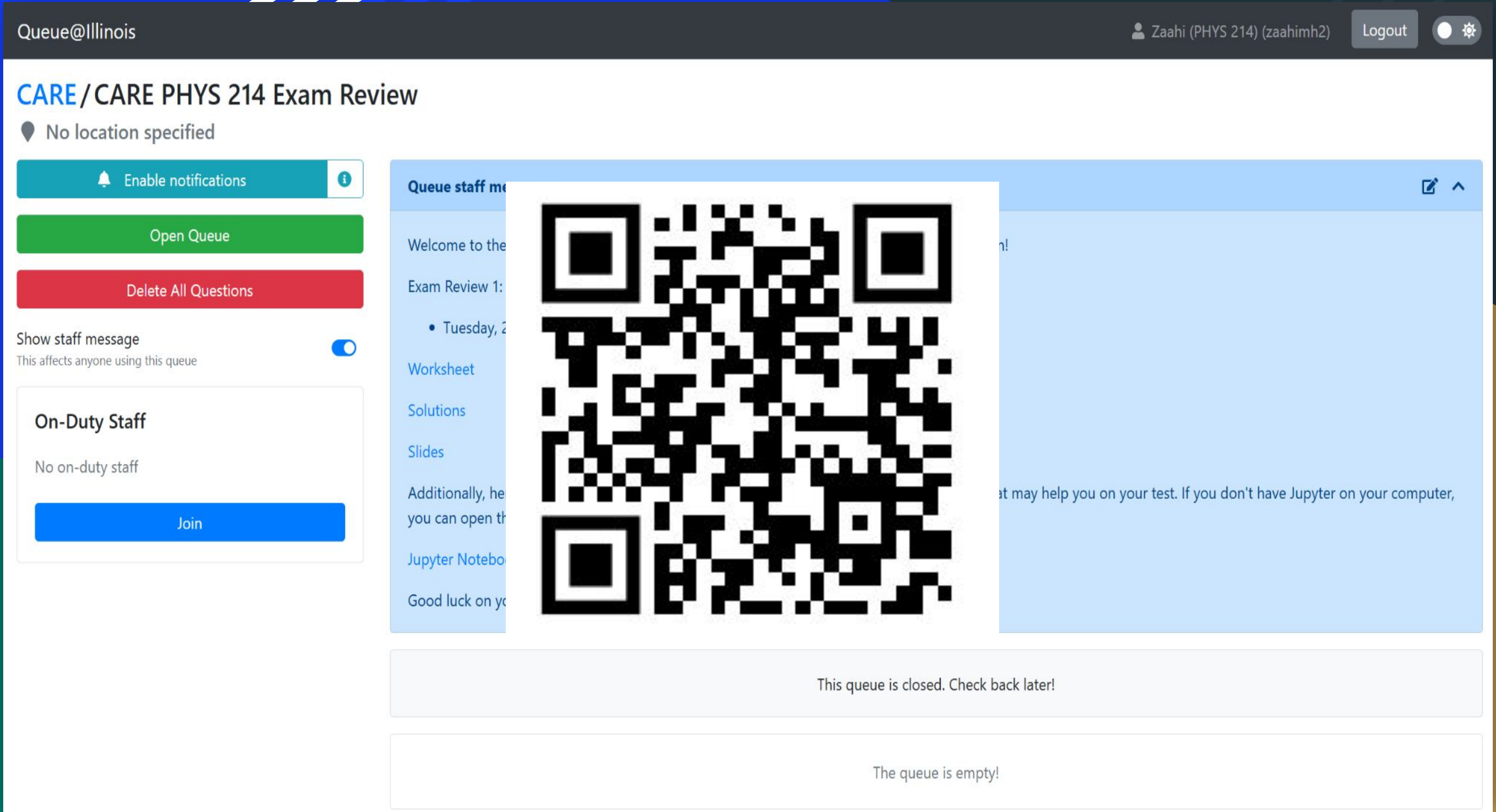
PHYS 214 Exam 1 Review

Alex, Luke, Zaahi


Queue@Illinois
Zaahi (PHYS 214) (zaahimh2)
Logout
CARE / CARE PHYS 214 Exam Review
No location specified
Enable notifications
Open Queue
Delete All Questions
Show staff message
This affects anyone using this queue
On-Duty Staff
No on-duty staff
Join
Queue staff me
Welcome to the
n!
Exam Review 1:
Tuesday, 2
Worksheet
Solutions
Slides
Additionally, he
at may help you on your test. If you don't have Jupyter on your computer,
you can open th
Jupyter Notebo
Good luck on yo
This queue is closed. Check back later!
The queue is empty!

