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3. Under STUDENT # enter your 9-digit Identification Number.

4. Enter 228 under COURSE, and your section number (see label above) under SEC.

5. Under CODE enter the exam code given above.

6. During the exam, you may use pencils, a calculator, and one handwritten 8.5 x 11 inch sheet with formulas and notes, without attachments.

7. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot answer a question, mark only one answer on the answer sheet. For each question, mark only one answer on the answer sheet.

8. When you are asked to open the exam, raise your hand if this is not the case. A proctor will check your name sticker and your student ID some time during the exam. Also raise your hand if this is not the case.

9. When you are asked to open the exam, make sure that your copy of the exam paper is complete.

10. Good luck!

Useful Information:

- Speed of light: \( c = 3.00 \times 10^8 \text{ m/s} \)
- 1 in = 10.9 cm

Signature: Please sign the cover sheet under your name sticker. A proctor will check your name sticker and your student ID some time during the exam.

Your name sticker with exam code

Profs. Coleman and Andrei
February 21, 2008
Physics 228 - Exam I
1. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?
   a) +2.4 cm  
   b) −0.25 cm  
   c) +1.0 cm  
   d) +0.6 cm  
   e) −4.0 cm

2. X-rays of wavelength 0.129 nm are incident on a crystal, and a first-order maximum is observed at an angle of 8°15' to the plane of the tank on a vertical axis. Cross the oil-syrup interface at a point 0.90 m from the axis and at the critical angle. The index of refraction of the oil is closest to:
   a) 2.00  
   b) 1.98  
   c) 2.02  
   d) 1.96  
   e) 1.94

3. The tank shown in the figure holds a layer of oil, 1.88 m thick, which floats on a layer of syrup that is 0.69 m thick. Both liquids are clear and do not intermix. A ray, which originates at the bottom of the tank on a vertical axis, crosses the oil-syrup interface at a point 0.90 m from the axis and at the critical angle. The local length of the mirror is closest to:
   a) +28.2 cm  
   b) +56.5 cm  
   c) -21.6 cm  
   d) -56.5 cm  
   e) +21.6 cm

4. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?
   a) +2.4 cm  
   b) −0.25 cm  
   c) +1.0 cm  
   d) +0.6 cm  
   e) −4.0 cm

5. Coherent monochromatic light of wavelength 625 nm passes through a pair of thin parallel slits whose spacing is 2.81 × 10^-6 m. The angle of the first maximum is observed at an angle of 8.1° to the plane of the tank on a vertical axis. Cross the oil-syrup interface at a point 0.90 m from the axis and at the critical angle. How many bright fringes can be formed on one side of the central bright fringe?
   a) 2  
   b) 3  
   c) 4  
   d) 5  
   e) 6

6. A single slit forms a diffraction pattern, with the first minimum at an angle of 4°. Monochromatic light at a wavelength of 640 nm is used. The width of the slit, in mm, is closest to:
   a) 78.1 cm  
   b) 28.2 cm  
   c) 19.6 cm  
   d) 21.6 cm  
   e) 36.2 cm

7. The tank shown in the figure holds a layer of oil, 1.88 m thick, which floats on a layer of syrup that is 0.69 m thick. Both liquids are clear and do not intermix. A ray, which originates at the bottom of the tank on a vertical axis, crosses the oil-syrup interface at a point 0.90 m from the axis and at the critical angle. The local length of the mirror is closest to:
   a) +28.2 cm  
   b) +56.5 cm  
   c) -21.6 cm  
   d) -56.5 cm  
   e) +21.6 cm
7. A metallic sheet has a large number of slits, 5.0 mm wide and 20 cm apart, and is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the grating. The microwave wavelength is 6.0 cm. The largest angle from the normal, at which an intensity maximum occurs, is closest to:

a) 74°
b) 64°
c) 84°
d) 69°
e) 79°

8. Light of wavelength 425.0 nm in air falls at normal incidence on an oil film that is 850.0 nm thick. The oil is floating on a water layer 1500 nm thick. The refractive index of water is 1.33, and that of the oil is 1.40. The number of wavelengths of light that fit in the oil film is closest to:

a) 2.80
b) 4.69
c) 2.66
d) 2.00
e) 3.53

9. When an object is placed 30 cm from a converging lens, the image formed is positioned 60 cm from the lens. If the object is moved 5 cm closer to the lens, the position of the image changes by 40 cm. What is the focal length of the lens?

