Advanced Electromagnetics:
21st Century Electromagnetics

# Concept of Diffraction From Gratings

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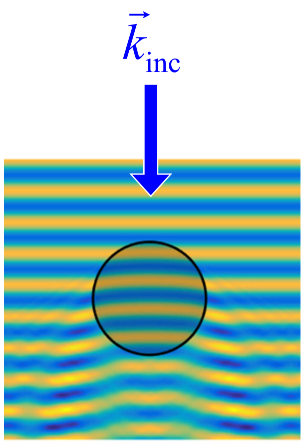
## Fields are Perturbed by Objects




A portion of the wave front is delayed after travelling through the dielectric object.

The rest of the wave front is not delayed.

Slide 2

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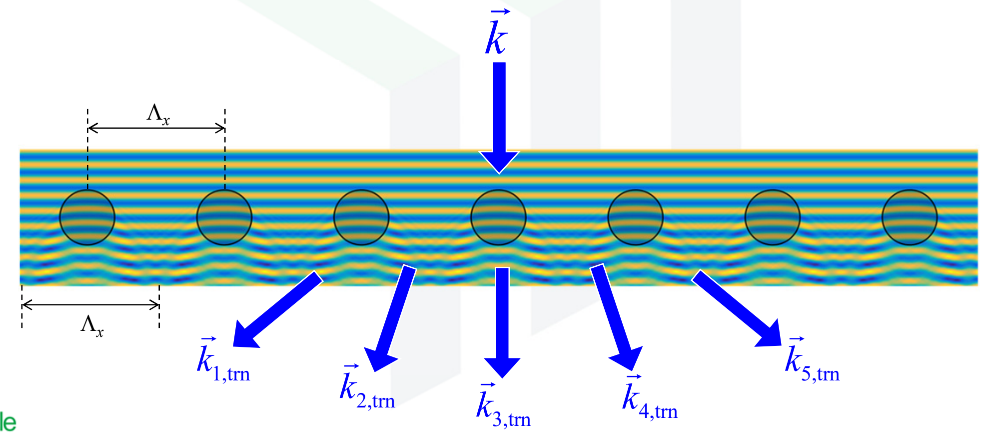
# Fields in Periodic Structures

**Waves in periodic structures take on the same periodicity as their host.**

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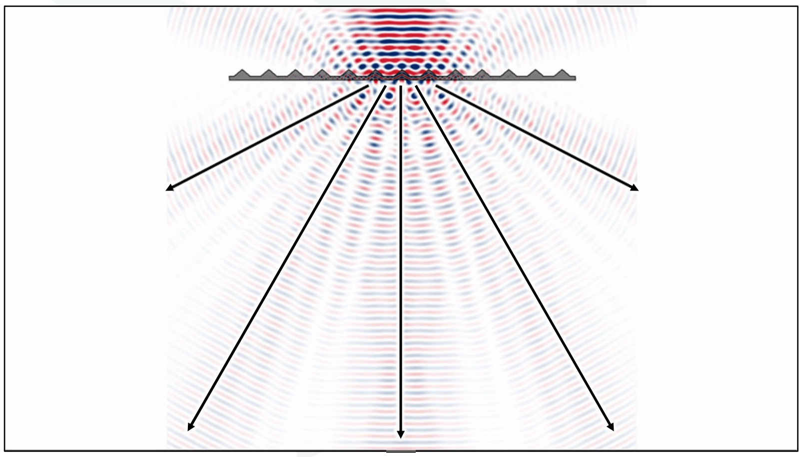
# Diffraction from Gratings

The field is no longer a pure plane wave. The grating "chops" the wave front and sends the power into multiple discrete directions that are called *diffraction orders*.



