Unit 11: Quiz

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The problems in the quiz will be automatically graded.

You are given only **ONE** attempt for each problem. You will be able to see the solution after you submit your answers.

If the answer is numeric and has more than 4 decimal places, just give your answers to **4 decimal places (0.0001 accuracy)** unless otherwise stated.

e.g. for 0.123456... you just need to round it up to 0.1235

Problem 1

1/1 point (graded)

1. Consider a collection of 9 bears. There is a family of red bears consisting of one father bear, one mother bear, and one baby bear. There is a similar green bear family, and a similar blue bear family. We draw 5 consecutive times from this collection *without replacement* (i.e., not returning the bear after each draw). Let X denote the number of red bears that are chosen, among these 5 selected bears. Find the variance of X.

0.5555556

Answer: 0.5556

Explanation

1. Method #1. We keep track (in order) of the kind of bears that we get. Let X denote the number of red bears selected. For $i = 1, 2, 3, 4, 5$, let $X_i = 1$ if the ith bear selected is red, and $X_i = 0$ otherwise.

So $X = X_1 + X_2 + X_3 + X_4 + X_5$.

Thus

$$\text{Var}(X) = \text{Var}(X_1 + \cdots + X_5)$$
$$= \sum_{i=1}^{5} \text{Var}(X_i) + \sum_{i \neq j} \text{Cov}(X_i, X_j).$$

We have

$$\text{Var}(X_i) = \mathbb{E}(X_i^2) - (\mathbb{E}(X_i))^2 = 1/3 - (1/3)^2 = 2/9.$$

Also,

$$\text{Cov}(X_i, X_j) = \mathbb{E}(X_i X_j) - \mathbb{E}(X_i)\mathbb{E}(X_j)$$
$$= (3/9)(2/8) - (1/3)(1/3) = -1/36.$$ So altogether
$$\text{Var}(X) = (5)(2/9) + (20)(-1/36) = 5/9.$$

Method #2. Refer to the red father bear as red bear #1, and the red mother bear as red bear #2, and the red baby bear as red bear #3.

For $i = 1, 2, 3$, let $Y_i = 1$ if the ith red bear is selected (at any time, i.e., on any of the five selections), and $Y_i = 0$ otherwise.

So we have $X = Y_1 + Y_2 + Y_3$.

$$\text{Var}(X) = \text{Var}(Y_1 + Y_2 + Y_3) = \sum_{i=1}^{3} \text{Var}(Y_i) + \sum_{i \neq j} \text{Cov}(Y_i, Y_j).$$

We have $\text{Var}(Y_i) = \mathbb{E}(Y_i^2) - (\mathbb{E}(Y_i))^2 = 5/9 - (5/9)^2 = 20/81$.

Also

$$\text{Cov}(Y_i, Y_j) = \mathbb{E}(Y_i Y_j) - \mathbb{E}(Y_i)\mathbb{E}(Y_j)$$
$$= (5/9)(4/8) - (5/9)(5/9) = -5/162.$$

So altogether $\text{Var}(X) = (3)(20/81) + (6)(-5/162) = 5/9$.

Submit You have used 1 of 1 attempt

Problem 2

2/2 points (graded)

2. Suppose that a drawer contains 8 marbles: 2 are red, 2 are blue, 2 are green, and 2 are yellow. The marbles are rolling around in a drawer, so that all possibilities are equally likely when they are drawn. Alice chooses 2 marbles without replacement, and then Bob also chooses 2 marbles without replacement. Let Y denote the number of red marbles that Alice gets, and let X denote the number of red marbles that Bob gets.

2a. Find the covariance of X and Y.

-3/28 ✔ **Answer:** -0.1071429

2b. Find the correlation of X and Y.

-0.3333333 ✔ **Answer:** -0.3333333

Explanation

2a. First we note that $0 \leq X \leq 2$ and $0 \leq Y \leq 2$, with the additional constraint that $0 \leq X + Y \leq 2$. So we have $XY = 1$ if $X = 1$ and $Y = 1$, or otherwise $XY = 0$. (You can try the various combinations of the X and Y, if you do not see this immediately.) Thus

$\mathbb{E}(XY) = (1)P(X = 1 \;\&\; Y = 1) + (0)(1 - P(X = 1 \;\&\; Y = 1))$. So

$\mathbb{E}(XY) = \frac{\binom{2}{1}\binom{6}{1}}{\binom{8}{2}} \frac{\binom{1}{1}\binom{5}{1}}{\binom{6}{2}} = 1/7$. Thus

$\mathrm{Cov}(X, Y) = \mathbb{E}(XY) - \mathbb{E}(X)\mathbb{E}(Y) = 1/7 - (1/2)(1/2) = -3/28$.

2b. We have $\mathrm{Var}(X) = \mathbb{E}(X^2) - (\mathbb{E}(X))^2$.

We calculate

$$\begin{aligned}\mathbb{E}(X^2) \\ &= (0^2)(6/8)(5/7) + (1^2)((2/8)(6/7) + (6/8)(2/7)) + (2^2)(2/8)(1/7) \\ &= 4/7\end{aligned}$$

and we know $\mathbb{E}(X) = 1/2$, so $\mathrm{Var}(X) = 4/7 - (1/2)^2 = 9/28$.

Similarly, $\mathrm{Var}(Y) = 9/28$. So the correlation of X and Y is

$\rho(X, Y) = \frac{\mathrm{Cov}(X,Y)}{\sqrt{\mathrm{Var}(X)\,\mathrm{Var}(Y)}} = \frac{-3/28}{\sqrt{(9/28)(9/28)}} = -1/3$.

Submit You have used 1 of 1 attempt

✔ Correct (2/2 points)

Problem 3

1/1 point (graded)

3. A bag of candy contains 10 green M&M's and 10 red M&M's. Suppose that 10 students pick 2 candies each, without replacement. Let X denote the number of students who get one red and one green candy. Find $\mathrm{Var}(X)$.

2.639726

Answer: 2.6397

Explanation

3. We can write $X = X_1 + \cdots + X_{10}$ where $X_j = 1$ if the jth pair has 1 red and 1 green, or $X_j = 0$ otherwise. Then $\mathbb{E}(X_j) = 10/19$ for each j. Also,
$\text{Var}(X) = \text{Var}(X_1 + \cdots + X_{10}) = \sum_{i=1}^{10} \text{Var}(X_i) + \sum_{i \neq j} \text{Cov}(X_i, X_j)$.

We have
$\text{Var}(X_i) = \mathbb{E}(X_i^2) - (\mathbb{E}(X_i))^2 = 10/19 - (10/19)^2 = 90/361$ for each i.
Also $\text{Cov}(X_i, X_j) = \mathbb{E}(X_i X_j) - \mathbb{E}(X_i)\mathbb{E}(X_j)$
$= (10/19)(9/17) - (10/19)^2 = 10/6137$ for each $i \neq j$.
So altogether we have
$\text{Var}(X) = (10)(90/361) + (90)(10/6137) = 16200/6137 = 2.64$.

Submit You have used 1 of 1 attempt

Correct (1/1 point)

Problem 4

0/1 point (graded)

4. Suppose X and Y have joint density $f_{X,Y}(x, y) = e^{1-x}$ for x, y in the region where $0 < x < y < 1$, and $f_{X,Y}(x, y) = 0$ otherwise. Find the covariance of X and Y.

[Note: It might look strange to have a joint probability density function of X and Y with no y's in it, but this is OK. This function is constant with regard to y, i.e., it does not change as y changes. You can check, for instance, that $f_{X,Y}(x,y)$ is a valid probability density function because it is nonnegative and because $\int_0^1\int_x^1 e^{1-x}\,dy dx = 1$.]

[Hint: Just to save you having to do so many integration by parts, for your convenience, we have: $\int_0^1 e^{-x}\,dx = 1-e^{-1}$ and $\int_0^1 xe^{-x}\,dx = 1-2e^{-1}$ and $\int_0^1 x^2e^{-x}\,dx = 2-5e^{-1}$ and $\int_0^1 x^3e^{-x}\,dx = 6-16e^{-1}$.]

