* Complex numbers

$C = a + ib$

$Re\{c\} = a$

$Im\{c\} = b$

Alternatively $c = Ae^{i\phi} = A(\cos\phi + i\sin\phi)$

$$A = \sqrt{a^2+b^2}$$
$$\phi = \tan^{-1}\frac{b}{a}$$

In MR,

$$c(t) = A e^{i(-\omega)t} e^{i\phi_0} = A e^{-i\omega t} e^{i\phi_0}$$

ϕ_0 ; starting phase

ω ; angular frequency (in clockwise)

* Cross product

$M \times B$; a cross product of two vectors M and B

i, j, k ; unit vectors in x, y, and z

$$M \times B = \begin{vmatrix} i & j & k \\ M_x & M_y & M_z \\ B_x & B_y & B_z \end{vmatrix} = \begin{pmatrix} B_z M_y - B_y M_z \\ -B_z M_x + B_x M_z \\ B_y M_x - B_x M_y \end{pmatrix}$$

* Rotation matrices

$$R_z(\alpha) = \begin{pmatrix} \cos\alpha & \sin\alpha & 0 \\ -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$\Rightarrow$ left-handed convention (clockwise rotation)

$$R_z^{-1}(\alpha) = R_z(-\alpha) = R_{-z}(\alpha)$$

In MR, a common rotation is the precession of the magnetization vector about z-axis at Larmor frequency ω_0.

$$R_z(\omega_0 t) = \begin{pmatrix} \cos\omega_0 t & \sin\omega_0 t & 0 \\ -\sin\omega_0 t & \cos\omega_0 t & 0 \\ 0 & 0 & 1 \end{pmatrix}$$