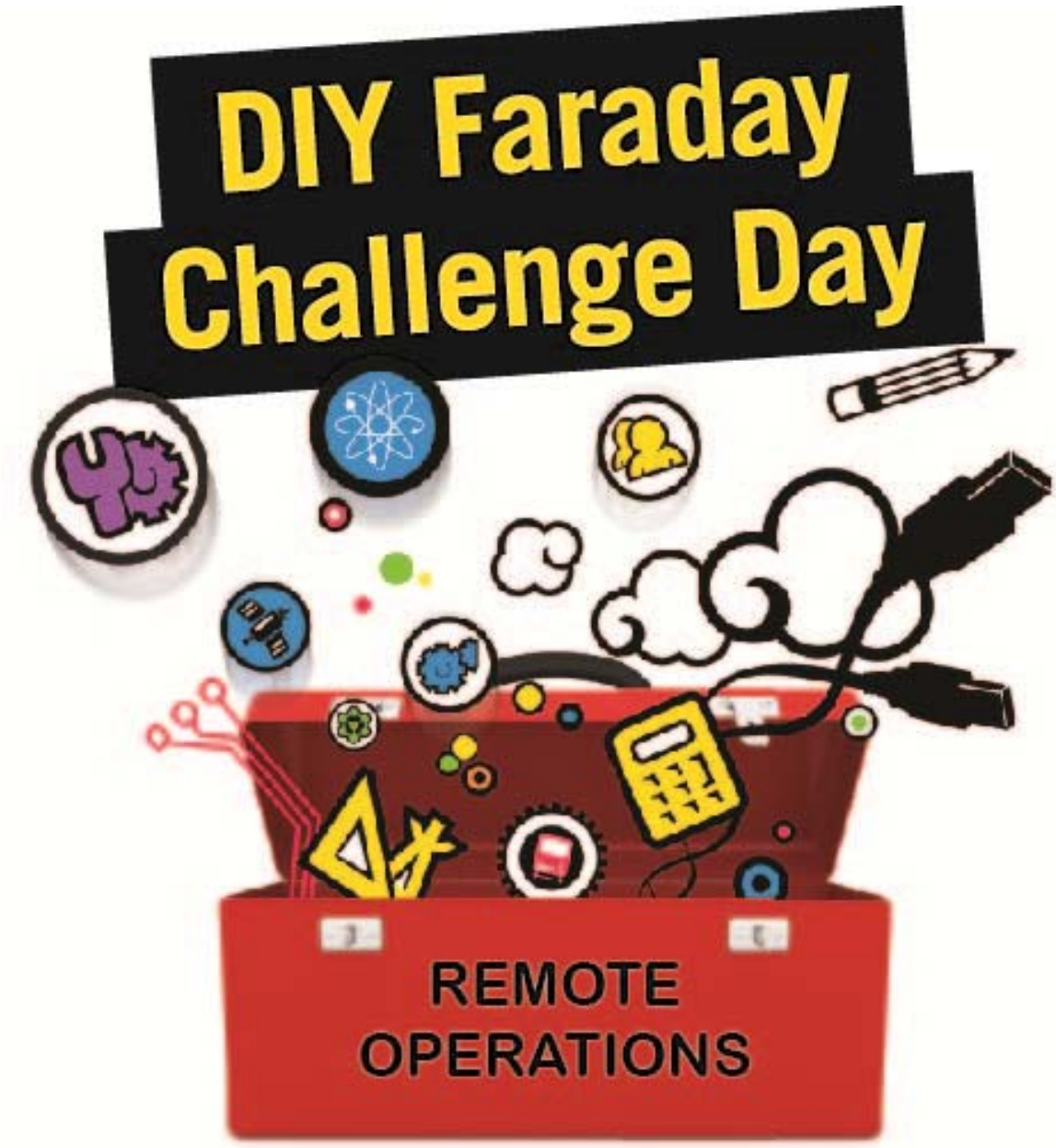


Teachers' pack

Contents

The Faraday Challenge: Remote Operations

Creative problem solving for different ability levels

This cross-curricular Science, Design and Technology, Engineering and Mathematics (STEM) activity day encourages the development of students' problem solving, team working and communication skills. Students achieve a better understanding of what engineering is and the science, maths and technology elements within engineering, leading to increased engagement in science or technology lessons afterwards.

