Materials for cleaner, quicker and low-cost ways to meet our energy needs?

Key Stage 4 Programme

Pupil Name	Name
Handbook Designed by	Dr Ali Hammad

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1	Monday 26th December	3:15 pm – 4:15 pm	Science Department, Ely College
2	Monday 3rd December	3:15 pm – 4:15 pm	Science Department, Ely College
3	Monday 10th December	3:15 pm – 4:15 pm	Science Department, Ely College
4	Monday 17th December	3:15 pm – 4:15 pm	Science Department, Ely College
5	Monday 7th January	3:15 pm – 4:15 pm	Science Department, Ely College
6 (Feedback)	Monday 14th January	3:15 pm – 4:15 pm	Science Department, Ely College
7 (Feedback)	Monday 21st January	3:15 pm – 4:15 pm	Science Department, Ely College

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Baseline Assignment	Monday 3rd December
Tutorial 2	Structural Properties of Ceramics	Monday 10th December
Tutorial 3	How polymers translate electrical energy	Monday 17th December
Tutorial 4	How ceramics convert kinetic energy	Monday 7th January
Tutorial 5	Final Assignment	Monday 14th January

Assignment Submission – Lateness and Plagiarism

Lateness

Submission after midnight on 9th August	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Uni Pathways – Pupil Feedback Report

Grade	Marks	Guidance
1st	70+	
2:1	60-69	
2:2	50-59	
3rd	40-49	
Working towards a pass	0-39	
Did not submit	DNS	No assignment received by the Brilliant Club

Lateness	
Any Lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor	Dr Ali Hammad		
Title of Assignment			
Name of Pupil			
Name of School	Ely College		
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 - *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 2 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Learning Feedback Comment 3 – *Enter Key Learning Priority Here*	
What you did in relation to this Key Learning Priority *Enter feedback here*	How you could improve in the future *Enter feedback here*
Resilience comment	
How you showed learning resilience during the course *Enter feedback here*	How you could build learning resilience in the future *Enter feedback here*

