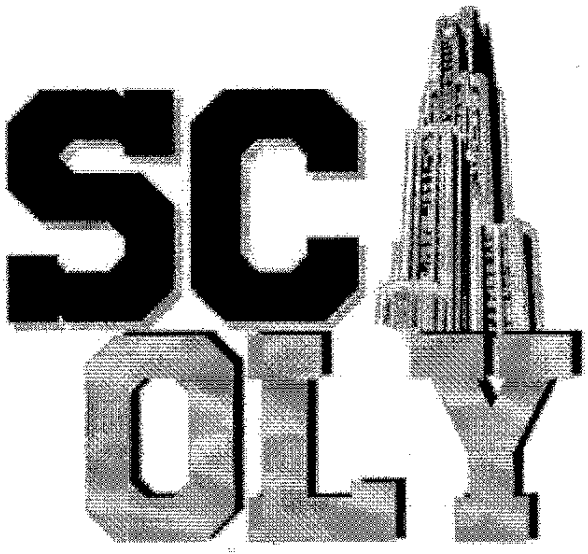
Crave the Wave

Test

Pitt Invy 2023

Pitt Invy is a Division B Invitational hosted by the University of Pittsburgh and the Science Olympiad at Pitt student organization on the Oakland Campus in Pittsburgh, Pennsylvania, and also represents the Pittsburgh Urban Program.



Team Number: 12

Team Name: _____

Participant Names: Jason Cedillo, Ankit Panda

Points: 39 2/3 / 122 Lab - 4/21 Total = 43.67/143

Rank: ____

This test was written by Aaron Wang.

Scoring: Each question is worth 2 points, and the bonus questions are worth 4 points each.

Circle your answers.

1. What is the period of this wave? Y = sin(5/21*pi*t + 2022) (2 points)

X

2. If the wavelength of a wave of light in a vacuum is 2022 meters, then what is the period? (2 points)

$6.7446600 4 \times 10^{-6}$ seconds

+2

3. If the frequency of a light wave is 43 Hz, then what is its period? (2 points)

+2 $\frac{1}{43}$ seconds ✓

4. How fast does light travel through diamond (use a refractive index of 2.419)? (2 points)

X

5. Light with a wavelength of 475 nm travels through amber (use a refractive index of 1.55); calculate the period of the light wave. (2 points)

X

6. Fill in the blanks: Energy is proportional to _____ and _____ but inversely proportional to _____ and _____. (2 points)

+2 Wavelength Period Amplitude Frequency

+6

7. What type of filter blocks/attenuates longer wavelengths but does not do that to shorter wavelengths? (2 points)

+2

Short-pass filter ✓

8. You are in a car going at 10 m/s while an ambulance with its siren (at 1000 Hz) sounding rushes past you as it moves in the same direction that you are moving in at 30 m/s. Calculate the observed frequency that you hear when the ambulance with its blaring siren is (a) moving toward you from behind and (b) after the ambulance has passed you and is now moving away from you in front of you. (2 points)

X

$f = \left(\frac{343-10}{343-30}\right)1000$ 1030.959

?

9. Concave lenses produce which type of image? (2 points)

P X

10. Describe the image in a glass mirror (real/virtual, same or different size, same or different distance) (2 points)

+1 1/3

Same Size, Same Distance, Real $2 \cdot \frac{2}{3} = \frac{4}{3}$

11. List the portions of the electromagnetic spectrum in order of:
    a. Shortest to longest wavelength (⅔ point)

X

Gamma, X-ray, UV, Visible, Infared, Radar, FM, TV, Shortwave, AM

    b. Least to most energy (⅔ point)

X

AM, Shortwave, TV, FM, Radar, Infared, Visible, UV, X-ray, Gamma Ray

    c. Shortest to longest period (⅔ point)

X

12. In diffraction, do longer or shorter wavelengths get diffracted more? Do longer or shorter frequencies get diffracted more? (2 points)

✓

+2

Longer Wavelengths, shorter frequencies.

