# Lab 5 Solutions: Independence, Screening, and Normal Distribution

Your name and Student ID

February 24, 2021

**Instructions**

- Due date: Tuesday, March 2 at 10:00pm PST with 2 hour grace period.
- Late penalty: 50% late penalty if submitted within 24 hours of due date, no marks for assignments submitted thereafter.
- This assignment is graded on **correct completion**, all or nothing. You must pass all public tests and submit the assignment for credit.
- Submission process: Follow the submission instructions on the final page. Make sure you do not remove any `\newpage` tags or rename this file, as this will break the submission.

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.**
- If your code runs off the page of the knitted PDF then you will LOSE POINTS! To avoid this, have a look at your knitted PDF and ensure all the code fits in the file (you can easily view it on Gradescope via the provided link after submitting). 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.

**Instructions**

Part 1 of this lab focuses on calculating probability of independent events.

**Section I: Breakout Problems on Independence**

## Blood Type

**From Baldi and Moore (3E question 10.28, 4E question 10.30)** All human blood can be one of the following types: O, A, B, or AB, but the distribution of blood types varies a bit among different populations of people.
Here are the distributions of blood types for a randomly chosen person in China and in the United States:

Check out the following table:

| | $O$ | $A$ | $B$ | $AB$ |
|---|---|---|---|---|
| China | 0.35 | 0.27 | 0.26 | 0.12 |
| U.S. | 0.45 | 0.40 | 0.11 | 0.04 |

Choose an American person and a Chinese person at random, independently of each other.

**1. [1 point] What is the probability that both have type O blood?**

*Type your answer here, replacing this text.*

**2. [1 point] What is the probability that both have the same blood type?**

*Type your answer here, replacing this text.*

**3. [1 point] From Baldi and Moore (3E question 10.29, 4E not present)**

*Universal blood donors.*
People with type O-negative blood are universal donors.
That is, any patient can receive a transfusion of type O-negative blood.
Only 7.2 % of the American population have O-negative blood.
If 10 people appear at random to give blood, what is the probability that at least 1 of them is a universal donor?

*Type your answer here, replacing this text.*

**From Baldi and Moore (3E question 10.46, 4E not present)**

*Mendelian inheritance.*

Some traits of plants and animals depend on inheritance of a single gene.
This is called *Mendelian inheritance*, after Gregor Mendel (1822-1884). Each of us has an ABO blood type, which describes whether two characteristics called A and B are present.
Every human being has two blood type alleles (gene forms), one inherited from our mother and one from our father.
Each of these alleles can be A, B, or O. Which two we inherit determines our blood type.
Here is a table that shows what our blood type is for each combination of two alleles.

| Alleles inherited | Blood type |
|---|---|
| A and A | A |
| A and B | AB |
| A and O | A |
| B and B | B |
| B and O | B |
| O and O | O |

We inherit each of a parent's two alleles with probability .50, and we inherit independently from our mother and our father.

Punnett squares are used in genetics courses to organize this type of information. The alleles for one parent label the rows and for the other parent label the columns.

**4. [1 point] Rachel and Jonathan both have alleles A and B. What blood types can their children have?**

*Type your answer here, replacing this text.*

**5. [1 point] Jasmine has alleles A and O. Tyrone has alleles B and O. What is the probability that a child of these parents has blood type O?**

*Type your answer here, replacing this text.*

**6. [1 point] If Jasmine and Tyrone have three children, what is the probability that all three have blood type O? What is the probability that the first child has blood type O and the next two do not?**

The next calculations assume that they do not have any twins or triplets, so that each child is independent.

what is the probability that all three have blood type O?

*Type your answer here, replacing this text.*

what is the probability that the first child has blood type O and the next two do not?

*Type your answer here, replacing this text.*

## The Flu

**7. [2 points] From Baldi and Moore (2E question 10.20 to 10.23)**

The November 2009 Gallup-Healthways Well-Being Index survey asked a random sample of 28,606 American adults whether they had the flu on the day before the interview. Here are the results by age group: |age group | flu| no flu| total| |———-|——-|———-|———| | 18 to 29 | 88| 2,486| 2,574| | 30 to 44 | 132| 5,162| 5,294| | 45 to 64 | 276| 11,733| 12,009| | 65+ | 122| 8,607| 8,729| |total | 618| 27,988| 28,606|

The events "adult is in a specified age group" and "adult has the flu" are called **independent** if the probability of flu does not vary across the age groups.

