It's About Time Exam Key
Spartan Science Olympiad Club

1. How many seconds are in 1 minute?

60 s

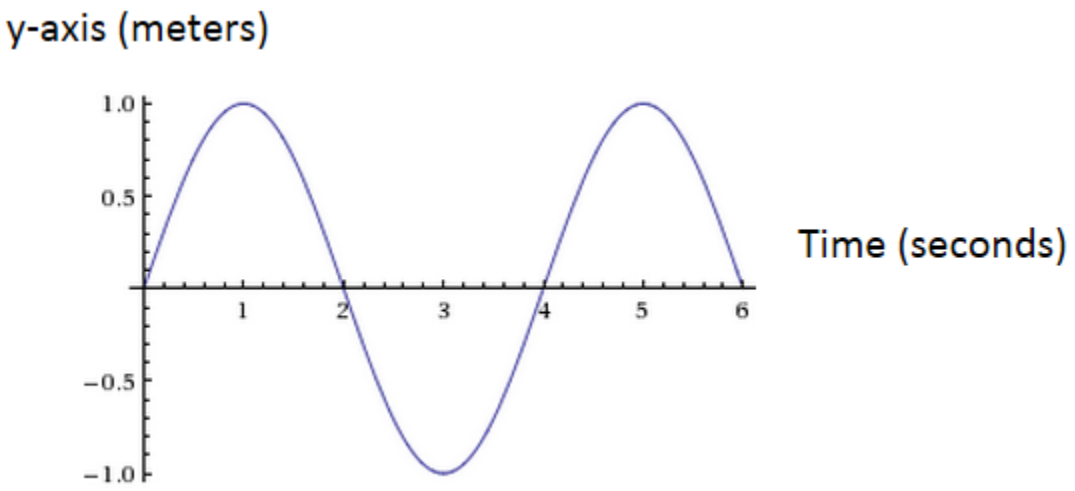
2. The current time standard for the United States is based on a certain mechanism in the cesium atom. Which property is this?
   E. Transition of the 6s electron in the hyperfine splitting
3. What is measured from the cesium atom to keep time?
   D. **Microwave radiation**
4. Quartz clocks work primarily 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
   C. The material exhibits internal generation of mechanical strain in the presence of an electrical field
   D. A and C
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.**
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?
   D. 24 Hz (screw rotates once per tooth on gear B, gear B rotates twice to turn gear A) 2*12=24 turns per second to keep second hand moving on time.
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?
   Initial vertical velocity = 0 m/s
   $y(t) = (0\ m/s) - \frac{1}{2}*g*\Delta t^2$

   $\Delta t=sqrt(-2*y/g)=sqrt(-2*(-150\ m)/(9.8\ m/s^2))= 5.53\ s$

8. You are sitting at the train station and a train rushes past you at 4/5 the speed of light. It also happens to have clocks on it at every point and is billions of meters long. The clocks on the train each have a second hand that ticks once a second. How often do you see a clock tick?
   C. Less than once a second
9. Your twin sister gets in a rocket ship a blasts away from Earth at 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?
   B. He is younger than you
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.**
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?
    Only east component matters. Distance/speed=10 m/(4 m/s)=2.5 s

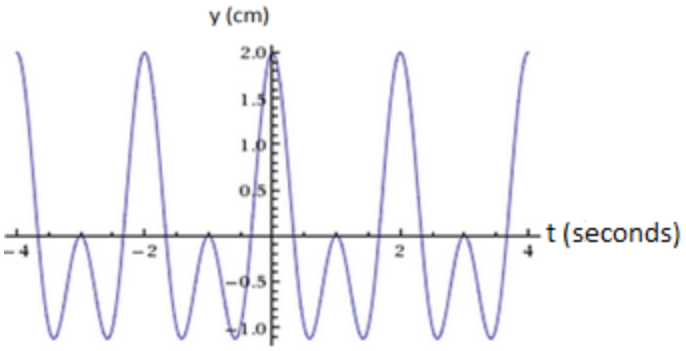
12. Cesium-137 decays into Barium-137m with a half-life of 30.17 years. How many years does it take for 16 grams of Cesium-137 to decay to 2 grams?
    16 grams = 2^4 grams. The Cs-137 must halve 4 times to reach 2 grams.
    4*(30.17 years) = 120.7 years
13. You discover a new planet between Mercury 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?
    $T^2 \sim a^3$. So T^2/a^3 is a constant. Earth is 1 AU from Sun and has a period of revolution of 1 year. $T^2/a^3 = 1\ yr^2/AU^3$.
    $T=\text{sqrt}(1\ yr^2/AU^3 * a^3)=\text{sqrt}(1\ yr^2/AU^3 * (0.2\ AU)^3) = 0.089$ yr, (0.09 years to 1 sig fig.)

