OSLO® Optical design software as an educational tool

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Abstract

OSLO® optical design software is an ideal alternative solution for an optics class which needs experiment for its curriculum in order to enhance the learning efficiency of students. Education edition of OSLO® is free and easy to use.
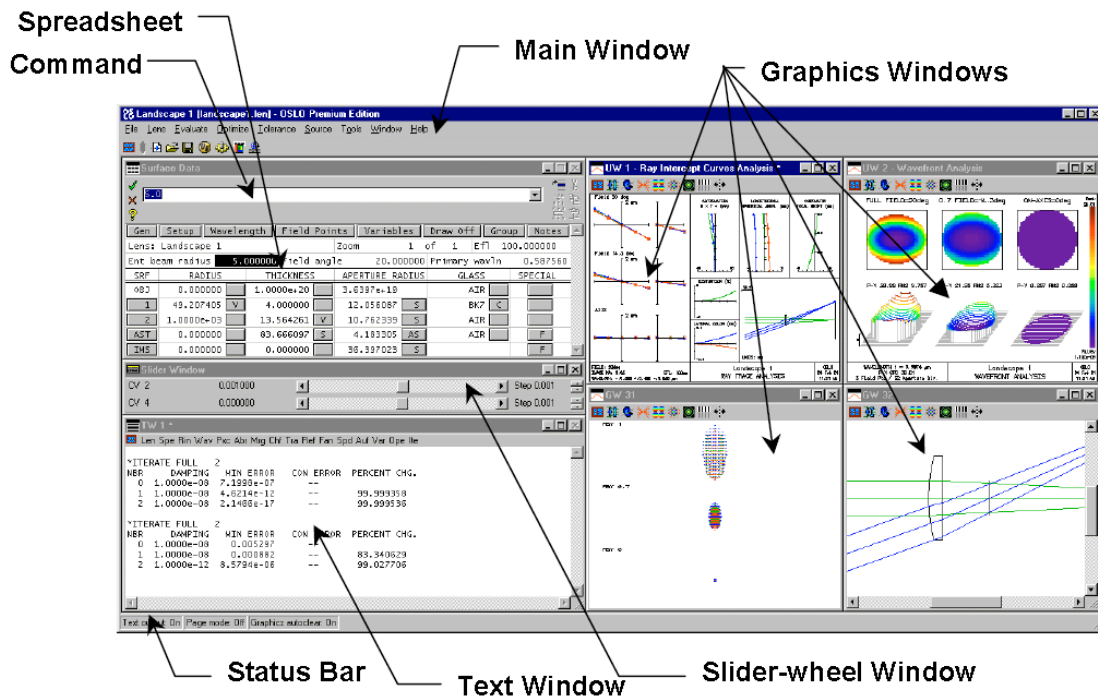
Introduction

In order to enhance the learning efficiency especially in the area of science and engineering classes, it is crucial to combine experiments into the curriculum. Students gain deeper understanding of the concept by applying the theories on actual devices, confronting errors, and solving errors. However, on certain subjects, it is almost impossible to incorporate that due to cost, and time. Unfortunately, the optics is one of the subjects that cannot experiment every single concept.

