Calculating the Response Rate of a Cumulative Record.

Figure 1 shows the cumulative record of a VR-25 schedule. Notice the long vertical bars that go from above to below the cumulative record that are labeled "Time bars". On the cumulative records provided for this assignment, the distance between two time bars is always five minutes. If you look at the cumulative records shown in the assignment you'll notice that each one has four time bars, or three complete five-minute intervals. That is, you have 15 minutes of time (plus a little bit before the first time bar and a little bit after the last time bar). Figure 1 also labels the pen resets. As we've discussed in class, these are an "artifact" of the way a cumulative record records data, and should not be confused with the time bars.

![Pen resets](Image)

Figure 1: Time bars and pen resets on the cumulative record. Each of the two “square brackets” (one on the top, one on the bottom) show a five minute period between two time bars.

When you calculate the response rate of a cumulative record you are, essentially, calculating a slope. That means that you need to know the number of responses made in some period of time. If you had to count individual responses on a cumulative record this would be a difficult and tedious task. However, there are some "short cuts". On all of the cumulative records provided for this assignment, there are 75 responses between pen resets. That is, if you were to start at the bottom of the cumulative record and follow the line to the top of the cumulative record, whereupon the pen would reset to the bottom, this would be 75 responses. If you look at the VR-25 schedule shown in Figure 2, you will see that I have indicated on the left side that there are 75 responses in the vertical distance that the pen moves between pen resets. If you look along the bottom of the cumulative record in Figure 2 you will see each complete group of 75 responses numbered in red. Thus, on this particular cumulative record, there are 17 complete groups of 75 responses each, or, a total of $17 \times 75 = 1275$ responses.
Figure 2: There are 75 responses between pen resets. Complete units of 75 responses are indicated below the cumulative record in red numbers. There are 17 complete pen reset units of 75 responses.

To calculate the slope you also need the time. While you could work out the particular amount of time it took for the 1275 responses we’ve identified to take place, our cumulative record provides us with a convenient measure of time with the time bars. Thus, it is probably easier to use the time bars to work in 5 minute units of time. With respect to calculating the response rates for your assignment you could use any period of time you want; you should, however, think a little bit about the issue of sample size when picking a time to work with. For the purposes of this example, I'll use the full 15 minutes provided on our VR-25 cumulative record. You'll probably have noticed that the 1275 responses we have so far do not account for the full 15 minutes of time between the first and last time bars. If you look at Figure 3 you'll see some responses circled in red on the left and right sides of the cumulative record. To find the total number of responses made within the 15 minutes, we also need to count up these responses as well. Unfortunately, these responses on the left and right are not nice even units of 75 responses. To find out how many responses there are you need to get a ruler and take three measurements.

Figure 3: To calculate the total number of responses in 15 minutes between the first and last time bar (indicated by the square bracket at the top) we also need to determine how many responses are made on the left and right, indicated by red circles.

As shown in Figure 4, the first thing you need to measure is the vertical distance on the cumulative record for 75 responses. It is important to realize that everybody's printer is a little bit different. Therefore, to complete your assignment you'll need to actually print out the cumulative records and do this calculation yourself. In the following example that I'm providing here for calculating the slope on this VR-25 schedule, I'm basing my distance calculations on a cumulative record printed out on a Brother HL-2030 printer.
Needless to say, you probably have a different printer. Therefore, don't automatically assume that the heights that I'm using in this example are going to be the same heights that you'll have on cumulative records that you print out. Ok, when I print out this VR-25 cumulative record, I get a vertical height of 26 mm. That is, 75 responses are made in a vertical height of 26 mm.

![Measure height with a ruler](image)

Figure 4: Measure this distance to get the vertical height in which 75 response are recorded.

Next, you need to measure the heights shown in Figure 5 (height A and height B). These are the heights corresponding to the responses made on the left and right that were circled in red back in Figure 3. When I do this on my copy of the VR-25 I get a vertical height of 9 mm for A and a vertical height of 8 mm for B.

![Height A and Height B](image)

Figure 5: The heights you need to calculate for the responses on the left and right.

I know this might seem complicated and possibly pointless, but we're almost done. Now that you've got these three measurements, we can convert the distances into responses by using ratios. We know that there are 75 responses in 26 mm. We want to know how many responses are in 9 mm and 8 mm. To find the responses for A we solve the following:

\[
75 \text{ resp.} / 26 \text{ mm} = X \text{ resp.} / 9 \text{ mm} \\
\text{getting } X = (75 \text{ resp.})(9 \text{ mm}) / 26 \text{ mm} \\
\text{and } X = 675 / 26 = 25.9 \text{ responses.}
\]

With rounding, call this 26 responses. Next, to find the number of responses in B:

\[
75 \text{ resp.} / 26 \text{ mm} = Y \text{ resp.} / 8 \text{ mm} \\
\text{getting } Y = (75 \text{ resp.})(8 \text{ mm}) / 26 \text{ mm} \\
\text{and } Y = 600 / 26 = 23.0 \text{ responses}
\]

So, in the 15 minutes we've got the 1275 responses based on the 17 complete pen resets, 26 responses over on the left side, and another 23 responses over on the left, or 1275 + 26 + 23 = 1324 responses in total.
Finally, to calculate the response rate divide 1324 responses by 15 minutes, giving a value of 88.3 responses/minute. That is, when averaged over a 15 minute period, the rat whose behaviour is shown on this particular cumulative record made 88.3 responses per minute.

You can follow this same basic protocol to calculate response rates for any cumulative record on any schedule and for any amount of time.