KANISHKA ARORA
SC20B152

Galaxies Assignment – 4

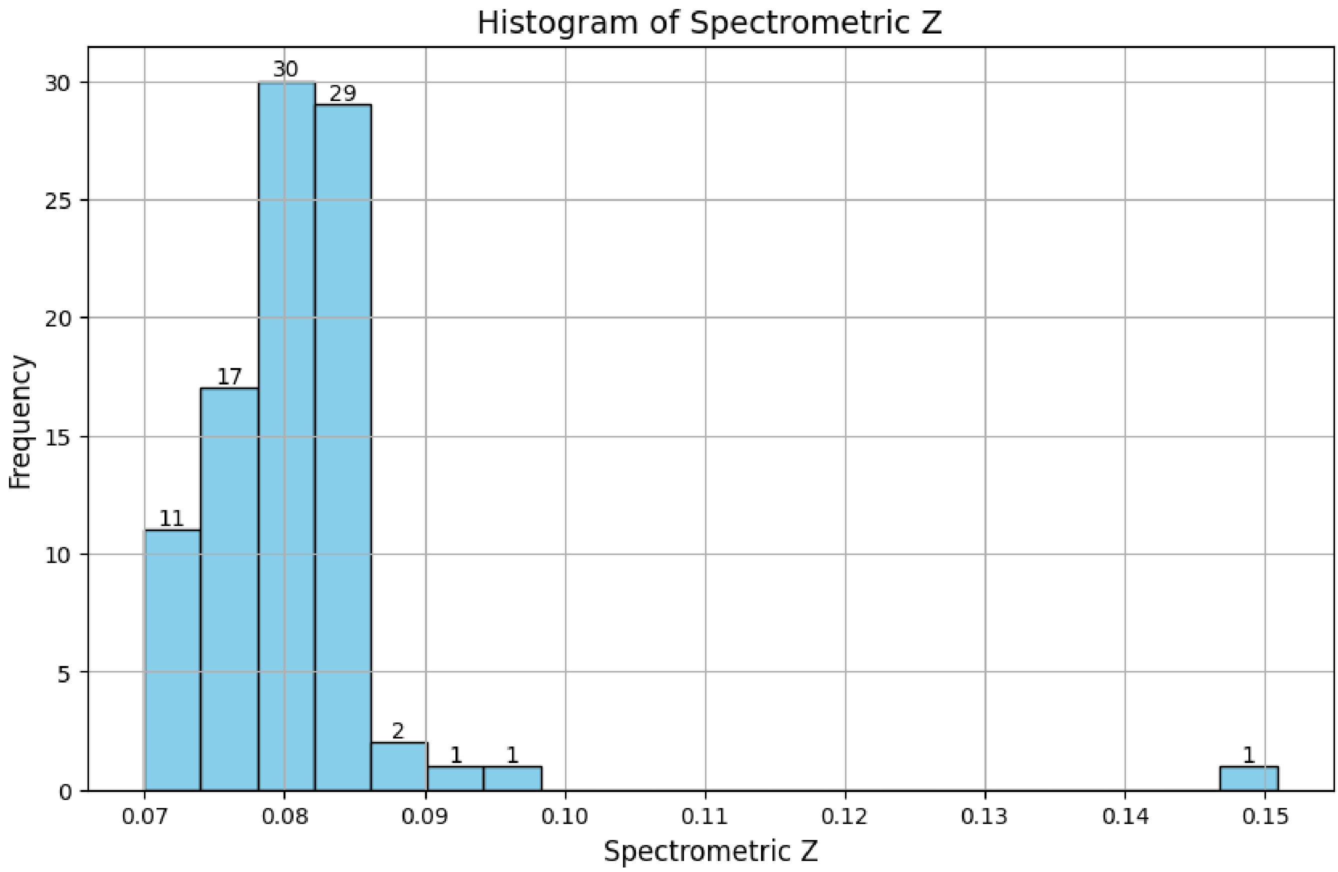
Question – 1

Identify galaxies that you think are members of a cluster. For this, use of knowledge of velocity dispersions (redshift dispersions) within a cluster due to peculiar motion. The choice of lower and upper redshift cut for cluster members will be subjective but should be guided by some logic.