I suggest that computer simulations are good solution for the problem. The main purpose of simulation programs is designing and developing the actual products. It can achieve faster development time, decrease the possibility of error, and less development cost. Simulations also can be great learning tool. Students can verify the theory that they just learned, play with the parameters and see how it changes the behavior, farther more, attempt to design their own system. By doing this, they will gain deeper understanding of the concept.
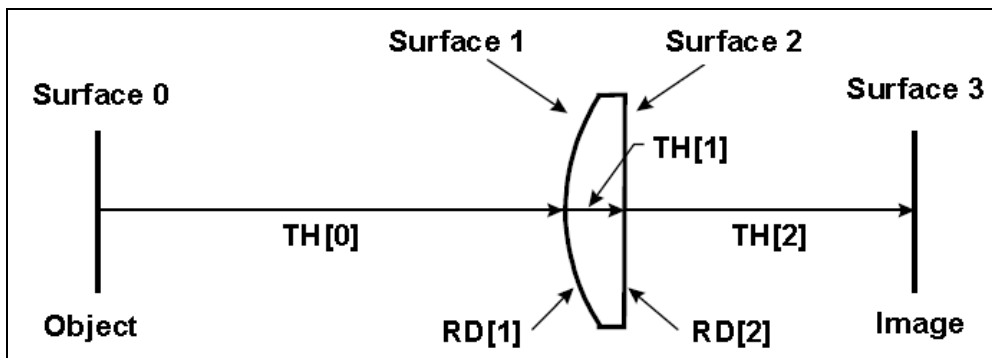
Optics simulation tools

As I doing the research, I found several optical tools that are available on the market: Zemax, Code V, and OSLO. All of the tools provide powerful functionality. Other than OSLO, I needed to request the trial license or purchase the product. Average cost of products is around few thousand. OSLO provides education edition without charge and request. The only the limitation is a system can have up to, or including, 10 surfaces which is sufficient for educational purpose. So I decided to use OSLO.

<Figure1: OSLO optical design software>

Basic concept

I started with the OSLO reference manual Chapter 1 Quick start[3]. Manual was well written, and easy to read. It took me only about 3~4 hours to grasp the basic concept and functionality. For the readers who are not familiar with the tool, I'll explain briefly.

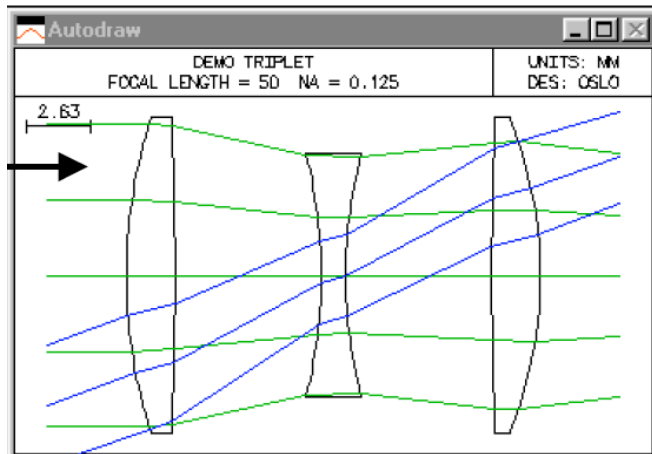< Figure2 Concept of surface, thickness, and radius >

Figure 2 indicates the concept of surfaces, thickness, and radiuses. The index of surface starts with zero. Surface 0 indicates the object. Last surface indicates the image, in this figure it is surface 3. Surfaces in between object and image are either aperture stop or lenses. Thickness 0 (TH[0]) indicates the distance between the object to the first lens. In other words, TH[0] indicates the distance of surface 0 and surface 1. TH[1] indicates the distance between surface 1 and surface 2 and respectively for TH[2]. Radius 1 indicates radius of surface 1. If the radius is positive, the center of the radius is on right side of the surface.

SRF	RADIUS	THICKNESS	APERTURE RADIUS	GLASS	SPECIAL
OBJ	0.000000	1.0000e+20	3.6397e+19	AIR	
1	51.680000 V	4.000000	9.856408 S	BK7 C	
2	0.000000	9.135000 V	8.636644 S	AIR	
AST	0.000000	88.227848 S	4.411393 AS	AIR	F
IMS	0.000000	0.000000	36.397016 S		F

Gen | Setup | Wavelength | Field Points | Variables | Draw Off | Group | Notes

Lens: Landscape 1 — Zoom 1 of 1 Efl 99.999979
Ent beam radius 5.000000 Field angle 20.000000 Primary wavln 0.587560

<Figure 3: data spreadsheet>

Figure 3 shows the data spreadsheet. It contains the data that I explained above: surface (SRF), radius, and thickness. There are two extra data that I haven't described: Entrance beam radius, and Field angle. Entrance beam radius (Ent beam radius) defines the angle of beam that impinges on surface 1. More specifically, it indicates the radius of the beam on the axis to the surface 1, which is equal to the entrance pupil radius. Field angle indicates the angel of additional ray from object to the surface 0. On Figure 4, Blue ray affects by Field angel and the distance between each ray affects by entrance beam radius.

