Midterm Quiz 2 - Verified MM Learners

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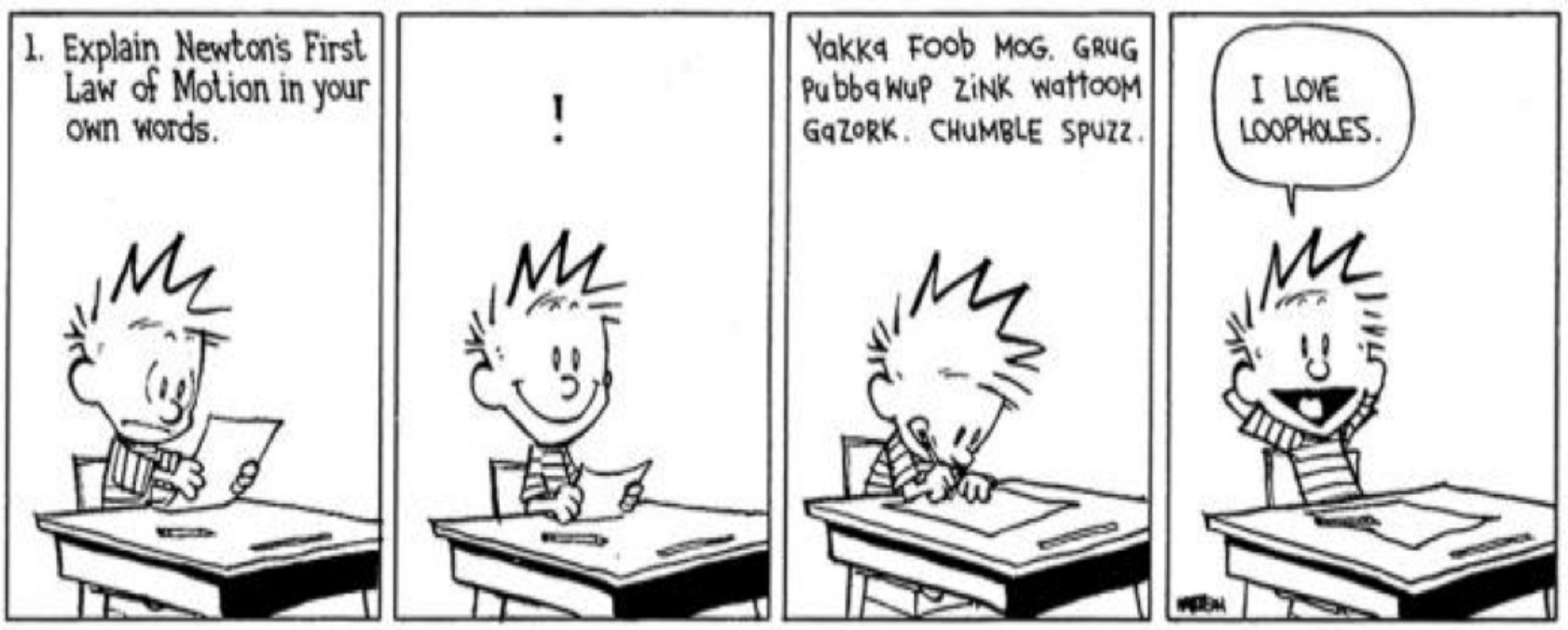
Midterm Quiz 2 due Apr 10, 2023 14:00 +08 Completed

90 Minute Time Limit

Instructions

- **Work alone.** Do not collaborate with or copy from anyone else.
- Work the problems in any order you wish, but submit each answer before ending the exam.
- You may use any of the following resources:
  - One sheet (both sides) of handwritten (not photocopied or scanned) notes
- If any question seems ambiguous, use the most reasonable interpretation (i.e. don't be like Calvin):



- **If you experience any technical issues (i.e. Math Processing Error), please save your current selected answers and refresh the page. If the issue persists, then please finish the exam and let the Instructors know about the issue in a private Piazza post afterwards.**
- Good Luck!

This is the beginning of Midterm Quiz 2. Please make sure that you submit all your answers before the time runs out. Once you submit an answer to a question, you cannot change it. There is no overall Submit button.

