Review Session 9

API-201, 12.03.21
Sophie Hill

Final Exam

- December 9th, 9am- 12pm, location TBA
- Same rules as the midterm regarding calculators etc.
- The final is *cumulative* but focuses more on the 2nd half of the semester
- Note: we have uploaded past exams and practice problems but the syllabus this year is slightly different to prior years
- Teaching team will hold extra Office Hours over the next few days (TBA)

Disclaimer: I have not seen the exam!

Final Exam: what to expect?

There are some topics that are very likely to come up:

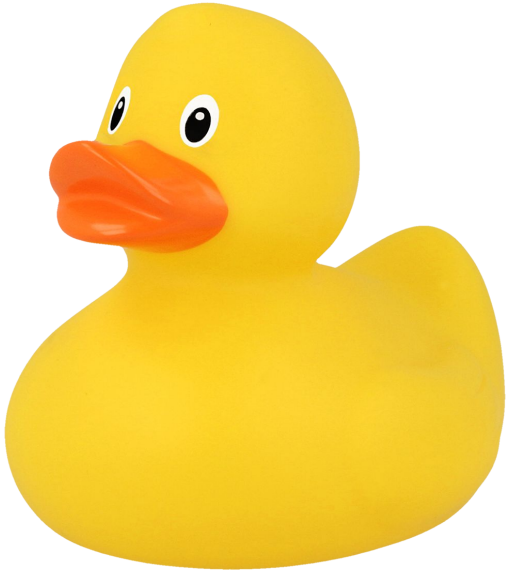
- Conducting a **hypothesis test**
- Something from **pre-midterm** classes (Bayes Rule? Decision tree?)
- **Evaluating evidence** (practical vs statistical significance; cherry-picking; multiple comparisons; bias in data)
- **Qualitative evidence** (pros/cons of different methods; types of "mixed methods" designs)

Preparation: where to start?

I would strongly recommend that you start by shoring up your foundations:

1. **Definitions** (Glossary in Handout 16 + …)
2. **Relationships between concepts** (PSet 6, Q1.2 + …)
3. **Hypothesis testing** (Handout #15, Summary table + …)

1. Definitions



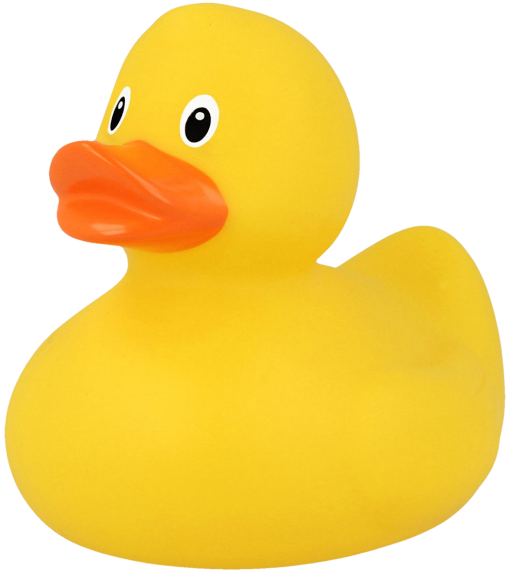
Can you explain these definitions to a rubber duck?

