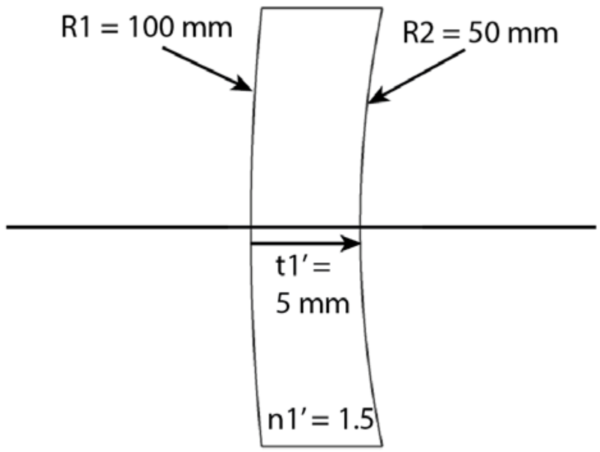
Do all problems and show your work. Credit is not given for answers only.

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.

(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.

(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.

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.

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?

(b)Where is the image formed?

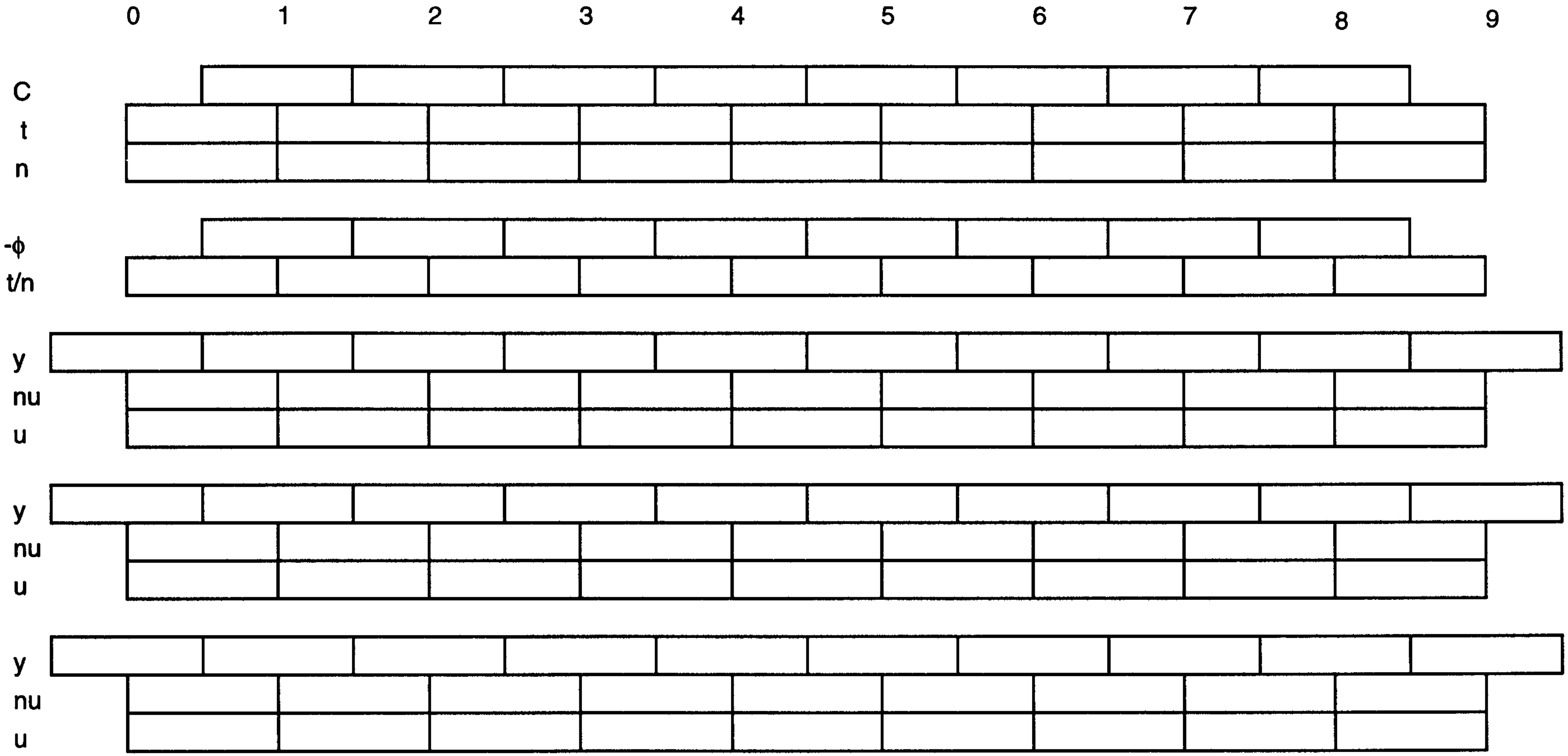
(c) Is the image upright or inverted?

(d) What is the power of the mirror?

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

(f) Is the mirror convex or concave?

YNU Method



Thin Lens YNU Method

	0	1	2	3	4	5	6	7
f								
$-\phi$								
t								
y								
u								
y								
u								
y								
u								

Thin lens or general system $$\phi = \frac{1}{f}$$	Focal Lengths $$f'_R = n'f \qquad f_F = -nf$$
Single surface $$\phi = \frac{n' - n}{R}$$	Total power of two elements $$\phi = \phi_1 + \phi_2 - \left(\frac{t'_1}{n'_1}\right)\phi_1\phi_2$$
Front Principal Plane $$\delta = \frac{d}{n} = \frac{\phi_2}{\phi}\left(\frac{t'_1}{n'_1}\right)$$	Rear Principal Plane $$\delta' = \frac{d'}{n'} = -\frac{\phi_1}{\phi}\left(\frac{t'_1}{n'_1}\right)$$
Front Focal Distance $$FFD = f_F + d$$	Back Focal Distance $$BFD = f'_R + d'$$
Gaussian Imaging Eq. $$\frac{n'}{z'} - \frac{n}{z} = \frac{1}{f}$$	Newtonian Imaging Eq. $$z_F z'_F = f_F f'_R$$
Transverse Magnification $$m = \frac{nz'}{n'z}$$	Longitudinal Magnification (small shift) $$\overline{m} = \frac{n'}{n}m^2$$
Nodal Points $$z_{PN} = z'_{PN} = f_F + f'_R$$	Mirrors Thickness and indices switch sign after reflection
Paraxial Refraction (Reflection) Equation $$n'_j u'_j = n_j u_j - y_j \phi_j$$	Paraxial Transfer Equation $$y_{j+1} = y_j + n'_j u'_j \frac{t'_j}{n'_j}$$