13. Do longer or shorter wavelengths bend more in refraction? (2 points)

~~Longer Wave~~ Longer Wavelengths X

14. If a light ray moves from air (Refractive index 1.000293) to water (Refractive index 1.33), and the light ray's angle of incidence is 30 degrees, then what would its angle of refraction be? (2 points)

X

+5 1/3

15. What does the Huygens-Fresnel Principle describe? (2 points)

X

16. Which seismic wave is the first one to arrive? (2 points)

P-Waves ✓

+2

17. Consider a string fixed at one end with length L. What is the longest wavelength that a standing wave could have in this situation? (2 points)

4L ✓

+2

18. What type of filter do you get when you combine a low-pass and high-pass filter? (2 points) Medium pass filter X

19. In a Neutral Density Filter, with optical density d and the incident intensity i0, write an expression for the intensity AFTER THE FILTER I. (2 points)

X

20. If the angle of incidence on a mirror is 50 degrees, what is the angle of reflection? (2 points) 50 degrees ✓

+2

+6

21. What phenomena allows fiber optic cables to transmit light without allowing the signal to escape? (2 points)

Reflection +1

+1

22. Assuming the small-angle approximation, suppose you have a simple pendulum with a length of L. If the period is reduced to one half the original period, what is the length of the new pendulum arm in terms of the original arm, assuming that the pendulum always stays on planet Earth? (2 points)

$\frac{L}{2}$ X

23. Identify three ways in which you can tell S-waves and P-waves apart. (2 points)

+ 2/3

- P waves come before ✓
- P waves are longitudinal X
- S waves are slower and move through only solids ✓

+1 1/3

24. Where do P-waves and S-waves originate? (2 points)

epicenter ✓

+2 1/3

25. You swing a slinky in a circle in the air. The wave formed by the angle of the slinky relative to its position at a specific instant is _____. (2 points)

a. Longitudinal
b. Latitudinal
c. Transverse
d. Torsional

+2 ✓

26. Identify two things you can infer from an object's emission spectrum. (2 points)

elements in object
chemical make up

+1

27. Identify two things you can infer from an object's absorption spectrum. (2 points)

X

28. In Longitudinal waves, is the direction of motion parallel or perpendicular to the direction of oscillation? (2 points)

Parallel ✓

+2

29. Identify two differences between Love and Rayleigh waves. (2 points)

1- Rayleigh Waves move in a circular motion, Love Waves don't. ✓

2. Love Waves have no vertical displacments. ✓

30. You see a rainbow in the sky after a heavy storm. Explain how this rainbow formed, specifically mentioning two or more possible wave phenomena which could have played a role in its formation and appearance. (2 points)

+2

Refraction

+1

+7

31. According to the Kerr Effect, if the index of refraction was measured after applying an electric field of 1 V/m to Benzene (refractive index of 1.501), what electric field would be needed to double that index of refraction? (2 points)

X

32. According to the Pockels Effect, by what factor does the electric field have to DOUBLE the refractive index? (2 points)

X

33. Surface waves are a combination of what two waves? (2 points)

Longitudinal and Transverse ✓

+2

34. According to the Rayleigh Criterion, to have an angular resolution of 0.01 radians for light with a wavelength of 500 nanometers, what would the diameter of the lens' aperture need to be? Assume a circular aperture. (2 points)

X

35. Drilling a screw (twisting and spinning) would be most like which type of wave? (2 points)

torsional wave ✓

+2

36. Identify three uses of radio waves. (2 points)

Communication, Radars, Navigation X

44

37. Identify three uses of microwave radiation. (2 points)

Heating food

Steiralized (kill bactoia)

Cosmic microwave back ground

X

38. Calculate the frequency that light with a wavelength of 400nm would have (if the speed of light in a vacuum is 3*10^8 m/s). (2 points)

750000 hz

X

39. A sound wave has a frequency of 10,000 Hz. Given that the speed of sound is 343 m/s, find its wavelength. (2 points)

$\frac{343}{10,000} = 0.0343$

✓

+2

+2

40. A submarine at the surface of the Pacific ocean makes a beep sound underwater. You are swimming 5 miles away, slightly below the surface, while your friend is 5 miles above sea level in a helicopter. Which of you will hear the sound wave first, and why? (2 points)

you will, the sound travels faster in water.

+1

+1

41. True or False - Waves made by plucking a taut guitar string are travelling waves. If this statement is false, modify it to make it true. (2 points)

false, waves made by plucking a guitar string are standing waves.

