Variables:

: The separation distance between two stages (45mm).

: Transition length for the slider actuators (25mm).

: Rotation angle for each stage .

: Needle insert minimum depth (65mm).

: Needle insert depth (100mm).

: Needle insert depth (range 100mm).

: The needle point on the top stage.

: The needle point in the bottom stage.

: The target point.

: The entrance point

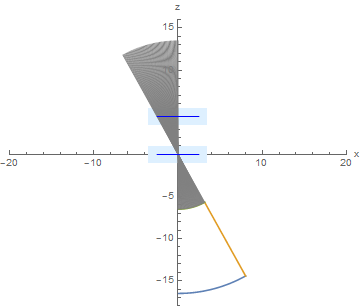
**The coordinate origin** is at the center of the bottom stage.

The workspace for a 1 stage MK3 is defined by a cross section in the xz plane. The workspace is defined by revolving three arcs about the *z-*axis.

Arc 1: circle segment defined by minimum needle depth:

Arc 2: (line):

Arc 3:



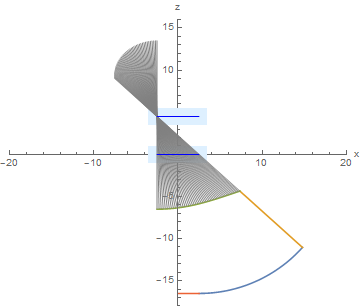
Draw the 2 stage MK3 robot cross section. This should be revolved about the zaxis.

Top arch:

Side slant:

Bottom arc:

Bottom flat side



Forward Kinematics (vector calculation):

Given:, , depth

For one stage MK3

Inverse Kinematics (vector calculation, *z* value is zero, z-value is *s* (45)):

Given:, depth

After get the coordinate of each stage, separately substitute into following equations: