

Led torch or spotlight

Guide for teachers

Introduction

For this activity, the role of the teacher is to support the students in their work. It means teachers must lead the students and give advices if students are not able to continue with the activity. The teacher cannot forget the following requirements: students have to solve the problems, which arise developing the project; take decisions; search for information; use knowledge they studied and learn new knowledge they need.

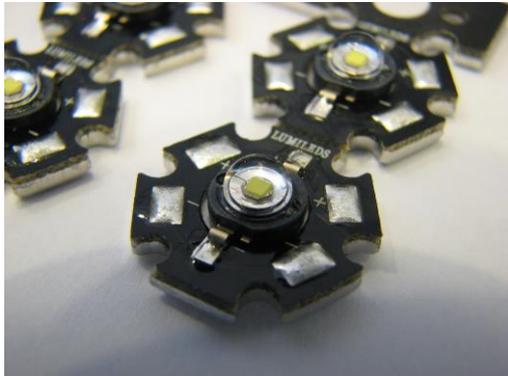
The project is divided in "steps". Students will receive information about their work in each step when they finish their task from the previous step.

1. First step. What students want to do?

The final objective of this project is to design and make a torch or a spotlight for a concrete use.

The students will use a 3w Led. They must decide the use of their torch or spotlight. They can use an ultraviolet led or not. They have two possibilities for the reflection surface: paraboloid or truncated pyramid.

They must take decisions during the activity development, for example, the led they will use, the reflection surface and the dimensions of their torch or spotlight. This project also contains some inquiry tasks such as searching for examples of torch applications, reflection surfaces, and cases to protect the internal components of their torch or spotlight.



3w led. Hexagonal¹



3w led. Ultraviolet (uv)



Black light



Black light



Black light



Black light

¹ Source of images and drawings: author or Wikimedia Commons



Torch. Paraboloid



Torch. Paraboloid



Spotlight. Truncated pyramid



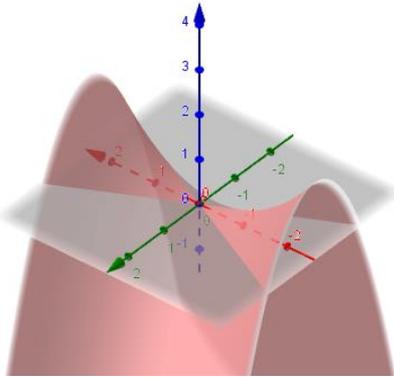
Spotlight. Truncated pyramid

2. Second step. Theoretical background

Students took a decision about the reflection surface: paraboloid or truncated pyramid. In this step, they have to apply their knowledge about these shapes, learn new knowledge, take decisions and solve problems.

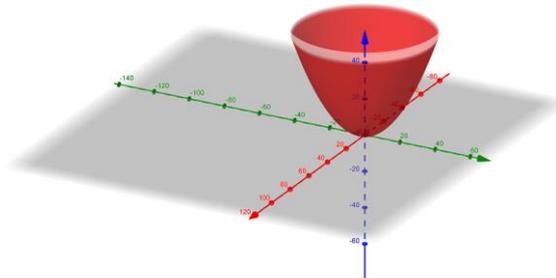
a) Paraboloid

A paraboloid is a quadric surface and it has a cartesian equation. There are two kinds of paraboloids: hyperbolical and elliptical.



Hyperbolic paraboloid

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} - z = 0$$



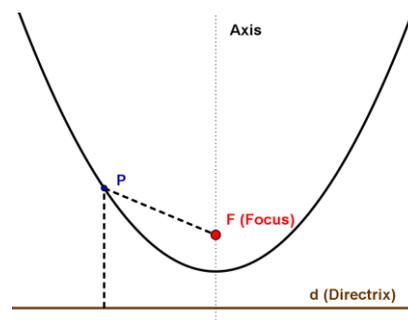
Elliptic paraboloid

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - z = 0$$

For torches and spotlights are used elliptical paraboloids obtained as the surface revolution of a parabola. A parabola is one of the conics section and, at same time, the graph of a polynomial second grade power function. So, students have to learn about the relation between the quadric equation of a parabola (locus equation), the function equation of a parabola and the quadric equation of a revolution elliptical paraboloid.