Units for the Exam

- Waves
- Interference
- Diffraction
- Photons & The Photoelectric Effect

Wave Equation

General Wave Propagation: $y(x, t) = A\cos(kx - \omega t + \phi)$

k = wave number (how the wave repeats in SPACE) [m^{-1}]

ω = angular frequency (how the wave repeats in TIME) [rad/s]

ϕ = phase shift (the starting phase of the wave) [rad]

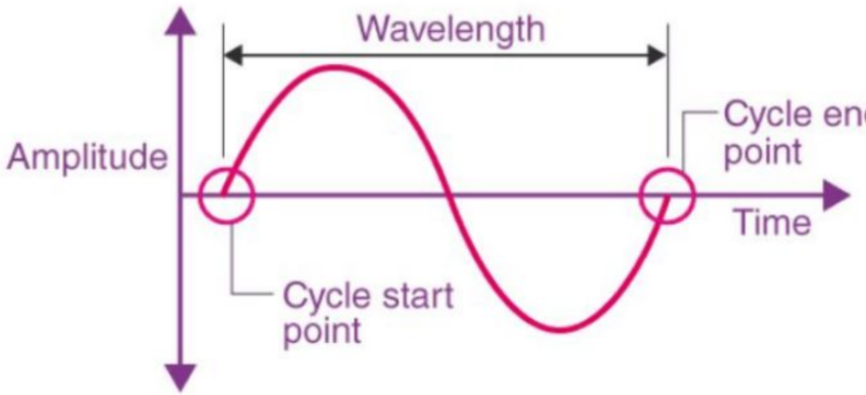
Properties of Waves

$\lambda = 2\pi/k$; $f = \omega/ 2\pi$

$v = \omega/k$ $v = \lambda f$

Intensity: $I(x,t) = |y(x,t)|^2$

$I_{average} = |A|^2/2$



Interference

Superposition (adding): A fancy way of saying that when two waves interact, the resulting wave is the SUM of the two individual waves

$y_1(x, t) = A_1\cos(k_1 x - \omega_1 t + \phi_1)$

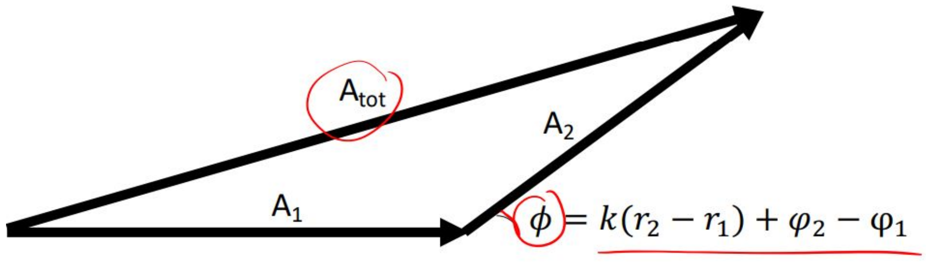
$y_2(x, t) = A_2\cos(k_2 x - \omega_2 t + \phi_2)$

$y_{tot}(x, t) = y_1(x, t) + y_2(x, t) = A_1\cos(k_1 x - \omega_1 t + \phi_1) + A_2\cos(k_2 x - \omega_2 t + \phi_2)$

If $\phi_1 = \phi_2$, the angular frequencies (ω) are the SAME, and the distance is the SAME, then the waves are IN PHASE

