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JAVA BASED OPTICS VIRTUAL LABORATORY AS A SUPPORT TO THE TEACHING OF OPTICS IN TECHNICAL DEGREES

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In this work an Optics Virtual Laboratory is presented. This Virtual Laboratory is a set of different applets, tools based in Java, which allow the visualization of different physical laws in the field of Optics. The applets have the advantage in that the student can dynamically interact with the computer, giving a useful tool for significance learning. In this work three applets are analyzed: the first one corresponds to an animation of the Young's double slit experiment. In this applet the interference pattern produced by the light coming from two light sources in a screen can be seen. The other two applets permit the visualization of the formation of images by a convergent and a divergent lens.

1. Introduction

The use of the computer as an aid to education, mainly in technical degrees, has been grown during the last years. This is due to the fact that the computer is a useful tool for the visualization of the concepts explained in the theoretical classes. The creation of simple programs allows the increase of the active participation of the student in relation to the contents of the subject. In addition, because the programs can give the possibility of getting numerical values, the student can use the tools as a medium to check the problems proposed in the classroom or designed by the student himself. Moreover, the use of computer generated programs permits the simulation of complex phenomena, which in other case would be impossible to study. It cannot be forgotten the enormous acceptance that the incorporation of multimedia programs, as "Power Point", has in education. It can also be said that the use of the computer allows the increase of the student significant learning.

The incorporation of the computer as a complement to education emerged from the effort of the educationalists to adapt the Technology to the particular needs of education. This effort still continues in order to incorporate the new technologies of information and communications to education. In that direction, adequating the use of Internet to education is one of the most important aims. The reason is that Internet gives a great number of resources which properly grouped constitute powerful tools for the learning of a specific matter. In addition, the World Wide Web allows a continuous updating of materials. By this updating it is possible to control the quality and the adequation of materials to the specific matters which will be taught. In general, it can be said that the principal characteristic of Internet is its great dynamism.

Another interesting aspect in the incorporation of Internet to Education is the possibility of creating programs which could be used by whoever has access to Internet, programs generated in Java language called applets. By means of the creation of these programs for didactical objectives the aforementioned advantages in relation with the computer and the advantages offered by Internet can be shared.

The aim of this work is to present some applets from a virtual Laboratory of Optics. These applets allow the visualization of different physical phenomena such as, refraction and reflection of light, diffraction by a grating, formation of images by means of lenses and mirrors, etc. The advantage of this virtual Laboratory is that the student can interact with the different applets, introducing the numerical values and analyzing in an active manner the mentioned physical phenomena.

In this work we present three applets. The first one simulates the Young's Double Slit experiment and the other two present how a convergent and a divergent lens form images. A brief introduction is included for each applet in order to clarify the concepts in which the applets are based.

2. Applets

a. Young's Double slit Experiment

In this applet the Young's double slit experiment is presented. This is a classical experiment, proposed by Young in the XIX century, who efficiently demonstrated that light is a wave phenomena.

i. Introduction

In Young's Experiment a luminous light is generated, by means of the light source *S*, which illuminates two parallel slits, S_1 and S_2, separated a distance *a*. According to Huygens principle, S_1 and S_2 behave as two coherent secondary sources, whose interference diagram is observed in a second screen, *P*, separated a distance, *d*, from the double slit.

The waves generated by S_1 and S_2 will have complex amplitudes [1]:

$$U_1(\mathbf{r})=A_1 \exp(-jkr_1)$$
$$U_2(\mathbf{r})=A_2 \exp(-jkr_2)$$

The phase difference between the two waves is:

$$\delta = kr_2 - kr_1 = \frac{2\pi}{\lambda}(r_2 - r_1)$$

The constructive interference condition is:

$$\delta = \frac{2\pi}{\lambda}(r_2 - r_1) = 2m\pi \quad m=0, \pm1, \pm2, \pm3, \ldots$$

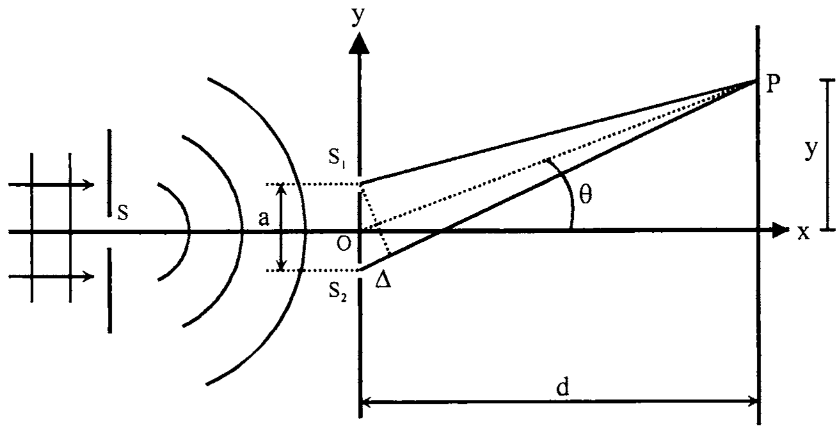


Figure 1. Young's Double slit experiment.

