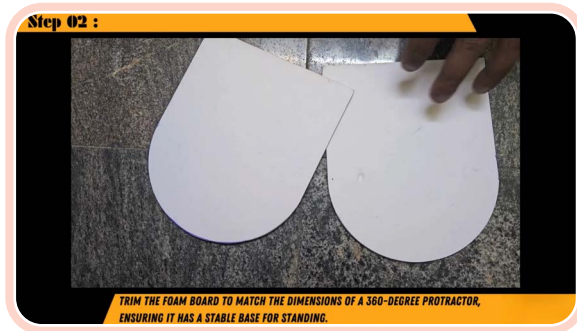
- Paper cutter
- Hand gloves
- Marker pen or pencil
- Hot glue gun with glue sticks



Procedure

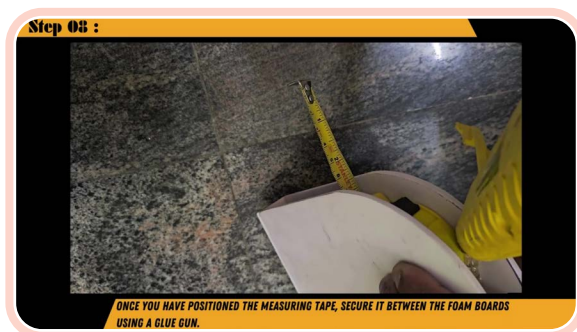
1. Use foam board to create a strong structure for the advanced clinometer:

- Mark and cut plates from a foam board as shown in the image.
- Make two semi-circular shapes to mount the protractors.
- Create a strong structure for the advanced clinometer using these plates.

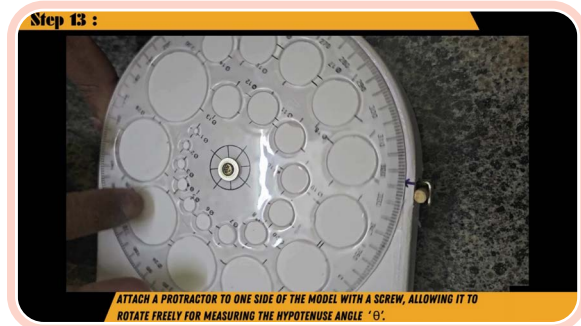
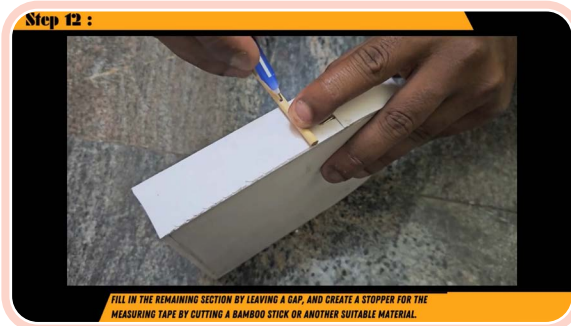


2. Mount measuring tape and one protractor:

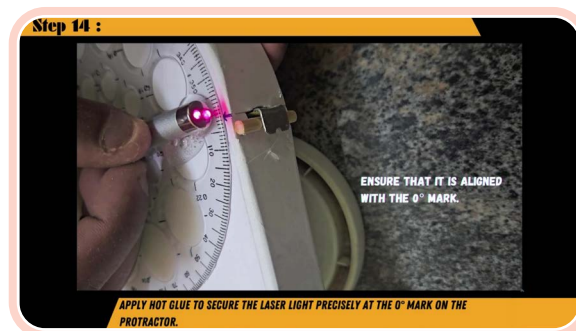
- Use a hot glue gun and attach a 5m retractable tape inside the clinometer. Close sides of the clinometer using a rectangular foam board plate.



- Use a small piece of bamboo stick as a stopper as shown in the image. Mark a line on the clinometer just above the retractable measuring tape as a 'zero mark' line.
- Mount one 360-degree protractor on one of the two sides of the clinometer using a screw and washer in such a way that the protractor can be rotated freely.

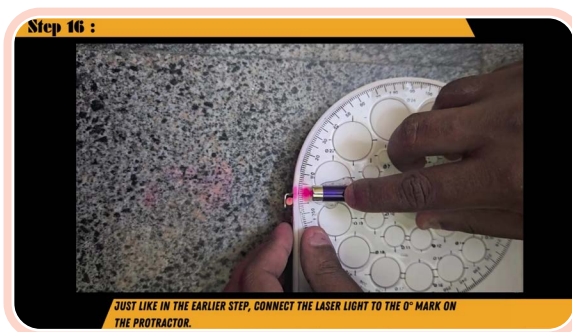
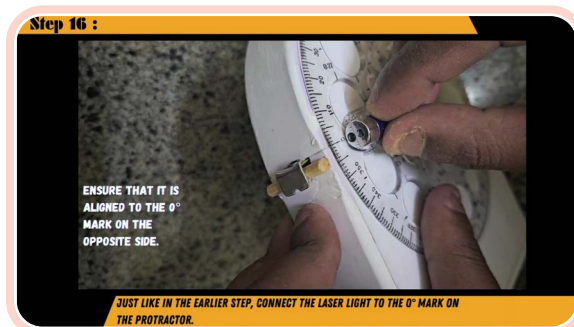
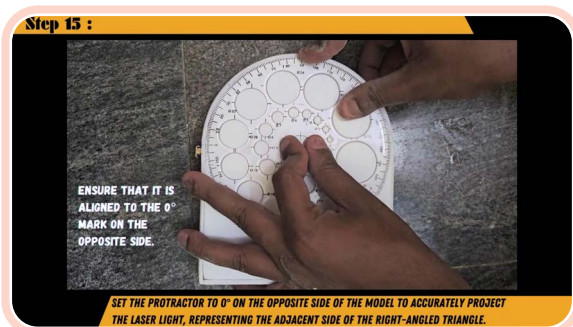


- Use a hot glue gun to mount one of the two laser pointers on the protractor that can be rotated freely.
- Ensure that the laser beam is aligned accurately with 'zero mark' on this protractor. Verify this by turning the laser beam on.
- Try rotating the protractor and see that the laser pointer is also rotating freely with it.



3. Mount a second protractor (fixed one) and laser pointer on it:

- Use a hot glue gun to mount the second 360-degree protractor on the opposite side of the clinometer in such a way that it is fixed and its 'zero' mark is also aligned with the 'zero' mark drawn just above the retractable measuring tape.
- Use a hot glue gun and mount the second laser pointer on this protractor.
- Ensure that the laser beam from this pointer too is aligned accurately with the 'zero mark' on the protractor on which it is mounted.
- Verify this by turning the laser beam on.
- This protractor and the laser pointer mounted on it will be used for projecting a laser beam to measure height of the clinometer from the ground surface.



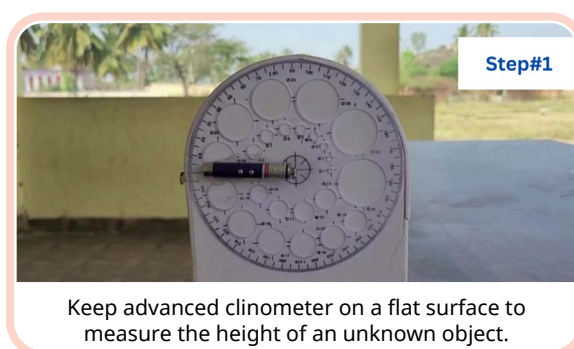
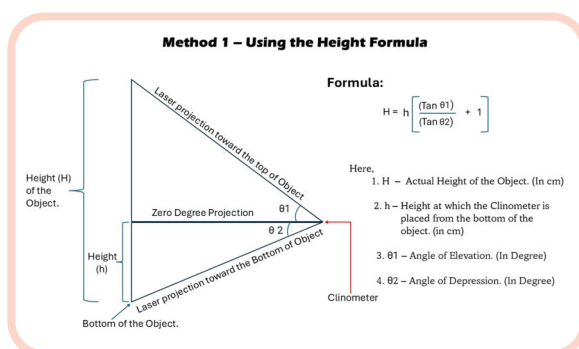
How does the 'Advanced Clinometer' model work?

Testing the advanced clinometer to measure height of an object:

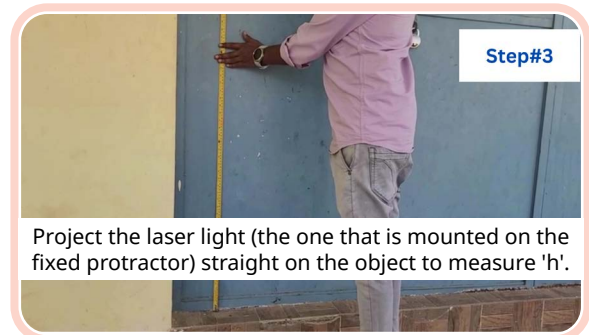
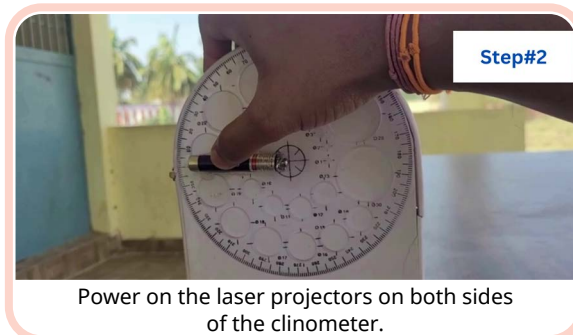
- We are going to use two methods for measuring the height of an object using a clinometer.
- You can use either of the two methods or demonstrate both the methods to students.

1. Method#1 for calculating the height (Using Height formula):

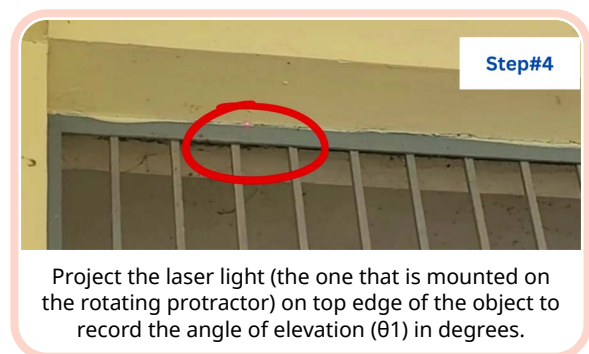
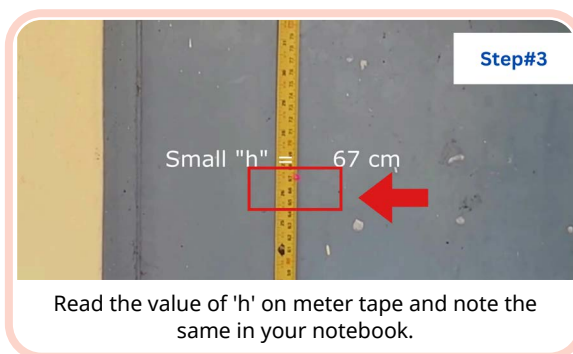
- Refer the diagram for method#1 to calculate the height of an object.
- Keep the advanced clinometer on a flat surface as shown in the image.



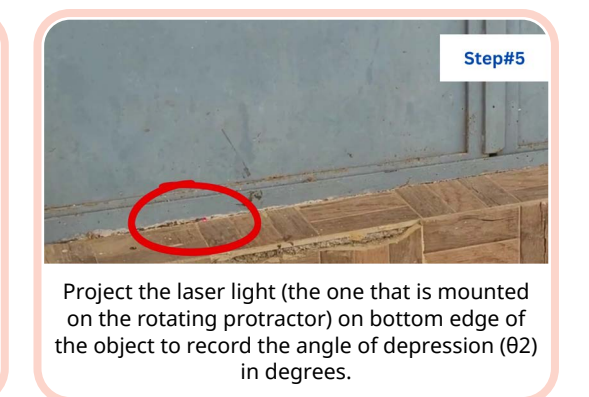
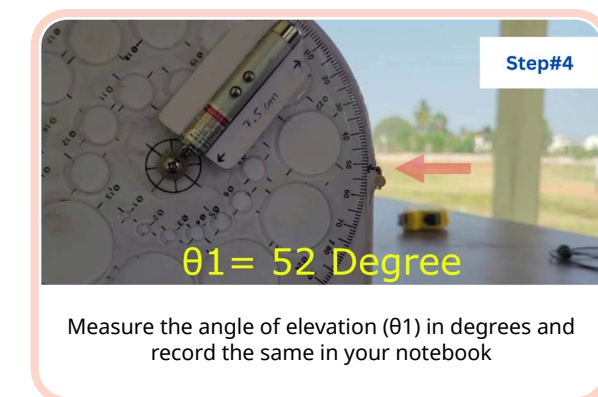
- Power both the laser pointers on.
- Project the laser light (the one that is mounted on the fixed protractor) straight on the object to measure 'h'.



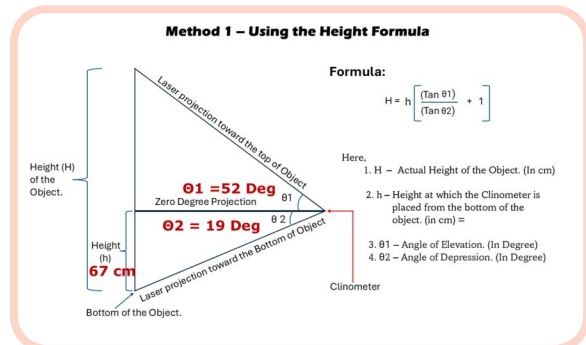
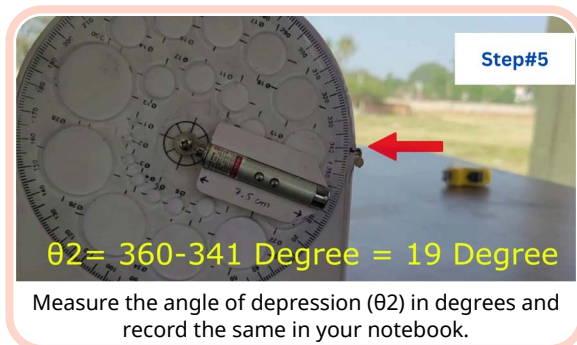
- Note down the value of 'h' in your notebook.
- Project the laser light (the one that is mounted on the rotating protractor) on the top edge of the object to record the 'angle of elevation' (θ_1) in degrees.



- Note down the value of ' θ_1 ' in your notebook.
- Now, project the laser light (the one that is mounted on the rotating protractor) on bottom edge of the object to record the angle of depression (θ_2) in degrees.



- Note down the value of 'θ₂' in your notebook.
- Refer the formula to calculate height of an object (gate) by using the measured values of 'h', 'θ₁' and 'θ₂' as shown.

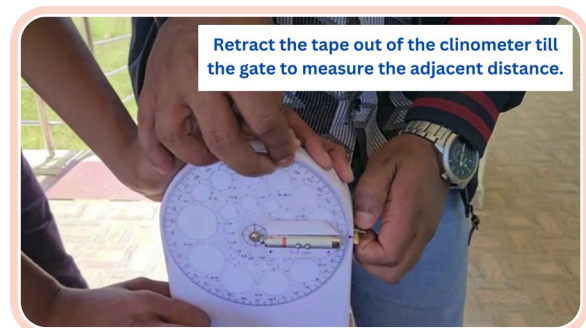
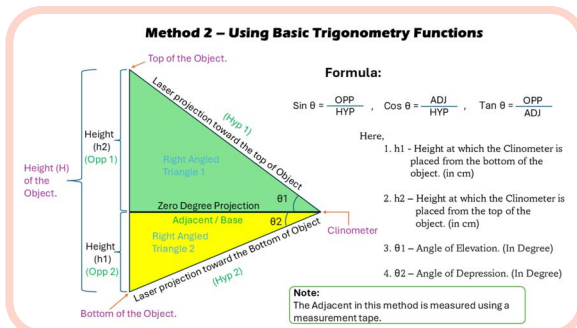


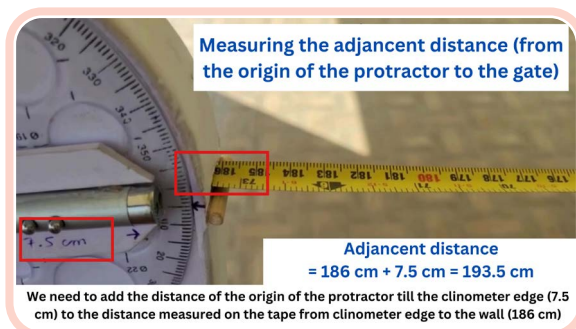
Calculations for Method#1

$$\begin{aligned}
 h &= 67 \text{ cm} \\
 \theta_1 &= 52 \text{ Degree} \\
 \theta_2 &= 360-341 = 19 \text{ Degree} \\
 H &= h \times \left[\frac{\tan \theta_1}{\tan \theta_2} + 1 \right] \\
 \therefore H &= 67 \times \left[\frac{\tan 52}{\tan 19} + 1 \right] \\
 &= 67 \times \left[\frac{1.28}{0.34} + 1 \right] \\
 &= 67 \times [4.72] \\
 \therefore H &= 316.24 \text{ cm}
 \end{aligned}$$

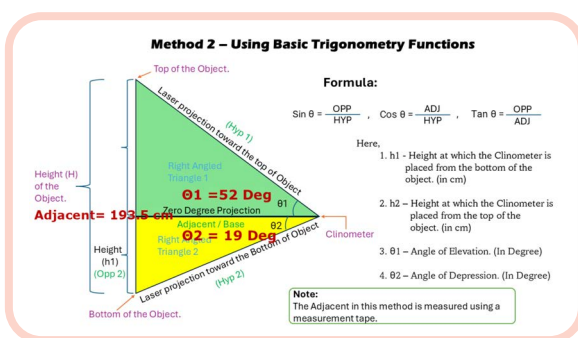
2. Method#2 for calculating the height (using trigonometry function):

- Refer the diagram for method#2 to calculate the height of an object using trigonometry function $\tan \theta$.
- Keep the advanced clinometer on a flat surface as shown in the image. Retract the tape out of the clinometer till the gate to measure the adjacent distance.
- We need to add the distance of the origin of the protractor till the clinometer edge (7.5 cm in this case) to the distance measured on the tape from the clinometer edge to the wall (186 cm in this case).





- Refer the formula to calculate height of an object (gate) by using the measured values of 'Adjacent', 'θ1' and 'θ2' as shown.
- Please note- 'θ1' and 'θ2' remain the same as that of the first method.



Calculations for Method#2

Adjacent/Base = 186 cm + 7.5 cm = 193.5 cm

θ1 = 52 Degree

θ2 = 360-341 = 19 Degree

1. (tan θ1) = (tan 52) = (Opposite 1)/Adjacent

∴ Opposite 1 = (tan 52) x Adjacent = 1.28 x 193.5 cm = 247.67 cm

2. (tan θ2) = (tan 19) = (Opposite 2)/Adjacent

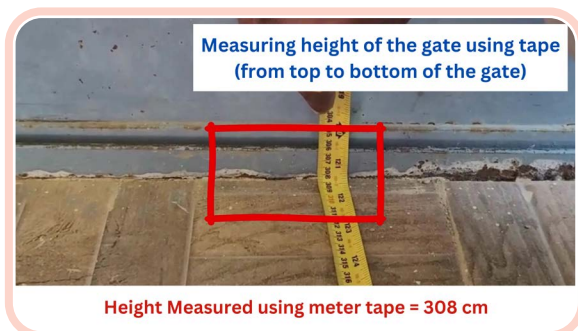
∴ Opposite 2 = (tan 19) x Adjacent = 0.344 x 193.5 cm = 66.63 cm

∴ H = Opposite 1 + Opposite 2 = 247.67 cm + 66.63 cm

H = 314.3 cm

3. Calculating percentage error in measurement of height in both methods:

- Measure the actual height of an object (gate in this case) using a measuring tape. Record this value in your notebook.
- Calculate the % error in measurement of the height in both methods as shown.



