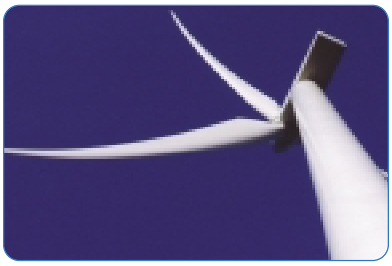
Intel Education

Design and Discovery

STUDENT BOOKLET

A TRANSITION YEAR MODULE



STUDENT BOOKLET

Intel Ireland Public Affairs

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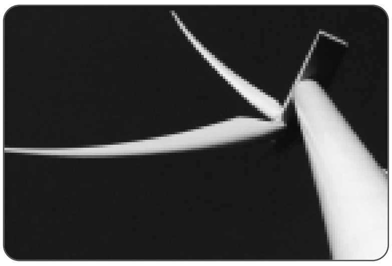

STUDENT BOOKLET

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CONTENTS

Pre-Survey

Design and Discovery Pre-Survey

Please answer the questions below honestly. There are no right or wrong answers. Your survey will be kept confidential. Select the number indicating your level of agreement with the statements. Thank you for sharing your thoughts.

	Disagree	Disagree a little	Agree a little	Agree
1. I like taking things apart and putting them back together again.	1	2	3	4
2. I am interested in my maths class.	1	2	3	4
3. I am good at designing things.	1	2	3	4
4 I like to know how things work.	1	2	3	4
5. I enjoy doing projects in school that involve maths and science.	1	2	3	4
6. I often think about what I want to do after I graduate from school.	1	2	3	4
7. I know what an engineer does.	1	2	3	4
8. I am good at solving problems.	1	2	3	4
9. I would like a career that requires a maths or science background.	1	2	3	4
10. I can explain my ideas to someone else so they can understand them.	1	2	3	4
11. I would like a career that involves designing things.	1	2	3	4
12. It is important for me to be good at science.	1	2	3	4
13. Creative thinking is one of my strengths.	1	2	3	4
14. I try to think of different ways to solve a problem before deciding on a solution.	1	2	3	4
15. I like to find out things on my own.	1	2	3	4
16. I like working with a team to create things or solve problems.	1	2	3	4
17. I could be a successful engineer.	1	2	3	4
18. I try to solve problems first before asking for help.	1	2	3	4
19. I consider myself mechanically inclined.	1	2	3	4
20. I am interested in pursuing a career in engineering.	1	2	3	4

Notes:

Design and Discovery Pre-Survey (continued)

21. Describe what you think an engineer does at work. What kinds of skills are needed to become an engineer?

____

____

____

22. Name some things that have been created by an engineer?

____

____

23. What type of career are you interested in?

____

24. The courses/skills that you most need for your career choice are (check all that apply):

art ☐ computers ☐ English ☐ maths ☐ science ☐ writing ☐

other (what? _______________________________________)

26. What types of things do you think you will learn while participating in this program?

____

____

First two letters of your:

___ ___	___ ___	___ / ___ / ___
first name*	last name*	Date of birth*

Thank you for your time and thoughts.

**This information will allow us to follow your responses over time.*
We will summarize all data, however, and no one will be identified.

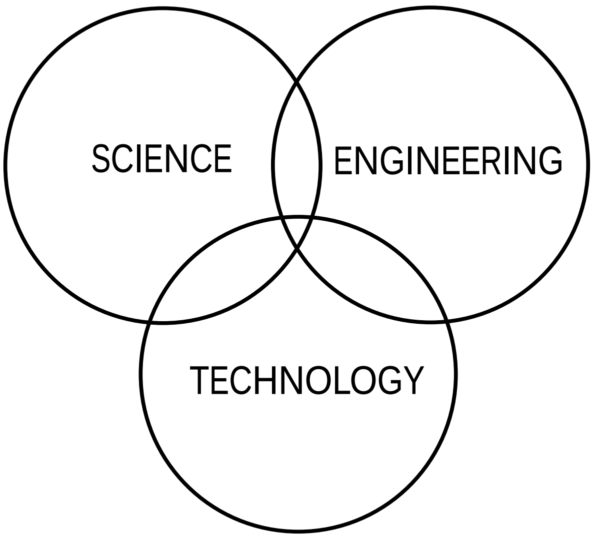
Notes:

____

____

Introduction

Design and Discovery - A Transition Year Module



"Science seeks to understand the natural world, and often needs new tools to help discover the answers."

"Technologies (products and processes) are the result of engineered designs. They are created by technicians to solve societal needs and wants."

"Engineers use new scientific discoveries to design products and processes that meet society's needs."

To the student:

Design and Discovery is a hands-on, inquiry-based module produced by Intel for Transition Year students. The course introduces engineering through design and it is hoped that having completed the course you will appreciate the importance of engineering and design in the world around you. The course is organised into 13 sessions. Each session is intended to be two-hours long (three forty-minute classes). It is hoped that the module can therefore be completed in 13 weeks. Each activity includes a student worksheet, which must be completed by you. Many activities also include student reading and sometimes homework. The readings often provide real-world examples of professionals working in the design and engineering world. You will also be required to record your progress in a design notebook. Design and Discovery will give you the opportunity to sample through hands-on activities some of the exciting areas of engineering such as material science, electronics and robotics.

Notes:

Introduction (continued)

Early on in the module you will be introduced to the ten-step design process. Working through these steps will help you identify a problem. Through the process of data gathering and experimentation it is hoped that by the end of the module you will have developed a solution and built a prototype, which you could display and present on Transition Year evening. You may then like to do some further work on your project and enter the Young Scientist and Technology Exhibition, which is held in the RDS in Dublin each January.

Design Notebooks

The design notebook is a diary of progress of an idea. It is a place to record ideas, inspirations, discoveries, sketches, and notes. It is very important for students planning to participate in a science fair such as the young scientist exhibition or who are interested in applying for a patent.

Design Notebook Guidelines

- Date and sign each page.
- Number each page.
- Never remove pages.
- Do not erase.
- Include explanation notes with any sketches or diagrams.
- Keep accurate and detailed notes.
- Be consistent and thorough.

Science Fairs

Participating in science fairs provides opportunities for students to share their hard work by showcasing their projects.

The Young Scientist and Technology Exhibition is Ireland's national science and technology fair which has been running for over 40 years. It provides an opportunity for the country's best young scientists and inventors to come together to share ideas. The exhibition takes place every January in the RDS, Dublin. Winners of the physical science section go on to participate in the Intel International Science and Engineering Fair (ISEF) which takes place in the USA every May. In order to enter the Young Scientist and Technology Exhibition a student must be between 12 and 18 years of age on 31 October, from any secondary school throughout Ireland both North and South and be prepared to put time and effort into developing a project, which will be a credit to them and their school.

Notes:

Introduction (continued)

Students can choose to enter a project in one of the following four categories.

1. Biological and Ecological Sciences
2. Chemical, Physical and Mathematical Sciences
3. Social and Behavioural Sciences
4. Technology

For a project to be accepted into the technology category the core of the project must be the application of technology in new or improved products, enhanced efficiencies, new innovations or better ways to do things. The category could include things related to the Internet, communications, electronic systems, robotics, control technology, applications of technology, biotechnology, innovative developments to existing problems, computing and automation.

The Chemical, Physical and Mathematical Sciences category covers projects on chemistry, physics, mathematics, engineering, computer programming, electronics and encryption as well as earth and space sciences such as meteorology, geophysics and astronomy.

For more information on the Young Scientist and Technology Exhibition and how to enter please visit http://www.btyoungscientist.ie

Notes:

Planner

Design and Discovery - A Transition Year Module

Session No. (3x40 mins)	Topic	Notes and Comments	Date Started	Date Completed
1	Jump Into The Designed World I			
2	Jump Into The Designed World II			
3	Material Science			
4	Electronic Engineering I			
5	Electronic Engineering II			
6	Making Machines and Observing Functionality			
7	Robotics			
8	The 3 R's Of Problem Identification	* __ weeks to exhibition		
9	A Solution Taking Shape	* __ weeks to exhibition		
10	Project Analysis and Planning for Models	* __ weeks to exhibition		
11	Making It! Models, Trials and Tests	* __ weeks to exhibition		
12	Prototype Practicalities	* __ weeks to exhibition		
13	Prototype Review and Presentation	* __ weeks to exhibition		

Dates to Remember

Transition Year Evening/Science Fair

Date ____________

Young Scientist & Technology Exhibition (www.btyoungscientist.ie)

Date ____________

Notes:

Understanding the Design Process

SESSION 1
Jump into the Designed World I

SESSION 2
Jump into the Designed World II

SESSION 3
Material Science

The Perfect Paper Clip

Reading: Session 1, Activity B

Why in the world would you study a paper clip as you learn about engineering and design? Henry Petroski, a professor of civil engineering, has written many interesting books about design and engineering in everyday things. In his book, *Invention by Design,* he devotes a whole chapter to paper clips. He notes that the paper clip, although one of the simplest of objects, can provide many lessons about the nature of engineering.

We take paper clips for granted—it seems as if they've always been around. In fact, they've been in use only since around the time of the Industrial Revolution. Before that, paper was held together with straight pins. However, the straight pin was difficult to thread through more than a few sheets of paper because it left holes in the paper, and it bulked up piles of paper.

With the developments of the Industrial Revolution, however, volumes of paper increased as technology enabled business to expand nationally and internationally. The paper clip had a clear advantage over the straight pin in holding together a group of papers, and eliminated pricked fingers! The increase in technology associated with the Industrial Revolution also allowed paper clips to be produced in quantities that kept the cost per clip low.

Early versions of the paper clip had problems that later versions sought to remedy. The paper clip we know and love today, with its (almost) perfect design, did not start out that way. Earlier models got tangled together, slipped off too easily, had too much "springiness" or not enough…

As Henry Petroski notes, the paper clip we are familiar with works because:

"… its loops can be spread apart just enough to get it around some papers, and when released, can spring back to grab the papers and hold them. This springing action, more than its shape per se, is what makes the paper clip work. Springiness, and its limits, are also critical for paper clips to be made in the first place."

The most successful paper clip yet designed is the Gem* clip. The shape of the Gem clip was introduced in England in the late 19th century by a company known as Gem, Limited. The classic Gem has certain proportions that seem to be "just right."

Petroski quotes an architecture critic who had the Gem in mind when he wrote:

"Could there possibly be anything better than a paper clip to do the job that a paper clip does? The common paper clip is light, inexpensive, strong, easy to use, and quite good-looking. There is a neatness of line to it that could not violate the ethos of any purist. One could not really improve on the paper clip, and the innumerable attempts to try—such awkward, larger plastic clips in various colors, or paper clips with square instead of rounded ends—only underscore the quality of the real thing."

Notes:

1B Reading: The Perfect Paper Clip (continued)

The Gem became to paper clips what Kleenex* is to facial tissue because of a patent issued to William Middlebrook, of Waterbury, Connecticut, in 1899. The unique aspect of Middlebrook's patent was that, although there were many inventors patenting all sorts of sizes and shapes of paper clips, Middlebrook was patenting the machine that would form the paper clip economically.

Petroski writes:

"The complexity of Middlebrook's machine is clear from his patent drawings, and it is apparent that he was engaged in serious mechanical engineering…The principles upon which the machine works, bending wire around pegs, are well suited to the Gem design and it to them. In short, Middlebrook's machine and the Gem were made for each other."

So the combination of a well-designed paper clip and a well-designed machine led to the success of the Gem clip today.

The architecture critic aside, many believe that even the Gem could use improvement: It goes on only one way; it doesn't just slip on; it doesn't always stay on; it tears the papers; it doesn't hold many papers well.

This is what makes engineering and inventing so challenging. All design involves conflicting objectives and thus compromise. The best designs will always be those that come up with the best compromise.

Of course, inventors will always look for ways to improve upon an object. They will continue to look for ways to make a better paper clip. Newer clips, for instance, may be plastic coated, or shaped like Gems, yet their proportions never seem to be quite right. One improvement to the paper clip has been the introduction of a turned-up lip on the end of the inner loop. This allows the paper clip to slide onto the papers without actually opening the clip. As mentioned above, design involves tradeoffs. This "improvement" adds to the bulk of bundled papers.

One key point to remember is that the laws of nature always bind invention, design, engineering, and manufacturing. Change in one area of design may lead to design weakness in another.

To inventors, the quest for the perfect paper clip remains elusive. Perhaps the simple paper clip isn't so simple a device after all!

Adapted from:
Petroski, Henry. *Invention by Design: How Engineers Get from Thought to Thing.* Cambridge, MA: Harvard University Press, 1996.

Notes:

Build a Better Paper Clip

Worksheet: Session 1, Activity B

Exploration
Explore the paper clips and pins (two types of fasteners) that you have in front of you. Pins were used to fasten paper together before the invention of the paper clip. Pay close attention to your hands and fingers as you use each one to fasten together pieces of paper. What do you notice?

You might notice the action needed to separate the paper clip loops so it slips onto the papers; the way your fingers direct the clip onto the papers. Each of these actions is unconscious, and the ease with which the object is used indicates a successful design.

Explore the properties of the shape and the materials of each paper clip design. Observe the operation of each design, make notes about each, and apply what you learn to designing a unique, new paper clip. What is common about the way each shape works to do the job? What properties in the material (the metal) allow each to do the job of fastening paper together?

Design
You have wire, tools, and examples of paper clips. You must now design a prototype of a new paper clip that meets several design requirements listed below. Try out your ideas and make drawings of your designs. Choose one to engineer and test it. Be prepared to present your model.

Requirements

- Your paper clip will be unique. It cannot look like any paper clip you have ever seen before, but may have features of other clips.
- It can be no bigger than 2 inches square.
- It must not be a hazard to small children.
- You may use other materials to enhance your design, but your main material must be wire.
- It must hold 10 pieces of paper together.
- You should use your design notebook to draw your various designs.

Notes:

The Design Process

Worksheet: Session 1, Activity C

Getting From "Think" To "Thing"
We will be using a design process to guide the development of a project from your idea to the design of a prototype. The steps of the design process are iterative, or cyclical. That means that throughout the stages of designing a product, you will revisit many of these steps as you refine your ideas.

1. **Identify a design opportunity.**
   Notice that design opportunities are everywhere and often come from a need, problem, or improvement to an existing solution. The goal is to identify many design opportunities and then narrow them down later.

2. **Research the design opportunity.**
   Gather lots of information about the nature of the problem in order to narrow your choices down. Find out about user needs and similar products.

3. **Brainstorm possible solutions to the problem.**
   Try to come up with five to ten ideas for solving the problem or addressing the design opportunity. Brainstorming may involve the use of SCAMPER and other techniques.

4. **Write a design brief.**
   Define the problem clearly in a problem statement. Describe the user needs and a proposed solution. Draw a sketch of the solution.

5. **Research your solution.**
   Do a literature review and talk to experts to find similar solutions and other approaches.

6. **Refine your solution.**
   Analyze the solution for feasibility, safety, and implications of the idea. Consider materials and methods for constructing the project.

7. **Prepare design requirements and conceptual drawings.**
   Write up the criteria the solution must meet (requirements) and sketch drawings.

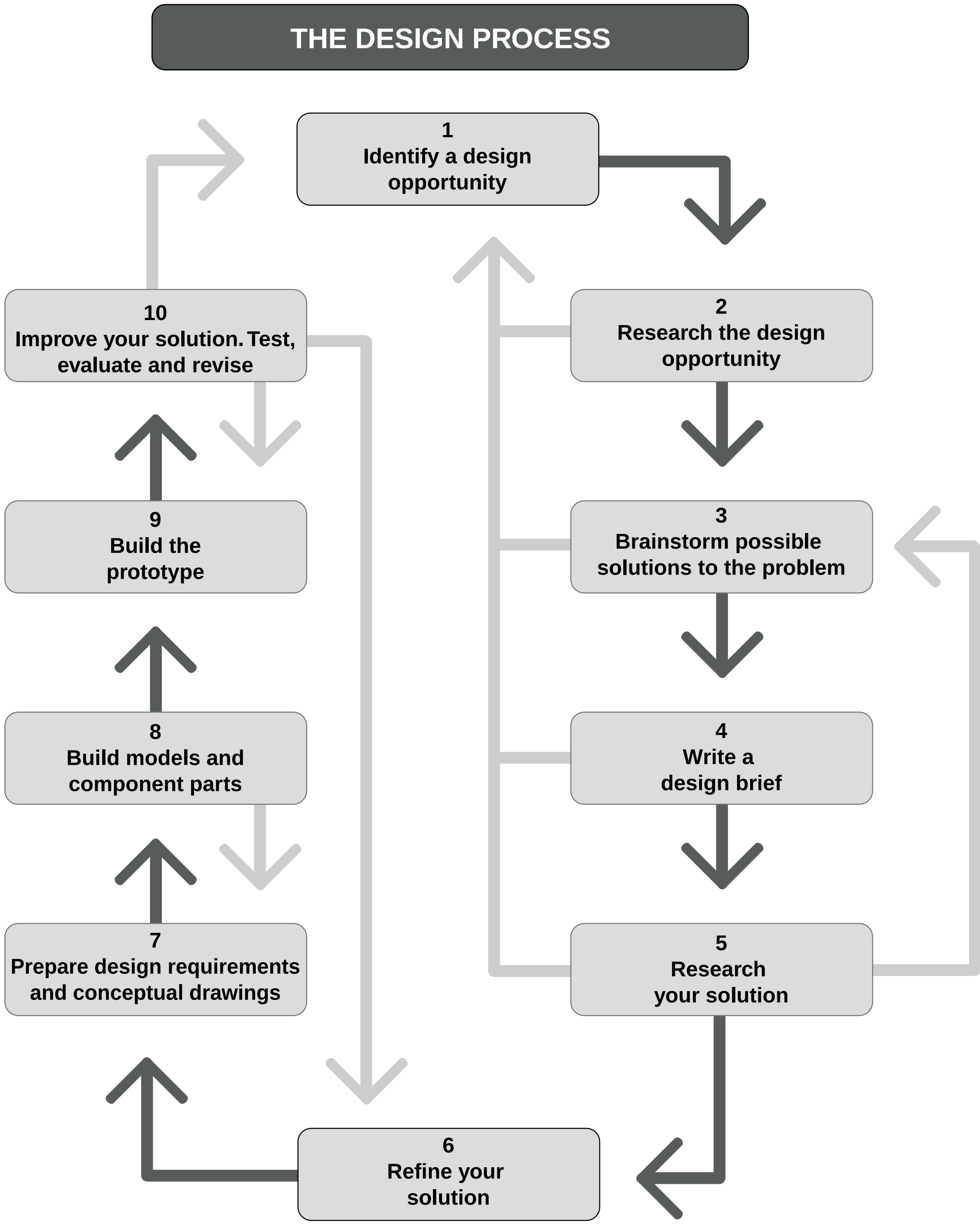
8. **Build models and component parts.**
   Analyze the project design for its systems, components, and parts. Now build a model of the entire design and/or its systems.

