Name: _____

Class: _____

Due Date: _____

C.3 Wave Phenomena

Understandings

- Waves traveling in two and three dimensions can be described through the concepts of wavefronts and rays.
- Wave behavior at boundaries in terms of reflection, refraction, and transmission.
- Wave diffraction around a body and through an aperture.
- Wavefront-ray diagrams showing refraction and diffraction.
- Snell's law, critical angle, and total internal reflection.
- Snell's law as given by $\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$ where n is the refractive index and θ is the angle between the normal and the ray.
- Superposition of waves and wave pulses.
- Double-source interference requires coherent sources.
- The condition for constructive interference as given by path difference $= n\lambda$.
- The condition for destructive interference as given by path difference $= \left(n + \frac{1}{2}\right)\lambda$.
- Young's double-slit interference as given by $s = \frac{\lambda D}{d}$ where s is the separation of fringes, d is the separation of the slits, and D is the distance from the slits to the screen.

Equations

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$$

Constructive interference: path difference $= n\lambda$

Destructive interference: path difference $= \left(n + \frac{1}{2}\right)\lambda$

$s = \frac{\lambda D}{d}$

Additional HL Understandings

- Single-slit diffraction including intensity patterns as given by $\theta = \frac{\lambda}{b}$ where b is the slit width.
- The single-slit pattern modulates the double slit interference pattern.
- Interference patterns from multiple slits and diffraction gratings as given by $n\lambda = d \sin\theta$.

Additional HL Equations

$\theta = \frac{\lambda}{b}$

$n\lambda = d \sin\theta$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Use your favorite sources to answer the following questions

1. Define *wavefront.*

2. Define *ray.*

3. **Use a pencil and ruler!** Draw 3 wavefronts and 6 rays after a small rock falls vertically and hits water.

4. **Use a pencil and ruler!** Draw 2 wavefronts and 8 rays after a long thin rod falls horizontally and hits water.

5. Define *superposition.*

6. **Use a pencil and ruler!** Draw a before, during, and after image of two pulses on a rope traveling in opposite directions which go through constructive interference.

7. **Use a pencil and ruler!** Draw a before, during, and after image of two pulses on a rope traveling in opposite directions which go through destructive interference.

8. **Use a pencil and ruler!** Draw a before and after image of a single pulse wave on a string striking and being reflected from a vertical pole with a fixed end.

9. **Use a pencil and ruler!** Draw a before and after image of a single pulse wave on a string striking and being reflected from a vertical pole with a free/loose end.

10. What is the equation, units, and meaning of *index of refraction n*? What is the range of values for the *refractive index* of an object? What is the *refractive index* for a vacuum?

11. **Use a pencil and ruler!** Define *reflection* and draw a labeled figure.

12. State the equation for the *law of reflection*.

13. **Use a pencil and ruler!** Define *refraction* and draw a labeled figure. (Do not confuse *refraction* with *rarefaction*!)

14. State the equation for refraction: *Snell's law*.

15. **Use a pencil and ruler!** Define *dispersion* and draw a labeled figure.

16. **Use a pencil and ruler!** Define *total internal reflection* and *critical angle*. Draw a labeled figure.

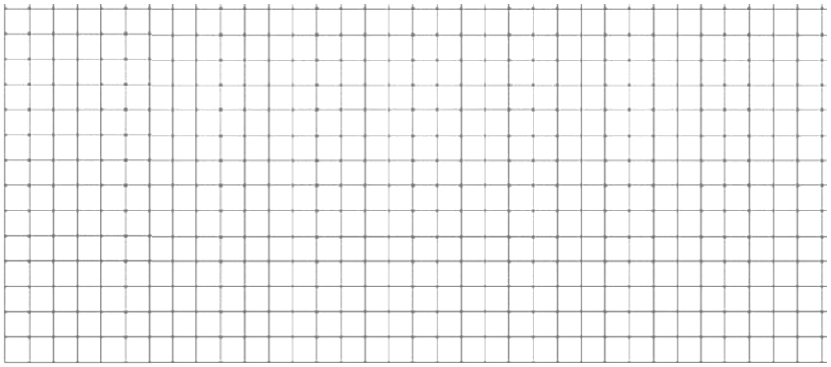
17. Define *diffraction*. Give two examples.

