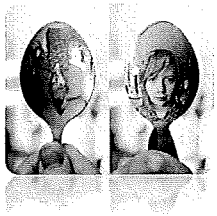
Name: ANSWER Session 1: Section: _____

Sp15. Exam1. Optics.

At half-time and end time, submit online the single script file. NO ZIP please.

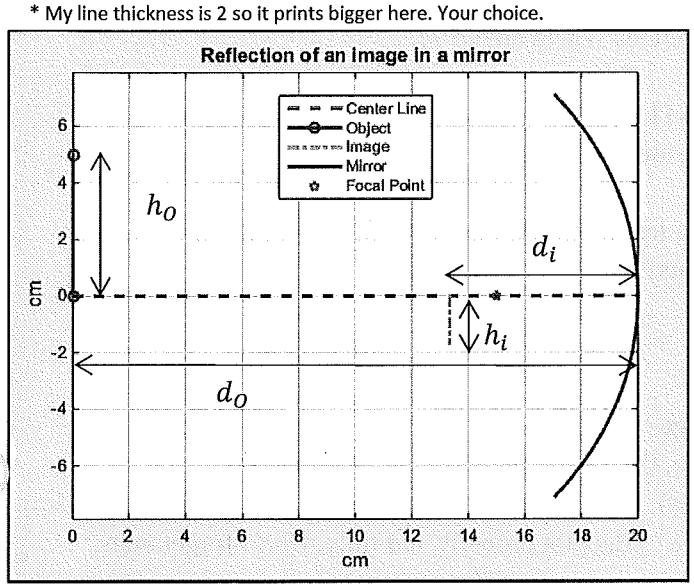


NO QUESTIONS WILL BE ANSWERED IF THEY PERTAIN TO WHY THE CODE DOES NOT WORK. NO QUESTIONS WILL BE ANSWERED REGARDING THIS INSTRUCTION SHEET EITHER. EVERYTHING IS WRITTEN HERE. **READ FULLY FIRST**. REFRAIN FROM RAISING YOUR HAND.

HOWEVER, PLEASE ASK FOR HELP IMMEDIATELY IF YOUR PC STARTS ACTING WEIRD!!!
SAVE OFTEN TO YOUR P:// DRIVE OR FLASHDRIVE!

Why is our reflection in a spoon upside down?

* My line thickness is 2 so it prints bigger here. Your choice.



This is all due to optics. Your position with respect to the spoon (i.e. mirror), and which side of the spoon you are looking at, influence how your mirrored image will be!

In order to easily determine details about your image (height and distance), we will plot the following schematic at left. The parameters that can/should easily change are:

- d_O distance at which the object is located (cm)
- R radius of the mirror (cm)
- h_O height of the object (cm)

→ GIVENS

From these values, the image's characteristics and the focal point are easily calculated.

Your code should plot the ***center line*** (blue dash line) and a ***line for the object*** (red with a circle marker). Keep in mind these should move/vary if the parameter's values change!

To plot ***the mirrored image*** (dash dot line type), its position from the mirror (d_i in cm) and the image height (h_i in cm) (h_i can be negative) are calculated beforehand using:

$$d_i = \frac{1}{\frac{2}{R} - \frac{1}{d_O}} \qquad h_i = -\frac{d_i}{d_O} * h_O$$

The ***mirror data-points*** (color of your choice but different than already used colors) can be calculated using simple circle formulas, with $-45° \leq \theta \leq 45°$:

$$x(\theta) = R\,(\cos(\theta) - 1) + d_O$$
$$y(\theta) = R\,\sin(\theta)$$

The ***focal point*** represents the point by which all rays of light that hit the mirror will pass. The focal point is a single point, so there is no need for vectors to plot a line. Simply use these coordinates in the `plot( )` command, with a marker `'p'` to indicate it on the figure. Its scalar coordinate is simply:

$$x_{fp} = d_O - \frac{R}{2}$$
$$y_{fp} = 0$$

(5pts) Step1:

Givens Required

d_o
R
h_o

Find

schematic of mirrored image. where located?