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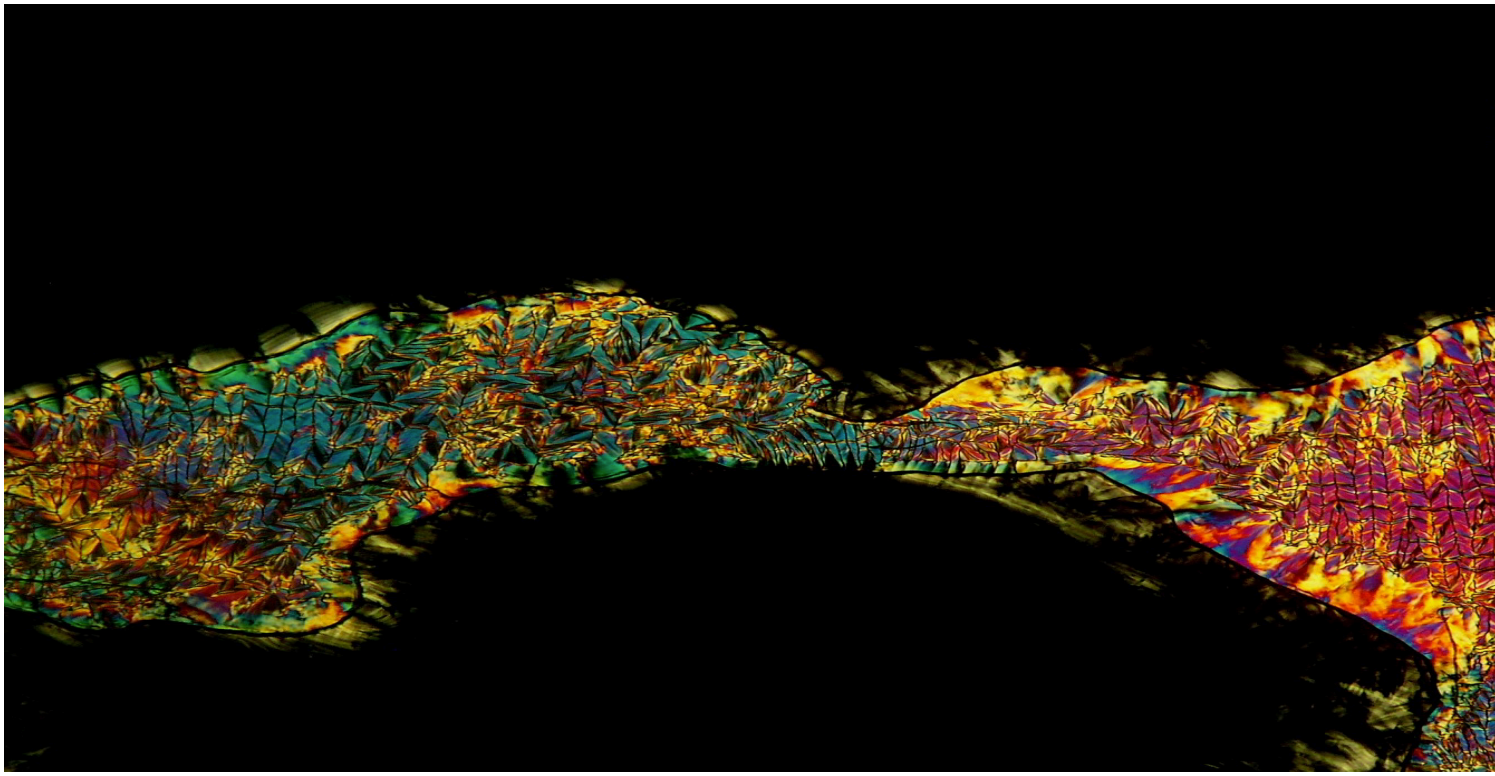
Course rationale

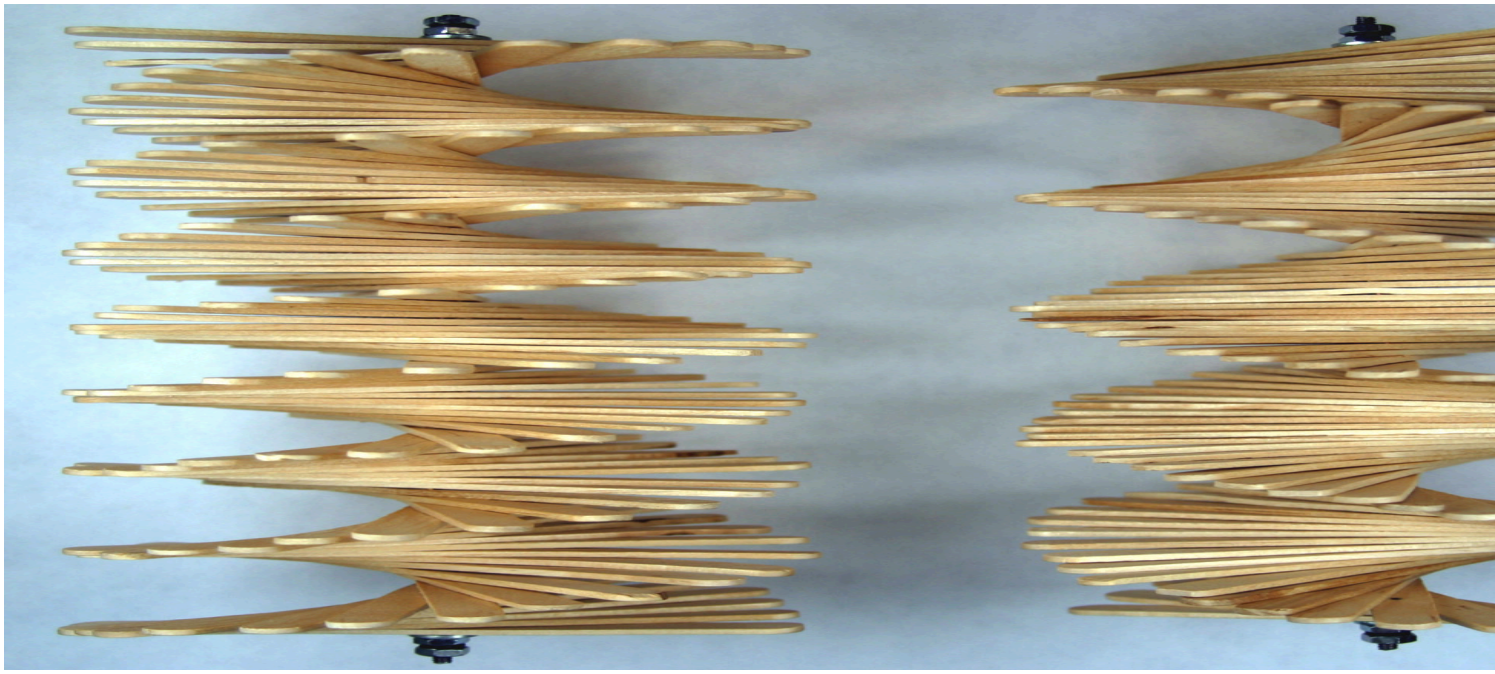
Sources of Energy: Light and Sound
Source: http://wwww.phoenixisrisen.co.uk/?p=7278

We know that energy requirements are growing but there is also a continued depletion of oil and natural gas reserves, concerns for the environment, and increased reliance on nuclear power to solve future energy problems. In this course, you will explore the potential of materials for resolving our energy problems to timely respond to our energy needs. During Uni Pathways, we will use different techniques to understand how electrical energy at the macro-scale (organic compound) where molecules move independently, and kinetic energy at nano-scale (inorganic compound) where they remain somewhat organised, transforms into crystalline materials. The crystalline materials are represented by liquid crystal an intermediate state between the crystalline at low temperatures and the ordinary liquid state at high temperatures. The resulting combination of liquid and solid in materials could hold the potential for energy conversion, transmission and storage as well as its cleaner, quicker and low-cost use.

In this course, you will explore how liquid crystals respond to temperature (thermotropic) as semiconductors. You will use temperature to see how liquid crystal changes its colour from red to orange, yellow, green, blue and purple showing its structure as made up of mixtures of long, thin molecules stacked in rotating layers, like a spiral staircase (helix). You will also learn that when light strikes a liquid crystal, some of it is reflected depending on high tightly twisted the helix is, the more tightly twisted helixes (see model on the left) reflect wavelengths on the blue end of the spectrum, and the more loosely twisted helixes (see model on the right) reflect wavelengths on the red end. You will also observe how changes in temperature impact the spacing of helix and the wavelength of light reflected and detected by the colour change.



Liquid crystals
Source: http://wwww.nisenet.org/catalog/exploring-materials-liquid-crystals



Spiral staircase helix
Source: http://www.nisenet.org/catalog/exploring-materials-liquid-crystals

In your final assignment you will use temperature to detect the chemical and physical changes in materials such as polymers and ceramics to model new ways of conserving energy. You will write a scientific report on your findings with references which will be preceded by a submission of an abstract and a group presentation. This will enable you to develop modelling and presentational skills in a collaborative way at the

university level to help you progress in your education, and in becoming scientists.

