MAYKU FormBox

Mayku STEM Pack

This document contains five curriculum packs complete with 13 lesson plans for use with the Mayku FormBox. Each lesson plan has been put together by experienced design & technology teachers and includes comprehensive step by step guides with images, downloads and links. Designed for students aged 11-14 and above, with a focus on teaching STEM subjects through design and practical work in the classroom. Easy for any teacher to pick up and use without prior familiarity with the machine.

Summary

- Lesson 1 - Design a terrarium with CAD.
  Give students guidelines on how to design using CAD software. Introduce them to how it is used in the industry and why. Students will follow a step-by-step process to construct an object.
- Lesson 2 - How to 3D print your templates.
  Teach students the history and context behind 3D printing, explain how the machine works. Explain how slicer software works, prepare the design made in the last lesson to be printed and set it printing.
- Lesson 3 - Forming and casting the terrarium base.
  Collect the 3D print and use it as a template in the FormBox to make the whole class one base mould and cover each. Students will then cast concrete bases using the mould.
- Lesson 4 - Build your own worlds.
  Students will then design their own models inside the terrarium using modeling clay and other materials.

Lesson 1

Introduction to Vacuum Forming

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 50 minutes

Learning Objectives: Give students a basic understanding of the different kinds of plastics and manufacturing methods associated with them. Focus in on the vacuum forming process and how the FormBox works to change the properties of plastics.

Main Activity: Students have hands-on experience vacuum forming an object.

Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- Mayku Cast Sheet (one per student)
- Hologram template part 1 (included with FormBox)
- Hologram template part 2 (included with FormBox)
- Scissors
- Smartphone

Activity	Instructions	Supplementary Materials & References	Time
Students are taught the types of plastics that are made and their properties.	• Introduce the main kinds of plastic that you will find in day-to-day life. Explain how there are many different kinds, and each has different properties based on its chemical composition. Explain some advantages of each. Durability, hardness, chemical resistance, flexibility etc. • Raise the issue of sustainability and how some plastics can be recycled and others can't. Introduce bioplastics like PLA that are made from plants.	• Types of plastics • PLA Information	10min
Students are taught how various plastic items are manufactured in the industry.	• Briefly explain the difference between common manufacturing methods such as injection moulding, compression moulding, pressure casting, and thermoforming. Today we'll be learning more about vacuum forming.		10min
Students are taught how vacuum forming works.	• A heater heats up a sheet of thermoplastic - which softens when it gets warm. This is then pulled around a shape that you've designed. A vacuum sucks all the air out from around your design and hardens it in the shape of the template. • You can then take this out and use for things like packaging or as a mould to cast with for making chocolates or soaps. • Explain that the sheet they used with the FormBox this week is PETg, the same material water bottles are made from.	• Wikipedia page on vacuum forming • How bathtubs are made	5min
Students are taught how the FormBox works.	• The FormBox has a ceramic heater in the top that gets hot. It has two trays that hold your sheet of plastic and bring it up to get softened. A regular household vacuum cleaner plugs into the back this creates the suction needed to make your form. • Show them how to set up the machine and give them a tour of its	Mayku FormBox Vacuum Cleaner Mayku Cast Sheet	5min

	parts.		
Students have hands-on experience vacuum forming an object using the FormBox.	(Demo to the whole class and then split up into groups of 4 for students to try themselves.) ● Take a Mayku Cast Sheet and peel the protective film from the top of the sheet. Remember, you can put this into recycling. Place the sheet in the FormBox, and start to heat the plastic.  ● Place the hologram template in the centre of the vacuum plate. [Don't forget the yellow ring around the base of the shape]  ● When the plastic is ready you will see ripples at the edges of the sheet and a droop in the middle. Form the template with the Mayku Cast Sheet.  ● Allow the plastic to cool and remove the whole thing from the	Mayku FormBox Vacuum Cleaner Mayku Cast Sheet (one per student)	20min

	FormBox. Gently pop the template out.  • Carefully cut away the excess with a pair of scissors.  • To get a video to view, visit mayku.me/hologram. Place it upside-down on the centre of your phone screen. Turn the lights off and view your hologram.  • For even more hologram videos, search '3D phone hologram video' on YouTube.		
Extension Task Students do further research in how vacuum forming is used.	• Find 5 uses of vacuum forming in the world		10min

Lesson 2

Designing for Manufacture

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 50 minutes

Learning Objectives: Give students a basic understanding of manufacturing at scale. Provide some context for the way manufacturing is changing in the 21st century. Teach students the fundamental design considerations required for Vacuum Forming. Explain why these are necessary.

Main Activity: Students will become familiar with the above and design a product that adheres to the requirements of Vacuum Forming templates.