a) 16 cm
b) 25 cm
c) 36 cm
d) 20 cm
e) 32 cm

10. In the investigation of a new type of optical fiber (index of refraction $n=1.270$), a laser beam is incident on the flat end of a straight fiber in air. What is the maximum angle of incidence $\theta$ if the beam is not to escape from the fiber?

a) 51.5°
b) 42.2°
c) 45.3°
d) 39.1°
e) 48.4°

11. A beam of light is linearly polarized in a vertical plane and has an intensity $I_0$. The beam passes through an ideal polarizer whose axis is set horizontally. The ratio of the intensity of the beam after it has passed through the polarizer to its intensity before passing through the polarizer is closest to:

a) 0.25
b) 0.43
c) 1.2
d) 0.37
e) 0.19
12. A laser positioned on a ship is used to communicate with a small two-man research submarine resting on the bottom of a lake. The laser is positioned 12 m above the surface of the water, and it strikes the water 20 m from the side of the ship. The water is 76 m deep and has an index of refraction of 1.33. How far is the submarine from the side of the ship?

a) 74.1 m  

b) 94.1 m  

c) 84.1 m  

d) 25.5 m  

e) 104 m

13. Two lasers are shining on a double slit, with slit separation d. Laser one has a wavelength of \( \frac{d}{20} \), while laser two has a wavelength of \( \frac{d}{15} \). The lasers produce separate interference patterns on a screen placed at a large distance L away from the slits. Which of the following statements is correct?

a) Laser One has its first maximum closer to the central maximum.

b) The interference patterns of the two lasers exactly overlap.

c) Laser Two has its first maximum closer to the central maximum.

d) The relative position of the first maximum will depend on the ratio \( \frac{d}{L} \).

e) The number of bright fringes will be the same for both lasers.

14. Three sources of monochromatic coherent light of a single wavelength and intensity \( I \) are combined. If the phase angles between source 1 and 2 is 90°, and the phase angle between source 1 and 3 is also 90°, what is the intensity of the combined beam?

a) \( I \) 

b) 0 

c) 3I 

d) 9I 

e) 0 

15. Light of wavelength 500 nm passes through a double-slit device. The 6th and 12th interference fringes are observed to be absent. Which of the following is true?

a) The missing fringes are due to the interference pattern of light coming from a single slit.

b) The missing fringes are due to destructive interference between two different slits.

c) The missing fringes are due to the interference pattern of light coming from a single slit.

d) The missing fringes are due to destructive interference between two different slits.

e) The slit width is 12 times smaller than the slit separation.
There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in the answer sheet and the cover page under your name sticker. Good luck!

Useful Information

speed of light: \( c = 3.00 \times 10^8 \text{ m/s} \)

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Useful Information

speed of light: \( c = 3.00 \times 10^8 \text{ m/s} \)
1. Coherent monochromatic light of wavelength 625 nm passes through a pair of thin parallel slits whose spacing is $2.81 \times 10^{-6}$ m. At most, how many bright fringes can be formed on one side of the central bright fringe (not counting the central bright fringe)?

a) 6  

b) 4  

c) 2  

d) 5  

e) 3

2. A metallic sheet has a large number of slits, 5.0 mm wide and 20 cm apart, and is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the grating. The microwaves wavelength is 6.0 cm. The largest angle from the normal, at which an intensity maximum occurs, is closest to:

a) 74°  

b) 84°  

c) 79°  

d) 69°  

e) 64°

3. In the investigation of a new type of optical fiber (index of refraction $n=1.270$), a laser beam is incident on the flat end of a water filled optical fiber at normal incidence on a water-air interface. What is the maximum angle of incidence $\theta_1$ if the beam is not to escape from the fiber?

