HAWAI'I PACIFIC UNIVERSITY

PHYS 2054: PRACTICE EXAM 1

Campus/Centre:	(x) Downtown campus ( ) Loa Campus

Examination Day:	**TBD**	**Examination Date:**	**TBD**
Examination Time:	**TBD**	**Duration:**	**80 min**

Course Abbreviation & Number:	**PHYS 2054**
Course Title:	**General Physics III**

Name of Student: ____

Student Number: ____

INSTRUCTIONS TO CANDIDATES

1. This examination consists of 5 pages.
2. There are 8 conceptual and 8 quantitative questions in this examination. Answer ALL questions.
3. **All working must be shown.**
4. **Units must be shown.**
5. A list of selected formulae is provided below.

LIST OF SELECTED FORMULAE

Interference / double slit

$$\phi = k(r_2 - r_1) = \frac{2\pi}{\lambda_n}(r_2 - r_1)$$
$$d \sin\theta = m\lambda_n \quad \text{(constructive)}$$
$$d \sin\theta = \left(m + \frac{1}{2}\right)\lambda_n \quad \text{(destructive)}$$
$$E_P = 2E\left|\cos\frac{\phi}{2}\right|$$
$$I = I_0 \cos^2\frac{\phi}{2}$$

Thin film interference

0 or 2π phase shift

$$2t = m\lambda_n \quad \text{(constructive)}$$
$$2t = \left(m + \frac{1}{2}\right)\lambda_n \quad \text{(destructive)}$$

π phase shift

$$2t = \left(m + \frac{1}{2}\right)\lambda_n \quad \text{(constructive)}$$
$$2t = m\lambda_n \quad \text{(destructive)}$$

Diffraction gratings

$$d \sin\theta = m\lambda_n$$

Xray diffraction

$$2d \sin\theta = m\lambda$$

Circular apertures

$$\sin\theta_1 \approx 1.22\frac{\lambda}{D}$$
$$\sin\theta_2 \approx 2.23\frac{\lambda}{D}$$
$$\sin\theta_3 \approx 3.24\frac{\lambda}{D}$$

Single slit

$$a \sin\theta = m\lambda_n$$
$$I = I_0\left\{\frac{\sin[(\pi a/\lambda)\sin\theta]}{(\pi a/\lambda)\sin\theta}\right\}^2$$

gamma

$$\gamma = \frac{1}{\sqrt{1 - u^2/c^2}}$$

Length contraction

$$L = \frac{L_p}{\gamma}$$

Time dilation

$$\Delta t = \gamma \Delta t_p$$

Lorentz

$$x' = \gamma(x - ut)$$
$$t' = \gamma(t - ux)$$
$$v_x' = \frac{v_x - u}{1 - uv_x/c^2}$$
$$v_x = \frac{v_x' - u}{1 - uv_x'/c^2}$$

Doppler

$$f = f_0\frac{\sqrt{c + u}}{\sqrt{c - u}}$$

Momentum

$$\vec{p} = \gamma m \vec{v}$$

Photons

$$E = hf = \frac{hc}{\lambda}$$
$$p = \frac{hf}{c} = \frac{h}{\lambda}$$

Photoelectric

$$eV_0 = hf - \phi$$

Uncertainty

$$\Delta x \Delta p \leq \hbar/2$$
$$\Delta E \Delta t \leq \hbar/2$$

Energy

$$E = K + mc^2 = \gamma mc^2$$
$$E^2 = (mc^2)^2 + (pc)^2$$

Compton

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\phi)$$

Useful constants

$c = 2.998 \times 10^8$ m/s -- $h = 6.626 \times 10^{-34}$ kg m^2/s -- $hc = 1240$ eV nm

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Conceptual Section (Circle the correct answer)

1. Monochromatic coherent light passing through two thin slits is viewed on a distant screen. Which of the following statements is true? [2]
   A. The fringes are perfectly spaced at equal distances on the screen.
   B. The fringes move closer together when the light intensity increases.
   C. The fringes move farther apart when the distance to the screen increases.
   D. The fringes move farther apart when the distance between the slits increases.

2. A two-slit interference experiment is submerged in water and the fringes are displayed on a screen. Then the whole apparatus is removed from the water. How does the fringe pattern change? [2]
   E. The fringes are closer together.
   F. The fringes are farther apart.
   G. The separation between fringes is unchanged.
   A. It depends on which hemisphere the experiment was performed.

3. The width in a single-slit diffraction experiment is increased. What happens to the distance between minima on a viewing screen? [2]
   A. They stay the same width apart.
   B. They move closer together.
   C. They move farther apart.
   D. They can move closer together or farther apart depending upon the wavelength.

4. Why is a diffraction grating better than a two-slit setup for measuring wavelengths of light? [2]
   A. The total light increases in intensity when it passes through the diffraction grating.
   B. The equation to find the maxima for a diffraction grating is less complicated.
   C. The diffraction grating acts more like a single slit with a large central maximum.
   D. The intensity peaks formed by a diffraction grating are more narrow than a double slit's peaks.

5. You are an observer on Earth. As the speed of a spaceship moving away from you begins to decrease, you observe [2]
   A. the length of the spaceship gets shorter.
   B. the length of the spaceship gets longer.
   C. the length of the spaceship does not change.
   D. the length of the spaceship gets either longer or shorter depending on its distance from you.

6. An astronaut in an inertial reference frame measures a time interval Δt between her heartbeats. What will observers in all other inertial reference frames measure for the time interval between her heartbeats? [2]
   A. Less than Δt.
   B. More than Δt.
   C. The same Δt.
   D. Negative Δt.

7. Monochromatic light strikes a metal surface and electrons are ejected from the metal. If the intensity of the light is decreased, what will happen to the ejection rate and maximum energy of the electrons? [2]
   A. Lower ejection rate; lower maximum energy
   B. Same ejection rate; same maximum energy
   C. Same ejection rate; lower maximum energy
   D. Lower ejection rate; same maximum energy

8. If the accuracy in measuring the momentum of a particle increases, the accuracy in measuring its position will [2]
   A. decrease.
   B. remain the same.
   C. increase.
   D. It is impossible to say since the two measurements are independent.

Quantitative Section

1. Light with wavelength 442 nm passes through a double-slit system that has a slit separation distance of $d = 0.400$ mm. Determine how far away a screen must be placed so that dark fringes appear directly opposite both slits, with only one bright fringe between them.
   (a) Determine separation distance between the two slits. [3]

   (b) At this same distance, for what wavelength of light will the first-order bright fringes be observed at these same points on the screen with only two minima separating them? [3]

2. Solar cells are often coated with a transparent, thin film of silicon monoxide (SiO, nSiO = 1.45) to minimize reflective losses from the surface. Suppose a silicon solar cell (nSi = 3.5) is coated with a thin film of silicon monoxide for this purpose.
   (a) Determine the minimum film thickness that produces the least reflection at a wavelength of 550 nm, near the center of the visible spectrum. [3]

   (b) Suppose a solar cell's coating was incorrectly manufactured so that it has the most reflection at 550 nm. Determine the minimum film thickness that could produce this reflection. [3]

3. Red light of wavelength 633 nm from a helium–neon laser passes through a slit 0.350 mm wide. The diffraction pattern is observed on a screen 3.00 m away.
   (a) What is the distance on the screen from the central maximum to the first minimum? [2]

   (b) What is the distance on the screen from the central maximum to the second minimum? [2]

   (c) What is the width of the first bright fringe beyond the central bright fringe? [2]

4. Three discrete spectral lines occur at angles of 10.1°, 13.7°, and 14.8° in the first-order spectrum of a grating spectrometer.

   (a) If the grating has 3660 slits/cm, what are the wavelengths of the light? [3]

   (b) At what angles are these lines found in the second-order spectrum? [3]

5. The first-order diffraction maximum is observed at 12.6° for a crystal having a spacing between planes of atoms of 0.250 nm.

   (a) What wavelength x-ray is used to observe this first-order pattern? [3]

   (b) How many orders can be observed for this crystal at this wavelength? [3]

6. The pupil of a cat's eye narrows to a vertical slit of width 0.500 mm in daylight. Assume the average wavelength of the light is 500 nm. What is the angular resolution for horizontally separated mice? [3]

7. A deep-space vehicle moves away from the Earth with a speed of 0.800c. An astronaut on the vehicle measures a time interval of 3.00 s to rotate her body through 1.00 rev as she floats in the vehicle. What time interval is required for this rotation according to an observer on the Earth? [3]

8. A jet stream of particles is ejected by a galaxy. Such jet streams are believed to be evidence of supermassive black holes at the center of a galaxy. Suppose two jet streams of material from the center of a galaxy are ejected in opposite directions. Both jet streams move at 0.750c relative to the galaxy center. Determine the speed of one jet stream as observed by the other. [3]

9. The total energy of a proton ($m_{\mathrm{p}} = 1.672 \times 10^{-27}$ kg) is twice its rest energy. Find the momentum of the proton. [3]

10. Lithium, beryllium, and mercury have work functions of 2.30 eV, 3.90 eV, and 4.50 eV, respectively. Light with a wavelength of 400 nm is incident on each of these metals. Find the maximum kinetic energy for the photoelectrons in each case. [3]

11. X-rays are scattered from a target at an angle of 55.0° with the direction of the incident beam. Find the wavelength shift of the scattered x-rays. (rest mass of an electron, $m_r = 9.109 \times 10^{-31}$ kg) [3]

END OF EXAMINATION