Science Mathematics probability theory, a branch of mathematics concerned with the analysis of random phenomena. The outcome of a random event cannot be determined before it occurs, but it may be any one of several possible outcomes. The actual outcome is considered to be determined by chance.The word probability has several meanings in ordinary conversation. Two of these are particularly important for the development and applications of the mathematical theory of probability. One is the interpretation of probabilities as relative frequencies, for which simple games involving coins, cards, dice, and roulette wheels provide examples. The distinctive feature of games of chance is that the outcome of a given trial cannot be predicted with certainty, although the collective results of a large number of trials display some regularity. For example, the statement that the probability of heads in tossing a coin equals one-half, according to the relative frequency interpretation, implies that in a large number of tosses the relative frequency with which heads actually occurs will be approximately one-half, although it contains no implication concerning the outcome of any given toss. There are many similar examples involving groups of people, molecules of a gas, genes, and so on. Actuarial statements about the life expectancy for persons of a certain age describe the collective experience of a large number of individuals but do not purport to say what will happen to any particular person. Similarly, predictions about the chance of a genetic disease occurring in a child of parents having a known genetic makeup are statements about relative frequencies of occurrence in a large number of cases but are not predictions about a given individual.(Read Steven Pinkers Britannica entry on rationality.)This article contains a description of the important mathematical concepts of probability theory, illustrated by some of the applications that have stimulated their development. For a fuller historical treatment, see probability and statistics. Since applications inevitably involve simplifying assumptions that focus on some features of a problem at the expense of others, it is advantageous to begin by thinking about simple experiments, such as tossing a coin or rolling dice, and later to see how these apparently frivolous investigations relate to important scientific questions. The fundamental ingredient of probability theory is an experiment that can be repeated, at least hypothetically, under essentially identical conditions and that may lead to different outcomes on different trials. The set of all possible outcomes of an experiment is called a sample space. The experiment of tossing a coin once results in a sample space with two possible outcomes, heads and tails. Tossing two dice has a sample space with 36 possible outcomes, each of which can be identified with an ordered pair (i, j), where i and j assume one of the values 1, 2, 3, 4, 5, 6 and denote the faces showing on the individual dice. It is important to think of the dice as identifiable (say by a difference in colour), so that the outcome (1, 2) is different from (2, 1). An event is a well-defined subset of the sample space. For example, the event the sum of the faces showing on the two dice equals six consists of the five outcomes (1, 5), (2, 4), (3, 3), (4, 2), and (5, 1). A third example is to draw n balls from an urn containing balls of various colours. A generic outcome to this experiment is an n-tuple, where the ith entry specifies the colour of the ball obtained on the ith draw (i = 1, 2,, n). In spite of the simplicity of this experiment, a thorough understanding gives the theoretical basis for opinion polls and sample surveys. For example, individuals in a population favouring a particular candidate in an election may be identified with balls of a particular colour, those favouring a different candidate may be identified with a different colour, and so on. Probability theory provides the basis for learning about the contents of the urn from the sample of balls drawn from the urn; an application is to learn about the electoral preferences of a population on the basis of a sample drawn from that population. Another application of simple urn models is to use clinical trials designed to determine whether a new treatment for a disease, a new drug, or a new surgical procedure is better than a standard treatment. In the simple case in which treatment can be regarded as either success or failure, the goal of the clinical trial is to discover whether the new treatment more frequently leads to success than does the standard treatment. Patients with the disease can be identified with balls in an urn. The red balls are those patients who are cured by the new treatment, and the black balls are those not cured. Usually there is a control group, who receive the standard treatment. They are represented by a second urn with a possibly different fraction of red balls. The goal of the experiment of drawing some number of balls from each urn is to discover on the basis of the sample which urn has the larger fraction of red balls. A variation of this idea can be used to test the efficacy of a new vaccine. Perhaps the largest and most famous example was the test of the Salk vaccine for poliomyelitis conducted in 1954. It was organized by the U.S. Public Health Service and involved almost two million children. Its success has led to the almost complete elimination of polio as a health problem in the industrialized parts of the world. Strictly speaking, these applications are problems of statistics, for which the foundations are provided by probability theory. In contrast to the experiments described above, many experiments have infinitely many possible outcomes. For example, one can toss a coin until heads appears for the first time. The number of possible tosses is n = 1, 2,. Another example is to twirl a spinner. For an idealized spinner made from a straight line segment having no width and pivoted at its centre, the set of possible outcomes is the set of all angles that the final position of the spinner makes with some fixed direction, equivalently all real numbers in [0, 2). Many measurements in the natural and social sciences, such as volume, voltage, temperature, reaction time, marginal income, and so on, are made on continuous scales and at least in theory involve infinitely many possible values. If the repeated measurements on different subjects or at different times on the same subject can lead to different outcomes, probability theory is a possible tool to study this variability. Because of their comparative simplicity, experiments with finite sample spaces are discussed first. In the early development of probability theory, mathematicians considered only those experiments for which it seemed reasonable, based on considerations of symmetry, to suppose that all outcomes of the experiment were equally likely. Then in a large number of trials all outcomes should occur with approximately the same frequency. The probability of an event is defined to be the ratio of the number of cases favourable to the eventi.e., the number of outcomes in the subset of the sample space defining the eventto the total number of cases. Thus, the 36 possible outcomes in the throw of two dice are assumed equally likely, and the probability of obtaining six is the number of favourable cases, 5, divided by 36, or 5/36. Now suppose that a coin is tossed n times, and consider the probability of the event heads does not occur in the n tosses. An outcome of the experiment is an n-tuple, the kth entry of which identifies the result of the kth toss. Since there are two possible outcomes for each toss, the number of elements in the sample space is 2n. Of these, only one outcome corresponds to having no heads, so the required probability is 1/2n. It is only slightly more difficult to determine the probability of at most one head. In addition to the single case in which no head occurs, there are n cases in which exactly one head occurs, because it can occur on the first, second,, or nth toss. Hence, there are n + 1 cases favourable to obtaining at most one head, and the desired probability is (n + 1)/2n. Welcome to the Engineering Library. This Living Library is a principal hub of the LibreTexts project, which is a multi-institutional collaborative venture to develop the next generation of open-access texts to improve postsecondary education at all levels of higher learning. The LibreTexts approach is highly collaborative where an Open Access textbook environment is under constant revision by students, faculty, and outside experts to supplant conventional paper-based books. Campus BookshelvesBookshelvesLearning Objects Home is shared under a not declared license and was authored, remixed, and/or curated by LibreTexts. The probability of a specified event is the chance or likelihood that it will occur. There are several ways of viewing probability. One would be experimental in nature, where we repeatedly conduct an experiment. Suppose we flipped a coin over and over and over again and it came up heads about half of the time; we would expect that in the future whenever we flipped the coin it would turn up heads about half of the time. When a weather reporter says there is a 10% chance of rain tomorrow, she is basing that on prior evidence; that out of all days with similar weather patterns, it has rained on 1 out of 10 of those days. Another view would be subjective in nature, in other words an educated guess. If someone asked you the probability that the Seattle Mariners would win their next baseball game, it would be impossible to conduct an experiment where the same two teams played each other repeatedly, each time with the same starting lineup and starting pitchers, each starting at the same time of day on the same field under the precisely the same conditions. Since there are so many variables to take into account, someone familiar with baseball and with the two teams involved might make an educated guess that there is a 75% chance they will win the game; that is, if the same two teams were to play each other repeatedly under identical conditions, the Mariners would win about three out of every four games. But this is just a guess, with no way to verify its accuracy, and depending upon how educated the educated guesser is, a subjective probability may not be worth very much. We will return to the experimental and subjective probabilities from time to time, but in this course we will mostly be concerned with theoretical probability, which is defined as follows: Suppose there is a situation with \(n\) equally likely possible outcomes and that m of those \(n\) outcomes correspond to a particular event; then the probability of that event is defined as \(\frac{m}{n}\). If you roll a die, pick a card from deck of playing cards, or randomly select a person and observe their hair color, we are executing an experiment or procedure. In probability, we look at the likelihood of different outcomes. We begin with some terminology. The result of an experiment is called an outcome. An event is any particular outcome or group of outcomes. The sample space is the set of all possible simple events. If we roll a standard 6-sided die, describe the sample space and some simple events. The sample space is the set of all possible simple events: \(\{1,2,3,4,5,6\}\) Some examples of events: We roll a 1: outcome \(\{1\}\) We roll a 5: outcome \(\{5\}\) We roll a number bigger than 4: outcomes \(\{5,6\}\) We roll an even number: outcomes \(\{2,4,6\}\) Two dice are rolled. Write the sample space. Solution We assume one of the dice is red, and the other green. We have the following 36 possibilities. Green Red 1 2 3 4 5 6 1 (1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6) 2 (2, 1) (2, 2) (2, 3) (2, 4) (2, 5) (2, 6) 3 (3, 1) (3, 2) (3, 3) (3, 4) (3, 5) (3, 6) 4 (4, 1) (4, 2) (4, 3) (4, 4) (4, 5) (4, 6) 5 (5, 1) (5, 2) (5, 3) (5, 4) (5, 5) (5, 6) 6 (6, 1) (6, 2) (6, 3) (6, 4) (6, 5) (6, 6) The entry (2, 5), for example, indicates that the red die shows a 2 and the green shows a 5. This is different than the entry (5, 2) which indicates that the red die shows a 5 and the green die shows a 2. A family has three children. Write a sample space. Solution The sample space consists of eight possibilities. { BBB, BBG, BGB, BGG, GBB, GBG, GGB, GGG } The possibility BGB, for example, indicates that the first born is a boy, the second born a girl, and the third a boy. We illustrate these possibilities with a tree diagram. Given that all outcomes are equally likely, we can compute the probability of an event \(E\) using this formula: \(P(E)=\frac{\text { Number of outcomes corresponding to the event } \mathrm{E}}{\text { Total number of equally likely outcomes }}\) If we roll a 6-sided die, calculate P(rolling a 1) P(rolling a number bigger than 4) Solution Recall that the sample space is \(\{1,2,3,4,5,6\}\) There is one outcome corresponding to rolling a 1, so the probability is \(\frac{1}{6}\) There are two outcomes bigger than a 4, so the probability is \(\frac{2}{6}=\frac{1}{3}\) Probabilities are essentially fractions, and should be reduced to lowest terms. Let's say you have a bag with 20 cherries, 14 sweet and 6 sour. If you pick a cherry at random, what is the probability that it will be sweet? Solution There are 20 possible cherries that could be picked, so the number of possible outcomes is 20. Of these 20 possible outcomes, 14 are favorable (sweet), so the probability that the cherry will be sweet is \(\frac{14}{20}=\frac{7}{10}\). There is one potential complication to this example, however. It must be assumed that the probability of picking any of the cherries is the same as the probability of picking any other. This wouldn't be true if (let us imagine) the sweet cherries are smaller than the sour ones. (The sour cherries would come to hand more readily when you sampled from the bag.) Let us keep in mind, therefore, that when we assess probabilities in terms of the ratio of favorable to all potential cases, we rely heavily on the assumption of equal probability for all outcomes. At some random moment, you look at your clock and note the minutes reading. What is probability the minutes reading is 15? What is the probability the minutes reading is 15 or less? Answer There are 60 possible readings, from 00 to 59. \(\frac{1}{60}\) \(\frac{16}{60}\) (counting 00 through 15) A standard deck of 52 playing cards consists of four suits (hearts, spades, diamonds and clubs). Spades and clubs are black while hearts and diamonds are red. Each suit contains 13 cards, each of a different rank: an Ace (which in many games functions as both a low card and a high card), cards numbered 2 through 10, a Jack, a Queen and a King. Compute the probability of randomly drawing one card from a deck and getting an Ace. Solution There are 52 cards in the deck and 4 Aces so \[P(A c e)=\dfrac{4}{52}=\frac{1}{13} \approx 0.0769 onumber\] We can also think of probabilities as percents: There is a 7.69% chance that a randomly selected card will be an Ace. Notice that the smallest possible probability is 0 if there are no outcomes that correspond with the event. The largest possible probability is 1 if all possible outcomes correspond with the event. An impossible event has a probability of 0. A certain event has a probability of 1. The probability of any event must be \(0 \leq P(E) \leq 1\). In the course of this chapter, if you compute a probability and get an answer that is negative or greater than 1, you have made a mistake and should check your work. Probability theory is a branch of mathematics that investigates the probabilities associated with a random phenomenon. A random phenomenon can have several outcomes. Probability theory describes the chance of occurrence of a particular outcome by using certain formal concepts.Probability theory makes use of some fundamentals such as sample space, probability distributions, random variables, etc. to find the likelihood of occurrence of an event. In this article, we will take a look at the definition, basics, formulas, examples, and applications of probability theory. What is Probability Theory? Probability theory makes the use of random variables and probability distributions to assess uncertain situations mathematically. In probability theory, the concept of probability is used to assign a numerical description to the likelihood of occurrence of an event. Probability can be defined as the number of favorable outcomes divided by the total number of possible outcomes of an event Probability theory is a field of mathematics and statistics that is concerned with finding the probabilities associated with random events. There are two main approaches available to study probability theory. These are theoretical probability and experimental probability. Theoretical probability is determined on the basis of logical reasoning without conducting experiments. In contrast, experimental probability is determined on the basis of historic data by performing repeated experiments.Probability Theory ExampleSuppose the probability of obtaining a number 4 on rolling a fair dice needs to be established. The number of favorable outcomes is 1. The possible outcomes of the dice are {1, 2, 3, 4, 5, 6}. This implies that there are a total of 6 outcomes. Thus, the probability of obtaining 4 on a dice roll, using probability theory, can be computed as 1 / 6 = 0.167.Probability Theory Basics There are some basic terminologies associated with probability theory that aid in the understanding of this field of mathematics.Random ExperimentA random experiment, in probability theory, can be defined as a trial that is repeated multiple times in order to get a well-defined set of possible outcomes. Tossing a coin is an example of a random experiment.Sample SpaceSample space can be defined as the set of all possible outcomes that result from conducting a random experiment. For example, the sample space of tossing a fair coin is {heads, tails}.EventProbability theory defines an event as a set of outcomes of an experiment that forms a subset of the sample space. The types of events are given as follows:Independent events: Events that are not affected by other events are independent events.Dependent events: Events that are affected by other events are known as dependent events.Mutually exclusive events: Events that cannot take place at the same time