Answer – 1

I have taken the range 0.07 to 0.1 spectrometric redshift as the galaxies which belong to the cluster as the majority of galaxies are in that range.

We had a total of 92 galaxies to be found withing the cluster. The data file from the SQL query was converted into a csv file for ease and duplicate data was removed. The histogram for the remaining 92 were plotted as it can be seen here.



The galaxies outside that range aren't considered as part of the cluster.

Question – 2

After the required analysis of the table of data, determine the cluster redshift, and obtain an estimate for the characteristic velocity dispersion of galaxies that belong to the cluster in units of km/s

Answer – 2

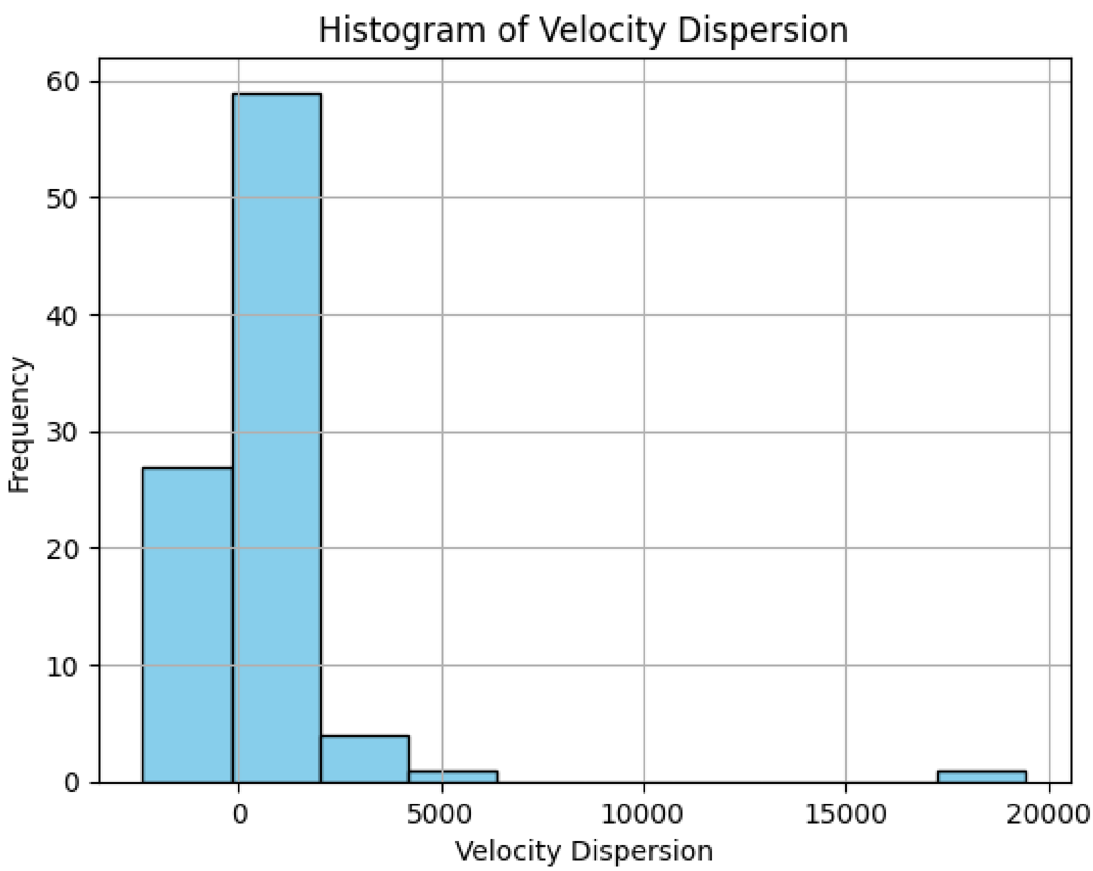
The cluster redshift was simply found by taking the average of all the individual galaxy spectrometric redshifts. The value of the cluster redshift came out to be approximately **0.0784.**

The velocity distributions of individual galaxies can be found out by the following relation below.

