

matpowersym() — Powers of a symmetric matrix

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Description

`matpowersym(A, p)` returns A^p for symmetric matrix or Hermitian matrix A . The matrix returned is real if A is real and complex if A is complex.

`_matpowersym(A, p)` does the same thing, but instead of returning the result, it stores the result in A .

Syntax

numeric matrix `matpowersym(numeric matrix A, real scalar p)`

void `_matpowersym(numeric matrix A, real scalar p)`

Remarks and examples

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Do not confuse `matpowersym(A, p)` and `A : ^p`. If $p=2$, the first returns $A*A$ and the second returns A with each element squared.

Powers can be positive, negative, integer, or noninteger. Thus `matpowersym(A, .5)` is a way to find the square-root matrix R such that $R*R=A$, and `matpowersym(A, -1)` is a way to find the inverse. For inversion, you could obtain the result more quickly using other routines.

Powers are obtained by extracting the eigenvectors and eigenvalues of A , raising the eigenvalues to the specified power, and then rebuilding the matrix. That is, first X and L are found such that

$$AX = X * \text{diag}(L) \tag{1}$$

For symmetric (Hermitian) matrix A , X is orthogonal, meaning $X'X = XX' = I$. Thus

$$A = X * \text{diag}(L)X' \tag{2}$$

A^p is then defined

$$A^p = X * \text{diag}(L : ^p) * X' \tag{3}$$

(1) is obtained via `symeigensystem()`; see [M-5] [eigensystem\(\)](#).

Conformability

`matpowersym(A, p)`:

A: $n \times n$
p: 1×1
result: $n \times n$

`_matpowersym(A, p)`:

input:

A: $n \times n$
p: 1×1

output:

A: $n \times n$

Diagnostics

`matpowersym(A, p)` and `_matpowersym(A, p)` return missing results if *A* contains missing values.

Also:

1. These functions do not check that *A* is symmetric or Hermitian. If *A* is a real matrix, only the lower triangle, including the diagonal, is used. If *A* is a complex matrix, only the lower triangle and the real parts of the diagonal elements are used.
2. These functions return a matrix of the same storage type as *A*. That means that if *A* is real and A^p cannot be expressed as a real, a matrix of missing values is returned. If you want the generalized solution, code `matpowersym(C(A), p)`. This is the same rule as with scalars: $(-1)^{.5}$ is missing, but $C(-1)^{.5}$ is `1i`.
3. These functions are guaranteed to return a matrix that is numerically symmetric, Hermitian, or `symmetriconly` if theory states that the matrix should be symmetric, Hermitian, or `symmetriconly`.

Concerning theory, the returned result is not necessarily symmetric (Hermitian). The eigenvalues *L* of a symmetric (Hermitian) matrix are real. If $L: \sim p$ are real, then the returned matrix will be symmetric (Hermitian), but otherwise, it will not. Think of a negative eigenvalue and $p = .5$: this results in a complex eigenvalue for A^p . Then if the original matrix was real (the eigenvectors were real), the resulting matrix will be `symmetriconly`. If the original matrix was complex (the eigenvectors were complex), the resulting matrix will have no special structure.

Also see

[M-5] `matexpsym()` — Exponentiation and logarithms of symmetric matrices

[M-5] `eigensystem()` — Eigenvectors and eigenvalues

[M-4] `matrix` — Matrix functions