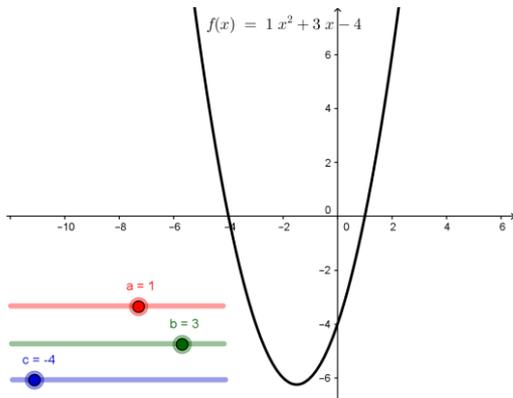


Parabola. Conic section



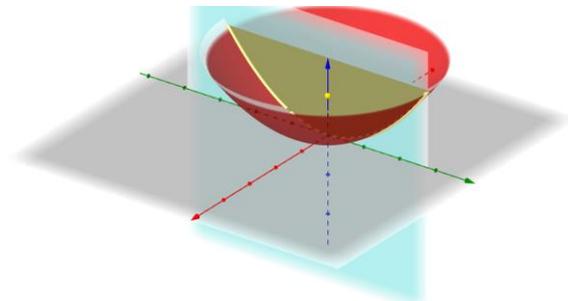
Parabola. Locus.

$$d(P,F)=d(P,d)$$



Parabola. Graph of a function

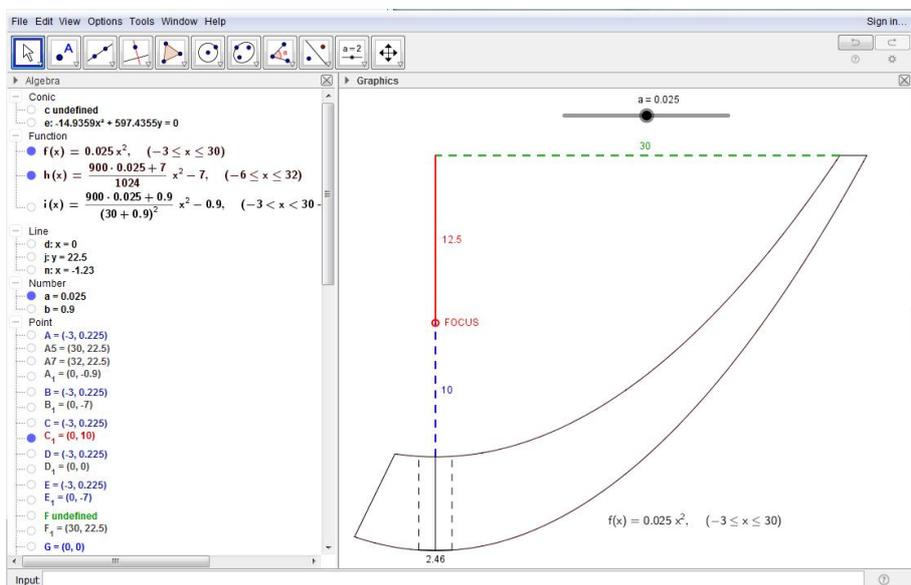
$$f(x) = ax^2 + bx + c$$



Paraboloid.

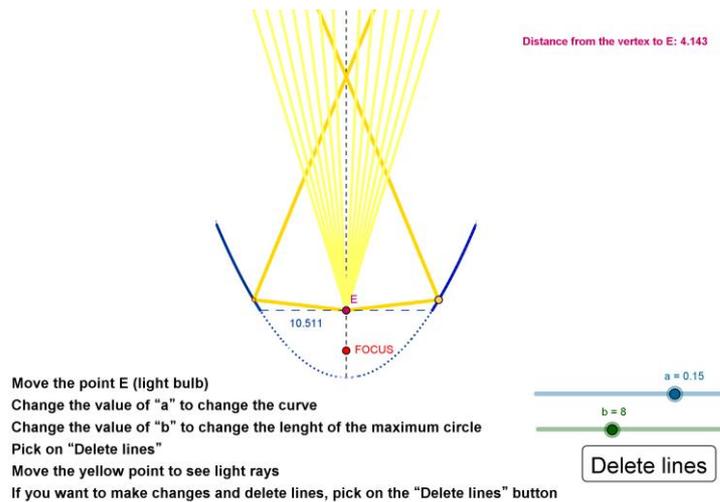
Surface revolution of a parabola

The students will receive a Geogebra file (template_parabola_curve.ggb) which could use to print a template and therefore obtain the reflection surface. The template allows them to get the parabola. They obtain the ellipsoidal paraboloid turning the parabola around the axis. Using this GeoGebra file, they can decide the size, the focus location and the curve form. They must explain the process used to get that GeoGebra file.



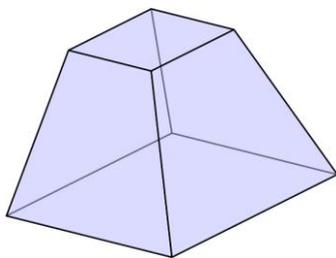
Then, they will use another GeoGebra file. In this file, they can “model” a parabola used like a light reflector (parabola_light_reflection.ggb). They can change the focus situation and the curve form. When they decide their parabola form and, therefore,

their paraboloid form, they can print the template (using the file `template_parabola_curve.ggb`).

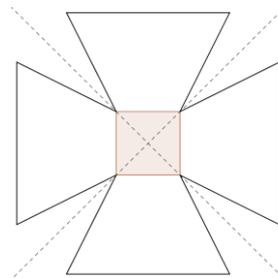


b) Truncated pyramid

A truncated pyramid (or pyramidal frustum) is the polyhedron obtained cutting a pyramid. To make one, we could use the truncated pyramid development.



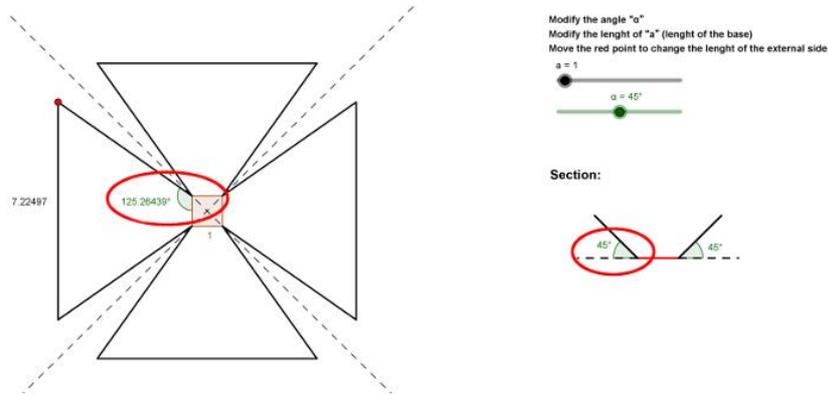
Truncated pyramid



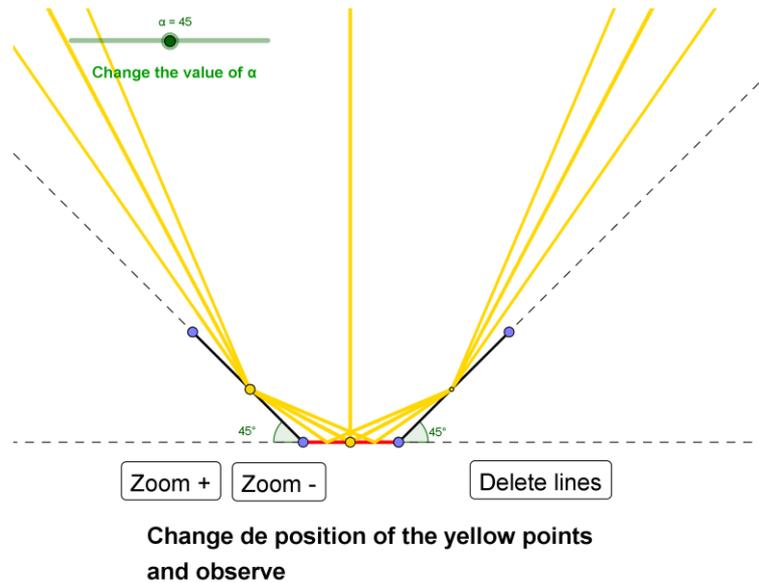
Plain development of a truncated square pyramid

Students will receive a GeoGebra file (`plain_develop_truncated_pyramid.ggb`) to print the truncated square pyramid development. They can change the inclination angle of the faces and, base and top side lengths.

