Crave the Wave B

Holt Invitational Science Olympiad 2016

02/13/2016

School Name: ____

Team Name: ________________________ Team Number: ________________________

Team Members: ____

- Carefully read the rules below
- Clearly write your school name and team information.
- Do not turn this page until told to do so.
- Follow instructions to Start and Stop the exam.
- No electronic device except calculators are allowed
- All work must be legible and you must show your work to receive maximum points. Only partial points will be awarded for correct answers if the calculation steps are missing.
- Answers without units will be considered incorrect.
- Only use the constant value provided below to answer your questions
- Assume the velocity of light in the air is equal to that in the vacuum and is equal to 3×10^8 m/sec
- Assume the velocity of sound in air is equal to 343 m/sec
- Assume refractive index of air, water and diamond are 1, 1.333 and 2.42 respectively
- Assume bulk modulus of water and steel are 2.2×10^9 Pa and 159×10^9 Pa respectively
- Assume density of water and steel are 1000 kg/m3 and 7861 kg/m3
- Drawing should be to scale and angles should be accurate.
- Accuracy of the answers will be used to break the ties.

2 point problems (20 problems @ 2 points each)

***Instruction**: Circle the best possible answer*

1. A medium is able to transport a wave from one location to another because the particles of the medium are _____.
   a. frictionless
   b. isolated from one another
   c. able to interact
   d. very light

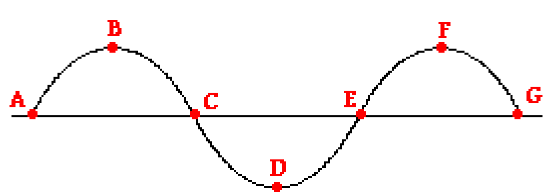
2. A transverse wave is transporting energy from east to west. The particles of the medium will move _____.
   a. east to west only
   b. both eastward and westward
   c. north to south only
   d. both northward and southward

3. A sound wave is a mechanical wave, not an electromagnetic wave. This means that _____.
   a. Particles of the medium move perpendicular to the direction of energy transport.
   b. A sound wave transports its energy through a vacuum.
   c. Particles of the medium regularly and repeatedly oscillate about their rest position.
   d. A medium is required in order for sound waves to transport energy.

4. If you strike a horizontal rod vertically from above, what can be said about the waves created in the rod?
   a. The particles vibrate horizontally along the direction of the rod.
   b. The particles vibrate vertically, perpendicular to the direction of the rod.
   c. The particles vibrate in circles, perpendicular to the direction of the rod.
   d. The particles travel along the rod from the point of impact to its end.

5. Which of the following is not a characteristic of mechanical waves?
   a. They consist of disturbances or oscillations of a medium.
   b. They transport energy.
   c. They travel in a direction that is at right angles to the direction of the particles of the medium.
   d. They are created by a vibrating source.

6. Indicate the interval that represents one full wavelength.
   a. A to C
   b. B to D
   c. A to G
   d. C to G



7. A tennis coach paces back and forth along the sideline 10 times in 2 minutes. The frequency of her pacing is ________ Hz.
   a. 5
   b. 0.20
   c. 0.12
   d. 0.083

8. Olivia accompanies her father to the park for an afternoon of fun. While there, she hops on the swing and begins a motion characterized by a complete back-and-forth cycle every 2 seconds. The period of swing is __________.
   a. 4
   b. 0.5
   c. 2
   d. 0.2

9. As the frequency of a wave increases, the period of the wave ___________.
   a. decreases
   b. increases
   c. remains the same
   d. cannot predict

10. An ocean wave has an amplitude of 2.5 m. Weather conditions suddenly change such that the wave has an amplitude of 5.0 m. The amount of energy transported by the wave is __________.
    a. halved
    b. doubled
    c. quadrupled
    d. remains the same

