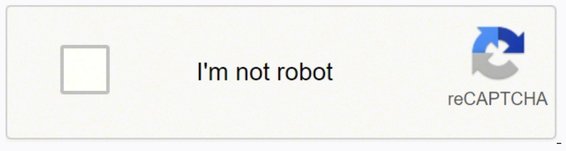

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Is the height of a randomly selected student discrete

Learning Outcomes Use probability distributions for discrete and continuous random variables to estimate probabilities and identify unusual events. In this section, we work with probability distributions for discrete random variables. Here is an example: Consider the random variable the number of times a student changes major. (For convenience, it is common practice to say: Let X be the random variable number of changes in major, or X = number of changes in major, so that from this point we can simply refer to X, with the understanding of what it represents.) Here is the probability distribution of the random variable X: Here is what it tells us: For a randomly selected student, we cannot predict how many times he or she will change majors, but there is a predictable pattern described by the probability distribution (or model) above. So this is a random variable for which we are assuming the values range from 0 to 8. (In reality, a negligible proportion of students change majors more than 8 times.) The table provides a way to assign probabilities to outcomes. Note that if we add up the probabilities of all possible outcomes (0.135 + 0.271 + … + 0.002), we get exactly 1, which is not surprising (because one of the possible outcomes 0, 1, … , 8 will occur for sure). Another way to represent the probability distribution of a random variable is with a probability histogram. The horizontal axis accounts for the range of all possible values of the random variable (in our case, 0–8), and the vertical axis represents the probabilities of those values. The heights of the bars add to 1, which is not surprising since the heights represent probabilities. Let's summarize the features of a probability distribution: The outcomes described by the model are random. This means that individual outcomes are uncertain, but there is a regular, predictable distribution of outcomes in a large number of repetitions. The model provides a way of assigning probabilities to all possible outcomes. The probability of each possible outcome can be viewed as the relative frequency of the outcome in a large number of repetitions, so like any other probability, it can be any value between 0 and 1. The sum of the probabilities of all possible outcomes must be 1. Comment Where do these probability distributions come from? Recall that probability distributions can come from data, such as the distribution of boreal owl eggs. Scientists observe thousands of nests and record the number of eggs in each nest. Then they calculate the relative frequency of each outcome. The relative frequency of each outcome represents the empirical probability for that outcome. We can also use a mathematical formula to represent a probability distribution. In this case, we make assumptions about how outcomes will be distributed. In other words, we use a mathematical formula to describe the predicted relative frequencies for all possible outcomes. We do not look at mathematical formulas for probability distributions in this course, but we want you to be aware that not all probability distributions come from data. Recall the probability distribution of the random variable X = number of changes in major: Let's see what kinds of probability questions we can answer using it. 1. What is the probability that a college student will change majors at most once? The phrase "at most once" means either the student never changes majors (X = 0) or the student changes majors once (X = 1). Therefore, to find this probability, we need to add the probabilities that are highlighted in the table: So, P(a college student changes majors at most once) = P(X = 0) + P(X = 1) = 0.135 + 0.271 = 0.406 The probability that a randomly selected college student will change majors at most once is about 0.406. We can also say that about 40.6% of the time, a randomly selected college student will change majors at most once. 2. John's parents are concerned that he has decided to change his major for the second time. John claims that he is not unusual. What is the probability that a randomly selected college student will change his major as often as or more often than John? To answer the question about John, we need know the probability that a randomly selected student will change his major 2 or more times. We need to add together the probabilities shaded in the table. P(change major 2 or more times) = P(X = 2) + P(X = 3) + … + P(X = 8) = 0.594 Here is another way to figure this out. We can use the idea that all of the probabilities together make up 100% of the possibilities. So if we add up all the probabilities in the table we should get 1. Now if we figure out the probability that someone changes majors 0 or 1 times, we can just subtract this from 1 to find the probability that someone changes majors 2 or more times. As we learned previously, this is the