absolutely summable impulse response: $\sum |h[n]|$ is finite. **EX:** $\sum_{n=0}^{\infty}(\frac{3}{4})^n = \frac{1}{1-\frac{3}{4}} = 4$ but $\sum_{n=1}^{\infty}\frac{1}{n} \to \infty$.
Necessary and sufficient for **BIBO stability** of an **LTI** system. Also see **poles**.

---

affine system $y[n] = ax[n] + b$ for constants a and $b \neq 0$. This is a linear-plus-constant function.
Affine systems are *not* **linear systems**, although they do look like linear systems.

---

aliasing **EX:** $x(t) = \cos(2\pi 6t)$ **sampled** at 10 Hz: $t = \frac{n}{10} \to x[n] = \cos(1.2\pi n) = \cos(0.8\pi n)$.
Ideal **interpolation** (for a **sinusoid**) $n = 10t \to x(t) = \cos(2\pi 4t)$. 6 Hz aliased to 4.
Can avoid aliasing by **sampling** faster than **Nyquist** rate, or use an **antialias** filter.

---

amplitude of a **sinusoid**: $|A|$ in sinusoidal signal $A\cos(\omega t + \theta)$. Amplitude is always ≥ 0.

---

antialias filter Analog lowpass filter that ensures that the **sampling** rate exceeds **Nyquist** rate,
ensuring that **aliasing** does not occur during interpolation of the sampled signal.

---

argument of a complex number: another name for **phase**. Matlab: `angle(1+j)`=0.7854=$\pi/4$.

ARMA Auto-Regressive Moving-Average **difference equation**. $\#y[n] > 1$ and $\#x[n] > 1$.

---

average power Continuous time: Average power=$MS(x) = \frac{1}{T}\int_0^T |x(t)|^2 dt$ for $x(t)$ period=T.
Discrete time: Average power=$MS(x) = \frac{1}{N}\sum_{n=0}^{N-1}|x[n]|^2$ for $x[n]$ period=N.

---

band-pass filter (BPF) **Filter** with **frequency response** $H(e^{j\omega})$ small at **DC** $\omega = 0$ and small at $\omega = \pi$,
but large at some intermediate band $a < \omega < b$. BPFs reduce high-frequency noise.

---

bandwidth Maximum **frequency** in a cont.-time signal $x(t)$. Sometimes defined as twice this.

---

beat signal **EX:** $\cos(99t) + \cos(101t) = 2\cos(1t)\cos(100t)$ like varying **amplitude** $\cos(100t)$.
This beating sound can be used to tune a piano; also models a tone on AM radio.

BIBO stable Bounded-Input-Bounded-Output system: $x[n] \to \boxed{\textbf{BIBO}} \to y[n]$. Means:
If $|x[n]| \leq M$ for some constant M, then $|y[n]| \leq N$ for some constant N.
An **LTI** system is BIBO stable iff all of its **poles** are inside the unit circle.

---

cascade connection of systems: $x[n] \to \boxed{\textbf{g[n]}} \to \boxed{\textbf{h[n]}} \to y[n]$. Overall **impulse response**:
$y[n] = h[n] * (g[n] * x[n]) = (h[n] * g[n]) * x[n] \to$ **convolve** their **impulse responses**.

---

causal: **signal**: $x[n] = 0$ for $n < 0$; causal **system** has a causal **impulse response** $h[n]$.

---

comb filter $y[n] = x[n] + x[n-1] + \ldots + x[n-M+1]$ eliminates all $A_k\cos(\frac{2\pi}{M}kn + \theta_k)$ in $x[n]$.
transfer function=$H(z) = (z - e^{j\frac{2\pi}{M}})\ldots(z - e^{j\frac{2\pi}{M}(M-1)})/z^{M-1}$ has **zeros** at $e^{j\frac{2\pi}{M}k}$,
which are the M^{th} **roots of unity**. Eliminates all **harmonics** of periodic function.