9. **Build the prototype.**
   Develop project specifications and create a working prototype.

10. **Improve your solution. Test, evaluate, and revise.**
    Evaluate the prototype for function, feasibility, safety, aesthetics, and other criteria. Revise or build another prototype.

Notes:

1C Worksheet: The Design Process (continued)



Notes:

Form Follows Fuction- What Does That Mean?

Reading: Session 1, Activity C

The scientist seeks to understand what is; the engineer seeks to create what never was.
—attributed to Theodore Van Karman

Every thing is supposed to function—it's supposed to do something, to work. Engineering is about function: does the product work, does it meet specifications, can it be manufactured efficiently, etc. All of this involves solving problems. We are going to be problem solvers and create things that function; we will think like engineers.

We will also learn the skills of good industrial designers. The *form* of an object (how it is designed and constructed) should follow the task it is to perform. In other words, you must know exactly what you want something to do before you can design and build it. How effectively something *functions* is often related to its *form*, or the quality of its design. Designers are concerned with qualities such as ease of use, efficient operation, and appealing aesthetics. We will pay attention to form in our project development. Though we will not focus on packaging design or marketing aesthetics, we will talk about the subtle but powerful influences of the "visual attraction" and "tactile appeal" of a product. Our goals are to meet an identified need with an idea that could work.

Science, Engineering, and Design: Where Do They Intersect?
While both engineers and scientists experiment and research problems, they differ in the kind of problems they work on. Engineers tend to work on problems that are of immediate concern to many people's daily lives. Scientific problems often build on basic understanding and may not have an immediate application in daily life.

The work of designers and engineers overlaps as well. Both seek to develop solutions to specific and immediate problems and needs. While design is involved in the entire process, engineering is the more specific process of making the idea meet specifications and function. One is useless without the other.

The First Step To a Good Design Is a Good Description Of the Real Problem
The ability to really see a need, and then be able to describe that need, is at the heart of successful product development. It requires a heightened awareness of the way people use things, and an ability to observe one's surroundings. Watching for difficulties people experience in doing a task, or how a particular product is used in an unintended way, takes practice and skill. Our job will be to learn to watch for opportunities for improving a tool or product.

Notes:

The Potato Peeler Upgrades

Worksheet: Session 2, Activity A

Ready to SCAMPER? SCAMPER is a technique that gets you to think about improving an existing design. It is an acronym that helps you remember seven different ways to think up new improvements. It is useful for being creative in a systematic way. It generates ideas you might not have on your own. Try it!

S Substitute one thing for another.

C Combine with other materials, things, or functions.

A Adapt: Can it be used for something else?

M Minimize/Magnify: Make it larger or smaller.

P Put to other uses: Can you put it to another use? In this case, use it for another vegetable? If you make it larger, would it work for some other food?

E Eliminate/Elaborate: Remove some part or material, or make one section more detailed or refined.

R Reverse/Rearrange: Flip-flop some section of the item, move parts around.

SCAMPER	Peeler Improvement	Benefit
Substitute	Different handle material	Rubber handle, more comfortable to hold
Combine	Combine peeling with other functions	Peeler with potato scrubbing brush
Adapt	Adapt peeler for other uses	Potato, carrot, and asparagus peeler
Magnify/ Minimize	Longer cutting edge on blade	Better for peeling large potatoes
	Fold-away blade	Safer when stored in drawer
Put to other uses	Larger and sharper blade	Can be used for food with thicker skin
Eliminate/ Elaborate	Eliminate plastic. Have one-piece metal peeler rolled to form handle.	Striking all-metal appearance
	Curved blade	Fits round curved surface of potato
Rearrange/ Reverse	Blade angled at 120º to handle	Better ergonomics for peeling
	Gouge at base of handle instead of at tip of blade	Easier to use

Adapted from: Baxter, Mike. *Product Design: Practical Methods for the Systematic Development of New Products,* 1st ed. Cheltenham, United Kingdom: Stanley Thornes, 1995.

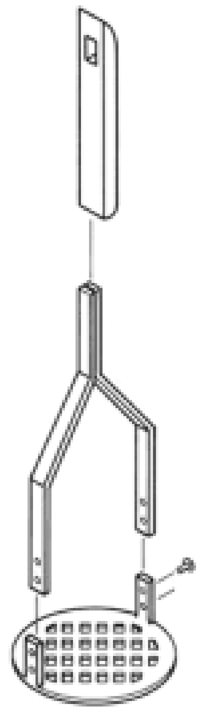
Notes:

SCAMPER and the Potato Masher

Worksheet: Session 2, Activity B

The Potato Masher, Improve It!

Apply SCAMPER to each of the potato masher parts. Sketch and make notes in your design notebook about your improvement ideas. Draw your best ideas on this technical drawing of the standard potato masher.



Notes:

Design Opportunities are Everywhere

Worksheet: Session 2, Activity C

Problem Identification: What Makes a Good Problem To Solve?
Many important engineering and design ideas start with a problem or need. You have the capacity to solve important problems, and make amazing things happen. Good ideas are inside you. Good problems often start with things you know about or have some personal connection to. Perhaps it's something that bothers you and you think about how it could be different. Maybe you have a relative or friend who struggles with something. Sometimes a problem to solve just comes from an idea of yours that sounds like a fun or easier way to do something.

In this activity, you will practice identifying design opportunities. Some of these opportunities may be problems while others may be needs, or simple improvements.

Who knows about problems? What kinds of problems are there?

- Health problems: Doctors and nurses would know, researchers too.
- Safety problems: Emergency room staff would know, firemen and police would know.
- Problems of a specific group: The elderly, the very young, people in wheelchairs, left-handed people, short people, deaf people. Try to understand through experience what it would be like to be in their shoes. Research the associations or organizations of these groups.
- Inconvenient problems: What bugs you? Always losing your keys?

Make a list of the people or organizations you could call for more information about problems or things that don't work well enough:

Notes:

2C Worksheet: Design Opportunities are Everywhere (continued)

ZIBA Design Activity Mapping
As a group, you'll do a practice Activity Mapping. This is a useful tool for identifying problems. The Activity Mapping has four primary user goals that summarize what people are trying to accomplish when engaging in an activity.

Activity Mapping

1. Pre-activity: Describes what is done before the activity
   ↓
2. Activity: Explains what is involved in the activity
   ↓
3. Post-activity: Includes what is involved after the activity
   ↓
4. Assessment: Involves how one knows if the activity has been successful

Now, do your own Activity Mapping for a problem that you identify. This can be done in your design notebook.

Where Can You Find Problems To Solve?
The answer is: everywhere. With attention and focus on designed things you see and use wherever you go, you will see all kinds of problems just waiting for your ideas and creativity. You will be taking a trip today to observe a public place (a mall, a park, or a store). *Look for problems to solve.* Watch how people use things in that place. *Look for problems to solve.* Study a few objects and items in that place. *Look for problems to solve.* Take notes:

Notes:

2C Worksheet: Design Opportunities are Everywhere (continued)

What Problems Would You Like To Solve?
They can be big problems or small problems. You decide. Creativity takes practice and patience. And it takes a few good strategies. One strategy is called “brainwriting.” Brainwriting is different from brainstorming because you don’t talk. You write your ideas on paper, quietly.

Write down 10 “problems” you are aware of (these may be from the field trip). Include things that exist that could use improvement. Write this list in your design notebook or in the space below.

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

Save this list. Revisit it as you work through the other *Design and Discovery* sessions. Add new design opportunities as you think of them.

Notes:

Material Class and Properties

Worksheet: Session 3, Activity A

Materials engineers design new materials and determine what materials are best used for certain structures and devices. They determine this by understanding the properties of materials so that they can select the most appropriate material or combination of materials for a particular use.

In this activity, you will test materials to learn about their properties. After each test, rate each material that you tested in the chart on page 30. For each property, come up with examples of objects where each property is important.

Density Test

1. Question: What materials are more dense?

2. Materials: a brick, block of wood, and block of Styrofoam, ruler, balance and measuring cylinder.

3. Test: Compare the density of a brick, a block of wood, and a block of Styrofoam.
   Find the volume of the material (cm^3). Regular shape (LxWxH). Irregular shape (Measuring cylinder).
   Find mass of material on electronic balance (g).
   Calculate density

$$Density = \frac{Mass}{Volume} \; g/cm^3$$

Record your results in the chart below

Material	Length(cm)	Width(cm)	Height(cm)	Volume (cm^3)	Mass (g)	Density
Brick						
Wood						
Styrofoam						

4. Rate: Rate the materials according to their density (high, medium, low)

5. Discuss design issues: Think of examples of other objects where high density is important. Think of examples of objects where low density is important.

Ductility vs Brittleness Test

1. Question: How easily does it stretch when force is applied?

2. Materials: For optional demonstration: 2 chocolate bars with caramel filling (1 frozen; 1 room temperature). For testing: 1 wooden popsicle stick, 1 plastic eating utensil, 1 metal eating utensil, 1 piece of tile

Notes:

3A Worksheet: Material Class and Properties (continued)

3. Test: Bend the wooden popsicle stick, a plastic utensil, and a metal utensil. What happens? Which one is most ductile?

4. Rate materials from the most ductile to the least ductile.

5. Discuss design issues: Ductility is important in designing products which can only be allowed to bend by a certain amount or that need to be flexible when used and return to their original shape when not in use. What are examples of applications where ductile materials are needed?

Strength Test (Tensile Test)

1. Question: How much weight can it hold without failing or breaking?

2. Materials: 8x1 strips of aluminium foil, heavy duty zip lock Ziploc plastic bags, paper, 2 buckets, 2kgs of sand, rice, or beans (as weights), 2 C-clamps

3. Test: Before assembling the materials, weigh the individual materials. Attach a bucket with a C-clamp to the material to be tested and attach the material with a C-clamp to a table. Be sure to have a larger bucket below to catch the weights. Fill the bucket slowly with weights. How much weight will it take until the material breaks? Record results and compare.

4. Rate materials: strong, medium, weak in strength.

5. Discuss design issues: Material strength is important in structural applications. What are examples of this? Material strength is also important in transportation applications. What are examples of this?

Fatigue Test

1. Question: How much repeated stress can cause the material to fail or break?

2. Materials: plastic multipurpose cable tie, copper or aluminium wire (or steel paper clips) cut to same size as tie, small piece of thin plywood.

3. Test: Bend each item back and forth as you count how many times it takes to break. Record the times. Be sure that students use the same amount of strength or stress when bending the material back and forth over and over.

4. Rate materials: high, medium, low. (most turns=high fatigue resistant)

5. Discuss design issues: For what objects is fatigue important? For what objects is material fatigue not important?

Notes:

3A Worksheet: Material Class and Properties (continued)

Electrical Conductivity Test

1. Does electricity pass through the material easily?
2. Materials: battery, wire, bulb, aluminium foil, cardboard, plastic bag, ceramic tile – all 1X8 with the same thickness.
3. Test: Make an electrical circuit with each material and see if the bulb lights.
4. Rate: yes or no if the bulb lights. Record your results in the chart below.

Material	Aluminium	Cardboard	Plastic	Ceramic
Bulb Lights?				
Conductor/ Insulator				

5. Discuss design issues: When is it important to use a material that conducts electricity? When it is important to use a material that does not conduct electricity?

Thermal Conductivity Test

1. Question: Does heat pass through it easily?
2. Materials: candle, matches, same material as above
3. Test: Investigate the ability of materials to transmit heat by holding each material about a few inches from the candle flame for 10 seconds. Take the material away from the flame and compare how hot it is and how long it stays hot. A material that is very hot and remains hot for awhile, has higher thermal conductivity than a material the does not feel hot and cools quickly. Record results and repeat.
4. Rate: high conductivity, medium, low
5. Discuss design issues: What are other examples of objects that need a material that is a thermal conductor? When is the use of insulation materials necessary?

Notes:

3A Worksheet: Material Class and Properties (continued)

Optical Properties Test

1. Question: How easily does light pass through it? (Transparent, translucent, opaque)
2. Materials: flashlight or bulb and battery, samples of transparent (plastic bag), translucent (plastic cup—hazy type), and opaque (colored plastic bucket)
3. Test: Compare materials by shining a light through them.
4. Rate: transparent, translucent, opaque
5. Discuss design issues: What are examples of objects made that are transparent, translucent, and opaque? When are these properties important?

Notes:

3A Worksheet: Material Class and Properties (continued)

Property	Definition
Density	How heavy objects are that occupy the same volume.
Ductility	How easily a material stretches when force is applied.
Strength	How much weight a material can hold without failing or breaking.
Fatigue	How easily a material withstands repeated stresses.
Electrical Conductivity	Whether or not electricity passes through the material.
Thermal Conductivity	How easily heat passes through the material.
Optical Properties	How easily light passes through (transparent, translucent, opaque)
Corrosion	If the material degrades easily because of the physical environment.

Material	**Density** (High, Medium, Low)	**Ductility** (High, Medium, Low)	**Strength** (Strong, Medium, Weak)	**Fatigue Prone** (High, Medium, Low)	**Electrical Cond.** (Yes/No)	**Thermal Cond.** (High, Medium, Low)	**Optical** (Transparent, Translucent, Opaque)
Metal							
Polymer							
Ceramic							
Composite							
Example							

Notes:

Material Class and Properties

Reading: Session 3, Activity A

From the Stone Age to the Information Age, humans have made use a wide array of materials to improve their lives. Stroll through the halls of a museum and you will see that major epochs have been shaped and even defined by certain materials. From iron and steel to textiles and microprocessors, materials have a seemingly infinite range of properties and applications.

Not surprisingly, the field of materials science covers a wide range of disciplines. Materials engineers contribute to the field by evaluating materials for how well they distribute stress, transfer heat, conduct electricity, and meet other design specifications.

New materials are constantly being invented, and new uses for existing materials continue to emerge. In recent years, for example, researches from Nike have figured out how to grind up used athletic shoes and create a new material for resurfacing running tracks and basketball courts. Researchers from Patagonia have developed a method to reuse the plastic in soda bottles to make a synthetic fiber that is spun into soft fleece for making sportswear.

Let's take a look at four of the major classes of materials.

Materials Class	Definition	Examples	Properties	Applications
Metals	Metals are materials that display certain properties such as a metallic lustre and the capacity to lose electrons and to form positive ions. When a metal is mixed with another metal or non-metal, the substance formed is called an alloy.	**Pure metals:** aluminium iron lead copper silver gold platinum **Alloys:** *steel (iron+carbon) brass (copper+zinc) bronze (copper+tin)	strong dense ductile opaque good conductors of heat and electricity	electrical wiring, structures (buildings, bridges) automobiles (body, springs) aeroplanes (engine, fuselage, landing gear assembly) trains (rails, engine components, body, wheels) shape memory materials magnets

Notes:

3A Reading: Material Class and Properties (continued)

Materials Class	Definition	Examples	Properties	Applications
Ceramics	Ceramic materials are inorganic materials with non-metallic properties. Ceramics are compounds made of metallic and non-metallic elements and include such compounds as oxides, nitrides, and carbides. The term ceramic comes from the Greek word *keramikos*, which means burnt stuff. The properties of ceramics are normally achieved through a high-temperature heat treatment process called firing.	structural ceramics refractories porcelain glass	lower density than metals strong low ductility (brittle), low thermal conductivity, corrosion resistant high durability	dinnerware figurines vases sinks and bathtubs electrical and thermal insulating devices water and sewage pipes floor and wall tiles dental fillings abrasives, glass television tubes
Polymers	The word polymer means "many parts." A polymer contains many chemically bonded parts or units that are bonded together to form a solid. Two important polymers are plastics and elastomers. Plastics are a large group of organic, man-made compounds based on a polymer of carbon and hydrogen. They are obtained from crude oil. Elastomers are rubbers	**Plastics** nylon polystyrene polyvinyl chloride (PVC) acrylic **Elastomers:** rubber	low density poor conductors of heat and electricity different optical properties usually low densities some soft and flexible, others hard and rigid	fabrics car parts packaging materials bags packing materials (Styrofoam*) fasteners (Velcro*) glue containers, telephone headsets CD cases lunch boxes rubber bands
Composites	Composites are two or more distinct substances that are combined to produce a new material with properties not present in either individual material. Many new combinations include ceramic fibres in metal or polymer matrix.	Fibreglass (glass and a polymer) plywood (layers of wood and glue) concrete (cement and sand)	Lower density than metals strong low ductility (brittle), low thermal conductivity corrosion resistant	golf clubs tennis rackets bicycle frames tyres cars aerospace materials paint

Notes:

3A Reading: Material Class and Properties (continued)

***Steel**
Steel is probably the most important engineering material. It is an alloy of iron and carbon. There can be between 0.05% and 1.5% carbon added to the iron, depending on the hardness required. This versatile construction material has several very important properties: it is exceptionally strong and can be formed into practical shapes. For example, while an earthquake will shatter the glass in a window, it will probably still leave the steel frame intact.

Sometimes other substances such as chromium or nickel are also added along with the carbon and the product is then known as a steel alloy. Stainless steel is an example of a steel alloy. It consists of iron, carbon and at least 12% chromium.

Ceramics and Dental Use
Dentists have developed a way to use ceramics for fillings despite the special demands on materials to be used inside the mouth. In adapting ceramics for dental use, materials scientists had to develop ceramics that would not be affected by acids, would have low thermal conductivity, would be resistant to wear from chewing, would not expand or contract when exposed to heat or cold, and would be appealing cosmetically.

Semiconductor Materials
There is a small group of materials that are neither good electrical conductors nor good electrical insulators. Instead, their ability to conduct electricity is intermediate. These materials are called semiconductors. Because a semiconductor can conduct electricity under some conditions but not others they provide a good medium for the control of electric current. Silicon is the best known semiconductor as it forms the basis of most integrated circuits.

References
Exploring Materials Engineering, Web site, Chemical and Engineering Department, San Jose State University, www.engr.sjsu.edu/WofMatE.

Materials Science and Engineering, Web site, The Minerals, Metals and Materials Society, www.crc4mse.org/Index.html.

Notes:

Materials Applications

Worksheet: Session 3, Activity B

Using the materials properties chart from the previous activity, you will solve each problem to determine the best materials for particular uses.

1. For each problem, determine the following:
    - Which properties are important to solving the problem?
    - Which materials have the important properties?
    - What types of materials would you use to make this product?

