Assignment 5

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- Homework 5 Solutions will be released Tuesday, October 6th.
- Remember: autograder is meant as sanity check ONLY. It will not tell you if you have the correct answer. It will tell you if you are in the ball park of the answer so *CHECK YOUR WORK*.

Helpful hints:

- Every function you need to use was taught during lecture! So you may need to revisit the lecture code to help you along by opening the relevant files on Datahub. Alternatively, you may wish to view the code in the condensed PDFs posted on the course website. Good luck!
- Knit your file early and often to minimize knitting errors! If you copy and paste code for the slides, you are bound to get an error that is hard to diagnose. Typing out the code is the way to smooth knitting! We recommend knitting your file each time after you write a few sentences/add a new code chunk, so you can detect the source of knitting errors more easily. This will save you and the GSIs from frustration! **You must knit correctly before submitting.**
- To avoid code running off the page, have a look at your knitted PDF and ensure all the code fits in the file. If it doesn't look right, go back to your .Rmd file and add spaces (new lines) using the return or enter key so that the code runs onto the next line.

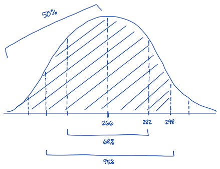
[7 points] Part 1: Pregnancy Length Probabilities

An average pregnancy for humans lasts 266 days, with a standard deviation of 16 days. Assume that human pregnancies are Normally distributed.

1. [3 marks] Approximately what proportion of births are expected to occur on or before 298 days? To aid your answer, hand-draw (or use any software) to sketch a Normal curve, and shade in the area under the Normal density curve the question represents. Add dashed lines at the mean +/- 1SD, 2SD and 3SD. Then calculate the proportion asked about in the first sentence. You shouldn't need to use R to perform any calculations for this question. Report the proportion to one decimal place.

(Use the code chunk below to include an image file of your drawing. To do so you need to delete the hashtag, upload the image to Datahub into the `src` directory and replace the file name with your file name. JPG or PNG will both work.)

```r
knitr::include_graphics("src/HW05 Question 1.pdf")
```



$50\% + \frac{95\%}{2} = 50\% + 47.5\% = \boxed{97.5\%}$

2. [1 mark] Check your answer from part a) using R code. Create a vector called `p2` that stores 2 values: your answer from part a and the absolute difference between your answer from a and the exact probability that you calcuated with code.

```r
p2 <- c(97.5, abs(0.975 - pnorm(q = 298, mean = 266, sd = 16)))

p2
```

```
## [1] 97.500000000  0.002249868
```

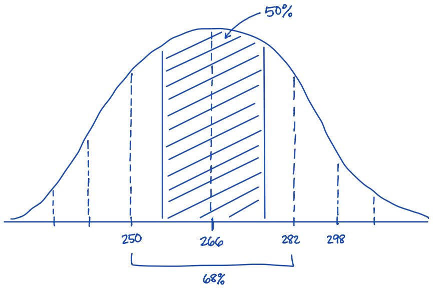
```r
check_problem2()
```

```
## [1] "Checkpoint 1 Passed: Correct number of elements in your vector!"
## [1] "Checkpoint 2 Error: Incorrect answer for part a."
## [1] "Checkpoint 3 Passed: Correct absolute difference!"
##
## Problem 2
## Checkpoints Passed: 2
## Checkpoints Errored: 1
## 66.67% passed
## --------
## Test: FAILED
```

3. [3 marks] What is the range, in days, that the middle 50% of pregnancies last? To aid your answer, hand-draw (or use any software) to sketch a Normal curve, and shade in the area that the middle represents. Then, use R to calculate the requested range. Round the lower and upper bound of the range each to two decimal places.

(Use the code chunk below to include an image file of your drawing. To do so you need to delete the hashtag, upload the image to Datahub into the `src` directory and replace the file name with your file name. JPG or PNG will both work.)

```r
knitr::include_graphics("src/HW05 Question 3.pdf")
```


50%
250
266
282
298
68%

```r
round(qnorm(p = 0.75, mean = 266, sd = 16), 2)
```

```
## [1] 276.79
```

```r
round(qnorm(p = 0.25, mean = 266, sd = 16), 2)
```

```
## [1] 255.21
```

The upperbound of the middle 50% of pregnancy lengths is 276.79 days and the lowerbound is 255.21 days.

