CS70: Jean Walrand: Lecture 29.

Probability Review

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1. True or False

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1. True or False
2. Some Key Results

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3. Quiz 1: G

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Probability Review

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3. Quiz 1: G ($\approx 40\%$)

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Probability Review

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3. Quiz 1: G ($\approx 40\%$)
4. Quiz 2: PG ($\approx 40\%$)
5. Quiz 3: R

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3. Quiz 1: G ($\approx$ 40%)
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Probability Review

1. True or False
2. Some Key Results
3. Quiz 1: G ($\approx 40\%$)
4. Quiz 2: PG ($\approx 40\%$)
5. Quiz 3: R ($\approx 20\%$)
6. Common Mistakes

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1. True or False
2. Some Key Results
3. Quiz 1: G ($\approx$ 40%)
4. Quiz 2: PG ($\approx$ 40%)
5. Quiz 3: R ($\approx$ 20%)
6. Common Mistakes

True or False

- Ω and A are independent.

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- $X = Expo(\lambda) \implies Pr[X > 5 | X > 3] = Pr[X > 2]$.

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- $[A_n - 2\sigma\frac{1}{n}, A_n + 2\sigma\frac{1}{n}] = 95\%$-CI for μ. No
- $[A_n - 2\sigma\frac{1}{\sqrt{n}}, A_n + 2\sigma\frac{1}{\sqrt{n}}] = 95\%$-CI for μ.

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- If $0.3 < \sigma < 3$, then

  $$[A_n - 0.6\frac{1}{\sqrt{n}}, A_n + 0.6\frac{1}{\sqrt{n}}] = 95\%\text{-CI for } \mu.$$

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- If $0.3 < \sigma < 3$, then
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- If $0.3 < \sigma < 3$, then
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Match Items

[1] $Pr[X \geq a] \leq \frac{E[f(X)]}{f(a)}$;

[2] $Pr[|X - E[X]| > a] \leq \frac{var[X]}{a^2}$

[3] $Pr[X \geq a] \leq \min_{\theta > 0} \frac{E[e^{\theta X}]}{e^{\theta a}}$

[4] $g(\cdot)$ convex $\Rightarrow E[g(X)] \geq g(E[X])$

[5] $E[Y] + \frac{cov(X,Y)}{var(X)}(X - E[X])$.

[6] $\sum_y yPr[Y = y | X = x]$

[7] $Pr[|\frac{X_1 + \cdots + X_n}{n} - E[X_1]| \geq \epsilon] \to 0$,

[8] $E[(Y - E[Y|X])h(X)] = 0$.

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[1] $Pr[X \geq a] \leq \frac{E[f(X)]}{f(a)}$

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- WLLN

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- WLLN (7)

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- MMSE

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- WLLN (7)
- MMSE (6)
- Projection property

Match Items

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- MMSE (6)
- Projection property (8)

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- MMSE (6)
- Projection property (8)
- Chebyshev

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- MMSE (6)
- Projection property (8)
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- LLSE

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- Projection property (8)
- Chebyshev (2)
- LLSE (5)

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- WLLN (7)
- MMSE (6)
- Projection property (8)
- Chebyshev (2)
- LLSE (5)
- Markov's inequality

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- WLLN (7)
- MMSE (6)
- Projection property (8)
- Chebyshev (2)
- LLSE (5)
- Markov's inequality (1)

Quiz 1: G

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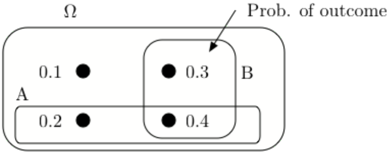
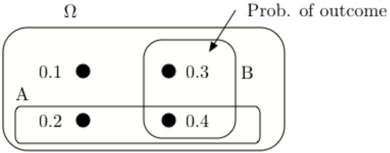
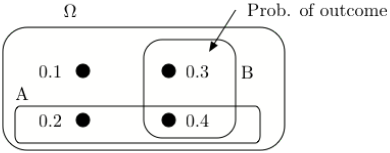


Quiz 1: G



1. What is $P[A|B]$?

Quiz 1: G



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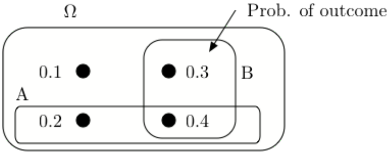
   $Pr[A|B] =$

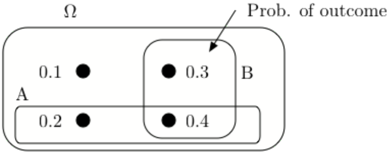
Quiz 1: G



1. What is $P[A|B]$?

   $Pr[A|B] = \frac{Pr[A \cap B]}{Pr[B]} =$

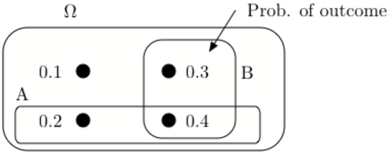
Quiz 1: G



1. What is $P[A|B]$?

   $Pr[A|B] = \frac{Pr[A \cap B]}{Pr[B]} = \frac{0.4}{0.7}$

Quiz 1: G

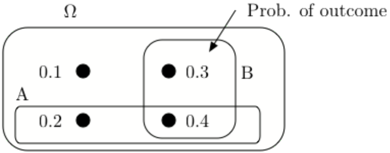


1. What is $P[A|B]$?

   $Pr[A|B] = \frac{Pr[A \cap B]}{Pr[B]} = \frac{0.4}{0.7}$

2. What is $Pr[B|A]$?

Quiz 1: G



1. What is $P[A|B]$?

   $Pr[A|B] = \frac{Pr[A \cap B]}{Pr[B]} = \frac{0.4}{0.7}$

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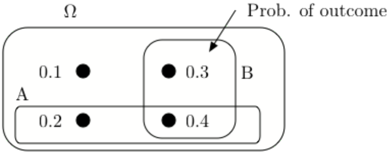
   $Pr[B|A] =$