18. What is the relationship between the slit width and wavelength of the wave which gives maximum diffraction?

19. What is the relationship between the slit width and wavelength of the wave which gives minimum diffraction?

20. Light passes through a slit which is equal to the lights wavelength. What happens to the intensity of the central maximum as the slit width decreases?

21. **Use a pencil and ruler!** Draw an intensity vs. displacement graph for *single source interference*.



22. For double source interference state the equations and define each variable for

    a. constructive interference:

    b. for destructive interference:

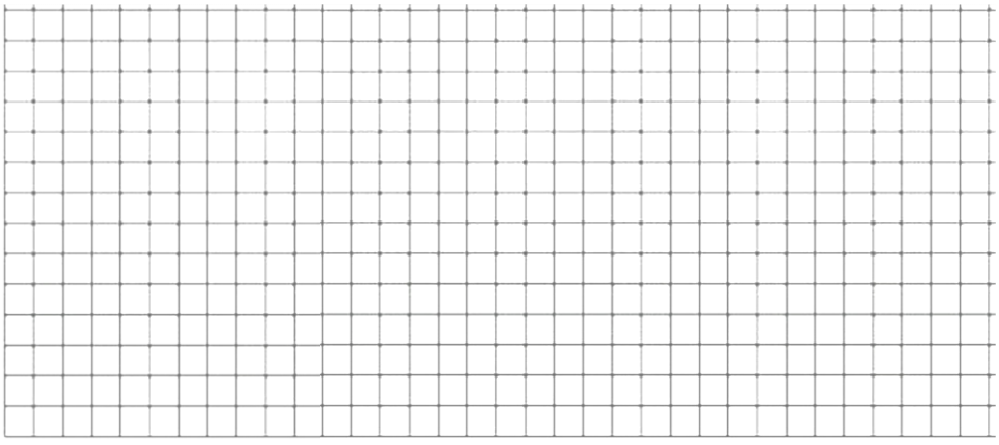
23. The equation for double slit wave interference is $s = \frac{\lambda D}{d}$. Define the following variables and draw a neat and detailed *intensity vs. displacement* graph for double slit interference:

    a. s: distance between maximum intensities (or bright spots)

    b. λ: wavelength of wave entering the double slit

    c. D: distance from double slit to screen

    d. d: distance between two slits



Additional HL Content

24. **Use a pencil!** Draw the lab setup and the intensity vs. distance graph for single slit diffraction.

25. Derive the equation $\theta = \frac{\lambda}{b}$. Define each variable.

26. What will happen to the thickness of the central maximum $2\theta = \frac{2\lambda}{b}$ if
    a. the wavelength λ of a wave passing through a single slit is increased?

    b. the wavelength λ of a wave passing through a single slit is decreased?

    c. the opening of a single slit b is increased?

    d. the opening of a single slit b is decreased?

27. What happens when white light passes through a single slit?

28. **Use a pencil!** Draw the lab setup and the intensity vs. displacement graph for Young's double slit experiment.

29. State the equation for double slit **constructive interference** and define each variable.

30. State the equation for double slit **destructive interference** and define each variable.

31. What happens to the intensity pattern as the number of slits increases?
https://www.geogebra.org/m/g6fsxcyn

32. **Use a pencil and ruler!** Carefully draw an *intensity vs. distance* graph for the following number of slits:

One slit
Two slits

Three slits
Four slits
Five slits

Six slits

33. What is a *diffraction grating*? What is its purpose?
https://www.geogebra.org/m/g6fsxcyn

34. Describe the equation $n\lambda = d \sin\theta$ for multiple slit diffraction.
https://www.geogebra.org/m/g6fsxcyn

35.Describe the meaning of the single slit *envelope*.