

OPTI 435/535 Midterm 2009 Solutions

Problem 1

The wavefront error is given by

$$W[r, \theta] = 0.00004 * r^4 - 0.00003 * r^3 * \text{Cos}[\theta]$$

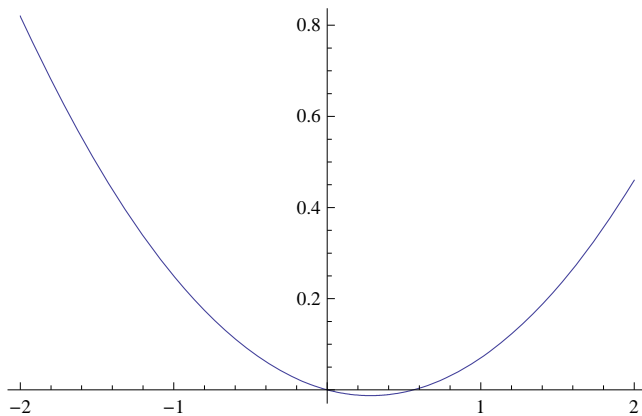
$$0.00004 r^4 - 0.00003 r^3 \text{Cos}[\theta]$$

Next calculate the power error in diopters

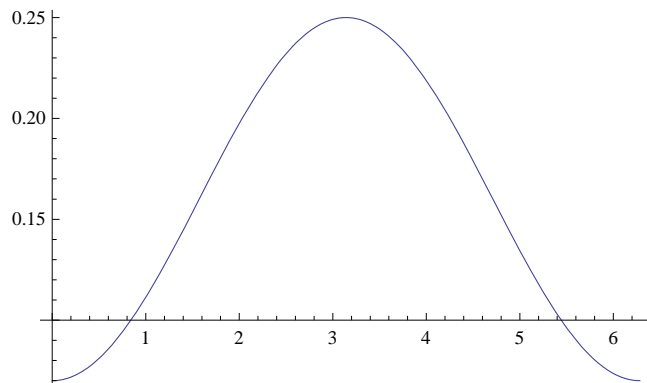
$$d\phi[r, \theta] = \text{FullSimplify}[1000 * D[W[r, \theta], r] / r]$$

$$r (0.16 r - 0.09 \text{Cos}[\theta])$$

$$\text{Plot}[r (0.16 r - 0.09), \{r, -2, 2\}]$$



$$\text{Plot}[0.16 - 0.09 * \text{Cos}[\theta], \{\theta, 0, 2\pi\}]$$



Problem 2

The screenshot shows the 'Astigmatic Decomposition' window with the 'Plus Cylinder Form' selected. The input fields for Rx1 and Rx2 are: Sphere (1), Cylinder (2), Axis (40) for Rx1; and Sphere (1), Cylinder (2), Axis (30) for Rx2. The resulting 'Net' values are: Sphere (2.03), Cylinder (3.94), Axis (35.00), J0 (-0.674), J45 (-1.851), and M (4.000).

| | Sphere | Cylinder | Axis | J0 | J45 | M |
|------------|-------------|-------------|--------------|--------|--------|-------|
| Rx1 | 1 | 2 | 40 | -0.174 | -0.985 | 2.000 |
| Rx2 | 1 | 2 | 30 | -0.500 | -0.866 | 2.000 |
| Net | 2.03 | 3.94 | 35.00 | -0.674 | -1.851 | 4.000 |

Plus Cylinder Form
 Minus Cylinder Form

The screenshot shows the 'Astigmatic Decomposition' window with the 'Minus Cylinder Form' selected. The input fields for Rx1 and Rx2 are the same as in the previous screenshot. The resulting 'Net' values are: Sphere (5.97), Cylinder (-3.94), Axis (125.00), J0 (-0.674), J45 (-1.851), and M (4.000).

| | Sphere | Cylinder | Axis | J0 | J45 | M |
|------------|-------------|--------------|---------------|--------|--------|-------|
| Rx1 | 1 | 2 | 40 | -0.174 | -0.985 | 2.000 |
| Rx2 | 1 | 2 | 30 | -0.500 | -0.866 | 2.000 |
| Net | 5.97 | -3.94 | 125.00 | -0.674 | -1.851 | 4.000 |