% Error in Measurement (Actual vs Measured by clinometer)

1. Actual measured height by tape = 308 cm
2. Height calculated by clinometer (Method#1) = 316.24 cm
3. Height calculated by clinometer (Method#2) = 314.3 cm

A. Percentage error in reading by Method#1:

% Error in method 1 = $\frac{(316.24-308)}{308} \times 100 = 2.67\%$

B. Percentage error in reading by Method#2:

% Error in method 1 = $\frac{(314.3-308)}{308} \times 100 = 2.04\%$

∴ **Method#2 seems to be little more accurate than Method#1**



Click on the link or scan QR code to watch DIY video of the advanced Clinometer.



Click on the link or scan QR code to watch the working video of the advanced Clinometer.

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of trigonometric concepts and formulae.
- How does trigonometry help in real-world applications?
- Conduct a quick Q&A session to evaluate their understanding of the Clinometer:
 - o What are the advantages and limitations of using a clinometer?
 - o What errors could affect our measurements, and how can we reduce them?
 - o How can we use the clinometer in geographical surveying?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Evaluate the understanding of the working principle of both the models.
- Check for creativity and accuracy in assembling the model.
- Verify the accuracy of measurements of heights. Ask them to explain sources of error.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - Modify the design by adding a digital inclinometer sensor for more accuracy.
 - Use a mobile app clinometer to compare manual vs. digital methods. (Smartphone App Integration).
 - Create a 3D-printed version of the clinometer for enhanced precision.

Activity 19

Making a Model to Learn Trigonometric Ratios



Grade

10



Subject

Mathematics



Topic/
Concept

Trigonometry

Objective

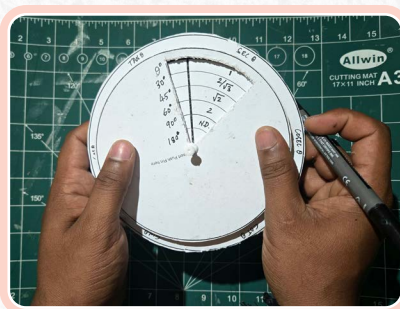
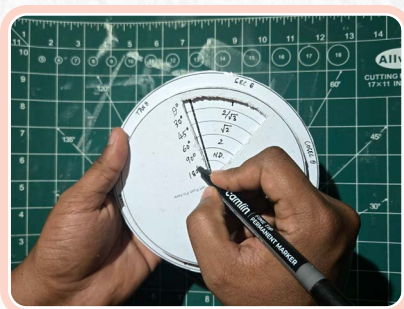
To visualize and understand the concept of Trigonometric Ratios and Trigonometric values of specific angles.

What will you help students learn?

- To construct a hands-on model to visualize and understand the six trigonometric ratios:
 - Sine (sin)
 - Cosine (cos)
 - Tangent (tan)
 - Secant (sec)
 - Cosecant (csc)
 - Cotangent (cot)
- To recall and understand trigonometric values at specific angles (0° , 30° , 45° , 60° , 90° , and 180°) through interactive engagement.
- To explore the practical application of trigonometry using a physical rotating model.
- Relate angles and their trigonometric values.

What will you build/make?

A DIY model to learn trigonometric ratios.



<https://youtu.be/4I7PxTwwsQ0>

Click the link or scan QR code to watch DIY cum working video of the project.

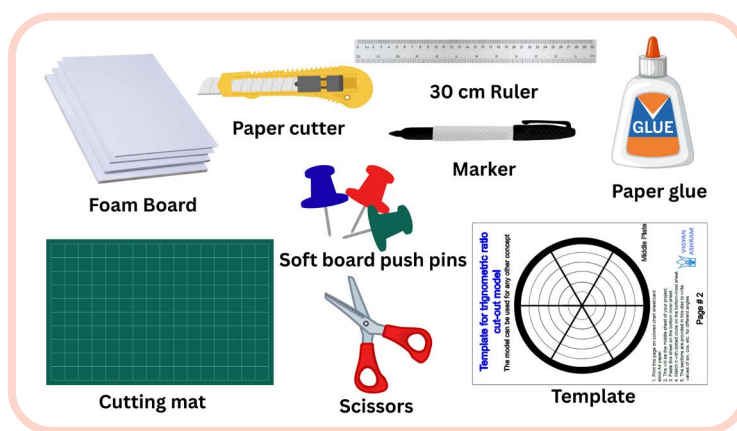
What will you need?

Materials Needed

- Printed templates of the model (Link to download the image is given in the procedure)
- Three A4 size papers
- Colored chart sheet/cardstock sheet (Optional)
- Two A4 size foam board sheets
- Marker pen or pencil and ruler
- Soft board push pins
- Bold colored markers

ATL Tools/Equipment

- Scissors
- Paper cutter
- Cutting mat
- Hand gloves
- Paper glue



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Preparation:

- Click the link or scan QR code to download and print the template on A4 size paper. This template is required for building this model.
- Gather all materials and tools listed.
- Ensure the printed templates are ready and accessible.



<https://tinyurl.com/mr43ncuj>

2. Creating the Base Plate:

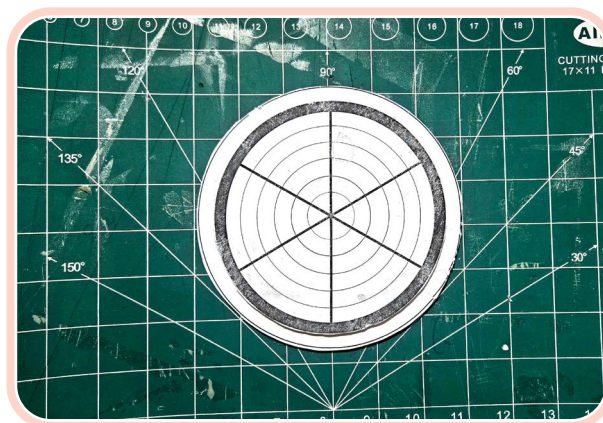
- Take a print of the base disc/plate from the template on A4 size plain white paper.
- Cut it precisely using the scissors. Take care while using the scissors.

- Take one A4 size foam board sheet.
- Apply paper glue evenly on one side of the base plate cut-out.
- Carefully paste the base plate cut-out onto the foam board.
- Smooth out any air bubbles to ensure a flat surface.
- Wear hand gloves and use a paper cutter to cut the base plate from the foam board.



3. Creating the Middle Disc/Plate:

- Take a print of the middle disc/plate from the template on A4 size plain white paper.
- As an option, you can take this print of A4 size coloured chart sheet/ card stock.
- Cut out the disc using the scissors, following safety protocols.
- Use paper glue to paste this middle disc cut-out on the base disc. The base disc has a dotted line circle of the same diameter for proper alignment.



4. Creating the Top Disc/Plate:

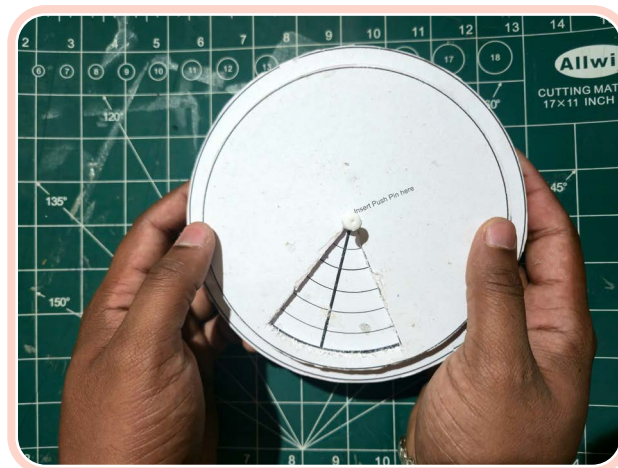
- Take a print of the top disc/plate from the template on A4 size plain white paper.
- As an option, you can take this print of A4 size coloured chart sheet/ card stock.

- Cut out the disc using the scissors, following safety protocols.
- Take another A4 size foam board sheet.
- Apply paper glue evenly on one side of the top plate cut-out.
- Carefully paste the top plate cut-out onto the foam board.
- Smooth out any air bubbles to ensure a flat surface.
- Wear hand gloves and use a paper cutter to cut the top plate from the foam board.
- Cut out a window in one of the sectors on the top plate (there is marking provided on the top plate), which matches the size of the sectors on the middle disc.



5. Assembling the Model:

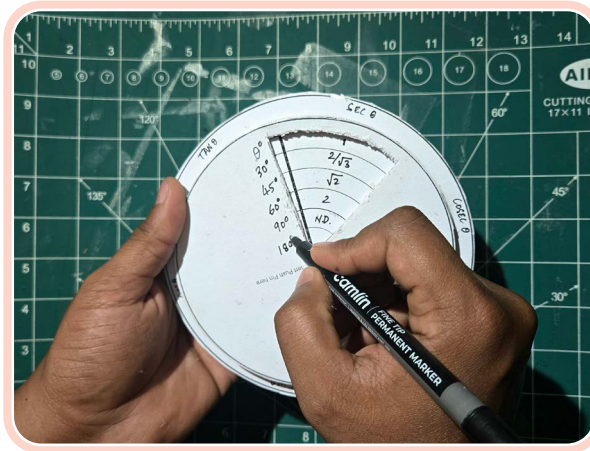
- Place the top disc over the middle disc, aligning it appropriately.
- Insert a soft board push pin through the center of all three layers (base plate, middle disc, top disc) to allow rotation.



6. Preparing the middle and top disc/plate

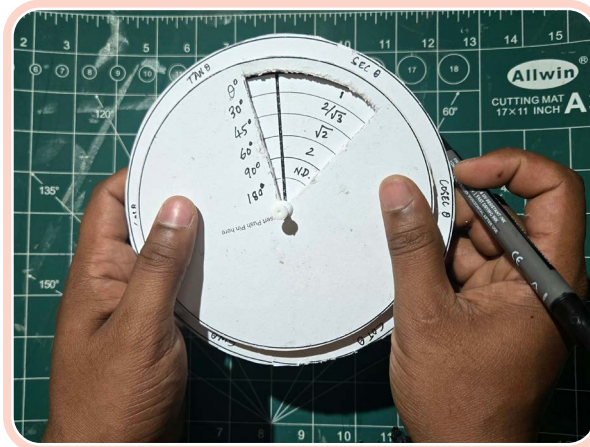
- This middle disc is already divided into six equal sections.
- As the middle disc is also already pasted on the base disc, write values of one of the six trigonometric ratios (sin, cos, tan, sec, cosec, cot) for angles 0° , 30° , 45° , 60° , 90° , and 180° in each section using a bold coloured marker.

- On top of each sector, write 'sin, cos, tan, sec, csc, cot' on the base plate
- Along the edge of the window on the top disc/plate, write the angles (0° , 30° , 45° , 60° , 90° , 180°) clearly using a bold coloured marker.



7. Using the Model:

- Rotate the top disc to align the window over a specific trigonometric ratio on the middle disc.
- Read the corresponding values of the trigonometric ratios for the angles displayed along the edge of the window.



How does the model work?

The DIY trigonometric ratio model is designed to help students visually understand and memorize the six trigonometric ratios (sine, cosine, tangent, secant, cosecant, and cotangent) at specific angles (0° , 30° , 45° , 60° , 90° , and 180°).

The model consists of three layers:

1. **Base Plate:** A stationary bottom layer that provides alignment markings for proper placement of the middle and top discs.

2. **Middle Disc:** This rotating disc is divided into six equal sections, with each section labelled with one of the trigonometric ratios and their values at specific angles.
3. **Top Disc:** A rotating layer with a cut-out window that allows users to align different angles with trigonometric ratios. The angles are written along the edge of this window.

Working Mechanism:

- The top disc rotates over the middle disc, aligning the window with one of the trigonometric ratio sections on the middle disc.
- Students can rotate the top disc to different sections on the middle disc- sine, cosine, tangent, secant, cosecant, and cotangent and read the corresponding values for 0° , 30° , 45° , 60° , 90° , and 180° written on the edge of the window on top disc.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/4I7PxTwwsQ0>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of Trigonometric Ratios.
- How do the trigonometric ratios change with different angles?
- Why are certain trigonometric ratios undefined at specific angles?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Assess whether the model works as desired.
- Check for creativity and accuracy in assembling the model.
- Conduct a quick Q&A session to evaluate their understanding of the working of the Model.
 - o Ask students to explain how the model represents trigonometric ratios.
 - o How can this model help in visualizing the unit circle and the values of trigonometric functions?
 - o Challenge students to use the model to solve trigonometry problems.
- Observe if students can construct a functional model.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can add more angles to the model (15° , 75° , etc.).
 - Extend the model to display negative angles and their trigonometric values.
 - Try using colour coding for different quadrants to relate trigonometry to the unit circle.
 - You can attach an interactive digital component (e.g., an LED indicator for a selected ratio).
 - Modify the model to include real-world applications such as heights and distances.

Activity 20

Calculating Surface Areas of Paper 3D Shapes using 2D Net Pull-Up Models



Grade ► **8, 9 and 10**



Subject ► **Mathematics**



Topic/
Concept ► **Mensuration**

Objective

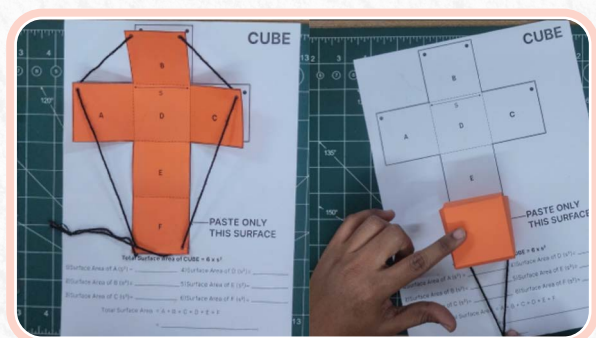
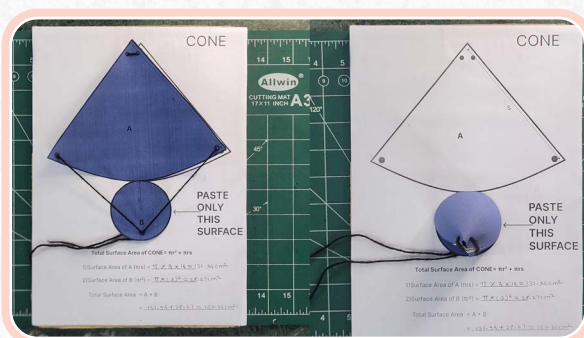
To reinforce the concept of Surface Area of 3D shapes by creating and using 2D Nets.

What will you help students learn?

- The concept of surface areas of various 3D shapes using their 2D nets.
- Visualize and construct 3D shapes from 2D nets.
- Calculate and record the surface areas of various 3D shapes using their 2D nets.
- Integrate technology and manual crafting in understanding geometry.

What will you build/make?

Interactive 3D models using pull-up mechanisms crafted from 2D nets integrating geometry, 2D and 3D design software, and crafting.



<https://youtu.be/J59CGBgDPWU>



https://youtu.be/kxhsZTPDd_Y?si=LJ_7R-MLn0REjMg



<https://youtu.be/Jye1Y2qXbIo?si=Fx5KoKnyCYHZQY5A>

Click the links or scan QR codes to watch DIY cum working video of the project.

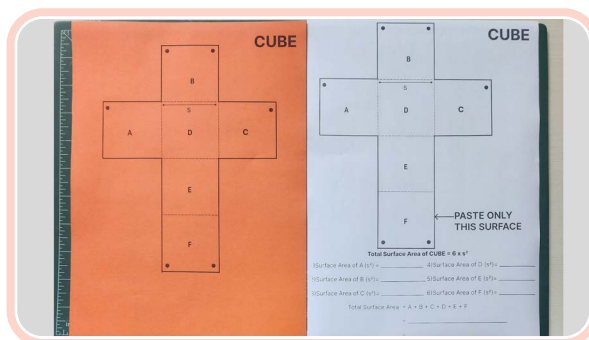
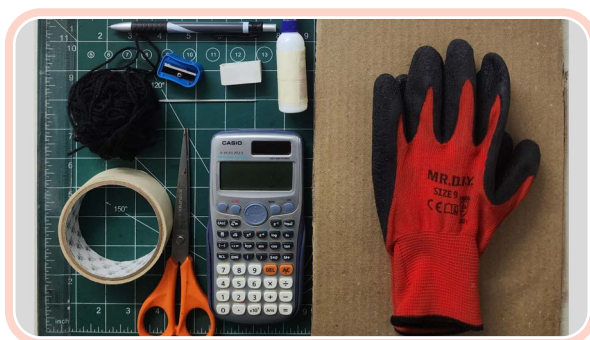
What will you need?

Materials Needed

- Pre-designed printable templates of 2D nets (Link to download the image is given in the procedure)
- Cardstock paper
- Strings (thin and durable)
- Paper glue
- Needle
- Cardboard sheets
- Pencils

ATL Tools/Equipment

- Ruler
- Scissor
- Cutting mat
- Eraser
- Calculator



Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Constructing 2D Nets Using Printable Templates:

- **Introduction:** Briefly explain the relationship between 3D shapes and their 2D nets.
- Click the link or scan QR code to download and print the template on A4 size paper. This template is required for building 2D nets for various 3D shapes like cube, cuboid, prism, etc.



<https://tinyurl.com/ywbb4x4y>

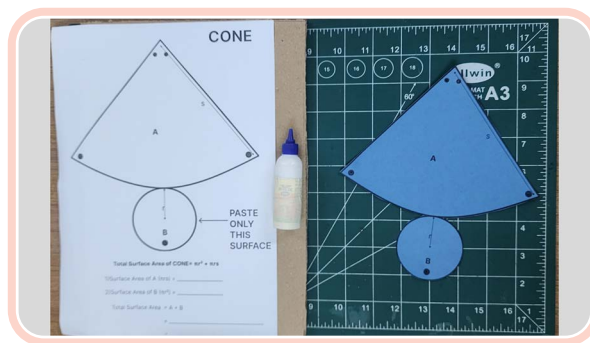
- There are two pages for each shape. The first page includes 2D net for that particular shape and the second page contains the formulas for surface area for that shape. For each shape, print the first page that includes 2D net on A4 size colored cardstock paper. The second page can be printed on A4 size white paper.

2. Activity:

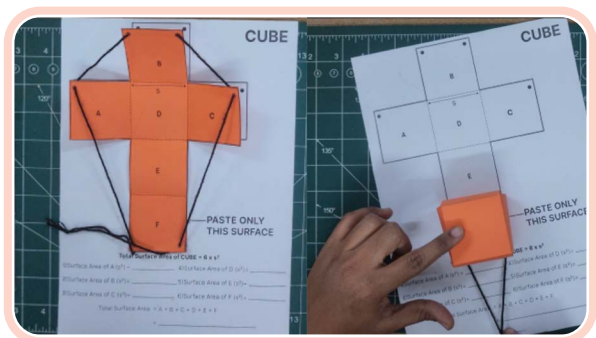
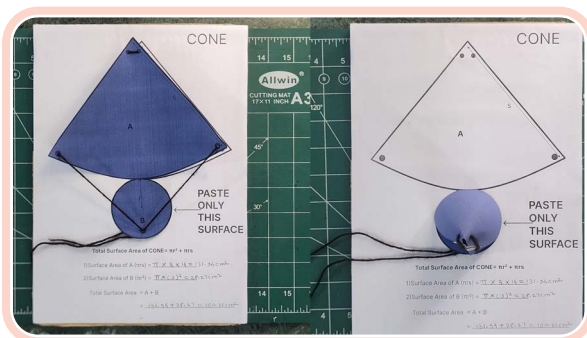
- Distribute pre-designed templates of 2D nets for shapes like cubes, cuboids, pyramids, prisms, etc.
- Click the link or scan QR code to watch the DIY cum working video of the project.
- Keep the page with formulae aside.
- Cut the 2D net from the template. Students cut along the solid lines and fold along the dotted lines to create 3D shapes.
- Then cut cardboard sheets to 21 x 29.7 cm (A4 size). First, paste the printed page with surface area calculations on the cardboard, then paste the 2D net on the designated area of the page.



