Activity 16 Solution + Practice Problems

Activity 16 Solution

1a How many times brighter is a star of magnitude 10 than one of magnitude 13?

That is 3 magnitudes of difference. Each magnitude is about a factor of 2.5. The easiest way is to do 2.5 x 2.5 x 2.5 on your calculator and get 15.625.

The same thing can be accomplished by doing 2.5^3. This requires that your calculator have a y^x key.

15.625 is an approximate answer, because 2.5 is not exactly $100^{1/5}$.

If you want a more exact answer, or if there is a lot of difference in magnitudes, to find out how much brighter star 1 is than star 2, you do

$100^{(m_2-m_1)/5}$

In this case, that is $100^{3/5}$ which is 15.849.

I will make sure that answers on multiple choice tests are sufficiently different that it will be obvious which answer is the right one. For example, in this problem a multiple choice question could have answers like 1.6, 3, 16, 160, 1000. You'd pick 16 because that is the only one that is close.

1b Very similar problem with magnitudes -2 and 2.

That is 4 magnitudes of difference. You can do 2.5 x 2.5 x 2.5 x 2.5 on your calculator or you can do

In this case, that is $100^{4/5}$ which is 39.8. On a multiple choice test, the right answer would be "about 40."

2a Very similar problem with magnitudes 5 and 15.

You can do 2.5^{10} or you can do $100^{10/5} = 100^2 = 10\,000$.

You can see why I prefer the second way. It is exact, and fairly easy if the magnitude difference happens to be a multiple of 5.

2b Very similar problem with magnitudes -1.5 and 5.

$100^{6.5/5} = 100^{1.3} = 398.1$.

If you do $2.5^{6.5}$ you get 386.0.

3 Compute m-M for the star designated “10 Lacertae”

$m = 4.9$ (the star’s apparent magnitude, probably not visible from our pad, but certainly visible if you are in a very dark place).

$M = -4.8$ (the star’s absolute magnitude, which is how bright it would be if it were only 10 parsecs away).

$m - M = 9.7$

4 Compute 2.5^{m-M}

$2.5^{9.7} = 7245.$

Of course, I slightly prefer:

$100^{9.7/5} = 7586.$

That’s how much brighter 10 Lacertae would be if it were at the benchmark distance of 10 parsecs. It must be a lot farther than 10 parsecs to appear so dim. Now we need to compute how much farther.

5 Take square root of what you got in 4

Well $\sqrt{7586} = 87.1$. That means 10 Lacertae is 87 times as far away as the benchmark distance.

6 Multiply what you got in 5 by the benchmark distance

87.1×10 parsecs = 871 parsecs.

7 Use the parallax angle to get the distance

$\frac{1 \text{ parsec}}{0.00308} = 263$ parsecs. That’s quite the disagreement. It is my understanding that the parallax measurement was revised.

8 This one I suggested everyone skip, because it is fairly advanced

What makes this one advanced is that it involves undoing exponentiation. The function that undoes exponentiation (the technical name is “the inverse function”) is the logarithm. If you are comfortable with logarithms see me and I will help you understand 8.

9a Convert 263 parsecs to light-years

They say 1 parsec is 3.26 light-years, so that means that 263 parsecs is 263 * 3.26 light-years. Punching that into a calculator turns out to be 857 light-years.

9b Convert 263 parsecs to light-years

Earlier on they say 1 parsec is 3.26 light-years, so that means that 263 parsecs is 263 * 3.26 light-years. That turns out to be 857 light-years.

9c How long does it take light to go 857 light-years?

Trick question with an easy answer: 857 years.

9d When did the light we are seeing now leave 10 Lacertae?

2018 - 857 = 1161 A.D.

Practice Problems

1 Motorcycle and bicycle headlights

Suppose a motorcycle with a headlight of 108 Watts and a bicycle with a headlight of 3 Watts are coming at you. If they were the same distance away how much brighter would the motorcycle headlight look?

A. $\frac{108\text{ Watts}}{3\text{ Watts}} = 36$ times

2 What if the motorcycle was twice as far away?

Considering the previous problem, how much brighter would the motorcycle headlight appear to be if the motorcycle was twice as far away?

The inverse square law for light says this reduces the apparent brightness by

$\frac{1}{2^2} = \frac{1}{4}$.

Since it was 36 times as bright now it is $\frac{36}{4} = 9$ times as bright.

3 How about if the motorcycle was 3 times as far away?

$\frac{1}{3^2} = \frac{1}{9}$.

Since it was 36 times as bright now it is $\frac{36}{9} = 4$ times as bright.

4 Motorcycle and bicycle headlights again

How far away would the motorcycle have to be to appear equally bright?

$\sqrt{36}$ = 6 times as far away as the bicycle.

If you are wondering how square roots got in the game, ask yourself the question, what if the motorcycle was k times as far away. The answer would be $\frac{1}{k^2}$ as bright. We are looking for k such that $\frac{1}{k^2} = \frac{1}{36}$. Solving this equation involves taking the square root.

5 Motorcycle and bicycle headlights final question

If the bicycle is at the benchmark distance of 100 yards, and the motorcycle headlight appears equally bright, how far away is it?

100 yards × 6 = 600 yards

6 Some star brightness questions

Suppose Star 1 is 49 times as bright as Star 2, but it appears equally bright. How much farther away must Star 1 be than Star 2?

$\sqrt{49}$ = 7 times as far away as Star 2.

7 Star brightnesses again

Suppose Star 2 is at the benchmark distance of 10 parsecs. How far away must Star 1 be?

10 parsecs × 7 = 700 parsecs