ASSIGNMENT: SIMULATING DIFFRACTION

For this assignment, you are given a Fresnel simulation package written for MATLAB (*FieldPropagation2021.m*). This code numerically implements the Fresnel formulation of wave propagation, and should only be used as a propagation engine/function to be called by another MATLAB script that you will write yourselves. PLEASE DO NOT MODIFY THE PROVIDED CODE. You can refer to the (*FieldPropagationSampleUse.m*) file to see how this code can be used. You are asked to utilize this code for analyzing certain scenarios concerning micromirrors and tunable diffraction gratings. Please provide your simulation codes together with a report summarizing your results. Feel free to contact your lecturers for any questions.. Here is what you are asked to do:

1. In this question, we will analyze the effect of mirror size on the resolution of a micromirror based beam scanning or steering system. Assume that a collimated beam of 500 nm wavelength is perpendicularly incident on a circular micromirror. For values ranging from 0.2 mm to 2 mm with 0.2 mm steps, plot the full-width at half maximum (FWHM) angular spot size and peak spot intensity of the reflected beam as a function of mirror diameter after 10m of propagation. Represent the input and output profiles with 1024×1024 points with a point spacing of 5 μm. Comment on the implications of the results for a micromirror based projector system.

2. When disucssing micromirros, we covered how dynamic deformation of a micromirror effects the far field profile of the diffracted spot. Can you demonstrate this effect using your propagation software, based on the information provided in slide 251 of the lecture notes? You can assume that the illumination is monochromatic with $\lambda = 500nm$, and perform the simulations for maximum deformation values of $\lambda/10$, λ, 10λ. Comment briefly on the results.

3. Consider the 1D reflective binary diffraction grating shown below in Figure 1. We have briefly covered in class what happens to the diffraction profile if the grating depth is tuned; here we will try to reach the same results through simulations. Use the following parameters in your simulations:

   - Incident beam wavelength: $\lambda = 500$ nm
   - Incident beam properties: Collimated light of circular profile with 0.25 mm radius
   - Grating period: $\Lambda = 10$ μm
   - Tunable grating depth d
   - Propagation distance $z = 2$ m
   - Simulation grid: 1024×1024 points with a point spacing of 1 μm

   (a) For d values ranging from 0 to 1 μm with steps of 25 nm, plot the 0th and 1st diffraction order intensities as a function of grating depth. **Present the plots in the angular domain**. Comment on the results. Is the diffraction angle what you expected? How are the diffraction order intensities modified? Can you tell the 1st order diffraction efficiency?

   (b) Now assume that the beam is not monochromatic, but is composed of two wavelengths $\lambda_1 = 500$ nm and $\lambda_2 = 510$ nm emanating *from two different sources*. For a grating depth of $d = 100$ nm, plot the *total* far-field diffraction profile ($z = 2$m) on separate plots for illuminating beam radius values ranging from 0.1 mm to 0.5 mm with 0.1 mm steps. Comment on the changes in the diffraction profile. What is the implication of your results if you want to build a diffraction grating based spectrometer?

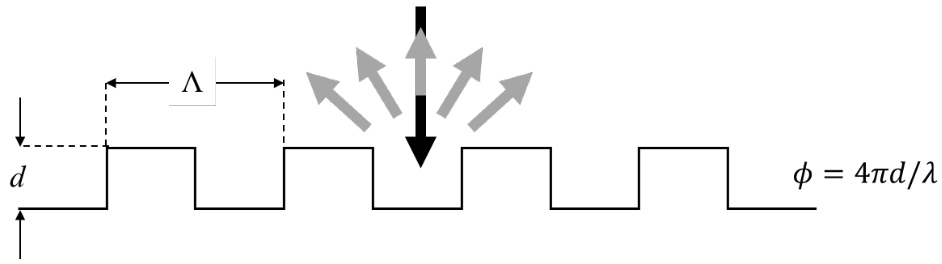

Figure 1: Schematic depictions of the reflective binary diffraction grating with tunable grating depth

Hint: *Since the wavelength components are mutually incoherent, they will superpose in intensity, rather than amplitude; therefore, you can treat their contributions independently. Please note that the grid output by the* ***FieldPropagation2023*** *function is wavelength dependent. You will need to use the* ***interp1*** *function of MATLAB for this exercise. Also, reviewing the discussion on the resolving power of gratings would be immensely helpful*