<https://youtu.be/J59CGBgDPWU>



- Use a needle to make holes in the marked areas and weave strings through them to create the pull-up mechanism.



3. Surface Area Calculation:

- Refer to the video and explain how to calculate the surface area of each 3D shape using its 2D net.
- Students write calculated surface areas on the templates.
- Click the links or scan QR codes to watch the DIY cum videos to learn how to thread/weave the strings for different 2D nets.



https://youtu.be/kxhsZTPDd_Y?si=_LJ_7R-MLn0REjMg



<https://youtu.be/Jye1Y2qXbIo?si=Fx5KoKnyCYHZQY5A>

- Surface Area Calculation: Repeat the process of calculating and recording the surface areas for all other shapes.

How does the model work?

When the string threaded through a 2D net is pulled, it gets transformed to a 3D shape. Students can calculate the surface area of each 3D shape using its 2D net.

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of 3D shapes.
- How does the surface area of a shape relate to its 2D net?
- Check students' calculations on the templates for correctness.

Assessment of Project Understanding

- Monitor students as they cut, fold, and assemble 2D nets into 3D shapes to evaluate their ability to follow instructions, accuracy, and problem-solving skills.
- Ensure they use the provided formulas and understand how the surface area of a 3D shape corresponds to its 2D net.
- Assess how well students apply the concepts to new shapes beyond the provided templates.
- Display the pull-up models with calculated surface areas labelled and encourage peer reviews. This allows students to explain their work and receive feedback.

- Conduct a quick Q&A session to evaluate their understanding of the working of the Model.
 - o What challenges did you face during the activity, and how did you overcome them?
 - o How could these models be useful in real-life applications like design or packaging?
- Use their answers to gauge their conceptual understanding and ability to apply the knowledge.
- Observe the functionality of the project during testing and analyze its accuracy.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

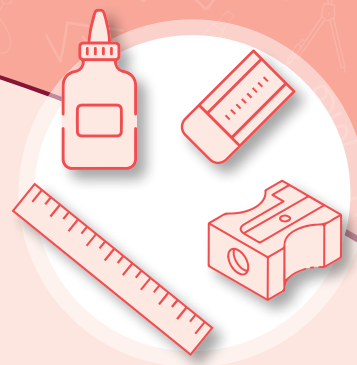
Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can extend the activity to include complex shapes like dodecahedrons, truncated pyramids, etc. to challenge students further.
 - Allow students to add creative touches, like colors, patterns, or textures, to their nets. This can integrate art and design into the lesson.
 - You can experiment with materials like plastic sheets, foam boards, or fabric to explore how different materials affect the construction and durability of models.
 - Connect with physics (e.g., exploring the strength of shapes in structures) or economics (e.g., cost-effectiveness of packaging materials).

Activity 21

Constructing a Pythagorean Theorem Model using Graph Paper and Cardboard



Grade ▶ **8, 9 and 10**



Subject ▶ **Mathematics**



Topic/ Concept ▶ **Triangles and its Properties**

Objective

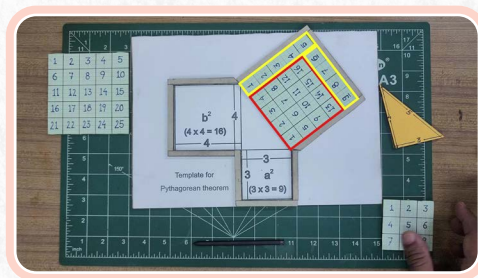
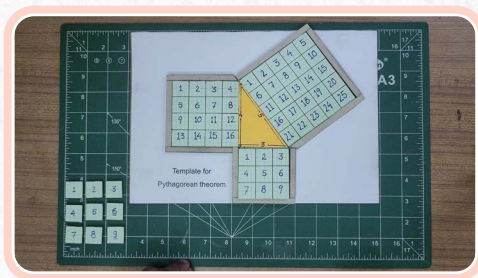
To reinforce understanding of the Pythagorean theorem using tangible visual models.

What will you help students learn?

- Understand that the areas of squares on the triangle's legs add up to the square on the hypotenuse.
- Understand the relationship between the sides of a right-angled triangle.
- Visualize the geometric proof of the Pythagorean theorem through a hands-on activity.
- Construct a 3D model illustrating the Pythagorean Theorem.
- Application of $a^2 + b^2 = c^2$ in real-life scenarios.
- Understand mathematical proofs through visualization.

What will you build/make?

A Pythagorean Theorem Model using Graph Paper and Cardboard.



Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/TgcgCQI5Xfs>

What will you need?

Materials Needed

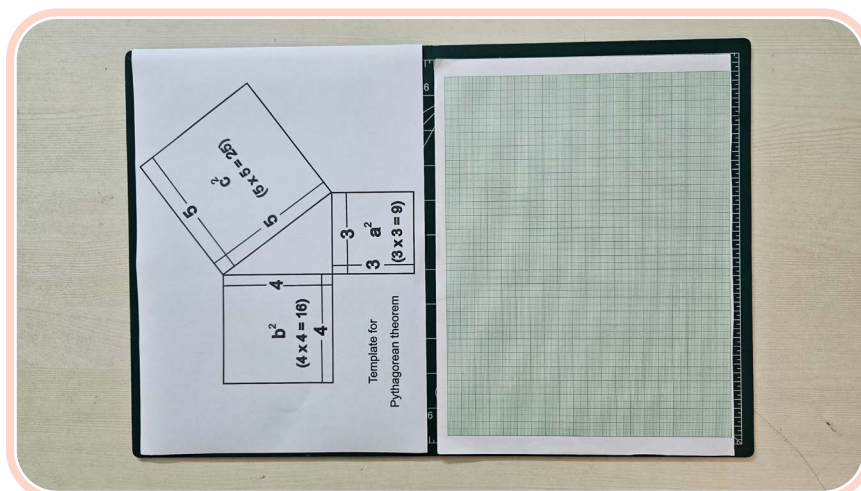
- Graph Paper
- Printable Template of the Pythagorean Theorem (Link to download the template is given in the procedure)
- Cardboard
- Ruler
- Pencil
- Scissors
- Eraser
- Sharpener
- Color Markers
- Paper Glue
- Cardboard Pieces

ATL Tools/Equipment

- Scissors
- Cutting Mat
- Ruler
- Pencil and Eraser
- Color Markers

Software/Application

- GeoGebra (Web based application)- Optional

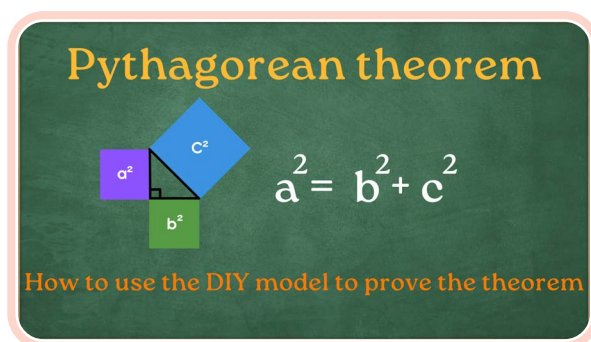


Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

- Begin with a brief explanation of the Pythagorean theorem using the formula $a^2 + b^2 = c^2$.

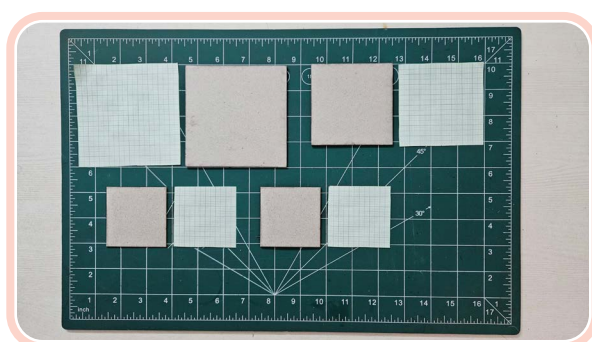


2. Drawing Squares on a Graph Paper:

- Distribute graph paper to each student.
- Using a ruler and pencil, guide students to draw 3 squares on the graph paper corresponding to-
 - 1st Square: a^2 :** This square will be of dimensions 3 units x 3 units. Since 1 unit = 2 cm, they will draw a square of 6 cm x 6 cm on a graph paper.
 - Make 2 such squares of a^2 on graph paper.
 - 2nd Square: b^2 :** This square will be of dimensions 4 units x 4 units. Since 1 unit = 2 cm, they will draw a square of 8 cm x 8 cm on a graph paper.
 - 3rd Square: c^2 :** This square will be of dimensions 5 units x 5 units. Since 1 unit = 2 cm, they will draw a square of 10 cm x 10 cm on a graph paper.

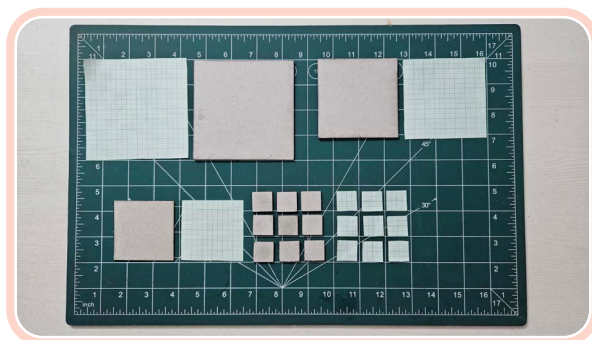
3. Cutting the Squares on Graph Paper and on Cardboard:

- Instruct students to neatly cut out the 4 squares drawn on the graph paper using scissors.
- Similarly, ask students to cut 4 squares of the same dimensions on cardboard.



4. Cutting one of the two pieces of a^2 (3 units x 3 units) drawn on Graph Paper and on cardboard sheet into 9 pieces:

- Ask students to cut the extra square of a^2 (3 units x 3 units), they had cut from the Graph Paper and cardboard sheet, into 9 pieces.
- Size of the smaller squares will be 1 unit x 1 unit. Refer to the image.

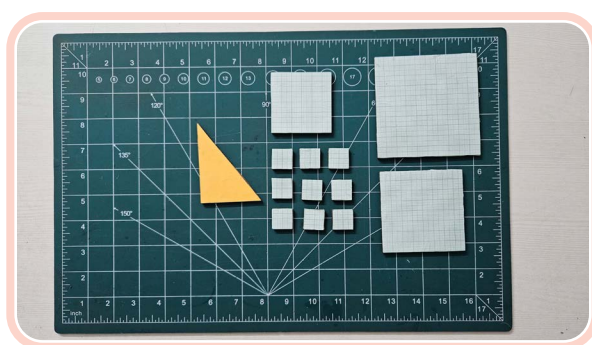


5. Making a right-angle triangle as per the given dimensions:

- Instruct students to neatly draw a right-angled triangle with base = 6 cm (3 units) and height = 8 cm (4 units) on a colored craft paper and on the cardboard.
- Cut these triangles.

6. Pasting Squares Drawn on Graph Paper and Triangle Drawn on Color Craft Paper on their corresponding Cardboard pieces:

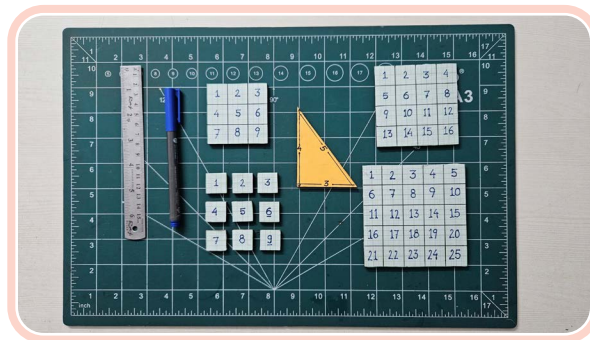
- Ask students to paste the graph paper squares onto the corresponding cardboard squares using paper glue.
- Paste the colour paper triangle on the cardboard triangle using paper glue.
- Ensure alignment and neatness.
- Let the glue dry.



7. Writing numbers inside the squares:

- Draw lines inside the squares to form the grid of 1 unit x 1 unit (2 cm x 2 cm).
- Use a color maker pen to write the numbers inside as shown in the image.

- Also draw the dimensions on the triangle (base = 3 units x height = 4 units, hypotenuse = 5 units)

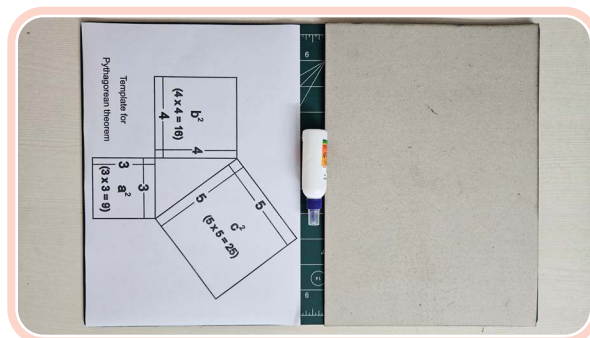


8. Assembling the 3D Model:

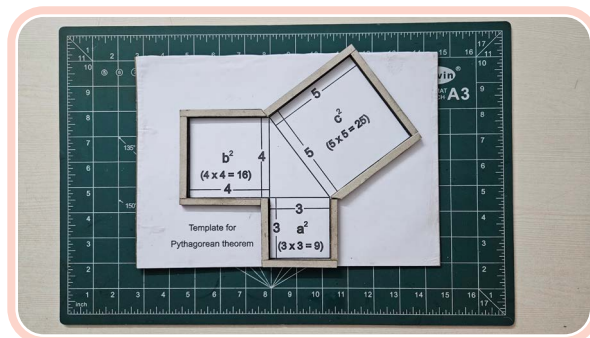
- Click the link or scan QR code to download and print the Pythagorean theorem template on A4 size white paper.
- Cut one cardboard sheet corresponding to a size of A4 paper.
- Paste the printed Pythagorean theorem template on the cardboard sheet (of A4 size).



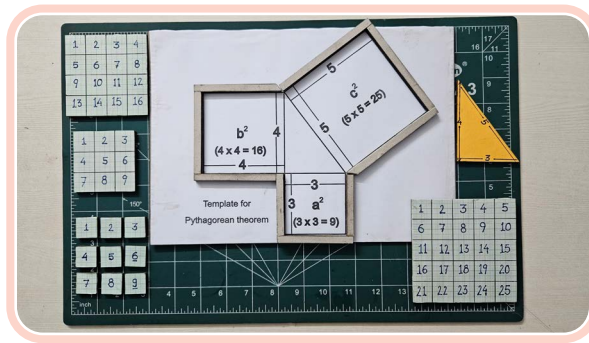
<https://tinyurl.com/4yftd7ze>



- Provide additional cardboard pieces to form raised boundaries around each square marked on the printed template.
- Use glue to paste these boundaries, creating a 3D representation of the squares a^2 , b^2 , and c^2 .



- Students can arrange the pieces on the 3D model as shown in the image below.



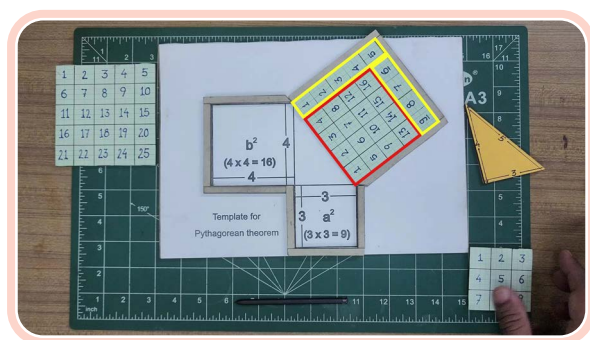
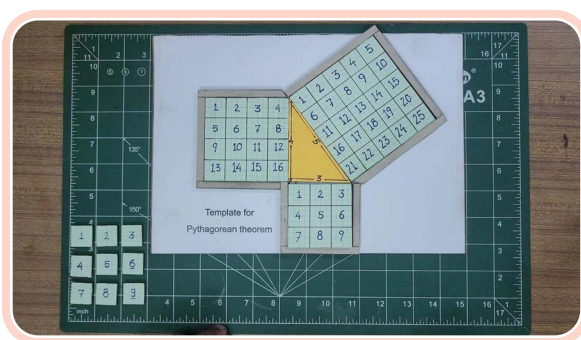
How does the Pythagorean Theorem Model work?

1. Demonstration and Explanation:

- Click the link or scan QR code to watch DIY cum working video of the project.
- Engage the class in a discussion about how the areas of a^2 and b^2 combine to equal c^2 .
- Testing the Pythagorean Theorem Model:
 - Place the right-angle triangle on the template.
 - Place the square of 5 units (c^2) along the hypotenuse of the right-angle triangle.
 - Place the square of 4 units (b^2) along its height.
 - Place the square of 3 units (a^2) along its base.
 - Ensure the squares are firmly placed.



<https://youtu.be/TgcgCQI5Xfs>



- Remove the 5 units square (c^2) on the hypotenuse and place the square of units (b^2) on it.
- Try to fill in the extra space along the 4 units square (b^2) with the nine 1 unit-squares. They will fit in perfectly.
- This proves that $5^2 = 4^2 + 3^2$

2. Web-based simulation to prove the Pythagorean Theorem (Optional):

- Click the link or scan QR code to go to GeoGebra, a web-based simulation tool, where students can simulate the Pythagorean theorem. Use the same dimensions that we used in our cardboard model.



<https://www.geogebra.org/m/f7UdJmAb>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of the Pythagorean Theorem.
- What does the Pythagorean theorem tell us about right triangles?
- How does creating a model help in understanding the theorem better?
- Can this theorem be applied to other types of triangles? Why or why not?
- Where is this theorem used in real-world applications and why is it important?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Check for creativity and accuracy in developing the model.
- Evaluate their understanding of the working of the Pythagorean Theorem Model. Ask them to demonstrate the model
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project.
(Rubric for this is provided in the note for the teacher)

Design Thinking/Extensions and Modifications

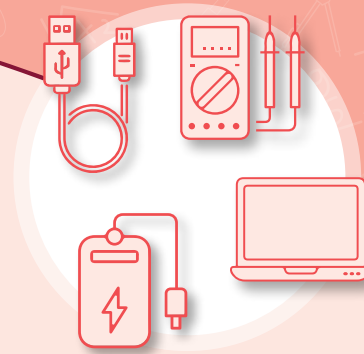
Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

How can you modify this model?

- Construct models with different Pythagorean Triples like (5, 12, 13) or (8, 15, 17).
- Use the Web-based simulation application called 'GeoGebra' to simulate Pythagorean theorem as mentioned earlier.
- Have students calculate the areas of the squares for any given dimensions of the triangle by calculations first and then verify it with the GeoGebra simulation results.

Activity 22

Building a Temperature and Humidity Monitoring System with Data Visualization



Grade

8, 9 and 10



Subject

Mathematics



Topic/
Concept

Data Handling, Graphs and Charts, Graphical representation of statistical data

Objective

The reinforce concepts in data collection, visualization and analysis using IoT.