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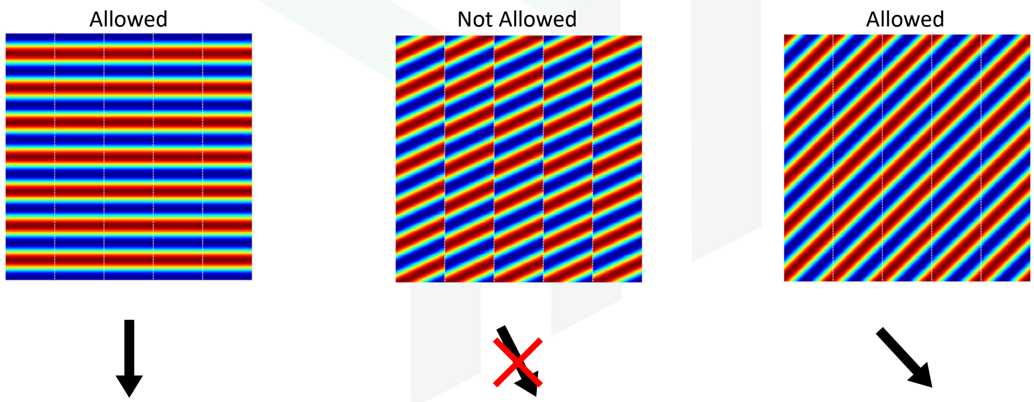
# Reason for Discrete Diffraction Orders (1 of 2)

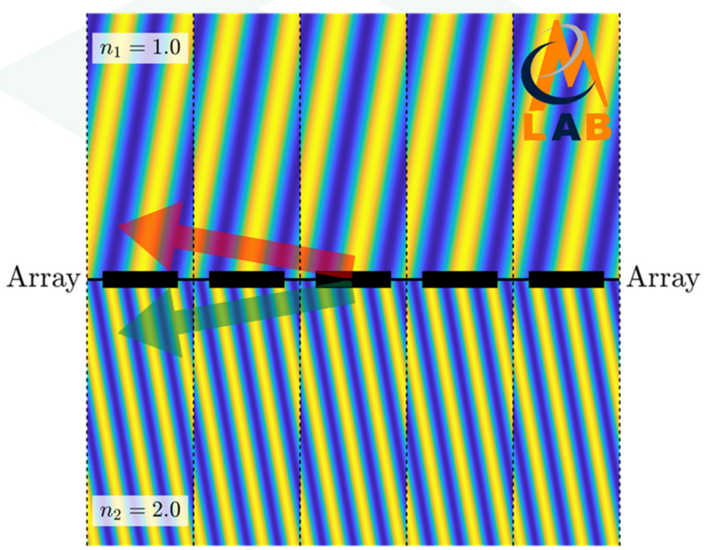
The field must be continuous so only discrete directions are allowed.
The allowed directions are called the diffraction orders.
The allowed angles are calculated using the famous grating equation.





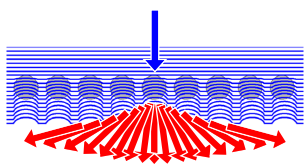


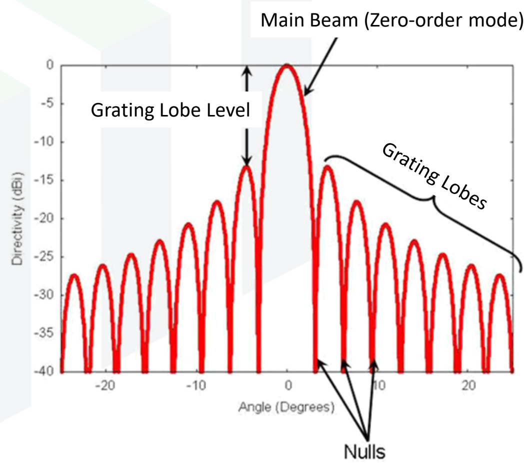

# Reason for Discrete Diffraction Orders (2 of 2)



# Grating Lobes

If the power exiting a periodic structure is plotted as a function of angle, the following would be obtained. The power peaks are called *grating lobes* or sometimes *side lobes*. The power minimums are called *nulls*.