After submitting all answers, please click the "End my Exam" button, above, before exiting from ProctorTrack to complete your exam.

Information for Question 1

There are five questions labeled "Question 1." Answer all five questions. For each of the following five questions, select the probability distribution that could best be used to model the described scenario. Each distribution might be used, zero, one, or more than one time in the five questions.

These scenarios are meant to be simple and straightforward; if you're an expert in the field the question asks about, please do not rely on your expertise to fill in all the extra complexity (you'll end up making the questions below more difficult than I intended).

Question 1

1.4/1.4 points (graded)
Time between people entering the ID-check queue at an airport

Exponential ✔

‹ Previous Next ›

Submit You have used 1 of 1 attempt

Question 1

1.4/1.4 points (graded)
Number of phone calls made by a telemarketer until one is answered

Geometric ✔

Submit You have used 1 of 1 attempt

Question 1

1.4/1.4 points (graded)
Number of days in a year where the temperature is more than 3 degrees higher than forecast

Binomial ✔

Submit You have used 1 of 1 attempt

Question 1

1.4/1.4 points (graded)
Number of penalty kicks taken at the World Cup until one of them is saved by the goalkeeper

Geometric ✔

Submit You have used 1 of 1 attempt

Question 1

0.0/1.4 points (graded)
Time from when a house is put on the market until the first offer is received

Exponential ✖ **Answer:** Weibull

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Questions 2a, 2b

10.0/10.0 points (graded)
Five classification models were built for predicting whether a neighborhood will soon see a large rise in home prices, based on public elementary school ratings and other factors. The training data set was missing the school rating variable for every new school (3% of the data points).

Because ratings are unavailable for newly-opened schools, it is believed that locations that have recently experienced high population growth are more likely to have missing school rating data.

- Model 1 used imputation, filling in the missing data with the average school rating from the rest of the data.

- Model 2 used imputation, building a regression model to fill in the missing school rating data based on other variables.

- Model 3 used imputation, first building a classification model to estimate (based on other variables) whether a new school is likely to have been built as a result of recent population growth (or whether it has been built for another purpose, e.g. to replace a very old school), and then using that classification to select one of two regression models to fill in an estimate of the school rating; there are two different regression models (based on other variables), one for neighborhoods with new schools built due to population growth, and one for neighborhoods with new schools built for other reasons.

- Model 4 used a binary variable to identify locations with missing information.

- Model 5 used a categorical variable: first, a classification model was used to estimate whether a new school is likely to have been built as a result of recent population growth; and then each neighborhood was categorized as "data available", "missing, population growth", or "missing, other reason".

a. If school ratings cannot be reasonably well-predicted from the other factors, and new schools built due to recent population growth can be reasonably well-classified using the other factors, which model would you recommend?

- ○ Model 1
- ○ Model 2
- ○ Model 3
- ○ Model 4
- ◉ Model 5

✔

b. In which of the following situations would you recommend using Model 2? [All predictions and classifications below are using the other factors.]

- ○ Ratings can be well-predicted, and reasons for building schools can be well-classified.
- ◉ Ratings can be well-predicted, and reasons for building schools cannot be well-classified.
- ○ Ratings cannot be well-predicted, and reasons for building schools can be well-classified.
- ○ Ratings cannot be well-predicted, and reasons for building schools cannot be well-classified.

✔

Submit You have used 1 of 1 attempt

Information for Question 3

In a diet problem (like we saw in the lessons and homework), let x_i be the amount of food i in the solution ($x_i >= 0$), and let M be the maximum amount that can be eaten of any food.

Suppose we added new variables y_i that are binary (i.e., they must be either 0 or 1): if food i is eaten in the solution, then it is part of the solution ($y_i = 1$); otherwise $y_i = 0$.

There are five questions labeled "Question 3." Answer all five questions. For each of the following five questions, select the mathematical constraint that best corresponds to the English sentence. Each constraint might be used, zero, one, or more than one time in the five questions.

Question 3

0.0/1.4 points (graded)
Select the mathematical constraint that corresponds to the following English sentence:

If neither cheese sauce nor peanut butter is eaten, then broccoli can't be eaten either.

