1. An object is placed 200 cm from a screen. When a converging lens is placed between the object and screen at a distance of 160 cm from the object, an image is formed on the screen. Without moving the object or screen, an image can also be formed on the screen when the distance from the object to the lens is

A) 8 cm  
B) 16 cm  
C) 20 cm  
D) 32 cm  
E) 40 cm

If the object is 160 cm from the lens, the image must be 200 cm - 160 cm = 40 cm from the lens. The image distance can be interchanged with the object distance.

2. This figure shows an image produced by a lens. Which statement is correct?

A) Both the Object and Image are at the focal points.  
B) Each of the 5 rays of light take the same time to travel from the object to the image.  
C) The image is virtual.  
D) The magnification is +1.0.  
E) This is a diverging lens.

Light travels in the path that takes the least amount of time. Since light can take any of the paths shown, they must all be the least time, and take the same amount of time.

3. A narrow slit is illuminated with sodium light of wavelength 589 nm. If the central maximum extends to ±30°, how wide is the slit?

A) 0.5 mm  
B) 2200 nm  
C) 33,000 nm  
D) 1180 nm  
E) 5890 nm

\[
d \sin \theta = m\lambda
\]

\[
d = \frac{589\text{nm}}{\sin 30°}
\]

4. A helium-neon laser (\(\lambda = 632.8\) nm) is used to calibrate a diffraction grating. If the first order

http://hep/physics126 w02/exams/EXAM3.htm
maximum occurs at 20.5°, what is the line spacing?

\[
d \sin \theta = m\lambda
\]

\[
d = \frac{632.8 \text{ nm}}{\sin 20.5^\circ}
\]

A) \(1.81 \times 10^{-6} \text{ m}\)
B) \(1.0 \times 10^{-5} \text{ m}\)
C) \(1.0 \times 10^{-4} \text{ m}\)
D) \(1.31 \times 10^{-6} \text{ m}\)
E) \(676 \times 10^{-7} \text{ m}\)

5. The reason two slits are used, instead of one slit, in a double slit interference experiment is

A) to provide a path length difference.
B) one slit is for E, the other slit is for B.
C) one slit is frequency, the other is for wavelength.
D) for horizontal and vertical polarization.
E) to increase the intensity.

Interference is the combination of two coherent rays of light. The two slits provide the two coherent rays and a path length difference between them.

6. At what distance could one theoretically distinguish two automobile headlights separated by 1.5 meters? Assume a pupil diameter of 0.5 cm and yellow headlights seen at wavelength \(5 \times 10^{-7}\) m. Assume eye fluid surrounding the pupil has an average \(n = 1.33\).

A) 6 km
B) 12 km
C) 9 km
D) 3 km
E) 16 km

\[
D \sin \theta = 1.22 \frac{\lambda'}{n}
\]

\[
\sin \theta = 1.22 \frac{500 \text{ nm}}{5 \text{ mm} \times 1.33} = \frac{1.5 \text{ m}}{L}
\]

7. A starship navigator measures the distance between the earth and the sun. We measure this distance to be 93 million miles. If the ship is moving at a speed of 0.9 \(c\) the navigator measures the distance to be

A) 40 million miles.
B) 30 million miles.
C) 80 million miles.
D) 215 million miles.
E) 93 million miles.
8. The half-life of a muon is 2.2 μs. How fast must it be moving if its half-life doubles?

\[ t = \gamma t_0 \]
\[ \gamma = 2 \]

- A) 0.87 \( c \)
- B) 0.75 \( c \)
- C) 0.97 \( c \)
- D) 0.72 \( c \)
- E) 0.50 \( c \)

9. A spaceship moving toward the earth with a speed of 0.8 \( c \) is flashing a laser toward the earth once every 10 seconds. For observers on earth who see the flashes, the speed of the light from the flashes is

- A) 1.0 \( c \)
- B) 1.8 \( c \)
- C) 0.89 \( c \)
- D) 1.4 \( c \)
- E) 0.6 \( c \)

The speed of light is 1.0\( c \), regardless of the speed of the source or observer.

10. A spaceship moving past the earth with a speed of 0.8 \( c \) is flashing a laser toward earth once every 10 seconds. For the observers on earth who see the flashes, the time between flashes is

- A) 13.4 s
- B) 16.7 s
- C) 12.5 s
- D) 9.7 s
- E) 6.0 s

\[ t = \gamma t_0 \]
\[ t = \frac{10 \text{ sec}}{\sqrt{1-0.8^2}} \]

11. A consequence of Einstein's theory of relativity is:

- A) Moving clocks run faster than when they are at rest.
- B) Moving rods are shorter than when they are at rest.
- C) Light has both wave and particle properties.
- D) The laws of physics must appear the same to all observers moving with uniform velocity relative to each other.
- E) Everything is relative.
A and E are false, D is a postulate, C is quantum mechanics, not relativity.

12. Gateway Computer’s founder Ted Waitt is funding UM Physics graduate Gerry Jackson to develop a method to transport antimatter to hospitals for use in cancer treatment. How much energy would be released when one microgram of antimatter is combined with one microgram of matter and they completely annihilate?

A) 2 μJ  
B) 2 MJ  
C) 1.8 × 10^8 J  
D) 600 J  
E) 9 × 10^7 J

\[ E = mc^2 = 2 \times 10^{-6} \times 9 \times 10^{16} \]

13. An electron is accelerated through a potential difference of 25,000 V. What is the de Broglie wavelength of the electron?

A) 3.94 × 10^{-15} m  
B) 2.34 × 10^{-3} m  
C) 4.0 × 10^{-5} m  
D) 7.8 × 10^{-12} m  
E) 5.5 × 10^{-12} m

Find the velocity from the electron accelerating through a potential difference of 25,000 V. Then use \( \lambda = \frac{h}{\beta P} \). You can also do the problem using relativity:

\[ E = mc^2 + KE \]
\[ E = \gamma mc^2 \]
\[ \gamma = \frac{mc^2 + KE}{mc^2} = \frac{511 keV + 25 keV}{511 keV} = 1.0492 \]
\[ \beta = \sqrt{1 - \frac{1}{\gamma^2}} = 0.3018 \]
\[ \lambda = \frac{h}{\beta \gamma mc} = 7.67 \times 10^{-12} m \]

14. Assume we can localize a particle to an uncertainty of 0.5 nm. What will be the resulting uncertainty in the particle’s momentum?

A) 1.1 × 10^{-25} kg m/s  
B) 4.2 × 10^{-25} kg m/s  
C) 2.1 × 10^{-25} kg m/s  
D) 13 × 10^{-25} kg m/s
E) \( 6.6 \times 10^{-25} \text{ kg m/s} \)

\[ \Delta x \Delta p \geq \frac{\hbar}{2\pi} \]

15. Einstein explained the photoelectric effect by postulating that

A) light is quantized in discrete energy packets with energy \( hf \).
B) the speed of light is constant for all observers.
C) the energy of oscillators is quantized with energy \( hf \).
D) electrons are bound in the metal with a potential energy.
E) electrons move in circular orbits.

B is the postulate for relativity, C is Plank’s postulate for black body radiation, D is true, but not relevant, E is Bohr’s hypothesis.

16. What is the maximum kinetic energy (in eV) of a photoelectron emitted from a surface whose work function is 5 eV when illuminated by a light whose wavelength is 200 nm?

A) 1.89
B) 1.2
C) 3.1
D) zero
E) 6.2

\[ KE_{\text{max}} = \frac{hc}{\lambda} - \phi_0 \]

17. The intensity of a light beam with a wavelength of 500 nm is 2000 W/m\(^2\). The photon flux (in number/m\(^2\)-s) is about

A) \( 5 \times 10^{17} \)
B) \( 5 \times 10^{19} \)
C) \( 5 \times 10^{21} \)
D) \( 5 \times 10^{23} \)
E) \( 5 \times 10^{25} \)

The number of photons is the total energy divided by the energy per photon.

\[ \# \text{photons} = \frac{\text{Energy}}{hf} = \frac{\text{Energy}}{hc/\lambda} \]

\[ \# \text{photons} = \frac{\text{Energy}}{m^2 \cdot s} = \frac{\lambda}{m^2 \cdot s \cdot hc} \]

18. A photon collides with a stationary electron. After the collision the wavelength of the scattered wave is

A) greater than or equal to the initial wavelength.
B) equal to the initial wavelength.
C) less than or equal to the initial wavelength.
D) increased if the photon is scattered forward and decreased if it is scattered backward.
E) none of the above - photons and electrons cannot collide.

For any value of the scattering angle, the wavelength of light after the scatter is greater than or equal to the wavelength before the scatter.

\[ \lambda' - \lambda = \frac{h}{m_c} (1 - \cos \theta) \]

19. The measurements of alpha particle scattering made by Geiger and Marsden and interpreted by Rutherford showed for the first time that

A) protons are more massive than electrons.
B) neutrons must be present in atomic nuclei.
C) electrons circulate around the nucleus in circular orbits.
D) all of the positive charge of the atom is concentrated in a region much smaller than the size of the atom.
E) alpha particles are helium atoms stripped of electrons.

The deflection of the alpha rays showed the mass and charge must be concentrated in a small region of space.

20. The Bohr model of the atom was successful in explaining some properties of the hydrogen atom. However, it failed to properly predict

A) the energy levels.
B) the size of the atom.
C) the wavelengths observed in the emission spectrum.
D) the value of the electrons angular momentum.
E) the quantization of angular momentum.

Bohr’s postulate was that angular momentum was quantized. However, the values of the angular momentum were wrong.