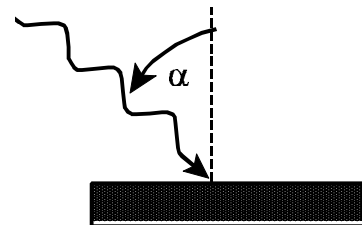


SCIENCE/ENGINEERING PHYSICS TEST 1997-98

LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE & WAVE-PARTICLE DUALITY

For each of the following multiple choice problems select the BEST answer and place the appropriate capital, block letter in the space provided. [2.25 pts each]

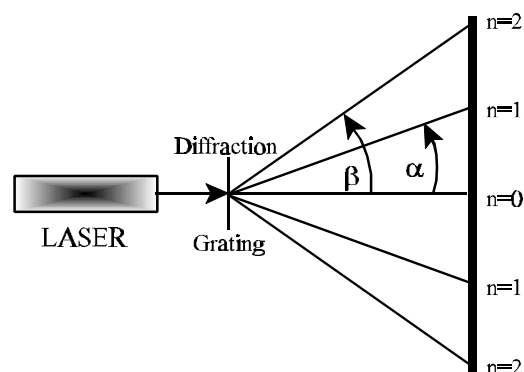
- ___ 1. Light which has a wavelength of 5500\AA in air is shining on a horizontal surface at an angle of $\alpha = 63.0^\circ$ as shown to the right. At this angle the reflected light is total polarized. What is the index of refraction of this horizontal surface?
 A. 1.0 B. 1.15 C. 1.28 D. 1.53 E. 1.96



A monochromatic light source is shined through a diffraction grating which has 750 slits per cm. A diffraction pattern is shined onto a wall located $L = 7.0$ meters from the grating and it is noted that the first order antinode occurs at an angle of $\alpha = 22.6^\circ$ from the central antinode.

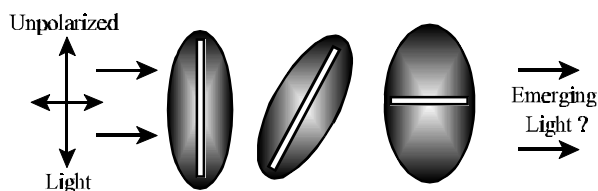
- ___ 2. What is the distance between adjacent slits in this diffraction grating?
 A. 0.0013 cm B. 0.0065 cm C. $154,000\text{\AA}$
 D. $48,000\text{\AA}$ E. $65,000\text{\AA}$

- ___ 3. What is the wavelength of this light source?
 A. 5124\AA B. 4150\AA C. 5900\AA D. 6300\AA E. 8200\AA
- ___ 4. At what angle β will the second order antinode be found?
 A. 10.5° B. 22.0° C. 32.0° D. 38.0° E. 50.2°



- ___ 5. What will be the linear distance x between the first and second antinodes on the screen?
 A. 190 cm B. 269 cm C. 385 cm D. 520 cm
 E. 655 cm

Unpolarized light is shined upon a series of three polarizers arranged as shown to the right. The initial light beam has an intensity of 580 foot candles. The angle between the transmission axis of the first and second polarizers is 28° while the third polarizer is perpendicular to the first polarizer.



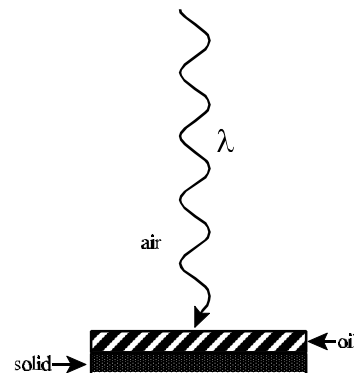
- ___ 6. What will be the intensity of the light beam after passing through the first polarizer?
 A. 290 ft cd B. 48 ft cd C. 218 ft cd D. 590 ft cd E. 99.7 ft cd
- ___ 7. What will be the intensity of the light after passing through the second polarizer?
 A. 290 ft cd B. 48 ft cd C. 218 ft cd D. 590 ft cd E. 99.7 ft cd
- ___ 8. What will be the intensity of the light emerging from the third polarizer?

