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LESSON 4
DISCRETE PROBABILITIES

SAMIE L.S. LY

LESSON 4/5 IN A NUTSHELL

DISCRETE PROBABILITIES

FREQUENCY DISTRIBUTION CALCULATIONS

BINOMIAL PROBABILITY FUNCTION

- UNDERSTAND CONTEXTS

CONTINUOUS PROBABILITES

NORMAL PROBABILITY DISTRIBUTION

- UNDERSTAND Z-TABLE

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

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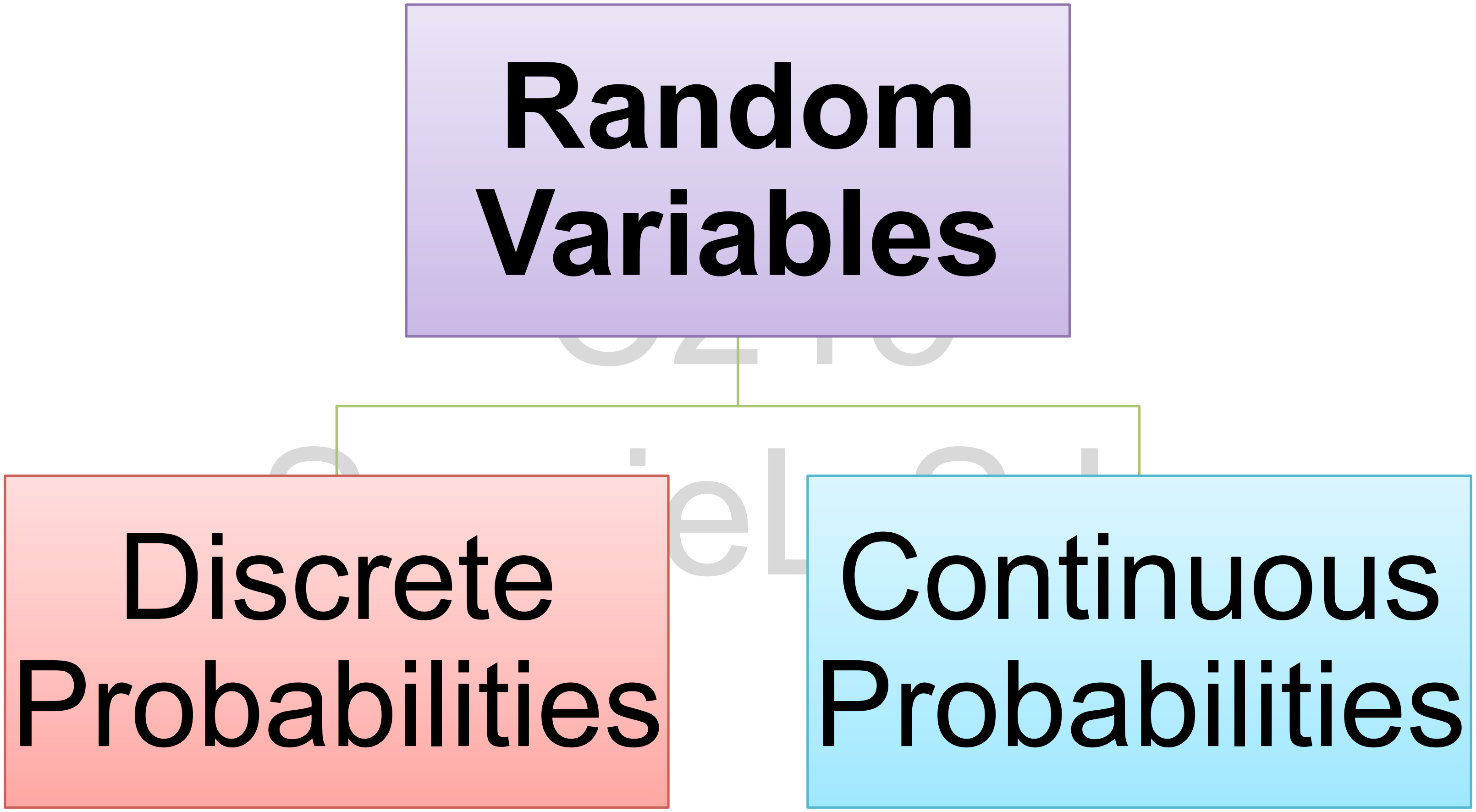
- Random Variables
- Discrete Probability Distribution
- Expected Value and Variance
- Binomial Probability Distribution