The conditional probabilities of flu among those age 65 and older is _____ and flu among those 18 to 29 years old is _____.

**Calculate and compare the probability of flu among those age 65 and older and the probability of flu among those 18 to 29 years old.**

*Type your answer here, replacing this text.*

This shows that the events "age group" and "adult has the flu" are **not** independent.

Another way to check for independence is to see if the overall probability of flu differs from the age-group stratum specific probabilities of flu. Do this, too.

*Type your answer here, replacing this text.*

## Testing for HIV

### From Baldi and Moore (question 10.14)

Enzyme immunoassay tests are used to screen blood specimens for the presence of antibodies to HIV, the virus that causes AIDS. Antibodies indicate the presence of the virus. The test is quite accurate but is not always correct. Here are approximate probabilities of positive and negative test results when the blood tested does and does not actually contain antibodies to HIV. [Hint: these are conditional probabilities, given HIV status.]

- P( test positive + | antibodies present ) = 0.9985
- P( test positive + | antibodies absent ) = 0.0060
- P( test negative – | antibodies present ) = 0.0015
- P( test negative – | antibodies absent ) = 0.9940

Suppose that 1% of a large population carries antibodies to HIV in its blood.

**8. [1 point] Draw a tree diagram representing the HIV status of a person from this population (outcomes: antibodies present or absent) and the blood test result (outcomes: test positive or test negative).**

(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.)

```
#Take off the '#' in the following code and replace the code with you file name
#knitr::include_graphics("src/Your-file-name.JPG")
```

**9. [1 point] What is the probability that the test is positive for a randomly chosen person from this population?**

*Type your answer here, replacing this text.*

**From Baldi and Moore (10.16)**

Continue your work and probability assumptions from Question 6.

**10. [1 point] What is the probability that a person has the antibody, given that the test is positive? Explain in your own words what this means.**

*Type your answer here, replacing this text.*

**11. [1 point] Identify the test's sensitivity, specificity, and positive predictive value.**

*Type your answer here, replacing this text.*

**According to the CDC's Behavioral Risk Factor Surveillance System (BRFSS) about 60% of American adults live a sedentary lifestyle.**

**Noting that random sampling gives us independent observations, you randomly select 10 adults from this population. Find the following probabilities:**

**12. [1 point] All 10 have a sedentary lifestyle**

*Type your answer here, replacing this text.*

**13. [1 point] At least one does not have a sedentary lifestyle**

*Type your answer here, replacing this text.*

**Section 2: Normal Distribution**

Part 2 of this lab introduces the normal distribution.

Notation reminder: Baldi and Moore use a compact notation for specifying that a population has a distribution that follows a normal curve with mean $\mu$ and standard deviation $\sigma$ : N( $\mu$ , $\sigma$ )

R Functions Reminder: `qnorm` takes a probability as its input and gives back a value on the distribution (aka a z-score if the distribution is N(0,1)). By default, it assumes the probability area you enter (as a decimal, not a percent) is the area below (or less than) the z score you need. The `pnorm` function takes a z value or an X value as its input and gives back a probability area.

**Question 14. Z scores.** (From Baldi and Moore, 3E question 11.27, 4E question 11.29) Use R to find the standardized value z that satisfies each of the following conditions. In each case, sketch a standard Normal curve with your value of z marked on the axis. You do not have to attach your diagrams.

**14. [1 point] The probability is 0.8 that a randomly selected observation falls below z.**

```
p14 <- NULL # YOUR CODE HERE
p14
```

```
## NULL
```

```
. = ottr::check("tests/p14.R")
```

```
## [1] "Checking: range of p14"
## -- Failure (???): p14a ---------------------------------------------------------
## p14 > 0 & p14 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p14"
## -- Failure (???): p14b ---------------------------------------------------------
## all.equal(p14, qnorm(0.8, mean = 0, sd = 1), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p14a failed:
##     Error: p14 > 0 & p14 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p14b failed:
##     Error: all.equal(p14, qnorm(0.8, mean = 0, sd = 1), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**15. [1 point] The probability is 0.35 that a randomly selected observation falls above z.**

