SCHOOL NAME: ____ TEAM NUMBER: ________

Islip Invitational 2013
Astronomy Examination

Do not open this booklet until instructed to do so.
For some of the questions, a color inlay has been provided for increased clarity.

You are allowed to separate the packet and work in any order as long as the packet is stapled in the correct order when submitted to the event supervisor.

All of your answers must be placed on the provided answer sheet. No questions placed in the exam booklet will be graded for the event.

The total points from Section III will serve as the first tiebreaker, if needed. Additional tiebreakers will be employed, as appropriate.

Student Names: ____

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Section I: Multiple Choice (1 point each)

1. Standard candles of choice for measuring the nature of dark energy are
   a. RR Lyrae stars
   b. M dwarf stars
   c. Cepheid variables
   d. Type 1a supernovae

2. We use the Period-Luminosity relation to find distances to which of the following?
   a. Mira variables
   b. Cataclysmic variables
   c. Cepheid variables
   d. Semi-variables

3. The heavy elements in our bodies were formed
   a. In a black hole
   b. In neutron stars
   c. In interstellar space
   d. In the interior of stars

4. 21-cm radiation is produced by
   a. Electrons spiraling in a magnetic field
   b. Cold hydrogen gas
   c. The cooling big bang
   d. Small dust grains

5. The central engines of quasars are thought to be
   a. Supernovae explosions
   b. Novae explosions
   c. Accretion onto a supermassive black hole
   d. Accretion onto a low-mass black hole

6. For a star cluster, the position of the main sequence turnoff indicates
   a. The cluster age
   b. The number of stars in the cluster
   c. The mass of the cluster
   d. All of the above

7. Stars leave the main sequence because
   a. They want to go to the center of the galaxy.
   b. They have exhausted their hydrogen supply near the center.
   c. They have exhausted their helium supply near the center.
   d. Their center becomes a black hole.

8. An O8 V star has an apparent magnitude of +1.Use the method of spectroscopic parallax to determine the approximate distance to the star.
   a. 100 pc
   b. 400 pc
   c. 1000 pc
   d. 1500 pc

9. Spectra from neutral atoms compared with spectra from ionized atoms of the same element
    a. Are slightly blueshifted.
    b. Are the same.
    c. Are slightly redshifted.
    d. Have different sets of spectral lines.
    e. Have the same sets of spectral lines but different widths for those lines.

10. Suppose you see two stars: a blue star and a red star. Which of the following can you conclude about the two stars? Assume that no Doppler shifts are involved.
    a. The red star has a hotter surface temperature than the blue star.
    b. The red star is more massive than the blue star.
    c. The blue star is more massive than the red star.
    d. The blue star has a hotter surface temperature than the red star.
    e. The blue star is farther away than the red star.

11. As astronomers use the term, the parallax of a star is
    a. One half of the Doppler shift due to its radial velocity.
    b. The time it takes for a star to move one second of arc of proper motion.
    c. Always equal to 1 AU.
    d. One half of the angle that a star shifts when seen from opposite sides of the Earth's orbit.
    e. The time it takes a Cepheid variable star to go through one cycle of its brightness changes.

12. Which of the following statements about spectroscopic binary stars is false?
    a. Visually we can only see one star.
    b. Some of the lines in the spectrum are double, with the spacing changing over time.
    c. An analysis of the ways the lines in the spectrum change allows us to calculate the star's distance directly.
    d. We can use the spectrum to determine the sum of the masses of the two stars.
    e. We can often use the changes in the positions of the spectral lines to measure the radial velocity of the stars in the system.

13. How do astronomers know that pulsating variable stars are actually expanding and contracting in diameter?
    a. They discover this by looking at the position on the H-R diagram.
    b. They can measure the star's changing pull on a companion star around it.
    c. They can measure a regularly varying Doppler shift in the emission spectrum.
    d. It is clear from the light curves.
    e. Astronomers are just hypothesizing; at the distance of the stars, there is no way to show that stars are expanding and contracting.