Quiz 1: G



1. What is $P[A|B]$?

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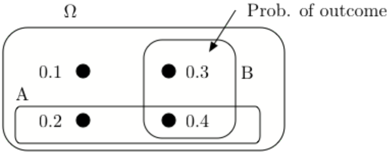
   $Pr[B|A] = \frac{Pr[A \cap B]}{Pr[A]} =$

Quiz 1: G



1. What is $P[A|B]$?

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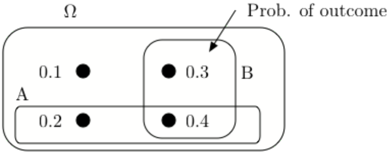
Quiz 1: G



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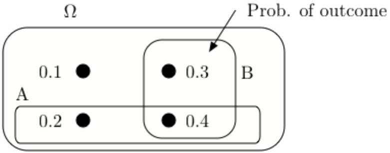
   $Pr[B|A] = \frac{Pr[A \cap B]}{Pr[A]} = \frac{0.4}{0.6}$

3. Are A and B positively correlated?

Quiz 1: G



1. What is $P[A|B]$?

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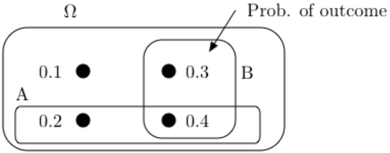
   $Pr[B|A] = \frac{Pr[A \cap B]}{Pr[A]} = \frac{0.4}{0.6}$

3. Are A and B positively correlated?

   No.

Quiz 1: G



1. What is $P[A|B]$?

   $Pr[A|B] = \frac{Pr[A \cap B]}{Pr[B]} = \frac{0.4}{0.7}$

2. What is $Pr[B|A]$?

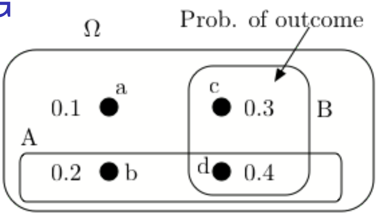
   $Pr[B|A] = \frac{Pr[A \cap B]}{Pr[A]} = \frac{0.4}{0.6}$

3. Are A and B positively correlated?

   No. $Pr[A \cap B] = 0.4 < Pr[A]Pr[B] = 0.6 \times 0.7$.

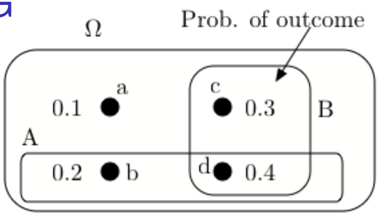
Quiz 1: G

Quiz 1: G



ω	$X(\omega)$	$Y(\omega)$
a	0	0
b	1	0
c	0	2
d	1	2

Quiz 1: G



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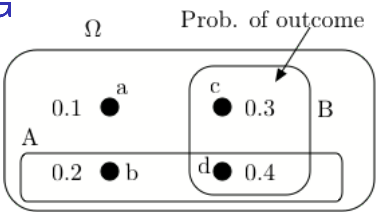
4. What is $E[Y|X]$?

Quiz 1: G



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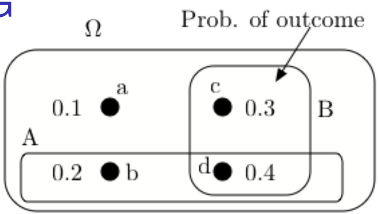
4. What is $E[Y|X]$?

$$E[Y|X=0] \quad =$$

Quiz 1: G



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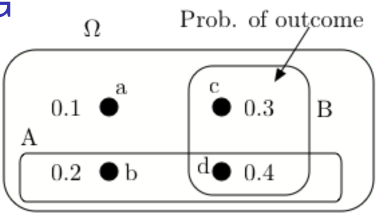
4. What is $E[Y|X]$?

$$E[Y|X=0] \quad = \quad 0 \times Pr[Y=0|X=0] + 2 \times Pr[Y=2|X=0]$$

Quiz 1: G



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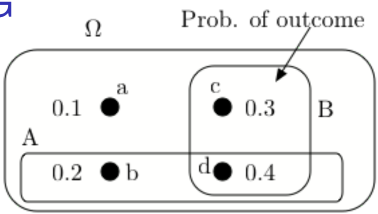
Quiz 1: G



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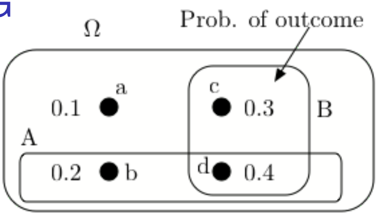
$$E[Y|X=0] = 0 \times Pr[Y=0|X=0] + 2 \times Pr[Y=2|X=0]$$
$$= 2 \times \frac{0.3}{0.4} =$$