Step2 and 3 are done above. There are no assumptions for Step4. Step5/6: Do not solve by hand unless you want to check your results. Only the graphical solution in MATLAB will be graded.

The grading points below are only awarded if a file is submitted. ZERO points otherwise.

Step7a/b: Do this directly in the script, as we have practiced in the labs. There are no 7c.

- name/section/purpose of code (**3pts**)
- commands to clean up previous execution of MATLAB codes (**3pts**)
- detailed comments (which is considered the algorithm 7a) (**5pts**)
- spacing/indent of code (**5pts**)
- appropriate variable names (absolutely NO single letters this time) (**5pts**)
- semi-colon hiding all givens and calculations (**5pts**)

Requirements for the program itself:
(**6pts**) Define a variable for each given.
(**12pts**) Calculate properly the characteristics for the image, and create the two vectors to plot it.
(**35pts**) Define all vectors necessary to plot the center line, the mirror, and object (7 vectors)
(**2pts**) Plot correctly, using colors and line specifiers (**2pts**). Make axis equal scale and turn on the grid (**2pts**).
(**5pts**) Title, label and legend (location : `'bestoutside'`) the plot properly and fully. Don't forget units.

(**5pts**) – Reuse your code to fill in the following table.

Test case	d_O (cm)	R (cm)	h_O (cm)	Where is the image ? A. Before the focal point B. at the focal point C. between focal point and mirror D. other: _____	Is the image upside down? Special observation?
#1	10	5	6	A	yes
#2	5	5	2.5	B	yes
#3	4	10	4	D: after !	yes impossible
#4	5	10	4	B	no. superposed

```
%optics & mirrored image
%by caroline
%sp15 exam1. session 1. 10:30am

clc;
clear;
close all;
%no format compact. useless for this code.

%define mirror data
radius = 5;
d_object =10; %cm

%define object
height_object = 6; %cm

%calculate image height and distance, and x/y image
d_image = 1/(2/radius - 1/d_object);
h_image = -d_image/d_object*height_object;
xim = [d_object-d_image,d_object-d_image];
yim = [0,h_image];

%x/y mirror
angl  = linspace(-45,45); %degrees
xMirror = radius*cosd(angl)+d_object-radius;
yMirror = radius*sind(angl);

%x/y object
xobj = [0,0];
yobj = [0,height_object];

%x/y center line
xCenterLine = [0, d_object];
yCenterLine = [0 0];

%plot all (use ... when line gets too long. DOES NOT WORK WITH COMMENTS)
plot(xCenterLine,yCenterLine,'--',  xobj,yobj,'-o',   ...
    xim,yim,'-.',xMirror,yMirror,...
    d_object-radius/2 , 0 ,'p','linewidth',2);
axis equal;
title('Reflection of an image in a mirror');
grid on;
legend('Center Line','Object','Image','Mirror','Focal Point','location','bestoutside');
xlabel('cm');
ylabel('cm');
```

3

3

6

12

15

10

10

4

2

Comments 5

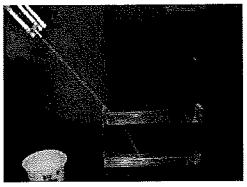
spacing/indent 5

; ALL 5

var names 5

Very identical to the lab with the three vectors. To plot lines, just figure out the trig and the data points!

Name: ANSWER Session 2: Section: _____



Sp15. Exam1. Optics.

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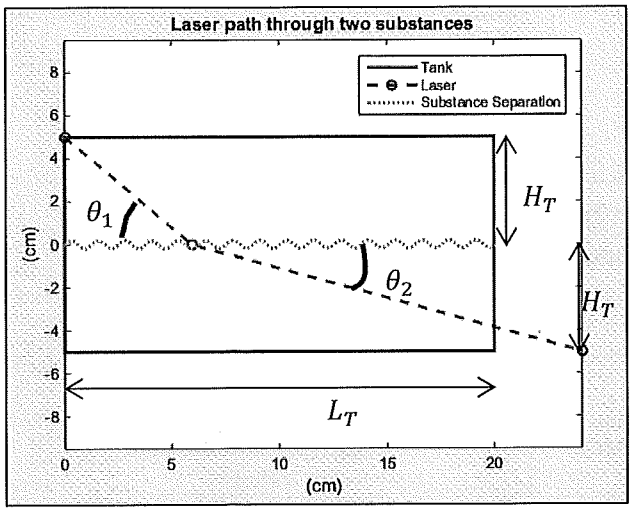
HOWEVER, PLEASE ASK FOR HELP IMMEDIATELY IF YOUR PC STARTS ACTING WEIRD!!!
SAVE OFTEN TO YOUR P:// DRIVE OR FLASHDRIVE!

When pointing a laser into a tank full of water, why does the laser "bend"?

* My line thickness is 2 so it prints bigger here. Your choice.



This is all due to optics and the index of refraction of each substance. Tank dimensions (H_T (cm) and L_T (cm)) are known, as well as the angle of incidence θ_1 (degrees), and the indices of refraction of each substance (n_{top} *and* n_{bottom}). These should all be easy to change in the code.

In order to easily determine whether the end of the laser is within the tank or outside, we will plot the following schematic at left.

Your code should **plot the rectangular tank**. Keep in mind the dimensions can change. Notice it is centered on zero horizontally, to facilitate further plots.

The **substance separation** (dotted line, different color than tank) is a sine function based on the tank dimensions:

$$y(x) = 0.04\, H_T \sin(5\, x)$$

To plot ***the laser path*** (dashed line with a circle marker, different color than tank and separation), assume the initial laser point will always be at the very top left of the tank. Using basic trigonometry, determine the coordinates of the other two points. The angle of refraction θ_2 is calculated as:

$$\theta_2 = \sin^{-1}\left(\frac{\sin(\theta_1)\; n_{bottom}}{n_{top}}\right)$$

Note: $\sin^{-1}()$ is accomplished using the function `asind( )`, or `asin( )` depending on the unit system you chose.

(5pts) Step1:

Givens Needed

H_T L_T

θ_1

n_{top}

n_{bottom}

Find

end of laser position?

Step2 and 3 are done above.

Step4: Assume the intersection between the laser and the substance separation is a rough idea. The points will not match exactly on the sine function.
Step5/6: Do not solve by hand unless you want to check your results. Only the graphical solution in MATLAB will be graded.

The grading points below are only awarded if a file is submitted. ZERO points otherwise.

Step7a/b: Do this directly in the script, as we have practiced in the labs. There are no 7c.

