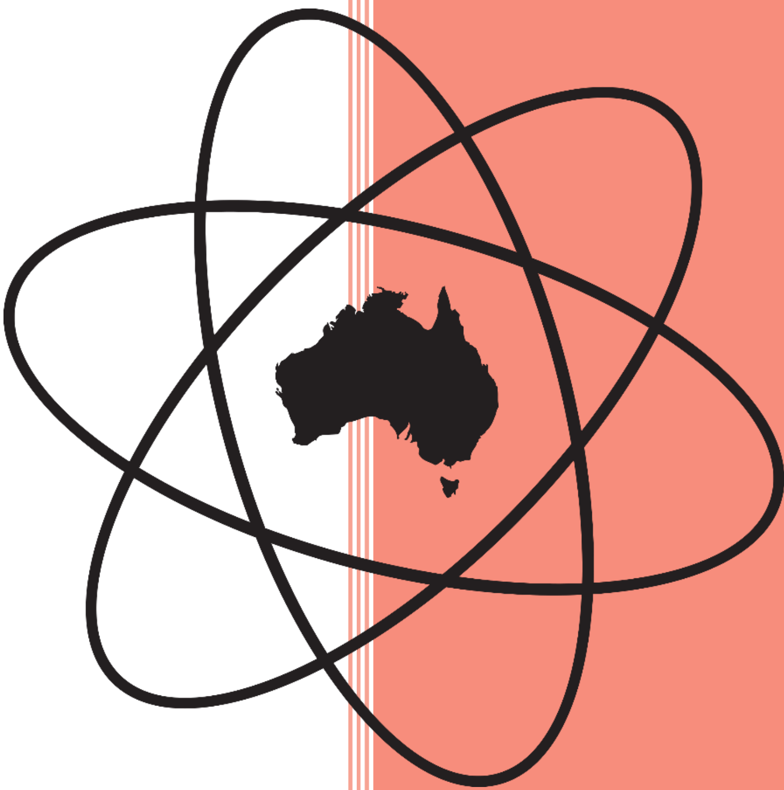
National Science Week

Science experiments to do at home



Young Scientists of Australia
Melbourne Chapter

1 Night Vision

Rhodopsin is a protein in the eye that helps with dark vision. It can be 'bleached' by being exposed to light. There's a super cool experiment you can do at home with just a dark room and your phone to see this in action.

Firstly, you need to be in a super dark room, so it's best to try this at night unless you have super good black out curtains. In the dark room, cover one eye. Then, with the brightness up high, look at your phone screen with the other eye for 10-15 minutes. After 10-15 minutes have passed, put your phone down. With the room still dark, close and open each eye in turn, testing out your dark vision with each eye individually.

The eye that was closed should have much better dark vision, as it wasn't 'bleached' by your phone's light! If you look only through the eye that was exposed to your phone, everything will be much darker.

2 Oobleck - The Dr. Seuss experiment

Is it a solid or is it a liquid… or both?

Oobleck is a non-Newtonian substance which means that changes its viscosity depending on the force applied to it! This means it can feel like a solid when you hit it or apply any pressure to it or when you just hold it will feel like liquid slime! The funny name comes from a Dr. Seuss book called 'Bartholomew and the Oobleck, .

Materials
- 1 cup of water
- 2 cups of corn starch
- Mixing bowl
- Few drops of food colouring

How to make Oobleck
- Pour the corn starch into the mixing bowl
- Pour the water into the mixing bowl
- Add food colouring
- Mix until all combined
- Have fun and get messy!

Note – make sure when you dispose of the Oobleck you add lot of water to the mixture before you pour it down the drain this will stop the Oobleck from blocking the pipes

3 FIREWORKS IN A GLASS

Don't just save the fireworks for New Year's Eve, try them at home!

Materials

- 2 Glasses
- Room temperature water
- Oil
- Food colouring

How to make fire works!