Quiz 1: G



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$$E[Y|X=0] = 0 \times Pr[Y=0|X=0] + 2 \times Pr[Y=2|X=0]$$
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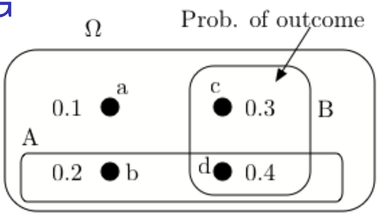
Quiz 1: G



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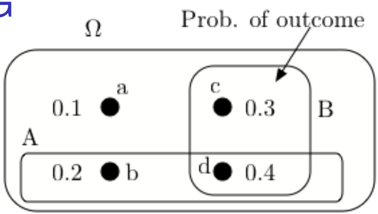
Quiz 1: G



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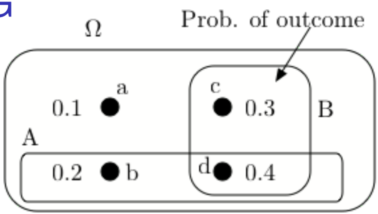
Quiz 1: G



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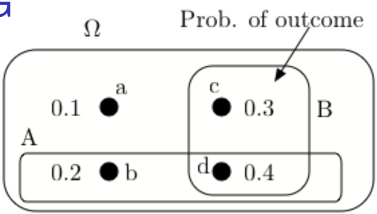
&=
\end{aligned}$$

Quiz 1: G



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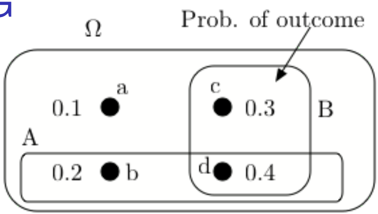
Quiz 1: G



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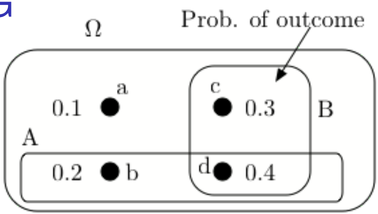
$$

Quiz 1: G



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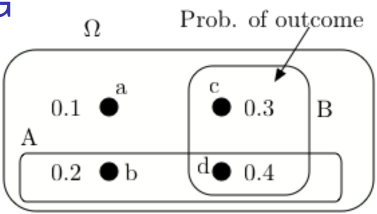
$$

5. What is $cov(X, Y)$?

Quiz 1: G



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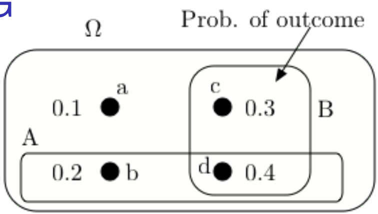
5. What is $cov(X,Y)$?

   $cov(X,Y) =$

Quiz 1: G



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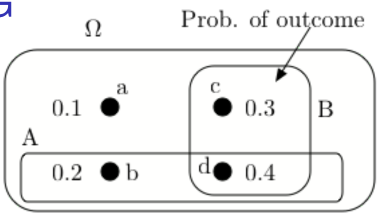
5. What is $cov(X,Y)$?
$cov(X,Y) = E[XY] - E[X]E[Y] =$

Quiz 1: G



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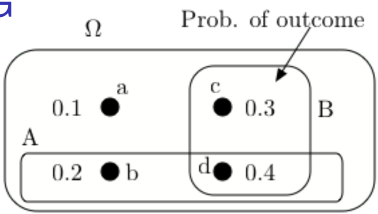
5. What is $cov(X, Y)$?

$cov(X, Y) = E[XY] - E[X]E[Y] = 0.8 - 0.6 \times 1.4 =$

Quiz 1: G



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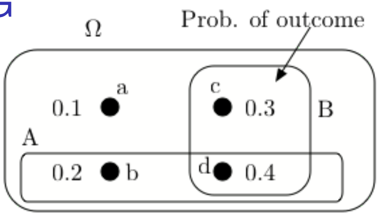
5. What is $cov(X, Y)$?

$cov(X,Y) = E[XY] - E[X]E[Y] = 0.8 - 0.6 \times 1.4 = -0.04$

Quiz 1: G



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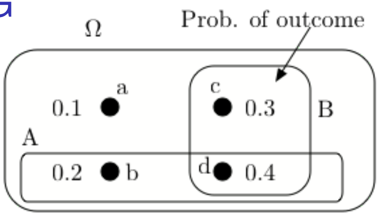
   $cov(X,Y) = E[XY] - E[X]E[Y] = 0.8 - 0.6 \times 1.4 = -0.04$

6. What is $L[Y|X]$?

Quiz 1: G



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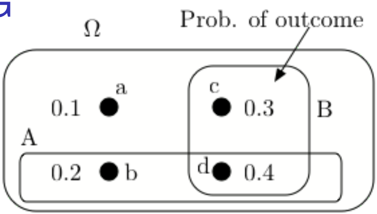
   $L[Y|X] =$

Quiz 1: G



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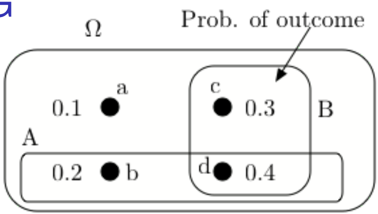
$L[Y|X] = E[Y] + \frac{cov(X,Y)}{var(X)}(X - E[X]) =$

