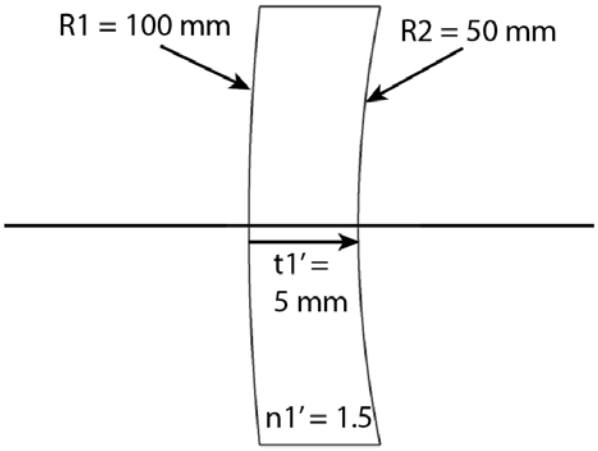
Do all problems and show your work. Credit is not given for answers only.

1. The parameters of a meniscus lens are shown in the figure below.



(a) Use Gaussian reduction on the lens above to find the location of all six cardinal points, as well as the FFD and BFD. Show all work.

First calculate the surface powers

$$\phi_1 = \frac{1.5 - 1}{100} = 0.005\ mm^{-1}$$

$$\phi_2 = \frac{1 - 1.5}{50} = -0.01\ mm^{-1}$$

The total power is

$$\phi = \phi_1 + \phi_2 - \left(\frac{t'_1}{n'_1}\right)\phi_1\phi_2 = -0.00483\ mm^{-1}$$

The offsets for the principal planes are

$$d = \frac{\phi_2}{\phi}\left(\frac{t'_1}{n'_1}\right) = 6.897\ mm$$

$$d' = -\frac{\phi_1}{\phi}\left(\frac{t'_1}{n'_1}\right) = 3.448\ mm$$

The various focal lengths are given by

$$f = \frac{1}{\phi} = f'_R = -f_F = -206.897\ mm$$

The front and back focal distances are given by

$$FFD = f_F + d = 213.793\ mm$$

$$BFD = f'_R + d' = -203.448\ mm$$

Since the system is in air, the nodal points are located at the principal planes.

(b) Set up the ynu raytrace for this meniscus lens. Trace a ray with $y_1 = 1$ and $n_1 u_1 = 0$ through the system and use it to determine the location of the rear focal point, the BFD and the location of the rear principal plane. Include your spreadsheet in the results and show how you made the calculations.

See below

(c) Reverse raytrace a ray with $y_2 = 1$ and $n'_2 u'_2 = 0$ through the system and use it to determine the location of the front focal point, the FFD and the location of the front principal plane. Include your spreadsheet in the results and show how you made the calculations.

Thick Meniscus									
	0		1		2		3		
R			100		50				
C			0.01		0.02				
t				5				P'F'	-206.897
n		1		1.5		1		PF	206.8966
								V2F'	-203.448
-phi			-0.005		0.01			V1F	213.7931
t/n		-213.793		3.333333		-203.448		d	6.896552
								d'	3.448276
y	1		1		0.983333		0		
nu		0		-0.005		0.004833			
u		0							
y	0		1.033333		1		1		
nu		-0.00483		-0.01		0			
u									

2. Two thin lenses in air are separated by a distance of $t'_1 = 20\ mm$. The focal length of the first lens is $f_1 = 100\ mm$ and the focal length of the second lens is $f_2 = -50\ mm$. An object with height $h = 1\ mm$ is located 200 mm to the left of the first lens. Using ynu raytracing, calculate the location of the image and its magnification. Include your spreadsheet.

Two thin lenses								V2O'	-69.2308
	0		1		2		3	m	0.384615
f			100		-50				
-phi			-0.01		0.02				
t/n		200		20		-69.2308			
y	0		20		18		0		
nu		0.1		-0.1		0.26			
u		0.1							
y	1		1		0.8		0.384615		
nu		0		-0.01		0.006			
u									
		-0.1	-0.1	-0.1	-0.1	-0.1	-0.1		

3. Examine the image below. If the woman's hand is $z = -250\ mm$ from the mirror and the magnification is $m = 2$, answer the following.

(a) What is the focal length of the mirror?

$$f = \frac{m}{1-m} z = 500\ mm$$

(b)Where is the image formed?

Remember to change the sign of the index after reflection, so $n' = -1$.

$$z' = n'(1-m)f = 500\ mm$$

(c) Is the image upright or inverted?

The magnification is positive, so the image is upright.

(d) What is the power of the mirror?

$$\phi = \frac{1}{f} = 0.002\ mm^{-1}$$

(e) What is the radius of curvature of the mirror?

$$\phi = -\frac{2}{R} \Rightarrow R = -1000\ mm$$

(f) Is the mirror convex or concave?

Since R is negative and/or the power is positive, the mirror must be concave.