SECTION B – Physical Optics

1. In Young’s double slit experiment, the second order bright band of one light source overlaps the third order band of another light source. If the first light source has a wavelength of 660 nm, what is the wavelength of the second light source?
A) 1320 nm B) 990 nm C) 495 nm D) 440 nm E) 330 nm

2. A student performs an experiment similar to Young’s Double Slit Experiment. Coherent light passes through two narrow slits and produces a pattern of alternating bright and dark lines on a screen. Which of the following would cause the bright lines on the screen to be further apart?
I. Increasing the distance between the slits
II. Decreasing the distance between the slits
III. Decreasing the wavelength of the light
A) I only B) II only C) III only D) I & III only E) II & III only

3. A diffraction grating of 1000 lines/cm has red light of wavelength 700 nm pass through it. The distance between the first and third principal bright spots on a screen 2 m away is
A) 14 cm B) 28 cm C) 42 cm D) 140 cm E) 280 cm

4. Monochromatic light with a wavelength of 6x10–7 meters falls upon a single slit. After passing through the slit, it forms a diffraction pattern on a screen 1 m away. The distance between the center maximum and the first maximum away from the center is 3 mm. What is the thickness of the slit?
A) 0.1 mm B) 0.2 mm C) 0.3 mm D) 0.4 mm E) 0.5 mm

1. 5. In a Young's double-slit experiment, the slit separation is doubled. To maintain the same fringe spacing on the screen, the screen-to-slit distance *D* must be changed to
	1. A) *D*/2 B)  C)  D) 2*D* E) 4*D*

6. Monochromatic light falls on a single slit 0.01 cm wide and develops a first–order minimum (dark band) 0.59 cm from the center of the central bright band on a screen that is one meter away. Determine the wavelength of the light.
A) 1.18 x10–2 cm B) 5.90 x10–3 cm C) 1.18 x10–4 cm D) 5.90 x10–5 cm E) 1.18 x10–6 cm

7. Which station broadcasts with 3.27 m radio waves?

 A) 91.7 MHz B) 92.5 MHz C) 98.5 MHz D) 102.5 MHz E) 106.3 MHz

8. Pioneering radio station KFKA started broadcasting 78 years ago at 1310 (1.31 MHz) on the AM dial. What is the approximate length of its radio wave?
A) 23m B) 230 m C) 2300 m D) 23000 m E) 3x108 m

9. The length of the most effective transmitting antenna is equal to one–fourth the wavelength of the broadcast wave. If a radio station has an antenna 4.5 meters long then what is the broadcast frequency of the radio station?
A) 1.4 x 10–8 Hz B) 6.0 x 10–8 Hz C) 1.7 x 107 Hz D) 6.7 x 107 Hz E) 3.0 x 108 Hz

10. A radio signal with a wavelength of 1.2 x 10–4 m is sent to a distance asteroid, is reflected, and returns to Earth 72 hours and 48 minutes later. How far from Earth is the asteroid?

 A) 1.9 x 1010 km B) 3.9 x 1010  km C) 7.9 x 1010  km D) 1.9 x 1011 km E) 5.4 x 1011 km

11. In the electromagnetic spectrum, rank the following electromagnetic waves in terms of increasing wavelength.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Smallest Wavelength Light |  | Largest Wavelength Light |
| A) | Ultraviolet | X–ray | Radio Waves |
| B) | Ultraviolet | Radio Waves | X–ray |
| C) | Radio Waves | Ultraviolet | X–ray |
| D) | Radio Waves | X–ray | Ultraviolet |
| E) | X–ray | Ultraviolet | Radio Waves |

12. Two sources, in phase and a distance *d* apart, each emit a wave of wavelength λ. See figure below. Which of the choices for the path difference ∆*L* = *L*1 – *L*2 will *always* produce destructive interference at point P?