complement rule. P(change major 2 or more times) = 1 – [P(X = 0) + P(X = 1)] = 1 – [0.135 + 0.271] = 0.594 Do you think John has given a convincing argument that he is not unusual? Yes! Fifty-nine percent of the time, a college student will change majors as often as or more often than John did. Stating this same result in terms of probability, we might say, "There is a 59% probability that a randomly selected college student will change majors 2 or more times while in college." We found that changing a major 2 or more times is not very unusual, since it happens about 59% of the time. So… 3. How often would John need to change his major to be considered unusual? One way to answer this question is to just a make a judgment call about what we might consider "unusual" based on the table. For example, we might notice that the probability that a student will change majors 5 or more times is about 5%. P(change majors 5 or more times) = P(X = 5) + P(X = 6) + P(X = 7) + P(X = 8) = 0.036 + 0.012 + 0.003 + 0.002 = 0.053 An event that occurs only 5% of the time is pretty unusual. Are there other ways to more definitively determine what might be considered unusual? Well, we might use a measure of center, such as the mean, to determine a "typical" number of times that students change majors. Values that are 2 standard deviations above the mean could be used to identify unusual behavior. We will come back to this question after we have developed an understanding of mean and standard deviation for a probability distribution. Discrete and Continuous Random Variables: A variable is a quantity whose value changes. A discrete variable is a variable whose value is obtained by counting. Examples: number of students present number of red marbles in a jar number of heads when flipping three coins students' grade level A continuous variable is a variable whose value is obtained by measuring. Examples: height of students in class weight of students in class time it takes to get to school distance traveled between classes A random variable is a variable whose value is a numerical outcome of a random phenomenon. ■ A random variable is denoted with a capital letter ■ The probability distribution of a random variable X tells what the possible values of X are and how probabilities are assigned to those values ■ A random variable can be discrete or continuous A discrete random variable X has a countable number of possible values. Example: Let X represent the sum of two dice. Then the probability distribution of X is as follows: X 2 3 4 5 6 7 8 9 10 11 12 P(X) To graph the probability distribution of a discrete random variable, construct a probability histogram. A continuous random variable X takes all values in a given interval of numbers. ■ The probability distribution of a continuous random variable is shown by a density curve. ■ The probability that X is between an interval of numbers is the area under the density curve between the interval endpoints ■ The probability that a continuous random variable X is exactly equal to a number is zero Means and Variances of Random Variables: The mean of a discrete random variable, X, is its weighted average. Each value of X is weighted by its probability. To find the mean of X, multiply each value of X by its probability, then add all the products. The mean of a random variable X is called the expected value of X. Law of Large Numbers: As the number of observations increases, the mean of the observed values, , approaches the mean of the population, . The more variation in the outcomes, the more trials are needed to ensure that is close to . Rules for Means: If X is a random variable and a and b are fixed numbers, then If X and Y are random variables, then Example: Suppose the equation Y = 20 + 100X converts a PSAT math score, X, into an SAT math score, Y. Suppose the average PSAT math score is 48. What is the average SAT math score? Example: Let represent the average SAT math score. Let represent the average SAT verbal score. represents the average combined SAT score. Then is the average combined total SAT score. The Variance of a Discrete Random Variable: If X is a discrete random variable with mean , then the variance of X is The standard deviation is the square root of the variance. Rules for Variances: If X is a random variable and a and b are fixed numbers, then If X and Y are independent random variables, then Example: Suppose the equation Y = 20 + 100X converts a PSAT math score, X, into an SAT math score, Y. Suppose the standard deviation for the PSAT math score is 1.5 points. What is the standard deviation for the SAT math score? Suppose the standard deviation for the SAT math score is 150 points, and the standard deviation for the SAT verbal score is 165 points. What is the standard deviation for the combined SAT score? *** Because the SAT math score and SAT verbal score are not independent, the rule for adding variances does not apply!

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