

SOLAR SYSTEM

Gopher Invitational - January 6, 2018

Directions:

1. There is a separate sheet for answers. Please use it. Answers not marked on it will not be scored.
2. The test is worth 99 points in total. Episodes I-III and V have questions worth 1 point each. Episode IV has questions worth 2 points each. Episode VI has questions worth 4, 4, and 8 points, respectively.
3. There are several tiebreaker questions throughout the test. They are marked by a **[T]**.
4. Numerical answers should be in the units AU (distance) and years (time), unless otherwise stated.
5. Answers should be exact, or stated using 3 decimal places.
6. Before starting, carefully read the Science Olympiad code of ethics, provided on the next page. By writing your team number on this sheet of paper, you agree to abide by the code of ethics.
7. When the proctor states, "Time is up" or equivalent, there should be no continued writing; put your pencil(s) down and stare, with a hateful gaze, at the proctor until they come to collect your test.

Science Olympiad Code of Ethics (Read Carefully)

The goal of competition is to give one's best effort while displaying honesty, integrity, and good sportsmanship. Everyone is expected to display courtesy and respect (see Science Olympiad Pledges below). Teams are expected to make an honest effort to follow the rules and the spirit of the problem (not interpret the rules so they have an unfair advantage). Failure by a participant, coach, or guest to abide by these codes, accepted safety procedures, or rules below, may result in an assessment of penalty points or, in rare cases, disqualification by the tournament director from the event, the tournament, or future tournaments.

1. Actions and items (e.g., tools, notes, resources, supplies, electronics, etc.) are permitted, unless they are explicitly excluded in the rules, are unsafe, or violate the spirit of the problem.
2. While competing in an event, students may not leave without the event supervisor's approval and must not receive any external assistance. All electronic devices capable of external communication (including cell phones) must be turned off, unless expressly permitted in the event rule and left in a designated spot if requested.
3. Students, coaches and other adults are responsible for ensuring that any applicable school or Science Olympiad policy, law or regulation is not broken. All Science Olympiad content (e.g., policies, requirements, clarifications, FAQs, etc. on soinc.org) must be treated as if it were included in the printed rules.
4. All pre-built devices presented for judging must be constructed, impounded, and operated by one or more of the 15 current team members unless stated otherwise in the rules. If a device has been removed from the event area, appeals related to that device will not be considered.
5. Officials are encouraged to apply the least restrictive penalty for rules infractions (see examples in the Scoring Guidelines). Event supervisors must provide prompt notification of any penalty, disqualification or tier ranking.
6. State and regional tournament directors must notify teams of any site-dependent rule or other rule modification with as much notice as possible, ideally at least 30 days prior to the tournament.
7. If you draw an "X-Wing" by your team number on the answer sheet, you will receive 1 additional point. If you do not know what an "X-Wing" is, look on the board. Crude drawings are acceptable, but will be heavily judged.

Episode I - The Phantom Matching

There are 14 questions in this section. Each answer will be used exactly once. This section continues on the next page. Mark your answers clearly on the sheet provided.

1. Breccia
A.
An
astronomical text which contains the position of
celestial
bodies in the sky as seen from Earth at specific
times.
These positions are given in coordinates.
2. Declination
B.
Plains
composed of basalt on the Moon. From the Latin
word
for 'sea', so-called due to their large landmass. They
were
left by eruptions of now-extinct volcanoes.
3. Ephemeris C.
Term that describes two celestial bodies appearing to be
ninety degrees apart, from the perspective of the
observer. Ex. The moon and sun from Earth
4. Librations D.
The line which delimits night (shadowed portion) and day
(sunlit portion) on a celestial body. The Moon's phases
illustrate this.

5. Mare E.
A type of rock that is composed of a matrix of different materials, minerals and fragments of other rocks. Found on the moon and the earth.
6. Mascon F.
The gentle rocking motion of the Moon as it orbits the Earth that allows observation of the side that normally faces away from our planet.
7. Nadir G.
A region in the crust of a celestial body which is denser than average and as such acts to create a local gravitational anomaly.
8. Neap Tide H.
A Latin term meaning 'swamp' that is used to describe topographical features on the moon which resemble dark plains or swamps.
9. Occultation I.
The point with a negative ninety degree inclination in relation to the observer, or the point directly beneath their feet.