Overall objectives

- To learn about light energy in materials at macro-scale (organic compound)
- To learn about kinetic energy at nano-scale (inorganic compound)
- To learn about how liquid crystals can contribute to renewable energy
- To model polymers and present findings in a scientific way

Mark scheme

STEM Mark scheme

Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Knowledge and Understanding	• All content included is relevant to the general topic and to the specific question/title • Good understanding of all the relevant topics • Scientific terms are defined and used accurately throughout • Clear justification on how the content included is related to the specific issues that are the focus of the assignment.	• Most of the content included is relevant to the general topic and to the specific question/title • Good understanding of most the relevant topics • Scientific terms are used accurately but not always clearly defined. • Adequate justification on how the content included is related to the specific issues that are the focus of the assignment.	• Some of the content included is relevant to the general topic and to the specific question/title • Good understanding on some of the relevant topics but occasional confusion on others. • Scientific terms are used mostly accurately with occasional confusion and often not defined. • Some justification on how the content included is related to the specific issues that are the focus of the assignment.

Critical Evaluation/ Problem solving	• Moved beyond description to an assessment of the value or significance of what is described • Evaluative points are consistently explicit/systematic/reasoned/justified. • Effective critiques on the reliability of sources provided • Consistently demonstrate clear, analytical and logical steps to solving problems	• Mostly description but some assessment of the value or significance of what is being described • Evaluative points are mostly explicit/systematic/reasoned/justified • Some evidence of critiques on the reliability of sources provided • Some examples of solving problems but not consistently clear, analytical and logical	• Only description with minimal assessment of the value or significance of what is described • Evaluative points are at times explicit/systematic/reasoned/justified • Limited evidence of critiques on the reliability of sources provided • Demonstrate clear steps to solving problems but not consistently analytical or logical

Structure and Presentation	• Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment • The introduction clearly outlines how the essay/report will deal with the issues • The conclusion summarises all the main points clearly and concisely • All calculations formulas and methods are clearly structured, clear to follow and correct • Tables and graphs are effectively constructed including appropriate headings, units and scales • All sources are referenced correctly in an agreed	• Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment • The introduction adequately describes how the essay/report will deal with the issues • The conclusion summarises most of the main points clearly • Calculations, formulas and methods are mostly structured, clear to follow and correct • Most tables and graphs are well constructed • Most sources are referenced correctly in an agreed format	• Ideas are presented in paragraphs and arranged in a structure • The introduction mentions how the essay/report will deal with the issues • The conclusion summarises some of the main points clearly • Calculations, formulas and methods are not always structured, clear to follow and correct. • Some tables and graphs are well constructed but contain some errors • Some sources are referenced correctly in the agreed format with occasional errors.

	format		

Subject vocabulary

Word	Definition	In a sentence
Energy	In Physics, energy is the capacity for doing work. It may exist in potential, kinetic, thermal, electrical, chemical, nuclear and other various forms	Heat transfers work from one body to another to designate energy according to its nature.
Light Energy	Light energy is the only form of energy that can be seen directly. It is emitted by hot objects like lasers, bulbs and the sun.	Light is formed through chemical, radiation and mechanical means, and which can be converted to other forms of energy
Sound Energy	Sound energy is a form of energy that is associated with the vibration of matter	Sound is a mechanical wave and as such consists physically in oscillatory and elastic compression and in oscillatory displacement of a fluid. Therefore, the medium acts as a storage for both potential and kinetic energy.
Materials	Materials can be classified based on different properties such as physical and chemical properties.	In the physical sense, materials are studied in the field of materials sciences.
Polymer	From Greek poly (many) and meros (parts). A large molecule composed of many repeated subunits.	Polymers are long chain molecules that are made from many repetitions of a smaller subunit, called a monomer.
Atom	The smallest constituent of ordinary matter that has the property of a chemical element.	The atom is an indivisible unit of chemical property.
Chemical bond	The interaction between atoms, ions and molecules that enables	The connecting bonds that hold atoms, molecules and ions

