

4 Further Probability & Statistics – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)
chi-squared test	卡方检验	_____
probability generating function	概率母函数	_____

Recall

In **Part 1** you met continuous random variables (the density $f(x)$, the cumulative $F(x)$, and the median). Part 2 adds a **test** that compares observed and expected counts, and a **function** that packs a whole distribution into one.

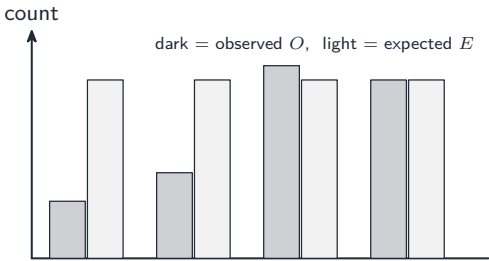
New ideas

■ 1 The chi-squared test

A **chi-squared test** 卡方检验 compares **observed** counts O with the **expected** counts E from a model:

$$\chi^2 = \sum \frac{(O - E)^2}{E}.$$

A **small** χ^2 means the data fits the model well; a **large** χ^2 (above the table value) means it fits badly.



Worked example. Observed 20, 30, 25, 25 with each expected = 25: $\chi^2 = \frac{(20-25)^2 + (30-25)^2 + 0 + 0}{25} = \frac{50}{25} = 2$.

Micro-check. In a chi-squared test, does a **large** value mean the model fits well or badly? [1]

■ 2 Probability generating functions

The **probability generating function** 概率母函数 of a discrete variable X is

$$G(t) = E(t^X) = \sum_x P(X = x) t^x.$$

It packs the whole distribution into one function. The mean comes from its derivative at $t = 1$: $E(X) = G'(1)$.

Worked example. If $P(X=0) = 0.5$, $P(X=1) = 0.3$, $P(X=2) = 0.2$, then $G(t) = 0.5 + 0.3t + 0.2t^2$, so $G'(t) = 0.3 + 0.4t$ and $E(X) = G'(1) = 0.7$.

Micro-check. The PGF gives the mean by $E(X) = G'(?)$ — state the value. [1]

Watch out: in χ^2 , divide each $(O - E)^2$ by its **own** E before adding — not by the total. A **large** χ^2 means a **bad** fit. The PGF gives the mean from $G'(1)$, not $G(1)$ (which is always 1).

Practice

4.1 Write the formula for the chi-squared statistic χ^2 . [1]

4.2 Observed counts are 10, 20, 30 with expected counts 20, 20, 20. Find χ^2 . [2]

4.3 State what a **large** value of χ^2 tells you about the model. [1]

4.4 A variable has $G(t) = 0.4 + 0.4t + 0.2t^2$. Find $G'(t)$ and hence $E(X) = G'(1)$. [2]

4.5 State what the probability generating function $G(t)$ "packs" into one function. [1]

4.6 Challenge. A variable has $G(t) = \frac{1}{4} + \frac{1}{2}t + \frac{1}{4}t^2$. Find $E(X)$. [3]