

Part 2. Astronomy

Chapter 26. The Solar System

37. Knowing that the speed of light is 300,000 km/s, show that it takes about 8 min for sunlight to reach Earth.

38. How many days does sunlight take to travel the 50,000 AU from the Sun to the outer reaches of the Oort cloud?

39. The light-year is a standard unit of distance used by astronomers. It is the distance light travels in one Earth year. In units of light-years, what is the approximate diameter of our solar system, including the outer reaches of the Oort cloud? (Assume that 1 light-year equals 63,000 AU.)

40. The nearest star to our Sun is Alpha Centauri, which is about 4.4 light-years away. Assume that it too has an Oort cloud about 1.6 light-years in diameter. Show that there is enough space between us and it to fit about 1.75 solar systems.

41. If the Sun were the size of a beach ball, Earth would be the size of a green pea 110 m away. Show that the nearest star, Alpha Centauri (4.4 light-years away), would be about 30,000 km distant. (Hint: Find the distance to Alpha Centauri in units of AU.)

Ex1. The distance between Earth and the Moon is 384,401 km. How long would it take to drive from Earth to the Moon if you drive at 55 mi/h?
State your answer in years.

Ex2. If you could fly to the Sun on a jet that moves at 1000 km/h, how long would it take? State your answer in years. Distance (Sun-Earth) = 1.5×10^{11} m

Think and rank

42. Rank these planets in order from longest to shortest year:
(a) Mercury, (b) Venus, and (c) Earth.
43. Rank these planets in order of increasing number of moons:
(a) Mars, (b) Venus, and (c) Earth.
44. Rank in order of increasing average density:
(a) Jupiter, (b) Saturn, and (c) Earth.
45. Rank in order of increasing pressure at the center of each planet:
(a) Jupiter, (b) Saturn, and (c) Earth.
46. Rank in order of decreasing number of people who have seen a:
(a) solar eclipse, (b) lunar eclipse, and (c) new Moon.
47. Rank in order of increasing average distance from the Sun:
(a) Kuiper belt objects, (b) asteroids, and (c) Oort cloud objects

MCQ.

Q1. The Sun contains what percentage of the solar system's mass?

- A.** About 35% **B.** 85% **C.** The percentage varies over time **D.** Over 99%
- Q2.** The solar system is like an atom in that both
A. are governed principally through the electric force.
B. consist of a central body surrounded by objects moving in elliptical paths.
C. are composed of plasma.
D. are mainly empty space.
- Q3.** The nebular theory is based on the observation that the solar system
A. follows patterns indicating that it formed progressively from physical processes.
B. has a structure much like an atom.
C. is highly complex and appears to have been built by chaotic processes.
D. appears to be very old.
- Q4.** When a contracting hot ball of gas spins into a disk shape, it cools faster due to
A. increased radiation transfer. **B.** increased surface area.
C. decreased insulation. **D.** increased convection currents.
E. eddy currents.
- Q5.** Each second, the burning Sun's mass
A. increases. **B.** remains unchanged. **C.** decreases.
- Q6.** Compared to your weight on Earth, your weight on Jupiter would be about
A. 3000 times as much. **B.** half as much.
C. 3 times as much. **D.** 300 times as much. **E.** 100 times as much.
- Q7.** When the Moon assumes its characteristic thin crescent shape, the position of the Sun is
A. almost directly in back of the Moon.
B. almost directly behind Earth, so that Earth is between the Sun and the Moon.
C. at right angles to the line between the Moon and Earth.
- Q8.** When the Sun passes between the Moon and Earth, we have
A. a lunar eclipse. **B.** a solar eclipse. **C.** met our end.
- Q9.** Asteroids orbit
A. the Moon. **B.** Earth. **C.** the Sun.
D. all of the above
E. none of the above
- Q10.** With each pass of a comet about the Sun, the comet's mass
A. remains virtually unchanged. **B.** actually increases.
C. is appreciably reduced.
- Q11.** Which of the following orbits around the Sun?
A. Planets. **B.** Asteroids. **C.** Comets. **D.** All of the above.
- Q12.** As a nebula shrinks under the influence of gravity, it ...
A. spins slower. **B.** spins faster. **C.** loses its spin **D.** spins into a protosun
- Q13.** Strictly speaking, in every second that passes, the mass of the Sun
A. decreases. **B.** remains constant.
C. increases. **D.** reinvents itself.

