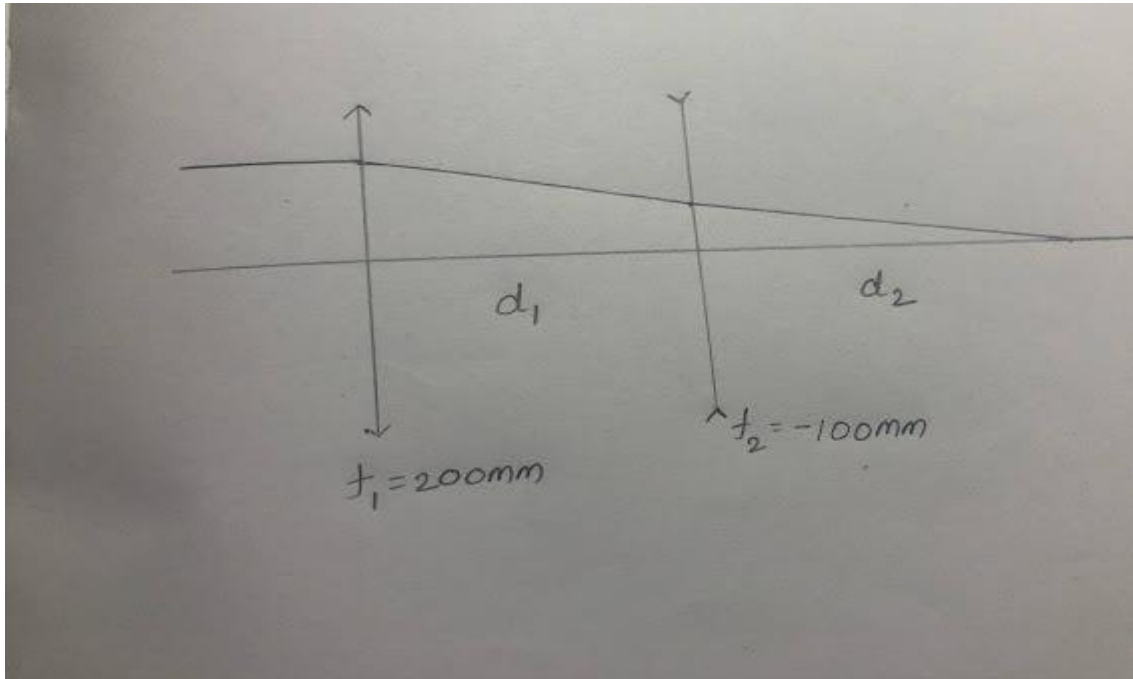


## First Order Design

Consider two lenses  $\phi_1$  and  $\phi_2$  separated by a distance  $d_1$ . The object is placed at Infinity and the image should be formed in the right plane to  $\phi_2$ .



Consider a ray parallel to axis at height  $y_0$  and  $u_0=0$

	0	1	2	3
$\phi$	0	$\phi_1$	$\phi_2$	0
$d$		$d_1$	$d_2$	
$y$	$y_0$	$y_0$	$y_0(1 - d_1\phi_1)$	0
$u$	0	$-\phi_1 y_0$	$-y_0(\phi_1 + \phi_2 - d_1\phi_1\phi_2)$	

$$y_1 = y_0$$

$$u_1 = 0 - (\phi_1 * y_0) = -\phi_1 y_0$$

$$y_2 = y_1 + (d_1 * (-\phi_1 y_0)) = y_0(1 - d_1\phi_1)$$

$$u_2 = -\phi_1 y_0 - \phi_2 y_0(1 - d_1\phi_1) = -y_0(\phi_1 + \phi_2 - d_1\phi_1\phi_2) = -y_0\phi$$

