Discrete Distributions

Distribution	Parameters	Possible Description	Range Ω_X	$\mathbb{E}[\mathbf{X}]$	$\mathbf{Var}(\mathbf{X})$	PDF/PMF	CDF ($\mathbb{P}(X \le x)$)
Uniform (disc)	$X \sim Unif(a,b)$ for $a,b \in \mathbb{Z}$ and $a \le b$	Equally likely to be any *integer* in $[a,b]$	$\{a,\ldots,b\}$	$\frac{a+b}{2}$	$\frac{(b-a)(b-a+2)}{12}$	$\frac{1}{b-a+1}$	
Bernoulli	$X \sim Ber(p)$ for $p \in [0,1]$	Takes value 1 with prob p and 0 with prob $1-p$	$\{0,1\}$	p	$p(1-p)$	$p^k(1-p)^{1-k}$	
Binomial	$X \sim Bin(n,p)$ for $n \in \mathbb{N}$, $p \in [0,1]$	Sum of n independent Bernoulli trials, each with parameter p	$\{0,1,\ldots,n\}$	np	$np(1-p)$	$\binom{n}{k}p^k(1-p)^{n-k}$	
Poisson	$X \sim Poi(\lambda)$ for $\lambda > 0$	# of events that occur in a unit of time independently with rate λ per unit time	$\{0,1,\ldots\}$	λ	λ	$e^{-\lambda}\frac{\lambda^k}{k!}$	
Geometric	$Geo(p)$ for $p \in [0,1]$	# of independent Bernoulli trials with parameter p up to and including first success	$\{1,2,\ldots\}$	$\frac{1}{p}$	$\frac{1-p}{p^2}$	$(1-p)^{k-1}p$	$1-(1-p)^x$
Hypergeometric	$HypGeo(N,K,n)$ for $n,K \le N$ and $n,K,N \in \mathbb{N}$	# of successes in n draws (w/out replacement) from N items that contain K successes in total	$\{\max(0,n+K-N),$ $\ldots,\min(n,K)\}$	$n\frac{K}{N}$	$n\frac{K(N-K)(N-n)}{N^2(N-1)}$	$\frac{\binom{K}{k}\binom{N-K}{n-k}}{\binom{N}{n}}$	
Negative Binomial	$NegBin(r,p)$ for $r \in \mathbb{N}, p \in [0,1]$	# of trials until r^{th} success in Bernoulli process	$\{r,r+1,\ldots\}$	$\frac{r}{p}$	$\frac{r(1-p)}{p^2}$	$\binom{k-1}{r-1}p^r(1-p)^{k-r}$	
Multinomial	$\mathbf{X} \sim Mult_r(n,\mathbf{p})$ for $r,n \in \mathbb{N}$ and $\mathbf{p} = (p_1,p_2,...,p_r)$, $\sum_{i=1}^r p_i = 1$	generalization of the binomial distribution, n trials with r categories each with probability p_i	$k_i \in \{0,\ldots,n\}$, $i \in \{1,\ldots,r\}$ and $\Sigma k_i = n$	$\mathbb{E}[\mathbf{X}] = n\mathbf{p} = \begin{bmatrix} np_1 \\ \vdots \\ np_r \end{bmatrix}$	$Var(X_i) = np_i(1-p_i)$ $Cov(X_i,X_j) =$ $-np_ip_j, i \ne j$	$\binom{n}{k_1,\ldots,k_r}\prod_{i=1}^r p_i^{k_i}$	
Multivariate Hypergeometric	$\mathbf{X} \sim$ $MVHG_r(N,\mathbf{K},n)$ for $r,n \in \mathbb{N}$, $\mathbf{K} \in \mathbb{N}^r$ and $N = \sum_{i=1}^r K_i$	generalization of the hypergeometric distribution, n draws from r categories each with K_i successes (w/out replacement)	$k_i \in \{0,\ldots,K_i\}$, $i \in \{1,\ldots,r\}$ and $\Sigma k_i = n$	$\mathbb{E}[\mathbf{X}] = n\frac{\mathbf{K}}{N} = \begin{bmatrix} n\frac{K_1}{N} \\ \vdots \\ n\frac{K_r}{N} \end{bmatrix}$	$Var(X_i) =$ $n\frac{K_i}{N}\cdot\frac{N-K_i}{N}\cdot\frac{N-n}{N-1}$ $Cov(X_i,X_j) =$ $-n\frac{K_i}{N}\frac{K_j}{N}\cdot\frac{N-n}{N-1}, i \ne j$	$\frac{\prod_{i=1}^r\binom{K_i}{k_i}}{\binom{N}{n}}$	