Episode I - The Phantom Matching

10. Palus J,
The act of one celestial body obscuring another as a
result of moving between the observer and the
object being observed.
11. Quadrature K.
The position of a celestial body, such as the Moon, in the
equatorial coordinate system. This is measured by
degrees in relation to the celestial equator.
12. Tektites L.
The point in a celestial sphere with a ninety degree
inclination in relation to the observer, or the point
directly above them.
13. Terminator M.
Objects made from natural glass that are created from
the impact of meteorites. They can be found on the
Earth and the Moon.
14. Zenith N.
When the Moon is at its First Quarter or Last Quarter, its
forces are partially cancelled out by the Sun. This leads
to a lower high tide than normal.
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Episode II - Attack of Multiple Choices

There are 15 questions in this section. Choose the best answer. Mark answers clearly on the sheet provided. Answer choices were arranged through random distribution.

15. Venus has an atmosphere of mostly what gas?
- Sulfur Dioxide
 - Carbon Monoxide
 - Carbon Dioxide
 - Methane
16. Mercury's surface is composed of what rock?
- Silicate Rock
 - Anorthositic Rock
 - Obsidian
 - Basalt
17. The highest tides on Earth result from what phenomenon?
- Aphelion
 - Perihelion
 - Apogee
 - Perigee
18. What is the eccentricity of Venus' orbit?
- 0.007
 - 0.015
 - 0.0934
 - 0.100

For Questions 19-25, answer questions about features on the moon.

19. What moon feature is shown in Figure 2-A?
- Lacus Mortis
 - Lacus Excellentiae
 - Lacus Somniorum
 - Lacus Timoris
20. What moon feature is shown in Figure 2-B?
- Palus Epidemiarum
 - Palus Putredinis
 - Sinus Aestuum
 - Sinus Fidei

Episode II - Attack of the Multiple Choices

21. What moon feature is shown in Figure 2-C?
- Mare Anguis
 - Mare Crisium
 - Mare Nubium
 - Mare Undarum
22. What moon feature is shown in Figure 2-D?
- Mare Humorum
 - Mare Ingenii
 - Mare Insularum
 - Mare Nectaris
23. What moon feature is shown in Figure 2-E?
- Mons Ampère
 - Mons Dieter
 - Mons Esam
 - Mons Pico
24. What moon feature is shown in Figure 2-F?
- Vallis Bohr
 - Vallis Bouvard
 - Vallis Rheita
 - Vallis Snellius
25. What moon feature is shown in Figure 2-G?
- Mons Bradley
 - Mons Huygens
 - Mons La Hire
 - Mons Usov
26. What was the first successful mission to land on Mars?
- Mariner 9
 - Phobos 1
 - Viking Project
 - Curiosity

Episode II - Attack of the Multiple Choices

27. In what year was Io discovered?

- a. 1610
- b. 1781
- c. 1846
- d. 2006

28. What is the correct order of space probes to observe Io?

- a. Pioneer, Voyager, Galileo
- b. Galileo, Voyager, Pioneer
- c. Voyager, Pioneer, Galileo
- d. Pioneer, Galileo, Voyager

29. What is the prominent gas in the atmospheric composition of Io?

- a. Carbon Monoxide
- b. Sulfur Dioxide
- c. Carbon Dioxide
- d. Methane

Episode III - Revenge of the Short Answer Questions

There are 14 questions in this section. Mark answers clearly on the sheet provided.

30. Name a physical phenomenon that is an example of occultation.

Use Figure 3-A to answer 31-37.

31. Identify the celestial body shown in Figure 3-A.

32. The celestial body in Figure 3-A is a satellite of which planet?

33. Give the eccentricity of the orbit of Figure 3-A.

34. What is the most recent attempted mission to visit the celestial body shown in Figure 3-A?

35. Identify the most prominent feature on Figure 3-A.

36. Give an example of the feature from the previous prompt.

37. Identify the cause of the feature from Prompt 36. **[T]**

38. What is the primary composition of Mars' polar ice caps?

39. Identify the temperature of Mars' polar ice caps in the winter. **[T]**

Use Figures 3-B to 3-E to answer 40-43.