Chapter 27. Stars and Galaxies

Think and Solve

34. Suppose Star A is four times as luminous as Star B. If these stars are both 500 light-years away from Earth, how will their apparent brightness compare? How will the apparent brightness of these stars compare if Star A is twice as far away as Star B?

35. The brightest star in the sky, Sirius, is about 8 light-years from Earth. Show that if you could somehow travel there at jet-plane speed, 2000 km/h, the trip would take about 4.3 million years. (Note: 1 light-year equals 9.46×10^{12} km.)

36. If you were to travel straight up from the core of our galaxy and then look back, you would have a grand view of the Milky Way's spiral shape. If the distance from the core to the outer edges was 50,000 light-years, how much surface area are you looking at? Assume the galaxy is a circle whose area can be found by the equation $\text{area} = \pi r^2$.

37. Assume the Milky Way contains 100 billion stars evenly distributed with none concentrated toward the center. What would be the surface area density of stars?

Use the equation: $\text{surface area density} = \text{number of stars} / \text{surface area}$.

38. Use the information in the preceding problem to figure out the average amount of space around a single star in units of AU (Note: 1 light-year = 63,000 AU.)

39. From your answer to the preceding problem, would it be possible for two galaxies with stars evenly distributed to pass right through each other?

Ex.1. Earth is about 0.000016 light-year from the Sun and about 4.2 light-years from the next nearest star, which is Proxima Centauri. How far away is Proxima Centauri in Earth–Sun distances?

Ex.2. Our distance from the center of the Milky Way galaxy is about 26,000 light-years. How many Earth–Proxima Centauri distances is that?

Ex.3. The Milky Way and Andromeda galaxies are about 2,500,000 light-years apart. The diameter of the Milky Way galaxy is about 100,000 light-years. How many Milky Way diameters distant is the Andromeda galaxy.

Ex.4. The Andromeda galaxy is moving toward the Milky Way galaxy at a rate of about 300,000 mi/h. In how many years will these two galaxies collide?

Think and rank

40. Rank the appearance of the North Star in order of increasing height from the horizon as seen from (a) Alaska, (b) Florida, and (c) Vermont.

41. Rank the objects in order of increasing intrinsic motion as viewed from Earth: (a) the Moon, (b) Venus, and (c) the North Star.

42. Rank the following stars in order of increasing radius

	Star A	Star B	Star C
Surface temperature (K):	6,000	4,000	30,000
Luminosity (solar units):	1	100	0.01

43. Rank these stages of stellar development from earliest to latest: (a) white dwarf, (b) nova, and (c) red giant.

44. Rank the nuclear fuels in order of being consumed, from first to last: (a) carbon, (b) helium, and (c) hydrogen.

45. Rank the following features of a black hole in order of increasing radius: (a) photon sphere, (b) singularity, and (c) event horizon.

46. Rank in order of increasing size: (a) solar system, (b) Local Group, and (c) galaxy

MCQ

1. Summer and winter constellations are different because
 - A. of the spin of Earth about its polar axis.
 - B. the night sky faces in opposite directions in summer and winter.
 - C. of the tilt of Earth's polar axis.
 - D. the universe is symmetrical and harmonious.
2. Polaris is always directly over
 - A. the North Pole. B. any location north of the equator.
 - C. the equator. D. the South Pole.
3. The star nearest Earth is
 - A. Proxima Centauri. B. Polaris. C. Mercury. D. the Sun.
4. The property of a star that relates to the amount of energy per unit time it is producing is its
 - A. luminosity. B. apparent brightness. C. color. D. volume. E. mass.
5. The longest-lived stars are those of
 - A. low mass. B. high mass. C. intermediate mass. D. infinite mass.
6. We do not see stars in the daytime because
 - A. the Sun blocks them. B. they simply don't exist in the daytime part of the sky.
 - C. skylight overwhelms starlight. D. of the lack of contrast with moonlight.
 - E. the solar wind obscures them from view.
7. After our Sun burns its supply of hydrogen, it will become a
 - A. white dwarf. B. black dwarf. C. black hole. D. red giant. E. blue giant.
8. A black hole is
 - A. an empty region of space with a huge gravitational field.
 - B. a small region that has the mass of many galaxies.
 - C. the remains of a giant collapsed star.
 - D. as large as its photon sphere.
9. The shape of an active starburst galaxy tends to be
 - A. elliptical. B. spiral. C. irregular. D. all of the above
10. Scientists estimate the age of our universe to be about
 - A. 5000 years old. B. 1 billion years old.
 - C. 14 billion years old. D. 42 billion years old
- Q11. A Which of these stars radiates light of the longest wavelength?
 - A. Red star B. Yellow star C. Blue Star D. Violet star
- Q12. We measure the Sun's luminosity as L_{Sun} . If we were on a spaceship twice as far away from the Sun, its apparent brightness would appear ...
 - A. the same B. half as much. C. one quarter as much D. four times as much
- Q13. On the H-R diagram, the Sun is ...
 - A. an average star B. seen to be special.
 - C. a low-temperature star D. especially bright
- Q14. A dying star that has collapsed to a small size and is cooling off would appear in which part of the H-R diagram?
 - A. Lower right. B. Lower left. C. Upper right. D. Upper left.