---

complex conjugate of complex number $z = x + jy$ is $z^* = x - jy$; of $z = Me^{j\theta}$ is $z^* = Me^{-j\theta}$.
Properties: $|z|^2 = zz^*$; $Re[z] = \frac{1}{2}(z + z^*)$; $Im[z] = \frac{1}{2j}(z - z^*)$; $e^{j2\angle z} = \frac{z}{z^*}$.

---

complex exponential Continuous time: $x(t) = e^{j\omega t}$. Discrete time: $x[n] = e^{j\omega n}$ where ω=**frequency**.
Fourier series are expansions of periodic signals in terms of these functions.

---

complex plane	Plot of **Imaginary part** of complex number vs. **real part** of complex number. You can visualize $z = 3 + j4$ at Cartesian coordinates $(3, 4)$ in the complex plane.
conjugate symmetry	If $x(t)$ is real-valued, then $x_{-k} = x_k^*$ in its **Fourier series** expansion, where x_k^* is **complex conjugate** of x_k. **DFT:** If $x[n]$ is real-valued, then $X_{N-k} = X_k^*$
convolution	$y[n] = h[n] * x[n] = \sum_{i=0}^{n} h[i]x[n-i] = \sum_{i=0}^{n} h[n-i]x[i]$ if $h[n]$ and $x[n]$ **causal**. $x[n] \rightarrow$ |**LTI**| $\rightarrow y[n] = h[n] * x[n]$ where $h[n]$=**impulse response** of **LTI** system.
correlation	Continuous time: $C(x, y) = \int x(t)y(t)^* dt$. Discrete time: $C(x, y) = \sum x[n]y[n]^*$.
correlation coefficient	$C_N(x, y) = \frac{C(x,y)}{\sqrt{C(x,x)C(y,y)}}$ where $C(x, y)$=**correlation** and $C(x, x) = E(x)$=**energy**. $\|C_N(x, y)\| \leq 1$ by Cauchy-Schwarz$\neq$, so $C_N(x, y)$=(the similarity of $x[n]$ and $y[n]$).
DC	term in **Fourier series** is constant x_0 or a_0 (continuous time) or X_0 (discrete time). DC means Direct Current, which does not vary with time, vs. AC, which is a **sinusoid**.
delay	$x[n]$ delayed by $D > 0$ is $x[n - D]$: D seconds later; shift $x[n]$ graph right by $D > 0$.
DFT	N-point DFT of $\{x[n]\}$ is $X_k = \frac{1}{N} \sum_{n=0}^{N-1} x[n]e^{-j\frac{2\pi}{N}nk}$ for $k = 0, 1 \ldots N - 1$. Use **fft**. Discrete Fourier Transform computes coefficients X_k of the discrete-time Fourier series $x[n] = X_0 + X_1 e^{j\frac{2\pi}{N}n} + X_2 e^{j\frac{4\pi}{N}n} + \ldots + X_{N-1}e^{j2\pi\frac{N-1}{N}n}$ where $x[n]$ has period=N.