$\mathrm{Cov}(X,Y) =$ 0.2042954 ✖ **Answer:** 0.0238

Explanation

4. We have $\mathrm{Cov}(X,Y) = \mathbb{E}(XY) - \mathbb{E}(X)\mathbb{E}(Y)$.

We compute

$$\begin{aligned}\mathbb{E}(XY) &= \int_0^1\int_x^1 xye^{1-x}\,dy dx = \int_0^1 xe^{1-x}\int_x^1 y dy dx\\ &= \int_0^1 xe^{1-x}(1-x^2)/2\,dx = \int_0^1 xe^{1-x}(1-x^2)/2\,dx\\ &= \tfrac{e}{2}\int_0^1 e^{-x}(x-x^3)\,dx = 7-(5/2)(e) = 0.2043.\end{aligned}$$

Also we compute

$$\begin{aligned}\mathbb{E}(X) &= \int_0^1\int_x^1 xe^{1-x}\,dy dx = \int_0^1 xe^{1-x}\int_x^1 1\,dy dx\\ &= \int_0^1 xe^{1-x}(1-x)\,dx = e\int_0^1 e^{-x}(x-x^2)\,dx\\ &= 3-e = 0.2817\end{aligned}$$

and

$$\begin{aligned}\mathbb{E}(Y) &= \int_0^1\int_x^1 ye^{1-x}\,dy dx = \int_0^1 e^{1-x}\int_x^1 y dy dx\\ &= \int_0^1 e^{1-x}(1-x^2)/2\,dx = \tfrac{e}{2}\int_0^1 e^{-x}(1-x^2)\,dx\\ &= 2-e/2 = 0.6409.\end{aligned}$$

So we conclude that

$$\begin{aligned}\mathrm{Cov}(X,Y) &= \mathbb{E}(XY) - \mathbb{E}(X)\mathbb{E}(Y) \\ &= 0.2043 - (0.2817)(0.6409) = 0.0238.\end{aligned}$$

Submit You have used 1 of 1 attempt

Problem 5

4/5 points (graded)

5. Suppose X and Y have joint probability density function

$$f_{X,Y}(x,y) = 70e^{-3x-7y}$$

for $0 < x < y$; and $f_{X,Y}(x,y) = 0$ otherwise.

5a. Find the probability density function $f_X(x)$ of X. Then compute $f_X(0.1)$

$f_X(0.1) =$ 3.678794 ✔ **Answer:** 3.678794

5b. Use the formula of $f_X(x)$ you found in **5a** to find $f_{Y|X}(y \mid x) = \frac{f_{X,Y}(x,y)}{f_X(x)}$ for fixed $x > 0$. Then compute $f_{Y|X}(0.1 \mid 0.2)$ and $f_{Y|X}(0.2 \mid 0.1)$

$f_{Y|X}(0.1 \mid 0.2) =$ 14.09627 ✖ **Answer:** 0

$f_{Y|X}(0.2 \mid 0.1) =$ 3.476097 ✔ **Answer:** 3.476097

5c. Use the formula of $f_{Y|X}(y \mid x)$ you found in **5b** to find $\mathbb{E}(Y \mid X = x) = \int_x^\infty y f_{Y|X}(y \mid x)\, dy$, for a fixed $x > 0$. Then compute $\mathbb{E}(Y \mid X = \frac{6}{7})$

$\mathbb{E}(Y \mid X = \frac{6}{7}) =$ 1 ✔ **Answer:** 1

5d. Use the formula of $\mathbb{E}(Y \mid X = x)$ you found in **5c** to find $\mathbb{E}(Y) = \int_0^\infty \mathbb{E}(Y \mid X = x) f_X(x)\, dx$

.

17/70 ✔ **Answer:** 0.2429

Explanation

5a. For $x > 0$, we have $f_X(x) = \int_x^\infty 70e^{-3x-7y}\, dy = 10e^{-10x}$; for $x < 0$, we have $f_X(x) = 0$.

5b. For $x > 0$, we have $f_{Y|X}(y \mid x) = \frac{f_{X,Y}(x,y)}{f_X(x)} = \frac{70e^{-3x-7y}}{10e^{-10x}} = 7e^{7x-7y}$ for $y > x$; and $f_{Y|X}(y \mid x) = 0$ for $y \le x$.

5c. For $x > 0$, we have $\mathbb{E}(Y \mid X = x) = \int_x^\infty (y)(7e^{7x-7y})\, dy = x + 1/7$.

5d. We compute $\mathbb{E}(Y) = \int_0^\infty (x + 1/7)(10e^{-10x})\, dx = 1/10 + 1/7 = 17/70 = 0.2429$.