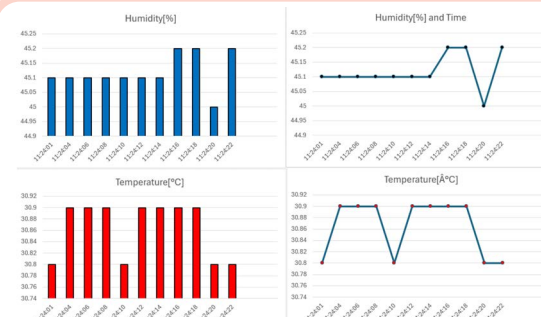
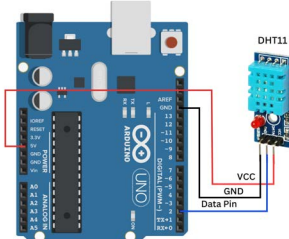
What will you help students learn?

- Learn to interface sensors with Arduino for data collection.
- Understand how to use Arduino Cloud for logging data in real time.
- The working principles of digital temperature and humidity sensors.
- Skills in data preprocessing and formatting for visualization like column and line charts using Microsoft Excel.
- A practical understanding of IoT (Internet of Things) and data-driven decision-making.
- Interpret time-series data for temperature and humidity and recognize trends or anomalies in environmental monitoring.
- To present their findings through graphs and visual data representation.

What will you build/make?

A system with Data Visualization, which will collect and plot the temperature and humidity data in the form of Column and Line charts using Microsoft Excel.

Circuit Diagram of Temperature and Humidity data logger System



Click the link or scan QR code to watch
DIY cum working video of the project.



<https://youtu.be/4vQDinlpXUA>

What will you need?

Materials Needed

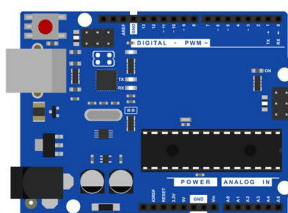
- Arduino Uno
- DHT11 sensor
- Breadboard
- Jumper Cables
- USB Cable
- Power Supply (USB Power Bank)

ATL Tools/Equipment

- Computer with Arduino IDE and MS Excel software
- Multimeter (Optional)
- Internet connection

Software/Application

- Arduino IDE software- To write and upload program to the Arduino microcontroller.
- Arduino Cloud- To collect and download the real-time data of temperature and humidity in .csv format.
- Microsoft Excel -To plot the collected data in column and line charts for visualization



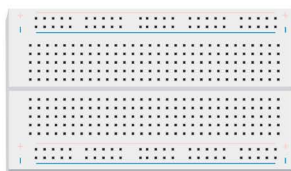
Arduino Uno



DHT-11 sensor



Arduino cable



Breadboard (Optional)



Jumper wires



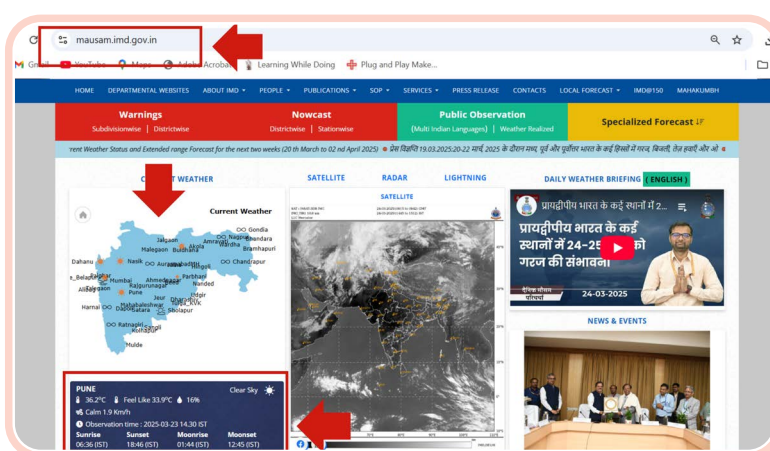
Laptop with Arduino IDE and MS Excel software

Procedure

Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

1. Introduction:

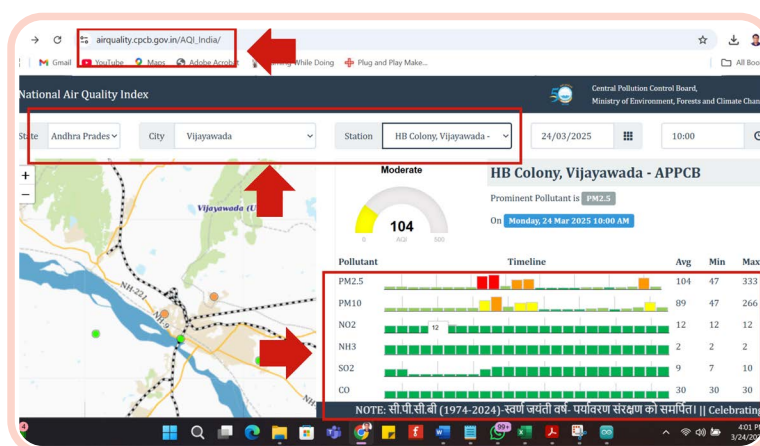
- Begin with a short discussion on the importance of measuring environmental parameters like temperature and humidity.
- Explain real-life applications of collecting temperature and humidity data: agriculture, weather forecasting, HVAC (Heating, ventilation, and air conditioning) systems, healthcare, and smart homes.



- Click the link or scan QR code to visit the website of the Indian Meteorological Department to see the weather forecast of your town.
- Explain real-life applications of collecting other environmental data like: AQI- Air Quality Index, CO₂, Ozone, Noise pollution, etc.



<https://mausam.imd.gov.in/>



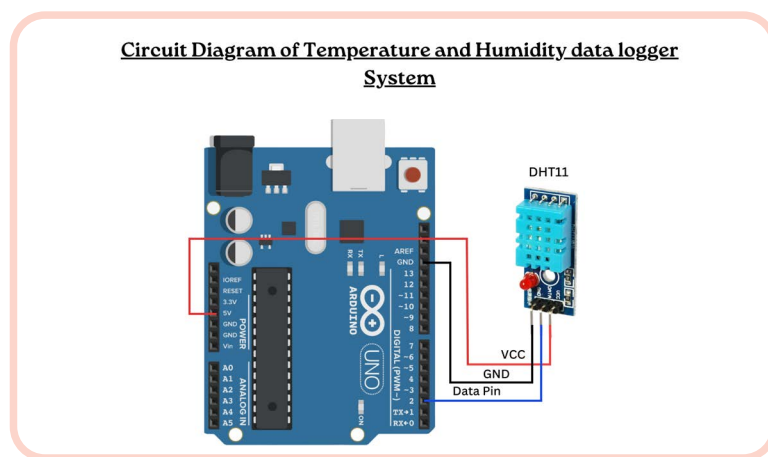
- Click the link or scan QR code to visit the website of Central Pollution Control Board to see the real-time data of AQI (Air Quality Index) of your town.
- Show examples or data to highlight how temperature and humidity affect human comfort, material preservation, and system performance.
- Introduce the components (Arduino uno, DHT11 sensor) and describe their role in the project.
- Outline the goal: to build a system that collects and visualizes this data using accessible tools like Arduino and Microsoft Excel.



https://airquality.cpcb.gov.in/AQI_India/

2. Hardware Setup:

- Refer to the circuit diagram for setting up the components.



- Connect the DHT11 sensor to the Arduino:
 - o VCC pin of DHT11 → 5V on Arduino.
 - o GND pin of DHT11 → GND on Arduino.
 - o Data pin of DHT11 → Digital Pin 2 on Arduino.

3. Write and upload the Arduino Code:

- Open Arduino IDE and copy the code given to read and display temperature and humidity data. Click the link or scan QR code to download the code (.ino file).
- You can also copy the code given here and paste in the Arduino IDE.



<https://tinyurl.com/4fjnjk4>

```

unsigned long timeNow = 0;
unsigned long timeLast = 0;
int startingHour = 11;
int seconds = 0;
int minutes = 24;
int hours = startingHour;
int days = 0;
int dailyErrorFast = 0;
int dailyErrorBehind = 0;
int correctedToday = 1;
#include "DHT.h"
#define DHTPIN 2
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
void setup() {
  Serial.begin(9600);
  dht.begin();
}
void loop() {
  delay(2000);
  timeNow = millis()/1000;
  seconds = timeNow - timeLast;
  if (seconds == 60) {
    timeLast = timeNow;
    minutes = minutes + 1;
  }
  if (minutes == 60){
    minutes = 0;
    hours = hours + 1;
  }
}

```

```

if (hours == 24){
  hours = 0;
  days = days + 1;
}
if (hours ==(24 - startingHour) &&
correctedToday == 0){
  delay(dailyErrorFast*1000);
  seconds = seconds +
dailyErrorBehind;
  correctedToday = 1;
}
if (hours == 24 - startingHour + 2)
{
  correctedToday = 0;
}
Serial.print(hours);
Serial.print(":");
Serial.print(minutes);
Serial.print(":");
Serial.print(seconds);
Serial.print(",");
float h = dht.readHumidity();
float t = dht.readTemperature();
if (isnan(h) || isnan(t)) {
  Serial.println(" Failed to read from
DHT sensor!");
  return;
}
Serial.print(" Humidity[%] ");
Serial.print(h);
Serial.print(",");
Serial.print(" Temperature[°C] ");
Serial.println(t);
}

```

- Install the required Arduino library for DHT11 sensor if you do not have this library installed on your computer.
- To install this library, first click the link or scan QR code to download this library on your computer.
- Then, click the link or scan QR code to watch the video to learn how to install the library on your computer.



<https://tinyurl.com/4vxaj8u5>



https://youtu.be/apVl1c_9kY

- To install the DHT library using an alternative method, you can click the link or scan QR code to watch the video.
- Upload the code to the Arduino board. Open the serial monitor and read the temperature and humidity data from the DHT11 sensor. Click the link or scan QR code to watch the video to learn how to upload the code and read the data on the serial monitor.



<https://youtu.be/8mheXTUTzBc>



<https://youtu.be/NXtr44bekuo>

4. Set up an Arduino Cloud account:

- Open Arduino Cloud in your browser.
- Setup your account on Arduino cloud.
- Click the link or scan QR code to watch the video to learn how to set-up your Arduino Cloud Account.



<https://youtu.be/50QTJNrM4oU>

5. Data Collection and Download:

- Once inside the Arduino cloud, click on the 'CREATE NEW' sketch option and open a new sketch.
- It will prompt you to download 'Arduino Cloud Agent' if you are using the Arduino cloud for the first time with your account. The Arduino port will not be detected until it downloads and installs the 'Arduino Cloud Agent'.
- Run the same Arduino code for temperature and humidity in a new sketch within the Arduino cloud.
- Open the serial monitor in the Arduino cloud and you will see that the sensor has started sending the temperature and humidity data on the Arduino cloud.
- Once it records the data for a certain time period (depending on how long you want to plot the data for), download the data in .csv format from Arduino Cloud. The .csv file should contain columns for Timestamp, Temperature, and Humidity data.
- Click the link or scan QR code to watch the video to learn how to download the Arduino cloud agent and also to download the recorded sensor data from Arduino cloud in .csv format.

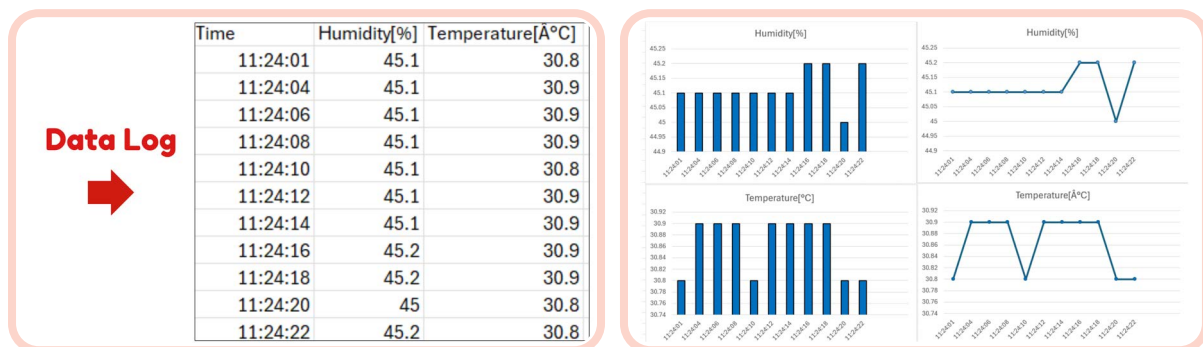


https://youtu.be/YG_zGZU-YfM

6. Data Visualization in Microsoft Excel:

- Open the .csv file in Microsoft Excel. (Avoid altering the .csv file format before importing it into Excel and always save and back up the .csv file to avoid data loss.)

- Organize the data into columns labelled as:
 - o Timestamp
 - o Temperature
 - o Humidity
- Plot the data:
 - o Create the line charts for temperature and humidity against time.
 - o Also, create the column charts to compare the temperature and humidity values at specific timestamps.



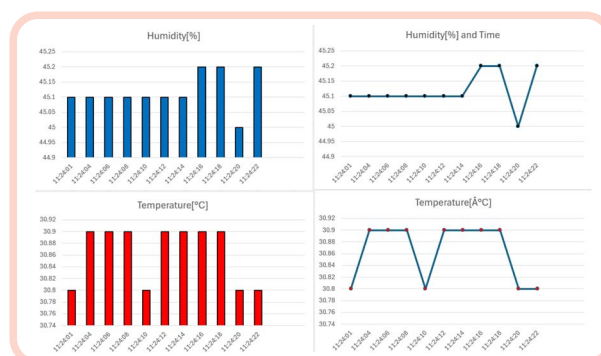
- Click the link or scan QR code to watch the video to learn how to use the downloaded temperature and humidity data in .csv format to plot the column and line charts using Microsoft Excel software.



https://youtu.be/f_246OxhwC8

7. Customize the charts:

- Add chart titles, axis labels and legends for better understanding of the chart.
- Format the columns and lines for clarity (e.g., use different colors for temperature and humidity).



- Click the link or scan QR code to watch the video to learn how to customize and format the charts in Microsoft Excel.



https://youtu.be/TLy94_5hE44

How does the model work?

The DHT11 sensor detects temperature and humidity from the surroundings. It sends this data to the Arduino board at a certain time interval. We can read this data on the serial monitor of an Arduino IDE software. However, we cannot download the data directly from there to plot it in the form of column and/or line charts. So, to make it possible, we are using the Arduino cloud to download the data in the format that excel can read it. The Arduino code has also been written in such a way that it records the data of temperature and humidity with timestamp. We are using Microsoft Excel software to plot the collected data of temperature and humidity against the time in the form of column and line charts.

Click the link or scan QR code to watch the video of the complete project from start to end.



<https://youtu.be/4vQDinlpXUA>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of Data collection.
- Ask the following questions:
 - What data did you collect in this project?
 - How does data visualization enhance the interpretation of collected data?
 - What is the relationship between temperature and humidity?
- How and why do the temperature and humidity readings vary with time?

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and correctly assemble and operate the set up.
- Observe the functionality of the project during testing and analyze its accuracy.
- Assess the correctness of the hardware setup.
- Verify the accuracy of the data collected (cross-check with the values of temperature and humidity from the known source).
- Evaluate the quality of the Excel charts (clarity, labelling, and interpretation).
- Conduct a quick Q&A session to evaluate their understanding of the project developed for monitoring the temperature and humidity with data visualization.
 - How do we see the variation in these values on a graph?
 - What are the practical applications of temperature and humidity monitoring systems?
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can add a Real-time clock (RTC) module to enhance timestamp accuracy.
 - You can try implementing wireless data transmission using Wi-Fi or Bluetooth modules connected with Arduino uno or use microcontrollers like ESP32, which have in-built wifi and Bluetooth functionality.
 - Use additional sensors (e.g., light or pressure) and visualize multidimensional data.
 - You can automate data plotting using Python or another scripting language.

Activity 23

Creating Pie Charts using Teachable Machine, Image Recognition and MS Excel



Grade

8, 9, and 10



Subject

Mathematics



Topic/
Concept

**Data Handling,
Graphs and Charts,
Graphical representation
of statistical data**

Objective

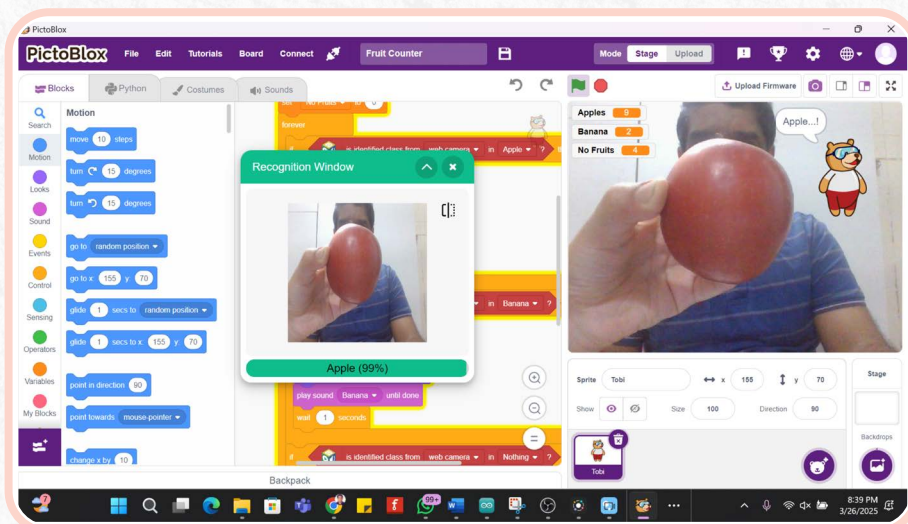
To reinforce concepts in data handling by creating Pie Charts using Machine Learning, Image Recognition and MS Excel.

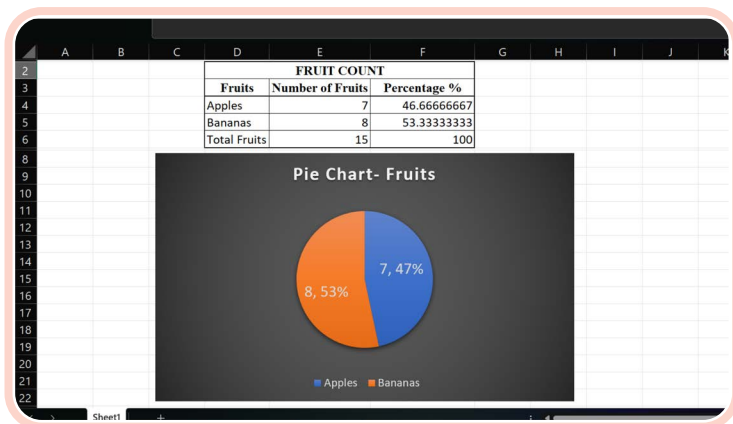
What will you help students learn?

- Learn basic machine learning concepts, image recognition technology and their real-world applications.
- To train, test, and troubleshoot ML model.
- The importance of data quality and variety in training accurate ML models.
- Gain experience in data collection and analysis using Excel.
- Understand data representation and visualization through charts.

What will you build/make?

A Machine Learning Model using Google's Teachable Machine to recognize images and implement it in PictoBlox to count objects (fruits).





<https://youtu.be/Jaf-kh1x8GI>

Click the link or scan QR code to watch DIY cum working video of the project.

What will you need?