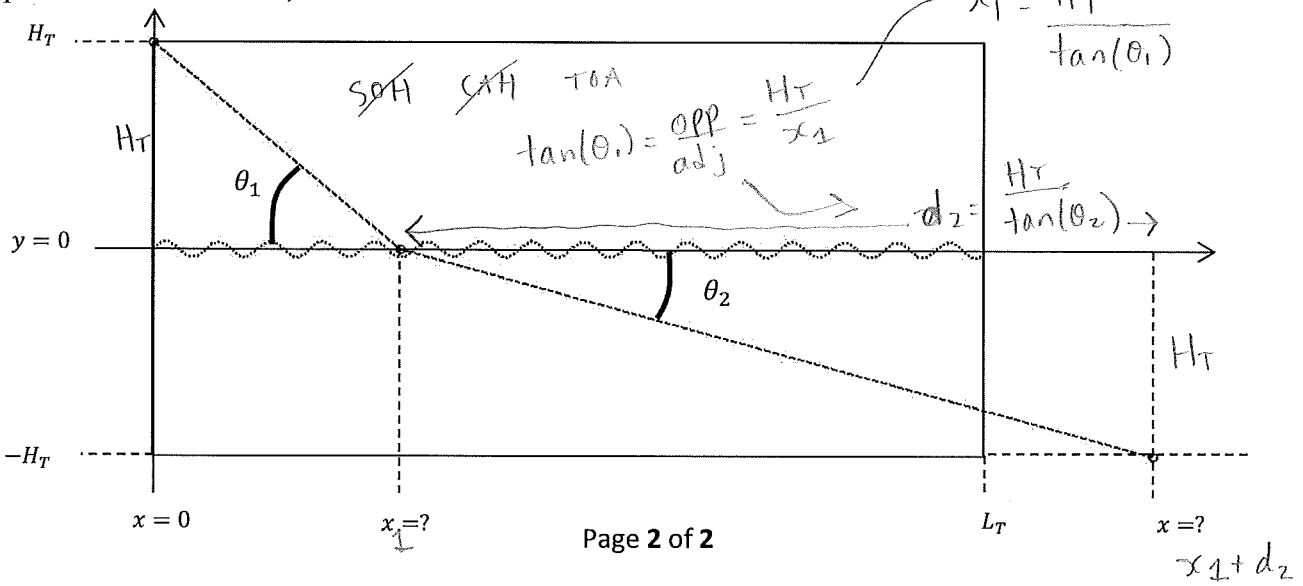
- name/section/purpose of code (**3pts**)
- commands to clean up previous execution of MATLAB codes (**3pts**)
- detailed comments (which is considered the algorithm 7a) (**5pts**)
- spacing/indent of code (**5pts**)
- appropriate variable names (absolutely NO single letters this time) (**5pts**)
- semi-colon hiding all givens and calculations (**5pts**)

Requirements for the program itself:
(**10pts**) Define a variable for each given.
(**10pts**) Define the vectors to plot the tank.
(**10pts**) Define the vectors to plot the substance separation.
(**5pts**) Calculate the coordinates of the laser, define the vectors to plot it (**10pts**).
(**4pts**) Plot correctly, using different colors and line specifiers (**2pts**). Make axis equal scale (**1pt**).
(**5pts**) Title, label and legend (location : `'best'`) the plot properly and fully. Don't forget units.

(**6pts**) – Reuse your code to fill in the following table.

Test case	H_T (cm)	L_T (cm)	θ_1 $(degrees)$	n_{top} $(no\ unit)$	n_{bottom} $(no\ unit)$	Will the end of the laser be: A. in the tank B. outside the tank C. other: _____
#1	5	20	40	2.419 (diamond)	1.000293 (air)	B. outside
#2	5	20	60	1.333 (water)	1.39 (kerosene)	A.
#3	10	50	40	2.419	1.000293	A
#4	10	50	40	1.000293 (air)	1.333	A.
#5	10	30	40	1.000293	2.419 diamond is strong	C. not going through
#6	10	30	20	1.000293	2.419	B. outside

To help determine coordinates, use this as draft:



```
%laser hitting water/other substance
%by Caroline
%spring 15, session 2. 3:30pm

clc;
clear;
close all;
%format compact; useless.

%define liquids top and bottom
ntop = 2.419;
nbottom = 1.000293;

%define angle of incidence
angleIn = 40; %degrees

%define length of tank
lengthtank = 20; %meters

%calculate angle of refraction, measure distances for each point
angleBottom = asind(sind(angleIn)*nbottom/ntop);

%define x/y line for tank
height = 5;
xTank = [0 lengthtank lengthtank 0 0];
yTank = [-height -height height height -height];

%define x/y for laser
xLaser = [0 height/tand(angleIn), height/tand(angleIn)+height/tand(angleBottom)];
yLaser = [height, 0, -height];

%define x/y line for substance separation
xCenter = linspace(0,lengthtank);
yCenter = sin(xCenter*5)*height*.04;

%plot tank and laser
plot(xTank,yTank,xLaser,yLaser,'--o',xCenter,yCenter,':','linewidth',2);
axis equal;
legend('Tank','Laser','Substance Separation');
title('Laser path through two substances');
xlabel('(cm)');
ylabel('(cm)');
```

out