14. A team of astronomers discovers one of the most massive stars ever found. If this star is just settling down in that stage of its life where it will be peacefully converting hydrogen to helium in its core, where will we find this star on the H-R diagram?
    a. Among the supergiants, in the upper right.
    b. A little bit below the Sun on the main sequence.
    c. Among the most brilliant of the white dwarfs, in the lower left.
    d. Near the very top of the main sequence, in the upper left.
    e. It could be anywhere on the diagram; we would need more information to determine its proper place.

15. The period-luminosity relationship of certain variable stars was discovered by
    a. Edward Pickering
    b. John Goodricke
    c. Edwin Hubble
    d. Henrietta Leavitt
    e. Henry Norris Russell

16. The higher the intrinsic brightness of a Cepheid variable,
    a. The lower it is on the main sequence of the H-R diagram.
    b. The larger the telescope we need to observe it.
    c. The smaller its mass.
    d. The closer it is to us.
    e. The longer the period of its variations.

17. If an astronomer wants to find the distance to a non-variable star and is located too far away for parallax measurements, she can
    a. Use the star's light curve.
    b. Use Kepler's Laws as modified by Newton.
    c. Search for planets around the star since it is much easier to get the distance to dense planets.
    d. Use the star's spectrum and spectral class to determine its luminosity.
    e. There is no way to even begin to estimate such a distance.

18. A white dwarf, compared to a main sequence star with the same mass, would always be
    a. Larger in diameter.
    b. The same size in diameter.
    c. Smaller in diameter.
    d. Younger in age.
    e. Less massive.

19. The hydrogen lines in spectral type A stars
    a. Are most narrow for supergiants.
    b. Are most narrow for main sequence stars.
    c. Cannot be used to estimate the luminosity of the star.
    d. Are very weak and difficult to see.
    e. Are useful in determining the apparent magnitude of the star.

20. We know that giant stars are larger in diameter than the Sun because
    a. They are hotter but have about the same luminosity.
    b. They are cooler but have about the same luminosity.
    c. They have a larger absolute magnitude than the Sun.
    d. They are less luminous but have about the same temperature.
    e. They are more luminous but have about the same temperature.

21. Kepler's third law means that
    a. All orbits with the same semimajor axis have the same period.
    b. A planet's period does not depend on the eccentricity of its orbit.
    c. Planets that are farther from the star move at slower average speeds than nearer planets.
    d. The period of the planet does not depend on its mass.
    e. All of the above are correct.

22. Why is it so difficult for astronomers to see new stars in the process of birth?
    a. Most stars are born inside dusty clouds which block any light that may be coming from the stars.
    b. Protostars which are not yet performing fusion do not give off a lot of visible light.
    c. The size of a newly forming star is typically quite small and thus hard to make out
    d. Birth happens very quickly, so it is hard to catch stars in the act.
    e. All of the above are correct.

23. Astronomers studying regions like the Orion Giant Molecular Cloud have observed that a wave of star formation can move through them over many millions of years. What sustains such a wave of star formation in a giant molecular cloud?
    a. Radio waves from complex molecules move slowly through the cloud, causing stars to form.
    b. When a group of stars form, they remove so much material from the cloud that only a big empty place is left, into which new matter from other clouds falls, creating more stars.
    c. When massive stars form, their UV radiation and later their final explosions compress the gas in the cloud and cause a new group of stars to form.
    d. When giant molecular clouds collide with each other, they do so not just once, but many times.
    e. The dust in these clouds is so heavy: it is always setline inward toward the cloud's center causing star formation in its wake.

24. When a star settles down to a stable existence as a main-sequence star, what characteristics determines where on the main sequence in an H-R diagram the star will fall?
    a. The fraction of the atmosphere that consists of hydrogen.
    b. The speed and direction of its rotation.
    c. Its mass.
    d. Whether it is located on the outer regions or the central regions of the molecular cloud that gave its birth.
    e. The size of the disk around it.