The internal angle of a face was obtained through a calculation with the inclination angle. Students have to explain the relation between the internal angle of a face and the inclination angle, that is, explain the expression introduced in GeoGebra.



Then, they will use other GeoGebra file:truncated_pyramid_light_reflection.ggb. In this file, they can “model” a truncated square pyramid used like a light reflector. They can change the inclination angle of the shapes to observe the influence on the reflected light rays. They have to decide the inclination angle and, top and side lengths of their truncated pyramid.



If they want to use a rectangle-truncated pyramid (not a square truncated pyramid), they have to modify the GeoGebra file.

When students have answered the question and they have taken the decisions, they can print the template.

3. Third step. Making the reflection surface and mounting the led

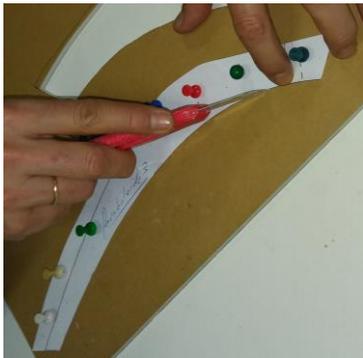
i) Making the reflection surface

a) Paraboloid. Making the reflection surface

In this step, students have to decide the material and the system they will use to make a paraboloid. They can use the template obtained in the previous step to generate the paraboloid rotating the curve around the axis of the parabola. Alternatively, they can use other system, for example, generating a 3D model based on the parabola and printing the model to 3D printer.

The system for obtaining a paraboloid by rotating a parabola is simple but they have to solve several practical problems and decide what materials they will use.

Examples:



Cutting the curve (using foam board)



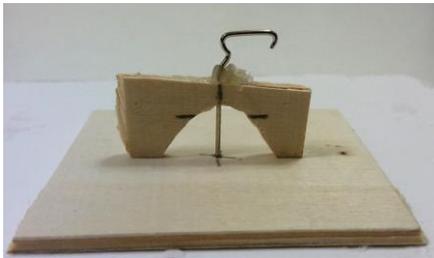
Mould. Internal structure



Mould. First step (cement adhesive)



Mould. Second step (Big. 30 cm. Aguaplast)



Small curve (2 cm)



Small mould made with plaster (2 cm)

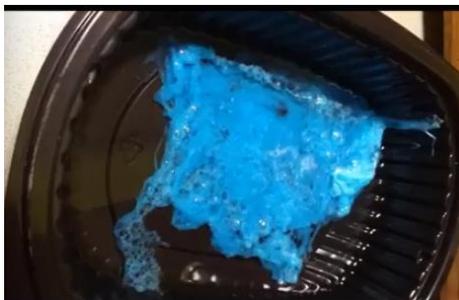


PVC



Fiberglass

To build the model, they can use the materials illustrated in the examples included above but it is easy to do a small paraboloid using the mould with a thermofusible plastics or, for example, polystyrene dissolved in acetone.



Polystyrene dissolved in acetone



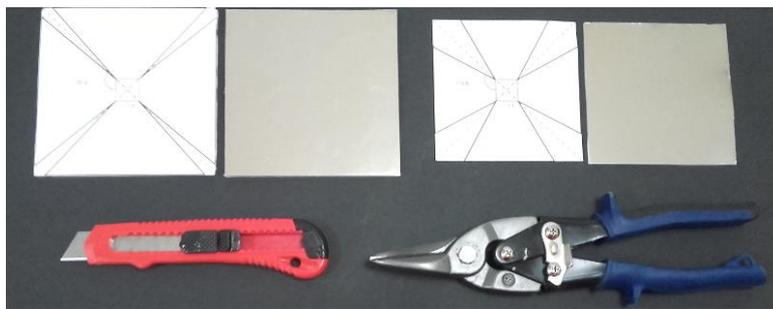
Using a heat gun to bend and shape a plastic

Students have to obtain a reflection surface. They can use a spray or a chrome kit or search for other system.

