a) Probabilities if we do not use smoothing.
Training example: woolloommoooloo mall

Letter	Counts	Estimated Frequency
w	1	1/19 ≈ 0.052631
o	8	8/19 ≈ 0.421052
l	5	5/19 ≈ 0.263157
m	3	3/19 ≈ 0.157894
a	1	1/19 ≈ 0.052631
(space)	1	1/19 ≈ 0.052631
other letters	0	0
Total	19	1

Mon

b) Using Laplace Add one smoothing method.

According to this method,

$$P(w) = \frac{\#(w) + 1}{N + V}$$

where N is the number of tokens and V is vocabulary size.

Training Example: "woolloommooloo mall

letter	Modified Counts	Probability
w	2	2/46 ≈ 0.043478
o	9	9/46 ≈ 0.195652
l	6	6/46 ≈ 0.130434
m	4	4/46 ≈ 0.086956
a	2	2/46 ≈ 0.043478
(space)	2	2/46 ≈ 0.043478
other letters (x21)	1 (x21)	1/46 ≈ 0.021739 (x21)
Total:	46	1

c) Using Written-Bell smoothing method. 14 Fri

Acc. to this method,

$$P(w) = \frac{r}{(n+r)(|V|-r)}$$

where r is the count of distinct tokens, n is the length of text & V is vocabulary size

Training example : woolloommooloo mall

Letter	Modified Count	
w	1	1/25 = 0.04
o	8	8/25 = 0.32
l	5	5/25 = 0.2
m	3	3/25 = 0.12
a	1	1/25 = 0.04
(space)	1	1/25 = 0.04
new letters total	6	6/25 = 0.24
Total:	25	

After splitting the probability reserved for new letters equally among remaining 27 - 6 = 21 letters, the final estimated frequency will be as follows:

13
Thu

Letter	Probability
w	1/25 = 0.04
o	8/25 = 0.32
l	5/25 = 0.2
m	3/25 = 0.12
a	1/25 = 0.04
(space)	1/25 = 0.04
other letters	6/(25)(21) ≈ 0.011428