Materials Needed

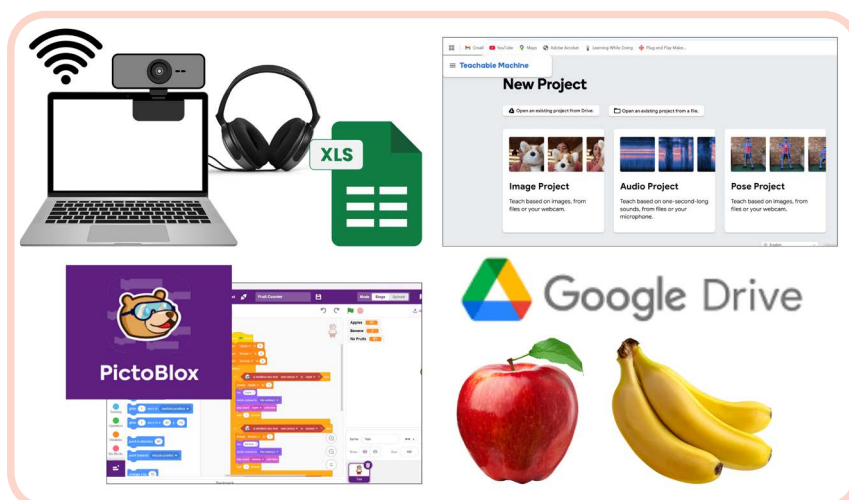
- Apples and bananas (preferably 2-3 of each with varying sizes and textures)

ATL Tools/Equipment

- Computer with PictoBlox Software, internet access and in-built webcam
- External Webcam (Optional- in case the computer does not have in-built webcam)
- Headphones with mic and Speakers
- Internet connection

Software/Application

- PictoBlox software with login credentials (used as a platform for implementing the ML model and developing block-based code)
- Google Teachable (A web-based tool to train image classification models used in PictoBlox)
- Microsoft Excel
- Google Drive



Procedure

The process of building the model is divided into 3 focused sessions:

Session 1:

- Introduction to data, types of charts, and pie charts.
- Introduction to Google Teachable Machine.
- Introduction to ML with Teachable Machine module in PictoBlox.

Session 2:

- Developing an ML model using Google Teachable Machine.

Session 3:

- Developing block coding for image recognition in PictoBlox
- Generating Pie Charts in Excel.

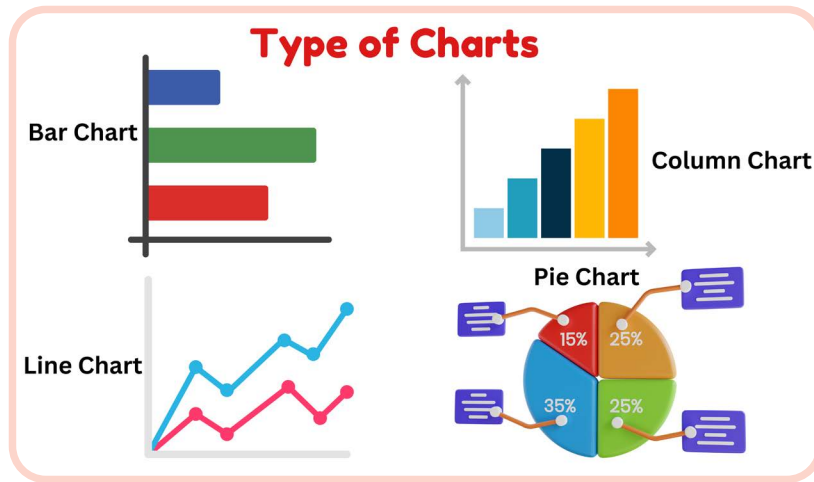
Please Note: Meanings of words in the activity plan you may want to know are given in the Annexure

Session 1: Introduction to Data Representation and Tools

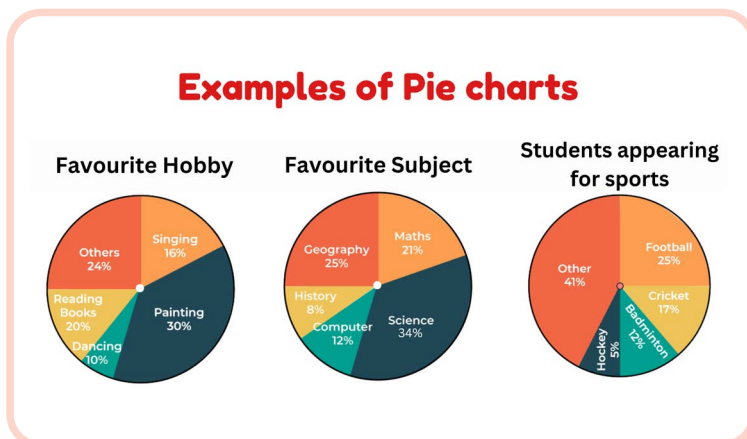
1. Understanding Data and Pie Charts:

- **What is Data and what is its importance?**
 - **Definition-** Data is information that is collected and organized for reference or analysis. It can be numbers, words, images, or observations that help us understand and make decisions about the world around us.
 - **Importance-** Data helps us make informed decisions, spot trends, and solve problems. In this activity, data is essential to count how many times each fruit is recognized so we can visualize the results in the form of a pie chart.
- **Types of Charts:**
 - **Bar Charts:** Represent data with rectangular bars where the length shows the value. Useful for comparing different categories.
 - **Column Charts:** Similar to bar charts but with vertical bars. These are useful for comparing data across different groups or time periods.

- **Line Charts:** Display information as a series of data points connected by straight lines. Great for showing trends over time.
- **Pie Charts:** Show data as slices of a circle, where each slice represents a proportion of the whole. Ideal for showing percentages and parts of a group.



- **Pie Charts:**
 - Explain pie charts with examples.



<https://www.youtube.com/watch?v=G6VeLmKOfZ8>

Click the link or scan QR code to learn more about pie charts.

2. Introduction to Google Teachable Machine:

- **What is Machine Learning (ML)?**

Machine Learning is a type of technology that helps computers learn from data and improve their performance over time without being explicitly programmed for each task. It's like teaching a computer to recognize patterns so it can make decisions or predictions on its own.

Examples in Real Life:

- **Voice Assistants** like Siri or Alexa that learn how to understand and respond to your questions.
- **Email filters** that recognize and send spam emails to your spam folder.
- **Face recognition** in mobile phones that unlock the device when it sees your face.
- **Self-driving cars** that learn to detect traffic signs and obstacles.

- **Introduction to Google's Teachable Machine:**

Google's Teachable Machine is a free, easy-to-use web tool that lets anyone train a simple machine learning model right in their browser. You don't need any coding skills to use it.

Features and Applications:

- o Train with Images, Sounds, or Poses: You can create models that recognize different types of input, like pictures, audio, or body movements.
- o Simple Interface: Just click to record examples for each class and train the model in seconds.
- o Exportable Models: Once trained, you can download or host the model online and use it in applications like PictoBlox.
- o Educational Use: Great for teaching the basics of artificial intelligence and machine learning.
- o Real-World Uses: Useful for building smart applications like object detection, gesture recognition, or custom voice commands.

Click the link or scan QR code to learn more about Google Teachable Machine.



<https://www.youtube.com/watch?v=SUonhsR9KCA>

3. Introduction to PictoBlox and ML Module:

- **Installation of the software:**

- o Guide students on how to install PictoBlox on a computer.
- o Click the link or scan QR code to download the software.



<https://tinyurl.com/bdewc3e6>

- **What is PictoBlox?**

- o Introduce PictoBlox block coding to the students.
- o Click the link or scan QR code to learn more about the PictoBlox Software.
- o Explain machine learning with the 'Teachable Machine' extension inside PictoBlox. Click the link or scan QR code to go through one such project.



<https://tinyurl.com/4y6x2wwh>



<https://www.youtube.com/watch?v=snPQ3N1dCkM>

Session 2: Developing an ML Model Using Google Teachable Machine

1. Preparation:

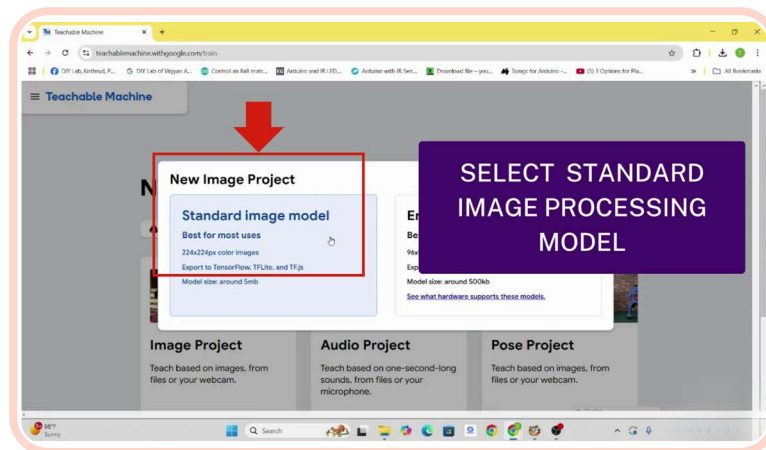
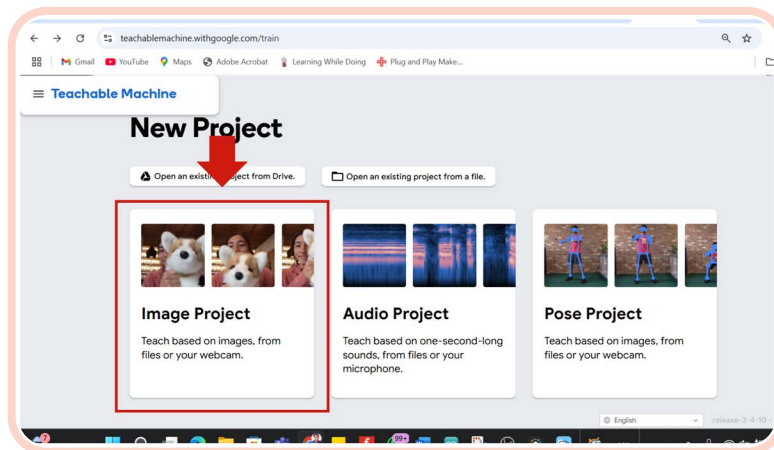
- Gather at least 2-3 different apples and bananas (varied size, texture, color).

2. Creating the Image Recognition Model:

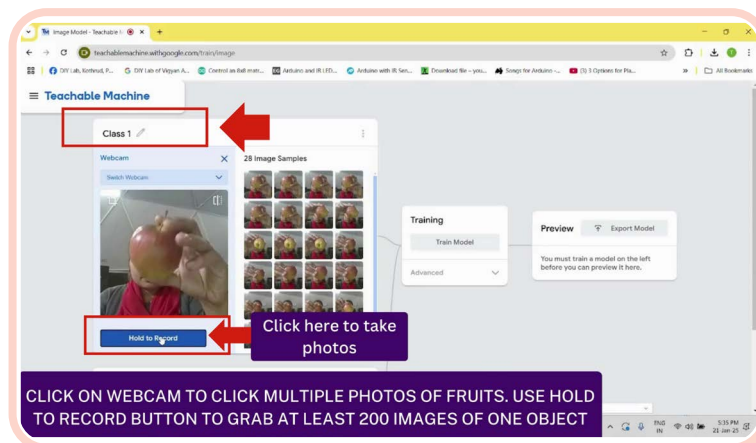
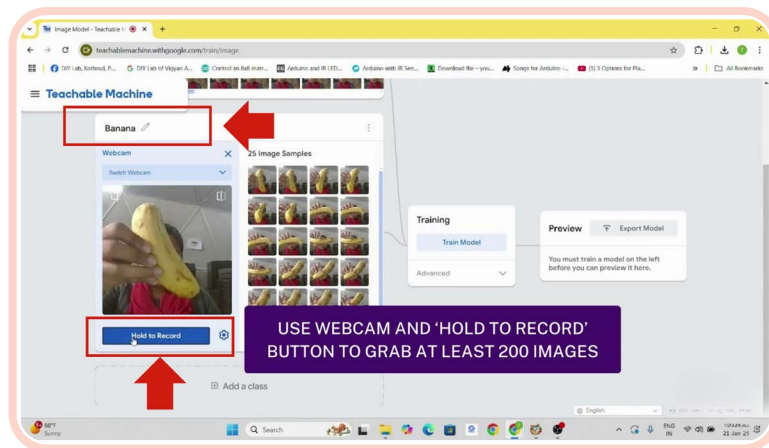
- Click the link or scan QR code to go to the website of 'Google Teachable Machine'.
- Select 'Standard Image Model' within 'Image Project' of 'Google Teachable Machine'.



<https://teachablemachine.withgoogle.com/>

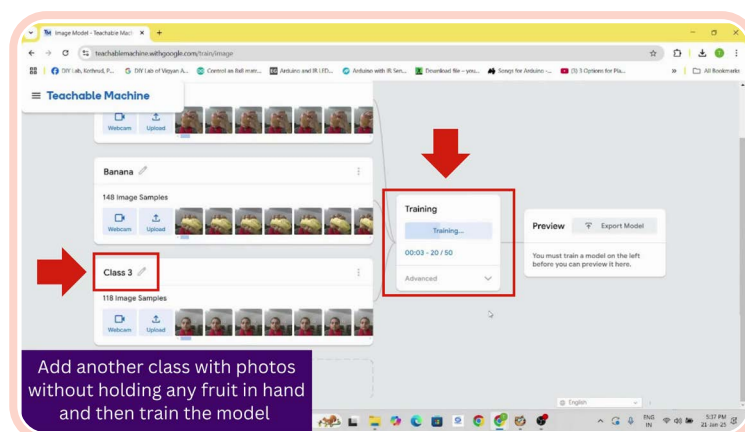


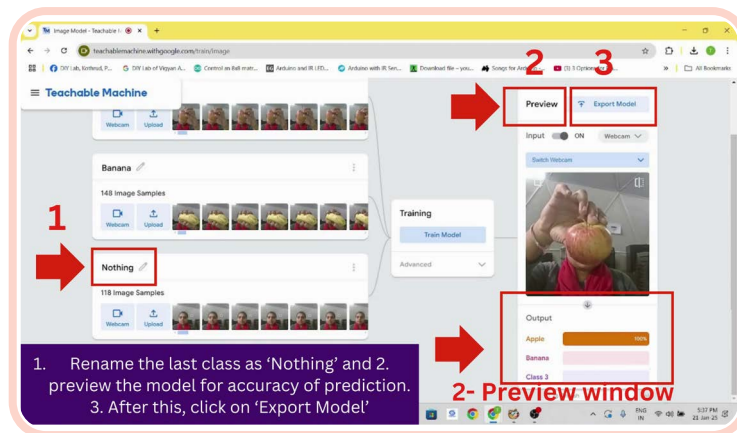
- Create a separate class for each fruit (Banana and Apple) and start capturing images using the webcam (at least 200 images for each class). Tips for accurate training:
 - Use good lighting.
 - Take images from multiple angles.
 - Ensure the background is neutral.



3. Training the Model:

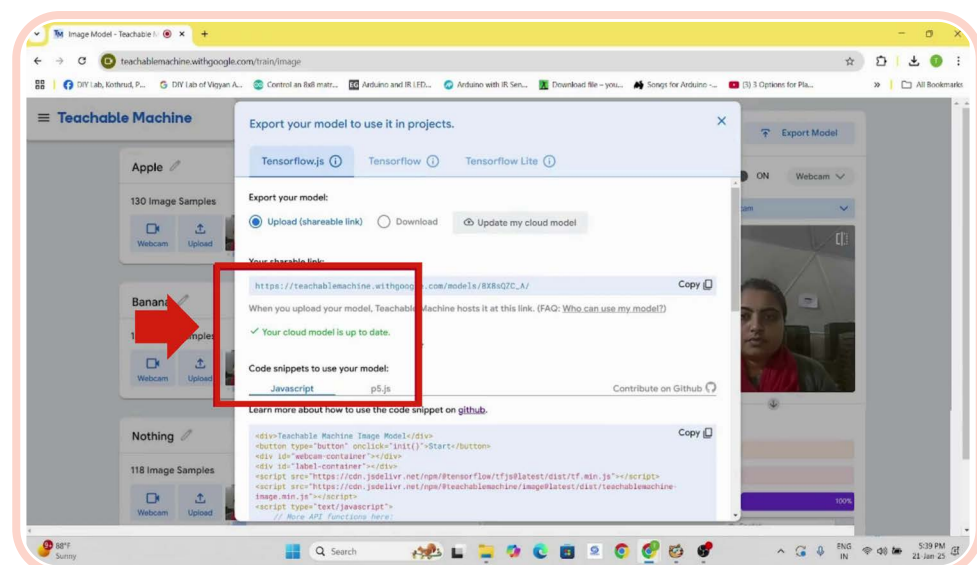
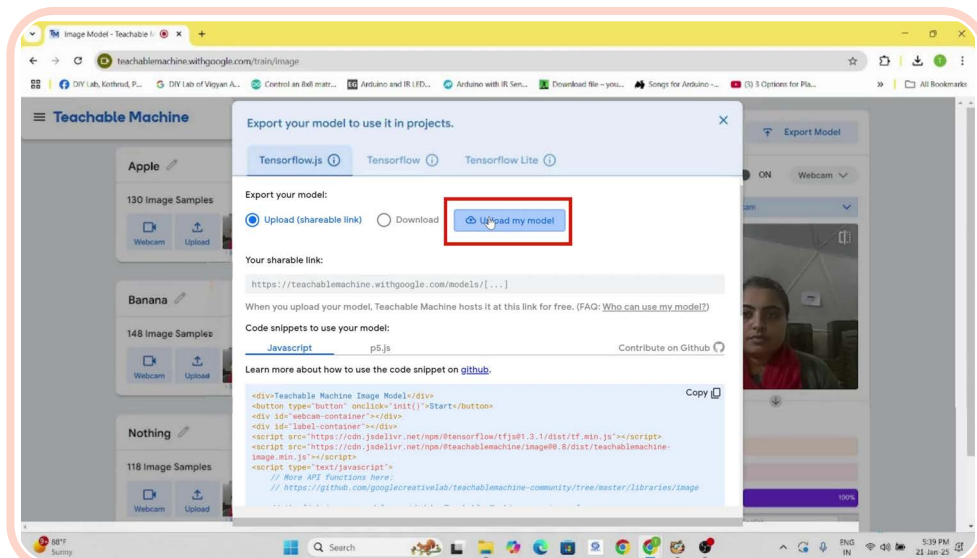
- After creating all the required classes, train the model.
- Once the training is complete, click on the 'Preview' button to test the model for the accuracy of prediction and adjust if necessary.
- For example, add more photos if the accuracy of prediction for the model is not good or add another class by clicking photos without holding any fruits in front of the camera. This is required for the model to predict only when there is a fruit in front of the camera.
- Once you are able to achieve a good level of accuracy of prediction, export the model either to your Google Drive or to the PictoBlox software directly.

