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Astronomy

This article is about the Astronomy event in general. For information on topics for specific years, see Astronomy#Topics.

In Astronomy, teams answer questions on math and physics relating to the year's topic. For 2022, the topic of Astronomy is Variability of Low & Mid-Mass Stars. Some questions pertain to specific objects on the year's DSO list.

Test questions in Astronomy frequently rely on a significant amount of background knowledge - hence, gathering information on topics tangentially related to the rules may be beneficial.

Prior to the 2004 season, this event was called Reach for the Stars. Although it had the same name as the Division B event Reach for the Stars, the content areas for the two events were similar to how they are today.

Astronomy	
Type	Earth Science
Category	Study
Description	Teams will demonstrate an understanding of Variability of Low & Mid-Mass Stars.
Event Information	
Approx. Time	50 minutes
Impound	No
Allowed Resources	One of the following: ▪ two three-ring binders ▪ one computer/tablet and one three-ring binder ▪ two computer/tablets Always: ▪ two calculators
Rotates	No, only topics rotate
Eye Protection	None
Latest Appearance	2022

Forum Threads

2022 (https://scioly.org/forums/viewtopic.php?f=386&t=23490)	2021 (https://scioly.org/forums/viewtopic.php?f=348&t=18299)	2020 (https://scioly.org/forums/viewtopic.php?f=285&t=15378)	2019 (https://scioly.org/forums/viewtopic.php?f=285&t=12226)	2018 (https://scioly.org/forums/viewtopic.php?f=265&t=10853)
2017 (http://scioly.org/phpBB3/viewtopic.php?f=227&t=9297)	2016 (http://scioly.org/phpBB3/viewtopic.php?f=208&t=7697)	2015 (http://scioly.org/phpBB3/viewtopic.php?f=187&t=5961)	2014 (http://www.scioly.org/phpBB3/viewtopic.php?f=167&t=5001)	2013 (http://www.scioly.org/phpBB3/viewtopic.php?f=144&t=3688)
2012 (http://scioly.org/phpBB3/viewtopic.php?f=121&t=2965)	2011 (http://scioly.org/phpBB3/viewtopic.php?f=93&t=2201)	2010 (http://www.scioly.org/phpBB3/viewtopic.php?f=67&t=1388)	2009 (http://www.scioly.org/phpBB3/viewtopic.php?f=17&t=209)	

Contents

Topics

The topic for Astronomy typically changes each year. The changes do not follow any pattern.

Season	Topic
2022	Variability of Low & Mid-Mass Stars
2021	Star Formation and Evolution and Galaxy Formation and Evolution [1]
2020	Star Formation and Evolution and Galaxy Formation and Evolution
2019	Stellar Evolution and Starburst Galaxies
2018	Stellar Evolution and Type II Supernovae
2017	Stellar Evolution and Type Ia Supernovae
2016	Stellar Evolution and Exoplanets
2015	Stellar Evolution and Star and Planet Formation
2014	Stellar Evolution and Variable Stars
2013	Stellar Evolution and Type II Supernovae
2012	Stellar Evolution and Type Ia Supernovae
2011	Active Galaxies
2010	Galaxies
2009	Variable Stars
2008	Variable Stars
2007	Variable Stars

[1] **Remained the same topic due to the 2021 Rules Replay**

Question Marathon Threads

2022 (https://scioly.org/forums/viewtopic.php?f=387&t=23463)	2021 (https://scioly.org/forums/viewtopic.php?f=297&t=18471)	2020 (https://scioly.org/forums/viewtopic.php?f=297&t=15708)	2019 (https://scioly.org/forums/viewtopic.php?f=297&t=12419)	2018 (https://scioly.org/forums/viewtopic.php?f=266&t=10947)
2017 (http://scioly.org/phpBB3/viewtopic.php?f=228&t=9654)	2016 (https://scioly.org/forums/viewtopic.php?f=217&t=7980)	2015 (http://scioly.org/phpBB3/viewtopic.php?f=193&t=6527)	2014 (http://www.scioly.org/phpBB3/viewtopic.php?f=173&t=5021)	

Official Resources

Website	www.soinc.org/astronomy-c (https://www.soinc.org/astronomy-c)

Division C Results

1st	**West Windsor-Plainsboro High School South**
2nd	Mountain View High School
3rd	Iolani School

Deep Sky Objects

In terms of this event, the Deep Sky Objects (DSOs) are objects selected before the year that relate in some way to the topic of the year. There are generally about 16 of them, and participants are expected to research the characteristics that make them unique and relevant. Other information is also necessary, including, but not limited to, constellation, alternate names, magnitude, type of star, stellar classification, right ascension/declination, color index, and images.

