1. **Trigonometric Identities**
   - $\sin(-x) = -\sin x$
   - $\cos(-x) = \cos x$
   - $\sin^2 x + \cos^2 x = 1$
   - $1 + \tan^2 x = \sec^2 x$
   - $1 + \cot^2 x = \csc^2 x$
   - $\sin(x+y) = \sin x \cos y + \cos x \sin y$
   - $\cos(x+y) = \cos x \cos y - \sin x \sin y$
   - $\tan(x+y) = \frac{\tan x + \tan y}{1 - \tan x \tan y}$
   - $\sin(2x) = 2 \sin x \cos x$
   - $\cos(2x) = \cos^2 x - \sin^2 x$
     $= 2\cos^2 x - 1$
     $= 1 - 2\sin^2 x$
   - $\sin x + \sin y = 2 \sin\left(\frac{x+y}{2}\right) \cos\left(\frac{x-y}{2}\right)$
   - $\sin x - \sin y = 2 \cos\left(\frac{x+y}{2}\right) \sin\left(\frac{x-y}{2}\right)$
   - $\cos x + \cos y = 2 \cos\left(\frac{x+y}{2}\right) \cos\left(\frac{x-y}{2}\right)$
   - $\cos x - \cos y = -2 \sin\left(\frac{x+y}{2}\right) \sin\left(\frac{x-y}{2}\right)$
2. **Complex Numbers**
   - $z = x + jy = re^{j\phi}$
   - $r = |z| = \sqrt{x^2 + y^2}$
   - $\phi = \arctan \frac{y}{x}$
   - $x = r\cos\phi, y = r\sin\phi$
   - $e^{j\phi} = \cos\phi + j\sin\phi$
   - $z^* = x - jy = re^{-j\phi}$
   - $|z|^2 = zz^*$
   - $|z_1 z_2| = |z_1||z_2|, z_1, z_2 \in \mathbb{C}$
   - $\left|\frac{z_1}{z_2}\right| = \frac{|z_1|}{|z_2|}, z_1, z_2 \in \mathbb{C}$
3. **Signal Energy and Power**
   - Energy $E = \lim_{T\to\infty} \int_{-T}^{T} |x(t)|^2 dt$
   - Power $P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 dt$
4. **Standard Signals**
   - Step function $u(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$
   - Unit rectangle $\text{rect}(t) = \begin{cases} 1 & |t| \leq 1/2 \\ 0 & \text{else} \end{cases}$
   - Unit ramp $r(t) = \begin{cases} t & t \geq 0 \\ 0 & \text{else} \end{cases}$
   - Unit triangle $\Delta(t) = \begin{cases} 1 - |t| & |t| \leq 1 \\ 0 & \text{else} \end{cases}$
   - $\text{sinc}(t) \triangleq \frac{\sin(\pi t)}{\pi t}$
   - Impulse function $\delta(t)$ satisfies,
     $\delta(t) = 0 \forall\ t \neq 0,\ \int_{-\infty}^{\infty} \delta(t) dt = 1$
     $f(t)\delta(t-\tau) = f(\tau)\delta(t-\tau)$
     $\int_{-\infty}^{\infty} f(t)\delta(t-\tau) dt = f(\tau)$
   - Impulse train: $\delta_T(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$
5. **System Properties** S is the system, $x(t)$ is input, $y(t)$ is output.
   - BIBO stability: Given $|x(t)| < \infty\ \forall\ t$, $y(t)$ should satisfy $|y(t)| < \infty\ \forall\ t$.
   - Causality: $y(t)$ only depends on past and present values of input.
   - Time invariance: True if $x(t-\tau)$ has output $y(t-\tau)\ \forall \tau$.
   - Linearity: $ax_1(t) + bx_2(t)$ has output $ay_1(t) + by_2(t)$, given $x_1(t)$ and $x_2(t)$ have respective outputs $y_1(t)$ and $y_2(t)$.
   - Memory: If output depends on past and/or future input values.
   - Invertibility: If input can be uniquely recovered from output.
6. **Signal Properties**
   - Odd signal: $x(-t) = -x(t)$
   - Even signal: $x(-t) = x(t)$
   - Real signal: $x^*(t) = x(t)$
   - Purely imaginary signal: $x^*(t) = -x(t)$
7. **Convolution** $x(t)$ is input, $y(t)$ is output, $h(t)$ is impulse response.
   - $y(t) = \int_{-\infty}^{\infty} x(\tau)h(t-\tau) d\tau$
     $= \int_{-\infty}^{\infty} x(t-\tau)h(\tau) d\tau = (x \star h)(t)$
   - $(x \star h)(t) = (h \star x)(t)$
   - $(f \star (g \star h))(t) = ((f \star g) \star h)(t)$
   - $f \star (\alpha g + \beta h) = \alpha(f \star g) + \beta(f \star h)$
   - Time invariant

8. **Fourier Series**
   - Fourier coeff.: $c_k = \frac{1}{T_0}\int_{\tau}^{\tau+T_0} f(t)e^{-jk\omega_0 t}dt$, $\omega_0 = \frac{2\pi}{T_0}$, $k \in \mathbb{Z}$
   - Fourier series: $x(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\omega_0 t}$
   - c_0: average of signal
   - Parseval's Theorem: Power$= \sum_{k=-\infty}^{\infty}|c_k|^2$

