Camp Eberhart Astronomy Program
AstroCamp Star Identification Award

Requirements:

- Demonstrate a basic understanding of the highlighted topics 1-9 below.
- Know the magnitudes of the five (5) brightest stars in the sky.
    - Sirius (-1.46)
    - Canopus (-0.72)
    - Rigil Kentarus (Alpha Centauri) (-0.27)
    - Arcturus (-0.04)
    - Vega (0.03)
- Identify twenty (20) stars at night by name. At least one must be of each magnitude zero through six currently visible. For example:
    - Magnitude 0: Vega (0.03)
    - Magnitude 1: Antares (0.96)
    - Magnitude 2: Polaris (2.02)
    - Magnitude 3: Albireo (3.08)
    - Magnitude 4: Alcor (4.0)
    - Magnitude 5: Eta Ursae Minoris (5.0)
    - Magnitude 6: 38 Bootis (5.8)
- Locate:
    - One double star
    - One variable star
    - One open star cluster
    - One globular star cluster
    - One emission nebula
    - One reflection nebula
    - One dark nebula
    - One elliptical galaxy
    - One spiral galaxy

CAMP EBERHART

1. What is a Star?

a. Composition
   i. 91% Hydrogen, 9% Helium, <.4% all others, by number of atoms
   ii. In form of plasma; charged atoms (ions) stripped of electrons

b. Processes for Radiation
   i. Atoms are forced together and heated by gravitational attraction
      1. Core is at a temp of 15 million°K (27 million°F)
   ii. Atoms in core undergo nuclear fusion
      1. In the Proton - Proton reaction, 2 hydrogen atoms combine in a 5 step process to form helium and release energy.
      2. The Sun fuses 600 million tons of hydrogen into 596 tons of helium every second!
      3. The 4 million ton mass loss is turned into energy according to Einstein's $E = mc^2$.
      4. Equivalent to 100 billion H bombs every second!
      5. Produces enough energy for almost 500,000 years of global use at current rates every second!!

2. Why Do Some Stars Appear to Twinkle?

a. Earth's turbulent, non-uniform atmosphere of temperature and density differences rapidly shifts & breaks up star's tiny beam of light coming to eyes
b. Planets, having an apparent size larger than stars, don't twinkle

3. Stellar Magnitudes

a. Measure of brightness of celestial objects
   i. Lower number is brighter; larger is dimmer
   ii. 5 magnitudes = 100x difference in brightness. Stars of 1st magnitude are 100x brighter than 6th magnitude stars.
   iii. Brightest naked eye stars are of 1st magnitude (or slightly less)
   iv. Dimmest naked eye stars are of 5th or 6th magnitude
   v. Examples: Sun -26, full moon -12, Venus -4, Jupiter -2, Vega, Deneb, Arcturus are mag 0, Uranus +5, Neptune +8, asteroids +6-+12, dimmest star seen by Hubble Space Telescope +31.5.

b. Magnitude Types
   i. Apparent Magnitude (m) - observed brightness as seen in sky from earth
   ii. Absolute Magnitude (M) - brightness of star seen at the standard distance of 10 parsecs (32.6 light years). Used to eliminate different distances when comparing brightness of stars or other celestial objects.

4. Solar Parameters

a. Visual magnitude (brightness in sky): -26 (375,000xFull moon & 5.1 billion x brightest star)
b. Absolute magnitude (brightness if 32.6 light years [10 parsecs] away): +5
a. Diameter 864,000 miles (1.4 million km). Nearly twice the diameter of the Moon's orbit.
c. Composition: 91% Hydrogen, 9% Helium, <.4% all others by number of atoms
d. Surface temperature: 5,800°K (9000°F); core 15 million°K (27 million°F)
e. Age: 4.6 billion years
f. Mass: $2x10^{30}$ kg = 3.33 billion Earths = 1000 Jupiters
g. Volume: $1.41x10^{18}$ km^3 = 1,300,000 Earths
h. Density: 1.41 x water
i. Surface gravity: 28xEarth
j. Mean Distance from Earth: 1,500,000 km (93 million mi)
k. Rotation Period: approximately 25 days

5. Double or Multiple Stars

a. Some Can Be Seen Visually in a Telescope - over 65,000 cataloged
    i. Apparent or Optical Binaries - stars that only appear to be close together but are actually light years apart. This type of double star is only an optical illusion.
    ii. Visual Binaries - system of stars physically related by gravity, revolving around a common center of mass (barycenter)
b. Some Cannot be Seen Visually in a Telescope
    i. Spectroscopic Binaries - Stars that are so close together that they can only be seen using a spectroscope to see the shift of spectral lines.
    ii. Astrometric Binaries - stars that are so close that they are revealed as binary only by their wobbly path across the sky.
    iii. Eclipsing Binary - stars that periodically pass in front of each other, causing the total brightness of the pair to decrease for a short time.