The challenge has been specifically designed to give students the opportunity to be creative in their solutions and to succeed, independent of their level of ability. This activity is therefore suitable for a range of different ability levels.

The challenge

Students work in teams to design and make a prototype device that can be operated remotely to pick up objects and accurately locate them on a given target. Devices such as these are increasingly used in medical engineering. They are also used in space to collect samples from places where humans cannot easily get to.

In this challenge the device will be simulating a heart and kidney transplant. Objects representing the human heart (tennis ball) and a kidney (ping-pong ball) must be picked up and accurately placed in their appropriate holes in an MDF/cardboard cutout of a human torso.

The device must:
- be operated remotely from a distance of 1.1m
- be able to be accurately controlled in order to perform small and accurate movements
- be able to be moved in both the horizontal and vertical planes
- be able to carefully pick up several different sized and shaped objects.

Who is it for?

The Faraday Challenge 'Remote Operations' has been designed for six teams of six students (36 students in total) **aged 12 – 13 years** (year 8, and equivalent).

This set of resources provides you with the basic materials you need to run an activity day which brings science, design and technology, engineering and maths together in an engaging way.

Each team will be asked to assign: a team leader; an accountant; an assessment coordinator; two scientists; two mathematicians; two design and technologists; manufacturers and designers. Each team member will need to be assigned more than one role and feed into different aspects of the day.

You can adapt this set of resources for larger numbers of students if, for example, you wish to run the event for a whole year group. If this is the case you will need to increase the number of team booklets and practical resources appropriately.

Snapshot of the day and some top tips

08.30 Set up for the day	▪ **Tables and stations laid out** (room requirements, p. 10) ▪ **Test area** (materials and equipment, p. 6) ▪ **Materials shop/Technician's area** (materials and equipment p. 8) ▪ **Get extra help from colleagues** (at least two colleagues)
09.15 Students take their places	▪ **One team per table** ▪ **Explain student roles and responsibilities** (teams assign roles)
09.30 Session one	▪ **Introduce challenge and generate initial ideas** (Introductory Presentation Slides 1–4)
10.15	▪ **Exploring the challenge in more detail:** video clips provide context and example solutions (Introductory Presentation Slides 5 – 17)
10.40	▪ **Teams develop their ideas** (Introductory Presentation Slides 18 – 21): aim for development of ideas to be 80% complete by break time.
11.00 Break time	▪ **10 minute break** ▪ **Shopping lists ready** (teams ready to buy materials)
11.10 Session two	▪ **Introduce and open the shop** (Introductory Presentation Slide 22) ▪ **Manufacturing starts!** (teams develop chosen idea into viable solution – aim for manufacture to be 60% complete by lunch time) ▪ **Interview the teams:** informal assessment of idea progression and team-working
12.30 Lunch time	▪ **30 minute break**
13.00 Session three	▪ **Learning logs completed:** scripts finished at start of session (if using digital video cameras, video learning logs handed in for download) ▪ **Finishing touches to devices** ▪ **Test devices** ▪ **Shop shuts at 13.30**
14.00-15.00 Faraday Challenge	▪ **Prototypes presented:** learning logs presented and devices tested ▪ **Scores announced:** achievement of all teams celebrated ▪ **Certificates awarded:** for each participating student (p. 17)

Top tips for running the day

(*for a Faraday Challenge Day involving six teams of six students*)

- Set up the room

  It is essential to set the room up before the students arrive – see 'Room requirements and layout' on page 10. You will need a large area for the following areas of the room:
  - the shop (the bigger the better)
  - the glue station (four hot glue guns need to be available)
  - the vice/cutting table
  - the testing area where students will be testing their devices

- Get the team tables ready

  On each team table, make sure you have the following:
  - table number and team information
  - student booklets (one per team – see page 19)
  - 150 Faradays (see page 22 for printable Faraday notes in four denominations)
  - student roles and responsibilities sheet (see page 21 for this)
  - plain paper (for students to use to design their device)

- Prepare the materials shop
  - It is a good idea to produce price tags for the materials at the shop
  - The materials resource list (within the Student booklet) can be modified or adapted to your personal needs
  - The technician's balance sheet (see page 18) needs to be filled in by the shop technician and used as a 'check' against the accounting record sheets from each team

- Explain the student roles and responsibilities

  Explain the roles and responsibilities sheet to the groups as they come in, and make sure they start assigning the various roles before you start the day (and before they open the booklets)

- Keep an eye on the clock

  It is important to regularly make reference to the time and what needs to be completed in each session in order to keep the teams on track

- The Remote Operations Introductory Presentation is your guide

  The 'Remote Operations Introductory Presentation.ppt' contains all the information needed for the students and normally takes about 40 minutes to go through (notes and tips are included). You can adapt this PowerPoint presentation to fit the needs of you and your students.

