Science Olympiad

Hawk and Hornet 2026 Invitational

November 15th, 2025

Astronomy C Test

Directions:

- Each team will be given 50 minutes to complete this exam
- 3 sections: Section A (General), Section B (DSO). Section C (Astrophysics)
- Use 2-3 decimal places in final answers for Section C, partial credit will be given for work
- Tiebreakers: Astrophysics #2e, General #18, DSO #4c, DSO #4d, Astrophysics #1h
- Good luck!

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Questions? Email ethankchen6@gmail.com

Name(s): _____ Team #: C___

Section A: __/26 Section B: __/36 Section C: __/26

Total: __/88

Section A (General)

(1 pt unless otherwise specified)

1) What are standard candles?
   a) Objects with a varying apparent magnitude
   b) Objects with a varying absolute magnitude
   c) Objects with a known apparent magnitude
   d) Objects with a known absolute magnitude

2) Kepler's Third Law is derived by equating what two forces?
   a) Gravitational Force and Centrifugal Force
   b) Gravitational Force and Orbital Velocity
   c) Gravitational Force and Tidal Force
   d) Centrifugal Force and Tidal Force

3) Cepheids and RR Lyrae variable stars follow what relation?
   a) Mass-Radius Relationship
   b) Mass-Luminosity Relationship
   c) Period-Mass Relationship
   d) Period-Luminosity Relationship

4) Cepheid and RR Lyrae variable stars pulsate due to what element in their stellar atmospheres?
   a) Hydrogen
   b) Carbon
   c) Helium
   d) Oxygen

5) If the said element above is more ionized, it is then more opaque, allowing less radiation to escape and absorbing more.
   a) True
   b) False

6) A stellar classification of V denotes what classification?
    a) Giants
    b) Main Sequence
    c) Supergiants
    d) Cepheids

7) The blue loop in stellar evolution occurs after what stage of evolution?
    a) Main Sequence
    b) Planetary Nebula Phase
    c) Subgiant Branch
    d) Horizontal Branch

8) What are Population I stars?
    a) Metal-Rich, Younger Stars,
    b) Metal-Rich, Older Stars
    c) High-Mass, Old Stars
    d) Metal-Poor, Younger Stars

9) What happens directly before the horizontal branch of an HR diagram?
    a) Helium Flash
    b) Ignition of Hydrogen Fusion
    c) Type Ia Supernova
    d) Roche-Lobe Overflow

10) Where are white dwarfs found on the Hertzsprung-Russell Diagram?
    a) Center
    b) Top right
    c) Lower Right
    d) Lower Left

11) Carbon Stars are a type of star with an abundance of carbon in the atmosphere. This is a result of what stage of stellar evolution?

a) Main Sequence
b) T-Tauri Stage
c) Red Giant Branch
d) Asymptotic Giant Branch

12) If a planet had its orbital period doubled, by what factor would its orbital radius increase?

a) $\sqrt{2}$
b) $\sqrt[3]{4}$
c) 2
d) $\sqrt{3}$

13) Kepler's 2nd Law is derived from which law?

a) Law of Conservation of Momentum
b) Kepler's 1st Law
c) Newton's Law of Gravitation
d) Newton's Third Law

14) Why are standard candles so important?

a) Can help determine average brightness of certain stars
b) Can help determine distance to objects in space
c) Not important in Astronomy
d) Determines age of stars

15) What are the end states of stars after nuclear fusion from lowest mass to highest mass.

a) Black Hole, Neutron Star, White Dwarf
b) Red Giant, Neutron Star, Black Hole, White Dwarf
c) Red Giant, White Dwarf, Neutron Star, Black Hole
d) White Dwarf, Neutron Star, Black Hole

Short Answer

16) What is a classical novae? (2)

17) When a Helium Flash occurs, why does the overall radius of the star actually decrease? (2)

18) How was the Schwarzschild Radius derived? (2.5)

19) Why are protostars generally brighter than their main-sequence counterparts? (2.5)

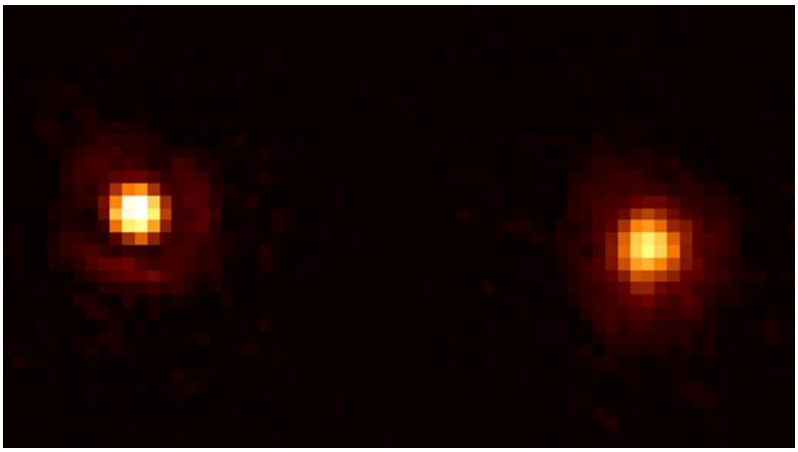
20) Why can no star fuse Iron? (2)

Section B (DSOs)

(1 pt each unless otherwise specified)

1)

a) What DSO is shown on the right?



b) Which objects are the primary and secondary stars respectively?

c) In 1995, the Hubble Space Telescope successfully resolved this system. What was the angular separation then?

d) What was the physical separation then?

e) In 2007, what was discovered around the secondary star?

f) What is the average radius of the primary in $R_{\odot}$?