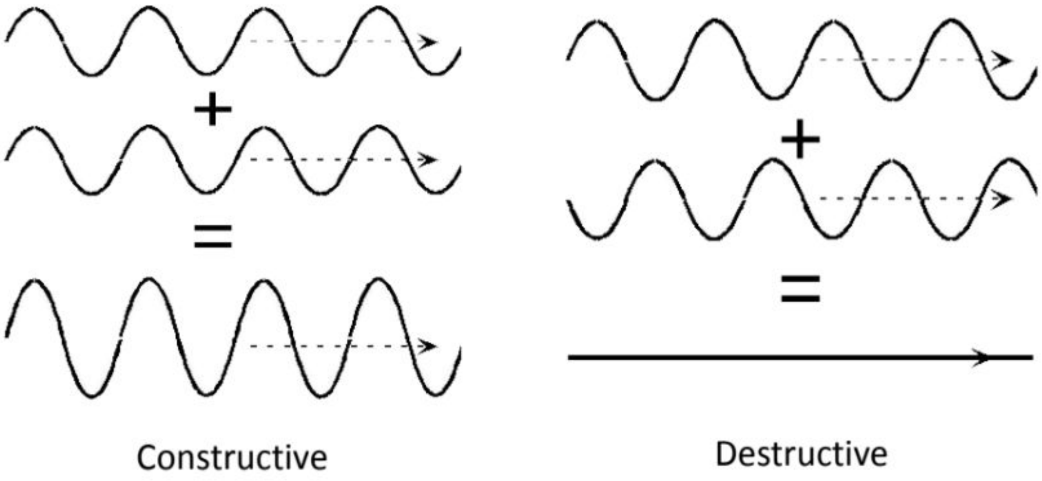
Phasors and Law of Cosines

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



Interference (Cont.)

Phase difference = $k(r_2 - r_1) = \phi$ for a two source system at different distances



In general, for two sources with the same amplitude/intensity:

$$I_{\text{tot}} = 4I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$$

In your equation sheet, this is written as:

$$I_{total} = 2A^2 \cos^2\left(\frac{kr_1 + \phi_1 - kr_2 - \phi_2}{2}\right)$$

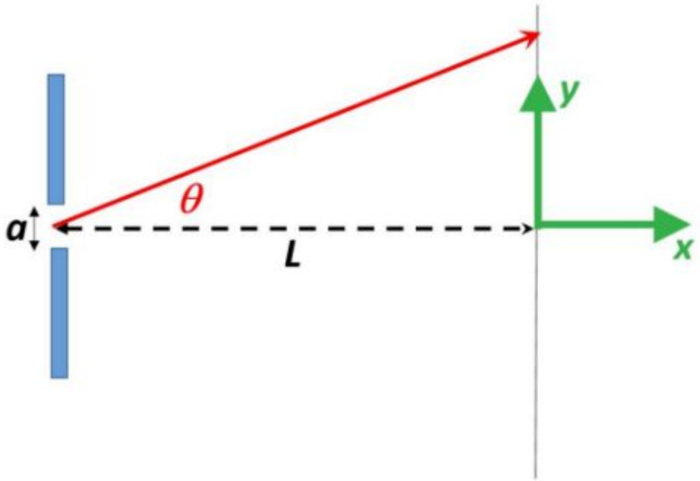
Diffraction

- Single slit diffraction:
  - *a* = slit width
  - θ_o = angle of first <u>minimum</u>
  - λ = wavelength

- Small *a* ⟶ Large θ_o

- Small angles
  - $\theta \cong \sin(\theta) \cong \tan(\theta) \cong y_o/L$

$$a \sin(\theta_\circ) = \lambda$$

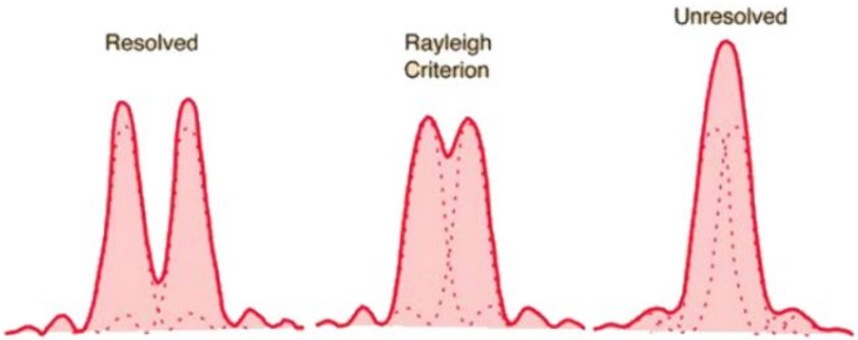


Diffraction (Cont.)

