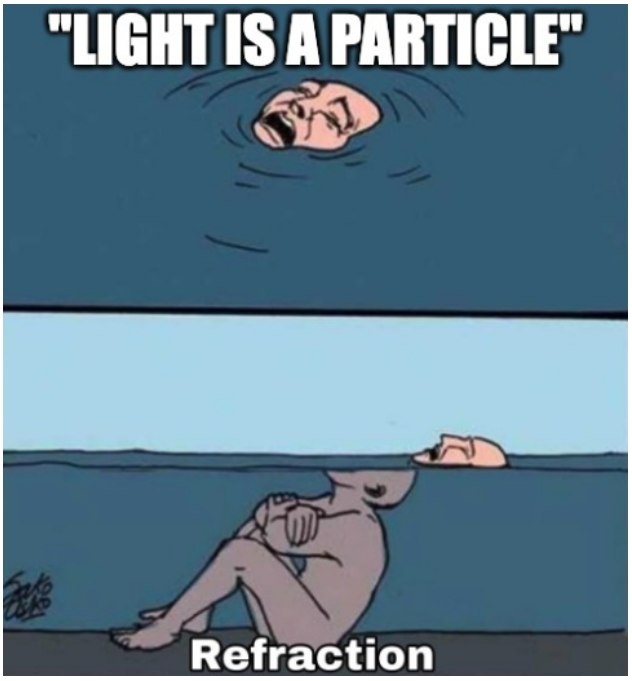

Grade 12 Physics
Light Key

First Name: _____**KEY**_____

Last Name: _____

Directions:

- Please answer to 2 decimal points
- The test is designed to be completed in 75 minutes

For grading use only

Page:	2	3	4	Total
Points:	7	11	16	34
Score:				

Multiple Choice (10 marks)

1. (1 point) Which technology primarily uses total internal reflection?
   - **A. Fiber optics**
   - B. Solar panels
   - C. Microwave ovens
   - D. X-ray machines

2. (1 point) What is the wavelength of light with frequency 6.00×10^{14} Hz in a vacuum?
   - A. 200 nm
   - **B. 500 nm**
   - C. 650 nm
   - D. 800 nm

3. (1 point) A ray of light passes from water (n = 1.33) into glass (n = 1.50). Which of the following correctly describes how the light ray behaves at the boundary?
   - A. It speeds up and bends away from the normal.
   - **B. It slows down and bends toward the normal.**
   - C. It maintains the same speed but changes direction.
   - D. It slows down and bends away from the normal.

4. (1 point) For destructive interference in thin films, the path difference should be:
   - A. $n\lambda$
   - B. $2n\lambda$
   - C. $\frac{\lambda}{2}$
   - **D.** $(n + \frac{1}{2})\lambda$

5. (1 point) Which phenomenon explains rainbow patterns on CDs/DVDs?
   - A. Refraction
   - B. Polarization
   - **C. Diffraction**
   - D. Total internal reflection

6. (1 point) A light ray enters glass (n=1.5) from air (n=1.0). If the angle of incidence is 30°, what is the angle of refraction?
   - **A. 19.47°**
   - B. 19.47°
   - C. 30.00°
   - D. 48.59°

7. (1 point) A convex lens has a focal length of 15 cm. An object is placed 10 cm from the lens. The image formed will be:
   - A. Real, inverted, and larger than the object.
   - **B. Virtual, upright, and larger than the object.**
   - C. Real, inverted, and smaller than the object.

D. Virtual, upright, and smaller than the object.

8. (1 point) The energy of a photon with wavelength 450 nm is:
   A. 1.33×10^{-19} J
   B. 2.89×10^{-19} J
   C. 5.67×10^{-19} J
   D. 4.42×10^{-19} **J**

9. (1 point) Polarization by reflection occurs when:
   A. Angle equals Brewster's angle
   B. Light is completely absorbed
   C. Total internal reflection occurs
   D. Light is transmitted

10. (1 point) A coil of wire moves through a magnetic field, inducing a current. If the speed of the coil's motion doubles, the induced current will:
    A. Stay the same
    B. Stay the same
    C. Double
    D. Become zero

Long Answer (40 marks)

11. Thin Film Interference
    (a) (4 points) A soap bubble (n=1.33) in air appears yellow-green (=550 nm) at its thinnest point. Calculate the minimum thickness of the film.
    (b) (4 points) Explain why thicker regions of the bubble appear redder, and why colors change when viewed from different angles.

Solution:

11. Thin Film Interference

(a) Minimum thickness of the film: For constructive interference in a thin film with a higher refractive index than air, the condition is:

$$2t = \frac{\lambda}{2n}$$

Solving for t:

$$t = \frac{\lambda}{4n} = \frac{550 \text{ nm}}{4 \times 1.33}$$

$$t = \frac{550}{5.32} = 103.38 \text{ nm}$$

(b) Color changes in different thicknesses and angles: - Thicker regions of the film cause a longer path difference, shifting towards longer wavelengths (redder colors). - Changing the viewing angle alters the effective thickness and interference conditions, leading to a spectrum of colors.

12. Double-Slit Interference
    (a) (4 points) Calculate fringe spacing for 650 nm light through slits 0.15 mm apart, projected 1.2 m away
    (b) (4 points) Explain what happens to the pattern if blue light (=470 nm) replaces red light (=700 nm)

Solution:

12. Double-Slit Interference

(a) Fringe spacing: The fringe spacing is given by:

$$y = \frac{\lambda L}{d}$$

Substituting the values:

$$y = \frac{(650 \times 10^{-9}\ \mathbf{m})(1.2\ \mathbf{m})}{0.15 \times 10^{-3}\ \mathbf{m}}$$

$$y = \frac{7.8 \times 10^{-4}}{1.5 \times 10^{-4}} = 5.2\ \mathbf{mm}$$

(b) Effect of replacing red light with blue light: - Blue light has a shorter wavelength than red light. - Since $y \propto \lambda$, the fringe spacing decreases, making the fringes closer together.

13. Layered Media Refraction
    (a) (4 points) Light travels from air (n=1.00) through 5 cm of water (n=1.33), then 3 cm of glass (n=1.52). If the initial angle is 30°, calculate the final angle in the glass.
    (b) (4 points) Calculate the total lateral displacement of the light beam through the system.

Solution:

(a) Final angle in the glass:

Using Snell's law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

For air to water ($n_1 = 1.00$, $n_2 = 1.33$, $\theta_1 = 30°$):

$$1.00 \sin 30° = 1.33 \sin\theta_2$$

$$0.500 = 1.33 \sin\theta_2$$

$$\sin\theta_2 = \frac{0.500}{1.33} = 0.3759$$

$$\theta_2 = \sin^{-1}(0.3759) = 22.1°$$

For water to glass ($n_2 = 1.33$, $n_3 = 1.52$):

$$1.33 \sin 22.1° = 1.52 \sin\theta_3$$

$$1.33 \times 0.3759 = 1.52 \sin\theta_3$$

$$0.500 = 1.52 \sin\theta_3$$

$$\sin\theta_3 = \frac{0.500}{1.52} = 0.3289$$

$$\theta_3 = \sin^{-1}(0.3289) = 19.2^\circ$$

(b) Total lateral displacement:

Lateral displacement in each medium:

$$d = t\tan\theta$$

For water ($t_1 = 5$ cm, $\theta_2 = 22.1^\circ$):

$$d_1 = 5\tan 22.1^\circ = 5 \times 0.406 = 2.03 \text{ cm}$$

For glass ($t_2 = 3$ cm, $\theta_3 = 19.2^\circ$):

$$d_2 = 3\tan 19.2^\circ = 3 \times 0.348 = 1.04 \text{ cm}$$

Total lateral displacement:

$$d_{\text{total}} = d_1 + d_2 = 2.03 + 1.04 = 3.07 \text{ cm}$$