

# CS70 In Simpler Terms - Note 6

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## 1 Uniform Distribution

$Unif\{1, 2, \dots, n\}$ , deals with the set  $= \{1, 2, \dots, n\}$

- Rolling Dice problems -  $n = 6$
- $Pr(X = x) = \frac{1}{n} = \frac{1}{6}$  in the case of rolling a dice
- $E(X) = \sum_{x=1}^n x \frac{1}{n} = \frac{1}{n} \frac{(n+1)n}{2} = \frac{n+1}{2} = \frac{7}{2}$  for dice
- $E(X^2) = \frac{1}{n}(1^2 + 2^2 + \dots + n^2) = \frac{1}{n} \frac{n(n+1)(2n+1)}{6} = \frac{(n+1)(2n+1)}{6}$
- $Var(X) = E(X^2) - E(X)^2 = \frac{n^2-1}{12}$

## 2 Bernoulli Distribution

$$Pr(X = x) = \begin{cases} 1 - p, & x = 0 \\ p, & x = 1 \\ 0, & \text{otherwise} \end{cases}$$

- $P(\text{Success}) = p, P(\text{Fail}) = 1 - p$
- $P(X = x) = (1 - p)^{1-x} p^x$   $1 - x$  failures until success on  $x$ th trial
- $E(X) = 0 * (1 - p) + 1 * P(X = 1) = p$
- $E(X^2) = 0^2 * (1 - p) + 1^2 * p = E(X) = p$
- $Var(X) = p - p^2 = p(1 - p)$

## 3 Indicator r.v. Revisited

Indicator r.v. essentially follow the Bernoulli Distribution

- Let  $X_i$  = indicator r.v. and  $X_i = 1$  if trial  $i$  is a success, and 0 otherwise
- $X = X_1 + X_2 + \dots + X_n$
- $E(X) = E(X_1 + \dots + X_n) = E(X_1) + \dots + E(X_n)$
- $E(X_i) = Pr(\text{trial } i \text{ is a success}) = p \Rightarrow E(X) = np$
- $Var(X) = Var(X_1) + Var(X_2) + \dots + Var(X_n) = np(1 - p)$

## 4 Binomial Distribution

$Bin(n, p)$

- Flipping coin problems
- $Pr(X = i) = \binom{n}{i} p^i (1 - p)^{n-i}$  for  $i = 0, 1, \dots, n$
- if  $X \sim Bin(n, p)$ ,  $\sum_{i=0}^n Pr(X = i) = 1$
- Practical Example: Error Erasure Code
  - $n+k$  packets, and each packet has probability  $p$  of getting lost ( $(1-p)$  of successfully transferring)
  - $X \sim Bin(n+k, 1-p)$
  - Probability of receiving at least  $n$  packets  $= Pr(X \geq n) = \sum_{i=n}^{n+k} Pr(X = i) = \sum_{i=n}^{n+k} \binom{n+k}{i} (1-p)^i p^{n+k-i}$