DEMO TRIPLET
FOCAL LENGTH = 50   NA = 0.125
UNITS: MM
DES: OSLO
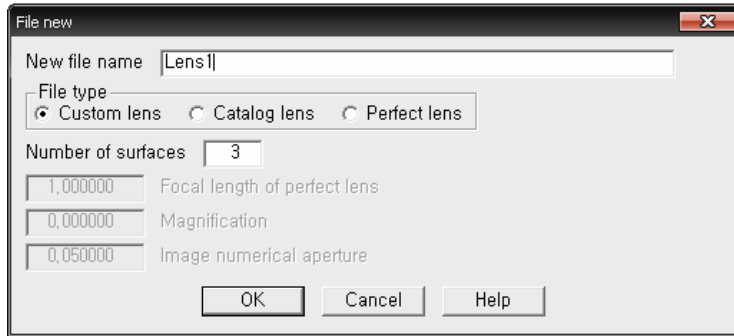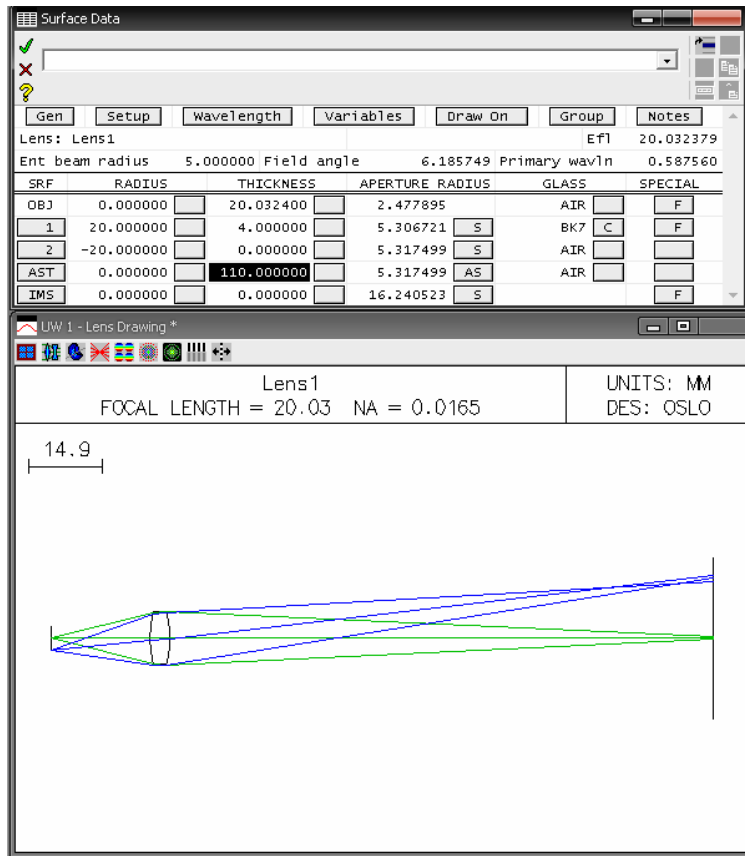2.63