2. Make a sketch of the object for each problem and label the materials.

Problems

1. Erin Foods has a problem. Erin started making a new product that requires using hot corn syrup. The corn syrup must be portioned out with a spoon into large bottles while it is still hot (175ºC). The operator will be using a big spoon that she will be holding for more than an hour a day. The company needs a new spoon to serve this purpose.

2. A new golf club manufacturer would like to make lightweight, sturdy, and electrically non-conductive golf clubs but doesn't know where to start. The golf club heads should be hard and wear resistant and must withstand repeated strokes of high force against the golf ball.

Notes:

3B Worksheet: Materials Applications (continued)

3. Hang Dry Clothespin Manufacturers is undertaking an aggressive campaign to encourage people to conserve energy by hanging their clothes out to dry. They would like to come up with a new modern clothespin that will appeal to the masses.

4. Eircom is trying to come up with a new phone booth for the 21st century. Not only will the phone booth contain pay phones, but will also be a private public place for people to use their cell phones and plug in their laptop computers. The booth must be private, but allow for daylight to pass through and allow people to see if it is occupied.

Notes:

Material Choice

Worksheet: Session 3, Activity C

Did you know that when you purchase a beverage, you pay more for the packaging than the beverage itself? So, what does it take to produce a beverage container and how are decisions made about what type of container to use?

The challenge: Your class has decided to go into the fruit juice business. You have already come up with delicious recipes and are now considering how you will package the drinks. As employees, the owner has asked for your input on which type of beverage container to use. You are to do a cost analysis of aluminium, plastic, and glass and make a case for one of these materials.

This chart shows the number of containers per kg of material, the raw material cost per kg, the production cost per container, and the average shipping cost per kg. Using this information, rank aluminium, glass, and plastic in the total cost to produce and deliver one container. You will need to first determine how much one container weighs

Material	# containers /kg	Material €/kg	Production €/container	Shipping €/kg
Aluminium	30	.70	.10	.50
Glass	2	03	.06	.50
Plastic	15	.50	.04	.50

The next chart shows the total cost of returning the material to a state where it can reused to make a new container instead of using raw materials. The chart also includes the cost of disposing the material into a landfill as an alternative to recycling. Calculate the cost to purchase scrap material and reprocess it and compare this amount to the cost of the raw material (in the above chart.) For each material, is it more economically advantageous to recycle scrap material or dispose of it in a landfill?

Material	Scrap €/kg	Process Scrap €/kg	Disposal €/kg
Aluminium	.35	.15	.02
Glass	.01	.01	.02
Plastic	.10	.50	.02

Notes:

3C Worksheet: Material Choice (continued)

Global warming has been linked to the increase in emissions to the atmosphere of carbon dioxide. Carbon dioxide is emitted by the burning of fossil fuels. Fossil fuels are burned to create energy that is used to manufacture and transport materials. Manufacturing beverage containers using recycled materials decreases the total carbon dioxide emissions because reprocessing consumes less energy than processing the raw material. The following chart summarizes the kilograms of carbon dioxide emissions avoided by using recycled materials. From which material do you gain the most benefit by recycling?

Material	kgs of CO_2 avoided per kg of material recycled
Aluminium	4.5
Glass	.20
Plastic	.8

What type of beverage container do you think the juice company should use? Make a case for aluminium, glass, or plastic.

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___

___

Extending the Life of the Container
Design challenge: You have been asked to design a beverage container that would not be considered waste after its use. Consider how the container might be recycled and reconstituted for another use or how the container might be redesigned to achieve a secondary use. Be innovative! Sketch your design idea.

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Notes:

Materials Scavenger Hunt

3D Worksheet: Homework

Walk through your home like a detective. Look for objects and what they are made of. Write a sentence about each item you find where the materials it is made of matter!

What is it?

What does it do?

How and why do the materials matter?

What is it?

What does it do?

How and why do the materials matter?

Notes:

3D Worksheet: Materials Scavenger Hunt (continued)

What is it?

What does it do?

How and why do the materials matter?

What is it?

What does it do?

How and why do the materials matter?

Think about the end-of-year projects you are considering. What material property requirements might your project have?

Notes:

Notes:

Engineering Fundamentals

SESSION 4
Electronic Engineering I

SESSION 5
Electronic Engineering II

SESSION 6
Making Machines and Observing Functionality

SESSION 7
Robotics

Electronic Engineering I

Worksheet: Session 4

Have you ever wondered how burglar alarms work, or how street lights turn on automatically when it gets dark? Or perhaps you have seen Christmas tree lights that twinkle, turning on and off every few seconds. In this module you will find out how to build electric circuits to do these sorts of things. You will be using some modern pieces of electrical equipment that have ‘silicon chips’ inside them. They can be easily damaged, so take care of them! While you do the work in this module, try to think of ways you could use the circuits you build in a project of your own. Most of the time you will be working with small pieces of electrical equipment that you put onto a circuit board, using a battery to make them work. However, before you begin there is a number of key ideas that you need to know. (Most of them you may have met in your Junior Certificate work in Science or Technology.)

Safety

You should know that electricity can be dangerous. If too much current flows through you, it can kill. This can happen if you use electricity from the mains electricity supply. In this module you do not need to use the mains supply at all. However, your teacher may ask you to use a powerpack that is connected to the mains. You must use the powerpack ONLY in the way that your teacher tells you. DO NOT change any of the controls ‘just to see what happens’. You could damage the apparatus you use; but more importantly, you could harm yourself or other students in your group.

Notes:

Worksheet: Session 4

Key ideas in electricity

1. Electricity needs a complete circuit to make things work.
2. The movement of electricity round a circuit is called an electric current (or just current for short).
3. To make current move round a circuit there has to be a battery or powerpack that supplies a voltage. You will be using a 'nine volt' (9V) battery.
4. A battery has a positive terminal marked with a + sign. It also has a negative terminal, marked with a – sign. We say that current flows from the positive terminal to the negative terminal.
5. The general rule is that the greater the voltage applied to a circuit, the more current will flow.
6. Current goes through devices in a circuit, e.g. lamps, motors, buzzers; but voltage is measured across each of the devices.
7. Metals allow current to flow through them very easily. We say metals conduct electricity easily. They have a low resistance. If a substance does not conduct electricity at all easily we say it has a high resistance. If a substance has a very, very high resistance we usually call it an insulator. Plastic, rubber and wood are insulators.
8. Some substances are neither good nor bad conductors; they suddenly change their ability to conduct as the voltage changes. These substances are known as semiconductors. Often they contain the element called silicon.

Check your understanding

Here are a few questions for you to do in your group. Discuss the questions with your partner(s) and decide on your answers together. This should take you no more than 10 minutes. Your teacher will check your answers when you have finished.

Q.1 The diagram show a battery and lamps connected with some wires.

(i) Why won't the bulbs light?

(ii) What would you do to make the circuit work properly?

(You can draw on the diagram if you want.)

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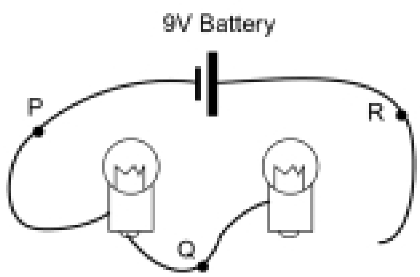

Notes:

Worksheet: Session 4

Q.2 We measure the amount of current flowing through a circuit in amps (A). Suppose the circuit is made to work properly so that both bulbs light. Also suppose we measured the current flowing through the wire at P as one amp (1A).
(i) What would you predict the size of the current to be at point Q?
(ii) What would you predict the size of the current to be at point R?

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Q.3 Assume you had built the circuit so that both bulbs were glowing. What do you think would happen if you connected a wire from point P to point Q?

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Q.4 Imagine that the circuit was working properly, with both lamps glowing. Now imagine you replaced the 9V battery by a 90V battery. Write down what you think would happen, and why it would happen.

____

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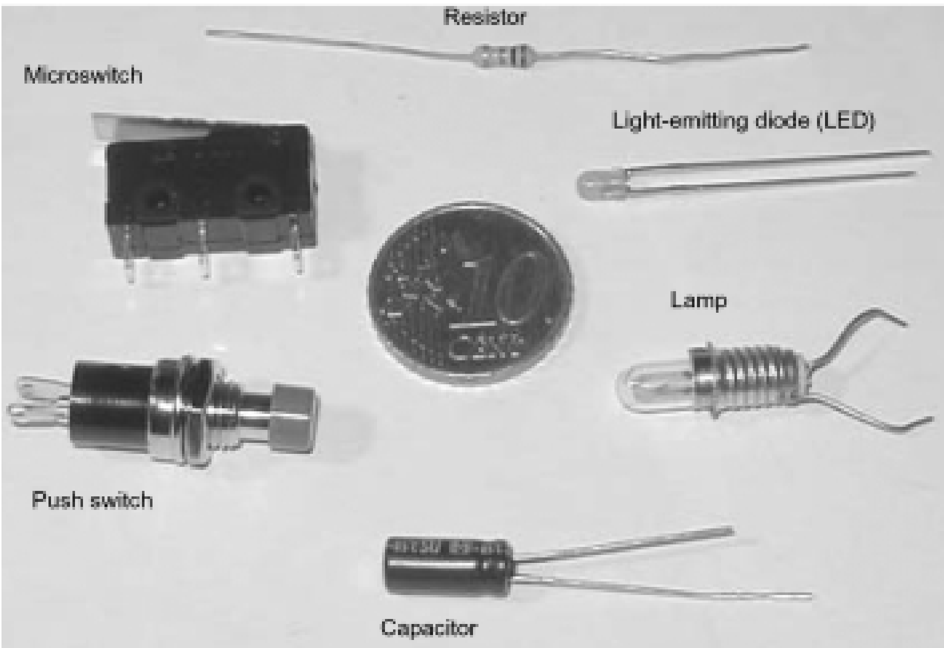
You are going to use small electrical components. You can see pictures of some them below.



Notes:

Worksheet: Session 4

Supplies
For Each Pair Of Students

- 1 x Breadboard
- 1 x 9V battery (PP3)
- 1 x clip for battery
- 2 x 4093B CMOS chip
- 2 x 2003A Darlington Driver chip
- 2 x Small 3V lamp
- 2 x Lamp holder
- 2 x Resistors, 1K, 10K, 22k, 47k (each)
- 2 x Capacitors, 10mF, 22mF, 47mF, 100mF (each)
- 1 x Push switch
- 1 x Micro switch
- 1 x Buzzer
- 8 x Selection of wires—best purchased as a kit that should supply enough for all groups.

Shortly, you will build a circuit using the lamps and LEDs. Because the components are small, we need a special way to build circuits with them. We use a 'bread board'.

Below is a picture of part of one in use. It is vital that you understand how bread boards are made. They can be confusing at first because they have so many 'holes' where the components can fit, and because the connections between the holes are hidden under the plastic. The bread board you use may not look exactly like the one in the photo, but it will work in exactly the same way. Here are the key things you need to know:

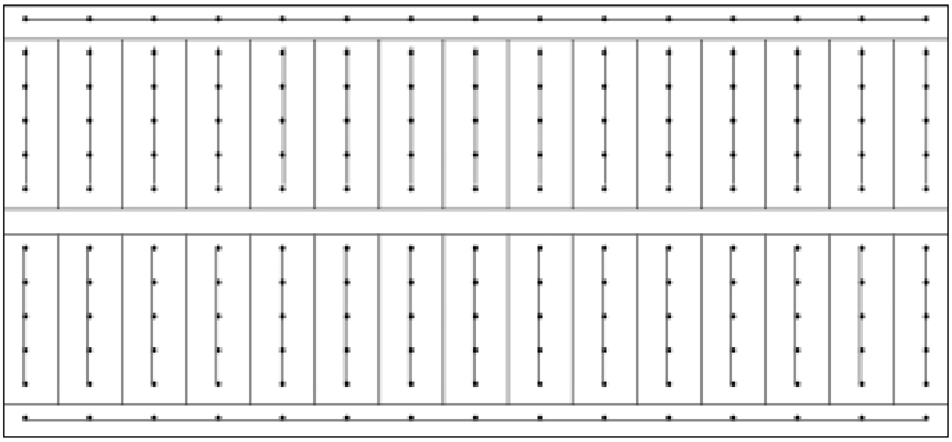
- The bread board has four main parts:
- One or more horizontal rows of holes at the top. All these holes are connected together by a wire running underneath.
- One or more horizontal rows of holes at the bottom. These holes are also connected together.
- Two sets of five rows of holes separated by a gap. These holes are connected vertically only. So, for example, two holes side-by-side are NOT connected. The columns are not connected across the gap.

Look carefully at the photo of the bread board in use and the diagram showing the way the holes on a bread board are connected. Make sure you can understand why the components and wires are connected the way they are shown.

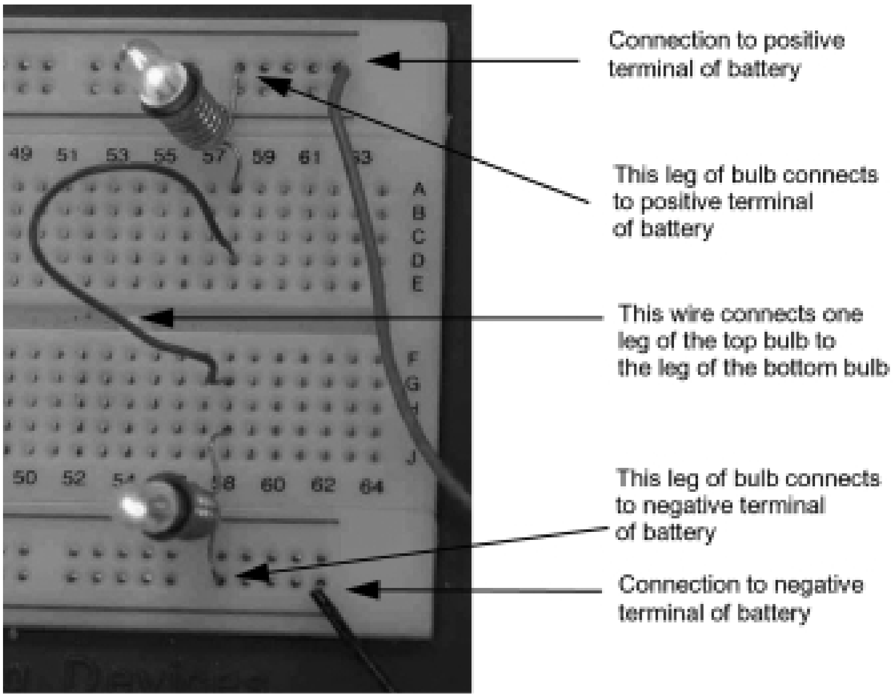
Notes:

Worksheet: Session 4

Diagram showing the connections on a bread board



Picture of a bread board in use



Notes:

Electronic Engineering I

Key Concepts

Key concepts

The work begins with a brief revision of key ideas in electricity that most students should have met in Junior Certificate Science; especially:

(i) a complete circuit is needed for an electric current to flow;
(ii) a resistor will make the flow of current round a circuit more difficult;
(iii) the voltage of a battery or power pack is a measure of the 'push' that can make a current flow.

Additional ideas that are developed include:

(iv) current is not used up when it flows through a circuit;
(v) not all electrical component obey Ohm's law, e.g. silicon chips, capacitors, light emitting diodes (LEDs);
(vi) circuits inside silicon chips can be turned on or off by changing the voltage they sense (rather than current).

It is not expected that students will master such ideas. However, this should not prevent them from being able to observe the effects of operating their circuits. Thus, at the end of this unit of work they should be able to:

(i) know how to use switches that normally open and/or normally closed connections;
(ii) know uses for reed switches.
(iii) use a logic gate to detect changes in the states of switches attached to the gate inputs;
(iv) use the output of a logic gate to switch on (or off) an LED or buzzer;
(v) suggest uses for such circuits;

Notes:

Key Concepts (continued)

If students progress rapidly through the core work, their are suggestions for further practicals that they can undertake. These involve them in building circuits that can be used

(i) as timing circuits, e.g. to make LEDs flash on and off, and
(ii) to control motors.

Throughout this section, students should be encouraged to think of applications for the circuits they build, and how they might form part of their final project.
If students progress rapidly through the core work, their are suggestions for further practicals that they can undertake. These involve them in building circuits that can be used

(i) as timing circuits, e.g. to make LEDs flash on and off, and
(ii) to control motors.

Throughout this section, students should be encouraged to think of applications for the circuits they build, and how they might form part of their final project.

Notes:

Building Simple Circuits

Worksheet 4A

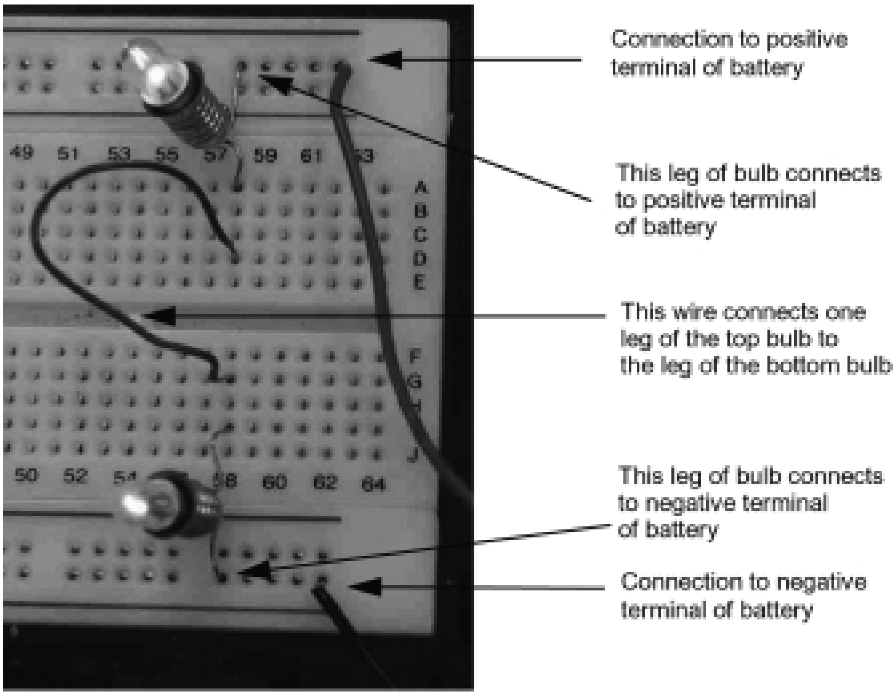
Goal
Get familiar with using breadboards to build simple circuits

Outcome
Participants will be able to use a breadboard to light lamps and use LEDs in a circuit.

Description
Students build a circuit to make 2 lamps light then replace one lamp with an LED.