	the formation of chemical compounds	together through a shared region
Molecule	An electrically neutral group of two or more atoms held together by chemical bonds	A group of atoms connected together by chemical bonds
Monomer	From the Greek mono (one) and meros (parts). A molecule that can undergo polymerisation thereby contributing constitutional units to the essential structure of a macromolecule	A molecule that can react in a polyfunctional way such that it can create a long chain (macromolecule or polymer).
Ceramics	A ceramic is a non-metallic solid material comprising of an inorganic compound of metal and non-metal atoms primarily held in ionic and covalent bonds.	Ceramics is characterized by diversity. It is a class of materials broadly defined as inorganic, non-metallic solids. Serve as dielectric resonators to store and transfer communication signals.
Liquid crystals	Liquid crystal is a substance that blends the structures and properties of the normally disparate liquid and crystalline solid states.	Liquids can flow, for example, while solids cannot, and crystalline solids possess special symmetry properties that liquids lack.

Knowledge Organiser

Important ideas and vocabulary	
Renewable Energy	Energy from sources that can be replenished on a human timescale
Conservation of Energy	Energy experiences conversion, transmission and storage
Semiconductor	Solid substance that has conductivity that is between a conductor and an insulator
Helix	A smooth curve where the tangent at any point makes a constant angle with fixed line
Thermotropic	The order of components is changed by temperature
Nanoscale	The length-scale that is applicable to nanotechnology (between 10^{-7}m and 10^{-9}m)
Macroscale	The length-scale where phenomena are observable without magnification

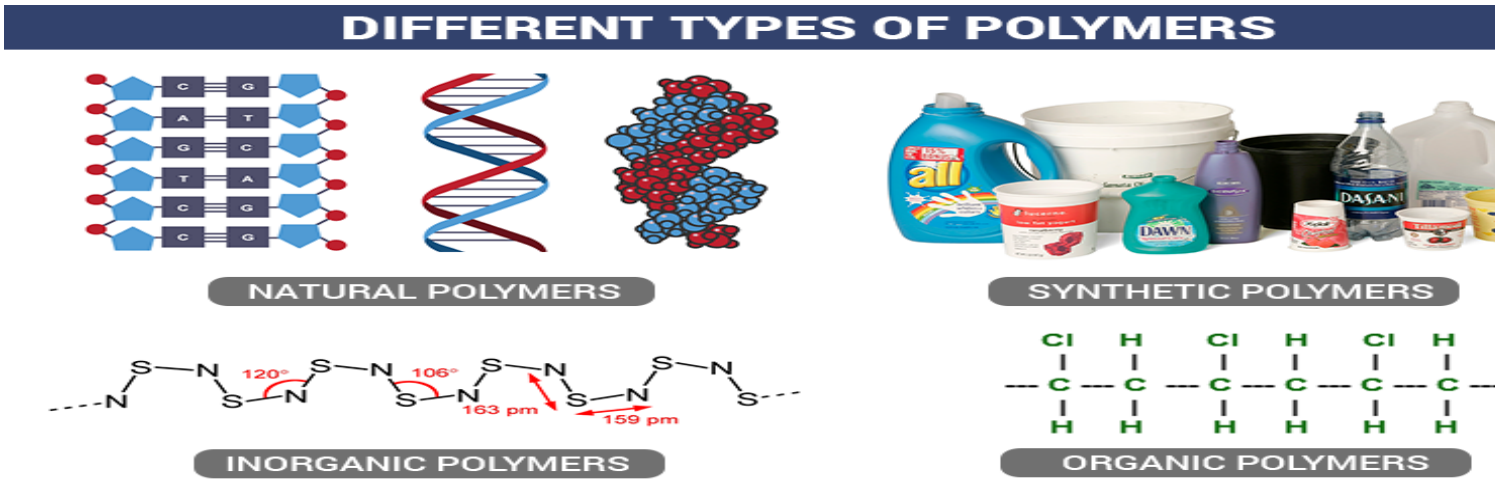
Types of polymer	Chemical formula
Polyethylene (PE)	$(C_2H_4)_n$
Polystyrene (PS)	$(C_8H_8)_n$
Nylon	$(C_{12}H_{22}O_2)_n$
Polypropylene (PP)	$(C_3H_6)_n$
Polytetrafluoroethylene (PTFE)	$(C_2F_4)_n$

Baseline assignment: How can we know if temperature is bringing about changes in the material?