- Learning Logs can be presented in person or digitally
  - Students can create a short learning log to present what they have learnt throughout the day (see page 12).
  - For video learning logs you can use whatever portable digital video recorders you or the students have, including smart phones. Free video editing software can be found online.
  - If students do not have access to video recording equipment they can present their learning logs as a team in front of the group just before they test their product.
  - Try and keep the learning logs to about 2 minutes long, as everyone will need to watch each of the six presentations/films during the challenge stage at the end of the day.
  - Giving the students a structure helps with ensuring the deadline for the learning logs is met. If using digital video cameras, teachers/technicians will then have a chance to review the logs and prepare the snippets to show as a continuous video clip for each team.
  - We find it easier for one adult to 'own' the whole learning log/video production process, manage and assess it.

- Assign the assessment matrix to one teacher/technician
  - The assessment matrix (see page 15) needs to be filled in by one person throughout the day.
  - The various sections can be assessed throughout the day, making it easier to announce the winners at the end of the day.

The following table provides a structure for assessment of teams throughout the day:

Assessment	**When to assess**
Initial ideas sheets	End of session one (break time)
Development of ideas	End of session two
Team accounting sheet	13.30 – upon closure of the shop
Quality of final product and function of device	During the Faraday Challenge
Team work	During session two – having observed the teams all day you can make a judgment on this.
Learning Log	During the presentation of the learning log – before each team attempts the final Faraday Challenge

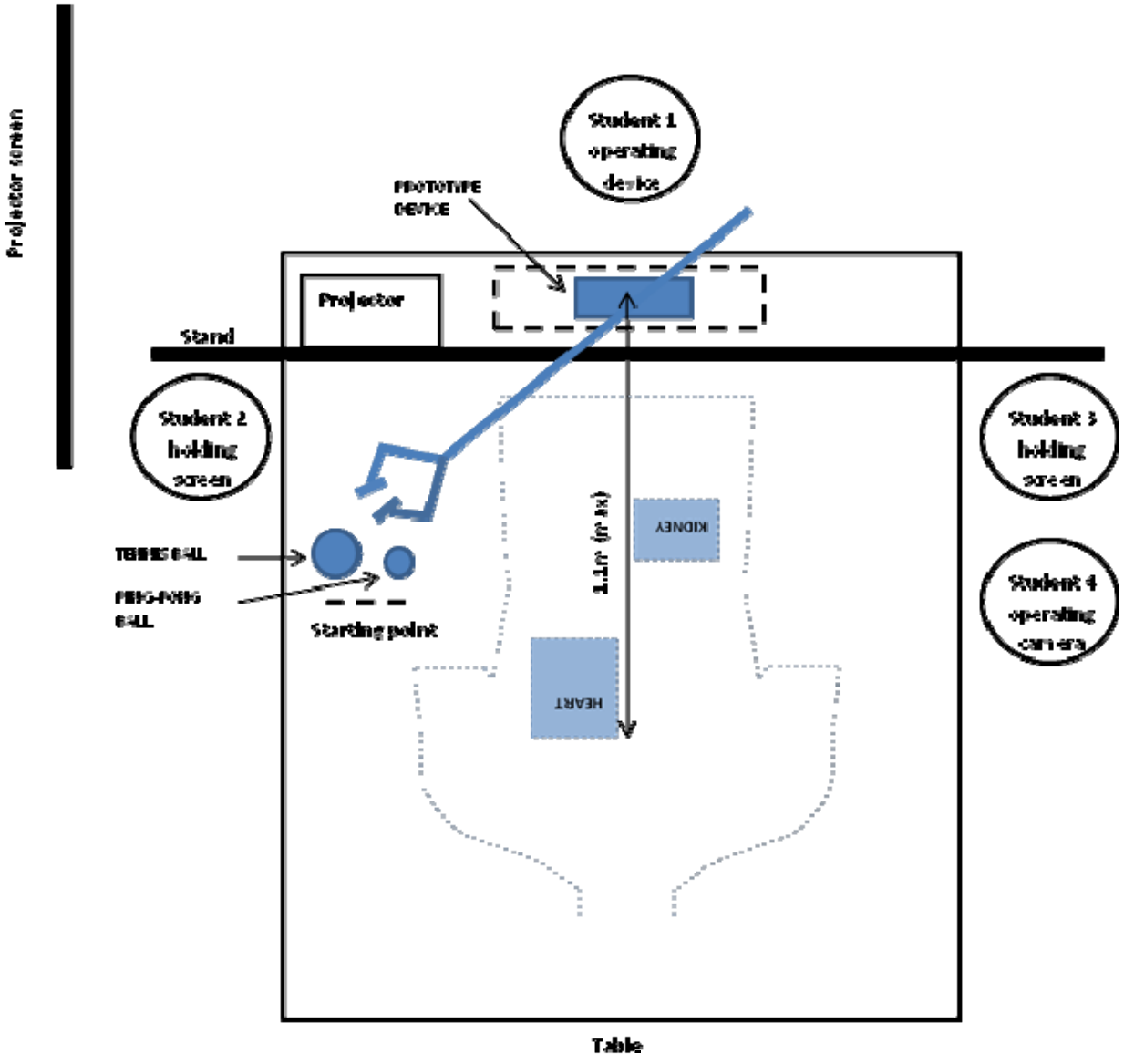
- Get the test area ready for the final Faraday Challenge