Supplies
Breadboard, electrical wire, 2 lamps, 1 LED

Procedure
1. Build the circuit shown in the photo to make two lamps light.

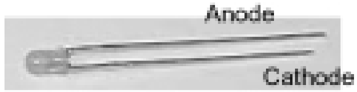


Notes:
When you do this, hold the legs of the bulb holders near the bottom, not at the top near the holder itself. That way you will find it easier to put the legs into the holes. You may find it difficult at first to get the legs and/or wires into the holes. Keep trying: often the connectors in the holes are stiff at first. If it really is impossible, try a different set of holes. The last thing to connect into the circuit is the battery.

Notes:

4A Worksheet: Building Simple Circuits (continued)

2. Investigating LEDs
   (i) First, look at the picture of an LED. It has two legs, one shorter than the other. The longer leg is called the anode; the shorter is the cathode. When you pick up an LED, if you look carefully you will find there is a small flat portion on the coloured barrel; this also marks the cathode.



   (ii) Remove the bottom lamp on the bread board. Try replacing it with an LED. Note where you have put the anode and cathode legs. Does the LED light up? Try changing the LED round so that the anode goes where the cathode went (and vice versa). What happens now?

   ____

   ____

   (iii) Now make the circuit work with two LEDs and no lamps.
   (iv) Which is the general rule that LEDs obey? (a) The cathode must eventually connect to the positive ‘end’ of a circuit, or (b) the cathode must eventually connect to the negative ‘end’ of a circuit?

   ____

   ____

Follow-up work

1. Find out where LEDs are used in your home. Write down a list of two or three uses.

   ____

   ____

2. Use the internet or a library to find out why LEDs are so often used instead of ordinary lamps. Bring your findings to the next lesson.

   ____

   ____

3. Write down one or two ways in which you could use LEDs in a project. E.g. in toy, or model. Are there things that you would like to make LEDs do that they do not do in the circuit you built?

   ____

   ____

Notes:

Using Simple Switches

Worksheet 4B

Goal
Investigate how a switch works.

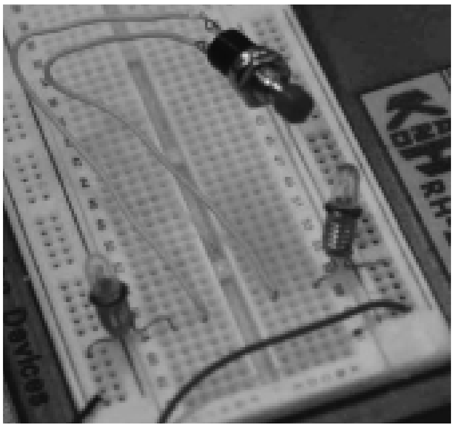
Outcome
Students will be able to connect switches into a circuit and explain how they work.

Description
Students connect a push switch and a micro switch into the circuit from Activity 1 and investigate their differences.

Supplies
Breadboard, electrical wire, 2 lamps, 1 LED, 1 push switch and 1 micro switch

Procedure

1. Try connecting the push switch as shown in the photo below.



2. Does it matter which way round the switch is put into the circuit? (Try it.)

   ____

   ____

3. Explain what the switch does. For example, does it behave like a light switch at home, that locks into place when it is pressed, or does it only work when you hold the button down, or…?

   ____

   ____

Notes:

4B: Using Simple Switches (continued)

4. Now connect the micro switch. When you use the micro switch, make sure you use the labels as shown, i.e. with the lever pointing to the right.It has a lever that is very sensitive—a slight push on the lever, and the switch will work. However, you can see that it has three terminals (and three wires attached).

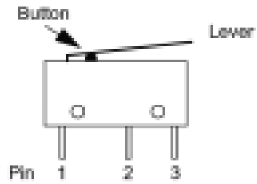
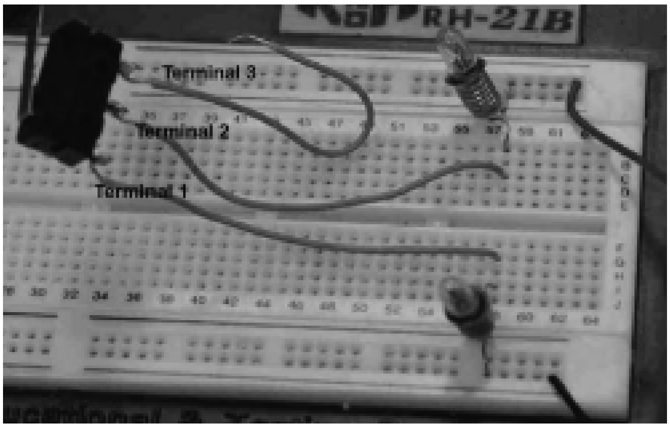


Diagram of a micro switch



Your task is to investigate how this switch works. Try using two of the three wires in turn to put the switch in the same circuit as you have just used. Carefully note down which two leads you use each time, and what happens before and after the lever is pressed: Call the wires 1, 2 and 3 as shown in the diagram above.

Wires used	What happens to the lamps *before* the lever is pressed?	What happens to the lamps *after* the lever is pressed?
1 and 2	*Light off*	*Light on*
1 and 3	*Light on*	*Light off*
2 and 3	*Light off*	*Light off*

5. One set of contacts in the micro switch is known as ‘normally open (NO)’. another set is said to be ‘normally closed (NC)’. Which pins make the NO contacts, and which pins make the NC contacts?
Pins 1 and 2 are NO; pins 1 and 3 are NC.

In this part of the work, there is nothing more for the students to do than get the circuit working. Observations and results should be recorded in their design notebooks.

Notes:

4B: Using Simple Switches (continued)

Follow-up

1. Which switch is the most sensitive? What do you think is the point of having a lever on the micro switch?

2. Briefly describe two applications that would make use of the ‘ordinary’ switch, and two for the microswitch. The examples you use could be ones that you might use in a project, or an application in industry; e.g. for controlling machines.

Notes:

Using a ‘Silicon Chip’

Worksheet 4C

Goal
Investigate the use of a ‘Silicon Chip’

Outcome
Students will be able to use a silicon chip as part of a simple circuit.

Description
Students build a circuit consisting of a silicon chip and and an LED and investigate the effect of the silicon chip when the circuit is broken.

Supplies
1 Breadboard, some electrical wire, 1 *4093* silicon chip, 1 LED.

Procedure
Almost everything we use in the home or at work now makes use of microelectronic circuits. In this lesson you are going to investigate the use of one type of ‘chip’ called a logic gate. The silicon chip itself that makes the device work is hidden inside the body made of insulating material. The chip you use has fourteen legs (often called ‘pins’) that we use to make the connections to the silicon chip inside. It is known by its number; in this case it is a 4093.

1. Look carefully at the 4093. At one end you should see a small semi-circle or notch marked at one end. You will use this to tell you which way round to put the chip in a circuit. The pins (legs) are numbered from one to fourteen as shown in the diagram. Pin number 14 connects to the positive terminal of the battery, and pin number 7 goes to the negative terminal. You will only use pins 1, 2 and 3 (as well as 7 and 14) in your circuits. Pins 1 and 2 are inputs, pin 3 is the output.

2. The circuit you are going to build is shown in the photo below.

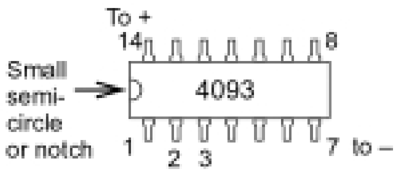
Before you start, please not that It is vital that you put the chip the right way round in the circuits you build. (Make sure you can identify the end with the semi-circle or notch.) If the chip has not been used before you will find that the legs do not quite fit in the holes correctly. You will have to gently bend them inwards by a very small amount. Ask your teacher for advice before doing this. Make the circuit as shown in the photo. The battery should only be connected when everything else is in place. The LED should light up. If it doesn’t, carefully check all the connections are made to the right places, and that the wires are properly seated in the holes.

Notes:

4C Worksheet: Using a 'Silicon Chip' (continued)

3. Try removing the LED and replacing it by a buzzer.

At this stage you might wonder what the point of this circuit is—after all there are simpler ways of making an LED light. Well, the idea is that this chip can do something that ordinary circuits can't do. Especially, it can make something happen when a circuit is broken. (You may recall that up until now you we expect devices in a circuit to turn off if a circuit is broken.) To see how the chip behaves you will have to investigate its properties more closely.



We shall use a short-hand to draw up a table of results. Here are the rules:

If a pin is connected to the + of the battery, we shall say that the pin is 'ON'.

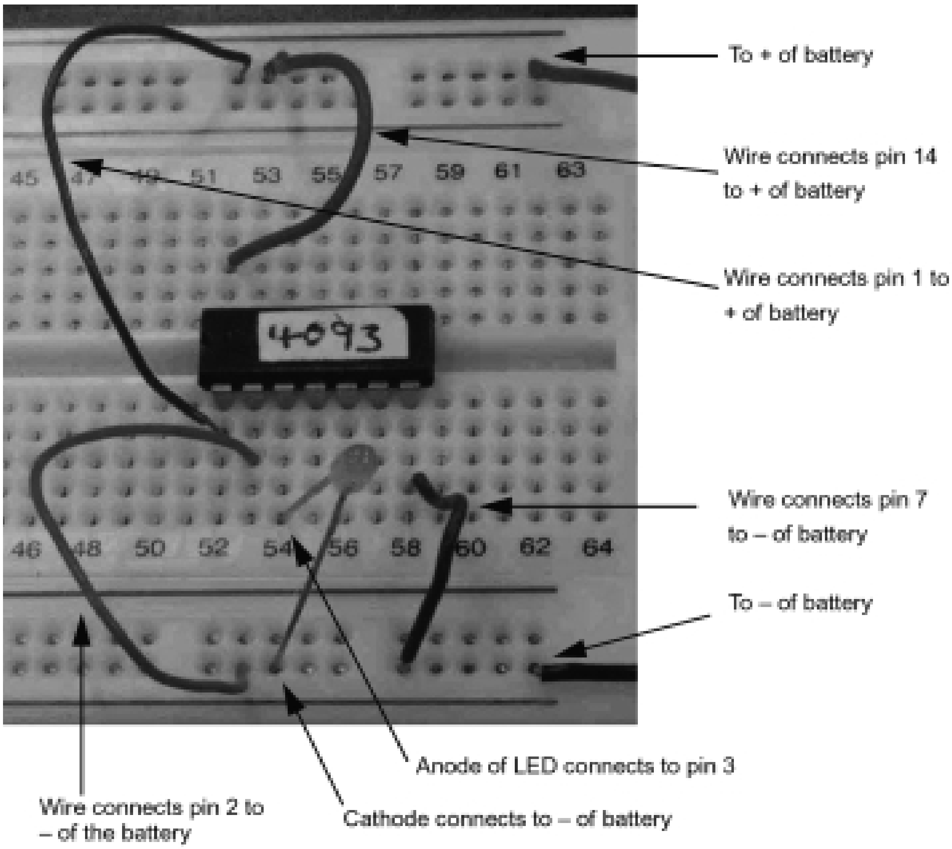
If a pin is connected to the – of the battery, we shall say that the pin is 'OFF'.

If the output pin (3) is live, i.e. LED turns on, it is 'ON'; if the LED is off, the pin is 'OFF'.
For example, if you look at your circuit you just made, the pattern is this:

	Pin 1	Pin 2	Pin 3
	Connected to +	Connected to –	Live (turns LED on)
Code	ON	OFF	ON

Notes:

4C Worksheet: Using a 'Silicon Chip' (continued)



Notes:

Completing the Input Pattern for the 4093

Worksheet 4D

Goal
To investigate further the properties of the 4093

Outcome
Students investigate how changing the pin input can affect the pin output.

Description
Students vary the inputs on the pins of the 4093 and record the outputs in a table.

Supplies
1 Breadboard, some electrical wire, 1 4093 silicon chip, 1 LED.

Procedure

Use the same circuit as in the last practical to complete the table of results below.

Note that you can make the input to a pin ON by connecting it to the + of the battery, and 'OFF' by connecting it to the – of the battery.

Pin 1	Pin 2	Pin 3 (output)
OFF	*OFF*	*ON*

Students should populate this table and the teacher can check when completed.

Notes:

Electronic Engineering II

Worksheet: Session 5

Students should study their Student Booklet prior to commencing the practical work contained in the activities.

Supplies
For Each Pair Of Students

- 1 x Breadboard
- 1 x 9V battery (PP3)
- 1 x clip for battery
- 2 x 4093B CMOS chip
- 2 x 2003A Darlington Driver chip
- 2 x Small 3V lamp
- 2 x Lamp holder
- 2 x Resistors, 1K, 10K, 22k, 47k (each)
- 2 x Capacitors, 10mF, 22mF, 47mF, 100mF (each)
- 2 x LEDs, red, green (each)
- 1 x Motor
- 1 x Reed switch and magnet (sold as pair)
- 1 x Push switch
- 1 x Micro switch
- 1 x Buzzer
- 8 x Selection of wires—best purchased as a kit that should supply enough for all groups.

Notes:

A Reed Switch Circuit

Worksheet: Session 5 Activity A

Reed Switches

The pattern you should have discovered tells you that when one (or both) of the inputs is connected to the positive of the battery the output is OFF; otherwise the output is ON. Now imagine that you have the job of designing a burglar alarm which turns on if the front or back door in a house is opened. We could do this if we find a way of wiring the doors to make a complete circuit to a battery and a 4093 chip. Here is one way of doing this; but first you need to know something about devices that are used in real burglar alarm systems. They are called reed switches, and are operated by magnets.

A reed switch: no magnet near

A reed switch: with magnet near
(These diagrams are much larger than real reed switches)

A reed switch has two thin pieces of metal that are contained in a small glass tube which has had all the air removed. When a magnet is brought near to the glass, the two metal contacts are attracted together, and the contacts are connected.

Your teacher will show you a reed switch, but they are too fragile to be used without being held in a protecting plastic case. You will use a reed switch and magnet that can be used as part of a real burglar alarm system.

Notes:

5A: A Reed Switch Circuit (continued)

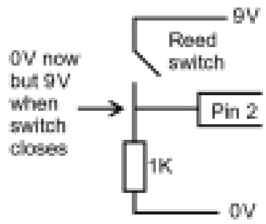
Goal
To become familiar with how a reed switch operates and how they might be used in everyday life.

Outcome
Students will be able to build a reed switch circuit and understand how they might be used in a burglar alarm system.

Description
Students add a reed switch to the circuit they built in Session 4, then swap the LED for a buzzer.

Supplies
As in Session 4 plus a reed switch.

Procedure
1. Build the circuit shown in the photo below.
   (i) What happens when you bring the magnet near to the reed switch?

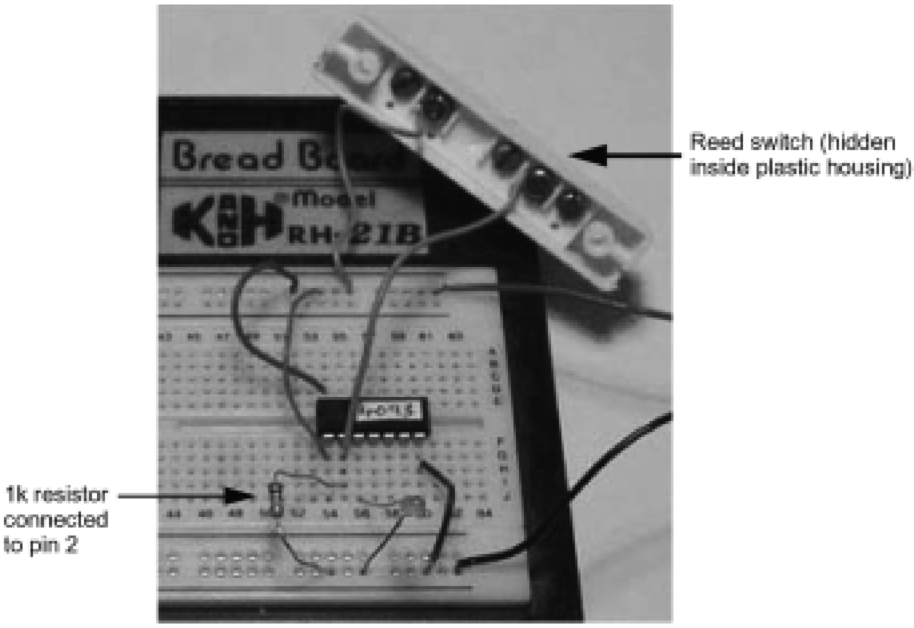


2. Swap the LED for a buzzer.

Notes:

5A: A Reed Switch Circuit (continued)

3. How would you change the circuit so that it uses two reed switches.
   (i) See if you can find two ways of doing this. What are the advantages/ disadvantages/uses of the two ways if you were to use them in a real burglar alarm?
   (ii) How could you make use of them in a real burglar alarm system?



To follow-up

1. The reed switch and magnet are made of white plastic. Why do you think this might be? (That is, why white, and why plastic?)

2. Think about how you would put the switch and magnet to use in your home on a door or window. Where would the switch go, and where would the magnet go?

Notes:

5A: A Reed Switch Circuit (continued)

3. Are these devices suitable for all types of door and window? How could you change the design to be suitable in other cases?

4. Think how you might make a reed switch and magnet combination that could be hidden from view. Sketch your design, and write a brief explanation.

5. In industry it can be important to prevent something happening if a circuit is left unconnected; i.e. left ‘open’. Think of examples, e.g. a safety guard for a machine that prevent the machine form starting if the guard is not down. (Why could this be a vital safety device?) How could you adapt your circuit to act as part of such a safety system?

Notes:

Making an LED Flash

Worksheet: Session 5 Activity B

Flashing LEDs

There is a neat trick that can be played on a 4093 chip to make it repeatedly flash an LED on an off. To make it do this, you need to use a capacitor and a resistor (see the photo on page 65).

A capacitor stores electric charge. It has two ‘legs’, and like an LED one must be connected (eventually) to the positive and one to the negative terminal of a battery. You will find a + sign on the body of the capacitor near one of the legs. The larger the value of the capacitor the more charge it can store. We measure a capacitor’s ability to store charge by the value of its capacitance, measured in units of farads. A one farad (1F) capacitor can store a large amount of charge, and it is more common to use much smaller values in electronic circuits. You will use a value of 10 or 100 micro-farads (10 µF or 100 µF) . (One micro-farad is one millionth of a farad.)

A resistor can help to control how much current flows through a circuit. A very high resistance would be one hundred million ohms, 100M Ω. However, you will use a resistor of value between 1 thousand (1k Ω) and 47 thousand ohms, 47k Ω.