- ○ $y_{peanutbutter} + y_{cheesesauce} = 0$
- ○ $y_{peanutbutter} = 1 - y_{cheesesauce}$
- ○ $y_{broccoli} \leq y_{cheesesauce} + y_{peanutbutter}$ ✔
- ◉ $y_{broccoli} + y_{cheesesauce} + y_{peanutbutter} \leq 2$
- ○ $x_{cheesesauce} \leq M y_{cheesesauce}$
- ○ $y_{cheesesauce} = 1$
- ○ $x_{broccoli} \leq M y_{peanutbutter}$
- ○ $x_{broccoli} \geq M y_{peanutbutter}$

✖

Submit You have used 1 of 1 attempt

ℹ Answers are displayed within the problem

Question 3

1.4/1.4 points (graded)
Select the mathematical constraint that corresponds to the following English sentence:

Either cheese sauce or peanut butter (or both) must be eaten if broccoli is eaten.

- ○ $y_{peanutbutter} + y_{cheesesauce} = 0$
- ○ $y_{peanutbutter} = 1 - y_{cheesesauce}$
- ◉ $y_{broccoli} \leq y_{cheesesauce} + y_{peanutbutter}$
- ○ $y_{broccoli} + y_{cheesesauce} + y_{peanutbutter} \leq 2$

- $x_{cheesesauce} \leq M y_{cheesesauce}$
- $y_{cheesesauce} = 1$
- $x_{broccoli} \leq M y_{peanutbutter}$
- $x_{broccoli} \geq M y_{peanutbutter}$

Submit You have used 1 of 1 attempt

Question 3

0.0/1.4 points (graded)

Select the mathematical constraint that corresponds to the following English sentence:

If any amount of cheese sauce is eaten, then its binary variable $y_{cheesesauce}$ must be 1.

- $y_{peanutbutter} + y_{cheesesauce} = 0$
- $y_{peanutbutter} = 1 - y_{cheesesauce}$
- $y_{broccoli} \leq y_{cheesesauce} + y_{peanutbutter}$
- $y_{broccoli} + y_{cheesesauce} + y_{peanutbutter} \leq 2$
- $x_{cheesesauce} \leq M y_{cheesesauce}$
- $y_{cheesesauce} = 1$
- $x_{broccoli} \leq M y_{peanutbutter}$
- $x_{broccoli} \geq M y_{peanutbutter}$

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 3

1.4/1.4 points (graded)

Select the mathematical constraint that corresponds to the following English sentence:

Neither peanut butter nor cheese sauce can be eaten.

- $y_{peanutbutter} + y_{cheesesauce} = 0$
- $y_{peanutbutter} = 1 - y_{cheesesauce}$

- $y_{peanutbutter} = 1 - y_{cheesesauce}$
- $y_{broccoli} \leq y_{cheesesauce} + y_{peanutbutter}$
- $y_{broccoli} + y_{cheesesauce} + y_{peanutbutter} \leq 2$
- $x_{cheesesauce} \leq M y_{cheesesauce}$
- $y_{cheesesauce} = 1$
- $x_{broccoli} \leq M y_{peanutbutter}$
- $x_{broccoli} \geq M y_{peanutbutter}$

Submit You have used 1 of 1 attempt

Question 3

1.4/1.4 points (graded)

Select the mathematical constraint that corresponds to the following English sentence:

If peanut butter is not eaten, then no amount of broccoli may be eaten.

- $y_{peanutbutter} + y_{cheesesauce} = 0$
- $y_{peanutbutter} = 1 - y_{cheesesauce}$
- $y_{broccoli} \leq y_{cheesesauce} + y_{peanutbutter}$
- $y_{broccoli} + y_{cheesesauce} + y_{peanutbutter} \leq 2$
- $x_{cheesesauce} \leq M y_{cheesesauce}$
- $y_{cheesesauce} = 1$
- **$x_{broccoli} \leq M y_{peanutbutter}$**
- $x_{broccoli} \geq M y_{peanutbutter}$

Submit You have used 1 of 1 attempt

Question 4a

5.0/5.0 points (graded)

A consulting company has created a stochastic discrete-event simulation model of a large city's 9-1-1 emergency dispatch operations, including incoming calls, dispatching of the appropriate response (police, firefighters, paramedics, etc.), and the amount of time until the emergency assistance arrives at the scene.