It is important to know as much as possible for DSOs, as they will almost always show up on a test. Some tests end up being almost completely on DSOs and their characteristics.

For lists of this year's and past years' DSOs, please see the DSO list.

Stellar Life Cycle

> *For information regarding stellar evolution, please see the Stellar Evolution main page and the Star and Planet Formation main page.*

Supernovae

> *For more information about supernovae, please see Astronomy/Type Ia Supernovae and Astronomy/Type II Supernovae.*

A supernova is an event where a star explodes, destroying itself and releasing huge amounts of energy. It is distinct from a nova, which is a smaller explosion that does not destroy the progenitor star. Depending on the star's mass, the supernova may leave behind a neutron star or a black hole.

Type Ia supernovae are caused not by high-mass stars reaching the end of their lives, but by white dwarves that gain too much mass. They generally occur in binary systems in which a white dwarf pulls enough mass off of its companion to go supernova. This limit is 1.4 solar masses. When the white dwarf exceeds this limit, it blows itself up in a supernova that is significantly brighter than a Type II supernova. They are distinguished from other type I supernovae by the presence of a strong silicon absorption line in their spectra. All Type Ia supernovae are of the same brightness, and this fact can be used to determine intergalactic distances.

Type II supernovae occur when a star of at least eight solar masses cannot fuse any more elements together to create energy. This happens when iron is created; no nuclear energy can be made from iron with fusion or fission. When this happens, the star blows itself apart. Heavy elements - elements with atomic numbers greater than 26 - are created in these supernovae. If the star's core has a mass of 1.4 to 3.2 solar masses, a neutron star is formed. Neutron stars are incredibly dense - a neutron star with a diameter of about 12 km has the same mass as the Sun. Some neutron stars rotate quickly enough to emit beams of radiation at the magnetic poles; these are called pulsars, as the beams appear to "pulse" at a constant rate. However, if the core has a mass greater than 3.2 solar masses, a black hole is formed. These are made of degenerate elementary particles and have infinite density. Their gravity is so great that at a certain distance, called the event horizon, not even light can escape. This is where they get the name "black" holes.

Type Ib **and** type Ic **supernovae occur via the same core-collapse mechanism as type II supernovae, but originate from stars that have lost their hydrogen envelopes. Like type Ia supernovae, they are characterized by a lack of hydrogen absorption lines in their spectra; type Ic supernovae also lack helium absorption lines.**

Stellar Classification

Stars are classified in many ways. The two most common methods are discussed here.

Spectral Class

First, stars can be categorized through Spectral Class (Letters O, B, A, F, G, K and M, with O being the hottest and M being the coolest). Each of these classes have special properties, relating to temperature and spectra. A common mnemonic for spectral classification is "Oh Be A Fine Girl, Kiss Me".

Spectral Class Properties

Type	Temperature (Kelvin)	Color	Hydrogen
O	30,000-60,000	Blue	Weak
B	10,000-30,000	Blue-White	Medium
A	7,500-10,000	White	Strong
F	6,000-7,500	White	Medium
G	5,000-6,000	Yellow	Weak
K	3,500-5,000	Yellow-Orange	Very Weak
M	2,000-3,500	Red	Very Weak

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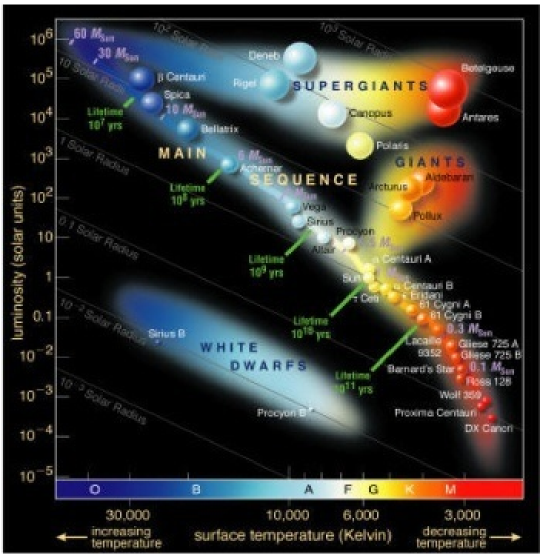
Yerkes Classification