7. APPENDIX #2 – GLOSSARY OF KEY TERMS

- **Alpha** (α): The threshold below which one rejects the null hypothesis. If $p\ value < \alpha$ then reject H_0. Otherwise, fail to reject H_0.
- **Central Limit Theorem (CLT):** Gives us the sampling distribution for sample proportions and other estimation procedures.
- **Confidence Interval:** A range around an estimate representing our best guess of the population parameter. For a $(1-\alpha)\%$ confidence interval, $(1-\alpha)\%$ of such intervals contain the true value of the population parameter.
- **Estimate:** Best guess of the value of the population parameter of interest from your sample. Varies from sample to sample.
- **Null hypothesis**: Initial claim that we want to test in a hypothesis test.
- **p-value**: The probability of an estimate as far away or farther away from the null hypothesis as the actual estimate from the sample, assuming the null hypothesis is true. Obtained from the sampling distribution.
- **Population parameter**: A quantity in the population of interest that we want to estimate.
- **Rejection Region**: Given a null hypothesis and significance level, the range of estimates or test statistics that would cause us to reject the null hypothesis. Also called the Critical Region.
- **Sampling fluctuations**: The notion that estimates vary from sample to sample.
- **Sampling distribution**: The probability distribution of estimates for samples of a given size.
- **Standard error**: The standard deviation of the sampling distribution, quantifying how much estimates of a given sample size will vary.
- **Significance Level** (α): See alpha (α).

Handout #16

1. Definitions



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- **Significance Level** (α): See alpha (α).

Other key terms to add to this list:

- Beta
- Power
- Type I / II errors
- Practical significance
- Systematic error
- Non-response bias
- Reporting bias
- Cherry-picking
- Regression to the mean
- Underpowered study
- etc. !

Handout #16

2. Relationships between concepts

Concepts	How they relate to each other
p-value and Significance Level (α)	We decide whether to reject the null hypothesis or not based on the p-value. If the p-value is very small, we reject because it suggests that the estimate is very unlikely to have occurred if the null hypothesis were true. The threshold for what we call a p-value so small that we reject the null hypothesis is called alpha. If p-value < alpha, we reject the null hypothesis. Otherwise, we fail to reject the null hypothesis.
Confidence Interval and Significance Level (α)	The lower the significance level, the wider the confidence interval. As we lower the significance level, say from alpha=0.05 to alpha=0.01, we are *raising the threshold* required for us to reject the null. So the confidence interval around our estimate gets wider, and hence it becomes "harder" for the confidence interval to not include the null value.

PSet 6, Q1.2

2. Relationships between concepts

Factors that affect Statistical Power

Factor	Relationship with Statistical Power
Sample size (n)	
Significance level of the test (α)	
Size of true impact	+
Variance of the outcome	-
Sampling design features	Varies

Handout #17

2. Relationships between concepts

Factors that affect Statistical Power

Factor	Relationship wi
Sample size (n)	
Significance level of the test (α)	
Size of true impact	
Variance of the outcome	
Sampling design features	

This often shows up in the exam as a **TRUE/FALSE** question (e.g. "Increasing the sample size increases statistical power, all else equal").

Handout #17

3. Hypothesis testing

			Sampling Distribution		
Target parameter	**Sample Size(s)**	**Estimate**	**Shape**	**Mean of Estimator**	**Standard Error**
q	n	$\hat{q}$	Approximately normal	q	$\sqrt{\frac{q(1-q)}{n}}$
μ	n	$\bar{x}$	Approximately normal*	μ	$\frac{s}{\sqrt{n}}$
$q_1 - q_2$	$n_1 and\ n_2$	$\hat{q}_1 - \hat{q}_2$	Approximately normal	$q_1 - q_2$	$\sqrt{\frac{q_1(1-q_1)}{n_1} + \frac{q_2(1-q_2)}{n_2}}$
$\mu_1 - \mu_2$	$n_1 and\ n_2$	$\bar{x}_1 - \bar{x}_2$	Approximately normal*	$\mu_1 - \mu_2$	$\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$

CLT Conditions: Large enough random samples (all 4 rows); independent samples (last 2 rows)
* Since σ is usually unknown, we use s instead and the sampling distribution is t (instead of Normal).
When sample sizes are large enough, the t and Normal distributions are approximately equal.

Handout #15

3. Hypothesis testing

	Scenario 1	**Scenario 2**
Method #1: p-value	p-value < α	p-value > α
Method #2: Rejection Region	Estimate **falls** in the rejection region	Estimate **does not fall** in the rejection region
Method #3: Confidence Interval	Confidence interval **does not include** the value under the null hypothesis	Confidence interval **includes** the value under the null hypothesis
Conclusion	**Reject** the null hypothesis	**Fail to reject** the null hypothesis

Handout #16

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Once you are confident with this material, move on to practice problems / past exams.