```
p15 <- NULL # YOUR CODE HERE
p15
```

```
## NULL
```

```
. = ottr::check("tests/p15.R")
```

```
## [1] "Checking: range of p15"
## -- Failure (???): p15a ---------------------------------------------------------
## p15 > 0 & p15 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p15"
## -- Failure (???): p15b ---------------------------------------------------------
## all.equal(...) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p15a failed:
##     Error: p15 > 0 & p15 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p15b failed:
##     Error: all.equal(...) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**Full-Term Birth Weights (From Baldi and Moore, 3E question 11.31, 4E question 11.33)**

For babies born at full term (37 to 39 completed weeks of gestation), the distribution of birth weight (in grams) is approximately normally distributed with a mean of 3350 grams and a standard deviation of 440 grams, N(3350,440).

**16. [1 point] What is the 25th percentile of the birthweights for full term babies?**

```
p16 <- NULL # YOUR CODE HERE
p16
```

```
## NULL
```

```
. = ottr::check("tests/p16.R")
```

```
## [1] "Checking: range of p16"
## -- Failure (???): p16a ---------------------------------------------------------
## p16 > 3000 & p16 < 3100 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p16"
```

```
## -- Failure (???): p15b ---------------------------------------------------------
## all.equal(p16, qnorm(0.25, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p16a failed:
##     Error: p16 > 3000 & p16 < 3100 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p15b failed:
##     Error: all.equal(p16, qnorm(0.25, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**17. [1 point] What is the 90th percentile of the birthweights for full term babies?**

```
p17 <- NULL # YOUR CODE HERE
p17
```

```
## NULL
```

```
. = ottr::check("tests/p17.R")
```

```
## [1] "Checking: range of p17"
## -- Failure (???): p17a ---------------------------------------------------------
## p17 > 3900 & p17 < 4000 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p17"
## -- Failure (???): p17b ---------------------------------------------------------
## all.equal(p17, qnorm(0.9, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p17a failed:
##     Error: p17 > 3900 & p17 < 4000 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p17b failed:
##     Error: all.equal(p17, qnorm(0.9, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**18. [1 point] What is the range of the middle 50% of birthweights for full term babies? Write this as a vector containing two values to indicate the lowerbound and upperbound of the middle 50%.**

```
p18 <- NULL # YOUR CODE HERE
p18
```

```
## NULL
```

```
. = ottr::check("tests/p18.R")
```

```
## [1] "Checking: first value of p18"
## -- Failure (???): p18a ---------------------------------------------------------
## all.equal(p18[1], qnorm(0.25, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## [1] "Checking: second value of p18"
## -- Failure (???): p18b ---------------------------------------------------------
## all.equal(p18[2], qnorm(0.75, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p18a failed:
##     Error: all.equal(p18[1], qnorm(0.25, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
##
## Test p18b failed:
##     Error: all.equal(p18[2], qnorm(0.75, mean = 3350, sd = 440), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**Question 5. Newborn Respirations. (From Baldi and Moore, 3E questions 11.15-11.17, 4E question 11.17-11.19)**

**19.** [**1 point**] The respiratory rate per minute in newborns varies according to a distribution that is approximately Normal with mean 50 and standard deviation 5. The probability (convert to a percentage and round to two decimal places) that a randomly chosen newborn has a respiratory rate of 55 per minute or more is approximately:

```
p19 <- NULL # YOUR CODE HERE
p19
```

```
## NULL
```

```
. = ottr::check("tests/p19.R")
```

```
## [1] "Checking: range of p19"
## -- Failure (???): p19a ---------------------------------------------------------
## p19 > 0 & p19 < 100 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p19"
## -- Failure (???): p19b ---------------------------------------------------------
```