Quiz 1: G



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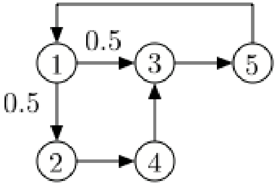
$cov(X, Y) = E[XY] - E[X]E[Y] = 0.8 - 0.6 \times 1.4 = -0.04$

6. What is $L[Y|X]$?

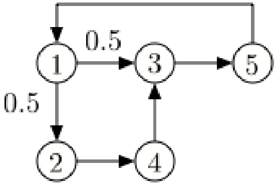
$L[Y|X] = E[Y] + \frac{cov(X,Y)}{var(X)}(X - E[X]) = 1.4 + \frac{-0.04}{0.6 \times 0.4}(X - 0.6)$

Quiz 1: G

Quiz 1: G

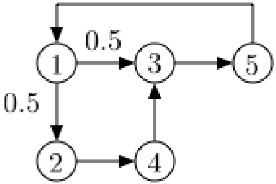


Quiz 1: G



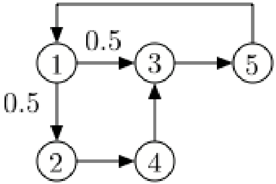
7. Is this Markov chains irreducible?

Quiz 1: G



7. Is this Markov chains irreducible? Yes.

Quiz 1: G



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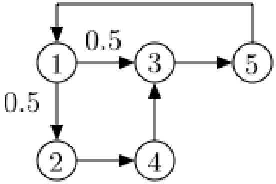
Quiz 1: G



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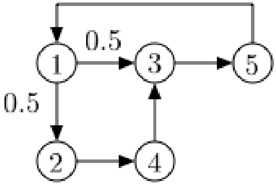
   No.

Quiz 1: G



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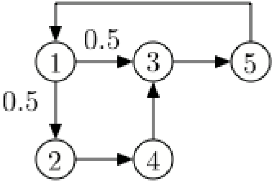

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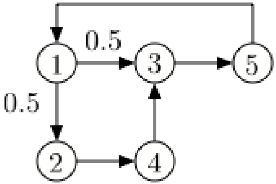
Quiz 1: G



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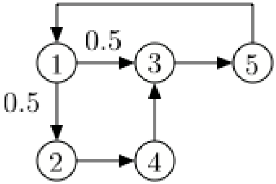

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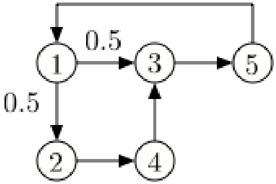

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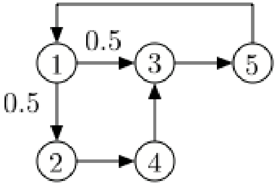

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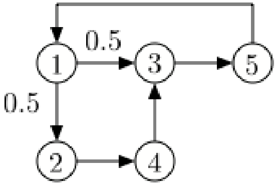
Quiz 1: G



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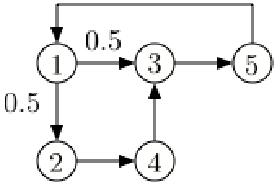

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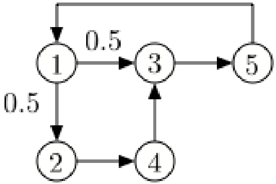
Quiz 1: G



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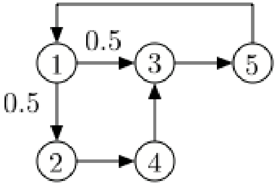
    Let $a = \pi(1)$.

Quiz 1: G



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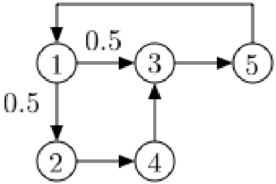
    Let $a = \pi(1)$. Then $a = \pi(5)$,

Quiz 1: G



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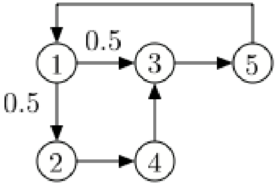
    Let $a = \pi(1)$. Then $a = \pi(5), \pi(2) = 0.5a$,

Quiz 1: G



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    Let $a = \pi(1)$. Then $a = \pi(5), \pi(2) = 0.5a, \pi(4) = \pi(2) = 0.5a,$

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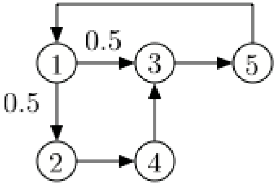

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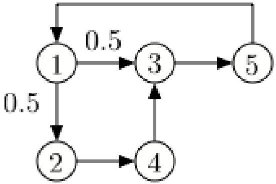
Quiz 1: G



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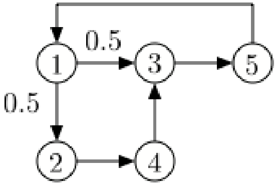
Quiz 1: G



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Quiz 1: G

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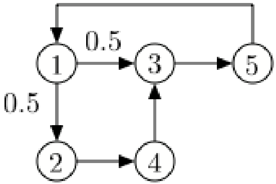