In case that the separation of the sources S_1 and S_2 is small in comparison with distance, *d*, between the plane of the gratings and the screen, *P*, the following relation can be established:

$$\delta = \frac{2\pi}{\lambda}(r_2 - r_1) = \frac{2\pi}{\lambda}\Delta \approx \frac{2\pi a}{\lambda}\operatorname{sen}\theta = \frac{2\pi a y}{\lambda d}$$

The resultant intensity in the screen has the following sinusoidal pattern:

$$I = I_0 \cos^2\left(\frac{\pi a y}{\lambda d}\right)$$

The points of maximum intensity correspond to:

$$\frac{2\pi a y}{\lambda d} = 2m\pi$$

and the separation between two consecutive maxima is:

$$\Delta y = \frac{\lambda d}{a}$$

ii. Description of the applet

In this applet the student can vary the values of the wavelength, λ, the separation between the double slit, a, and the distance of the double slit to the screen, d. The interference pattern can be observed in the screen.

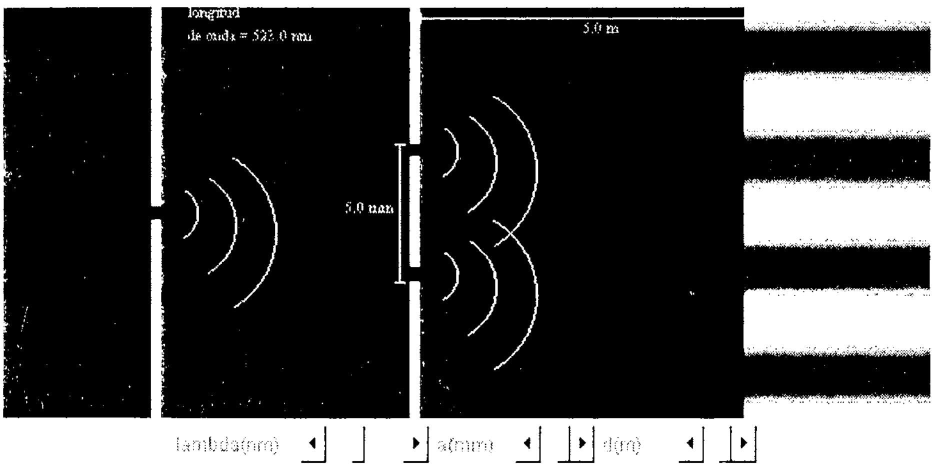


Figure 2. Applet which simulates the Young's Double slit experiment.

3. Formation of images by lenses

These two applets serve to visualize how a convergent and a divergent lens form images.

b. Introduction

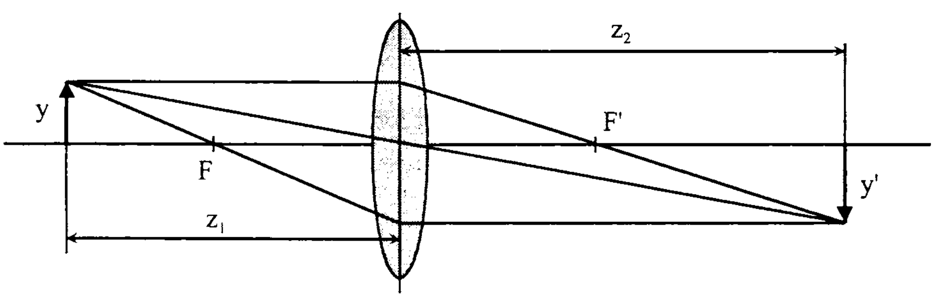


Figure 3. Image formation by a convergent thin lens.

Lenses are optical elements which produce image by refraction [1]. Depending on the characteristics of the lenses these can be classified as convergent or divergent lenses. In the paraxial approximation, small angles, and for thin lenses the equation that governs the formation of images by lenses is [2]:

$$\frac{1}{z_1}+\frac{1}{z_2}=\frac{1}{f}$$

where z_1 and z_2 are the distances of the object and the image to the lens, respectively, and f is the focal length of the lens. When the lens is convergent the focal length f is positive whereas when the lens is divergent the focal length is negative.

