In ca 130 BC, Hipparchos created the first detailed star catalog of thousands of naked-eye stars. He ranked them according to their brightness with the brightest being assigned the First Rank, the next brightest the Second Rank, and so on. Today, astronomers use this same brightness scaling for stars which they call the apparent magnitude scale. As it turns out, the human eye can discern a brightness change of 2.5122-times, and that is why the star brightness rankings have such a specific pattern. For example, a star with a magnitude of +2.0 is 2.51 times brighter than a star of magnitude +3.0. The difference in brightness between a +6.0 magnitude star and a +3.0 star is 3.0 magnitudes, which corresponds to a brightness change of 2.512 x 2.512 x 2.512 = 15.9 times. A magnitude difference of 5.0 corresponds to a change of 100 times. Now, let's do some star math!! (Note; In the following problems we have stated star magnitudes to the nearest integer to simplify the math!)

Question 1) The star Sirius has a magnitude of -1.0 while the star Kruger 60B has a magnitude of +11.0. What is the magnitude difference between these stars? How many times fainter is Kruger 60B than Sirius?

Question 2) The apparent magnitudes of the sun and moon are -26.0 and -18.0. How many magnitudes brighter is the sun than the moon? How many magnitudes brighter is the sun than Kruger 60B? By what factor is Kruger 60B fainter then the sun?

Question 3) If the brightest object the human eye can observe (just short of instant blindness!) is the sun with a magnitude of -26.0, and if the faintest star we can see with the naked eye has a magnitude of +7.0, by what factor is the faintest object less discernable than the brightest object we can see? In other words, complete this sentence: "The sun is …….. times brighter than the faintest star we can see with the naked-eye."

Question 4) The Palomar Sky Survey was a photographic survey of the northern sky performed during the 1940's. Nearly 1 billion objects have been identified in these photographs. The faintest stars have apparent magnitudes of +20.0. How many magnitudes fainter than the faintest naked-eye star (magnitude +7.0) are the stars in the Palomar Survey? By what factor are these stars fainter than naked-eye stars? (http://www-gsss.stsci.edu/gsc/gsc2/GSC2home.htm)

Question 5) In 1996, the Hubble Space Telescope photographed a small piece of the sky with a time-exposure lasting over 10 days. Although only 1,500 galaxies were detected, the faintest of these have a magnitude of +30.0, how many magnitudes fainter than the sun are these faint galaxies? By what factor are these galaxies fainter than the dimmest stare we can see with the human eye? (http://www.stsci.edu/ftp/science/hdf/hdf.html)

Question 6) The Sloan Digital Sky Survey is mapping ¼ of the entire sky. It has performed detailed studies on over 200 million stars and other objects. The faintest objects have magnitudes of +22.0. How much fainter are the galaxies in the Hubble Deep Field in terms of magnitudes? In terms of brightness? (http://www.sdss.org/tour/index.html)

Question 7) Compare the magnitude of the sun with the magnitude of the faintest objects astronomers have detected with the Hubble Space Telescope. How many magnitudes fainter are the Hubble objects than the sun? By what factor is the sun brighter than the faintest known astronomical objects?

Hint: use the relationships that a difference of 5 magnitudes is a factor of 100 in brightness. So, 8 magnitudes = 5 + 3 magnitudes or a factor of 100 x 2.512 x 2.512 x 2.512.

Question 1) The star Sirius has a magnitude of -1.0 while the star Kruger 60B has a magnitude of +11.0. What is the magnitude difference between these stars? How many times fainter is Kruger 60B than Sirius? Answer: a) +11 – (-1) = +12 magnitudes. B) 12 = 5 + 5 + 2 so the factors are 100 x 100 x 2.512 x 2.512 = 63,000 times fainter than Sirius.

Question 2) The apparent magnitudes of the sun and moon are -26.0 and -18.0. How many magnitudes brighter is the sun than the moon? How many magnitudes brighter is the sun than Kruger 60B? By what factor is Kruger 60B fainter then the sun? Answer: -26 – (-18) = -8 magnitudes or ' 8 magnitudes brighter' because the sign is negative. This is a factor of 100 x 2.512 x 2.512 x 2.512 = 1,600.

Question 3) If the brightest object the human eye can observe (just short of instant blindness!) is the sun with -26.0, and if the faintest star we can see with the naked eye is +7.0, by what factor is the faintest object less discernable than the brightest object we can see? In other words, complete this sentence: "The sun is ……. times brighter than the faintest star we can see with the naked-eye." Answer: The magnitude difference is 26.0 + 7.0 = 33.0. The brightness difference is 33 = 5+5+5+5+5+5+3 or 100x100x100x100x100x100x2.512x2.512x2.512 = 16 trillion times. "The sun is 16 trillion times brighter than the faintest star we can see with the naked eye".

Question 4) The Palomar Sky Survey was a photographic survey of the northern sky performed during the 1940's. Nearly 1 billion objects have been identified in these photographs. The faintest stars have apparent magnitudes of +20.0. How many magnitudes fainter than the faintest naked-eye star (magnitude +7.0) are the stars in the Palomar Survey? By what factor are these stars fainter than naked-eye stars? (http://www-gsss.stsci.edu/gsc/gsc2/GSC2home.htm). Answer: 20-7 = 13 magnitudes fainter or a brightness of 100 x 100 x 2.512 x 2.512 x 2.512 = 160,000 times.

Question 5) In 1996, the Hubble Space Telescope photographed a small piece of the sky with a time-exposure lasting over 10 days. Although only 1,500 galaxies were detected ,the faintest of these have a magnitude of +30.0 ,how many magnitudes fainter than the sun are these faint galaxies? By what factor are these galaxies fainter than the dimmest stare we can see with the human eye? (http://www.stsci.edu/ftp/science/hdf/hdf.html) .Answer: 30 – 7 = 23 magnitudes or 5+5+5+5+3 magnitudes or a brightness of 100 x 100 x 100 x 100 x 2.512 x 2.512 x 2.512 = 1.6 billion times.

Question 6) The Sloan Digital Sky Survey is mapping ¼ of the entire sky. It has performed detailed studies on over 200 million stars and other objects. The faintest objects have magnitudes of +22.0. How much fainter are the galaxies in the Hubble Deep Field in terms of magnitudes? In terms of brightness? (http://www.sdss.org/tour/index.html) Answer: 30 – 22 = 8 magnitudes or a brightness of 100 x 2.512 x 2.512 x 2.512 = 1600.

Question 7) Compare the magnitude of the sun with the magnitude of the faintest objects astronomers have detected with the Hubble Space Telescope. How many magnitudes fainter are the Hubble objects than the sun? By what factor is the sun brighter than the faintest known astronomical objects? Answer: -26 – (30) = -56 magnitudes .The brightness factor is 100x100x100x100x100x100x100x100x100x100x100 x 2.512 = 2.5 $x10^{22}$ times or 25,000 billion billion times fainter.