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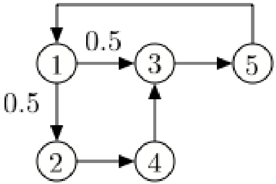
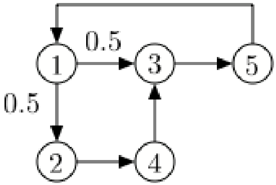


12. Write the first step equations for calculating the mean time from 1 to 4.

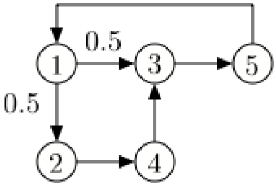
Quiz 1: G



12. Write the first step equations for calculating the mean time from 1 to 4.

$$\beta(1) = 1 + 0.5\beta(2) + 0.5\beta(3)$$

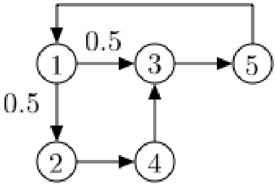
Quiz 1: G



12. Write the first step equations for calculating the mean time from 1 to 4.

$$\beta(1) = 1 + 0.5\beta(2) + 0.5\beta(3)$$
$$\beta(2) = 1$$

Quiz 1: G



12. Write the first step equations for calculating the mean time from 1 to 4.

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$$\beta(3) = 1 + \beta(5)$$

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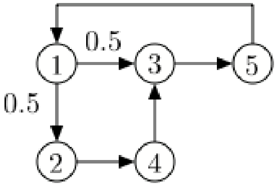

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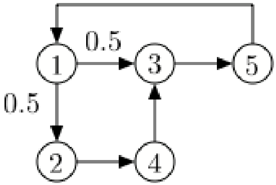

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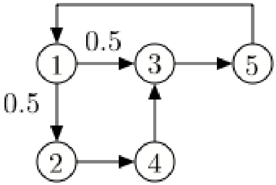
Quiz 1: G



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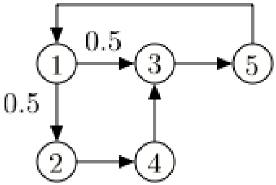
$$\beta(1) \quad = \quad 1 + 0.5 \times 1 + 0.5 \times (1 + (1 + \beta(1)))$$

Quiz 1: G



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$$\begin{aligned}\beta(1) &= 1 + 0.5 \times 1 + 0.5 \times (1 + (1 + \beta(1))) \\ &= 2.5 + 0.5\beta(1).\end{aligned}$$

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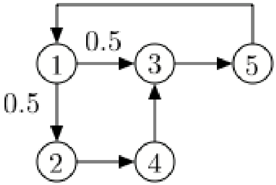

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Hence, $\beta(1) = 5$.

Quiz 1: G

14. Which is $E[Y|X]$? Blue, red or green?

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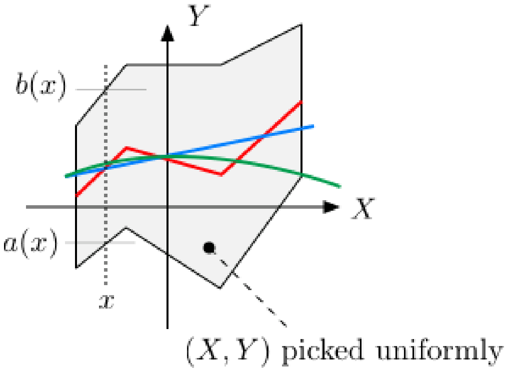

Quiz 1: G

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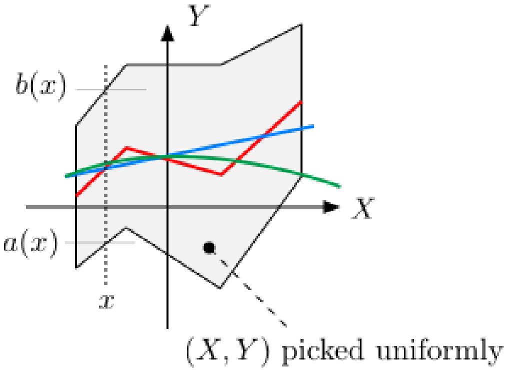

Answer: Red.

Quiz 1: G

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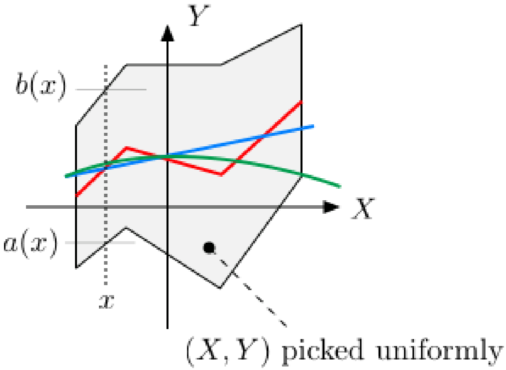

Answer: Red.
Given $X = x, Y = U[a(x), b(x)]$.

