Galileo Challenge (Grades 9 to 12)
Wednesday, March 7, 2007

1. Do not start writing the contest until instructed to do so.
2. The first five questions are for administration purposes only; they will not count towards your final score, but must be completed if you wish to be recognized as an official contestant.
3. The 35-question multiple-choice contest corresponds to Questions 6 to 40, all of which have five possible answers – A, B, C, D, and E – only one of which is correct. Completely fill in the Scantron box that corresponds to your solution for each question. If you are unsure of this coding system, speak to the supervising teacher.
4. You may use rulers, geometric tools, and paper for rough work. Calculators are recommended.
5. Diagrams are not drawn to scale, while most numerical figures are rounded for simplicity.
6. You will have a total of forty-five minutes to complete the contest.

1. Fill in all the letters of your school code.

2. What grade are you in?

   (A) 8 or below   (B) 9   (C) 10   (D) 11   (E) 12

3. What is your age?

   (A) 13 or below   (B) 14   (C) 15   (D) 16   (E) 17 or above

4. Are you willing to have your name posted on our website at <www.spacesim.org>?

   (A) Yes   (B) No

5. Are you interested in participating in a simulated space mission at our facilities or having a Planetarium exhibit visit your school?

   (A) Yes   (B) No   (C) Maybe

Part A – Identify the astronomic entity referred to in each question.

6. The theory concerning this event, supported by Hubble's law, postulates that the universe began expanding from an immensely dense and hot state 13.7 million years ago.

    (A) Big Rip   (B) Big Bang   (C) inflation   (D) Big Crunch   (E) galaxy formation

7. Its boundary being the event horizon and its particles kept apart by electromagnetic force, this predicted object has a gravitational pull so powerful that even radiation cannot escape it.

    (A) quasar   (B) wormhole   (C) black hole   (D) hypernova   (E) compact star

8. These variable Population I giant yellow stars, named by John Goodricke in 1784, have periodic light fluctuations and a luminosity ranging from 10^3 to 10^4 times that of the sun.

    (A) supernova   (B) red giant   (C) binary star   (D) Cepheid variable   (E) W Virginis variable

9. The Van Allen Belt around Earth is the most notable example of this invisible region, usually a doughnut-shaped cluster of energetically charged particles held together by a magnetic field.

    (A) ionosphere   (B) radiation belt (C) asteroid belt   (D) Main sequence   (E) plasma belt

10. Surrounding Earth and each outer planet is this region where electric forces hold free ions together and objects are dominated and organized by the magnetic fields between their poles.

    (A) magnetopause (B) magnetosphere (C) magnetic tail (D) radiation belt   (E) magnetic storm

11. Occurring at a rate of about forty a year in the Milky Way, this cataclysmic explosion is caused by the accumulation of high amounts of hydrogen on the surface of a white dwarf star.

    (A) supernova   (B) nebula   (C) nova   (D) stellar flare   (E) hypernova

12. Forming from the collapse and density increase of Bok globules, this stellar antecedent can take up to 10 million years to evolve from a condensing cloud to a main-sequence star.

    (A) star   (B) protostar   (C) nebula   (D) stellar wind   (E) cloud

13. Separated from the termination shock by the heliosheath, this Solar System border and boundary around the sun contains interstellar gas and dust that stops movement of solar wind.

    (A) solar flare   (B) hydrogen wall (C) heliopause   (D) heliosphere   (E) magnetopause

14. Emitting synchrotron emission in all three wavebands, this type of active galaxy is composed of large ellipsoidal structures called lobes, high-energy particle beams known as jets, and hotspots.

    (A) radio   (B) dwarf   (C) starburst   (D) blazar   (E) spiral

15. Known in Welsh as the "rot of the stars" and described as a "falling Meteor", this foul-smelling substance is deposited on Earth by meteor showers, but evaporates shortly afterwards.

