E1 Formula Sheet

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1 Set theory

Properties:

$$A \cup B = B \cup A \tag{1}$$
$$A \cap B = B \cap A \tag{2}$$
$$(A \cup B) \cup C = A \cup (B \cup C) \tag{3}$$
$$(AB)C = A(BC) \tag{4}$$
$$(A \cup B) \cap C = (A \cap C) \cup (B \cap C) \tag{5}$$
$$(AB) \cup C = (A \cup C) \cap (B \cup C) \tag{6}$$

De Morgan's rule:

$$\overline{E_1 \cup E_2 \cup \cdots \cup E_n} = \overline{E_1} \cap \overline{E_2} \cap \cdots \cap \overline{E_n} \tag{7}$$
$$\overline{E_1 \cap E_2 \cap \cdots \cap E_n} = \overline{E_1} \cup \overline{E_2} \cup \cdots \cup \overline{E_n} \tag{8}$$

2 Mathematics of probability

General rules:

$$P(\overline{E}) = 1 - P(E) \tag{9}$$
$$P(A \cup B) = P(A) + P(B) - P(AB) \tag{10}$$
$$P(A \cap B) = P(AB) = P(A|B)P(B) \tag{11}$$
$$P(A|B) = \frac{P(AB)}{P(B)} \tag{12}$$
$$P(A|B) = 1 - P(\overline{A}|B) \tag{13}$$

Mutually exclusive events:

$$P(A \cup B) = P(A) + P(B) \tag{14}$$

Statistically independent events:

$$P(AB) = P(A)P(B) \tag{15}$$
$$P(A|B) = P(A) \tag{16}$$
$$P(B|A) = P(B) \tag{17}$$

Total probability theorem:

$$P(A) = P(A|E_1)P(E_1) + P(A|E_2)P(E_2) + \cdots + P(A|E_n)P(E_n) = \sum_{i=1}^{n} P(A|E_i)P(E_i) \tag{18}$$

Bayes' theorem:

$$P(E_i|A) = \frac{P(A|E_i)P(E_i)}{\sum_{j=1}^{n} P(A|E_j)P(E_j)} \tag{19}$$

3 Counting

Number of ways to arrange n objects:

$$n! = n(n-1)(n-2)\cdots 3 \times 2 \times 1 \tag{20}$$

Permutations (arrangements) of n objects taken k at a time:

$${}_nP_k = \frac{n!}{(n-k)!} \tag{21}$$

Combinations of n objects taken k at a time:

$${}_nC_k = \binom{n}{k} = \frac{n!}{k!(n-k)!} \tag{22}$$

4 Probability distributions

Distribution	**Mean**	**Variance**	**Median**	$P(X \leq x)$
Uniform(a, b)	$\frac{a+b}{2}$	$\frac{(b-a)^2}{12}$	$\frac{a+b}{2}$	`uniform.cdf(x, a, b)`
$\mathcal{N}(\mu, \sigma)$	μ	σ^2	μ	`norm.cdf(x, mu, sigma)`
Lognormal(μ, σ)	$\left[\exp\left(\mu + \frac{1}{2}\sigma^2\right)\right] \exp(2\mu + \sigma^2)$	$\exp\left(\sigma^2\right) - 1$	$\exp\left(\mu\right)$	`lognorm.cdf(x, sigma, np.exp(mu))`
Binomial(n, p)	np	$np(1-p)$	$\lfloor (n+1)p \rfloor$	`binom.cdf(x, n, p)`
Poisson(λ)	λ	λ	$\lfloor \lambda \rfloor$	`poisson.cdf(x, lambda)`
Exponential(λ)	$\frac{1}{\lambda}$	$\frac{1}{\lambda^2}$	$\frac{\ln 2}{\lambda}$	`expon.cdf(x, 1/lambda)`

Table 1: Common probability distributions.

Note: the $\lfloor \cdot \rfloor$ symbol means to round down to the nearest integer.