40. Identify the solar eclipse event occurring in Figure 3-B.

41. Identify the solar eclipse event occurring in Figure 3-C.

42. Identify the part of the sun shown in Figure 3-D.

43. Identify the part of the sun shown in Figure 3-E.

Episode IV - A New Calculation

There are 10 questions in this section. Calculations may use answers to previous questions. You do not need to show work, but scratch paper is provided.

44. Planet
X has an orbital period of 8 Earth years. Calculate the semi-major axis, in terms of AU.
45. Planet
Y is located in a galaxy far, far away. It revolves around a sun with a mass of $1 * 10^{30}$ kg. Planet Y's orbital path has a semi-major axis of 85 AU and a semi-minor axis of 84 AU. Calculate the distance between Planet Y and its sun at the perihelion.
46. Calculat
e the eccentricity of Planet Y's orbit path.
47. Calculat
e the location of Planet Y's sun. Suppose Planet Y's orbit path is centered at (0,0)
48. Calculat
e the instantaneous speed of Planet Y at the perihelion. Give your answer in km/s. **[T]**
49. Planet
Z has a moon that causes a high tide once every 24 days. The high tide is +5 meters and the low tide is -3 meters. Find an equation that can be used to predict future tides, in terms of days. Use $t = 0$ to represent a high tide.
50. If $t=0$ represents 12:00 A.M., calculate the displacement of the tide at 3:30 P.M. of Planet Z on the same day.
51. Calculat
e the distance between the craters Aristarchus and Moretus on Earth's moon. Give your answer in km. **[T]**
52. Planet
 Θ has a mass of 1,000,000 kg and a volume of $36,000 \pi$ m³. A cat of 1 kg stands on the surface of Planet Θ .

Calcula

te the force, in Newtons, that the cat exerts on Planet Θ .

53.

Calculat

e the time interval between when all the terrestrial planets line up.

Episode V - The True/False Strikes Back

There are 20 questions in this section. Answer with either a true or a false and mark on the answer sheet accordingly. Answers must be completely true to be labeled true.

54. Earth's moon has a diameter that is larger than that of Io.
55. Phobos is the largest moon of Mars.
56. At any given location on Earth, on average, a total solar eclipse can be viewed every 10 years.
57. Within the inner planets, Venus and Mars have experienced the most meteor impacts.
58. None of the inner planets have a majority nitrogen atmosphere.
59. The large oceans of lava on the surface of Venus formed between 300 and 500 million years ago.
60. One lunar year on Earth is about 354 solar days.
61. The lunation of Earth's moon varies between 27 and 29 solar days.
62. The Mars 2 mission, conducted by the USSR, was the first to successfully orbit the planet.
63. The Schiaparelli EDM lander, operated by the ESA, was the last spacecraft to successfully land on Mars.
64. Io was named by Simon Marius.
65. Phobos and Deimos can be seen with the naked eye.
66. Phobos and Deimos have the same number of craters.
67. Out of the inner planets, Mercury has the greatest fluctuation in surface temperature.
68. The Saros cycle was first used by Greek astronomers to calculate the dates of eclipses.
69. Solar wind ensures that Mercury and Venus essentially have no atmosphere.

Episode V - The True/False Strikes Back

70. The Saros cycle lasts approximately 223 synodic months.

71. Lunar maria cover around 30% of the lunar surface.

72. Mare Tranquillitatis, on Earth's moon, is primarily made up of basalt.

73. Io has a geological composition closer to the terrestrial planets than to other outer system bodies.

Episode VI - Return of the Long Answer Questions

There are three questions in this section. Mark all answers on the answer sheets provided..

74.

Compare and contrast Earth's moon and Mars' moons, in terms of how they became satellites of their respective planets.

Use substantive geographic examples where appropriate. (4 points) **[T]**

75.

Explain, in detail, how the lunar maria formed on Earth's moon. (4 points) **[T]**

76.

Explain how Johannes Kepler derived each of his three laws of planetary motion. Include specific details about each law.

Use examples if necessary. (8 points)

“Do or Do Not, There is No Try”

- Yoda