Quiz 1: G

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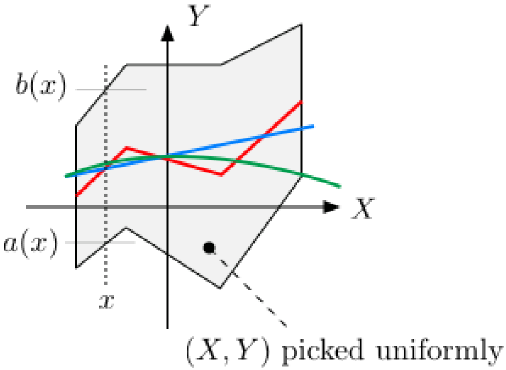

Answer: Red.
Given $X = x, Y = U[a(x), b(x)]$. Thus, $E[Y|X = x] = \frac{a(x)+b(x)}{2}$.

Quiz 1: G

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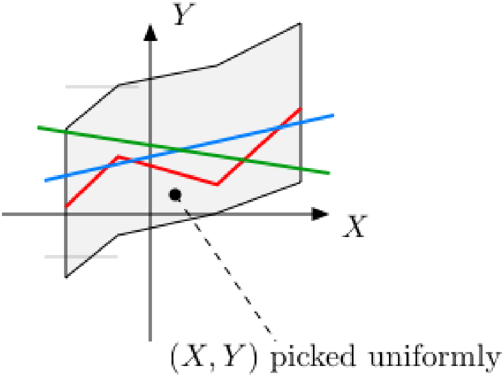

Quiz 1: G

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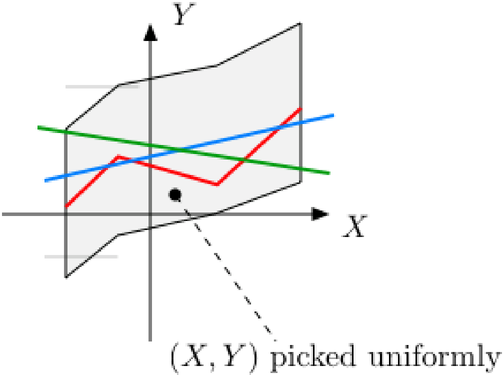

Answer: Blue.

Quiz 1: G

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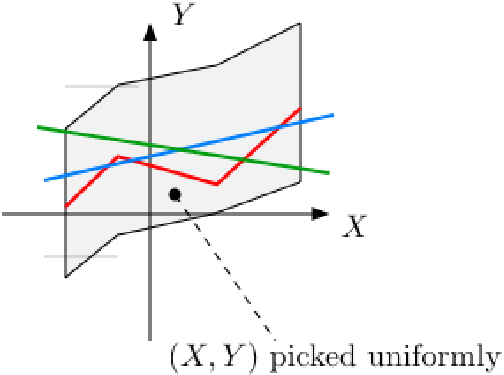

Answer: Blue.
Cannot be red (not a straight line).

Quiz 1: G

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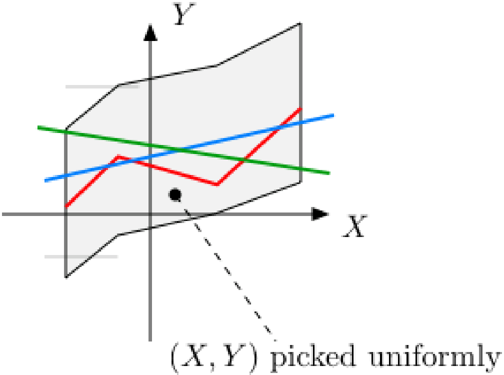

Answer: Blue.
Cannot be red (not a straight line).
Cannot be green: X and Y are clearly positively correlated.

Quiz 2: PG

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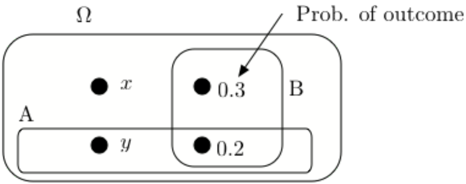

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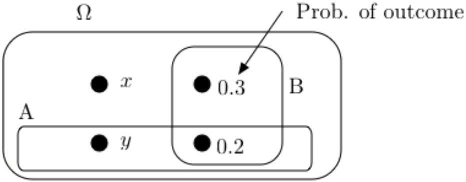
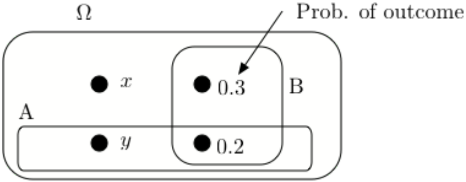


1. Find (x, y) so that A and B are independent.

Quiz 2: PG



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   We need
   $$Pr[A \cap B] = Pr[A]Pr[B]$$

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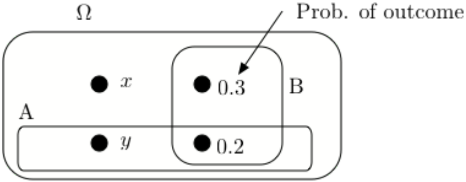

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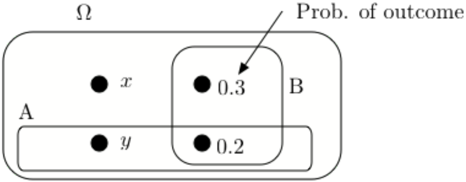
Quiz 2: PG



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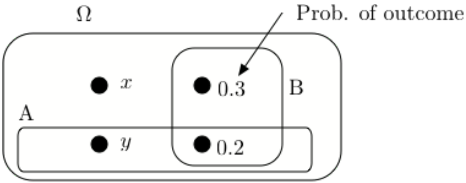

