Problem 1: 2D Transformations

Here are four letter shapes that, in this particular font, are simple transformations of one another:

![q b p d](dimensions are in millimeters).

Each letter is positioned with its baseline at $y = 0$ and its left edge aligned with $x = 0$.

Express the transformation required to turn $p$ into each of $q$, $b$, and $d$ in the three following ways:

1. as a sequence of affine transformations, using only translation, rotation about the origin, and reflections across coordinate axes. Describe the transformations in words.

2. as a single $3 \times 3$ homogeneous transformation matrix.

3. as a single rotation about a point or a single reflection across a line.

(That’s 9 answers: three ways of expressing each of three transformations.)

Problem 2: 3D Transformations

Suppose I apply a rotation that maps the $x$ axis to the $y$ axis, the $y$ axis to the $z$ axis, and the $z$ axis to the $x$ axis.

1. What axis and angle can be used to describe this rotation?

2. What is the 3-by-3 matrix of the rotation?