$\phi$  is effective power of the system

Surface 3 is image plane. And  $y_3 = 0$

$$y_3 = y_0(1 - d_1\phi_1) + d_2[-y_0(\phi_1 + \phi_2 - d_1\phi_1\phi_2)] = 0$$

$$y_0(1 - d_1\phi_1) = d_2[y_0(\phi_1 + \phi_2 - d_1\phi_1\phi_2)]$$

$$y_0(1 - d_1\phi_1) = d_2y_0\phi$$

$$d_2 = (1 - d_1\phi_1) / \phi$$

$$d_1 + d_2 < 300\text{mm}$$

### Config1 (EFL F=400mm):

$$\Phi = 1/F = 1/400$$

$$\text{Assume } f_1 = 200\text{mm} \rightarrow \phi_1 = 1/200$$

$$\text{Assume } d_1 + d_2 = 250\text{mm}$$

$$d_2 = 400(1 - d_1\phi_1) = 400 - 2d_1$$

$$250 = 400 - d_1$$

$$d_1 = 150\text{ mm}$$

$$d_2 = 100$$

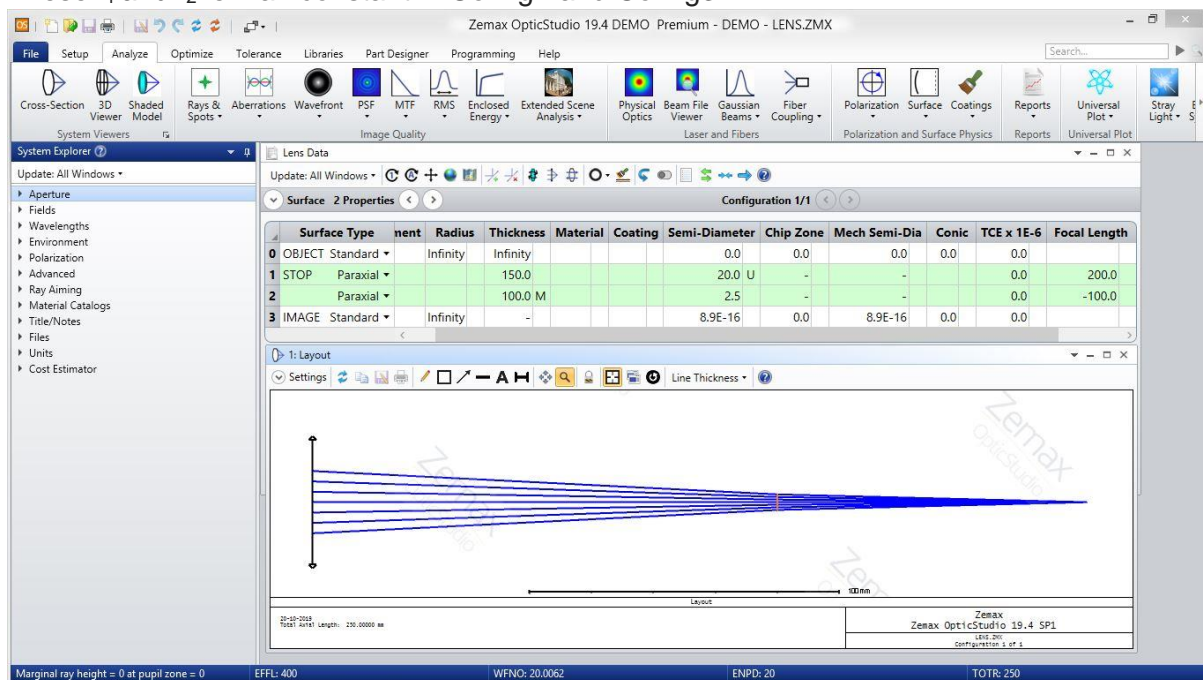
$$\Phi = \phi_1 + \phi_2 - d_1\phi_1\phi_2$$

$$1/400 = 1/200 + \phi_2 - (150)(1/200)\phi_2$$

$$-1/400 = 0.25 \phi_2$$

$$\phi_2 = -1/100 \rightarrow f_2 = -100\text{mm}$$

These  $f_1$  and  $f_2$  remain constant in Config2 and Config3



### Config2(EFL=35cm):

$$\Phi = \phi_1 + \phi_2 - d_1\phi_1\phi_2$$

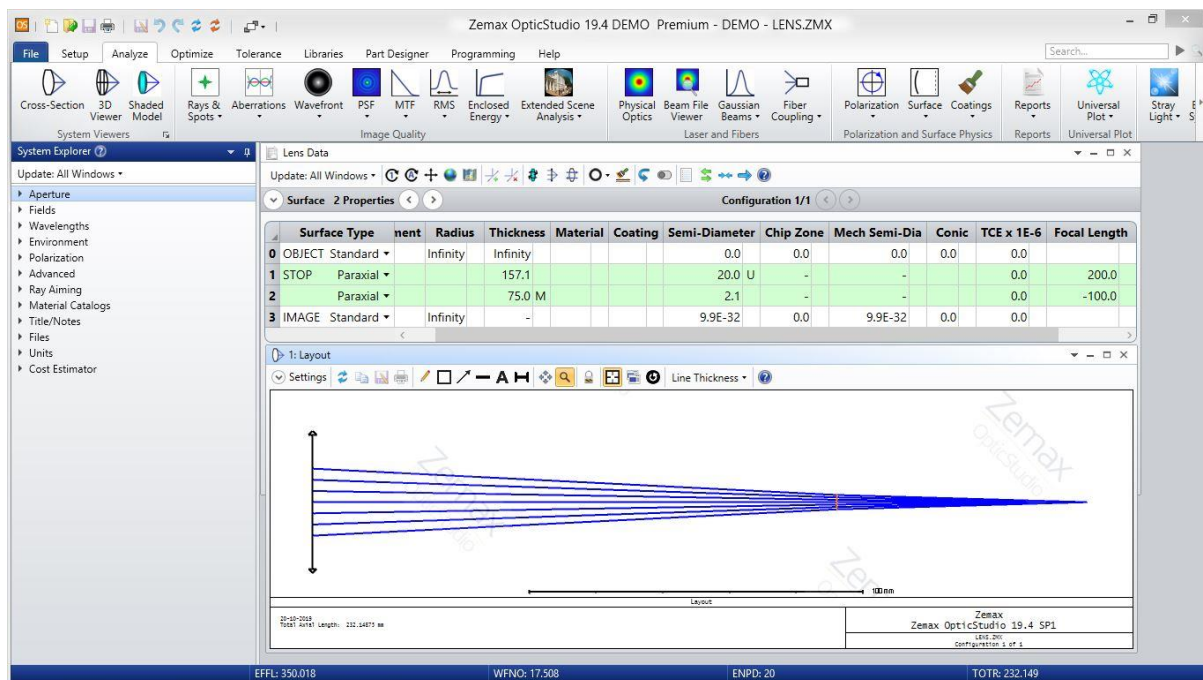
$$1/350 = 1/200 + (-1/100) - d_1(1/200)(-1/100)$$