```
## all.equal(...) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p19a failed:
##     Error: p19 > 0 & p19 < 100 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p19b failed:
##     Error: all.equal(...) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**20.** [**1 point**] The probability (convert to a percentage and round to two decimal places) that a randomly chosen newborn has a respiratory rate per minute between 40 and 55 is approximately:

```
p20 <- NULL # YOUR CODE HERE
p20
```

```
## NULL
```

```
. = ottr::check("tests/p20.R")
```

```
## [1] "Checking: range of p20"
## -- Failure (???): p20a ---------------------------------------------------------
## p20 > 0 & p20 < 100 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p20"
## -- Failure (???): p20b ---------------------------------------------------------
## all.equal(...) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p20a failed:
##     Error: p20 > 0 & p20 < 100 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p20b failed:
##     Error: all.equal(...) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**Drosophila (From Baldi and Moore, 3E questions 11.20 and 11.22, 4E question 11.23)**

The common fruit fly, Drosophila melanogaster, is the most studied organism in genetic research because it is small, easy to grow, and reproduces rapidly. The length of the thorax (where the wings and legs attach) in

a population of male fruit flies is approximately Normal with mean 0.800 millimeters (mm) and standard deviation 0.078 mm.

**21. [1 point]** Choose a male fruit fly at random. The probability (convert to a percentage and round to two decimal places) that the fly you choose has a thorax longer than 1 mm is about:

```
p21 <- NULL # YOUR CODE HERE
p21
```

```
## NULL
```

```
. = ottr::check("tests/p21.R")
```

```
## [1] "Checking: range of p21"
## -- Failure (???): p21a ---------------------------------------------------------
## p21 > 0 & p21 < 100 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p21"
## -- Failure (???): p21b ---------------------------------------------------------
## all.equal(...) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p21a failed:
##     Error: p21 > 0 & p21 < 100 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p21b failed:
##     Error: all.equal(...) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

##Questions 22-29 are ADDITIONAL PRACTICE - not for credit!

**Late Pre-Term Birth Weights (From Baldi and Moore, 3E question 11.32, 4E question 11.34)**

How much of a difference do a couple of weeks make for birthweight? Late preterm babies are born with 35 to 37 weeks of completed gestation. The distribution of birth weight (in grams) or late preterm babies is approximately normally distributed with a mean of 2750 grams and a standard deviation of 560 grams, N(2750,560).

**22. [1 point] What is the 25th percentile of the birthweights for late-preterm babies?**

```
p22 <- NULL # YOUR CODE HERE
p22
```

```
## NULL
```

```
. = ottr::check("tests/p22.R")
```

```
## [1] "Checking: range of p22"
## -- Failure (???): p22a ---------------------------------------------------------
```

```
## p22 > 2300 & p22 < 2400 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p22"
## -- Failure (???): p22b ---------------------------------------------------------
## all.equal(p22, qnorm(0.25, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p22a failed:
##     Error: p22 > 2300 & p22 < 2400 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p22b failed:
##     Error: all.equal(p22, qnorm(0.25, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**23. [1 point] What is the 90th percentile of the birthweights for late-preterm babies?**

```
p23 <- NULL # YOUR CODE HERE
p23
```

```
## NULL
```

```
. = ottr::check("tests/p23.R")
```

```
## [1] "Checking: range of p23"
## -- Failure (???): p23a ---------------------------------------------------------
## p23 > 3400 & p23 < 3500 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p23"
## -- Failure (???): p23b ---------------------------------------------------------
## all.equal(p23, qnorm(0.9, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p23a failed:
##     Error: p23 > 3400 & p23 < 3500 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p23b failed:
##     Error: all.equal(p23, qnorm(0.9, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
```

```
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**24. [1 point] What is the range of the middle 50% of birthweights for late-preterm babies? Write your answer as a vector containing the lower and upperbounds of the middle 50%.**

```
p24 <- NULL # YOUR CODE HERE
p24
```

```
## NULL
```

```
. = ottr::check("tests/p24.R")
```

```
## [1] "Checking: first value of p24"
## -- Failure (???): p24a ---------------------------------------------------------
## all.equal(p24[1], qnorm(0.25, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## [1] "Checking: second value of p24"
## -- Failure (???): p24b ---------------------------------------------------------
## all.equal(p24[2], qnorm(0.75, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p24a failed:
##     Error: all.equal(p24[1], qnorm(0.25, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
##
## Test p24b failed:
##     Error: all.equal(p24[2], qnorm(0.75, mean = 2750, sd = 560), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**25. [1 point] Compare your answers to the parts of full term babies (problems 14-18) to late-preterm babies. What do you notice?**

*Type your answer here, replacing this text.*

**Z scores. (From Baldi and Moore, 3E question 11.25, 4E question 11.27)**

Use R's pnorm function to find the proportion of observations from a standard Normal distribution that fall in each of the following regions. In each case, sketch a standard Normal curve and shade the area representing the region.You do not have to attach your diagrams.

**26. [1 point]** $z \leq$ -2.25