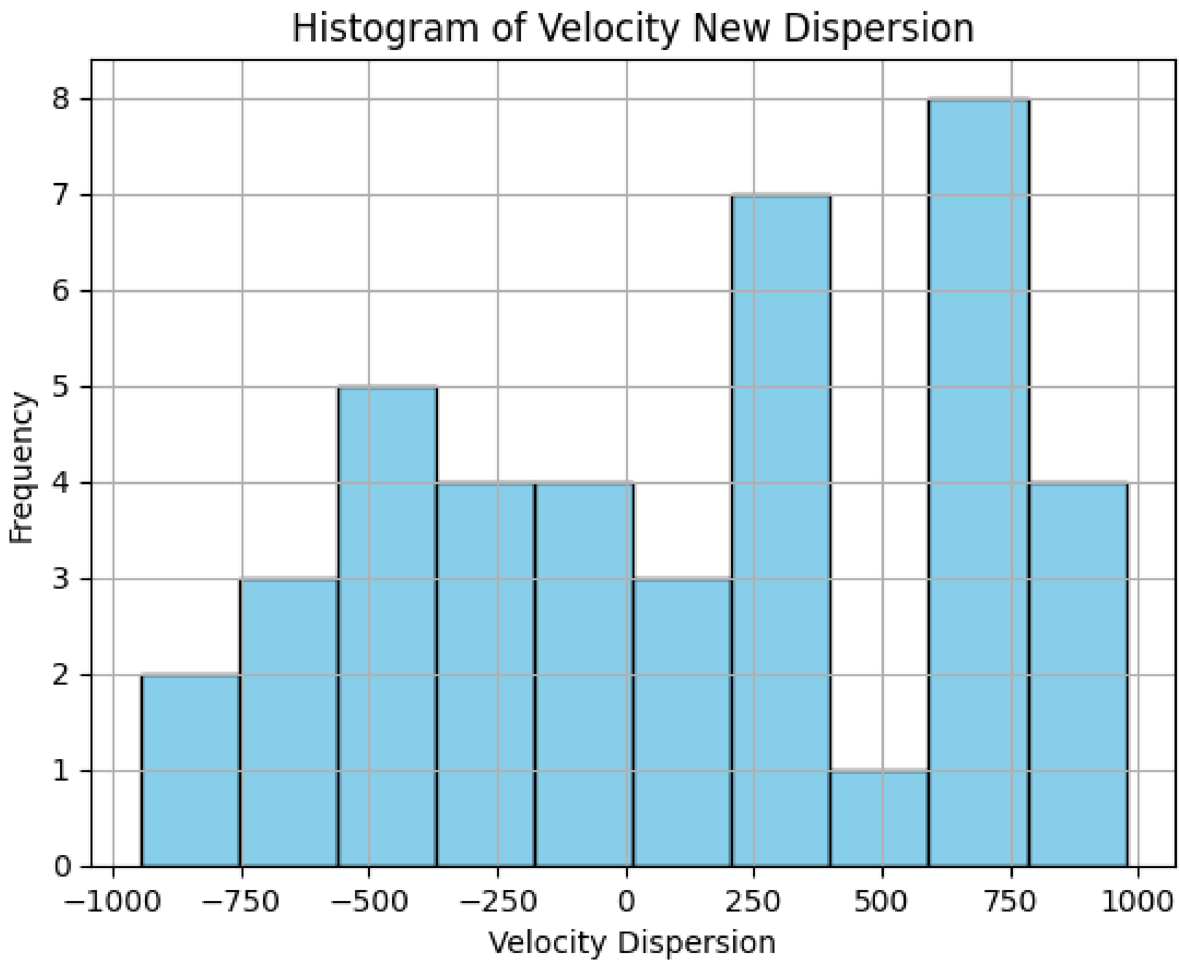
$$\frac{\sigma_i}{c} = \frac{(1 + z_i)^2 - (1 + z_c)^2}{(1 + z_i)^2 + (1 + z_c)^2}$$