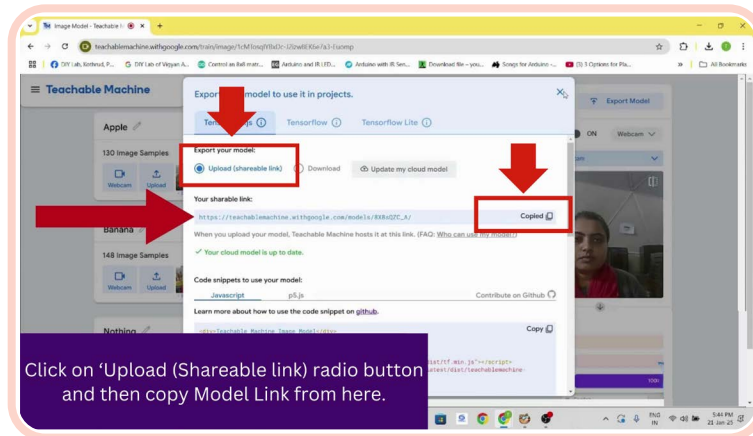




4. Exporting the Model:

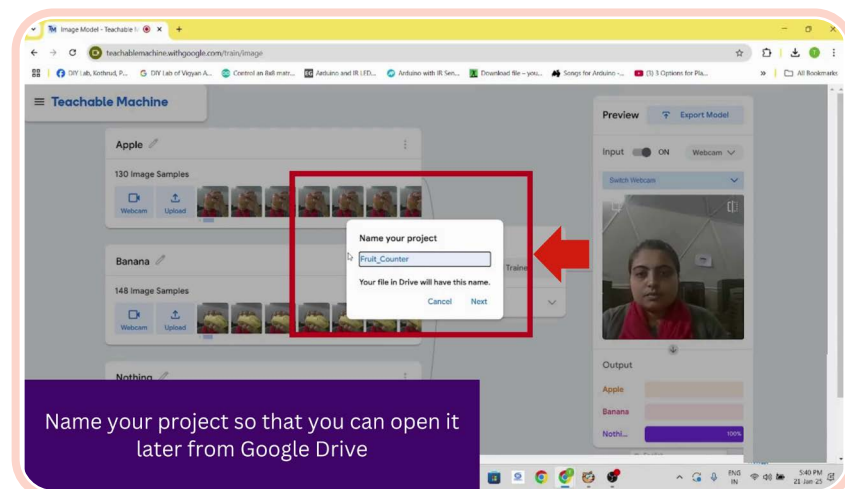
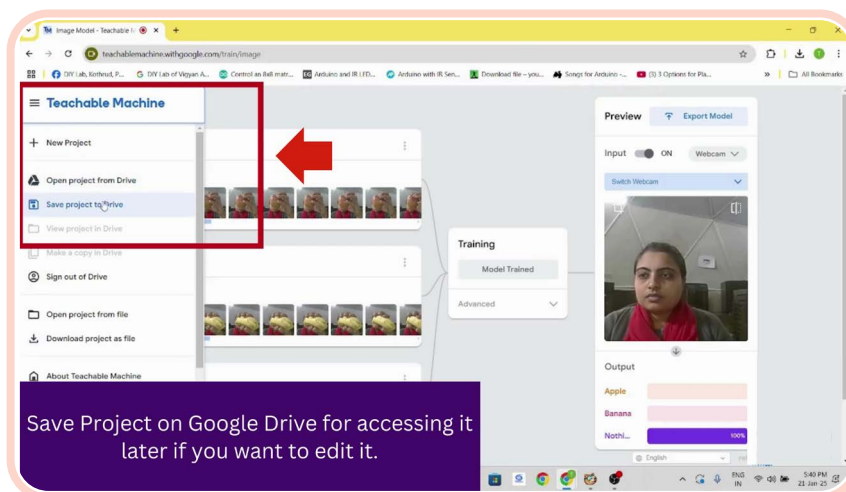
- Click on the 'Upload my model' button. This will upload the model to Google cloud.
- Click on 'Upload (shareable link) button and copy the link from the window to paste it directly into the PictoBlox software for block coding.

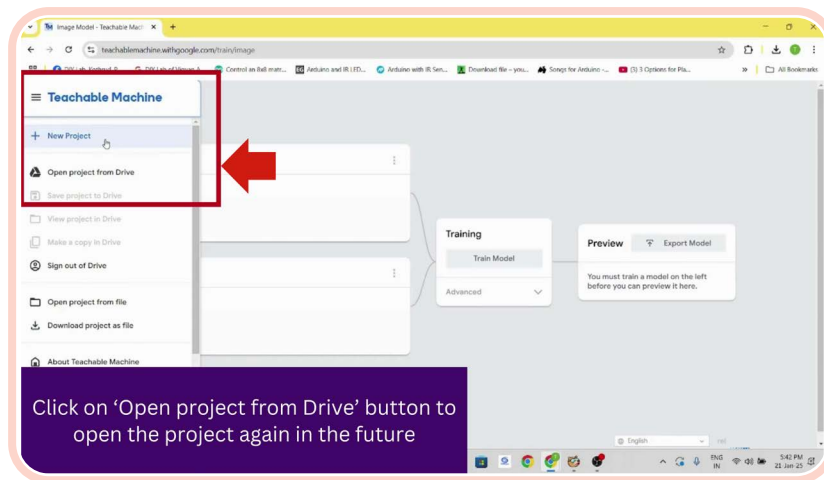




5. Re-opening the model from Google Drive (Optional- Required only in case you want to edit the 'Google Teachable Machine' model in future):

- Save the 'Google Teachable Machine' model on your Google Drive.
- If you want to edit the model in future, you can reopen this model by visiting the Google Teachable Machine website and click on the 'Open project from Drive' button.
- After editing the model, you have to re-train it before testing and using it again.



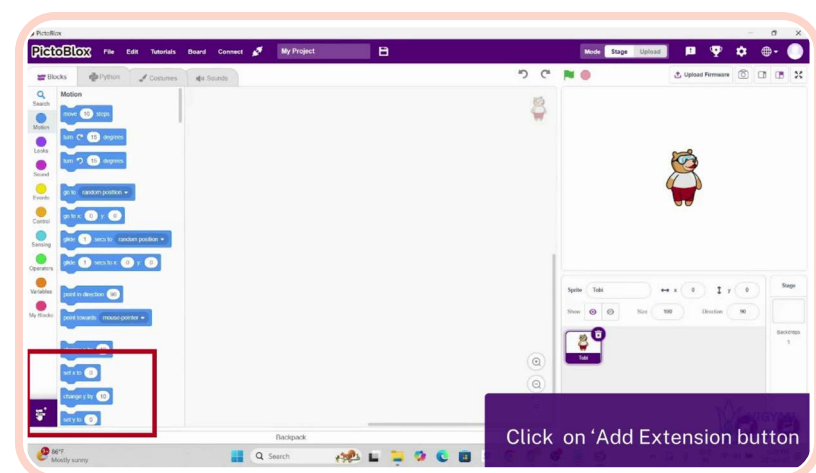
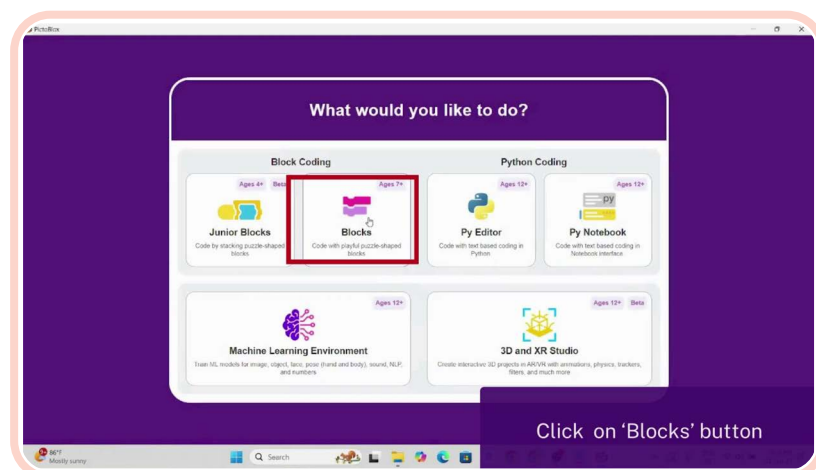


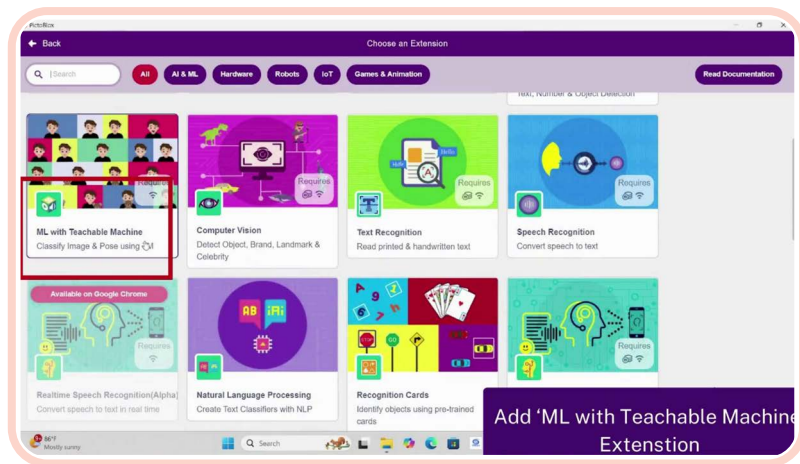
Session 3: Implementing the ML Model in PictoBlox

and Data Visualization

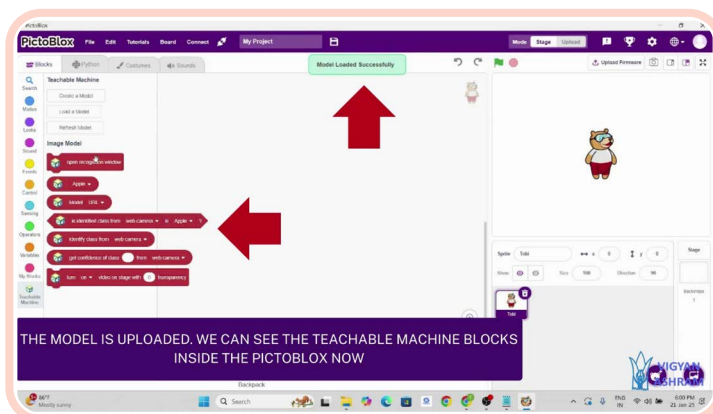
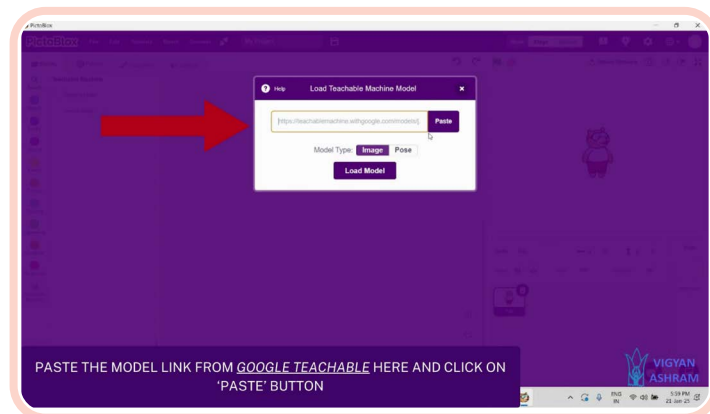
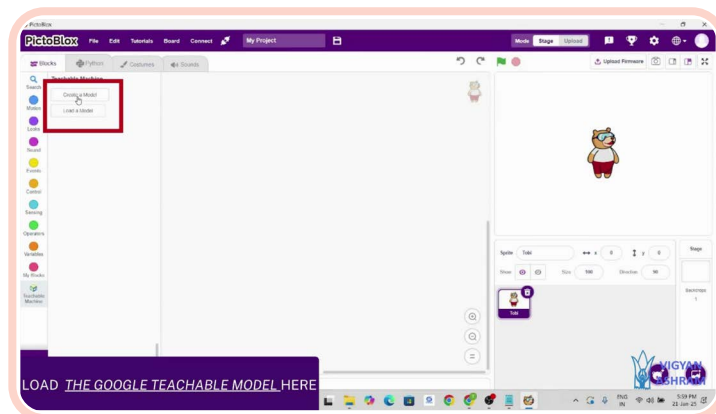
1. Integrating the ML Model into PictoBlox:

- Open PictoBlox 'Block coding' window and add ML with Teachable Machine extension.



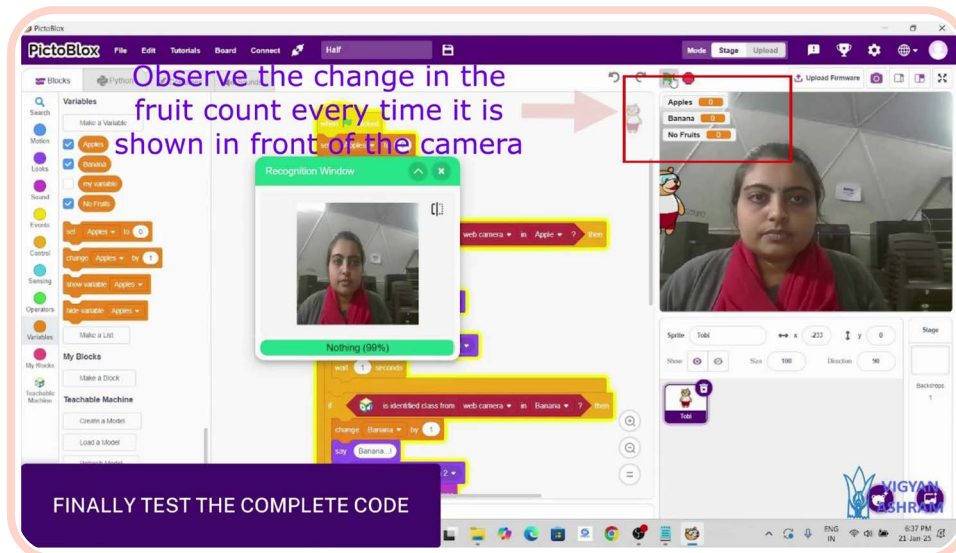
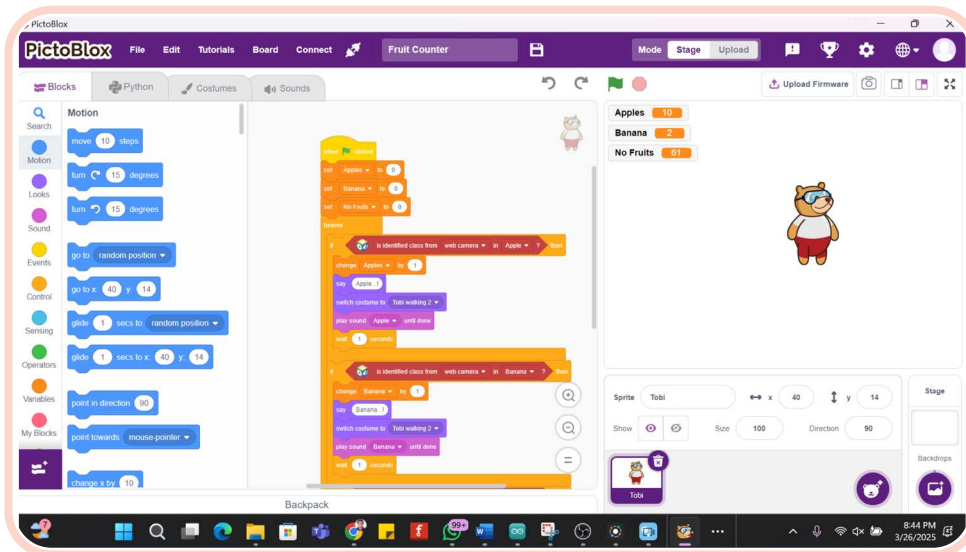


- Enter the model link to connect Teachable Machine with PictoBlox.



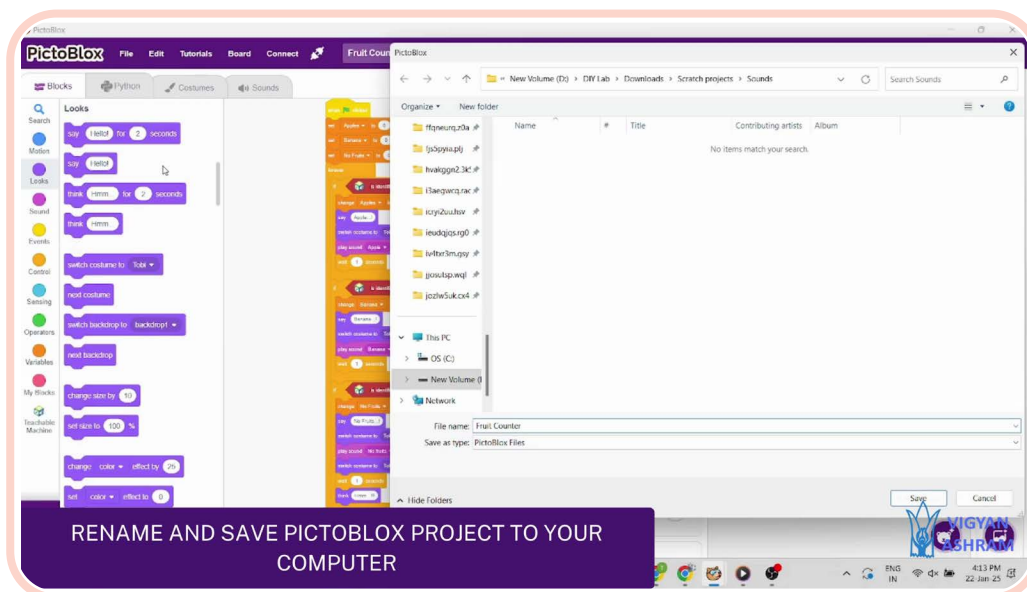
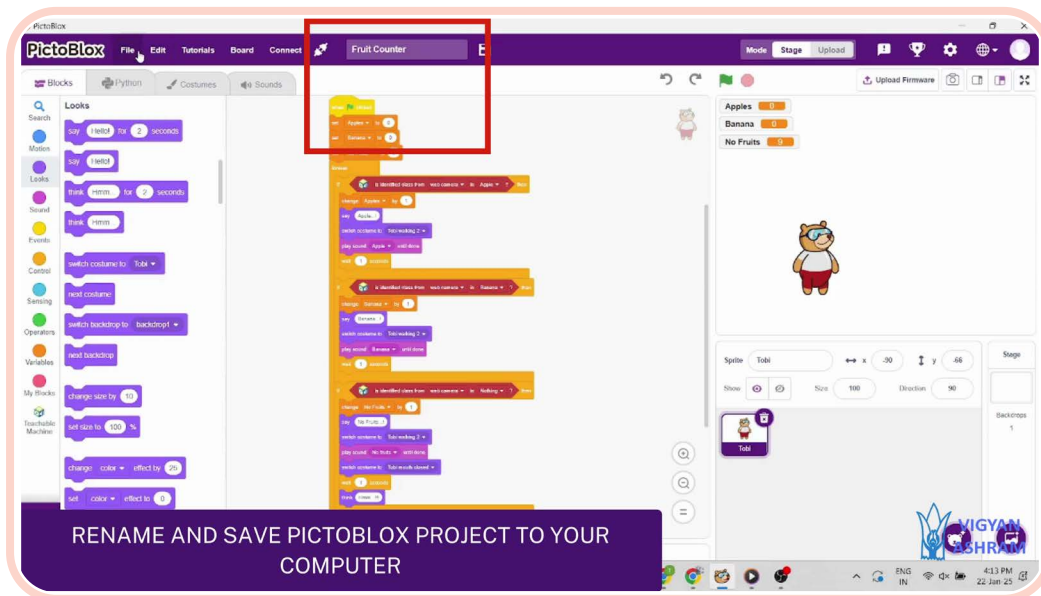
2. Developing the Recognition Program:

- Create a block-based program to to:
 - Recognize apples and bananas.
 - Display text and sound feedback (e.g., "Apple").
 - Create a counter for apples and bananas using variables.
 - Test the model within PictoBlox by clicking on the green flag and also opening the web camera in the stage window.



- Once you are sure of the model working as intended, save the PictoBlox model on your local computer.
- Test the program again after saving. Start showing the apple and banana in front of the web camera and observe the change in the fruit counter.

- Note the count of each fruit after your experiment is over.