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   Hence,

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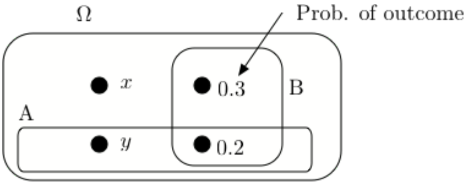

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   Hence,

   $$y = 0.2 \text{ and } x =$$

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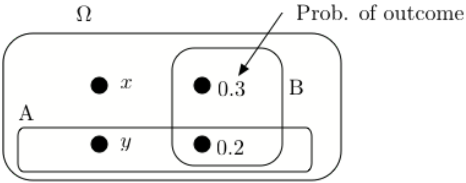

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   $$Pr[A \cap B] = Pr[A]Pr[B]$$

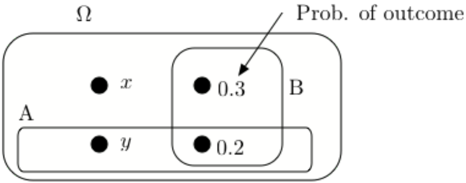
   That is,

   $$0.2 = (y + 0.2) \times 0.5 = 0.5y + 0.1$$

   Hence,

   $$y = 0.2 \text{ and } x = 0.3.$$

Quiz 2: PG



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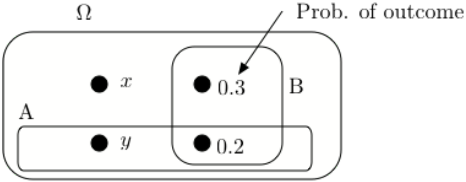

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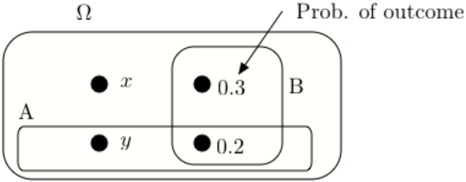

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Quiz 2: PG

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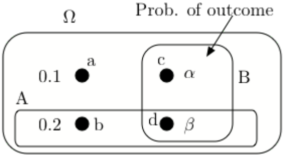

ω	$X(\omega)$	$Y(\omega)$
a	0	0
b	1	0
c	0	2
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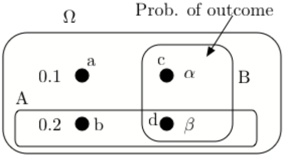
Quiz 2: PG



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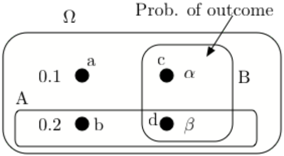
Quiz 2: PG



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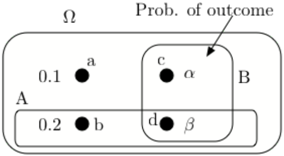

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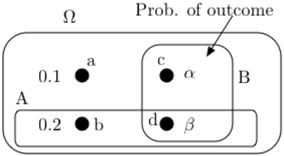

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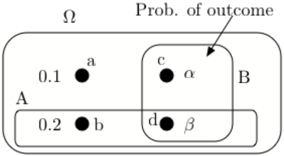

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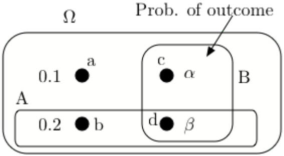

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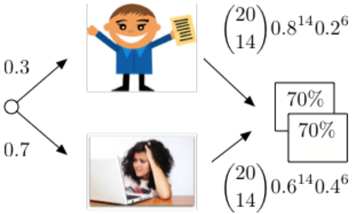

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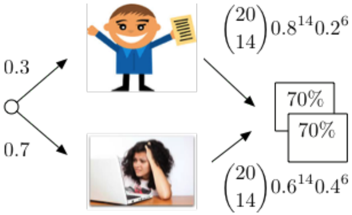

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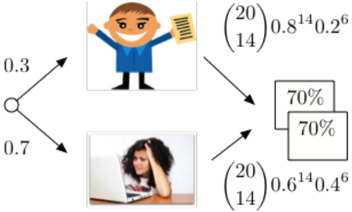

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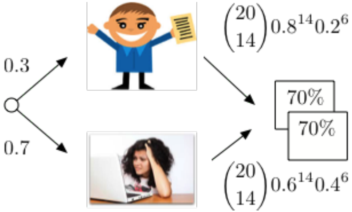

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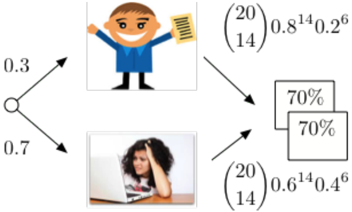

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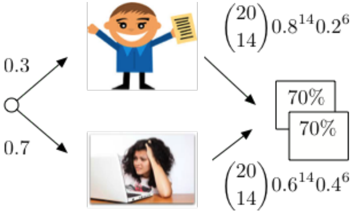

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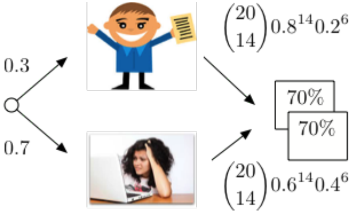