Where i stands for the ith galaxy taken into account and c is the speed of light. The value of the velocity dispersion of the cluster came out to be approximately **1292.867 km/sec.** We can observe that the velocity value is close to 1000 km/sec which is the average observed value that was told to us in class.

The below is the histogram plot for velocity dispersion values for the galaxies in the cluster.



As I mentioned before, we take velocities of galaxies upto the 1000 km/sec threshold and ignore the velocities of galaxies above that. On doing that we get the following histogram plot.



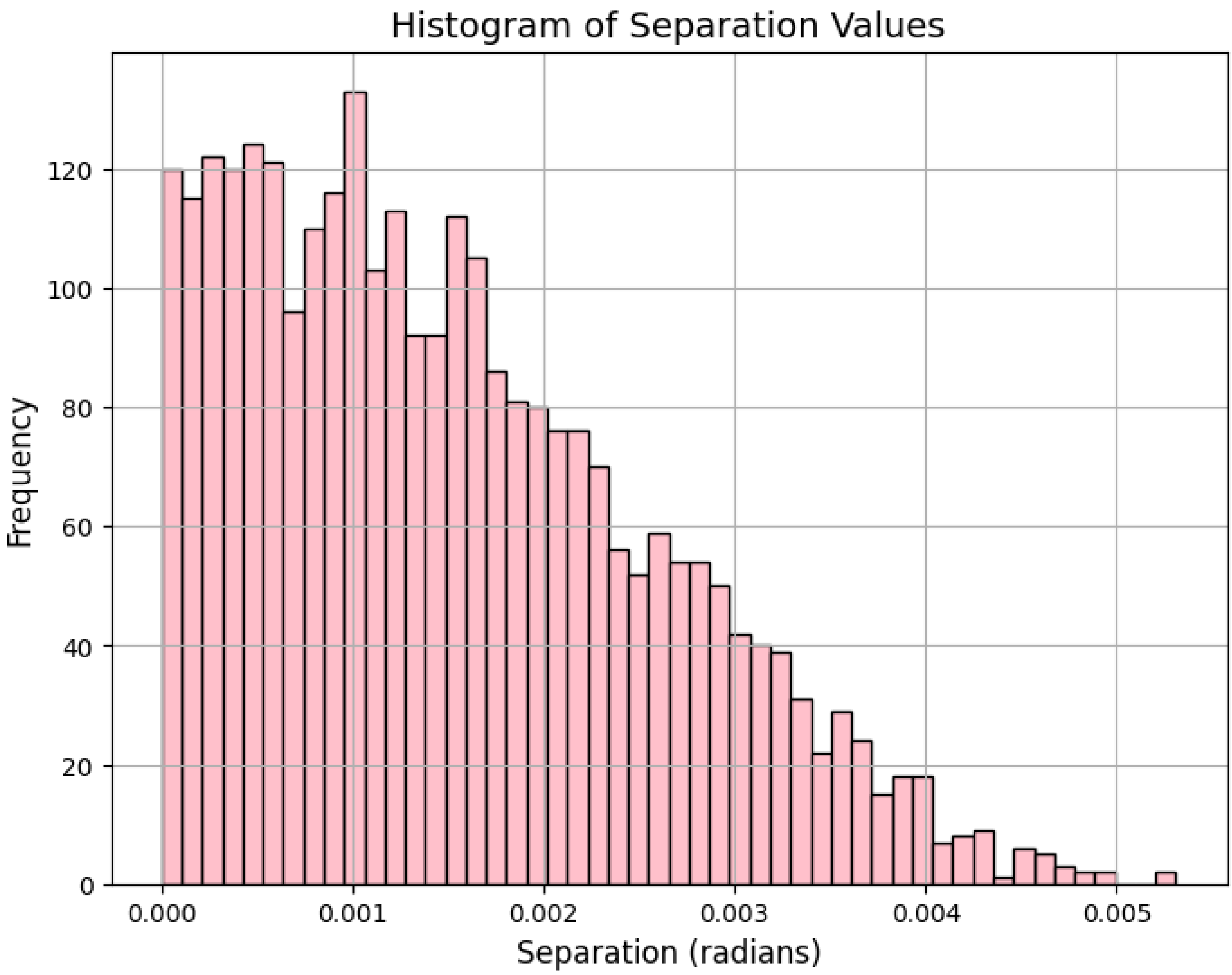
Please consider that negative velocities just indicate an opposite direction of motion contrary to the original one.