$$1/350 + 1/200 = d_1/(20000)$$

$$d_1 = 157.14 \text{ mm}$$

$$d_2 = 350(1 - d_1\phi_1) = 350(1 - (157.14/200))$$

$$d_2 = 75 \text{ mm}$$



### Config3(EFL=30cm):

$$\Phi = \phi_1 + \phi_2 - d_1\phi_1\phi_2$$

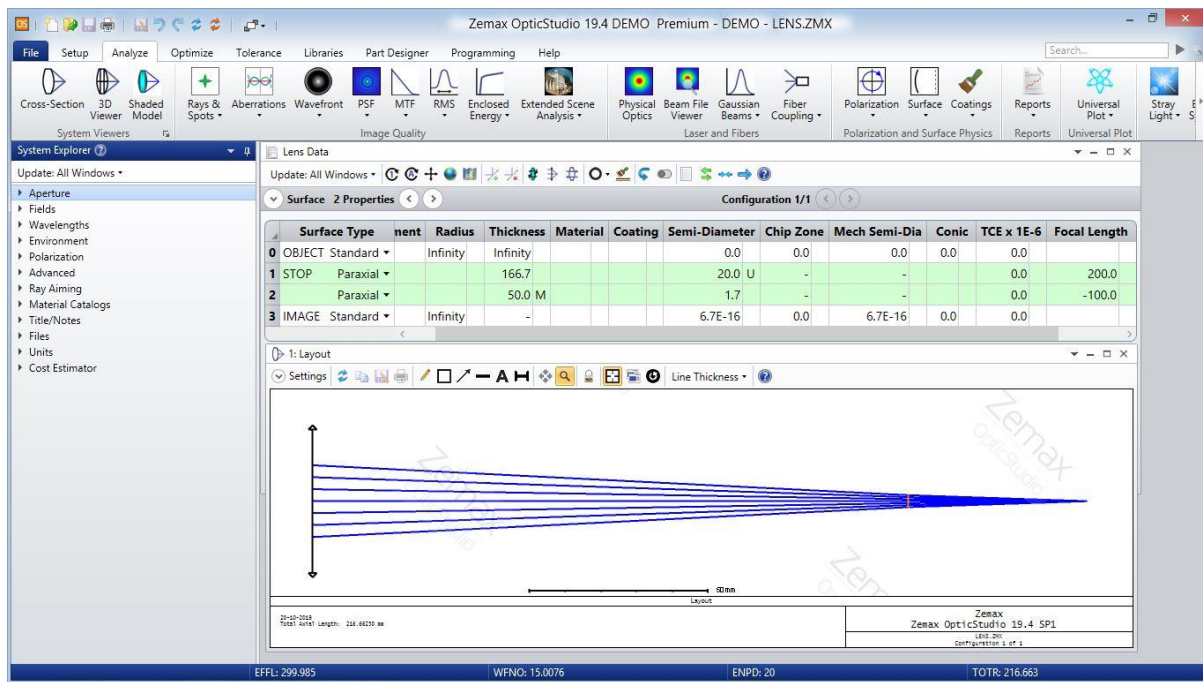
$$1/300 = 1/200 + (-1/100) - d_1(1/200)(-1/100)$$

$$1/300 + 1/200 = d_1/(20000)$$

$$d_1 = 166.67 \text{ mm}$$

$$d_2 = 300(1 - d_1\phi_1) = 300(1 - (166.67/200))$$

$$d_2 = 50\text{mm}$$



	EFL(mm)	f <sub>1</sub> (mm)	f <sub>2</sub> (mm)	d <sub>1</sub> (mm)	d <sub>2</sub> (mm)	TOTR(mm)
Config1	400	200	-100	150	100	250
Config2	350	200	-100	157.14	75	232.14
Config3	300	200	-100	166.67	50	216.67