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

- A. 290 ft cd B. 48 ft cd C. 218 ft cd D. 590 ft cd E. 99.7 ft cd

- ___ 9. Each of the following experiments successfully demonstrated the wave nature of light except:
 A. diffraction of light through a single slit.
 B. interference of light in a thin soap film.
 C. polarization of light through selective absorption.
 D. refraction of light through a glass plate.
 E. the emission of light from a blackbody radiator.

Monochromatic light is normally incident upon a thin layer of oil ($n_{\text{oil}} = 1.5$) which is spread out on a solid surface ($n_{\text{solid}} = 2.0$). The space immediately above the oil film is filled with air ($n_{\text{air}} = 1.0$). Light, which has a wavelength of $\lambda = 6000\text{\AA}$ in air, is normally incident on the film from above as shown to the right.



- ___ 10. What will be the wavelength of this light within the oil film?
 A. 4000\AA B. 4500\AA C. 9000\AA D. 5500\AA E. 7200\AA
- ___ 11. What is the minimum thickness of the oil film if the incident light is to be brightly reflected?
 A. 6000\AA B. 4000\AA C. 3000\AA D. 2000\AA E. 1000\AA
- ___ 12. How will the phase of the light reflected from the air-oil interface compare with the phase of the light reflected from the oil-solid interface?
 A. Insufficient information B. They will differ by 270° C. They will differ by 180°
 D. They will be the same E. They will differ by 90° .

A monochromatic light source, which has a wavelength of 7200\AA , is shined through a single slit which is 0.022 millimeters wide.

- ___ 13. At what angle will the third order node be found ?
 A. 2.55° B. 5.63° C. 6.61° D. 9.22° E. 12.3°
- ___ 14. What will be the distance between the second and third antinodes formed on a screen located 2.5 meters away from the single slit?
 A. 0.084 m B. 1.22 m C. 0.012 m D. 0.332 m E. 11.2 m

- ___ 15. Which of the following modern technologies makes use of the concept of thin film interference?
 A. fiber optical cables B. torque wrenches C. electrical power generators
 D. camera lenses E. automobile engine superchargers
- ___ 16. Which of the following modern technologies makes use of the concept of critical angle ?

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

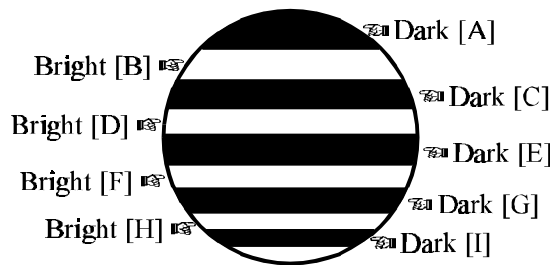
- A. fiber optical cables B. torque wrenches C. electrical power generators
 D. camera lenses E. automobile engine superchargers

- ____ 17. Which of the following processes cannot be used to produce linearly polarized light?
 A. scattering B. diffraction C. double refraction D. selective absorption E. reflection

Light, which has a wavelength of $\lambda = 3150 \text{ \AA}$, is shined upon a surface which has an ionization potential of -3.25 eV ;

- ____ 18. What is the energy, in Joules, of each of the incoming light photons?
 A. $1.02 \times 10^{-18} \text{ J}$ B. $6.3 \times 10^{-19} \text{ J}$ C. $9.7 \times 10^{-18} \text{ J}$ D. $6.8 \times 10^{-17} \text{ J}$ E. $3.2 \times 10^{-16} \text{ J}$
- ____ 19. What will be the velocity of the resulting emitted photoelectrons?
 A. $3.8 \times 10^3 \text{ m/sec}$ B. $7.1 \times 10^2 \text{ m/sec}$ C. $8.9 \times 10^5 \text{ m/sec}$
 D. $3.8 \times 10^5 \text{ m/sec}$ E. $4.9 \times 10^5 \text{ m/sec}$
- ____ 20. What will be the wavelength of the emitted photoelectrons?
 A. 12 \AA B. 1350 \AA C. 195 \AA D. 15 \AA E. 1950 \AA
- ____ 21. What will be the frequency of the light that can just barely free an electron from this surface?
 A. $5.2 \times 10^{12} \text{ Hz}$ B. $9.9 \times 10^{13} \text{ Hz}$ C. $6.1 \times 10^{13} \text{ Hz}$ D. $7.8 \times 10^{14} \text{ Hz}$ E. $6.1 \times 10^{12} \text{ Hz}$

Light, which has a wavelength of 5600 \AA [yellow] is shined upon a thin soap film stretched across a vertical oriented loop of wire. [Assume an index of 1.00 for air and 1.36 for the soap film] As the loop is held vertically the soap film gradually flows downward until the top portion of the film [A] appears to be transparent [Dark] while the area below consists of alternating bands of bright and dark as shown to the right.



- ____ 22. What will be the thickness of the film at the point where bright band F appears?
 A. 1400 \AA B. 2800 \AA C. 2060 \AA D. 7000 \AA E. 5145 \AA
- ____ 23. What will be the thickness of the film at the point where Dark band A appears?
 A. 1400 \AA B. 2800 \AA C. 2060 \AA D. 7000 \AA E. much less than 1030 \AA

Suppose this soap film is turned horizontally and the film becomes uniform with a thickness of 1325 \AA .

- ____ 24. What maximum wavelength of light can be shined on this film [assume the light beam strikes the film perpendicularly!] so that the reflected light undergoes complete constructive interference?
 A. 7200 \AA B. 4350 \AA C. 3600 \AA D. 5300 \AA E. 2650 \AA

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

- _____ 25. What percentage of normally incident light will be transmitted through this soap film?
A. 88% B. 91% C. 92% D. 95% E. 99%

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

- _____ 26. The sky is blue because;
- A. the dispersion effect of the atmosphere tends to refract blue light downward.
 - B. short waves of visible light tend to be scattered by the molecules of the atmosphere.
 - C. the molecules of the atmosphere tend to fluoresce in the blue area of the visible spectrum.
 - D. long waves of light tend to reflect more easily than short waves of light.
 - E. dust particles in the atmosphere tend to interfere with the passage of red light.
- A 6430 Å monochromatic light source is used to illuminate two parallel glass plates separated at one end by a wire which has a diameter of 0.045 mm. The two plates are $L = 22.0$ cm long.**
- _____ 27. How many bright interference fringes will be visible along the length of these two glass plates ?
- A. 12 B. 68 C. 122 D. 140 E. 260
- _____ 28. The pattern of dark and bright fringes produced by single and double slits is due to;
- A. interference and reflection B. reflection and polarization C. diffraction and interference
D. polarization and diffraction E. interference and refraction
- _____ 29. Although optical microscopes cannot be used to observe thing smaller than about 4000 Å, electron microscopes can be used to observe thing down to about 10 Å. Which of the following can BEST be used to account for this difference?
- A. The wavelengths of electrons are significantly smaller than the shortest wavelengths of visible light.
 - B. The electronics involved in electron microscopes is much more sophisticated.
 - C. Electron microscopes use lenses that are corrected for spherical and chromatic aberration while optical microscopes do not.
 - D. Electrons move much faster than light and are not deflected as much by the electromagnetic force.
 - E. Electron microscopes are not as susceptible to vibrations.
- _____ 30. The principle purpose of the Michelson-Morley Interferometer was;
- A. to measure the speed of light in a vacuum.
 - B. to show that light waves could NOT pass through a vacuum.
 - C. to determine where the center of the universe was located.
 - D. to develop a technique that could be used to measure small vibrations through the use of interference.
 - E. to detect and measure the medium for light.
- _____ 31. According Max Planck's explanation of the Blackbody Radiation experiment ;
- A. light behaves like a wave because light waves are emitted coherently from heated bodies.
 - B. the rate at which light energy is emitted from an object is proportional to the 4th power of the temperature.
 - C. the wave properties of light will always dominate the particle properties.
 - D. light is both a wave and a particle depending on what measurements you are making.
 - E. the light emitted by a blackbody radiator is more consistent with a particle model of light than a wave model.

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

- ___ 32. In the PhotoElectric experiment Einstein expected;
- A. there to be an instantaneous current as soon as the light source was turned on.
 - B. that low frequency light would produce a current more quickly than high frequency light.
 - C. infrared light would produce a higher current than ultraviolet light.
 - D. that the incident light would produce a higher current if the source was cycled on and off rapidly.
 - E. the photo current to slowly rise to a maximum and then stabilize.

Which property of light could BEST be used to account for the fact that;

- ___ 33. Even the largest and best telescopes are limited in their abilities to resolve two adjacent stars.
A. reflection B. refraction C. polarization D. interference E. diffraction
- ___ 34. Some types of sunglasses can cause the display of an LCD calculator to completely black out.
A. reflection B. refraction C. polarization D. interference E. diffraction
- ___ 35. Some optical devices such as camera lenses and computer monitors appear to exhibit a slightly purple cast.
A. reflection B. refraction C. polarization D. interference E. diffraction
- ___ 36. Soap bubbles exhibit the colors of the rainbow.
A. reflection B. refraction C. polarization D. interference E. diffraction

As a magazine publisher you are concerned with what minimum resolution would be required of the pictures printed in the magazine if the readers are to be unable to see the individual dots of those pictures. Assuming that the average person's pupil has a diameter of 6.0 mm, that the wavelength of yellow light is $\lambda = 5900 \text{ \AA}$ and that the average person holds the magazine 38.0 cm from the eyes;

- ___ 37. What will be the minimum resolution [in dots per cm] required to print pictures in this magazine without the individual dots being visible?
A. 620 B. 460 C. 380 D. 220 E. 150

A thin film having an index of refraction of $n = 1.65$ is surrounded by air. It is illuminated normally by white light and is viewed by reflection. Analysis of the reflected light shows that the visible wavelengths $\lambda_1 = 4125 \text{ \AA}$ and $\lambda_2 = 5500 \text{ \AA}$ are missing from the reflected light.

- ___ 38. What is the thickness of this thin film?
A. 5000 \AA B. 5800 \AA C. 4750 \AA D. 7200 \AA E. 6980 \AA
- ___ 39. What visible wavelength/wavelengths will be brightest in the reflected interference pattern?
A. 4300 \AA B. 4700 \AA C. 5350 \AA D. 6210 \AA E. 6600 \AA

Suppose, instead, that this film was resting on a sheet of glass which has an index of $n_{\text{glass}} = 1.83$,

- ___ 40. What visible wavelength/wavelengths would be missing from the reflected light?
A. 4300 \AA B. 4700 \AA C. 5350 \AA D. 6210 \AA E. 6600 \AA

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

Essay: Select one of the following topics and write a clear essay! Show me what you know! [15 pts]

- A. What was the purpose of the Michelson-Morley interferometer? What result did they expect? what actually happened? What conclusion did this experiment lead to?
- B. What was the photoelectric effect? What predictions did the classical wave theory make about this experiment? How did Einstein explain the results of this experiment? What consequence did this experiment have for the wave theory of light?
- C. What is "blackbody radiation"? What predictions were made for this effect according to classical physics? What interpretation did Max Planck make regarding this experiment?
- D. Is light a wave or is it a particle? How do you know? Support your assertion with evidence!

USEFUL INFORMATION!

$$1\text{eV} = 1.6 \times 10^{-19} \text{ J}$$

$$c = 3.0 \times 10^8 \text{ m/s}$$

$$1 \text{ Angstrom}(\text{\AA}) = 1.0 \times 10^{-10} \text{ m}$$

$$m_{\text{electron}} = 9.11 \times 10^{-31} \text{ kg}$$

SCIENCE/ENGINEERING PHYSICS TEST 1997-98
LIGHT - POLARIZATION, DIFFRACTION, INTERFERENCE
& WAVE-PARTICLE DUALITY

- | | | | |
|-------|-------|-------|---------|
| 1. E | 11. D | 21. D | 31. E |
| 2. A | 12. D | 22. E | 32. E |
| 3. A | 13. B | 23. E | 33. E |
| 4. E | 14. A | 24. A | 34. C |
| 5. B | 15. D | 25. D | 35. D |
| 6. A | 16. A | 26. B | 36. D |
| 7. C | 17. B | 27. D | 37. D |
| 8. B | 18. B | 28. C | 38. A |
| 9. E | 19. E | 29. A | 39. B,E |
| 10. A | 20. D | 30. E | 40. B,E |