25. In a Type Ia supernova, the cause of the violent outburst is
    a. The sudden emission of a shell of stellar material from a dying low-mass star.
    b. The collapse of a very massive protostar to the main sequence.
    c. An enormous release of neutrinos during a flash episode of hydrogen fusion.
    d. The transfer of so much mass from a companion star that the white dwarf collapses, causing an enormous amount of sudden fusion.

26. Massive stars cannot generate energy through iron fusion because
    a. Iron fusion requires very high density.
    b. Iron is the most tightly bound of all nuclei.
    c. Stars contain very little iron.
    d. No star can get hot enough for iron fusion.
    e. Massive stars supernova before they create an iron core.

27. After the core of the massive star becomes a neutron star, the rest of the star's material
    a. Falls inward very slowly, taking billions of years to get really compressed.
    b. Makes a planetary nebula, which gently moves outward from the center.
    c. Is vaporized by the incredible heat of the dying star and evaporates.
    d. Explodes outward as a supernova.
    e. Continues regular fusion and returns to the main sequence.

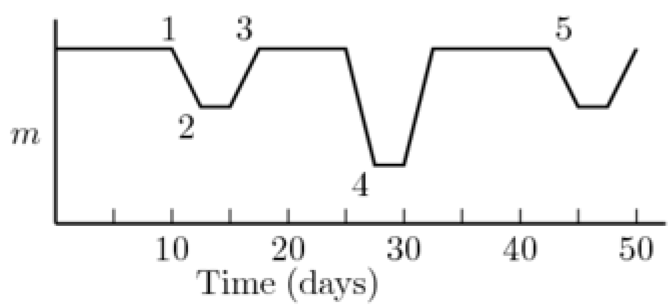
28. As a star becomes a giant, its outer layers are expanding. The energy for expanding these layers comes from
    a. A magnetic dynamo effect in the star's outer layers, caused by a much stronger magnetic field inside the star.
    b. The fusion of hydrogen into helium in a shell around the core.
    c. The long-term fusion of hydrogen to helium in the core.
    d. An explosion in the core.
    e. The fusion of helium into carbon in the core.

29. When neutron stars were first predicted theoretically, no scientist expected to be able to detect one of them across interstellar distances. What enabled astronomers to find neutron stars in the late 1960s?
    a. They give off a lot more light than expected, and can be seen glowing with a reddish light from far away.
    b. They are so large, their dark outline blocks a significant amount of starlight from behind them.
    c. Strongly magnetic neutron stars were found whose whirling beams of energy were seen as pulsars.
    d. Some neutron stars soon collapse to be white dwarfs, which can be detected farther away.
    e. Astronomers have actually only found one neutron star and that was discovered very close to us by sheer luck.

30. A Type II supernova
    I. Occurs when a white dwarf exceeds the Chandrasekhar limit.
    II. Is the result of helium flash.
    III. Is characterized by a spectrum that shows hydrogen lines.
    IV. Occurs when the iron core of a massive star collapses.
    a. I only
    b. II only
    c. III only
    d. IV only
    e. III and IV only

Section II: Short Answer (2 points each)

Questions 31 through 33 refer to the following light curve showing a binary.



31. What type of variable star is shown in the diagram?
32. What is the period of the binary?
33. Using the numbers shown on the light curve, indicate where the cool star is in front of the hotter star.

Questions 34 through 38 refer to the following table of stars.

Star	mv	Mv	d (pc)	Parallax (sec of arc)	Spectral Type
65 Tau	4.2			0.025	A7 IV
HR 4621	2.6	−0.3			B2 IV
α Pic		1.8	20		A7 V
58 Ori		−6.0		0.005	M2 I
HR 2491	−1.5		2.5		A1 V

34. Which star would appear the faintest in the sky?
35. Which star has the greatest luminosity?
36. Which star is closest to the Earth?
37. Which star has the greatest surface temperature?
38. Which star has the greatest diameter?