Further, stars can be classified into different luminosity classes. This is done by the Yerkes Classification system:

Yerkes Classification

Designation	Definition
0 or 1a	Hypergiant/Extremely Luminous Supergiant
1a	Luminous Supergiants
1ab	Intermediate luminous supergiants
1b	Less luminous supergiants
II	Bright giants
III	Giants
IV	Subgiants
V	Main Sequence
D	White dwarfs



The H–R Diagram

H–R Diagram

The Hertzsprung–Russell **diagram relates the absolute magnitudes and luminosities of stars with their spectral types and temperatures. They are especially important in understanding stellar evolution. Although some diagrams may have more characteristics labeled on them than others, including characteristics not listed above like Color Index, they all have basically the same shape. Here, a basic introduction to the diagram and its usefulness will be given.**

First, the H–R Diagram reveals key relationships in characteristics of stars. The first and most apparent of these is in the main sequence**, which contains all of the stars that form a band in the middle of the diagram. The vast majority of stars fall within this band, including the Sun. Also, giants are found in a group above the main sequence, and white dwarves have their own conglomerate on the lower-left part of the diagram. The fact that these stars occupy distinct sections shows how a star's age can change its physical properties.**

Another use of the H–R Diagram is that it can predict the location of a new, previously unknown star based on certain observations. For example, say a new star was discovered that had a temperature of 10,000 K and was known to be part of the main sequence. By looking at the diagram, it can be predicted that the star will have a luminosity of between 100 to 1000 solar luminosities.

The axes of H–R diagrams relate the luminosity of the star (often in relation to the Sun), to the temperature of the star. Temperatures can be represented in degrees (Kelvin), through Spectral Class (Letters O, B, A, F, G, K and M), or both.

Variable Stars

Main article: Astronomy/Variable Stars

Variable stars are split into two categories, intrinsic variables and extrinsic variables.

Intrinsic Variable Stars

These variables vary in brightness due to changes in the properties of the star itself. For example, pulsating variable stars expand and contract, increasing their radius and changing their luminosity. The most well known type of variables stars are:

- **Cepheid Variables** are stars that lie on the instability strip and have a fixed period-luminosity relationship. This relationship allows for the determining of distances to objects and galaxies. Additionally, Cepheid variables pulsate via the kappa-mechanism, where if the opacity of a star increases with temperature, more heat is trapped, causing the star to expand. However, as it expands, it becomes more transparent, releasing that heat, and decreasing in size once again.
- **RR Lyrae Variables** are stars that are similar to Cepheid variables, but are older and have shorter periods than Cepheids. They have relatively lower mass so are more common than Cepheid, but they are also fainter. The brightness varies based on similar mechanism as Cepheids, although they can have modulation in periods called Blazhko effect due to resonance.
- **Mira Variables** are asymptotic giant branch red giants that have luminosity amplitudes of 2 to 11 magnitudes. The prototype of this type of star was Omicron Ceti, also known as Mira. The entirety of the star is expanding and contracting, causing the fluctuations in luminosity.

Extrinsic Variable Stars

Extrinsic variable stars change in luminosity as a result of external changes.

- **Rotating variable stars** vary in brightness due to its rotation, potentially causing sunspots to appear into view. These darker regions on the star reduce the luminosity, and thus appear to have variable luminosity.
- **Eclipsing variable stars** are stars that vary in brightness due to our view being obscured by another object. Just as astronomers can detect the minute difference in brightness of exoplanet transits in transit photometry, they can detect the variations in brightness. As the secondary star travels around the primary, the primary star's brightness appears to dim, even though the star itself may not be undergoing any changes to its properties.

Groups of Stars

Astronomy also frequently deals with groups of stars, in addition to stellar properties themselves.

Stellar Populations

Populations of stars are classified by their metallicity, or by how much heavy metals a star has.

