# TRANSITION YEAR

## Inspiration for Science Teachers

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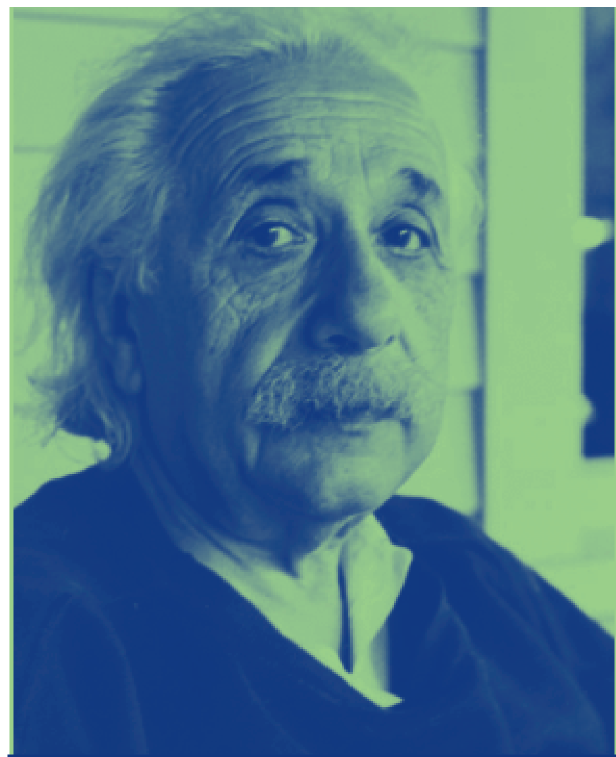
NDP
NATIONAL DEVELOPMENT PLAN

AN ROINN OIDEACHAIS AGUS EOLAÍOCHTA
DEPARTMENT OF EDUCATION AND SCIENCE


By Anna M. Walsh



*" I have no special talent. I am only passionately curious"*

Albert Einstein

This pack, by Anna M. Walsh, is a compilation of activities, presentations and practical adventures intended to unleash some of this *"passionate curiosity"*.

Surely curiosity is the cornerstone of all scientific endeavours.

Anna Walsh worked as a Physics Teacher in the UK. She now lives in Kilkenny and is committed to producing materials that support teachers in their efforts to communicate and promote science in the classroom.

*annawalshkk@eircom.net*

**Transition Year Inspiration for Science Teachers** is a student centred and teacher friendly approach to Science in Transition Year. As well as promoting a curiosity about Science and the development of an interest in scientific thinking, it also promotes the Transition Year rationale of skills development and personal development through its unique and refreshing approach. I trust that this will be a valuable teaching and learning resource for both teachers and students and on your behalf thank Anna M Walsh for her creative approach to Transition Year Science. *Michael O'Leary, Transition Year National Coordinator, Second Level Support Service.*

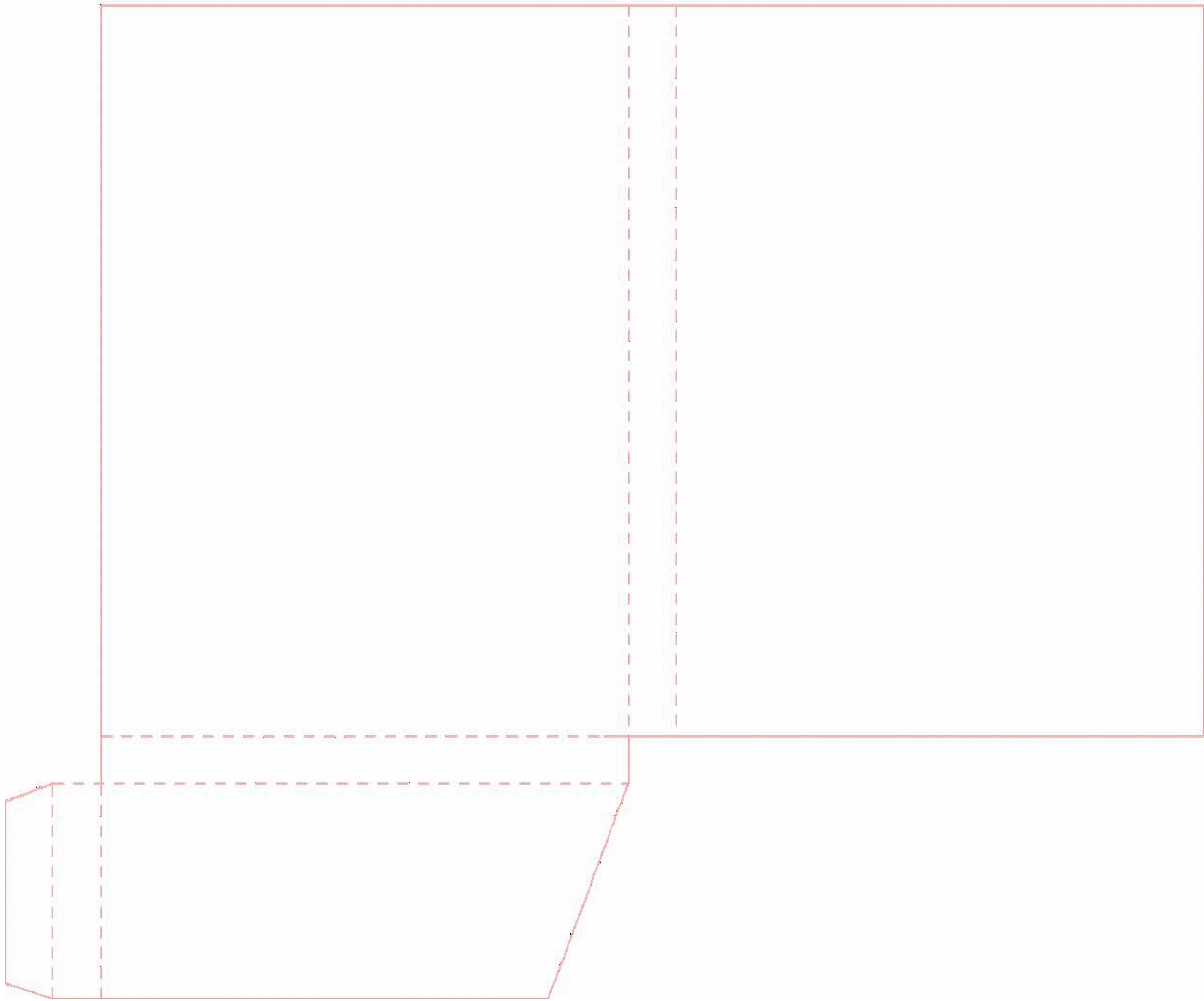
This initiative is funded by the **Teacher Education Section of the Department of Education and Science under the National Development Plan**

# TRANSITION YEAR

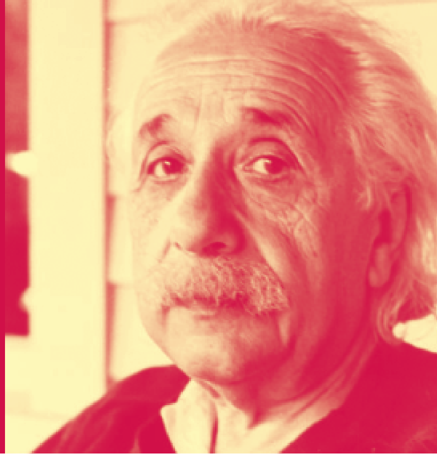
## Inspiration for Science Teachers


By Anna M. Walsh

# Contents



# THE EINSTEIN CHALLENGE



## SYNOPSIS

Einstein is an inspirational figure in the world of physics and world famous for being a genius but young people are rarely given access to the nature of his life's work. This challenge aims to give students a glimpse at the wonders of the physical world they live in, hidden from our everyday experience, but revealed by Einstein. It is not intended to be an in depth explanation of his ideas, it only seeks to sow the seeds of curiosity. Do not shy away from this exercise on the grounds that your own understanding of Einstein's work is minimal. All presentation materials are heavily scripted and support the teacher throughout. Tips on how to deal with any "tricky questions" are provided.

## TY OBJECTIVES

- To inform students of the life and works of Albert Einstein.
- To generate a sense of wonder about the universe they live in and promote an interest in the further study of science.
- To encourage collective decision making and develop presentation skills.

## EQUIPMENT REQUIREMENTS

- Digital Projector for Power Point presentation

## TEACHER GUIDANCE

A detailed understanding of Special and General Relativity is not required by any teacher attempting this. Your brief is not to provide full explanation of Einstein's work, merely to report some of its conclusions. In depth "why?" questions should unapologetically lead to the remark: "If you want to find out, continue studying/reading about science." (Recommended readings are suggested at the end of these notes). Feedback from teachers suggests that their concerns about being unable to satisfy student's questions invariably are not realised. Most reports suggest that students are too engrossed to ask many questions!

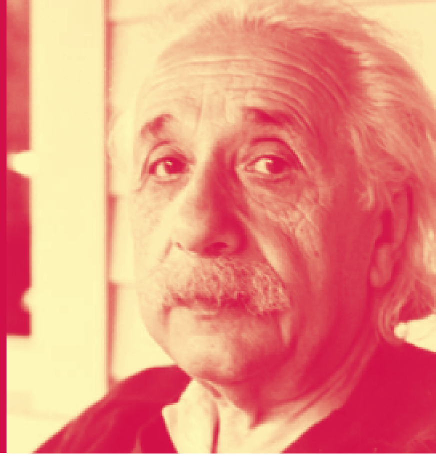
This exercise has been designed to have three parts, but all sections are independent. If time does not allow for all parts to be covered the core Einstein Challenge (Part 2) can be carried out without the other two.

*•PART 1: Introduction: a brief biography of Einstein (power point presentation and script provided)*

*•PART 2: The Einstein Challenge. The class are put into small think tank groups. A power point presentation helps you to introduce some of Einstein's ideas and challenges the groups to answer a series of multiple choice questions along the way. The questions explore some of Einstein's conclusions in the areas of Special and General Relativity. At the end of the challenge they will use their score to calculate a collective "brain power", comparing their own to Einstein's, and then award themselves a certificate.*

*• PART 3: An optional extension exercise: The newspaper report. In this part students are asked to imagine that they woke up this morning and the speed of light had dropped to just 200km/hour. Suddenly all the conclusions of special relativity that they have been introduced to are part of our everyday experience. Students can write the newspaper article reporting on some of their observations of this new universe.*

# THE EINSTEIN CHALLENGE



## PRESENTATION NOTES

### PART 1: INTRODUCTION: WHO IS ALBERT EINSTEIN?

- Ask your class to put their hand up if they have heard of Einstein.
- Now ask them to put their hand up if they know why he is so famous…. Explore the answers and bring out the likely conclusion: many people have heard of Einstein but have little idea of what he discovered. Hopefully by the end of this session they will be enlightened.

The following notes along with the power point presentation should help you deliver a short introduction to Einstein the person….

**Biography Notes** *Corresponds with new slide on power point presentation*

- Born 1879 to a Jewish Family in Ulm, Germany
- Was born with an unusual shaped head and didn't start talking until he was about three…..other than that there was nothing remarkable about him as an infant.
- At five his father gave him a magnetic compass. This sparked his obsession with understanding how the world worked.
- You might expect a genius to excel at school but Einstein's journey through educational institutions was a rocky one
- In his first school he had 70 pupils in his class. Lessons consisted of repeating things over and over. Albert hated it.
- When his father asked his teacher what career he thought Albert should follow he replied "It doesn't matter. He'll never amount to anything"
- Albert did well in Maths and Science but failed miserably in other subjects.
- At fifteen he had had enough and took himself out of school without any qualifications.
- He still wanted to study science. He applied to study at the Swiss "Polytechnic" in Zurich but failed the entrance exam (he failed the language part). A number of years later he did get in.
- At sixteen he started to think about the questions that would ultimately lead him to becoming very famous… "What would it be like to travel at the speed of light?"
- You might expect a world famous scientist to have carried out their greatest work in some fancy university laboratory but most of his ideas were put on paper when he should have been doing something else….namely his job (as a clerk in a Swiss patent office)
- He publishes some of his ideas in 1905. Called by many…. "The Year of Miracles".
- In 1919 some of his ideas are confirmed by other scientists and he becomes world famous.
- 1921 he got the Nobel Prize for Physics.
- 1940 he becomes an American citizen
- As well as a famous physicist Einstein becomes well known for his work in promoting peace and justice.
- In 1954 Einstein turns down an offer to become the president of Israel.
- Dies April 18 1955
- Time magazine name him "Person of the Century"

### PART 2: TAKE THE EINSTEIN CHALLENGE:

In this part divide your class into "Think Tank" groups (3 or 4 in each). Each group should give themselves a name. Use the power point presentation to guide you through the challenge. Within their group they should discuss each question and come up with an answer. The groups should record their answer and award themselves a score on the score sheet provided. The total score is out of 100 and can be taken as a % measure of their collective/ relative "Brain Power".