2)

a) What is the Sharpless Catalog?

b) What causes the red glow of Sharpless 29?

c) What is the approximate distance to Sharpless 29?

d) Sharpless 29 is located nearby two other bright HII regions. What are these regions?

e) Who discovered Sharpless 29 and when?

f) What is the more unique and more peculiar name to Sharpless 29

3)

a) How old is the Ophion Star Family?

b) Knowing the age, what is the maximum possible mass for a main sequence star in this cluster in $M_{\odot}$.

c) Roughly what distance and constellation is Ophion located in

d) What is a usual explanation for the cause of runaway stars?

e) What did astronomers analyze compared to Gaia Data Release 3 to discover the Ophion Star Family?

f) What is the leading hypothesis for the large average velocity of this cluster relative to nearby stars?

4) The questions below relate to WDJ181058.67+311940.94

a) What is the total mass of this system?

b) At their current orbital period, what is the combined orbital radius in Earth radii?

c) Before collision, the stars will be simulating to orbit in just 30 seconds. What would be the orbital radius in Earth radii? (1.5)

d) Does a higher mass white dwarf have a higher radius? Why or why not?

e) When a Type Ia supernovae does occur in this system, it is estimated to be 200,000 times brighter than Jupiter. Knowing the apparent magnitude of Jupiter to be -2.94 (at min), what is the apparent magnitude of WDJ181058.67+311940.94 at supernovae?

f) When will the Type Ia supernovae of WDJ181058.67+311940.94 occur?

5)

a) What DSO is imaged on the right?

b) What wavelength was the image captured in?

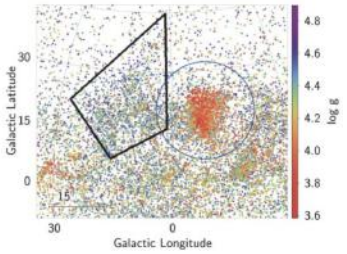
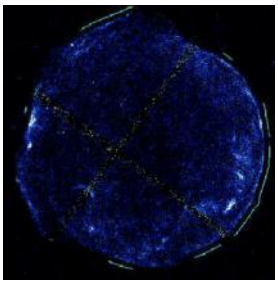
c) What is the energy source for this DSO?

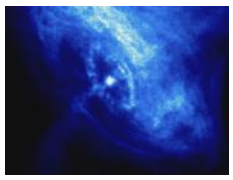
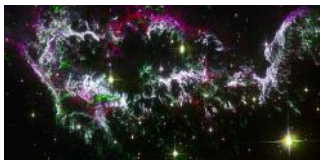
d) What is the name for this energy source?

e) What type of nebulae surrounds this DSO?

f) Name the three bright stars in the center of the nebulae

Write the name of the DSO in the space provided above the images (0.5 each)

Section C (Astrophysics)

1) In 1861, a comet passed near Earth and was visible to the naked eye for 3 months. The semi-major axis is 55.1 AU and orbital eccentricity is 0.985.
    a) To the nearest year, when is the next perihelion? (1)

    b) What is the orbital velocity in km/s at perihelion? (1)

    c) What is the orbital velocity in km/s at aphelion? (1)

    d) What is the apparent magnitude of the Sun at aphelion? (2)

    e) What is the escape velocity of the comet at perihelion in km/s? (1)

f) Assume the comet has a mass of 10^{14} kg. What is the orbital energy (J) of the comet at any point in its orbit? (2)

g) To achieve escape velocity, what would be the energy (J) that would have to be added to the comet? (2)

h) The comet's position is at perihelion. Assume we wanted to fire a rocket engine for 30 minutes to achieve the comet's escape velocity. What would be the force of the rocket engine in kilonewtons, assuming it is constant? (3)

2) There exists a well known general relation for Main Sequence Stellar Mass and Luminosity, $\frac{L}{L_\odot} = \left(\frac{M}{M_\odot}\right)^{3.5}$. Since this relation is based on observational data of stars, it is then similarly possible to make a Mass-Radius Relation utilizing the same method.

a) Generally, at what distance [pc] does stellar parallax become unreliable? (1)

b) When stellar parallax becomes unreliable, what does this mean for our dataset? (1)