9. **Fourier Transform**
   - $F(j\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt$
   - $f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(j\omega)e^{j\omega t}d\omega$
   - Linearity: $\mathcal{F}[af_1(t) + bf_2(t)]$ $= a\mathcal{F}[f_1(t)] + b\mathcal{F}[f_2(t)]$
   - Time scaling: $\mathcal{F}[f(at)] = \frac{1}{|a|}F\left(j\frac{\omega}{a}\right)$
   - Time reversal: $\mathcal{F}[f(-t)] = F(-j\omega)$
   - Complex conjugate: $f^*(t) \Longleftrightarrow F^*(-j\omega)$
   - Duality: $F(t) \Longleftrightarrow 2\pi f(-j\omega)$
   - Time shifting: $\mathcal{F}[f(t-\tau)] = e^{-j\omega\tau}F(j\omega)$
   - Derivative: $\mathcal{F}[f^{'}(t)] = j\omega F(j\omega)$
   - Convolution: $\mathcal{F}[(f_1 \star f_2)(t)] = F_1(j\omega)F_2(j\omega)$
   - Parseval's theorem: Energy $= \int_{-\infty}^{\infty}|f(t)|^2dt$ $= \frac{1}{2\pi}\int_{-\infty}^{\infty}|F(j\omega)|^2d\omega$
   - Multiplication: $\mathcal{F}[f_1(t)f_2(t)]$ $= \frac{1}{2\pi}(F_1 \star F_2)(j\omega)$
   - Modulation: $\mathcal{F}[f(t)e^{j\omega_0 t}] = F(j(\omega - \omega_0))$
   - Periodic signal: $f(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\omega_0 t}$ $\Longleftrightarrow \sum_{k=-\infty}^{\infty} c_k 2\pi\delta(\omega - k\omega_0)$

10. **Fourier Transform Pairs**
    - $\delta(t) \Longleftrightarrow 1$
    - $\delta(t-\tau) \Longleftrightarrow e^{-j\omega\tau}$
    - $1 \Longleftrightarrow 2\pi\delta(\omega)$
    - $u(t) \longleftrightarrow \pi\delta(\omega) + \frac{1}{j\omega}$
    - $e^{j\omega_0 t} \Longleftrightarrow 2\pi\delta(\omega - \omega_0)$
    - $cos(\omega_0 t) \Longleftrightarrow \pi(\delta(\omega - \omega_0) + \delta(\omega + \omega_0))$
    - $sin(\omega_0 t) \Longleftrightarrow j\pi(\delta(\omega + \omega_0) - \delta(\omega - \omega_0))$
    - $\text{rect}(t/T) \Longleftrightarrow T\text{sinc}(\omega T/2\pi)$
    - $e^{-at}u(t) \Longleftrightarrow \frac{1}{a+j\omega}$
    - $e^{-a|t|} \Longleftrightarrow \frac{2a}{a^2+\omega^2}$
    - $\text{sinc}(t/2\pi) \Longleftrightarrow 2\pi\text{rect}(\omega)$
    - $\Delta(t) \Longleftrightarrow \text{sinc}^2(\omega/2\pi)$
    - $\text{sinc}^2(t) \Longleftrightarrow \Delta(\omega/2\pi)$
    - $\delta_T(t) \Longleftrightarrow \omega_0\delta_{\omega_0}(\omega)$
    - $\sum_{k=-\infty}^{\infty}\delta(t-kT) \Longleftrightarrow \frac{2\pi}{T}\sum_{k=-\infty}^{\infty}\delta(\omega - \frac{2\pi k}{T})$

11. **Sampling Theorem:** Given a bandlimited signal with bandwidth B Hz, for perfect recovery, the sampling rate $\frac{1}{T}$ must satisfy $\frac{1}{T} \geq 2B$.

12. **Laplace Transform**
    - Unilateral Laplace transform: $F(s) = \int_0^{\infty} f(t)e^{-st}dt$. Remember, a Laplace transform is incomplete without it's region of convergence (RoC).
    - Linearity: $\mathcal{L}[af_1(t) + bf_2(t)]$ $= a\mathcal{L}[f_1(t)] + b\mathcal{L}[f_2(t)]$
    - Time scaling: $\mathcal{L}[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$
    - Time shifting: $\mathcal{L}[f(t-\tau)] = e^{-s\tau}F(s)$
    - Frequency shift: $\mathcal{L}[f(t)e^{s_0 t}] = F(s - s_0)$
    - Convolution: $\mathcal{L}[(f_1 \star f_2)(t)] = F_1(s)F_2(s)$
    - Integration: $\mathcal{L}[\int_0^t f(\tau)d\tau] = \frac{1}{s}F(s)$
    - Derivative: $\mathcal{L}[f^{'}(t)] = sF(s) - f(0)$
    - Multiplication by t: $\mathcal{L}[tf(t)] = -F'(s)$

13. **Unilateral Laplace Transform Pairs**
    - $\delta(t) \Longleftrightarrow 1$, ROC: All s
    - $u(t) \Longleftrightarrow \frac{1}{s}$, ROC: $Re\{s\} > 0$
    - $r(t) \Longleftrightarrow \frac{1}{s^2}$, ROC: $Re\{s\} > 0$
    - $e^{-at}u(t) \Longleftrightarrow \frac{1}{a+s}$, ROC: $Re\{s\} > -Re\{a\}$
    - $cos(\omega_0 t) \Longleftrightarrow \frac{s}{s^2+\omega_0^2}$, ROC: $Re\{s\} > 0$
    - $sin(\omega_0 t) \Longleftrightarrow \frac{\omega_0}{s^2+\omega_0^2}$, ROC: $Re\{s\} > 0$
    - $\frac{r}{(k-1)!}t^{k-1}e^{\lambda t} \Longleftrightarrow \frac{r}{(s-\lambda)^k}$, ROC: $Re\{s\} > Re\{\lambda\}$