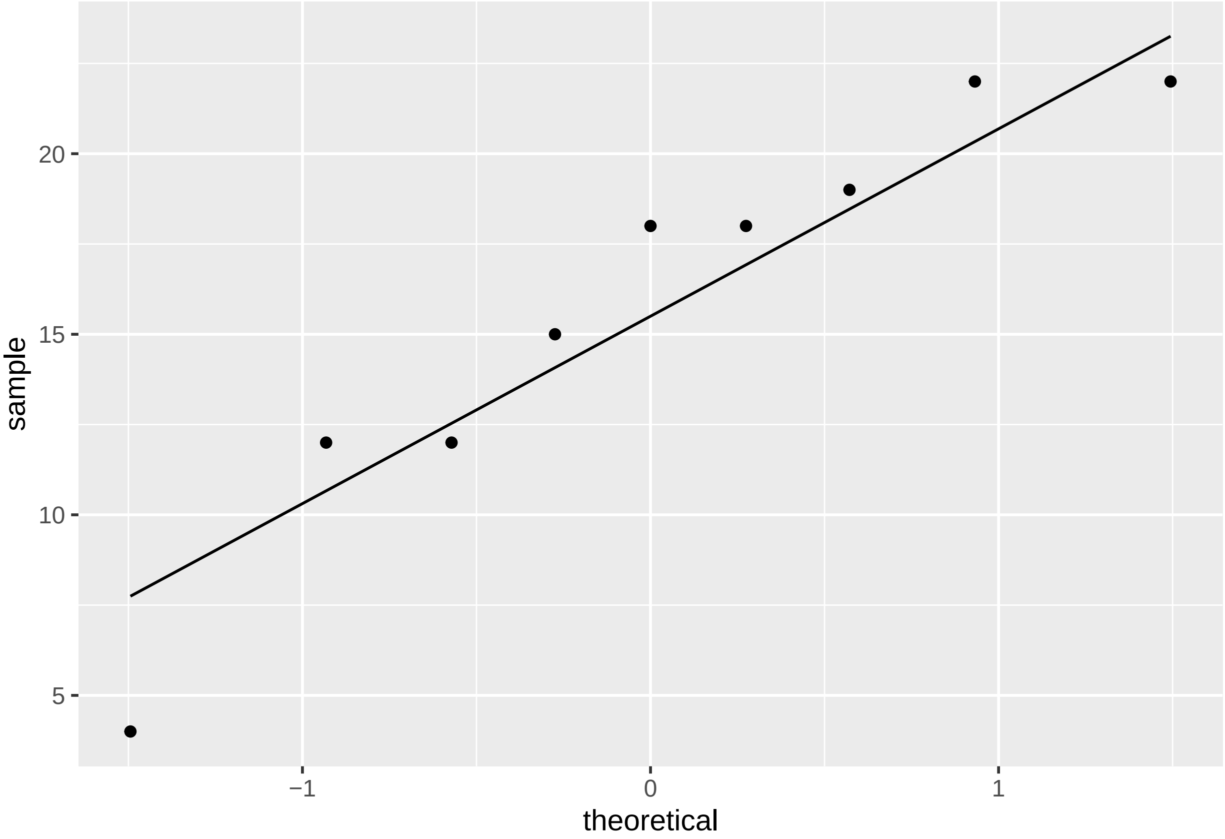
[7 points] Part 2: Assessing Normality and Interpreting QQ Plots

The number of trees for nine plots of land, each of 0.1 hectare, have been recorded. They are: 18, 4, 22, 15, 18, 19, 22, 12, 12. Are these data Normally distributed?

4. [3 marks] Make a Normal quantile plot for these data using R. Remember, to make a ggplot of these data, you need to first input the data as a vector and then convert that vector to a data frame. Example code has been provided to you to get you started. After making the plot, assess whether the data appear to approximately follow a Normal distribution.

```
library(tidyverse)
# example code
counts <- c(1, 2, 3)
tree_data <- data.frame(counts)

num_trees <- c(18, 4, 22, 15, 18, 19, 22, 12, 12)
data <- data.frame(num_trees)
ggplot(data, aes(sample = num_trees)) + stat_qq() + stat_qq_line()
```



The data does not appear to follow a normal distribution because the points on the Q-Q plot are not very close to following a straight line. The closer to a straight line, the closer to normal distribution.

5. [4 marks] Read this blog post by Sean Kross (up to and including the Takeaways). No need to read the updates, or to understand the code Sean is using–it is different from the code we've been learning in class. Pay most attention to the presentation of the Quantile-Quantile plots for all the distributions he presents. Important note: Sean is plotting "Q-Q" plots and we've been plotting Normal quantile plots. Q-Q plots are a little different, but the same takeaways apply, meaning that if you understand how to interpret Q-Q plots, you can also apply those interpretations to Normal quantile plots.

Look at the charts entitled "Skewed right" and "Skewed left" and the Quantile-Quantile plots beside them. Why does the Quantile-Quantile plot for the skewed right plot curve upwards and to the right (i.e., above the line), while the Quantile-Quantile plot for the skewed left plot curve downwards and to the left?

The Q-Q plot for the skewed right plot curves upwards and to the right because the quantiles of the dataset do not match what the quantiles of the dataset would theoretically be if the dataset was normally distributed. Most of the data is distributed to the left and and the Q-Q plot shows that the actual quantiles are much greater than the theoretical quantiles, meaning that there is a greater concentration of data beyond the right side of a Gaussian distribution.The Q-Q plot for the skewed left plot curves downwards and to the left because there is more data to the left of the Gaussian distribution. The points appear below the blue line because those quantiles occur at much lower values (between -9 and -4) compared to where those quantiles would be in a Gaussian distribution (between -4 and -2).

