Center for Academic Resources in Engineering (CARE)
Peer Exam Review Session

Phys 214 — University Physics: Quantum Physics

Quiz 1 Worksheet

The problems in this review are designed to help prepare you for your upcoming exam. Questions pertain to material covered in the course and are intended to reflect the topics likely to appear in the exam. Keep in mind that this worksheet was created by CARE tutors, and while it is thorough, it is not comprehensive. In addition to exam review sessions, CARE also hosts regularly scheduled tutoring hours.

Tutors are available to answer questions, review problems, and help you feel prepared for your exam during these times:

Session 1: Tuesday, Feb. 4, 6 PM-7:20 PM: Alex, Luke, and Zaahi

Can't make it to a session? Here's our schedule by course:

https://care.grainger.illinois.edu/tutoring/schedule-by-subject

Solutions will be available on our website after the last review session that we host.

Step-by-step login for exam review session:

1. Log into Queue @ Illinois: https://queue.illinois.edu/q/queue/844
2. Click "New Question"
3. Add your NetID and Name
4. Press "Add to Queue"

Please be sure to follow the above steps to add yourself to the Queue.

Good luck with your exam!

1. In a photoelectric effect demonstration, the intensity of the incident light is gradually increased, but no photocurrent is detected. Provide an explanation for this result.

2. Three speakers lie on the perimeter of a circle. The sound intensity at each source is I_0 while the total intensity at the center of the circle is observed to be zero. Use phasors to determine the relative phase shift of each speaker such that this is possible.

3. A laser with time-varying frequency is directed at a barrier with a narrow slit followed by a screen. Assuming the laser intensity is constant, as the frequency increases, how does the number of photons per second arriving at the screen change?

4. A laser is directed at a barrier with a narrow slit followed by a screen. Applying a small angle approximation, if the slit width is halved while the wavelength is doubled, by what factor does the location of the first diffraction minimum change? Use small angle approximation.

5. A single slit diffraction experiment is set up such that the central bright spot is 10 cm in width, and the screen is 3 m away from the slit. Using light with wavelength of 900 nm, calculate the slit spacing a.

6. Following up on the previous question, calculate the position of the **maximum** of the single-slit diffraction problem.

7. A wave is traveling along the positive x-axis with speed 5 meters per second. Which equation could describe this wave?

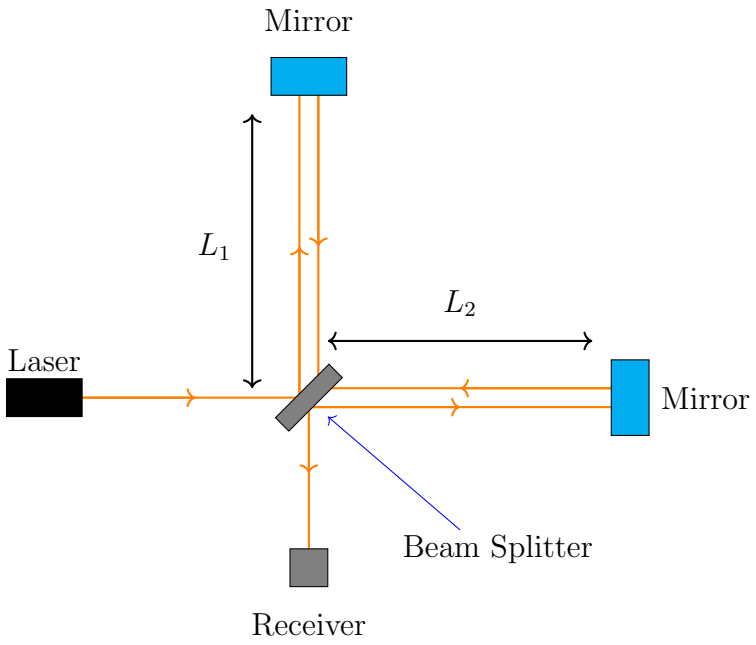
a) $\sin(12x + 2.6t)$

b) $3\cos(x - 0.3\pi t)$

c) $12\cos(x - 5t)$

d) $\sin^2(x + t - \pi)$

8. An interferometer has two arms of equal length ($L_1 = L_2$). A 200 W laser with wavelength 1064 nm is directed at the central beam splitter (shown below).



