HAWAI’I PACIFIC UNIVERSITY

PHYS 2054: FIRST PRACTICE EXAMINATION

SEMESTER: SPRING 2019

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 11 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

$$\Delta x\Delta p \le \hbar/2$$

$$\Delta E\Delta t \le \hbar/2$$

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. In a two-slit interference experiment, the fringes are displayed on a screen. Then the whole apparatus is immersed in the nearest swimming pool. How does the fringe pattern change? [2]
   A. The fringes are closer together.
   B. The fringes are farther apart.
   C. The separation between fringes is unchanged.
   D. It depends on the color of the swimming pool.

2. Monochromatic light is directed at normal incidence on a thin transparent film. There is destructive interference for the reflected light, so the reflected light intensity is very low. What happened to the energy of the incident light? [2]
   A. The energy is directed in all directions from scattered light.
   B. The energy is converted to sound energy.
   C. The energy is transmitted through the film as transmitted light intensity.
   D. The energy is destroyed and no longer exists.

3. The width in a single-slit diffraction experiment is reduced. What happens to the width of the central bright fringe? [2]
   A. It becomes more intense.
   B. It becomes wider.
   C. It becomes narrower.
   D. It stays the same.

4. A lens is designed to work in the near-ultraviolet, visible, and near-infrared. The best resolution of this lens from a diffraction standpoint is [2]
   A. the same for all wavelengths.
   B. in the near-ultraviolet.
   C. in the visible.
   D. in the near-infrared.

5. You are a passenger on a spaceship. As the speed of the spaceship increases, you observe [2]
   A. the length of your spaceship is getting shorter.
   B. the length of your spaceship is getting longer.
   C. the length of your spaceship is not changing.
   D. the length of your spaceship gets either longer or shorter depending on the direction you travel.

6. The special theory of relativity predicts that there is an upper limit to the speed of a particle. Therefore, there is an upper limit on which the following properties of a particle? [2]
   A. The kinetic energy.
   B. The linear momentum.
   C. The total energy.
   D. None of these.

7. A beam of red light, a beam of yellow light, and a beam of violet light each deliver the same power on a surface. Which beam has the greatest number of photons hitting the surface per second? [2]
   A. The violet beam.
   B. The yellow beam.
   C. The red beam.
   D. It is the same for all beams.

8. If the accuracy in measuring the position of a particle increases, the accuracy in measuring its momentum 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. Coherent light with wavelength 600 nm passes through two very narrow slits and the interference pattern is observed on a screen 3.00 m from the slits. The first-order bright fringe is at 4.84 mm from the center of the central bright fringe.

   (a) Determine separation distance between the two slits. [3]

   (b) For what wavelength of light will the first-order dark fringe be observed at this same point on the screen? [3]

2. A plastic film with index of refraction 1.85 is put on the surface of a car window to increase the reflectivity and keep the interior of the car cooler. The window glass has a refractive index of 1.52.

   (a) What minimum thickness is required if light with wavelength 550 nm in air reflected from the two sides of the film is to interfere constructively? [3]

   (b) What is the next greatest thickness for which there will also be constructive interference? [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. Define the width of a bright fringe as the distance between the minima on either side.

   (a) What is the width of the central bright fringe? [3]

   (b) What is the width of the first bright fringe on either side of the central one? [3]

4. Monochromatic light at normal incidence is deviated in the first order through an angle of 13.5° by a transmission grating having 5000 slits/cm.

   (a) What is the wavelength of the light? [3]

   (b) What is the second-order deviation of this wavelength? [3]

5. Monochromatic x rays are incident on a crystal for which the spacing of the atomic planes is 0.440 nm. The first-order maximum in the Bragg reflection occurs when the incident and reflected x rays make an angle of 39.4° with the crystal planes. What is the wavelength of the x rays? [3]

6. You are asked to design a space telescope for earth orbit. When Jupiter is 5.93×10^8 km away (its closest approach to the earth), the telescope is to resolve, by Rayleigh's criterion, features on Jupiter that are 250 km apart. What minimum diameter mirror is required? Assume $\lambda = 500$ nm. [3]

7. How fast must a rocket travel relative to the earth so that time in the rocket "slows down" to half its rate as measured by earth-based observers? [3]

8. Two particles are created in a high-energy accelerator and move off in opposite directions. The speed of one particle, as measured in the laboratory, is 0.650c and the speed of each particle relative to the other is 0.950c. What is the speed of the second particle, as measured in the laboratory? [3]

9. A 60 kg person is standing at rest on level ground. How fast would she have to run to double her total energy? [3]

10. When ultraviolet light with a wavelength of 400.0 nm falls on a certain metal surface, the maximum kinetic energy of the emitted photoelectrons is 1.10 eV. What is the maximum kinetic energy of the photoelectrons when light of wavelength 300.0 nm falls on the same surface? [3]

11. A beam of x rays with wavelength 0.0500 nm is Compton scattered by the electrons in a sample. At what angle from the incident beam do you find x rays with a wavelength of 0.0542 nm? (rest mass of an electron, $m_r = 9.109 \times 10^{-31}$ kg) [3]

END OF EXAMINATION