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SCHOLARSHIP EXEMPLAR

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Tick this box if you have NOT written in this booklet

Scholarship 2021
Statistics

Time allowed: Three hours
Total score: 40

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write your answers in this booklet.

Make sure that you have Formulae Booklet S–STATF.

Show ALL working. Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–24 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Question	Score
ONE	
TWO	
THREE	
FOUR	
FIVE	
TOTAL	

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QUESTION ONE

(a) (i) Overwhelmingly Apple's phones listed on this retailer's website tend to be the most expensive. The cheapest Apple phones are \$750, and the most expensive are \$2750. The median price for an Apple phone is around \$1400, much greater than that of an Oppo or Samsung phone. 75% of Apple phones are more expensive than 75% of both Oppo and Samsung phones. Oppo and Samsung did have phones that were greater than \$1500 too, though their median prices fell at both around \$600. Samsung phone prices had a greater inter quartile range, from about \$300 to \$900. Oppo phone prices had an inter quartile range of around \$400 to \$700.

There were less oppo phones in total, leading to less data.

Black was the most commonly listed colour of phone, contributing to 30% of Apple's listings and around 50% of both Oppo's and Samsung's. Apple appears to have a relatively even split of phone colours, with blue, red and white all making up around 23-26%. Oppo and Samsung have an equal to or less percent of listings for colours other than black aside from samsung for white phone listings, which make up around 26%.

All of Apple's listed white phones are more expensive than all of Oppo's, and all of Apple's blue phones are more expensive than all of Samsung's. For Black phones, Samsung's listings are split into two distinct groups of between \$200 to \$600 and between \$1750 to \$2750, with none in between. Apple's black phone listing's however are all between \$750 - \$2,000. ~~the only other phone where~~

(ii) We would need to know whether the sample of phone models listed on this specific retailer's website is representative of the total population of Apple, Samsung and Oppo phones in New Zealand. There could be differences that prevent the data from being representative. For example, the data showed that Apple's phones tended to be the most expensive, but this retailer could have specifically chosen Apple as the brand for high end customers, and decided not to list less expensive models. Or, while Oppo only had two models that cost more than \$1000 from this retailer, they may produce many more that are availible from other retailers in New Zealand.
Additionally, other retailers may set different price points for their phones. This retailer may choose to mark up their phones from Apple especially highly and decide to take a loss on Oppo phones. There is no way to know.
We would need a sample that extended to more stores that listed these phones for sale within New Zealand.

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(b)(i) For Apple phones, there is a moderate, positive and linear relationship between screen size and weight. There ~~is a small sample~~ are less Apple phones listed on this retailer's website than Samsung.
For Samsung phones, there is a moderate, positive relationship between screen size and weight.
The data looks like it could ~~be~~ fit either a linear or exponential ~~(curved)~~ (non-linear) model, and it is hence hard to determine whether the trend is linear or not. ~~~~ A linear model is definitely plausible.
Both scatters are consistent, and neither fan out in either direction.
There are no obvious outliers among the Apple listings, and there are two in the Samsung listings.
While these two Samsung outliers follow the general trend, one is particularly light (125g) with only a 4 inch screen, and one is particularly heavy (275g) with a nearly 8 inch screen.

(ii) Apple: weight = $-39.21 + 38.81 \times (7.5)$
weight = 251.9 grams

Samsung: weight = $-16.11 + 31.41 \times (7.5)$
weight = 219.5 grams.

Since we know the weight of this phone is 225 grams, and the provided models suggest that a phone with a screen size is likely going to weigh around 251.9 grams if it is Apple or around 219.5 grams if it is Samsung, it is more likely that this phone is Samsung. The prediction based on the Samsung model is closer. ~~It could however~~

(iii) While the provided models predict that this phone is more likely to be a Samsung phone, it could feasibly be either Samsung or Apple.

- A reservation I have about using these predictions is that no Apple phones have more than 7.5 inch screen sizes, and only one Samsung phone does, at nearly 8 inches. There is a severe lack of data for phones with 7.5 inch screens availible from this specific retailer. It is therefore hard to compare this new release to existing data ~~of the~~ of phones with similar screen sizes, and the models are not based off phones with 7.5 inch screens.

- ~~Anor~~ A reservation I have about the model for Samsung phones is that it is not a great fit. The linear correlation is only 0.71, and I would propose that an exponential model may fit the data better. This could yield a more accurate prediction.

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- ~~Overall~~ ~~A~~ reservation I have about the data overall is that it may not be ~~is not~~ representative of the population. The data is for "Apple and Samsung branded mobile phones listed on one US electronics retailer's website". This population may not be representative of all Apple & Samsung phones.

~~Also~~

- Finally, the total Apple phone's listed is only 13, and this could ~~be~~ be a very small sample of data.

QUESTION TWO

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a)(i) Both retail sales of electronics and accomodation show ~~an~~ clear seasonality. Electronics sales tend to peak each year in the final quarter - this is expected as electronics are often Christmas gifts, or purchased on Boxing day (both december. Accomodation sales tend to peak in the first and final quarters of each year. These are the warmest months and include the entirity of summer, so it is expected that people travel and purchase accomodation during these months. Electronics sales do not have a major dip in any quarter - they dip slightly in Q1. Accomodation sales are particularly low in Q2 and Q3 of each year, ~~they~~ likely because these include the coolest months and months where many are in full time employment. Therefore, less people have the need for accomodation. Electronics likely have more stable demand year round as people choose to upgrade phones / other items.

~~which isn't majorly affected~~

(ii) The trend in electronics sales ~~have~~ increased from around $600 million per quarter in 2010 to $1,200 million per quarter in 2020. The average ~~quar~~ increase is $60 million per year, however the rate of increase has accellerated. Between 2010 and 2015, ~~the increase~~ electronics sales were relatively steady, increasing at an average of only $20 million per year. Between 2015 and 2019, the ~~trend~~ trend increased to ~~appro~~ around $50 million per year. Between 2019 and ~~today~~ the end of 2020, the ~~year average quarterly sales~~ trend increased a whole $500 million. This is likely due to COVID, which meant more people had to work & learn at home increasing demand for electronics. In accomodation sales, the trend steadily increased from $650 million in 2010 to $1100 million in 2019, but had a sudden dip ~~between~~ in 2020, ~~heading~~ going back down to $850 million. This was likely due to COVID, which sent people into lockdown and resulted in international border closures reducing the need for accomodation.

(ii) An issue with the data from figure 5 for making forecasts for retail sales of electronics and accomodation in 2021 ~~is~~ is the impact of COVID. Both ~~retail sales~~ accomodation and ~~retail~~ electronics sales were affected in 2020, the former negatively and the latter positively. This could lead to less accurate forecasts into 2021, COVID is highly unpredictable and models may struggle to account for it. Accomodation sales may rebound or be further hurt, and ~~elec~~ electronics sales may slow down or further accellerate

(b) Between 1960 and 1999, fixed telephone subscriptions increased from around 20 per 100 people to 50 per 100 people in NZ. They began to decline in

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2000, hitting 35 per 100 in 2016 and accelerating down to 30 per 100 in 2017. ~~Nobody had~~ Very few had mobile cellular subscriptions until 1990, which was followed by a boom in growth until 2008 to around 110 subscriptions per 100 people, and again from 2013 to 2017 reaching around 135 subscriptions per 100 people. The financial crisis in 2008 may have affected growth of mobile cellular subscriptions. Nobody had fixed broadband subscriptions until 2000, followed by an exponential increase until 2007, and then a steady, linear increase in fixed broadband subscriptions until 2017, the year it overtook fixed telephone. In 2017 about 35 per 100 NZ ers had fixed broadband subcriptions. These trends are expected as the growth of the internet and mobile phone industries has lead to computers and mobile phones outcompeting traditional landline phones in the past decade. The latter ~~was~~ was too still modern techlology in the 20th century, likely explaining fixed telephone subscription growth through to 1999.

(c)(i) Fiji → NZ

2005 - 205000 3530000

2008 - 600000 4620000

$\frac{600000 - 250000}{250000}$ $\frac{4620000 - 3530000}{3530000}$

= 1.4 = 140% increase = 0.3088 = 30.9% increase

As ~~mobile~~ mobile subscriptions from 2005-2008 increased 140% in Fiji and ~~a~~ 30.9% in New zealand, this claim is justified.

(ii) Model for samoa vs Fiji - Samoa = 0.15 x Fiji
Model for Samoa vs NZ - Samoa = 0.0375 x NZ
~~Sn~~ - ~~22000000~~ 75,000
I created these visually using $\frac{\text{rise}}{\text{run}}$

Fiji model - Samoa = 0.15 x (640,000) = 96000
NZ model - Samoa = 0.0375 x (~~47~~00,000) = 101250
- ~~22000000~~ 75,000

I averaged the two models for my final answer → average = 98625

QUESTION THREE

(a) ② Plan - a plan was constructed to ensure the study could be efficiently conducted and to establish the aims and methodology

① Problem - a problem was identified - whether phone notifications affected memory.

③ Data - Data was collected using the described methodology and random allocation. Two independent groups were used to ~~compare~~ seperate the control and treatment variables.

④ Analysis - The results were analysed, likely using dot plots and box/whiskers to determine ~~in memory~~ if there was a difference in the number of words remembered between the two groups that could have been caused by the notifications (the treatment variable)

⑤ Conclusion - Rerandomisation was conducted to determine the liklihood of the results being due to chance, and determine whether there was a causal relationship between presense of notifications and the number of words remembered.

b) Students were randomly allocated as this ensures that any difference between the two groups was a result of the treatment variable - the notificartions - and not other factors. This allows for a causal relationship to be determined.

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(c) The rerandomisation shows that of 1000 randomisations only 69 had a difference in the mean of 0.85 or greater. The data showed that those with no mobile phone notifications remembered an average 0.85 words more than ~~those~~ with notifications. As the tail proportion is 69/1000 or 0.069, we can determine that there is some evidence against chance acting alone to produce these findings. This means the findings are likely statistically significant.

(d) Blocking could be used to split participants into groups of high / low memory ability. Random allocation could then take place, however ensuring the same number of individuals with high and low memory ability in each group.

(e) The results and randomisation tail proportion suggest that there is a statistically significant difference in number of words remembered between gamers (who recalled an average of 1.2 words more) and non gamers. However, there are many limitations to this, ~~[illegible]~~ and further limitations that do not support the claim "Playing video games significantly affects your memory for the better".
Firstly the sample of gamers may be significantly bigger or smaller than non gamers, affecting

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results. Secondly, this data was collected through a questionaire. These can be subject to non-sampling biases. For example, participants' responses may have been affected by the hawthorne effect, where they modify their responses according to what they believe to be desirable. This could lead to dishonesty and inaccurate results.

QUESTION FOUR

(a) The variable 'island' was created from the variable 'region'. This can be done as everyone in a region also belongs to an island that has the region within. For example, everyone from Canterbury region would also be a part of Te Waiponamu (South Island)

The variable school level was created from the variable year level. Every year level fits into a school level, for example all Year 5s are 'Primary or Intermediate'

(b)(i) The majority of students who participate in Tatauranga Ki Te Kura Aotearoa have always been from the North Island, but the margin by which this is the case has decreased from 81.5% in 2005 to 73.3% in 2019. As the sample is 8000, the margin of error in the sample is approximately $\frac{1}{\sqrt{8000}} = 1.1\%$.
The majority of participants have always had mobile phones. This variable was subject to a rapid increase between 2005 to 2007, from 58% who do to 69.3%, reaching 98.3% by 2019.
There has been wide variation in the amount of students at primary/intermediate or high school, initially (in 2005) 58.6% were primary/intermediate though this dropped as low as 30.4%.

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due to a steady decline until 2015 before jumping back up to around 44% in 2017/2019.

(ii) Colours were used to differentiate between categorical variables, for example purple for secondary school and blue for primary/intermediate

Dots and lines were used ~~...~~ to provide a visualization for the differences in percentages. Wider dots/longer lines meant greater percentage differences.

(iii) Firstly, this is a sample from a sample. We calculated that due to this sample being 8,000 people large, it could be extrapolated with an MOE of ±1.1% to the wider population of survey participants. However, this would need to be extrapolated further to represent NZ Y3-13 students overall. Sampling error could take place, meaning that those who took the survey may not represent the NZ Y3-13 population. Also, non-sampling error may have taken place. Those who took the survey may have been more or less likely to access phones, or may be from targeted regions or age groups that are therefore overrepresented in the survey data. Participants may have also modified their responses to what they believe is desirable (like having a phone) exhibiting the Hawthorne effect.

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(c) Assuming that this random sample is representative of all NZers Y3-13 that own mobile phones, this claim still has flaws.
~~Firstly, it is inherently false~~

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QUESTION FIVE

(a)(i) The sample data distributions show that apps ~~apple~~ uploaded to the Apple App store in the selected hour tended to be larger than those uploaded to the Android Google Play Store. There was a significantly larger interquartile range for apps uploaded to the Apple App store, spanning near 0mb to 775mb, compared to a range of near 0 to 100mb for apps uploaded to the Android Google play store. The apple app data is ~~was~~ relatively evenly spread between 0mb and 425mb, with one outlier at 775mb. The Android app data is ~~was~~ right / positively skewed with no notable outliers. The mean android app size is around 20mb, and the mean apple app size is around 205mb. It can be concluded that of the apps uploaded in this selected hour, Apple apps tended to be larger, there were also less apps uploaded to Apple than to Android, ~~with~~ with a difference in means of 192.72.

The bootstrap confidence interval suggests that of all app uploads to the ~~two platforms Android~~ Android Google Play store and Apple App store, the difference in mean app size is highly likely to fall between 137.64 and 261.69 mb. As this does not include 0, we can conclude that it is highly likely that the mean app size upload to the Apple App store is between 137.6 and 261.7mb larger than the ~~average~~ average upload to the Android google play store.

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ii) Problem - The student would identify the problem he wants to research, which is whether the average size of the largest mobile phone app students at his school have and whether this is related to the type of phone they have - Apple / android.

Plan - The student would plan how he will carry out his statistical inquiry. He would need to determine his variables - size of largest phone app and type of phone, numerical and categorical respectively. He would plan his method of collecting this data - such as a questionnaire of students, asking them these questions. This method could be subject to self report bias or the Hawthorne effect but is likely far less time consuming than going through every participant's phone.

Data - The student would then need to collect their data. They could ask every student in each of their classes to check their phones and fill out a survey (printed or google form) they created. They could send this to their whole school, but more realistically a sample of students from the school would be selected.

Analysis - The student coud plot their gathered data on to dot plot / box & whisper data distribution and analyse the features of their recorded data.

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If the means were significantly different, it would indicate ~~maten~~ there was a notable difference in largest app size and phone type. To clarify: the two plots would be for apple & android phones (y axis, categorical) and the numerical x-axis of the plot would be for the largest app size on the student's phone.

Conclusion - Finally, the student would construct confidence intervals for their data through bootstrapping. This would determine what the average difference in mean was ~~for~~ between the two groups for the whole school - an inferential claim could be made. It is possible that the confidence interval includes 0 and does not provide a definitive answer.

(b) (i) The probability would be 0·1883 that an android phone had battery between 60% and 70%.

(ii)

(iii) ~~computer 39%~~ ~~unplugged from outlet w/ 30~~ ~~23%~~ ~~Power 61%~~ ~~Up 23%~~ next page

	Computer		Outlet	
	within 30	not	within 30	not

	Computer	Outlet	
Unplugged within 30m	13.8%	9.2%	23%
not	25.2%	51.8%	77%
	39%	61%	100

~~8%~~. 51.8% charged through an outlet and did not unplug within the first 30 mins.

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Annotated Scholarship Exemplar Template

Subject	Statistics	***Standard***	93201	***Total score***	27

Q	***Score***	***Annotation***
1	7	Three key comparative features, with specific numerical evidence, have been described from Figures 1 to 3. The candidate has recognised that a non-linear model may be more suitable for Samsung phones using Figure 4. The missed Outstanding mark for this question is from 1 (a) (ii) where only 1 additional piece of information was given before generalising to the whole population. The candidate has only listed one set of reasons focussed around the price of phones.
2	6	Sufficient and insightful descriptions of three key features (trend, seasonal and unusual) of the electronic and accommodation sales time series data were given, importantly with numerical evidence. The impact of 2020's COVID-19 on the spending data and impact on future modelling was described with enough detail, recognising the struggle modelling will have to take into account unpredictable events. Predictions for Samoa mobile phones in 2009 was done incorrectly. The process should have been to assume a linear step increase in the missing years taking the 2007 and 2010 figures as the start and end values. A value for 2009 should have been calculated on a pro-rata basis and then checked for reasonableness using the scatter graphs in Figure 7.
3	3	Insufficient correct statistical terminology was used to identify the key experimental design principles in 3 (a). The part of the question in 3(a) that was in bold was emphasising the need for correct such terminology. There is an incorrect assumption in the design of the experiment in 3 (d) that the number of experimental units in each group had to be the same. An explicit statement about the inability to make a causal claim due to the observational status of the study was required for one of the Outstanding marks in 3 (e).
4	5	Sufficient numerical evidence comparing two time points (at least 8 years apart) across at least two different variables was seen in 3 (b) (i) describing the results of the biennial Census at School survey since 2005 through to 2019. Only one reason was given in 3 (b) (iii) identifying reservations for sample to population inferences explicitly linked to mobile phone ownership.
5	6	For question 1 (a) (i) two features from the sample data in the Bootstrapping output (sample difference in means and comparing spreads of the two samples) and a correct inference, with direction using the confidence interval limits and identifying the population parameter are seen. It is important to note that features in the output based on the sample are discussed, not just the inference from the confidence interval. The two way table seen for 5 (b) (iii) was set up perfectly but the conditional probabilities and relative comparison not followed through.

Confirmation of check	***Y / N***
This exemplar has been checked for similarities with current online exemplars.	Y/N