Submit You have used 1 of 1 attempt

✱ Partially correct (4/5 points)

Problem 6

2/2 points (graded)

6. Roll two 4-sided dice. Let X denote the maximum value, and let Y denote the minimum value.

6a. Find $\mathbb{E}(X \mid Y = 3)$.

3.666667 ✔ **Answer:** 3.6667

6b. Find $\mathbb{E}(Y \mid X = 3)$.

1.8 ✔ **Answer:** 1.8

Explanation

6a. The conditional mass of X, given $Y = 3$, is $f_{X|Y}(3 \mid 3) = 1/3$; $f_{X|Y}(4 \mid 3) = 2/3$; and $f_{X|Y}(x \mid 3) = 0$ otherwise. So $\mathbb{E}(X \mid Y = 3) = (3)(1/3) + (4)(2/3) = 11/3$.

6b. The conditional mass of Y, given $X = 3$, is $f_{Y|X}(1 \mid 3) = 2/5$; $f_{Y|X}(2 \mid 3) = 2/5$; $f_{Y|X}(3 \mid 3) = 1/5$; and $f_{Y|X}(y \mid 3) = 0$ otherwise. So $\mathbb{E}(Y \mid X = 3) = (1)(2/5) + (2)(2/5) + (3)(1/5) = 9/5$.

Submit You have used 1 of 1 attempt

Problem 7

2/2 points (graded)

7. Consider a pair of continuous random variables X, Y with constant joint density on the triangle with vertices at $(0,0)$, $(2,0)$, and $(0,8)$.

7a. Fix y with $0 < y < 8$. Find $\mathbb{E}(X \mid Y = y)$, then compute $\mathbb{E}(X \mid Y = 4)$.

1/2

✔ **Answer:** 0.5

7b. Fix x with $0 < x < 2$. Find $\mathbb{E}(Y \mid X = x)$, then compute $\mathbb{E}(Y \mid X = 1)$

2

✔ **Answer:** 2

Explanation

7a. For $0 < y < 8$, we have $f_Y(y) = \int_0^{(8-y)/4} 1/8 dx = (1/8)(8-y)/4 = (8-y)/32$. So we get $f_{X|Y}(x \mid y) = \frac{f_{X,Y}(x,y)}{f_Y(y)} = \frac{1/8}{(8-y)/32} = 4/(8-y)$. So we conclude $\mathbb{E}(X \mid Y = y) = \int_0^{(8-y)/4} (x)(4/(8-y)) dx = (8-y)/8$.

7b. For $0 < x < 2$, we have $f_X(x) = \int_0^{8-4x} 1/8 dy = (2-x)/2$. So we get $f_{Y|X}(y \mid x) = \frac{f_{X,Y}(x,y)}{f_X(x)} = \frac{1/8}{(2-x)/2} = 1/(4(2-x))$. So we conclude $\mathbb{E}(Y \mid X = x) = \int_0^{8-4x} (y) 1/(4(2-x)) dy = 4 - 2x$.

Submit You have used 1 of 1 attempt

✔ Correct (2/2 points)

Problem 8

3/3 points (graded)

8. Suppose that a drawer contains 8 marbles: 2 are red, 2 are blue, 2 are green, and 2 are yellow. The marbles are rolling around in a drawer, so that all possibilities are equally likely when they are drawn. Alice chooses 2 marbles without replacement, and then Bob also chooses 2 marbles without replacement. Let Y denote the number of red marbles that Alice gets, and let X denote the number of red marbles that Bob gets.

8a. Find $\mathbb{E}(X \mid Y = 0)$.

0.6666667 ✔ **Answer:** 0.6667

8b. Find $\mathbb{E}(X \mid Y = 1)$.

0.3333333 ✔ **Answer:** 0.3333

8c. Find $\mathbb{E}(X \mid Y = 2)$.

0 ✔ **Answer:** 0

Explanation

8a. Intuitively, if Alice got no reds, then Bob is drawing 2 marbles from a collection of 2 reds and 4 non-reds, so $\mathbb{E}(X \mid Y = 0) = 2/6 + 2/6 = 2/3$.

