Angular Measure Exercise

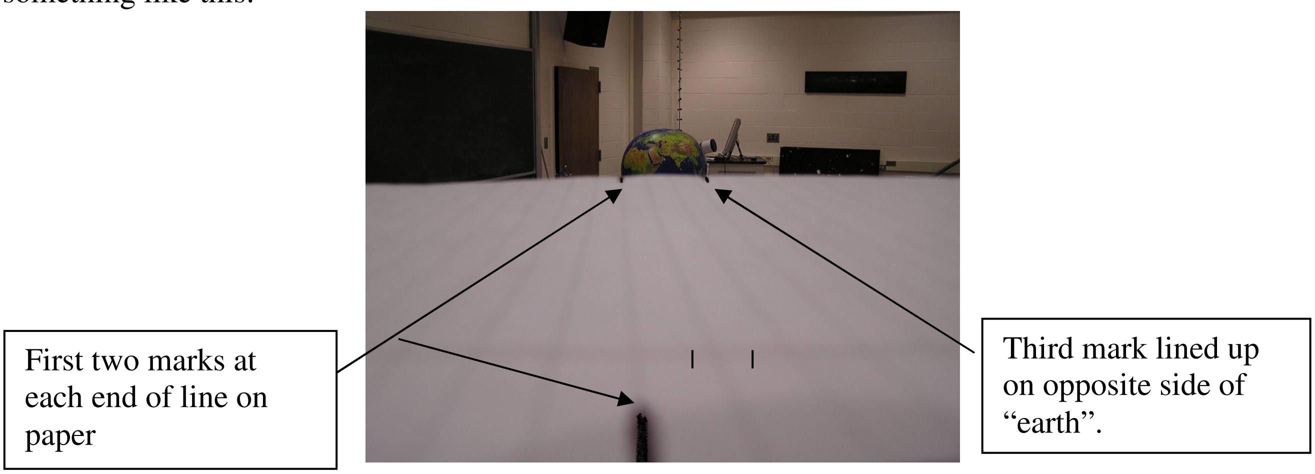
Name:____________________ Partner(s):_________________________.

Work together, but each of you should take your own measurements and do your own calculations. Show all your work.

<u>Background</u>

To locate things in the sky, to find our way around from star charts, and to figure out how far away things are, we need familiarity with angular measure. We also need convenient ways to measure (at least roughly) angles in the field.

1) Take a piece of lined notebook paper and mark both ends of one of the lines that is about in the middle of one long side. Holding the sheet parallel to the floor with the mark right under one eye, with your eye as close to the sheet as possible (being careful not to poke yourself), look straight along that line at one side of the "earth" at the front of the room (the mark on the other end of the line should help you line things up well). Without moving anything, mark on the paper where the <u>opposite edge</u> of the "earth" looks like it is. It should look something like this:



Now put the paper down and draw two lines: one each from the "eye mark" to each mark on the opposite side. This should leave you with a narrow "V" shape. Use the protractor to measure the angle between the two lines—Ta Da! You've measured the angular distance between the two opposite sides of the "earth" (also known as the angular size of the object).

Record your answer here:_____________degrees.

2) If the <u>linear</u> distance between you and the "earth" were smaller, would the <u>angular</u> distance you determine between the same two points on the globe be larger, smaller, or the same as what you reported above?

Make a prediction for this here:________________.

3) Try it now by moving closer to the "earth" (about 1/2 the distance you were in part 1 is good) and, looking along the same paper in the same way, measure the new angular distance between opposite sides of the "earth". Was your prediction correct? Record your results and comparisons to your prediction below:

4) Could an object with a smaller linear size that was closer to you have the same angular size as the “earth” at the front of the room? Explain in a sentence or two:

Summary so far:

Angular measure all by itself doesn't tell us anything about the absolute linear size (how many meters across it is) of an object or about its distance from us. An object that has a smaller linear size but is closer can have the same angular size as an object with a larger linear size that is farther away. As an extreme example, you can hold your thumb close enough to you eye to just completely cover up the “earth” at the front of the room (so they both have the same angular size), but clearly your thumb is not the same linear size as the “earth”.

5) Use a meter- (or 2 meter-) stick to measure the linear diameter of the “earth” and record it here (with units!):__________________ . With this information and the angular size you measured in part 1 you should be able to calculate how far away it was when you measured its angular size. Please do so (Hint: Draw a circle centered on your eye showing the angle that the “earth” occupies. The radius of the circle your draw should correspond to the distance from you to the “earth”):

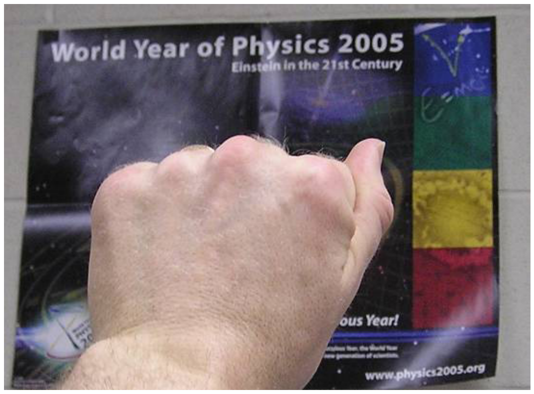
6) Is that a reasonable result? Explain.

More

OK, to use at night, looking at the sky, we would probably like some more convenient technique than what we just went through to measure angles. Even a more crude measurement that is more convenient would be worthwhile. A technique that uses only things we always have with us would be extra helpful.

Since we mostly always have our bodies with us, maybe we can use that or parts thereof. Remember that the ratio of any particular angle to 360 degrees (all the way around a circle) is about the same as the ratio of the linear size of the object making that angle to the circumference of a circle that has a radius equal to the distance the object is from your eye.

You will definitely need your partner’s direct help for this part.



7) Measure across the <u>widest</u> part of the back of your closed fist as shown in the figure above.
Width of fist:_______________cm.

8) Now with your fist <u>at arms length</u>, have your partner help you measure the distance from your eye to your fist—carefully! To do this, hold one end of a piece of string near your eye and have your partner hold the string straight and mark on the string where your fist is. Use a meter stick to measure on the string the eye-to-fist distance and record it here: _____________________cm.

9) Draw an isosceles (two equal length sides) triangle below with a short side equal to the fist width measurement and the two equal sides as long as the length of your eye-to-fist measurement. You can

10) Use angle and circumference ratios to calculate the angular size of your fist:

11) Also record the angular size of your fist on the board (or in the open spreadsheet) at the front of the room.
12) Why might it be that everyone's fist comes out to <u>about</u> 10 degrees? Shouldn't it be true that people with smaller hands have hands with smaller angular size?

13) Repeat an angular size determination for some other (smaller) part of your hand (e.g. thumb width or knuckle length) and record the results below (be sure you say what part of your hand you are using).

Summary:
1) This exercise shows how angular measure is related to an object's distance and size.
2) Using objects of known linear size (e.g. fist, knuckle, etc.) at known distances (e.g. arms length) you now have a convenient way to roughly measure angles in the field. This will be helpful in finding your way around the sky.
3) Out of class activity: If you are out in the evening when the Big Dipper is visible in the northwest try using these new angle measuring tools to measure the angular distance across the opening of the bowl of the Big Dipper (should be about 10 degrees).