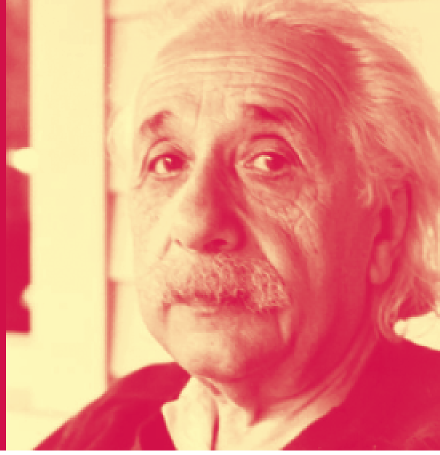
LOOK AT THE PRESENTATION AS YOU GO THROUGH THE NOTES. THE PRESENTATION PROVIDES YOU WITH A SCRIPT. THE NOTES GIVE SOME BACKGROUND KNOWLEDGE, SUPPORT AND ANSWERS.

**Notes on presentation/questions. (numbers refer to slide numbers)**

2. This question establishes the value of the speed of light (in a vacuum) and gives you an opportunity to emphasize how fast it is compared to everyday speeds.

4. **Question 1: ANSWER: A**

# THE EINSTEIN CHALLENGE



## PRESENTATION NOTES

5. This establishes the principle that the speed of light seems to act as a fundamental speed limit to all things. This was Einstein's starting point and all of his conclusions follow from this fact.

7. **Question 2: ANSWER: B**

If students doubt his right to make this conclusion it is worth pointing out that despite their best endeavours physicists since Einstein have failed to conclusively prove this to be wrong. The Universe seems to come with a universal speed limit!

10. **Question 3: ANSWER: A.**

18. **Question 4: ANSWER: C.**

19-20. • Whilst it may not be correct physics it is perhaps important (at this level) to use the phrase "how heavy" an object is to give your students a sense of "mass".
•Use the example of pushing a truck to give them a sense of how extra mass hinders further acceleration
•The idea of gaining mass may sound like science fiction but it is important to emphasise that this effect has been proven by experiments.
•Where does this mass come from? $E=mc^2$….In simple language: the energy put into the rocket by the engines "turns" into mass. Couldn't you just put more and more energy in and overcome this? Einstein said no, eventually your mass would become infinite, even with all the energy in the universe you would never have enough to get yourself to match the speed of light. It's as if nature has put a complete ban on anything with mass travelling at or over the speed of light.
•The idea of infinity will need to be touched upon.

23. **Question 5: ANSWER A.**

It's important to emphasize that the shrinking is just in the direction of motion. If anyone wants to know how much shrinking you would observe you can use this example: An observer on earth measures a space rocket when it is at rest as being 12m long. This rocket takes off and flies past the observer, in a straight line, at a steady speed of 120000km per sec relative* to that observer. All measurements taken by the observer on earth will now measure the rocket to be 11m long.

*Please note that no comprehensive discussion of relative motion is attempted in this exercise (although it is hinted at on the last slide). Whilst the concept is obviously essential to any full explanation of Special and General Relativity remember this exercise is designed to describe the observations of Einstein's theories, not to fully explain them.

27. **Question 6: ANSWER: C**

Students may insist that the measuring device of a ruler is at fault. It is important to emphasize that all measuring devices/techniques within the rocket will fail to measure any change in length.

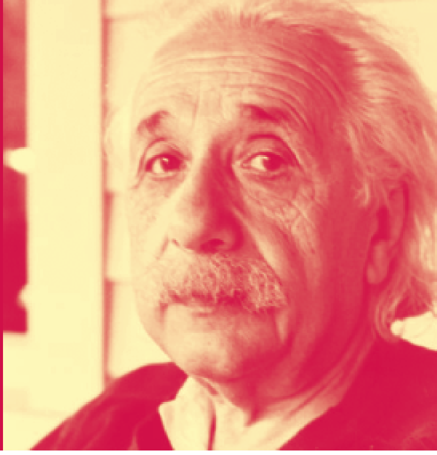
30. **Question 7: ANSWER B**

33. **Question 8: ANSWER B**

Einstein's theories, as far as he developed them, suggest that you can only travel forward in time and there is no way of getting back.
N.B. Subsequent work on black holes suggest that it may be possible to travel back in time inside a singularity (if you survived !!!). If anyone brings this up, and used it as a basis for giving answer A, then allow them the points for this question!

36. **Question 9: ANSWER A.**

# THE EINSTEIN CHALLENGE



## PRESENTATION NOTES

If your group demands an example….. A clock on a rocket passing by you at 90% the speed of light will only register 0.436secs whilst your clock on earth ticks by 1 second (according to the person on earth).

41. **Question 10: ANSWER A**

43. **Question 11: ANSWER C**

The stronger gravity the slower time ticks by. Here on earth that means that at the top of the highest mountain (where gravity is slightly weaker) time ticks by a tiny, tiny, tiny bit faster.

44. Obviously the drama comes about when you talk about black holes. You could expand this discussion with the following examples.

(For those not familiar with the science of black holes: A black hole is a region of space that contains so much mass that its gravitational field is so powerful that nothing can escape it once it has fallen past a certain point (the "event horizon"). Not even electromagnetic radiation (Ie.g. light) can escape its pull and hence the interior is rendered invisible/"black".)

• The greater the gravitational field you experience the greater the effect on time. The closer you get to a black hole the slower time ticks by (as the strength of gravity increases). If you were to watch someone falling into a black hole you would never see them actually enter it. As they get closer and closer their time would appear to slow to the extreme that time would appear to be almost "frozen" at the edge of the event horizon.

• It's possible that if your parents when on holiday sight seeing at the local black hole (obviously not too close to get sucked in but close enough to experience strong gravitational fields) that when they returned you could be older than them. What felt like a week long holiday to them was 40 years to you!

*WITH ALL ANSWERS COMPLETED each group can calculate their total score.*

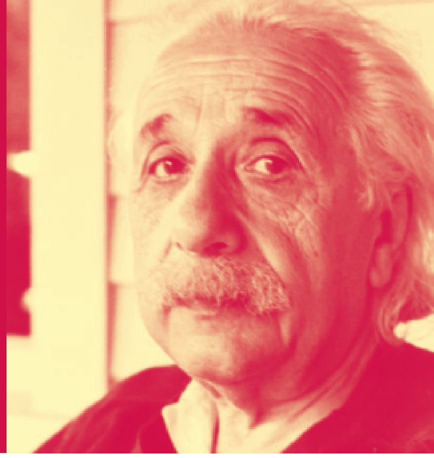
48. **FINAL QUESTION:** an opportunity to think without multiple choice answers.
It is my expectation that most pupils with predict that the rocket passenger will observe the opposite effect on the earth observer (less mass, lengthening and time speeding up). In fact the rocket passenger will make the same observations ( the earth observer will gain in mass, shorten and time will slow). This illustrates Einstein's principle of relative motion (there is no place that we can claim to be at rest, all motion is relative) …the rocket passenger is equally justified in claiming that the rocket is in fact at rest and it is the earth that is moving past them at 120000km/sec therefore they would make the same observations.
This introduces a counterintuitive argument that is well explained by the recomm ended reading suggested at the end of these notes. You may use this as an opportunity to discuss the idea that there is no such thing as absolute motion or leave it as an open ended puzzle that will hopefully encourage a few students to want to understand more.

**RECOMMENDED READING:**
Ideal for students (and teachers who need to refresh/expand their Special/
General Relativity knowledge):

•"Albert Einstein and His Inflatable Universe" by Dr Mike Goldsmith
(part of the "Dead Famous" series)
Published by Scholastic Ltd ISBN 0-439-99216-8

•"The Space and Time of Uncle Albert" by Russell Stannard
Published by Faber and Faber ISBN 0-571-14282-6

# THE EINSTEIN CHALLENGE

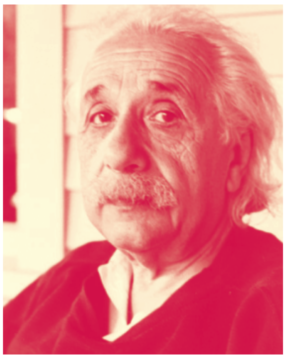


## THINK TANK GROUP NAME: ....................

| Question | Your Answer | Points for a Correct Answer | Your Points |
|---|---|---|---|
| 1 | | 9 | |
| 2 | | 9 | |
| 3 | | 8 | |
| 4 | | 9 | |
| 5 | | 9 | |
| 6 | | 10 | |
| 7 | | 9 | |
| 8 | | 10 | |
| 9 | | 9 | |
| 10 | | 9 | |
| 11 | | 9 | |

Total Score: ____________%

(Your relative brain power) of Einstein's



*As a Member of the*

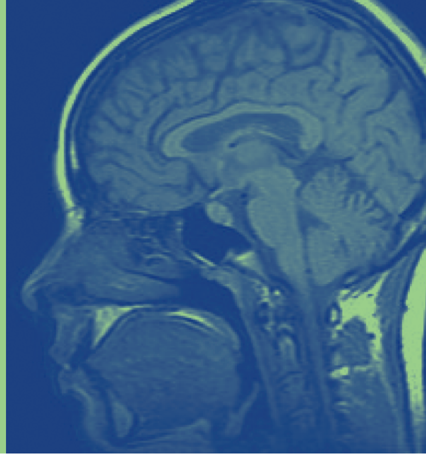
*Think Tank Group*

*has demonstrated*

%

of **EINSTEIN'S** Brain Power!!

# MEDICAL PHYSICS
# IMAGING TECHNOLOGY



## SYNOPSIS

What do real physicists actually do? Students often have very narrow or non existent ideas about employment opportunities for qualified physicists. This exercise explores the work of physicists in the field of modern medicine. The centre piece is a power point presentation that guides the teacher and student through the physics behind X ray, CT, MRI, PET and MEG imaging techniques. Students are quizzed throughout and ultimately set a challenge to determine the appropriate scan for three patients.

## TY OBJECTIVES

- To give students basic knowledge of Scanning Technologies.
- To broaden students expectations of employment opportunities for physics specialists

## EQUIPMENT REQUIREMENTS

- Digital Projector for Power Point presentation
- Examples of Scans/X rays etc (optional)

## TEACHER GUIDANCE

No expert knowledge of medical imaging techniques is required. The power point presentation provides a script for you to use and is largely self explanatory. Supporting notes are provided. If you wish to do some background reading information is readily available on the following websites….

**www.howstuffworks.com**
(x rays/CT/MRI)

**www.wikipedia.org**
(all types: n.b. add word "scan" to all searchs e.g "PET scan")

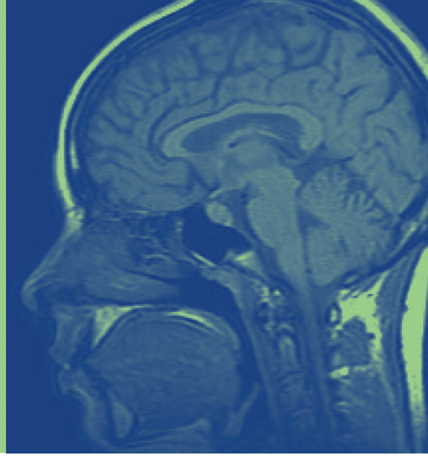
**www.radiologyinfo.org**
(all except MEG)

*Please be sensitive to the fact that some student may have had, or know people who have used these medical imaging techniques to diagnose serious medical conditions. The power point presentation encourages no discussion of medical issues but you must be prepared to deal carefully with any digressions introduced by students.*

The length of time required is dependant on your willingness to invite discussion and elaborate on the issues the presentation raises. It could be completed within one session or easily extended into two.