RANDOM VARIABLES

IS A NUMERICAL DESCRIPTION OF THE OUTCOME OF AN EXPERIMENT

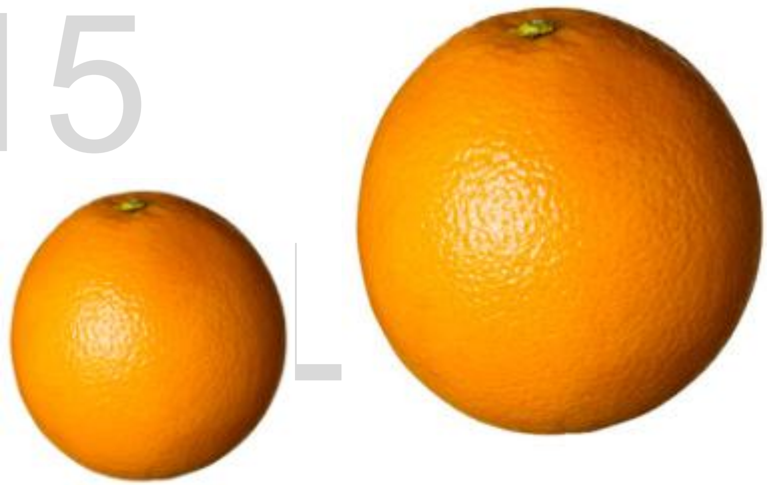


Bowerman, et al. (2017) pp. 255

DISCRETE RANDOM VARIABLE

Discrete Random Variable assuming a finite number of values or an infinite sequence of values.

For example: Catching 1 fish, 2 fish, 3 fish…



CONTINUOUS RANDOM VARIABLE

Continuous Random Variable assuming any numerical value in an interval or collection of intervals.

For example: 1.5 lbs, 200 grams, 1.67 meters

PROBLEM #4.1

The mark on a statistic exam that consists of 100 multiple-choice questions is a random variable.

a. What are the possible values of this random variable?

0, 1, 2, …, 100

b. Are the values countable? Explain.

Yes.

c. Is there a finite number of values? Explain.

Yes, there are 101 values

d. Is the random variable discrete or continuous? Explain

The variable is discrete because it is countable.

- **Discrete Probability Distribution**
- **Expected Value and Variance**
- **Binomial Probability Distribution**

PROBABILITY DISTRIBUTION

Probability distribution defined by probability function a table, formula, or a graph that describes the values of a random variable and the probability associated with these values.

1	2	0
1	1	2
1	1	0

X	P(x) or f(x)
0	2/9= 0.222
1	5/9= 0.556
2	2/9= 0.222

Bowerman, et al. (2017) pp. 257

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DISCRETE PROBABILITY FUNCTION

Required conditions for a discrete probability function

$$f(x) \geq 0$$

$$\Sigma f(x) = 1$$

X	P(x) or f(x)
0	2/9= 0.222
1	5/9= 0.556
2	2/9= 0.222
Total	1.00

Bowerman, et al. (2017) pp. 257

PROBLEM #4.2

Determine whether each of the following is a valid probability distribution.

a.

x	0	1	2	3
P(x)	.1	.3	.4	.1

No the sum of probabilities is not equal to 1.

b.

x	5	-6	10	0
P(x)	.01	.01	.01	.97

Yes, because the probabilities lie between 0 and 1 and sum to 1.

c.

x	14	12	-7	13
P(x)	.25	.46	.04	.24

No, because the probabilities do not sum to 1.

PROBLEM # 4.3

Probability Distribution of the Number of Color Televisions

The *Statistical Abstract of the United States* is published annually. It contains a wide variety of information based on the census as well as other sources. The objective is to provide information about a variety of different aspects of the lives of the country's residents. One of the questions asks households to report the number of color televisions in the household. The following table summarizes the data. Develop the probability distribution of the random variable defined as the number of color televisions per household.