+2

42. What is the fundamental frequency for an organ pipe that is closed on one end if the pipe is 20 meters long? What would opening the currently-closed end of the pipe do to its fundamental frequency? (2 points)

43. Which seismic waves cause the most damage? (2 points)

S waves

44. What type of breakers are a mix between plunging and surging breakers? (2 points)

45. What is the first, second, and third order diffracted angle of light leaving a diffraction grating if the incident angle of the entering light is 60 degrees, the wavelength of the light is 500 nm, and the distance between slits is 1 mm? (2 points)

+3

46. What is Brewster's angle (the angle of incidence) with mediums of m1 = 1 and m2 = 1.5? (2 points)

X

47. What is the energy of a photon wave with a wavelength of 100 nanometers? (2 points)

$\frac{62}{5}$ electron-volts

X

48. What waves are the waves that roll in an ocean-like motion? (2 points)

Rayleigh waves ✓

+2

49. What is the breaker type for a breaking wave with an Iribarren number ξ_0 of 2.0? (2 points)

?

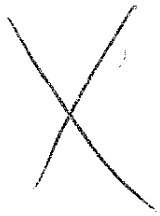
X

50. If a wave has a fundamental frequency of 1000 Hz, what would the eighth harmonic frequency be? (2 points)

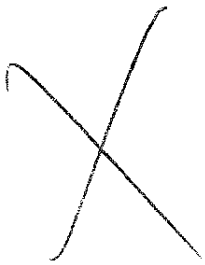
X

+2

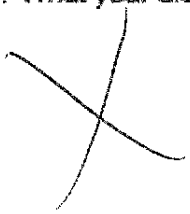
51. According to Malus' Law, if the initial intensity of light that passes through a linear polarizer is 1 W/m^2, and the final intensity of light that passes through the linear polarizer is 0.25 W/m^2, then what is the angle between the light's initial polarization direction and the polarizer's axis? (2 points)



52. According to Young's double slit experiment, calculate the perpendicular distance from a point P to a point on the central antinodal line if the distance between slits is 1 mm, the line that P is on is the fourth order, the wavelength is 500 nm, and the distance from point P to the sources of light is 1 meter. (2 points)



53. Name two things that can cause a tsunami, or a seismic sea wave. In which ocean was the most devastating tsunami ever recorded? What year did this happen? (2 points)



54. In a fiber-optic cable, does the core (inside/center part) or the cladding (outer part that surrounds the core) have a higher index of refraction? (2 points)

+2 Core ✓

55. Which filter uses destructive interference to do its job? (2 points)

Absorption Filter X

BONUS (for really advanced SCIOLY people)

56. Let's say we have a signal with the equation y = sin(20*pi/3t) + cos(80*pi/3t). What would be the minimum frequency we would need to sample this wave? (4 points)

X

57. Suppose you are trying to construct a low pass filter with a resistor and a capacitor. Should they be connected in series or parallel? Next, give approximate values for the resistance and the capacitance that should be used to create a cut-off frequency of 100 Hz. (4 points)

X

+2

58. Suppose you wanted to construct a band pass filter that will only pass a narrow range of frequency through (this is called a narrow band filter) by using an inductor and a capacitor. Would you connect the capacitor and inductor in series or parallel? If you wanted to create a cut-off frequency (hint, this is the resonance frequency) of 100 Hz, around what values of the inductance and the capacitance would you choose to make that happen? (4 points)

4/21

Answer Sheet

Crave the Wave Hands-on Activities

1. Graph 1 equation: X

   Graph 2 equation: X

   Graph 3 equation: X

   Graph 4 equation: X

   Graph 5 equation: X

2. a. Period: 1 ✓

   Frequency: 1 ✓

   b. Length of pendulum:

3. a. toward you, because ✓ the frequency increases while it comes towards you.

   b. ~~It is~~ Away from you, because the ✓ Frequency is lower.

4. Length of string: X

5. Laser and a prism

   Index of refraction: X

   Angle of incidence: X

   Angle of refraction: X

6. Top wave: X

   Middle wave: X

   Bottom wave: ✓

7. Type of breaker for:

   Top diagram: ✓

   Middle diagram: X

   Bottom diagram: X