are mutually exclusive events.Equally likely events: Two or more events that have the same chance of occurring are known as equally likely events.Exhaustive events: An exhaustive event is one that is equal to the sample space of an experiment.Random VariableIn probability theory, a random variable can be defined as a variable that assumes the value of all possible outcomes of an experiment. There are two types of random variables as given below.Discrete Random Variable: Discrete random variables can take an exact countable value such as 0, 1, 2... It can be described by the cumulative distribution function and the probability mass function.Continuous Random Variable: A variable that can take on an infinite number of values is known as a continuous random variable. The cumulative distribution function and probability density function are used to define the characteristics of this variable.ProbabilityProbability, in probability theory, can be defined as the numerical likelihood of occurrence of an event. The probability of an event taking place will always lie between 0 and 1. This is because the number of desired outcomes can never exceed the total number of outcomes of an event. Theoretical probability and empirical probability are used in probability theory to measure the chance of an event taking place.Conditional ProbabilityWhen the likelihood of occurrence of an event needs to be determined given that another event has already taken place, it is known as conditional probability. It is denoted as P(A | B). This represents the conditional probability of event A given that event B has already occurred.ExpectationThe expectation of a random variable, X, can be defined as the average value of the outcomes of an experiment when it is conducted multiple times. It is denoted as E[X]. It is also known as the mean of the random variable.VarianceVariance is the measure of dispersion that shows how the distribution of a random variable varies with respect to the mean. It can be defined as the average of the squared differences from the mean of the random variable. Variance can be denoted as Var[X].Probability Theory Distribution FunctionProbability distribution or cumulative distribution function is a function that models all the possible values of an experiment along with their probabilities using a random variable. Bernoulli distribution, binomial distribution, are some examples of discrete probability distributions in probability theory. Normal distribution is an example of a continuous probability distribution.Probability Mass FunctionProbability mass function can be defined as the probability that a discrete random variable will be exactly equal to a specific value.Probability Density FunctionProbability density function is the probability that a continuous random variable will take on a set of possible values.Probability Theory Formulas There are many formulas in probability theory that help in calculating the various probabilities associated with events. The most important probability theory formulas are listed below.Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Empirical probability: Number of times an event occurs / Total number of trials.Addition Rule: P(A B) = P(A) + P(B) - P(AB), where A and B are events.Complementary Rule: P(A') = 1 - P(A). P(A') denotes the probability of an event not happening.Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Probability mass function: f(x) = P(X = x)Probability density function: p(x) = p(x) = \(\frac{\mathrm{d} F(x)}{\mathrm{d} x}\) = F'(x), where F(x) is the cumulative distribution function.Expectation of a continuous random variable: \(\int xf(x)dx\), where f(x) is the pdf.Expectation of a discrete random variable: \(\sum xp(x)\), where p(x) is the pmf.Variance: Var(X) = E[X2] - (E[X])2Applications of Probability Theory Probability theory is used in every field to assess the risk associated with a particular decision. Some of the important applications of probability theory are listed below:In the finance industry, probability theory is used to create mathematical models of the stock market to predict future trends. This helps investors to invest in the least risky asset which gives the best returns.The consumer industry uses probability theory to reduce the probability of failure in a product's design.Casinos use probability theory to design a game of chance so as to make profits.Related Articles:Probability RulesProbability and StatisticsGeometric DistributionImportant Notes on Probability TheoryProbability theory is a branch of mathematics that deals with the probabilities of random events.The concept of probability in probability theory gives the measure of the likelihood of occurrence of an event.The probability value will always lie between 0 and 1.In probability theory, all the possible outcomes of a random experiment give the sample space.Probability theory uses important concepts such as random variables, and cumulative distribution functions to model a random event and determine various associated probabilities.Example 1: When two dice are rolled what is the probability of getting a sum of 8?Solution: When two dice are rolled there are 36 possible outcomes.To get the sum as 8 there are 5 favorable outcomes.[(2, 6), (6, 2), (3, 5), (5, 3), (4, 4)]Using probability theory formulas,Probability = Number of favorable outcomes / total number of possible outcomes.= 5 / 36Answer: The probability of getting the sum as 8 when two dice are rolled is 5 / 36.Example 2: What is the probability of drawing a queen from a deck of cards?Solution: A deck of cards has 4 suits. Each suit consists of 13 cards.Thus, the total number of possible outcomes = (4)(13) = 52There can be 4 queens, one belonging to each suit. Hence, the number of favorable outcomes = 4.The card probability = 4 / 52 = 1 / 13Answer: The probability of getting a queen from a deck of cards is 1 / 13Example 3: Out of 10 people, 3 bought pencils, 5 bought notebooks and 2 got both pencils and notebooks. If a customer bought a notebook what is the probability that she also bought a pencil.Solution: Using the concept of conditional probability in probability theory, P(A | B) = P(AB) / P(B). Let A be the event of people buying pencils and B be the event people of buying notebooks. P(A) = 3 / 10 = 0.3 P(B) = 5 / 10 = 0.5 P(AB) = 2 / 10 = 0.2 Substituting the values in the given formula, P(A | B) = 0.2 / 0.5 = 0.4Answer: The probability that a customer bought a pencil given that she bought a notebook is 0.4.Show more >go to slidego to slidego to slideBreakdown tough concepts through simple visuals.Math will no longer be a tough subject, especially when you understand the concepts through visualizations.Book a Free Trial ClassFAQs on Probability Theory Probability theory is a branch of mathematics that deals with the likelihood of occurrence of a random event. It encompasses several formal concepts related to probability such as random variables, probability theory distribution, expectation, etc.What are the Two Types of Probabilities in Probability Theory?The two types of probabilities in probability theory are theoretical probability and experimental probability. Theoretical probability gives the probability of what is expected to happen without conducting any experiments. Experimental probability uses repeated experiments to give the probability of an event taking place.What are the Formulas for Probability Theory?The main probability theory formulas are as follows:Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Why is Probability Theory Used in Statistics?Probability theory is useful in making predictions that form an important part of research. Further analysis of situations is made using statistical tools. Thus, statistics is dependent on probability theory to draw sound conclusions.Can the Value of Probability Be Negative According to Probability Theory?According to probability theory, the value of any probability lies between 0 and 1. 0 implies that an event does not happen and 1 denotes that the event takes place. Thus, probability cannot be negative.What is a Random Variable in Probability Theory?A random variable in probability theory can be defined as a variable that is used to model the probabilities of all possible outcomes of an event. A random variable can be either continuous or discrete.What are the Applications of Probability Theory?Probability theory has applications in almost all industrial fields. It is used to gauge and analyze the risk associated with an event and helps to make robust decisions. Probability theory is a branch of mathematics that investigates the probabilities associated with a random phenomenon. A random phenomenon can have several outcomes. Probability theory describes the chance of occurrence of a particular outcome by using certain formal concepts.Probability theory makes use of some fundamentals such as sample space, probability distributions, random variables, etc. to find the likelihood of occurrence of an event. In this article, we will take a look at the definition, basics, formulas, examples, and applications of probability theory. What is Probability Theory? Probability theory makes the use of random variables and probability distributions to assess uncertain situations mathematically. In probability theory, the concept of probability is used to assign a numerical description to the likelihood of occurrence of an event. Probability can be defined as the number of favorable outcomes divided by the total number of possible outcomes of an event Probability theory is a field of mathematics and statistics that is concerned with finding the probabilities associated with random events. There are two main approaches available to study probability theory. These are theoretical probability and experimental probability. Theoretical probability is determined on the basis of logical reasoning without conducting experiments. In contrast, experimental probability is determined on the basis of historic data by performing repeated experiments.Probability Theory ExampleSuppose the probability of obtaining a number 4 on rolling a fair dice needs to be established. The number of favorable outcomes is 1. The possible outcomes of the dice are {1, 2, 3, 4, 5, 6}. This implies that there are a total of 6 outcomes. Thus, the probability of obtaining 4 on a dice roll, using probability theory, can be computed as 1 / 6 = 0.167.Probability Theory Basics There are some basic terminologies associated with probability theory that aid in the understanding of this field of mathematics.Random ExperimentA random experiment, in probability theory, can be defined as a trial that is repeated multiple times in order to get a well-defined set of possible outcomes. Tossing a coin is an example of a random experiment.Sample SpaceSample space can be defined as the set of all possible outcomes that result from conducting a random experiment. For example, the sample space of tossing a fair coin is {heads, tails}.EventProbability theory defines an event as a set of outcomes of an experiment that forms a subset of the sample space. The types of events are given as follows:Independent events: Events that are not affected by other events are independent events.Dependent events: Events that are affected by other events are known as dependent events.Mutually exclusive events: Events that cannot take place at the same time are mutually exclusive events.Equally likely events: Two or more events that have the same chance of occurring are known as equally likely events.Exhaustive events: An exhaustive event is one that is equal to the sample space of an experiment.Random VariableIn probability theory, a random variable can be defined as a variable that assumes the value of all possible outcomes of an experiment. There are two types of random variables as given below.Discrete Random Variable: Discrete random variables can take an exact countable value such as 0, 1, 2... It can be described by the cumulative distribution function and the probability mass function.Continuous Random Variable: A variable that can take on an infinite number of values is known as a continuous random variable. The cumulative distribution function and probability density function are used to define the characteristics of this variable.ProbabilityProbability, in probability theory, can be defined as the numerical likelihood of occurrence of an event. The probability of an event taking place will always lie between 0 and 1. This is because the number of desired outcomes can never exceed the total number of outcomes of an event. Theoretical probability and empirical probability are used in probability theory to measure the chance of an event taking place.Conditional ProbabilityWhen the likelihood of occurrence of an event needs to be determined given that another event has already taken place, it is known as conditional probability. It is denoted as P(A | B). This represents the conditional probability of event A given that event B has already occurred.ExpectationThe expectation of a random variable, X, can be defined as the average value of the outcomes of an experiment when it is conducted multiple times. It is denoted as E[X]. It is also known as the mean of the random variable.VarianceVariance is the measure of dispersion that shows how the distribution of a random variable varies with respect to the mean. It can be defined as the average of the squared differences from the mean of the random variable. Variance can be denoted as Var[X].Probability Theory Distribution FunctionProbability distribution or cumulative distribution function is a function that models all the possible values of an experiment along with their probabilities using a random variable. Bernoulli distribution, binomial distribution, are some examples of discrete probability distributions in probability theory. Normal distribution is an example of a continuous probability distribution.Probability Mass FunctionProbability mass function can be defined as the probability that a discrete random variable will be exactly equal to a specific value.Probability Density FunctionProbability density function is the probability that a continuous random variable will take on a set of possible values.Probability Theory Formulas There are many formulas in probability theory that help in calculating the various probabilities associated with events. The most important probability theory formulas are listed below.Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Empirical probability: Number of times an event occurs / Total number of trials.Addition Rule: P(A B) = P(A) + P(B) - P(AB), where A and B are events.Complementary Rule: P(A') = 1 - P(A). P(A') denotes the probability of an event not happening.Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Probability mass function: f(x) = P(X = x)Probability density function: p(x) = p(x) = \(\frac{\mathrm{d} F(x)}{\mathrm{d} x}\) = F'(x), where F(x) is the cumulative distribution function.Expectation of a continuous random variable: \(\int xf(x)dx\), where f(x) is the pdf.Expectation of a discrete random variable: \(\sum xp(x)\), where p(x) is the pmf.Variance: Var(X) = E[X2] - (E[X])2Applications of Probability Theory Probability theory is used in every field to assess the risk associated with a particular decision. Some of the important applications of probability theory are listed below:In the finance industry, probability theory is used to create mathematical models of the stock market to predict future trends. This helps investors to invest in the least risky asset which gives the best returns.The consumer industry uses probability theory to reduce the probability of failure in a product's design.Casinos use probability theory to design a game of chance so as to make profits.Related Articles:Probability RulesProbability and StatisticsGeometric DistributionImportant Notes on Probability TheoryProbability theory is a branch of mathematics that deals with the probabilities of random events.The concept of probability in probability theory gives the measure of the likelihood of occurrence of an event.The probability value will always lie between 0 and 1.In probability theory, all the possible outcomes of a random experiment give the sample space.Probability theory uses important concepts such as random variables, and cumulative distribution functions to model a random event and determine various associated probabilities.Example 1: When two dice are rolled what is the probability of getting a sum of 8?Solution: When two dice are rolled there are 36 possible outcomes.To get the sum as 8 there are 5 favorable outcomes.[(2, 6), (6, 2), (3, 5), (5, 3), (4, 4)]Using probability theory formulas,Probability = Number of favorable outcomes / total number of possible outcomes.= 5 / 36Answer: The probability of getting the sum as 8 when two dice are rolled is 5 / 36.Example 2: What is the probability of drawing a queen from a deck of cards?Solution: A deck of cards has 4 suits. Each suit consists of 13 cards.Thus, the total number of possible outcomes = (4)(13) = 52There can be 4 queens, one belonging to each suit. Hence, the number of favorable outcomes = 4.The card probability = 4 / 52 = 1 / 13Answer: The probability of getting a queen from a deck of cards is 1 / 13Example 3: Out of 10 people, 3 bought pencils, 5 bought notebooks and 2 got both pencils and notebooks. If a customer bought a notebook what is the probability that she also bought a pencil.Solution: Using the concept of conditional probability in probability theory, P(A | B) = P(AB) / P(B). Let A be the event of people buying pencils and B be the event people of buying notebooks. P(A) = 3 / 10 = 0.3 P(B) = 5 / 10 = 0.5 P(AB) = 2 / 10 = 0.2 Substituting the values in the given formula, P(A | B) = 0.2 / 0.5 = 0.4Answer: The probability that a customer bought a pencil given that she bought a notebook is 0.4.Show more >go to slidego to slidego to slideBreakdown tough concepts through simple visuals.Math will no longer be a tough subject, especially when you understand the concepts through visualizations.Book a Free Trial ClassFAQs on Probability Theory Probability theory is a branch of mathematics that deals with the likelihood of occurrence of a random event. It encompasses several formal concepts related to probability such as random variables, probability theory distribution, expectation, etc.What are the Two Types of Probabilities in Probability Theory?The two types of probabilities in probability theory are theoretical probability and experimental probability. Theoretical probability gives the probability of what is expected to happen without conducting any experiments. Experimental probability uses repeated experiments to give the probability of an event taking place.What are the Formulas for Probability Theory?The main probability theory formulas are as follows:Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Why is Probability Theory Used in Statistics?Probability theory is useful in making predictions that form an important part of research. Further analysis of situations is made using statistical tools. Thus, statistics is dependent on probability theory to draw sound conclusions.Can the Value of Probability Be Negative According to Probability Theory?According to probability theory, the value of any probability lies between 0 and 1. 