- **Population I** has the greatest concentration of metals, and most of them are relatively new stars that have taken metals expelled from other stars. The Sun is included within this group, as are many stars in the outer reaches of our galaxy. These make up the majority of stars in spiral and irregular galaxies. Open clusters, which are mostly located in the spiral arms of a galaxy contain mostly Population I stars.
- **Population II** has some heavy metals, but not as much as Population I, as they are older and did not benefit from as much metal dust as newer stars did. Stars in globular clusters and near the core of our galaxy belong to this population. Smaller galaxies also have more stars in this population. Population II stars also make up the majority of stars in elliptical galaxies. There is also a hypothetical
- *Population III* consisting of the very first stars with little to no metal content, as they did not exist near the beginning of the universe. They did not last very long, but helped the metals to form for the later populations.

Galaxies

For more information about galaxies, please see Astronomy/Galaxies and Astronomy/Active Galaxies.

Cosmology

For more information on cosmology, please see the Quantum Quandaries page under the Relativity and Cosmology section.

Math and Calculations

A notorious portion of the Astronomy event is the math portion. Due to the abstract nature of some of the concepts in the event, and the fact that these concepts are unlikely to be covered in any depth in any high school class, the math portion can be very intimidating to some. However, at its core, the math is not that difficult, and the difficulty is knowing how to apply these mathematical relationships, as opposed to actually using them to crunch the numbers. Developing a greater grasp on the math and becoming able to perform calculations accurately can help an Astronomy team go from being decent at the event to becoming very good at the event. Being comfortable with these equations can also help develop a deeper understanding of the governing relationships.

For the competition itself, math questions may vary. Some will be simple plug-and-play questions, whereas others will require more critical thinking, either by using multiple equations to arrive at the answer, using provided data to determine a relationship, or other various tasks. Either way, practice is very important with the Astronomy math. Luckily, the math does not normally change from year to year in the same way that the DSOs or the overall governing topic do, so past tests are a great resource for studying these. This is especially important because, on most tests, math is graded as partial credit. This means that even if the wrong answer is given, work that demonstrates an understanding of the concept can still earn points.

Orbital Motion

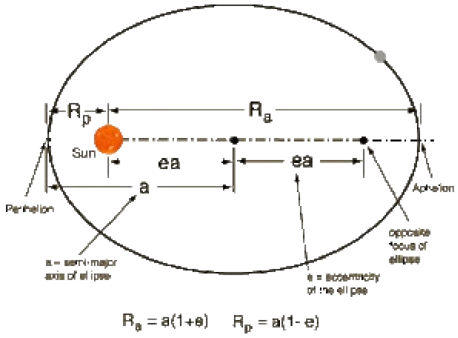
A significant part of the math involved in Astronomy relates to orbital motion, either between a planet and a star, or between stars in a binary system.

Kepler's Laws

Kepler's Laws govern the orbits of satellites. They were originally formed with respect to planetary motion around the sun, but they apply to other elliptical orbits as well.

Kepler's First Law

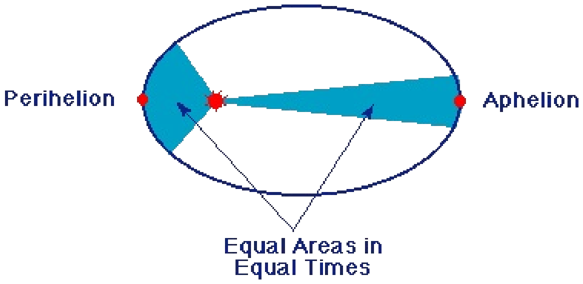
The first law says that all of the orbits of the planets are elliptical with the Sun at one focus. **In terms of ellipses, the foci are two points along the semi-major axis (a in the diagram) of the ellipse around which the planet orbits. At any given point in time, the sum of the planet's distances to both foci is constant, giving it is slightly flattened shape. In the case of a circle, both foci are at the same point. The diagram below illustrates this point.**



A diagram demonstrating Kepler's First Law. For a more basic diagram, see the Solar System page.

