## Question 3

**Intent of Question**

The primary goals of this question are to: (1) assess a student's ability to use blocking in designing an experiment, and (2) describe a mechanism for randomly assigning treatments to experimental units in the context of the selected blocking.

**Solution**

**Part (a):**

Acceptable blocking schemes:

| | | | |
|---|---|---|---|
| Blocks: | 1 and 12 | 2 and 3 | 4 and 5 |
| | 6 and 7 | 8 and 9 | 10 and 11 |
| | | | |
| Blocks: | 1 and 12 | 2 and 5 | 3 and 4 |
| | 6 and 7 | 8 and 11 | 9 and 10 |

Blocks: 1 and 12 2, 3, 4, and 5 6 and 7 8, 9, 10, and 11

We want to create blocks of homogeneous "units." Exposure (side of house) would have an effect on heat gain through a window, so the best blocking scheme would take side of house into account when creating blocks.

The blocking schemes above create blocks that are similar with respect to exposure (side of house). Since there are two treatments (types of windows), the optimal blocking scheme would create blocks consisting of two window boxes each.

**Part (b):**

For each block we could select one of the window boxes and then flip a coin to determine which type of window would be installed in that window box. For example, if the coin lands face up, install type A; otherwise install type B. Continue this process until half of the windows in the block are assigned to one type, then install the remaining window type in the other boxes.

**Scoring**

Each part is scored as either essentially correct (E), partially correct (P), or incorrect (I).

**Part (a)** is essentially correct (E) if:

1. one of the sets of blocks given in the solution is identified;
2. the justification for the blocking scheme demonstrates an understanding that windows of both types should be used in equal numbers on each side of the house because of differing exposure to sun, light, heat, etc.

Part (a) is partially correct (P) if it includes one of the two elements above.

## Question 3 (continued)

Part (a) can be partially correct (P) if the student confuses treatments with blocks, for instance by assigning the two "blocks" to be even- and odd-numbered window boxes. The justification must be that the exposure is similar for the boxes on each side of the house, and thus each side must receive equal numbers of type A and type B windows.

**Part (b)** is essentially correct (E) if it:

1. assigns window types at random to the window boxes in each block in a way that is consistent with the blocks the student identifies in part (a) and that ensures an equal number of each type of window within each block;
2. describes a mechanism for random assignment, such as a coin toss, roll of a die, use of random number table, etc.

Part (b) is partially correct (P) if it includes only one of the two elements above.

NOTES:

- If students confuse treatments with blocks in part (a), they receive credit for the first element above *only* if they are logically consistent. It is consistent if they use a scheme that randomly assigns half of each type of window to go on each wall.

- By itself, "at random" is not sufficient as an answer and should be scored as incorrect.

- By itself, "at random within each block" is not sufficient for an essentially correct answer but can be scored as partially correct.

**4 Complete Response**

Both parts essentially correct

**3 Substantial Response**

One part essentially correct and the other part partially correct

**2 Developing Response**

One part essentially correct and the other part incorrect

*OR*

Both parts partially correct

**1 Minimal Response**

One part partially correct

(a) A randomized block experiment will be used to compare the heat gain for the two types (A and B) of windows. How would you group the window boxes into blocks? (Clearly indicate your blocks using the window box numbers.) Justify your choice of blocks.

Block similar windows and randomly choose whic of the two will be A and which will be B. The blocks should be (12, 1), (2, 3), (4, 5), (6, 7), (8, 9), (10, 11). Each of these sets of windows are facing in the same direction, and should recieve aproxamitely the same amount of light.

(b) For the design in part (a), describe how you would assign window types (A and B) to the numbered window boxes.

For each pair listed in (a), flip a coin, if it is heads, the first # will be "A", if it is tails, the first # will be "B." The other number will get whichever type of window the first does not get.



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(a) A randomized block experiment will be used to compare the heat gain for the two types (A and B) of windows. How would you group the window boxes into blocks? (Clearly indicate your blocks using the window box numbers.) Justify your choice of blocks.

Randomly assign half of the windows on each wall to window type A or B. The assignments must be random in order for the experiment to be valid. The assignments must also be done according to wall. Heat gain will depend on sunlight exposure for each window, which will vary according to the direction each window faces. In order to control against sunlight exposure, the assignments must be blocked by wall (North, South, east, west)

(b) For the design in part (a), describe how you would assign window types (A and B) to the numbered window boxes.

A fair coin toss can be used to assign half of each wall's windows to type A. The remaining windows will be assigned to type B.



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(a) A randomized block experiment will be used to compare the heat gain for the two types (A and B) of windows. How would you group the window boxes into blocks? (Clearly indicate your blocks using the window box numbers.) Justify your choice of blocks.

- Block 1 will include the following windows: window box numbers 2, 4, 6, 8, 10, & 12
- Block 2 will include the following windows: window box numbers 1, 3, 5, 7, 9, & 11.

I have chosen the window boxes as listed above to insure that no window will receive more "sun time" than the others. For instance, when the sun rises in the east, the "suntime" the eastern windows will receive will be approx. equal to the time the western windows receive at sunset. And to ensure that the north / south alignment of windows does not create an advantage for one block or the other, I have Window box #1 (block 2) facing NE and Window box #6 (block 1) facing SE. then I have Window box #12 (block 1) facing NW and window box #7 (block 2) facing SW.

(b) For the design in part (a), describe how you would assign window types (A and B) to the numbered window boxes.

To assure that this experiment will be randomized, I will use a random # generator to assign window types to the numbered boxes. The numbered boxes will randomly be assigned a 1 or 2 # and then, according to the random # generator, I will assign an A type window for 1 and a B type window for 2.

## Question 3

**Sample: 3A**
**Score: 4**

This is a complete response that identifies a scheme to create blocks of homogeneous units (e.g., windows with about the same exposure to sunlight) and explains how to randomly assign treatments to units within blocks. The response to part (a) creates six blocks from six pairs of windows so that the two windows in each block are on the same side of the house and will receive about the same amount of sunlight. Part (b) clearly describes a coin-tossing mechanism for randomly assigning the two treatments to the two windows in each block, so that each treatment is used once in each block.

**Sample: 3B**
**Score: 3**

This is a substantial response that identifies a scheme to create blocks of homogeneous units (e.g., windows with about the same exposure to sunlight), but it does not completely describe a mechanism for randomly assigning treatments to units within blocks. The response to part (a) contains some extraneous information on the random assignment of treatments, but it clearly recommends four blocks of windows corresponding to the four walls and explains that sunlight exposure will vary according to the direction each window faces. This implies that blocking by walls will create sets of windows such that windows within the same set will have similar levels of exposure to sunlight. Part (b) mentions a random assignment mechanism based on coin tossing but does not clearly describe how it will be used to assign each treatment to half of the windows in each block.

**Sample: 3C**
**Score: 2**

This is a developing response that recognizes the need to balance the treatment assignment with respect to the four sides of the house, but it does not identify an appropriate blocking scheme and does not describe a mechanism for assigning treatments to windows that would achieve the desired balance. This response assigns all of the odd windows to one block and all of the even windows to a second block. The response includes a discussion that confuses not giving either block more exposure to sunlight than the other with the proper goal of giving each treatment, on average, about the same exposure to sunlight. If blocking is effective, exposure to sunlight will vary greatly among blocks. The discussion of the random assignment mechanism is difficult to follow, but it appears to make an independent random selection of the treatment for each window, ignoring the blocks described in part (a). This is a form of a completely randomized design that does not guarantee that each treatment is used for six of the windows.