0 implies that an event does not happen and 1 denotes that the event takes place. Thus, probability cannot be negative.What is a Random Variable in Probability Theory?A random variable in probability theory can be defined as a variable that is used to model the probabilities of all possible outcomes of an event. A random variable can be either continuous or discrete.What are the Applications of Probability Theory?Probability theory has applications in almost all industrial fields. It is used to gauge and analyze the risk associated with an event and helps to make robust decisions. Probability theory is an advanced branch of mathematics that deals with measuring the likelihood of events occurring. It provides tools to analyze situations involving uncertainty and helps in determining how likely certain outcomes are. This theory uses the concepts of random variables, sample space, probability distributions, and more to determine the outcome of any situation.For Example: Flipping a CoinFlipping a coin is a random event with two possible outcomes: heads or tails. Each time you flip a fair coin, there are exactly two possible outcomes, each with an equal chance of occurring. Therefore, the probability of landing on heads is 1/2, and similarly, the probability of landing on tails is also 1/2.Different Approaches In Probability TheoryProbability theory studies random events and tells us about their occurrence. The four main approaches for studying probability theory are:Theoretical ProbabilityTheoretical probability deals with assumptions to avoid unfeasible or costly repetition of experiments. The theoretical Probability for an event A can be calculated as follows:P(A) = (Number of outcomes favorable to Event A) / (Number of allpossible outcomes)The image shown below shows the theoretical probability formula.Note: Here we assume the outcomes of an event as equally likely.Now, as we learn the formula, let's put this formula in our coin-tossing case. In tossing a coin, there are two outcomes: Head or Tail. Hence, The Probability of the occurrence of a Head on tossing a coin is P(H) = 1/2Similarly, The Probability of the occurrence of a Tail on tossing a coin is P(T) = 1/2 Read more about- Theoretical probabilityExperimental ProbabilityExperimental probability is found by performing a series of experiments and observing their outcomes. These random experiments are also known as trials. The experimental probability for Event A can be calculated as follows:P(E) = (Number of times event A happened) / (Total number of trials)The following image shows the Experimental Probability Formula,Now, as we learn the formula, let's put this formula in our coin-tossing case. If we tossed a coin 10 times and recorded heads 4 times and tails 6 times, then the Probability of occurrence of heads on tossing a coin: P(H) = 4/10Similarly, the Probability of Occurrence of Tails on tossing a coin: P(T) = 6/10 Read more about- Experimental ProbabilitySubjective probabilityrefers to the likelihood of an event occurring, as estimated by an individual based on their personal beliefs, experiences, intuition, or knowledge, rather than on objective statistical data or formal mathematical models.Example: A cricket enthusiast might assign a 70% probability to a teams victory based on their understanding of the teams recent form, the opponents strengths and weaknesses, and other relevant factors.Axiomatic ProbabilityAxiomatic probability is based on the formal, mathematical foundation established by Andrey Kolmogorov. It treats probability as a set function defined on a -algebra of events, satisfying a set of axioms (rules). This approach is highly abstract and provides a rigorous framework for probability theory.Example: For a fair coin, there are two possible outcomes: Heads (H) or Tails (T). So, the sample space S is:S = {Heads,Tails}P(Heads) + P(Tails) = 1So, using the axiomatic framework, weve established that:P(Heads) = 0.5, P(Tails) = 0.5 Read more about- Axiomatic ProbabilityBasics of Probability TheorySome important concepts of probability theory are:Random ExperimentIn probability theory, any event that can be repeated multiple times and whose outcome is not hampered by its repetition is called a Random Experiment. For example, tossing a coin, rolling the dice, etc., are random experiments.Sample SpaceThe set of all possible outcomes for any random experiment is called the sample space. For example, throwing dice results in six outcomes, which are 1, 2, 3, 4, 5, and 6. Thus, its sample space is (1, 2, 3, 4, 5, 6)EventThe outcome of any experiment is called an event. Various types of events used in probability theory are,Independent Events: The events whose outcomes are not affected by the outcomes of other future and/or past events are called independent events. For example, the output of tossing a coin in repetition is not affected by its previous outcome.Dependent Events: The events whose outcomes are affected by the outcome of other events are called dependent events. For example, picking oranges from a bag that contains 100 oranges without replacement.Mutually Exclusive Events: The events that can not occur simultaneously are called mutually exclusive events. For example, obtaining a head or a tail in tossing a coin, because both (head and a tail can not be obtained together.Equally likely Events: The events that have an equal chance or probability of happening are known as equally likely events. For example, observing any face in rolling the dice has an equal probability of 1/6.Random VariableA variable that can assume the value of all possible outcomes of an experiment is called a random variable in Probability Theory. Random variables in probability theory are of two types, which are discussed below,Discrete Random VariableVariables that can take countable values, such as 0, 1, 2, ..., are called discrete random variables.Examples: The number of heads when flipping 3 coins, the number of cars in a parking lot, or the number of correct answers on a test.Continuous Random VariableVariables that can take an infinite number of values in a given range are called continuous random variables.Examples: The height of a person, the time it takes for a chemical reaction to occur, or the temperature of a substance.Probability Theory FormulasVarious formulas are used in probability theory, and some of them are discussed below,Theoretical Probability Formula: (Number of Favourable Outcomes) / (Number of Total Outcomes)Empirical Probability Formula: (Number of times event A happened) / (Total number of trials)Addition Rule of Probability: P(A B) = P(A) + P(B) - P(AB)Complementary Rule of Probability: P(A') = 1 - P(A)Independent Events: P(AB) = P(A) P(B)Conditional Probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Read in Detail: Bayes' TheoremProbability Theory in StatisticsProbability has various applications in Statistics. These are mentioned below:Descriptive Statistics: Probability theory helps in understanding and interpreting data summaries and distributions.Inferential Statistics: This forms the basis for making inferences about populations from samples, including hypothesis testing and the construction of confidence intervals.Regression Analysis: Probability distributions of errors are used to estimate the relationships between variables.Bayesian Statistics: Uses probability to represent uncertainty about the parameters of interest and updates this uncertainty as more data becomes available.Applications of Probability TheoryProbability theory is widely used in our lives, It is used to find answers to various types of questions, such as Will it rain tomorrow? What is the chance of landing on the Moon? What is the chance of the evolution of humans? And others. Some of the important uses of probability theory are,Probability theory is used to predict the performance of stocks and bonds.In casinos and gambling, probability theory is used to find the chances of winning.Probability theory is used in weather forecasting.Probability theory is used in Risk mitigation.In consumer industries, the risk of product failure is mitigated by using Probability theory.Solved Questions on Probability TheoryWe can study the concept of probability with the help of the example discussed below.Question 1: Let's take two random dice and roll them randomly. Now now the probability of getting a total of 10 is calculated.Solution:Total Possible events that can occur (sample space) {(1,1), (1,2),..., (1,6),..., (6,6)}. The total spaces are 36.Now the required events, {(4,6), (5,5), (6,4)} are all which adds up to 10.So the probability of getting a total of 10 is = 3/36 = 1/12Question 2: A fair coin is tossed three times. What is the probability of getting exactly two heads?Solution:Total possible outcomes when tossing a coin three times = 23 = 8.Possible outcomes: HHH, HHT, HTH, THH, HTT, THT, TTH, TTT.Outcomes with exactly two heads: HHT, HTH, THH (3 outcomes).Probability of getting exactly two heads: P(exactly2heads)=Numberoffavorableoutcomes/ Totaloutcomes. P(exactly2heads)=3/ 8.Question 3: A standard deck of cards contains 52 cards. What is the probability of drawing an Ace or a King from the deck?Solution:Total number of cards = 52.Number of Aces = 4.Number of Kings = 4.Total number of favorable outcomes (Aces or Kings) = 4 + 4 = 8.Probability of drawing an Ace or a King: P(AceorKing)=Numberoffavorableoutcomes/TotaloutcomesP(AceorKing)=NumberofAcesorKings/Totalnumber of cards.P(Ace or King) = 8/52 = 2/13. Question 4: Consider a jar with 7 red marbles, 3 green marbles, and 4 blue marbles. What is the probability of randomly selecting a non-blue marble from the jar?Solution:Given,Number of Red Marbles = 7, Number of Green Marbles = 3, Number of Blue Marbles = 4So, Total number of possible outcomes in this case: 7 + 3 + 4 = 14Now, Number of non-blue marbles are: 7 + 3 = 10According to the formula of theoretical Probability we can find, P(Non-Blue) = 10/14 = 5/7Hence, theoretical probability of selecting a non-blue marble is 5/7.Question 5: Consider for players Naveena and Isha, playing a table tennis match. The probability of Naveena winning the match is 0.76. What is the probability of Isha winning the match?Solution:Let N and M represent the events that Naveena wins the match and Isha wins the match, respectively.The probability of Naveenas winning P(N) = 0.62 (given)The probability of Isha's winning P(I) = ?Winning of the match is an mutually exclusive event, since only one of them can win the match.Therefore,P(N) + P(I) =1P(I) = 1 P(N)P(I) = 1 0.62 = 0.38Thus, the Probability of Isha winning the match is 0.38.Question 6: If someone takes out one card from a 52-card deck, what is the probability of the card being a heart? What is the probability of obtaining a 7-number card?Solution:Total number of cards in a deck = 52Total Number of heart cards in a deck = 13So, the probability of obtaining a heart,P(heart) = 13/52 = 1/4Total number of 7-number cards in a deck = 4So, the probability of obtaining a 7-number card,P(7-number) = 4/52 = 1/13Question 7: Find the probability of rolling an even number when you roll a die containing the numbers 1-6. Express the probability as a fraction, decimal, ratio, or percent.Solution:Out of 1 to 6 number, even numbers are 2, 4, and 6.So, Number of favorable outcomes = 3.Total number of outcomes = 6.Probability of obtaining an even number P(Even)= 1/2 = 0.5 = 1 : 2 = 50%People Also Read:Probability DistributionPermutations and CombinationsBinomial Theorem ,the free encyclopedia that anyone can edit.107,590 active editors 7,028,025 articles in EnglishLesley James McNair (25May 1883 25July 1944) was a lieutenant general of the United States Army who served in both world wars, and previously saw service in the Veracruz occupation and the Pancho Villa Expedition. During World WarI, he served with the American Expeditionary Forces on the Western Front. At 35, he became the Army's second-youngest general officer. During the early stages of World WarII, he was the commander of Army Ground Forces, and played the leading role in the organization, equipping, and training of Army units before they departed for overseas combat. He was killed on 25July 1944 while in France as commander of the fictitious First United States Army Group, part of Operation Quicksilver, a deception plan for the invasion of Normandy. McNair died when the US Eighth Air Force attempted to use heavy bombers in support of ground combat troops, and several planes dropped payloads short of their targets. He received a posthumous promotion to general. (Fullarticle...)Recently featured: Second Test, 1948 Ashes seriesDaily News BuildingHippocampusArchiveBy emailMore featured articlesAboutState flag of Transnistria... that the state flag of Transnistria (pictured) features communist symbols, even though Transnistria is not a communist state?... that actor Suja Khondokar served as a flight attendant aboard the inaugural commercial flight of Biman Bangladesh Airlines?... that Peru's fishing industry is the world's largest producer of fishmeal and fish oil?... that the Albanian noble Blasius Mataranga may have been captured and killed by the Balsha familyafter they lured him into peace talks with a false promise of safe conduct?... that Mayu Sakai found drawing Peter Pan Syndrome difficult because of its fantasy elements?... that American football player Bob Wicks was teammates with the same quarterback from fourth grade through college?... that from 1986 to 1988, a Boston TV station was the only one in the U.S. to broadcast digital audio in its video signal?... that Archbishop LetardII of Nazareth was one of only a few fellow bishops about whom William of Tyre had something nice to say?... that some Italians eat eggplants with chocolate?ArchiveStart a new articleNominate an articleOzzy OsbourneOzzy Osbourne (pictured), the lead singer of Black Sabbath, dies at the age of 76.A fighter jet crashes into a college in Dhaka, Bangladesh, killing more than 30 people.In golf, Scottie Scheffler wins the Open Championship.A tourist boat capsizes during a thunderstorm in H Long Bay, Vietnam, leaving at least 36 people dead.Ongoing: Gaza warRussian invasion of UkrainetimelineSudanese civil wartimelineRecent deaths: Des van JaarsveldtBryan BramanPhoebe AsiyoGary KarrClaus PeymannWayne ThomasNominate an articleJuly 25: National Day of Galicia, Saint James's Day, Tenjin MatsuriThe Concorde involved in the Air France Flight 4590 accident1261 Alexios Strategopoulos led Nicaean forces to recapture Constantinople, leading to the reestablishment of the Byzantine Empire and the end of the Latin Empire.1893 The Corinth Canal was formally opened, bisecting the narrow Isthmus of Corinth in Greece to connect the Ionian Sea's Gulf of Corinth with the Aegean Sea's Saronic Gulf.1950 Korean War: After American troops withdrew, North Korean forces captured the village of Yongdong in South Korea.2000 Air France Flight4590 (plane used pictured), a Concorde en route from Paris to New York, crashed in Gonesse, France, killing all 109 passengers on board and four people on the ground.2010 WikiLeaks published 75,000 classified documents about the War in Afghanistan in one of the largest leaks in U.S. military history.Sibylla, Queen of Jerusalem (d.1190)Matt LeBlanc (b.1967)Meg Donnelly (b.2000)Azimzhan Askarov (d.2020)More anniversaries: July 24July 25July 26ArchiveBy emailList of days of the yearAboutThe Carousel at Glen Echo ParkAmusement rides on the National Register of Historic Places (NRHP) are located throughout the United States. These individual ride listings consist mainly of carousels, but also include roller coasters, trains, and other ride types. Many NRHP-listed rides operate within amusement parks, with more than one present in Cedar Point, Lagoon, and Santa Cruz Beach Boardwalk. There are also high concentrations in New York City, the Greater Binghamton area in New York state, and Portland, Oregon. The first NRHP amusement ride listing was added in 1975 for the Idora Park Merry-Go-Round (delisted in 1985). The listing for the Crescent Park Looff Carousel was added in 1976 and is the ride that has existed on the NRHP the longest. The listing for the Portland Zoo Railway Historic District was created in 2020 and is the newest ride entry on the NRHP. Several NRHP-listed rides, including the Leap-the-Dips roller coaster, have a higher National Historic Landmark status. Of the nearly 100,000 NRHP listings, fewer than 100 are for amusement rides. (Fulllist...)Recently featured: Tages discographyKerivoulinesAccolades received by InceptionArchiveMore featured listsHudson Yards is a 28-acre (11-hectare) real-estate development located in Hudson Yards, a neighborhood of the New York City borough of Manhattan. It is situated on the waterfront of the Hudson River, on a platform built over the West Side Yard, a storage depot for the Long Island Rail Road. Related Companies and Oxford Properties are the primary developers and major equity partners in the project, with the master plan designed by the architectural firm Kohn Pedersen Fox. Construction began in 2012 and the first phase opened in 2019, with completion of the second phase expected by 2032. Major office tenants in the development include Warner Bros. Discovery, L'Oral, and Wells Fargo among others. This photograph shows the skyscrapers of Hudson Yards, viewed across the Hudson River from Weehawken, New Jersey, in 2021.Photograph credit: Tony JinRecently featured: Emperor angelfishAmlia RodriguesAtari video game burialArchiveMore featured picturesCommunity portal The central hub for editors, with resources, links, tasks, and announcements.Village pump Forum for discussions about Wikipedia itself, including policies and technical issues.Site news Sources of news about Wikipedia and the broader Wikimedia movement.Teahouse Ask basic questions about using or editing Wikipedia.Help desk Ask questions about using or editing Wikipedia.Reference desk Ask research questions about encyclopedic topics.Content portals A unique way to navigate the encyclopedia.Wikipedia is written by volunteer editors and hosted by the Wikimedia Foundation, a non-profit organization that also hosts a range of other volunteer projects: CommonsFree media repository MediaWikiWiki software development Meta-WikiWikimedia project coordination WikibooksFree textbooks and manuals WikidataFree knowledge base WikinewsFree-content news WikiquoteCollection of quotations WikisourceFree-content library WikispeciesDirectory of species WikiversityFree learning tools WikivoyageFree travel guide WiktionaryDictionary and thesaurusThis Wikipedia is written in English. Many other Wikipedias are available; some of the largest are listed below. 