  The area should include:

  - Several tables or one large table to put a cut-out torso on (this needs only be cut out of MDF/cardboard – a rough outline of a body with two holes cut out in the location of the heart and kidneys (see page 9)). Silver foil food trays can be placed in the cut outs to hold the balls.

  - A stand that is located at one end of the area and allows a sheet or piece of material to be hung over it. The aim is to ensure the students cannot directly see the body but their device can work 'through' the screen.

  - A video camera, that can be held above the body with the image projected onto a screen. The operator must be able to see the screen clearly. This projects the image as a mirror image and adds to the degree of precision that is needed.



- Make sure you have support
  - **Your colleagues**

    You will need support from a teacher/technician to run the shop during the day, a judge to complete the assessment of the teams and allocate scores, and someone to help students should they need some additional guidance.

  - **STEM Ambassadors**

    Engineers (including IET members), scientists and other STEM professionals are available to come and support you by volunteering their time to help run the Faraday Challenge Day, or any other STEM activity you may have running in your school. Contact STEMNET (www.stemnet.org.uk/contact) who can find to you a STEM Ambassador in your area.

    STEM Ambassadors can be from the science and engineering industry, university students and/or parents and can form the start of active links with local businesses. You could even suggest visiting their offices to run the Faraday Challenge Day for the students there, and combine the event with a careers talk from the company.

What you'll need to run the challenge

Materials and equipment (for six teams of six students)

You should be able to run the day using materials and equipment that you can find in a typical Science laboratory and Design and Technology department. If there are things listed here that are not available in your school, you should be able to purchase them at low cost from your local hardware store or education resource suppliers – if unsure ask your Science technician or Design and Technology materials purchaser.

Materials needed:

Item	Size	Quantity
Elastic bands	various	1 pack
Fishing line	-	approx. 18 m
Jubilee clips	20 – 32 mm	6
Paper fasteners	19 mm	1 box
String	-	1 reel
Hex nuts and machine screws	M3 x 16 mm	50
	M3 x 30 mm	50
Foil tray	Medium	2
Ping-Pong ball (kidney)	-	1
Tennis ball (heart)	-	1
Modelling foam	30 mm x 150 mm x 150 mm	12
MDF (or alternative)	6.0 mm x 1200 mm x 20 mm	15
	6.0 mm x 600 mm x 20 mm	6
	6.0 mm x 150 mm x 150 mm	20
Pre-cut arms (optional)	See template (page 14)	optional

Equipment needed for the design and build stages of the day:

Item	Size	Quantity
Hacksaw/coping saw	Junior	6
Hot glue guns and glue sticks	-	4
Screwdrivers	various	12
Files, all-purpose, with handle	-	6
Glass paper	approx. 200 mm x 200 mm	6
Ruler	30 cm	6