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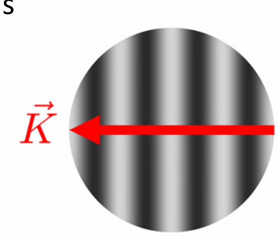
# Field in a Periodic Structure

The dielectric function $\varepsilon_r(\vec{r})$ of a sinusoidal grating can be written as

$$\varepsilon_r(\vec{r}) = \varepsilon_{r,avg} + \Delta\varepsilon\cos\left(\vec{K}\bullet\vec{r}\right)$$

A wave $E(\vec{r})$ propagating through this grating takes on the same symmetry as the grating.

$$\begin{aligned} E(\vec{r}) &= A(\vec{r})e^{-j\vec{k}_{inc}\bullet\vec{r}} \\ &= A\left[\varepsilon_{r,avg} + \Delta\varepsilon\cos\left(\vec{K}\bullet\vec{r}\right)\right]e^{-j\vec{k}_{inc}\bullet\vec{r}} \\ &\vdots \\ &= \underbrace{A\varepsilon_{r,avg}e^{-j\vec{k}_{inc}\bullet\vec{r}}}_{\text{Wave 1}} + \underbrace{\frac{A\Delta\varepsilon}{2}e^{-j\left(\vec{k}_{inc}-\vec{K}\right)\bullet\vec{r}}}_{\text{Wave 2}} + \underbrace{\frac{A\Delta\varepsilon}{2}e^{-j\left(\vec{k}_{inc}+\vec{K}\right)\bullet\vec{r}}}_{\text{Wave 3}} \end{aligned}$$



$$\left|\vec{K}\right| = \frac{2\pi}{\Lambda}$$

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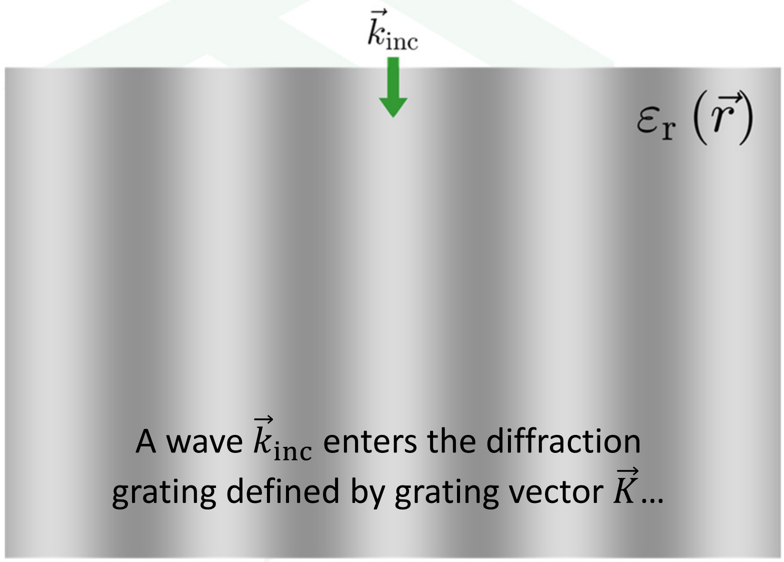
# Grating Produces New Waves (1 of 7)




A wave $\vec{k}_{\mathrm{inc}}$ enters the diffraction grating defined by grating vector $\vec{K}$...