1,000,000+ articles DeutschEspaolFranaisItalianoNederlandsPolskiPortugusSvenskaTing Vit 250,000+ articles Bahasa IndonesiaBahasa MelayuBn-lm-gCatalaetinaDanskEestiEsperantoEuskaraMagyarNorsk bokmlRomnSimple EnglishSloveninaSrpskiSrpskohrvatskiSuomiTrkeOzbekcha 50,000+ articles AsturianuAzrbaycancaBosanskiFryskGaeilgeGalegoHrvatskiKurdLatvieuLietuviNorsk nynorskShqipSlovenina Retrieved from " 2Calendar yearYearsMillennium2ndmillenniumCenturies12thcentury13thcentury 14thcenturyDecades1240s1250s1260s 1270s1280sYears1258125912601261 126212631264vte1261 by topicLeadersPolitical entitiesState leadersReligious leadersBirth and death categoriesBirths DeathsEstablishments and disestablishments categoriesEstablishments DisestablishmentsArt and literature1261 in poetryvte1261 in various calendarsGregorian calendar1261MCCLXIAb urbe condita2014Armenian calendar710 Assyrian calendar6011Balinese saka calendar11821183Bengali calendar667668Berber calendar2211English Regnal year45Hen.346Hen.3Buddhist calendar1805Burmese calendar623Byzantine calendar67696770Chinese calendar (MetalMonkey)3958 or 3751to (MetalRooster)3959 or 3752Coptic calendar977978Discordian calendar2427Ethiopian calendar12531254Hebrew calendar50215022Hindu calendars- Vikram Samvat13171318- Shaka Samvat11821183- Kali Yuga43614362Holocene calendar11261Igbo calendar261262Iranian calendar639640Islamic calendar659660Japanese calendarBun' 2 / Kch 1()Javanese calendar11701171Julian calendar1261MCCLXIKorean calendar3594Minguo calendar651 before ROC651Nanakshahi calendar207Thai solar calendar18031804Tibetan calendar(male Iron-Monkey)1387 or 1006 or 234to(female Iron-Bird)1388 or 1007 or 235Michael VIII Palaiologos (12231282)Year 1261 (MCCLXI) was a common year starting on Saturday of the Julian calendar.March 13 Treaty of Nymphaeum: Emperor Michael VIII Palaiologos signs a trade and defense agreement with the Republic of Genoa, to counterweight the Venetian presence in the region. Genoa agrees to ally with the Empire of Nicaea, by providing a fleet of up to 50 galleys during the projected Nicaean siege of Constantinople, while 16 galleys are to be immediately sent against the Latin Empire.[1]July Michael sends his general Alexios Strategopoulos with a small advance force of 800 soldiers, most of them Cumans, to keep watch on the Bulgarians and scout the defending positions of the Latin forces in the surroundings of Constantinople. When they reach the village of Selymbria, Strategopoulos is informed by local farmers that the entire Latin garrison and the Venetian fleet, are absent conducting a raid against the Nicaean island of Daphnousia. He decides not to lose such a golden opportunity and makes plans (without the consent of Michael) to retake the capital.[2]July 25 Reconquest of Constantinople: Alexios Strategopoulos and his men hide at a monastery near the city gates, before entering through a secret passage. After a short struggle, the guards who are completely taken by surprise are killed and the Venetian quarter is set ablaze. Panic spreads through the capital and Emperor Baldwin II rushes out to save his life, evacuating along with many other Latins with the help of the Venetian fleet. Baldwin manages to escape to the still Latin-held parts of Greece, but Constantinople is lost for good.[3]August 15 Michael enters Constantinople in triumph and is crowned as emperor of the Byzantine Empire at the Hagia Sophia. To solidify his claim, the legitimate ruler, John IV Laskaris, is blinded on Michael's orders on December 25, his 11th birthday. Michael banishes him to a monastery and marries his two sisters to lesser Latin and Bulgarian nobles in an attempt to wipe out the Laskarid dynasty.[4]Kublai Khan releases 75 Chinese merchants who were captured along the border of the Mongol Empire. By doing this, Kublai hopes to bolster his popularity and depend on the cooperation of his Chinese subjects to ensure that his army receives more resources.[5]June 13 Al-Mustansir II becomes the first Abbasid ruler in Cairo (after his escape during the Siege of Baghdad). He is sent with an army by Sultan Baibars to recover Baghdad, but is killed in a Mongol ambush near Anbar (modern Iraq), on November 28. The Abbasid caliphs continue as religious figureheads for the Mamluks in Egypt until the 16th century.[6]June 12 King Henry III of England obtains a papal bull to absolve himself from his oath to maintain the Provisions of Oxford. He hires an army of 300 French knights as a bodyguard and takes up position in the Tower of London. He dismisses the baronial officials (led by Simon de Montfort) who wish the royal power to be modified by the principle of representation. This sets the stage for the Second Barons' War.[7]August Battle of Callann in Ireland: Norman forces under John FitzThomas are defeated by a Gaelic army led by King Fnghin Mac Carthaigh. John FitzGerald is killed during the fighting.[8]February The Japanese Bun' era ends and the Kch era begins during the reign of the 11-year-old Emperor Kameyama (until 1264).Early Following disputes, northern academics from the University of Cambridge in England set up a University of Northampton by royal charter but it is suppressed by the Crown in 1265.[9]The earliest extant Chinese illustration of "Pascal's Triangle" is from Yang Hui's (or Qianguang's) book Xiangjie Jiuzhang Suanfa, published this year.May 25 Pope Alexander IV dies after a pontificate of 6-years at Viterbo. He is succeeded by Urban IV as the 182nd pope of the Catholic Church.August 29 Urban IV offers the crown of Sicily to Charles of Anjou, youngest son of King Louis VIII of France, hoping to strengthen his position.Wurmsbach Abbey (located in Bollingen) is established by Count Rudolf V of Rapperswil in Switzerland.February 1 Walter de Stapledon, English bishop of Exeter (d. 1326)February 11 Otto III, Duke of Bavaria, king of Hungary and Croatia (d. 1312)February 28 Margaret of Scotland, queen consort of Norway (d. 1283)March 1 Hugh Despenser the Elder, English chief adviser (d. 1326)July 25 Arthur II, Breton nobleman (House of Dreux) (d. 1312)October 9 Denis I ("the Poet King"), king of Portugal (d. 1325)Abu Abdallah ibn al-Hakim, Andalusian vizier and poet (d. 1309)November 'Ala' al-Dawla Simnani, Persian Sufi mystic and writer (d. 1336)Albertino Mussato, Paduan statesman, poet and chronicler (d. 1329)Constantine Palaiologos, Byzantine prince and general, son of Michael VIII (d. 1306)Daniel of Moscow (Aleksandrovich), Russian prince (d. 1303)Zangpo Pal, Tibetan religious leader (d. 1323)Elizabeth of Sicily, queen consort of Hungary (House of Anjou) (d. 1303)Konoe Iemoto, Japanese nobleman (kugy) and regent (d. 1296)Pier Saccone Tarlati di Pietramala, Italian nobleman and condottiero (d. 1356)Wadysaw I okietek ("Elbow-High"), king of Poland (d. 1333)February 28 Henry III ("the Good"), duke of Brabant (b. 1230)April 1 Ahi Evran, Bektashi Sufi preacher and poet (b. 1169)May 25 Alexander IV, pope of the Catholic Church (b. 1199)July 8 Adolf IV of Holstein, German nobleman (House of Schaumburg)July 25 Nicephorus II of Constantinople, Byzantine patriarchAugust John FitzThomas, 1st Baron Desmond, Norman Irish nobleman, killed in battleAugust 24 Ela of Salisbury, English noblewoman (b. 1187)September 18 Konrad von Hochstaden, German archbishopSeptember 22/27 Plaisance of Antioch, queen consort of Cyprus (b. 1235)October 27 Sancho of Castile, Spanish archbishop (b. 1233)November 2 Bettisia Gozzadini, Bolognese noblewoman and academic lawyer (b. 1209)November 9 Sanchia of Provence, Queen of the Romans, German queen consort (b. 1225)November 26 Hj Shigetoki, Japanese samurai (b. 1198)November 27 Athanasius III of Alexandria, Egyptian popeNovember 28 Al-Mustansir II, Abbasid ruler (caliph) of Cairo, killedAbu Bakr Ibn Sayyid al-Ns, Andalusian theologian (b. 1200)An-Nasir Dawud, Kurdish ruler, Ayyubid ruler (emir) of Damascus (b. 1206)Benedict II of Esztergom, Hungarian chancellor, governor and archbishopConrad I, Burgrave of Nuremberg ("the Pious"), German nobleman and knight (b. 1186)Qin Jiushao, Chinese mathematician and writer (b. 1202)Sayf al-Din Bakharzi, Persian poet and sheikh (b. 1190)Stephen of Bourbon, French Dominican preacher (b. 1180)^ Steven Runciman (1952). A History of The Crusades. Vol III: The Kingdom of Acre, p. 240. ISBN978-0-241-29877-0.^ Bartusis, Mark C. (1997). The Late Byzantine Army: Arms and Society, 12041453, pp. 4041. University of Pennsylvania Press. ISBN0-8122-1620-2.^ Nicol, Donald M. (1993). The Last Centuries of Byzantium, 12611453, p. 35 (Second ed.). Cambridge: Cambridge University Press. ISBN978-0-521-43991-6.^ Hackel, Sergei (2001). The Byzantine Saint, p. 71 (2001 ed.). St. Vladimir's Seminary Press. ISBN0-88141-202-3.^ Rossabi, Morris (1988). Khubilai Khan: His Life and Times, p. 51. Los Angeles: University of California Press. ISBN978-0-520-06740-0.^ Lock, Peter (2013). The Routledge Companion to the Crusades. Routledge. p.112. ISBN9781135131371.^ Williams, Hywel (2005). Cassell's Chronology of World History. London: Weidenfeld & Nicolson. pp.144146. ISBN0-304-35730-8.^ BBC History, July 2011, p. 12.^ Lawrence, C. H. (1984). "The University in State and Church". In Aston, T. H.; Catto, J. I. (eds.). The History of the University of Oxford. Vol.1. Oxford University Press.Retrieved from " 3One hundred years, from 1101 to 1200See also: Renaissance of the 12th centuryMillennia2ndmillenniumCenturies11thcentury12thcentury13thcenturyTimelines11thcentury12thcentury13thcenturyState leaders11thcentury12thcentury13thcenturyDecades1100s1110s1120s1130s1140s1150s1160s1170s1180s1190sCategories:Births Deaths Establishments DisestablishmentsvteEastern Hemisphere at the beginning of the 12th centuryThe 12th century is the period from 1101 to 1200 in accordance with the Julian calendar. In the history of European culture, this period is considered part of the High Middle Ages and overlaps with what is often called the "'Golden Age' of the Cistercians". The Golden Age of Islam experienced significant development, particularly in Islamic Spain.In Song dynasty China, an invasion by Jurchens caused a political schism of north and south. The Khmer Empire of Cambodia flourished during this century, while the Fatimids of Egypt were overtaken by the Ayyubid dynasty. Following the expansions of the Ghaznavids and Ghurid Empire, the Muslim conquests in the Indian subcontinent took place at the end of the century.Main article: 1100sThe Ghurid Empire converted to Islam from Buddhism.1101: In July, the Treaty of Alton is signed between Henry I of England and his older brother Robert, Duke of Normandy in which Robert agrees to recognize Henry as king of England in exchange for a yearly stipend and other concessions. The agreement temporarily ends a crisis in the succession of the Anglo-Norman kings.11011103: David the Builder takes over Kakheti and Hereti (now parts of Georgia).1102: King Coloman unites Hungary and Croatia under the Hungarian Crown.1102: Muslims conquer Seoro de Valencia.11031104: A church council is convened by King David the Builder in Urbnisi to reorganize the Georgian Orthodox Church.1104: In the Battle of Ertsukhi, King David the Builder defeats an army of Seljuks.1104: King Jayawarsa of Kadiri (on Java) ascends to the throne.[citation needed]1106: Battle of Tinchebray.11071111: Sigurd I of Norway becomes the first Norwegian king to embark on a crusade to the Holy Land. He fights in Lisbon and on various Mediterranean isles and helps the King of Jerusalem to take Sidon from the Muslims.1108: By the Treaty of Devol, signed in September, Bohemond I of Antioch has to submit to the Byzantine Empire, becoming the vassal of Alexius I.1109: On June 10, Bertrand of Toulouse captures the County of Tripoli (northern Lebanon/western Syria).1109: In the Battle of Nako, Boleslaus III Wrymouth defeats the Pomeranians and re-establishes Polish access to the sea.1109: On August 24, in the Battle of Hundsfeld, Boleslaus III Wrymouth defeats Emperor Henry V of Germany and stops German expansion eastward.Main article: 1110s1111: On April 14, during Henry V's first expedition to Rome, he is crowned Holy Roman Emperor.1113: Paramavishnulok is crowned as King Suryavarman II in Cambodia. He expands the Khmer Empire and builds Angkor Wat during the first half of the century. He establishes diplomatic relations with China.1115: The Georgian army occupies Rustavi in the war with the Muslims.1115: In Java, King Kamesvara of Kadiri ascends to the throne. Janggala ceases to exist and comes under Kadiri domination, highly possible under royal marriage. During his reign, Mpu Dharmaja writes Kakawin Smaradahana, a eulogy for the king which become the inspiration for the Panji cycle tales, which spread across Southeast Asia.[1]1116: The Byzantine army defeats the Turks at Philomelion.1116: Death of doa Jimena Daz, governor of Valencia from 1099 to 1102.c. 1119: The Knights Templar are founded to protect Christian pilgrims in Jerusalem.Main article: 1120sA Black and White Photo of the 12th century Cuenca Cathedral (built from 1182 to 1270) in Cuenca, Spain1120: On January 16, the Council of Nablus, a council of ecclesiastic and secular lords in the crusader Kingdom of Jerusalem, establishes the first written laws for the kingdom.1120: On November 25, William Adelin, the only legitimate son of King Henry I of England, drowns in the White Ship Disaster, leading to a succession crisis which will bring down the Norman monarchy of England.1121: On August 12, in the Battle of Didgori, the greatest military victory in Georgian history, King David the Builder with 45,000 Georgians, 15,000 Kipchak auxiliaries, 500 Alan mercenaries and 100 French Crusaders defeats a much larger Seljuk-led Muslim coalition army.1121: On December 25, St. Norbert and 29 companions make their solemn vows in Premontre, France, establishing the Premonstratensian Order.1122: The Battle of Beroia (Modern-day Stara Zagora, Bulgaria) results in the disappearance of the Pechenegs Turkish tribe as an independent force.1122: On September 23, the Concordat of Worms (Pactum Calixtinum) is drawn up between Emperor Henry V and Pope Calixtus II bringing an end to the first phase of the power struggle between the papacy and the Holy Roman Empire.1122: King David the Builder captures Tbilisi and declares it the capital city of Georgia, ending 400 years of Arab rule.1123: The Jurchen dynasty of China forces Koryo (now Korea) to recognize their suzerainty.1124: In April or May, David I is crowned King of the Scots.1125: On June 11, in the Battle of Azaz, the Crusader states, led by King Baldwin II of Jerusalem, defeat the Seljuk Turks.1125: In November, the Jurchens of the Jin dynasty declare war on the Song dynasty, beginning the JinSong wars.1125: Lothair of Supplinburg, duke of Saxony, is elected Holy Roman Emperor instead of the nearest heir, Frederick of Swabia, beginning the great struggle between Guelphs and Ghibellines.1127: The Northern Song dynasty loses power over northern China to the Jin dynasty.1128: On June 24, the Kingdom of Portugal gains independence from the Kingdom of Len at the Battle of So Mamede; (recognised by Len in 1143).Main article: 1130sThe temple complex of Angkor Wat, built during the reign of Suryavarman II in Cambodia of the Khmer Era.11301180: 50-year drought in what is now the American Southwest.11301138: Papal schism, Pope Innocent II vs. Antipope Anacletus II.1130: On March 26, Sigurd I of Norway dies. A golden era of 95 years comes to an end for Norway as civil wars between the members of Harald Fairhair's family line rage for the remainder of the century.1130: On Christmas Day, Roger II is crowned King of Sicily, the royal title being bestowed on him by Antipope Anacletus II.1132: The Southern Song dynasty establishes China's first permanent standing navy, although China had a long naval history prior. The main admiral's office is at the port of Dinghai.11321183: the Chinese navy increases from a mere 3,000 to 52,000 marine soldiers stationed in 20 different squadrons. During this time, hundreds of treadmill-operated paddle wheel craft are assembled for the navy to fight the Jin dynasty in the north.1135: King Jayabaya of Kadiri ascends to the throne.