What is the minimum increase in L_2 required so that only 100 W goes to the detector? (Note that when the arms are of equal length, the detector receives 200 W).

a) 266 nm

b) 133 nm

c) 532 nm

9. A wave propagating through the ocean is measured by a sensor and can be described by the equation $f(x,t) = \cos(0.4x - 2t)$.

   (i) What is the wavelength, frequency and amplitude of the wave?

   (ii) In which direction is the wave traveling?

   a) $-x$ b) $+x$ c) The direction is time dependent

10. A spacecraft is being pushed by a laser of wavelength 400 nm emitting photons at a rate of 10^{22} photons per second. Calculate the acceleration of the spacecraft given its mass is 4000 kg. Values are given in meters per second.

a) 3.25×10^{-6}

b) 1.53×10^{-3}

c) 4.14×10^{-9}

d) 1.7×10^{-5}

e) 5.5×10^{-4}

11. Light with wavelength 100 nm is incident on a metal. The speed of the ejected photoelectrons is measured to be 10^6 meters per second. Find the work function of this metal.

a) 1.99×10^{-18}

b) 1.53×10^{-18}

c) 4.55×10^{-18}

12. An interferometer with equal arm lengths is sourced by a laser of wavelength 700 μm. If the length of one arm is increased by 0.12 mm, by what amount are the waves out of phase?

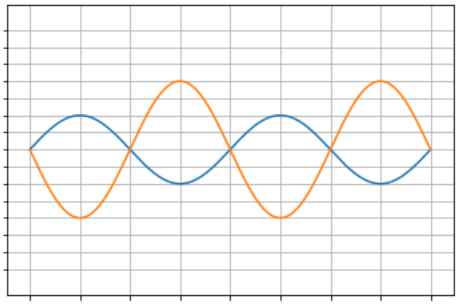
13. Continuing from the previous question, assuming that the intensity received at the detector was 4 W/m^2 when the arm lengths were equal, what is the new intensity?
Values are given in W/m^2

a) 2.95
b) 0
c) 0.898
d) 1.21
e) 4

14. The distance to the first minimum of a circular diffraction pattern is found to be 0.012 cm from the center. Assuming the distance to the screen is 10 mm and the diameter of the opening is 200 μm, what is the wavelength of the light used? Values are given in μm

a) 1.97
b) 2.28
c) 0.94

15. Below are two waves undergoing interference. Sketch the resulting waveform and determine the amplitude. What would the amplitude of this wave be if interference was constructive?



16. A material with work function $\Phi = 3.4$ eV has a laser beam with $\lambda = 200$ nm and power $P = 2.3 \times 10^{-4}$ W.

a) Calculate the energy E_{e^-}, the maximum energy of each ejected electron.

b) Calculate N_γ, the number of photons hitting the material per second.

c) Say we have a device that detects the power of the ejected electrons. Calculate the maximum power P this device could measure (assuming every photon ejects an electron, and each electron has maximum energy).

17. A bird watcher wants to take a picture of two red birds across a lake. The lake is 1.5 km long, and the birds are 10 cm apart. The wavelength of red light the bird emit is $\lambda = 700$ nm. Approximating the image of the birds as two bright spots, calculate the minimum aperture diameter D required to be able to distinguish the two birds as separate spots.

18. Express the Law of Cosines formula (listed below) in terms of Intensities I_1, I_2, and I_{tot}:

$$A_1^2 + A_2^2 + 2A_1A_2\cos\phi = A_{tot}^2$$