Resources Required: “Rules of vacuum forming” handout

Activity	Instructions	Supplementary Materials & References	Time
Introduction	Recap the things learnt in the previous lesson, remind students about the main points. Open discussion about what students found to be vacuum formed in the extension task.		5min
Students are taught about how objects are designed to be manufactured at scale	Explain the difference between one-off, batch and mass manufacture. How a hand made object takes a long time to make but can be more customised, and how if you want to make thousands of something, you need to use industrial machinery in a factory. Explain some background about the industrial revolution and what it was. Talk a little bit about the maker movement and how 3D printing and other desktop machines are bringing the power of the factory to the tabletop.	• The industrial revolution	15min
Students are introduced to the notion of “design for manufacture”. Students are taught the basic design rules for vacuum forming.	Explain that plastic items have to be carefully designed to work with these manufacturing processes. Introduce Draft angles, Air holes, and Undercuts as considerations for vacuum-form template design. Show examples of these using the FormBox starter kit, ie. a successfully formed item will be able to be removed without issue. While one with undercuts will become trapped inside. Hand out information flyers for the students reference which diagrammatises these fundamentals.	• Example of an object with undercuts trapped in a vacuum form. • Example of an object without undercuts that can move freely out of a vacuum form. • “Rules of vacuum forming” handout	15min
Students sketch their own product using drawing materials.	Students will then be tasked with designing a product to vacuum form, those designs will have to adhere to all of the constraints explained earlier. In this lesson they will sketch out their idea, the products that they make can be free-reign, limited to one product type or link to a current or previous / future module. ie. homewares, vehicle design, childrens toys etc.	Sketching materials, pens, pencils, markers etc. paper or sketchbooks.	15min

	Provide individual support to students, giving advice on how to adjust their designs to suit the manufacturing process. Next lesson they will be sculpting their design in Playdoh and forming them on the FormBox		
Extension Task	Ensure the sketches are completed to a good quality, students can include additional context for their designs such as materials, colour, texture etc.	Sketching materials, pens, pencils, markers etc. paper or sketchbooks.	15min

Lesson 3

Make Your Product

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 50 minutes

Learning Objectives: Students are tasked with designing and making their own objects with the FormBox using the knowledge learnt in the previous lessons.

Main Activity: Students will design and make their own object using the FormBox.

Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- Mayku Form Sheet (one per student)
- Design from the previous lesson + extension
- Playdoh

Activity	Instructions	Supplementary Materials & References	Time
Introduction	Recap the things learnt in the previous lesson, remind students about the main points. Ensure all the students have their designs to work from.	"Rules of vacuum forming" handout	5min
Students design their own object using Playdoh.	Your students will have 15 minutes to turn their designs into a 3D shape with Playdoh to vacuum form later on, those designs will have to adhere to all of the constraints explained earlier. Provide individual support to students, giving advice on how to adjust their designs to suit the manufacturing process.	Small amount of playdoh for each student	15min
Remind students how the FormBox works	Make an example form using the FormBox to remind the class how the machine works and safety considerations.	Mayku FormBox Vacuum Cleaner Mayku Form Sheet	5min
Students use the Formbox to vacuum form their designs.	Once their design is ready, or after 20 minutes, whichever is sooner, the student can place their design in the FormBox to form it with a Mayku Form sheet. [White HIPS]. Ensure that each student is able to interact with the machine in groups of 4, [2 minutes approximately per group].	Mayku FormBox Vacuum Cleaner Mayku Form Sheet (one per student)	20min

	 Whilst using the FormBox, reinforce the material properties of plastics introduced earlier on.		
Review and summarise.	Ask the students to critique their own designs, did they follow the design guidelines? How could they be improved next time? Reinforce the idea of manufacture at scale, how they spent a long time sculpting one object, but now they can replicate it many times. Collect the Playdoh and tidy up.		5min
Extension Task Students are encouraged to further develop the vacuum form that they made in the workshop.	Decorate the vacuum formed shape using things like markers, paint, tape, glitter etc. at home and show next lesson.		20min

Lesson 1

How Are Plastics Made?

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 55 minutes

Learning Objectives: Give students a basic understanding of the different kinds of plastics and how those plastics are manufactured. Give some detail on the chemical composition of these plastics, and how the various compositions affect their properties.

Main Activity: Students are given background knowledge on plastics that they can relate to everyday objects. Students can identify plastics based on their properties.