Number of Color Televisions	**Number of Households (thousands)**
0	1,218
1	32,379
2	37,961
3	19,387
4	7,714
5	2,842
Total	101,501

Source: *Statistical Abstract of the United States*, 2000, Table 1221

PROBLEM # 4.3

Number of Color Televisions X	P(x) or f(x)
0	1,218/101,501 = .012
1	32,379/101,501 =.319
2	37,961/101,501= .374
3	19,387/101,501= .191
4	7,714/101,501= .076
5	2,842/101,501= .028
Total	1.00

a. What is the probability of a household owning 3 color-televisions?

$P(X=3) = 0.191$

b. Are the events mutually exclusive?

c. What is the probability of a household owning 2 or more color televisions?

$P(X \geq 2) = P(2) + P(3) + P(4) + P(5) = 0.374 + 0.191 + 0.076 + 0.028 = 0.669$

Expected Value and Variance

Binomial Probability Distribution

EXPECTED VALUE

ALSO KNOWN AS THE MEAN,
OF A RANDOM VARIABLE IS A MEASURE OF ITS CENTRAL LOCATION

$$\boxed{E(x) = \mu = \Sigma x f(x)}$$

Variance

$$\boxed{\mathrm{Var}(x) = \sigma^2 = \Sigma(x - \mu)^2 f(x)}$$

$$\sigma^2 = \sum x^2 \, \mathrm{P(x)} - \mu^2$$

Bowerman, et al. (2017) pp. 258

PROBLEM #4.4

Number of Color Televisions X	P(x) or f(x)
0	.012
1	.319
2	.374
3	.191
4	.076
5	.028
Total	1.00

Find the mean, variance, and standard deviation for the population of the number of color televisions per household in Problem # 4-3.

$$E(X) = \mu = \Sigma\, x\, P(x)$$

$$= 0\,P(0) + 1\,P(1) + 2\,P(2) + 3\,P(3) + 4\,P(4) + 5\,P(5)$$

$$= 0\,(.012) + 1\,(.319) + 2(.374) + 3\,(.191) + 4\,(.076) + 5(.028)$$

$$= 2.084$$

PROBLEM #4.4

$$Var(x) = \sigma^2 = \Sigma(x - \mu)^2 f(x)$$

E(X) =2.084

Find the mean, variance, and standard deviation for the population of the number of color televisions per household in Problem #4.3.

Number of Color Televisions X	P(x) or f(x)	x-μ	$(x-\mu)^2 f(x)$
0	0.012		
1	0.319		
2	0.374	-0.084	0.003
3	0.191		
4	0.076	1.916	0.279
5	0.028	2.916	0.238
Total	1		

PROBLEM #4.4

$$Var(x) = \sigma^2 = \Sigma(x - \mu)^2 f(x)$$

E(X) =2.084

Find the mean, variance, and standard deviation for the population of the number of color televisions per household in Problem #4.3.

Number of Color Televisions X	P(x) or f(x)	x-μ	$(x-\mu)^2 f(x)$
0	0.012	-2.084	0.052
1	0.319	-1.084	0.375
2	0.374	-0.084	0.003
3	0.191	0.916	0.160
4	0.076	1.916	0.279
5	0.028	2.916	0.238
Total	1		1.107

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Shortcut formula for Population Variance

$$\sigma^2 = \sum x^2 \, \mathrm{P(x)} - \mu^2$$

$\sum x^2 \, \mathrm{P(x)} = 0^2(0.012) + 1^2(0.319) + 2^2(0.374) + 3^2(0.191) + 4^2(0.076) + 5^2(0.028) = 5.450$

$\sigma^2 = \sum x^2 \, \mathrm{P(x)} - \mu^2 = 5.450 - (2.084)^2 = 1.107$

Bowerman, et al. (2017) pp. 260

PROBLEM #4.5

The recent census in a large county revealed the following probability distribution for the number of children under 18 per household.

Number of Children	0	1	2
Number of Households	24,750	37,950	59,400
Number of Children	3	4	5
Number of Households	29,700	9,900	3,300

a. Develop the probability distribution of X, the number of children under 18 per household.

b. Determine the following probabilities.