6. Variable Stars - these change in brightness over time. There are over 284,000 stars cataloged in the International Variable Star Index compiled by the American Association of Variable Star Observers (AAVSO).

a. Period - time to compete one cycle of brightness change.
b. Amplitude - difference in magnitude from minimum to maximum
c. Variations may be periodic, semi-periodic or irregular, with time scales from less than one second to centuries.
d. Variability is represented by a graph of brightness vs time called a light curve
e. Named using letters, starting with R to Z, then RR-RZ, SS-SZ,...,ZZ, then AA-AZ, BB-BZ,...,QZ. Then V335, V36, V337,...
f. Extrinsic Variables - variability not due to the stars, but to a movement of stars

i. Eclipsing Binary - stars that periodically pass in front of each other during their orbit, causing the total brightness of the pair to decrease for a short time. (Algol, Beta Lyrae, 51 Pegasi (by planet!))
ii. Rotating stars - show small changes in light that may be due to dark or bright patches on their stellar surfaces ("starspots") and are often binary systems.
iii. Pulsars (type PSR) - normally radio variables, except the Crab Nebula and Vela pulsars which show optical pulses due to rapid rotation of a beam like a lighthouse. These are neutron stars left over from a supernova explosion.

g. Intrinsic Variables - variability caused by changes in the star itself
   i. Pulsating Variables - 2/3 of all known variables are of this type (Cepheid & long period Mira types)
   ii. Cataclysmic Variables - stars with occasional violent thermonuclear outbursts. Most are close binary systems having strong influence on the evolution of each star. A hot dwarf star is surrounded by an accretion disk formed by matter lost by the larger and cooler star.
      1. Novae (Type N) - invisible star suddenly becomes visible; white dwarf collects hydrogen from companion, causing a runaway thermonuclear fusion on surface. Star is NOT destroyed
      2. Supernovae (type SN) - Catastrophic explosion; star is destroyed
         a. Type I - exploding white dwarf in close binary
         b. Type II - massive star whose core collapses after hydrogen fuel runs out
   iii. Eruptive Variables - stars varying due to violent processes and flares occurring in their chromospheres and coronae usually accompanied by shell events or mass outflow in the form of stellar winds and/or by interaction with the surrounding interstellar medium (R Corona Borealis)

7. Star Clusters - Groups of stellar siblings gravitationally bound and moving through space together

a. Galactic or Open Clusters - Loose cluster of dozens to hundreds young stars that form in the disk of a galaxy. Ex: Hyades, Pleiades, Double Cluster in Perseus, Big Dipper
b. Globular Clusters - Compact, spherical cluster of 10,000 to 1 million old, metal poor stars that appear in the halo around and outside a galaxy. Ex: M13 in Hercules, M3 in Bootes, M22 in Sagittarius, M5 in Serpens

8. Nebulae - Gas and/or dust in space illuminated by star(s)

a. Planetary Nebulae (PN) - Roundish (like a planet) outer atmosphere expelled by old dwarf star after hydrogen fuel in core is exhausted, leaving a white dwarf. Ex: Ring Nebula in Lyra (M57), Dumbbell Nebula in Vulpecula (M27), Owl Nebula in Ursa Major (M97)

b. Emission Nebulae - Gas emits light due to ionization by embedded or nearby hot stars. Ex: Lagoon Nebula in Sagittarius (M8), Swan or Omega Nebula in Sagittarius (M17), Trifid Nebula in Sagittarius (M20), Orion Nebula (M42)
c. Reflection Nebulae - Light reflects off dust. Ex: Trifid Nebula in Sagittarius (M20),
d. Absorption or Dark Nebulae - Dark gas/dust cloud seen in silhouette against a background of stars or emission nebulae. Ex: Horsehead Nebula in Orion, Coal Sack Nebula in Crux, Pelican Nebula in Cygnus.
e. Supernova Remnants - Gaseous remnants of stars that have undergone supernova explosions. Ex: Crab Nebula in Taurus (M1), Veil Nebula in Cygnus (NGC 6960-6992)

9. Galaxies - Islands of 100's of billions of stars, dust & gas gravitationally bound together

a. Elliptical Galaxies - Uniform system of stars ranging in shape from spherical to highly flattened. Has little or no gas and dust to make new stars, so most stars are very old. Denoted E0-E7 with increasing flattening. Ex: M32 & M110 in Andromeda
b. Lenticular Galaxies - Intermediate between elliptical & spiral. They differ from ellipticals because they have a central bulge surrounded by a thin flat disk, but are different from spirals because they have no spiral structure. Denoted S0.
c. Spiral Galaxies - consisting of a roughly spherical central nuclear bulge of old red stars, a surrounding thin, flat, spiral shaped disk of young stars and a sparse spherical halo of old stars that surrounds it all. Denoted Sa-Sb-Sc-Sd. Ex: M31 in Andromeda, M51 in Canes Venatici, M81 in Ursa Major, M101 in Ursa Major, M33 in Triangulum
d. Barred Spiral Galaxies - Similar to spirals but spiral arms emanate from a short, straight bar of material that straddles the nuclear bulge. Denoted SBa, SBb, SBc, SBd. Ex: M83 in Hydra
e. Irregular Galaxies - have no ordered structure. Denoted Irr. Ex: NGC 6822 in Sagittarius, NGC 147 in Andromeda