Familiarise yourself with the entire presentation before you start.

# MEDICAL PHYSICS
## IMAGING TECHNOLOGY



Students will be answering twelve "True or False" style questions at various stages of the presentation. Ideally students should work in small groups/teams. At the end of the presentation they will be set a further challenge where they are given three case histories of patients who require scans. The students have to choose the best type of scan for each patient based on what they have learned.

The presentation opens with a question: What do physicists do in real life? Encourage your group to describe the types of jobs they think physicists have. The idea that physicists are employed by hospitals may not be familiar to many.

## PRESENTATION NOTES

*Numbers refer to slide numbers.*

1. What do physicists do in real life? Ask the group to give answers.

**10. TRUE OR FALSE CHALLENGE:**

1. TRUE
2. FALSE: accidentally discovered by Wilhelm Röntgen (German) in 1895 whilst experimenting with a cathode ray tube (an "electron gun").
3. TRUE

11. "Tomography" comes from the Greek words "tomos" meaning "slice" and "graph" meaning "image".

15. It might be useful to demonstrate the difference between the X ray image and the CT "slice" using a student. Use a flat piece of paper to show the plane of the images in relation to the body.

**18. TRUE OR FALSE CHALLENGE:**

4. FALSE: computerized tomography
5. TRUE
6. FALSE: Typical exposure up to 8mSv per CT scan (over 100X more than a typical X ray)

22. "Spin" is a very difficult concept and it would be advisable not to attempt a detailed explanation of what it is (a useful analogy: the nucleus acts like a wobbly spinning top) and to focus on the important outcome of this property, namely that is causes the hydrogen nucleus to behave like a tiny magnet (dipole).

23. The nuclear magnetic dipoles can align themselves in two "orientations": Most take up a low energy state N-S-N-S as you would expect but a few take up and a "high energy" state N-N-S-S orientation. This may appear contrary to school level science teaching but whilst very unstable it is (for

a short time at least) possible! The nucleus can undergo a transition/change from one state to another by the absorbing or emitting of a photon whose energy equals the difference between the two energy states. This photon frequency will tend be in the radio part of the spectrum (typically 15-80 MHz), hence the use of radio waves in MRI.

24. By "timing" we are talking about the order of a second.

29. Primary magnetic fields used in clinical MRI scanners can be as strong as 3T.

Some research machines are using 20T.

35. The loud banging noise mentioned is caused when the current in the gradient coils change. This can create large forces on the coils that actually cause them to move and clang against each other.

The coil that generates the radio pulse is also used to detect the resulting radio signal.

40. In some cases claustrophobics can be sedated.

**41. TRUE OR FALSE CHALLENGE:**

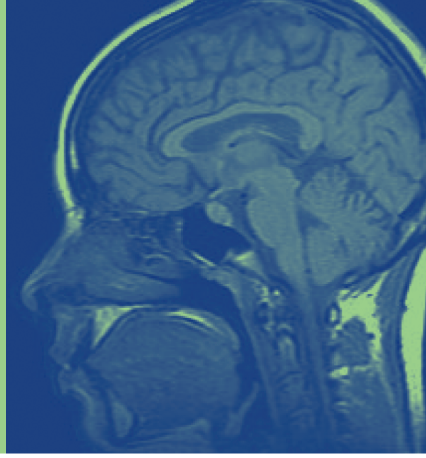
7. FALSE: No evidence of health risk
8. FALSE: The materials and maintenance of such low temperatures is expensive.
9. FALSE: They are permitted but unlikely to be able to cope. If sedation is not an option alternatives are found.

45. The introduction of "Antimatter" could be an opportunity to digress, make as little or as much as you like of this.

47. Again an opportunity to digress if you think your group is receptive and curious to know how radioactive glucose is a source of positrons. The full name of the glucose type molecule used is "Fluorodeoxyglucose". One of the fluorine atoms in the molecule is replaced with the unstable $Fl^{18}$ isotope through a complex radiochemistry process. The $Fl^{18}$ is produced in a cyclotron by bombarding $O^{18}$ with protons. It has a half life of about 2 hrs (hence the need to use it soon after production). One of its protons decays into a neutron and a positron is ejected. Radiotracers can also be made using water or ammonia molecules.

**51. TRUE OR FALSE CHALLENGE:**

10. FALSE: Radiation exposure from a PET scan can be similar to CT scan, however PET scans should be used sparingly
11. FALSE:
12. TRUE:



53. In order for the magnetic field to be measurable at least 50,000 active neurons are needed. The magnetic fields are of the order of $10^{-15}$ T.

54. So far MEG is only able to probe the brain to a depth of about 15cm. MEG is particularly useful in monitoring patients during epileptic fits and its non-invasive nature makes it highly suitable for use with children.

## PATIENT SCAN EXERCISE

This exercise consolidates some of the information provided by the presentation. It will work best if students work in small groups, encouraging discussion and sharing their knowledge.

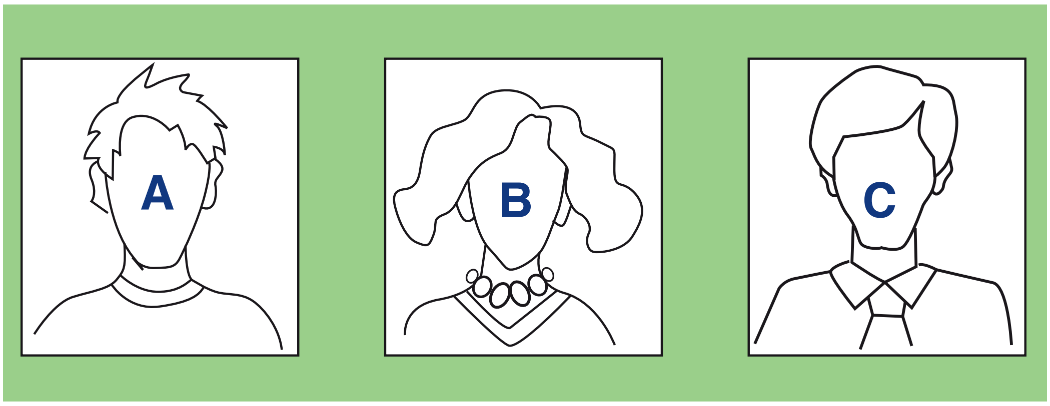
**Each group needs to consider each patients case and decide WHICH TYPE OF SCAN WOULD BE MOST SUITABLE for them.**

The answers are not fixed, but you would expect your students to conclude:

**PATIENT A:** CT scan would suffice. An MRI scan could be offered with sedation to combat the patient’s claustrophobia. PET scan would be ok but a very expensive option.

**PATIENT B:** A standard X ray is all that is required.

**PATIENT C:** A PET scan would give good real time images of blood flow. MRI is out of the question as the patient has a pacemaker.



# MEDICAL PHYSICS

## PATIENT

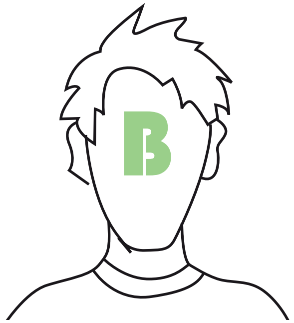

### Reason for Investigation

Doctors suspect that the patient may have a lump growing in her stomach. Details of its size and whereabouts are required.

**Patient's Survey:**

| | |
|---|---|
| Age | 65 |
| *Do you have any of the following?* | |
| Pacemaker | NO |
| Metal Implants in bones | NO |
| Dental Implants | NO |
| Have you ever worked in the armed forces or metal industry? | NO |
| *Do you suffer from any of the following?* | |
| High Blood Pressure | NO |
| Claustrophobia | YES |

## PATIENT



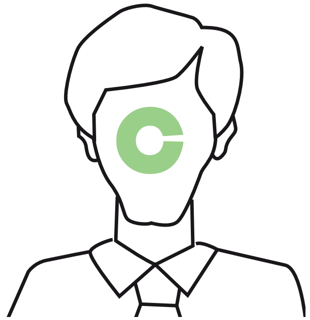

### Reason for Investigation

Doctors suspect that the patient may have broken a rib bone during a fall from a horse.

**Patient's Survey:**

| | |
|---|---|
| Age | 15 |
| *Do you have any of the following?* | |
| Pacemaker | NO |
| Metal Implants in bones | YES |
| Dental Implants | NO |
| Have you ever worked in the armed forces or metal industry? | NO |
| *Do you suffer from any of the following?* | |
| High Blood Pressure | NO |
| Claustrophobia | NO |

## PATIENT




### Reason for Investigation

Doctors suspect that the patient may have a problem with part of their heart. They would like to have images showing the blood flowing through the patient's heart.

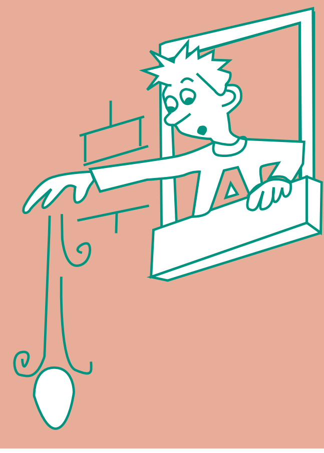
**Patient's Survey:**

| | |
|---|---|
| Age | 56 |
| *Do you have any of the following?* | |
| Pacemaker | YES |
| Metal Implants in bones | NO |
| Dental Implants | NO |
| Have you ever worked in the armed forces or metal industry? | YES |
| *Do you suffer from any of the following?* | |
| High Blood Pressure | YES |
| Claustrophobia | NO |

# TRUE OR FALSE CHALLENGE

| Quest | TRUE | FALSE |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| | | |

# THE EGG DROP CHALLENGE



## SYNOPSIS

Challenge your students to drop a raw egg from the 1st floor of a building and for it to reach the ground without breaking. With a bit of newspaper, sellotape, a few straws and a piece of string it can be done!

Drawing on teamwork, design and construction skills students find this exercise very entertaining and informative.

## TY OBJECTIVES

•Develops problem solving skills and teamwork. Students have to work with limited resources and within strict time constraints.

• Students need to create solutions that demonstrate a practical understanding of air resistance and impact/energy absorbing structures.