$P(X \leq 2)$

$P(X > 2)$

$P(X \geq 4)$

PROBLEM #4.5

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Number of Children	3	4	5
Number of Households	29,700	9,900	3,300

a. Develop the probability distribution of X, the number of children under 18 per household.

x		P(x)
0	24,750/165,000	=.15
1	37,950/165,000	=.23
2	59,400/165,000	=.36
3	29,700/165,000	=.18
4	9,900/165,000	=.06
5	3,300/165,000	=.02

x		P(x)
0	24,750/165,000	
1	37,950/165,000	
2	59,400/165,000	
3	29,700/165,000	
4	9,900/165,000	
5	3,300/165,000	

PROBLEM #4.5

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1	37,950/165,000	=.23
2	59,400/165,000	=.36
3	29,700/165,000	=.18
4	9,900/165,000	=.06
5	3,300/165,000	=.02

b. Determine the following probabilities.

(i) $P(X \leq 2)$ **= P(0) + P(1) + P(2) = .15 + .23 + .36 = .74**

(ii) $P(X > 2)$ **= P(3) + P(4) + P(5) = .18 + .06 + .02 = .26**

(iii) $P(X \geq 4)$ **= P(4) + P(5) = .06 + .02 = .08**

PROBLEM # 4.6

The number of pizzas delivered to university students each month is a random variable with the following probability distribution.

x	0	1	2	3
P(x)	.1	.3	.4	.2

a. Find the probability that a student has received delivery of two or more pizzas this month.

b. Determine the mean of the number of pizzas delivered to students each month.

PROBLEM # 4.6

The number of pizzas delivered to university students each month is a random variable with the following probability distribution.

x	0	1	2	3
P(x)	.1	.3	.4	.2

a. Find the probability that a student has received delivery of two or more pizzas this month.

$P(X \geq 2) = P(2) + P(3) = .4 + .2 = .6$

PROBLEM # 4.6

The number of pizzas delivered to university students each month is a random variable with the following probability distribution.

x	0	1	2	3
P(x)	.1	.3	.4	.2

b. Determine the mean and variance of the number of pizzas delivered to students each month.

$\mu = E(X) = \Sigma\, x\, P(x) = 0\,(0.1) + 1\,(0.3) + 2(0.4) + 3(0.2) = 1.7.$

$\sigma^2 = V(X) = \Sigma\,(x-\mu)^2\, P(x) = (0-1.7)^2\,(0.1) + (1-1.7)^2\,(0.3) + (2-1.7)^2\,(0.4) + (3-1.7)^2\,(0.2) = 0.81$

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PROBLEM #4.7

If the pizzeria makes a profit of $3 per pizza, determine the mean and variance of the profits per student.

Mean of Profit

E(Profit) = 3$ x E(X) = 3(1.7) = 5.1

PROBLEM #4.8

The probability that a university graduate will be offered no jobs within a month of graduation is estimated to be 5%. The probability of receiving one, two or three job offers has similarly been estimated to be 43%, 31%, and 21%, respectively.

Determine the following probabilities.

A graduate is offered fewer than two jobs.

