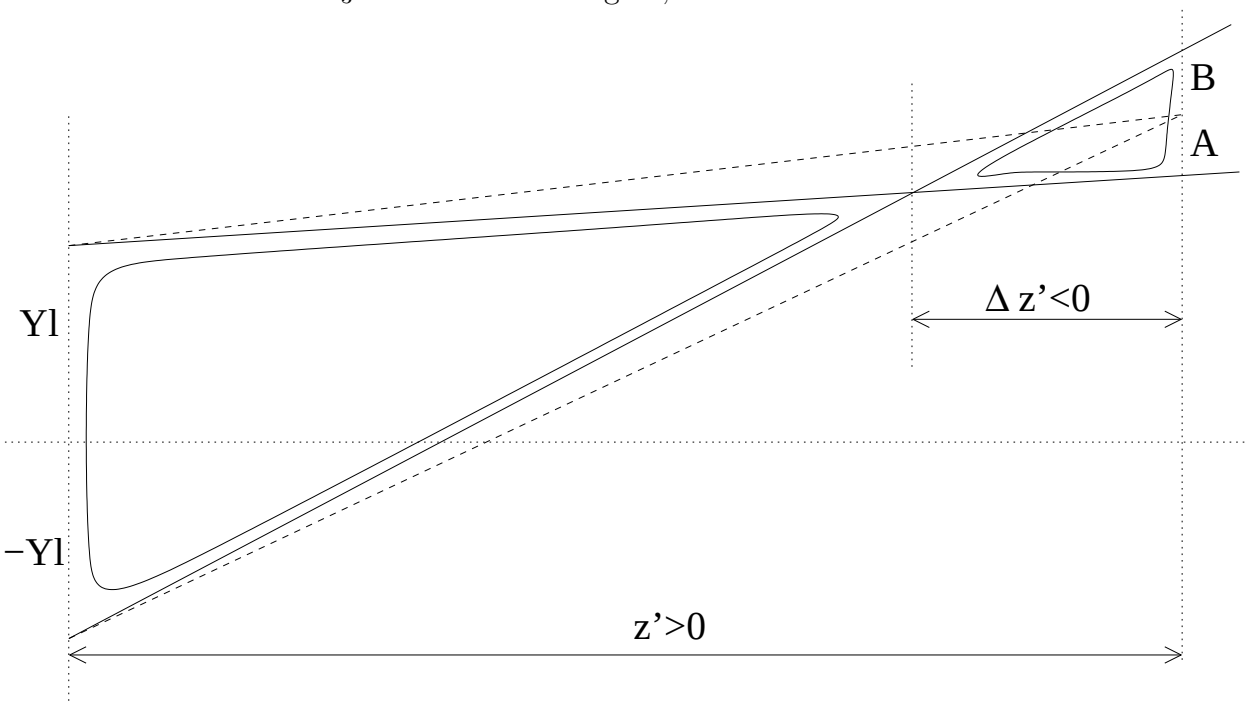
Solutions to homework #5 due 2007/2/27

Problem 1
OSLO Tutorials
Problem 2
Astigmatism and curvature can be visualized in the following graph. The dashed curves are the paraxial rays. The solid rays are the rays with astigmatism, and in this case a negative value of the coefficient B_3. I marked two lengths, A and B.



According to equation 3.1 (page 63), $A = 3B_3 y_L h^2$, and $B = -3B_3 y_L h^2$. If we assume that A and B are small compared to z', then there are two similar triangles, which are marked. For those we can write