Kepler's Second Law

The second law is slightly more complex. This law says that a planet traces out equal areas in equal time**. Since the satellite does not trace out as much area when it is closer to the Sun, it has to move faster in order for this law to be true, so this law basically proves that objects move faster the closer they are to the central object. This law is more easily explained with a diagram.**



Proving this law requires a little bit of physics and calculus. This YouTube video (http://www.youtube.com/watch?v=Pa3Of_3vpRc) has a very clear and direct explanation of this, which is understandable even without a background in calculus. A quick summary of the video is that an elliptical orbit can be regarded as a circular orbit when the angle that the object is tracing out is infinitely small, so by manipulating the formulas for angular momentum [math]\displaystyle{ \left(L=mv_{\perp}r\right) }[/math] and partial area of a circle [math]\displaystyle{ \left(A=\frac{\theta r^2}{2}\right) }[/math], a value for the change in area with respect to the change in time ([math]\displaystyle{ {\operatorname{d}\!A\over\operatorname{d}\!t} }[/math] for those familiar with derivatives) can be found. This expression only depends on the angular momentum (which is always conserved) and the mass of the satellite, neither of which changes over time. Therefore, Kepler's Second Law must be true.

Kepler's Third Law

All of these laws are important for a basic knowledge of astrophysics, but Kepler's Third Law is the one of most relevance to the Astronomy event. According to this law, the square of the satellite's period is directly proportional to the cube of the length of its semi-major axis. **This law can be presented symbolically as** [math]\displaystyle{ p^2\propto a^3 }[/math]**. If we want an actual equation, we have to use a constant.**

[math]\displaystyle{ p^2=\left(\frac{4\pi^2}{GM} \right) a^3 }[/math]

Where G is the gravitational constant and M is the mass of the central object.

In the case of the Earth, when p is expressed in solar years, M is expressed in solar masses, and a is expressed in AU, G cancels out. Then, the formula is simply

[math]\displaystyle{ p^2=\frac{a^3}{M} }[/math]

Where M is the total mass of the system in solar masses. Thus, when talking about our solar system, the solar mass is 1 and we get the most common form of Kepler's Third Law:

[math]\displaystyle{ p^2=a^3 }[/math]

IMPORTANT: **This formula only works if the correct units are used such that everything cancels. If years are not for period or AU is not used for semi-major axis length, then it will likely result in an incorrect answer.**

See this YouTube video (http://www.youtube.com/watch?v=FjAdqr1Qbac) for a proof of this law.

Binary Systems

Orbital calculations involving planets often assume that the location of the massive body (eg the sun) is fixed and that the less massive object orbits the center of mass of the massive body. This approximation works for most practical purposes when the ratio of the bodies' masses is very large. However, more technically, both bodies in a binary system orbit their shared center of mass, or barycenter. For example, in a system that contained only Jupiter and the Sun, the barycenter would be located just outside the sun (it actually shifts around constantly with multiple significantly massive planets). The difference is far more pronounced when the bodies are similar in mass, such as Pluto and Charon or two binary stars.

For the remainder of this section, we will assume two massive bodies in isolation. The physics becomes far more complicated when one considers more than two bodies. One of the most important things to note is that the two bodies orbit in direct opposition to each other with the same period. The more massive body is always closer to the center of mass, while the less massive object orbits further from the barycenter. These are related such that for an object with a mass ma and a distance from the barycenter ra and a second object with a mass mb and a distnance rb:

[math]\displaystyle{ \frac{m_a}{m_b}=\frac{r_b}{r_a} }[/math]

As the period is constant, the object must travel the full circumference in one period. Therefore as circumference is proportion to radius, so also the orbital velocity is directly proportional to the distance from the barycenter.

[math]\displaystyle{ \frac{v_a}{r_a}=\frac{v_b}{r_b} }[/math]

We can also extend Kepler's Third Law to binary systems. Using the result above that:

[math]\displaystyle{ p^2=\frac{a^3}{M} }[/math]

where M is the mass of the system, we substitute the sum of the values of both stars, yielding:

[math]\displaystyle{ m+M=\frac{a^3}{p^2} }[/math]

Here, M,m are both in solar masses, a is in AU, and p is in years. This only works because again, the units cancel out.

Determining Distances

A large part of the Astronomy event is being able to determine distances to objects in space from Earth. Often a question will give certain information and the participant will have to interpret and use the information to find the distance, luminosity, or some other characteristics of the object in question.