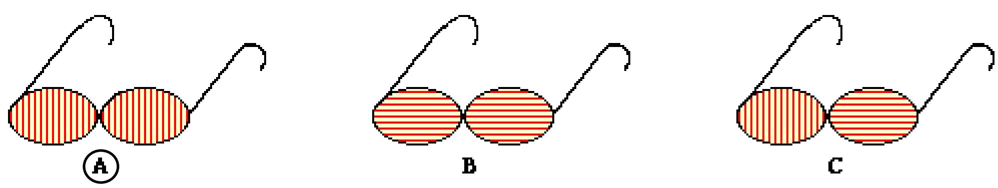
11. Two waves are traveling through the same container of nitrogen gas. Wave A has a wavelength of 1.5 m. Wave B has a wavelength of 4.5 m. The speed of wave B must be ________ the speed of wave A.
    a. one-ninth
    b. one-third
    c. the same as
    d. three times larger than

12. The speed of a wave depends upon _____
    a. The properties of the medium through which the wave travels.
    b. The wavelength of the wave.
    c. The frequency of the wave.
    d. Both the wavelength and the frequency of the wave.

13. Dawn and Aram have stretched a slinky between them and begin experimenting with waves. As the frequency of the waves is doubled,
    a. The wavelength is halved and the speed remains constant
    b. The wavelength remains constant and the speed is doubled
    c. Both the wavelength and the speed are halved.
    d. Both the wavelength and the speed remain constant.

14. A standing wave is formed when ____.
    a. A wave refracts due to changes in the properties of the medium.
    b. A wave reflects off a canyon wall and is heard shortly after it is formed.
    c. Red, orange, and yellow wavelengths bend around suspended atmospheric particles.
    d. Two identical waves moving different directions along the same medium interfere.

15. Consider the three pairs of sunglasses below. Identify the pair of glasses is capable of eliminating the glare resulting from sunlight reflecting off the calm waters of a lake? _________ Explain. (The polarization axes are shown by the straight lines.)

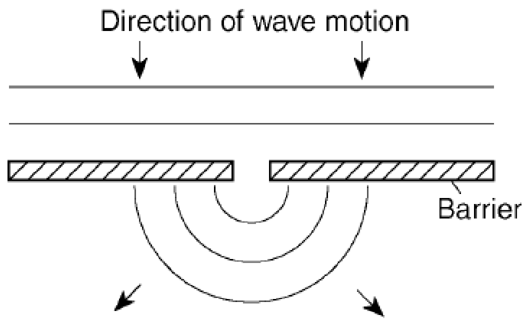


16. A light wave is an electromagnetic wave that has both an electric and magnetic component associated with it. Electromagnetic waves are often distinguished from mechanical waves. The distinction is based on the fact that electromagnetic waves ______.

    a. can travel through materials and mechanical waves cannot
    b. come in a range of frequencies and mechanical waves exist with only certain frequencies
    c. can travel through a region void of matter and mechanical waves cannot
    d. electromagnetic waves cannot transport energy and mechanical waves can transport energy

17. As observed from the Earth, the light from a star is shifted toward lower frequencies. This is an indication that the distance between the Earth and the star is –
    a. Increasing
    b. Decreasing
    c. Constant
    d. Cannot say

18. The diagram below shows wave fronts spreading into the region behind a barrier.



Which wave phenomenon is represented in the diagram?

a. Reflection
b. Refraction
c. Diffraction
d. Diffusion

19. The driver of a car hears the siren of an ambulance which is moving away from her. If the actual frequency of the siren is 2,000 hertz, the frequency heard by the driver may be

a. 1900 hz
b. 2000 hz
c. 2100 hz
d. 5000 hz

20. Radiations such as radio, light, and gamma are propagated by the interchange of energy between

a. Magnetic fields only
b. Electric fields only
c. Gravitational fields
d. Electric and Magnetic fields

3 points problems (10 problems @ 3 points each)

***Instruction**: Show your calculation and draw a circle around the final answer(s) –*

21. Mac and Tosh stand 8 meters apart and demonstrate the motion of a transverse wave on a snakey. The wave can be described as having a vertical distance of 32 cm from a trough to a crest, a frequency of 2.4 Hz, and a horizontal distance of 48 cm from a crest to the nearest trough. Determine the amplitude, period, and wavelength of such a wave.

    Amplitude = 16 cm

    (Amplitude is the distance from the rest position to the crest position which is half the vertical distance from a trough to a crest.)