Common mistakes

❌ “If the data are not Normally distributed then we cannot apply the Central Limit Theorem.”

❌ “If the confidence intervals around two estimates overlap, then the difference is not statistically significant.”

❌ “There is a 95% chance that a 95% confidence interval contains the true value.”

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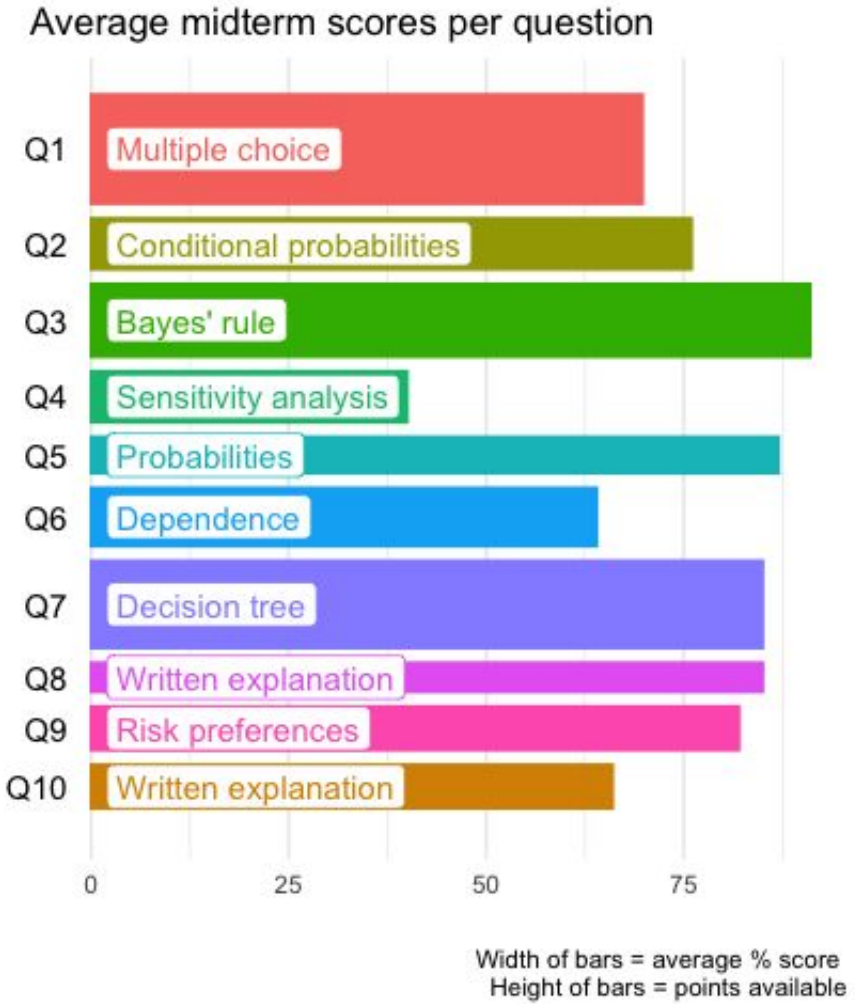
Exam strategy

Looking back on the midterm:



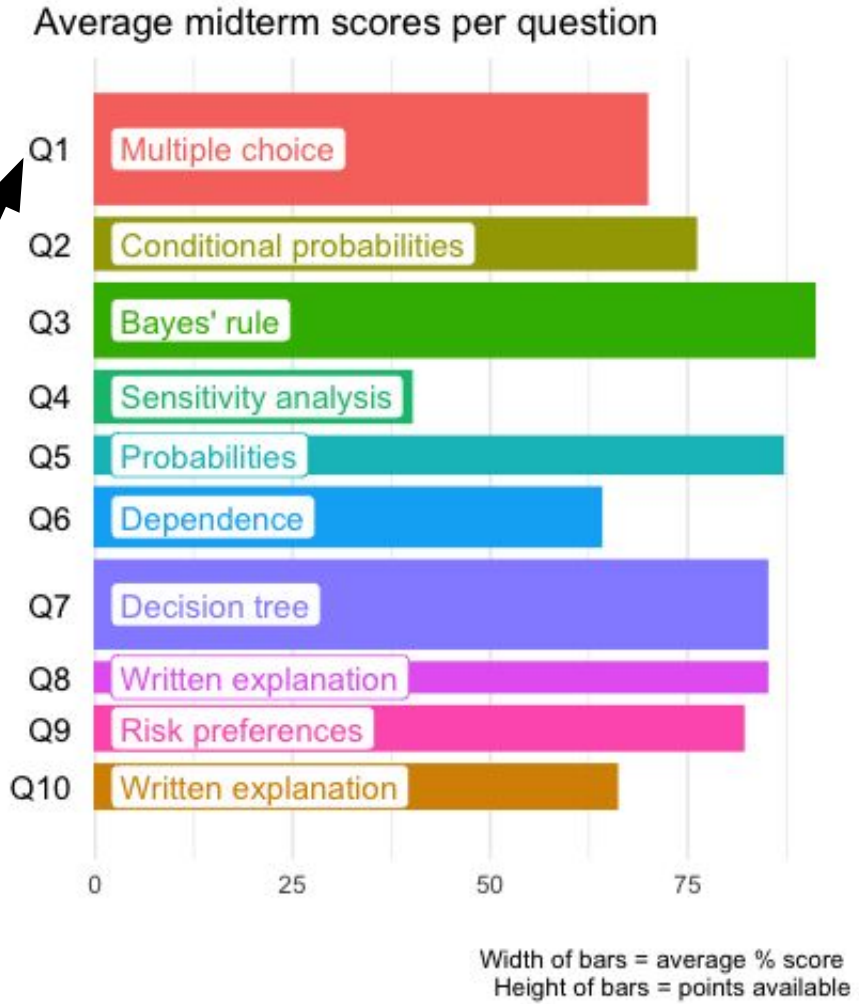
Exam strategy

Looking back on the midterm:

The average score on the multiple choice questions was only 70%…

These questions should be relatively straightforward, but there's no partial credit.

So: pay attention!