Figure 3 shows the formation of images by a thin convergent lens whereas Figure 4 shows the image formation by a divergent lens

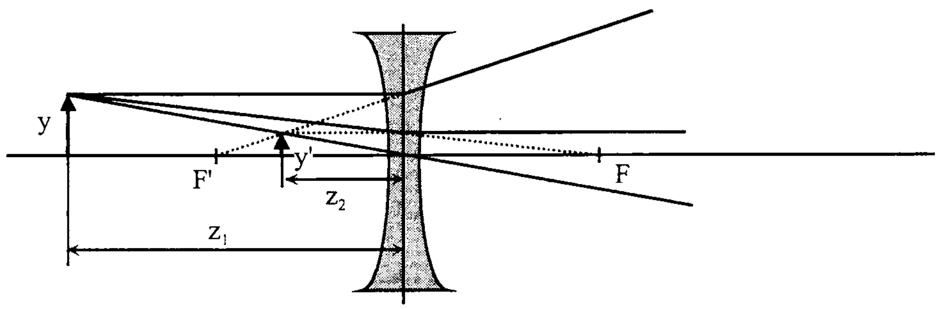


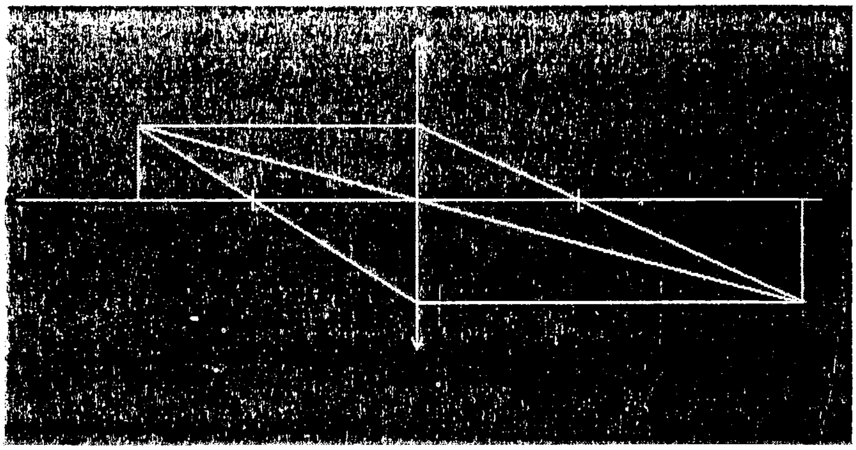
Figure 4. Image formation by a divergent thin lens.

It is possible to construct the image of a point source by using graphical tools, as can be seen in Figures 3 and 4. In a convergent lens a ray which travels parallel to the axis deviates after refraction passing through the focus F'. A central ray which passes through the center of the lens doesn't deviate, and a focal ray passing through the focal point F emerges parallel to the axis. In the case of a divergent lens, a ray parallel to the axis after passing through the lens emerges from this with its extension passing through the image focus of the lens, F'. A central ray doesn't deviate, and a focal ray addressed to the object focal of the lens, F, and after passing through the lens emerges parallel to the axis.

c. *Description of the applet*

i. Convergent lens

In this applet the student can vary using the mouse the location of the light source. The applet simulates the graphical method explained in section 3.1 for a convergent lens and obtains the image of the source. Figure 5 shows a photo of the applet

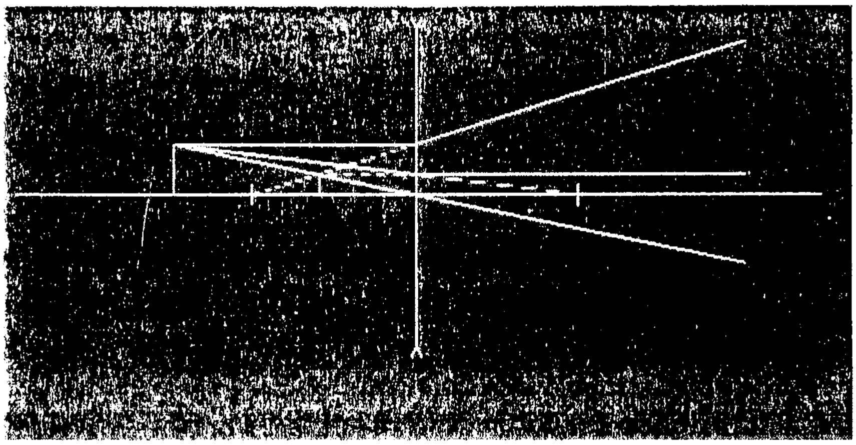


Factor de amplificación: 1.34

Figure 5. Applet which shows the image formation by a convergent thin lens.

Divergent lens

In this applet the student can vary using the mouse the location of the light source. The applet simulates the graphical method explained in section 3.1 for a divergent lens and obtains the image of the source. Figure 6 shows a photo of the applet



Factor de amplificación: 0.473

Figure 6. Applet which shows the image formation by a divergent thin lens.

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