```
p26 <- NULL # YOUR CODE HERE
p26
```

```
## NULL
```

```
. = ottr::check("tests/p26.R")
```

```
## [1] "Checking: range of p26"
```

```
## -- Failure (???): p26a ---------------------------------------------------------
## p26 > 0 & p26 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p26"
## -- Failure (???): p26b ---------------------------------------------------------
## all.equal(p26, pnorm(-2.25, 0, 1), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p26a failed:
##     Error: p26 > 0 & p26 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p26b failed:
##     Error: all.equal(p26, pnorm(-2.25, 0, 1), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**27.** [**1 point**] z $\geq$ -2.25

```
p27 <- NULL # YOUR CODE HERE
p27
```

```
## NULL
```

```
. = ottr::check("tests/p27.R")
```

```
## [1] "Checking: range of p27"
## -- Failure (???): p27a ---------------------------------------------------------
## p27 > 0 & p27 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p27"
## -- Failure (???): p27b ---------------------------------------------------------
## all.equal(p27, pnorm(-2.25, 0, 1, lower.tail = F), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p27a failed:
##     Error: p27 > 0 & p27 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p27b failed:
##     Error: all.equal(p27, pnorm(-2.25, 0, 1, lower.tail = F), tol = 0.01) is not TRUE
```

```
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**28.** [**1 point**] $z > 1.77$

```
p28 <- NULL # YOUR CODE HERE
p28
```

```
## NULL
```

```
. = ottr::check("tests/p28.R")
```

```
## [1] "Checking: range of p28"
## -- Failure (???): p28a ---------------------------------------------------------
## p28 > 0 & p28 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p28"
## -- Failure (???): p28b ---------------------------------------------------------
## all.equal(p28, pnorm(1.77, 0, 1, lower.tail = F), tol = 0.01) is not TRUE
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p28a failed:
##     Error: p28 > 0 & p28 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p28b failed:
##     Error: all.equal(p28, pnorm(1.77, 0, 1, lower.tail = F), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**29.** [**1 point**] $-2.25 < z < 1.77$

```
p29 <- NULL # YOUR CODE HERE
p29
```

```
## NULL
```

```
. = ottr::check("tests/p29.R")
```

```
## [1] "Checking: range of p29"
## -- Failure (???): p29a ---------------------------------------------------------
## p29 > 0 & p29 < 1 is not TRUE
##
## `actual`:
## `expected`: TRUE
##
## [1] "Checking: value of p29"
## -- Failure (???): p29b ---------------------------------------------------------
## all.equal(p29, pnorm(1.77, 0, 1) - pnorm(-2.25, 0, 1), tol = 0.01) is not TRUE
```

```
##
## `actual` is a character vector ('target is NULL, current is numeric')
## `expected` is a logical vector (TRUE)
##
## Test p29a failed:
##     Error: p29 > 0 & p29 < 1 is not TRUE
##
##     `actual`:
##     `expected`: TRUE
##
## Test p29b failed:
##     Error: all.equal(p29, pnorm(1.77, 0, 1) - pnorm(-2.25, 0, 1), tol = 0.01) is not TRUE
##
##     `actual` is a character vector ('target is NULL, current is numeric')
##     `expected` is a logical vector (TRUE)
```

**Submission**

For assignments in this class, you'll be submitting using the **Terminal** tab in the pane below. In order for the submission to work properly, make sure that:

1. Any image files you add that are needed to knit the file are in the `src` folder and file paths are specified accordingly.
2. You **have not changed the file name** of the assignment.
3. The file knits properly.

Once you have checked these items, you can proceed to submit your assignment.

1. Click on the **Terminal** tab in the pane below.
2. Copy-paste the following line of code into the terminal and press enter.

cd; cd ph142-sp21/lab/lab05; python3 turn_in.py

3. Follow the prompts to enter your Gradescope username and password. When entering your password, you won't see anything come up on the screen–don't worry! This is just for security purposes–just keep typing and hit enter.
4. If the submission is successful, you should see "Submission successful!" appear as output.
5. If the submission fails, try to diagnose the issue using the error messages–if you have problems, post on Piazza.

The late policy will be strictly enforced, **no matter the reason**, including submission issues, so be sure to submit early enough to have time to diagnose issues if problems arise.