

**Tutorial 3: Solutions**

1. In general we have that  $\mathbf{E}[aX + bY + c] = a\mathbf{E}[X] + b\mathbf{E}[Y] + c$ . Therefore,

$$\mathbf{E}[Z] = 2 \cdot \mathbf{E}[X] - 3 \cdot \mathbf{E}[Y].$$

For the case of independent random variables, we have that if  $Z = a \cdot X + b \cdot Y$ , then

$$\text{var}(Z) = a^2 \cdot \text{var}(X) + b^2 \cdot \text{var}(Y).$$

Therefore,  $\text{var}(Z) = 4 \cdot \text{var}(X) + 9 \cdot \text{var}(Y)$ .

2. See online solutions.

3. (a) We can find  $c$  knowing that the probability of the entire sample space must equal 1.

$$\begin{aligned} 1 &= \sum_{x=1}^3 \sum_{y=1}^3 p_{X,Y}(x, y) \\ &= c + c + 2c + 2c + 4c + 3c + c + 6c \\ &= 20c \end{aligned}$$

Therefore,  $c = \frac{1}{20}$ .

(b)  $p_Y(2) = \sum_{x=1}^3 p_{X,Y}(x, 2) = 2c + 0 + 4c = 6c = \frac{3}{10}$ .

(c)  $Z = YX^2$

$$\begin{aligned} \mathbf{E}[Z | Y = 2] &= \mathbf{E}[YX^2 | Y = 2] \\ &= \mathbf{E}[2X^2 | Y = 2] \\ &= 2\mathbf{E}[X^2 | Y = 2] \end{aligned}$$

$$p_{X|Y}(x | 2) = \frac{p_{X,Y}(x,2)}{p_Y(2)}.$$

Therefore,

$$p_{X|Y}(x | 2) = \begin{cases} \frac{1/10}{3/10} = \frac{1}{3} & \text{if } x = 1 \\ \frac{1/5}{3/10} = \frac{2}{3} & \text{if } x = 3 \\ 0 & \text{otherwise} \end{cases}$$

$$\begin{aligned} \mathbf{E}[Z | Y = 2] &= 2 \sum_{x=1}^3 x^2 p_{X|Y}(x | 2) \\ &= 2 \left( (1^2) \cdot \frac{1}{3} + (3^2) \cdot \frac{2}{3} \right) \\ &= \frac{38}{3} \end{aligned}$$

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Department of Electrical Engineering & Computer Science  
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(d) Yes. Given  $X \neq 2$ , the distribution of  $X$  is the same given  $Y = y$ .

$$\mathbf{P}(X = x | Y = y, X \neq 2) = \mathbf{P}(X = x | X \neq 2).$$

For example,

$$\mathbf{P}(X = 1 | Y = 1, X \neq 2) = \mathbf{P}(X = 1 | Y = 3, X \neq 2) = \mathbf{P}(X = 1 | X \neq 2) = \frac{1}{3}$$

(e)  $p_{Y|X}(y | 2) = \frac{p_{X,Y}(2,y)}{p_X(2)}$ .

$$p_X(2) = \sum_{y=1}^3 p_{X,Y}(2, y) = c + 0 + c = 2c = \frac{1}{10}.$$

Therefore,

$$p_{Y|X}(y | 2) = \begin{cases} \frac{1/20}{1/10} = \frac{1}{2} & \text{if } y = 1 \\ \frac{1/20}{1/10} = \frac{1}{2} & \text{if } y = 3 \\ 0 & \text{otherwise} \end{cases}$$

$$\mathbf{E}[Y^2 | X = 2] = \sum_{y=1}^3 y^2 p_{Y|X}(y | 2) = (1^2) \cdot \frac{1}{2} + (3^2) \cdot \frac{1}{2} = 5.$$

$$\mathbf{E}[Y | X = 2] = \sum_{y=1}^3 y p_{Y|X}(y | 2) = 1 \cdot \frac{1}{2} + 3 \cdot \frac{1}{2} = 2.$$

$$\text{var}(Y | X = 2) = \mathbf{E}[Y^2 | X = 2] - \mathbf{E}[Y | X = 2]^2 = 5 - 2^2 = 1.$$

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