

It's About Time Exam
Spartan Science Olympiad Club

Instructions:

- Show all work for mathematical solutions. Give your answers correct units.
- Give the best answer for each multiple choice question. All multiple choice questions have one best response, but partial credit may be given for other responses.

1. How many seconds are in 1 minute?

2. The current time standard for the United States is based on a certain mechanism in the cesium atom. Which property is this?
 - a. Vibrations of a lattice of cesium atoms
 - b. Orbit of the 1s electron around the nucleus
 - c. Rotation of the nucleus
 - d. Decay of Cesium-137 into Barium-137m
 - e. Transition of the 6s electron in the hyperfine splitting
 - f. Emission spectra of cesium gas lamp

3. What is measured from the cesium atom to keep time?
 - a. Visible light
 - b. Ultraviolet radiation
 - c. Infrared radiation
 - d. Microwave radiation
 - e. Gamma radiation
 - f. X-rays

4. Quartz clocks work primarily because quartz is a piezoelectric material. Piezoelectric materials exhibit which of the following properties?
 - a. The material accumulates electrical charge when subject to mechanical stress
 - b. The material increases in resistance as the electric potential across it increases
 - c. The material exhibits internal generation of mechanical strain in the presence of an electrical field
 - d. The material produces an electric current when light is shone upon it
 - e. A and C
 - f. B and D
 - g. All of the above

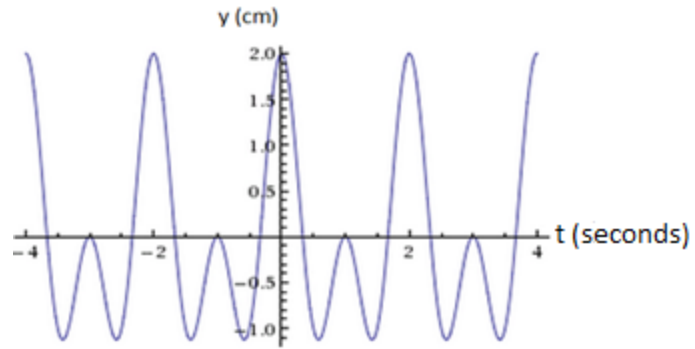
5. How is a 1 Hz frequency attained in a quartz clock?
 - a. The quartz is cut to a special shape and size to vibrate at a fundamental frequency when driven by an electrical signal. This known frequency is divided to an accurate 1 Hz through a microchip.
 - b. All quartz vibrates at a certain fundamental frequency which is an exact multiple of 1 second when a voltage is applied. This known frequency is divided to an accurate 1 Hz through a microchip.
 - c. The quartz crystal's oscillation frequency is determined by an electrical pulse with a frequency of 1 Hz. The crystal's 1 Hz oscillations are harnessed mechanically to ultimately drive the second hand of the watch.
 - d. There is a hyperfine splitting transition of the 3s electron emits radiation with frequency nearly exactly 32,768 Hz, or 2^{15} Hz. Then the electrical signal driven by this radiation is passed to a microchip where a chain of digital divide-by-2 stages can derive a 1 Hz signal.

6. A second hand of a clock is rigidly attached to a Gear A with 24 teeth, driven by Gear B, which has 12 teeth. Gear B is driven by a screw attached to a motor. At what rate does the motor need to rotate to drive the second hand at 1 cycle per 60 seconds?
 - a. 0.5 Hz
 - b. 2 Hz
 - c. 12 Hz
 - d. 24 Hz
 - e. 48 Hz
 - f. 288 Hz
 - g. 720 Hz

7. A cannon shoots a ball a 12 m/s horizontally over the edge of a cliff 120 m high. At what time does the ball hit the ground?