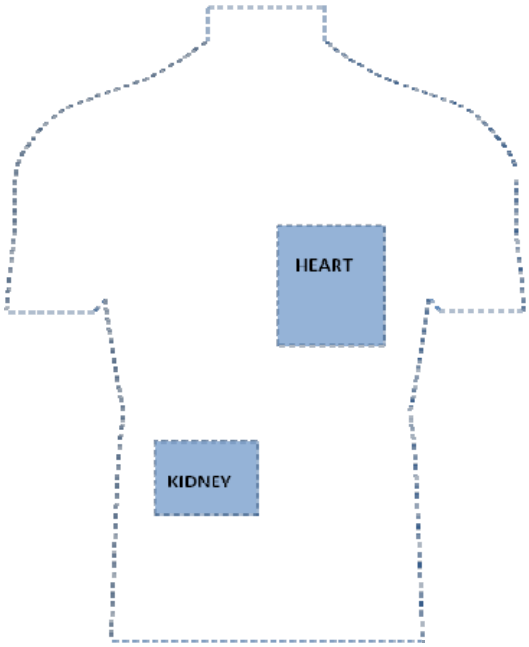
Equipment needed for the final challenge at the end of the day:

Item	Size	Quantity
Video camera	-	1
Projector	-	1
White board/screen	-	1
Fabric	min. 2 m x 2 m	1
Portable digital video cameras (optional)	-	6
Stopwatch	-	1

Students will also need their pencil cases and a calculator during the challenge.

Model of a human torso

The MDF/cardboard model of a human torso can be prepared by you before the Faraday Challenge Day, or you could ask a group of students to create it in a D&T class or after-school club before the event. The MDF/cardboard sheet needs to be approximately 50 x 43 cm (approx. 20 x 17 inches) so that it can be the approximate size of a real torso. Students can create the torso shape by tracing around one of their fellow students.



Hole 1: Located where the human heart would be.

On the MDF/cardboard torso trace around the bottom of a foil tray at the position where the human heart would be.

Place the tray in the hole – this will serve as the container in which the Tennis ball can be placed in the final stage of the challenge using the devices made by students.

Hole 2: Located where the right human kidney would be.

On the MDF/cardboard torso trace around the bottom of a foil tray at the position where the human kidney would be.

Place the tray in the hole – this will serve as the container in which the ping-pong ball can be placed in the final stage of the challenge using the devices made by students.

Introductory PowerPoint presentation

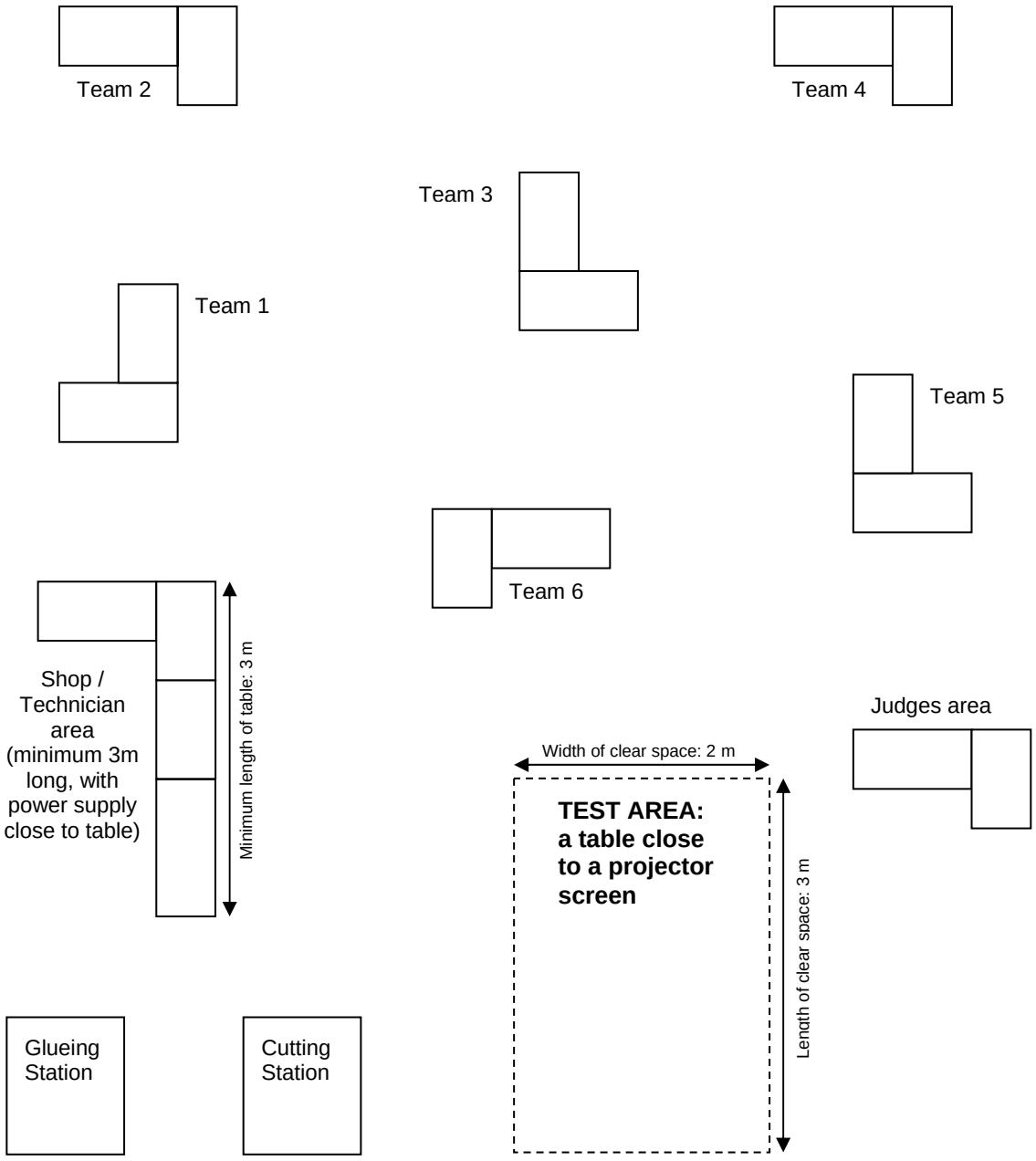
The Remote Operations PowerPoint presentation guides you and the students through the day and includes a series of film clips. The film clips help to set the context for the challenge and provides examples of gripper solutions, and sliding and lever mechanisms.

