2016 Union County College Regionals Science Olympiad Astronomy Test



Wednesday, January 6, 2016

Team Number: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Team Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Event Session: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Hello Science Olympiad competitors,

Welcome to another wonderful day of competition! For this test, you will be gauging your knowledge of the wonderful science of Astronomy! (Woohoo!) Before you begin testing your mastery of the cosmos, there are some important rules that you need to consider before perfecting this art:

1. Remember, NO CHEATING!!!!! (If I notice that you are cheating (which includes, but certainly NOT exclusive, looking over another team’s shoulder, utilizing the internet, and utilizing any other resource OTHER than those stipulated in the rules), I will throw you immediately into a supermassive black hole. (Not really – but I will disqualify you from the competition and put your team in last place.)
2. You will have 50 minutes to take the exam. I will be giving time reminders at 30, 15, 10, 5, 2, and 1, but feel free to ask me at any time for the remaining time. Once I say time, everyone MUST put down any utensils and supplies and put the test FACEDOWN. (Make sure, of course, to reorganize any unstapled tests – otherwise, we will have such a headache reorganizing the tests for grading.) I or another proctor will be going around to collect the tests. If I see anyone attempting to answer questions beyond the time limit, see number 1.
3. Every answer must have units at all times, and the units matter. (As you can tell from the answer form.)
4. Every question will be worth 1 point unless there are multiple parts, in which case each part will be worth 1 point. (But if there’s a question without any parts, that question is still worth only 1 point) There will be 5 tiebreaker questions, and order of importance will be how many of the tiebreaker questions you get correct. I will NOT go by submission time to break ties – unless for some reason, the tiebreak question results in a tie, in which case, I’ll use the number of parts correct on Part 3. If that goes to a tie, then I will use submission order. But don’t feel too rushed!
5. All answers must be rounded to 3 decimal places.
6. Above all, have fun!

Good luck everyone, and may the force be with you!

Part 1: General Knowledge

1. What spectral type has the strongest lines of neutral hydrogen?
   1. B
   2. O
   3. A
   4. M
2. What is the line along which protostars move in the H-R Diagram?
   1. Tauri line
   2. Hayashi line
   3. Sagan line
   4. Kelvin line
3. What is the term called for the zone in which conditions for life on planets are just right?
   1. Goldilocks zone
   2. Venus zone
   3. Earth zone
   4. Mars zone
4. What is the lowest mass at which a star can begin hydrogen core fusion?
   1. 0.2 Solar Masses
   2. 0.8 Solar Masses
   3. 0.5 Solar Masses
   4. 1.4 Solar Masses
5. What quantity is best discerned in an exoplanet by the transit method?
   1. Atmospheric composition
   2. Radius
   3. Density
   4. Mass
6. What quantity is best discerned in an exoplanet by the radial velocity method?
   1. Radius
   2. Density
   3. Atmospheric composition
   4. Mass
7. About how many solar masses is the mass approximately of a T Tauri star and a Herbig Ae/Be star respectively?
   1. 0-2 Solar Masses & 2-8 Solar Masses
   2. 0-5 Solar Masses & 3-6 Solar Masses
   3. 2-6 Solar Masses & 4-7 Solar Masses
   4. 0-8 Solar Masses and 2-5 Solar Masses
8. Which method of discovery has discovered the most planets since 1995?
   1. Radial velocity
   2. Transit
   3. Direct visual
   4. Gravitational Microlensing
9. What is the maximum possible mass of a white dwarf?
   1. 2.00 Solar Masses
   2. 1.44 Solar Masses
   3. 1.2 Solar Masses
   4. 1.0 Solar Masses
10. What two spectral types of stars cause the glow that forms H II regions? (TB1)
    1. A & F
    2. G & M
    3. M & A
    4. O & B

Part 2: Deep Sky Object Identification

Use Image Set A for this part of the test.

1. This object is one of the most studied objects in the night sky and has been crucial in understanding star and planetary system formation.
   1. List the number of this object.
   2. Name two alternate designations of this object.
   3. What is the name for the four massive stars at the center of this object?
2. List the number of this exoplanet that is expected to spiral into its parent star in less than a million years. (TB2)
3. List the number of the object that is so close to Earth that no stars can be seen between the Sun and it due to it being a dark absorption nebula.
4. 2MASSJ22282889-431026 is a brown dwarf.
   1. Name the number of this object.
   2. What two telescopes discovered the object?
   3. What was so momentous about the discovery of the object and its analysis?
5. This object, when discovered in 1995, changed the field of studying exoplanets forever.
   1. List the number of this object.
   2. Name what this object is called.
   3. What method was used to detect this object?
   4. What type of object is this object?
   5. Who discovered this object?
6. List the number of the DSO that has the third-highest proper motion as of 2014, behind only Barnard’s Star and Kapteyn’s Star.
7. Give the name and number of the object that could be hosting a brown dwarf or exoplanet in its dust disk.
8. Give the number and the name of the object that contains a protoplanetary disk.
   1. What is so important about dark bands that were discovered in said protoplanetary disk?
   2. What type of object is accompanied by this object?
9. List the following numbers in order of how close they are to their parent stars: 14, 1, 15, 4
10. Kepler-186 is a main-sequence dwarf star containing 5 planets.
    1. Name the name of the image that contains Kepler-186.
    2. What achievement does Kepler-186f achieve?