Questions 39 through 41 refer to the following information. Report answers in proper scientific notation.
A binary system has a period of 32 days, an orbital velocity of 153 km/s, and an orbit that is nearly edge-on.

39. Determine the circumference of the orbit.
40. Determine the radius of the orbit.
41. Determine the mass of the binary system.

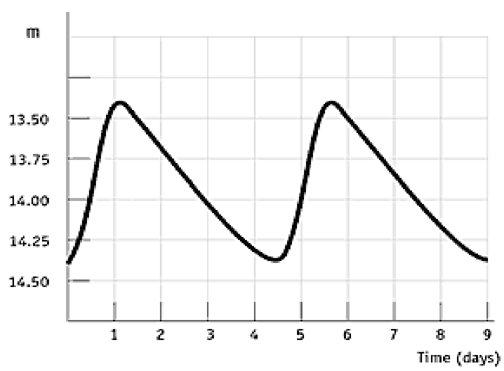
Questions 42 through 45 refer to the following information.
Consider two stars, radiating like blackbodies. One, a main sequence A star with a mass of twice the mass of the Sun, lies at a distance of 100 light years, and has a surface temperature of 9000K and a radius of 10^6 km. The second, a red giant with mass equal to the mass of the Sun, has a surface temperature of 3000K and a radius 100 times larger than that of the A star.

42. Calculate the ratio of the luminosity of the red giant to that of the A star.
43. What is the peak wavelength at which the A star emits? Express your answer in Angstrums.
44. Express the distance of the A star in terms of parsecs.
45. With a sufficiently powerful space-based telescope, one could resolve the two stars. Suppose that the two stars subtend the same angle. Calculate the distance of the red giant in terms of light years.

Section III: Identification (1 point each)

Questions 46 through 48 provide different light curves of variable stars. Based on the provided information, determine the type of variable star represented in each question.

46.



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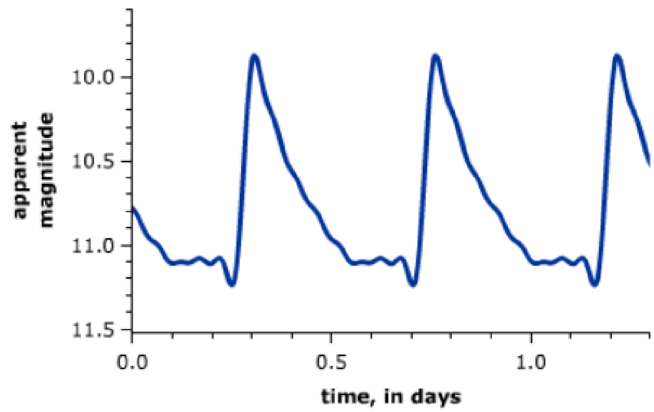
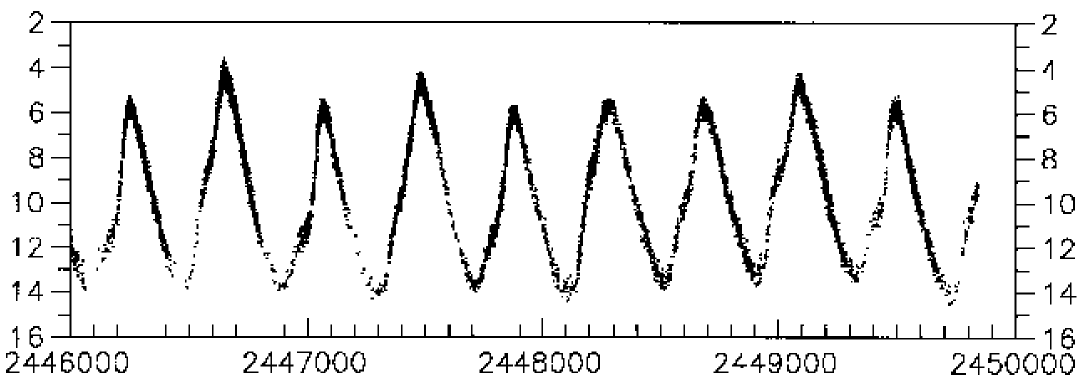


48.