Resources Required: -

Activity	Instructions	Supplementary Materials & References	Time
Introduction to the topic	Introduce the topic of the lesson [This lesson plan leads in with a task set in the previous lesson whereby students are asked to bring in an unusual plastic object that they have in the home] Students present the unusual plastic object that they have found in the home. Discussion about how they all look so diverse, today we're going to find out why and how.		10min
Students are taught where plastic comes from and how it is made	Explain how crude oil is refined into various kinds of plastics, briefly cover the extraction of crude oil from the Earth and the processes associated with its refinement. Briefly cover fractional distillation and the separation of crude oil. If you have time, preface this section with how natural oil is created from organic matter over time.	Crude Oil Extraction	10min
Students are taught the fundamentals of polymerisation and long chain molecules	Continue to explain how monomers are linked in a chain to form polymers. Hydrocarbons become plastics with the addition of various chemicals.	Introduction to Polymers	10min
Students are taught the properties associated with different plastic types	Introduce various plastics such as Polystyrene, Nylon, Polypropylene etc. explain what is different about them, in terms of hardness, elasticity, melting point etc.	Different kinds of plastics	5min
Students are shown the uses of different types of plastics	Link these properties to their uses, explain why you would want a certain plastic to be used for a particular job because of its properties.		5min
Students link this knowledge to their found objects	Return to the objects that the students gathered from the home. Activity in groups to work out what type of plastic each of those objects are made from, and why that material was chosen. Groups share with the class what they found and what they think it's made from and why, teacher to verify. Whole class records this as a list in their workbooks.		15min

Extension Task	Each student should gather 4 plastic bags from home for the next class.		5min

Lesson 2

How can We Reduce, Reuse and Recycle?

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 15 minutes

Lesson length: 60 minutes

Learning Objectives: Explore the issue of the long lifetime of plastics and the challenges associated with recycling them. Investigate alternatives to traditional plastics in contemporary product design.

Main Activity: Use the FormBox to recycle plastic bags into various objects.

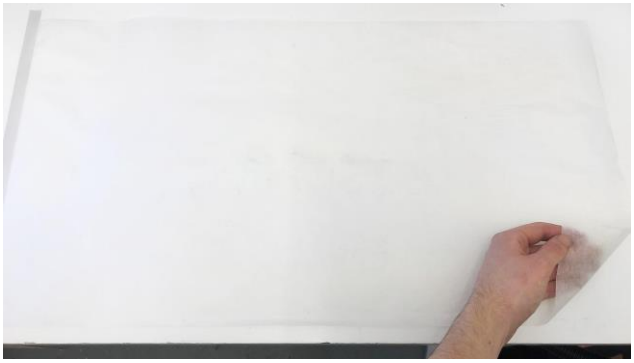
Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- 4 Plastic shopping bags per student
- Iron (Ideally one iron per 4 students)
- Greaseproof paper
- Masking tape
- Ruler
- Scissors
- Forming Template

Activity	Instructions	Supplementary Materials & References	Time
Recap the last lesson	Recap the information from the previous lesson. Reiterate how crude oil is a finite resource and how most plastics are designed to be durable and therefore last for thousands of years.		5min
Students learn the challenges associated with plastic recycling	Explain how some plastics are easier to recycle than others, but that all of the recycling processes and costly and require additional energy. Introduce bioplastics and how some materials like PLA have the properties of plastics, but are made from renewable resources unlike of traditional oil-based plastics. Give some examples of contemporary design that utilises other materials instead of plastic, like metals or wood, which is more environmentally friendly. Show some examples of plastics being reused or “upcycled”.	How plastic is recycled How PLA is made from corn Sustainable design materials	10min
Introduction to the main activity	Introduce how the students will be recycling plastic bags into different products.		
Demonstration of the lamination process to the class	Before the students begin, demonstrate the entire process to the whole class. Begin by cutting plastic bags into single sheets along the seams of the bag, ensure that any doubled-over edges and reinforced handles are cut off.	4 Plastic shopping bags Iron Greaseproof paper Masking tape Ruler Scissors	5min

You will need 8 layers of plastic, which would require 4 bags.

Tape down a length of greaseproof paper to the table with masking tape.

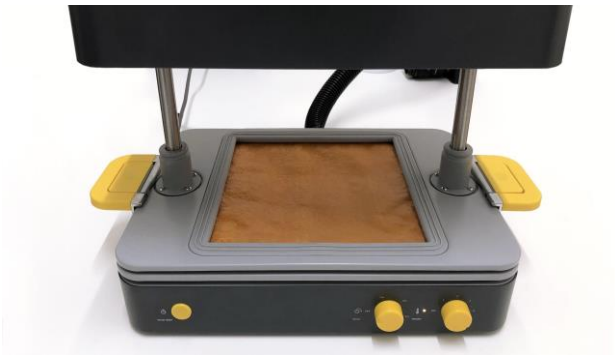


Lay the first two layers of plastic on top of the sheet of greaseproof paper, lining up the edges of the sheets.

Lay another length of greaseproof paper on top of the layers of plastic.

Use an iron which is turned up to the highest temperature to laminate the plastic sheets together. Begin in the centre and use a circular or zigzag motion to cover the whole area. Ensure you apply pressure and spend enough time across the whole area to fully fuse the layers together.

Fully peel away the top layer of greaseproof paper and check that the plastic is fully laminated.

