Purpose:

The class lecture notes show that a simple explicit method applied to a paraxial beam propagation equation is unstable. This exercise is meant to demonstrate that instability is in no way a negligible drawback that perhaps could be dealt with "somehow."

Task: Use p1.m to explore a few parameter choices to visualize typical instability properties. This script is set up to propagate a beam at an angle — so that a "useful" simulated propagation distance is such that the waveform visibly shifts to the side in the computational domain.

- No matter what the input parameters, in particular the propagation step, simulation never reaches a "useful distance". For example, the instability onset is at mere 2 mm propagation distance for a 25 micron propagation step. Decreasing the latter to 5 micron, the onset only shifts to about 3 mm.

- Instability grows from noise even for a very smooth initial condition.

- If the initial condition contains a cusp (e.g. at the domain boundary), it seeds the unstable growth very quickly. In this exercise, use a wider beam to induce such a situation. When the beam waist is increased from 40 to 140 micron, the first spots at which numerical noise starts to grow rapidly are at the domain edges.

Lesson:

- unstable method is practically useless

- instability shows up fastest with "sharp features" present in the solution. This observation can be useful for 'stress testing,' e.g. with methods in which explicit determination of stability is not possible.