Emergency response is not first-come-first-served. When resources are limited, a more-important problem (like gunfire or a burning building) will be prioritized over a less-important problem (like a cat stuck in a tree), and a more time-sensitive event (like a robbery in progress) might be prioritized over a less-time-sensitive event (like the discovery of a robbery that took place the day before).

When a new call for help comes in, the system automatically runs a simulation to quickly give an estimate of the expected wait time until help arrives, which the operator relays to the caller. Wait time is a combination of the time until the appropriate resource (e.g., a police unit) has no higher-priority emergency to respond to, and the time it takes that resource to drive to the scene.

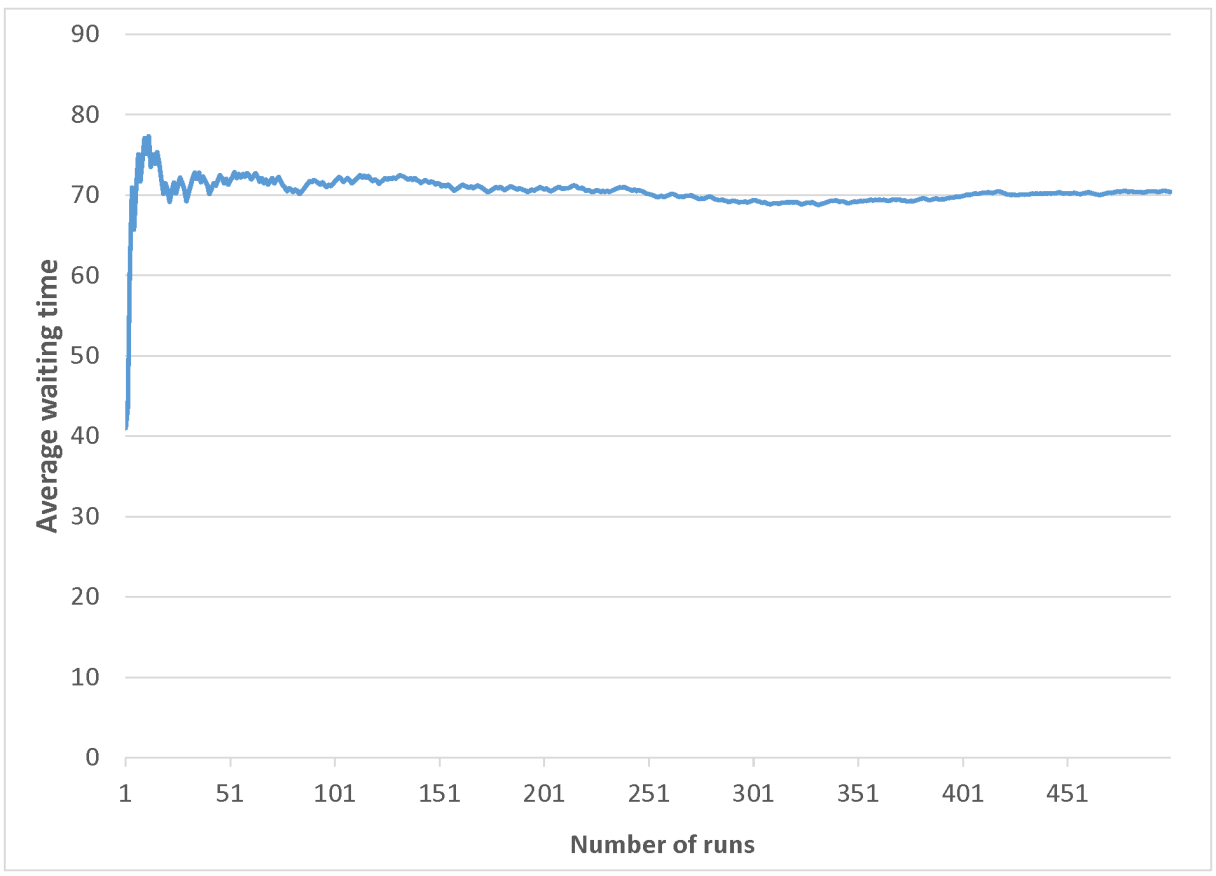
How many times does the system need to run the simulation for each new help caller (i.e., how many replications are needed)?

- ○ Once, because the outcome will be the same each time
- ◉ Many times, because of the variability and randomness
- ○ Once, because each patient is unique

✔

Submit You have used 1 of 1 attempt

Information for Question 4b



The figure above shows the average of the first *x* simulated wait times, as new replications ("runs") are run and added into the overall average. It is not showing the wait time just for each replication. For example, after *x*=101 replications, the wait time of the 101st replication is not necessarily 72, but the average of those 101 replications is about 72.

Question 4b

2.0/5.0 points (graded)

If the goal is to report the expected wait time to within +/- 2 minutes, what can you conclude from the figure above? Select all of the answers that are correct.

- ☑ The simulation could have been stopped after 400 runs (replications). ✱

- [ ] The simulation could even have been stopped after 5 runs (replications).
- [ ] The simulated wait time was 50 or less at least once out of all the runs (replications). ✔
- [x] The expected wait time of simulated runs (replications) is likely to be between 75 and 85.
- [ ] There is significant variability in the simulated wait time of the runs (replications). ✔

✱

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 4c

6.0/6.0 points (graded)

Suppose it is discovered that simulated wait times are 25% higher than actual wait times, on average. What would you recommend that they do?

- ( ) Scale down all estimates by a factor of 1/1.25 to get the average simulation estimates to match the average actual wait times.
- (•) Investigate to see what's wrong with the simulation, because it's a poor match to reality.
- ( ) Use the 25%-higher estimates, because that's what the simulation output is.

✔

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Answers are displayed within the problem

Information for Question 5

For each of the optimization problems below, select its most precise classification. In each model, x are the variables, all other letters (a,b,c) refer to known data, and the values of c are all positive.

There are seven questions labeled "Question 5". Answer all seven questions. Each classification might be used, zero, one, or more than one time in the seven questions.

Question 5

1.0/1.0 point (graded)

Minimize $\sum_i c_i x_i^2$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \geq 0$

Convex quadratic program ✔

Submit You have used 1 of 1 attempt

Question 5

0.0/1.0 point (graded)
Minimize $\sum_i (\log c_i) x_i$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \geq 0$

General non-convex program ✖ **Answer:** Linear program

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 5

1.0/1.0 point (graded)
Minimize $\sum_i c_i \sin x_i$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \geq 0$

General non-convex program ✔

Submit You have used 1 of 1 attempt

Question 5

0.0/1.0 point (graded)
Maximize $\sum_i c_i x_i$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \in \{0, 1\}$

Linear program ✖ **Answer:** Integer program

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 5

0.0/1.0 point (graded)
Minimize $\sum_i c_i |x_i - 6|$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \geq 0$

Linear program ✖ **Answer:** Convex program

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 5

1.0/1.0 point (graded)
Maximize $\sum_i c_i x_i$

subject to $\sum_i a_{ij} x_i \geq b_j$ for all j

all $x_i \geq 0$

Linear program ✔

Submit You have used 1 of 1 attempt

Question 5

0.0/1.0 point (graded)
Maximize $\sum_i c_i x_i$

subject to $\sum_i \sum_k a_{ikj} x_i x_k \leq b_j$ for all j

all $x_i \geq 0$

Linear program ✖ **Answer:** General non-convex program

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Questions 6a,6b,6c

8.0/12.0 points (graded)
An airline is analyzing its customer service phone lines, to determine how many people (operators) to have available for answering calls at different times of day.

At busy times (about 10% of the times), the arrival rate is 10 calls/minute. At other times, the arrival rate is 2 calls/minute. Once an operator answers a call (at any time), it takes an average of 5 minutes to complete the call.

[NOTE: This is a simplified version of the call center system. If you have deeper knowledge of how call centers work, please do not use it for this question; you would end up making the question more complex than it is designed to be.]

a. The first model the airline tries is a queuing model with 100 operators always available. What would you expect the queuing model to show?

- (●) Wait times are low at both busy and non-busy times.
- ( ) Wait times are low at busy times and high at non-busy times.
- ( ) Wait times are low at non-busy times and high at busy times.
- ( ) Wait times are high at both busy and non-busy times.

✔

b. The second model the airline tries is a queuing model with 25 operators available during busy times and 5 operators available during non-busy times. What would you expect the queuing model to show?

- ( ) Wait times are low at both busy and non-busy times.
- ( ) Wait times are low at busy times and high at non-busy times.
- (●) Wait times are low at non-busy times and high at busy times.
- ( ) Wait times are high at both busy and non-busy times.
  ✔

✖

The airline now has decided that, when there are 31 calls waiting, the airline will turn on an AI operator that can handle 20 calls simultaneously. The AI operator then stays on until no more calls are waiting.

The airline would like to model this new process with a Markov chain, where each state is the number of calls waiting (e.g., 0 calls waiting, 1 call waiting, etc.).

Notice that now, the transition probabilities from a state like "3 calls waiting" depend on whether the AI operator is currently on, and therefore depend on whether the system was more recently in the state "31 calls waiting" or "0 calls waiting".

c. Which of the following statements about the process (the call center system) and its relation to the Markov chain's memoryless property (previous states don't affect the probability of moving from one state to another) is true?

- ( ) The process is memoryless, so the Markov chain is an appropriate model.
- ( ) The process is memoryless and the Markov chain is an appropriate model only if the arrivals follow the Poisson distribution and the call durations follow the Exponential distribution.
- (●) The process is not memoryless, so the Markov chain model would not be well-defined.

✔

Submit You have used 1 of 1 attempt

ⓘ Answers are displayed within the problem

Questions 7a,7b

5.0/10.0 points (graded)

A retailer is testing two different customer retention approaches. The retailer is using A/B testing: For each customer, the retailer randomly selects one approach or the other to use. The results after 2000 trials are shown below.

	Trials	Customer loss rate	95% confidence interval
Option A	1036	9.7%	7.9%-11.5%
Option B	964	5.2%	3.8%-6.6%

Note: The "customer loss rate" is the fraction of customers who stop doing business with the retailer. Lower customer loss rates are better.

a. What should the retailer do?

- ○ Switch to exploitation (utilize Option A only; A is clearly better)
- ◉ Switch to exploitation (utilize Option B only; B is clearly better)
- ○ More exploration (test both options; it is unclear yet which is better)

✔

Later, the retailer developed 7 new options, so they used a multi-armed bandit approach where each option is chosen with probability proportional to its likelihood of being the best. The results after 2000 total trials are shown below.

	Customer loss rate	Average customer order value	Median customer order value
Option #1	3.2%	$112	$100
Option #2	4.2%	$98	$75
Option #3	5.2%	$174	$125
Option #4	5.5%	$153	$100
Option #5	6.5%	$122	$80
Option #6	10.8%	$132	$100
Option #7	15.0%	$106	$75

b. If the retailer's main goal is to find the option that has the lowest customer loss rate (lowest fraction of customers who stop doing business with the retailer), which type of tests should they use to see if the option that appears best is significantly better than each of the other options?

- ○ Binomial-based (e.g., McNemar's) tests ✔
- ◉ Other non-parametric tests ✖
- ○ Parametric tests

Submit You have used 1 of 1 attempt

ⓘ Answers are displayed within the problem

Information for Question 8a

For each of the mathematical optimization models, select the variable-selection/regularization method it most-precisely represents (or select "none of the above" if none of the other choices are appropriate). In each model, x is the data, y is the response, a are the coefficients, n is the number of data points, m is the number of predictors, and T and λ are appropriate constants.

There are four questions labeled "Question 8a". Answer all four questions. Each of the choices might be used zero, one, or more than one time in the four questions.