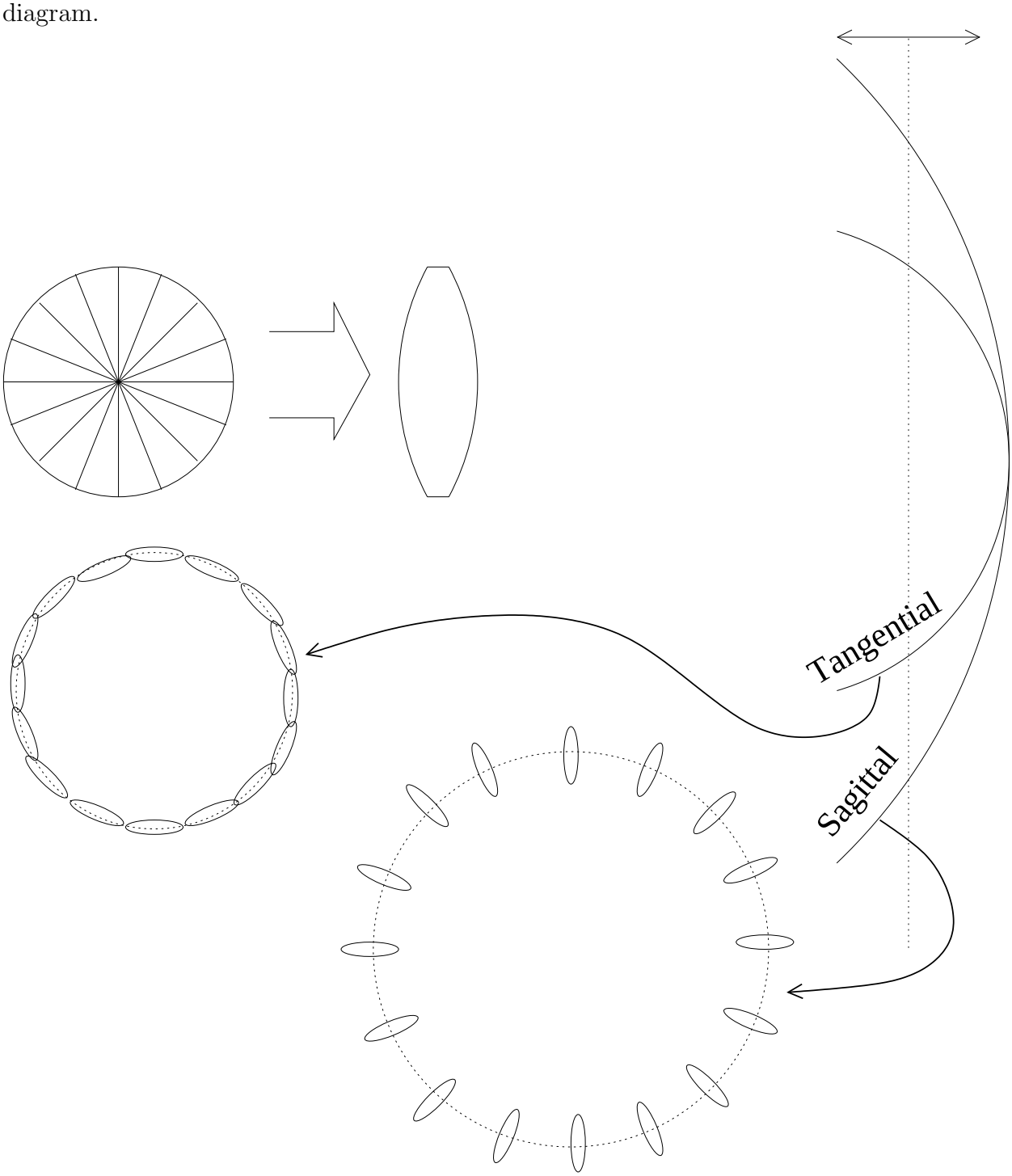
$$\frac{2y_L}{z' + \Delta z'} \approx \frac{2 \times 3B_3 y_L h^2}{\Delta z'}$$

$$\Delta z' \approx \frac{6B_3 y_L h^2 \left(z' + \Delta z'\right)}{2y_L} \approx 3z' B_3 h^2$$

This is the longitudinal shift for tangential rays (in the y-direction). For sagittal rays we can draw a very similar diagram and end up with a very similar result. In all three cases (the two tangential and sagittal part of astigmatism, and the curvature), the result is that we eliminate a factor of y (or s), and we include an extra factor of z'. This is the same result as for spherical aberration.

Problem 3

Explain how a bicycle wheel is focused when there is astigmatism. Look at the following diagram.



What the figure shows is that at the tangential focus, the image is well-focused in the tangential direction. That is, it has a narrow extent in the tangential direction and a wider extent in the sagittal direction. For an arbitrary object point which is not just along the y-axis, the tangential direction is the radial direction. If the image of the wheel is at the tangential focal plane, it will look like it is in focus because all the sharp lines are perpendicular to

the tangential (radial direction). Similarly, the portion of the spokes which is at the sagittal focus will look like it is in focus because the lines in the image are perpendicular to the direction in which the image is sharp, which is the sagittal direction.