8.0 Curved Surfaces and/or Lenses

8.1 Radius of Curvature

8.1.1 Spherometer

A spherometer is an instrument that measures the sag of a surface with great precision. A common spherometer is the Aldis spherometer in which three small balls are arranged to form an equilateral triangle. In the center of the triangle there is a probe mounted on a micrometer. In use, the surface to be measured is placed on the balls, and the probe is brought into contact with the surface. The sag of the surface is measured using a micrometer. If we denote the sag of the surface by h, the distance between the center of the balls d, and the radii of the balls by r, then the radius of curvature of the unknown surface is given by

$$R = \frac{d^2}{6h} + \frac{h}{2} \pm r,$$

Where the positive sign is taken when the unknown surface is concave, and the negative sign when convex.

If the balls are arranged to form a triangle of sides d_1, d_2, and d_3, the radius of curvature is given by

$$R = \frac{(d_1 + d_2 + d_3)^2}{54h} + \frac{h}{2} \pm r.$$

If a ring spherometer of radius r is used, the radius of curvature is given by

$$R = \frac{r^2}{2h} + \frac{h}{2}.$$

The major source of inaccuracy in using a spherometer is determining the exact point of contact between the probe and the surface being tested.

In some spherometers the point of contact is determined by observing the Newton’s ring interference pattern formed between the test surface and an optical surface mounted on the end of the probe. As the probe is brought up to the surface, the ring pattern expands, but when the point of contact is reached, no further motion occurs.

8.1.3 Newton's Rings

A Fizeau interferometer can also be used to measure radius of curvature of a surface. A surface having a long radius of curvature can be compared interferometrically with a flat surface to yield Newton's rings as shown in Fig. 8.1.3-1. When viewed from above we see a series of concentric rings around a central dark spot. The radius ρ_m of the m^{th} dark ring from the center is given by

$$\rho_m = \sqrt{m\lambda R},$$

where R is the radius of curvature of the surface being measured.

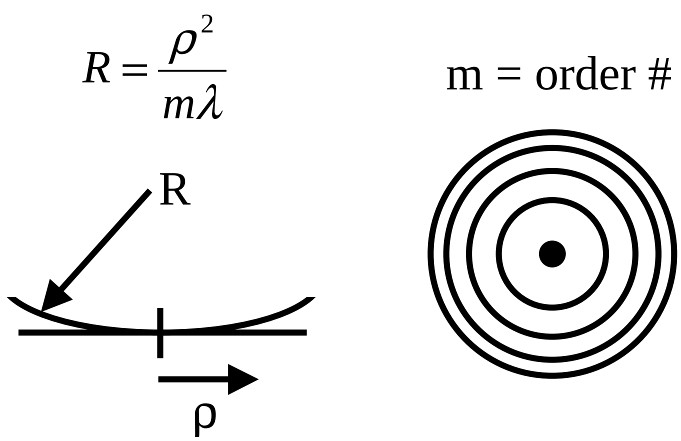

Fig. 8.1.3-1 Radius of curvature measurement using Newton's rings.

Shorter radius of curvatures can be measured with a Fizeau interferometer if a reference surface of approximately the same radius of curvature as the surface being measured is available. For example, Fig. 8.1.3-2 shows the result of comparing a reference surface having radius of curvature R with a test surface having approximately the same radius of curvature. Naturally, one surface is concave, while the other is convex. If d is the diameter of the piece under test, and m is the number of fringe spacings the fringes depart from straightness, the difference in radius of curvature of the two surfaces is given by

$$\Delta R = \frac{4m\lambda R^2}{d^2}.$$

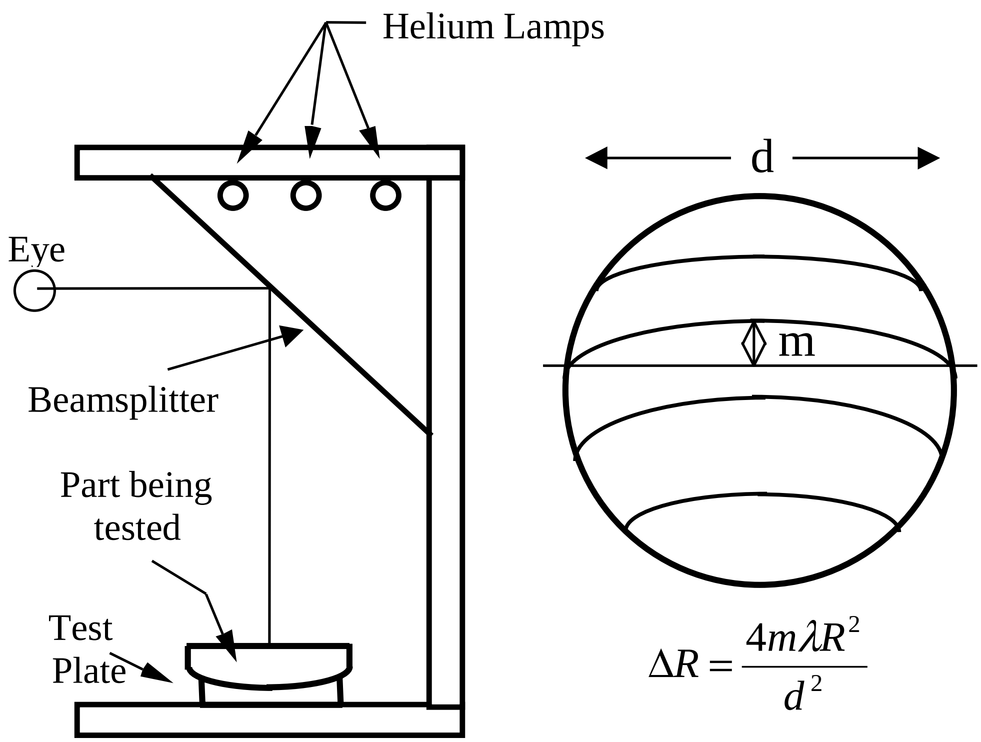

Fig. 8.1.3-2. Radius of curvature measurement using a spherical test plate.