Question 8a

1.0/1.0 point (graded)

Minimize $\sum_{i=1}^{n} \left(y_i - \left(a_0 + \sum_{j=1}^{m} a_j x_{ij}\right)\right)^2$

None of the above ✔

Submit You have used 1 of 1 attempt

Question 8a

1.0/1.0 point (graded)

Minimize $\sum_{i=1}^{n} \left(y_i - \left(a_0 + \sum_{j=1}^{m} a_j x_{ij}\right)\right)^2$

subject to $\lambda \sum_{j=1}^{m} |a_j| + (1-\lambda) \sum_{j=1}^{m} (a_j)^2 \leq T$

Elastic net ✔

Submit You have used 1 of 1 attempt

Question 8a

1.0/1.0 point (graded)

Minimize $\sum_{i=1}^{n} \left(y_i - \left(a_0 + \sum_{j=1}^{m} a_j x_{ij}\right)\right)^2$

subject to $\sum_{j=1}^{m} (a_j)^2 \leq T$

Ridge regression ✔

Submit You have used 1 of 1 attempt

Question 8a

1.0/1.0 point (graded)

Minimize $\sum_{i=1}^{n} \left(y_i - \left(a_0 + \sum_{j=1}^{m} a_j x_{ij}\right)\right)^2$

subject to $\sum_{j=1}^{m} |a_j| \leq T$

Lasso regression ✔

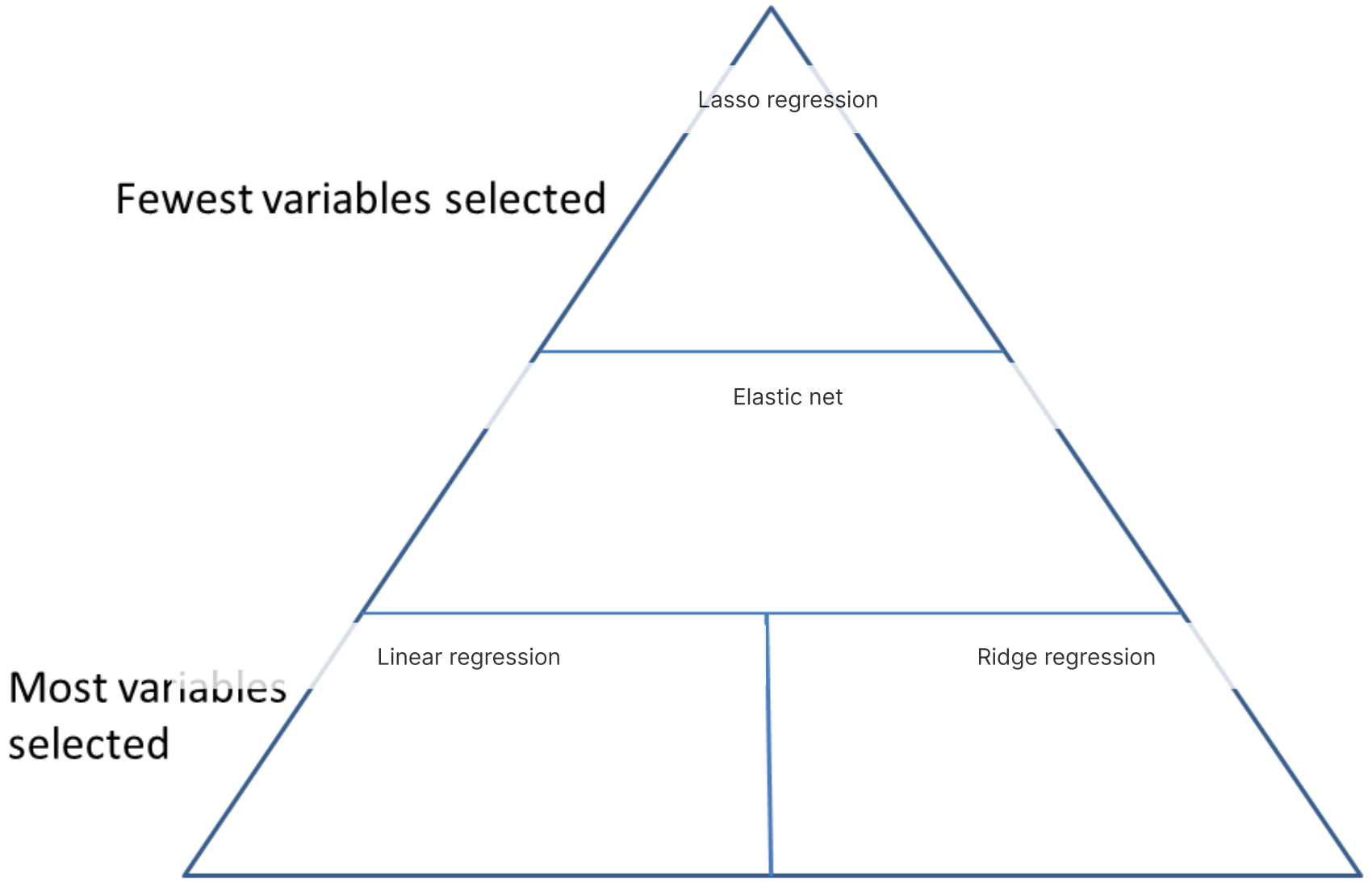
Submit You have used 1 of 1 attempt

Question 8b

4/4 point (graded)

⌨ Keyboard Help

Rank the following regression and variable-selection/regularization methods from fewest variables selected to most variables selected. All four methods will be used (the bottom contains two equivalent spaces).



Submit You have used 1 of 1 attempts. Reset Show Answer

FEEDBACK

✔ Correctly placed 4 items

✔ Final attempt was used, highest score is 4.0

ℹ **Good work! You have completed this drag and drop problem.**

Question 8c

6.0/6.0 points (graded)

Select all of the following reasons that you might want to use stepwise regression, lasso, etc. to limit the number of factors in a model.

☑ Because there isn't enough data to avoid overfitting a model with many factors

- [x] To find a simpler model
- [ ] To find a more-complex model

✔

Submit You have used 1 of 1 attempt

Question 8d

1.5/3.0 points (graded)

In the simple linear regression model

$$minimize \sum_{i=1}^{n} (y_i - (a_0 + \sum_{j=1}^{m} a_j x_{ij}))^2$$

i. What are the variables from a regression perspective?

- ( ) Only x_{ij} ✔
- ( ) Both x_{ij} and a_j