[2]11351154: The Anarchy takes place, during a period of civil war in England.1136: Suger begins rebuilding the abbey church at St Denis north of Paris, which is regarded as the first major Gothic building.1137: On July 22, the future King Louis VII of France marries Eleanor, the Duchess of Aquitaine.1138: On October 11, the 1138 Aleppo earthquake devastates much of northern Syria.1139: in April, the Second Lateran Council ends the papal schism.1139: On July 5, in the Treaty of Mignano, Pope Innocent II confirms Roger II as King of Sicily, Duke of Apulia, and Prince of Capua and invests him with his titles.1139: On July 25, the Portuguese defeat the Almoravids led by Ali ibn Yusuf in the Battle of Ourique; Prince Afonso Henriques is acclaimed King of Portugal by his soldiers.Main article: 1140sAverroes in a 14th-century painting by Andrea di Bonaiuto11401150: Collapse of the Ancestral Puebloan culture at Chaco Canyon (modern-day New Mexico).1141: The Treaty of Shaoxing ends the conflict between the Jin dynasty and Southern Song dynasty, legally establishing the boundaries of the two countries and forcing the Song dynasty to renounce all claims to its former territories north of the Huai River. The treaty reduces the Southern Song into a quasi-tributary state of the Jurchen Jin dynasty.1143: Manuel I Komnenos is crowned as Byzantine emperor after the death of John II Komnenos.1143: Afonso Henriques is proclaimed King of Portugal by the cortes.1143: The Treaty of Zamora recognizes Portuguese independence from the Kingdom of Len. Portugal also recognizes the suzerainty of the pope.1144: On December 24, Edessa falls to the Atabeg Zengi.11451148: The Second Crusade is launched in response to the fall of the County of Edessa.1147: On October 25, the four-month-long Siege of Lisbon successfully brings the city under definitive Portuguese control, expelling the Moorish overlords.1147: A new Berber dynasty, the Almohads, led by Emir Abd al-Mu'min, takes North Africa from the Almoravides and soon invades the Iberian Peninsula. The Almohads began as a religious movement to rid Islam of impurities.1147: The Wendish Crusade against the Polabian Slavs (or "Wends") in what is now northern and eastern Germany.Main article: 1150s1150: Ramon Berenguer IV, Count of Barcelona marries Petronilla, the Queen of Aragon.1151: The Treaty of Tudiln is signed by Alfonso VII of Len and Raymond Berengar IV, Count of Barcelona, recognizing the Aragonese conquests south of the Jcar and the right to expand in and annex the Kingdom of Murcia.1153: The Treaty of Wallingford, ends the civil war between Empress Matilda and her cousin King Stephen of England fought over the English crown. Stephen acknowledges Matilda's son Henry of Anjou as heir.1153: The First Treaty of Constance is signed between Emperor Frederick I and Pope Eugene III, by the terms of which, the emperor is to prevent any action by Manuel I Comnenus to reestablish the Byzantine Empire on Italian soil and to assist the pope against his enemies in revolt in Rome.1154: the Moroccan-born Muslim geographer Muhammad al-Idrisi publishes his Geography.1154: On December 27, Henry II is crowned King of England at Westminster Abbey.1155: Pope Adrian IV grants overlordship of Ireland to Henry II of England in the bull Laudabiliter.1156: On June 18, the Treaty of Benevento is entered into by Pope Adrian IV and the Norman Kingdom of Sicily. After years of turbulent relations, the popes finally settles down to peace with the Hauteville kings. The kingship of William I is recognized over all Sicily, Apulia, Calabria, Campania, and Capua. The tribute to the pope of 600 schifati agreed upon by Roger II in 1139 at Mignano is affirmed and another 400 shift is added for the new lands.1158: The Treaty of Sahagn ends the war between Castile and Len.Main article: 1160sThe Liuhe Pagoda of Hangzhou, China, 11651161: the Song dynasty Chinese navy, employing gunpowder bombs launched from trebuchets, defeats the enormous Jin dynasty navy in the East China Sea in the Battle of Tangdao and on the Yangtze River in the Battle of Caishi.1161: Kilij Arslan II, Sultan of Rum, makes peace with the Byzantine Empire, recognizing the emperor's primacy.1161: In the siege of Ani, troops from the Kingdom of Georgia take control over the city, only to have it sold for the second time to the Shaddadids, a Kurdish dynasty.1162: Genghis Khan, the founder of the Mongol Empire, is born as Temjin in present-day Mongolia.1163: The Norwegian Law of Succession takes effect.11651182: Tensions and disputes between the Pagan Empire and the Kingdom of Polonnaruwa causes the Sinhalese under Parakramabahu the Great to raid Burma.1168: King Valdemar I of Denmark conquers Arkona on the Island of Rgen, the strongest pagan fortress and temple in northern Europe.1169: Political disputes within the Pandya Empire sparks the decade-long Pandyan Civil War.1169: On May 1, the Norman invasion of Ireland begins. Richard fitzGilbert de Clare ('Strongbow') allies with the exiled Irish chief, Dermot MacMurrough, to help him recover his kingdom of Leinster.Main article: 1170sThe defense of the Carroccio during the battle of Legnano (1176) by Amos Cassioli (18321891)1170: The Treaty of Sahagn is signed by Alfonso VIII of Castile and Alfonso II of Aragon. Based on the terms of the accord, Alfonso VIII agrees to provide Alfonso II with three hostages, to be used as tribute payments owed by Ibn Mardan of Valencia and Murcia.1170: On December 29, Thomas Becket is murdered in Canterbury Cathedral.1171: Saladin deposes the last Fatimid Caliph Al-'id and establishes the Ayyubid dynasty.1171: On November 11, Henry II of England lands in Ireland to assert his claim as Lord of Ireland.1172: The Pandyan city of Madurai is sacked by the Sinhalese army due to an attempt to drive off the rival throne claimant, Kulasekara Pandyan.1173: Sinhalese king Parakramabahu the Great gains a decisive victory by invading the Chola Empire as an ally of the Pandyas in the Pandyan Civil War.1174: On July 12, William I of Scotland is captured by the English in the Battle of Alnwick. He accepts the feudal overlordship of the English crown and pays ceremonial allegiance at York.1175: Hnen Shnin (Genk) founds the Jdo sh (Pure Land) sect of Buddhism.1175: The Treaty of Windsor is signed by King Henry II of England and the High King of Ireland, Ruaidr Ua Conchobair.1176: On May 29, Frederick Barbarossa's forces are defeated in the Battle of Legnano by the Lombard League which results in the emperor's acknowledgment of the pope's sovereignty over the Papal States and Alexander acknowledging the emperor's overlordship of the imperial Church.1176: On September 17, The Battle of Myriokephalon (Myriocephalum; Turkish: Miryakefalon Sava) is fought between the Byzantine Empire and the Seljuk Turks in Phrygia. It is a serious reversal for the Byzantine forces and will be the final, unsuccessful, effort by the Byzantines to recover the interior of Anatolia from the Seljuk Turks.1177: The Treaty or Peace of Venice is signed by the papacy and its allies, and Frederick I, Holy Roman Emperor. The Norman Kingdom of Sicily also participates in negotiations and the treaty thereby determines the political course of all of Italy for the next several years.1178: Chinese writer Zhou Qufei, a Guangzhou customs officer, writes of an island far west in the Indian Ocean (possibly Madagascar), from where people with skin "as black as lacquer" and with frizzy hair were captured and purchased as slaves by Arab merchants.1179: The Treaty of Cazola (Cazorla) is signed by Alfonso II of Aragon and Alfonso VIII of Castile, dividing Andalusia into separate zones of conquest for the two kingdoms, so that the work of the Reconquista would not be stymied by internecine feuding.Main article: 1180s1180: The Portuguese Navy defeats a Muslim fleet off the coast of Cape Espichel.11801185: the Genpei War in Japan.1181: Parakramabahu the Great conducts a large-scale raid on Burma, after a ship transporting a Sinhalese princess to the Khmer Empire is attacked by Burmese naval fleets.1182: Religious reformations of Theravada Buddhism in Pagan Burma under the patronage of Narapatisithu are continued with the end of the Polonnaruwa-Pagan War.1182: Revolt of the people of Constantinople against the Latins, whom they massacre, proclaiming Andronicus I Comnenus as co-emperor.1183: On January 25, the final Peace of Constance between Frederick Barbarossa, the pope and the Lombard towns is signed, confirming the Peace of Venice of 1177.1183: On September 24, Andronicus I Comnenus has his nephew Alexius II Comnenus strangled.1184: On March 24, Queen Tamar, King of Georgia, accedes to the throne as sole ruler after reigning with her father, George III, for six years.1184: Diet of Pentecost organised by Emperor Frederick I in Mainz.1185: The Uprising of Asen and Peter against the Byzantine Empire leads to the restoration of the Bulgarian Empire.1185: Andronicus I Comnenus is deposed and, on September 12, executed as a result of the Norman massacre of the Greeks of Thessalonika.1185: The cathedral school (Katedralskolan) in Lund, Sweden, is founded. The school is the oldest in northern Europe and one of the oldest in all of Europe.1185: Beginning in this year the Kamakura shogunate deprives the emperor of Japan of political power.1186: On January 27, the future Holy Roman Emperor Henry VI marries Constance of Sicily, the heiress to the Sicilian throne.1187: On July 4, in the Battle of Hattin, Saladin defeats the king of Jerusalem.1187: In August, the Swedish royal and commercial center Sigtuna is attacked by raiders from Karelia, Couronia, and/or Estonia.[3]1188: The Riah were introduced into the Habt and south of Tetouan by the Almohad caliph, Abu Yusuf Yaqub al-Mansur, and Jochem and Acem were introduced in Tamesna.[4]1189: On September 3, Richard I is crowned King of England at Westminster.1189: On November 11, William II of Sicily dies and is succeeded by his illegitimate cousin Tancred, Count of Lecce instead of Constance.11891192: The Third Crusade is an attempt by European leaders to wrest the Holy Land from Saladin.Main articles: 1190s and 1200sRichard I of England, or Richard the Lionheart.1190: On June 10, Emperor Frederick Barbarossa drowns in the River Salef, leaving the Crusader army under the command of the rivals Philip II of France and Richard I of England, which ultimately leads to the dissolution of the army.1191: Holy Roman Emperor Henry VI attacked the Kingdom of Sicily from May to August but fails and withdrawn, with Empress Constance captured (released 1192).1191: On September 7, Saladin is defeated by Richard I of England at the Battle of Arsuf.1192: In April, Isabella I begins her reign as Christian Queen of the Kingdom of Jerusalem1192: In the Battle of Jaffa, King Richard the Lionheart defeats Saladin.1192: In June, the Treaty of Ramla is signed by Saladin and Richard Lionheart. Under the terms of the agreement, Jerusalem will remain under Muslim control. However, the city will be open to Christian pilgrims. The Latin Kingdom is reduced to a coastal strip that extends from Tyre to Jaffa.1192: Minamoto no Yoritomo is appointed Sei-i Taishgun, "barbarian-subduing great general", shgun for short, the first military dictator to bear this title.1192: Sultan Shahbuddin Muhammad Ghori establishes the first Muslim empire in India for 14 years (11921206) by defeating Prithviraj Chauhan.1193: Nalanda, the great Indian Buddhist educational centre, is destroyed.1194: Emperor Henry VI conquers the Kingdom of Sicily.1195: On June 16, the struggle of Shamqori. Georgian forces annihilate the army of Abu Baqar.1198: The brethren of the Crusader hospital in Acre are raised to a military order of knights, the Teutonic Knights, formally known as the Order of the Knights of the Hospital of St. Mary of the Teutons in Jerusalem.1199: Pope Innocent III writes to Kaloyan, inviting him to unite the Bulgarian Church with the Roman Catholic Church.1200: Construction begins on the Grand Village of the Natchez near Natchez, Mississippi. This ceremonial center for the Natchez people is occupied and built until the early 17th century.[5]Eastern Hemisphere at the end of the 12th centuryChina is under the Northern Song dynasty. Early in the century, Zhang Zeduan paints Along the River During the Qingming Festival. It will later end up in the Palace Museum, Beijing.In southeast Asia, there is conflict between the Khmer Empire and the Champa. Angkor Wat is built under the Hindu king Suryavarman II. By the end of the century, the Buddhist Jayavarman VII becomes the ruler.Japan is in its Heian period. The Chj-jinbutsu-giga is made and attributed to Toba Sj. It ends up at the Kzan-ji, Kyoto.In Oceania, the Tui Tonga Empire expands to a much greater area.Europe undergoes the Renaissance of the 12th century. The blast furnace for the smelting of cast iron is imported from China, appearing around Lapphyttan, Sweden, as early as 1150.Alexander Neckam is the first European to document the mariner's compass, first documented by Shen Kuo during the previous century.Christian humanism becomes a self-conscious philosophical tendency in Europe. Christianity is also introduced to Estonia, Finland, and Karelia.The first medieval universities are founded. Pierre Abelard teaches.Middle English begins to develop, and literacy begins to spread outside the Church throughout Europe.[6] In addition, churchmen are increasingly willing to take on secular roles. By the end of the century, at least a third of England's bishops also act as royal judges in secular matters.[7]The Ars antiqua period in the history of the medieval music of Western Europe begins.The earliest recorded miracle play is performed in Dunstable, England.Gothic architecture and trouvre music begin in France.During the middle of the century, the Cappella Palatina is built in Palermo, Sicily, and the Madrid Skylitzes manuscript illustrates the Synopsis of Histories by John Skylitzes.Fire and plague insurance first become available in Iceland, and the first documented outbreaks of influenza there happens.The medieval state of Serbia is formed by Stefan Nemanja and then continued by the Nemanji dynasty.By the end of the century, both the Capetian dynasty and the House of Anjou are relying primarily on mercenaries in their militaries. Paid soldiers are available year-round, unlike knights who expected certain periods off to maintain their manor lifestyles.[8]In India, Hoysala architecture reaches its peak.In the Middle East, the icon of Theotokos of Vladimir is painted probably in Constantinople. Everything but the faces will later be retouched, and the icon will go to the Tretyakov Gallery of Moscow.The Georgian poet Shota Rustaveli composes his epic poem The Knight in the Panther's Skin.Shahab al-Din Suhrawardi founds his "school of illumination".In North Africa, the kasbah of Marrakesh is built, including the city gate Bab Agnaou and the Koutoubia mosque.In sub-Saharan Africa, Kente cloth is first woven.In France, the first piedfort coins were minted.The city of Tula burns down, marking the end of the Toltec EmpireIn West Africa the Ife Empire is established.See also: Timeline of historic inventions 12th century1104: The Venice Arsenal of Venice, Italy, is founded. It employed some 16,000 people for the mass production of sailing ships in large assembly lines, hundreds of years before the Industrial Revolution.1106: Finished building of Gelati.1107: The Chinese engineer Wu Deren combines the mechanical compass vehicle of the south-pointing chariot with the distance-measuring odometer device.1111: The Chinese Donglin Academy is founded.1165: The Liuhe Pagoda of Hangzhou, China, is built.1170: The Roman Catholic notion of Purgatory is defined.[9]1185: First record of windmills.Wikimedia Commons has media related to 12th century.^ Soekmono, R, Drs., Pengantar Sejarah Kebudayaan Indonesia 2, 2nd ed. Penerbit Kanisius, Yogyakarta, 1973, 5th reprint edition in 1988 p.57^ Britannica, T. Editors of Encyclopaedia (1998, July 20). Kairi. Encyclopedia Britannica.^ Enn Tarvel (2007). Sigtuna hukkumine. Archived 2017-10-11 at the Wayback Machine Haridus, 2007 (7-8), p 3841^ Notice sur les Arabes hilaliens. Ismal Hamet. p.248.^ Francine Weiss and Mark R. Barnes (May 3, 1989). "National Register of Historic Places Registration: Grand Village of the Natchez Site / Fatherland Plantation Site (22-Ad-501)" (pdf). National Park Service. and Accompanying 3 photos, from 1989.(680KB)^ Warren 1961, p.129.^ Warren 1961, p.159.^ Warren 1961, p.60-61.^ Le Goff, Jacques (1986). The Birth of Purgatory. Chicago: University of Chicago Press. ISBN0226470822.Warren, Wilfred Lewis (1961). King John. University of California Press. p.362. ISBN9780520036437. {{cite book}}: ISBN / Date incompatibility (help)Retrieved from " 4The following pages link to 12th century External tools(link counttransclusion countsorted list) See help page for transcluding these entriesShowing 50 items.View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Antisemitism in Christianity (links | edit)Catharism (links | edit)List of decades, centuries, and millennia (links | edit)Dialect (links | edit)House of Habsburg (links | edit)House of Hohenzollern (links | edit)History of Mali (links | edit)Maimonides (links | edit)Passport (links | edit)Sumba (links | edit)Taoism (links | edit)Weregild (links | edit)Zanzibar (links | edit)20th century (links | edit)1040 (links | edit)15th century (links | edit)16th century (links | edit)17th century (links | edit)18th century (links | edit)14th century (links | edit)1st century (links | edit)13th century (links | edit)4th century (links | edit)11th century (links | edit)1282 (links | edit)7th century (links | edit)10th century (links | edit)9th century (links | edit)8th century (links | edit)6th century (links | edit)5th century (links | edit)3rd century (links | edit)2nd century (links | edit)4th century BC (links | edit)1st century BC (links | edit)2nd century BC (links | edit)3rd century BC (links | edit)5th century BC (links | edit)6th century BC (links | edit)21st century BC (links | edit)11th century BC (links | edit)1000s (decade) (links | edit)1040s (links | edit)1299 (links | edit)1154 (links | edit)1163 (links | edit)1160s (links | edit)1141 (links | edit)1135 (links | edit)1204 (links | edit)View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Retrieved from " WhatLinksHere/12th_century"Probability theory is a fundamental aspect of statistics and data science, providing the mathematical framework to quantify uncertainty and make predictions based on data. This article delves into the core concepts of probability theory, exploring the nature of probability, independent and dependent events, conditional probability, and Bayes' Theorem.What is Probability?Probability is a measure of the likelihood that a particular event will occur. It quantifies uncertainty and is expressed as a number between 0 and 1:0 indicates an impossible event.1 indicates a certain event.The probability of an event AAA is denoted by P(A)P(A)P(A), and it is calculated as:P(A)=NumberoffavorableoutcomesTotalnumberofpossibleoutcomesP(A) = \frac{\text{Number of favorable outcomes}}{\text{Total number of possible outcomes}}P(A)=TotalnumberofpossibleoutcomesNumberoffavorableoutcomesExample: Rolling a DieConsider rolling a fair six-sided die. The probability of rolling a 4 (event AAA) is:P(A)=160.167P(A) = \frac{1}{6} \approx 0.167P(A)=610.167Since there is one favorable outcome (rolling a 4) out of six possible outcomes (1, 2, 3, 4, 5, 6), the probability of