

## pinv() — Moore–Penrose pseudoinverse

Description	Syntax	Remarks and examples	Conformability
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## Description

`pinv(A)` returns the unique Moore–Penrose pseudoinverse of real or complex, symmetric or non-symmetric, square or nonsquare matrix  $A$ .

`pinv(A, rank)` does the same thing, and it returns in  $rank$  the rank of  $A$ .

`pinv(A, rank, tol)` does the same thing, and it allows you to specify the tolerance used to determine the rank of  $A$ , which is also used in the calculation of the pseudoinverse. See [M-5] `svsolve()` and [M-1] **tolerance** for information on the optional  $tol$  argument.

`_pinv(A)` and `_pinv(A, tol)` do the same thing as `pinv()`, except that  $A$  is replaced with its inverse and the rank is returned.

## Syntax

```

numeric matrix   pinv(numeric matrix A)
numeric matrix   pinv(numeric matrix A, rank)
numeric matrix   pinv(numeric matrix A, rank, real scalar tol)

real scalar      _pinv(numeric matrix A)
real scalar      _pinv(numeric matrix A, real scalar tol)

```

where the type of  $rank$  is irrelevant; the rank of  $A$  is returned there.

To obtain a generalized inverse of a symmetric matrix with a different normalization, see [M-5] `invsym()`.

## Remarks and examples

The Moore–Penrose pseudoinverse is also known as the Moore–Penrose inverse and as the generalized inverse. Whatever you call it, the pseudoinverse  $A^*$  of  $A$  satisfies four conditions,

$$\begin{aligned}
 A(A^*)A &= A \\
 (A^*)A(A^*) &= A^* \\
 (A(A^*))' &= A(A^*) \\
 ((A^*)A)' &= (A^*)A
 \end{aligned}$$

where the transpose operator  $'$  is understood to mean the conjugate transpose when  $A$  is complex. Also, if  $A$  is of full rank, then

$$A^* = A^{-1}$$

`pinv(A)` is logically equivalent to `svsolve(A, I(rows(A)))`; see [M-5] `svsolve()` for details and for use of the optional `tol` argument.

## Conformability

`pinv(A, rank, tol)`:

*input:*

*A:*  $r \times c$   
*tol:*  $1 \times 1$  (optional)

*output:*

*rank:*  $1 \times 1$  (optional)  
*result:*  $c \times r$

`_pinv(A, tol)`:

*input:*

*A:*  $r \times c$   
*tol:*  $1 \times 1$  (optional)

*output:*

*A:*  $c \times r$   
*result:*  $1 \times 1$  (containing rank)

## Diagnostics

The inverse returned by these functions is real if  $A$  is real and is complex if  $A$  is complex.

`pinv(A, rank, tol)` and `_pinv(A, tol)` return missing results if  $A$  contains missing values.

`pinv()` and `_pinv()` also return missing values if the algorithm for computing the SVD, [M-5] `svd()`, fails to converge. This is a near zero-probability event. Here *rank* also is returned as missing.

See [M-5] `svsolve()` and [M-1] **tolerance** for information on the optional `tol` argument.

## References

- James, I. M. 2002. *Remarkable Mathematicians: From Euler to von Neumann*. Cambridge: Cambridge University Press.
- Moore, E. H. 1920. On the reciprocal of the general algebraic matrix. *Bulletin of the American Mathematical Society* 26: 394–395.
- Penrose, R. 1955. A generalized inverse for matrices. *Mathematical Proceedings of the Cambridge Philosophical Society* 51: 406–413.

## Also see

- [M-5] **invsym()** — Symmetric real matrix inversion
- [M-5] **cholinv()** — Symmetric, positive-definite matrix inversion
- [M-5] **luinv()** — Square matrix inversion
- [M-5] **qrrinv()** — Generalized inverse of matrix via QR decomposition
- [M-5] **svd()** — Singular value decomposition
- [M-5] **fullsvd()** — Full singular value decomposition
- [M-4] **matrix** — Matrix functions
- [M-4] **solvers** — Functions to solve  $AX=B$  and to obtain  $A$  inverse

Eliakim Hastings Moore (1862–1932) was born in Marietta, Ohio. He studied mathematics and astronomy at Yale and was awarded a Ph.D. for a thesis on  $n$ -dimensional geometry. After a year studying in Germany and teaching posts at Northwestern and Yale, he settled at the University of Chicago in 1892. Moore worked on algebra, including fields and groups, the foundations of geometry and the foundations of analysis, algebraic geometry, number theory, and integral equations. He was an inspiring teacher and a great organizer in American mathematics, playing an important part in the early years of the American Mathematical Society.

Roger Penrose (1931– ) was born in Colchester in England. His father was a statistically minded medical geneticist and his mother was a doctor. Penrose studied mathematics at University College London and Cambridge and published an article on generalized matrix inverses in 1955. He taught and researched at several universities in Great Britain and the United States before being appointed Rouse Ball Professor of Mathematics at Oxford in 1973. Penrose is perhaps best known for papers ranging from cosmology and general relativity (including work with Stephen Hawking) to pure mathematics (including results on tilings of the plane) and for semipopular and wide-ranging books making controversial connections between physics, computers, mind, and consciousness. He was knighted in 1994.