	Add another layer of plastic to the 2 layers you just laminated and repeat the process. All 8 layers of plastic should be laminated together in this way. When this is complete, allow the plastic to cool. Trim a 235mm x 235mm square from this sheet with a pair of scissors so that it will fit in the FormBox. 		
Students are briefly taught how vacuum forming works	A heater heats up a sheet of thermoplastic - which softens when it gets warm. This is then pulled around a shape that you've designed. A vacuum sucks all the air out from around your design and hardens it in the shape of the template.		10min
Students are taught how the FormBox works	The FormBox has a ceramic heater in the top that gets hot. It has two trays that hold your sheet of plastic and bring it up to get softened. A regular household vacuum cleaner plugs into the back this creates the suction needed to make your form.	Mayku FormBox Vacuum Cleaner	
Students are shown a demo of the FormBox in use	Take the recycled sheet you made earlier and place the sheet in the FormBox, and start to heat the plastic.  Place the template in the centre of the vacuum plate. In our example here we have made a recycled coffee cup lid and a mask. A whole variety of objects can be made, try and link this object to a past or upcoming project. When the plastic is ready you will see it soften across the whole sheet, be sure not to overheat the plastic. Form the template with the recycled sheet.	Mayku FormBox Vacuum Cleaner Recycled plastic sheet	

	 Allow the plastic to cool and remove the whole thing from the FormBox. Gently pop the template out. Carefully cut away the excess with a pair of scissors.   		
Students complete the main activity	Students begin the above process either alone or in small groups. Ensure that the class is well supervised and each student has a go at the process. Pay particular attention to the hazardous tools in the room.	Mayku FormBox Vacuum Cleaner 4 Plastic shopping bags per student Iron (Ideally one iron per 4	25min

		students) Greaseproof paper Masking tape Ruler Scissors Forming Template	
Discussion of results and linking of the main outcome to the content learnt in the previous lesson	After the activity is complete discuss benefits and disadvantages of recycling. Compare the properties of the recycled plastic to the original kind used for the object which has been remade. Link back to the composition of plastics covered in the previous lesson.		5min
Extension Task	-		

Lesson 1

Introduction to Aerodynamics

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 60 minutes

Learning Objectives: Explain the basics of air flow and its effects, lift, drag, downforce. Explain how various vehicles and even buildings are designed to be aerodynamic.

Main Activity: Students will understand how objects are designed to be aerodynamic and can draw these shapes and annotate the effects on airflow around them.

Resources Required: -

Activity	Instructions	Supplementary Materials & References	Time
Introduction to the topic	Introduce the students to the topic by providing a brief outline of the activities.		5min
Students learn the effects of airflow on a moving object	Use a video of a wind tunnel as a visual example of how air moves around an object. Outline how the forces generated by moving air can be useful or dangerous.	Video of a wind tunnel	10min
Students are taught how lift is used for flight in aircraft	Explain how an aerofoil works to generate lift. Explain the principles of thrust and drag. Formulate basic equations for lift to overcome the weight of the aircraft.	The aerodynamics of flight	10min
Students are taught how minimising drag increases speed and efficiency	Explain using diagrams how the design of a vehicle can affect the the amount of drag acting upon it. Explain how the weight of a vehicle affects its speed. Explain how vehicles are designed to minimise weight.		10min
Students are taught how downforce is used to stabilize vehicles	Explain using diagrams how downforce is utilised to stabilize cars. Show how car parts create these forces.	Aerodynamic effects on cars	10min
Students are taught how airflow is modelled to make buildings safe from strong winds	Show how the designs of tall buildings need to consider the movement of air around them in order to ensure the building maintains stability.	The effects of wind on buildings	5min
Students to annotate a diagram showing what they have learnt in the lesson	Students should be able to annotate a diagram of the forces shown in the lesson.		10min

Extension Task	Sketch out a design for an aerodynamic car body.		20min

Lesson 2

Design and Make a Lightweight Car Body

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 60 minutes

Learning Objectives: Apply the principles learnt in the previous lesson to design and make custom car bodies that make good use of aerodynamic shapes.

Main Activity: Students will design and make custom car bodies using modelling clay and the Mayku FormBox.

Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- Mayku Form Sheet (one per student)
- Playdoh

Activity	Instructions	Supplementary Materials & References	Time
Recap of the previous lesson	Remind the students what was learnt in the previous lesson		5min
Students are tasked with 3D modelling an aerodynamic car shape	Students will need to model an aerodynamic car shape in 3D using playdoh, based from the design they drew in the extension task.  This model will then be vacuum formed into a plastic shell to demonstrate lightweight design. In order to ensure all students have time to use the FormBox, you may wish to limit the students design to 6cm^3 so that 4 students can use the machine at the same time.	Students extension task response from the previous lesson.	20min