1. What is temperature?
2. How can temperature be measured?
3. What are the different scales that are used to measure temperature?
4. Which of these scales is used in the International System of Units (SI)?
5. Can you keep cooling a material indefinitely?
6. How do polymers respond to temperature? When cooled down and when heated up?
7. How can the change in behaviour of a material under temperature be measured?
8. (*) How can temperature be described on a microscopic scale (in terms of molecules)?
9. (*) What is the relationship between temperature and energy? Can this be described with a mathematical law?

Tutorial 1

What are the mechanical properties of polymers



Purpose: To provide an overview of different types of polymers

Objectives:

1. To learn about the mechanical properties of material such as polymers
2. To learn about how polymers form and translate
3. To learn about how polymers translate into light energy
4. To explore if polymers can provide renewable energy

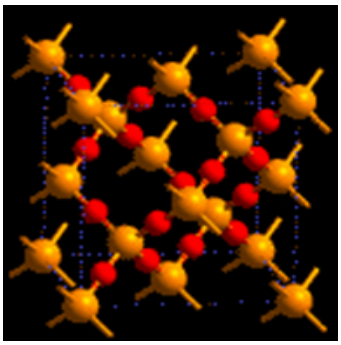
Activities:

1. Group discussion on the meaning of 'triplet' and its involvement in energy transfer in polymers? (polyethylene, DNA)
2. Group activity using a kit or clay to model polymers to observe how they respond to changes in their attributes and properties
3. Group discussion and writing on polymers to build consensus

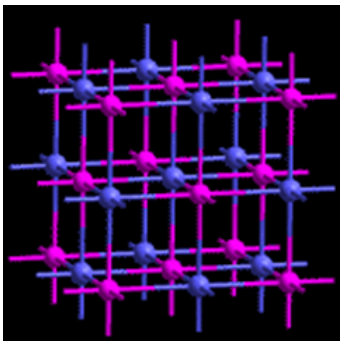
Source: https://www.ncbi.nlm.nih.gov/pubmed/16852213

Tutorial 2

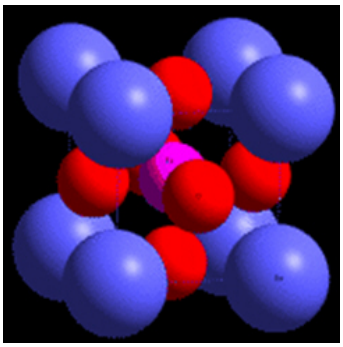
What are the structural properties of ceramics?



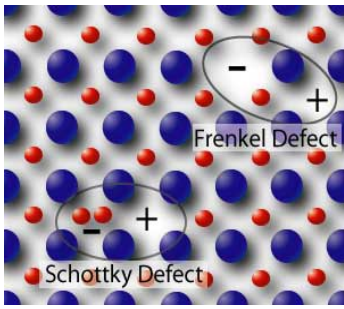
Silica structure



Nitride ceramics



Ferroelectric ceramics



Imperfections

Purpose: To learn about the mechanical properties of material such as polymers

Objectives:

1. To learn about structural properties of ceramics
2. To learn about how ceramics are shaped through vibration of matter
3. To learn about the conversion of ceramics into sound energy
4. To explore if ceramics can provide renewable energy

Activities:

1. Group discussion on 3D printing on it relates to the coating of a substance by ceramic glaze.
2. Group activity to identify the most important structural clay tile in construction
   Example article below:

"Back of Every NATCO Home You Build"

FOR over thirty years NATCO HOLLOW TILE has been used in the construction of skyscrapers, industrial buildings of all kinds, housing projects, churches, schools, as well as attractive homes of every type and size. On the modern farm NATCO HOLLOW TILE is being used more and more every year.

