Example

Obtain refraction data and biometric measurements from the patient using an autorefractor and an optical biometer (Huvitz HRK-8000A Auto-REF Keratometer and IOLMaster 700 used here).

Specifically, you will need:
- axial length (AL, mm)
- corneal radius of curvature, first meridian (CR1, mm)
- corneal radius of curvature, second meridian - perpendicular to first meridian (CR2, mm)
- axis of the second meridian (CR2_axis, degrees)
- crystalline lens thickness (LT, mm)
- anterior chamber depth (ACD, mm)
- sphere (Sph, diopters)
- cylinder (Cyl, diopters)
- cylinder axis (Cyl_axis, degrees)
- vertex distance for the refraction data (VD, mm)

In addition, for the spherical eye model, you need to compute:
- vitreous chamber depth (VCD, mm), defined as AL-ACD-LT
- spherical equivalent refraction (SER, diopters), defined as Sph + (Cyl/2)
- mean corneal radius of curvature (CR, mm), defined as (CR1+CR2)/2

Example measurements for a real patient can be found in the sample.csv file, or seen in tabulated form below:

AL	CR1	CR1_axis	CR2	CR2_axis	LT	ACD	Sph	Cyl	Cyl_axis		CR	SER	VCD
24.7914560	8.01306374	178.550876	7.87138679	88.5508764	3.57510566	3.91537432	-1.66	-0.3	33.3356		7.94222526	-1.81	17.3009761

Spherical schematic eye model

Beginning with the simpler model, open the Gullstrand_Spect_SER_Spher_Cornea.zmx file in Zemax. A window similar to the one below should appear.

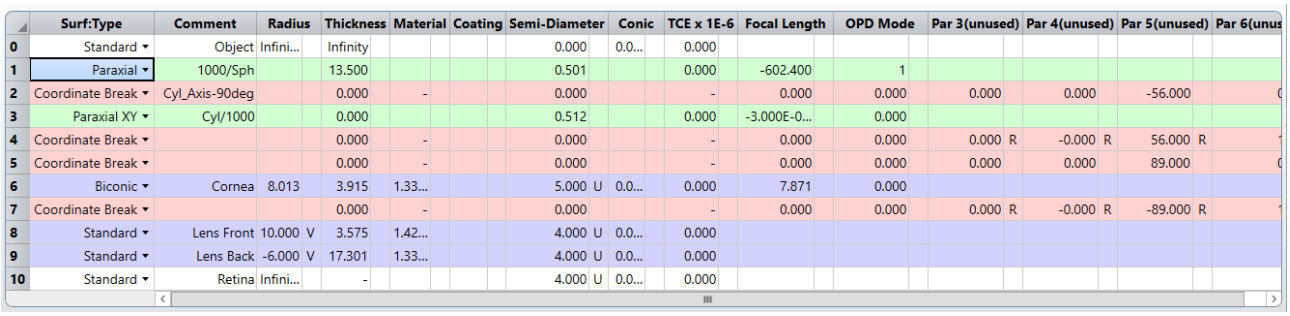
	Surf:Type	Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Conic	TCE x 1E-6	Focal Length	OPD Mode	Par 3(unused)	Par 4(unused)	Par 5(unused)	Par 6(unused)
0	Standard	Object	Infini...	Infinity			0.000	0.0...	0.000						
1	Paraxial	1000/SER		13.500			0.500		0.000	1.000E+008	1				
2	Coordinate Break	0		0.000	-		0.000		-	0.000	0.000	0.000	0.000	0.000	0
3	Paraxial XY	0		0.000			0.500		0.000	0.000	0.000				
4	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	0.000 R	1 R
5	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000	0.000	0.000	0
6	Standard	Cornea	7.800	3.600	1.33...		5.000 U	0.0...	0.000						
7	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	0.000 R	1 R
8	Standard	Lens Front	10.000 V	3.600	1.42...		4.000 U	0.0...	0.000						
9	Standard	Lens Back	-6.000 V	16.696	1.33...		4.000 U	0.0...	0.000						
10	Standard	Retina	Infini...	-			4.000 U	0.0...	0.000						