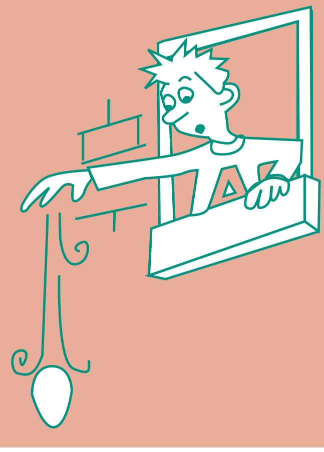
## EQUIPMENT REQUIREMENTS

Students work in small groups. Each group needs:

- 1 raw egg
- 3 large sheet of newspaper
- 1m of sellotape
- 1m of string
- 5 plastic/paper straws
- 1 pair of scissors

(Can be done with 2 sheets, 0.5m of string /sellotape if you want the challenge to be tougher)

# THE EGG DROP CHALLENGE

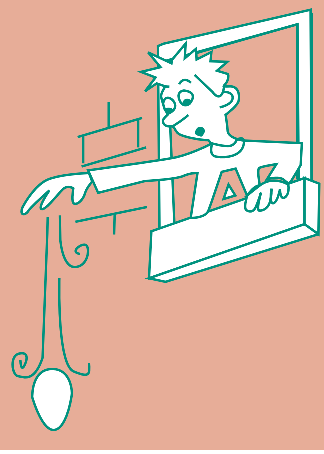


## TEACHER GUIDANCE

SELECT A GOOD LOCATION FOR THE EGG DROP (1st Floor level). Pick a safe place where the class can assemble below. It can be from an open window or a balcony.

| Approx Timings | Activity | Comments |
|---|---|---|
| 10 mins | Put students into groups | • Ideally no more than 5 in a group. Obviously you need time in the session to complete all the drops so too many groups can be a problem.<br>• Students get more benefit if groups are chosen by a random method and not just based on friendship groups. Let each team choose a name |
| 10 mins | Introduce the Task. Read out the rules and explain timings<br><u>Rules:</u><br>• If at any time your egg becomes broken then the group will have failed the challenge.<br>• From the moment the egg is released to the moment it reaches the ground no member of your group can touch it (e.g. no catching)<br>• You can only make one attempt at the drop….no practice runs<br><u>Timinings</u><br>10mins brainstorming/planning<br>20mins construction | Eggs can get broken before the drop is even completed so I have found it important to give incentives groups to take great care of them (hence rule (1)). You may wish to offer to look after all eggs until a group needs it. Replacement eggs are worth having so a group can continue but they cannot be deemed as winners even if their egg drop is successful. |
| 10 mins | Brainstorming session | **<u>See notes on successful designs*</u>**<br>It is useful to move between the groups and listen in. If little progress is being made then ask questions that guide them to thinking about ways of controlling the speed of the eggs descent and protecting the egg from any impact. |
| 20 mins | Construction | The main problems is casualty eggs and sellotape that gets tangled up. Give out sellotape by sticking it in a long strip to the table. It is important to emphasize that they cannot have any extra equipment even if they make a mistake. They have to manage with what they have! |
| 30 mins | The "Dropping Ceremony" | It is best to pre pick a place either in or near your classroom where you can do this safely. Usually you need just one member of each team with their egg upstairs. Send the rest of the group to the landing site, to help you inspect each egg as it lands. |
| 10mins | Feedback Session | Good idea to return to class and discuss where some designs failed and some succeeded. Even comment on how groups worked together as a team. |

# THE EGG DROP CHALLENGE



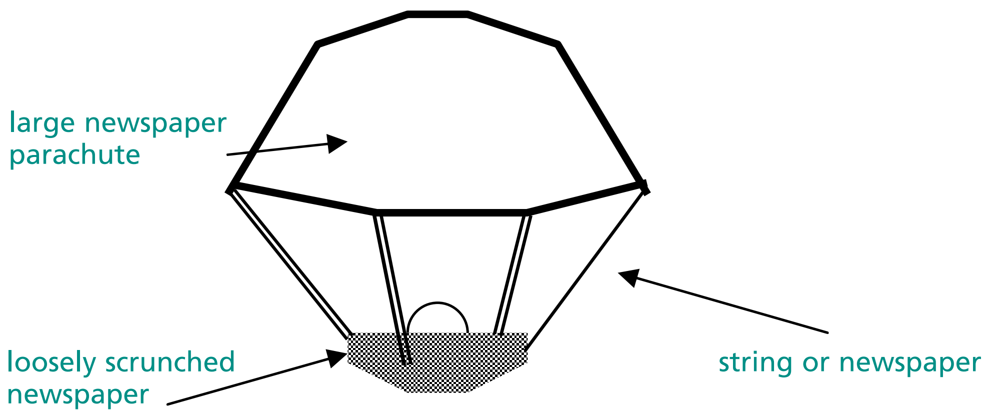
## NOTES ON SUCCESSFUL DESIGNS...

Many groups tend to concentrate all their efforts on a cradle structure designed to protect the egg from the impact. Although some come very close they are not likely to succeed.

There are commonly two types of design that are likely to produce an unbroken egg.

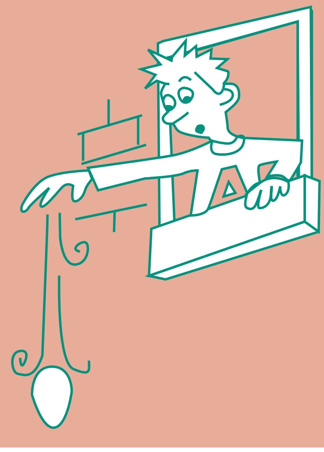
**TYPE 1: PARACHUTE AND EGG CUSHION**

A parachute made from one large sheet of newspaper combined with a loosely scrunched newspaper cushion under the egg to absorb the impact. The cushion




part is crucial to the success of this design. Often groups come up with the idea of a parachute but make it too small. Many groups build very elaborate "baskets" to cradle their eggs but they contain no padding and, even with the braking effect of the parachute, cannot absorb enough of the energy of the final impact.

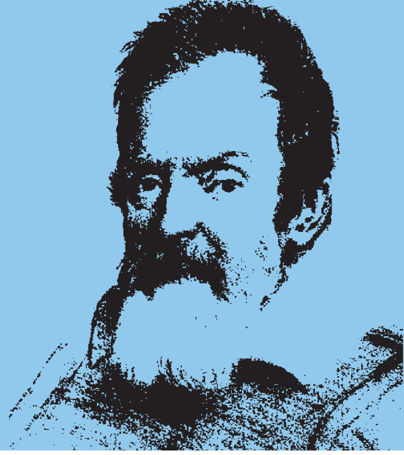
N.B it is important that the egg is securely held in the basket. It is very disappointing when it lands safely but then rolls out at the last minute!



**TYPE 2: THE ROPE TRICK**

Many groups come up with this idea but very few succeed. It sounds simple but is hard to get right. The newspaper can be cut into long strips and stuck together to form a "rope" that can lower the egg down to the ground. Due to rule (3) groups are not allowed to test their rope during construction to see if it will be long enough…they will have to use their estimating skills. The groups that try this often get carried away with their rope and forget to provide a good cushion of scrunched newspaper to the egg to cope will any short fall or knocks.

# THE RETRIAL OF GALILEO



## SYNOPSIS

This trial provides a piece of classroom drama that brings to life an important event in the history of science. Whilst this event is often billed as a great battle between science and the church it is also important for its illustration of how our understanding of the world around us does not always come about in incremental steps. Advances in scientific knowledge often lead to "revolutionary" changes in ideas, changes that even scientists find hard to accept. The example of the Ptolemaic view of the universe versus the Copernican view is a perfect example for school students. The scientific concepts are quite simple and it is easy to empathize with any reluctance to let go of the old view.

## TY OBJECTIVES

- To introduce the idea that scientific knowledge often advances in "revolutions".
- To inform students of the Geocentric and Heliocentric models of the universe.
- To encourage teamwork and communication skills

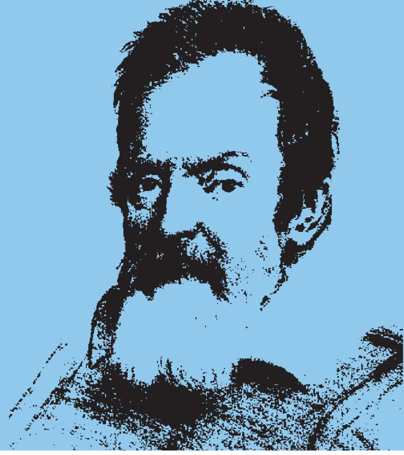
## EQUIPMENT REQUIREMENTS

- Digital Projector for Power Point presentation.

## TEACHER GUIDANCE

The outcome of this activity is a re-enactment of the trial of Galileo that took place before the Inquisition in 1633. He was charged with heresy for asserting his belief that the sun was at the centre of the universe and the earth was in motion around it. He was sentenced to be held under house arrest for the rest of his life and forced to publicly renounce his beliefs. You do not need to be a skilled drama practitioner to carry out this activity, everything is scripted and it is the arguments of both sides that are of key importance.

# THE RETRIAL OF GALILEO



## NOTES ON THE PTOLEMAIC AND COPERNICAN UNIVERSE MODEL

As an introduction to this exercise it would be a good idea to teach a little about the old "Earth Centered" view of the universe (Ptolemaic) and the new "Sun Centered" (Copernican) view that Galileo supported. Use the power point presentation to support you in this. Edit the presentation so if it reflects the depth to which you wish to discuss the background (you may not wish to tackle a debate about the laws of motion). Below are some brief notes and references to websites for in depth reading.

How far you do with this depends on how much time you have available.
The introduction is to help student identify the key difference in physical placement of planets etc and some of the arguments for and against each model.

**Ptolemaic model ( look at: www.wikipedia.org/wiki/Geocentric_model)**

- Ptolemy was born around 85AD in Egypt. He refined the "Earth Centred" model of the universe that dominated at the time and so his name is often given to it: "Ptolemaic" model.
- Earth was fixed at the centre of the universe orbited by the moon the sun and five planets (others were unknown as telescopes had not been invented).
- These were said to be held in place by crystal spheres
- Outside of these spheres was the celestial sphere containing the fixed constellations of stars.
- The earth was believed to be corrupt and imperfect.
- All other "heavenly bodies" were believed to be perfect: perfectly smooth, round, without a blemish.
- Parts of the Old Testament suggest that the sun moves round the earth and this gave great weight to belief in this system. Also humans were seen as God creation and should take up residence in the centre of the universe.
- People understanding of motion was based on ancient Greek thinking and they were convinced that if the earth was moving they would be able to feel this motion and that free falling objects would reveal this motion by failing to fall directly below the point where they were released. Galileo and Newton later showed that this was a flawed understanding of motion.
- The biggest drawback of this system was that it did not tie up with observations of the planets and made forward planning of calendars very inaccurate.
- Ptolemy introduced "epicycles" (extra circles) to some of the planets spheres to try and reduce the anomalies but they were still a far from perfect match.

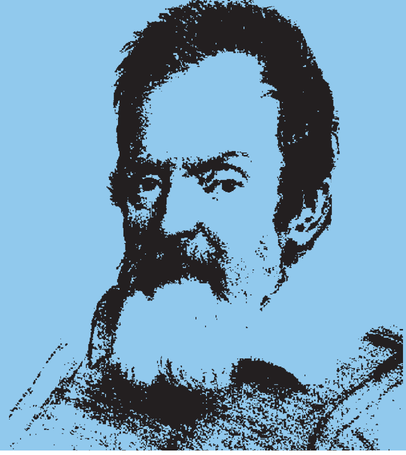
**Copernican model ( look at: www.wikipedia.org/wiki/Heliocentrism)**

- Copernicus 1473-1543 was a Polish Astronomer
- He proposed a model of a "Sun-Centred" model of the universe as an answer to the failure of the Ptolemaic model to make accurate predictions of the positions of the planets
- He only published his work on his deathbed. He left it to others, like Galileo, to establish the model as a true picture of the universe and not just as a useful calculation tool.

**Galileo's Observations ( look at: www.wikipedia.org/wiki/Galileo)**

- Galileo did not invent the telescope but was the first to be able to produce one that could magnify distant object up to x30.
- With his telescope he saw mountains on the moon, four moons around Jupiter and spots on the sun. Looking at the haze of the Milky Way he could see it was made of millions of stars. This all contradicted the idea of perfect celestial bodies.

# THE RETRIAL OF GALILEO

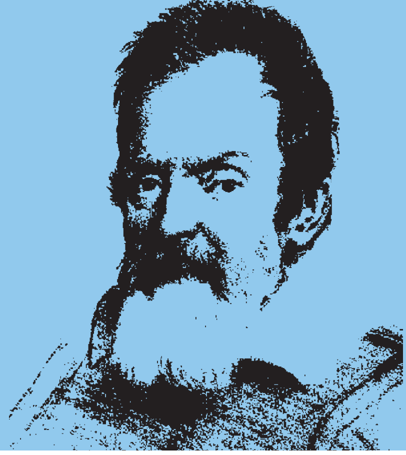


## CONDUCTING THE TRIAL

Divide your class into eight groups. Each group will be assigned a "witness" character. They will be given a sheet of information about their characters background, beliefs and view of Galileo's ideas. The sheet will also contain a list of questions that they may be asked by the "Grand Inquisitor" (played by you). The groups will be given some time to formulate the responses of the witness to such questions. One member of the group must volunteer to play the part of their witness in the trial. How far you wish to take the drama of this event is a matter for you, a small element of simple costumes, props and a courtroom layout to chairs and table greatly add to the effect. When all characters are prepared then you can begin the trial. You can appoint a "Clerk to the court" who calls each witness when you give the signal. When all the evidence is delivered you may do a brief summing up. All the class become members of the court when not giving evidence and will be asked to vote on the final verdict (all except Galileo who should remain on the witness stand). They have to decide… should Galileo be forced to recant: To state that the earth centered view of the universe is in fact true and ask for clemency.
In coming to their decision they must try to imagine themselves living at that time. Who would they trust? What would they believe? The verdict is then to be delivered by the Grand Inquisitor.