			
Students are briefly taught how vacuum forming works	Briefly explain how vacuum forming works: A heater heats up a sheet of thermoplastic - which softens when it gets warm. This is then pulled around a shape that you've designed. A vacuum sucks all the air out from around your design and hardens it in the shape of the template. Explain that the sheet they used with the FormBox this week is High Impact Polystyrene, it is light and strong.		5min
Students are taught how the FormBox works	The FormBox has a ceramic heater in the top that gets hot. It has two trays that hold your sheet of plastic and bring it up to get softened. A regular household vacuum cleaner plugs into the back this creates the suction needed to make your form. Show them how to set up the machine and give them a tour of its parts.	Mayku FormBox Vacuum Cleaner	5min
Students use the FormBox to vacuum-form their models	(Demo to the whole class and then split up into groups of 4 for students to try themselves.) Take a Mayku Form Sheet and place the sheet in the FormBox, start to heat the plastic.  Place 4 car models evenly spaced around the vacuum plate.  When the plastic is ready you will see ripples at the edges of the sheet and a droop in the middle. Form the models with the Mayku Form Sheet.	Mayku FormBox Vacuum Cleaner Mayku Form Sheet (one per student)	20min

	 Allow the plastic to cool and remove the whole thing from the FormBox. Gently remove the models.  Carefully cut away the excess around the car designs with a pair of scissors. 		
Group discussion of the designs	Discuss as a group how the students applied aerodynamic design to their car bodies. What worked well? What would they do differently next time? 		5min
Extension Task	Students can try to make the car work, by building wheels and axles or attaching the shell to an existing toy car. Bring the cars in next lesson to race.		60min

Lesson 1

Observing Microbes in the Lab

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 55 minutes

Learning Objectives: Teach students how microbes are incubated and observed in the lab to study their biology and behaviour. Introduce some notable microbes and how these are useful or dangerous to Humans.

Main Activity: Students are taught how microbes are incubated and observed in the lab to study their biology and behaviour. Introduction to some notable microbes and how these are useful or dangerous to Humans.

Resources Required: -

Activity	Instructions	Supplementary Materials & References	Time
Students are Introduced to the topic	Introduce students to the subject matter		5min
Students are taught a brief history of the study of microbes	Explore the historical context of cellular biology and how our understanding of microbes and their relation to the natural world has changed over time.	A Brief History of Microbiology	10min
Students are taught the difference between bacteria, viruses and fungi	Outline the physiological and cellular differences between bacteria, viruses and fungi. Explain how they behave differently and are comprised of different constituent parts. Explore some examples of each.	Introduction to Bacteria, Viruses, Fungi, and Parasites	10min
Students are taught how microbe samples are cultivated in a laboratory	Outline the various methods of cell observation in the lab, including microscopy, cultivation, animal and human testing etc.		10min
Students are taught how groups of microbes multiply	Focus in on cell cultivation and how colonies of microbes multiply.		10min
Students are taught how lab-grown microbe cultures can be used	Explore why scientists aim to better understand microbe behaviour. Explain why penicillin is important and how it was discovered. Explore some of the other applications for lab grown cells such as for vaccinations, transplants and chemical applications.	Wikipedia entry on penicillin	10min
Extension Task	Research what microbes you would find around the home and where.		20min

Lesson 2

Design and create custom “Microbe City” petri-dishes

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 30 minutes

Lesson length: 60 minutes

Learning Objectives: Students will go into more detail about how petri-dishes work and what they are made from. Students will learn how microbe samples are collected and how to identify different types of bacteria based on their appearance in a petri-dish.

Main Activity: Students will design and make their own “Microbe Cities” by designing a shape from modelling clay and turning it into a plastic dish using the FormBox, before filling it with Agar and collecting bacteria samples to incubate.

Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- Mayku Cast Sheet (one per student)
- Playdoh
- Roll of tape
- Pre-prepared agar solution

Activity	Instructions	Supplementary Materials & References	Time
Recap of the previous lesson	Remind students of the main points from the previous lesson. Focus in on the cultivation of microbe cultures.		5min
Students are taught how petri-dishes work and what they are made from	Introduce what petri-dishes are used for. Explain the ingredients of the agar and nutrient solution and how this allows microbe colonies to grow on the surface. Explain the different types of solution and how they cultivate different types of microbe.	Wikipedia entry on agar plates	10min
Introduce the main activity	Students will design and make their own “Microbe Cities” by designing a shape from modelling clay and turning it into a plastic dish using the FormBox, before filling it with Agar and collecting bacteria samples to incubate.		15min
Students design their microbe city	Each student will have a small amount of playdoh to use to sculpt a landscape: rural, urban or under-sea. This model will then be vacuum formed into a plastic shell to create a dish. In order to ensure all students have time to use the FormBox, you may wish to limit the students design to 6cm^3 so that 4 students can use the machine at the same time. The 3D shape must fit within the inside of a roll of tape, with a gap	Playdoh Rolls of tape	

