Student #: _____ Student Name: _____

Physics 12 Homework Unit 5: The Wave Nature of Light

1. Upon observing an interference pattern produced onto a screen, how could you identify whether a single slit or double slit produced the pattern?

2. Distinguish between diffraction and refraction.

3. What is dispersion, and how is it related to diffraction and refraction?

_____ 4. Light travelling in one material enters another material in which it travels faster. The light wave will:

(a) increase in frequency
(b) increase in wavelength
(c) decrease in frequency
(d) decrease in wavelength
(e) travel through the new material inverted

_____ 5. Two point sources are vibrating in phase producing two-dimensional water wave interference. The first anti-nodal line on either side of the central one will occur at locations where the path difference of the arriving waves is:

(a) $\lambda/4$
(b) $\lambda/2$
(c) $3\lambda/4$
(d) λ
(e) 2λ

_____ 6. A wave diffracts as it travels through an opening in a barrier. Which of the following variables can be altered to change the amount of diffraction the wave experiences?

I. distance between the source of the waves and the barrier
II. amplitude
III. frequency
IV. wavelength
V. slit width

(a) I and II
(b) II, III, and IV
(c) I, III, and IV
(d) III, IV, and V
(e) I and IV

_____ 7. A student is performing a double-slit experiment to determine the wavelength of a light source. She has measured the distance between dark bands, the distance between the slits and the screen. She still needs to measure:

(a) the speed of the light
(b) the width of each slit
(c) the distance between the slits
(d) the angle between the right bisector and the first minima
(e) the distance between the centre of the slits and the first minima

_____ 8. As a student is performing a double slit experiment to determine the wavelength of a light source, she realizes that the nodal lines are too close together to be accurately measured. To increase the distance between the nodal lines, she could:

(a) decrease the slit separation
(b) decrease the distance between the slits and the screen
(c) move the light source closer to the slits
(d) both (a) and (b)
(e) (a), (b), and (c)

_____ 9. The brightest and clearest diffraction patterns are seen when light is shone through:

(a) a single slit
(b) a double slit
(c) a diffraction grating
(d) a polarizing filter
(e) a thin soap film

_____ 10. Thin films of soap sometime display an array of colours. This display is the result of:

(a) reflection, diffraction, and interference
(b) reflection, refraction, and interference
(c) reflection, refraction, and polarization
(d) refraction, interference, and polarization
(e) reflection, interference, and polarization

_____ 11. A beam of light is unpolarized. This means that:

(a) the vibrations are confined to a single plane
(b) the vibrations are occurring in all possible directions
(c) the vibrations are occurring in all directions perpendicular to the direction of light propagation
(d) the light has reflected from a horizontal surface
(e) the light has passed through a calcite crystal which causes double refraction

_____ 12. The greater the number of lines on a diffraction grating of a given size,

(a) the greater the range of wavelengths that can be diffracted
(b) the smaller the range of wavelengths that can be diffracted
(c) the greater the distance between the bright fringes produced
(d) the smaller the distance between the bright fringes produced
(e) the less clear the diffraction pattern will be

_____ 13. Which of the following correctly describes the motion of the electric and magnetic fields of a microwave transmitted by a cell phone?

(a) Both the electric and magnetic fields oscillate in the same plane and perpendicular to the direction of wave propagation.
(b) Both the electric and magnetic fields oscillate perpendicular to each other and to the direction of wave propagation.
(c) The electric field oscillates perpendicular to the direction of wave propagation. The magnetic field oscillates parallel to the direction of wave propagation.
(d) Both the electric and magnetic fields oscillate parallel to the direction of wave propagation.

_____ 14. In a laboratory experiment, you shine a green laser past a strand of hair. This produces a light and dark pattern on a screen. You notice that the lab group next to you has produced a similar pattern on a screen, but the light and dark areas are spread farther apart. Which of the following could cause the light and dark pattern to spread?

(a) The second group used thinner hair.
(b) The second group is using a red laser.
(c) The second group had the screen closer to the hair.
(d) The second group held the laser farther from the hair.

_____ 15. An observer can hear sound from around a corner but cannot see light from around the same corner. Which of the following helps to explain this phenomenon?

(a) Sound is a longitudinal wave, and light is an electromagnetic wave.
(b) Sound is a mechanical wave, and light is a transverse wave.
(c) Light travels at a speed much faster than that of sound.
(d) Light has a much smaller wavelength than sound.

16. A double slit apparatus is held $1.2\,\text{m}$ from a screen.

    (a) When red light ($\lambda = 600\,\text{nm}$) is sent through the double slit, the interference pattern on the screen shows a distance of $12.5\,\text{cm}$ between the first and tenth dark fringes. What is the separation of the slits?

    (b) What will be the difference in path length for the waves travelling from each slit to the tenth nodal line? (Answer as a fraction of wavelength λ.)

17. Blue light ($\lambda = 475\,\text{nm}$) is sent through a single slit with a width of $2.1\,\mu\text{m}$. What is the maximum possible number of bright fringes produced on the screen?

18. Determine the distance that the *third* bright fringe would lie from the central bisector in a single slit diffraction pattern generated with $542\,\text{nm}$ light incident on a $1.2 \times 10^{-4}\,\text{m}$ slit falling onto a screen $68\,\text{cm}$ away.

19. Predict whether violet light ($\lambda = 404\,\text{nm}$) or red light ($\lambda = 702\,\text{nm}$) will have a wider central maximum in a single-slit diffraction pattern. Calculate the difference if the light is incident on a $6.9 \times 10^{-5}\,\text{m}$ wide slit falling onto a screen $85\,\text{cm}$ away.

20. News media often conduct live interviews from locations halfway around the world. There is obviously a time-lag between when a signal is sent and when it is received.

    (a) Calculate how long the time-lag should be for a signal sent from locations on Earth separated by $2.00 \times 10^{4}\,\text{km}$.

    (b) Suggest reasons why the actual time-lag differs from the value in (a).

21. The newest commercial imaging satellites can resolve objects separated by only $0.25\,\text{m}$. If one of these satellites orbits Earth at an altitude of $650\,\text{km}$,

    (a) Determine the size of the satellites' circular imaging aperture. (Use $455\,\text{nm}$ light for the light in the lenses of the satellites.)

    (b) Describe why the value from part (a) is a theoretical best-case result. What other effects would play a role in a satellites ability to resolve objects on the surface of Earth?

22. A skydiver is falling towards the ground. How close to the ground will she have to be before she is able to distinguish two yellow baseballs lying $25.0\,\text{cm}$ apart, reflecting $625\,\text{nm}$ light in air? Her pupil diameter is $3.35\,\text{mm}$. Assume that the speed of light inside the human eye is $2.21 \times 10^8\,\text{m/s}$.

23. The telescope on Mount Palomar has a diameter of $200\,\text{in}$. Suppose a double star were 4 light-years away. Under ideal conditions, what must be the minimum separation of the 2 stars for their image to be resolved? (Use a wavelength of $400\,\text{nm}$.)

24. For a ruby laser of wavelength $694\,\text{nm}$, the end of the ruby crystal is the aperture that determines the diameter of the light beam emitted. If the diameter is $2.0\,\text{cm}$ and the laser is aimed at the moon, find the approximate diameter of the light beam when it reaches the moon, assuming the spread is due solely to diffraction? (Use Earth-moon distance from the equation sheet.)

25. A beam of monochromatic red light with a wavelength of $700\,\text{nm}$ in air travels in water.

    (a) What is the wavelength in water?
    (b) Does a swimmer underwater observe the same colour or a different colour for this light?