Teachers' notes can be found within the notes section of each PowerPoint slide, or you can refer to the *Remote Operations Introductory Presentation Slides and Notes* booklet.

Room requirements and layout

You will need a large room and it is essential to set the room up before the students arrive.

Below is an outline of the room layout for a Faraday Challenge Day, including positioning of tables and work stations.



PROJECTOR SCREEN

Each team table and the judges area need six chairs.

Schedule for the day

The Faraday Challenge is a daylong event, running from approximately 9 am – 3 pm. The schedule below gives a guideline as to how to set the day out for each section of the Faraday Challenge Day.

09.15 **Students are seated at their team tables**
Teams assign the various roles and responsibilities before continuing with the day

09.30 **Session one**
- Deliver the introductory PowerPoint presentation with film clips and directions for the day
  Teachers notes can be found within the notes section of each PowerPoint slide, or refer to the Remote Operations Introductory Presentation and Notes booklet
- Teams to embark on initial ideas stage (each subject pair to work on specific details)
  Introductory Presentation Slides 1-4 and initial ideas sections should take approximately 45 minutes
- Teams continue with development of ideas stage (bring together the 3 pairs with their subject expertise)
- Team to decide on which idea to develop
- Learning log briefing

11.00 **Break (shop opens)**

11.10 **Session two**
- Introduce use of shop and technician – money (*Faradays*), resources, equipment
- Teams to develop chosen idea into viable solution (application of scientific research into creative engineering solution)
- Teams start manufacturing their device

12.30 **Lunch**

13.00 **Session three**
- Students finish preparing their learning logs at the beginning of the session (hand in any digital video cameras if used)
- Students build their final idea for the engineering solution
- Teams put their engineering solution (their built device) to the test before the challenge commences!

13.30 **Shop shuts**

14.00 **Faraday STEM Challenge commences**
- Learning logs are presented in front of the class (digital or verbal)
- Teams present their engineering solution and test their device

14.45 **Results announced**

Student learning logs

Students can create a short learning log to present what they have learnt throughout the day. The learning logs should last between 2-3 minutes in total and can be presented in two ways:

- As a verbal presentation from each team

  In this case each team would present their verbal learning log to the judges and the other participating student teams

- As a video learning log recorded on a portable digital video camera

  In this case the *video production manager* from each team will need to be briefed and given adequate time to record snippets from each of their team members. A teacher or technician would then need to edit the clips from each team to make a single clip to represent each team, and organize for a projector for the presentation of these video clips.