1) Click on row “1” and enter the spherical equivalent refraction (SER, -1.81) into the “Focal length” field. The value entered must be 1000/SER, so in this example (1000/-1.81) = -552.486 was entered.
2) Enter the vertex distance (VD, 13.500) into the “Thickness” field.
3) Click on row “6” and enter the mean corneal radius (CR, 7.942) in the “Radius” column.
4) Also on row “6”, enter the anterior chamber depth (ACD, 3.915) into the “Thickness” column.
5) On row “8”, enter the lens thickness (LT, 3.575) into the “Thickness” column.
6) On row “9” enter the vitreous chamber depth (VCD, 17.301) into the “Thickness” column.
7) Finally, click “Optimize” in the menu bar at the top of the window and then click the “Optimize!” button on the ribbon that appears. Click “Start” to start the optimization, and click “Exit” to close the optimization window when it is finished.
8) The optimized lens radii can be found in rows “8” and “9” in the “Radius” column (9.676, -5.807 for this example).

	Surf:Type	Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Conic	TCE x 1E-6	Par 1(unused)	Par 2(unused)	Par 3(unused)	Par 4(unused)	Par 5(unused)	Par 6(unused)
0	Standard	Object	Infini...	Infinity			0.000	0.0...	0.000						
1	Paraxial	1000/SER		13.500			0.500		0.000	-552.486	1				
2	Coordinate Break	0		0.000	-		0.000		-	0.000	0.000	0.000	0.000	0.000	0
3	Paraxial XY	0		0.000			0.512		0.000	0.000	0.000				
4	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	0.000 R	1 R
5	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000	0.000	0.000	0
6	Standard	Cornea	7.942	3.915	1.33...		5.000 U	0.0...	0.000						
7	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	0.000 R	1 R
8	Standard	Lens Front	9.676 V	3.573	1.42...		4.000 U	0.0...	0.000						
9	Standard	Lens Back	-5.807 V	17.301	1.33...		4.000 U	0.0...	0.000						
10	Standard	Retina	Infini...	-			4.000 U	0.0...	0.000						

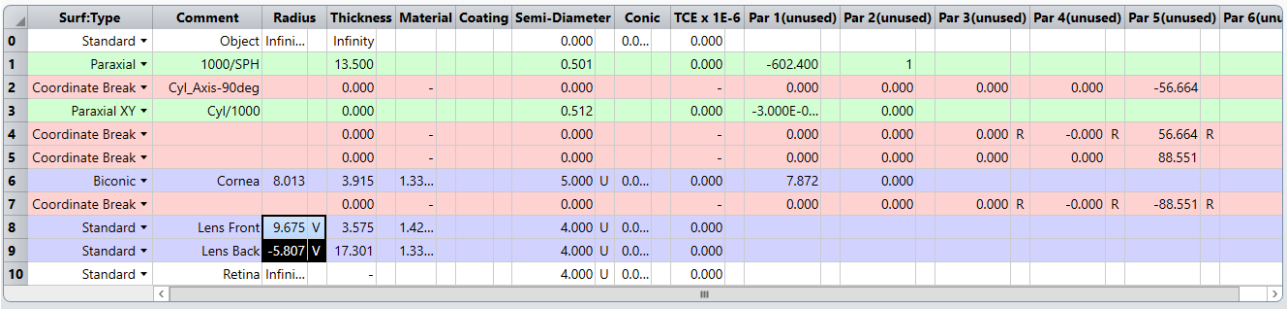
Biconic schematic eye model

Open the Gullstrand_Spect_SCA_Bi_Cornea.zmx file in Zemax to find a window similar to the one below.