Notes:

5B Worksheet: Making an LED Flash (continued)

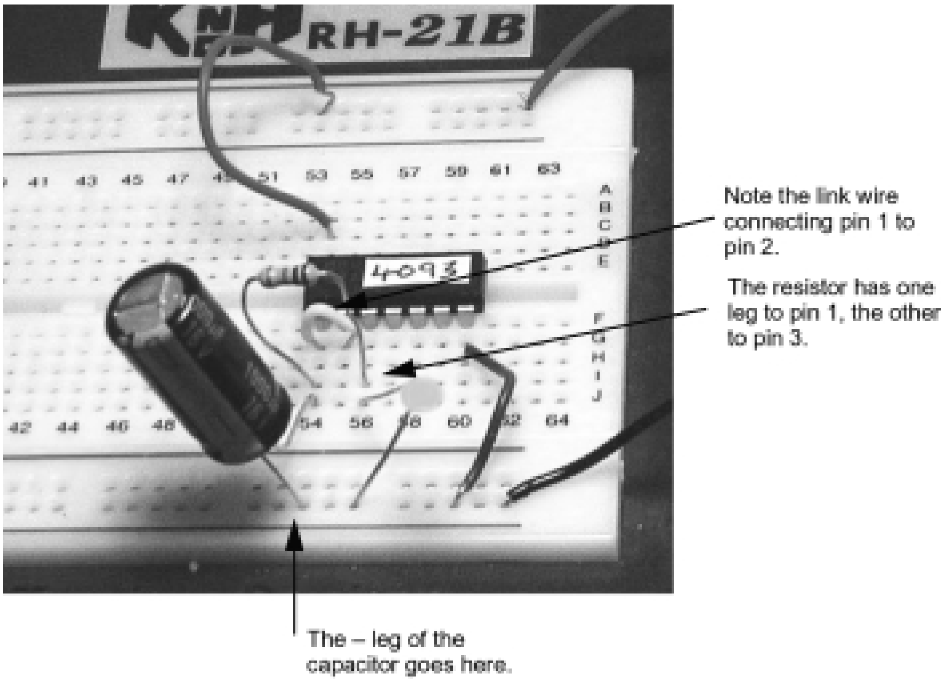
Goal
To learn how to make an LED flash in a simple circuit.

Outcome
Students will understand how varying capacitor and resistor values affect the flash rate of the LED.

Description
Students add a resistor and a capacitor to the circuit from the previous activity and observe the effect of varying the resistor and capacitor values on the flash rate of the LED.

Supplies
As in Session 5 plus 1 resistor and 1 capacitor.

Procedure
1. Build the circuit shown in the photo.



2. Count, and note, the number of flashes given in 1 second, or 10 seconds if the LED flashes quickly.

Notes:

5B Worksheet: Making an LED Flash (continued)

3. Now change the capacitor and resistor for other values that your teacher has available. Investigate how the flashing rate changes as the capacitor and resistor values change. Note: take care how you do this. What is the systematic way (rather than trial and error)?
   (i) Write down short sentences to summarise your findings. E.g. ‘As the value of the capacitor increases, the flashing rate …’
   Note: your circuit may appear not to work with some values of capacitor and resistor. Why might this be? There are two way it might seem not to be working (assuming you have not made a mistake in putting the circuit together).

Things to think about

1. Write down at least two ways you could use a flashing LED circuit in a toy or some other device that people might buy. (It would be fairly easy to adapt the circuit to control more than one LED.)

2. Can you think of any uses for flashing LED circuits in industry?

Notes:

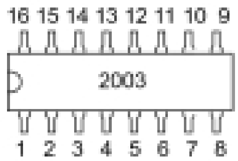
Controlling a Motor

Session 5, Activity C

Making motors turn

The 4093 chip is very useful, but some devices that you might want to use such as motors need more current to flow them than is good for the 4093. You may not have thought much about the way this chip works, but the current mainly flows from pin 8 through the output pin 3 and through the LED, buzzer etc. that is connected to it. The chip senses the voltage that is applied to the input pins 1 and 2, but almost no current flows through these pins. The chip will get very hot, and finally stop working if too much current goes through it. So, if we want to use a motor, as a device to turn on and off, we have to use another chip connected to the 4093 that can allow higher currents to flow through it. Such a chip has the code number 2003. Also, it is important to know that when motors are switched on or off, very high voltages can be produced. The voltages may only last for a tiny fraction of a second, but they can cause damage to the chips or other electrical components. A small electrical component called a diode can protect the circuit. Fortunately, the 2003 has a number of diodes built into it, so it can safely be used with small motors.

The numbering system for the 2003 pins is shown in the diagram below. When you use this chip, the negative of the battery MUST be connected to pin 8, and the positive to pin 9.



Notes:

5C Worksheet: Controlling a Motor (continued)

Goal
Students learn about the current capacities of different silicon chips and why this needs to be considered when using circuits to turn on and off other devices.

Outcome
Students will use a simple circuit to turn on and off a motor.

Description
Students build a circuit using a 2003 chip connected to a motor. They use the 2003 to turn the motor on and off. If they have time students can try adapting their previous circuits using the 4093 chip, a micro switch or a reed switch to turn the motor on and off.

Supplies
Components from previous activities plus 1 electric motor, and 1 2003 chip.

Procedure
1. Connect the 2003 chip into a circuit as shown in the photo opposite. You will use pin 1 to turn the motor on and off. Notice that the motor is connected between the positive of the battery and pin 16.
2. In the photo, you can see that one wire is connected to pin 1, but its other end is not connected to anything. Try connecting the free end to the positive of the battery, and then to the negative of the battery. What happens? Which of the following two statements is correct?
   (i) A positive voltage at pin 1 turns the motor on.
   (ii) A positive voltage at pin 1 turns the motor off.

Exercises
1. The motor you have used turns very quickly (about 4000 revolutions every minute). Suppose you wanted to use it to drive a small four-wheeled buggy. Suggest a way of connecting the motor to the wheels so that the wheels only turn at 500 rotations per minute. Sketch a diagram to show how your idea would work.

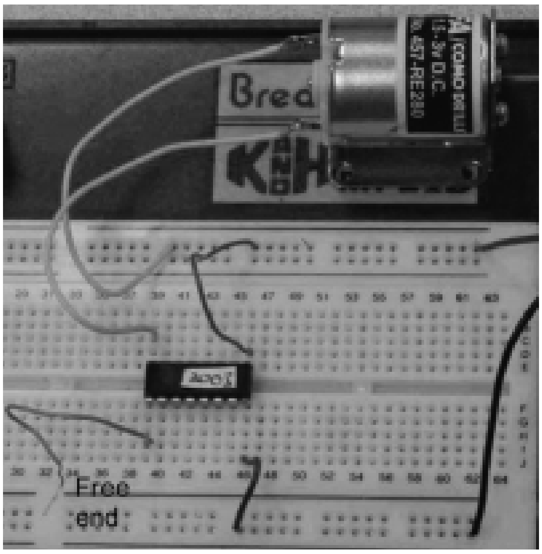
Notes:

5C Worksheet: Controlling a Motor (continued)

2. Think of a way of making the motor turn on and off in short pulses. Build the circuit.

Note: please do not let the motor run for more than a few seconds at a time. You may damage it if you leave it running for more than 10 seconds at a time.

3. Now you can use the circuit you built with the 4093 chip that made an LED light to turn the motor on and off as shown in the photo below. If you look carefully, you can see that one wire is used to connect pins 1 and 2 together. Another wire goes from pin 1 but is not connected to anything else. (You will use it shortly.)
Remember, the connections to the battery should be the last to be made. Connect the free end of the wire to the positive of the battery, and then to the negative of the battery. what happens?

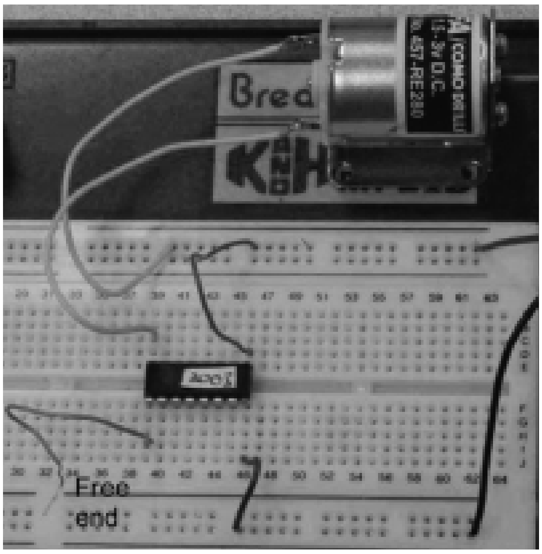


4. Try swapping the two wires to the motor. Does it change the direction of rotation of the shaft?

5. If you have time, try adapting your previous circuits using a micro switch, or reed switch to turn the motor on and off.

Notes:

5C Worksheet: Controlling a Motor (continued)



Something to think about

1. With your partner, think of two ways you could use a motor in a project. (You don't have to use the circuits you have built, although you can if you want.) Write down the key points of your ideas.

Notes:

Design, Build, Make It Go!

Worksheet: Session 6, Activity A

Make a Rolling Toy Design Challenge: Using any or all of the materials in your kit, make a rolling toy that travels 1-1.5 metres on its own power. It does not need to go in a straight line.

If you get stuck along the way, here are some hints:

- Consider a wind-up toy. How does it work?
- Wind-up toys convert potential energy into kinetic energy as they unwind.
- How is the energy stored and released? (Often this is a spring.)
- What could be used instead of springs to store and release energy?

Notes:

Slinky

Reading: Session 6, Activity A

Patented by Richard James, Upper Darby, Pennsylvania for James Industries.
Filed 1 November 1945 and published as GB 630702 and US 2415012.

This is the familiar toy which consists of coils that move downstairs, along the floor, or from hand to hand. Richard James was a mechanical engineer working for the U.S. Navy. While on a ship undergoing trials, a lurch caused a torsion spring to fall accidentally from a table to the floor. Its springy movement made him think. When he saw his wife Betty that night he showed her the spring and said “I think there might be a toy in this.” Two years of experimentation followed to achieve the right tension, wire width, and diameter. The result was a steel coil with a pleasant feeling when handheld, with an ability to creep like a caterpillar down inclined planes or stairs, and an interesting action when propelled along the floor. Betty came up with the name of Slinky*, from slithering.

James managed to persuade Gimbels, the department store, to give him some space at the end of a counter. He would demonstrate the toy and hope to sell some of his stock of 400. It was a miserable November night, and Betty and a friend were on hand to buy a couple to encourage sales. They never had the chance, as crowds gathered around and the entire stock went in an hour and a half. A company, James Industries, was set up to make the product. A machine was devised which coiled 24 meters in 10 seconds. The price was $1 in 1945, which had increased to $2 by 1994. Over 250 million have been made, with some variations, including brightly colored plastic models. The only substantial change in the design is that the end wires are now joined together to prevent loose wires damaging, for example, an eye. The trademark was registered in the United States in 1947 and in Britain in 1946.

Besides the obvious fun possibilities, the toy has been used by science teachers to demonstrate the properties of waves. NASA has used them to carry out zero gravity physics experiments in the space shuttle. And in Vietnam, American troops used them as mobile radio antennae.

Van Dulken, Stephen. *Inventing the 20th Century, 100 Inventions That Shaped the World.* New York: New York University Press, May 2002. www.nyupress.nyu.edu*

Notes:

What is a Mechanical Engineer?

Reading : Session 6, Activity A

What Do Mechanical Engineers Do?
Mechanical engineers turn energy into power and motion. Machines, tools, and equipment are designed, produced, tested, and improved by mechanical engineering teams. Examples include fuel-efficient cars, scooters, toys, power plants, hydraulic systems, medical devices, laser-based tools, sports equipment, measurement devices, and the list goes on and on… In fact, almost every object with moving parts that you encounter today involved a mechanical engineer.

In the future, mechanical engineers will continue to develop new materials, work on problems such as environmental pollution control and in the electric power, airline, and telecommunications industries. They will be involved with laser technology, computer-aided design, automation, and robotics.

Where Do Mechanical Engineers Work?
Mechanical engineers work in all areas of manufacturing industries. They can work in research and development, management, maintenance, and production operations. Some engineers become consultants in the research, design, and testing of technologies. Creativity combined with mechanical engineering skills is a great start for an inventor!

For more information on mechanical engineering as a career go to the resources section at the back of this folder. Students could be asked to familiarize themselves with the role of an mechanical engineer as homework.

Notes:

Gears, Cranks, Crankshafts and Belts

Worksheet: Session 6, Activity B

Make a Crankshaft Device

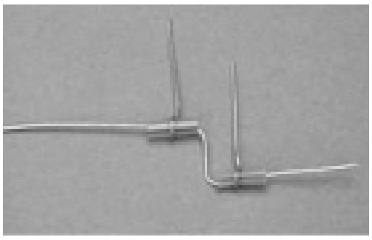
Do you remember playing with jack-in-the-box toys when you were small? They have a crank mechanism something like the toy you will make today. With this crankshaft toy, you will see how the direction of a force can be changed mechanically. Turning the crank around and around makes other parts go up and down!

Supplies

- Small box (250 ml milk carton will do)
- 3 pieces 16-gauge steel wire: one 20 cm length, two 7.5 cm lengths
- 1 straw
- Electrical tape or long bead (for crank handle)
- Needle-nose pliers

Steps

1. Cut off the top of a milk carton to make a small box with one side open.
2. Turn the box so the opening is on the table, and drill or poke (using the wire) a hole in the right and left sides of the box at the same height.
3. Drill or poke two holes in the top. They should be in a straight line with the other two holes.
4. Cut two short pieces of straw about 1/3 the length of the box.
5. Wrap the end of one of the small pieces of wire around one of the pieces of straw. Make it secure, but not too tight, as the straw should spin freely on the wire that will go through it. Repeat with the other wire and the other straw.



6. Place the straws (with wires dangling for now) over the long piece of wire, leaving one more inch of wire on what will be the crank handle end.
7. Make the center two bends between the straws, leaving a straw-length section of wire between the bends.

Notes:

6B: Gears, Cranks,Crankshafts and Belts (continued)

8. Bend the shorter non-crank end of the wire at the outside edge of one straw.

9. Bend the longer crank end of the wire at the outside of the other straw.

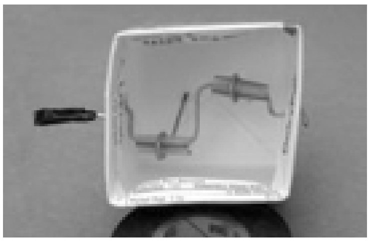
10. From the inside of the box, stick the non-crank end of the wire through one of the holes and bend the end on the outside of the box so it doesn't slide out. You will need to put careful tension to make this fit into the box. Try to keep the wire in the same form.

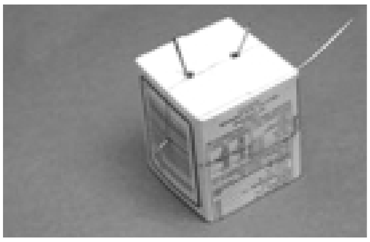
11. Reach into the underside of the box and gently turn the smaller wires so they poke through the holes in the top of the box.

12. Stick the other end of the wire into the other hole, and make two bends outside the box, making a crank.

13. Secure a large bead or electrical tape on the crank to make a handle.

Crank the handle and watch the wires go up and down. It may need some adjustment to get the best motion. Now it's all up to you! How will you turn the up and down motion into something fun?





Notes:

Using Motors to Produce Motion

Session 6, Activity C

Goal
To investigate some aspects of using motors to produce motion.

Outcome
Students will use a Lego Technic kit to build a buggy and study how it works.

Description
This activity is designed to introduce you to some aspects of using motors to produce motion. A familiar example is the use of an electric mixer in food preparation; but no doubt you will be able to think of many more examples where motors are used. We can’t easily investigate a food mixer in class; instead you will use a LEGO Technic kit to build a small buggy, and study how that works. You may do this work with your group partner(s); or you may do it as a class activity. Much of what you will learn applies to larger scale devices such as food mixers, or cars that use motors (whether they be electric, petrol or diesel).

Procedure
Exercise 1
Build the small LEGO buggy by following the instructions on the separate sheets. However, as you do this, write down brief notes and/or draw diagrams in answer to the questions below.

Do NOT connect the motor to the battery pack until you are told do so.

1. How many cogs are there on the large gear wheel?

___

2. How many cogs are there on the small gear wheel to which the large one connects?

___

3. The large and small gear wheels are at right angles to the axles of the buggy. How is the motion of the gear wheels transferred to the front axle?

___

4. Would you say the finished buggy is stable? Explain your answer.

___

Notes:

6C: Using Motors to Produce Motion (continued)

Ask your teacher for permission to try out the buggy. Please do NOT leave the buggy switched on for more than a few seconds—otherwise the batteries run down very quickly.

Exercise 2

1. Work out a way to measure the speed of the buggy. You MUST write down your plan. You may be asked to discuss your ideas with other students.

2. When your teacher gives permission, try our your ideas. You should finish up with an estimate of the speed of the buggy in cm/second. How accurate do you think your estimate is? Could you improve the accuracy? If so, how?

3. The diameter of the wheels is about 3cm, so the radius is about 1.5cm. Use the formula for the circumference of a circle to calculate the circumference of one of the wheels.

   circumference = 2 x π x radius = 2 x 3.14 x radius

4. The circumference is also how far the buggy will go when the wheels revolve once. Use your result for the speed of the buggy to calculate how many times the wheels would turn in 1 second. Your answer will have units of 'revolutions per second'. Then convert your answer to revolutions per minute. Give your answer as a whole number. Write down your results, e.g. by saying 'The wheels turned at XX revolutions per second', 'The wheels turned at XX revolutions per minute'.

Now we shall try to estimate the speed of the motor itself. You will remember that the wheels are driven using gear wheels. The first thing to do is to work out how the gears affect the speed of the buggy.

Exercise 3

1. If the large gear wheel goes round once, how many times will the small gear wheel go round? (Look back to your answers in Exercise 1.)

2. Suppose the wheels were turning at 300 revolutions each minute, how fast would the motor actually be turning? Check your answer with your teacher before continuing with the next question.

Notes:

6C: Using Motors to Produce Motion (continued)

3. Now using your answer to question 4 of Exercise 2, estimate the actual speed of the LEGO motor.

4. In the information that LEGO provide about the motor, it says that it turns at about 350 revolutions per minute. How does your answer compare with that figure? Why do you think your result is likely to be at least a little different from the one LEGO claims?

More about gears and using motors

You should have discovered that the effect of using a large gear wheel attached to the motor, and a small gear wheel connected to the wheels makes the wheels rotate faster than the motor turns. In such a case we say that there is ‘high gearing’.

