Final Exam Practice Questions Workbook

Instructions. You are working for a new airline company to help them in this competitive market. Literally, they listed PSYC08 as the only requirement to apply. The job is to analyze various data deemed important in the success of the airline and the safety of the passengers. Always make sure to include all relevant descriptive data, assumptions, tests of assumptions, graphs, and explain the results. Miscalculations can have drastic consequences! Compute multiple comparisons as necessary. Make sure to give conclusions and interpretations in ~~plain~~ plane language (terrible joke). After all, these executives and engineers do not understand what all these statistical values mean.

Question 1. To help choose which aircraft would be popular, AirNOVA had five passengers try out each one of their aircrafts, an Airbus A321, an Airbus A319, a Boeing B777, or a Boeing B767. They rated their enjoyment of the flights out of 10. Unfortunately, the last statistician who worked on the data left mid-analysis and the original data was lost. Fill in the missing information and calculate the ANOVA. Make sure to provide a conclusion.

Subject	1	2	3	4	5	GM
Mean	4	6	7	*MISSING*	7	5.6

$$SS_{Total} = 128.9$$

$$SS_{Treatment} = 5((-1.6)^2 + (-0.7)^2 + (MISSING)^2 + (-0.1)^2)$$

Question 2a. Our aircraft computer system will monitor engine temperature to ensure they are running correctly. If engine temperature is in the extreme 5% (either too cold or too hot from average running temperature), it will register a warning to the pilots. Of course, due to fluctuations in air temperature, density, and wind speed, as well as the temperature sensor itself, these warning may a mistake. Calculate the probability that on a four-engine plane a temperature warning read-out will be a false alarm.

Question 2b. AirNOVA is considering changing the sensitivity of the sensors to 1% or 10%. Given the "better to be safe than sorry" philosophy of air travel, what would you recommend to be done. List how changing the sensitivity in either direction will affect false alarms or failing to detect actual issues.

Question 3. AirNOVA wants to run simulations on their aircraft safety. They have four aircraft (A321, A319, B777, and B767). Rating are between 0 (not safe at all) and 15 (extremely safe). The n for each plane is 10 ($N = 40$). Provide possible means and weights which will satisfy the requirements of the simulation:

1. There should be some difference in safety
2. When doing a linear contrast, one of the contrasts should explain the entire effect while the others explain none
3. The contrasts should be orthogonal

Note you do not need to test the significance of the contrasts or effect, just give the *SS* and describe the findings.

Question 4a. Two separate one-way ANOVAs were run, analyzing fuel-efficiency between the Airbus planes and the Boeing planes. Both were statistically significant, each had different $df_{Treatment}$. AirNOVA wants to test whether one effect differs significantly from the other. What method could you use to test this? Provide a theoretical explanation to back up your decision.

Question 4b. What other option could be done if both ANOVAs had the same $df_{Treatment}$?

Question 5. AirNOVA wants to provide a smooth experience for passengers by reducing turbulence. While frightening to passengers, even severe turbulence poses very little risk to an aircraft. AirNOVA tested how turbulence varies across times of day and altitude. Some of the data was lost as engineers are constantly misplacing their notes after each test. Fill in the source table and complete the analysis. $SS_{Cells} = 78$.

Source	*SS*	*df*	*MS*	*F*	*F crit*
Time of day		1		7	
Altitude	27				
Interaction					
Error		24	3		
Total		31			

Question 6. AirNOVA wanted to investigate fuel efficiency. The media praised their environmental conscientiousness, but secretly they just wanted to save money on flight costs. They tested how time of day of the flights and altitude affects fuel efficiency on their aircraft. Some of the data was, again, lost. Maybe they should invest in competent data collectors rather than focus on how much gas their planes use? Fill in the source table and complete the analysis.

Source	SS	df	MS	F	F crit
Altitude					4.20
Time of day	150				
Interaction				10.50	
Error					
Total	760				

Source	SS	df	MS	F	F crit
Time of day @ 30k ft	114				
Time of day @ 35k ft	216				
Altitude @ Morning	13.2				
Altitude @ Afternoon	19.8				
Altitude @ Evening					
Error					
Total					

Question 7. AirNOVA investigated whether plane type and rotation angle (the angle the plane points when taking off) affects passenger comfort, as well as whether they interact. Again, some data was lost. Compute the rest of the ANOVA. $df_{Cells} = 3$.

Source	SS	df	MS	F	F crit
Plane type	10				
Take off angle	80				4.49
Interaction			50		
Error	80				
Total					

Question 8. One problem for passenger comfort is flight time. AirNOVA wants to make sure that over time its passengers are more comfortable than its leading competitor, AirNull. Ten passengers were surveyed, the first five were assigned to an AirNOVA flight and the other five to the competitor's flight. They were assessed on their comfort (scale of 1-10) over half-hour intervals. Is there a difference across time in comfort, as well as across aircraft type? Is there an interaction? Omnibus findings should be tested with proper *post hoc* tests.

Passenger	30 mins	60 mins	90 mins	120 mins
1	7	7	6	6
2	8	8	7	6
3	7	6	6	6
4	6	7	6	5
5	8	8	8	7
6	6	7	5	5
7	7	6	4	4
8	7	8	6	5
9	7	7	6	6
10	5	5	3	2

MEANS	30 mins	60 mins	90 mins	120 mins	Airline
AirNOVA	7.2	7.2	6.6	6	6.75
AirNull	6.4	6.6	4.8	4.4	5.55
Time	6.8	6.9	5.7	5.2	6.15

VARIANCE	30 mins	60 mins	90 mins	120 mins
AirNOVA	0.7	0.7	0.8	0.5
AirNull	0.8	1.3	1.7	2.3

Question 9a. AirNOVA wanted to see how much money passengers spent on in-flight entertainment (IFE) between its Airbus and Boeing models, and across time of day. Compute the *SS* for the plane type, time of day, and interaction.

Group	Airbus night	Airbus day	Boeing night	Boeing day
Mean IFE	160	150	170	120
n	5	5	5	5

Question 9b. Although the data is a one-way design, compute it as a factorial using only linear contrasts to obtain the *SS*.

Question 9c. Describe, theoretically, the parallels between approaches in 9a and 9b.

Question 10. Given that AirNOVA business executives do not understand statistics, they see each test you conduct as completely separate. Describe how every test used is essentially a modification of the basic one-way between subjects design. Start with the structural model of a one-way ANOVA, and describes changes pertaining to ANCOVA, RM-ANOVA, and different types of factorial design. What are the similarities and differences between these designs (calculation of *SS* and theory)? For example, what are the similarities and differences in block design versus factorial?

Question 11a. AirNOVA wanted to analyze passenger comfort by taking into account three parameters: the plane type used (Airbus or Boeing), the time of day travelled (morning, or evening), and the interior lighting (low, or high). Describe the structural model that would be used in this case, and, if you can, how they would be estimated with sample statistics. Different passengers will be tested in each level of the three factors.

Question 11b. Describe the structural model, and how it is estimated, if the same passengers are repeated across two factors of plane type and interior lighting. In other words, both factors are within-design. In this situation, the time of day factor is not analyzed.

Question 11c. Describe the structural model of Question 11a, and how it is estimated, but the same passengers were repeated across plane type and interior lighting. In other words, these two factors are a within-subjects condition but the time of day remains between-subjects.

Question 11d. Describe the structural model of Question 11a, and how it is estimated, but the same passengers were repeated only across plane type. Here, time of day and interior lighting remains between-subjects.

Question 11e. Describe the structural model for a four-way ANOVA with passenger and plane type a within factor, and time of day and interior lighting a between-factor.

Question 12. AirNOVA is planning on running a large number 2x2 designs (meaning the row, column, and interaction *df* each equal 1). The SS_{Error} for each ANOVA will be fixed at 240 and there will be an $n = 5$ for every group. Because there are going to be dozens of comparisons across all these types of analyses, AirNOVA is asking you to limit the number of computations and figure out a way to create an omega (ω) for the minimum *SS* needed for an effect to be considered significant.

Question 13. Before hiring you as a statistician, AirNOVA utilized mostly one-way ANOVA analyses, regardless of whether there were one or two independent variables. The main argument was that the omnibus treatment remains the same and they can compute further comparisons with *post hoc* tests. Describe why this is not the best idea and what added benefit is provided by using a factorial design.

Question 14. An ANOVA was analyzed with a 2-row (Airbus vs. Boeing) and 3-column (morning, afternoon, evening) factorial design looking at fuel efficiency. The results found no effect of row, but an effect of column and an interaction. Simple effects for the row factor found no difference between plane type at either morning or afternoon, but did find a difference between plane types during the evening. The executives were perplexed. How can there be no difference in the main effect of row (Airbus vs. Boeing) but one of the simple effects finding a difference between both rows. Explain the logic of simple effects and why finding a significant interaction, even at the absence of a main effect, is expected.

Question 15. One of the former statisticians thinks somehow doing a *t* test versus an ANOVA on the same set of data will give you different answers. Show how this is incorrect by computing both an ANOVA and a *t* test on the current data investigating inflight-entertainment purchases across two different aircraft types. Describe the shared components between the theory calculation of *t* and *F* to cause this.

Flight	Airbus	Boeing
1	120	110
2	130	100
3	115	105
4	120	115
5	115	110
Avg	120	108
s^2	37.5	32.5

Question 16. Outlier cut offs are usually typically set at ±2.5 or ±4 standard deviations, but has been as high as ±6 standard deviations. Describe what cut off thresholds are most appropriate for small versus large sample sizes, and explain the reasoning.

Question 17. AirNOVA is investigating whether certain types of planes are more susceptible to turbulence than others. They recorded up to five flights with different types of planes. Their *a priori* hypotheses were that the A319 would have more turbulence than the A320, as well as the B767. They also hypothesized that the B777 would have more turbulence than the A320. Calculate the *a priori* hypotheses. Don't worry about computing the final ANOVA.

Flight #	A319	A320	767	777
1	8	6	6	8
2	7	5	4	7
3	8	6	5	8
4	6	3	4	9
5	7	4		
Avg	7.2	4.8	4.75	8
s^2	0.7	1.7	0.917	0.667

Question 18a. Part of AirNOVA's revenue is from targeted advertisements. To choose ads that would best fit their demographics, they investigated whether age differences exist for passengers between aircraft type (Airbus or Boeing) and time of day (morning, afternoon, evening). They reasoned that older individuals tend to be workers who fly for business, and so may want earlier flights to make mid-day meetings, or evening flights to make meetings the next day. Test the planned comparisons that morning flights will have older individuals than afternoon flights, and that evening flights will have older individuals than afternoon flights.

Flight	Morning	Afternoon	Evening
Airbus	44	47	49
	52	45	51
	44	48	56
	48	44	48
Boeing	52	40	43
	53	45	49
	48	47	47
	47	48	45

AVERAGE	Morning	Afternoon	Evening	Plane
Airbus	47	46	51	48
Boeing	50	45	46	47
Time of day	48.5	45.5	48.5	47.5

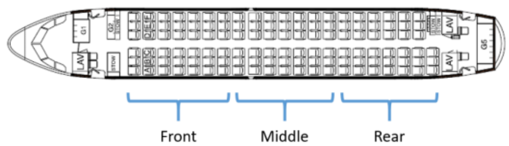
VARIANCE	Morning	Afternoon	Evening
Airbus	14.6667	3.3333	12.6667
Boeing	8.6667	12.6667	6.6667

Question 18b. Compute the rest of the analysis. Test any relevant *post hocs*.

Question 18c. A covariate of previous flight experience was found to account for 25% of the total variability. Re-compute the ANOVA with this in mind. Does anything change? If so, compute any relevant *post hocs*.

Question 18d. Describe the relationship between the *a priori* and any *post hoc* findings.

Question 19. A one-way ANOVA looked at passenger safety ratings in front seats, middle seats, and rear seats in AirNOVA's Boeings. Another one-way investigated the same thing except with AirNOVA's Airbuses. Is it possible to combine the data to look at whether there are differences between Airbuses and Boeing models? How would you treat the data from each one-way?



Question 20. Pilot's training is an important part of airline operability (we hope that AirNOVA is stricter with hiring pilots than they were with former statisticians). A series of 20 pilots were trained on each aircraft (Boeing and Airbus) as well as ability to operate either a 2-engine aircraft or a 4-engine aircraft. This gives a basic 2x2 design. However given the variability in pilot scores, parametric assumptions cannot be met. Describe how you can rectify this by attaining main effects nonparametrically, and how you would attempt to investigate any interaction. What would happen if one of these factors were within-subjects?

Question 21. AirNOVA is an equal-opportunist employer. We tested the operability of eight male and eight female pilots for four of our aircraft (separate pilots per aircraft). Higher numbers mean better score on the ability to maneuver and handle the aircraft. Are there any differences apparent in the pilot skill? Test any relevant *post hocs*.

AVERAGE	B777	B767	B757	B737
Male	25	26	27	19
Female	23	26	29	21

VARIANCE	B777	B767	B757	B737
Male	9.0	25.0	4.0	9.0
Female	9.0	16.0	16.0	16.0

Question 22a. In the event of an emergency, pilots set their transponder code to "7700", called "Squawking 7700" (other codes include 7500 for hijacking, and 7600 for loss of radio communication). Squawking 7700 tells air-traffic controllers that there is a problem onboard. During simulation training, AirNOVA tested three different common emergency scenarios (engine failure, loss of cabin pressure, and a medical emergency) for three of their aircrafts (B777, B767, and B757). We recorded how fast pilots were at setting the 7700 emergency code, in seconds. Each aircraft/emergency scenario had separate pilots. First, test the *a priori* hypothesis that engine failures would be responded to faster than loss of cabin pressure, and that due to better ergonomics pilots would respond faster on B777s than both B767 and B757s, but faster reaction times on B767s than B757s.

Problem	B777	B767	B757
Engine failure	7.5	8	9
	5	7.5	13
	5.5	5.5	11
Loss of cabin pressure	9	8.5	5
	5	7.5	4
	7	11	6
Medical emergency onboard	9	11.5	11
	11	13.5	16
	13	8	15

MEANS	B777	B767	B757
Engine	6	7	11
Pressure	7	9	5
Medical	11	11	14

VARIANCE	B777	B767	B757
Engine	1.75	1.75	4
Pressure	4	3.25	1
Medical	4	7.75	7

Question 22b. Compute the proper analysis.

Question 22c. Are there any *post hoc* tests that need to be done? Previous data has shown B757s have had cabin pressure problems in the past. Given the findings, is this surprising?

Question 22d. In plain language, describe what these findings mean to the executive officers of AirNOVA. Remember, they do not understand statistical values, they just want to know about the safety of their pilots and aircraft.

Question 23a. AirNOVA wanted to evaluate its pilot training program, specifically how many days of training it took to properly certify pilots to fly each of its aircraft (separate pilots were trained on each aircraft: A321, A319, B777). Ten pilots were trained on each aircraft, with five using Simulator 1 and five using Simulator 2. Fill in the missing data to evaluate whether some aircraft took longer to train on, as well as whether one simulator type was better than the other. We can tell you that the difference between one of the row means (simulator type) and the grand mean is equal to -3.

Source	*SS*	*df*	*MS*	*F*	*Fcrit*
Rows					
Columns	140				
Interaction			0		
Error			25		
Total					

Question 23b. Even though there was no significant interaction, what are the simple effects?

Question 24. While we prefer to keep the same sample size in each cell when doing factorial designs, this is not always possible. For future reference, please describe what happens to each of the *SS* in the events that the *n*s are unequal in some cells for a between-subjects factorial.

Question 25a. When looking over data calculated by a previous statistician, you notice that all three *q* tests (NK, HSD, and WSD) were calculated for *post hoc* testing, but there were more significant tests using WSD than NK. Is this possible, why or why not?

Question 25b. Which of the three tests would you use when using *post hocs* to test whether improvements to aircraft improved safety rating? Why?

Question 25c. Which of the three tests would you use when evaluating whether certain inflight entertainment options were more enjoyable than others? Why?

Question 26. Explain why the Bonferroni correction method gets more conservative with the more comparisons you do. Additionally, explain why if you do two comparisons you do not technically need to correct for multiple comparisons. Finally, explain why the critical *t* for Bonferroni and Dunnett critical differ even when the number of comparisons being correct for is the same.

Question 27. Corporate wanted to charge different prices for food service based on which class of seating passengers took (Economy, Business, Premium, or First). Individuals from each class tried either fish or chicken and rated their experience of it. Complete the data, do a series of *a priori* tests, test the ANOVA, and compute any necessary *post hoc* tests. At the end, say which menu should receive higher or lower pricing for each seating class (or whether it matters). Note that the largest variance was in business class but the obtained F_{Max} value of 9.00 was smaller than the F_{Max} critical off 37.5, maintaining homogeneity of variance. All groups had the same n.

AVERAGE	Economy	Business	Premium	First Class	Menu mean
Fish	8			6	6.75
Chicken	9	8		1	5.25
Class mean	8.5	7		3.5	

VARIANCE	Economy	Business	Premium	First Class
Fish	2.25	6.25	12.25	6.25
Chicken	6.25		6.25	6.25

Question 28. Turns out that some previous data was calculated using a between subjects factorial design when some subjects actually were actually repeated across the levels of one of the factors (mixed design). How does the ANOVA values change when going from a between-subjects factorial (different subjects in each level of both factors) design to a mixed-design (same subjects in all levels of one factor, different subjects in all levels of the other factor)? Explain why getting this right is very important, especially when it comes to the residual (error) variance.

Question 29a. What are the main theoretical differences between *a priori* and *post hoc* testing. Specifically, how is FWE corrected between the two? Why are these distinctions important?

Question 29b. On that note, explain the main differences between t and q and how each handles corrections for multiple comparisons.

Question 30. You are not going to be with AirNOVA forever, and eventually will move on to better career prospects. Please describe the appropriate analysis steps from start to finish when conducting an ANOVA, and how outcomes at some steps may affect subsequent steps. Provide a theoretical reason for why each step is necessary.

Question 31a. There are two popular textbooks that can be used to train pilots on four key topics related to flying: physics, air law, aviation history, and aircraft operations. Three prospective AirNOVA pilots were given Text 1 to study, and another three were given Text 2 to study. They were tested on all four topics. Is one text better than another text overall or when it comes specifically to certain topics?

Pilot	Group	Physics	Air law	History	Operations
1	Text 1	82	85	77	79
2	Text 1	77	79	71	68
3	Text 1	87	88	80	72
4	Text 2	75	77	68	87
5	Text 2	70	71	66	82
6	Text 2	80	74	67	92

Question 31b. How would the results and interpretation of the data change if the between and within factors were switched? That is, the between subject factor was the course content, and the within-subject factor was the textbook used. Re-compute the ANOVA.

Question 31c. For the data in 30a, a third variable of hours of sleep correlated with each pilot's average score and explained 12% of the total variability. Add in the covariate and re-compute the source table. Does anything change?

Question 32. Many of the higher-up executives who have no understanding of statistics get confused when a factorial design is presented to them talking about main effects, interactions, and simple effects. Describe in plain language what these three effects mean.

Question 33. Another problem with the previous statistician was they would do many types of linear contrasts over the various datasets they would receive. Some would be orthogonal and some were not orthogonal. Executives did not seem to think it was an issue since the $k - 1$ rule was always met, and all contrast weights summed to zero. Describe what rule may have been broken and what the consequences would be. Also, describe orthogonality, and what happens if it is violated or met. Finally, describe why $k - 1$ is a rule when computing orthogonal contrasts.

Question 34. An evaluation of engine fuel on fuel efficiency was tested between four types of fuel (Fuel 1 to Fuel 4) separately for five Boeings and five Airbuses. Given the data below, are there any fuels that are best suited for one plane over the other? The partial η^2 for the interaction effect was equal to 0.25.

Contrast	*Fuel 1*	*Fuel 2*	*Fuel 3*	*Fuel 4*	$SS_{Contrast}$
a	1	1	1	-3	7.5
b	1	1	-2	0	60
c	1	-1	0	0	80

SOURCES	*SS*	*df*	*MS*	*F*	*F crit*
Plane Type	40				
Fuel Type					
Interaction					
Error	420				
Total					

Question 35a. Aircraft mechanics are trained to service either Boeings or Airbuses, not both. Maintaining the aircraft is the most important safety aspect for AirNOVA. They evaluated how well mechanics for Boeing and Airbus can address concerns with five key components of an aircraft: the engines, avionics, control surfaces, landing gear, and hydraulics. Four Boeing mechanics and four Airbus mechanics were tested on all five maintenance components. Complete the ANOVA table. We know the total SS_{Error} is equal to 59.

SOURCE	SS	df	MS	F	Fcrit
Between Subjects					
Groups					
Subjects within groups					
Within Subjects					
Treatment	48.5				
Treatment x groups					
Treatment x subjects within					
Total	127.5				

Mechanic	Aircraft specialty	Mean repair ability
1	Boeing	6.6
2	Boeing	7.2
3	Boeing	7.6
4	Boeing	6
5	Airbus	7.8
6	Airbus	4.2
7	Airbus	7.2
8	Airbus	7.4

Question 35b. Turns out that we tested separate mechanics on each of the five components, and not the same mechanics. There was some misinformation from management. Fix the ANOVA source table to account for this.

Question 36. AirNOVA wanted to evaluate whether its passengers were more comfortable than its competitor airlines. They surveyed four passengers each from a short-haul flight (less than 2 hours), a medium length flight (2 to 6 hours) or a long-haul flight (greater than 6 hours), separately for their own flights or a competitor's flights (24 passengers in total). Is there any evidence that AirNOVA's flights offer better comfort than the competitors do?

Airline	< 2hrs	2 - 6 hrs	> 6 hrs
AirNOVA	10	8	7
	9	7	6
	6	6	4
	7	7	7
Competitor	6	2	1
	7	3	2
	9	4	3
	6	3	2

Question 37. A dataset originally computed as a mixed-factorial design had the between-subject condition not significant. The executives believed this was due to the power tug-of-war that exists across the between and within factors and want you to reanalyze the data as a fully-between factorial. Does it violate any statistical rules to analyze a within-subjects factor as a between-subjects factor?

Question 38. Previously you explained what Type I and Type II errors are. Explain how the Type I/II error rate changes when either: (a) n increases, (b) s^2 decreases, or (c) number of conditions (levels) increases.

Question 39. The previous, now fired, statistician ran a factorial design using plane type (Airbus or Boeing) and airline type (Air Canada, Air Lingus, AirNOVA) to measure passenger spending. Unfortunately they did it as a fully between factorial design when in fact the aircraft type was within-factor (i.e., the same subjects rode on both types of aircraft). Re-compute the factorial source table as a mixed-factorial. The between-subject error ($SS_{Subjects\ within\ groups}$) equals 28.2. All *n*s are equal.

Source	*SS*	*df*	*MS*	*F*	F_{crit}
Rows	19.5	1	19.5	5.27	4.07
Columns	28.2	2	14.1	3.81	3.22
Interaction	7.4	2	3.7	1.0	3.22
Error	155.4	42	3.7		
Total	210.5	47			

Question 40. AirNOVA is planning what the average hourly pilot wages should be (got to get that bread, am I right). AirNOVA is comparing hourly wages across three types of flight lengths (long haul, medium haul, and short haul), and four types of aircraft (B777, B767, A321, A319). Human Resources department wants to show that there is no difference among wages for either factor, that is, the main effects for haul-length and aircraft type should both equal zero. This is so that the pilot union would not complain that some pilots make more than others. But AirNOVA wants to encourage incentive to move around, so they want a significant interaction. Using that knowledge, fill in the rest of the mean hourly wages that would satisfy this requirement, and complete the source table. In each cell, we measured 3 pilots (n = 3). Make sure to draw a figure, in fact starting right away with what the figure should look like may actually help you.

Cells	*Long Haul*	*Medium Haul*	*Short Haul*	*Row means*
B777	40			
B767	35			
A321			35	
A319				
Col means	30			

Source	*SS*	*df*	*MS*	*F*	F_{crit}
Rows	0				
Columns	0				
Interaction					
Error	900				
Total					

Question 41a. A mixed-design ANOVA is going to be run looking at flight times between airlines. In total, 15 participants will be selected, and will be observed across four flight times. Each cell in the analysis will have five observations. Compute the *df* for each component that would be in the ANOVA source table.

Question 41b. In another mixed-design, there are 105 total observations, organized across three between-subject groups. The interaction $df = 8$. Compute the source table's *df*.

Question 42. While telling statistics jokes to engineers around the coffee machine, you overhear executives in the boardroom talking about your results to shareholders. One clear part of a sentence is "… our analyses proved that there was no difference between AirNOVA and our main competitors for safety, but there was in environmental impact." Explain the error in their terminology, and why this is a mistake made by the public and nonscientists.

Question 43. One of the executives looking over your data found that in one analysis, your obtained F was 3.2106 points higher than the critical, and in another case it was 18.2917 points higher. They interpreted this as the second analysis being more significant (i.e., a stronger effect) than the first. Explain in which situations this would and would not be true.

Question 44. When conducting a simulation, you are planning the main effects for rows and columns would equal zero. You do not care whether there is an interaction or not. In this situation, must the column means equal the row means?

Question 45. Five separate ANOVAs are going to be run on a single dataset. Each of these ANOVAs will have five groups with seven participants in each groups. Because five analyses are being done on the same dataset, corrections for multiple comparisons need to take place. What will the critical cut off value be?

Question 46a. A set of contrasts was run comparing the average number of passengers on flights over four successive days (D1 = 118, D2 = 124, D3 = 140, and D4 = 150). There were five flights on each plane (n = 5 for each day) giving 20 total flights. MS_{Error} for the one-way ANOVA was 37.525. Below is the linear contrast setup. Compute an omega statistic for the minimum possible L value that a contrast needs for there to be significance.

Contrast	*D1*	*D2*	*D3*	*D4*
a	1	-1	0	0
b	0	1	-1	0
c	0	0	1	-1

Question 46b. Of the nonsignificant contrasts, what would the minimum number of daily flights (minimum n) needed for 80% power?

Question 47. A study looked at pilot error performance across different flight lengths and flight times. Different pilots were assigned different flight lengths, and every pilot was recorded across multiple flight time durations. Fill in the missing source table information.

SOURCE	*SS*	*df*	*MS*	*F*
Between				
Time of day			52.75	
Error	683.3			
Within				
Length of flight				
Length x time				10.0928
Error				
Total	1714.5	71		

SOURCE	*SS*	*df*	*MS*	*F*
Length @ morning				
Simple effect	105.6			
Error				
Length @ afternoon				
Simple effect	105.5			
Error	235.1			
Length @ evening				
Simple effect	345.8	2		
Error	31.5			

Question 48. The airliner wanted to see if there were, on average, more flights on certain days of the weeks. They recorded the number of flights across all seven days for three weeks and averaged them together (averages shown in table shown below). There was a significant difference when computing the ANOVA (MS_{Error} = 150.7143). Using the NK test, answer (1) how many post hoc comparisons will take place, (2) how many will take place at an r = 2, and (3) how many r = 2 tests will be significant.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
28	21	31	32	66	77	41