Angular size and Resolution Activity – Philip Blanco

Equipment: Each pair of partners needs:

- This document (pages 1 and 2)
- a 2-meter stick or measuring wheel to measure a distances around 40 paces,
- enough space for partners to be separated by those distances (e.g. outdoors or in a hallway)
- chalk, painter's or masking tape to mark distances on the floor (optional)

1. Angular size, actual size, and distance are related.

Just looking at something does not tell you its *actual* size. For familiar objects in a familiar setting (such as people in a landscape) we can often make an intelligent guess of actual size based on (1) our distance from the object and (2) "how big it looks", or "how much of our field of view is taken up". However, in astronomy or in unfamiliar surroundings with few visual cues of distance (such looking at objects in the sky, or lights in the distance on a dark night), all we can measure is an object's angular size

Mathematically, the angular size of an object is related to its actual size and how far away it is. In degrees, the formula relating these three is:

$$\text{Angular size in degrees } (°) = \frac{180°}{\pi} \times \frac{\text{Object's actual size}}{\text{Object Distance}}$$

…as long as the Actual size and Distance are measured in the same units (e.g. meters). Of course this equation can be rearranged to solve for one value in terms of the other two. Astronomers frequently measure an object's angular size with a telescope, and then knowing the distance tells us it's actual size, or knowing the object's actual size gives us its distance.

2. Angular resolution limits the detail in an image.

All optical instruments, including the human eye, are limited in the amount of detail they can distinguish, or *resolve*. This has nothing to do with the magnification, but comes from the fact that light waves will spread out, or diffract, around obstacles, causing the image to blur. Increasing the magnification would then just make a larger blurry image! The larger the diameter of a telescope's objective lens or mirror, the higher the resolution, i.e. the telescope can distinguish details at smaller angular separations.

Activity – Measuring the angular resolution limit of your eyes.

To demonstrate this, you can measure the angular resolution of your unaided eyes with the following procedure: One of your partners will stand on a "zero position" mark on the floor some distance away and will hold up an eye-test chart for you to view with both eyes open. The test chart consists of an array of vertical bars and an array of horizontal bars, printed on the next page. Beyond a certain distance, the human eye cannot resolve the bars and the arrays appear to be gray blotches rather than black stripes on a white background.

Begin by standing so far from your partner that the chart cannot possibly be resolved. Your partner will fold the page in half and hold up the chart overleaf with either the vertical bars or the horizontal showing, but you will not know which orientation is used. Slowly, approach your partner and when you believe you can resolve the bars, indicate with hand signals whether the bars are horizontal or vertical.

Repeat this test several times, varying your distance somewhat while your partner changes the bars visible to you. Each time you "read" the chart, your partner should give the thumbs-up (correct) or thumbs-down (incorrect) signal and then you should turn away briefly while your partner randomly rearranges the chart for the next test (or your partner can turn their back on you while doing this). Make a tape or chalk mark on the floor at the ditance which you can consistently see the bars' correctly.

Record the maximum distance, and then compute the angular resolution of your unaided eye in degrees using the formula above. For "Object's Actual Size", use the center-to-center angular separation of the bars, which should be 0.75 cm, but photocopying may change this.