The ideal time to present the learning logs would be the end of the day when the challenge commences (14.00 on the schedule) as an introduction to the final testing of each team's device.

Suggested format for learning logs

Segment	Focus	Suggested length of segment
1.	Team leader to introduce team and school. Individual team members to then introduce themselves and their roles and responsibilities.	20 seconds
2.	Team to talk through the decisions surrounding why they have chosen their specific idea to develop: How is it going to work? What are the problems and how are they going to solve them?	30 seconds
3.	**Science specialists** To clearly demonstrate the science in the design of the prototype	30 seconds
4.	**Maths specialists** To clearly demonstrate the maths in the design of the prototype	30 seconds
5.	**Design and Technology specialists** To clearly present the practical application of the design, how will they make all the bits fit together To discuss how the design developed including choice of materials, construction methods, sizes etc.	30 seconds
6.	Each member of the team to present their key learning throughout the day	20 seconds

Assessing the learning logs

Teams need to demonstrate to the judges what they know about each of the three subject areas and how they have used this to help the design and manufacture of the prototype device.

Students can be assessed on the following key content areas:

General content

- Are they capturing real learning (and not just *doing*?)
- Are the science, mathematics and design and technology specialists talking clearly about the application of this knowledge and understanding?
- Is it interesting to listen to?
- Is it original in its content?

Science

There is a lot of science in this task. Teams should identify the key areas and discuss them in relation to their device. For example:

- What forces are being applied?
- What interactions, between which aspects of the design, are causing the changes in motion required for the device to function?

Mathematics

Teams should identify the mathematical aspects of the problem they have been asked to solve. They should be encouraged to brainstorm all the different aspects of mathematics they can see at work within their device in order to ensure that they score well. For example:

- Can the device be simplified? If so, can this be represented mathematically? (i.e. a diagram, or using variables?)
- Can ratio or proportion be applied to aspects of their device?

Design and Technology

The two key features are the ‘claw’ or ‘gripper’ mechanism and the ‘trigger’ or ‘handle’. Both these features need a lot of thought in terms of ergonomics and function. Students could cover the following in their learning log:

- How have they designed the levers to achieve the movement needed?
- How do they plan to ensure the degree of accuracy needed to be successful?
- Why have they used the materials chosen?
- What construction methods have they chosen and why?
- What were the main problems encountered and how were these overcome?

If students will be developing video learning logs their technical abilities can also be assessed in terms of producing the film. For example:

- Quality of the audio (can you hear what everyone is saying)
- Are they using the zoom feature?
- Do the clips ‘stitch’ together well?
- Is it creatively produced?

Remote arm template

For pre-cut arms (optional)
Approximate height 120 mm

Example risk assessment

Activity	Faraday STEM Challenge Day: Remote operations		
Persons at risk	Students taking part in a Faraday Challenge Day		
Maximum group size	36 students	Minimum staffing ratio (including teachers and STEM Ambassadors)	1:12

Risk assessment	
Hazards	Control Measures
1. Basic use of hand tools (hand drill, tenon saw, coping saw) – risk of cutting or abrasion	All cutting and drilling of materials to be performed at a designated area. To be manned by technician at all times.
2. Use of glue guns – risk of burning skin	Warm glue guns to be used throughout the day. The area for glueing to be overseen by a technician or another suitably experienced responsible adult. Glue guns hot enough to cause burning of the skin.
3. Use of fishing wire – potential to cut	Students to be made aware of the danger and also how the material MUST be used (i.e. attached to a handle and not to be 'pulled' directly by hand).

Further action required:

1. Ensure all persons staffing the Faraday Challenge Day are aware of, and competent to comply with this risk assessment and the control measures.

Working practice	
Group structure	
Restrictions	
Emergency procedure	
Safety equipment	
Staff member(s) producing this risk assessment	
Date of this review	

Assessment matrix

Assessment Categories		Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Team feedback	20						
Initial ideas	15						
Development of ideas	40						
Balance sheet	10						
Final product	20						
Function of device	50						
Learning Log	20						
Total Score	175						

Results table

First	
Second	
Third	
Fourth	
Fifth	
Sixth	

IET Education
The Institution of Engineering and Technology
Faraday

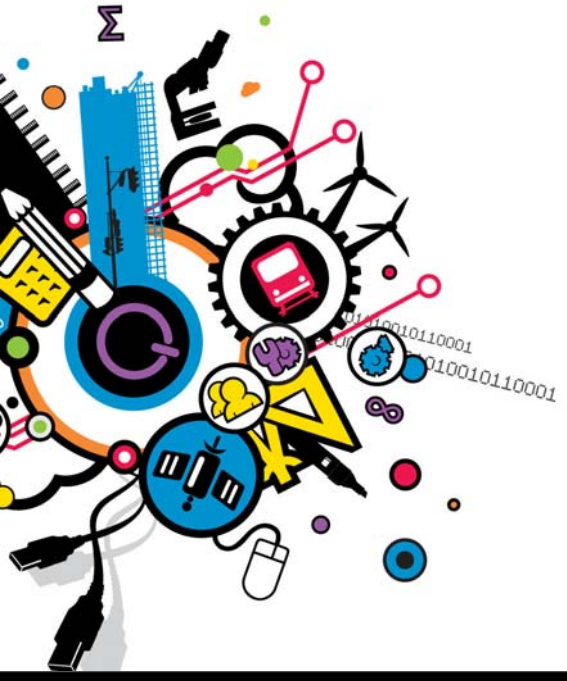
For taking part in the Faraday Challenge Day

Awarded to

_____

of

_____



Technician's balance sheet

Faradays spent at each visit to the shop	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total Faradays spent						

Student booklet

The student booklet outlines the challenge context and brief, assessment matrix, timings for the day and all other information and worksheets needed by each team to complete the challenge. The student booklet includes each page as a separate document numbered in the following order:

1 Faraday Challenge Day student booklet cover

2 Brief and context

3 Assessment criteria sheet 1

4 Assessment criteria sheet 2

5 Materials resource list

6 Timings for the day

7 Team accounting sheet

8 Learning log help sheet (if learning logs are to be presented as verbal presentations)

9 Video help sheet 1 (if using a video camera, otherwise can be adapted to be a help sheet for a successful presentation)

10 Video help sheet 2 (if using a video camera, otherwise can be adapted to be a help sheet for a successful presentation)

11 Top tips for using a digital camera

The video help sheets and digital camera top tips can be used when learning logs are presented as video clips. The learning log help sheet can be used when learning logs are presented as verbal presentations.

Student Team Registration Form

Team No: ….

Faraday Challenge Date: ……..

Your School Name: ……..

Your Teacher's Name: ……..

Team Members

1 ……..

2 ……..

3 ……..

4 ……..

5 ……..

6 ……..

Student roles and responsibilities

The team that wins will work together in the most effective and efficient way.

It is crucial that each and every member of your team understands what their role is and what they are responsible for.

When you discuss the roles and responsibilities at the start of the day, you must think about what you are good at and which areas you are responsible for.

The team probably needs the following team members:

- **A team leader** – ultimately responsible for the work that needs to be done and the standard of the work. Also ensures the team works well together and everyone is on task. This role is NOT about being the loudest member of the group!
- **Two scientists, two mathematicians and two design and technologists** – responsible for bringing different skills and knowledge to the problem. They are also responsible for working with the 'Learning log manager' to prepare the material/information for the video/presentation.
- **An accountant** – responsible for the accounting sheet and the money.
- **Learning log manager** – a very important role. You will be in charge of designing and producing the learning log for your team. You will need to be able to produce your team's video/presentation to a high standard but also capture the learning that takes place during the day.
- **Assessment coordinator** – responsible for getting the assessment tasks done on time and checking the standard.
- **Manufacturers** – will each produce different parts of the actual device. Your team will need to assign more than one person to this role.
- **Designers** – responsible for producing the 'development of ideas' sheets, outlining the journey from first idea to final solution. Your team will need to assign more than one person to this role.

Additional Information:
It might be a good idea (depending on the members of your team) to have a person in charge of time management – making sure everyone knows what assessment deadlines are coming up, what needs to be completed and by when.

It will be necessary for each team member to take on several roles. Roles can overlap, and some roles 'fit together' better than others.

Faradays (special currency for the day)

Faradays are provided in denominations of one (F1), five (F5), ten (F10) and twenty (F20) Faradays – students use these as their currency for the day to buy materials and resources.

Each team will need F150.

The 'materials shop' will need plenty of F1 F5 and F10 notes to provide change for students purchasing materials.

You can photocopy the following pages to create the amount needed to run the day.