A) d sin θ B) x/L1 C) (x/L2)d D) λ/2 E) 2 λ

13. Waves are produced by two point sources S and S’ vibrating in phase. See the accompanying diagram. X represents the location of the 2nd interference minima. The path difference SX – S’X is 4.5 cm. The wavelength of the waves is approximately

 A) 1.5 cm B) 1.8 cm C) 2.3 cm D) 3.0 cm E) 4.5 cm

14. A transmission diffraction grating is ruled with 5000 lines per cm. Through what angle will the first order maxima be deflected when light with a wavelength of 4.5 x 10–7 m strikes the grating?

 A) 5.2° B) 6.4° C) 13° D) 27° E) 34°

15. In an experiment to measure the wavelength of light using a double slit apparatus, it is found that the bright fringes are too close together to easily count them. To increase only the spacing between the bright fringes, one could
A) increase the slit width
B) decrease the slit width

C) increase the slit separation

D) decrease the slit separation

E) none of these

16. Two point sources in a ripple tank radiate waves in phase with a constant wavelength of 0.02 meter. The first‑order interference maximum appears at 6° (use sin 6° = 0.1). The separation of the sources is most nearly

 (A) 0.001 m (B) 0.002 m (C) 0.06 m (D) 0.1 m (E) 0.2 m

17. Which of the following is true of a single‑slit diffrac­tion pattern?
(A) It has equally spaced fringes of equal intensity.
(B) It has a relatively strong central maximum.
(C) It can be produced only if the slit width is less than one wavelength.
(D) It can be produced only if the slit width is exactly one wavelength.
(E) It can be produced only if the slit width is an integral number of wavelengths.

 Radio waves Infrared radiation Visible light Ultraviolet radiation Gamma radiation

18. For the five types of electromagnetic radiation listed above, which of the following correctly describes the way in which wavelength, frequency and speed, change as one goes from the left to right on the list?
Wavelength Frequency Speed
(A) Decreases Decreases Decreases
(B) Decreases Increases Remains the same
(C) Increases Decreases Remains the same
(D) Increases Decreases Increases
(E) Increases Increases Increases

19. A radar operates at a wavelength of 3 centimeters. The frequency of these waves is
(A) 10–10 Hz (B) 106 Hz (C) 108 Hz (D) 3 x 108 Hz (E) 1010 Hz

20. Plane sound waves of wavelength 0.12 m are
inci­dent on two narrow slits in a box with nonreflecting walls, as shown. At a distance of 5.0 m from the center of the slits, a first‑order maximum occurs at point *P*, which is 3.0 m from the central maxi­mum. The distance between the slits is most nearly

(A) 0.07 m (B) 0.09 m (C) 0.16 m (D) 0.20 m (E) 0.24 m

21. A radio station broadcasts on a carrier frequency of 100 MHz. The wavelength of this radio wave is most nearly

(A) 3.0 x 10-3 m (B) 1.0 m (C) 3.0 m (D) 3.3 m (E) 3.0 x106 m

22. If one of the two slits in a Young’s double-slit demonstration of the interference of light is covered with a thin filter that transmits only half the light intensity, which of the following occurs?

(A) The fringe pattern disappears.

(B) The bright lines are brighter and the dark lines are darker.

(C) The bright lines and the dark lines are all darker.

(D) The bright lines and the dark lines are all brighter.

(E) The dark lines are brighter and the bright lines are darker.

23. A diffraction grating is illuminated by light of wavelength 600 nm. On a screen 100 cm away is a series of bright spots spaced 10 cm apart. If the screen is now placed 30 cm from the diffraction grating, the new spacing between adjacent bright spots on the screen is most nearly