If the verdict goes the same way as 1633 then you can deliver the sentence given to Galileo of house arrest for the rest of his days in exchange for his public renouncement of his views. You might get Galileo to do this and mention to the class that legend has it that after making his renouncement he tapped the floor and muttered under his breath… "Yet still she moves".

# THE RETRIAL OF GALILEO



## WITNESS 1

You are a prosperous farmer living near Rome. Despite your lack of education you are very self confident and you have been very successful in your business dealings. You don't read much but you have heard of this Professor of Mathematics, Galileo, who has been arguing that the Earth moves round the sun instead of the sun moving round the earth. You have heard stories about the magic glass (Galileo's telescope) through which one can see magic sights, but you think it may be a trick.

To you Galileo's ideas are laughable. You can see for yourself that the sun rises and sets and moves across the sky, just like the moon. You can't feel the earth moving beneath your feet. You have heard of a "scientific" argument that if the earth was really moving and you threw a ball straight up into the air, it would then fall behind you. You know this does not happen so this proves that the Earth does not move.

*Decide the answers to the following…*

1. *What is your name (something Italian?)*
2. *What do you grow on your farm?*
3. *Have you looked through Galileo's telescope?*
4. *What do you think about Galileo's idea that the earth moves around the sun?*

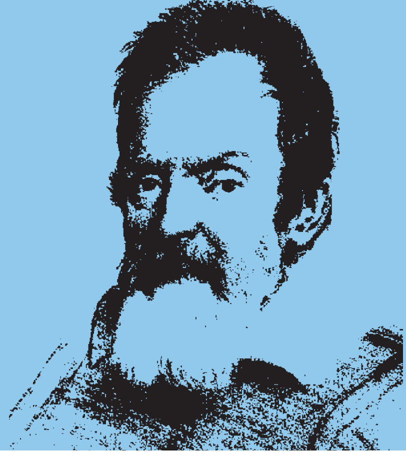
## WITNESS 2

You are a priest in a small village outside Florence where Galileo has been living. You care very much about the faith of the people in your village and that they should lead good and happy lives. Often the villagers suffer and do bad things. Sometimes unfortunate things happen to those who lead good lives and some wrong doers get rich. You teach that it will not be like that in heaven where everyone will get what they deserve. You have heard that Galileo believes the Earth is not at the centre of the universe, and that the Moon and the planets have bumpy surfaces like the earth. Even the sun is said to have spots on it.
You believe that earth is full of sin and imperfect. The rest of God's creation is perfect in everyway (no bumpy or blotchy surfaces are possible).
You believe that the death of Jesus Christ could only have taken place at the centre of the universe, so no matter what, the earth must be in the middle.

*Decide the answers to the following…*

1. *What is your name (something Italian?)*
2. *Can you give the court a quick idea of the sermon you preached last Sunday?*
3. *Galileo claims to have seen mountains on the moon and spots on the sun, what do you make of that?*

# THE RETRIAL OF GALILEO



## WITNESS 3

You were a friend and are now a follower of the Giordano Bruno who agreed with the teachings of Copernicus. He believed that the Sun was at the centre of the universe, and that the Earth and planets move around it. This model best fitted the measurements and observations of the planets from earth. Bruno also believed that the other planets were like the earth and that they also were inhabited by people. Bruno had been a monk and so he added to this a belief that each planet would have its own Christ. They must have lived and died to save the people on these other planets. Bruno was condemned by the Holy Inquisition in 1600 and burnt to death at the stake.

You are delighted that Galileo has brought Copernicus's ideas to everyone's attention.

It seems to you that the sun's heat and light are a sign of God's power and so their rightful place is at the centre of the universe.

*Decide the answers to the following…*

1. *Your name? What is your profession*
2. *Are you happy to come and give evidence to the Holy Inquisition or are you feeling afraid?*
3. *Who's ideas do you follow?*
4. *What happened to him?*
5. *Do you support Galileo, if so why?*

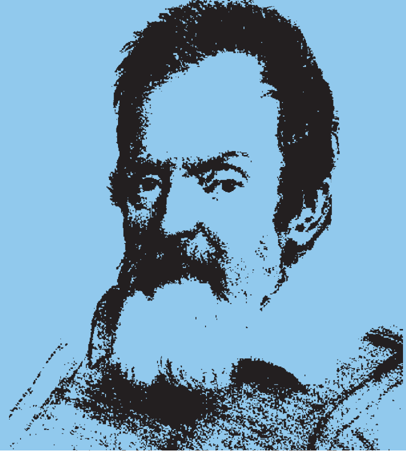
## WITNESS 4

You are Christina, The Grand Duchess of Tuscany. Your family employs Galileo to be Chief Mathematician at the University of Pisa and pays him a good salary. When he first got into trouble with the Church you supported him and he wrote a long letter to you telling you how as a scientist he should have the freedom to think. He has shown you marvellous sights through the telescope he made for you. You have seen mountains and craters on the Moon.
You believe that seeing is believing, so the telescope proves that Galileo is seeing the truth.
You see that there is a possibility of making money from this telescope invention, it could be very useful for ships at sea.

*Decide the answers to the following…*

1. *How do you know Galileo*
2. *What has he shown you?*
3. *What do you think about the church bringing Galileo to trial?*

# THE RETRIAL OF GALILEO



## WITNESS 5

You are Cardinal Bellarmine a very important person in the Church. You have read the books of Copernicus and Galileo. You understand the mathematics and can see that a model of a sun centered universe makes it easier to calculate the dates of the calendar (which get badly out of step using the earth centered model). You are horrified that Galileo wants everyone to take the sun centered universe as a true model of God's creation. The bible tells us that the sun moves across the sky. You take the bible as a word for word truth, there can be no interpretation. You have written to Galileo several times warning him to pay attention to the words of the bible and the teaching of the Church. You are now in support of banning Copernicus' book so that it doesn't give people any false ideas.
You are deeply committed to the idea that educated people should dedicate their work to supporting the teaching of the church, not destroying it.

*Decide the answers to the following…*

1. *How well do you understand the ideas of Copernicus and Galileo?*
2. *Do you see any good in these ideas?*
3. *What advice would you give to Galileo?*
4. *Will you be looking through Galileo's telescope?*

## WITNESS 6

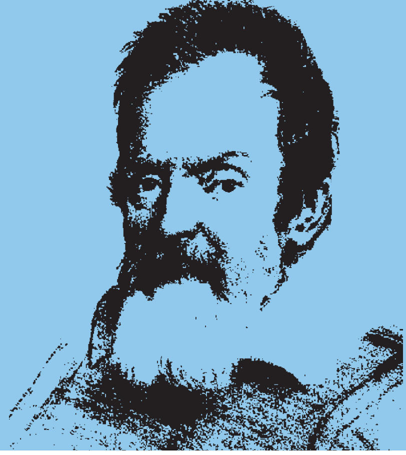
You are the Papal Nuncio, a personal messenger from the Pope and also a Cardinal. The Pope was once a friend of Galileo's. Galileo had travelled to Rome to ask permission to write a book explaining the two different theories of the universe, the old earth-centered theory and the new sun-centered theory. After some thought the Pope had given him permission but on condition that throughout his book he showed that the old view was in fact the truth. When the Pope read the book he was furious because Galileo had made fun of the old view (the one held to be true by the Church). You have come to insist that Galileo fall into line and put right his wrong doing.

You have read Galileo's book. The book is written as if it was a conversation between three men. You are most insulted that the character in the book who supports the Popes view of the world is call "Simplicus".
You believe that all people who go against the Church's teachings are heretics and should be punished.

*Decide the answers to the following…*

1. *What is your name (something Italian) and who have you come here to represent?*
2. *Can you describe the relationship between Galileo and the Pope?*
3. *What do you feel about Galileo's book?*
4. *Do you support the work of the Inquisition?*

# THE RETRIAL OF GALILEO



## WITNESS 7

You are a professor of astronomy from another part of Italy. When you were young you were taught the old view that the sun, moon and all the planets were carried around the Earth by crystal spheres moved by the hand of God himself. Then you read Copernicus and Galileo's books and have looked through Galileo's telescope when it was on public show. You have read some interesting news from Denmark about a comet seen to be moving through where the crystal spheres should be (not possible in the old view). Friends of yours in England and Germany often write to you about their new ideas. Some of them think that it may be magnetism that makes the planets move.

You like Galileo's ideas and are excited by his evidence but are not fully convinced of it. What you don't understand is why, if the earth is moving, the stars in the night sky keep their positions in their "constellations", surely they would appear to move about. (What he didn't realize is that stars are in fact much, much further away than was believed at the time, so any movement due to the earths orbit around the sun is unnoticeable).
Although you have your doubts you want to go on working with all the ideas available.

*Decide the answers to the following…*

1. *What is your name and age?*
2. *Do you know Galileo personally?*
3. *Are you convinced by his ideas?*

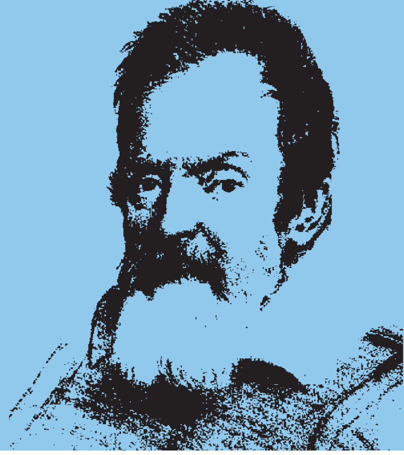
## WITNESS 8

You are Galileo himself. As a young man you are well educated in religion, medicine and mathematics. You have read the work of Copernicus and built on his work. You are convinced that the sun is at the centre of the universe and that the earth, planets and stars orbit around it. You have been interested in many different sciences during your life , from the firing of guns to the strength of different materials to how fast things fall and how the stars and the planets move. You are an expert at making reliable telescopes.
You friends have warned you that this kind of trouble would happen. You are now seventy and nearly blind. Your greatest wish is that you can continue to write about your scientific ideas.
You have always considered yourself a good Catholic, and your favourite daughter is a nun.

You are utterly convinced that you are right about the Sun and the Earth. *Decide the answers to the following…*

1. *What is it that you believe about the position of the earth?*
2. *Are you against the Church?*
3. *Describe your state of health*
4. *If found not guilty what will you do?*

# THE RETRIAL OF GALILEO



## GUIDELINES FOR THE INQUISITOR (TEACHER)

Some witness statements are harder than others. In assigning witnesses it may be helpful to know…

**Easiest:** Witnesses 1, 2, 8
**Medium:** Witness 4
**Hardest:** Witnesses 3, 5, 6, 7

It's important to visit each group as they are preparing their statements, to give guidance and deeper explanation if required.

Questions prepared by each witness group
(Use these as the basis for your questions in the trial)

Witness 1: (a simple farmer) •What is your name? • What do you grow on your farm? • Have you looked through Galileo's telescope? • What do you think about Galileo's idea that the earth moves around the sun?

Witness 2: (a priest) •What is you name? • Can you give the court a quick idea of the sermon you preached last Sunday? • Galileo claims to have seen mountains on the moon and spots on the sun, what do you make of that?

Witness 3: (Friend of Bruno) • What is your name? What is your profession? • Are you happy to come and give evidence to the Holy Inquisition or are you feeling afraid? • Who's ideas do you follow? • What happened to him? • Do you support Galileo, if so why?

Witness 4: (Duchess Christina of Tuscany) • What is your name? • How do you know Galileo? • What has he shown you? • What do you think about the church bringing Galileo to trial?