Part 3: Exoplanet and Distance Calculations

Use Image Set B when noted to complete this section.

1. A star is detected to have a parallax of 0.15 arcseconds. Find out the approximate distance to that star from Earth in parsecs.
2. Image Number 21 shows the light curve of an exoplanet. Answer the following questions about the light curve:
   1. Approximately how long in days did the transit take?
   2. Using the light curve graph, calculate the approximate radius of the planet in Jupiter radii given that the parent star’s radius is about 2.5 Solar Radii. (Use the fact that 1 Jupiter radius = 70,000 km and that 1 Solar Radius = 700,000 km)
3. Image Number 22 shows a radial velocity graph of an exoplanet revolving around a main-sequence star.
   1. What is the period of the star’s orbit?
   2. Calculate the mean separation between the exoplanet and its host star in kilometers if the exoplanet’s mass is 0.01 times the mass of the star and the star’s mass is 2 Solar Masses. (1 Solar Mass = 1.989 \* 10^30 kg)
   3. Looking at the graph, is the eccentricity of the planet’s orbit close to 0 degrees?
   4. What effect on the radial velocity graph would changing the eccentricity of the planet’s orbit have?
4. On your way to stellar hegemony (aka the Large Magellanic Cloud), you notice a small planet revolving around a normal star. You have been bored after traveling for 25 years, so you decide to investigate this planet. You find that this planet is full of Whos. (Yes, like the Whos in *Horton Hears A Who!*) Quite conveniently enough, however, you notice a mad scientist traveling in a quite retro (at least by 22nd century standards) spaceship with a weird contraption. You find out from the Whos that the mad scientist wants to turn the planet into a blackbody. In this problem, you will find out why this is such a big deal. (TB3)
   1. If the mad scientist succeeds in his plan, what will be the planet’s equilibrium temperature in Kelvin given that the surface temperature of the star is 4000 K, the albedo is 0.25, the radius of the star is 2.0 Solar Radii, and the orbital distance is 0.25 Solar Radii.
   2. Given that the maximum temperature that the Whos can withstand is 5000 K, will the Whos survive?
5. Suppose Star A has a mass of 2 Solar Masses and Planet A has a mass of 2 Earth Masses. The mean separation between Star A and Planet A is ½ AU. (For this problem, let the mass of Planet Earth be 5.972 \* 10^24 kg, let the mass of the Sun be 1.989 \* 10^30 kg, and let 1 AU be 1.50 \* 10^8 km.) Using that knowledge,
   1. Calculate the tangential velocity of Planet A along its orbit around Star A in meters per second.
   2. Calculate the gravitational force between Star A and Planet A in Newtons.

Part 4: H-R Diagram

Use the H-R Diagram below to answer the following questions.



1. Name either one of the two quantities that is measured on the x-axis and either one of the two quantities that is measured on the y-axis.
2. Where would you see white dwarfs?
3. Where would you find T-Tauri objects (approximately)?
4. Of the group of letters B, K, E, L, and A, name the order, from least time to most time, of the letters in terms of time spent on the main-sequence in the star’s lifetime.
5. Which two letters occupy the giant branch of the H-R Diagram?

Part 5: Term Identification

For each question, give the term that the question is referring to.

1. An object whose only similarities to a star are that it burns deuterium in its core.
2. A special type of object F that young stars undergo stages of about 10-20 times before entering the main-sequence.
3. An intermediate life stage of most stars; it consists of stars burning helium in their cores.
4. A technique that uses the rotational velocity of a galaxy to determine its distance from Earth.
5. A type of variable and pre-main-sequence star that uses gravity to power itself as it heads towards hydrogen fusion.
6. An end stage of a star; one of these objects famously was the subject of a bet between Stephen Hawking and Kip Thorne.
7. An object whose maximum possible mass is determined by the Chandrasekhar limit, after whom the Chandra X-Ray Observatory is named.
8. A tool used to track stellar evolution and the absolute magnitude and temperature of stars and star clusters; it was named after two American astronomers.
9. A technique that uses main-sequence fitting to determine a star’s distance from Earth.
10. This is a term for a type of object that orbits very close to its host star, is named after a certain big satellite of Sol, and which 51 Pegasi b is a famous example of.

Part 6: Short Answer

1. Why do you not find protostars to the east of the subject of Question 2?
2. What causes the rapid and profound fluctuations in luminosity in FU Orionis stars?
3. Explain what was so important about the discovery of 51 Pegasi b.
4. Explain the difference between a super-Earth and a mini-Neptune.
5. Why is iron bad for the core of a post-main-sequence high-mass star? (TB4)

Part 7: Miscellaneous (But don’t worry; these questions will still be related to the rules; they just don’t have a common theme)

1. What is the term for the mass at which a gas cloud begins contracting into a protostar? (TB5)
2. If the B-V color index of a star is 0.05, would it be more likely to be blue, white, or yellow?
3. Around which object was the first exoplanet discovered and by whom?
4. What are the four types of brown dwarfs and how are they categorized with respect to the four types?
5. What is a disadvantage of the radial velocity method for discovering exoplanets?

Well, that’s all she wrote! I hope you enjoyed this Astronomy exam and I wish you the best of luck in your journey towards Astronomy hegemony! (Or a gold medal. Results may vary. See the Science Olympiad director for more details) And above all, have fun!

The End =)