difference equation	$y[n] + a_1 y[n-1] + \ldots + a_N y[n-N] = b_0 x[n] + b_1 x[n-1] + \ldots + b_M x[n-M]$. **ARMA**; describes an **LTI** system; this is how it is actually implemented on a chip.
duration	Continuous time: If signal **support**=$[a, b] \rightarrow$ duration=$(b - a)$=how long it lasts. Discrete time: If signal **support**=$[a, b] \rightarrow$ duration=$(b - a + 1)$. Note the "+1".
energy	Continuous: $E(x) = \int_a^b \|x(t)\|^2 dt$. Discrete: $E(x) = \sum_{n=a}^{b} \|x[n]\|^2$ if **support**=$[a, b]$.
Euler's	**formula**: $e^{j\theta} = \cos\theta + j\sin\theta$. **Polar$\Leftrightarrow$rectangular**: $Me^{j\theta} = M\cos\theta + jM\sin\theta$.
even function	$x(t) = x(-t)$: $x(t)$ is symmetric about the vertical axis $t = 0$. **EX:** $\cos(t), t^2, t^4$. A **periodic** even function has **Fourier series** having $b_k = 0$ and x_k real numbers.
`fft`	Matlab command that computes **DFT**. Use: `fft(X,N)/N`. See also `fftshift`.
`fftshift`	Matlab command that swaps first and second halves of a vector. Used with `fft`. Displays the **line spectrum** with negative **frequencies** to left of positive ones.
filter	**LTI** system with **frequency response** performing some task, e.g., **noise** reduction.
FIR	Finite Impulse Response system: its **impulse response** $h[n]$ has finite **duration**. FIR systems are: also **MA** systems; always **BIBO stable**; all **poles** are at **origin**.
Fourier series	$x(t) = x_0 + x_1 e^{j\frac{2\pi}{T}t} + x_2 e^{j\frac{4\pi}{N}t} + x_3 e^{j\frac{6\pi}{N}t} + \ldots + x_1^* e^{-j\frac{2\pi}{T}t} + x_2^* e^{-j\frac{4\pi}{N}t} + x_3^* e^{-j\frac{6\pi}{N}t} + \ldots$ where $x_k = \frac{1}{T}\int_0^T x(t)e^{-j\frac{2\pi}{T}kt}dt$ for integers k and $x(t)$ is real-valued with period=T.

Fourier series (trig form)	$x(t)=a_0+a_1\cos(\frac{2\pi}{T}t)+a_2\cos(\frac{4\pi}{T}t)+\ldots+b_1\sin(\frac{2\pi}{T}t)+b_2\cos(\frac{4\pi}{T}t)+\ldots$ where $a_k=\frac{2}{T}\int_0^T x(t)\cos(\frac{2\pi}{T}kt)\,dt$ and $b_k=\frac{2}{T}\int_0^T x(t)\sin(\frac{2\pi}{T}kt)\,dt$ and $x(t)$ has period=T. **BUT:** note $a_0=\frac{1}{T}\int_0^T x(t)\,dt=M(x)$=**DC** term is a special case: note $\frac{1}{T}$, not $\frac{2}{T}$.
frequency	of a **sinusoid**: ω in signal $A\cos(\omega t+\theta)$. Units of $\omega:\frac{\text{RAD}}{\text{SEC}}$. Units of $f=\frac{\omega}{2\pi}$: Hertz.
frequency response	$H(e^{j\omega})=H(z)\vert_{z=e^{j\omega}}$ where $H(z)$ is **transfer function**. Sometimes write: $H(\omega)$. $\cos(\omega_o n)\rightarrow\boxed{\textbf{LTI}}\rightarrow A\cos(\omega_o n+\theta)$ where $H(e^{j\omega_o})=Ae^{j\theta}$. A=**gain** of system. $x[n]=\sum X_k e^{j\frac{2\pi}{N}kn}\rightarrow\boxed{\textbf{LTI}}\rightarrow y[n]=\sum Y_k e^{j\frac{2\pi}{N}kn}$ where $Y_k=H(e^{j\frac{2\pi}{N}k})X_k$.
fundamental	**Sinusoid** $c_1\cos(\frac{2\pi}{T}t+\theta_1)$ at **frequency** $\frac{1}{T}$ Hertz in **Fourier series** of **periodic** $x(t)$.
gain	Gain=$\vert H(e^{j\omega})\vert$=**magnitude** of **frequency response**. Describes **filtering** effect.
harmonic	**Sinusoid** $c_k\cos(\frac{2\pi}{T}kt+\theta_k)$ at **frequency** $\frac{k}{T}$ Hz in **Fourier series** of **periodic** $x(t)$.
high-pass filter (HPF)	**Filter** with **frequency response** $H(e^{j\omega})$ small at **DC** $\omega=0$ and large at $\omega=\pi$. HPFs enhance edges in images and signals, but also amplify high-frequency noise.
histogram	Plot of #times a signal value lies in a given range vs. range of signal values (bins). Can be used to compute good approximations to **mean**, **mean square**, **rms**, etc.
IIR	Infinite Impulse Response system: **impulse response** $h[n]$ has infinite **duration**.
imaginary part	of a complex number: $Im[x+jy]=y$; $Im[Me^{j\theta}]=M\sin\theta$. Matlab: `imag(3+4j)`=4. Note that the imaginary part of $3+j4$ is 4, **NOT** j4! A **VERY** common mistake!
impulse	Discrete time: $\delta[n]=0$ unless $n=0$; $\delta[0]=1$. Continuous time: wait for EECS 306.
impulse response	$h[n]$: Response to an impulse: $\delta[n]\rightarrow\boxed{\textbf{LTI}}\rightarrow h[n]$. y[n]=$b_0$x[n]+...+$b_M$x[n-M], $x[n]\rightarrow\boxed{\textbf{LTI}}\rightarrow y[n]=h[n]*x[n]$; see **convolution**. then $h[n]=\{b_0,b_1\ldots b_M\}$.
inter-ference	A signal nature (60 Hz) or humans (jamming) adds to a desired signal that obscures the desired signal. Unlike added **noise**, interference is usually known approximately.
interp-olation	The act of reconstructing $x(t)$ from its **samples** $x[n]=x(t=n\Delta)$. Also: D-to-A. Zero-order hold: $\hat{x}(t)=x[n]$ for $\{n\Delta<t<(n+1)\Delta\}$; linear; exact using a **sinc**. Exact interpolation of discrete **Fourier series**: set $n=t/\Delta$ in all the **sinusoids**.
inverse z-xform	Get $x[n]$ from its **z-xform** $X(z)=\mathcal{Z}\{x[n]\}$. **EX:** $X(z)=\frac{z}{z-3}\rightarrow x[n]=3^n u[n]$. Do this by inspection or **partial fraction expansion** of **rational function** $X(z)$.
line spectrum	Plot of the x_k in **Fourier series** of a signal vs. **frequency** ω. Also for X_k in **DFT**. x_k is depicted in plot by a vertical line of height $\vert x_k\vert$ at $\omega=\frac{2\pi}{T}k$ where T=**period**.