The same satisfactory qualities that make NATCO HOLLOW TILE the choice of so many discriminating architects, engineers and contractors all over the country are in the NATCO HOLLOW TILE you use in your clients' homes.

NATCO homes are permanent — yet economical. They resist heat and cold — are cool and pleasant in summer — warm and comfortable in winter. You save your clients unending expense for paint and repairs and reduce general depreciation to a minimum.

NATCO HOLLOW TILE comes in large units that are quickly, easily and economically laid. One tile takes the place of from eight to twelve common brick. When the air cells of the tile are sealed up in the finished wall, you have a home that is proof against dampness and extremes of temperature. Being of burned clay, NATCO HOLLOW TILE resists fire and is practically everlasting.

Architects should write for a copy of our new book on NATCO HOMES. It shows some mighty attractive moderate priced homes, with descriptions and floor plans.

NATIONAL·FIRE·PROOFING
·COMPANY·

901 Federal Street - Pittsburgh, Pa.

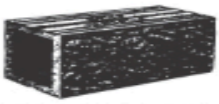
NATCO HOLLOW TILE

NATCO XXX TILE FOR A STUCCO FINISHED HOME

NATCO DOUBLE SHELL TILE FINISHED FACE, ROUGH IN TEXTURE-GLAZED OR UNGLAZED

NATCO DRAIN TILE FOR DRAINING LOW LANDS

NATCO BACKUP TILE USED WITH VENEER OF FACE BRICK



NATCO GLAZED BUILDING BLOCK ROCKFACED, FOR FOUNDATIONS AND BUILDINGS

Tutorial 3

How polymers translate into electric energy?

Purpose: To provide an overview of how polymers translate electric energy

Objectives:

1. To learn about electric energy systems
2. Learn about polymerization in the electric energy
3. Learn how the transmission system carry power from the generating centres to the load centres
4. Learn about how polymers affect the distribution of transmission system to provide power to homes and industries.

Activities:

1. Group discussion on piezoelectric material and how it can produce electricity
2. Group activity to build a solar cell that produces energy from light

Tutorial 4

How ceramics convert kinetic energy?

Purpose: To provide an overview of how ceramics convert kinetic energy

Objectives:

1. Learn about kinetic energy systems
2. Learn about metalisation of ceramics based on kinetic energy
3. Learn about conversion, storage and distribution of energy
4. Analyse how polymers and ceramics can be combined for renewable energy.

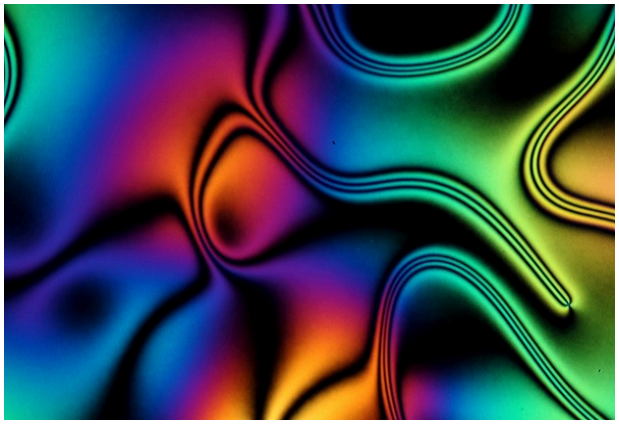
Activities:

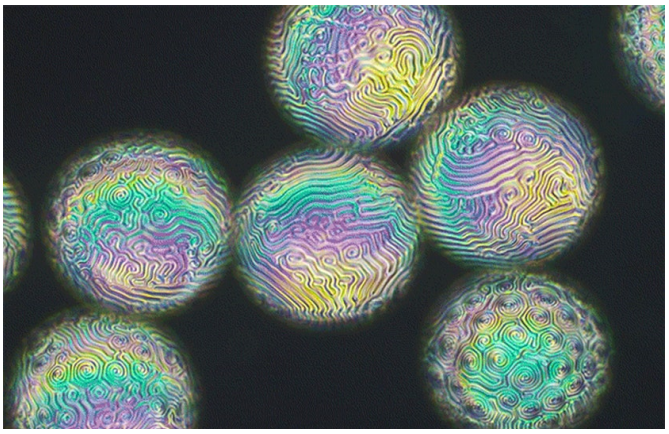
- Group discussion on how kinetics be used to generate a ceramic coating
- Group activity on the applications of ceramic in microelectronics design and fabrication

Source: https://www.sciencedaily.com/releases/2017/02/170221151317.htm

Tutorial 5

Liquid crystals: enabling the flow of electric and kinetic energy systems?





Polarization microscope image of. Liquid crystals.

Dancing liquid crystals droplets in Soapy water

Source:

https://news.science360.gov/pic-day

https://cosmomagazine.com/physics/dancing-liquid-crystals

Purpose: To provide an overview of liquid crystals as intermediary material in electric and kinetic energy systems

Objectives:

1. To learn about liquid crystals as going with the flow material
2. To learn about how liquid crystals combine polymers and ceramics
3. To learn about the practical developments in liquid crystals
4. To model liquid crystals for renewable energy

Activity: Watch footage of liquid crystal
https://www.youtube.com/watch?v=DL1uRjH_gWM
Discuss spontaneous changes in liquid crystals and potential applications in display technology.
Source https://www.phy.cam.ac.uk/research/research-groups/tcm/soft

Final assignment

Use temperature to detect the chemical and physical changes in materials such as polymers and ceramics to model new ways of conserving energy?

1. How is temperature related to kinetic energy of the atoms and molecules in the material?
2. How can temperature be used to change the movement in the material?
3. What is meant by a physical change and what is meant by a chemical change?
4. Can temperature change the physical state of the material? Give examples to explain
5. Can temperature change the chemical state of the material? Give examples to explain
6. How do polymers and ceramics respond to temperature? Upon heating and cooling?
7. Which one of the polymers and ceramics is more resistant to changes in temperature?
8. What is a thermotropic material?
9. How does a liquid crystal respond to temperature? Upon heating and upon cooling?
10. What happens to the emission of light by a liquid crystal as the temperature changes?

Tutorial 6 – Feedback Tutorial

What is the purpose of Tutorial 6?

1. To receive feedback on final assignments.
2. To share examples of best practice with the other pupils in your group.
3. To write targets for improvement in school lessons.
4. To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well	What I could have improved on
•	•
•	•
•	•

My target for future work is….

Tutorial 7 – Feedback Tutorial

What is the purpose of Tutorial 6

1. To receive feedback on final assignments.
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Final assignment feedback

What I did well	What I could have improved on
•	•
•	•
•	•

My target for future work is….

Reflecting on Uni Pathways

What did you enjoy most about Uni Pathways?
• • •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism

When should I use a reference?

You should use a reference when you:

- Quote directly from another piece of work
- Summarise or rephrase another piece of work
- Include a specific statistic or fact from a source

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment:** After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography:** This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. Websites – Author(if possible), title of the web page, website address, [date you accessed it, in square brackets:

    E.g. Dan Snow, 'How did so many soldiers survive the trences?'

    http://bbc.co.uk/guides/z3kgjxs#zg2dtfr[11 July 2014]

    b. Books – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. Articles – Author, 'title of the article' (with quotation marks), where the article comes from (newspaper, journal etc.) date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to makr the First World War's centenary', Guardian, 10 July 2014.

Notes

Notes

Notes

Course Title

Key Stage 4 Programme

researchersinschools.org