<Figure 4: ray draw>

Simulation

I started the research on this subject because of homework 4. I wasn't sure whether the focal point of A is on same plane as the ray from axis O. Therefore I decided to solve homework 4 problem 4 with OSLO.
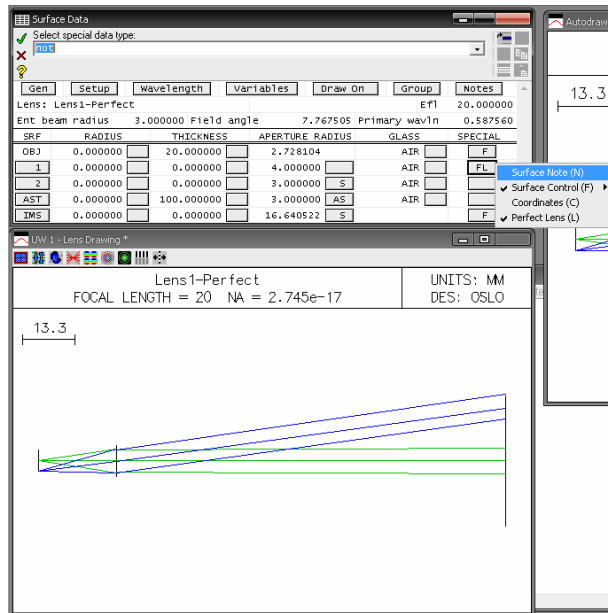
Design lens 1

<Figure 5: lens type>

I started with Custom lens and soon I confronted with a problem. The lens is not working how it supposed to work because it is not a perfect thin lens. The rays from the focal point of the lens supposed to travel parallel with the horizontal line, but the simulation shows something different.

<Figure 6: Lens 1 >

I designed a lens radius of 20 and -20 with thickness 4. The BK7 indicates the type of glass which has 1.517 of refraction rate [4]. The surface data spreadsheet shows focal length is 20.03. Therefore if I locate the object at 20.03 from the lens, it is supposed to show the rays parallel with the horizontal line. In fact, it converged on 110 from the surface 3.