rolling a 4 is approximately 0.167.Figure 1: Probability Distribution for Rolling a Die, highlighting the probability of rolling a 4.Independent and Dependent EventsEvents can be categorized as independent or dependent based on whether the occurrence of one event affects the probability of another.1. Independent EventsIndependent events are events where the occurrence of one event does not affect the probability of the other. The probability of two independent events AAA and BBB occurring together is the product of their individual probabilities:P(AB)=P(A)P(B)P(A \cap B) = P(A) \times P(B)P(AB)=P(A)P(B)Example: Tossing Two CoinsWhen tossing two fair coins, the outcome of the first toss does not affect the outcome of the second toss. If AAA is the event of getting a heads on the first toss and BBB is the event of getting a heads on the second toss:P(A)=12,P(B)=12P(A) = \frac{1}{2}, \quad P(B) = \frac{1}{2}P(A)=21,P(B)=21The probability of getting heads on both tosses (event ABA \cap BAB) is:P(AB)=1212=14=0.25P(A \cap B) = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = 0.25P(AB)=2121=41=0.252. Dependent EventsDependent events are events where the occurrence of one event affects the probability of the other. The probability of two dependent events AAA and BBB occurring together is calculated using conditional probability.Example: Drawing Cards Without ReplacementConsider drawing two cards from a deck without replacement. If AAA is the event of drawing an Ace on the first draw and BBB is the event of drawing an Ace on the second draw, the events are dependent.Probability of drawing an Ace first: P(A)=452P(A) = \frac{4}{52}P(A)=524Probability of drawing an Ace on the second draw, given that an Ace was drawn first: P(BA)=351P(B|A) = \frac{3}{51}P(BA)=513The probability of both events occurring is:P(AB)=P(A)P(BA)=4523510.0045P(A \cap B) = P(A) \times P(B|A) = \frac{4}{52} \times \frac{3}{51} \approx 0.0045P(AB)=P(A)P(BA)=5245130.0045Conditional ProbabilityConditional probability is the probability of an event occurring given that another event has already occurred. It is denoted by P(AB)P(A|B)P(AB) and is calculated as:P(AB)=P(AB)P(B)P(A|B) = \frac{P(A \cap B)}{P(B)}P(AB)=P(B)P(AB)Where:P(AB)P(A \cap B)P(AB) is the probability of both events AAA and BBB occurring.P(B)P(B)P(B) is the probability of event BBB occurring.Example: Probability of Drawing a Red Card Given an AceConsider a standard deck of 52 cards. Let AAA be the event of drawing a red card, and BBB be the event of drawing an Ace.P(AB)=252P(A \cap B) = \frac{2}{52}P(AB)=522 (since there are 2 red Aces in a deck).P(B)=452P(B) = \frac{4}{52}P(B)=524 (since there are 4 Aces in a deck).The conditional probability of drawing a red card given that an Ace is drawn is:P(AB)=252452=24=0.5P(A|B) = \frac{\frac{2}{52}}{\frac{4}{52}} = \frac{2}{4} = 0.5P(AB)=524522=42=0.5This result shows that if an Ace is drawn, there is a 50% chance it is a red Ace.Bayes' TheoremBayes' Theorem is a powerful tool in probability theory that allows us to update our beliefs based on new evidence. It relates the conditional probability of events AAA and BBB:P(AB)=P(BA)P(A)P(B)P(A|B) = \frac{P(B|A) \times P(A)}{P(B)}P(AB)=P(B)P(BA)P(A)Where:P(AB)P(A|B)P(AB) is the posterior probability of AAA given BBB.P(BA)P(B|A)P(BA) is the likelihood of BBB given AAA.P(A)P(A)P(A) is the prior probability of AAA.P(B)P(B)P(B) is the marginal probability of BBB.Example: Medical TestingSuppose a diagnostic test for a disease has the following characteristics:Sensitivity (true positive rate) = P(PositiveTestDisease)=0.99P(\text{Positive Test}|\text{Disease}) = 0.99P(PositiveTestDisease)=0.99Specificity (true negative rate) = P(NegativeTestNoDisease)=0.95P(\text{Negative Test}|\text{No Disease}) = 0.95P(NegativeTestNoDisease)=0.95Prevalence of the disease in the population = P(Disease)=0.01P(\text{Disease}) = 0.01P(Disease)=0.01If a person tests positive, what is the probability they actually have the disease?Using Bayes' Theorem:P(DiseasePositiveTest)=P(PositiveTestDisease)P(Disease)P(PositiveTest)P(\text{Disease}|\text{Positive Test}) = \frac{P(\text{Positive Test}|\text{Disease}) \times P(\text{Disease})}{P(\text{Positive Test})}P(DiseasePositiveTest)=P(PositiveTest)P(PositiveTestDisease)P(Disease)Where P(PositiveTest)P(\text{Positive Test})P(PositiveTest) is calculated as:P(PositiveTest)=P(PositiveTestDisease)P(Disease)+P(PositiveTestNoDisease)P(NoDisease)P(\text{Positive Test}) = P(\text{Positive Test}|\text{Disease}) \times P(\text{Disease}) + P(\text{Positive Test}|\text{No Disease}) \times P(\text{No Disease})P(PositiveTest)=P(PositiveTestDisease)P(Disease)+P(PositiveTestNoDisease)P(NoDisease)Substitute the values:P(PositiveTest)=(0.990.01)+(0.050.99)=0.0099+0.0495=0.0594P(\text{Positive Test}) = (0.99 \times 0.01) + (0.05 \times 0.99) = 0.0099 + 0.0495 = 0.0594P(PositiveTest)=(0.990.01)+(0.050.99)=0.0099+0.0495=0.0594Finally, calculate the posterior probability:P(DiseasePositiveTest)=0.990.010.05940.167P(\text{Disease}|\text{Positive Test}) = \frac{0.99 \times 0.01}{0.0594} \approx 0.167P(DiseasePositiveTest)=0.05940.990.010.167This result indicates that despite a positive test result, there is only a 16.7% chance that the person actually has the disease, emphasizing the importance of understanding and applying Bayes' Theorem in medical testing and other areas.Law of Total ProbabilityThe Law of Total Probability is used to calculate the probability of an event based on multiple, mutually exclusive scenarios that cover all possible outcomes. If events B1,B2,,BnB_1, B_2, \dots, B_nB1,B2,,Bn are mutually exclusive and exhaustive, then for any event AAA:P(A)=i=1nP(ABi)P(Bi)P(A) = \sum_{i=1}^{n} P(A|B_i) \times P(B_i)P(A)=i=1nP(ABi)P(Bi)Example: Probability of Rain Based on Weather ForecastsSuppose the probability of rain depends on three different weather forecasts:P(RainForecast1)=0.8P(\text{Rain}|\text{Forecast 1}) = 0.8P(RainForecast1)=0.8P(RainForecast2)=0.6P(\text{Rain}|\text{Forecast 2}) = 0.6P(RainForecast2)=0.6P(RainForecast3)=0.4P(\text{Rain}|\text{Forecast 3}) = 0.4P(RainForecast3)=0.4And the probabilities of each forecast being accurate are:P(Forecast1)=0.5P(\text{Forecast 1}) = 0.5P(Forecast1)=0.5P(Forecast2)=0.3P(\text{Forecast 2}) = 0.3P(Forecast2)=0.3P(Forecast3)=0.2P(\text{Forecast 3}) = 0.2P(Forecast3)=0.2Using the Law of Total Probability, the overall probability of rain is:P(Rain)=(0.80.5)+(0.60.3)+(0.40.2)=0.4+0.18+0.08=0.66P(\text{Rain}) = (0.8 \times 0.5) + (0.6 \times 0.3) + (0.4 \times 0.2) = 0.4 + 0.18 + 0.08 = 0.66P(Rain)=(0.80.5)+(0.60.3)+(0.40.2)=0.4+0.18+0.08=0.66There is a 66% chance of rain based on the combined accuracy of the forecasts.ConclusionUnderstanding the basics of probability theory is crucial for data science, as it lays the groundwork for statistical inference, machine learning, and decision-making under uncertainty. By mastering concepts such as independent and dependent events, conditional probability, and Bayes' Theorem, you can make more informed decisions based on data.Probability theory is a branch of mathematics that deals with the analysis of random phenomena. The fundamental object of probability theory is a random variable, which is a quantity whose outcome is uncertain. Probability theory allows us to make predictions about the likelihood of various outcomes, ranging from the simple flip of a coin to the complex interactions of particles in physics.The Basics of ProbabilityAt the core of probability theory is the concept of a probability space, which consists of three elements: a sample space, events, and the probability function. The sample space is the set of all possible outcomes of a random experiment. An event is a subset of the sample space, and the probability function assigns a number between 0 and 1 to each event, representing the likelihood of that event occurring.Probabilities are typically expressed as fractions or percentages. A probability of 0 means an event is impossible, while a probability of 1 means an event is certain. For example, the probability of rolling a six on a fair die is 1/6, or approximately 16.67%.Conditional Probability and IndependenceConditional probability is the probability of an event occurring given that another event has already occurred. It is denoted as P(A|B), the probability of event A given event B. Two events are independent if the occurrence of one does not affect the probability of the other occurring. If events A and B are independent, then P(A|B) = P(A).For instance, if we flip two coins, the probability of getting heads on the second coin is not affected by whether we got heads or tails on the first coin. Thus, the events are independent.Bayes' TheoremBayes' Theorem is a fundamental result in probability theory that relates conditional probabilities. It states that:P(A|B) = [P(B|A) * P(A)] / P(B)This theorem allows us to update our beliefs about the likelihood of an event based on new evidence. It is widely used in various fields, including statistics, machine learning, and decision-making processes.Random Variables and DistributionsA random variable is a variable that takes on numerical values based on the outcome of a random event. Random variables can be discrete or continuous, depending on whether they take on a finite or infinite number of values. Each random variable has a probability distribution, which describes how probabilities are distributed over the values of the random variable.Common probability distributions include the binomial distribution for discrete variables and the normal distribution for continuous variables. The binomial distribution, for example, models the number of successes in a fixed number of independent Bernoulli trials, each with the same probability of success.The Law of Large Numbers and Central Limit TheoremThe Law of Large Numbers states that as the number of trials in an experiment increases, the average of the results will get closer to the expected value. This is why flipping a coin many times will tend to result in an equal number of heads and tails.The Central Limit Theorem is another cornerstone of probability theory, stating that the distribution of the sum (or average) of a large number of independent, identically distributed variables will tend to be normally distributed, regardless of the underlying distribution. This theorem underpins many statistical methods and justifies the use of the normal distribution in various applications.Applications of Probability TheoryProbability theory is foundational to many disciplines. In finance, it is used to model market risks and to price options. In computer science, algorithms often rely on probabilistic methods for tasks such as data compression and error correction. In everyday life, probability can inform decisions, such as the likelihood of rain affecting an outdoor event.In the realm of science, probability theory is essential for statistical inference, allowing researchers to draw conclusions from data subject to random variation. It is also integral to the study of quantum mechanics, where the behavior of particles is inherently probabilistic.ConclusionProbability theory is a versatile and powerful tool that helps us navigate uncertainty and make informed decisions. It provides a framework for understanding and quantifying randomness, which is a feature of many natural and human-made systems. Whether it's predicting the outcome of a game, assessing risk, or analyzing complex data, probability theory is a key component of logical reasoning and analytical thought. Probability theory is a branch of mathematics that deals with the analysis of random phenomena. It provides a framework for quantifying uncertainty and making predictions based on incomplete information. Probability theory is foundational to various fields, including statistics, finance, gambling, science, and artificial intelligence. By understanding the principles of probability, one can assess risks, make informed decisions, and derive meaningful insights from data. Ad description. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Basic Concepts of ProbabilityAt the core of probability theory are several fundamental concepts, including experiments, outcomes, events, and sample spaces. An experiment is a procedure that yields one or more outcomes, while an outcome is a possible result of that experiment. An event is a specific set of outcomes, and the sample space is the collection of all possible outcomes. These concepts form the basis for calculating probabilities and understanding how likely certain events are to occur.Types of ProbabilityThere are several types of probability, including theoretical probability, experimental probability, and subjective probability. Theoretical probability is based on the reasoning behind probability, often derived from mathematical models. Experimental probability, on the other hand, is based on the actual results of experiments conducted. Subjective probability reflects personal beliefs or opinions about the likelihood of an event occurring, which may not be grounded in empirical evidence.Probability DistributionsProbability distributions describe how probabilities are distributed over the values of a random variable. They can be discrete or continuous. Discrete probability distributions, such as the binomial and Poisson distributions, apply to scenarios where outcomes are countable. Continuous probability distributions, such as the normal and exponential distributions, apply to scenarios where outcomes can take on any value within a range. Understanding these distributions is crucial for data analysis and statistical inference.Law of Large NumbersThe Law of Large Numbers is a fundamental theorem in probability theory that states that as the number of trials in an experiment increases, the empirical probability of an event will converge to its theoretical probability. This principle underpins many statistical methods and justifies the use of large samples in data analysis. It assures researchers that with enough data, their estimates will become more accurate and reliable. Ad description. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Central Limit TheoremThe Central Limit Theorem (CLT) is another cornerstone of probability theory, stating that the distribution of the sum of a large number of independent and identically distributed random variables approaches a normal distribution, regardless of the original distribution of the variables. This theorem is vital for inferential statistics, as it allows statisticians to make inferences about population parameters based on sample statistics, even when the underlying distribution is not normal.Conditional ProbabilityConditional probability refers to the probability of an event occurring given that another event has already occurred. It is a critical concept in probability theory, particularly in the context of Bayesian statistics. The formula for calculating conditional probability is P(A|B) = P(A and B) / P(B), where P(A|B) is the probability of event A given event B. Understanding conditional probability is essential for analyzing dependent events and making predictions based on prior knowledge.Bayes TheoremBayes Theorem is a mathematical formula that describes how to update the probability of a hypothesis based on new evidence. It combines prior probability with the likelihood of the observed data to produce a posterior probability. The theorem is expressed as P(H|E) = [P(E|H) * P(H)] / P(E), where H is the hypothesis and E is the evidence. Bayes Theorem is widely used in various fields, including machine learning, medical diagnosis, and risk assessment.Applications of Probability TheoryProbability theory has numerous applications across various domains. In finance, it is used to assess risks and make investment decisions. In machine learning, probability models help in making predictions based on data. In healthcare, probability is essential for understanding the likelihood of diseases and the effectiveness of treatments. Additionally, probability plays a crucial role in quality control, insurance, and any field that involves uncertainty and decision-making. Ad description. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Science Mathematics probability theory, a branch of mathematics concerned with the analysis of random phenomena. The outcome of a random event cannot be determined before it occurs, but it may be any one of several possible outcomes. The actual outcome is considered to be determined by chance.The word probability has several meanings in ordinary conversation. Two of these are particularly important for the development and applications of the mathematical theory of probability. One is the interpretation of probabilities as relative frequencies, for which simple games involving coins, cards, dice, and roulette wheels provide examples. The distinctive feature of games of chance is that the outcome of a given trial cannot be predicted with certainty, although the collective results of a large number of trials display some regularity. For example, the statement that the probability of heads in tossing a coin equals one-half, according to the relative frequency interpretation, implies that in a large number of tosses the relative frequency with which heads actually occurs will be approximately one-half, although it contains no implication concerning the outcome of any given toss. There are many similar examples involving groups of people, molecules of a gas, genes, and so on. Actuarial statements about the life expectancy for persons of a certain age describe the collective experience of a large number of individuals but do not purport to say what will happen to any particular person. Similarly, predictions about the chance of a genetic disease occurring in a child of parents having a known genetic makeup are statements about relative frequencies of occurrence in a large number of cases but are not predictions about a given individual.