Questions

Q.1 Suppose you wanted the buggy to move much more slowly than the motor turns. How would you make this happen? (This arrangement could be called ‘low gearing’.)

Q.2 Imagine the buggy was very heavy. Would it be easier for the motor to move the buggy using high gearing, or low gearing?

Q.3 Look at the picture of the food mixer opposite. You can see on the side a lever near a series of numbers. What do you think the lever is for? Why are different settings needed on a food mixer?

Q.4 If you could see inside the mixer, suggest (in a simple way) what happens inside it when the lever is moved.

Notes:

6C: Using Motors to Produce Motion (continued)

Follow-up work

1. Most students want to learn to drive a car. If/when you take driving lessons, one of the most tricky things to do is to learn how to use the clutch pedal and change gears properly. Find out what the clutch does, and briefly write down what you find out. You may be asked to outline your findings to the rest of the class.

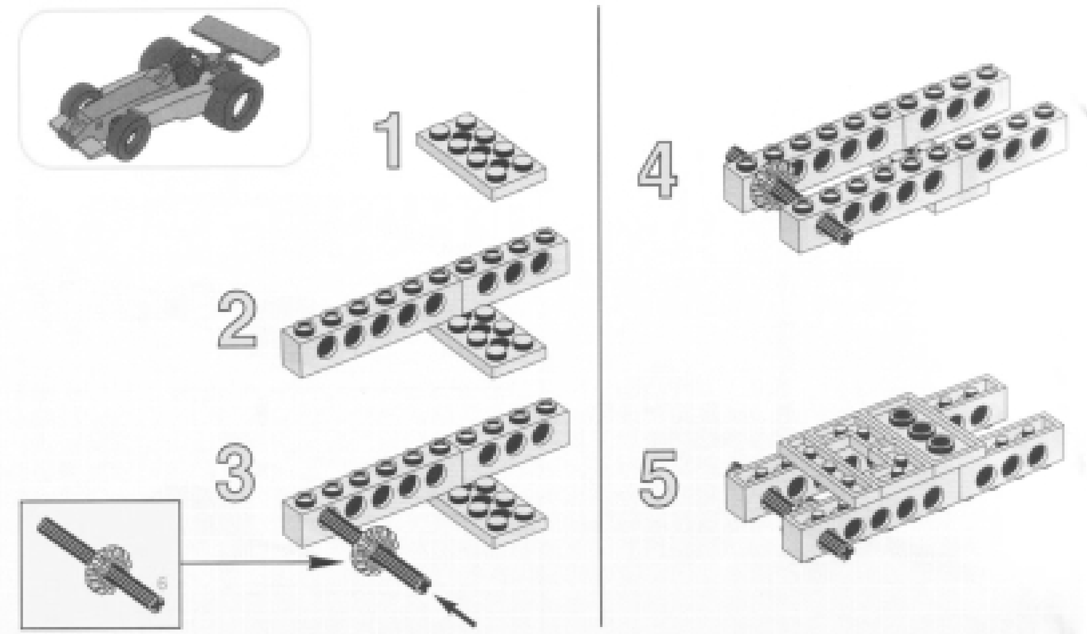
2. Most cars run on petrol or diesel fuel. However, car engines are not very efficient, and much research is taking place on trying to find more efficient engines. Some manufacturers are investigating the use of electric motors. Find out about alternatives to petrol an diesel engines. (Hint: try putting words such as 'Prius', 'energy efficiency', 'fuel cells" into Google or some other search engine on the internet.)

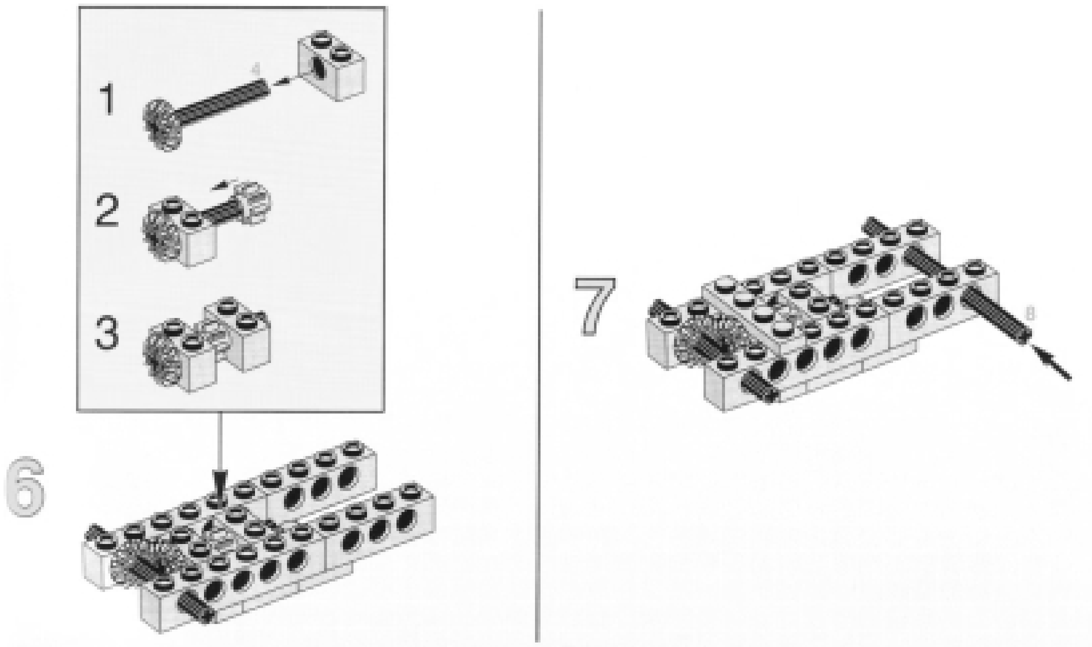
3. Look carefully at a food mixer that you may have at home. What are the key features of its design? Is it easy to use? Does it have any faults? Make some suggestions for improving the mixer so that it would be more appealing to customers.

Notes:

Using Motors to Produce Motion

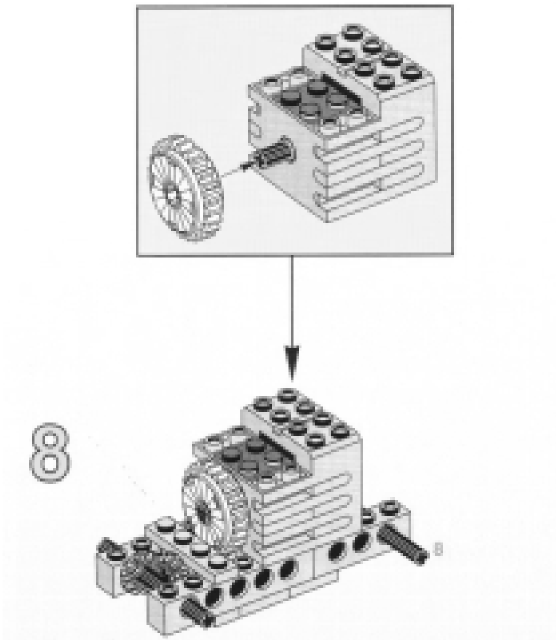
Worksheet: Instructions for making the LEGO buggy

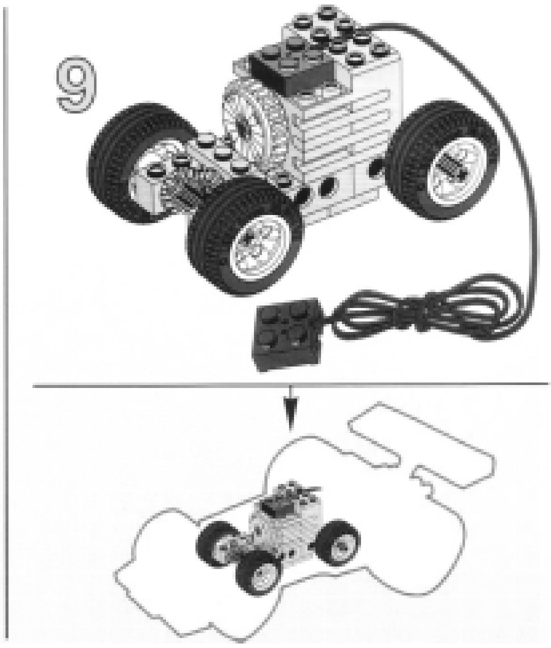




Notes:

6C Worksheet: Instructions for making the LEGO buggy (continued)





Notes:

Brainstorm - What is a robot?

Worksheet: Session 7, Activity A

You will have seen robots in action in film, in the news, on documentaries and in real life. Write down the names of three of these and the function that they were carrying out.

Robot Name	Function

Some formal definitions
The technical people have attempted to come up with really fancy definitions such as:

1. An intelligent robot is a machine able to extract information from its environment and use knowledge about its world to move safely in a meaningful and purposeful manner.

2. A robot is a system which exists in the physical world and autonomously senses its environment and acts in it.

3. A robot is a re-programmable, multi-functional, manipulator designed to move material, parts, or specialised devices though variable programmed motions for the performance of a task.

4. Robotics is the intelligent connection of perception to action.
   Which one of these best describes the robot? You could come up with a better definition, have a go. We will discuss these in class. Also we will go through everyone's 3 robot names and record these on the board. You should write down all of the robots on the list as you will need this in the next session.

Notes:

Robot Movement – Locomotion System

Worksheet: Session 7, Activity C

Locomotion Systems
Using the list of robots from the brainstorming session, pick examples for each locomotion system in the following table.

Locomotion system	Robot
Move on wheels	
Move on Tracks	
Walk	
Fly	
Swim	
Remain Stationary	

Sensing and interacting with the environment

Imagine if a robot could not interact in any way with the environment around it. Can you imagine what value it would be? Think about it! The reality is that it would be completely and totally useless! Take two examples of robots from the brainstorm list and describe how they react with the environment.

Bomb disposal robot

Robot Name	How it senses and interacts with the environment

Notes:

7C Worksheet: Robot Locomotion and Interaction (continued)

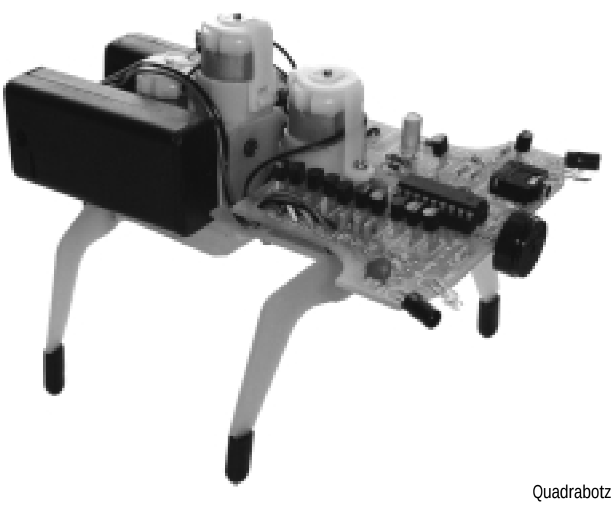
Energy Sources
If a robot is to move around then it nearly always gets its power from batteries. Providing they are charged up, batteries provide a steady stream of energy. Robotic forklift trucks are often used in industry for packing shelves. When they sense the batteries going low, they go to the "sick bay" and plug themselves in to the charger. The Mars Sojourner robot uses solar power to keep the batteries charged. Robots used in car assembly are usually stationary and can be connected to mains power. Have a look around the school, town and in your own home and try and find at least one item that is powered by:

1. Rechargeable batteries ______
2. Non-rechargeable batteries ______
3. Mains ______
4. Light ______
5. Movement ______

Exercise 3

Quadrabotz's anatomy
On the photograph of Quadrabotz see how many of the following parts you can label:

- Front, middle and back motors.
- Left and right LEDS and photo detectors
- The micro-controller
- Battery packs
- The PC programming socket
- On/Off switch
- Piezo sounder



Quadrabotz

Notes:

Robot Applications

Worksheet: Session 7, Activity D

In the grid, list out three strengths and weaknesses for both humans and robots.

Human	Robot
Strengths:	**Strengths:**
Weaknesses:	**Weaknesses**:

Notes:

Robot Applications

Reading: Session 7, Activity D

Programming
Every computer from the tiny one that controls Quadrabotz to the world's biggest super-computer understands just one's and zero's. All of these computers depend totally on humans to tell them what to do. Humans must program every step of the computer's activity whether that is to carry out a calculation, play a game or guide a missile. Quadrabotz is no exception. You can write the program on a PC and send it to the robot via the communications lead. Quadrabotz will faithfully follow your every command, no matter how silly or wrong they are! For instance we can tell Quadrabotz to beep, wait a moment and continuously repeat this action. Quadrabotz will keep doing this until its battery runs down. This not very useful you will agree but it just proves that you are in control of Quadrabotz, not the other way around. The wonderful thing about programming is that you can take what seems to be a collection of simple commands and put them together to create a really useful function. It is bit like painting where the artist works with a palette of paints to create a wonderful picture. So two of the most attractive things about programming are creativity and control. Given that you have total control and also given that we all make mistakes it is to be expected that our programs will contain errors and the robot will not perform as expected. Errors are an inescapable part of the task of programming. The programmer accepts this fact and continuously modifies the program removing all the errors and ensuring that it performs exactly the task it was designed for. There are two main categories of error:

Logical Errors: You want the robot to move forwards but you give it the command to move backwards. You only discover these errors when you run the program.

Syntax Errors: You have given the command to the robot to `burp(200)`. The program editor will actually tell you that this command is unknown to Quadrabotz when you attempt to download the program. The correct command spelling is `beep(200)`.

Don't worry about any errors that arise, this is an everyday part of programming. You cannot instruct Quadrabotz to self-destruct, unless you tell it to walk off the side of the table! In the real world, errors that arise in programs may not be so harmless.

A programming error in banking software might cause an ATM to give you €100 when you requested €10 even though you only had €20 to start with in your account! Banks do an awful lot of testing on their software to ensure that this does not arise.

Notes:

7D: Reading: Robot Applications (continued)

Aeroplanes are controlled by moving flaps on the wings and this is true of the most modern jets. In older planes the pilot's joystick was connected by a steel cable to the flap mechanism for direct control. Modern jets have a joystick just like on a games machine. The joystick is connected to a computer. The program in the computer monitors the movement of the joystick and then moves the flaps by the correct amount. A logical error in this program that caused the plane to go down when the pilot actually pulled the joystick to go up would be a disaster. Understandably, these programs are tested for years before they are released for commercial use.

Robotic lawn mower

Thankfully we are not working on such mission critical software so we can relax and have fun with Quadrabotz.

Pilot's joystick on the Airbus A330 just like a games machine!

An aeroplane on automatic pilot is a giant robot. It senses the effects of air currents and continually adjusts all of the various controls to provide a smooth flight. It will even execute a complex series of turns as it follows a flight plan from, say, Dublin to Athens. The pilot and co-pilot could both sit with the passengers and watch the in-flight movie but this would obviously cause panic.

Notes:

Robot Applications

Worksheet: Session 7, Activity D

Quadrabotz

Load "Exercise1.bbg"
This program delays for 20 jiffies. There are 20 jiffies in 1 second. Quadrabotz starts to run the program following each instruction faithfully. To start with, it does nothing for 1 second. The next line tells it to do a beep(220). It then goes back to the first instruction and repeats the whole program again. This causes Quadrabotz to beep once a second.

```
Delay(20)
Beep(220)
```

Write a program that will make two beeps one second apart, wait for two seconds. Quadrabotz will continuously execute your program so that you should hear BEEP-BEEP SILENCE(2 Secs), BEEP-BEEP SILENCE(2 Secs), etc.

Notes:

Programming

Worksheet: Session 7, Activity E

Quadrabotz design teams

Congratulations! You have now worked with Quadrabotz for a short while and you qualify to join the Quadrabotz engineering design team. You will be split into four separate teams to carry out an evaluation of version 1 of Quadrabotz and you will decide on what improvements need to be made for version 2. It is designed to be an educational robot and you have already learned many things from Quadrabotz version 1. There are four design teams looking at the following aspects of the design:

1. **Locomotion**
2. **Sensing and interacting with the environment**
3. **Intelligence**
4. **Power**

Each functional team will take 20 minutes to evaluate Quadrabotz and will report back to the executive design team where you will defend your well thought-out designs.

Just to get you thinking here are some issues that you may wish to consider as you develop the next generation Quadrabotz.

Team - Locomotion

- As a walking robot, how useful is it?

  ____

- What environments is this walking robot particularly suited to and what factors, if present, would cause problems?

  ____

- What are the limitations (ability to climb, step over stones, walk through grass etc.)?

  ____

  ____

  ____

Notes:

7E Worksheet: Programming (continued)

- Would two legs be better than four and what issues would that give rise to?

- What other system of locomotion would be more useful and fun to work with and learn from?

Team – Sensing and interacting with the environment

- What can Quadrabotz currently sense in the external environment?

- What additional things would it be useful for it to have an awareness of?

- If the Locomotion Team decide that the robot should walk on just two legs, how will it maintain its balance?

- Are there any manipulators that would be useful to include on the next generation robot?

- Is the beeper sufficient as a sounder?

- What other sound would be useful to make?

Team – Intelligence

- From what you have seen of the programming environment, is Quadrabotz really smart enough?

- Are there things that you would like to do, like more complex maths, or have the ability to measure distances?

Notes:

7E Worksheet: Programming (continued)

- Do you think the programming environment is OK for writing instructions for the robot? Are there improvements that you would make?

Team – Power

- Quadrabotz would certainly not survive long in a Robot Wars tournament, but do you think that it is powerful enough as an educational toy?

- If you feel that it is a bit of a weakling, in what ways would you beef it up? Bear in mind that more powerful batteries may be required.

- How would you be able to guarantee that the robot would run forever?

- How would you recharge the batteries?

- Are the 4 AA batteries sufficiently powerful to keep the robot going for a reasonable amount of time?

Projects Brainstorm

- **Light source seeker**. Quadrabotz can be placed in a dark room and programmed to locate and walk towards a torch light.

- **Item counter**. The obstacle detection feature could be used to sense when an object has passed in front of the robot. You could then programme it to beep for every ten items that passed by.

- **Oversize rejection**. A common issue in manufacturing is to automatically reject an item on the assembly line that is out of specification e.g. too wide or too tall. Quadrabotz could be positioned so that the obstacle detector was triggered by an oversized item and the front leg could then be programmed to kick the item off the assembly line. The assembly line track can be powered from one of the motors.

Notes:

7E Worksheet: Programming (continued)

- **Automatic traffic barrier**. The right sensor could be used to detect a car approaching the barrier. The front leg could then be used to raise the barrier. When the car triggers the left sensor the barrier is dropped.