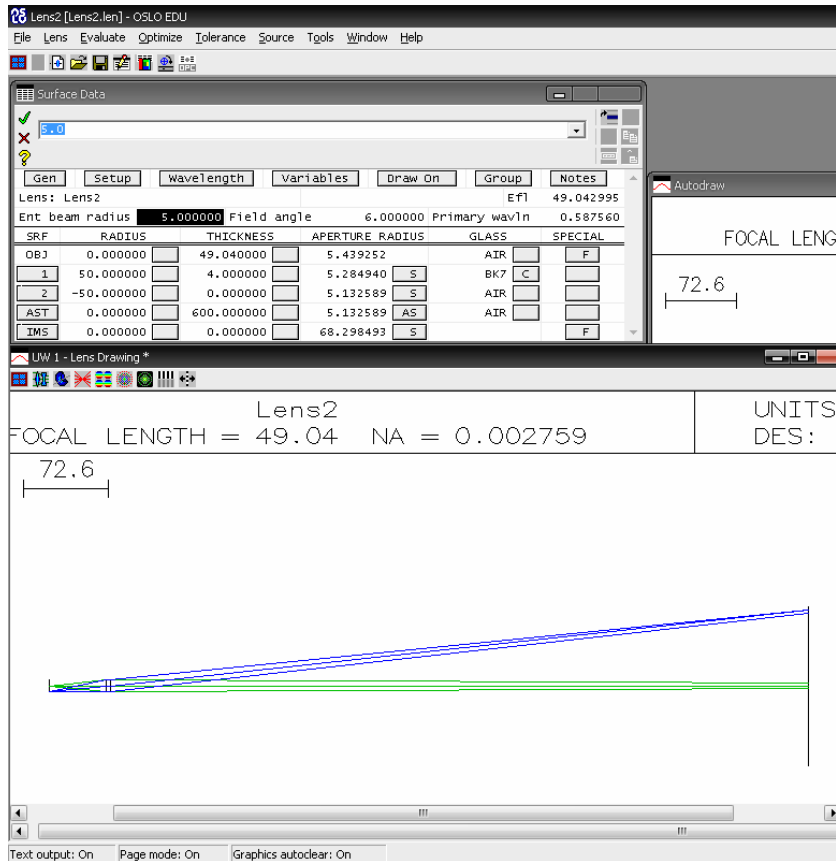< Figure7: Lens1- perfect lens mode>

I found an option called Perfect Lens. By applying this option, a surface works like a perfect lens with indicated focal length. I set the focal length 20. The ray drawing seems right.
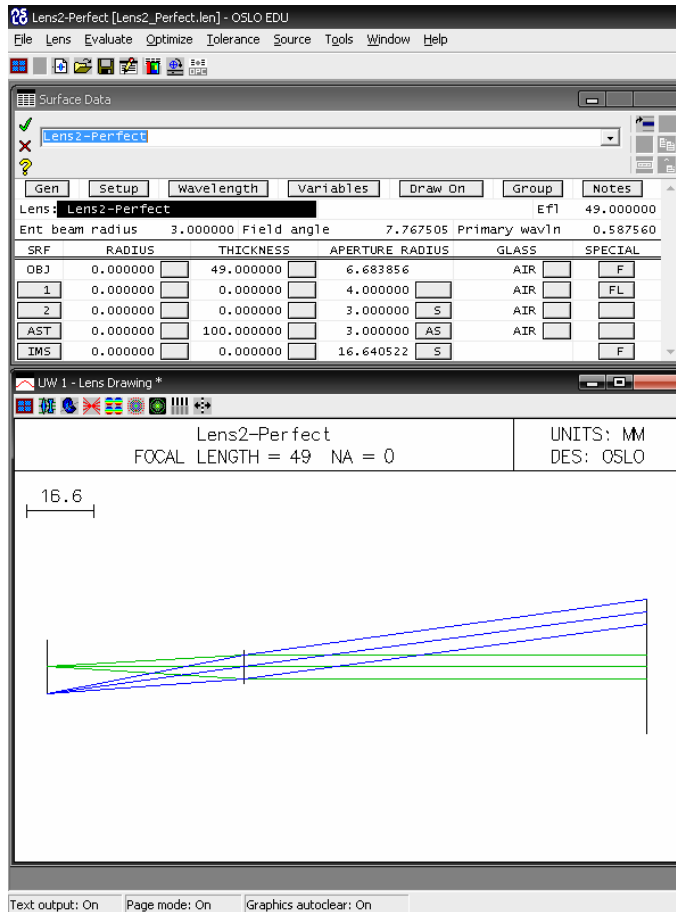
Since I designed two different versions of lenses, I decided to solve the problem with each model.