a) 51.5°  

b) 45.3°  

c) 48.4°  

d) 42.2°  

e) 39.1°

4. A single slit forms a diffraction pattern, with the first minimum at an angle of 40° from central maximum. Monochromatic light of wavelength 640 nm is used. The width of the slit, in nm, is closest to:

a) 914  

b) 955  

c) 873  

d) 996  

e) 832

5. X-rays of wavelength 0.129 nm are incident on a crystal, and a first-order maximum is observed at an angle of 8°.15' to the plane of atoms. What is the interplanar spacing?

a) About 0.25 nm  

b) About 0.30 nm  

c) About 0.45 nm  

d) About 0.40 nm  

e) About 0.35 nm

6. Light of wavelength 425.0 nm in air falls at normal incidence on an oil film that is 850.0 nm thick. The oil is floating on a water layer that is 1500 nm thick. The refractive index of water is 1.33, and that of the oil is 1.40. The number of wavelengths of light that fit in the oil film is closest to:

a) 3.53  

b) 2.80  

c) 2.66  

d) 2.00  

e) 4.69
7. Three sources of monochromatic coherent light of a single wavelength and intensity \( I \) are combined. If the phase angle between source 1 and 2 is \( \pi/2 \) radians and the phase angle between source 2 and 3 is also \( \pi/2 \) radians, what is the intensity of the combined beam?

a) 0  

b) \( I \)  

c) \( I \)  

d) 3\( I \)  

e) 9\( I \)

8. Light of wavelength 500 nm passes through a double slit device and produces a set of interference fringes on a distant screen. The 6th and 12th interference fringes are observed to be absent. Which of the following is true?

a) The slit width is 12 times smaller than the slit separation.  

b) The missing fringes are due to the interference pattern of light coming from a single slit.  

c) The missing fringes are due to destructive interference between light coming from different slits.  

d) The slit width is 1000 nm.  

e) The difference between the path length of the first and second source is 500 nm and 1000 nm at the first and second missing fringe.
11. The tank shown in the figure holds a layer of oil, 1.88 m thick, which floats on a layer of syrup that is 0.69 m thick. Both liquids are clear and do not intermix. A ray, which originates at the bottom of the tank on a vertical axis, crosses the oil-syrup interface at a point 0.90 m from the axis. The ray continues and arrives at the oil-air interface, 2.00 m from the axis and at the critical angle. The index of refraction of the oil is closest to:

- a) 2.02
- b) 1.96
- c) 2.00
- d) 1.94
- e) 1.98

12. Two lasers are shining on a double slit, with slit separation $d$. Laser one has a wavelength of $d/20$, while laser two has a wavelength of $d/15$. The lasers produce separate interference patterns on a screen placed at a large distance $L$ away from the slits. Which of the following statements is correct?

- a) The number of bright fringes will be the same for both lasers.
- b) Laser Two has its first maximum closer to the central maximum.
- c) The relative position of the first maximum will depend on the ratio $d/L$.
- d) Laser One has its first maximum closer to the central maximum.
- e) The interference patterns of the two lasers exactly overlap.

13. When an object is placed 30 cm from a converging lens, the image formed is positioned 60 cm from the lens. If the object is moved 5 cm closer to the lens, the position of the image changes by 40 cm. What is the focal length of the lens?

- a) 20 cm
- b) 36 cm
- c) 32 cm
- d) 16 cm
- e) 25 cm

14. A beam of light is linearly polarized in a vertical plane and has an intensity $I_0$. The beam passes through an ideal polarizer whose axis is set at 60° with the vertical and then through an ideal analyzer whose axis is set horizontally. The beam of light is horizontally polarized in a vertical plane and has an intensity $I$. Which of the following statements is closest to $I$?

- a) 0.02
- b) 0.12
- c) 0.13
- d) 0.21
- e) 0.19

15. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?

- a) +0.6 cm
- b) −3.25 cm
- c) −4.00 cm
- d) +2.4 cm
- e) +1.0 cm

16. The angle of reflection of the oil film at the oil-air interface is 90°, and the angle of incidence is 60°. What is the position of the image of the object on the tank, on a vertical axis, crossing the oil-syrup interface, from the oil-air interface?

- a) 98°
- b) 94°
- c) 90°
- d) 96°
- e) 70°
Physics 228– Exam I
February 21, 2008
Profs. Coleman and Andrei

Your name sticker
with exam code
⇒
SIGNATURE:

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1. Two lasers are shining on a double slit, with slit separation d. Laser one has a wavelength of \( \frac{d}{20} \), while laser two has a wavelength of \( \frac{d}{15} \). The lasers produce separate interference patterns on a screen placed at a large distance L away from the slits. Which of the following statements is correct?

a) The number of bright fringes will be the same for both lasers.
b) The interference patterns of the two lasers exactly overlap.
c) Laser One has its first maximum closer to the central maximum.
d) Laser Two has its first maximum closer to the central maximum.
e) The relative position of the first maximum will depend on the ratio \( \frac{d}{L} \).

2. X-rays of wavelength 0.129 nm are incident on a crystal, and a first-order maximum is observed at an angle of 8.15° to the plane of atoms. What is the interplanar spacing?

a) About 0.35 nm
b) About 0.30 nm
c) About 0.25 nm
d) About 0.45 nm
e) About 0.40 nm

3. In the investigation of a new type of optical fiber (index of refraction \( n = 1.270 \)) a laser beam is incident on the flat end of a straight fiber, forming a beam not to escape from the fiber's end. From the normal, at which an intensity maximum occurs, is closest to the normal at which an intensity maximum occurs.

a) 48.4°
b) 42.2°
c) 51.5°
d) 45.3°
e) 39.1°

4. Three sources of monochromatic coherent light of a single wavelength I are combined. If the phase angle between source 1 and 2 is \( \frac{\pi}{2} \) radians and the phase angle between source 1 and 2 is \( \frac{\pi}{2} \) radians, and the phase angle between source 1 and source 2 is \( \pi \) radians, what is the intensity of the combined beam? If the intensity and intensity I are combined. If the phase angle between source 1 and source 2 is \( \pi \) radians, and the phase angle between source 1 and source 2 is \( \pi \) radians, what is the intensity of the combined beam?

a) \( I \)
b) \( 0 \)
c) \( 2I \)
d) \( 4I \)
e) \( \frac{I}{2} \)

5. A metallic sheet has a large number of slits, 5.0 mm wide and 20 cm apart, and is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the sheet. What is the maximum angle of incidence \( \theta \) if the beam is not to escape from the fiber?

a) 48.4°
b) 42.2°
c) 51.5°
d) 45.3°
e) 39.1°

6. In the investigation of a new type of optical fiber (index of refraction \( n = 1.270 \)) a laser beam is incident on the flat end of a straight fiber, forming a beam not to escape from the fiber's end. From the normal, at which an intensity maximum occurs, is closest to the normal at which an intensity maximum occurs.

a) 48.4°
b) 42.2°
c) 51.5°
d) 45.3°
e) 39.1°
6. A laser positioned on a ship is used to communicate with a small two-man research submarine resting on the bottom of a lake. The laser is positioned 12 m above the surface of the water, and it strikes the water 20 m from the side of the ship. The water is 76 m deep and has an index of refraction of 1.33. How far is the submarine from the side of the ship?

- a) 25.5 m
- b) 94.1 m
- c) 84.1 m
- d) 104 m
- e) 74.1 m

7. Light of wavelength 500 nm passes through a double slit device produced a set of interference fringes on a distant screen. The 6th and 12th interference fringes are observed to be absent. Which of the following is true?

- a) The slit width is 12 times smaller than the slit separation.
- b) The difference between the path lengths from the slits to the screen is 500 nm and 1000 nm at the first and second order slit.
- c) The missing fringes are produced by destructive interference.
- d) The slit width is 1000 nm.
- e) The missing fringes are due to the interference pattern of light coming from a single slit.

8. A beam of light is linearly polarized in a vertical plane and has an intensity of $I_0$. The beam passes through an ideal polarizer whose axes are set horizontally. Then, the beam passes through an ideal analyzer whose axes are set at 60° with the vertical and then through an ideal interferometer. The beam passes through an ideal polarizer whose axes are set at 0° with the vertical and then through an ideal analyzer whose axes are set at 45° with the vertical. A beam of light is linearly polarized in a vertical plane and has an intensity of $I$. How far is the image from the side of the ship?

- a) 0.25
- b) 1.2
- c) 3.0
- d) 1.9
- e) 0.37

9. The radius of the curved part of lens L in the figure is 35.0 cm, and the refractive index of the lens material is 1.62. The focal length of L is closest to:

- a) -56.5 cm
- b) +56.5 cm
- c) +21.6 cm
- d) +28.2 cm
- e) -21.6 cm

10. Light of wavelength 500 nm passes through a double slit device.
10. The tank shown in the figure holds a layer of oil, 1.88 m thick, which floats on a layer of syrup that is 0.69 m thick. Both liquids are clear and do not intermix. A ray, which originates at the bottom of the tank on a vertical axis, crosses the oil-syrup interface at a point 0.90 m from the axis. The ray continues and arrives at the oil-air interface, 2.00 m from the axis and at the critical angle. The index of refraction of the oil is closest to:

(a) 1.98  
(b) 1.96  
(c) 1.94  
(d) 2.00  
(e) 2.02

11. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?

(a) $-4.0$ cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

12. Light of wavelength 425.0 nm in air falls at normal incidence on an oil film that is 850.0 nm thick. The oil is floating on a water layer 1500 nm thick. The index of refraction of water is 1.33, and that of oil is 1.40. The number of wavelengths of light that fit in the oil film is closest to:

(a) 2.00  
(b) 4.69  
(c) 2.80  
(d) 2.66  
(e) 3.53

13. When an object is placed 30 cm from a converging lens, the image formed is positioned 60 cm from the lens. If the object is moved forward 5 cm, the position of the image changes by 40 cm closer to the lens. The position of the image changes by 40 cm closer to the lens. If the object is moved forward 60 cm from the lens, the image formed is positioned 60 cm from the lens. What is the focal length of the lens?

(a) 32 cm  
(b) 66 cm  
(c) 22 cm  
(d) 16 cm  
(e) 20 cm

14. Coherent monochromatic light of wavelength 625 nm passes through a pair of thin parallel slits whose spacing is $2.81 \times 10^{-6}$ m. At most, how many bright fringes can be formed on one side of the central bright fringe (not counting the central bright fringe)?

(a) 5  
(b) 2  
(c) 3  
(d) 4  
(e) 6

15. A single slit forms a diffraction pattern with the first minimum closest to:

(a) 6  
(b) 4  
(c) 2  
(d) q  
(e) a

16. In the oil film is closest to:

(a) 3.53  
(b) 2.99  
(c) 2.80  
(d) 2.66  
(e) 2.00

12. Light of wavelength 425.0 nm in air falls at normal incidence on a water-air interface 425.0 nm in air. The index of refraction of water is closest to:

(a) 0.6 cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

11. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?

(a) $-4.0$ cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

12. Light of wavelength 425.0 nm in air falls at normal incidence on a water-air interface 425.0 nm in air. The index of refraction of water is closest to:

(a) 0.6 cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

11. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?

(a) $-4.0$ cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

12. Light of wavelength 425.0 nm in air falls at normal incidence on a water-air interface 425.0 nm in air. The index of refraction of water is closest to:

(a) 0.6 cm  
(b) +2.4 cm  
(c) +1.0 cm  
(d) $-0.25$ cm  
(e) +0.6 cm

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Physics 228—Exam I
February 21, 2008
Profs. Coleman and Andrei

Your name sticker with exam code
⇒
SIGNATURE:

1. The exam will last from 9:40 p.m. to 11:20 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.

2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.

3. Under STUDENT # enter your 9-digit Identification Number.

4. Enter 228 under COURSE, and your section number (see label above) under SEC.

5. Under CODE enter the exam code given above.

6. During the exam, you may use pencils, a calculator, and one handwritten 8.5 x 11 inch sheet with formulas and notes, without attachments.

7. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in the answer sheet and the cover page. Retain this question paper for future reference.

8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.

9. If you have a question, please raise your hand. A proctor will check your name sticker and your student ID number before the exam starts, and you will be asked to sign the cover sheet.

10. Good luck!

Useful Information

speed of light: \( c = 3 \times 10^8 \text{ m/s} \)

Information on the cover sheet:

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Useful Information

speed of light: \( c = 3 \times 10^8 \text{ m/s} \)
1. A beam of light is linearly polarized in a vertical plane and has an intensity $I_0$. The beam passes through an ideal polarizer whose axis is set at $60^\circ$ with the vertical and then through an ideal analyzer whose axis is set horizontally. The ratio of the intensity of the final beam to $I_0$ is closest to:
   a) 1.2  
   b) 0.37  
   c) 0.43  
   d) 0.19  
   e) 0.25

2. X-rays of wavelength 0.129 nm are incident on a crystal, and a first-order maximum is observed at an angle of $8.15^\circ$ to the plane of atoms. What is the interplanar spacing?
   a) About 0.35 nm  
   b) About 0.45 nm  
   c) About 0.40 nm  
   d) About 0.30 nm  
   e) About 0.25 nm

3. The radius of the curved part of lens $L_3$ in the figure is 35.0 cm, and the refractive index of the lens material is 1.62. The focal length of $L_3$ in the figure is 35.0 cm.
   a) -56.5 cm  
   b) -21.6 cm  
   c) +28.2 cm  
   d) +21.6 cm  
   e) +56.5 cm

4. Light of wavelength 425.0 nm in air falls at normal incidence on an oil film that is 850.0 nm thick. The oil is floating on a water layer 1500 nm thick. The refractive index of water is 1.33, and that of the oil is 1.40. The number of wavelengths of light that fit in the oil film is closest to:
   a) 3.53  
   b) 2.80  
   c) 2.00  
   d) 2.66  
   e) 4.69

5. A single slit forms a diffraction pattern, with the first minimum at an angle of 40\(^\circ\) from central maximum. Monochromatic light of wavelength 640-nm is used. The width of the slit, in nm, is closest to:
   a) 955  
   b) 832  
   c) 996  
   d) 873  
   e) 914

6. Three sources of monochromatic coherent light of a single wave are combined. If the phase angle between source 1 and 2 is $\pi/2$ radians, and the phase angle between source 2 and source 3 is also $\pi/2$ radians, what is the intensity of the combined beam? If light and intensity are combined, what is the intensity of the combined beam?
   a) $I$  
   b) $I/2$  
   c) $I/4$  
   d) $I/8$  
   e) $I/16$
7. Light of wavelength 500 nm passes through a double slit device and produces interference fringes on a distant screen. The 6th and 12th interference fringes are observed to be absent. Which of the following is true?

(a) The difference between the path lengths from the slits to the screen is 500 nm and 1000 nm at the first and second missing fringes.
(b) The slit width is 1000 nm.
(c) The slit width is 12 times smaller than the slit separation.
(d) The missing fringes are due to the interference pattern of light coming from a single slit.
(e) The missing fringes are produced by destructive interference between light coming from different slits.

8. The tank shown in the figure holds a layer of oil, 1.88 m thick, which floats on a layer of syrup that is 0.69 m thick. Both liquids are clear and do not intermix. A ray, which originates at the bottom of the tank on a vertical axis, crosses the oil-syrup interface at a point 0.90 m from the axis. The ray continues and arrives at the oil-air interface, 2.00 m from the axis and at the critical angle. The index of refraction of the oil is closest to:

(a) 1.94
(b) 2.02
(c) 1.96
(d) 1.98
(e) 2.00

9. A metallic sheet has a large number of slits, 5.0 mm wide and 20 cm apart, and is used as a diffraction grating for microwaves. A wide parallel beam of microwaves is incident normally on the grating. The microwave wavelength is 6.0 cm. The largest angle from the normal, at which an intensity maximum occurs, is closest to:

(a) 74°
(b) 79°
(c) 84°
(d) 69°
(e) 64°

10. A spherical mirror forms an image that is virtual, one-quarter of the size of the object, and is 3 cm from the mirror. What is the focal length of the mirror?

(a) +0.6 cm
(b) −0.75 cm
(c) +2.4 cm
(d) +1.0 cm
(e) −1.0 cm

11. Coherent monochromatic light of wavelength 625 nm passes through a double slit device.

(a) The interference pattern is formed on one side of the central bright fringe.
(b) The 7th and 11th interference fringes are absent. Which of the following is true?

(a) The differences in path length between the two interfering waves are 625 nm and 1250 nm at the first and second fringes.
(b) The difference in path length between the two interfering waves is 625 nm. The largest angle from the normal, at which an intensity maximum occurs, is closest to:

(a) 69°
(b) 62°
(c) 68°
(d) 65°
(e) 61°

12. The diagram shows a wavefront of light that is incident on a glass plate. The angle of incidence is 30°. The angle of refraction is 60°. The index of refraction of the glass is closest to:

(a) 1.50
(b) 1.55
(c) 1.60
(d) 1.65
(e) 1.70

The following is true:

(a) The angle of incidence is 30°, and the angle of refraction is 60°.
(b) The angle of incidence is 30°, and the angle of refraction is 60°.
(c) The angle of incidence is 30°, and the angle of refraction is 60°.
(d) The angle of incidence is 30°, and the angle of refraction is 60°.
(e) The angle of incidence is 30°, and the angle of refraction is 60°.
12. In the investigation of a new type of optical fiber (index of refraction \( n = 1.270 \)) a laser beam is incident on the flat end of a straight fiber in air. What is the maximum angle of incidence \( \theta_1 \) if the beam is not to escape from the fiber?

(a) 51.5°
(b) 39.1°
(c) 45.3°
(d) 42.2°
(e) 48.4°

13. When an object is placed 30 cm from a converging lens, the image formed is positioned 60 cm from the lens. If the object is moved 5 cm closer to the lens, the position of the image changes by 40 cm. What is the focal length of the lens?

(a) 36 cm
(b) 32 cm
(c) 25 cm
(d) 20 cm
(e) 16 cm

14. A laser positioned on a ship is used to communicate with a small two-man research submarine resting on the bottom of a lake. The laser is positioned 12 m above the surface of the water, and it strikes the water 20 m from the side of the ship. The water is 76 m deep and has an index of refraction of 1.33. How far is the submarine from the side of the ship?

(a) 94.1 m
(b) 84.1 m
(c) 104 m
(d) 74.1 m
(e) 25.5 m

15. Two lasers are shining on a double slit, with a separation of \( d \). Laser one has a wavelength of \( d/20 \), while laser two has a wavelength of \( d/15 \). The lasers produce separate interference patterns on a screen placed at a large distance \( L \) away from the slits. Which of the following statements is correct?

(a) The interference patterns of the two lasers exactly overlap.
(b) The number of bright fringes will be the same for both lasers.
(c) The relative position of the first maximum will depend on both lasers.
(d) Laser one has its first maximum closer to the central maximum.
(e) Laser two has its first maximum closer to the central maximum.