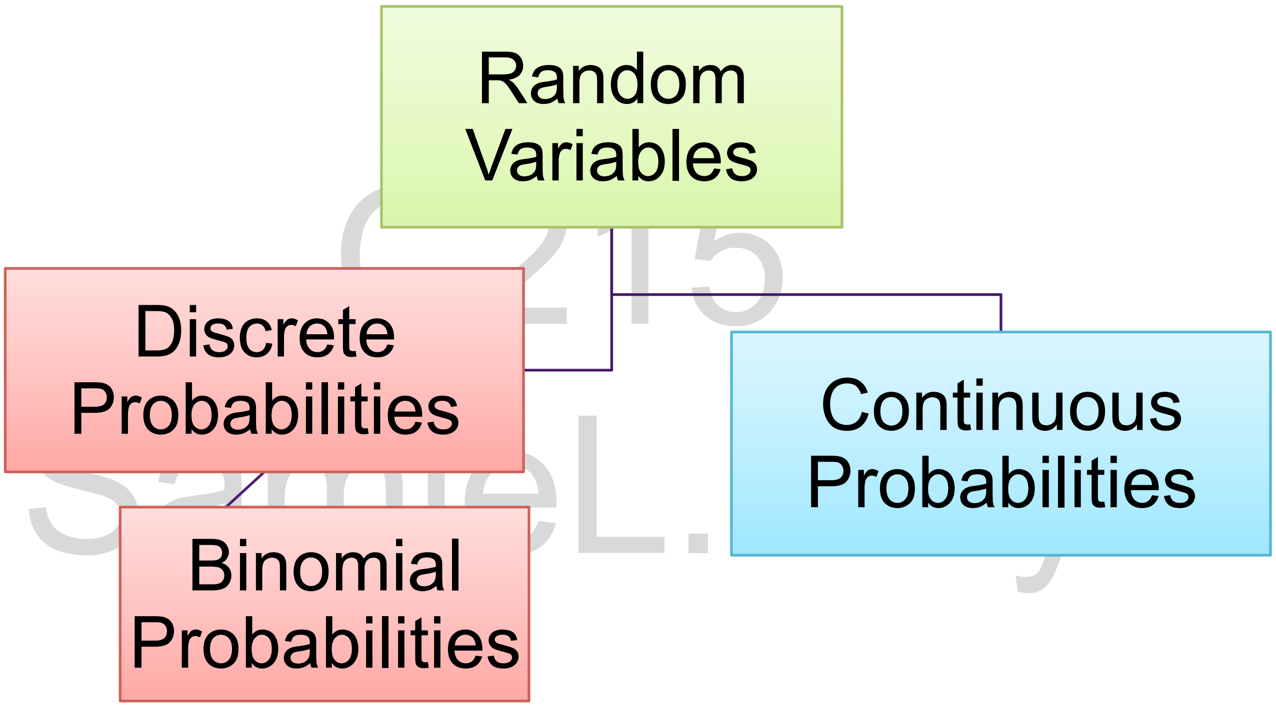
$P(X < 2) = P(0) + P(1) = .05 + .43 = .48$

A graduate is offered more than one job.

$P(X > 1) = P(2) + P(3) = .31 + .21 = .52$

Binomial Probability Distribution

BINOMIAL PROBABILITIES



Bowerman, et al. (2017) pp. 263

BINOMIAL EXPERIMENT

4 PROPERTIES OF A BINOMIAL EXPERIMENT

1. The experiment consists of a sequence of n identical trials
2. Two outcomes are possible on each trial. We refer to one outcome as a success and the other as a failure.
3. The probabilities of a success, denoted by p, does not change from trial to trial. Consequently, the probability of a failure, denoted by 1-p, does not change from trial to trial.
4. The trials are independent.

Bowerman, et al. (2017) pp. 266

BINOMIAL EXPERIMENT

PROPERTIES OF A BINOMIAL EXPERIMENT : TOSSING A COIN

1. **THE EXPERIMENT CONSISTS OF TOSSING THE COIN 5 TIMES. n=5.**
   Five identical trials

2. **Two possible outcomes:**

   HEAD   TAIL

3. **P(Head) = 0.5 = p**
   P(Tail) = 1- 0.5 = 1-p

4. **All tosses are independent.**

BINOMIAL PROBABILITY FUNCTION

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

x = the number of successes

p = the probability of a success on one trial

n = the number of trials

$f(x)$ = the probability of x successes in n trials

BINOMIAL PROBABILITY FUNCTION

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

Number of experimental outcomes providing exactly x successes in n trials

Probability of a particular sequence of trial outcomes with x successes in n trials

BINOMIAL PROBABILITY FUNCTION

Toss a coin 5 Times – n = 5

What is the probability of getting HEAD 2 times? x = 2

Given P(HEAD) = 0.5

Step 1: Find the number of experimental outcomes of getting 2 Heads out of 5 Tosses.

