**Diseases of the Eye**

**ABSTRACT:** Diseases of the eye, in this case, refers to the mal-development of the shape of an eye, leading the eye either being short or long when compared to a normal, healthy eye. Whether you are nearsighted or farsighted, having a long eye or short eye respectively, the near and far point in either case can be found using the mirror/lens equations, 1/q + 1/p = 1/f. Where f is the focal length, q is the distance to where the image is formed after light passing through a lens or combination of lenses, and p is the object’s distance, taken as the distance from the rim of the eye, not including the curvature of the cornea. The effective focal length is used when there is a combination of lenses and is found by 1/f\_eff = 1/f\_1 + 1/f\_2 + … + 1/f\_n, for n lenses. Power is defined as the reciprocal of the focal length and is denoted as P. The near point for a normal eye is 25cm and the far point is effectively infinity. Using the same power from a normal eye at 36.1 cm, the near point for a long eye is 21 +- 0.1 cm and the far point is 152 +- 1 cm. For a short eye, the near point is 45.6 +- 0.1 cm and the effective far point was infinity, denoted by a negative value of -51cm.

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**INTRODUCTION:**

The relevant diseases of the eye for this experiment refer to a nearsighted (Myopia) eye and a farsighted (Hyperopia) eye. In general, the lense equation is written as 1/f = 1/p + 1/q. Power is denoted as the reciprocal of the focal length, f. At a given object distance, p = 36.1 cm, a normal eye generates approximately 11 m^-1 of power. For a long eye at distance p, the power generated will be smaller than that of a normal eye. For a short eye, the power generated will be greater. Distance p = 36.1cm is unambiguously defined here because this is the distance at which a normal eye generates enough power to produce a clear image reflected on the retina. This experiment takes the optimal power at distance p, and uses this value to evaluate how each diseased eye can be corrected using the appropriate supplemental lens in front of the eye. The goal of this experiment is to evaluate the optimal focal length and power of a corrective lens for a short and long eye at distance p = 36.1cm. Further, another goal of this experiment is to evaluate the near point and far point of both a short eye and a long eye, taking 60m to be effectively a distance of infinity because at any distance past this value, a normal eye will generate roughly the same power as 60m. We take 25cm to be the near point for a normal eye.

**PROCEDURE:**

There are two main procedural challenges one must confront in order to evaluate and predict the near point and far point of a long or short eye: one must be able to accurately simulate the effects of the corneal lens and crystalline lens which produce and image on a simulated retina, and one must be able to experimentally find the appropriate corrective lens for both diseased eyes.

To accurately simulate an eye, a PASCO Human Eye Model, which contains a normal simulated corneal and crystalline lens was filled with water to simulate the refracted light passing through the inner tissue of an eye. A simple curved surface was placed at various distances at the back of well, representing the different distances to the retina in both diseased eyes as well as the distance to a normally placed retina. A light bulb with four colored arrows pointing in each cardinal direction was placed in front of the eye to simulate an object whose reflected light hits the lenses of the eye, which then produces an image on the simulated retina.

To determine the best corrective lens for a short or long eye, an additional lens was placed in front the simulated corneal lens, in order to represent the lenses of a pair of corrective eye glasses. The PASCO Lens Set was used to experimentally determine the appropriate corrective lens for each diseased eye.

The near and far point for normal eye were given. An spreadsheet was made with three main columns representing the short, normal and long eye. Under each section, four columns were made for the values of q, p, f, and the power, P, generated at a distance p. For a short eye, q was a fixed value of 0.097m. For a long eye, q was 0.13m. For a normal eye, q was measured to be 0.12m. For the values of p, 40 different values were chosen. The first 20 values were equally spaced between 0.125m and 1m, and the second 20 values were equally spaced between 1m and 60m, effectively representing an object distance of infinity. The effective focal length and power generated were then calculated under each section and recorded appropriately using the lens equations. The eye model was moved to a distance, p, where a normal eye generated a clear image on the simulated retina. The two rows which represented this value of p were highlighted in the normal eye section. Various lenses were placed in front of the eye, with the retinal distance q being the distance to the retina in the simulated eye, using the lens kit. The appropriate focal lengths of the corrective lenses for both short eye and a long eye were recorded when the corrective lens resulted in a clear image being produced on the simulated retina. The near point and far point for a short and long eye were found by using the lens equation, using the power generated in a normal at a distance of 0.25m and 60m respectively.