Continuous Distributions							
Distribution	**Parameters**	**Possible Description**	**Range Ω_X**	$\mathbb{E}[\mathbf{X}]$	$\mathbf{Var}(\mathbf{X})$	**PDF/PMF**	**CDF** $(\mathbf{F_X}(\mathbf{x}) = \mathbb{P}(\mathbf{X} \leq \mathbf{x}))$
Uniform	$Unif(a, b)$ for $a < b$	Equally likely to be any real number in $[a, b]$	$[a, b]$	$\frac{a+b}{2}$	$\frac{(b-a)^2}{12}$	$\frac{1}{b-a}$	$\begin{cases} 0 & \text{if } x < a \\ \frac{x-a}{b-a} & \text{if } a \leq x < b \\ 1 & \text{if } x \geq b \end{cases}$
Exponential	$Exp(\lambda)$ for $\lambda > 0$	Time until next event in Poisson process	$[0, \infty)$	$\frac{1}{\lambda}$	$\frac{1}{\lambda^2}$	$\lambda e^{-\lambda x}$	$\begin{cases} 0 & \text{if } x < 0 \\ 1 - e^{-\lambda x} & \text{if } x \geq 0 \end{cases}$
Normal	$\mathcal{N}(\mu, \sigma^2)$ for $\mu \in \mathbb{R}$, $\sigma^2 > 0$	Standard bell curve	$(-\infty, \infty)$	μ	σ^2	$\frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$	$\Phi\left(\frac{x-\mu}{\sigma}\right)$
Gamma	$Gam(r, \lambda)$ for $r, \lambda > 0$	Time to r^{th} event in Poisson process. Conjugate prior for Exp, Poi parameter λ	$(0, \infty)$	$\frac{r}{\lambda}$	$\frac{r}{\lambda^2}$	$\frac{\lambda^r}{\Gamma(r)} x^{r-1} e^{-\lambda x}$	Note: $\Gamma(r) = (r-1)!$ for integers r.
Beta	$Beta(\alpha, \beta)$ for $\alpha, \beta > 0$	Conjugate prior for Ber, Bin, Geo, NegBin parameter p.	$(0, 1)$	$\frac{\alpha}{\alpha+\beta}$	$\frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$	$\frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} x^{\alpha-1}(1-x)^{\beta-1}$	
Dirichlet	$\mathbf{X} \sim Dir(\alpha_1, \alpha_2, \ldots, \alpha_r)$ for $\alpha_i, r > 0$ and $r \in \mathbb{N}, \alpha_i \in \mathbb{R}$	Generalization of Beta distribution. Conjugate prior for Multinomial parameter $\mathbf{p}$	$x_i \in (0, 1)$; $\sum_{i=1}^r x_i = 1$	$\mathbb{E}[X_i] = \frac{\alpha_i}{\sum_{j=1}^r \alpha_j}$		$\frac{1}{B(\alpha)} \prod_{i=1}^r x_i^{a_i - 1}$, $x_i \in (0, 1), \sum_{i=1}^r x_i = 1$	
Multivariate Normal	$\mathbf{X} \sim \mathcal{N}_n(\boldsymbol{\mu}, \boldsymbol{\Sigma})$ for $\boldsymbol{\mu} \in \mathbb{R}^n$ and $\boldsymbol{\Sigma} \in \mathbb{R}^{n \times n}$	Multivariate generalization of Normal distribution.	$\mathbb{R}^n$	$\boldsymbol{\mu}$	$\boldsymbol{\Sigma}$	$\frac{1}{(2\pi)^{n/2}\|\Sigma\|^{1/2}} \cdot \exp(-\frac{1}{2}(\boldsymbol{x}-\boldsymbol{\mu})^T \Sigma^{-1} (\boldsymbol{x}-\boldsymbol{\mu}))$	