

BirdSO Mini Invitational

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11-18 December 2021

Directions:

You got this! This is test only event, and your entire score is based on this test. There is no build component.

Page	Points	Score
2	19	
3	16	
4	21	
5	19	
6	22	
Total:	97	

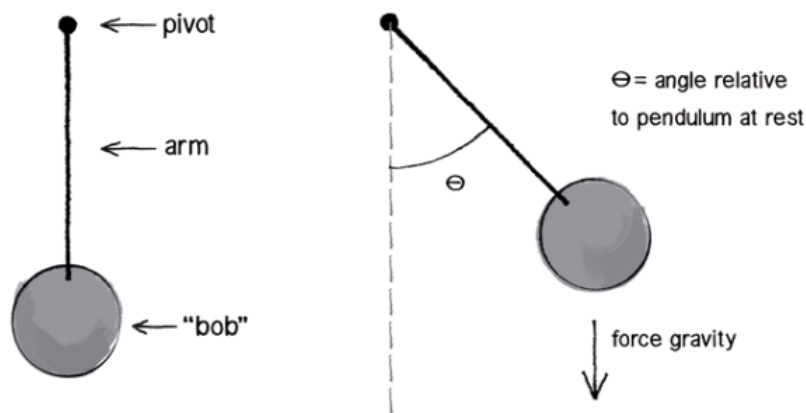
1. (1 point) How many seconds are in a year? (not leap year)
2. (1 point) 1) How often does a leap year occur?
2) When was the last leap year?
3. (1 point) Earth's orbital speed is constant.
 - A. True
 - B. False
4. (2 points) What day of the week is January 1st, 2000?
 - A. Monday
 - B. Tuesday
 - C. Wednesday
 - D. Thursday
 - E. Friday
 - F. Saturday
5. (2 points) What is the significance of the International Date Line, and how do you interpret your time/day across this location?
6. (1 point) What calendar is used by the majority of the world?

7. (1 point) UTC is based on Earth's rotation relative to distant celestial objects.
 - A. True
 - B. False
8. (1 point) Which of the 50 US states do not observe daylight saving time?
9. (1 point) How many hours difference is there between PDT and PST?
10. (2 points) Which of the following are valid ISO 8601 format dates for January 2nd, 2000?
 - ☐ 20000201
 - ☐ 20000102
 - ☐ 01022000
 - ☐ 02012000
11. (2 points) The second is the duration of _____ periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the _____ atom.
12. (1 point) Which isotopes of these atoms are potentially used in atomic clocks?
 - ☐ hydrogen 1
 - ☐ cesium 133
 - ☐ rubidium 87
 - ☐ strontium 87
13. (3 points) Calculate the frequency in Hz and energy in J of a photon with wavelength 4.3×10^{-8} m.

14. (1 point) The _____ effect refers to when a voltage is generated from mechanical stress on a crystal. Spelling counts!
15. (2 points) Calculate the length in meters of a piece of quartz in a watch with Young's modulus of $7.2 \times 10^{10} \text{ N/m}^2$, thickness a of 0.5 mm , fundamental frequency of $30,000 \text{ Hz}$, and a density of 2634 kg/m^3 .

$$f = \frac{1.875104^2}{2\pi} \frac{a}{l^2} \sqrt{\frac{E}{12\rho}},$$

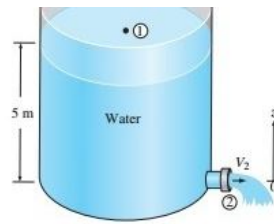
16. (1 point) What is the value of quartz on Moh's hardness scale? (Please enter a number)
17. (1 point) The atomic clock was invented after the quartz clock.
- A. True
- B. False
18. (1 point) Atomic clocks are radioactive.
- A. True
- B. False
19. (2 points) Explain why a quartz clock behaves similarly to a series RLC circuit.
20. (1 point) Quartz is an excellent material for timekeeping since its vibrational frequency is not highly affected by temperature and experiences a low amount of hysteresis.
- A. True
- B. False



21. (4 points)

Assume the angle relative to pendulum at rest θ is 15 degrees at the start. What is the velocity of the bob when that angle θ is 10 degrees? The length of the pendulum arm is 1 meter, and the mass of the bob is 1kg. You may assume $g = 9.8 \text{ m/s}^2$. Show your work for partial credit.

22. (2 points) For the same parameters in the question above, what is the frequency of oscillation for this pendulum?
23. (1 point) What is the earliest known timekeeping device?



24. (3 points)

A large tank of water open to the atmosphere on is filled to 5 meters high with respect to the outlet. Using Bernoulli's equation, set up and solve for the water velocity at the outlet v_2 .

Please state any assumptions you make for this problem.

25. (1 point) For the problem above, the exit velocity at the outlet v_2 is constant.

A. True

B. False

26. (2 points) When (what year) and where is the Royal Observatory found?

27. (1 point) Who received the first clock-making patent ever issued in the United States?

28. (1 point) Who invented the pendulum clock?

29. (1 point) Where was the first sundial discovered?

30. (1 point) What was the primary reason for the development of water clocks from sundials?

31. (1 point) Electromagnetic waves are longitudinal waves.

A. True

B. False

32. (2 points) Electromagnetic waves consist of both electric and magnetic field waves. These waves oscillate in

⁽¹⁾ *planes with respect to each other, and are* ⁽²⁾ *phase.*

☐ (1) perpendicular

☐ (1) parallel

☐ (2) in

☐ (2) out of

33. (1 point) What is the relationship between the amplitude of a wave and its frequency?