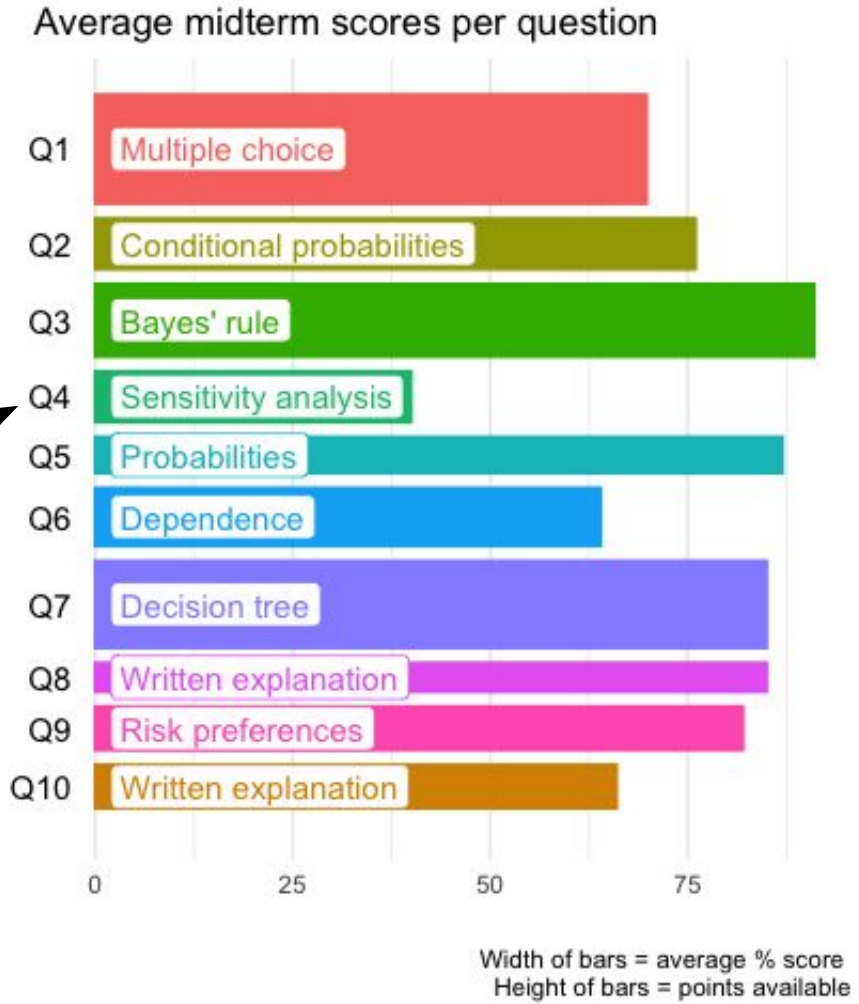


Exam strategy

Looking back on the midterm:

Yes, the sensitivity analysis question was tricky!

Don’t be discouraged if you get stumped – it’s OK to cut your losses and move on.

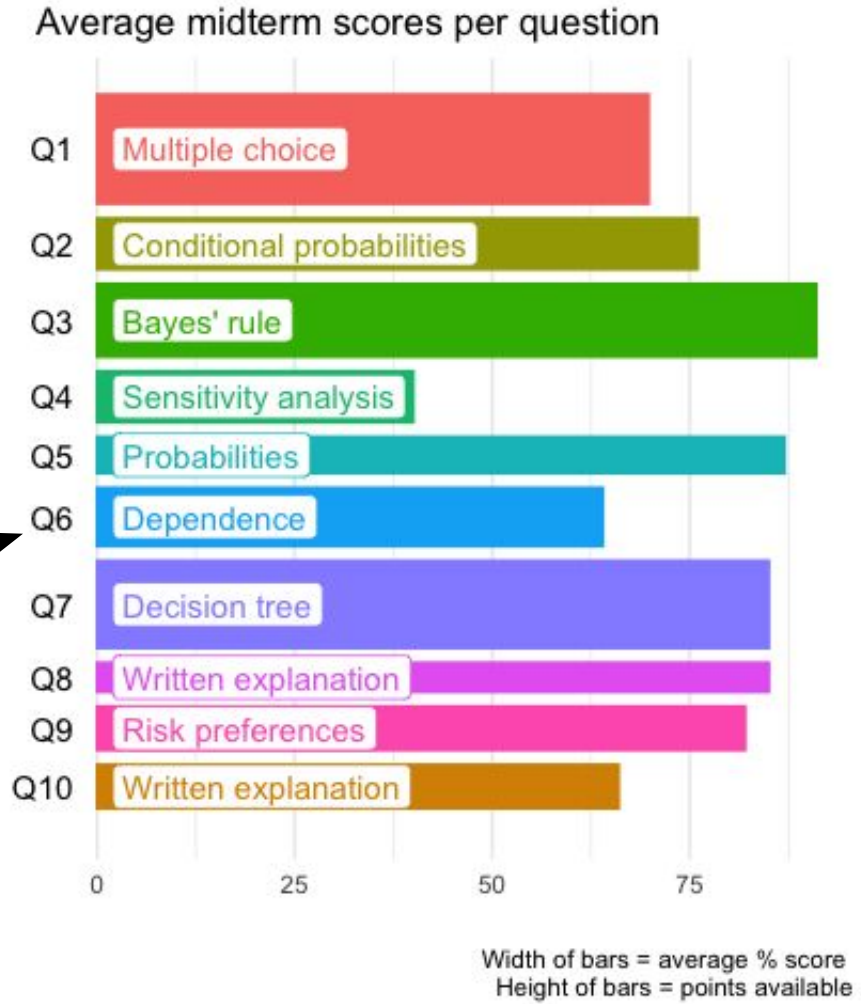


Exam strategy

Looking back on the midterm:

Many of you struggled on this question (about the MPs voting on a bill) because you failed to recognize it was about dependence.