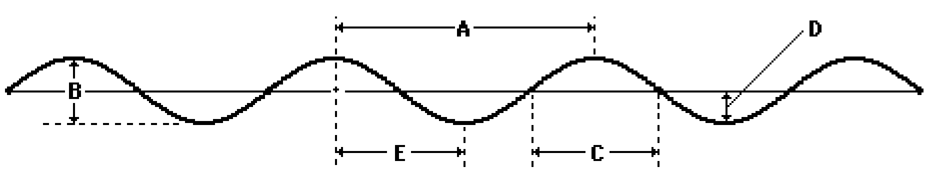
    Wavelength = 96 cm

    (Wavelength is the distance from crest to crest, which is twice the horizontal distance from crest to nearest trough.)

    Period = 0.42 s

    (The period is the reciprocal of the frequency. T = 1 / f)

22. Consider the diagram below in order to answer questions



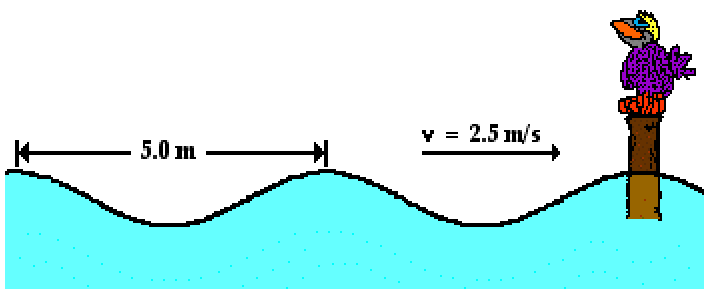
The wavelength of the wave in the diagram above is given by letter ___A___.
The amplitude of the wave in the diagram above is given by letter ___D__.
This wave is called a _______transverse wave____________ wave.

23. Describe how the fans in a stadium must move in order to produce a longitudinal stadium wave and a transverse stadium wave.

The fans will need to sway side to side to create longitudinal wave. Thus, as the wave travels around the stadium they would be moving parallel to its direction of motion.

The fans will have to rise up and sit down, then they would be creating a transverse wave. Thus, as the wave travels around the stadium they would be moving perpendicular to its direction of motion.

24. The water waves below are traveling along the surface of the ocean at a speed of 2.5 m/s and splashing periodically against Wilbert's perch. Each adjacent crest is 5 meters apart. The crests splash Wilbert's feet upon reaching his perch. How much time passes between each successive drenching? What is the wavelength and frequency of the wave?



If the wave travels 2.5 meters in one second then it will travel 5.0 meters in 2.0 seconds.

If Wilbert gets drenched every time the wave has traveled 5.0 meters, then he will get drenched every 2.0 seconds.

Wavelength = 5 m

Frequency = 0.5 hz

25. Calculate the speed of the wave in the following mediums –

Medium	**Wavelength**	**Frequency**	**Speed**
Zinc, 1-in. dia. coils	1.75 m	2.0 Hz	__3.5 m/s__
Copper, 1-in. dia. coils	1.19 m	2.1 Hz	__2.5 m/s__
Steel, 3-in. dia. coils	0.95 m	2.2 Hz	__2.1 m/s__

26. Ocean waves are observed to travel along the water surface during a developing storm. A Coast Guard weather station observes that there is a vertical distance from high point to low point of 4.6 meters and a horizontal distance of 8.6 meters between adjacent crests. The waves splash into the station once every 6.2 seconds. Determine the wavelength, frequency and the speed of these waves.

    The wavelength is 8.6 meters and the.

    The frequency can be determined from the period which is 6.2 seconds.
    $f = 1 / T = 1 / (6.2\ s)$
    $f = 0.161\ Hz$

    Now find speed using the $v = f \bullet \lambda$ equation.
    $v = f \bullet \lambda = (0.161\ Hz) \bullet (8.6\ m)$
    $v = 1.4\ m/s$

27. Suppose that a string is 1.2 meters long and vibrates in the first, second and third harmonic standing wave patterns. Determine the wavelength of the waves for each of the three patterns. Explain your answer.

First harmonic: 2.4 m

Second harmonic: 1.2 m

Third harmonic: 0.8 m

For the first harmonic, the length of the string is one-half of a wavelength. If the string is 1.2 meters long, then the full wavelength is 2.4 meters long.