(Read Steven Pinkers Britannica entry on rationality.)This article contains a description of the important mathematical concepts of probability theory, illustrated by some of the applications that have stimulated their development. For a fuller historical treatment, see probability and statistics. Since applications inevitably involve simplifying assumptions that focus on some features of a problem at the expense of others, it is advantageous to begin by thinking about simple experiments, such as tossing a coin or rolling dice, and later to see how these apparently frivolous investigations relate to important scientific questions. The fundamental ingredient of probability theory is an experiment that can be repeated, at least hypothetically, under essentially identical conditions and that may lead to different outcomes on different trials. The set of all possible outcomes of an experiment is called a sample space. The experiment of tossing a coin once results in a sample space with two possible outcomes, heads and tails. Tossing two dice has a sample space with 36 possible outcomes, each of which can be identified with an ordered pair (i, j), where i and j assume one of the values 1, 2, 3, 4, 5, 6 and denote the faces showing on the individual dice. It is important to think of the dice as identifiable (say by a difference in colour), so that the outcome (1, 2) is different from (2, 1). An event is a well-defined subset of the sample space. For example, the event the sum of the faces showing on the two dice equals six consists of the five outcomes (1, 5), (2, 4), (3, 3), (4, 2), and (5, 1). A third example is to draw n balls from an urn containing balls of various colours. A generic outcome to this experiment is an n-tuple, where the ith entry specifies the colour of the ball obtained on the ith draw (i = 1, 2,, n). In spite of the simplicity of this experiment, a thorough understanding gives the theoretical basis for opinion polls and sample surveys. For example, individuals in a population favouring a particular candidate in an election may be identified with balls of a particular colour, those favouring a different candidate may be identified with a different colour, and so on. Probability theory provides the basis for learning about the contents of the urn from the sample of balls drawn from the urn; an application is to learn about the electoral preferences of a population on the basis of a sample drawn from that population. Another application of simple urn models is to use clinical trials designed to determine whether a new treatment for a disease, a new drug, or a new surgical procedure is better than a standard treatment. In the simple case in which treatment can be regarded as either success or failure, the goal of the clinical trial is to discover whether the new treatment more frequently leads to success than does the standard treatment. Patients with the disease can be identified with balls in an urn. The red balls are those patients who are cured by the new treatment, and the black balls are those not cured. Usually there is a control group, who receive the standard treatment. They are represented by a second urn with a possibly different fraction of red balls. The goal of the experiment of drawing some number of balls from each urn is to discover on the basis of the sample which urn has the larger fraction of red balls. A variation of this idea can be used to test the efficacy of a new vaccine. Perhaps the largest and most famous example was the test of the Salk vaccine for poliomyelitis conducted in 1954. It was organized by the U.S. Public Health Service and involved almost two million children. Its success has led to the almost complete elimination of polio as a health problem in the industrialized parts of the world. Strictly speaking, these applications are problems of statistics, for which the foundations are provided by probability theory. In contrast to the experiments described above, many experiments have infinitely many possible outcomes. For example, one can toss a coin until heads appears for the first time. The number of possible tosses is n = 1, 2,. Another example is to twirl a spinner. For an idealized spinner made from a straight line segment having no width and pivoted at its centre, the set of possible outcomes is the set of all angles that the final position of the spinner makes with some fixed direction, equivalently all real numbers in [0, 2). Many measurements in the natural and social sciences, such as volume, voltage, temperature, reaction time, marginal income, and so on, are made on continuous scales and at least in theory involve infinitely many possible values. If the repeated measurements on different subjects or at different times on the same subject can lead to different outcomes, probability theory is a possible tool to study this variability. Because of their comparative simplicity, experiments with finite sample spaces are discussed first. In the early development of probability theory, mathematicians considered only those experiments for which it seemed reasonable, based on considerations of symmetry, to suppose that all outcomes of the experiment were equally likely. Then in a large number of trials all outcomes should occur with approximately the same frequency. The probability of an event is defined to be the ratio of the number of cases favourable to the eventi.e., the number of outcomes in the subset of the sample space defining the eventto the total number of cases. Thus, the 36 possible outcomes in the throw of two dice are assumed equally likely, and the probability of obtaining six is the number of favourable cases, 5, divided by 36, or 5/36. Now suppose that a coin is tossed n times, and consider the probability of the event heads does not occur in the n tosses. An outcome of the experiment is an n-tuple, the kth entry of which identifies the result of the kth toss. Since there are two possible outcomes for each toss, the number of elements in the sample space is 2n. Of these, only one outcome corresponds to having no heads, so the required probability is 1/2n. It is only slightly more difficult to determine the probability of at most one head. In addition to the single case in which no head occurs, there are n cases in which exactly one head occurs, because it can occur on the first, second,, or nth toss. Hence, there are n + 1 cases favourable to obtaining at most one head, and the desired probability is (n + 1)/2n. Probability theory is a branch of mathematics that investigates the probabilities associated with a random phenomenon. A random phenomenon can have several outcomes. Probability theory describes the chance of occurrence of a particular outcome by using certain formal concepts.Probability theory makes use of some fundamentals such as sample space, probability distributions, random variables, etc. to find the likelihood of occurrence of an event. In this article, we will take a look at the definition, basics, formulas, examples, and applications of probability theory. What is Probability Theory? Probability theory makes the use of random variables and probability distributions to assess uncertain situations mathematically. In probability theory, the concept of probability is used to assign a numerical description to the likelihood of occurrence of an event. Probability can be defined as the number of favorable outcomes divided by the total number of possible outcomes of an event Probability theory is a field of mathematics and statistics that is concerned with finding the probabilities associated with random events. There are two main approaches available to study probability theory. These are theoretical probability and experimental probability. Theoretical probability is determined on the basis of logical reasoning without conducting experiments. In contrast, experimental probability is determined on the basis of historic data by performing repeated experiments.Probability Theory ExampleSuppose the probability of obtaining a number 4 on rolling a fair dice needs to be established. The number of favorable outcomes is 1. The possible outcomes of the dice are {1, 2, 3, 4, 5, 6}. This implies that there are a total of 6 outcomes. Thus, the probability of obtaining 4 on a dice roll, using probability theory, can be computed as 1 / 6 = 0.167.Probability Theory Basics There are some basic terminologies associated with probability theory that aid in the understanding of this field of mathematics.Random ExperimentA random experiment, in probability theory, can be defined as a trial that is repeated multiple times in order to get a well-defined set of possible outcomes. Tossing a coin is an example of a random experiment.Sample SpaceSample space can be defined as the set of all possible outcomes that result from conducting a random experiment. For example, the sample space of tossing a fair coin is {heads, tails}.EventProbability theory defines an event as a set of outcomes of an experiment that forms a subset of the sample space. The types of events are given as follows:Independent events: Events that are not affected by other events are independent events.Dependent events: Events that are affected by other events are known as dependent events.Mutually exclusive events: Events that cannot take place at the same time are mutually exclusive events.Equally likely events: Two or more events that have the same chance of occurring are known as equally likely events.Exhaustive events: An exhaustive event is one that is equal to the sample space of an experiment.Random VariableIn probability theory, a random variable can be defined as a variable that assumes the value of all possible outcomes of an experiment. There are two types of random variables as given below.Discrete Random Variable: Discrete random variables can take an exact countable value such as 0, 1, 2... It can be described by the cumulative distribution function and the probability mass function.Continuous Random Variable: A variable that can take on an infinite number of values is known as a continuous random variable. The cumulative distribution function and probability density function are used to define the characteristics of this variable.ProbabilityProbability, in probability theory, can be defined as the numerical likelihood of occurrence of an event. The probability of an event taking place will always lie between 0 and 1. This is because the number of desired outcomes can never exceed the total number of outcomes of an event. Theoretical probability and empirical probability are used in probability theory to measure the chance of an event taking place.Conditional ProbabilityWhen the likelihood of occurrence of an event needs to be determined given that another event has already taken place, it is known as conditional probability. It is denoted as P(A | B). This represents the conditional probability of event A given that event B has already occurred.ExpectationThe expectation of a random variable, X, can be defined as the average value of the outcomes of an experiment when it is conducted multiple times. It is denoted as E[X]. It is also known as the mean of the random variable.VarianceVariance is the measure of dispersion that shows how the distribution of a random variable varies with respect to the mean. It can be defined as the average of the squared differences from the mean of the random variable. Variance can be denoted as Var[X].Probability Theory Distribution FunctionProbability distribution or cumulative distribution function is a function that models all the possible values of an experiment along with their probabilities using a random variable. Bernoulli distribution, binomial distribution, are some examples of discrete probability distributions in probability theory. Normal distribution is an example of a continuous probability distribution.Probability Mass FunctionProbability mass function can be defined as the probability that a discrete random variable will be exactly equal to a specific value.Probability Density FunctionProbability density function is the probability that a continuous random variable will take on a set of possible values.Probability Theory Formulas There are many formulas in probability theory that help in calculating the various probabilities associated with events. The most important probability theory formulas are listed below.Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Empirical probability: Number of times an event occurs / Total number of trials.Addition Rule: P(A B) = P(A) + P(B) - P(AB), where A and B are events.Complementary Rule: P(A') = 1 - P(A). P(A') denotes the probability of an event not happening.Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Probability mass function: f(x) = P(X = x)Probability density function: p(x) = p(x) = \(\frac{\mathrm{d} F(x)}{\mathrm{d} x}\) = F'(x), where F(x) is the cumulative distribution function.Expectation of a continuous random variable: \(\int xf(x)dx\), where f(x) is the pdf.Expectation of a discrete random variable: \(\sum xp(x)\), where p(x) is the pmf.Variance: Var(X) = E[X2] - (E[X])2Applications of Probability Theory Probability theory is used in every field to assess the risk associated with a particular decision. Some of the important applications of probability theory are listed below:In the finance industry, probability theory is used to create mathematical models of the stock market to predict future trends. This helps investors to invest in the least risky asset which gives the best returns.The consumer industry uses probability theory to reduce the probability of failure in a product's design.Casinos use probability theory to design a game of chance so as to make profits.Related Articles:Probability RulesProbability and StatisticsGeometric DistributionImportant Notes on Probability TheoryProbability theory is a branch of mathematics that deals with the probabilities of random events.The concept of probability in probability theory gives the measure of the likelihood of occurrence of an event.The probability value will always lie between 0 and 1.In probability theory, all the possible outcomes of a random experiment give the sample space.Probability theory uses important concepts such as random variables, and cumulative distribution functions to model a random event and determine various associated probabilities.Example 1: When two dice are rolled what is the probability of getting a sum of 8?Solution: When two dice are rolled there are 36 possible outcomes.To get the sum as 8 there are 5 favorable outcomes.[(2, 6), (6, 2), (3, 5), (5, 3), (4, 4)]Using probability theory formulas,Probability = Number of favorable outcomes / total number of possible outcomes.= 5 / 36Answer: The probability of getting the sum as 8 when two dice are rolled is 5 / 36.Example 2: What is the probability of drawing a queen from a deck of cards?Solution: A deck of cards has 4 suits. Each suit consists of 13 cards.Thus, the total number of possible outcomes = (4)(13) = 52There can be 4 queens, one belonging to each suit. Hence, the number of favorable outcomes = 4.The card probability = 4 / 52 = 1 / 13Answer: The probability of getting a queen from a deck of cards is 1 / 13Example 3: Out of 10 people, 3 bought pencils, 5 bought notebooks and 2 got both pencils and notebooks. If a customer bought a notebook what is the probability that she also bought a pencil.Solution: Using the concept of conditional probability in probability theory, P(A | B) = P(AB) / P(B). Let A be the event of people buying pencils and B be the event people of buying notebooks. P(A) = 3 / 10 = 0.3 P(B) = 5 / 10 = 0.5 P(AB) = 2 / 10 = 0.2 Substituting the values in the given formula, P(A | B) = 0.2 / 0.5 = 0.4Answer: The probability that a customer bought a pencil given that she bought a notebook is 0.4.Show more >go to slidego to slidego to slideBreakdown tough concepts through simple visuals.Math will no longer be a tough subject, especially when you understand the concepts through visualizations.Book a Free Trial ClassFAQs on Probability Theory Probability theory is a branch of mathematics that deals with the likelihood of occurrence of a random event. It encompasses several formal concepts related to probability such as random variables, probability theory distribution, expectation, etc.What are the Two Types of Probabilities in Probability Theory?The two types of probabilities in probability theory are theoretical probability and experimental probability. Theoretical probability gives the probability of what is expected to happen without conducting any experiments. Experimental probability uses repeated experiments to give the probability of an event taking place.What are the Formulas for Probability Theory? The main probability theory formulas are as follows:Independent events: P(AB) = P(A) P(B)Conditional probability: P(A | B) = P(AB) / P(B)Bayes' Theorem: P(A | B) = P(B | A) P(A) / P(B)Theoretical probability: Number of favorable outcomes / Number of possible outcomes.Why is Probability Theory Used in Statistics?Probability theory is useful in making predictions that form an important part of research. Further analysis of situations is made using statistical tools. Thus, statistics is dependent on probability theory to draw sound conclusions.Can the Value of Probability Be Negative According to Probability Theory?According to probability theory, the value of any probability lies between 0 and 1. 0 implies that an event does not happen and 1 denotes that the event takes place. Thus, probability cannot be negative.What is a Random Variable in Probability Theory?A random variable in probability theory can be defined as a variable that is used to model the probabilities of all possible outcomes of an event. A random variable can be either continuous or discrete.What are the Applications of Probability Theory?Probability theory has applications in almost all industrial fields. It is used to gauge and analyze the risk associated with an event and helps to make robust decisions. Science Mathematics probability theory, a branch of mathematics concerned with the analysis of random phenomena. The outcome of a random event cannot be determined before it occurs, but it may be any one of several possible outcomes. The actual outcome is considered to be determined by chance.The word probability has several meanings in ordinary conversation. Two of these are particularly important for the development and applications of the mathematical theory of probability. One is the interpretation of probabilities as relative frequencies, for which simple games involving coins, cards, dice, and roulette wheels provide examples. The distinctive feature of games of chance is that the outcome of a given trial cannot be predicted with certainty, although the collective results of a large number of trials display some regularity. For example, the statement that the probability of heads in tossing a coin equals one-half, according to the relative frequency interpretation, implies that in a large number of tosses the relative frequency with which heads actually occurs will be approximately one-half, although it contains no implication concerning the outcome of any given toss. There are many similar examples involving groups of people, molecules of a gas, genes, and so on. Actuarial statements about the life expectancy for persons of a certain age describe the collective experience of a large number of individuals but do not purport to say what will happen to any particular person. Similarly, predictions about the chance of a genetic disease occurring in a child of parents having a known genetic makeup are statements about relative frequencies of occurrence in a large number of cases but are not predictions about a given individual.