樣本空間 Sample Space and Events

can chosen to be larger than all possible outcomes

- *Sample Space* Ω: the set of all possible outcomes in a random phenomenon. Examples:

known

final outcome is not 100% predictable

discrete → countable

finite set

1. Sex of a newborn child: Ω = {girl, boy}
2. The order of finish in a race among the 7 horses 1, 2, …, 7:

   Ω = { all 7! Permutations of (1, 2, 3, 4, 5, 6, 7)}

   a list

3. Flipping two coins: Ω = {(H, H), (H, T), (T, H), (T, T)}

infinite set

4. Number of phone calls received in a year: Ω = {0, 1, 2, 3, …}

   countably infinite

5. Lifetime (in hours) of a transistor: $\Omega = [0, \infty)$

   uncountably infinite

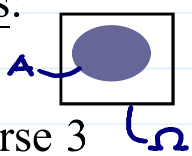
continuous → uncountable

might be difficult to identify in some cases

- *Event*: Any (measurable) subset of Ω is an event. Examples:

事件

1. A={girl}: the event - child is a girl.
2. A={all outcomes in Ω starting with a 3}: the event - horse 3 wins the race.



- A={(H, H), (H, T)}: the event - head appears on the 1st coin.
- A={0, 1, …, 500}: the event - no more than 500 calls received
- A=[0, 5]: the event - transistor does not last longer than 5 hours.

power set → 2^Ω: collection of all subsets in Ω | $\Omega=\{\omega_1, \dots, \omega_n\}$

- an event occurs ⇔ outcome ∈ the event (subset)

1/0 --- 1/0

- **Q**: How many different events if $\#\Omega = n < \infty$?

$2^\Omega = \{\phi, \{\omega_1\}, \dots, \{\omega_n\}, \{\omega_1, \omega_2\}, \dots, \Omega\}$

Ans. $\#2^\Omega = 2^n$

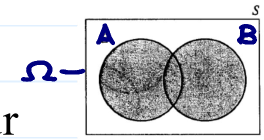
LNp.2-7.

- Set Operations of Events

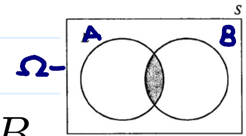
   - Union. $C = A \cup B \Rightarrow C$: either A or B occurs
   - Intersection. $C = A \cap B \Rightarrow C$: both A and B occur
   - Complement. $C = A^c \Rightarrow C$: A does not occur
   - Mutually exclusive (disjoint). $A \cap B = \emptyset \Rightarrow A$ and B have no outcomes in common.

     including countably infinite many

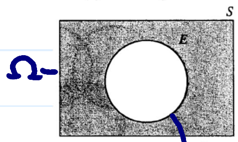
   - Definitions of union and intersection for more than 2 events can be defined in a similar manner



(a) Shaded region: $E \cup F$.

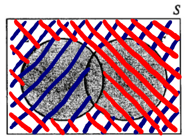


(b) Shaded region: EF.

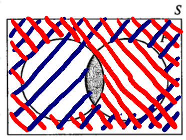


(c) Shaded region: E^c.

- Some Simple Rules of Set Operations
  - ➢ Commutative Laws. $A \cup B = B \cup A$ and $A \cap B = B \cap A$
  - ➢ Associative Laws. $(A \cup B) \cup C = A \cup (B \cup C)$
    $(A \cap B) \cap C = A \cap (B \cap C)$.
  - ➢ Distributive Laws. $(A \cup B) \cap C = (A \cap C) \cup (B \cap C)$
    $(A \cap B) \cup C = (A \cup C) \cap (B \cup C)$
  - ➢ DeMorgan's Laws.



(a) Shaded region: $E \cup F$.



(b) Shaded region: EF.

required, not optional

$(\cup_{i=1}^{n} A_i)^c = \cap_{i=1}^{n} A_i^c$ and $(\cap_{i=1}^{n} A_i)^c = \cup_{i=1}^{n} A_i^c$.

by induction (exercise)

❖ **Reading**: textbook, Sec 2.2

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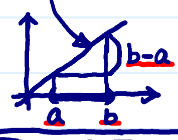
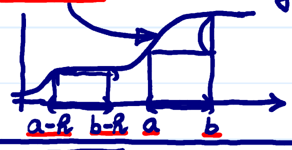
$\cancel{\Omega \to [0,1]}$

機率測度 → **Probability Measure** → a function: $2^{\Omega} \to [0,1]$

- The Classical Approach $\int g(x)dx$ ← length measure: $y=x$



weight measure $y=F(x)$: non-decreasing



$\int g(x)\,dF(x)$

  - ➢ Sample Space Ω is a *finite* set
  - ➢ Probability: For an event A,

probability space $(\Omega, \mathcal{F}, P)$ — collection of events

$$P(A) = \frac{\#A}{\#\Omega}$$

This explains why combinatorial Thm plays an important role in probability.