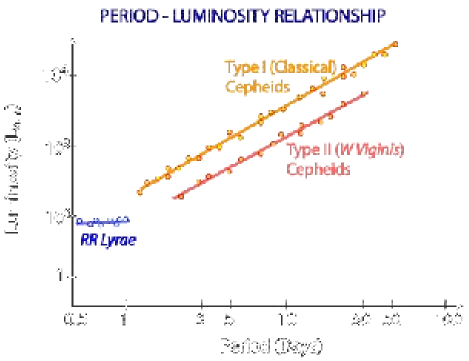
Cepheids and RR Lyrae

This section deals with the uses of Cepheids and RR Lyrae in determining distances. For information about their physical properties, please see Astronomy/Variable Stars

Cepheids and RR Lyrae are two types of variable stars that are especially good for finding distances to galaxies or other groups of stars because they have direct correlations between luminosity and period. In both Cepheids and RR Lyrae, the longer the period, the higher the luminosity. Cepheids typically have periods of about 1 to 50 days. Type I Cepheids**, or Classical Cepheids, are brighter, newer Population I stars (see section about stellar populations above for an explanation).** Type II Cepheids **are similar to Type I in terms of the relationship, but they are smaller, dimmer Population II stars. These are also called W Virginis stars.**

RR Lyrae **are different from Cepheids in that they are older and fainter than Cepheids. RR Lyrae stars typically have shorter periods than Cepheids - usually less than one day. They have masses about half that of our Sun, and are Population II stars. Also, the luminosity does not increase as much to a change in period, as** most RR Lyrae have absolute magnitudes close to 0.75**. Therefore, they are only useful in our galaxy and the one closest to us, Andromeda. However, this makes them very useful in determining distance, because once an RR Lyrae star has been found, one only needs to know the apparent magnitude in order to put it into the distance modulus equation and find distance. RR Lyrae have been linked to globular clusters, since most variable stars in globular clusters are RR Lyrae. They are named after the original RR Lyrae in the constellation Lyra.**

These variable stars are useful in calculations because once the period is found, the luminosity can be calculated or determined through the use of a period-luminosity graph. Then, through other formulas, the distance can also be determined. This gives them the use as "standard candles" in galaxies relatively close to ours in our universe. NGC 4603, one of the listed DSO's, is the furthest galaxy that a Cepheid has been used to calculate distance at 108 million light years away. Cepheids are more rare due to their shorter life span, being more massive than RR Lyrae. Their brightness make it easier to observe, and they are especially useful if there is a Supernova Ia in the same galaxy, to serve as a calibration to the distance ladder.



A period-luminosity graph

Distance Equations

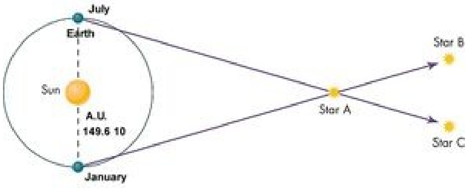
There are many equations that are used to find distances to objects in space. Several of these equations can be found in the Astronomy formula sheet.

Triangulation/Parallax

Triangulation **is often used to determine distances. This method is based on parallax shifts, apparent changes in a star's location when viewed from different locations. The parallax of a star is one-half of the angular shift seen of an object produced over six months, which corresponds to a distance of 2 AU. In other words, it is the angle subtended by a star as the Earth moves by 1 AU. The parallax decreases as distance increases. The equation for parallax is:**

[math]\displaystyle{ D=\frac{1}{p} }[/math]

Thus, a parsec is defined as the distance to a star that has a parallax of one arcsecond. Parallax is only useful to measure stars up to 1000 parsecs away, since past that the parallax is so small that it is not accurate.



A diagram of parallax showing how the apparent position of Star A changes from January to July. Over this time span, the Earth travels 2 AU, so half of the total change is used as the value for parallax, in arcseconds. This value can then be used to determine distance in parsecs using 1/parallax.

Hubble's Law

Hubble's Law uses the fact that objects in space are receding from us to determine distance. Edwin Hubble found that the recessional velocity is proportional to the distance away an object is and created an equation, [math]\displaystyle{ v=H_oD }[/math]**, where v is the recessional velocity,** [math]\displaystyle{ H_o }[/math] **is Hubble's constant, and D is the distance. The exact value of Hubble's constant is disputed, but most values are about 70 km s^{-1} Mpc^{-1}.**

The value of v is found by looking at an object's spectrum. The recessional velocity is the redshift multiplied by the speed of light, and in order to find redshift, a spectrum must be used. Redshift is how much a spectrum shifts toward the red side of the spectrum due to recession. Redshift, or Z, is found by dividing the change in wavelength of the spectrum by the wavelength the object was expected to have.

Distance Modulus

The distance modulus equation is also very important. It relates an object's distance with the difference between the apparent magnitude (m) with the absolute magnitude (M). This difference is known as the distance modulus.

[math]\displaystyle{ 5~(log_{10}(d)-1)=m-M }[/math]

where d is in parsecs, and m,M are apparent and absolute magnitudes respectively.

This equation can be written in many different ways so that different values can be found, but the essential purpose of the formula remains the same. A good way to practice using this equation before the competition is to take the apparent magnitude and approximate distance to a DSO and use them to find the absolute magnitude. This experience will save time if this concept comes up during a test.

Radiation Laws

The radiation laws show relationships between stellar temperature, radius, and luminosity. Both Wien's Law and Stefan's Law are proportionality statements that can be turned into equations by introducing a proportionality constant. In this event, math questions will typically approximate a star or other luminous object with a black body.

Wien's Law: **Wien's displacement law states that the wavelength where a blackbody emits most of its radiation is inversely proportional to the temperature. In equations,**

$$\displaystyle{ \lambda_{max}\propto\frac1T,\quad\lambda_{max}=\frac{b}{T} },$$

where $\displaystyle{ {\lambda}_{max} }$ is the maximum output of radiation from an object, $\displaystyle{ T }$ is Temperature in Kelvin, and $\displaystyle{ b=2900\mu m\cdot K }$ is known as Wien's displacement constant.

For example, the sun has surface temperature $\displaystyle{ T=5778K }$, so its radiation peaks at $\displaystyle{ \lambda_{max}=\frac{2.9\cdot 10^{-3} m\cdot K}{5778K}=502nm }$, a yellow-green color.

Stefan–Boltzmann Law: **The Stefan–Boltzmann law states that the total energy emitted from a black-body per unit surface area is proportional to the fourth power of its temperature. In equations,**

$$\displaystyle{ j^*\propto T^4,\quad j^*=\sigma T^4, }$$

where $\displaystyle{ j^* }$ is the total energy emitted per unit area, $\displaystyle{ T }$ is Temperature in Kelvin, and $\displaystyle{ \sigma=5.67\cdot 10^{-8}\frac{W}{m^2\cdot K^4} }$ is known as the Stefan–Boltzmann constant.

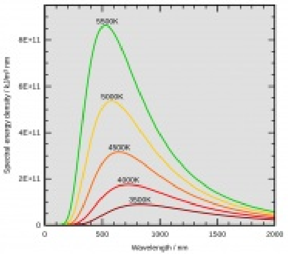
Since all blackbodies we encounter are spheres, it has surface area $\displaystyle{ A=4\pi R^2 }$, where $\displaystyle{ R }$ is the radius of the object. Combining these equations, the total luminosity is

$$\displaystyle{ L=4\pi {R}^{2}\sigma {T}^{4}. }$$

For example, the sun has radius and temperature $\displaystyle{ R=6.96\cdot 10^8 m,~T=5778K }$. Plugging these into the equation, its luminosity is $\displaystyle{ 3.85\cdot 10^{26}\mathrm{W} }$, which is close to the experimental value of $\displaystyle{ 3.83\cdot 10^{26}\mathrm{W} }$.

Planck's Law: **Planck's law states that a hotter blackbody emits more energy at every frequency than a cooler blackbody. The equation form of the law is complicated, but on a radiance vs. temperature graph the curve for a hotter blackbody never dips below that of a cooler one.**

The actual equation for Planck's law, known as the Planck function, is rarely used in calculation - it is usually only used in questions conceptually. It is a multivariable function that describes the radiance of a blackbody at different temperatures and wavelengths of light.



Inverse Square Law

An inverse square law is a relationship in which a quantity is inversely proportional to the square of the distance relating to that quantity. For example, suppose one measures intensity $\displaystyle{ I_1 }$ at distance $\displaystyle{ D }$ from the source. By the inverse square law, we have:

$$\displaystyle{ I_1\propto \frac{1}{D^2} }.$$

This law also applies to Newton's Law of Gravitation. The law states that:

$$\displaystyle{ F=\frac{GMm}{r^2} }$$

where $\displaystyle{ r }$ is the distance between the two objects. By the law, $\displaystyle{ F\propto\frac{1}{r^2} }$.