    (A) angel hair   (B) stardust   (C) meteorite   (D) slime mould   (E) star jelly
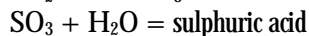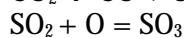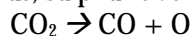
Part B – Use knowledge of astronomy, science, and mathematics to answer these questions.

16. Making up the majority, around 56.6%, of Mercury's composition are Potassium and Sodium. What series of one valence electron elements are they part of?

    (A) alkaline earth metals   (B) lanthanides   (C) noble gases   (D) alkali metals   (E) halogens

17. The apparent magnitude of an object is equal to: $M + 5(\log_{10}d - 1)$, where M is its absolute magnitude and d is its distance from Earth in parsecs. If the absolute and apparent magnitude of the star are equivalent, and $\log_2 8 = 3$, then how far away in parsecs must it be from the Earth?

    (A) 1   (B) 2   (C) 5   (D) 10   (E) 100

18. All planets are oblate spheroids distorted from their perfect spherical shape. This "flattening" is signified by the positive value of what variable, the diameter of a body's equatorial plane subtracted by the distance between its two poles?

    (A) synchronous rotation   (B) elasticity   (C) angular velocity (D) oblateness   (E) equatorial bulge

19. As the Julian calendar defines a year as 365.25 days, an extra day must be added to every fourth year. However, an actual year on Earth is approximately 365.2425 days long; thus, leap years must be skipped periodically to keep our calendar synchronized with planetary motion and seasons. According to this system, how many leap years are to be skipped every 400 years?

    (A) 1   (B) 2   (C) 3   (D) 4   (E) 5

20. Radiation from Type I supernovae comes primarily from the decay of Nickel-56, which has a half-life of 6 days, and its daughter Cobalt-56 with a half-life of 78 days. If there are initially 0.5 solar masses of the Nickel-56 and 0.1 of Cobalt-56, after approximately how many days will there be equal quantities of the two isotopes?

    (A) 15   (B) 18   (C) 60   (D) 64   (E) 86

21. To map the position of stars in the sky, celestial coordinate systems assign values to astronomical objects relative to the fundamental plane. The equatorial system uses the equator as this plane, while the horizontal system uses the observer's local horizon; between the two, there are four different coordinate names. Which of the following is NOT one of them?

    (A) zenith   (B) azimuth   (C) altitude   (D) declination   (E) right ascension

22. The parsec is a unit commonly used to measure astronomic distances. In the following diagram, A represents the Earth, B the Sun, and C an object exactly one parsec away from the sun. If the distance between the Earth and the Sun is 1 AU, and angle C is one arcsecond (1/3600th of a degree), what is the approximate length of a parsec?

    (A) 80 000 AU   (B) 120 000 AU   (C) 150 000 AU   (D) 200 000 AU   (E) 400 000 AU

Part C – All questions appear in sets of two dealing with the same topic.

23. On Venus, sulphuric acid is formed after the decomposition of carbon dioxide:
    $$CO_2 \rightarrow CO + O$$
    $$SO_2 + O = SO_3$$
    $$SO_3 + H_2O = \text{sulphuric acid}$$
    What is the chemical formula of the end product?

    (A) SO_3 (B) HSO_3 (C) H_2SO_3 (D) H_2SO_4 (E) H_3SO_4

24. What name is given to the last two reactions in Question 23?

    (A) decomposition (B) oxidization   (C) synthesis   (D) combustion   (E) single displacement

25. The escape velocity of a planet represents the speed without propulsion an object needs to go to leave it permanently. If Earth's escape velocity is 11.200 km/s, and a rocket launched east at the equator needs a speed of 11.665 km/s to exit, how fast does a rocket launched west need to go?

