

1. Light with a wavelength of 589 nm in a vacuum strikes the surface of an unknown liquid at an angle of 31.2° with respect to the normal to the surface. If the light travels at a speed of 1.97×10^8 m/s through the liquid, what is the angle of refraction?
 - A) 19.9°
 - B) 26.1°
 - C) 34.2°
 - D) 39.3°
 - E) 51.9°
2. A light ray is traveling in a diamond ($n = 2.419$). If the ray approaches the diamond-air interface, what is the minimum angle of incidence that will result in all of the light being reflected back into the diamond? The index of refraction for air is 1.000.
 - A) 24.42°
 - B) 32.46°
 - C) 54.25°
 - D) 65.58°
 - E) 77.54°
3. An object is placed at the focal point of a converging lens of focal length f . What is the image distance?
 - A) f
 - B) $2f$
 - C) $1/f$
 - D) $2/f$
 - E) at an infinite distance
4. A converging lens is used to focus light from a small bulb onto a book. The lens has a focal length of 10.0 cm and is located 40.0 cm from the book. Determine the distance from the lens to the light bulb.
 - A) 8.6 cm
 - B) 13 cm
 - C) 20 cm
 - D) 30 cm
 - E) 50 cm

5. A 6.0-cm object is placed 30.0 cm from a lens. The resulting image height has a magnitude of 2.0 cm; and the image is inverted. What is the focal length of the lens?
- A) 7.5 cm
 - B) 15.0 cm
 - C) 22.5 cm
 - D) 30.0 cm
 - E) 45.0 cm
6. Joseph uses a converging lens ($f = 0.12$ m) to read a map located 0.080 m from the lens. What is the magnification of the lens?
- A) +3.4
 - B) +3.0
 - C) +1.7
 - D) +0.60
 - E) +0.33

Use the following to answer question 7:

A diverging lens has a focal length of -10 cm. A 3-cm object is placed 25 cm from the lens.

7. What is the magnification of the image?
- A) +0.3
 - B) -0.3
 - C) +0.7
 - D) -0.7
 - E) +0.8
8. Two slits are separated by 2.00×10^{-5} m. They are illuminated by light of wavelength 5.60×10^{-7} m. If the distance from the slits to the screen is 6.00 m, what is the separation between the central bright fringe and the third bright fringe?
- A) 0.421 m
 - B) 0.224 m
 - C) 0.168 m
 - D) 0.084 m
 - E) None of these

9. Light of wavelength 530 nm is incident on two slits that are spaced 1.0 mm apart. How far from the slits should the screen be placed so that the distance between the $m = 0$ and $m = 1$ bright fringes is 1.0 cm?
- A) 7.9 m
 - B) 9.5 m
 - C) 16 m
 - D) 19 m
 - E) 36 m
10. Light of wavelength λ in vacuum strikes a lens that is made of glass with index of refraction 1.6. The lens has been coated with a film of thickness t and index of refraction 1.3. For which one of the following conditions will there be no reflection?
- A) $2t = \frac{\lambda}{2}$
 - B) $2t = \frac{\lambda}{1.33}$
 - C) $2t = \frac{\lambda}{1.6}$
 - D) $2t = \frac{1}{2} \left(\frac{\lambda}{1.6} \right)$
 - E) $2t = \frac{1}{2} \left(\frac{\lambda}{1.3} \right)$
11. In the year 2100, an astronaut travels on a journey at a speed of 2.0×10^8 m/s. According to observers on Earth, the trip lasts 16 hours. How long was the trip as measured on the watch of the astronaut?
- A) 6.7 hr
 - B) 8.9 hr
 - C) 12.0 hr
 - D) 16.1 hr
 - E) 21.5 hr

12. A spaceship leaves our solar system at a constant speed of $0.900c$ and travels to a point in the Andromeda galaxy. According to astronomers in an inertial reference frame on Earth, the distance to the galaxy is 2.081×10^{22} m. What distance does the crew on the ship measure on its journey?
- A) 9.07×10^{21} m
 - B) 9.85×10^{21} m
 - C) 1.91×10^{22} m
 - D) 2.83×10^{22} m
 - E) 4.77×10^{22} m
13. How much energy would be released if 1.0 g of material were completely converted into energy?
- A) 9×10^8 J
 - B) 9×10^9 J
 - C) 9×10^{11} J
 - D) 9×10^{13} J
 - E) 9×10^{16} J
14. The average power output of a nuclear power plant is 5.00×10^2 MW. In one minute, what is the change in the mass of the nuclear fuel due to the energy being taken from the reactor? Assume 100% efficiency.
- A) 9.3×10^{-17} kg
 - B) 9.3×10^{-11} kg
 - C) 3.3×10^{-13} kg
 - D) 3.3×10^{-7} kg
 - E) 9.3 kg
15. In a science fiction novel, a starship takes three days to travel between two distant space stations according to its own clocks. Instruments on one of the space stations indicate that the trip took five days. How fast did the starship travel, relative to the space station?
- A) 1.98×10^8 m/s
 - B) 2.40×10^8 m/s
 - C) 2.51×10^8 m/s
 - D) 2.83×10^8 m/s
 - E) 2.99×10^8 m/s

16. Determine the approximate energy of a single photon in a beam of light of wavelength 525 nm. (1 nm = 1.0×10^{-9} m, $1.0 \text{ eV} = 1.6 \times 10^{-19}$ J, $h = 6.63 \times 10^{-34}$ J-s)
- A) 2.0 eV
 - B) 2.4 eV
 - C) 2.8 eV
 - D) 4.2 eV
 - E) None of these
17. A laser emits photons of energy 3.0 eV with a power of 2 milliwatts. How many photons are emitted in one second?
- A) 3.0×10^{14}
 - B) 2.5×10^{15}
 - C) 1.8×10^{15}
 - D) 4.2×10^{15}
 - E) 2.5×10^{21}
18. Photons of energy 5.0 eV strike a metal whose work function is 8.2 eV. Determine which one of the following best describes the kinetic energy of the emitted electrons.
- A) 3.2 eV or less
 - B) 1.5 eV or more
 - C) 2.5 eV or more
 - D) 3.5 eV or more
 - E) None of these
19. What kinetic energy must each neutron in a beam of neutrons have if their wavelength is 0.10 nm? The mass of a neutron is 1.67×10^{-27} kg.
- A) 6.6×10^{-19} J
 - B) 1.3×10^{-20} J
 - C) 2.6×10^{-20} J
 - D) 6.3×10^{-20} J
 - E) 7.1×10^{-20} J
20. Determine the wavelength of incident electromagnetic radiation required to cause an electron transition from the $n = 6$ to the $n = 8$ level in a hydrogen atom.
- A) 1.2×10^3 nm
 - B) 2.2×10^3 nm
 - C) 3.4×10^3 nm
 - D) 5.9×10^3 nm
 - E) 7.5×10^3 nm

Answer Key

1. A
2. A
3. E
4. B
5. A
6. B
7. A
8. A
9. D
10. E
11. E
12. A
13. D
14. D
15. B
16. B
17. D
18. E
19. B
20. E