- Circular aperture diffraction
  - Similar to single slit; 1.22 factor

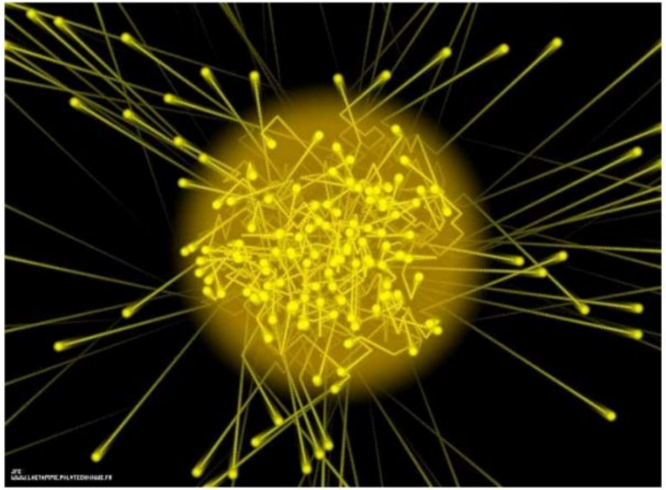
$$D\sin(\theta_{\circ}) = 1.22\lambda$$

- Rayleigh Criterion:
  - Center of one bright spot cannot overlap with other bright spot
  - ie. $\theta_o \leq \theta_{objects}$
    - θ_o = angle of first minimum of central bright spot
    - $\theta_{objects}$ = angle between two bright spots



Photons

Photons: the quantized bits of light (particles of light)



- Energy of a single photon with frequency f:

$$E = hf = \hbar\omega = \frac{1240 \text{ eV nm}}{\lambda}$$

- Momentum of a single photon with wavelength λ:

$$p = \hbar k = h/\lambda$$

- h = 6.626 x 10^{-34} J · s
- $\hbar$ ('h-bar') = h/2π

The Photoelectric Effect

This experiment proves the existence of photons and that light can be BOTH a particle and a wave

$$KE_{\text{electron}} = eV_{\text{stop}}$$

Stopping Potential: Voltage applied to stop electrons from flowing between the two plates

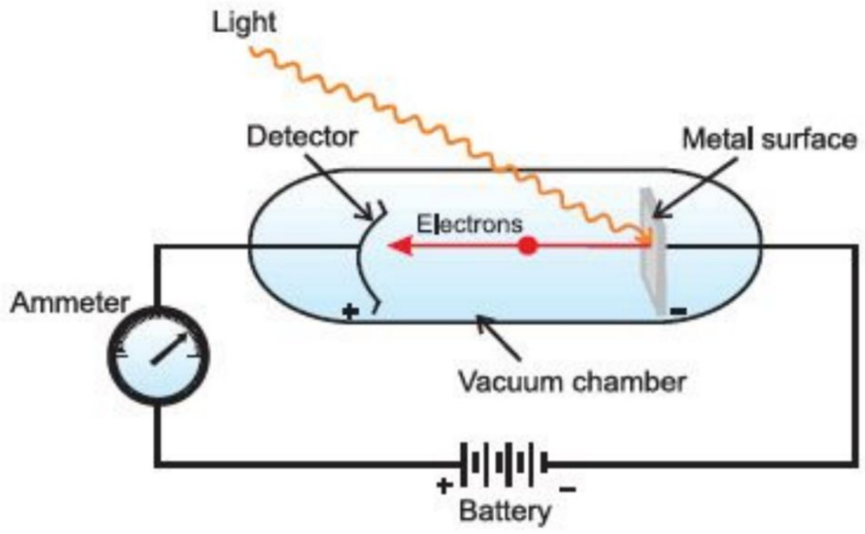
Work Function (property of the material the light is shining on)

$$KE_{\text{electron}} = hf - \Phi$$

Maximum Kinetic Energy of an ejected electron

Planck's constant times frequency of incoming photons (light)

The Photoelectric Effect Setup



$$\frac{\#\text{ photons}}{\text{sec}} = \frac{P\text{ Joules}}{\text{sec}} \times \frac{1\text{ photon}}{X\text{ Joules}}$$
$$\text{where } X = hf = hc/\lambda$$

Increasing the power of a photon source will not increase photon energy! It will only increase photon flux. Frequency/wavelength is what determines photon energy.

ADD FORCE EQUATION (dp/dt)

$$F = \frac{dp}{dt} = \frac{momentum}{second}$$

$$\frac{momentum}{second} = \frac{P\ joules}{second} * \frac{1\ photon}{hf\ joules} * \frac{\frac{h}{\lambda}\ momentum}{1\ photon}$$

Good luck!

Feel free to ask any questions you may have.

You got this!