Chapter 28. The Structure of Space and Time

THINK and RANK

1. Rank the following in order of increasing abundance in the universe:
(a) Helium. (b) Hydrogen. (c) Carbon.
2. Rank the following in order of increasing abundance in the universe:
(a) Dark matter. (b) Ordinary matter. (c) Dark energy.
3. Rank the following in order of longest ago to most recent:
(a) Star formation. (b) Inflation. (c) Big Bang.
4. Rank the following in order of increasing duration: One minute on the surface of
(a) Earth. (b) Mercury. (c) The Moon.

MCQ.

- Q1.** Which of the following is not accepted evidence for the Big Bang?
A. Cosmic background radiation B. Homogeneity of the temperature of the universe
C. The abundance of helium D. Dark energy
- Q2.** If the universe stopped expanding at this very moment, the cosmological redshift of distant galaxies would
A. promptly disappear.
B. gradually turn into a cosmological blueshift.
C. stop getting more redshifted than it already is.
D. not matter because such a sudden halt to expansion would knock all galaxies and planets off their orbits and we would no longer be here to talk about it
- Q3.** What percentage of galaxies were created during cosmic inflation?
A. 100% B. About 70% C. About 24% D. 0%
- Q4.** What do cosmic inflation and dark energy have in common?
A. Both relate to the expansion of the universe.
B. Both are still occurring.
C. They both arise from the vast voids of space between superclusters.
D. Nothing.
- Q5.** Light bends in a gravitational field. Why isn't this bending taken into consideration by surveyors who use laser beams as straight lines?
A. The bending of light occurs only in outer space.
B. Red light doesn't bend so much, which is why lasers are red.
C. Laser light is an exception to this rule.
D. Light travels so fast that the curvature is not noticeable for their surveying purposes.
- Q6.** Time slows in a gravitational field. Would time slow in the artificial gravity produced in a rotating space habitat? Why or why not?
A. No, because there is no acceleration.
B. Yes, because of the principle of equivalence.
C. No, because the space station is spinning at a constant rate.
D. Yes, even though the gravity is artificial.

- Q7.** Should it be possible in principle for a photon to orbit a star?
- A. yes, if the photon is moving at the speed of light
 - B. yes, if the star's mass-density is huge enough to make it a black hole
 - C. no, because photons, by definition, always move in straight paths
 - D. no, because stars already produce countless photons of their own
- Q8.** Dark matter is
- A. ordinary matter that is no longer emitting light.
 - B. altering the orbits of our planets.
 - C. attracted to ordinary matter.
 - D. repelled by ordinary matter.
- Q9.** Space in our local universe is
- A. not empty.
 - B. seething with energy.
 - C. not well understood.
 - D. all of these
- Q10.** Which theory for the fate of the universe assumes that dark energy will grow stronger?
- A. Heat death
 - B. Big Rip
 - C. Eternal inflation
 - D. all of these
- Q11.** If the distance between your eye and a lamp is halved,
- A. The light will appear to be two times brighter.
 - B. The light will appear to be two times dimmer.
 - C. The light will appear to be four times brighter.
 - D. The light will appear to be eight times dimmer.
- Q12.** Hubble's law has to do with the
- A. expansion of the universe.
 - B. steady state of the universe.
 - C. contraction of the universe.
 - D. cosmic background radiation
- Q13.** Scientific evidence supports the date of the Big Bang event at
- A. 7000 years ago.
 - B. 100,000 years ago.
 - C. 5 billion years ago.
 - D. 13.7 billion years ago
- Q14.** The Fate of the Universe
- A. Heat Death.
 - B. The Big Rip.
 - C. Other.
 - D. We really don't know.