Use the following information to answer questions 14 through 16. There is a string with a wave traveling through it. You pick one point on the string and watch it move up and down. The following image is a graph representing the movement of that piece of the string over 6 seconds of time. The x-axis tells you how much time has passed in seconds. The y-axis tells you how far that point on the string has moved from equilibrium. (in other words, how far the point is from being on a flat rope)



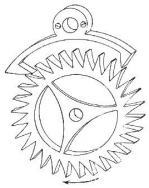
14. How far from equilibrium is the point after 1 second has passed?
    E.1.0 m
15. For these questions, answer YES or NO using only your knowledge from this graph.
    a. Can you determine the period of the wave from the graph? **Yes**
    b. Can you determine the frequency of the wave from the graph? **Yes**
    c. Can you determine the wavelength of this wave from the graph? **No**
    d. Can you determine the amplitude of the wave from the graph? **Yes**
16. Here is an additional piece of information: The wave is traveling through the string at 10 meters per second. Be sure to include units in the following answers!
    a. What is the period of this wave?
       4 s
    b. What is the frequency of this wave?
       0.25 Hz
17. Alice plays the trombone. If Alice plays a C, and then plays a C an octave higher, this doubles the pitch. If the pitch of the note is cut is doubled, what else is true?
    b.The wavelength halves

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?
    a. **x = 0.0 s**
19. What are the **periods** of the two original waves?
    E.2 s and 4 s
20. Which of these waves has the highest frequency?
    a.
    F.Gamma rays
21. An electromagnetic wave has a wavelength of 1 cm. Find the following properties. Write equations and show your work!
    a. Velocity
    c = 3.0 * 10^8 m/s
    b. Frequency **c = f * λ**
    f = 3.0*10^8 / .01 m = 3*10^10 Hz
    c. Energy
    E = hf
    ~2*10^-23 J
    d. Momentum
    P = h/λ
    6.6 *10^-32 kg*m/s
    e. Type of electromagnetic wave **Radio or microwave**

22. Which 2 months were named for Roman emperors?
    July (Julius) and August (Augustus)
23. How long is one full month on average in the Chinese Lunar Calendar?
    a.
    D.29.5
24. Which list contains only leap years?
    C.1932, 1948, 2000, 2004
25. To the closest power of 10, how old is the universe?
    a.
    D.10^{17} seconds
26.



27. Is a sidereal year is **C.Less than 1% longer than a solar year**
28. What is a gnomon? **D.The part of a sundial that points north**
29. If it is 1:48 AM in East Lansing, MI, what time is it in Paris, France?**7:48 AM**
30. The image to the left is a(n) **a. Anchor escapement**
31. A 1 m pendulum on Earth with mass 1 kg will have what period?
    $T=2*pi*sqrt(L/g)=2*pi*sqrt(1\ m/(9.8\ m/s^2))=2\ s$
32. If you double the mass on a pendulum, what happens to its frequency?
    C.It stays the same
33. What is the frequency of simple harmonic motion of a spring with a spring constant k=8 N/m and attached mass of 2 kg?
    $f=\omega/(2*pi)=sqrt(k/m)/(2*pi)=sqrt(8\ N/m/2\ kg)/(2*pi)=1/pi=0.3\ Hz$