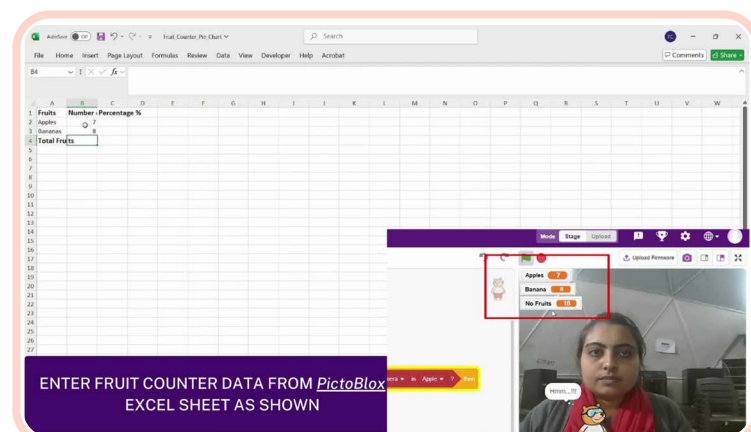
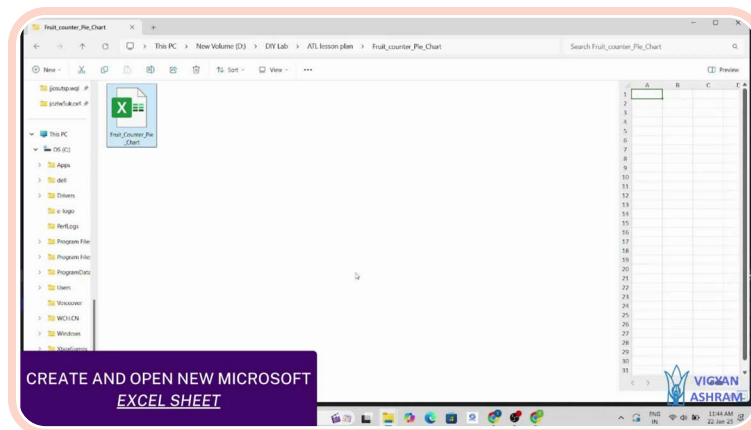


3. Data Collection and Interpretation:

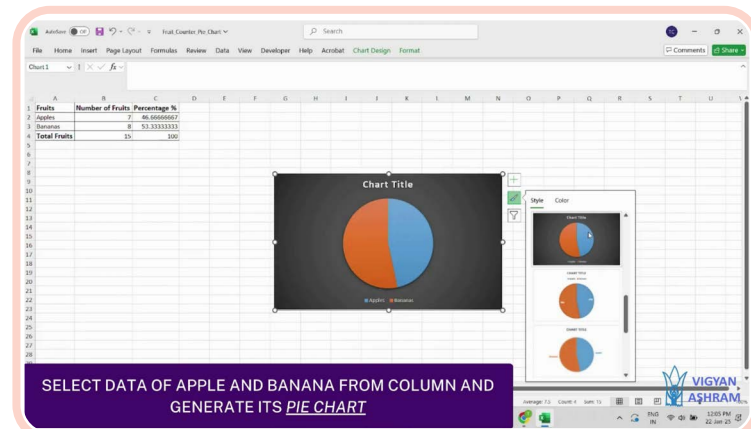
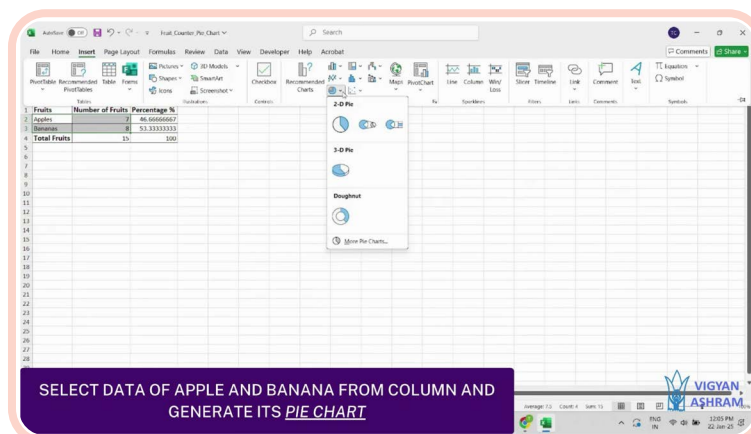
- Create a new Excel file in your computer and record the fruit count data from the PictoBlox program into the Excel file.
- Click the link or scan QR code to learn to create pie charts in Excel.



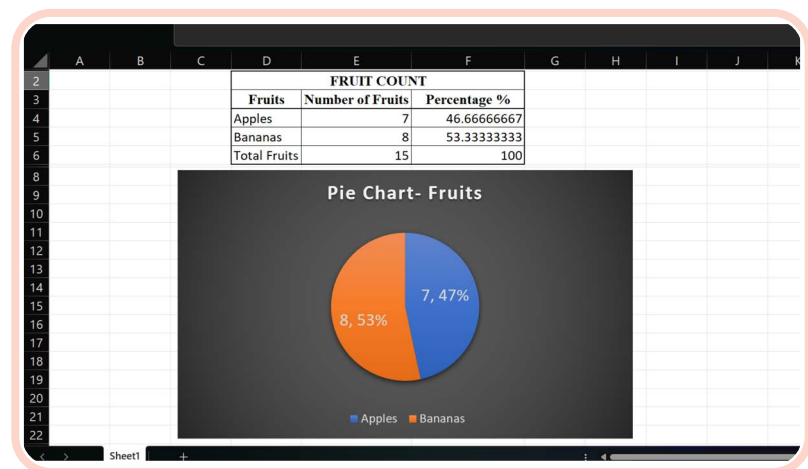
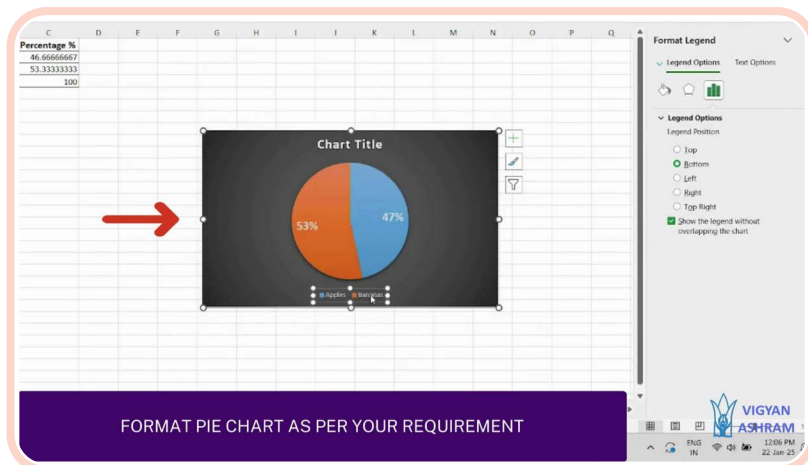
<https://www.youtube.com/watch?v=0WNjKBXyWMU>



- Create a pie chart to calculate the apple vs. banana percentage.



- Format the pie chart as per your requirements.



How does the Machine Learning model work?

The process begins by training a machine learning model using Google's Teachable Machine. Students take many images of fruits like apples and bananas using a web camera to create separate categories or "classes." The model learns to recognize these fruits based on their visual features.

This trained model is then imported into the PictoBlox software using the Machine Learning extension. When a fruit is shown to the webcam, the program identifies it and keeps a running count of how many apples and bananas are seen.

Once the counting is complete, the data (e.g., 7 apples, 3 bananas) is transferred to Microsoft Excel. There, students input the counts and generate a pie chart, which visually shows the proportion of each fruit recognized by the machine learning model. This activity helps students understand how ML can be used to collect and organize data and how that data can be visualized through charts.

Click the link or scan QR code to watch DIY cum working video of the project.



<https://youtu.be/Jaf-kh1x8GI>

How can you assess students' understanding?

Assessment of Concept Understanding

- Evaluate students' understanding of data collection.

Assessment of Project Understanding

- Observe and assess the students' ability to follow the procedure and train and export ML models.
- Ensure that PictoBlox correctly identifies fruits.
- Check if students record data and create charts correctly.
- Conduct a quick Q&A session to evaluate their understanding of the workflow of ML integration in PictoBlox.
 - o How does machine learning help in recognizing images?
 - o How does PictoBlox communicate with Teachable Machine?
 - o What factors can affect the accuracy of an ML model?
 - o How do pie charts/bar charts help in understanding data?
- Discuss the design and troubleshooting skills demonstrated during the activity.
- Ask- Where have you seen this application being used around you?

Assessment of Teamwork

Discuss individual contributions in group settings and award each group member the badges - 'Ideator, Goal Getter, Co-Creator and Questioner based on their involvement in the project. (Rubric for this is provided in the note for the teacher).

Design Thinking/Extensions and Modifications

Ask students the following questions and elicit answers from them. Some questions you can ask them and encourage them to think are given for your reference.

1. Can this model be used in real-life applications?
2. How can you modify this model?
 - You can train the ML model with other objects (e.g., oranges, pears).
 - Try using more categories and compare results.
 - Integrate more interactive elements (e.g., animations in PictoBlox).
 - You can automate data export from PictoBlox to Excel for direct chart creation.

Annexure – Glossary

SN.	Word/Term	Meaning
1	.txt / .csv	File formats used to store plain text data or tabular data.
2	1-Wire Digital Protocol	A communication method used by sensors like DS18B20 to send data using a single data line.
3	2D Net	A flat shape that can be folded into a 3D object
4	3.3V Battery	A small power source that supplies the necessary voltage to the circuit.
5	3D Model	A three-dimensional representation of an object
6	3V Coin Cell Battery	A small round battery providing 3 volts of power, used to light the LEDs.
7	Acceleration	The rate of change of velocity over time, measured in meters per second squared (m/s^2).
8	Acceleration Sensor	A component in the Phyphox app that measures the rate of speed change.
9	Acid-Base Reaction	A chemical reaction that produces CO_2 , water, and salt when vinegar reacts with baking soda.
10	Action and Reaction Forces	Paired forces acting on two interacting objects – as one exerts a force, the other responds with an equal and opposite force.
11	Acute Triangle	A triangle with all angles less than 90° .
12	ADC (Analog-to-Digital Converter)	A device that converts an analog signal (continuous data) into a digital signal (discrete values) for processing.
13	Additive Color Mixing	The process of creating color by mixing different colors of light, typically resulting in white when combined.
14	Aerodynamics	The way air interacts with moving objects, affecting speed and efficiency.
15	Algebraic Identity	A mathematical equation that holds true for all values of its variables, such as $(a+b)^2 = a^2 + 2ab + b^2$.
16	Algorithm	A step-by-step set of instructions used to complete a task, such as making the boy identify food types in the animation.
17	Alignment	The correct positioning of parts for smooth functioning.
18	Ambient conditions	The surrounding environmental factors such as temperature, humidity, and air pressure that can affect the performance of a component or device or system
19	Ambient Temperature	The temperature of the surrounding environment before the reaction begins.

SN.	Word/Term	Meaning
20	Amplitude	The height of the sound wave, determining loudness.
21	Analog Sensor Data	Continuous variable output from a sensor, often represented as a voltage level. It is measured through the Analog output pins like A0 to A5 on Arduino uno.
22	Analog System	A system that processes varying electrical signals, as opposed to digital binary signals.
23	Angle of Depression	The angle between the horizontal line and the line of sight when looking down.
24	Angle of Elevation	The angle between the horizontal line and the line of sight when looking up.
25	Angular Momentum	A measure of the amount of rotation an object has, which remains conserved unless acted upon by an external force.
26	Animation	A technique that gives the illusion of movement by displaying sequential images quickly.
27	Anode	The electrode in a circuit where current flows into the device from the external circuit; e.g. a longer leg of the LED, which must be connected to the positive terminal of the battery.
28	Anomalies	Irregular or unexpected values in the data, often indicating errors or unusual environmental events.
29	Anther	The part of a flower that produces pollen.
30	AQI - Air Quality Index	A scale used to report daily air quality and indicate how polluted the air currently is.
31	Arduino Cloud	An online platform for remote coding, device management, and data visualization for Arduino.
32	Arduino Cloud Agent	A local service that connects your Arduino hardware with Arduino Cloud via your browser.
33	Arduino IDE	A software platform used to write and upload code to Arduino boards.
34	Arduino Libraries	Prewritten code packages that make it easier to control hardware like sensors and displays.
35	Arduino Nano	A compact microcontroller board used to control and process sensor data.
36	Arduino Uno	A microcontroller board used for building electronic projects and processing data from sensors.
37	Arteries	Blood vessels that carry oxygenated blood away from the heart.
38	Artificial Intelligence (AI)	The ability of a computer to perform tasks that usually require human intelligence, such as recognition and decision-making.
39	Assembling	Putting together different parts to make a whole.
40	Automate	To make something work automatically using machines or technology.

SN.	Word/Term	Meaning
41	Automatic Emergency Braking (AEB)	A system that stops a vehicle without driver input when an obstacle is detected.
42	AUX Cable	A cable used to transmit audio signals from a device to the speaker system.
43	Axle	A rod or spindle that allows wheels to rotate.
44	Backdrop	The background of a Scratch or Pictoblox project, setting the scene for animations.
45	Baking Soda	A mild base (sodium bicarbonate) that can act as an alternative electrolyte
46	Balance	The even distribution of weight to maintain stability.
47	Base (of transistor)	The terminal that controls the flow of current between collector and emitter.
48	Base Plate	The fixed bottom part of the model.
49	Battery	A power source that provides voltage to drive current
50	Battery Clip	A connector that attaches the battery to the conductive dough, allowing current to flow into the circuit.
51	Battery Holder	A compartment that securely holds and connects a battery to the circuit.
52	BC-547 transistor	A general-purpose NPN transistor often used in amplifier circuits.
53	Biomimicry	Designing tools or systems based on models found in nature, like replicating the function of a hand.
54	Block Coding	A method of programming where code is built using drag-and-drop blocks.
55	Blocks	Visual programming components used in PictoBlox to create scripts.
56	Blood Circulation	The continuous movement of blood through the heart and blood vessels, supplying oxygen and nutrients while removing waste.
57	Blood Donor-Recipient Compatibility	A set of medical rules that determine which blood types can safely donate or receive blood from others.
58	Bluetooth Module	A module (e.g., HC-05) that allows wireless communication between devices at short ranges.
59	BO Motor	A small DC motor commonly used in DIY and robotics projects.
60	BO Motor Wheel	A supporting wheel designed for use with small motors.
61	Boundary	The edge or perimeter of a shape or structure in a model.
62	Breadboard	A board for making temporary electrical connections without soldering.

SN.	Word/Term	Meaning
63	Buzzer	An audio signalling device that makes a buzzing sound.
64	Cable Tie / Zip Tie	A plastic fastener used to hold or pull string ends easily in the gripper mechanism.
65	Calibration:	The process of adjusting a system to ensure accurate measurements.
66	Capacitors	An electronic component that stores and releases electrical energy, commonly used in filters and amplifiers.
67	Carbon Rods from Batteries	Conductive rods inside old dry cell batteries used as durable electrodes
68	Card stock	A thick, sturdy paper used as the diaphragm in the paper speaker.
69	Cardboard/Foam Sheet	A stiff sheet used as the base material for creating algebraic tiles.
70	Cathode	The negative electrode where reduction occurs
71	Centrifugal Force	The apparent outward force experienced by a rotating object.
72	Chassis	The base frame that supports the components of the RC car.
73	Chromosome	A DNA structure that carries genetic information.
74	Circuit	A closed-loop electrical pathway that allows current to flow.
75	Circulatory System	The system responsible for transporting blood throughout the body.
76	Class in ML Environment	A category or label used in machine learning to differentiate between different objects or data types.
77	Click Event	An action triggered when the user clicks on a sprite, used in Model 1 to play sounds indicating if food is healthy or junk.
78	Clinometer	A device used to measure angles of elevation or depression.
79	Closed Circuit	A complete circuit—current can flow and power devices
80	CO ₂ (Carbon Dioxide)	A gas produced in the acid-base reaction and monitored using the sensor.
81	Code Blocks	Predefined commands in Scratch or Pictoblox that allow users to program sprite actions and interactions.
82	Coil (Voice Coil)	A wire loop that creates a magnetic field when current flows through it, interacting with the magnets to create vibration.
83	Collector (of transistor)	The terminal through which current enters the transistor.
84	Color Blending	The visual effect created when different colors appear to merge or mix.
85	Column Chart	A graphical representation using columns to show comparisons among categories of data.
86	Compatibility	The ability of two things to work together.

SN.	Word/Term	Meaning
87	Compression	A force that pushes materials together, often used to stabilize or return to shape.
88	Conditionals	A programming concept where actions depend on a certain condition, such as "If the boy touches an apple, say 'Healthy food.'"
89	Conductive Medium	A material that allows electricity to pass through, such as copper tape.
90	Conductivity	The ability of a material to allow electric current to flow.
91	Conductor	A material that allows electric current to pass (e.g., copper tape)
92	Construction	The process of creating geometric figures using a set of given tools like a ruler and compass.
93	Control Block	A block that manages the flow of the program, like repeating actions or waiting for user interaction.
94	Copper Conductive Tape	Adhesive-backed tape made of copper that conducts electricity; used to create paper circuits
95	Cos (Cosine)	Adjacent side / Hypotenuse.
96	Cosec (Cosecant)	Hypotenuse / Opposite side.
97	Cot (Cotangent)	Adjacent side / Opposite side.
98	Cream of Tartar	A white, powdery acid (potassium bitartrate) often used in baking. In this activity, it acts as an ion source to improve conductivity in the dough.
99	Cross-Pollination	When pollen from a flower is transferred to a flower on a different plant of the same species, often with the help of wind, insects, or other agents.
100	Current (A)	The flow of electric charge through a circuit, measured in amperes.
101	Cutting Mat	A surface used to safely cut materials without damaging underlying surfaces.
102	Cutting Tools	Tools such as scissors or precision cutters used to cut tiles from templates.
103	Dabble Application	A mobile application that allows communication with Arduino via Bluetooth.
104	Data Logging	The process of collecting and storing data over time for analysis.
105	Data Visualization	The graphical representation of information, such as charts.
106	DC Motor	An electric motor that runs on direct current to produce rotational motion.
107	Debugging	The process of finding and fixing errors in a program to ensure it runs smoothly.
108	Decibel (dB)	A unit used to measure the intensity of sound.
109	Decomposition	The breakdown of a compound into simpler substances

SN.	Word/Term	Meaning
110	Deoxygenated Blood	Blood low in oxygen, returning from the body to the heart and then to the lungs for purification. Represented by blue LEDs.
111	Design-based Decisions	Choices made during the planning and construction of a project based on functionality.
112	Dexterity	Skill and ease in using the hands or fingers, often required to operate or build mechanical devices.
113	DHT11	A low-cost digital sensor that measures temperature and humidity.
114	Diaphragm	A thin surface (cardstock, in this case) that vibrates to push air and produce sound.
115	Diode	A component that allows current to flow in only one direction.
116	Distance Calculation	The process by which the Arduino calculates how far an object is using sensor data.
117	Drawing arm	The arm that creates the scaled version of the traced image.
118	DS18B20 Sensor	A digital waterproof temperature sensor used to detect changes in temperature.
119	Electrolysis	A chemical process that uses electricity to split a compound into its elements
120	Electrolyte	A substance that dissolves in water to produce a conductive solution that enables ion movement in an electrochemical cell.
121	Electromagnetism	A physical phenomenon where electric current produces a magnetic field, used in the speaker to generate movement.
122	Electronic Components	Various parts such as LEDs, buzzers, and switches that work together in an electrical circuit.
123	Emitter (of transistor)	The terminal through which current leaves the transistor.
124	Enamel Coating	The insulating layer on copper wire that must be removed for electrical contact.
125	Endothermic Reaction	A chemical reaction that absorbs heat from the surroundings, causing a drop in temperature.
126	Environmental Monitoring	The process of observing environmental parameters like temperature, humidity, or pollution.
127	Event Block	A type of Scratch or PictoBlox block that starts a script when an action occurs, such as clicking a sprite or pressing a key.
128	Exhaust Hood	A ventilation device in labs used to safely expel harmful fumes produced during chemical reactions.
129	Exothermic Reaction	A chemical reaction that releases heat into the surroundings.
130	Expanded Form	A mathematical expression written as a sum of terms rather than in its factored form.