- ( ) Both x_{ij} and y_i ✔
- (•) Only a_j
- ( ) Only y_i

✖

ii. What are the variables from an optimization perspective?

- ( ) Only y_i
- ( ) Both x_{ij} and a_j
- (•) Only a_j
- ( ) Only x_{ij}
- ( ) Both x_{ij} and y_i

✔

Submit You have used 1 of 1 attempt

Answers are displayed within the problem

Question 8e

4/7 point (graded)

⌨ Keyboard Help

Put the following seven steps in order, from what is done first to what is done last.

Step 1	Remove outliers
Step 2	Impute missing data values
Step 3	Scale data
Step 4	Fit lasso regression model on all variables
Step 5	Fit linear regression, regression tree, and random forest models using variables chosen by lasso regression
Step 6	Pick model to use based on performance on a different data set
Step 7	Test model on another different set of data to estimate quality

Submit You have used 1 of 1 attempts. Reset Show Answer

FEEDBACK

✔ Correctly placed 4 items

✖ Misplaced 3 items

✱ Final attempt was used, highest score is 4.0

ℹ **Good work! You have completed this drag and drop problem.**

There are five questions labeled "Question 9". Answer all five questions. For each question, select the most appropriate model/approach to answer the question/analyze the situation described. Each model/approach might be used zero, one, or more than one time in the five questions.

Question 9

1.4/1.4 points (graded)

Nobody knows exactly how investments will change in value. What's the best set to invest in?

Stochastic optimization ✔

Submit You have used 1 of 1 attempt

Question 9

1.4/1.4 points (graded)
How many checkout lanes should a supermarket open to avoid long wait times?

Queuing ✔

Submit You have used 1 of 1 attempt

Question 9

1.4/1.4 points (graded)
Find groups of analytics professionals that are highly interconnected on LinkedIn.

Louvain algorithm ✔

Submit You have used 1 of 1 attempt

Question 9

1.4/1.4 points (graded)
At an art auction, every museum is bidding strategically. How much should our museum bid?

Game theoretic analysis ✔

Submit You have used 1 of 1 attempt

Connect