7.2.5 When Gaussian Elimination Fails Altogether

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Now, we can see that when executing Gaussian elimination (LU factorization) with $Ax = b$ where A is a square matrix, one of three things can happen:

- The process completes with no zeroes on the diagonal of the resulting matrix U. Then $A = LU$ and $Ax = b$ has a unique solution, which can be found by solving $Lz = b$ followed by $Ux = z$.
- The process requires row exchanges, completing with no zeroes on the diagonal of the resulting matrix U. Then $PA = LU$ and $Ax = b$ has a unique solution, which can be found by solving $Lz = Pb$ followed by $Ux = z$.
- The process requires row exchanges, but at some point no row can be found that puts a nonzero on the diagonal, at which point the process fails (unless the zero appears as the last element on the diagonal, in which case it completes, but leaves a zero on the diagonal).

This last case will be studied in great detail in future weeks. For now, we simply state that in this case $Ax = b$ either has *no* solutions, or it has an *infinite* number of solutions.

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