Firstly, grab 2 glasses, fill one with water and try to get it to room temperature.
With the second add 2 tablespoons of oil. In the cup with the oil, add 2 drops of food colouring of your choice, stir the food colouring and oil so it breaks into smaller drops. Now for the fun part, pour the oil and food colouring into the water and watch the fireworks come to life ☺

This works as food colouring dissolves in water however it doesn't dissolve in oil, this allows the food colouring to dissolve/explode into the water.

4 Coin maths problem

You're tossing a coin with a friend that has infinite wealth. They're feeling generous today, so they give you a chance to make some money.

You will toss the coin; if it lands on heads, they pay you and the game ends. If it lands on tails, you toss it again. If you get heads on the first turn you get \$2. Every turn the game goes on the prize pool doubles, so if you get heads on the second turn you get \$4 and so on.

In general, if the game lasts until turn N, you get $\$2^N$ and the game only ends when the coin comes up heads.

How much money should you expect to win?

5 HOT ICE

To make hot ice we first need to create sodium acetate!
The sodium acetate in the solution in the refrigerator is an example of a supercooled liquid. That is, the sodium acetate exists in liquid form below its usual melting point.

Materials

- 1-liter clear vinegar (weak acetic acid)
- 4 tablespoons baking soda (sodium bicarbonate)

How to make the hot ice!

In a saucepan or large beaker, add baking soda to the vinegar, a little at a time and stirring between additions. The baking soda and vinegar react to form sodium acetate and carbon dioxide gas.

CAREFUL! If you don't add the baking soda slowly, you'll essentially get a baking soda and vinegar volcano, which would overflow your container.

You've made the sodium acetate, but it is too dilute to be very useful, so you need to remove most of the water. Here is the reaction between the baking soda and vinegar to produce the sodium acetate: $Na^+[HCO_3]^- + CH_3\text{–}COOH \rightarrow CH_3\text{–}COO^- Na^+ + H_2O + CO_2$

Boil the solution to concentrate the sodium acetate. You could just remove the solution from heat once you have 100-150 ml of solution remaining, but the easiest way to get good results is to simply boil the solution until a crystal skin or film starts to form on the surface. This will take about an hour on the stove over medium heat. If you use lower heat you are less likely to get yellow or brown liquid, but it will take longer. If discoloration occurs, it's okay.

Once you remove the sodium acetate solution from heat, immediately cover it to prevent any further evaporation. I poured my solution into a separate container and covered it with plastic wrap. You should not have any crystals in your solution. If you do have crystals, stir a very small amount of water or vinegar into the solution, just sufficient to dissolve the crystals.

Place the covered container of sodium acetate solution in the refrigerator to chill.

To demonstrate supercooling, crystallization, and heat release pour the solution onto a shallow dish. If the hot ice does not spontaneously begin crystallization, you can touch it with a crystal of sodium acetate (you can usually scrape a small amount of sodium acetate from the side of the container you used earlier). The crystallization will progress from the dish up toward where you are pouring the liquid. You can construct towers of hot ice. The towers will be warm to the touch!

6 PEN CHROMATOGRAPHY

Chromatography is used to separate chemical mixtures. If you are separating coloured compounds like ink, dyes or food colouring you can easily see the results by eye. You can also separate non-coloured compounds, like amino acids or sugars, and detect the results afterwards using staining techniques.

Materials

- Glass of water
- Coloured felt tip pens
- Paper towel
- Scissors

Method

- Cut a thin strip of paper towel
- With one of the felt tip pens, draw a line across the paper towel strip about 1cm from the bottom.
- Place the paper strip into the water so that only the edge of the paper touches the surface of the water.
- Once the water reaches the ink line, lift the paper strip off the surface of the water. You'll notice that the ink rises upwards as the water comes up through the ink line.
- As the water rises the ink will spread up the paper and split into its primary colours! The longer you leave your chromatography the more the colours will spread!

7 BAKING SODA VOLCANO

Materials

- Empty bottle
- Food colouring
- 1/2 cup Vinegar
- 1 or 2 tbsp Baking soda
- Baking dish or pan
- Jug

How to make the volcano!

- Mix the food colouring and vinegar together in the jug
- Put the baking soda in the bottle and place the bottle in the dish to avoid mess!
- Pour the vinegar mixture into the bottle and watch the lava flow!

8 PIXELOGRAPHY

Nanotechnology is all around us today. Almost every part of our lives has been infiltrated with scientists making our lives easier using really, really, small things. From our shampoos, to our smartphones, nanoscale structures are being used to do really nifty things. But since these structures are so tiny, scientists need to come up with new and creative ways in order to see them, and to work with them. A tried and tested technique is called crystallography. Over the past century scientists have gotten quite good at figuring out the atomic structure of anything that they can get their hands on and crystalize using rays of light. This is largely thanks to a father-son scientist duo from Adelaide called William and Lawrence Bragg.

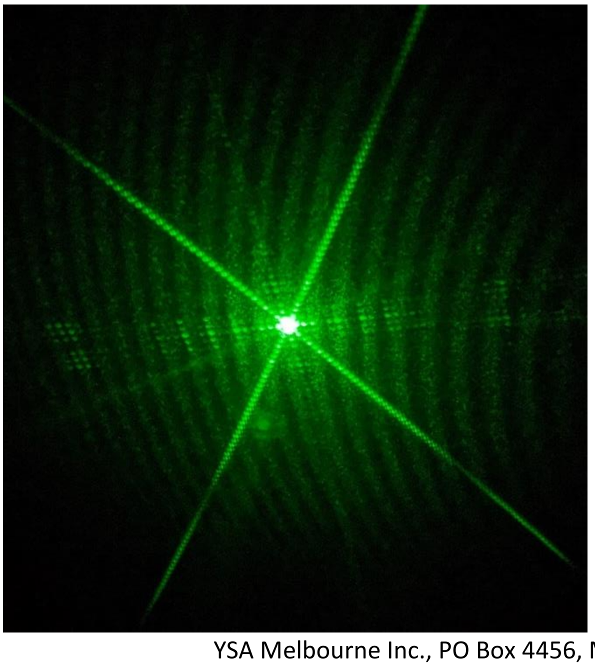
Together they have come up with a nifty little equation that can be used to calculate the size or separation of very small structures. But before we get into the maths, let's get into the experiment!

So, as you probably know, your phone screen has a lot of pixels in it. These pixels are essentially little lights that can be turned on and off and come in three different colours: red, green and blue. We can use a similar method to how scientists gain information about the atomic structure of crystals, to figure out the exact size of the pixels in your phone and to calculate your screen resolution!

