Directions: No books or notes may be used during this exam.

Multiple-choice Questions. 10 points each. CIRCLE THE LETTER corresponding to your answer for each question. If you don't know the answer, then make your best guess.

1. The resolving power of a diffraction grating is determined primarily by
   (A) its distance from the light source
   (B) its focal length
   (C) the width of each of its openings
   (D) its diameter
   (E) none of the above.

2. The complementary color of red is
   (A) blue
   (B) yellow
   (C) magenta
   (D) cyan
   (E) none of the above.

3. Which of the following explains why the Earth's sky is blue on a cloudless day?
   (A) Rayleigh Scattering
   (B) Huygens' Principle
   (C) Snell's Law of Diffraction
   (D) The Doppler Effect
   (E) none of the above.

4. The key concept used to determine how light interferes at different points in space is called
   (A) intensity
   (B) path difference
   (C) frequency
   (D) speed
   (F) none of the above.

5. The amount of time that it takes one light wave to pass a fixed point in space is called the
   (A) amplitude
   (B) frequency
   (C) period
   (D) wavelength
   (E) none of the above.
Definitions. 10 points each. For full credit, use proper grammar, spelling and complete sentences. (A complete sentence has both a subject and a predicate.)

6. Define focal length.
   
   The focal length is the distance from the optical device to the image when the object is very far away from the optical device.

7. Define unpolarized light.

   Unpolarized light is randomly polarized meaning that the electric field in the light wave points in random directions.

8. Define the photoelectric effect.

   The photoelectric effect occurs when light of a short enough wavelength is absorbed by a metal resulting in the creation of electrical energy.


   The Doppler Effect is the effect by which the frequency (and wavelength) of a wave changes due to the relative motion of the observer and/or source.

10. Define blackbody.

   A blackbody is an object that can emit and absorb any frequency (and wavelength) of light.
Short Answers. 10 points each. For full credit, use proper grammar, spelling and complete sentences. (A complete sentence has both a subject and a predicate.)

11. What are the postulates of Einstein's Theory of Special Relativity?
   1) The laws of physics are the same in all inertial reference frames.
   2) The speed of light is constant when measured in any inertial reference frame.

12. How would one build a spectrometer?

   One would build a spectrometer by combining two lenses with a diffraction grating or prism.

13. Under what conditions will total internal reflection occur?

   Total internal reflection will occur when the light is contained in a material with a higher index of refraction than its surroundings and when the angle of incidence is greater than some critical angle.

14. How was Einstein's Theory of General Relativity first tested experimentally?

   It was first tested by observing the deflection of starlight as it passed near the sun during a total solar eclipse.

15. Compare and contrast chromatic and spherical aberration.

   Chromatic aberration only occurs with lenses. It is due to dispersion caused by the index of refraction of the lens changing with wavelength (or frequency).

   Spherical aberration occurs with both lenses and mirrors that have spherical or circular shaped surfaces. It is due to the fact that spherical and circular surfaces cannot reflect light to a single focus. Parabolic shaped surfaces are required to create a single focus.
Numerical Problems. 10 points each. If the answer is incorrect, then partial credit may be awarded.

16. Light is initially polarized vertically. A polarizer has a polarization axis that points 30 degrees above the horizontal. What percentage of the intensity of the light is transmitted through the polarizer?

\[
\theta = 90^\circ - 30^\circ = 60^\circ \\
I(\text{out}) = I(\text{in}) \cos^2 \theta = I(\text{in}) \cos^2 60^\circ = I(\text{in}) \left(\frac{1}{2}\right)^2 = \frac{1}{4} I(\text{in}) = 25\% 
\]

17. One filter absorbs 10% of the intensity of the light that reaches it. Ten of these filters are stacked together. What percentage of the intensity of the light does the stack absorb?

\[
10^\circ \text{ absorbed} = 90^\circ \text{ transmitted} \\
\left(\frac{9}{10}\right)^{10} = 0.349 = 34.9^\circ \text{ transmitted} \\
100^\circ - 34.9^\circ = 65.1^\circ \text{ absorbed}
\]

18. The frequency of a light wave is 60 Hz. Calculate the wavelength of the wave.

\[
\nu = c = \lambda f \\
\lambda = \frac{c}{f} = \frac{300,000,000}{60} = 5,000,000 \text{ meters} = 5 \times 10^6 \text{ meters}
\]

19. A diffraction grating's openings are separated by 0.01 mm = 0.01 \times 10^{-3} m. A viewing screen is 1.00 m from the grating. The bright fringes near the center of the screen are spaced apart by 4.5 cm = 4.5 \times 10^{-2} m. What is the wavelength of the light in this case?

\[
x = \frac{\lambda D}{d} \\
\lambda = \frac{xd}{D} = \frac{(4.5\times10^{-2})/0.01\times10^{-3}}{1.00} \\
\lambda = 4.5 \times 10^{-7} \text{ m} = 450 \text{ nm}
\]

20. Two sources emit identical light waves that have the same intensity and wavelength, and are in-phase when they are emitted. When the path difference is 3520 nm, destructive interference occurs. The path difference is slowly increased by moving one of the sources. The next value of the path difference at which destructive interference occurs is 4160 nm. What is the wavelength of the light?

\[
\Delta L_m = (m + \frac{1}{2}) \lambda \\
\Delta L_{m+1} = ((m+1) + \frac{1}{2}) \lambda \\
\Delta L_{m+1} - \Delta L_m = \lambda \\
\lambda = 4160 - 3520 \leq 640 \text{ nm}
\]

If you have extra time, then check over your answers and make sure that you have printed your name, signed your name and printed your student ID # on the first page. Thanks.

I hope that you all have a good break.