Plus Cylinder Form
 Minus Cylinder Form

Problem 3

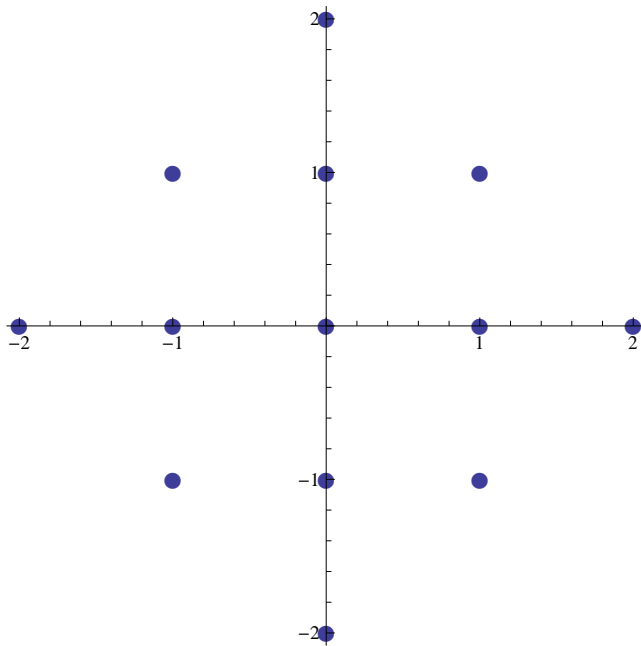
For a 1 mm spacing between the lenslets only the following coordinates pass through the pupil

```
points = {{-2, 0}, {-1, 0}, {0, 0}, {1, 0}, {2, 0},
          {-1, 1}, {0, 1}, {1, 1}, {0, 2}, {-1, -1}, {0, -1}, {1, -1}, {0, -2}}
```

```
{{-2, 0}, {-1, 0}, {0, 0}, {1, 0}, {2, 0}, {-1, 1},
          {0, 1}, {1, 1}, {0, 2}, {-1, -1}, {0, -1}, {1, -1}, {0, -2}}
```

The unaberrated spot pattern looks like

```
ListPlot[points, AspectRatio -> 1, PlotMarkers -> {Automatic, Medium}]
```



The spot shifts are given by $\Delta x = -f \frac{dW}{dx}$ and $\Delta y = -f \frac{dW}{dy}$. For $f = 24$ mm and $W = -0.002 x^2$

$$\Delta x = -f * D[-0.002 * x^2, x]$$

$$\Delta y = -f * D[-0.002 * x^2, y]$$

$$0.004 f x$$

$$0$$

So Δy always equals zero and Δx is only dependent on the x position. Possible values for Δx are therefore

$$\Delta x /. \{f \rightarrow 24, x \rightarrow -2\}$$

$$\Delta x /. \{f \rightarrow 24, x \rightarrow -1\}$$

$$\Delta x /. \{f \rightarrow 24, x \rightarrow 0\}$$

$$\Delta x /. \{f \rightarrow 24, x \rightarrow 1\}$$

$$\Delta x /. \{f \rightarrow 24, x \rightarrow 2\}$$

$$-0.192$$

$$-0.096$$

$$0$$

$$0.096$$

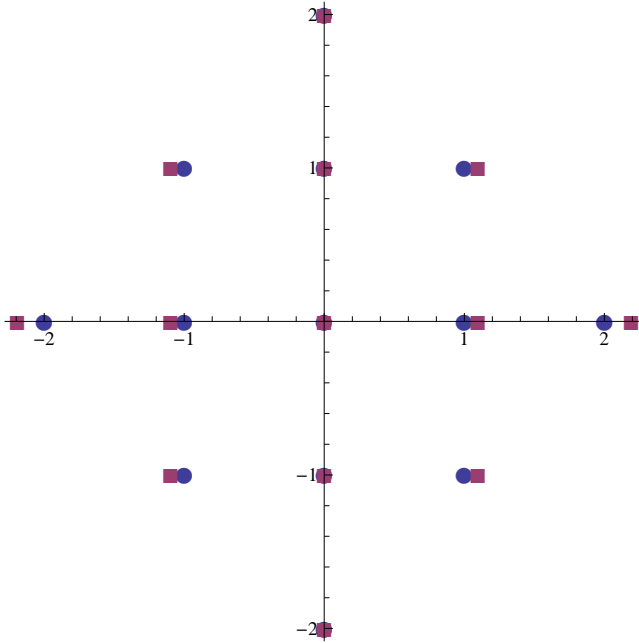
$$0.192$$

The aberrated spots are then located at

```

shiftedpoints =
  {{-2 - 0.192, 0}, {-1 - 0.096, 0}, {0, 0}, {1 + 0.096, 0}, {2 + 0.192, 0}, {-1 - 0.096, 1},
   {0, 1}, {1 + 0.096, 1}, {0, 2}, {-1 - 0.096, -1}, {0, -1}, {1 + 0.096, -1}, {0, -2}}
  {{-2.192, 0}, {-1.096, 0}, {0, 0}, {1.096, 0}, {2.192, 0}, {-1.096, 1},
   {0, 1}, {1.096, 1}, {0, 2}, {-1.096, -1}, {0, -1}, {1.096, -1}, {0, -2}}
ListPlot[{points, shiftedpoints}, AspectRatio -> 1, PlotMarkers -> {Automatic, Medium}]

```



Problem 4

- (a) Since the far point is in front of the eye, the person is near - sighted.
- (b) The accommodative amplitude is $1/(\text{Near Point in m}) - 1/(\text{Far Point in m}) = 2 \text{ D} - 1 \text{ D} = 1 \text{ D}$.
- (c) A -1 D lens will image infinity to their Far Point.