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Streetlight Modelling

Age group: 10-15

Topics: electric circuits, physics, light pollution, streetlights and shielding

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Street light modelling:

Modelling different shielding and their effects on the visibility of artificial stars with an easy electric circuit and measurement setup

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Lesson Plan Title: Modelling Streetlights	
Duration: 45 minutes	
Short Description of the Lesson	Students will gain an understanding of simple circuits used to light a small lamp. Students will measure the illumination of the lamp and design and make a light shield, then determine if the light shielding has reduced the electrical usage of the lamp.
Learning Goals	• Design and use a simple electrical circuit • Measure current, voltage and illumination • Calculate power • Design and make a light shield • Analyse data to determine if the light shield has saved power
Green Competences Linked	1.2: Supporting Fairness: A1 - Is committed to decreasing material consumption. 3.2: Adaptability: S3 - Can take into account local circumstances when dealing with sustainability issues and opportunities.
Target Group	Primary school students aged 10-12 years old. Second level students age 13-15
Educational Approach	Inquiry based learning
Link to School Curricula	Ireland: Primary SESE: Science Content Objective(s) / Learning Outcome(s): Energy and Forces > Magnetism and electricity - investigate current electricity by constructing simple circuits Environmental Awareness and Care > Science and the environment - recognise and investigate aspects of human activities that may have positive or adverse effects on environments > Environmental awareness - foster an appreciation of the ways in which people use the Earth's resources - come to appreciate the need to conserve resources Junior Cycle Science: E&S 7: illustrate how … human factors influence Earth's climate, evaluate effects of climate change and initiatives that attempt to address those effects. PW 2: … measure … potential difference, current, ... electrical power PW 4: Students should be able to research and discuss a technological application of physics in terms of scientific, societal and environmental impact

	PW 7: design, build, and test a device that transforms energy from one form to another in order to perform a function; describe the energy changes and ways of improving efficiency
Facility/ Equipment	• Classroom, with lights that are capable of being dimmed or turned off. If the room is bright, then a large cardboard box will be needed for the activity to be carried out in the dark
Tools/ Materials	• Low voltage lamp, mounted on a pole, representing a streetlight • Battery (to match voltage of lamp) • Variable resistor • Cables • Multimeter or Ammeter and Voltmeter • Lightmeter or Phone App to measure light intensity. Suitable phone apps include Lux Light Meter Free from Doggo Apps (Android). • Variety of scrap materials to create light shields, cardboard, paper, foil, tissue etc. • Scissors • Masking tape
Main Tasks **45 minutes**	**Task 1: Introduction to Light Pollution** **Task 2: Set up electrical circuit and make initial measurements** **Task 3: Design and Make light shield** **Task 4: Determine if light shield has reduced energy demand**
Extracurricular Activities	

Introduction

Energy efficient LEDs are advised to reduce energy costs in the home. But what about shielding your lights? Would that make a difference to how much power is used by a light?

Students will measure illumination provided by a model streetlight, measure the power used by the light, then design and make a full cut-off lamp shield that still provides the same illumination on the ground. Students will then measure the power used to provide that illumination and can calculate the energy savings.

1) Positive Examples of Cities changing their streetlights

Street light upgrade

Led by Cork County Council, PLEEP South West will upgrade 77,162 public lights across the region's local authorities, Cork County Council, Clare County Council, Kerry County Council, Limerick City & County Council and Waterford City & County Council, as well as Transport Infrastructure Ireland.

Benefits

Part of a National Public Lighting Energy Efficiency Project, twenty-one local authorities will collaborate in the upgrading of approximately 220,000 public lights to LED. Once complete, the project is set to reduce CO2 emissions by 22,000 tonnes each year, while saving the local authorities €12m in energy and maintenance costs annually.