linear combination	of two signals $x_1[n]$ and $x_2[n]$ is the signal $(ax_1[n]+bx_2[n])$ for constants a and b. **Lin. system**: Response to linear combination is linear combination of responses.
linear system	This means that if $x_1[n] \to$ |**LINEAR**| $\to y_1[n]$ and $x_2[n] \to$ |**LINEAR**| $\to y_2[n]$ then $(ax_1[n]+bx_2[n]) \to$ |**LINEAR**| $\to (ay_1[n]+by_2[n])$ for any constants a and b. Often works: if doubling input $x[n]$ doubles output $y[n]$, system is likely to be linear.
low-pass filter (LPF)	**Filter** with **frequency response** $H(e^{j\omega})$ large at **DC** $\omega=0$ and small at $\omega=\pi$. LPFs smooth edges in images and signals, but they do reduce high-frequency noise.
LTI system	is both **Linear** and **Time-Invariant**. So what? See **IMPULSE RESPONSE** and **FREQUENCY RESPONSE**.
MA	Moving-Average **difference equation**: $y[n]=b_0x[n]+b_1x[n-1]+\ldots+b_Mx[n-M]$. MA systems are: also **FIR** systems; always **BIBO stable**; all **poles** are at **origin**.
magnitude	of a complex number: $\|Me^{j\theta}\|=M$; $\|x+jy\|=\sqrt{x^2+y^2}$. Matlab: `abs(3+4j)`=5.
Matlab	Computer program used universally in communications, control, and signal processing. Matlab has been known to drive people crazy (look at what happened to me :)).
mean	Cont.: $M(x)=\frac{1}{T}\int_0^T x(t)dt$ for $x(t)$ period=T. $M(x)=x_0=a_0$ in **Fourier series**. Disc.: $M(x)=\frac{1}{N}\sum_{n=0}^{N-1}x[n]$ for $x[n]$ period=N. $M(x)=X_0$ in the **DFT** of $x[n]$.
mean square	Cont.: $MS(x)=\frac{1}{T}\int_0^T \|x(t)\|^2dt=M(x^2)\neq(M(x))^2$ for $x(t)$ periodic with period=T. Disc.: $MS(x)=\frac{1}{N}\sum_{n=0}^{N-1}\|x[n]\|^2$ for $x[n]$ period=N. Mean square=**average power**.
mean square error	**Fourier series** Periodic $x(t)=x_0+x_1e^{j\frac{2\pi}{T}t}+\ldots+x_1^*e^{-j\frac{2\pi}{T}t}+\ldots$ (infinite series). $\hat{x}(t)=x_0+x_1e^{j\frac{2\pi}{T}t}+\ldots+x_Me^{j\frac{2\pi}{T}Mt}+x_1^*e^{-j\frac{2\pi}{T}t}+\ldots+x_M^*e^{-j\frac{2\pi}{T}Mt}$ (finite series). MSE=MS$(x(t)-\hat{x}(t))$ is the **mean square** error in approximating $x(t)$ with $\hat{x}(t)$.
noise	An unknown signal that nature adds to a desired signal that obscures desired signal. A **lowpass filter** often helps reduce noise, while (mostly) keeping the desired signal.
notch filter	$y[n]=x[n]-2\cos(\omega_o)x[n-1]+x[n-2]$ eliminates $A\cos(\omega_on+\theta)$ component in $x[n]$. **transfer function**=$(z-e^{j\omega_o})(z-e^{-j\omega_o})/z^2$ has: **zeros** at $e^{\pm j\omega_o}$; **poles** at **origin**.
Nyquist sampling	**Sampling** a continuous-time signal $x(t)$ at twice its **bandwidth** (minimum rate). The minimum sampling rate for which $x(t)$ can be **interpolated** from its samples.
odd function	$x(t)=-x(-t)$: $x(t)$ is antisymmetric about the vertical axis $t=0$. **EX:** $\sin(t),t,t^3$. A **periodic** odd function has Fourier series having $a_k=0$ and x_k pure imaginary.
order	of this **MA** (also **FIR**) system is M: $y[n]=b_0x[n]+b_1x[n-1]+\ldots+b_Mx[n-M]$.
origin	of the **complex plane** is at Cartesian coordinates $(0,0)$. An elegant name for 0+j0.
orthogonal	signals $x(t)$ and $y(t)$ have **correlation** $C(x,y)=0$; $MS(x+y)=MS(x)+MS(y)$. **complex exponentials** and **sinusoids** that are **harmonics** yields **Fourier series**.