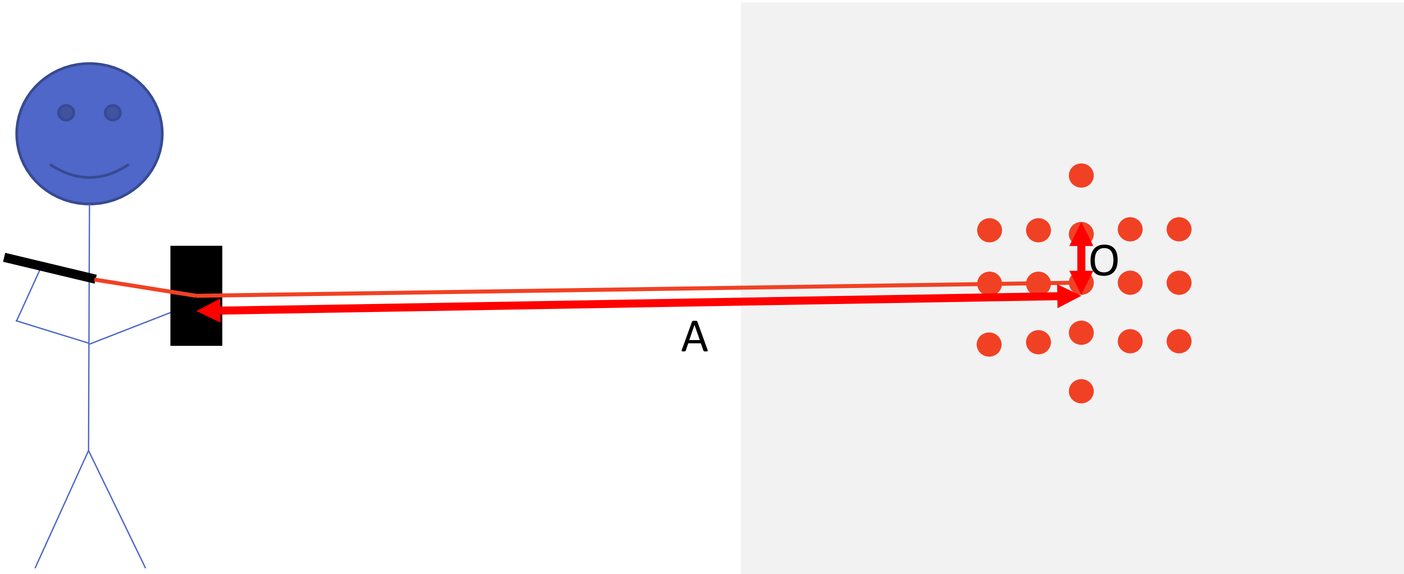
<u>What you will need:</u>

- A ruler
- A green laser pointer
- A smartphone (or any LCD screen)
- A blank wall/piece of paper
- Big brain energy

In a dark room, shine the laser at your phone screen so that it reflects onto the blank wall and change the relative angle between the phone and laser until a pattern like the one below appears



As you can see, there are several lines of spots, rather than just 1 laser spot. They are created through a process called diffraction, which is caused by waves of light bouncing through tiny spaces and interfering with one another. The spots that are going up in the vertical direction are due to diffraction caused by the pixels, so we can use these spots to calculate their size. What you need to do now is measure two things, the distance between you and the wall (distance A), and the distance between two of the vertical spots (distance O). You may want to recruit some help for this and if the spots are too close for your ruler to measure, move back a bit, they will spread out. If you are confused, look at the amazing diagram below:



Now that you've got these, we need to go do some maths! William and Lawrence Bragg came up with this nifty equation and called it Bragg's Law:

$$n\lambda = 2d \sin(\theta)$$

Where λ is the wavelength of the laser (about 532 nm), d is the size of the spacing causing the diffraction (which is what we want to find out), and θ is the angle that the light bounced off to in order to create the spot we measured. You can also assume n = 1. We can find θ by using this equation:

$$\theta = \tan^{-1}\left(\frac{O}{A}\right)$$

Where O and A are the lengths you've measured. Now, putting this all together to get the following:

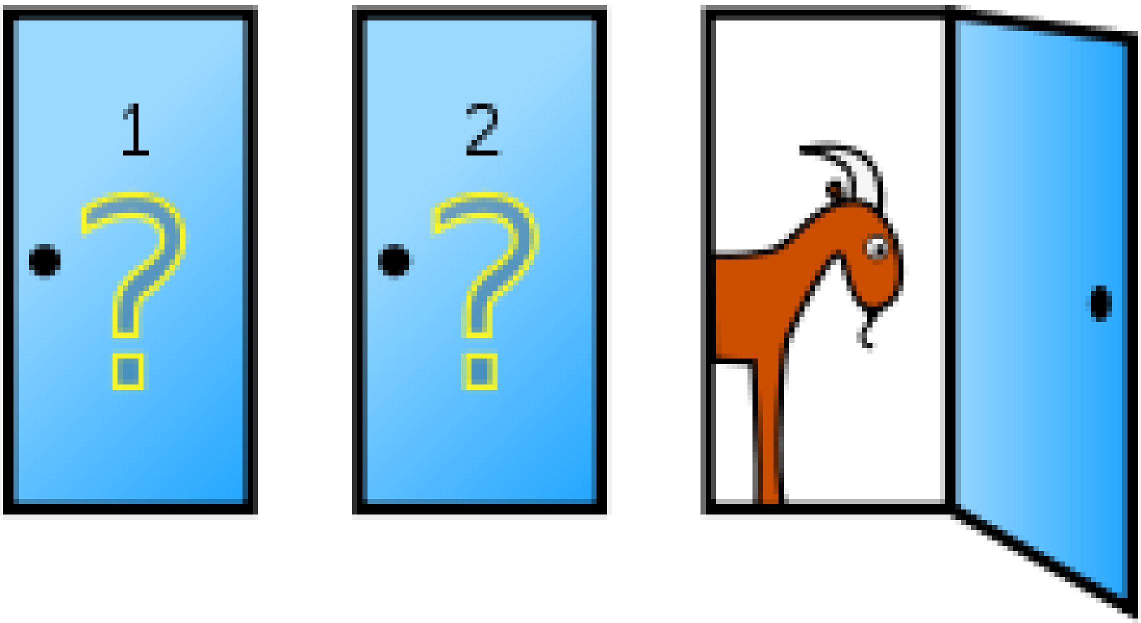
$$\frac{\lambda}{2\sin(\theta)} = d$$

Where d should now be approximately the size of the pixels in your phone! You can now calculate the resolution of your phone by measuring the size of your screen and figuring the amount of pixels/cm by dividing the length of your screen by the value you get for d (make sure they are both the same units of length!).

9 MONTY HALL PROBLEM

The most famous maths problem of all time! But do you know the answer?

Suppose you're on a game show, and you're given the choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice?



10 ONLINE SCIENCE

If you would prefer some fun online learning, then check out this fun website which combines Exciton Science's research into renewable energy and light technology with some good old-fashioned arcade game fun!

https://excitonscience.com/games?fbclid=IwAR0Rz70YbXwjHMYJC6iKqG52nxKHWkE9R1GHqJ2rVDtC9GhDOp2mbtWUbR0

11 MATHS PROBLEM SOLUTIONS

11.1 COIN PROBLEM

There are several ways to interpret this question, with vastly different answers.

One interpretation is to find the mean – essentially, is you were to perform the experiment infinitely many times, what would the average be? In this case, you have a ½ chance of earning $2, a ¼ chance of earning $4 and so on. The average is the sum of all these weighted probabilities:

$$Expected = \frac{1}{2}(2) + \frac{1}{4}(4) + \frac{1}{8}(8) + ... = 1 + 1 + 1 + ... = \infty$$

So, your average winnings should be infinite. However, your probability of winning an infinite amount is precisely 0, since you would have to toss infinite tails in a row. This measure doesn't seem particularly helpful.

Another option is to think about the single most likely outcome. You have a ½ chance of getting a mere $2; every other outcome is less likely. So, by this average (the mode) you will get $2.

11.2 MONTY HALL PROBLEM

Believe it or not, it's actually to your benefit to switch:

If you switch, you have roughly a 2/3 chance of winning the car. If you stick to your original choice you have roughly a 1/3 chance of winning the car.

The answer sounds unlikely. After door 3 is opened, you would think that you then have two doors to choose from…both with the same odds. However, you are actually much more likely to win if you switch.

Those who switched doors won about 2/3 of the time
Those who didn't switch won about 1/3 of the time

This fact has been proved over and over again with a plethora of mathematical simulations. If you're stumped and still don't believe it — don't worry, even mathematicians scratch their head on this one.

For a more in-depth explanation check out the Wikipedia article below!

https://en.wikipedia.org/wiki/Monty_Hall_problem#Solutions_using_conditional_probability_and_other_solutions