21: Physical Optics

Key Physics Terms

Electromagnetic spectrum: The range of all possible frequencies that electromagnetic waves can have. All have same speed in a vacuum and characteristics of reflection, refraction and interference. Includes, radio waves, gamma rays and visible light.
Electromagnetic wave: A transverse wave in which changing electric and magnetic field oscillate in phase, perpendicular to each other and the direction of travel.
Principle of superposition: When two or more waves occupy the same region of space simultaneously, the resulting wave disturbance is the sum of separate waves.
Interference: The superposition of two or more waves travelling through the same point in space simultaneously, resulting in a wave whose displacement is the superposition of the interacting waves.
Constructive interference: The superposition of two or more waves whose displacements are in the same direction; resulting in a wave of larger amplitude than the individual waves.
Destructive interference: The superposition of two or more waves whose displacements are in the opposite direction; resulting in a wave of larger amplitude than the individual waves.
Thin film interference: The principle that creates colors on thin layers of transparent substances. The light reflecting off the interior of the substance interferes with light reflecting off the exterior.
Coherent: Light wave that are all in phase or in step.
Monochromatic: Light waves that possess the same frequency, color, or wavelength.
Diffraction: The bending of waves around corners or small openings.
Young's double slit experiment: Experiment that measures the wavelength of light by interference from two small slits.
Polarization: Light where the electric field fluctuates in only one direction.
Unpolarized light: Light where the electric field fluctuates in many random directions.
Transverse wave: A wave where the particles vibrate perpendicular to the direction of the wave motion.
Longitudinal wave: A wave where the particles vibrate in a parallel direction to the wave motion.

Variables and Key Metric Units

λ = wavelength. Units, m
v = velocity of light in a particular medium, units m/s
θ = angle between central spot and given maxima or minima. Units,degrees
d = spacing between double slit, or assortment of slits in diffraction grating. Units, m
m = integer 0,1,2…
S = average intensity of light after it has been reduced by a polarizer. Units, W/m^2
S_o = original intensity of light prior to any polarization.
θ_p= angle between the axes of the two polarizers. Units, degrees

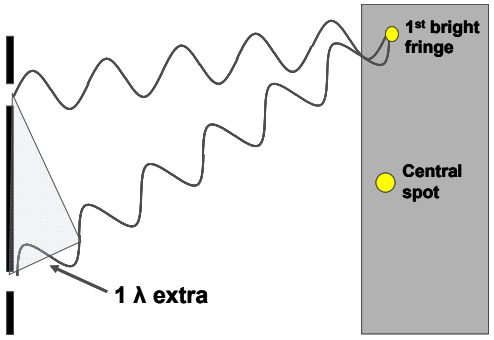
Key Formulas and Constants

3.0×10^8 m/s	speed of light in a vacuum
$\sin\theta = m\lambda/d$	bright fringe formula
$\sin\theta = (m + 1/2)\lambda/d$	dark fringe formula
$\sin\theta = m\lambda/d$	diffraction grating formula
• $S = S_o \cos^2\theta_p$	Malus' law

Physical Optics Problem Solving Tips

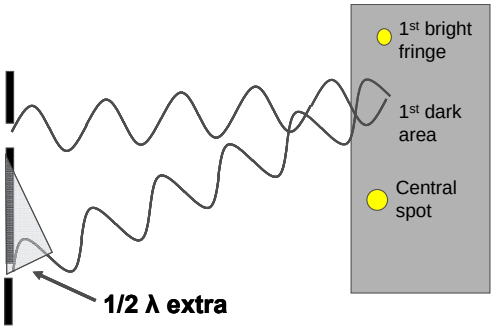
These tips will make it easier to solve any physics problems.
- Thoroughly read the entire problem.
- Draw a diagram if needed.
- Identify all given information.
- Identify the quantity to be found.
- Select appropriate formula(s) that incorporate what you know and what you want to find.
- Convert units if needed, especially for small measurements like wavelengths.
- Do any mathematical calculations carefully. Use the proper angular mode (degrees) on your calculator.

Sample Interference Diagrams

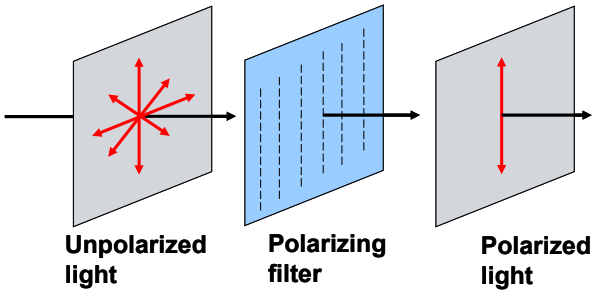


Notice how the waves are in phase and constructively interfere at the bright spots. The paths lengths differ by one or more whole wavelength.

Here the waves interfere destructively and form a dark fringe. To accomplish this, the path lengths differ by half multiples of wavelength.



Polarization Diagram



For the transverse wave shown here, randomly oriented electric field oscillations make up unpolarized light. This light passes through a filter that allows only one direction of motion.
A second filter could additionally be used to further reduce the intensity of the light emerging. This process is quantitatively described by Malus' law.

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then rewrite it on a blank sheet of paper. Review it again before the exams.