(Read Steven Pinkers Britannica entry on rationality.)This article contains a description of the important mathematical concepts of probability theory, illustrated by some of the applications that have stimulated their development. For a fuller historical treatment, see probability and statistics. Since applications inevitably involve simplifying assumptions that focus on some features of a problem at the expense of others, it is advantageous to begin by thinking about simple experiments, such as tossing a coin or rolling dice, and later to see how these apparently frivolous investigations relate to important scientific questions. The fundamental ingredient of probability theory is an experiment that can be repeated, at least hypothetically, under essentially identical conditions and that may lead to different outcomes on different trials. The set of all possible outcomes of an experiment is called a sample space. The experiment of tossing a coin once results in a sample space with two possible outcomes, heads and tails. Tossing two dice has a sample space with 36 possible outcomes, each of which can be identified with an ordered pair (i, j), where i and j assume one of the values 1, 2, 3, 4, 5, 6 and denote the faces showing on the individual dice. It is important to think of the dice as identifiable (say by a difference in colour), so that the outcome (1, 2) is different from (2, 1). An event is a well-defined subset of the sample space. For example, the event the sum of the faces showing on the two dice equals six consists of the five outcomes (1, 5), (2, 4), (3, 3), (4, 2), and (5, 1). A third example is to draw n balls from an urn containing balls of various colours. A generic outcome to this experiment is an n-tuple, where the ith entry specifies the colour of the ball obtained on the ith draw (i = 1, 2,, n). In spite of the simplicity of this experiment, a thorough understanding gives the theoretical basis for opinion polls and sample surveys. For example, individuals in a population favouring a particular candidate in an election may be identified with balls of a particular colour, those favouring a different candidate may be identified with a different colour, and so on. Probability theory provides the basis for learning about the contents of the urn from the sample of balls drawn from the urn; an application is to learn about the electoral preferences of a population on the basis of a sample drawn from that population. Another application of simple urn models is to use clinical trials designed to determine whether a new treatment for a disease, a new drug, or a new surgical procedure is better than a standard treatment. In the simple case in which treatment can be regarded as either success or failure, the goal of the clinical trial is to discover whether

the new treatment more frequently leads to success than does the standard treatment. Patients with the disease can be identified with balls in an urn. The red balls are those patients who are cured by the new treatment, and the black balls are those not cured. Usually there is a control group, who receive the standard treatment. They are represented by a second urn with a possibly different fraction of red balls. The goal of the experiment of drawing some number of balls from each urn is to discover on the basis of the sample which urn has the larger fraction of red balls. A variation of this idea can be used to test the efficacy of a new vaccine. Perhaps the largest and most famous example was the test of the Salk vaccine for poliomyelitis conducted in 1954. It was organized by the U.S. Public Health Service and involved almost two million children. Its success has led to the almost complete elimination of polio as a health problem in the industrialized parts of the world. Strictly speaking, these applications are problems of statistics, for which the foundations are provided by probability theory. In contrast to the experiments described above, many experiments have infinitely many possible outcomes. For example, one can toss a coin until heads appears for the first time. The number of possible tosses is n = 1, 2,. Another example is to twirl a spinner. For an idealized spinner made from a straight line segment having no width and pivoted at its centre, the set of possible outcomes is the set of all angles that the final position of the spinner makes with some fixed direction, equivalently all real numbers in [0, 2). Many measurements in the natural and social sciences, such as volume, voltage, temperature, reaction time, marginal income, and so on, are made on continuous scales and at least in theory involve infinitely many possible values. If the repeated measurements on different subjects or at different times on the same subject can lead to different outcomes, probability theory is a possible tool to study this variability. Because of their comparative simplicity, experiments with finite sample spaces are discussed first. In the early development of probability theory, mathematicians considered only those experiments for which it seemed reasonable, based on considerations of symmetry, to suppose that all outcomes of the experiment were equally likely. Then in a large number of trials all outcomes should occur with approximately the same frequency. The probability of an event is defined to be the ratio of the number of cases favourable to the eventi.e., the number of outcomes in the subset of the sample space defining the eventto the total number of cases. Thus, the 36 possible outcomes in the throw of two dice are assumed equally likely, and the probability of obtaining six is the number of favourable cases, 5, divided by 36, or 5/36. Now suppose that a coin is tossed n times, and consider the probability of the event heads does not occur in the n tosses. An outcome of the experiment is an n-tuple, the kth entry of which identifies the result of the kth toss. Since there are two possible outcomes for each toss, the number of elements in the sample space is 2n. Of these, only one outcome corresponds to having no heads, so the required probability is 1/2n. It is only slightly more difficult to determine the probability of at most one head. In addition to the single case in which no head occurs, there are n cases in which exactly one head occurs, because it can occur on the first, second,, or nth toss. Hence, there are n + 1 cases favourable to obtaining at most one head, and the desired probability is (n + 1)/2n. Probability theoryisa branch of mathematics focusing on the analysis of random phenomena. It is an important skill fordata scientistsusing data affected by chance. With randomness existing everywhere, the use of probability theory allows for the analysis of chance events. The aim is to determine the likelihood of an event occurring, often using a numerical scale of between 0 and 1, with the number 0 indicating impossibility and 1 indicating certainty. A classic example of this is a coin toss, where there can be two possible options: heads or tails. Here the possibility of flipping a head or a tail on a single toss is 50%. When conducting your own experiment you may find that the outcomes can vary. But if you continue flipping the coin, the outcome grows closer to 50/50. Probability plays a vital rolein many areas of scientific research. Researchers can integrate uncertainty into their research models as a way of describing their findings. This allows for apredictive distributionof findings tied to what may have been observed in the past. Randomness and uncertainty are popular themes tied to probability. In Nassim Talebs bestselling booksThe Black SwanandFooled By Randomness,the claim is made that rare events typically hold more importance than common ones because their effect size is not as restricted. Also, because of their rarity, results are unlikely to be determined. Taleb popularized what he calls ablack swan event,one that is rare, has a catastrophic impact when it does occur and can be explained in hindsight in a way that leads many to believe that it was actually predictable. Probability is commonly used by data scientists to model situations where experiments, conducted during similar circumstances, yield different results (as in the case of throwing dice or a coin). It also has many practical uses in the business world. Take for example theinsurance industry, where actuarial records chart life expectancyof individuals of a certain age. Instead of predicting what will happen to any one individual, the aim is to capture a collective result encompassing a large number of people. Similar approaches have been taken ingenetic science, where assessing the likelihood of a genetic disease is tied to frequency of occurrence as opposed to predictions about a specific individual. Another common application of probability is also commonly applied in clinical trials where new disease treatments, drugs or surgical treatments are being sought. In assessing whether a treatment can be deemed a success or failure, the clinical trial aims to determine whether the new treatment is more successful than a prevailing treatment standard. An example here is testing the efficacy of a new vaccine, such as thepoliomyelitis testing done for the Salk vaccinein 1954 involving almost two million children. Organized by theU.S. Public Health Service, the vaccine nearly eliminated polio as a health problem in the industrialized world. There arethree types of probability commonly usedto gatherstatistical inference data. These are: Also known as the axiomatic method, thistype of probability involves a set of axioms (rules) attached to it. For example, you could have a rule that the probability must be greater than 0.5% in order for it to be valid. This involves looking at the occurrence ratio of a singular event in comparison to the total number of outcomes. This type of probability is often used after data from an experiment has been gathered to compare a subset of data to the total amount of collected data. When using the subjective approach, probability is the likelihood of something happening based on ones experiences or personal judgment.Here there are no formal calculations for subjective probability for it is based on ones beliefs, judgment and personal reasoning. By way of example, during a sporting event, fans of one team share who they are rooting for. This is based on facts or opinions they personally hold regarding the game, the two teams playing and the odds of the team winning. Probability theory is a tool employed by researchers, businesses, investment analysts and countless others forrisk management and scenario analysis. Take epidemiology, which is the science of disease distribution. Researchers in this field study disease frequency, assessing how the probability differs across groups of people. A present-day example of this is theuse of probability by epidemiologiststo assess the cause-effect relationship between exposure and illness to the coronavirus. Probability theory is often usedto unlock key factors denoting the relationship between exposures and health risks.The aim here is to quantify uncertainty. This knowledge can fuel a course of action based on best outcomes for those affected by various diseases. Theactuarieswho are often employed in the insurance industry make primary use of probability, statistics and other data science tools to calculate the probability of uncertain future events occurring over a period of time. They then apply other data concepts to determine the amount of money that needs to be set aside to pay for future losses. Then theres the small-business world where owners cannot always turn to their hunches and instincts to run a successful company. In todays competitive business environment, probability analysis can provide entrepreneurs with key metrics pointing the way to the most profitable and productive paths. This analysis offers a controlled way to anticipate potential results. For example, if a business enterprise expects to receive between $500,000 and $750,000 in revenue each month, the graph will begin with $500,000 at the low end and $750,000 at the high end. For a typical probability distribution, the graph will resemble a bell curve, where the least likely outcomes fall nearer the extreme ends of the range and the most likely nearer to the midpoint of the extremes. A weather forecast serves as another example of probability theory. The probability for precipitation or severe weather is tied to a specific geographic location. As a result, forecasting can be viewed as the combination of the chance of a weather occurrence and the coverage of that event. According to aninformation statement of the American Meteorological Society: A probability forecast includes a numerical expression of uncertainty about the quantity or event being forecast. Ideally, all elements (temperature, wind, precipitation, etc.) of a weather forecast would include information that accurately quantifies the inherent uncertainty. Surveys have consistently indicated that users desire information about uncertainty or confidence of weather forecasts. The widespread dissemination and effective communication of forecast uncertainty information is likely to yield substantial economic and social benefits, because users can make decisions that explicitly account for this uncertainty. For data scientists, there are a number ofadvantages and disadvantages with probabilitythat need to be considered. The classical method of probability is used when all probable outcomes have an equal likelihood of happening and every outcome is known in advance. The coin toss example above uses the classical approach to probability. The classical approach offers a simple approach to real-world examples that is easy to digest for those not possessing a math or science background. With respect to limitations, the classical approach is unable to handle projects where an infinite number of possible outcomes exist. Its also ineffective in scenarios where each outcome is not equally likely, as in the case of tossing a weighted die. These limitations affect the ability of this approach to handling more complicated tasks. Unlike the classical approach, relative frequency offers the advantage of being able to handle scenarios where outcomes have differenttheoretical probability (or likelihood) of occurring.This approach can also manage a probability situation where possible outcomes are unknown. Although you can use relative frequency probability in more diverse situations and settings than classical probability, it has several limitations. The first limitation to relative frequency involves the problem of infinite repetitions. This is where experiments possessing an infinite number of times cannot be analyzed with this theory. So while a large number of trials can be conducted, that number cant be infinite. Problems that benefit from subjective probability are those that require some level of belief to make possible. For example, a candidate who may be down in the polls may use subjective probability to make a case for staying in the race. Subjective probability also benefits from what is known as thereference class problem.In a reference class problem, assigning a probability to a certain event might require that event to be classified. That classification can be subjective, and thus changing the classification can change the probability of the event. For example, if you want to determine the probability of a person contracting an infectious disease like COVID-19, we need to begin with assessing which classes of people are relevant to the problem. Its here where various reference classes can be established. A broad class such as all U.S. residents could be used. Or it could be narrowed down to, say, all residents of the states of X, Y and Z, where 80% of the deaths are occurring. In other words, depending on the reference class chosen, different probabilities will emerge. Probability allows data scientists to assess the certainty of outcomes of a particular study or experiment. An experiment is a planned study that is executed under controlled conditions. When a result is not already predetermined, the experiment is referred to as a chance experiment. Conducting a coin toss twice is an example of a chance experiment. Todays data scientists need to have an understanding of the foundational concepts of probability theory including key concepts involving probability distribution, statistical significance, hypothesis testing and regression.Learn morestatistics concepts that data scientists use regularly;probability distribution is only one of them. Job opportunities for computer scientists are projected to increase 22% from 2020 to 2030,according to the Bureau of Labor Statistics (BLS). As organizations seek out new solutions for capturing and analyzing huge amounts of data, data scientists will be in high demand across a wide swath of sectors and industries worldwide, with a median salary of$126.8K per year.Many of these job opportunities will require a masters degree in computer science or a related field. Check outonline masters in data science programsand find the best degree for your career goals. Last updated: April 2022

Probability teory. What is the definition of probability in classical probability theory. Basic probability theory definition. What is probability theory. Probability theory definition in statistics. Probability theory explained. Probability theory approach definition. Probability theory meaning. Random variable definition probability theory. What is probability theory in statistics. Theory of probability psychology definition. Theoretical probability.