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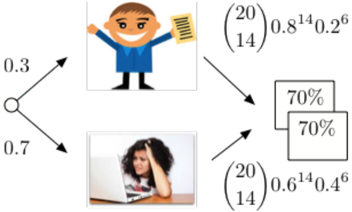

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Quiz 2: PG

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Hence,

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Quiz 2: PG

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$$L[X|V] = E[X] + \frac{cov(X,V)}{var(V)}(V - E[V])$$

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Thus,

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Quiz 3: R

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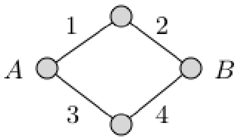

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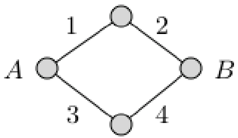

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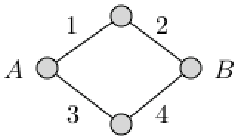
Quiz 3: R



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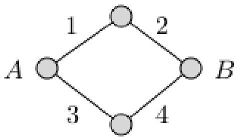

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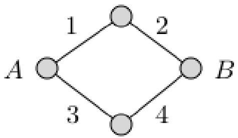

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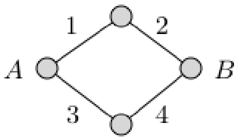

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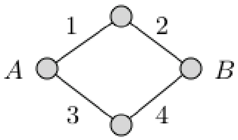

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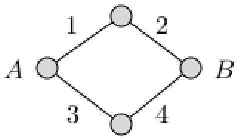

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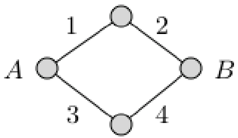
Quiz 3: R



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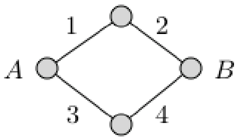

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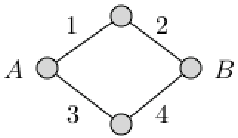

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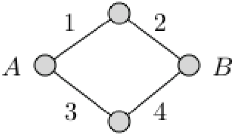
Quiz 3: R



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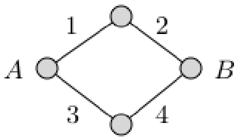

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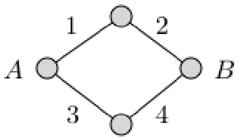
Quiz 3: R



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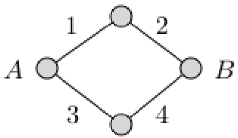

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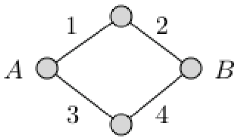
Quiz 3: R



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&\approx 0.4667.
\end{aligned}$$

Quiz 3: R

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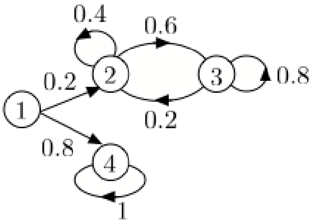

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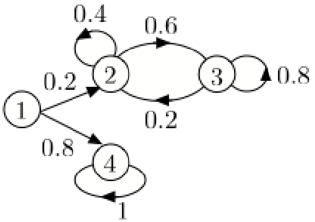

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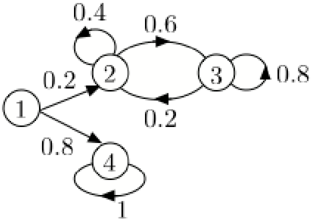
Quiz 3: R



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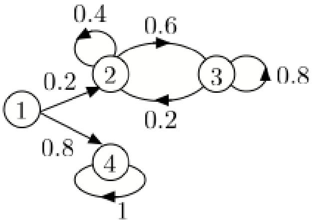
Quiz 3: R



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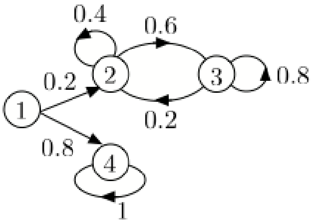
   With probability $\alpha := 0.2\pi_0(1) + \pi_0(2) + \pi_0(3)$, the MC ends up in $\{2, 3\}$.

Quiz 3: R



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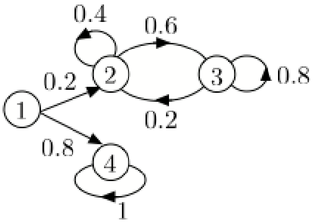
Quiz 3: R



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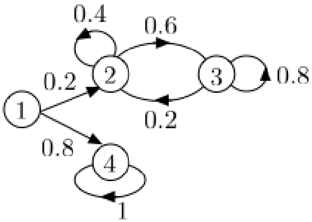

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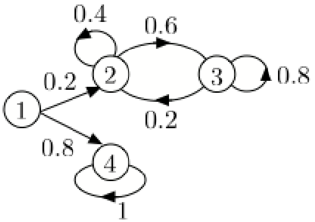
Quiz 3: R



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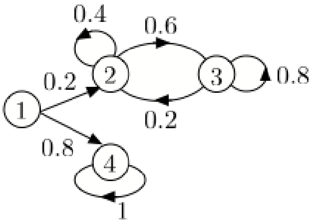
Quiz 3: R



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$$[0, 0.25\alpha, 0.75\alpha, 1-\alpha].$$

Quiz 3: R

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6. What is $L[Y|X]$? $L[Y|X] = -\frac{1}{2n-1}X$. Indeed, $var(X) = 1$, obviously!

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