	between the edge of the model and the edge of the tape. Show them an example of this. The roll of tape will give vacuum form the shape of a dish and the gap ensures that air can be pulled out from around the shape  .		
Students are briefly taught how vacuum forming works.	A heater heats up a sheet of thermoplastic - which softens when it gets warm. This is then pulled around a shape that you've designed. A vacuum sucks all the air out from around your design and hardens it in the shape of the template. Explain that the sheet they used with the FormBox this week is PETg, the same material water bottles are made from. It is chemical resistant, durable and transparent.	Mayku FormBox Vacuum Cleaner	5min
Students are taught how the FormBox works.	The FormBox has a ceramic heater in the top that gets hot. It has two trays that hold your sheet of plastic and bring it up to get softened. A regular household vacuum cleaner plugs into the back this creates the suction needed to make your form. Show them how to set up the machine and give them a tour of its parts.	Mayku FormBox Vacuum Cleaner Mayku Form Sheet	
Students vacuum-form their microbe city models	(Demo to the whole class and then split up into groups of 4 for students to try themselves.) Take a Mayku Cast Sheet and peel the protective film from the top of the sheet. Remember, you can put this into recycling. Place the sheet in the FormBox, and start to heat the plastic.  Place 4 microbe city models evenly spaced around the vacuum plate, rolls of tape around the outside must be included. When the plastic is ready you will see ripples at the edges of the sheet and a droop in the middle. Form the models with the Mayku Cast Sheet.	Mayku FormBox Vacuum Cleaner Mayku Form Sheet (one per student)	20min

	 Allow the plastic to cool and remove the whole thing from the FormBox. Gently pull the models out.  Carefully cut away the excess with a pair of scissors to create a dish shape. 		
Students fill their petri-dishes with agar	Students should pour some pre-prepared agar solution into each dish, do not fill up to the brim.  Leave the agar solution to set.	Pre-prepared agar and nutrient solution How to prepare various agar solutions	5min

			
Extension Task	Students can collect their microbe cities once the agar is set and collect samples using a cotton swab to incubate in the classroom.		15min
	In the following lesson students can observe what microbes have grown on their petri-dishes and identify them.	Identifying microbial colonies	15min

Lesson 1

Build a Terrarium with CAD

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 60 minutes

Learning Objectives: Give students guidelines on how to design using CAD software. Introduce them to how it is used in the industry and why.

Main Activity: Students will follow a step-by-step process to construct an object in a CAD software package which is taught on your school's curriculum.

Resources Required:

- Computers
- CAD software
- Reference model / step-by-step instructions for students

Activity	Instructions	Supplementary Materials & References	Time
Give students an overview of the next 4 lessons	Introduce the students to the topic. Outline the next 4 lessons.		5min
Students are taught the history of computer aided design	Contrast historical methods of engineering to the use of computer aided design today. Discuss the history of the medium. Discuss the advantages of using computer aided design to create technical drawings and 3D shapes.		10min
Students are shown the various applications for computer aided design	Give some examples of the use of digital design in engineering, science and product design.		5min
Students are taught the most commonly used tools in the CAD software used in your school	Run through the fundamental tools required to use the program. Teach students how to combine these tools to create more complex shapes. Encourage spatial reasoning and problem solving.		20min
Students will follow a set of instructions to build a shape with defined specifications	Use a master design and guide students through a step-by-step process for them to construct this shape using the tools that they learnt earlier. We have used a faceted shape in our project, however you may wish to design you own shape based on the age a skill level of your class. Note that the design should be able to be 3D printed and vacuum formed with ease in the following lessons.	Mayku Terrarium Project instructions with STL files for reference	20min
Extension Task	Students may design an object of their choice in their free time.		30min

Lesson 2

How to 3D Print Your Templates

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 60 minutes

Learning Objectives: Teach students the history and context behind 3D printing, explain how the machine works. Explain how slicer software works.

Main Activity: Students prepare the design made in the last lesson to be printed and set one print running for the whole class.

Resources Required:

- Computers
- FDM 3D Printer
- Slicer software

Activity	Instructions	Supplementary Materials & References	Time
Recap the previous lesson	Reiterate some of the main points from the previous lesson. Reiterate how computer aided design is complimented by computer aided manufacture, 3D printing is one of those manufacturing methods among many others.		5min
Introduce students to the concept of 3D printing	Explain briefly what 3D printing is.		5min
Explain the history and context of rapid prototyping	Explain the advantages of rapid prototyping for product development.		5min
Explain the differences between the main types of 3D printer	Illustrate the differences between FDM, SLA and SLS printing methods. Explain the benefits and disadvantages of each.		5min
Explain in more detail how an FDM printer works	Explain how an FDM printer works. Illustrate the different kinds of FDM printer designs. Run through the various materials that consumer grade FDM printers can use, including the advantages of each.		10min
Explain how slicer software works	Explain how slicer software prepares a 3D file to be printed. Run through the various options presented to optimise the print.		10min
Students will prepare the 3D file they made in the previous lesson to be printed	Students will use this knowledge to prepare their file that they built in the previous lesson to be printed.		10min
Start a the print using the correct settings	One print [or more depending of how many printers you have in the		10min

	department] can be started. Ensure students observe the printer working.		
Extension Task	-		