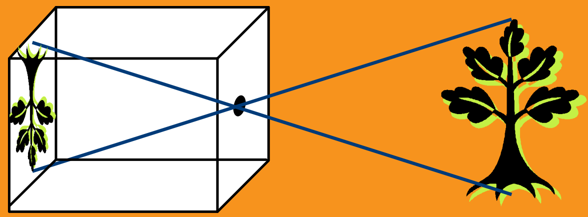
Witness 5: (Cardinal Bellarmine) • How well do you understand the ideas of Copernicus and Galileo? • Do you see any good in their ideas? • What advice would you give to Galileo? • Will you be looking through Galileo's telescope?

Witness 6: (Papal Nuncio- ask the court to rise as he enters) • What is your name and who have you come here to represent? • Can you describe the relationship between Galileo and the Pope? • What do you feel about Galileo's book? • Do you support the work of the Inquisition?

Witness 7: (A traveling scholar) • What is your name and age? • Do you know Galileo personally? • Are you convinced by his ideas?

Witness 8: (Galileo) • What is it that you believe about the position of the earth? • Are you against the church? • Describe your state of health. • If found not guilty what will you do?

# PINHOLE CAMERA PHOTOGRAPHY



## SYNOPSIS

Never mind digital cameras it amazing what photography can be done with an old black box with a pinhole in it. You'll be given a step by step guide as to the construction, picture taking and development process. If you have a lab with a reasonably good blackout this can even be done with groups of 25 or so.

## TY OBJECTIVES

- To introduce the fundamentals of cameras and photographic development.

## EQUIPMENT REQUIREMENTS

Equipment to make each camera

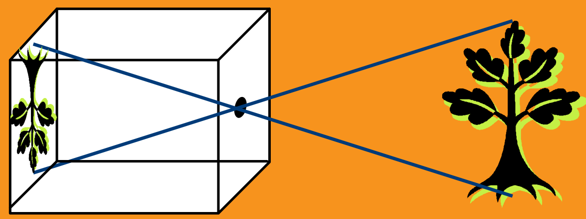
- 1 box/cylindrical container (aprox: 25cm x 10cm x 10cm min.) ideally with a removable lid at one end.
- Several squares (20cm x 20cm) of thick black bin liner plastic
- 1 large rubber band
- Matt black paint (ordinary school paint will do)
- Paintbrush
- Large pin (like an optical pin)
- Clamp Stand (standard lab equipment)
- 2 pieces of Blu-tack

Equipment for taking and developing photographs

- Light sensitive photographic (black and white) paper cut into pieces small enough to fit in the cameras*
- 1 or 2 red lights**
- 1 bottle of (black and white) developer
- 1 bottle of stop bath solution
- 1 bottle of fixer
- Three large plastic trays
- One or two pairs of tongs
- Rubber gloves/goggles and apron (for you)
- A simple washing line with pegs (for drying photos)

**Best to do this before starting the session.*
***Special photo development lights are available but red bulbs (low wattage) should do*

# PINHOLE CAMERA PHOTOGRAPHY



## TEACHER GUIDANCE

You can divide this whole exercise into two sessions:

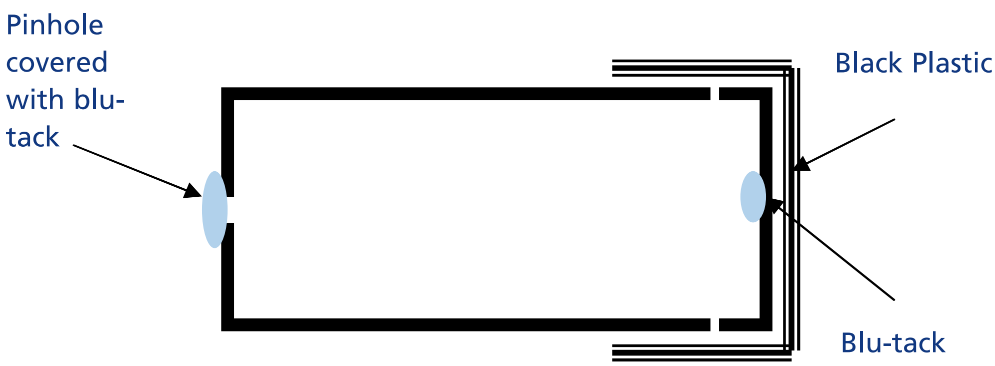
- Demonstrations/Explanations and Constructions of Pinhole Cameras
- Taking Photographs and Development.

If you have cameras that are already prepared then you can dive straight into the photography and the development.

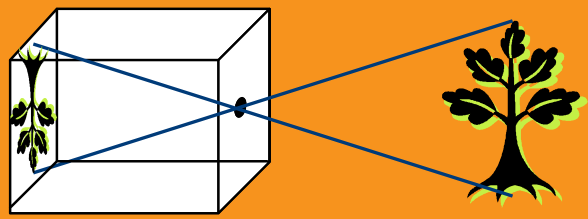
There are two fundamentals things that you must have to make this a success.
- A classroom/lab with a good black out (it doesn't have to be perfect)
- A place to take photos that is outside (rain can be a problem!)

**CONSTRUCTING A PIN HOLE CAMERA:**

All surfaces on the inside of the box need to be painted matt black. Let it dry. The pin hole should then be made. The size needs to be big enough to let enough light in but if it is too large the picture will not be sharp enough. Cover it with blu-tack. Initially make that hole the size of a thick optical pin (it can always be made a little bigger later). Place the piece of blu-tack on the inside of the lid (this is where the photographic paper will be put). Replace the lid. Cover the end with the pieces of black plastic and hold in place with the rubber band. The camera is now ready to use. When in use the camera needs to be held by a clamp stand.



# PINHOLE CAMERA PHOTOGRAPHY



## TAKING AND DEVELOPING PHOTOGRAPHS

To make this a success you need a bit of military planning (especially with large groups). In two parts of this process you will need to operate in low level light conditions (blackout with only one/two red lights). It's important to think carefully about how you are going to move about and minimize the amount of movement by your group at these times

### Step one: LOADING THE CAMERA.

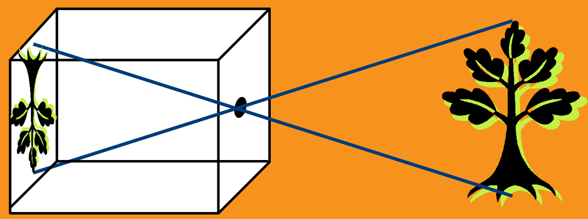
**THIS MUST BE DONE IN NEAR DARK CONDITIONS**

Have the groups open up their cameras and assemble them so that it will be easy for you to pass them a piece of photographic paper in the dark. Switch the main lights off, red light on. Hand over the paper so it can be attached to the inside of the camera lid with the blu-tack. (Only one side of the paper will react to light so it important to make sure they put the right side facing the pinhole). The groups must reassemble their cameras in the dark. When everybody's camera is light tight you can turn the light on again. The cameras can then be mounted on the clamp stands.

### Step two: TAKING PHOTOGRAPHS.

This works best if photos are taken outside. It's good to take photos of landscapes or people (not too close). It's best to use scenes that have a lot of contrast (e.g. a person standing against a light wall). When a scene has been chosen the camera needs to be positioned on a solid surface and pointed at the scene. It cannot be held due to the long exposure times. You will need to choose an exposure time depending on the light conditions. If it is a very sunny day 10 secs will probably be long enough. The first photo can be a trial. 20 secs or longer may be necessary at times. When ready the blu-tack can be removed and the exposure time counted out. The blu-tack is replaced and the photo is ready for development.

# PINHOLE CAMERA PHOTOGRAPHY

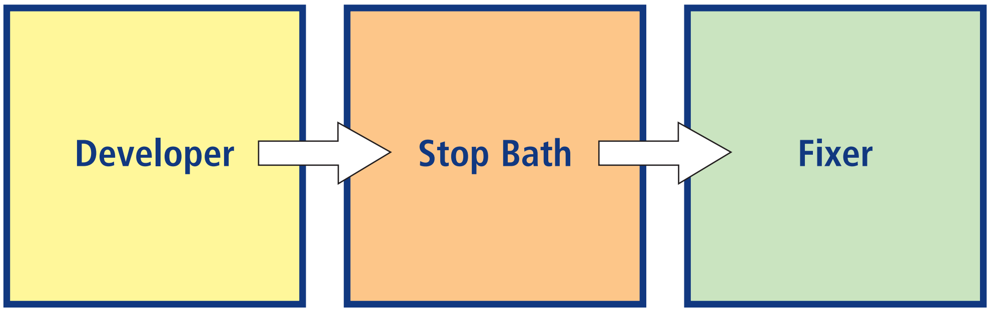


## TAKING AND DEVELOPING PHOTOGRAPHS

### Step three: DEVELOPING PHOTOGRAPHS.

**THIS MUST BE DONE IN NEAR DARK CONDITIONS**

More military planning required….. Depending on the number of students you have it is probably best that you take control of the development process. Set up your development station (ideally next to a sink)




Have one member of each group queue up with their camera. Turn the lights off (red light only). The nearest student opens up their camera and drops it into the "developer" tray. In a minute or so a picture should appear. When it appears developed enough pick it up using tongs and dip it in the stop bath for 10 secs Then move it to the fixer tray. Work your way through all of the cameras (at what ever speed you can manage). Once all pictures are in the fixer the light can be turned back on and they can then be rinsed and left to dry. (for precise timings follow manufacturers guidelines)

Then you can start again, reloading the cameras and taking other pictures, adjusting exposure times etc to get a better picture.

### EXTENSIONS:

Some students can get quite inventive with their photography.

- If photographing a person they could make a sudden move to a new position during the exposure….this creates a ghost like double image of the person.
- Some students on their last attempt have made more than one pinhole and got overlapping images.

# EVACUATE PLANET EARTH

## SYNOPSIS

What if the earth were to become uninhabitable? Where could the human race go? Evacuate Planet Earth challenges students to use factual information to solve a fictional crisis. Presented with six options, critical decisions need to be made. Collective decision making is never easy but each team must come up with a location to re-house the human race and then present its conclusion to the world.

Developing teamwork, decision making and presentation skills are just part of this exercise. Throughout this mini project students will gain access to some off the lesser known facts about the solar system they inhabit, start to build an appreciation for the enormity of space and the exciting discovery of planets outside our solar system.

## TY OBJECTIVES

- To enhance teamwork and decision making skills.
- To introduce factual information about our solar system and beyond.
- To develop presentation skills

## EQUIPMENT REQUIREMENTS

- Digital projector for power point presentation.
- Copies of Scientist reports

*If you choose to include student presentations you may need….*

- Video camera
- Television
- Large pieces of paper.

# EVACUATE PLANET EARTH

## TEACHER GUIDANCE

Your class should be split into teams of 4 or 5.

*Ask your class to consider the following imaginary crisis:*

World leaders can no longer put off informing the world of a catastrophe facing the human race. Scientists confirm that the earth's crust is unstable. Within the next 500-1000 years it will disintegrate and turn the planets surface into a hostile landscape of molten rock. This will ultimately devastate life as we know it making this planet impossible to live on. The only course of action is to start an evacuation of the planet. Assuming our technical knowledge is/will be such that we can build large spacecraft with self sustaining bio systems designed to create the correct atmosphere, food and water supply for as long as we need, it is up to you to make the first critical decision……

**WHERE ARE WE GOING TO GO ?!!!**

To make the decision easier scientists from all over the world have been working around the clock to produce the report "Operation Evacuate Earth" on the six best options. It is your job to study this report in your groups. Each group must make its own decision about where the human race is going to inhabit next, giving its reasons.

Each group can be given copies of the report.*

A *Power Point presentation* discussing the challenge and the main conclusions of the report has been provided on the accompanying CD. It will allow you to draw attention to the main points before students go off into groups to discuss the report and make a decision.

If it is possible to do this over two sessions then a lot more time can be given to the research. The report can be an outline for their decisions but they could include library or internet research to add extra evidence.
Recommended website: *www.bbc.co.uk/science/space* (good for TY age group).

*The activity can end at this point or continue…..*

Once the groups have come to a consensus they can announce their decision in the form of a PRESENTATION TO THE NATION. This provides a wonderful opportunity for groups to work on their presentation skills. You can take this as far as you like. Either a short announcement by each group to the whole class or use a video camera to generate a mock television event (best to allow max 5 mins). Groups can write, rehearse, and present their announcement in an imaginative and informative way.

# EVACUATE PLANET EARTH

## OPERATION EVACUATE EARTH

### SUMMARY OF OPTIONS

*Report by the Confederation of World Scientists*

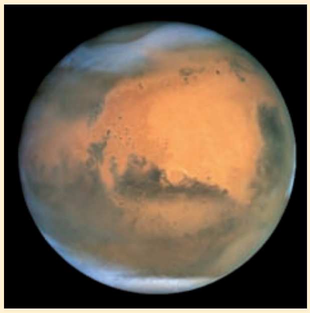
**The earths surface is about to break up becoming a sea of molten lava. The seas will evaporate all plant life will die...**

**WE MUST EVACUATE!**

## OPTION 1: THE MOON

- 384,400km from Earth.
- The moon has no atmosphere/air.
- The moon, like earth is showered with meteorites (large rocks) in late Oct/early Nov. Meteorites are burned up in our atmosphere so we are protected, on the moon they reach the surface and would cause damage.
- We are convinced that water ice is present at the north and south poles of the moon.
- Temperatures range from -173C to 127C
- Humans have actually travelled to the moon (between 1969-1972) unlike any other planet/moon.
- The moon has no magnetic field. The earth's magnetic field acts like a net and traps charged particles that stream out of the sun (the "solar wind"). These particles can be very dangerous to living things. We would need to create our own shield on the moon.
- One "day" on the moon lasts an earth month.

## OPTION 2: MARS

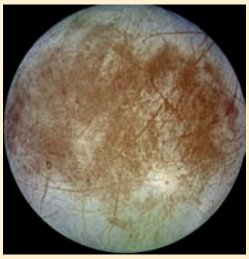


- Closer in temperature to the Earth than any other planet. Nevertheless temperatures can reach -133C in winter.
- Has a thin atmosphere, mostly made of carbon dioxide. Some scientists think it may be possible to alter this over a long period of time.
- A Martian year is as long as two earth years
- At its closest Mars is 78 million km away from earth. It would take about 5.25 earth months to travel there.
- Gravity is only a third as strong as on earth.
- The entire planet is vulnerable to giant storms. Dust storms and massive tornados are frequent.
- 1 "day" on Mars lasts about the same time as an earth day.

# OPTION 3:
# VENUS

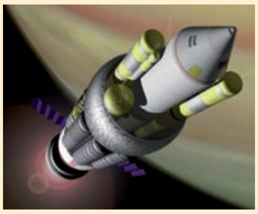
- Venus is almost identical in size and believed to have a similar composition as earth. Earth and Venus are often referred to as sister planets.
- It would take about 3.5 earth months to travel to Venus
- Venus has a very dense atmosphere. It's so dense and hot that it would put a pressure on you 90 times greater than the earth's atmosphere. This would simply crush a human body. All structures we build there would have to withstand this massive crushing pressure.
- The atmosphere is nearly all made of carbon dioxide and includes a 25km thick cloud that covers the whole planet (no sunny days). This cloud contains droplets of concentrated sulphuric acid.
- The average temperature on Venus is 467C (hot enough to melt lead)
- Some scientist think that the hostile conditions may be caused by volcanic activity which is expected to die out. A long time into the future conditions should then become more earth like.
- One "day" on Venus lasts 243 earth days.
- Venus has no magnetic field. We would not be protected from the dangerous "solar wind"

# OPTION 4:
## JUPITER'S MOON "EUROPA"



- Jupiter itself is not an option. It is the largest planet but it is mostly made of gas and liquid and has no solid surface for us to live on. In addition it has a very strong magnetic field. This traps so many charged particles that it has radiation belts around the planet that are so intense they would kill you straight away it you travelled through them.
- It takes about 18 months to travel to Jupiter and it has over 39 moons, one of which may be useful to us.
- Europa is Jupiter's second largest moon, about the same size as our own. It may be the only other place in the solar system to have watery seas. Alas the surface is frozen solid but scientists have reason to believe it may be liquid underneath.
- If Europa has liquid seas some scientist think that Europa is a place where simple forms of life could have developed. There is no clear evidence to prove this so far.
- There is no atmosphere on Europa and its average temperature is -170C

# OPTION 5:
## OUT OF OUR SOLAR SYSTEM



- We could attempt to leave our Solar System and explore other planetary systems.
- Since 1995 we have confirmed the existence of at least 200 other planets orbiting around other stars in our galaxy.
- Some astronomers think there may be planets around up to half of all the stars in our galaxy. That could mean 50 billion other planets.
- Travelling outside our solar system involves travelling unimaginably large distances. The nearest star is just over 4 "light years" away (if we could travel at the speed of light it would take 4 years to get there). Current space craft technology would allow us to travel this distance in 25,000 years! It will take far longer then anyone's life time. Maybe thousands of generations of humans will be born and pass away before any home can be found.
- So far all but one of the planets spotted from earth are "Gas giants" like Jupiter and so uninhabitable. Rocky planets like earth are much harder to spot but scientists have found one orbiting the star Gliese 581 in the constellation of Libra. This star is 20.5 light years away (which is quite close compared to most stars). The temperature of the planet is estimated to be between 0-40°C so liquid water may be able to exist there. On this planet one year lasts 13 days and gravity is five times stronger than on earth.

# OPTION 6:
## SPACE STATION/ COLONY IN ORBIT AROUND EARTH

- It may be possible not to leave earth entirely but just its surface.
- The scientists who have predicted the complete meltdown of the earth's surface may have got it wrong. A small number of scientists predict that it will only partly meltdown making it impossible to live on but a good source of fuels and materials.
- We could build large space stations/colonies that orbit the earth and live on these.
- Space planes could return to earth and bring back valuable resources.
- If scientist have not got it wrong and meltdown of the surface is complete then we would then start looking at options 1 to 5
- Any space station would be vulnerable to the man made problem of "space junk". Previous space missions and satellites have left over a million pieces of "junk" orbiting the earth at speed of over 25,000miles per hour. (The impact of a metal lump the size of tennis ball would be as devastating as 25 sticks of dynamite!!!)

# LASER MAZE

## SYNOPSIS

An excellent teamwork and problem solving exercise using the unique properties of laser light. The laser maze consists of a zigzag of ankle level invisible laser beams. If the beam is broken an alarm will sound. It is each groups challenge to guide as many members of their group through the maze blindfolded as they can! It's a race against the clock.

## TY OBJECTIVES

- To develop problem solving skills and teamwork.
- To introduce students to unique properties of laser light.

## EQUIPMENT REQUIREMENTS

- Large room with some open space and a reasonably good blackout.
- 1 standard He Ne laser
- 8-10 small mirrors (front silvered mirrors are perfect but ordinary mirrors will work)
- 8- 10 stands (to hold mirrors)
- Spare tables and/or chairs
- Water spray or chalk dust (to show up laser beam)
- Towel (if you use water spray)
- Push button buzzer or electronic light detection system (see notes overleaf)
- 10 blindfolds
- Stop clock

## TEACHER GUIDANCE

The laser maze was originally designed for use with a group of 10 students with the whole group forming one "team". A team has to develop a strategy of how **to guide as many blindfolded members of its team across the laser maze, without breaking the laser beam, in a set period of time** (see full details of challenge later). When the group arrives into the room the laser maze must already be set up. They should be given a period of time to inspect the laser maze and then work out a strategy of how to pass through the maze without breaking the laser beam.

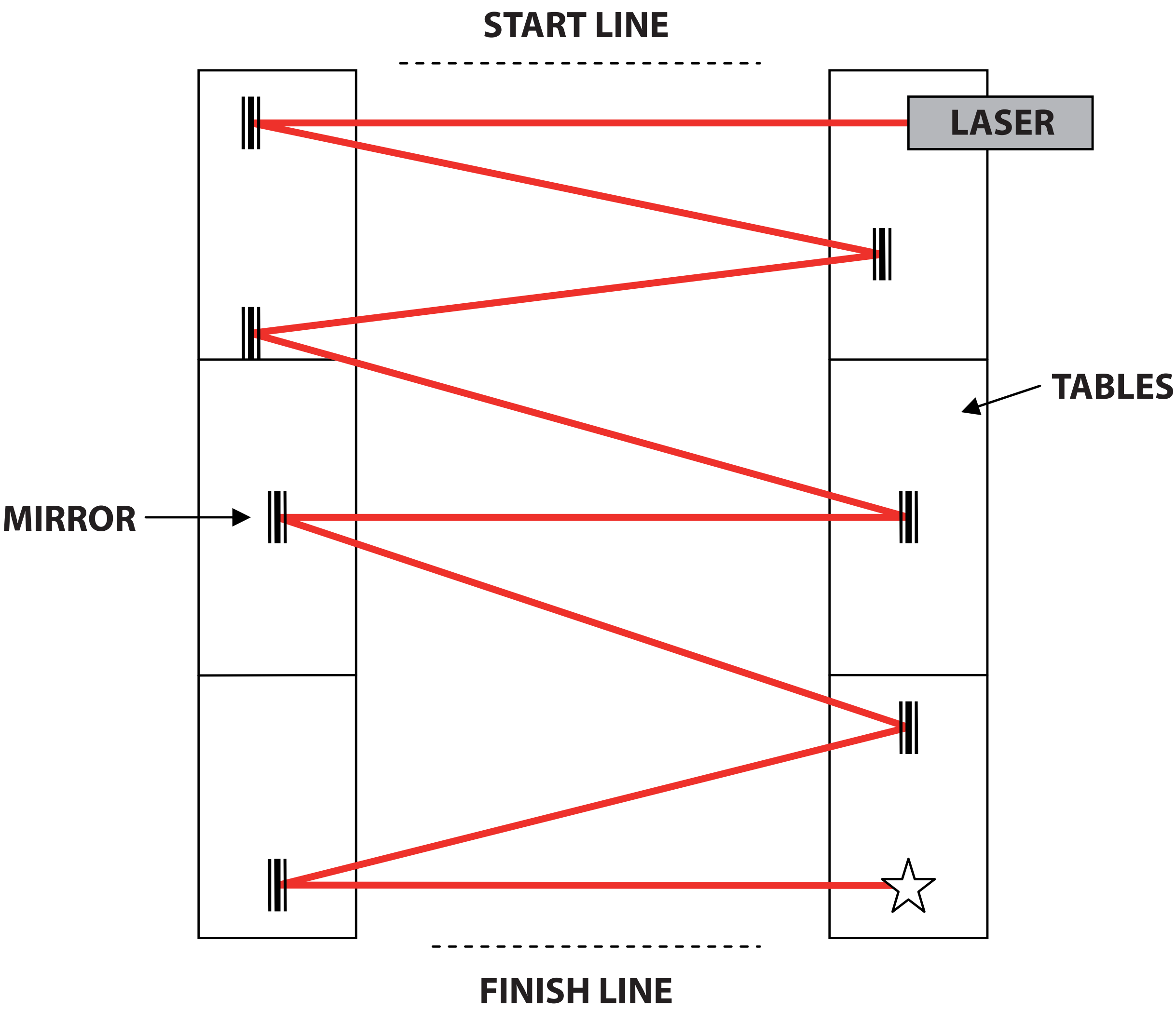
If you are working with a larger group then you may be able to allow two or three teams to compete with each other. Obviously the first team will be at a disadvantage because the other two teams will be able to watch their mistakes and could allow them to unfairly reassess their own plan. In this instance it may be better to make this an exercise of "learning from other people's mistakes". The next team can be given a few minutes to discuss what they have learned from the previous teams attempt and must improve on their results.

# LASER MAZE

## CONSTRUCTION OF THE LASER MAZE

The Laser Maze will typically take up one third to a half of the floor space in the classroom. A laser beam (at ankle level) undergoes a series of reflections off eight or so ordinary mirrors to create a zigzag of laser beams across the room. The lasers beam finally falls on a detector system (see later) that sets off a buzzer if the beam is broken. The mirrors, laser and detector are protected by rows of tables placed above them.