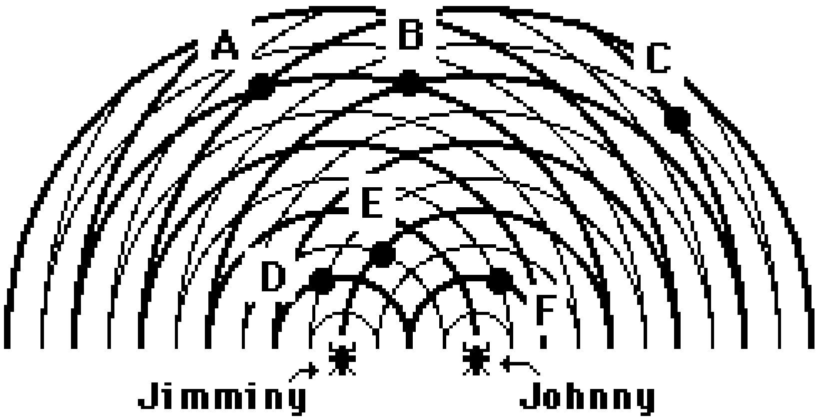
For the second harmonic, the length of the string is equivalent to a full wavelength. If the string is 1.2 meters long, then the wavelength is 1.2 meters long.

For the third harmonic, the length of the string is equivalent to three-halves of a wavelength. If the string is 1.2 meters long, then the wavelength of the third harmonic is 0.8 meters.

28. A pulse in a denser medium is traveling towards the boundary with a less dense medium. Complete the following sentences –

a. The speed of the transmitted pulse will be ____ greater than _______ (greater than, less than, the same as) the speed of the incident pulse.
b. The wavelength of the transmitted pulse will be ____ greater than _______ (greater than, less than, the same as) the wavelength of the incident pulse.
c. The frequency of the transmitted pulse will be _____ the same as ______ (greater than, less than, the same as) the frequency of the incident pulse.

29. Twin water bugs Jimminy and Johnny are both creating a series of circular waves by jiggling their legs in the water. The waves undergo interference and create the pattern represented in the diagram at the right. The thick lines in the diagram represent wave crests and the thin lines represent wave troughs. Several of positions in the water are labeled with a letter. Categorize each labeled position as being a position where either constructive or destructive interference occurs.



Points	Constructive interferences	Destructive interferences
A	X	
B	X	
C		X
D		X
E		X
F		X

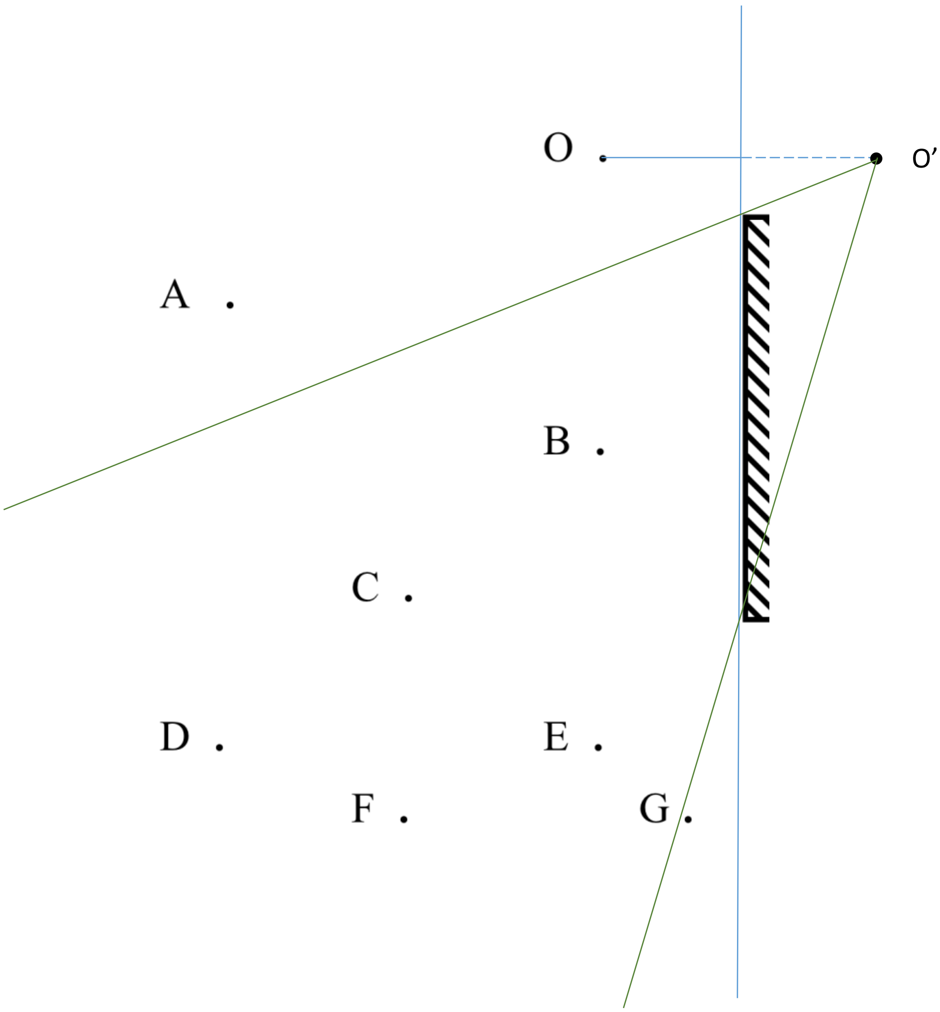
30. Different colored light sources shine on different colored sheets of paper. The indicated paper color represents the appearance of the paper when viewed in white light. Fill in the table below to show the color of light which reflects from the paper (i.e., the color observed).