Lesson 3

Forming and Casting the Terrarium Base

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

Lesson length: 60 minutes

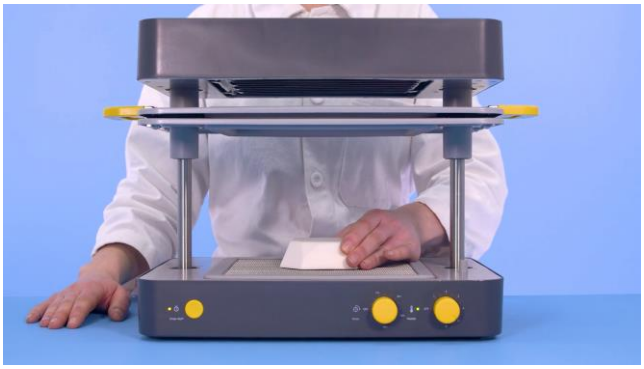
Learning Objectives: Students will learn how vacuum forming works and be introduced to casting. Students will begin to combine manufacturing methods for batch production.

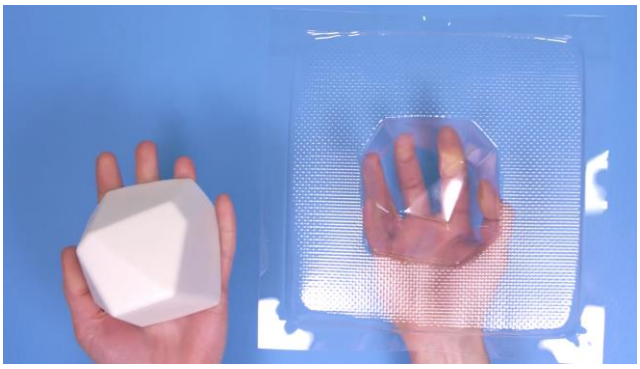
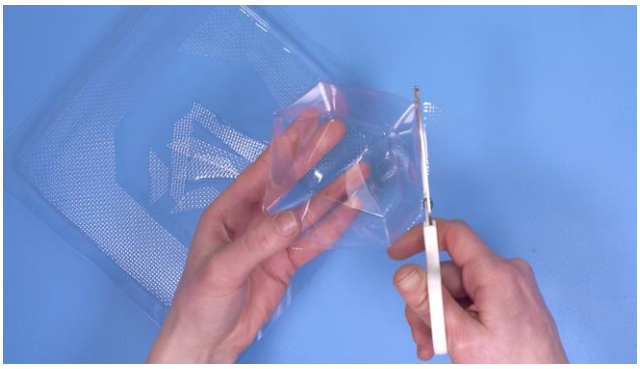
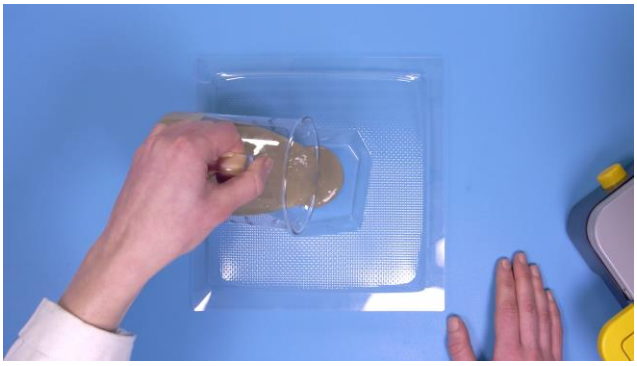
Main Activity: Collect the 3D prints from the previous lesson and use it as a template in the FormBox to make the whole class one base mould and cover each. Students will then cast concrete bases using the vacuum formed mould.

Resources Required:

- Mayku FormBox
- Vacuum Cleaner
- Mayku Cast Sheet (one per student)
- Terrarium base 3D print (one for the whole class)
- Terrarium cover 3D print (one for the whole class)
- Cement (200g est. per student)
- Water
- Mixing cups
- Mixing sticks