After this the subset of galaxies reduced from 92 to 41.

Question – 3
Estimate the characteristic size of the cluster in Mpc

Answer – 3

The characteristic size can be measure in the following way. First an array was created which had the values of all possible separations in the subset we were dealing with. Then an histogram was plotted to depict the same graphically.



In class we were told to take 80% of the full delta theta value.

Delta theta full = 0.00531 radians
80 percent of the delta theta full = $\delta\theta$ = 0.004245 radians

After this we calculate the angular diameter distance which is given by the following formula.

$$d_A(z) = \frac{c}{\sqrt{|\Omega_{\mathrm{k,0}}|}H_0(1+z)} \cdot S_k\left(H_0\sqrt{|\Omega_{\mathrm{k,0}}|}\int_0^z \frac{dz}{H(z)}\right)$$

$$S_k(x) = \begin{cases} \sin(x) & \text{for } k > 0 \\ x & \text{for } k = 0 \\ \sinh(x) & \text{for } k < 0 \end{cases}$$

We will consider the case of a flat universe, hence k = 0.

The code on computation revealed the following value for angular diameter distance.

r_A = 305.896 Mpc

The size of the cluster can be determined by the following formula.

$$D = r_A \times \delta\theta$$

Hence the product D will give us the size.

D = 1.299 Mpc

Question – 4

Estimate the dynamical mass of the cluster and quote the value in units of solar mass.

Answer – 4

The dynamical mass of the cluster was calculated by the following formula given below.

$$M_{cluster} = \frac{3 \times \sigma^2 \times R}{G}$$

σ = average velocity dispersion calculated for galaxies in the cluster
G = Gravitational Constant
R = size of cluster

We know all quantities and we simply have to just compute the mass.

The dynamical mass of the cluster turns out to be: **1.333 x 10^{14} MΘ**

Question – 4

Is the estimate of dynamical mass consistent with what is expected from the luminous mass? If not, explain with the support of numbers the inconsistency.

Answer – 5

Dynamical Mass: Dynamical mass is the total mass of a galaxy that is predicted using Newton's Inverse Square Law and the motions of astronomical objects around the galaxy. The dynamical method is based on the Virial theorem and uses data such as rotation velocities, velocity dispersions, and motions of satellite galaxies.

Luminous Mass: Calculated from the light we recive and the mass-luminosity relation.

Generally the dynamical mass is greater than the luminous mass of a galaxy.

The luminous mass of the milky way is around 9 x 10^{10} solar masses which is approximately 10^{10} **MΘ**. Taking lets say 100 such galaxies will give a total of 10^{13} **MΘ** which is less than the mass that we found using our dynamical methods and of the order 10^{14} **MΘ**.

The general range of mass for a galaxy cluster is 10^{14} – 10^{15} **MΘ**.