*A view of the layout from above...*




## NOTES

At the place marked ☆ a laser detection system needs to be put in place. This can either be a "low-tech" manual system or an automatic detection system. Both have the same objective: when the laser beam is broken a buzzer must sound.

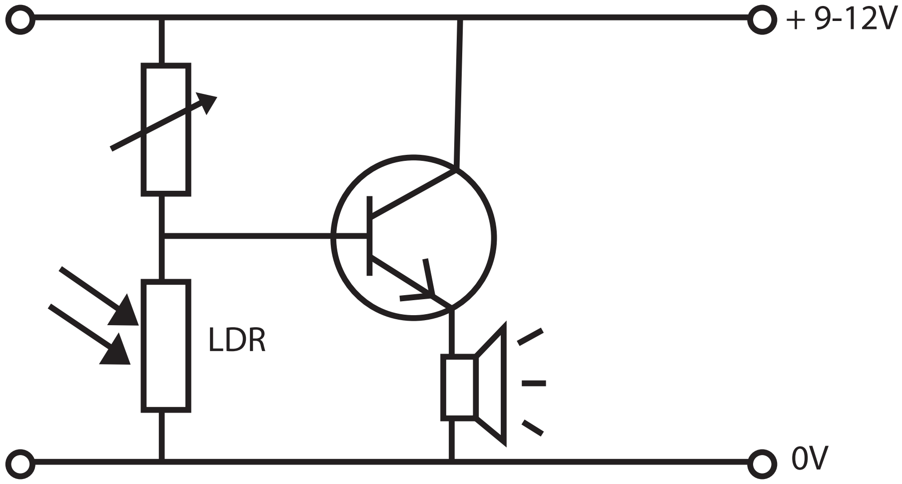
# LASER MAZE

## MANUAL DETECTIONS SYSTEM

The laser beam must be deflected onto a suitable surface/screen where it is visible to a select group of appointed observers. They must be provided with a push button buzzer that they can push if they see an interruption in the laser beam.

## AUTOMATIC SYSTEM

If you have the electronic know how or the appropriate equipment you can build a detector that will automatically trigger the buzzer if the laser beam is broken. You may be able to build this from standard electronic kits or build one from scratch using the following type of circuit....



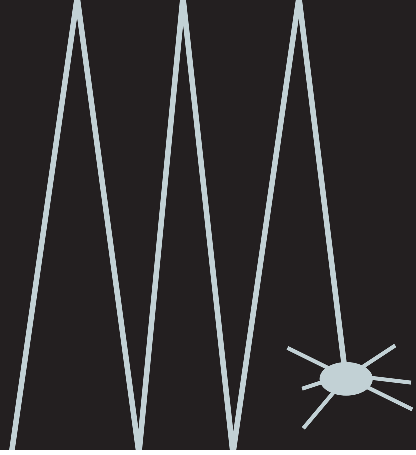

## STANDS

You may have a set of mirror stands as part of your standard classroom equipment. If you have no stands then mirrors stuck onto wine bottles with blu-tack can work well. Whatever you use you will need to be able to make small movements in the mirrors positions to allow you to adjust the position of the laser beam. Although the maze must be set up in advance of your students arriving remember to do a last minute alignment check before you start.

## MIRRORS

Front silvered mirrors are ideal for this project but it unlikely that you will have enough to build a maze. Regular mirrors work perfectly well but it is important to realise that they will cause the beam width to increase with each reflection.

# LASER MAZE



## HOW TO PLAY THE LASER MAZE

Show your students the Laser Maze, explaining how it works and exposing the laser beam using the water spray/chalk dust (be careful not to get it on mirrors). Explain the challenge…..

The ultimate aim of the "Laser Maze" is to move as many members of a team through the maze in a fixed amount of time, according to the following rules and conditions….

- All team members counted as having passed through the Laser Maze successfully must do so BLINDFOLDED!

- If the buzzer sounds, all of the blindfolded members of the team standing in the maze (at that time) must return to the start line.

- There is a maximum amount of time allowed for this challenge (e.g. 15-20 mins depending on your time constraints).

**Before preceding you must inform you class of the dangers and safety issues concerning the use of laser light.**

**Safety: All laser beams are at ankle level but all students must be told not to lie down and look directly into the beam. To do so could cause permanent damage to vision. It is also a good idea to remove/cover any highly reflective surfaces on shoes/clothing (especially below knee level).**

**As this exercise involves blindfolds the groups must take care to ensure the safety of their blindfolded team members. Any practices deem to be unsafe or reckless will be stopped and carry penalties (you may discount points). Gym mats can be put down in the area between the tables if you feel this is necessary.**

**Teacher notes:**
There is nothing to say that teams cannot leave markers in the maze to help guide their blindfolded team member. There is also nothing to say that non-blindfolded team members cannot enter the maze during the challenge. In fact if your students are really cunning they may realise that there is nothing in the rules to state that the blindfolded member of the team's feet must touch the ground! Interestingly many groups approach this with considerable caution and move very slowly. There is nothing to penalise groups for making as many triggers of the buzzer as they like. Often a bold approach, risking more triggers can achieve a better end result!

# LASER ART

## SYNOPSIS

This may be used as a practical exercise to initiate an interest in laser technology or the starting point of an open ended project to generate stunning "Laser Art" visual effects. Using basic classroom equipment and recycled "junk" students can be guided through the construction of a simple double rotating mirror system that will project a wide range of shapes and patterns onto a screen. The question is… do you stop there?

## TY OBJECTIVES

- To Introduce students to lasers and laser control technology
- To enhance practical construction skills
- To encourage innovative design and realisation of ideas.

## EQUIPMENT REQUIREMENTS

The mirrors and motors required to complete this project should cost nothing. See notes next to these items to see how you can acquire them from local dentists and from redundant electrical equipment.

Each group requires:

- 1 laser (standard classroom laser is ideal)
- 2 front silvered dental inspection mirrors *(See Note 1 overleaf).*
- 2 CD/DVD motors *(See Note 2 overleaf).*
- Blu-tack (or equivalent)
- Plastic coated wire
- 2 9V batteries
- 2 battery holders
- 2 variable resistors/rheostats (0- 100Ω) *(See Note 3 overleaf).*
- 2 switches
- Wire cutters/ strippers (may need solder and soldering irons)
- Screwdrivers (including very small ones)
- Clamp stands (to hold the motors, they must allow for 3D adjustment)

# LASER ART

*Note 1*

*It is essential that you use front silvered mirrors. Front silvered mirrors can be expensive to buy but dentists can be a good supply of free second hand ones. The mirrors that dentist inspect your teeth with are front silvered and inevitably they are discarded. It worth asking the local dentist if they could pass them to you before they reach the bin (some may be willing to donate new ones to a good cause!).*

*Note 2*

*Again you can come across these for free by removing them from broken CD players/walkmans/dvd players and computer disc drives. An appeal to students or local electrical repair services can produce plenty of these redundant appliances. The advantage of these motors over the simple motors that you may have in your labs is that they have a much smoother action (especially at low speeds of rotation). Besides which, students have great fun dismantling them.*

*Note 3*

*0-100Ω is just a suggestion, try a few different types to see which works best for your motor.*

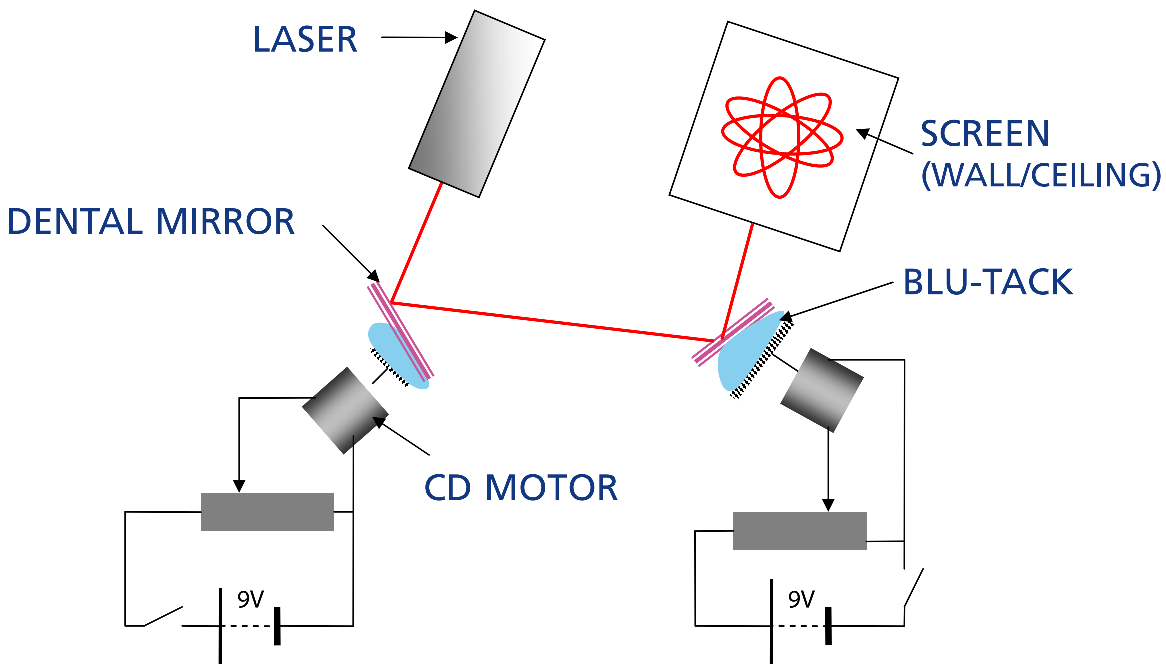
## TEACHER GUIDANCE

This project is ideally suited for working with just one or two small groups (**If you are limited to working with a large group you could construct the above yourself and use it for demonstration purposes)*. Partly because of the limitation imposed by the number of lasers you may have access to (you could share one laser between two groups) and also from the point of view of safety. In working with a large group a demonstration might be more appropriate.

*The use of laser light must be supervised by you at all times and all students must be well informed of the dangers of laser light. If shone directly into the eye laser light can cause permanent damage to vision. Students should remove all shiny objects from their arms/hands and should make an assessment of where the laser beam is expected to go and ensure students are safely positioned, BEFORE the laser is switched on.*

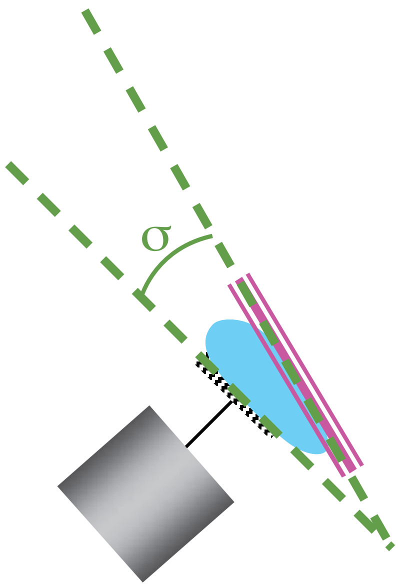
# LASER ART

*The following schematic diagram shows the basic construction of the Laser Art equipment.*




The basic idea is for a laser beam to reflect off one rotating mirror onto a second rotating mirror and then onto a screen. By varying the speed of rotation of the mirrors independently (by varying the two variable resistors) a whole array of patterns can be generated. The mirrors are best held onto the motors using blu-tack. Blu-tack is ideal because it will hold the mirror and allows for small manipulations of the position of the mirror. It is important to note that the plane of the reflective surface of the mirror is not parallel to the plane of rotation of the motor. A small angle $\sigma$ needs to be achieved.

# LASER ART




This causes the laser beam to trace out an oval shape. The size and the shape of the oval depends on the angle σ. All of this oval shape needs to land onto the second rotating mirror. The mirrors are quite small so need to ensure that σ is quite small and that the two mirrors are close together. The motors can be held by clamp stands or if you are feeling adventurous you can build your own stands.

At this point your project can draw to a close or if time is on your side and you have the appetite for an open ended journey encourage your students to take this one step further: to develop further systems of control to create even more sophisticated laser art ….