Combination Rule

$$C_n^N = \binom{N}{n} = \frac{N!}{n!(N-n)!}$$

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

$$f(x) = \frac{5!}{2!\,(5-2)!} p^x\,(1-p)^{(n-x)}$$

$$f(x) = \frac{5*4*3!}{2!\,(3)!} p^x\,(1-p)^{(n-x)}$$

$$f(x) = \quad 10 \quad p^x\,(1-p)^{(n-x)}$$

BINOMIAL PROBABILITY FUNCTION

Toss a coin 5 Times – n = 5

What is the probability of getting HEAD 2 times? X = 2

Given P(HEAD) = 0.5

Step 2: Find the probability of that particular sequence of trials using the information given P(HEAD) = 0.5

$$f(x) = \frac{n!}{x!(n-x)!} p^{x} (1-p)^{(n-x)}$$

$$f(x) = \quad 10 \quad p^{x} (1-p)^{(n-x)}$$

$$f(x) = \quad 10 \quad 0.5^{2} (1-0.5)^{(5-2)}$$

$$f(x) = \quad 10 \quad 0.5^{2} (1-0.5)^{(3)} = 0.3125$$

The probability of tossing 2 heads in 5 tosses is 0.3125.

PROBLEM # 4.14

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

Given a binomial random variable with n= 10 and p=.3, use the formula to find the following probabilities.

a. P (X=3)

b. P (X=5)

c. P (X=8)

PROBLEM # 4.14

$$P(X = x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{n-x}$$

Given a binomial random variable with n= 10 and p=.3, use the formula to find the following probabilities.

a. $P(X=3) = \frac{10!}{3!(10-3)!}(.3)^3(1-.3)^{10-3} = .2668$

a. $P(X=5) = \frac{10!}{5!(10-5)!}(.3)^5(1-.3)^{10-5} = .1029$

PROBLEM # 4.15

Pat Statsdud and the Statistics Quiz

Pat Statsdud is a student taking a statistics course. Unfortunately, Pat does not print the workbook before class, does not do practice problems, and regularly misses class. Pat intends to rely on luck to pass the next quiz. The quiz consists of 10 multiple-choice questions. Each question has five possible answers, only one of which is correct. Pat plans to guess the answer to each question.

a. What is the probability that Pat gets no answers correct?

b. What is the probability that Pat gets two answers correct?

PROBLEM # 4.15

Pat Statsdud and the Statistics Quiz

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a. What is the probability that Pat gets no answers correct?

10 identical trial, each with two possible outcomes, where success is defined as a correct answer.

Pat intends to guess, the probability of success is equally likely 1/5 or .2.

The trials are INDEPENDENT because the outcomes of any of the questions do not affect the outcomes of any other questions.

The experiment is binomial with n=10 and p=0.2

PROBLEM # 4.15

We produce the probability of no successes by letting n=10, p=0.2 and x=0.

$$P(0) = \frac{10!}{0!\,(10-0)!}(.2)^0(1-.2)^{10-0}$$

$$P(0) = \quad 1\,(1)\,(.8)^{10} = .1074$$

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PROBLEM # 4.15

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b. What is the probability that Pat gets two answers correct?

n=10, p=.2 and x=2:

$$P(2) = \frac{10!}{2!\,(10-2)!}(.2)^2(1-.2)^{10-2}$$

$$P(2) = \frac{10*9*8!}{2!\,(8)!}(.04)(.1678)$$

$$= 45(\ 0.006712) = \ .3020$$

CUMULATIVE PROBABILITY

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{(n-x)}$$

Binomial Probability Function allows us to determine the probability that X equals individual values.
Eg. P(X = 3)

a random variable is less than

a random variable is more than

Eg.P(X > 3), P(X ≤ 2)

Bowerman, et al. (2017) pp. 270

PROBLEM # 4.16

Will Pat fail the quiz? Find the probability that Pat fails the quiz. A mark is considered a failure if it is less than 50%.

In this quiz, a mark of less than 5 is a failure. Because the marks must be integers a mark of 4 or less is a failure. We wish to determine $P(X \leq 4)$.

So,

$P(X \leq 4) = P(x=0) + P(x=1) + P(x=2) + P(x=3) + P(x=4)$

$P(x=0) = .1074$

$P(x=2) = .3020$

Let's find $P(x=1)$, $P(x=3)$, $P(x=4)$

PROBLEM # 4.16

Will Pat fail the quiz? Find the probability that Pat fails the quiz. A mark is considered a failure if it is less than 50%.

In this quiz, a mark of less than 5 is a failure. Because the marks must be integers a mark of 4 or less is a failure. We wish to determine P(X≤*4)*. So,

P(X ≤ *4)* = P(x=0) + P(x=1) + P(x=2) + P(x=3)+ P(x=4)

$$P(1) = \frac{10!}{1!(10-1)!}(.2)^1(1-.2)^{10-1} = .2684$$

$$P(3) = \frac{10!}{3!(10-3)!}(.2)^3(1-.2)^{10-3} = .2013$$

$$P(4) = \frac{10!}{4!(10-4)!}(.2)^4(1-.2)^{10-4} = .0881$$

PROBLEM # 4.16

Will Pat fail the quiz? Find the probability that Pat fails the quiz. A mark is considered a failure if it is less than 50%.

In this quiz, a mark of less than 5 is a failure. Because the marks must be integers a mark of 4 or less is a failure. We wish to determine $P(X \leq 4)$. So,

$$P(X \leq 4) = P(x=0) + P(x=1) + P(x=2) + P(x=3) + P(x=4)$$

$$= .1074 + .2684 + .3020 + .2013 + .0881 = .9672$$

USING THE BINOMIAL TABLE

Toss a coin 5 Times – n = 5

What is the probability of getting HEAD 2 times? X = 2

Given P(HEAD) = 0.5

TABLE 5 BINOMIAL PROBABILITIES (*Continued*)

		p								
n	*x*	.10	.15	.20	.25	.30	.35	.40	.45	.50
2	0	.8100	.7225	.6400	.5625	.4900	.4225	.3600	.3025	.2500
	1	.1800	.2550	.3200	.3750	.4200	.4550	.4800	.4950	.5000
	2	.0100	.0225	.0400	.0625	.0900	.1225	.1600	.2025	.2500
3	0	.7290	.6141	.5120	.4219	.3430	.2746	.2160	.1664	.1250
	1	.2430	.3251	.3840	.4219	.4410	.4436	.4320	.4084	.3750
	2	.0270	.0574	.0960	.1406	.1890	.2389	.2880	.3341	.3750
	3	.0010	.0034	.0080	.0156	.0270	.0429	.0640	.0911	.1250
4	0	.6561	.5220	.4096	.3164	.2401	.1785	.1296	.0915	.0625
	1	.2916	.3685	.4096	.4219	.4116	.3845	.3456	.2995	.2500
	2	.0486	.0975	.1536	.2109	.2646	.3105	.3456	.3675	.3750
	3	.0036	.0115	.0256	.0469	.0756	.1115	.1536	.2005	.2500
	4	.0001	.0005	.0016	.0039	.0081	.0150	.0256	.0410	.0625
5	0	.5905	.4437	.3277	.2373	.1681	.1160	.0778	.0503	.0312
	1	.3280	.3915	.4096	.3955	.3602	.3124	.2592	.2059	.1562
	2	.0729	.1382	.2048	.2637	.3087	.3364	.3456	.3369	.3125
	3	.0081	.0244	.0512	.0879	.1323	.1811	.2304	.2757	.3125
	4	.0004	.0022	.0064	.0146	.0284	.0488	.0768	.1128	.1562
	5	.0000	.0001	.0003	.0010	.0024	.0053	.0102	.0185	.0312

The probability of tossing 2 heads in 5 tosses is 0.3125.

Bowerman, et al. (2017) pp. 269

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PROBLEM # 4.17

A sign on the gas pumps of a chain of gasoline stations encourages customers to have their oil checked, claiming that one out of four cars needs to have oil added. If this is true, what is the probability of the following events?

a. One out of the next four cars needs oil

$$P(X = 1) = \frac{4!}{1!(4-1)!}(.25)^1(1-.25)^{4-1} = .4219$$

b. Two out of the next eight cars need oil

Using Binomial Table: P(x=2) = 0.3115

c. Three out of the next twelve cars need oil

Using Binomial Table: P(x=2) = 0.3115

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TABLE 5 BINOMIAL PROBABILITIES (*Continued*)

		p								
n	x	.10	.15	.20	.25	.30	.35	.40	.45	.50
7	0	.4783	.3206	.2097	.1335	.0824	.0490	.0280	.0152	.0078
	1	.3720	.3960	.3670	.3115	.2471	.1848	.1306	.0872	.0547
	2	.1240	.2097	.2753	.3115	.3177	.2985	.2613	.2140	.1641
	3	.0230	.0617	.1147	.1730	.2269	.2679	.2903	.2918	.2734
	4	.0026	.0109	.0287	.0577	.0972	.1442	.1935	.2388	.2734
	5	.0002	.0012	.0043	.0115	.0250	.0466	.0774	.1172	.1641
	6	.0000	.0001	.0004	.0013	.0036	.0084	.0172	.0320	.0547
	7	.0000	.0000	.0000	.0001	.0002	.0006	.0016	.0037	.0078
8	0	.4305	.2725	.1678	.1001	.0576	.0319	.0168	.0084	.0039
	1	.3826	.3847	.3355	.2670	.1977	.1373	.0896	.0548	.0312
	2	.1488	.2376	.2936	.3115	.2965	.2587	.2090	.1569	.1094
	3	.0331	.0839	.1468	.2076	.2541	.2786	.2787	.2568	.2188
	4	.0046	.0185	.0459	.0865	.1361	.1875	.2322	.2627	.2734
	5	.0004	.0026	.0092	.0231	.0467	.0808	.1239	.1719	.2188
	6	.0000	.0002	.0011	.0038	.0100	.0217	.0413	.0703	.1094
	7	.0000	.0000	.0001	.0004	.0012	.0033	.0079	.0164	.0313
	8	.0000	.0000	.0000	.0000	.0001	.0002	.0007	.0017	.0039

TABLE 5 BINOMIAL PROBABILITIES (*Continued*)

		p								
n	*x*	.10	.15	.20	.25	.30	.35	.40	.45	.50
12	0	.2824	.1422	.0687	.0317	.0138	.0057	.0022	.0008	.0002
	1	.3766	.3012	.2062	.1267	.0712	.0368	.0174	.0075	.0029
	2	.2301	.2924	.2835	.2323	.1678	.1088	.0639	.0339	.0161
	3	.0853	.1720	.2362	$\boxed{.2581}$	.2397	.1954	.1419	.0923	.0537

BINOM.DIST function

x	number_s	3
n	trials	12
p of success	probability_s	0.25
	cumulative	FALSE
		0.258103609
		BINOM.DIST()

BINOMIAL DISTRIBUTION

Expected Value and Variance for the Binomial Distribution

Expected Value

$$E(x) = \mu = np$$

Variance

$$\mathrm{Var}(x) = \sigma^2 = np(1-p)$$

Standard Deviation

$$\sigma = \sqrt{np(1-p)}$$

Bowerman, et al. (2017) pp. 272

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First the Foundation, then Innovation

CASE #2

WARRANTY
NO WARRANTY

The number of accidents that occur annually on a busy stretch of highway is an example of:

a. a discrete random variable.

b. a continuous random variable.

c. expected value of a discrete random variable.

d. expected value of a continuous random variable.

A lab in Michigan State University orders 100 rats a week for each of the 52 weeks in the year for experiments that the lab conducts. Suppose the mean cost of rats used in lab experiments turned out to be $15.00 per week. Interpret this value.

a. Most of the weeks resulted in rat costs of $15.00

b. The median cost for the distribution of rat costs is $15.00

c. The expected or average costs for all weekly rat purchases is $15.00

d. The rat cost that occurs more often than any other is $15.00

Products are returned to stores for a variety reasons. A recent study showed that 60% are for operational reasons, 30% for cosmetic reasons, and the remaining for other reasons. The probability that an item returned for operational reasons will be under warranty is 0.7, while the probabilities that an item is returned for cosmetic or other reasons will be under warranty are 0.5 and 0.6, respectively.

a. If an item is returned, what is the probability that it is

i. with warranty

ii. without warranty?

b. If an item with a warranty is returned, what is the probability that it is for cosmetic reason?

c. **If at any time 50 items are returned to a store, how many are expected to be without warranties?**