(A) 30 cm (B) 10 cm (C) 3 cm (D) 1 cm (E) 3 mm

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|  | Solution | Answer |
| 1. | Using m λ = d sin θ, the value of sin θ is the same for both sources since the location of the spot is the same, but the first source is at m=2, and the second source is at m=3. Equating d sin θ for each gives m1 λ1 = m2 λ2 … (2)(660) = 3 (λ2) … λ2 = 440 nm. | D |
| 2. | Based on m λ = dx / L we want to increase x. Only II does this. | B |
| 3. | 1000 lines/cm gives a line spacing d = 1/1000 cm/line = 1x10–5 m/line. λ = 7x10–7 m.With diffraction gratings, we usually assume the small angle approximation does not work, so we find θ then use the geometry with tan θ or another trig function to find Y. Do this for each spot.m=1. m λ = d sin θ (1)(7x10–7) = (1x10–5) sin θ θ = 4.01° … tan θ = o/a … Y1 = 0.14 mRepeat for m=3 … Y3 = 0.43 m. Subtract Y3 – Y1 to find the distance between = 0.29 m*Note: Since the angle θ here actually came out to be small, the x/L small angle approximation could be used and the spacing x between spots could be assumed to be equal as well, so you could simply find x for the first spot and double it to find the spacing 1 to 3.* | B |
| 4. | Single slit. With the given values, we can see the angle is small so we can use the small angle approximation and apply m λ = dx / L. Recall for single slits, the first maximum off center is at x=1.5 unlike double slits. | C |
| 5. | From mλ = dx / L, d x2 needs L x2 also. | D |
| 6. | Single Slit. Again based on the given values we can see the angle is small so we can use mλ = dx / L … dark spot at m=1. Note: use L=100 cm to get an answer in cm. | D |
| 7. | Radio wave is EM and travels at light speed. Use c = f λ and solve. | A |
| 8. | Radio wave is EM and travels at light speed. Use c = f λ and solve. | B |
| 9. | λ = 4\*4.5, Radio wave is EM and travels at light speed. Use c = f λ and solve. | C |
| 10. | It travels at light speed and takes half the total time to travel the distance one way. Use v=d/t. Convert the time to seconds, find the distance in meters, then convert that to km. | B |
| 11. | λ changes the opposite of frequencies (high freq = low λ) … based on this and knowledge of the EM spectrum, the answer is E. | E |
| 12. | By definition, when the path difference equals ½ λ or any odd multiple of ½ λ’s for sources of the same λ, there will be destructive interference.  | D |
| 13. | Using path diff = m λ, with m=1.5 for the 2nd min, we have 4.5 cm = (1.5) λ. | D |
| 14. | 5000 lines/cm gives a line spacing d = 1/5000 cm/line = 2x10–6 m/line. Then use m λ = d sin θ, with m = 1 for the first max. | C |
| 15. | Based on m λ = dx / L we want to increase x. d is separation of slits and less d means more x | D |
| 16. | Using mλ = d sin θ … (1)(0.02) = d (0.1)  | E |
| 17. | Fact about single slits. | B |
| 18. | Known facts about the EM spectrum. | B |
| 19. | Radar wave is EM and travels at light speed. Use c = f λ and solve. | E |
| 20. | Since the slits are narrow, we can use m λ = d sin θ, but since θ is clearly large we cannot use the x/L small angle approximation. From the given diagram, the geometry shows sin θ = o/h = 3/5 .. rather than finding θ, we will just use this value for sin θ and plug in … m λ =d sin θ … (1) (0.12) = d (3/5)  | D |
| 21. | Radio waves are EM and travels at light speed. Use c = f λ and solve. | C |
| 22. | This is still a double slit pattern because there is still light making it through both slits. One of the light sources has reduced its amplitude; which means when it meets the second light source it will cause less interference than it originally did. This means less constructive interference and less destructive interference also. So bright spots become less bright, and dark spots become brighter. | E |
| 23. | From the first scenario given. We can determine the angle of the first spot using tan θ = o /a. tan θ = 10 / 100 = 5.71°. The problem says the remaining spots are spaced equally, which is a rough approximation. The angles are relatively small, but if we wanted to get accurate results we should find each spacing with d sin θ, but, this is just an approximation for the first few spots. When the screen is moved closer, the angle of the light leaving the grating will not change, but the spacing on the screen will decrease. Think about a diagram of this setup and it is clear that this must be true. Based on tan θ = o /a with the same angle θ but the adjacent side changed to 30 cm, we get a new location of the first spot at 3 cm, so the other spots will also approximately be located 3 cm apart as well for relatively small angles. | C |
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