Centroids

TASK: Complete the implementation of the **centroid** function, using **np.sum/sum** to approximate the integration over the transverse plane (x,y), the arguments are a provided set of 2d coordinates, and amplitude samples at those coordinates. The centroid may be defined for a sample approximated normalized transverse amplitude of intensity *I*:

$$\mathrm{c}_x = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} xI(x,y)dxdy \approxeq \sum_{j=0}^{N-1}\sum_{k=0}^{N-1} X_{j,k} \times I_{j,k}$$

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} I(x,y)dxdy = \sum_{j=0}^{N-1}\sum_{k=0}^{N-1} I_{j,k} = 1$$

An analogous c_y formula exists. Normalization of the transverse intensity lets the typical central moments of statistics be equal to the centroid. The general beam width may be calculated in a similar manner, letting the integral weighting *x* go to $(x - \mu_x)^2$

QUESTION: Which of the above two equations gives the normalization condition for the transverse intensity? How would the above calculated centroid change if the total intensity was not normalized to unity?

TASK: Using **small_angle_mirror_phase**, generate a mirror tilt phase about the transverse Y axis for a 0.001 rad tilt, and apply the phase on the example beam amplitude (complicated_amplitude).
HINT: Use the provided mirror tilt function
The centroid should linearly drift with propagation length as a result of a tilt mirror phasing.

QUESTION: Using the centroids of the tilted propagations and initial condition, make a small angle calculation of the angle of reflection. Does it match the expected angle of reflection?

NOTE: In a practical simulation, the effect of the mirror would be to rotate the simulation optical axis, rather than a transverse phasing, so that the centroid is a constant function of z (propagation distance). This is analogous to working in a zero transverse momentum frame for the propagating intensity, since the center of intensity is stationary.

Negligible diffraction

TASK: Propagate the example amplitude (complicated_amplitude) from z = 0 to z = 0.2m and z = 0.205m. Note we can essentially plot with the same coordinates for both z=0.2m and z = 0.205m, since the scale factor changes on the order of 2%.

NOTE: This negligible intensity change is the basis for a thin lens model, where the effect of a thin lens is only to modify the phase, not the intensity. A full treatment of the approximation requires the curvature of the lens (focusing power), which will increase the change in optical intensity over a given distance.