[15 points] Part 3: Conducting a general anxiety disorder study

Suppose that a new treatment for general anxiety disorder has undergone safety and efficacy trials and based on these data 30% of patients with general anxiety disorder are expected to benefit from the new treatment. You are conducting a follow-up study and so far have enrolled 8 participants with general anxiety disorder into your study. These patients do not know each other and represent individuals who responded to a call for study participants that they saw on a flyer on campus.

6. [2 marks] Let X represent the number of patients that you have enrolled who benefit from the treatment. Does X meet the assumptions of a Binomial distribution? Thoroughly explain why or why not.

X does not meet the assumptions of a Binomial distribution because there is not a fixed number of observations - we are not certain how many people out of the 8 will benefit from the treatment.

7. [1 mark] Use one of the distributions we learnt in class (where X meets the assumptions) to calculate (by hand) the probability that exactly 5 participants will benefit. Show your work.

P(X = 5) = 56 * 0.3ˆ5 * (0.7)ˆ3 = 0.04667544

8. [1 mark] Confirm your previous calculation using an R function and store your answer to p18.

```
p8 <- dbinom(x = 5, size = 8, prob = 0.3)
p8
```

```
## [1] 0.04667544
```

```
check_problem8()
```

```
## [1] "Checkpoint 1 Passed: You used the correct function to find the probability!"
##
## Problem 8
## Checkpoints Passed: 1
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

9. [2 marks] Calculate (by hand) the probability that 6 or more participants will benefit. Show your work.

P(X >= 6) = 1 - P(X = 5) = 1 - 0.04667544 = 0.95332456

10. [1 mark] Confirm your previous calculation using the function `pbinom()` and store your answer to p10.

```r
p10 <- 1 - pbinom(q = 5, size = 8, prob = 0.3)
p10
```

```
## [1] 0.01129221
```

```r
check_problem10()
```

```
## [1] "Checkpoint 1 Passed: You used the correct function!"
##
## Problem 10
## Checkpoints Passed: 1
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

11. [1 mark] Re-confirm your previous calculation, this time using the function `dbinom()` and store your answer to p11.

```
p11 <- dbinom(x = 6, size = 8, prob = 0.3) +
  dbinom(x = 7, size = 8, prob = 0.3) +
  dbinom(x = 8, size = 8, prob = 0.3)
p11
```

```
## [1] 0.01129221
```

```
check_problem11()
```

```
## [1] "Checkpoint 1 Passed: You used the correct function!"
##
## Problem 11
## Checkpoints Passed: 1
## Checkpoints Errored: 0
## 100% passed
## --------
## Test: PASSED
```

12. [2 marks] Interpret the binomial coefficient, $\binom{8}{7}$, in the context of this study. Write out all the possible combinations to achieve $\binom{8}{7}$.

$\binom{8}{7}$ represents the number of ways to choose 7 success from 8 people. The possible combinations are:

1, 1, 1, 1, 1, 1, 1, 0

1, 1, 1, 1, 1, 1, 0, 1

1, 1, 1, 1, 1, 0, 1, 1

1, 1, 1, 1, 0, 1, 1, 1

1, 1, 1, 0, 1, 1, 1, 1

1, 1, 0, 1, 1, 1, 1, 1

1, 0, 1, 1, 1, 1, 1, 1

0, 1, 1, 1, 1, 1, 1, 1

13. [4 marks] Calculate the number of patients you would expect to benefit from the treatment. Then calculate the standard deviation of this estimate. Write a sentence to interpret the meaning of the mean. If the mean is not a whole number, what whole number is most probable?

I would expact 0.3*8 = 2.4 patients to benefit from the treatment. The SD of this treatment is 1.296. The meaning of the mean is that we expect to find 2.4 people who benefit from the treatment per sample, on average. Since the mean is not a whole number, 2 would be the most probable since 2 is possible (within range) while 3 is beyond the calculated mean.

14. [1 mark] Should you apply a Normal approximation to these data using the μ and σ you calculated in the last question? Why or why not?

You should not apply a Normal approximation to these data using the μ and σ calculated in the last question because the sample size is too small. Normal approximation should only be used for larger sample sizes.

Check your score

Click on the middle icon on the top right of this code chunk (with the downwards gray arrow and green bar) to run all your code in order. Then, run this chunk to check your score.

```
# Just run this chunk.
total_score()
```

```
##                       Test Points_Possible          Type
## Problem 1  NOT YET GRADED               3 free-response
## Problem 2          FAILED               1    autograded
## Problem 3  NOT YET GRADED               3 free-response
## Problem 4  NOT YET GRADED               3 free-response
## Problem 5  NOT YET GRADED               4 free-response
## Problem 6  NOT YET GRADED               2 free-response
## Problem 7  NOT YET GRADED               1 free-response
## Problem 8          PASSED               1    autograded
## Problem 9  NOT YET GRADED               2 free-response
## Problem 10         PASSED               1    autograded
## Problem 11         PASSED               1    autograded
## Problem 12 NOT YET GRADED               2 free-response
## Problem 13 NOT YET GRADED               4 free-response
## Problem 14 NOT YET GRADED               1 free-response
```