34. (2 points) If the sampling rate of a signal is 50 Hz, what is the Nyquist frequency? And, how does the Nyquist frequency relate to aliasing?

35. (2 points) The sinc function is as described below.

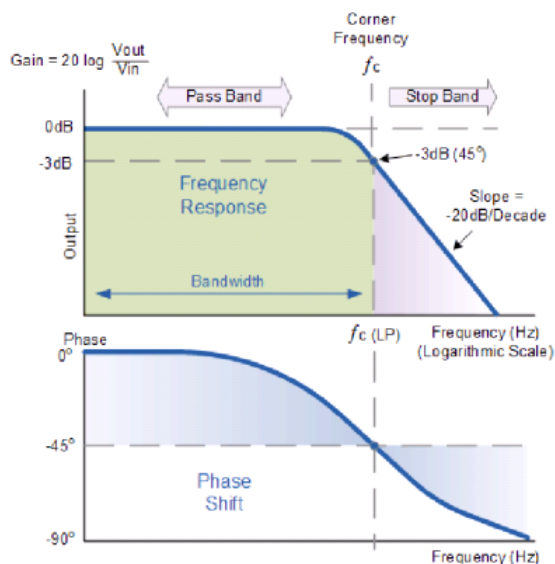
$$\text{sinc } x = \frac{\sin x}{x}$$

Describe what the result of a Fourier transform on this function results in.

36. (1 point) The fundamental frequency is also known as the _____ harmonic. (Write out your answer in a word)

37. (2 points) Suppose a violin has a string of length 40cm, and a third harmonic frequency of 500 Hz. Find the speed of the wave on this violin string.

38. (2 points) In terms of inductance L and capacitance C , what is the equation for resonance frequency of an LC circuit?
39. (1 point) The following plot is known as a *plot*.



40. (1 point) The image above shows an example of a low pass filter.
- A. True
- B. False
41. (2 points) A comet travels on an eccentric elliptical orbit which carries it as close as about 1AU to the Sun and as far as about 15AU. Compare the gravitational force between the comet and the Sun at these extremes in its orbit.
42. (2 points) The Earth orbits the Sun at a distance of 1AU with a period of 1 year. How long does it take an asteroid with a distance of 16AU from the Sun to orbit the Sun?
43. (2 points) The point in the moon's orbit where it is farthest from the earth is called _____, while its closest approach is known as _____.
44. (1 point) The velocity of a planet orbiting the sun is _____ when closer to the sun than when farther from the sun.
- A. greater
- B. lesser
- C. the same
45. (2 points) A black hole is an object whose gravitational field is so strong that even light cannot escape. Assuming no change in mass, approximately what radius would our Sun have to have in order to become a black hole?
- mass of the sun = 1.9891×10^{30} kilograms
46. (2 points) Two twins are 20 years old. One of them gets on a rocket and travels at 0.8 c, for what they experience to be 10 years. How old is the twin that remained on Earth when the traveling twin returns home?
47. (2 points) The half life of Uranium-238 is 4.5 billion years. Some ore that solidified around the time of the formation of the Earth contained 0.08% Uranium-238. Determine the percentage of Uranium-238 in this ore that would be measured by a scientist today.
48. (2 points) The half life of tritium is 12.3 years. After 49.2 years, a sample of tritium has been reduced to a mass of 4.00mg. Determine the starting mass in milligrams.

49. (1 point) The acceleration due to gravity is constant on all parts of Earth.
- A. True
 - B. False
50. (1 point) Kepler's laws of planetary motion improved the _{theory}.
- A. heliocentric
 - B. geocentric
 - C. big bang
 - D. string
51. (1 point) What date is known as the Unix Epoch, and why is it given that name?
52. (1 point) A consequence of poor time synchronization could be deadlock. What is deadlock?
53. (2 points) Explain how the Network Time Protocol works relative to using a client-server model.
54. (1 point) What port number is the Network Time Protocol assigned to?
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55. (1 point) What is the difference between internal and external time synchronization?
56. (1 point) Vis-Viva equation provides a relationship between velocity, the mass of the central object, the distance between the two bodies, and the semi-major axis. What motion equation can be derived by taking the limit of the vis-viva equation as the semi-major axis approaches infinity?
57. (2 points) Sucrose will dissolve into fructose and glucose when placed in an acidic solution. The rate law of the reaction is given as $r(t) = k[C_{12}H_{22}O_{11}]^t$ where $k = 0.216 \text{ h}^{-1}$. Find the amount of time, in seconds, that it will take for 17.5 grams of sucrose to dissolve from an initial 20 grams of sucrose.
58. (1 point) What is today's Julian date?
59. (2 points) What is the mean lifetime (in seconds) and the decay constant (in $1/s$) of the decay of Carbon-14?
60. (2 points) How must both general and special relativity be taken into account in correcting the atomic clocks carried by GPS satellites?
61. (2 points) Describe what it means for a computer program to have a race condition.
62. (2 points) Time-based side channel attacks are possible on certain implementations of cryptosystems—say, in its encryption algorithm—to recover information, such as the plaintext message. What property of this encryption algorithm allows these timing attacks to be performed?
63. (1 point) When was the Unix epoch?
64. (1 point) Two basketballs are dropped from the top of an infinitely tall building; the first basketball, after time t_1 , has dropped x meters, while the second basketball, after time t_2 , has dropped $5x$ meters. What is the ratio t_2/t_1 ?