- **Quadrabotz on wheels**. Two motors are attached to the two rear wheels of a three-wheeled cart. The single front wheel can be a castor type. The cart will be steered by moving one of the rear wheels at a time.

Links

Computer Science Lecture Notes "Introduction to Robotics"
http://www-scf.usc.edu/~csci445/

The NASA robotics site for educators
http://www.nasa.gov/audience/foreducators/topnav/subjects/technology/Robotics.html

Notes:

Thinking Creatively about Problems and Solutions

SESSION 8
The 3 R's of Problem Identification

SESSION 8
A Solution Taking Place

Revisit

Worksheet: Session 8, Activity A

It is now time to think about your end-of-year exhibition. This will give you the opportunity to show how hard you have worked and to celebrate your accomplishments. Listen to what other students and parents/visitors say when they visit you at your stand to look at your project. This will provide you with useful information on your prototype and presentation skills. You may then like to do some further work on your project and enter it into the Young Scientist and Technology Exhibition, which is held in the RDS in Dublin each January.

In Session 2 you listed 10 problems you would like to solve. It is now time to REVISIT that list, carry out RESEARCH and REFINE your ideas. You can add some new ideas if you like.

Remember the first step of the design process:

Design Process Step 1. Identify a Design Opportunity

Working with a partner or two other students sort through your lists and identify ten design opportunities.

1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________
7. ________________
8. ________________
9. ________________
10. ________________

Notes:

8A Worksheet: Revisit (continued)

Review the list with your partner/s and select your three favourites based on your discussion and your interest in pursuing the problem.

1.

2.

3.

Where could you gather data about other people's uses and impressions of the problems and improvements that you have identified?

Notes:

Research

Worksheet: Session 8, Activity B

You will now have a chance by surveying people from the general public to do some market research on the three design challenges you chose in the previous activity. Gathering data in this way will help you decide on one design opportunity.

Design Process Step 2. Research the Design Opportunity

Writing a Survey
Writing a survey is harder than it appears. Remember to include a brief introduction explaining what you are doing.

Survey Questions
Questions should be as simple as possible. Remember not to include too many questions and that you are looking for short answers.

Sample questions you might like to ask

1. Do you use this product?

Product 1 yes ❑ no ❑
Product 2 yes ❑ no ❑
Product 3 yes ❑ no ❑

2. What do you not like about this product?

Product 1 ________________

Product 2 ________________

Product 3 ________________

3. Would you use this product if (describe change)?

Product 1 yes ❑ no ❑
Product 2 yes ❑ no ❑
Product 3 yes ❑ no ❑

When you have written your survey you should test it on other members of the class. This will help you identify any questions that might need changing.When you have written your survey you should test it on other members of the class. This will help you identify any questions that might need changing.

Notes:

Refine the Problem

Worksheet: Session 8, Activity C

Review the results of your survey

Using the survey results write the pros and cons next to each of the three design challenges.

Design Challenge	Pros	Cons
1		
2		
3		

Select <u>One</u> design opportunity to address

Develop a Problem Statement

Write a clear problem statement. This is intended for someone who knows nothing about this problem. The problem statement should:

- Begin with a clear, concise, well-supported statement of the problem to be overcome
- Include data collected during the survey/observation in order to better illustrate the problem
- Establish the importance and significance of the problem
- Describe the target population

Notes:

Scamper to Solutions

Worksheet: Session 8, Activity C

You now need to consider possible solutions to your design project. In doing so, it is important to consider the outcome of the design - what do you want the product to do? Use SCAMPER to come up with some solutions. You do not have to use all the steps of SCAMPER

Design Process Step 3. Brainstorm Possible Solutions to the Problem

Substitute (What else can be used instead? Other ingredients? Other materials?)
Combine (Combine other materials, things, or functions.)
Adapt (Can it be used for something else?)
Minimise/Magnify (Make it bigger or smaller.)
Put to other uses (New ways to use as is? Other uses if modified? Other people or places to reach?)
Eliminate/Elaborate (Remove some part or materials, or make one section more detailed or refined.)
Reverse/Rearrange (Flip-flop some section of the item or move parts around. Interchange components? Different sequence? Turn it upside-down?)

List your design solution ideas below:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Review your solutions, asking yourself questions such as:

- Does it address the problem?
- Is it practical?
- Can it be made easily?
- Is it safe?
- Will it cost too much to make or use?
- Is it too similar to something else?

Having answered the questions **circle the three best** solutions

Notes:

Sample Design Brief

Worksheet : Session 9, Activity A

Design Process Step 4. Write a Design Brief

A Design Brief –What it is
A design brief contains:
- a short description of a design problem
- a proposed solution
- the profile of a typical user
- a proposed solution in terms of how it will solve the problem
- a sketch or sketches of the solution
- the basic requirements needed to produce a prototype

A Design Brief – What it does
- It helps clarify the problem that the designer/engineer is trying to solve.
- It doesn't provide a lot of detail about the solution but puts on paper the thinking and research about the problem. Often the act of writing and communicating the problem and proposed solution helps the designer move along in the design process.
- It also serves to introduce the idea to others for feedback.

Remember the design brief may be changed at any time throughout the design process.

Sample Design Brief: Bass Space (patent pending)
Erica is a *Design and Discovery* student. She has played the string bass for a few years and remembers as a beginner struggling with keeping her fingers together. This is Erica's design brief.

Describe the problem. Write a statement that focuses on what's wrong and not working. Recall the features of a problem statement

- Begins with a clear, concise, well-supported statement of the problem to be overcome.
- Includes data collected during the survey/observation in order to better illustrate the problem.
- Establishes the importance and significance of this problem.

When people start playing the string bass, most beginners cannot hold their hand correctly, preventing them from being able to play properly. As a string bass player, I have had personal experience with this and have seen other beginner string bass players also struggle with this.

Notes:

9A Worksheet: Sample Design Brief (continued)

Describe how the current product is used. Provide a context for the problem and explain any related solutions that resemble or relate to the problem but have failed to address the problem.

Currently, there is not a product for this. Sometimes, a string bass teacher may tell her students to tape their fingers together.

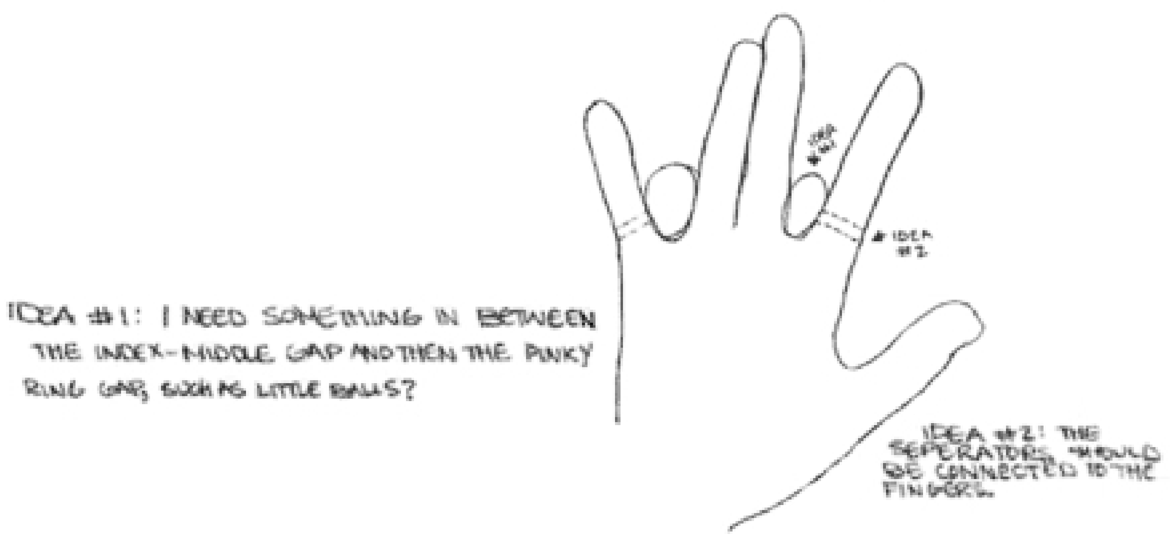
Describe a typical user (user profile). This addresses who uses the product and how their needs are or are not met. How will they benefit from a different product?

A typical user is a beginning string bass player. They struggle with holding their hand correctly and keeping their fingers in place. They will benefit from a product that helps them keep their fingers and hands in the correct form to learn to play the string bass. They will be much more comfortable and able to practise for longer periods of time.

Propose a solution: Describe how it will work, and how it solves the problem. Explain the features.

I'm not sure what type of material I would use, but the Bass Space would allow the player to keep her two middle fingers together and separate from her pointer finger and pinky. It would be adjustable in size depending on the size of the person's hands.

Draw a quick sketch of your ideas. This is a rough sketch and can include drawings of different angles of the solution.



Describe the basic requirements that will best suit the proposed product. For example, this describes the quality (for example: flexible or sturdy) and the type of materials (for example: metal or plastic).

The material needs to be stiff yet flexible to allow hand movement, it cannot break easily, it has to be adjustable for different size hands, will need to slide on and off easily, must be low on the fingers to allow the fingers to bend, must be cost efficient, must hold hand correctly, and it must be comfortable.

Notes:

My Design Brief

Worksheet: Session 9, Activity B

Writing your own design brief should help you clarify your ideas and think about them systematically. This is a working document: It will be your road map as you develop your ideas.

Describe the problem. Write a statement that focuses on what's wrong and not working. Recall the features of a problem statement:

- Begins with a clear, concise, well-supported statement of the problem to be overcome
- Includes data collected during the survey/observation in order to better illustrate the problem.
- Establishes the importance and significance of the problem

Describe how the current product is used. Provide a context for the problem and explain any related solutions that resemble or relate to the problem but have failed to address the problem.

Describe a typical user (user profile). This addresses who uses the product and how their needs are or are not met. How will they benefit from a different product?

Notes:

9B Worksheet: My Design Brief (continued)

Propose a solution: Describe how it will work, and how it solves the problem. Explain the features.

Draw a quick sketch of your ideas. This is a rough sketch and can include drawings of different angles of the solution.

Describe the basic requirements that will best suit the proposed product. This describes the quality (for example: flexible or sturdy), and the type of materials (for example: metal or plastic).

Notes:

The User

Worksheet: Session 9, Activity C

Now that you have a particular design idea in mind it is time to concentrate on the improvement and refinement of your design solution by gathering information about a typical user. It is also a good idea at this stage to look at other inventions and to find out about patenting your idea. This will help you see that there are many different approaches to solving problems and the result is often a variety of design solutions.

Design Process Step 5. Research Your Solution.

The User

Think about your product area. Consider the following questions.

- Who will use this product?

  ____

- What is the person's gender? Age? Experience with this type of product?

  ____

- Where will they use this product?

  ____

- Why will they use this product?

  ____

- What will they be doing to operate or use this product?

  ____

Using the above information, describe one person who will be the user. What are there characteristics and the scenario in which they will use the product? You may include a drawing of the person using the product if that helps.

____

____

What considerations will you need to keep in mind when you design the product to meet the needs of the user?

____

____

Notes:

Patents

Worksheet: Session 9, Activity D

In this activity, you will explore the patent website to find and learn from patents similar to your idea. You will also explore invention Web sites for inspiration and ideas for your project.

Remember you should be keeping detailed records in your design notebook. Be sure to record any changes and additions throughout the process and date everything!

Patent Search for a Problem or Idea
Visit the patent website http://www.patentsoffice.ie/

Patent Search for Your Design Solutions
Now that you are familiar with patents, you can use the patent site for your own research on design solutions. This process will help you to see if anyone else thought of an idea like yours and if so, how those solutions are similar to or different from your ideas. It should also help you plan your solution. If you find that your solution has already been patented or that there is another idea that is better than yours, you may need to take a few steps back and revisit your other problems and/or solutions.

How to do a search:

1. Come up with key words to search.
2. Once you have some results, explore each separate patent to find out about other inventors' approaches to problems and see that there are quite a variety of engineering solutions, materials and design ideas to the same problem!

Ask yourself the following questions:

- How do other inventors view the nature of the problem?
- In looking at the various patents that are similar, are the inventors designing for the same "user"?
- What materials have other inventors used to address the problem? How have others manufactured their inventions?
- Have other inventors' solutions caused unintended problems, like waste due to packaging?
- What do other inventors' sketches/designs look like? What are the similarities/differences in the design solutions?
- What components have other people used? Have they considered similar or very different components for their design solutions? Have they used the same essential components but arranged them in a different way?
- Do different parts of the various inventions captivate you? How can you recombine their ideas to improve on the solution to the original problem?

Notes:

9D Worksheet: Patents (continued)

Other useful Websites that you might like to check out include:

- Rolex* Awards for Enterprise: http://www.rolexawards.com*
- US Inventors Hall of Fame*: http://www.invent.org/index.asp*
- Invention Facts and Myths: http://www.ideafinder.com/history/of_inventions.htm*.
- HowStuffWorks: http://www.howstuffworks.com*
- Timeline of Inventions: http:www.cbc4kids.cbc.ca/general/the-lab/history-of-invention/default.html*

Notes:

Great Inventors

Reading: Session 9, Activity D

Margaret Knight, patent #220,925 (1879) Paper Bag Machine
Knight, the "female Edison," invented a square-bottomed paper bag machine that allowed folded bags to stand open by themselves. She received 26 more patents, including shoe manufacturing methods and improvements to rotary engines.

Harriet Williams Strong, patent # 374,378 (1887), Dam and Reservoir Construction
Strong, a widow with four children, registered patents on flood control/water storage dams and irrigation systems. The dams in her system used the pressure of the water itself in a lower dam to structurally support the higher dam. She became known as "The Walnut Queen" as her system was widely adopted, especially for irrigating walnut groves.

Elisha Gray and Alexander Graham Bell, patent #174,465 (1876) Telegraphy.
In the 1870s, two inventors Elisha Gray and Alexander Graham Bell both independently designed devices that could transmit speech electrically (the telephone). Both men rushed their respective designs to the patent office within hours of each other, Alexander Graham Bell patented his telephone first. Elisha Gray and Alexander Graham Bell entered into a famous legal battle over the invention of the telephone, which Bell won.

Orville and Wilbur Wright, patent #821,393 (1906) Flying Machine.
In 1900, the Wright brothers, Orville and Wilbur, successfully tested their new 50-pound biplane glider with its 17-foot wingspan and wing-warping mechanism at Kitty Hawk, in both unmanned and piloted flights. During 1902, the brothers flew numerous test glides using their new glider. After months of studying how propellers work the Wright Brothers designed a motor and a new aircraft sturdy enough to accommodate the motor's weight and vibrations. The craft weighed 700 pounds and came to be known as the Flyer.

Janet L. Rideout and Martha H. St. Clair, patent #4,724,232 (1988), Treatment of Human Viral Infections.
Rideout, a chemist who worked with retro-virus specialist St. Clair and three other colleagues, discovered that the AZT compound was effective in combating the AIDS virus.

Garrett Augustus Morgan, patent #1,475,824 (1922) Traffic Signal.
Morgan was an African-American businessman and inventor. Among his inventions was an early traffic signal, that greatly improved safety on America's streets and roadways. Indeed, Morgan's technology was the basis for modern traffic signal systems and was an early example of what we know today as Intelligent Transportation Systems.

Notes:

Notes:

Making, Modelling and Materializing

SESSION 10
Project Analysis and Planning for Models

SESSION 11
Making it! Models, Trials and Tests

Project Analysis

Worksheet : Session 10, Activity A

Now that you have narrowed down your design solution, you are ready for Step 6 of the design process. You need to do testing throughout your project development to ensure that your project is safe, durable, and works the way you want it to. It is also necessary to analyse the solution for cost, safety and other implications of the idea.

Design Process Step 6. Refine Your Solution.
Before you continue give your design project more thought and answer the following questions about your design solution.

Is my idea practical? If so, how?

Can it be made easily? How?

Is it as simple as possible? Explain.

Is it safe? How?

Notes:

10A Worksheet: Project Analysis (continued)

Is my project durable? Will it withstand use, or will it break easily? Explain.

Will it cost too much to make or use? Explain.

Is my idea really new? Explain.

Is my idea similar to something else? Explain.

Will people really use my product? How?

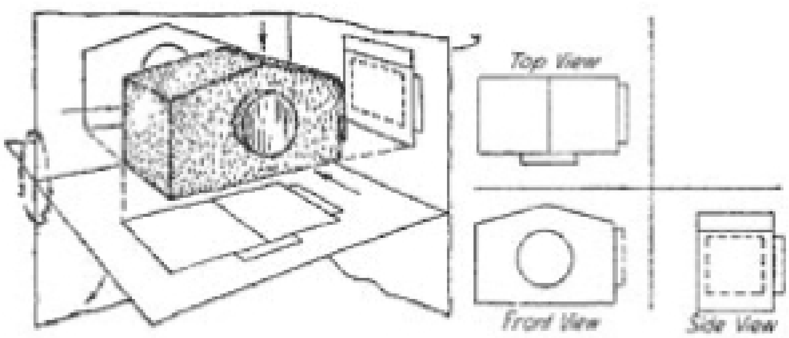
Notes:

Conceptual Drawing

Worksheet : Session 10, Activity B

Drawing From All Sides
Drawing your ideas can help you visualise your plan and will be very useful when you make your model. You may find it very useful to draw the different components and parts of your project from different perspectives. You will probably have several drawings of your project as your ideas evolve.

Design Process Step 7. Prepare Design Requirements and Conceptual Drawings.



Example of Conceptual Drawing

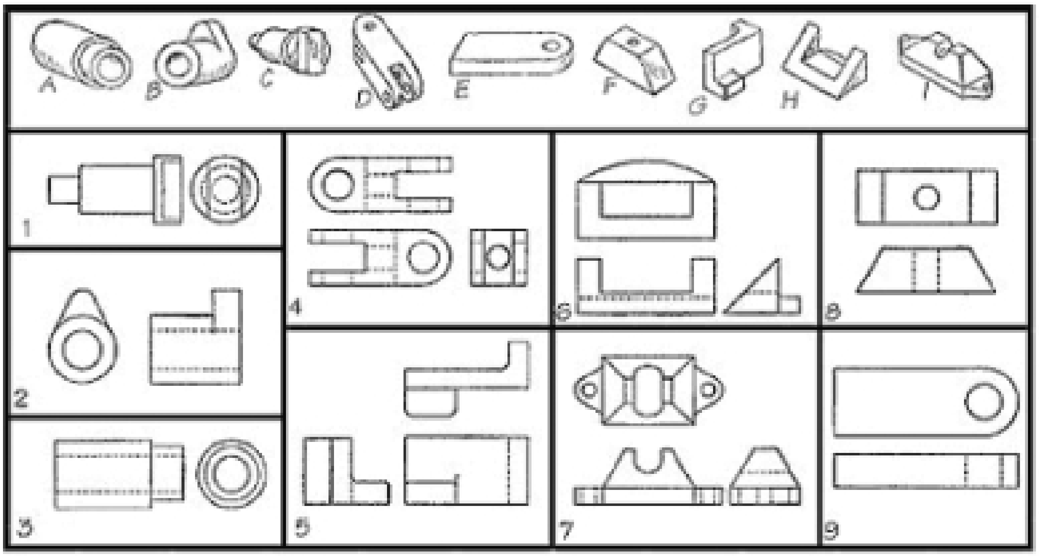
Compare the 3-D drawing of the object below to the three views of the object on the right.

