

1. (8 points) To generate a perspective view where the observer is standing at the origin and looking directly upwards, along the +Y-axis, which element of the 4 x 4 projection matrix cannot be zero? Circle the correct element in the matrix below.

$$\begin{bmatrix} a & b & c & d \\ e & f & g & h \\ i & j & k & l \\ m & n & o & p \end{bmatrix}$$

Answer:  $n$ . If  $n$  is nonzero, then the value for  $w$  after applying the transformation will have some dependence on the value of  $y$  before the transformation, which is exactly what we want in a perspective view. All of the other values can be zero depending on other aspects of the projection.

Another way to think about this is to consider the matrix that is built by `glFrustum`, which is listed in the lecture notes for Viewing II. In that matrix, the only value that must be nonzero is  $o$ ; however, that was because `glFrustum` assumes viewing down the Z-axis. In the case where we are viewing along the Y-axis, by extension,  $n$  would have to be the nonzero value.