	Color of Light	**Color of Paper**	**Color Observed**
a.	Blue	Red	black
b.	Red	Magenta	red
c.	Blue	Cyan	blue

6 points problems (5 problems @ 6 points each)

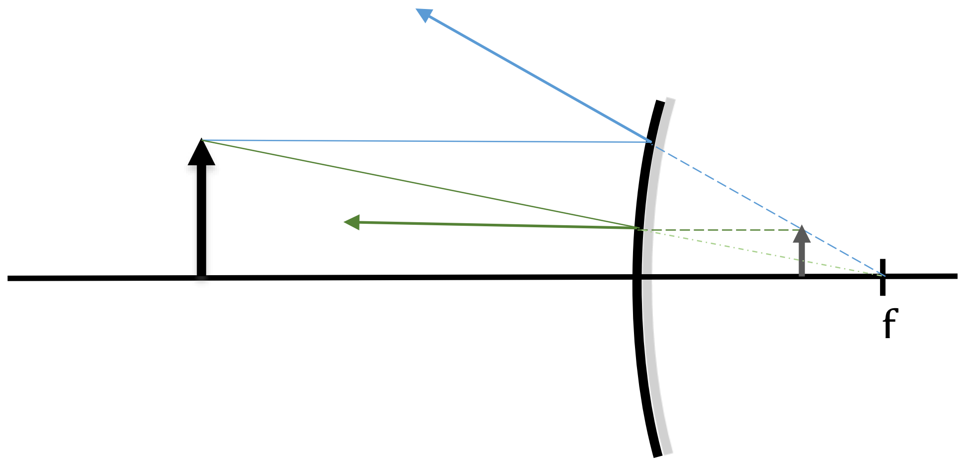
Instruction: *Show your calculation and draw to explain your answer. Drawing should be to scale and angles should be accurate.*

31. Which of the points (A, B, C, D, E, F) shown below can be seen reflected in the mirror by an observer at point O? Draw the ray diagram to explain.

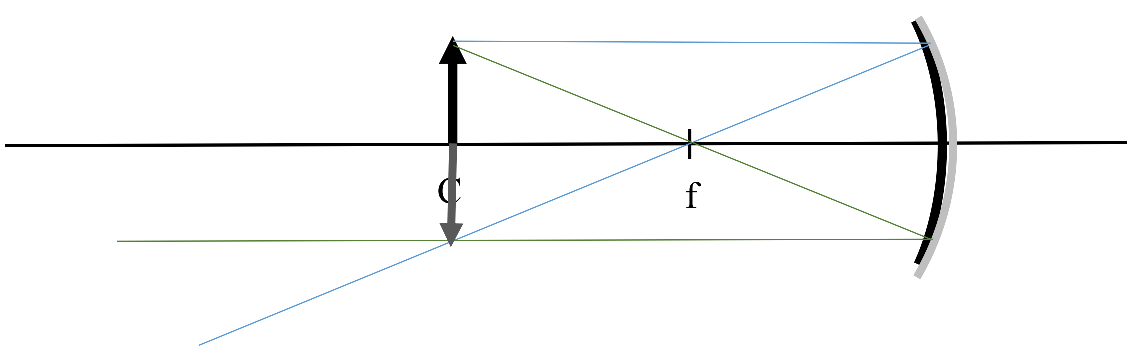


Points	Reflection visible at O	Reflection not visible at O
A		X
B	X	
C	X	
D	X	
E	X	
F	X	

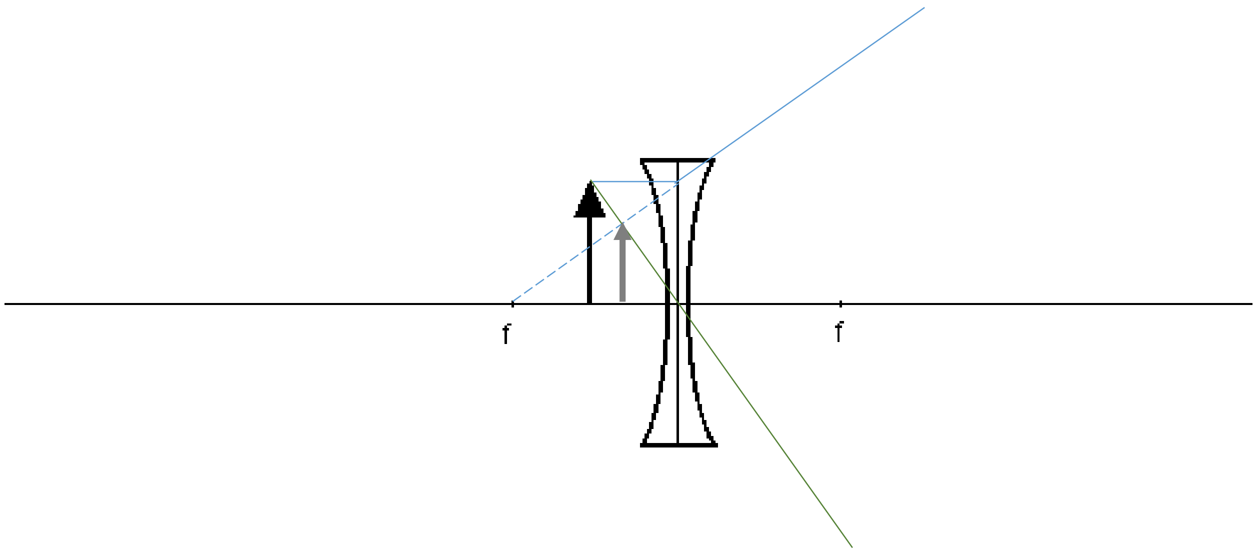
32. Draw to explain - where will the image be formed when an object represented by the arrow is placed in front of a convex mirror? Drawing should be to scale.



33. Draw to explain - where will the image be formed when an object represented by the arrow is placed in front of a concave mirror? Drawing should be to scale.



34. Draw to explain - where will the image be formed when an object represented by the arrow is placed in front of a concave mirror? Drawing should be to scale.



35. Using the Snell's law find the critical angle of water? A ray of light is traveling through water. It then encounters air at a boundary at an angle of 60 degrees to the normal. Draw and label the normal, the incident ray, and the refracted ray and write the angle values.

For critical angle (Θ_c) in a given median, the angle of refraction in air $\Theta_{air} = 90^o$.

$Sin(\Theta_{c\text{-}water})/Sin(\Theta_{air}) = N_{air}/N_{water}$

$Sin(\Theta_{c\text{-}water}) = N_{air}/N_{water} * Sin(90^o)$

$Sin(\Theta_{c\text{-}water}) = 1/1.333 * 1$

$\Theta_{c\text{-}water} = Sin^{-1}(1/1.333) = 48.61^o$

Since the angle of incidence (60^O) is higher than critical angle (48.61^o), the light ray will reflect back in the water and the angle of reflection will be equal to 60^O.