    (A) 10.335 km/s (B) 10.735 km/s (C) 11.335 km/s (D) 11.665 km/s (E) 12.665 km/s

26. Given the information in Question 25, what is the rotational velocity of Earth?

    (A) 465 m/s [W]   (B) 535 m/s [W]   (C) 200 m/s [E]   (D) 535 m/s [N]   (E) 465 m/s [E]

27. Eccentricity is the measure of how much an object's orbit deviates from the shape of a circle.
    $$\text{Eccentricity} = |e|$$
    $$e = \frac{v \times h}{\mu} - \frac{r}{|r|}$$
    In the formulae above, what is the range of possible eccentricity values?

    (A) –1 to 1   (B) 0 to 1   (C) –1 and higher   (D) 0 and higher   (E) 1 and lower

28. Perfectly circular orbits have an eccentricity of 0. Thus, in those orbits, what integer value can NONE of the non-e variables in the second Question 27 equation theoretically have?

    (A) –1   (B) 0   (C) 1   (D) 100   (E) none of the above

29. Saturn, a planet with a volume of approximately 9.05×10^{14} km³, has numerous flat rings. The innermost point of the D-ring is about 6,900 km away from the surface of Saturn, while its outermost point is about 14,500 km away. How far is the closest point of the D ring to the planet's centre in kilometres, rounded to the nearest hundred?

    (A) 65,400   (B) 66,900   (C) 67,200   (D) 68,900   (E) 70,500

30. What is the total approximate area of the D ring?

    (A) 3.4×10^9 (B) 4.2×10^9 (C) 4.6×10^9 (D) 2.4×10^{10} (E) 3.8×10^{10}
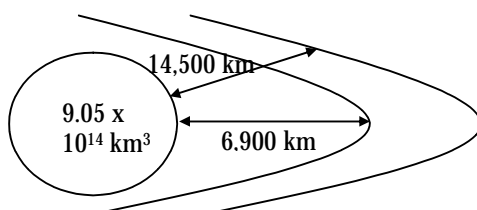
31. In intervals of 105.5 or 121.5 years, the Transit of Venus, a direct passing of Venus between the Sun and the Earth, occurs in pairs 8 years apart. Prior to its last sighting on June 8, 2004 at around noon, it was last seen in 1882. On what year will it occur next?

(A) 2012   (B) 2020   (C) 2109   (D) 2110   (E) 2125

32. The event described in Question 31 will occur when Venus and Earth are in the same relative position as they were on June 8, 2004. If the Earth year is about 365.2425 days, and the Venus one is 224.7 days, on exactly what day will the next Transit occur?

(A) June 6   (B) June 7   (C) June 8   (D) June 9   (E) June 10

33. The path of a comet has the shape of an ellipse, and each half of it models the form of an approximate parabola. In the diagram below, the x-axis represents the minor axis, while the y-value represents the distance of the comet from the minor axis in AU. If this distance can be modelled by the formula $-2x^2 + 12x$, what is the farthest the comet reaches from the minor axis?

(A) 8 AU   (B) 10 AU   (C) 12 AU   (D) 15 AU   (E) 18 AU
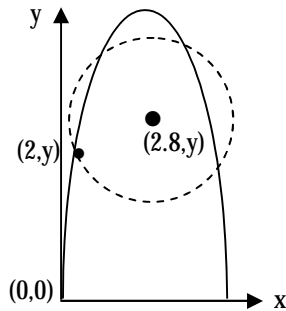
34. The first time the comet crosses the Earth's orbit, it is 2 AU right of the y-axis. If the Sun is located 2.8 AU right of the y-axis, what is the approximate distance from the origin to the Sun?

(A) 14.56 AU   (B) 16.83 AU   (C) 18.06 AU   (D) 20.56 AU   (E) cannot be determined

35. For certain stretches of time, Neptune is further away from the Sun than Pluto is. This occurs when the irregular elliptical orbit of Pluto temporarily crosses the circular path of Neptune. Which of the following lengths is relevant to determining the span of that unusual orbit?

