On March 25, 2000 NASA launched a satellite called the Imager for Aurora-to Magnetosphere Global Exploration (IMAGE). One of the instruments on board this satellite was called RPI – the Radio Plasma Imager. It operates something like a policeman's radar gun. It sends out a pulse of radio waves into space, and listens for the echos of plasma clouds near the satellite. By measuring the time between transmission and echo, scientists can determine how far away the cloud is located. They can also determine the temperature and density of the cloud by studying the properties of the reflected radio signal even though the cloud may be 100,000 kilometers away.

The table below gives the direction of the reflected pulse in Column 2, and the time it took for the radio wave to travel from the spacecraft to the distant cloud and back again in Column 3. Using the fact that the speed of the radio pulse is equal to the speed of light (300,000 km/sec) calculate the distance to the cloud in kilometers in Column 4. Using the fact that the radius of Earth is 6.378 kilometers, convert the distances in Column 4 to multiples of Earth's radius (Re).

Location	Direction (degrees)	Round Trip Time (Seconds)	Distance (in Km)	Distance (in Re)
1	300	0.042		
2	315	0.106		
3	350	0.276		
4	45	0.191		
5	60	0.166		
6	90	0.174		
7	120	0.170		
8	135	0.233		
9	215	0.306		
10	230	0.149		
11	270	0.051		

Answer - Extra Credit Problem

Note to Teachers: To complete this problem, students need to realize that they must divide the round-trip time by 2.0 to get the 'one-way' time to the cloud, and from this the cloud distance when multiplied by 300,000 km/sec.

Example: Location 2: Time = 0.106 seconds. One-way time = 0.106/2 = 0.053 seconds. Distance = 0.053 sec x 300,000 km/sec = 15,900 kilometers. To get this in units of Earth radii, 15,900 km /6378 km = 2.5 Re.

For additional credit, student may plot these points using a compass to get the angles and a 4-quadrant graph paper marked in units of 'Re' along both axis.

Location	Direction (degrees)	Round Trip Time (Seconds)	Distance (in Km)	Distance (in Re)
1	300	0.042	6,300	1.0
2	315	0.106	15,900	2.5
3	350	0.276	41,400	6.5
4	45	0.191	28,650	4.5
5	60	0.166	24,900	3.9
6	90	0.174	26,100	4.1
7	120	0.170	25,500	4.0
8	135	0.233	34,950	5.5
9	215	0.306	45,900	7.2
10	230	0.149	22,350	3.5
11	270	0.051	7,650	1.2