	Surf:Type	Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Conic	TCE x 1E-6	Focal Length	OPD Mode	Par 3(unused)	Par 4(unused)	Par 5(unused)	Par 6(unus
0	Standard	Object	Infini...	Infinity			0.000	0.0...	0.000						
1	Paraxial	1000/Sph		13.500			0.501		0.000	-602.400	1				
2	Coordinate Break	Cyl_Axis-90deg		0.000	-		0.000		-	0.000	0.000	0.000	0.000	-56.000	
3	Paraxial XY	Cyl/1000		0.000			0.512		0.000	-3.000E-0...	0.000				
4	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	56.000 R	
5	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000	0.000	89.000	
6	Biconic	Cornea	8.013	3.915	1.33...		5.000 U	0.0...	0.000	7.871	0.000				
7	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	-89.000 R	
8	Standard	Lens Front	10.000 V	3.575	1.42...		4.000 U	0.0...	0.000						
9	Standard	Lens Back	-6.000 V	17.301	1.33...		4.000 U	0.0...	0.000						
10	Standard	Retina	Infini...	-			4.000 U	0.0...	0.000						

1) Click on row “1” and enter the sphere (Sph, -1.66) into the “Focal length” field. The value entered must be 1000/Sph so in this example (1000/-1.66) = -602.400 was entered.
2) The cylinder axis (Cyl_axis) is entered on row “2”. The value entered must be Cyl_axis-90deg so type (33.3356-90) = -56.6644 into the “Tilt about Z” column.
3) The cylinder (Cyl, -0.3) value is to be divided by 1000 and entered into the column “X-power” on row “3”. That is, enter (-0.3/1000) = -0.0003.
4) On row “6” enter the corneal radius of curvature of the first meridian (CR1, 8.013) into the column “Radius”, and the corneal radius of curvature of the second meridian (CR2, 7.872) into column “X-radius”.
5) Enter the anterior chamber depth (ACD, 3.915) into the “Thickness” column on row “6”.
6) The axis of the meridian entered as “X-radius”, should be entered on row “5”, column “Tilt about Z”. Here, the second meridian CR2 was entered as “X-radius”, and the corresponding axis (CR2_axis, 88.551) was entered. The axis of the first meridian is assumed to be perpendicular to the axis of the second meridian.
7) On row “8” enter the lens thickness (LT, 3.575) into the “Thickness” column.
8) On row “9” enter the vitreous chamber depth (VCD, 17.301) into the “Thickness” column.
9) Finally, click “Optimize” in the menu bar at the top of the window and then click the “Optimize!” button on the ribbon that appears. Click “Start” to start the optimization, and click “Exit” to close the optimization window when it is finished.
10) The optimized lens radii can be found in rows “8” and “9” in the “Radius” column (9.675, -5.807, for this example).



	Surf:Type	Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Conic	TCE x 1E-6	Par 1(unused)	Par 2(unused)	Par 3(unused)	Par 4(unused)	Par 5(unused)	Par 6(unu
0	Standard	Object	Infini...	Infinity			0.000	0.0...	0.000						
1	Paraxial	1000/SPH		13.500			0.501		0.000	-602.400	1				
2	Coordinate Break	Cyl_Axis-90deg		0.000	-		0.000		-	0.000	0.000	0.000	0.000	-56.664	
3	Paraxial XY	Cyl/1000		0.000			0.512		0.000	-3.000E-0...	0.000				
4	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	56.664 R	
5	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000	0.000	88.551	
6	Biconic	Cornea	8.013	3.915	1.33...		5.000 U	0.0...	0.000	7.872	0.000				
7	Coordinate Break			0.000	-		0.000		-	0.000	0.000	0.000 R	-0.000 R	-88.551 R	
8	Standard	Lens Front	9.675 V	3.575	1.42...		4.000 U	0.0...	0.000						
9	Standard	Lens Back	-5.807 V	17.301	1.33...		4.000 U	0.0...	0.000						
10	Standard	Retina	Infini...	-			4.000 U	0.0...	0.000						