1. What is the best model of light to explain the shape of the wave fronts beyond the opening?
   a) Light is a wave and every point on a wave front of light can be treated as a point source.
   b) Rays of light bend when going around obstacles.
   c) Light refracts around obstacles.
   d) Light is a particle which spreads our after moving through an opening.
   e) None of the above.

2. The phenomenon above is most similar to which of the following?
   a) The dispersion of light after going through a prism.
   b) The bending of light after going through a crystalline material.
   c) A rainbow occurring due to water in the air during a rainstorm.
   d) The effect a diffraction grating has on incident light.
   e) None of the above.

3. The aperture for X is $5.44 \times 10^{-6}$ m wide. If $\lambda = 592$ nm light shines through the slit, how many dark fringes will be produced on either side of the central maximum?
   a) 3
   b) 4.5
   c) 5
   d) 9
   e) 18
4. Which model of light does the above graph show evidence for, and how does it do so?
   a) The wave nature of light from light being shown through a single slit.
   b) The wave nature of light from light being shown through double slits larger than the wavelength of light.
   c) The particle nature of light from light being shown through a double slit.
   d) The wave nature of light due to light being shown through two apertures similar to the wavelength of light.
   e) The wave nature of light from the dispersion of light from a prism.

5. Assume this graph was created by an apparatus similar to Young’s double slit. If the 0\textsuperscript{th} order dark fringe is at an 8° angle; at what angle would the 2\textsuperscript{nd} order dark fringe?
   a) 24.7°
   b) 30.0°
   c) 33.3°
   d) 44.1°
   e) 60.0°
You work as an energy production engineer at an energy production facility. You must analyze the nuclear power plant at the facility and gather information to create a marketing pamphlet.

6. The energy released by each fission within the core of this nuclear reactor is \(2.08 \times 10^2\) MeV. The number of fissions occurring each second is \(1.90 \times 10^{19}\). What is the power that the reactor generates?
   a) \(6.32 \times 10^8\) W
   b) \(6.32 \times 10^8\) J
   c) \(1.09 \times 10^{-17}\) W
   d) \(3.952 \times 10^{21}\) W
   e) \(3.952 \times 10^{21}\) J

7. If the initial mass of reactants before a fission is 236.05 u and 208 MeV of energy is produced by the fission, what is the mass of reactants after?
   a) \(2.2329 \times 10^{-1}\) u
   b) \(2.3583 \times 10^{-1}\) u
   c) \(2.2329 \times 10^2\) u
   d) \(2.3583 \times 10^2\) u
   e) \(2.3627 \times 10^2\) u

8. In another fission the incident neutron has a little more kinetic energy. In this new fission, Uranium \(^{235}_{92}\text{U}\) fissions into two fragments plus three neutrons:

   \[ \frac{1}{0}\text{n} + ^{235}_{92}\text{U} \rightarrow (2 \text{ fragments}) + 3\frac{1}{0}\text{n} \]

   The mass of a neutron is 1.008665 u and the mass of \(^{235}_{92}\text{U}\) is 235.043924 u. If 232.93 MeV of energy is released, what is the total mass of the two fragments?
   a) 116.5 u
   b) 232 u
   c) 233 u
   d) 236 u
   e) 237 u

9. What combination of elements could the fragments be?
   a) \(^{132}\text{Cesium}\) and \(^{10}\text{Beryllium}\)
   b) \(^{89}\text{Krypton}\) and \(^{209}\text{Polonium}\)
   c) \(^{139}\text{Barium}\) and \(^{133}\text{Cesium}\)
   d) \(^{92}\text{Krypton}\) and \(^{141}\text{Barium}\)
   e) \(^{138}\text{Barium}\) and \(^{226}\text{Radium}\)
10. As your plant becomes profitable, the energy company you work for wishes to use solar panels to augment the production of the facility. If the work function for the panels is 4.6 eV, what is the lowest frequency photon able to knock an electron free?
   a) 1.11 THz
   b) 1.11 PHz
   c) 6.94 GHz
   d) 6.94 THz
   e) 6.94 PHz

11. A very (...) high energy gamma ray is incident on the solar panel and knocks an electron free with a speed of 0.954c. The electron, after being knocked free, travels for a short time (t₁) before colliding with something. Another electron is knocked free by a lower energy gamma ray. This second electron travels at 0.3c for twice the time of the first electron. What is the ratio of time dilation experienced relative to the solar panel by the first electron to the second electron?
   a) 3
   b) 2.3333
   c) 1.3333
   d) 0.6666
   e) 0.3333

12. The primary reason that very large nuclei are unstable is due to
   A) the cumulative repulsive force of the protons.
   B) the cumulative attractive force between the protons and the orbiting electrons.
   C) the repulsive force between the neutrons and the protons.
   D) the extreme weakness of the gravitational attraction of the protons.
   Answer: A

13. A stable nucleus contains many protons very close to each other, all positively charged. Why do the protons not fly apart due to mutual Coulomb repulsion?
   A) An attractive nuclear force in the nucleus counteracts the effect of the Coulomb forces.
   B) There are an equal number of electrons in the nucleus which neutralize the protons.
   C) The neutrons in the nucleus shield the protons from each other.
   D) The Coulomb force does not operate within nuclei.
   E) The gravity of the protons and neutrons overcomes their repulsion at such close distances.
   Answer: A

14. The main reason that there is a limit to the size of a stable nucleus is
   A) the limited range of the gravitational force.
   B) the short range nature of the strong nuclear force.
   C) the weakness of the gravitational force.
   D) the weakness of the electrostatic force.
   Answer: B
15. In massive stars, three helium nuclei fuse together, forming a carbon nucleus, and this reaction heats the core of the star. The net mass of the three helium nuclei must therefore be
A) higher than that of the carbon nucleus.
B) less than that of the carbon nucleus.
C) the same as that of the carbon nucleus because mass is always conserved.
D) the same as that of the carbon nucleus because energy is always conserved.
Answer: A

16. A radioactive isotope of atomic number Z emits a beta-minus particle, and then the daughter nucleus emits a gamma ray. What is the atomic number of the resulting nucleus after both processes?
A) Z - 1
B) Z + 1
C) Z - 2
D) Z - 3
Answer: B

17. A set of twins, Andrea and Courtney, are initially 10 years old. While Courtney remains on Earth, Andrea rides on a spaceship that travels away from Earth at a speed of 0.60c for 10 years (as measured by Courtney). At the end of the trip, Courtney is 20 years old. How old is Andrea?
A) 10 years
B) 12 years
C) 18 years
D) 20 years
Answer: C

18. How fast would a rocket ship have to move past Earth to contract to half of its proper length as observed by an Earth-based physicist?
   a) 0.50c
   b) 0.72c
   c) 0.87c
   d) 0.90c
   e) 0.91c
   Answer: C

19. A spaceship is moving away from an asteroid with a speed of 0.80c relative to the asteroid. The spaceship then fires a missile with a speed of 0.50c relative to the spaceship. What is the speed of the missile measured by astronauts on the asteroid if the missile is fired away from the asteroid?
   A) 0.30c
   B) 0.50c
   C) 0.93c
   D) 1.3c
   E) 0.65c
   Answer: C
20. A beam of light falling on a metal surface is causing electrons to be ejected from the surface. If we now double the frequency of the light, which of the following statements are correct? (There could be more than one choice).
A) The kinetic energy of the ejected electrons doubles.
B) The speed of the ejected electrons doubles.
C) The number of electrons ejected per second doubles.
D) Twice as many photons hit the metal surface as before.
E) None of the above things occur.

21. What kind of lens would be suitable to correct myopia and hyperopia respectively?

a) Converging, converging
b) Converging, diverging
c) Diverging, diverging
d) Diverging, converging
e) Reverbing, adverbing

22. Assuming the eye has neither myopia nor hyperopia, what is the image distance d, measured from the cornea for a distant object?

a) 1.0 cm
b) 1.5 cm
c) 2.0 cm
d) 2.5 cm
e) 3.0 cm

23. For a distant object, the image produced by the cornea is:

a) real and inverted.
b) real and upright.
c) virtual and inverted.
d) virtual and upright.
e) Cow says moo
24. In the case of contact lenses, the cornea and the correcting lens are actually touching and act together as a single lens. If the focal length of both the cornea and the contact lens are doubled, then the image distance \( d_i \) for a distant object would be what?

   a) 1/4 the old value.
   b) 1/2 the old value.
   c) same as the old value.
   d) twice the old value.
   e) four times the old value.

25. Light enters air from water. The angle of refraction will be
   a) greater than the angle of incidence.
   b) equal to the angle of incidence relative to an axis normal to the surface.
   c) less than the angle of incidence.
   d) equal to the angle of incidence relative to an axis parallel to the surface.

26. Light goes from material having a refractive index of \( n_1 \) into a material with refractive index \( n_2 \). If the refracted light is bent away from the normal, what can you conclude about the indices of refraction?
   a) \( n_1 > n_2 \)
   b) \( n_1 \geq n_2 \)
   c) \( n_1 < n_2 \)
   d) \( n_1 \leq n_2 \)
   e) \( n_1 = n_2 \)

27. Where would the ray exit if material 3 had a higher index of refraction?
   a) Somewhere above location Y on the same vertical axis.
   b) Somewhere below location Y on the same vertical axis.
   c) At location Y
   d) The ray would undergo total internal reflection and not leave the material.
   e) It cannot be determined without knowing how much of a change in the index of refraction.

28. A convex lens has focal length \( f \). If an object is placed at a distance beyond \( 2f \) from the lens on the principal axis, the image is located at a distance from the lens
   a) of \( 2f \).
   b) between \( f \) and \( 2f \).
   c) of \( f \).
   d) between the lens and \( f \).
   e) of infinity.
29. Ultraviolet light with a frequency of 3.50E15 Hz strikes a metal surface and ejects electrons that have a maximum kinetic energy of 6.7 eV. What is the work function (in eV) of the metal?
   A) 3.5 eV
   B) 6.7 eV
   C) 7.78 eV
   D) 8.1 eV
   E) 11.3 eV

30. Radiation of a certain wavelength causes electrons with a maximum kinetic energy of 0.68 eV to be ejected from a metal whose work function is 2.85 eV. What will be the maximum kinetic energy (in eV) with which this same radiation ejects electrons from another metal whose work function is 2.01 eV?
   A) 0.68 eV
   B) 0.84 eV
   C) 1.33 eV
   D) 1.52 eV
   E) 1.85 eV