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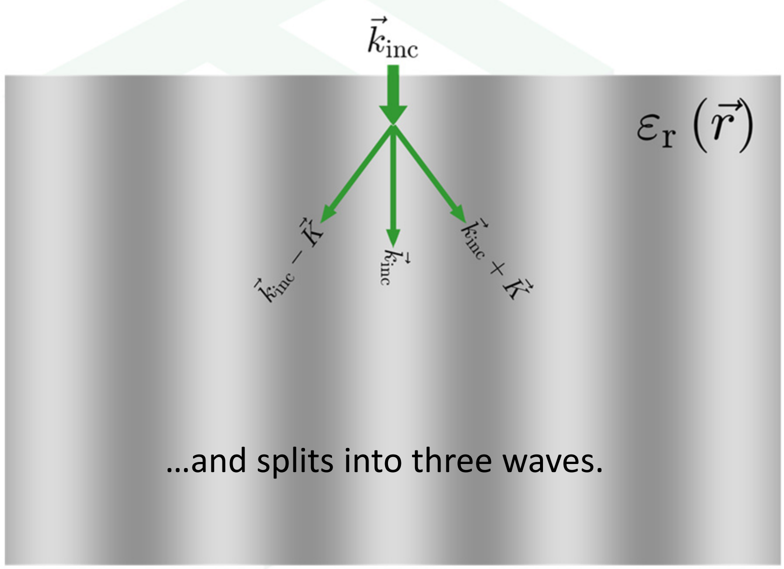
# Grating Produces New Waves (2 of 7)




...and splits into three waves.

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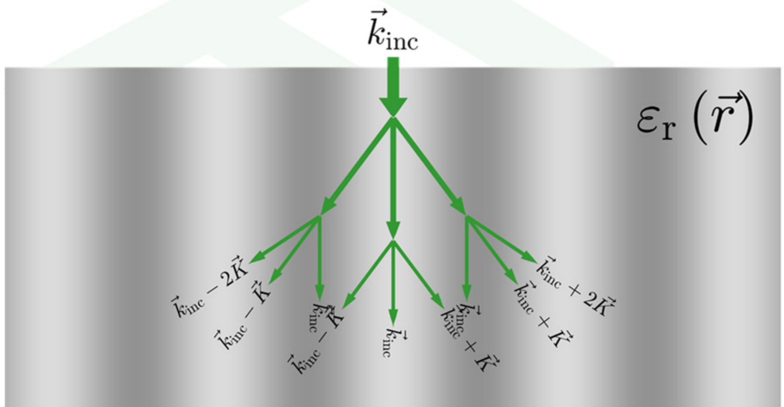
# Grating Produces New Waves (3 of 7)




Then each of these splits
into three waves…

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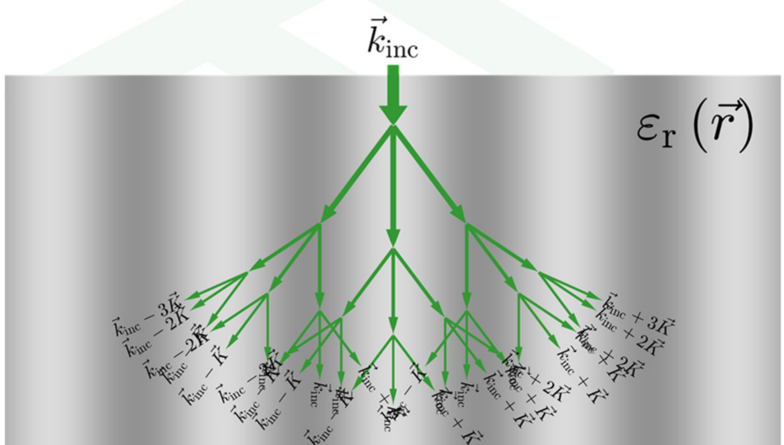
# Grating Produces New Waves (4 of 7)