Questions 49 through 60 refer to the images shown on the color inlay.

49. Identify Object A.
50. What is the eventual fate of "A" in Object A.
51. Identify Object B.
52. In which constellation does Object B reside?
53. Identify Object C.
54. Object C would be classified as which type of variable star?
55. Identify Object D.
56. What is the name of the nebula found to the west of Object D?
57. Identify Object E.
58. What is the declination of Object E, in degrees?
59. Identify Object F.
60. What is found in Object F as a direct result of the progenitor star's demise?

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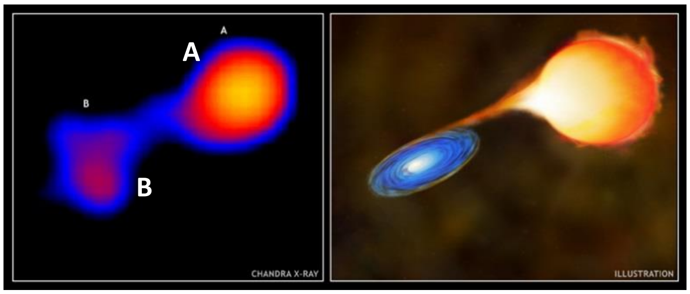
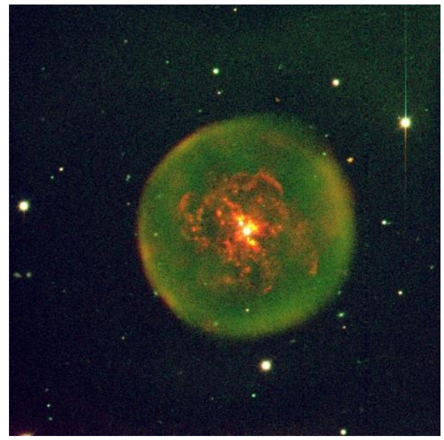
Islip Invitational 2013
Astronomy Color Inlay

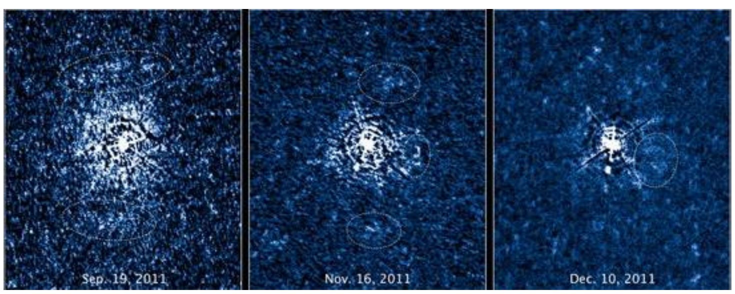
Object A



Object B

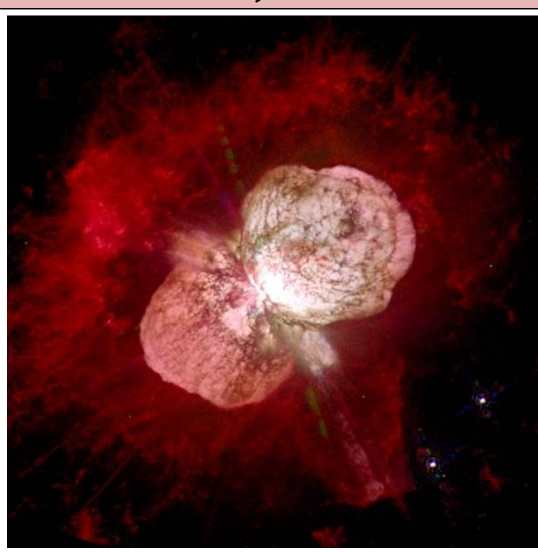


Object C



Object D

Object E



Object F