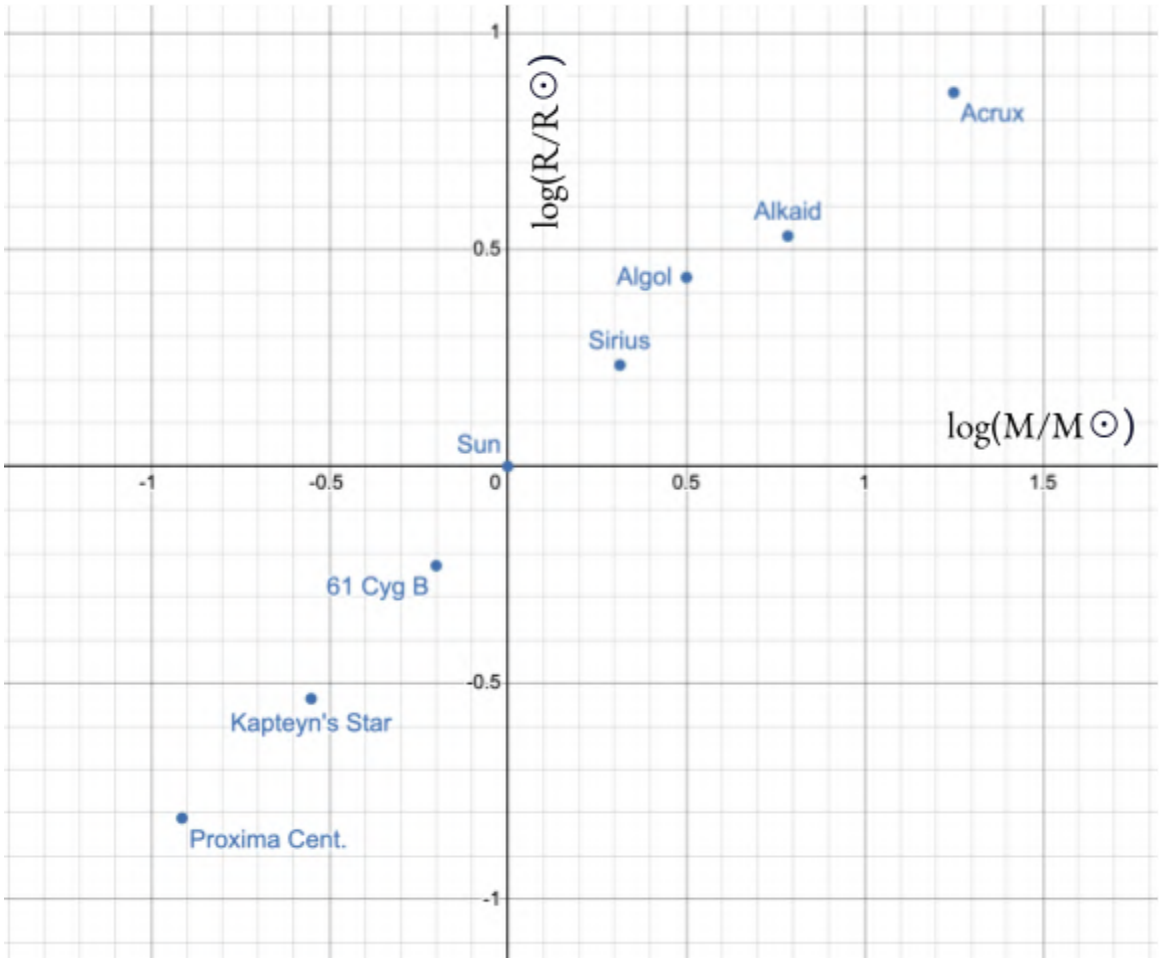
c) Interferometry data shows that Alpha Centauri B has an angular diameter of 6 mas. Knowing that the stellar parallax of the system is 0.75", what is the radius of Alpha Centauri B in $R_\odot$? (1)

It is also particularly convenient if stars are in a binary system, as their masses can be accurately determined.

d) α Centauri A and α Centauri B are observed to have a period of 79 years and an observed average angular separation of 17". Calculate the combined mass of the system in $M_{\odot}$? (1)

e) α Centauri A is observed at an average distance of 7.2147" from the center of mass. Determine the mass of each star in $M_{\odot}$. Note: the COM equation might be useful. (2)

Parts a - e can be repeated for multiple stars (preferably binary stars) to generate a catalog of stars with known mass and radii. A dataset has been prepared below with nearby stars.



f) Draw a line of best fit (ON THE ANSWER SHEET) and calculate the slope of the line. <u>The line must pass through (0,0).</u> A range of answers will be accepted. (1)

g) Why is the scale a logarithmic plot? (1)

h) For $\frac{R}{R_\odot} = \left(\frac{M}{M_\odot}\right)^{\alpha}$, determine the value of α in the Mass-Radius Relationship. (2)

i) What is the estimated radius of Vega ($\alpha\ Lyrae$) according to our model if it has a mass of 2.15 $M_\odot$? A range of answers will be accepted. (1)

j) Establish a Luminosity-Radius relation for the main sequence in $R_\odot$ and $L_\odot$, with $\alpha = 0.7$ (1)

k) Proxima Centauri has a point of $(-0.913, \ -0.812)$. What is the percent error of our model's prediction of Proxima Centauri's radius, with $\alpha = 0.9$? (1)