```
|
|
|
```

matrix-vector product - (column form)

```
  | -1  2  1 |   | 1 |     |-1 |       | 2|    | 1 |
  |  0  1  2 | x | -2| = 1x| 0 |   -2 x| 1| -1x| 2 |
  | -2  1  0 |   | -1|     |-1 |       | 1|    | 0 |
```

===

----

transpose conjugate:

```
    |  1+i   3-i  0  |              |1-i 2-i  1 |
 A =|  2+i    2  -1  |         A^H = |3+i  2  5+i|
    |  1     5-i  0  |              |0   -1 0   |
```

===

```
  | -1  2  1 |   |  1  0  2 |
  |  0  1  2 | x |  1  2  0 | =?
  | -2  1  0 |     |  2 -3  2 |


         | 1  0  2 |        | 1  2  0  |          | 2 -3 2|
   | -1|              | 2 |                   | 1 |
  =|  0|            + | 1 |               +  | 2 |
   | -2|              | 1 |                   | 0 |
```

===

Example : range and null space, rank, nullity of:

```
| -1  1  0 |
|  1  2  3 |
|  1 -2 -1 |
|  2 -1  1 |
```

rank(A) = 2

range(A) = span of first 2 columns of A

need x such that Ax = 0

$x = [1\ 1\ -1]^T$

Ax = 1st col + 2nd col - 3rd col = 0

```
general procedure: solve Ax = 0   [RREF]

                        |  1 |                           |  1 |
Null space(A) == span { |  1 | }  = set of all vector a *|  1 |
                        | -1 |                           | -1 |
dim(Null(A)) = 1

  2          1           3
rank(A) + dim(null(A)) = 3
=======================================================================
```