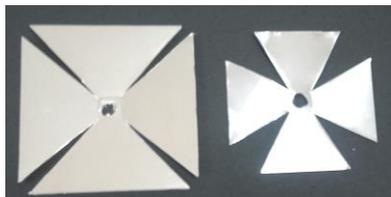
i) Making the reflection surface

a) Truncated pyramid. Making the reflection surface

In this step, students have to make a truncated pyramid from the template they can print using the GeoGebra file `plain_develop_truncated_pyramid.ggb`. They have to decide what is the material they want to use, cut it and fold and paste the faces of the pyramid.



Right: foam board and mirror coated paper Left: metal



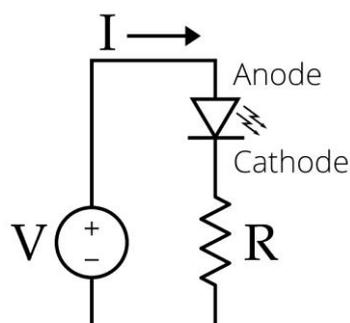
*Right: foam board and mirror coated paper
Left: metal*



*Right: foam board and mirror coated paper
Left: metal*

ii) Mounting the led

A led (or light-emitting diode) is a two-lead semiconductor light source. A led is a diode and, therefore, it has two terminals: the positive side (the anode), and the negative one (the cathode). It needs a voltage source to work.



Basic scheme of a led circuit

Students have to begin their work in this step searching for the suitable voltage for the 3w led they chose to use. They have to read the technical information of the led and decide what battery/batteries is the better option. If they decide to use several batteries, they have to connect them in a concrete configuration. Also, they have to use in the circuit a current limiting resistor and include a switch.



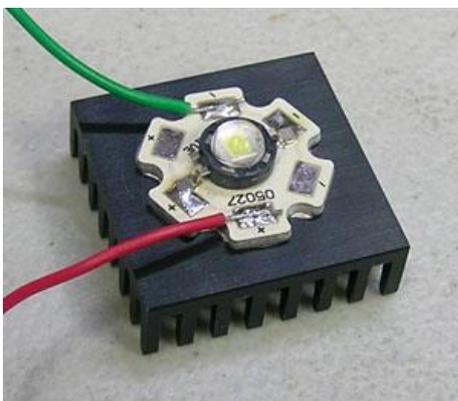
If students decided to use an ultraviolet led, it is important they know the kind of the light the led emits. If the led emit a Ultraviolet C Light (wavelength of 100–280nm), they must wear glasses with uv filters and other protections for the skin. Even, it is advisable to wear these protection measures if they use a Ultraviolet B led (wavelength of 280–315nm). For this reason, if students use UV-C or UV-B leds, they have to do it under teacher's supervision

A led generate hot in his back part, so it is necessary to dissipate the heat it produces. To do it, it is necessary to paste a heatsink with a thermal compound.

Students have to decide the kind of heatsink they want to use, the material of the heatsink (aluminium, copper or other) and if they will make one, use one they will obtain of other electronic device or opt for other option.



Kinds of headsinks. Bonded fin heatsink: pin, straight and flared fin



Led with a heatsink²

Led with a heatsink (plain heatsink)

Students must read technical information, understand it and use their acquired knowledge or learn new knowledge. For example, they must know and understand the mean of several words like “resistance”, “voltage” or “wavelength” in a concrete context or knowledge field.

4. Fourth step. Making the case

The last step is to make the case. They can design and print it to 3D printer, or folding and pasting different parts with a thermofusible plastic (polypropylene, pvc, methacrylate, etc.). They must make the case with some slots for the heat output generated by the led and transmitted to the heatsink.

Students have to keep in mind they are making a torch or a spotlight for a concrete use.

² Source of the image: <http://tardhaus.com/~scolwell/LED/lamp/index.html>