**Harold’s Probability**

**Cheat Sheet**

11 December 2024

**Probability**

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| **Rule** | **Formula** | **Definition** |
| **Notation** | $∩$ = “and”, Intersection, “$∧$”$∪$ = “or”, Union, “$∨$”$\overbar{˽}= $“not”, negation, “$¬$” | “and” implies multiplication.“or” implies addition.“not” implies negation. |
| **Independent** | If $P\left(B\right)=P(A)$ | The occurrence of one event does not affect the probability of the other, or vice versa. |
| **Dependent** | If $P\left(A∩B\right)\ne ∅$ | The occurrence of one event affects the probability of the other event. |
| **Disjoint**(“mutually exclusive”) | If $P\left(A∩B\right)=∅$Then $P\left(A∪B\right)=P\left(A\right)+P\left(B\right)$ | The events can never occur together. |
| **Probability**(“likelihood”) | $$0\leq P\left(E\right)\leq 1$$$$P\left(E\right)=\frac{\# Events (E)}{Sample Space \left(S\right)} = \frac{\# of Favorable Outcomes}{Total \# of Possible Outcomes}$$ |
| **Addition Rule** (“or”) | $$P\left(A∪B\right)=P\left(A\right)+P\left(B\right)-P(A∩B)$$ | http://upload.wikimedia.org/wikipedia/commons/thumb/7/7b/Venn_A_intersect_B_alt.svg/235px-Venn_A_intersect_B_alt.svg.pngS |
| **Multiplication Rule**(“and”) | if independent or disjoint:$$P\left(A∩B\right)=P\left(A\right) P(B)$$$$P\left(A∩B∩C\right)=P\left(A\right) P\left(B\right) P(C)$$if dependent:$$P\left(A∩B\right)=P\left(A\right) P\left(A\right)$$$$P\left(A∩B\right)=P\left(B\right) P(A|B)$$$$P\left(A∩B\right)=P\left(A\right)-P\left(A∩\overline{B}\right)$$ |
| **Complement Rule / Subtraction Rule**(“not”) | $$P\left(S\right)=P\left(A∪\overline{A}\right)=$$$$P\left(A\right)+P\left(\overline{A}\right)=1$$$$P(A)=1-P\left(\overline{A}\right)$$$$P(\overline{A})=1-P\left(A\right)$$$$P\left(B\right)+P\left(B\right)=1$$ | The complement of event A (denoted $\overline{A} or A^{c})$ means “**not A**”; it consists of all simple outcomes that are not in A. |
| **Conditional Probability**(“given that”) | $$P\left(B\right)=\frac{P(A∩B)}{P(B)}$$if independent or disjoint:$$P\left(B\right)=P(A)$$$$P\left(A\right)=P(B)$$ | Means the probability of event A given that event B occurred. Is a rephrasing of the Multiplication Rule. P(A|B) is the proportion of elements in B that are ALSO in A. |
| **Total Probability Rule** | $$P\left(A\right)=P(A∩B\_{1})+…+P(A∩B\_{n})$$$$=P\left(B\_{1}\right) P\left(B\_{1}\right)+…+P\left(B\_{n}\right) P\left(B\_{n}\right)$$$$P\left(A\right)=P(A∩B)+P(A∩\overbar{B})$$$$=P\left(B\right) P\left(B\right)+P\left(\overbar{B}\right) P\left(\overbar{B}\right)$$ | To find the probability of event A, partition the sample space into several disjoint events. A must occur along with one and only one of the disjoint events. |
| **Bayes’ Theorem** | $$P\left(B\right)=\frac{P\left(A∩B\right)}{P\left(B\right)}=\frac{P\left(A\right) P\left(A\right)}{P\left(B\right)}$$$$=\frac{ P\left(A\right) P\left(A\right)}{P\left(A\right) P\left(A\right)+P\left(\overbar{A}\right) P\left(\overbar{A}\right)}$$ | Allows P(A|B) to be calculated from P(B|A).Meaning it allows us to reverse the order of a conditional probability statement, and is the only generally valid method! |
| **De Morgan’s Law** | $$\overbar{P\left(A∪B\right)}≡\overbar{P(A)}∩\overbar{P(B)}$$$$\overbar{P\left(A∩B\right)}≡\overbar{P(A)}∪\overbar{P(B)}$$ | Uses negation to convert an “or” to an “and”.Uses negation to convert an “and” to an “or”. |

**Venn Diagrams**



**B**



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**Sources**:

* [SNHU MAT 229](https://www.snhu.edu/admission/academic-catalogs/coce-catalog#/courses/4188IbUYl) - Mathematical Proof and Problem Solving, [How To Prove It - A Structured Approach](https://www.amazon.com/How-Prove-Structured-Daniel-Velleman/dp/1108439535/ref%3Dsr_1_fkmr0_2?crid=3DLEIZI1MQFFK&keywords=How+To+Prove+It+-+A+Structured+Approach+3rd+Edition+-+Daniel+J.+Vellman&qid=1666431460&qu=eyJxc2MiOiIwLjgxIiwicXNhIjoiMC4wMCIsInFzcCI6IjAuMDAifQ%3D%3D&sprefix=how+to+prove+it+-+a+structured+approach+3rd+edition+-+daniel+j.+vellman%2Caps%2C131&sr=8-2-fkmr0&ufe=app_do%3Aamzn1.fos.18ed3cb5-28d5-4975-8bc7-93deae8f9840), 3rd Edition - Daniel J. Vellman, Cambridge University Press, 2019.
* [SNHU MAT 230](https://www.snhu.edu/admission/academic-catalogs/coce-catalog#/courses/4kVhSZLtg) - Discrete Mathematics, zyBooks.
* Learn more about probability distributions here: <http://blog.cloudera.com/blog/2015/12/common-probability-distributions-the-data-scientists-crib-sheet/>