8b. Intuitively, if Alice got 1 red, then Bob is drawing 2 marbles from a collection of 1 red and 5 non-reds, so $\mathbb{E}(X \mid Y=1) = 1/6 + 1/6 = 1/3$.
8c. Intuitively, if Alice got 2 reds, then Bob is drawing 2 marbles from a collection of 0 reds and 6 non-reds, so $\mathbb{E}(X \mid Y=2) = 0/6 + 0/6 = 0$.
Here is a more formal way to solve question **8**. We have

$$p_{X,Y}(2,0) = \frac{\binom{6}{0}\binom{2}{2}}{\binom{8}{2}} \frac{\binom{6}{2}\binom{0}{0}}{\binom{6}{2}} = (1/28)(1) = 1/28$$
$$p_{X,Y}(0,2) = \frac{\binom{6}{2}\binom{2}{0}}{\binom{8}{2}} \frac{\binom{4}{0}\binom{2}{2}}{\binom{6}{2}} = (15/28)(1/15) = 1/28$$
$$p_{X,Y}(1,1) = \frac{\binom{6}{1}\binom{2}{1}}{\binom{8}{2}} \frac{\binom{5}{1}\binom{1}{1}}{\binom{6}{2}} = (3/7)(1/3) = 1/7.$$
$$p_{X,Y}(1,0) = \frac{\binom{6}{1}\binom{2}{1}}{\binom{8}{2}} \frac{\binom{5}{2}\binom{1}{0}}{\binom{6}{2}} = (3/7)(2/3) = 2/7.$$
$$p_{X,Y}(0,1) = \frac{\binom{6}{2}\binom{2}{0}}{\binom{8}{2}} \frac{\binom{4}{1}\binom{2}{1}}{\binom{6}{2}} = (15/28)(8/15) = 2/7.$$
$$p_{X,Y}(0,0) = \frac{\binom{6}{2}\binom{2}{0}}{\binom{8}{2}} \frac{\binom{4}{2}\binom{2}{0}}{\binom{6}{2}} = (15/28)(2/5) = 3/14.$$

So $p_Y(0) = 1/28 + 2/7 + 3/14 = 15/28$ and $p_Y(1) = 1/7 + 2/7 = 3/7$ and $p_Y(2) = 1/28$. Thus:
8a. We have $p_{X \mid Y}(x \mid 0) = \frac{p_{X,Y}(x,0)}{p_Y(0)}$. Thus $p_{X \mid Y}(0 \mid 0) = \frac{3/14}{15/28} = 2/5$ and $p_{X \mid Y}(1 \mid 0) = \frac{2/7}{15/28} = 8/15$ and $p_{X \mid Y}(2 \mid 0) = \frac{1/28}{15/28} = 1/15$, so
$\mathbb{E}(X \mid Y=0) = (0)(2/5) + (1)(8/15) + (2)(1/15) = 2/3$.

8b. We have $p_{X\mid Y}(x\mid 1)=\frac{p_{X,Y}(x,1)}{p_Y(1)}$. Thus $p_{X\mid Y}(0\mid 1)=\frac{2/7}{3/7}=2/3$ and $p_{X\mid Y}(1\mid 1)=\frac{1/7}{3/7}=1/3$, so $\mathbb{E}(X\mid Y=1)=(0)(2/3)+(1)(1/3)=1/3$.

8c. We have $p_{X\mid Y}(x\mid 2)=\frac{p_{X,Y}(x,2)}{p_Y(2)}$. Thus $p_{X\mid Y}(0\mid 2)=\frac{1/28}{1/28}=1$, so $\mathbb{E}(X\mid Y=2)=(0)(1)=0$.

Submit You have used 1 of 1 attempt

✔ Correct (3/3 points)

Problem 9

2/2 points (graded)

9a. Suppose that, in a certain course, the expected value of a student's grade is 0.80. Even without knowing anything else about the distribution of the grade, find an upper bound on the probability that a student earns 0.95 or higher in the course.

0.8421053 ✔ **Answer:** 0.84

9b. In addition to knowing that the expected value of a student's grade is 0.80, suppose that you also know that the standard deviation of a student's grade is 0.05. Find a bound on the probability that the student's grade is in the range between 0.73 and 0.87.

0.4897959 ✔ **Answer:** 0.4898

Explanation

9a. If X denotes the grade, then $P(X \geq 0.95) \leq \frac{\mathbb{E}(X)}{0.95} = \frac{0.80}{0.95} = 0.84$.
9b. We have $P(0.73 \leq X \leq 0.87) = P(|X - 0.80| \leq 0.07) = P(|X - 0.80| \leq k\sigma_X)$ where $\sigma_X = 0.05$ is the standard deviation, and $k = 0.07/0.05$. So we have $P(0.73 \leq X \leq 0.87) \geq 1 - \frac{1}{(0.07/0.05)^2} = 0.49$.