**RESULTS AND ANALYSIS**

As described in the Procedures section, the optimal corrective lens for a short eye at a distance of p = 0.361m was found to have a focal length of -1m. This value makes sense with respect to the simulated data in the table because the corrective lens must generate a negative value for a short eye, where the power generated at any distance will be greater than that of a normal eye, so the corrective lens must reduce the overall power generated for the short eye. The optimal corrective lens for a long eye was found to have a focal length of 0.4m. This value makes sense for similar reasons, where the overall power generated must be increased due to the long eye producing too little power without a corrective lens. The power generated for this corrective lens was found to be 2.5m^-1, for a long eye, and the power generated for the short eye’s corrective lens was evaluated to be -1m^-1.

For calculating the near for a short and long eye, the fixed value of P = 12.5m^-1 was used because this is the power that is generated in a normal eye model for the near point of p = 0.25m in a normal eye. Thus, for a short eye, the near point, p, was found by using the lens equation with 1/f being 12.5m^-1. So, the near point was found by

p = (12.5m^-1 – 1/0.097m)^-1 = 0.456m. The far point was found by p = (8.35m^-1 – 1/0.097m)^-1 = -51m. This value tells us that the far point for a short eye will be effectively infinity because the short eye is farsighted, meaning it can generate enough power to produce a clear image at any distance greater the p = 60m, where the P = 8.35m^-1 at this distance.

For a long eye, the same procedure was used. The near point was found by p = (12.5m^-1 – 1/0.13m)^-1 = 0.21m. The far point was found by p = (8.35m^-1 – 1/0.13m)^-1 = 1.52m. These values indicate that any object placed at a distance less than or equal to 0.21m will produce a clear image for a nearsighted eye.