(A) BE   (B) BD   (C) CD   (D) AC   (E) AB

36. The most recent period when Neptune was farther from the Sun than Pluto was from 1979 to 1999, an integer number of years. If Neptune's orbit lasts 165 years, and Pluto's lasts 248 years, what is the smaller angle between the lengths from the sun of the two orbit intersection points?

(A) 41.29°   (B) 43.69°   (C) 143.81°   (D) 167.34°   (E) cannot be determined
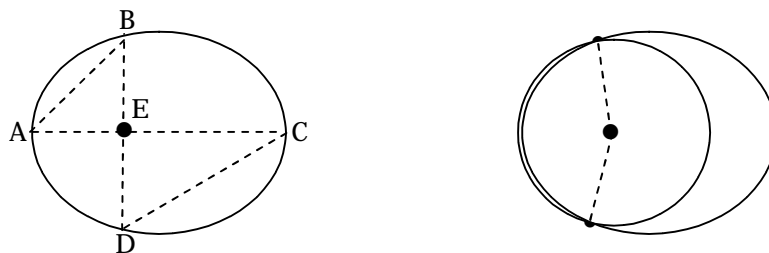
Part D – Answer the following questions based on the Hertzsprung-Russell diagram provided. Here, random stars are measured for luminosity and colour and placed accordingly on a scatter plot. Groups within this arrangement indicate trends and certain star types that are common.
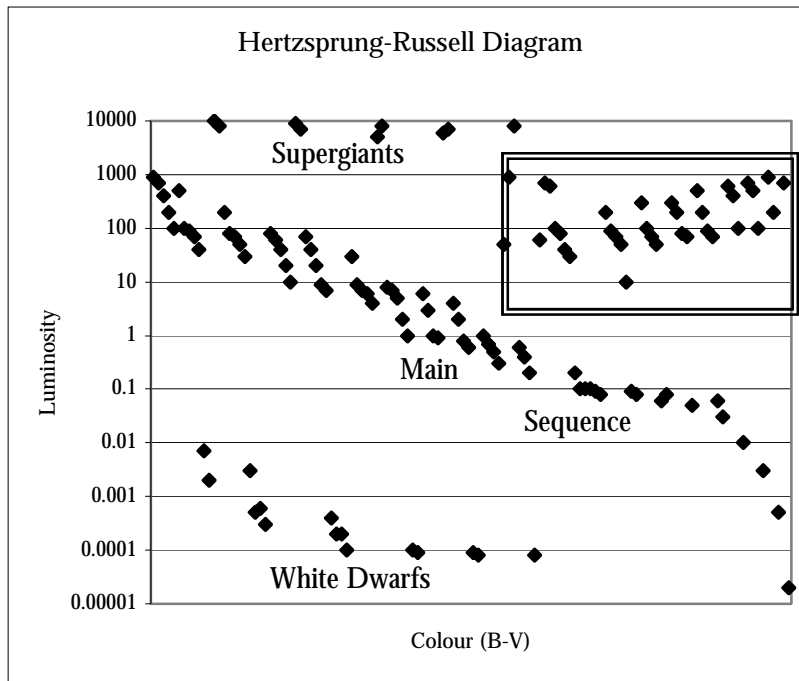
37. In the main sequence, what is the correlation between Colour (B-V) and Luminosity?

    (A) positive   (B) negative   (C) random   (D) horizontal   (E) vertical

38. In what group do all the highlighted stars belong?

    (A) bright giants   (B) red giants   (C) main sequence   (D) giants   (E) subgiants

39. If star luminosity is measured in solar units, to which group does the Sun belong?

    (A) main sequence (B) subgiants   (C) white dwarfs (D) supergiants   (E) giants

40. In the context of determining patterns in different-coloured stars, which of the following terms does NOT apply in any way to the luminosity scale or its values?

    (A) logarithmic   (B) real number   (C) complex number (D) relative   (E) dependent variable

The Ottawa-Carleton Educational Space Simulation thanks you for writing the 2007 Galileo Challenge!

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