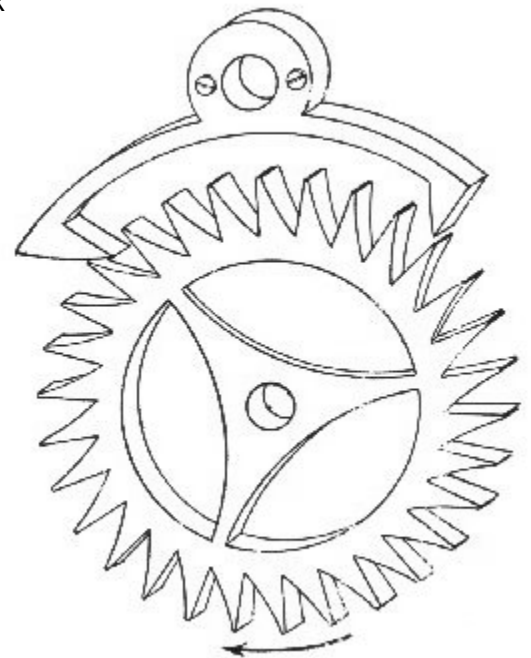
8. You are sitting at the train station and a train rushes past you at $\frac{4}{5}$ the speed of light. It also happens to have clocks on it at every point and is billions of meters long. The clock on the train has a second hand that ticks once a second. How often do you see the clock tick?
 - a. More often than once a second
 - b. Exactly once a second, but it ticks a shorter distance
 - c. Less than once a second
9. Your twin sister gets in a rocket ship a blasts away from Earth at $\frac{3}{5}$ the speed of light, goes to the center of the Milky Way, and then returns to Earth. When he returns which is true?
 - a. He is older than you
 - b. He is younger than you
 - c. You are the same age
10. You and your twin sister go on a vacation on a cruise spaceship to orbit a black hole. You tie a rope around you and jump from the spaceship towards the black hole. After a few minutes, you pull yourself back up to the spaceship. Which of the following is most plausible?
 - a. Your sister is now 10 years older than you.
 - b. Your sister wonder why you only spent a few seconds doing something as cool as black hole diving.
 - c. Your sister and you have synchronized watches.
 - d. Your sister has returned to being a baby.
11. You jump into a river 10 meters wide. It flows South at downstream at 4 m/s. You swim East at 3 m/s. You are a trained swimmer and keep your body perpendicular to the flow of the river even as it whisks you downstream. How long does it take you to cross the river?
12. Cesium-137 decays into Barium-137m with a half-life of 30.17 years. How many years does it take for 16 grams of Cesium-137 to decay to 2 grams?
13. You discover a new planet between Mercury and the Sun. It is only 0.2 AU from the Sun. (1 AU = the distance from the Sun to Earth). What is the orbital period of this planet, in years?

Use the graph on the right for questions 18 and 19. The graph shows the displacement of a particle over time which is encountering 2 wave disturbances.



18. When are both original waves at a crest?
- $x = 0.0$ s
 - $x = 0.25$ s
 - $x = 0.33$ s
 - $x = 0.5$ s
 - $x = 0.75$ s
 - $x = 1.0$ s
- 19.
20. What are wavelengths of the two original waves?
- - 0.5 s and 1 s
 - 0.5 s and 2 s
 - 0.5 s and 4 s
 - 1 s and 2 s
 - 2 s and 4 s
 - 1 s and 4 s
21. Which of these waves has the highest frequency?
- - Radio Waves
 - Infrared
 - Visible light
 - Ultraviolet
 - X-rays
 - Gamma rays
22. An electromagnetic wave has a wavelength of 1 cm. Find the following properties. Write equations and show your work!
- Velocity
 - Frequency
 - Energy
 - Momentum
 - Type of electromagnetic wave
23. Which 2 months were named for Roman emperors?
24. How long is one full month on average in the Chinese Lunar Calendar?
- - 28
 - 28.3
 - 29
 - 29.5

- f. 30
 - g. 30.4
 - h. 31
- 25.
26. Which list contains only leap years?
- a. 1900, 1950, 2000, 2050
 - b. 1900, 1964, 2000, 2016
 - c. 1932, 1948, 2000, 2004
 - d. 1914, 1946, 1982, 1996
 - e. 1920, 1940, 1960, 1980
27. To the closest power of 10, how old is the universe?
- a.
 - b. 10^1 seconds
 - c. 10^{10} seconds
 - d. 10^{14} seconds
 - e. 10^{17} seconds
 - f. 10^{20} seconds
 - g. 10^{23} seconds
- 28.
29. Is a sidereal year is
- a. Over 5% longer than a solar year
 - b. Between 1% and 5% longer than a solar year
 - c. Less than 1% longer than a solar year
 - d. The same length as a solar year
 - e. Less than 1% shorter than a solar year
 - f. Between 1% and 5% shorter than a solar year
 - g. Over 5% shorter than a solar year
30. What is a gnomon?
- a. A statue of a small bearded man used as a lawn ornament
 - b. The mass on the end of a pendulum
 - c. A lever pushed by oscillating quartz
 - d. The part of a sundial that points north
 - e. The tick mark representing seconds on an analog clock
31. If it is 1:48 AM in East Lansing, MI, what time is it in Paris, France?
32. The image to the left is a(n)
- a. Anchor escapement
 - b. Deadbeat escapement
 - c. Detent escapement
 - d. Pinwheel escapement
 - e. Verge escapement
33. A 1 m pendulum on Earth with mass 1 kg will have what period?



34. If you double the mass on a pendulum, what happens to its frequency?
- a. It quadruples
 - b. It doubles
 - c. It stays the same
 - d. It halves
 - e. It quarters
35. What is the frequency of simple harmonic motion of a spring with a spring constant $k=8 \text{ N/m}$ and attached mass of 2 kg ?