Parseval's theorem
Cont.: $\frac{1}{T}\int_0^T |x(t)|^2 dt = \sum_{k=-\infty}^{\infty} |x_k|^2 = a_0^2 + \frac{1}{2}\sum_{k=1}^{\infty}(a_k^2 + b_k^2)$ (see **Fourier series**).
Discrete time: $\frac{1}{N}\int_0^T |x[n]|^2 = \sum_{k=0}^{N-1} |X_k|^2$ where $\{X_k\}$ are the N-point **DFT** of $x[n]$.
States that **average power** can be computed in either the time or Fourier domains.

---

partial fraction expansion
of $\textbf{RATIONAL FUNCTION}$ $H(z) = \frac{N(z)}{D(z)} = \frac{A_1}{z-p_1} + \ldots + \frac{A_N}{z-p_N}$. Need: degree $D(z) >$ degree $N(z)$.
$\{p_1 \ldots p_N\}$ are the **poles** of the **transfer function** $H(z)$; $\{A_n\}$ are its **residues**.
Used to compute the **inverse z-transform** of a **rational function** by inspection.

---

periodic function
$x(t)$ has period=T $\rightarrow x(t) = x(t \pm T) = x(t \pm 2T) = x(t \pm 3T) = \ldots$ for ALL time t.
$A\cos(\omega t+\theta)$ has period $T = \frac{2\pi}{\omega}$; $A\cos(\omega n+\theta)$ is not periodic unless $\omega = 2\pi\frac{\text{RATIONAL}}{\text{NUMBER}}$.

---

phase of *complex number:* $\angle(Me^{j\theta}) = \theta$; $\angle(x+jy) = \tan^{-1}(\frac{y}{x})$. Use `angle(1+j)`$=\pi/4$.
phase of *a sinusoid:* θ in the **sinusoid** $A\cos(\omega t+\theta)$. Add π if $M<0, A<0$ or $x<0$ above.

---

phasor
Complex number $Me^{j\theta}$ used to represent sinusoid $M\cos(\omega t+\theta)$. So why do this?
$A\cos(\omega t+\theta) + B\cos(\omega t+\phi) = C\cos(\omega t+\psi) \Leftrightarrow Ae^{j\theta} + Be^{j\phi} = Ce^{j\psi}$ (much easier!).

---

polar form
of complex number: $Me^{j\theta}$; M=**magnitude**=distance from **origin** of **complex plane**
at angle θ=**phase** from real axis. z=x+jy$\rightarrow$M=$\sqrt{x^2+y^2}$; $\theta = \tan^{-1}(\frac{y}{x})$ if $x>0$.

---

poles
of a **rational-function transfer-function** $H(z) = \frac{N(z)}{D(z)}$ are the roots of $D(z) = 0$.
EX: $H(z) = \frac{z^2-3z+2}{z^2-7z+12} \rightarrow z^2-7z+12 = 0 \rightarrow \{\text{poles}\} = \{3,4\}$. `roots([1 -7 12]`=3,4.
An **LTI** system is **BIBO stable** if and only if all poles are inside the **unit circle**.

---

pole-zero diagram
Plot of **poles** using **X**'s and **zeros** using **O**'s of **LTI** system in the **complex plane**.
If all **X**'s are inside the **unit circle**, then system is **BIBO stable**. Matlab: `zplane(N,D)`.

---

quantization
of $x[n]$ represents each value of $x[n]$ with a finite #bits=N, so $x[n]$ can take 2^N values.
Produces slight roundoff error, which is neglected in EECS 206 since N=16 or 32.

---

rational function
of z is the ratio of two polynomials in z, so it has a **partial fraction expansion**.
Transfer functions in EECS 206 are rational functions with finite #**poles** & **zeros**.

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residues
The constants $\{A_n\}$ in the **partial fraction expansion** of a **rational function**.

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real part
of a complex number: $Re[x+jy] = x$; $Re[Me^{j\theta}] = M\cos\theta$. Matlab: `real(3+4j)`=3.

---

rectangular form
of complex number: $x+jy$. Coordinates (x,y) in **complex plane**. cf. **polar form**.
x=**real part**; y=**imaginary part**. z=$Me^{j\theta}$ $\rightarrow$ x=$M\cos\theta$; y=$M\sin\theta$ $\Leftrightarrow$ P$\rightarrow$R key.

---

rms
$\sqrt{\frac{1}{T}\int_0^T |x(t)|^2 dt} = \sqrt{MS(x)} = \sqrt{M(x^2)}$. **EX:** rms$[A\cos(\omega t+\theta)] = \frac{A}{\sqrt{2}}$ if $\omega \neq 0$.

M roots of unity
The M solutions to $z^M = 1$, which are $z = e^{j\frac{2\pi}{M}k}$ for $k = 1\ldots M$. *Unity* means "1."
The **zeros** of a **comb filter** are the M^{th} roots of unity, excluding the root $z=1$.

