

Arc-angle distances and areas table of the rotary "hex-pen" grid superimposed onto the antipodes map

Remember that the antipodes map and the "hex-pen" grid are based on perfectly spherical concepts, at sea level. But the earth is an oblate spheroid. To accommodate this difference when using the grid over the map so that the results are relevant to the earth's actual shape, the distance of each arc-angle is given within a variable range to encompass the difference between the polar and equatorial measurements. Thus the first value refers to the distance along a polar or north/south alignment and the second along the equatorial alignment. The many variable distance ranges that are given in the table below are calculated using the values recognised by the International Union of Geodesy and Geophysics in 1967 which are in "The World Almanac and Book of Facts" published in 1996. The relevant values are :

polar diameter	12,713.54 kms.
equatorial diameter	12,756.32 kms.
polar circumference	40008.0 kms.
equatorial circumference	40075.16 kms.
superficial area	510,069,522.6 sq. kms.

Due to the earth's shape the areas of hexagons and pentagons near the equator would be slightly more than those near the poles. But the variable range in areas for the hexagons and pentagons are difficult to calculate, unlike those for linear distances. Thus the values given for areas of the pentagons and hexagons are only approximate. Any great circle in the grid can divide the earth into two equal hemispheres, and even quarter it in association with a meridian and its anti-meridian. The surface area of an unitary longitudinal segment (1° wide), equivalent to the area covered by four minutes of the earth's rotation, is also given in the table. An unitary arc-angle is an arc that supports an angle of 1° at the earth's centre.

Arc-angle distances and areas table

types of arc-angles	angles at centre	variable distance ranges (in kms.)				
within a pentagon						
side	24°	2667.20 – 2671.67				
centre to midpoint of a side	16.01°	1779.24 – 1782.23				
centre to an apex	19.71°	2190.44 – 2194.11				
apex to midpoint of the opposite side	35.72°	3969.68 – 3976.34				
apex to an opposite apex	37.68	4187.50 – 4194.53				
within a hexagon						
side	24°	2667.20 – 2671.67				
centre to an apex	24°	2667.20 – 2671.67				
centre to midpoint of a side	21.14°	2349.36 – 2353.30				
midpoints of alternate sides	36°	4000.80 – 4007.51				
midpoints of opposite sides	42.28°	4698.71 – 4706.60				
apex to the opposite apex	48°	5334.40 – 5343.35				
composite (through pentagons and hexagons)						
centre of pentagon to centre of adjacent hexagon	37.15°	4128.60 – 4135.53				
centre of hexagon to centre of adjacent hexagon	42.28°	4698.71 – 4706.60				
centre of pentagon to centre of nearest pentagon	63.42°	7048.07 – 7059.90				
1/4 great circle circumference	90°	10002.00 – 10018.79				
1/2 great circle circumference (antipodes)	180°	20004.00 – 20037.58				
1 great circle circumference	360°	40008.00 – 40075.16				
unitary arc-angle	1°	111.13 – 111.32				
Area is given in sq. kms. Those of the pentagons and hexagons are approximate.						
	whole	1/2	1/5	1/10		
pentagon	12,084,291.72	6,042,145.86	2,416,858.34	1,208,429.17		
	whole	1/2	1/3	1/4	1/6	1/12
hexagon	18,252,901.09	9,126,450.54	6,084,300.36	4,563,225.27	3,042,150.18	1,521,075.09
The area of one hemisphere is 255,034,761.3 sq. kms. and a quarter of the earth is 127,517,380.7 sq. kms.						
The area of a 1° longitudinal segment from pole to pole is 1,416,859.78 sq. kms.						

Some limitations and advantages of the rotary "hex-pen" grid.

Because the grid is based on a perfect sphere, whereas the earth is an oblate spheroid, it is not possible to measure distances between places accurately. Moreover the places may not be exactly at the strategic points of the grid. An arc-angle difference of 1° could give a variation of more than 111 kms. For these reasons distances between places can only be approximate, depending on their proximity to the strategic points. Thus the two strategic points at the tip of each arc-angle that is aligned along a great circle of the grid serve as a distance marker for the approximation of distances between places close to the same points. Each strategic point is determined by its geographic coordinates.

However the grid makes up for these deficiencies in a unique manner. There is no need for any graduated scale to gauge distance and area measurements. The hexagon-pentagon network design of the grid, when superimposed onto an antipodes map of congruent size, serves as the basis of distance and area measurements. Moreover the grid can be rotated to any position over the map for this purpose. The previous article describes this aspect well. This unique feature is not incorporated in any contemporary map. Its origin can be traced to the perfect geometric symmetry of the hexagon-pentagon design of the football. I have incorporated this design onto the antipodes map to facilitate instant approximations of distances and areas.