The law is very common in physics - it also applies to the electrostatic force and the intensity of sound wave in a gas.

Other Math

This is not a comprehensive list, as these represent simply the most common math relationships that appear on Astronomy tests. Brief research will show other relationships that can sometimes appear on an Astronomy test. See the Astronomy formula sheet for additional Astronomy equations.

JS9

For information about using JS9, please see the Astronomy/JS9 page.

In some competitions, you might have to access the JS9 website (https://js9.si.edu/nso/nso.html) during the event to analyze some provided astronomical data. When working with JS9, practice is key. Being able to quickly navigate the software, and knowing what all of the analysis tools do during the event will give you a significantly better chance of being able to complete any JS9 questions that may arise.

The Competition

The competition usually consists of a test, which is normally a pencil-and-paper test, but also may be PowerPoint or station-based. Each team member may bring a laptop or a binder. It is advisable to bring as much information as possible, as a wide breadth of material may be covered. Organize this information so that it is easily referenced during the exam. Most Astronomy tests include mathematical computations, so it is important to have a calculator and a formula sheet ready.

Laptop or Binder?

The question of using laptops or binders as resources has plagued Science Olympians for years. In the end it comes down to personal preference, and experimentation with differing combinations of laptops or binders may be beneficial. Here is a list of advantages and disadvantages to help get a feel for each resource type.

- Binder
  - Advantages
    - Ability to take things in and out of the rings
    - The process of organizing the binder helps to retain information
    - Provides a hard-copy of information
    - Ability to write notes on the papers
  - Disadvantages
    - More limited in terms of data storage
    - If the binder is not used frequently, it can be difficult to find certain information
    - Large binders use up LOTS of paper and ink, making it expensive to update and maintain
- Laptop
  - Advantages
    - Much higher capacity for data storage
    - Easier to carry
    - Availability of Find/Search functions
    - Provides light if taking test in a planetarium
    - Cheaper (free) to update information and maintain the notes, as printing is not necessary
    - No limit on the amount of information available for use
  - Disadvantages
    - No hard-copy of the information (unless one binder and one laptop are used)
    - More difficult to write personal notes
    - Battery could run out during the event

Useful Resources

Formula Sheet for Math Portion of Astronomy
List of Deep Sky Objects
Reach for the Stars for some sample pictures

2017 SSSS Resources:

FuzzyLogic's Notes
Magikarpmaster629's Notes

2015 SSSS Resources:

- foreverphysics' Notes
- Nickf852's Notes
- Nickf852's DSO Info Sheet
- phys1cs' Notes

External Links

Astronomy Notes (http://astronomynotes.com/) - Good overall site for the basics of Astronomy
Swinburne Astronomy Online (https://astronomy.swin.edu.au/cosmos/U/Universe) - Good site for basics on different astronomy concepts.
American Association of Variable Star Observers (http://www.aavso.org) - For information on variable stars.
Chandra X-Ray Observatory (http://chandra.harvard.edu/index.html) - Most DSOs can be found here with lots of information, as well as a lot of information on astronomy.
Chandra X-Ray Observatory Science Olympiad Page (http://chandra.harvard.edu/edu/olympiad.html) - Resources specifically for Science Olympiad Astronomy, including webinars.
NASA Astronomy Picture of the Day (http://apod.nasa.gov/apod/astropix.html) - Great for finding images of DSOs
SIMBAD Astronomy Database (http://simbad.u-strasbg.fr/simbad/sim-fid) - Gathering quick facts about a DSO (such as coordinates, redshift, etc.)
NASA Space Math (http://spacemath.gsfc.nasa.gov/) - Provides work sheets for a wide variety of Astronomy math problems to practice that section.
List of Messier objects - Helpful for identification.
Khan Academy Cosmology and Astronomy (http://www.khanacademy.org/science/cosmology-and-astronomy?k) - Easy to digest videos on the basics of Astronomy.
Onward to the Edge (http://onwardtotheedge.wordpress.com/) - An astronomy blog run by scioly.org's own AlphaTauri, syo_astro, and foreverphysics.

See Also

- Astronomy/DSOs
- Astronomy/Stellar Evolution
- Astronomy/Type II Supernovae

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