The Big Bang - Hubble's Law

Galaxy	Distance (mpc)	Speed (km/s)
NGC-5357	0.45	200
NGC-3627	0.9	650
NGC-5236	0.9	500
NGC-4151	1.7	960
NGC-4472	2.0	850
NGC-4486	2.0	800
NGC-4649	2.0	1090

In 1921, Astronomer Edwin Hubble was measuring the speeds of nearby galaxies when he noticed a puzzling thing. When he plotted the speed of the galaxy against its distance, the points from each of the galaxies in his sample seemed to follow an increasing 'straight' line.

This turned out to be the first important clue that the universe was expanding. Each galaxy was moving away from its neighbor. The farther away the galaxy was from the Milky Way, the faster it was moving away from us.

The table shows the distance and speed of 7 galaxies. The distances are given in megaparsecs (mpc). One megaparsec equals 3.26 million light years. The speed is given in kilometers per second. Note, the speed of light is 300,000 kilometers/sec.

Problem 1 - Create a graph that presents the distance to each galaxy in mpc on the horizontal axis, and the speed in kilometers/sec on the vertical axis.

Problem 2 - What is the range of distances to the galaxies in this sample in light years?

Problem 3 - Does the data show that the distances and speeds of the galaxies are correlated, anti-correlated or uncorrelated (random)?

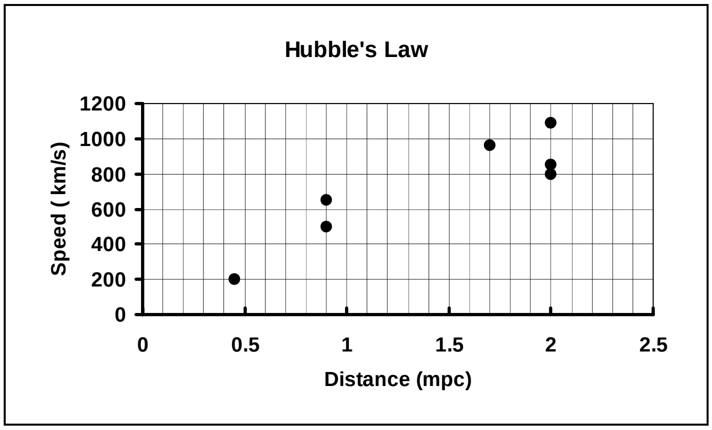
Problem 4 - By using a calculator, or using an Excel Spreadsheet, plot the data and use the 'Tools' to determine a best-fit linear regression. Alternatively, you may use the graph you created in Problem 1 to draw a best-fit line through the data points.

Problem 5 - The slope of the line in this plot is called Hubble's Constant. What is your estimate for Hubble's Constant from the data you used?

Problem 6 - An astronomer measures the speed of a galaxy as 2500 kilometers/sec. What would its distance be using your linear regression (now called Hubble's Law)?

Answer Key:

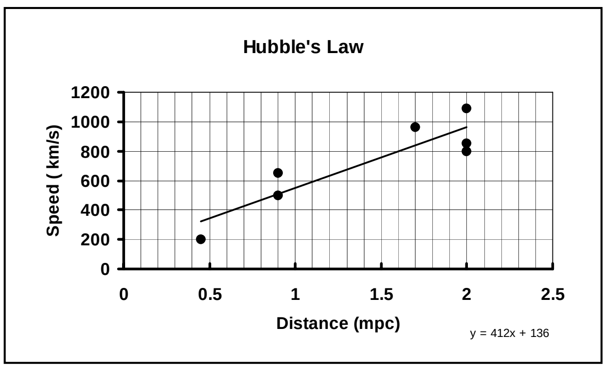
Problem 1 - Plot looks like this:



Problem 2 - The range is from 0.45 to 2 megaparsecs. Since 1 megaparses = 3.26 light years, the range is 450,000 parsecs x 3.26 light years/parsec = 1,467,000 light years to 2,000,000 parsecs x 3.26 light years/parsec = 6,520,000 light years.

Problem 3 - Because the data points show an increasing speed with increasing distance, the data indicate a correlated relationship between these two quantities.

Problem 4 - The result of using Excel 'Trendlines' is below:



Problem 5 - The regression line has a slope of '412' and the units will be kilometers/sec per megaparsec.

Problem 6 - The regression equation is Speed (km/s) = 412 x distance(mpc) + 136 so solving for distance you get Distance = (Speed - 136)/412 and so for Speed = 2500 km/s the distance is (2500-136)/412 = 5.74 megaparsecs (or 18,700,000 light years).