See:

https://www.corkcoco.ie/en/news/cork-county-council-leads-eu53-million-public-lighting-energy-efficiency-project-for-the-south-west

Street light upgrade

The Council has secured a £11.5 million loan from The Mayor of London's Energy Efficiency Fund (MEEF) to replace all its 20,000 traditional streetlights with modern LED equivalents – saving £1million a year in energy and maintenance costs.

Benefits

We will save 6,770,589 kWh per year, reducing our street lighting energy consumption by 74 per cent and saving around £1million

We will reduce our CO2 consumption by 2,080 tonnes per year - the equivalent of driving a medium sized car from Greenwich to Edinburgh and back 9,000 times.

See:

https://www.royalgreenwich.gov.uk/info/200258/parking_transport_and_streets/2299/street_light_upgrade

2) Modelling Setup:

Per group of 4 students:

- Low voltage lamp, mounted on a pole, representing a streetlight
  Battery (to match voltage of lamp)
  Variable resistor
  Cables
  Multimeter or Ammeter and Voltmeter

- Lightmeter or Phone App to measure light intensity. Suitable phone apps include: Lux Light Meter Free from Doggo Apps (Android).

- Variety of scrap materials to create light shields, cardboard, paper, foil, tissue etc.
  Scissors
  Masking tape

- Optional: “star box” created from a small box, covered with punctured foil, with a light source concealed inside.

Prior Knowledge

Power Equation: Power= Current*Voltage – this can be provided for younger students.

Use of multimeters, or ammeters and voltmeters

Simple circuits with variable resistors

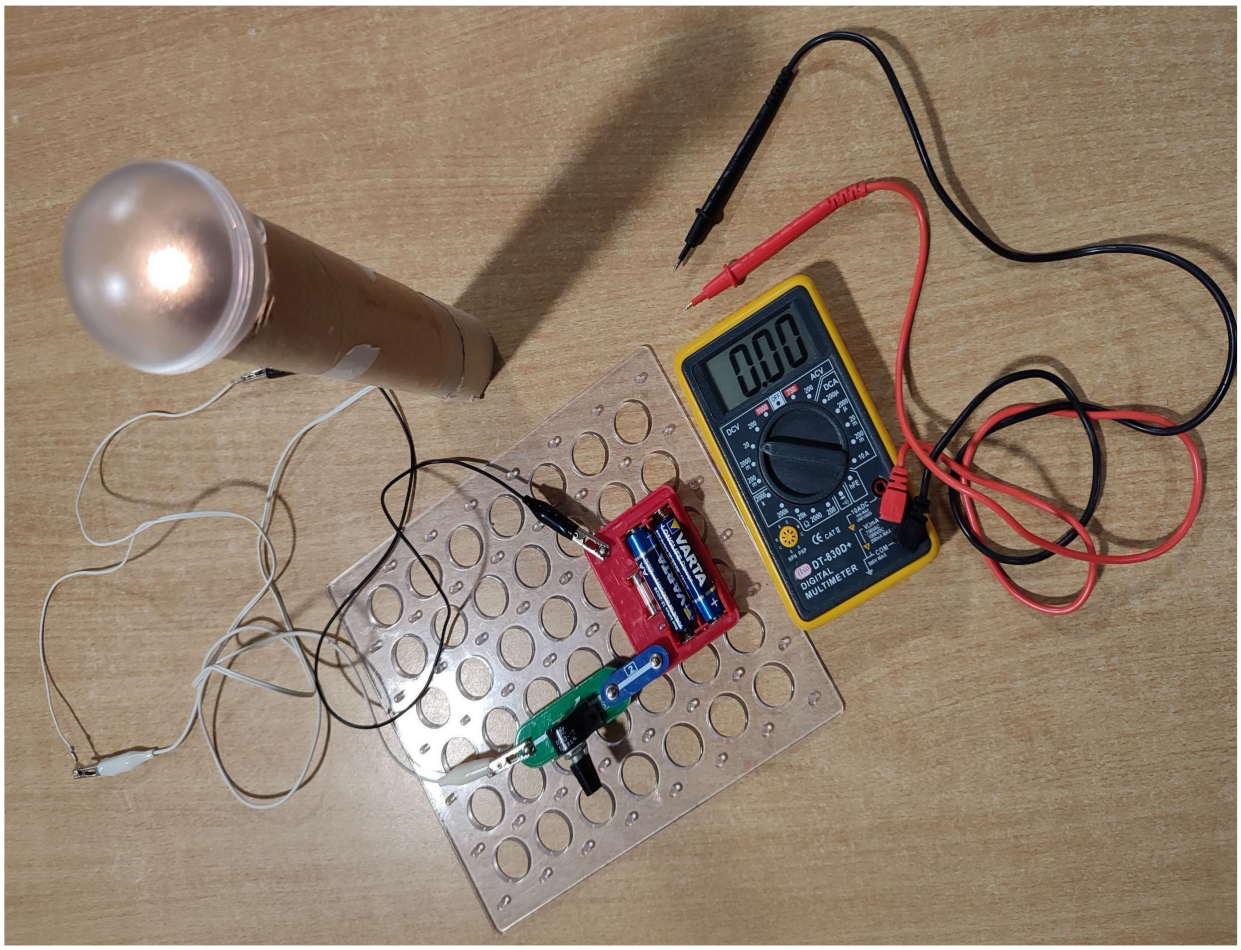
3) Experimental procedure and measurement

- Set up a model streetlight, using a lamp mounted on a pole. In this example a 2.5 V lamp is mounted on the cardboard tube from the centre of a wrapping paper roll.

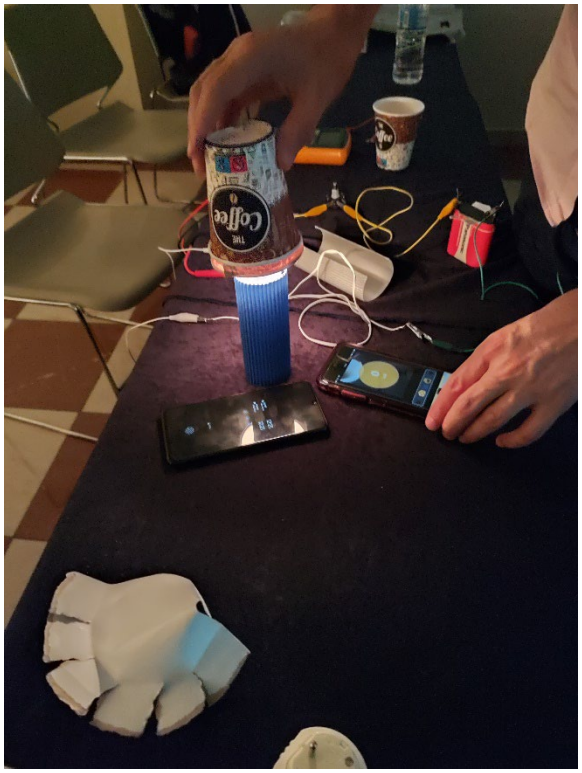
- Include a variable resistor in the circuit, so that you can adjust the brightness of the lamp.

- Measure the illumination on the ground with a lux-meter phone app, or a light meter. This will work best if the lamp is in a shaded place, with no other sources of light (use a big cardboard box if you need to).

- Measure the current and voltage supplied to the lamp and calculate the power used.



4) Investigate the effect of a shield



Modify the lamp's light spill by designing and making a lamp cover. Can you still direct light to the ground where it is needed?

There must be at least the same illumination on the ground, if there is more, then you can use the variable resistor to reduce the current in the circuit.

What power does the lamp now use? Measure current and voltage and calculate the power required.

Evaluate if your light shield solution would save energy if implemented on streetlights in your area.

5) Making a 'star box' to determine the visibility difference of stars

- Make a star box (foil with holes, with a light source inside)
- Compare how many "stars" can be seen with / without the light shield.