**Activity 3- Calculating Distance in Three Dimensions**

Similar to calculating distance in two dimensions, to calculate distance in three dimensions an equation based on the Pythagorean Theorem is used.

The equation used to calculate the distance between two points in three dimensions is:



**Example 1:**

A curious astronomer is given the coordinates of two stars. Star 1 is located at (-6, 4, 3) while Star 2 is located at (2, 7, -5). They wonder how far the stars are from each other. How far are the stars from each other? Assume your answer is in light years.

Use the above formula to calculate the distance.

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
d= √ [2-(-6)]2+ (7-4)2+ (-5-3)2

 = √ (8)2+ (3)2+ (2)2

= √ 64+ 9+ 4

= √ 77

= 8.77 light years.

**Example 2**

**Allow students to try this example individually before taking it up as a class.**

The curious astronomer tracks the two stars from the previous example. Over time, they notice that Star 2 has moved from its original spot to (4, 6, 3). How are is Star 1 from Star 2 now?

Once again, we use the distance formula.

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
d= √ [4-(-6)]2+ (6-4)2+ (3-3)2 The distance between the stars is now 10.77 light years

 = √ (10)2+ (2)2+ (0)2 The change in distance is 10.20-8.77= 1.43 light years

= √ 100+ 4

= √ 104

= 10.20 light years

**Important points to remember when calculating distances between points:**

* Be consistent! Pick one point to represent (x1, y1, z1) and the other point as (x2, y2, z2).
* When squaring a solution, there are usually 2 solutions (positive and negative). Because this equation deals with distance, only the positive solution will be used.

Now that we have covered the basics of calculating distances between points, let’s take a look at more distances between stars.

In the following chart, the coordinates of the Sun and some nearby stars have been listed.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Star** | **X** | **Y** | **Z** | **Distance from the Sun** | **Distance from Polaris** |
| Sun | 0.0 | 0.0 | 0.0 | 0.0 | 390 |
| Sirius | -3.4 | -3.1 | 7.2 | 8.6 | 384.15 |
| Alpha Centauri | -1.7 | 0.0 | 4.0 | 4.3 | 386.54 |
| Altair | 4.0 | 9.3 | 13.3 | 16.7 | 375.53 |
| Polaris | 99.5 | 28 | 376 | 390 | 0.0 |
| Procyon | -0.9 | 5.6 | -9.9 | 11.4 | 399.37 |
| Arcturus | 32.8 | 9.1 | 11.8 | 36 | 370.74 |
| 61 Cygni | -6.9 | -8.6 | 2.5 | 11.3 | 390.08 |
| Capella | -16.9 | -38.3 | 5.2 | 42.2 | 394.26 |
| Zubenelgenubi | 64.6 | -22 | 23 | 72 | 360 |

1. Using the chart above, calculate the distance of the stars to the sun to two significant figures (assume lightyears). Which star is closest to the Sun?

(Refer to chart)

The star closest to the Sun is Alpha Centauri.

2. If the distances were measured relative to Polaris, how far would the Sun and the other stars be? Answer to two significant figures and in light years.

(Refer to chart)

The closest star to Polaris is Zubenelgenubi.

3. Astronomers identify a new star in the star in the sky. Due to an unfortunate problem with their computers, they only manage to determine that it is 85 light years from the sun and its x and y coordinates are 64 and 20. Determine the complete coordinate for the new star and use your result to determine its distance to Polaris.

First solve for the z-coordinate using the distance from the sun to the new star

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
85 = √ (64-0)2+ (20-0)2+ (z-0)2

85 = √ (64)2+ (20)2+ (z)2

85= √ 4096+ 400+ z2

85 = √ 4496+ z2

7225 = 4496 + z2

2729= z2

Z= 52.2 The coordinate the of the new star is (64, 20, 52.2)

Use the distance formula again to solve for the distance between the new star and Polaris.

 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
d= √ (99.5-64)2+ (28-20)2+ (376-52.2)2

 = √ (35.5)2+ (8)2+ (323.8)2

= √ 120.25+ 64+ 104846.44

= √ 106170.69

= 325.84 light years