This was very similar to a PSet question - try to step back and identify the topics in each question.

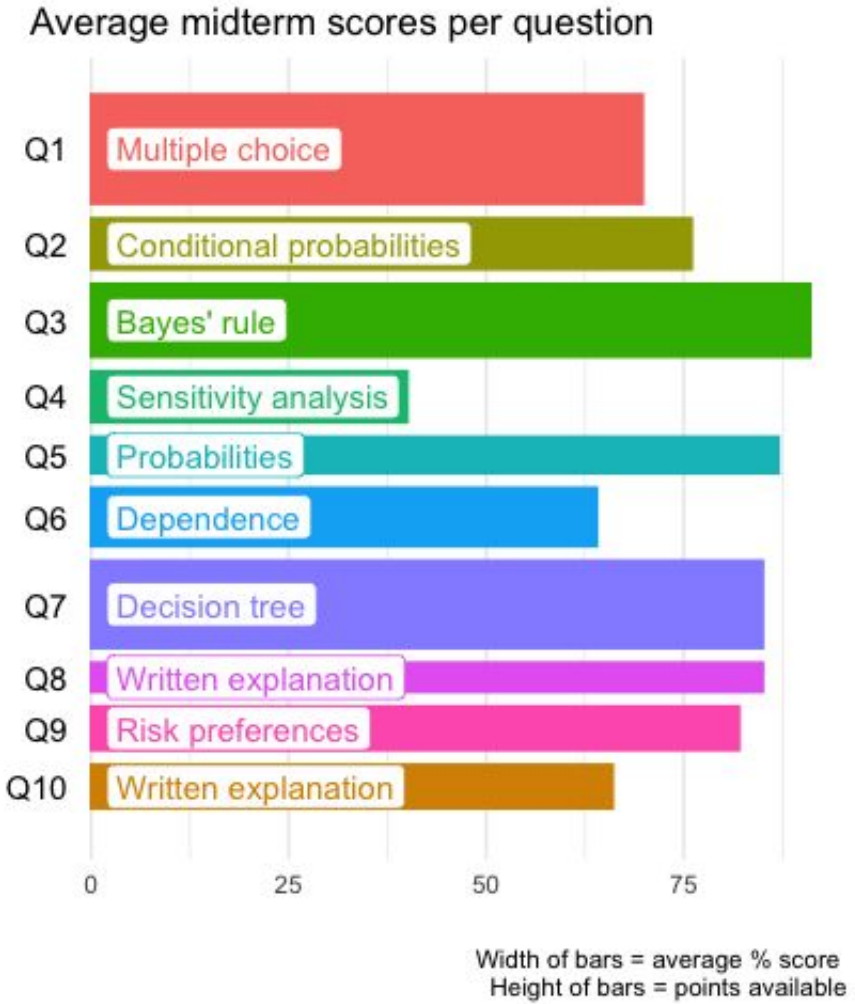


Exam strategy

Looking back on the midterm:

Average scores were even lower on the open-ended question discussing the quote about nuclear strategy.

Don’t neglect the “wordy” questions!



Exam tips

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Why?

- Your subconscious brain will start whirring away
- Gives you an “easy task” to complete → prevents panic!
- Reduces the chance of misreading a question
- If you know the points available for each question, you can manage your time better

PSA from Wally

During this busy time, remember to:

During this busy time, remember to:

Get some fresh air

During this busy time, remember to:

Get some fresh air

Hang out with friends

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Put your feet up!