Activity	Instructions	Supplementary Materials & References	Time
Introduction to the topic	Introduce students to how multiple methods of rapid manufacture can be combined. Introduce the main activity.		5min
Students are taught how vacuum forming works.	A heater heats up a sheet of thermoplastic - which softens when it gets warm. This is then pulled around a shape that you've designed. A vacuum sucks all the air out from around your design and hardens it in the shape of the template. You can then take this out and use for things like packaging or as a mould to cast with for making chocolates or soaps. Explain that the sheet they used with the FormBox this week is PETg, the same material water bottles are made from.		5min
Students are taught how the FormBox works.	The FormBox has a ceramic heater in the top that gets hot. It has two trays that hold your sheet of plastic and bring it up to get softened. A regular household vacuum cleaner plugs into the back this creates the suction needed to make your form. Show them how to set up the machine and give them a tour of its parts.		
Students have hands-on experience vacuum forming an object using	(Demo to the whole class and then each student will make a copy themselves.)		30min

the FormBox.	Take a Mayku Cast Sheet and peel the protective film from the top of the sheet. Remember, you can put this into recycling. Place the sheet in the FormBox, and start to heat the plastic.  Place the terrarium base template in the centre of the vacuum plate.  When the plastic is ready you will see ripples at the edges of the sheet and a droop in the middle.  Form the terrarium base template with the Mayku Cast Sheet.  Allow the plastic to cool and remove the whole thing from the FormBox. Gently pop the template out.		

	 Repeat with the terrarium cover template (to save plastic it is advisable to reduce the size of the terrarium so that one student can fit both the upper and lower templates on the vacuum plate together and use one sheet of plastic instead of two. Trim around the edges of the cover using a pair of scissors 		
Students are introduced to the casting process	Provide some common examples of cast objects, explain this as a popular manufacturing method, particularly in architecture.		5min
Show students how to mix concrete by providing a demonstration	Mix water and cement powder together in a container until it has the consistency of a thick milkshake Ensure there are no air bubbles or lumps in the mixture. Gently pour it into the terrarium base mould to just below the brim and sit aside to set for at least 24 hours. 		5min
Students mix their own concrete and pour into their moulds	Ensure all students pour one base each		10min
Extension Task	Research diverse uses of the vacuum forming and casting processes. Start designing the model you want to make inside of your terrarium. Gather materials to build the terrarium model.		20min

Lesson 4

Build Your Own Worlds

Suitable for: Students aged 11-14 (Key stage 3 / 6th-9th grade)

Preparation time: 10 minutes

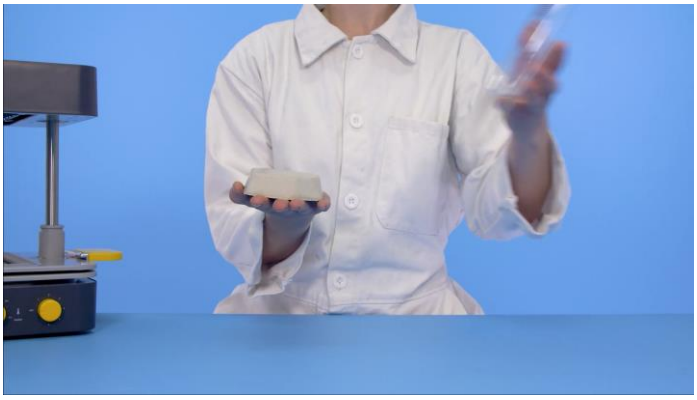
Lesson length: 50 minutes

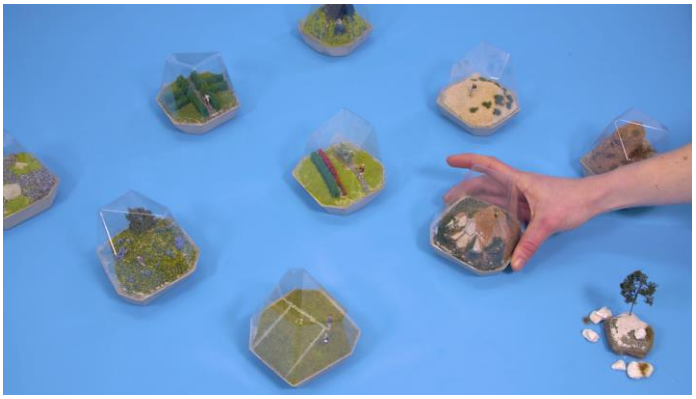
Learning Objectives: Students will learn about batch manufacture.

Main Activity: Students will design their own models inside the terrarium using modeling clay and other materials.

Resources Required:

- Cast concrete terrarium bases from the previous lesson
- Vacuum formed terrarium covers
- Modelling clay
- Various decorative materials

Activity	Instructions	Supplementary Materials & References	Time
Recap the previous lesson and collect the 3D printed parts	Reiterate the main points from the previous lesson. Collect the 3D prints that were started at the end of the previous lesson.		5min
Introduce the difference between one-off prototyping and batch manufacture	Explain the how batch manufacture can be utilised in industrial design. Explain the challenges and benefits associated with batch manufacture versus mass manufacture.		10min
As a class, students build a range of terrariums using the parts they have been manufacturing over the previous lessons	The concrete bases will now be hardened and can be removed from the mould by gently applying pressure from above.  The inside of the terrarium can be built from modeling clay and decorated using a variety of materials.		30min

	 The Transparent vacuum-formed cover can be placed on top. 		
Display the terrariums together as a group			5min
Extension Task	Task the students with branding the terrariums as a range of products to sell.		30min