The table below represents the raw data obtained from calculating f\_eff and P for each value of p under each section, representing the different types of eyes in our experiment.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Short Eye | | | | Normal Eye | | | | Long Eye | | | |
| **q (m)** | **p (m)** | **f\_eff (m)** | **Power (m^-1)** | **q (m)** | **p (m)** | **f\_eff (m)** | **Power (m^-1)** | **q (m)** | **p (m)** | **f\_eff (m)** | **Power (m^-1)** |
| 0.097 | 0.125 | 0.055 | 18.309 | 0.120 | 0.125 | 0.061 | 16.333 | 0.130 | 0.125 | 0.064 | 15.692 |
| 0.097 | 0.171 | 0.062 | 16.157 | 0.120 | 0.171 | 0.071 | 14.181 | 0.130 | 0.171 | 0.074 | 13.540 |
| 0.097 | 0.217 | 0.067 | 14.918 | 0.120 | 0.217 | 0.077 | 12.942 | 0.130 | 0.217 | 0.081 | 12.301 |
| 0.097 | 0.263 | 0.071 | 14.112 | 0.120 | 0.263 | 0.082 | 12.136 | 0.130 | 0.263 | 0.087 | 11.495 |
| 0.097 | 0.309 | 0.074 | 13.546 | 0.120 | 0.309 | 0.086 | 11.570 | 0.130 | 0.309 | 0.092 | 10.929 |
| 0.097 | 0.355 | 0.076 | 13.126 | 0.120 | 0.355 | 0.090 | 11.150 | 0.130 | 0.355 | 0.095 | 10.509 |
| 0.097 | 0.401 | 0.078 | 12.803 | 0.120 | 0.401 | 0.092 | 10.827 | 0.130 | 0.401 | 0.098 | 10.186 |
| 0.097 | 0.447 | 0.080 | 12.546 | 0.120 | 0.447 | 0.095 | 10.570 | 0.130 | 0.447 | 0.101 | 9.929 |
| 0.097 | 0.493 | 0.081 | 12.338 | 0.120 | 0.493 | 0.097 | 10.362 | 0.130 | 0.493 | 0.103 | 9.721 |
| 0.097 | 0.539 | 0.082 | 12.165 | 0.120 | 0.539 | 0.098 | 10.189 | 0.130 | 0.539 | 0.105 | 9.548 |
| 0.097 | 0.585 | 0.083 | 12.019 | 0.120 | 0.585 | 0.100 | 10.043 | 0.130 | 0.585 | 0.106 | 9.402 |
| 0.097 | 0.631 | 0.084 | 11.894 | 0.120 | 0.631 | 0.101 | 9.918 | 0.130 | 0.631 | 0.108 | 9.277 |
| 0.097 | 0.677 | 0.085 | 11.786 | 0.120 | 0.677 | 0.102 | 9.810 | 0.130 | 0.677 | 0.109 | 9.169 |
| 0.097 | 0.723 | 0.086 | 11.692 | 0.120 | 0.723 | 0.103 | 9.716 | 0.130 | 0.723 | 0.110 | 9.075 |
| 0.097 | 0.769 | 0.086 | 11.610 | 0.120 | 0.769 | 0.104 | 9.634 | 0.130 | 0.769 | 0.111 | 8.993 |
| 0.097 | 0.815 | 0.087 | 11.536 | 0.120 | 0.815 | 0.105 | 9.560 | 0.130 | 0.815 | 0.112 | 8.919 |
| 0.097 | 0.861 | 0.087 | 11.471 | 0.120 | 0.861 | 0.105 | 9.495 | 0.130 | 0.861 | 0.113 | 8.854 |
| 0.097 | 0.907 | 0.088 | 11.412 | 0.120 | 0.907 | 0.106 | 9.436 | 0.130 | 0.907 | 0.114 | 8.795 |
| 0.097 | 0.953 | 0.088 | 11.359 | 0.120 | 0.953 | 0.107 | 9.383 | 0.130 | 0.953 | 0.114 | 8.742 |
| 0.097 | 0.999 | 0.088 | 11.310 | 0.120 | 0.999 | 0.107 | 9.334 | 0.130 | 0.999 | 0.115 | 8.693 |
| 0.097 | 1.000 | 0.088 | 11.309 | 0.120 | 1.000 | 0.107 | 9.333 | 0.130 | 1.000 | 0.115 | 8.692 |
| 0.097 | 4.100 | 0.095 | 10.553 | 0.120 | 4.100 | 0.117 | 8.577 | 0.130 | 4.100 | 0.126 | 7.936 |
| 0.097 | 7.200 | 0.096 | 10.448 | 0.120 | 7.200 | 0.118 | 8.472 | 0.130 | 7.200 | 0.128 | 7.831 |
| 0.097 | 10.300 | 0.096 | 10.406 | 0.120 | 10.300 | 0.119 | 8.430 | 0.130 | 10.300 | 0.128 | 7.789 |
| 0.097 | 13.400 | 0.096 | 10.384 | 0.120 | 13.400 | 0.119 | 8.408 | 0.130 | 13.400 | 0.129 | 7.767 |
| 0.097 | 16.500 | 0.096 | 10.370 | 0.120 | 16.500 | 0.119 | 8.394 | 0.130 | 16.500 | 0.129 | 7.753 |
| 0.097 | 19.600 | 0.097 | 10.360 | 0.120 | 19.600 | 0.119 | 8.384 | 0.130 | 19.600 | 0.129 | 7.743 |
| 0.097 | 22.700 | 0.097 | 10.353 | 0.120 | 22.700 | 0.119 | 8.377 | 0.130 | 22.700 | 0.129 | 7.736 |
| 0.097 | 25.800 | 0.097 | 10.348 | 0.120 | 25.800 | 0.119 | 8.372 | 0.130 | 25.800 | 0.129 | 7.731 |
| 0.097 | 28.900 | 0.097 | 10.344 | 0.120 | 28.900 | 0.120 | 8.368 | 0.130 | 28.900 | 0.129 | 7.727 |
| 0.097 | 32.000 | 0.097 | 10.341 | 0.120 | 32.000 | 0.120 | 8.365 | 0.130 | 32.000 | 0.129 | 7.724 |
| 0.097 | 35.100 | 0.097 | 10.338 | 0.120 | 35.100 | 0.120 | 8.362 | 0.130 | 35.100 | 0.130 | 7.721 |
| 0.097 | 38.200 | 0.097 | 10.335 | 0.120 | 38.200 | 0.120 | 8.360 | 0.130 | 38.200 | 0.130 | 7.718 |
| 0.097 | 41.300 | 0.097 | 10.333 | 0.120 | 41.300 | 0.120 | 8.358 | 0.130 | 41.300 | 0.130 | 7.717 |
| 0.097 | 44.400 | 0.097 | 10.332 | 0.120 | 44.400 | 0.120 | 8.356 | 0.130 | 44.400 | 0.130 | 7.715 |
| 0.097 | 47.500 | 0.097 | 10.330 | 0.120 | 47.500 | 0.120 | 8.354 | 0.130 | 47.500 | 0.130 | 7.713 |
| 0.097 | 50.600 | 0.097 | 10.329 | 0.120 | 50.600 | 0.120 | 8.353 | 0.130 | 50.600 | 0.130 | 7.712 |
| 0.097 | 53.700 | 0.097 | 10.328 | 0.120 | 53.700 | 0.120 | 8.352 | 0.130 | 53.700 | 0.130 | 7.711 |
| 0.097 | 56.800 | 0.097 | 10.327 | 0.120 | 56.800 | 0.120 | 8.351 | 0.130 | 56.800 | 0.130 | 7.710 |
| 0.097 | 60.000 | 0.097 | 10.326 | 0.120 | 60.000 | 0.120 | 8.350 | 0.130 | 60.000 | 0.130 | 7.709 |