Submit You have used 2 of 2 attempts

✔ Correct (2/2 points)

Problem 10

3/3 points (graded)

10. A box of cereal contains, on average, 22oz of cereal inside (and, therefore, this is the amount claimed on the box), with standard deviation of $0.3\mathrm{oz}$. Use X to denote the amount of cereal in such a box.

10a. Find a bound on the probability that the stated weight is wrong by $0.5oz$ or more. I.e., find a bound on $P(|X - 22| \geq 0.5)$.

9/25 ✔ **Answer:** 0.36

10b. Can you find a bound on the probability that the box of cereal has at least 24oz of cereal?

11/12

✔ **Answer:** 0.9166

10c. Without knowing more about the problem, should we use Markov's inequality to give a bound on $P(X > 21)$? Why or why not?

- Yes
- No ✔

Explanation

10a. We have $P(|X-22| \geq 0.5) = P(|X-22| \geq k\sigma_X)$ where $\sigma_X = 0.3$ and $k = 0.5/0.3$. So we get $P(|X-22| \geq 0.5) \leq \frac{1}{(0.5/0.3)^2} = 0.36$.

10b. We have $P(X \geq 24) \leq \frac{22}{24} = 0.92$, by the Markov inequality.

10c. We have $P(X \geq 21) \leq \frac{22}{21} = 1.05$, but of course we automatically have an even better bound (without using the Markov inequality), namely, $P(X \geq 21) \leq 1$. So the Markov inequality does not give us any additional information in this case.

Submit You have used 1 of 1 attempt

✔ Correct (3/3 points)

Problem 11

2/2 points (graded)

11. An agricultural consultant has determined that the number of bees that should appear at noon in a certain flowerbed, on a randomly chosen day in the summertime, has an expected value of 15 bees, with standard deviation of 3 bees.

11a. Find a bound on the probability that 20 or more bees are present on such a day.

3/4

✔ **Answer:** 0.75

11b. Find a bound on the probability there are between 10 to 20 bees (inclusive) on such a day.

16/25

✔ **Answer:** 0.64

Explanation

11a. We use X for the number of bees. Then we get $P(X \geq 20) \leq \frac{15}{20} = 0.75$.

11b. We have $P(10 \leq X \leq 20) = P(|X - 10| \leq 5) = P(|X - 10| \leq k\sigma_X)$ where $\sigma_X = 3$ and $k = 5/3$. So we get $P(10 \leq X \leq 20) \geq 1 - \frac{1}{(5/3)^2} = 0.64$.

Submit

You have used 1 of 1 attempt

✔ Correct (2/2 points)

Problem 12

4/4 points (graded)

12. The number of customers in a large sandwich restaurant is randomly distributed. Over time, the manager has estimated that the average number of customers at lunchtime is 30, with standard deviation of 5.

12a. Find a bound on the probability that there are between 20 to 40 customers (inclusive) at lunchtime.

3/4

Answer: 0.75

12b. Find a bound on the probability that there are at least 40 customers at lunchtime.

3/4

Answer: 0.75

12c. Find a bound on the probability that there are at least 50 customers at lunchtime.

3/5

Answer: 0.60

12d. Find a bound on the probability that there are at least 60 customers at lunchtime.

1/2

Answer: 0.50

Explanation

12a. We use X to denote the number of customers. Then $P(20 \le X \le 40) = P(|X-30| \le 10) = P(|X-30| \le k\sigma_X)$ where $\sigma_X = 5$ and $k = 10/5 = 2$. So we conclude $P(20 \le X \le 40) \ge 1 - \frac{1}{2^2} = 3/4$.

12b. We have $P(X \ge 40) \le \frac{30}{40} = 3/4 = 0.75$.

12c. We have $P(X \ge 50) \le \frac{30}{50} = 3/5 = 0.60$.

12d. We have $P(X \ge 60) \le \frac{30}{60} = 1/2 = 0.50$.

Submit You have used 1 of 1 attempt

✔ Correct (4/4 points)