Design lens 2
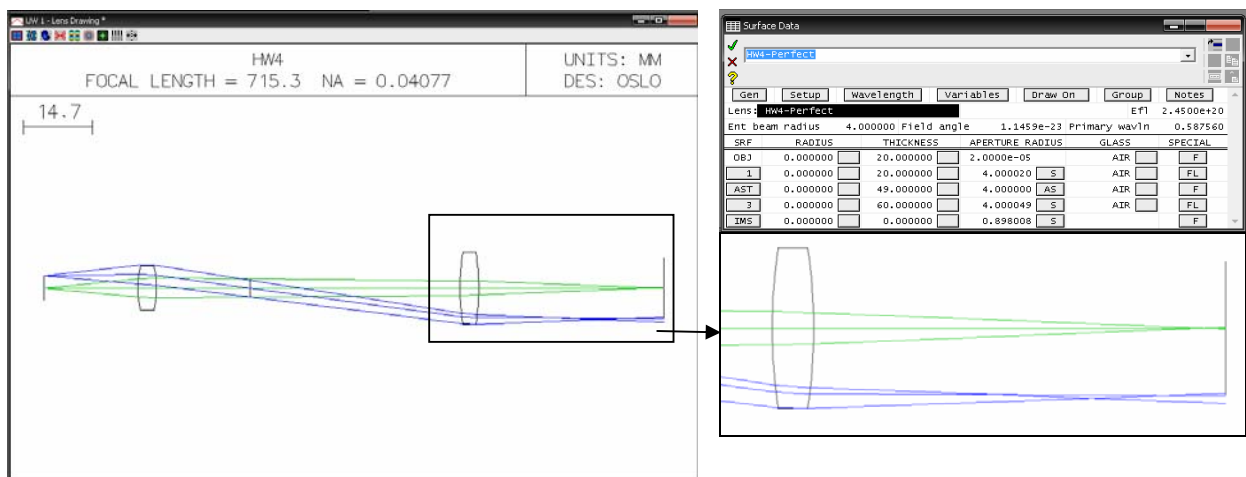
<Figure8: Lens2 >

The second lens of HW4.4 is longer focal length than first one, so I designed a lens radius of 50 and -50 with thickness 4. I used the BK7 for the material of the lens. The surface data spreadsheet shows focal length is 49.04. Therefore if I locate the object at 49.04 from the lens, it is supposed to show the rays parallel with the horizontal line. The result rays are not perfect: I could find the converging point farther than 1000. However, it is much better than Lens1 without Perfect lens mode.

<Figure 9: Lens2-Perfect mode>

Focus length of Lens2 perfect mode is 49 and it is working fine.
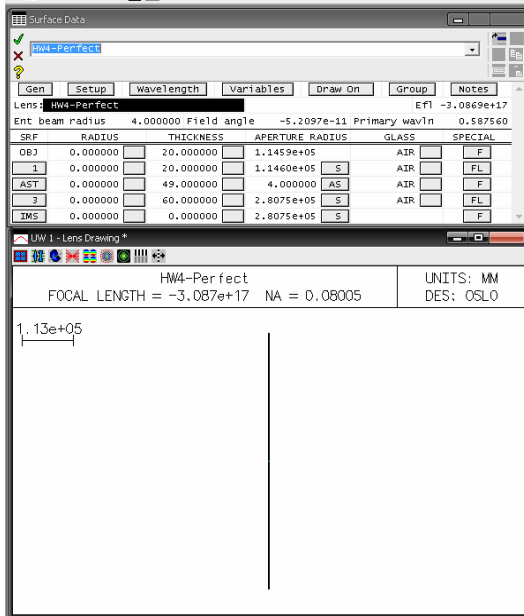
Result

<Figure10: Combine Lens1 and Lens2 >

I combined two normal lenses and the result was satisfying. For the rays from the axis

(Green), I was expecting to see the focus point around 49 and the simulation shows around 55. Considering the fact that it is not ideal thin lens, it is expectable error. The rays from the top of the object (blue) are different story. They are not even converging at a point. Considering the fact that it is not ideal thin lens and aberrations, it is acceptable error. It might need extra group of lenses to correct the problem.

<Figure11: Combine Lens1 and Lens2 – Perfect Lens >

I couldn't find the solution for the perfect lenses. The simulation is saying that it need several $10^4 \sim 10^5$ size of object, Lens1 and Lens2. I spend a lot of time on it, but I couldn't get the solution.

Conclusion

Even though I couldn't get a solution for Perfect lenses, normal lenses gave me sufficient result. By solving the homework problem with the OSLO, I've gain a lot of insight of lens characteristics. I could manually change the radius, aperture stop, and thickness of each lens and could be able to see how it affects on the ray trace. I highly recommend incorporating this tool into class curriculum without spending extra cost and with reasonable training time.

Reference

[1] OSLO® Development, http://www.sinopt.com/

[2] OSLO® Sales and support, http://www.lambdares.com/software_products/oslo/

[3] OSLO® Optics Reference Manual

http://www.lambdares.com/downloads/OSLO_Releases/OSLOOpticsReference.pdf

[4] Characteristic of BK7, http://www.pgo-online.com/intl/katalog/BK7.html