SN.	Word/Term	Meaning
131	Extensions	Additions that expand the original project.
132	Eye Wash Bottle	A safety tool used to rinse eyes in case of chemical exposure or splashes.
133	Flipbook Animation	A simple animation technique using a series of images flipped quickly to create motion.
134	Foam Board	A lightweight and sturdy material used as a base for mounting electronic components.
135	Force transmission	The process of transferring force through a linkage system like in a pantograph.
136	Fraction	A part of a whole, represented by a numerator and a denominator (e.g., $\frac{1}{4}$, $\frac{1}{2}$).
137	Frequency	The number of sound wave cycles per second, determining pitch.
138	Friction	The resistance that occurs when two surfaces move over each other.
139	Fulcrum	The point about which a lever pivots, allowing movement in the pantograph.
140	Fume Extractor	A device that removes harmful fumes created during soldering.
141	Galvanic Cell	A type of electrochemical cell that converts chemical energy into electrical energy through redox reactions.
142	Game Design	The process of planning and developing an interactive game or animation. This project is a simple educational game-like animation.
143	Gas Concentration	The amount of gas present in a given volume of air, measured here as CO ₂ .
144	GeoGebra	An interactive mathematics software that combines geometry, algebra, and calculus for dynamic visualizations and problem-solving.
145	Geometric Representation	A visual representation of mathematical concepts using shapes and spatial arrangements.
146	Germination	The process by which a seed grows into a new plant, supported by favorable conditions such as water and temperature.
147	Glue Gun	A tool used to melt and apply adhesive sticks to bond materials.
148	Glue/Adhesive	A sticky substance used to attach templates to cardboard sheets.
149	Graphite	A form of carbon used as an electrode material
150	Gripper	A mechanical device designed to grasp and hold objects, often mimicking a human hand.
151	Gyroscope	A rotating device that maintains orientation due to angular momentum.

SN.	Word/Term	Meaning
152	HC-05 Bluetooth Module	A wireless communication module used to connect Arduino with mobile devices.
153	Healthy Food	Nutritious food items such as fruits, vegetables, and nuts, which are beneficial for health.
154	Heart	The muscular organ that pumps blood throughout the body.
155	Honeybee	An insect that plays a key role in cross-pollination by collecting nectar and transferring pollen between flowers.
156	Humidity	The amount of water vapor present in the air, measured by sensors like DHT11.
157	HVAC Systems	Heating, Ventilation, and Air Conditioning systems used for regulating indoor environments.
158	HX711 Module:	A 24-bit ADC (Analog to Digital) module designed to amplify and convert the analog signal from a load cell into a digital format.
159	Hydrogen	A gas released at the cathode during electrolysis of water
160	Hypotenuse	The longest side of a right triangle, opposite the right angle.
161	Illusion	A misleading visual perception, such as colors blending when spun rapidly.
162	Illusion of Motion	A visual effect where static images appear to move due to persistence of vision.
163	Image Classification	The process of identifying and categorizing objects in an image.
164	Image Recognition	Technology that identifies objects in digital images.
165	Inertia	The tendency of an object to resist changes in its motion.
166	Insect Pollination	Pollination that occurs when insects (e.g., bees, butterflies) transfer pollen from one flower to another.
167	Insulation	A material or method that prevents the unintended flow of electricity.
168	Insulator	A material that resists the flow of electric current. The insulating dough is used to block current flow in unwanted areas of the circuit.
169	Interaction	When a user or a sprite takes action in the program, such as clicking on a food sprite to hear a sound.
170	Internet of Things	A network of physical devices connected to the internet that collect and share data.
171	Internet of Things (IoT)	A network of interconnected devices capable of collecting and exchanging data.
172	IR Sensor	An Infrared sensor that detects objects by reflecting infrared light.

SN.	Word/Term	Meaning
173	Jumper Cables	Wires used to make electrical connections on a breadboard.
174	Jumper Wires	Insulated wires used to connect different parts of a circuit.
175	Junk Food	Unhealthy food items high in sugar, fat, and processed ingredients, which can be harmful if consumed excessively.
176	Kinematics	The study of motion without considering the forces that cause it, applied in pantograph movement.
177	L298N Motor Driver:	An electronic module that controls the speed and direction of a DC motor.
178	LCD Display	An electronic screen used to show CO ₂ concentration in parts per million (ppm).
179	LED	A light-emitting diode; lights up when current flows in the correct direction
180	LED	Light Emitting Diode, emits light when current flows through it.
181	LED	A Light Emitting Diode that glows when current passes through.
182	LED (Light Emitting Diode)	A small electronic component that lights up when electric current passes through it in the correct direction.
183	Lever	A simple machine that helps transfer motion and force in the pantograph system.
184	Line Chart	A chart used to show trends over time by connecting data points with a continuous line.
185	Linkage	A system of connected levers used to transmit motion and force.
186	Lithium-ion Battery	A rechargeable battery that provides power to electronic circuits.
187	Load	The component in a circuit that uses electricity (e.g., LED)
188	Load Cell	A sensor that converts mechanical force or weight into an electrical signal.
189	Logical Thinking	The ability to break down a problem into smaller steps and solve it using a structured approach, essential for programming.
190	Loop	A control block that repeats a specific action multiple times, such as moving the boy continuously towards the food items.
191	Lungs	Organs that oxygenate the blood and remove carbon dioxide.
192	Machine Learning (ML)	A type of AI where computers learn from data instead of being explicitly programmed.
193	Machine Learning (ML)	A type of artificial intelligence that enables computers to learn from data.
194	Magnet	A material that produces a magnetic field; neodymium magnets are strong and ideal for compact speakers.
195	Mathematical Visualization	The process of using diagrams, graphs, and interactive models to understand mathematical concepts.

SN.	Word/Term	Meaning
196	Mechanical advantage	The factor by which a mechanism multiplies force, seen in pantograph motion.
197	Mechanism	A system of parts working together to perform a function or movement.
198	Metallic Probe	The metal tip of the DS18B20 sensor that is immersed into the reaction to detect heat.
199	Microcontroller	A compact integrated circuit designed to govern a specific operation in an embedded system.
200	Microsoft Excel	Spreadsheet software used to open CSV/TXT files and create charts for data visualization.
201	Middle Disc/Plate	The rotatable disc displaying the trigonometric ratios.
202	Mobile Sensor	The inbuilt motion-tracking system in smartphones that helps measure movement.
203	Model Training	The process of teaching an ML algorithm to recognize patterns in data.
204	Modifications	Changes made to improve something.
205	Momentum	The tendency of a moving object to keep moving unless stopped by an external force.
206	Motion Block	A block that moves a sprite in a specific direction, such as making the boy walk toward the food items.
207	Motor Driver	A circuit or component that controls motor speed and direction.
208	MQ-135 Sensor	A gas sensor capable of detecting CO ₂ and other air pollutants.
209	Multimeter	An instrument used to measure voltage, current, and resistance in a circuit.
210	Muscles	Tissues in the body that contract to move bones; in the gripper, the string-pulling action mimics muscle contraction.
211	Newton's Disc	A disc with segments colored in the seven colors of the rainbow; when spun, the colors blend to appear white, demonstrating that white light is a mix of all colors.
212	Newton's Third Law	A law of motion stating that for every action, there is an equal and opposite reaction.
213	Noise Pollution	Unwanted or harmful sound that disrupts normal environmental balance.
214	NPN Transistor	A type of bipolar junction transistor with current flowing from collector to emitter.
215	Obtuse Triangle	A triangle with one angle greater than 90°.
216	Ohm's Law	A fundamental electrical equation: $V = I \times R$.
217	OLED Display	A small digital screen used to display data.
218	Open Circuit	A circuit with a break in it—current cannot flow

SN.	Word/Term	Meaning
219	Operating current	The amount of electric current a device or circuit consumes during normal operation to function correctly and efficiently
220	Operating voltage	The specific voltage range within which a device or circuit functions safely and efficiently. It ensures proper performance without damage or malfunction
221	Optics	The branch of physics that deals with the behavior and properties of light.
222	Origami	The art of paper folding to create models or shapes
223	Oxidation	A chemical reaction where an element loses electrons, occurring at the anode.
224	Oxygenated Blood	Blood rich in oxygen, carried from the lungs to the heart and body.
225	Ozone	A gas composed of three oxygen atoms, significant in environmental monitoring for air quality.
226	Pantograph	A mechanical drawing tool consisting of interconnected arms that can enlarge or reduce drawings.
227	Paper Circuit	A simple electrical circuit constructed using conductive materials like copper tape.
228	Paper Glue	Adhesive used to stick paper parts together or secure components onto cardstock
229	Parallel Circuit	A type of circuit where components are connected across common points, allowing current to split and flow through multiple paths.
230	Parallel Connection	A circuit configuration where components are connected alongside each other, increasing the total current capacity.
231	Parallelogram	A four-sided geometric shape with opposite sides that are equal and parallel, forming the fundamental structure of a pantograph.
232	Perception	The way in which the brain interprets visual information received from the eyes.
233	Persistence of Vision	A phenomenon where the human eye retains an image for a short period, creating an illusion of motion.
234	pH Scale	A numerical scale (0-14) that measures how acidic or basic a substance is.
235	Pictoblox	A coding platform similar to Scratch that allows users to create animations and control robotics using block-based programming.
236	Pie Chart	A circular chart that represents data as slices of a whole.
237	Pivot point	The fixed joint where two arms of the pantograph rotate around each other.
238	Polarity	The direction in which current flows; important for LEDs

SN.	Word/Term	Meaning
239	Polarity	The direction of electrical flow, especially important in components like LEDs.
240	Pollen	The fine, powdery substance containing male reproductive cells of a plant.
241	Pollination	The process of transferring pollen from the male part (anther) to the female part (stigma) of a flower for fertilization.
242	Potentiometer	A variable resistor that adjusts voltage to control the speed of the motor.
243	Power Source	A device (like a 9V battery) that provides the energy needed to power the circuit.
244	ppm (Parts Per Million)	A unit of measurement indicating the concentration of a substance in air.
245	Precision Screwdriver	A small screwdriver used to adjust components like the LCD contrast knob.
246	Printable Template	A pre-designed guide used to accurately cut the foam board into bracket shapes.
247	Printable Template	A pre-designed guide for accurately placing circuit components.
248	Probe	A conductive element that detects the presence of water in this context.
249	Programming	The process of writing instructions for a computer to execute. In this lesson, students use block-based programming to create animations.
250	Proof	A logical argument demonstrating the truth of a theorem
251	Propeller	A rotating blade that pushes against water to move the boat forward.
252	Propulsion	The action of pushing or driving an object forward.
253	Prototype	An initial model or sample built to test a concept or design.
254	Protractor	A tool used to measure angles in degrees.
255	Pull-up Mechanism	A method of lifting and assembling a 3D shape from a 2D net using strings
256	Push Button	A switch that allows or interrupts the flow of electricity when pressed.
257	Push Button	A switch that allows electrical current to pass when pressed.
258	Push Button	A switch that completes the circuit when pressed.
259	Push Pin	A pin used to secure and rotate the discs.
260	PWM Controller	A device that regulates motor speed by varying the duty cycle of the applied voltage.

SN.	Word/Term	Meaning
261	Pythagorean Theorem	A formula: $a^2+b^2=c^2$, used to calculate the hypotenuse of a right triangle.
262	Pythagorean Theorem	A fundamental principle in geometry that states $a^2+b^2=c^2$ for a right triangle.
263	Python	A powerful and easy-to-learn programming language often used for data analysis and visualization.
264	Quadrilateral	A four-sided polygon with different classifications based on angles and side lengths.
265	Ratio of enlargement	The proportion by which the pantograph enlarges or reduces the input drawing.
266	RC Car (Remote-Controlled Car)	A small vehicle that is controlled using a wired or wireless remote.
267	Reaction Vessel	The container (jar/beaker) where the acid-base reaction takes place.
268	Real-Time Data	Data that is collected and available for use immediately as it is generated.
269	Real-Time Monitoring	Observing and recording data as it happens, without delay.
270	Rechargeable Battery	A battery that can be charged and reused multiple times, reducing waste and cost.
271	Recognition Window	A visual display in PictoBlox where the ML model identifies objects in real time through a web-camera.
272	Rectangular Tile	A rectangular-shaped tile representing product terms like ab , bc , or ac .
273	Recycling	The process of converting waste materials into reusable materials.
274	Reduction	A chemical reaction where an element gains electrons, occurring at the cathode.
275	Resistance	The opposition to the flow of electric current. Materials with high resistance, like insulating dough, limit current flow.
276	Resistor	A component that limits the flow of electrical current.
277	Return Mechanism	A system (like rubber bands) that brings a component back to its original position after movement.
278	RGB LED Module	A light-emitting diode that can produce different colors (Red, Green, Blue) based on electrical input.
279	Ribbon Cable	A flat, multi-wire cable used for making flexible and organized electrical connections.
280	Ribbon Cable	A flat, flexible cable with multiple conducting wires used to make electrical connections.
281	Right Triangle	A triangle with one 90° angle.

SN.	Word/Term	Meaning
282	Right Triangle	A triangle with one angle measuring 90 degrees.
283	Rocker Switch	A switch that allows current to flow or stop by toggling between on and off positions.
284	Rocker Switch	A switch used to turn the power supply on or off in a circuit.
285	Rotation point	The specific location where a pivot occurs in a mechanical system like a pantograph.
286	RPM (Revolutions Per Minute)	A unit measuring the speed of rotation in one minute.
287	RTC Module	Real-Time Clock; a module that keeps time accurately, even when the Arduino is off.
288	Scaling	The process of increasing or decreasing the size of an image while maintaining its proportions.
289	Scratch	A block-based visual programming language used to create animations, games, and interactive projects.
290	Script	A sequence of coding blocks in Scratch or PictoBlox that define the behavior of a sprite.
291	Sec (Secant)	Hypotenuse / Adjacent side.
292	Self-Pollination	When pollen from a flower lands on the same flower or another flower on the same plant, leading to fertilization.
293	Sensing Block	A block that allows a sprite to detect things like touching another sprite, which helps determine whether a food item is healthy or junk.
294	Sensor Calibration	The process of adjusting the sensor readings for higher accuracy.
295	Serial Communication	A method of communication where data is sent one bit at a time over a communication channel.
296	Serial Communication	A method of data transfer between Arduino and external devices.
297	Serial Monitor	A tool in the Arduino IDE that displays data sent from the board via USB.
298	Series Circuit	A type of circuit where components are connected end-to-end, so the same current flows through all components.
299	Series Connection	A circuit configuration where components are connected end-to-end, increasing the total voltage output.
300	Short Circuit	An undesired connection that allows current to flow along an unintended path, often causing circuit failure.
301	Simple machines	Basic mechanical devices that make work easier by amplifying force, including levers, pulleys, and gears.
302	Simulation	A digital representation of a real-world process, such as pollination, created through animation.

SN.	Word/Term	Meaning
303	Simulation	An interactive mathematics software that combines geometry, algebra, and calculus for dynamic visualizations and problem-solving.
304	Smart Homes	Homes equipped with devices that automate tasks and are often connected via the internet.
305	Soldering	The process of joining electronic components using melted metal (solder) for electrical connections.
306	Soldering Flux	A chemical used during soldering to clean surfaces and improve the quality of electrical connections.
307	Sound Block	A block that plays sounds when a certain event occurs, such as the boy saying "Healthy food" or "Junk food" when touching a sprite.
308	Sound Effects	Audio files (e.g., wind, buzzing, thunder) added to animations to enhance realism.
309	Sound Sensor	A device that detects sound levels and converts them into electrical signals.
310	Sound Wave	A wave of compression and rarefaction through a medium (like air) that is heard as sound.
311	Sound-reactive LEDs	LED lights that change their brightness, color, or patterns in response to the intensity or frequency of nearby sounds, creating an audio-visual experience
312	Speaker	A device that converts electrical signals into sound using vibrations.
313	Spectrum	A range of colors produced when light is separated into its component wavelengths.
314	Speed	A measure of how fast an object moves, calculated as distance divided by time.
315	Sprite	A character or object in the animation that can move and interact with other elements. In this project, food items and the boy are sprites.
316	Square Tile	A square-shaped tile representing squared terms like a^2 , b^2 , or c^2 .
317	Stigma	The part of a flower where pollen lands during pollination.
318	Structural Support	Elements like ice cream sticks used to reinforce and stabilize moving parts.
319	Surface Area	The total area covered by a shape, used in verifying algebraic identities.
320	Switch	A control device used to open or close an electric circuit
321	Teachable Machine	A web-based tool that allows users to train and export ML models without coding.

SN.	Word/Term	Meaning
322	Template	A pre-designed paper sheet with printed shapes representing algebraic terms, used as a guide for cutting and assembling tiles.
323	Tendons	Cord-like tissues in the human body that connect muscles to bones and help create movement—simulated by strings in the gripper.
324	Tension	A pulling force applied by a string or rope that creates motion in the system.
325	Terminal	A point where connections are made in an electrical circuit.
326	Test Tube	A cylindrical glass container used to mix or collect the chemicals.
327	Testing Circuit	A temporary setup used to check if the speaker functions properly before finalizing the build.
328	Text-to-Speech	A feature that converts text into spoken words.
329	Theorem	A mathematical statement that has been proven to be true using logical reasoning.
330	Thrust	The force that moves an object forward.
331	Thunderstorm	A weather event with rain, thunder, and lightning, shown in the animation as occurring two months after pollination.
332	Tiles	Cut-out pieces representing algebraic terms that can be arranged to visualize equations.
333	Timestamp	A record of the time at which a particular data entry is collected.
334	Tinkercad	A web-based circuit simulation tool.
335	Tinkercad	A web-based circuit simulation tool.
336	Tolerances on Resistor Values	The permissible variation in a resistor's actual resistance from its stated value, usually expressed as a percentage (e.g., $\pm 5\%$). It indicates the accuracy of the resistor.
337	Top Disc/Plate	The top layer with a window for revealing values.
338	Torque	A measure of the rotational force of a motor, affecting its ability to move objects.
339	Tracing arm	The section of the pantograph that follows the original image or shape.
340	Transistor	A semiconductor device used to amplify or switch electronic signals.
341	Trigonometric Ratios	Ratios of sides of a right triangle related to an angle.
342	Trigonometry	A branch of mathematics dealing with angles and their relationships.
343	Troubleshoot	Finding and fixing problems in a system or circuit.
344	Tweezers	A small handheld tool used for precise placement of small components like LEDs or copper tape

SN.	Word/Term	Meaning
345	Ultrasonic Sensor	A sensor that measures distance by emitting ultrasonic waves and timing their echo.
346	User Input	Interaction from the user, such as clicking a sprite or pressing a key, which influences what happens in the program.
347	Veins	Blood vessels that carry deoxygenated blood to the heart.
348	Velocity	The speed of an object in a given direction, measured in meters per second (m/s).
349	Vibration	Rapid back-and-forth movement, essential for producing sound in a speaker.
350	Vinegar	A weak acid (acetic acid) used in this experiment as the acid component.
351	Visible Spectrum	The portion of light visible to the human eye, including red to violet colors.
352	Visualization	Graphical representation of data, like column charts or line graphs.
353	Voltage (V)	The electrical potential difference between two points in a circuit, measured in volts.
354	Water Tub	A container filled with water used for testing the working of the boat model.
355	White Light	Light that contains all the colors of the visible spectrum combined.
356	Wi-Fi Module	A module used to wirelessly connect Arduino to the internet.
357	Wind Pollination	Pollination that occurs when wind carries pollen from one flower to another.
358	Wire Stripper	A tool used to remove insulation from wires for electrical connections.
359	Wooden Plank	A flat wooden board used as a stable base to mount and organize components in the model.
360	XX Chromosome	Represents a female in humans.
361	XY Chromosome	Represents a male in humans.
362	Zero PCB	A prototyping board used for soldering and creating permanent circuit connections.