---

running correlation — **Correlation** between a signal and **delayed** versions of another signal, regarded as a function of the **delay**: $RC[n]=C(x[i],y[i-n])$. Used for time delay estimation.

sampling — Act of constructing $x[n]=x(t=n\Delta)$ from values of $x(t)$ at integer multiples of Δ.

sawtooth — **Periodic** $x(t)=at$ for $0<t<b$ and $x(t)=0$ for $b<t<c$ (like chain of triangles).

sinc — $\text{sinc}(x)=\frac{\sin \pi x}{\pi x}$. Used in ideal interpolator, and also in $h[n]$ for ideal lowpass filter.

sinusoid — A function of time of the form $x(t)=A\cos(\omega t+\theta)=(\frac{A}{2}e^{j\theta})e^{j\omega t}+(\frac{A}{2}e^{-j\theta})e^{-j\omega t}$.

spectrum — See **line spectrum**. In EECS 206, all spectra are line spectra. Not so in EECS 306.

square wave — **Periodic** $x(t)=a$ for $c<t<d$ and $x(t)=b$ for $d<t<e$ (like chain of squares). $x(t)$ has **period**=e-c and "duty cycle" $\frac{d-c}{e-c}$ if $a>b$, so that a="on" and b="off."

stem plot — Plot of discrete-time signal using chain of vertical lines topped with circles. `stem(X)`.

step function — $u(t)=\begin{cases}1 & \text{for } t>0\\ 0 & \text{for } t<0\end{cases}$ and $u[n]=\begin{cases}1 & \text{for } n\geq 0\\ 0 & \text{for } n\leq -1\end{cases}$. Note that $u[0]=1$.

step response — $s[n]$: Response of a system to a **step function**: $u[n]\rightarrow \boxed{\textbf{LTI}}\rightarrow s[n]$

superposition — of two signals $x_1[n]$ and $x_2[n]$ is the signal $(ax_1[n]+bx_2[n])$ for constants a and b. **Linear system**: Response to a superposition is the superposition of the responses. Another term for **linear combination**, but applied specifically to system inputs.

support — of $x(t)$ is interval $[a,b]$ means that $x(t)=0$ for all $t>a$ and $t<b$. Same for $x[n]$.

system function — Another name for **transfer function** $H(z)$. Term used mostly in DSP.

Time-Invariance — If $x[n]\rightarrow \boxed{\textbf{TI}}\rightarrow y[n]$ then $x[n-D]\rightarrow \boxed{\textbf{TI}}\rightarrow y[n-D]$ for any constant **delay** D. A system is TI if there are no "n"s outside brackets. **EX:** $y[n]=nx[n]$ is *not* TI.

time scale — $x(at)$ is $x(t)$ compressed if $a>1$; expanded if $0<a<1$; time-reversed if $a<0$.

transfer function — $H(z)=\mathcal{Z}\{h[n]\}$=**z-transform** of **impulse response** of an **LTI** system. So what? Relates: **IMPULSE RESPONSE**, **FREQUENCY RESPONSE**, **DIFFERENCE EQUATION**, **POLE–ZERO DIAGRAM** descriptions.

triangle — **Periodic** $x(t)=a-|t|$ for $|t|<a$ and $x(t)=0$ rest of period (chain of triangles).

unit circle — The circle $\{z:|z|=1\}=\{z:z=e^{j\omega}\}$ in the **complex plane**, centered at **origin**. An **LTI** system is **BIBO stable** if and only if all **poles** are inside the unit circle.

zeros — of a **rational-function transfer-function** $H(z)=\frac{N(z)}{D(z)}$ are the roots of $N(z)=0$. **EX:** $H(z)=\frac{z^2-3z+2}{z^2-7z+12}\rightarrow z^2-3z+2=0\rightarrow\{\text{zeros}\}=\{1,2\}$. `roots([1 -3 2]`=1,2.

z-xform — of $x[n]$ is $X(z)=\mathcal{Z}\{x[n]\}=x[0]+x[1]z^{-1}+x[2]z^{-2}+\ldots$ **EX:** $\mathcal{Z}\{\underline{3},1,4\}=\frac{3z^2+z+4}{z^2}$.