…and each of these splits
into three waves…

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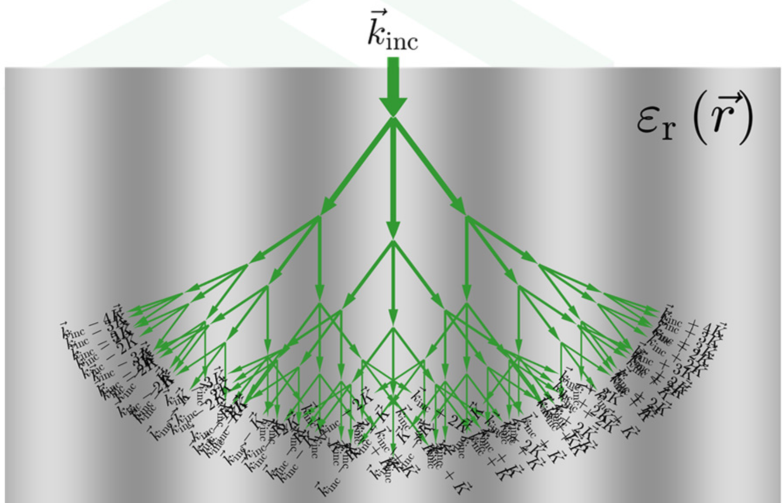
# Grating Produces New Waves (5 of 7)




…and so on.

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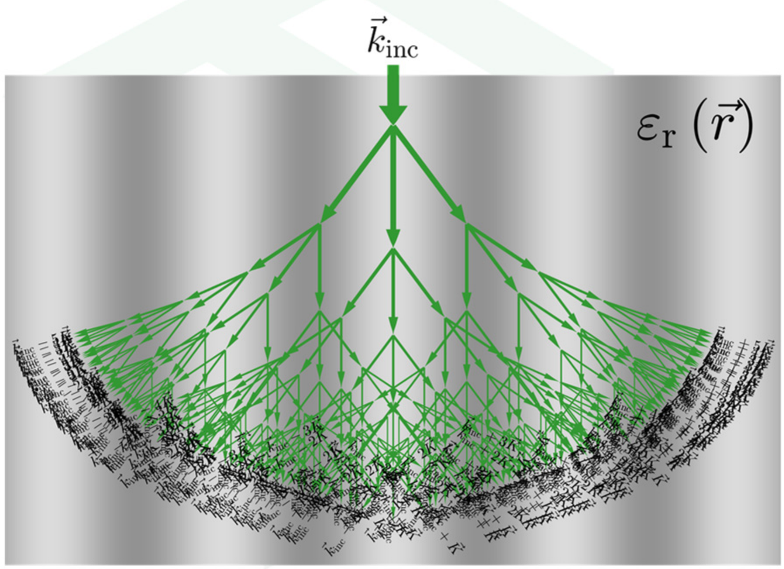
# Grating Produces New Waves (6 of 7)

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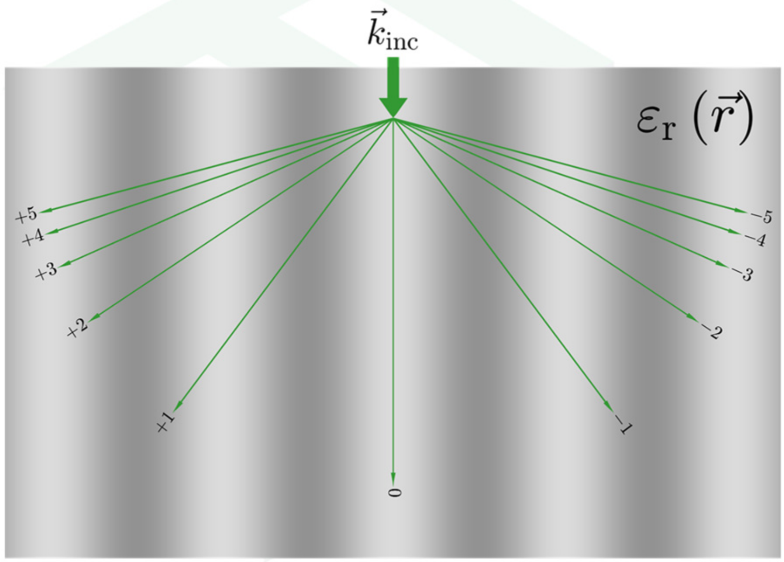
# Grating Produces New Waves (7 of 7)

All possible directions are defined by

$$\vec{k}(m) = \vec{k}_{\text{inc}} - m\vec{K}$$

$m$ = any integer

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