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For a finite matrix  
Unitary matrix: preserves norm  
of a complex vector  $\xi$

$$\|U\xi\|^2 = \|\xi\|^2$$

$$(U\xi)^\dagger (U\xi) = \xi^\dagger \xi$$

$$\xi^\dagger U^\dagger U \xi$$

True  $\forall \xi \Rightarrow U^\dagger U = I$

$$\Rightarrow (U\xi)^\dagger (U\xi) = \xi^\dagger \xi \quad \forall \xi$$

$U^\dagger U = I \Rightarrow U$  is invertible

$$U^{-1} = U^\dagger$$

A unitary operator  $U$  is  
invertible and  $U^{-1} = U^\dagger$