What do the three views show you about the object that you didn't know about the 3-D version?

Notes:

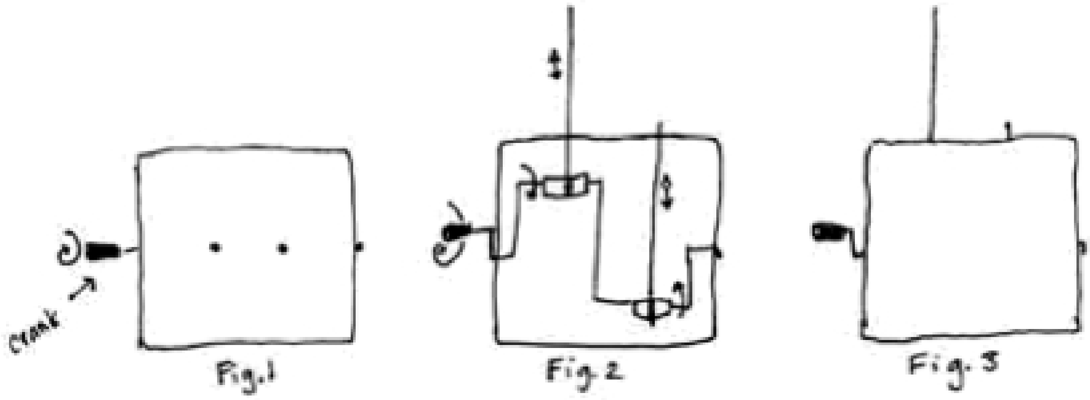
10B Worksheet: Conceptual Drawing (continued)

2. Match the object in the top row with its orthographic sketch.



A ___
B ___
C ___
D ___
E ___
F ___
G ___
H ___
I ___

3. What object is shown here? Label the different figures: interior, top and side.



Now You Try

In your design notebook try your hand at conceptual drawings. Be sure to draw different views as well as individual drawings of the components and parts. Make lots of drawings. Make them large enough to label components and show the direction of any movement that may be appropriate to your design. A video on the Bass Hand project and other project examples can be found at www.intel.com/education/design/resources/project_examples.htm

Notes:

The Design Process

Worksheet: Session 10, Activity C

The Design Process: Getting From “Think” To “Thing”

The checklist below is adapted from the design process steps. This is a tool to keep you organised and thinking about where you have been and where you want to go. It would also be a good idea, at this stage, to look at the planner at the beginning of the module to check how much time you have left to work on your project before the end-of-year exhibition.

1. Identify a design opportunity. (Session 8)

- ☐ Identified about 10 design opportunities (needs, problems, or cool things to design).
- ☐ Narrowed the list of opportunities to three for further research.

2. Research the design opportunity. (Session 8)

- ☐ Refined my design opportunities with interviews and other data-gathering research.
- ☐ Selected one design opportunity to address.
- ☐ Wrote a problem statement to clarify and explain to anyone what I will solve with a design solution.

3. Brainstorm possible solutions to the problem. (Session 8)

- ☐ Expanded my possible solutions using SCAMPER and other research.
- ☐ Evaluated my solutions using criteria that we determined.
- ☐ Narrowed my solutions to three possibilities.
- ☐ Began thinking about the types of materials I could use for my solutions.

4. Write a design brief. (Session 9)

- ☐ Wrote a design brief with a problem statement, description of user needs, a proposed solution, and a sketch of the solution.

5. Research your solution. (Session 9)

- ☐ Researched and refined my proposed solution using the U.S. Patent Office Web site and other resources.
- ☐ Took notes and wrote down information from my research.

Notes:

10C: The Design Process (continued)

6. Refine your solution. (Session 10)

- ☐ Interviewed experts and possible users to analyze my project for feasibility, safety, and other implications of my solution.
- ☐ Researched materials and methods that would be appropriate for constructing my project.
- ☐ Conducted a project analysis to consider any changes to my solution.

7. Prepare design requirements and conceptual drawings. (Session 10)

- ☐ Developed design requirements that focused on the needs of the user.
- ☐ Completed conceptual drawings.

8. Build models and component parts. (Sessions 10, and 11)

- ☐ Analyzed my project design for its systems, components, and parts.
- ☐ Planned models to build and what each model would test or be able to demonstrate.
- ☐ Built a model or models of components of my design.
- ☐ Developed a project plan for completing my design.

9. Build the prototype. (Session 12)

- ☐ Conducted further research, model building, and testing, as needed to complete a working prototype.
- ☐ Developed specifications.
- ☐ Completed first working prototype.
- ☐ Analyzed prototype for functional improvements.

10. Improve your solution. Test, evaluate and revise. (Session 13)

- ☐ Prioritized improvements needed and built new or revised prototype to meet priorities.
- ☐ Evaluated prototype for function, feasibility, safety, aesthetics, and other criteria.

Notes:

Materials and Modelling Plans

Worksheet: 10, Activity D

In this activity, you will start to plan your model. Like anything, the more planning you do in advance, the better your chances of achieving what you want. It's best to put answers to the questions below in your design notebook.

A Model is a small but exact copy of something

1. What do you want or need a model of? (List at least three possibilities.)

   ____

   ____

   ____

2. For each model possibility, consider the following questions and answer them in your design notebook:

   - Is this a system or a component of your design project?
   - What will this model help you understand about your idea?
   - Will it be a small or full-scale version?

3. As you plan, you may select and manipulate different materials. Be sure to make notes about the materials that you study: their flexibility, strength, and their suitability as a modeling material. Fill out the checklist below and write a list of what materials are available in school and what you need to get yourself and bring into the next class.

Material	Available in school	Must bring in

Tip: When planning your model, it is better to plan to build a bigger model so that the details can be seen, tested, and understood.

Notes:

Making Models

Worksheet: 11, Activity A

It is helpful to keep good records of your model building efforts. Good records allow you to adjust your design based on what you learn from each model you build. For each model record your plans, purpose, tests and results, and next steps using the questions below. You may find it easier to use your design notebook for these records.

Design Process Step 8. Build Models and Component Parts.

Plans
What do you want to build a model of? Is this a system or component of the product?

Purpose
What will this model help you understand about your design?

Tests and Results
What did your model show you about your design? What functions did you test? Did it function as intended? Did it meet requirements? Did the form suit you? Are the materials suitable? What modifications do you need to make? What new ideas do you have for your design?

Notes:

11A Worksheet: Making Models (continued)

Next Steps

What do you want to do next? Adjust this model? Build another version of this model? Build a model of something else?

For the next two class periods and at home you will continue to build your model/s. Remember to use your design notebook to record any changes.

Notes:

Notes:

Prototyping and Final Presentations

SESSION 12
Prototype Practicalities

SESSION 13
Prototype Review and Presentation

Prototype Planning
Worksheet: Session 12, Activity A

Budget
Worksheet: Session 12, Activity B

Prototype Work Session
Worksheet : Session 12, Activity C

Test it
Worksheet: Session 13, Activity B

Evaluate and Revise it
Worksheet: Session 13, Activity C

Present it
Worksheet: Session 13, Activity D

Project Reflection
Worksheet: Session 13, Activity E

Prototype Planning

Worksheet: Session 12, Activity A

Now that you have a model made, it's time to move on to the next step: building a prototype. Remember the differences between a prototype and a model.

Model: A small but exact copy of something.
Prototype: A working model of a machine or other object used to test it before producing the final version.

This is the first part of Step 9 of the design process: Build the Prototype - develop project specifications.

Design Process Step 9. Build the Prototype.

Building a prototype can be fun and challenging. Here are a few tips to keep in mind.

1. Make it large enough. Remember that others will want to see the detail and you will want to make sure all the parts work.
2. Pay attention to detail. Be sure that you show all the parts and components.
3. Make it strong. Use durable materials.
4. Make it "green." Use recyclable materials when possible.
5. Make it realistic. The prototype should be as close to the real product as possible.

Ask yourself the following questions.

1. What ideas do you have for developing your prototype?

____

____

____

2. What suggestions do your peers have for you?

____

____

____

Notes:

12A Worksheet: Prototype Planning (continued)

3. What materials are you considering using for your prototype?

____

____

____

Fill out the checklist below and write a list of what materials are available in school and what you need to get yourself and bring into the next class.

Material	Available in school	Must bring in

Draw a sketch of your prototype in your design notebook and label the materials.

Notes:

Budget

Worksheet: Session 12, Activity B

Prepare a budget for your project. Include the materials, how much you will need of each material, the cost for each material, and the total cost.

Materials	**Quantity**	**Cost**
	Total Cost =	

Notes:

Prototype Work Session. *Develop it!*

Worksheet : Session 12, Activity C

It is helpful to keep good records of your prototyping efforts. Good records allow you to adjust your design based on what you learn from each step of the process. The questions below can help with this record keeping.

Plans
How do you plan to build your prototype?

Purpose
What will this prototype be able to do?

Testing
Will the prototype meet your specifications? How will you test this and what data will you gather?

Next Steps
What do you want to do next? Adjust this prototype? Build another version of this prototype?

Notes:

Test it!

Worksheet: Session 13, Activity B

The time has now come for you to test and evaluate your prototype for function, feasibility, safety, and aesthetics and then make modifications. This process of testing and modification continues until you have a final working prototype.

Design Process Step 10. Improve Your Solution. Test, Evaluate and Revise.

User testing will help you to know if your product does what you want it to do. For example, does it work the way it is supposed to? Do people like the way it looks? It's best to conduct user testing with people who you think will be using this product and have more than one prototype (if possible) for them to compare.
In order to make the user testing most useful, select appropriate people to do the user testing and appropriate conditions to conduct the testing.

Sample Questions

1. What do you like and dislike about this product?

   ____

2. What do you think this product should do?

   ____

3. What could be done to make you want to use this product more?

   ____

4. What do you think of the way this product looks (the aesthetics)?

   ____

5. Is this product efficient, safe, and comfortable to use? If not, how could it be improved to make it more ergonomic?

   ____

6. What do you see as some problems with this product?

   ____

7. What can be done to solve these problems?

   ____

Notes:

13B: Test it! (continued)

Additional Questions

1. ______________________________
2. ______________________________
3. ______________________________

Observations

1. What does the user do with the product?
   ____
2. What are the user's perceptions of the product?
   ____
3. How successful or unsuccessful does the user think the product is?
   ____
4. How does it meet or fail to meet the user's needs?
   ____
5. How safe is the product?
   ____

Additional Observations

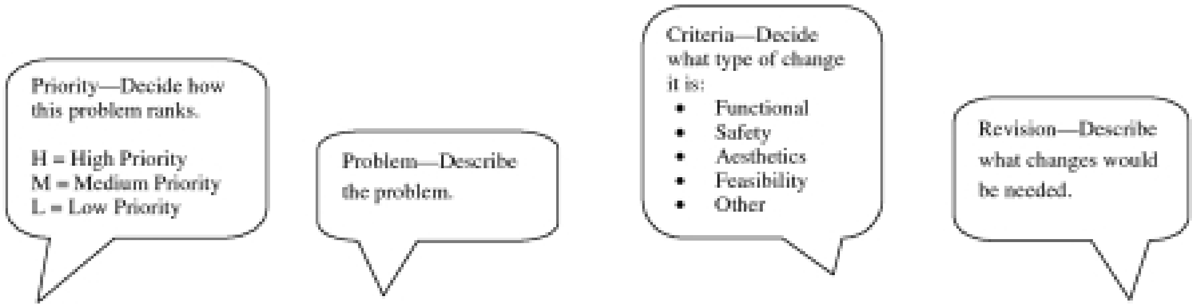
1. ______________________________
2. ______________________________
3. ______________________________

Notes:

Evaluate and Revise it

Worksheet: Session 13, Activity C

Now that you have feedback from your user testing, you need to organize the information in order to figure out which suggestions you will incorporate into your revisions. After completing the chart, decide which revisions are most feasible and what your process will be.



Priority	Problem	Criteria	Revision

Notes:

Present it

Worksheet: Session 13, Activity D

Design Your Display

You are now ready to design your display for Transition Year night or maybe you are planning to participate in the Young Scientist and Technology Exhibition. It is important when designing your presentation board, to keep in mind several design principles. Attention to the principles of graphic design will make your presentation more enticing and easier for others to use. Good design should attract viewers' attention to your project and then guide their understanding of the information you wish to convey.

Consistency

- Establish a style for your display and stick to it. Too much variation will make your display seem disjointed. Be consistent with all the elements.

Clarity

- Keep questioning whether your message is being conveyed clearly. Do the illustrations and charts convey what they are supposed to?
- Think about the clarity of your visual presentation. Is it cluttered? Question any possibly unnecessary elements like cute stickers, doodles, patterns, etc.

Attention To Detail

- Judges will notice if a display has grammar and spelling errors. Get people to proof your work.
- Make a checklist of the points you want to cover in your display and double-check that you present each.
- Make sure all your pieces are cut out with straight lines (use a ruler) as this will make your presentation look more polished and professional.

Elements Of Your Design
Colour

- Limit your design to two or three colours. Use tints and shades of these. A large number of colours make designs seem less planned and inconsistent.
- Determine how colour will be used and why. For example, you might want all your headers to be one-colour and text blocks to be another, so the headers will stand out.
- Keep in mind that different colours have different connotations and a power of their own. For instance, red usually demands attention. It can be used effectively for this purpose, but only if used in moderation.

Type

- Pick only one or two fonts for the text so your display will look consistent and unified. A large number of fonts, like too many colours, can seem disjointed and confusing.
- Decide on one or two techniques for emphasis in your type style. Some possibilities are: bold, italic, all caps (capitalising all the letters of a word), colour and choice of font.
- Don't use underlining if you have italic available. Underlining was designed to represent italic for typing since typewriters don't have italic.

Notes:

13D Worksheet: Present it (continued)

- Avoid writing words vertically (with the letters stacked) as this will reduce readability.
- All caps are less readable than standard text, so if you choose to use them, do so only with small quantities of text, such as titles.
- Narrow columns of text are easier to read than wide columns of text. Left-justified or full-justified text is easier to read than centred text (for longer items).

The Presentation
Now that you have completed your project you need to spend some time improving your presentation skills. Conduct a brainstorm with your team members. Ask yourself the following questions:
- What will you need to explain in the presentation?
- What will you need to show in the presentation?
- What presentation skills will make your presentation successful?
- How long is the presentation expected to be?

The following points should help you.

Presentation Content
- Problem clearly described
- Solution clearly explained
- Design process articulated
- Drawings, models, and prototypes explained
- Documentation on hand for questions

Drawing, Models, and Prototypes
- Design drawn in detail
- Models show how project works. Model may include parts and components
- Prototype is a working prototype
- Drawings, models, and prototypes explained in detail

Presentation Skills
- Presenter speaks clearly and explains project in detail
- Presenter is knowledgeable about all aspects of project and can answer questions.
- Presenter is well prepared
- Speaker holds interest (maintains eye contact, uses gestures, varies voice inflection)

Time permitting; you should practise your presentation with other students. You should also practise your presentation at home.

Notes:

Project Reflection

Worksheet: Session 13, Activity E

Project Reflection

1. In general, how do you feel about the fair? What did you like or dislike about it? How would you change it if you were to hold the fair again?

2. How did Design and Discovery meet or not meet your expectations?

3. Would you recommend Design and Discovery to a friend? Why or why not?

4. How did Design and Discovery influence the career you are considering?

5. How do you feel about your project?

6. What changes are you planning to make on your project or presentation board?

Notes:

Post-Survey

Design and Discovery Post-Survey

What you think is important to this science project. Please answer the questions below honestly. There are no right or wrong answers, and your surveys will be kept confidential. Thank you for sharing your thoughts. Circle the number indicating your level of agreement with the statements.

	Disagree	Disagree a little	Agree a little	Agree
1. I understand what I need to do to complete my project display at the TY end of year event and how to enter in the Young Scientist and Technology Exhibition.	1	2	3	4
2. Learning how computers work is interesting.	1	2	3	4
3. Continuous advances in computer technology are important.	1	2	3	4
4 I understand how I can use the computer for my science fair project.	1	2	3	4
5. I would like a career that requires a math or science background.	1	2	3	4
6. I would like a career that involves designing things.	1	2	3	4
7. My future career requires a computer . technology background.	1	2	3	4
8. I am good at solving problems.	1	2	3	4
9. If I try hard, I can learn anything.	1	2	3	4
10. I like to find out things on my own.	1	2	3	4
11. I am informed about different kinds of jobs that use:				
Maths.	1	2	3	4
Engineering design.	1	2	3	4
Science.	1	2	3	4
Computer technology.	1	2	3	4

12. Describe what you think an engineer does at work. What kinds of skills are needed to become an engineer?

Notes:

Design and Discovery Post-Survey (continued)

	Disagree	Disagree a little	Agree a little	Agree	X
In Design and Discovery it was interesting to:					
Interview and talk to engineers	1	2	3	4	X
Talk with teachers	1	2	3	4	X
Learn about problem solving	1	2	3	4	X
Work on group projects	1	2	3	4	X
Work on my science fair project	1	2	3	4	X
Use the computer for research	1	2	3	4	X
Use the computer to talk to other students	1	2	3	4	X
Talk about my work	1	2	3	4	X
Learn about design	1	2	3	4	X
Draw designs	1	2	3	4	X
Take field trips	1	2	3	4	X

Did you go on any field trips? Where?

____________________ ____

Why?

____

____

I plan to enter the science fair this year. ☐ Yes ☐ No ☐ Not sure

Do you know what your project will be? ☐ Yes ☐ Not completely ☐ No

If 'Yes', what is your topic?

____

First two letters of your:

______ ______ first name*

______ ______ last name*

______ / ______ / ______ Date of birth*

Thank you for your time and thoughts.

**This information will allow us to follow your responses over time.*
We will summarize all data, however, and no one will be identified.

Notes:

Notes:

Notes: