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Assignment 5

Exercise 9.1:

$$P(X = -1) = 0.2$$

$$P(X = 2) = 0.5$$

$$P(X = 6) = 0.3$$

$$\text{Expected Value} = (-1 * 0.2) + (2 * 0.5) + (6 * 0.3) = 2.6$$

$$\text{Mean} = (-1 + 2 + 6) / 3 = 2\frac{1}{3}$$

$$\text{Variance} = \frac{(-1 - \frac{1}{3})^2 + (2 - \frac{1}{3})^2 + (6 - \frac{1}{3})^2}{3} = \frac{110}{9}$$

$$\text{Standard Deviation} = \sqrt{\text{Variance}} = \sqrt{\frac{110}{9}} = 3.496$$

Exercise 9.2:

(a) Marginal Distributions

$$P(X) = [(0.12 + 0.08 + 0.10), (0.20 + 0.04 + 0.25), (0.08 + 0.10 + 0.03)]$$

$$P(Y) = [(0.12 + 0.20 + 0.08), (0.08 + 0.04 + 0.10), (0.10 + 0.25 + 0.03)]$$

$$P(X) = [0.3, 0.49, 0.21]$$

$$P(Y) = [0.4, 0.22, 0.38]$$

	-1	1	2	$P(X)$
0	0.12	0.08	0.10	0.3
1	0.20	0.04	0.25	0.49
3	0.08	0.10	0.03	0.21
$P(Y)$	0.4	0.22	0.38	

(b) X and Y Independent? **Solution: No**

Lets label our original joint distribution as F . If we are dealing with something that is independent, we should get $F(X, Y) = P(X) * P(Y)$ for all (x, y) in range, or each cell in the table. This is because $P(A, B) = P(A) * P(B)$ with independent events.

$F(X, Y)$				
	-1	1	2	$P(X)$
0	0.12	0.08	0.10	0.3
1	0.20	0.04	0.25	0.49
3	0.08	0.10	0.03	0.21
$P(Y)$	0.4	0.22	0.38	

$P(X) * P(Y)$				
	-1	1	2	
0	0.12	0.07	0.11	
1	0.20	0.11	0.19	
3	0.08	0.05	0.08	

As we can see, when we multiply the margins, we do not get the same the same as $F(X, Y)$, so because $F(X, Y) \neq P(X) * P(Y)$, we know that they are not Independent.

(c) $\text{Exp}(X)$ and $\text{Exp}(Y)$

$$\text{Exp}(X) = (0 * 0.3) + (1 * 0.49) + (3 * 0.21) = 1.12$$

$$\text{Exp}(Y) = (-1 * 0.4) + (1 * 0.22) + (2 * 0.38) = 0.58$$

(d) Distribution of $X + Y$.

We must first find all the possible values for $X + Y$. X can be $[0, 1, 3]$. Y can be $[-1, 1, 2]$
This means that the possible values for $X + Y$ are $[-1, 1, 2, 0, 3, 4, 5]$, thus

$$P(-1) = 0.12$$

$$P(0) = 0.20$$

$$P(1) = 0.08$$

$$P(2) = 0.10 + 0.04 + 0.08 = 0.22$$

$$P(3) = 0.25$$

$$P(4) = 0.10$$

$$P(5) = 0.03$$

(e) $P(X|Y = 2)$ and $P(Y|X = 1)$

i. $P(X|Y = 2)$

We know that

$$P(X|Y = 2) = \frac{P(X, Y = 2)}{P(Y = 2)}$$

Now lets compute

$$P(Y = 2) = 0.38$$

This means that

$$P(X = 0|Y = 2) = \frac{0.1}{0.38} = 0.26315 = 26.32\%$$

$$P(X = 1|Y = 2) = \frac{0.25}{0.38} = 0.65789 = 65.79\%$$

$$P(X = 3|Y = 2) = \frac{0.03}{0.38} = 0.07894 = 7.895\%$$

ii. $P(Y|X = 1)$

We know that

$$P(Y|X = 1) = \frac{P(X = 1, Y)}{P(X = 1)}$$

Now lets compute

$$P(X = 1) = 0.49$$

This means that

$$P(Y = -1|X = 1) = \frac{0.20}{0.49} = 0.40816 = 40.82\%$$

$$P(Y = 1|X = 1) = \frac{0.04}{0.49} = 0.08163 = 8.163\%$$

$$P(Y = 2|X = 1) = \frac{0.25}{0.49} = 0.5102 = 51.02\%$$

Exercise 9.3:

Let X be a random variable with values 0, 1, 3, and let Y be a random variable with values -1, 1, 2. Suppose that $P(X=0) = 0.5$, $P(X=1) = 0.4$, and $P(X=3) = 0.1$, with the following values of $P(Y|X)$

$$P(Y|X)$$

	-1	1	2
0	0.5	0.3	0.2
1	0.2	0.7	0.1
3	0.4	0.1	0.5

(a) Joint Distribution of X, Y

We are given all $P(X)$ and also all $P(Y|X)$. We must now solve for $P(X, Y)$ for the joint distribution. We know that $P(X) * P(Y|X) = P(X, Y)$, so we just need to multiply in the correct locations to have the correct values. This results in

$$P(X, Y)$$

	-1	1	2
0	0.25	0.15	0.1
1	0.08	0.28	0.04
3	0.04	0.01	0.05

(b) Distribution of Y

$$P(Y = -1) = 0.25 + 0.08 + 0.04 = 0.37 = 37\%$$

$$P(Y = 1) = 0.15 + 0.28 + 0.01 = 0.44 = 44\%$$

$$P(Y = 2) = 0.1 + 0.04 + 0.05 = 0.19 = 19\%$$

(c) Corresponding table for $P(X|Y)$

$$P(X, Y) = P(X|Y) * P(Y)$$

$$\frac{P(X, Y)}{P(Y)} = P(X|Y)$$

$$P(X, Y)$$

	-1	1	2
0	0.6757	0.341	0.5263
1	0.216	0.636	0.2105
3	0.108	0.0227	0.2623

(d) Distribution of $X + Y$

We must first find all the possible values for $X + Y$. X can be $[0, 1, 3]$. Y can be $[-1, 1, 2]$. This means that the possible values for $X + Y$ are $[-1, 1, 2, 0, 3, 4, 5]$, thus

$$P(-1) = 0.25$$

$$P(0) = 0.08$$

$$P(1) = 0.15$$

$$P(2) = 0.10 + 0.28 + 0.04 = 0.42$$

$$P(3) = 0.04$$

$$P(4) = 0.01$$

$$P(5) = 0.05$$

(e) $\text{Exp}(X)$, $\text{Exp}(Y)$, $\text{Exp}(X + Y)$.

(i) **$\text{Exp}(X) = 0.7$**

$$\text{Exp}(X) = (0 * 0.5) + (1 * 0.4) + (3 * 0.1) = 0.7$$

(ii) **$\text{Exp}(Y) = 0.45$**

$$\text{Exp}(Y) = (-1 * 0.37) + (1 * 0.44) + (2 * 0.19) = 0.45$$

(iii) **$\text{Exp}(X + Y) = 1.15$**

By Theorem 9.8 from page 260, (Proof on page 261), we know that $\text{Exp}(X + Y) = \text{Exp}(X) + \text{Exp}(Y)$

$$\text{Exp}(X + Y) = \text{Exp}(X) + \text{Exp}(Y) = 0.7 + 0.45 = 1.15$$

Problem 6

- (a) What is the value of a (written as "a" in the drawing)

Solution: $a = 9$

With a probability density function, the area under the function has to go to 1. This is because $P(A) + P(\bar{A}) = 1$. So we must find the complete area under the function before a , and then find out how long a must be by finding the difference of 1 and the area under the function before a .

(i) Area under $x < 2.0 = 0$

(ii) Area under $2.0 \leq x < 4.0 = 0.4$

The equation of this section is $Y = .2$. To find the area under this part of the function, we take the integral of this equation and give it a range from 2.0 to 4.0.

$$\int_2^4 0.2 \, dx = 4.0(0.2) - 2.0(0.2) = 0.4$$

(iii) Area under $4.0 \leq x < 6.0 = 0.3$

We must first find the equation of the line from $4.0 \leq x < 6.0$.

Slope $4.0 \leq x < 6.0$

$$m = \frac{0.1 - 0.2}{6.0 - 4.0} = -0.05$$

Equation Y

$$Y = -0.05(x - 4.0) + 0.2 = -0.05x + 0.4$$

Area Under Y from $4.0 \leq x < 6.0$

$$\int_4^6 -0.05x + 0.4 \, dx = \left(\frac{-0.05}{2} * 6^2 + (0.4 * 6) \right) - \left(\frac{-0.05}{2} * 4^2 + (0.4 * 4) \right) = 0.3$$

(iv) Area under $6.0 \leq a = 0.3$

So far our current area under the curve up until $x = 6.0$ is $0.4 + 0.3 = 0.7$. We need total area under the curve to be 1, so the remaining amount we need to have under the curve is $1 - 0.7 = 0.3$.

(v) Value of $a = 9$

We need 0.3 more under the curve, and we know that past 6, we keep the constant rate of 0.1. so

$$a = 6 + \frac{0.3}{0.1} = 9$$

- (b) Using the given f , what is the probability that a randomly chosen real number will fall in the interval $[5.0, 7.0]$?
- (c) What is the cumulative distribution function? Please both define it as done in the bulleted list above and produce a drawing.