

Solutionbank S3

Edexcel AS and A Level Modular Mathematics

Sampling

Exercise A, Question 1

Question:

Explain briefly what is meant by the term sampling and give three advantages of taking a sample as opposed to a census.

Solution:

The selection of individual elements of a population. Advantages: low cost, results obtained faster than a census, represents whole population, can be more reliable.

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Exercise A, Question 2

Question:

Define what is meant by a census. By referring to specific examples, suggest two reasons why a census might be used.

Solution:

Every item is observed/measured, e.g. National census for forecasting school places.
Census of a nursery school for numbers of carriers of a virus.

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Exercise A, Question 3

Question:

A factory makes safety harnesses for climbers and has an order to supply 3000 harnesses. The buyer wishes to know that the load at which the harness breaks exceeds a certain figure.

Suggest a reason why a census would not be used for this purpose.

Solution:

All the harnesses would be destroyed in testing them.

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Exercise A, Question 4

Question:

Explain:

- a why a sample might be preferred to a census,
- b what you understand by a sampling frame,
- c what effect the size of the population has on the size of the sampling frame,
- d what effect the variability of the population has on the size of the sampling frame.

Solution:

- a Cheaper, quicker.
- b The sampling frame is a list of all the members in the population (i.e. all the sampling units).
- c The larger the population, the longer the list, so the larger the sampling frame.
- d The variability of the population doesn't change how many members are in it, the list remains the same size so the size of the sampling frame isn't affected.

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Exercise A, Question 5

Question:

Using the random numbers 4 and 3 to give you the column and line respectively in the random number table (table x , p. 139), select a sample of size 6 from the numbers:

- a 0–99
- b 50–150
- c 1–600

Solution:

- a 01, 06, 64, 65, 94, 41 or 01, 18, 70, 97, 99, 56: others are possible.
- b 079, 056, 110, 086, 143, 108 or 136, 097, 148, 069, 137, 123; others are possible.
- c 010, 441, 172, 193, 249, 569 or 010, 184, 561, 547, 570, 278.

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Exercise A, Question 6

Question:

A company wishes to do consumer marketing research using a certain town. Suggest a suitable sampling frame and describe in detail a way of selecting a sample of 400 people aged over 21.

Solution:

Electoral roll, could use systematic sampling (large number in population)
(see next section).

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Exercise B, Question 1

Question:

Explain briefly the difference between a census and a sample survey.

Write brief notes on:

- a simple random sampling,
- b stratified sampling,
- c systematic sampling,
- d quota sampling.

Your notes should include the definition, and any advantages and disadvantages associated with each method of sampling

Solution:

A census is where information is obtained from every member of the population.

A sample is a sub-set of the population's information.

- a A simple random sample is a sample that is taken so that every member of the population has an equal chance of being included, all sub-groups of size n are equally likely to be chosen and sampling is taken without replacement. It can be difficult in a large population.
- b A stratified sample is where the population is divided into mutually exclusive groups and is where the proportion of the sample in each of these groups is the same as the proportion with which the group occurs in the population. It is good in easily stratified populations but you need to know the structure of the population. It is the most representative statistically. Within each strata members are selected by random sampling.
- c Choosing at regular intervals from an ordered list; good for large populations and easy to use; bias in ordered list can be a problem.
- d A quota sample has the proportions as for a stratified sample (see part **b**), but the 'quota' in each group allows the interviewer to choose who to interview to fill the quota required in the group. This is faster and cheaper than stratified sampling but can introduce 'interviewer bias' in who is interviewed.

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Exercise B, Question 2

Question:

- a Explain the purpose of stratification in carrying out a sample survey.
- b The headteacher of an infant school wishes to take a stratified sample of 20% of the pupils at his school. The school has the following numbers of pupils.

Year 1	Year 2	Year 3
40	60	80

Work out how many pupils in each age group there will be in the sample.

Solution:

- a Divides population into mutually exclusive groups, where the proportion in each group in the sample is the same as that in the population. It is used so that the 'results' obtained will represent the 'results' of the whole population as closely as possible because this 'stratification' reduces bias.
- b Year 1: 8, Year 2: 12 and Year 3: 16

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Exercise B, Question 3

Question:

A survey is to be done on the adult population of a certain city suburb, the population of which is 2000. An ordered list of the inhabitants is available.

- a What sampling method would you use and why?
- b What condition would have to be applied to your ordered list if the selection is to be truly random?

Solution:

- a Systematic sampling would be easy to use.
- b The ordered list would need to be truly random.

Note that if the structure of the sample of 2000 were known, it would be possible (and desirable) to take a stratified sample. With such a small sampling frame it would be possible to choose a simple random sample using random number tables, which would be truly random!

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Exercise B, Question 4

Question:

In a marketing sample survey the sales of cigarettes in a variety of outlets is to be investigated. The outlets consist of small kiosks selling cigarettes and tobacco only, tobacconist's shops that sell cigarettes and related products and shops that sell cigarettes and other unrelated products.

- a Suggest the most suitable form of taking a random sample.
- b Explain how you would conduct the sample survey.
- c What are the advantages and disadvantages of the method chosen?

Solution:

- a Stratified – three strata.
- b Questionnaire to 10% of each strata.
- c Advantages: information on each strata, results should reflect those of the population.
Disadvantages: not suitable if sample size is large, strata may overlap if not already defined.

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Exercise B, Question 5

Question:

- a Explain briefly:
- i why it is often desirable to take samples,
 - ii what you understand by a sampling frame.
- b State two circumstances when you would consider using
- i systematic sampling,
 - ii stratification when sampling from a population,
 - iii quota sampling.

Solution:

- a i Cost, takes less time than a census.
- ii List of sampling units used to represent the population.
- b Many possible answers, e.g.
- i shoppers at a supermarket when considering shopping
 - ii students in a secondary school when looking at school meals
 - iii voters asked which party they are going to vote for.

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Exercise B, Question 6

Question:

A factory manager wants to get information about the ways his workers travel to work. There are 480 workers in the factory, and each has a clocking in number. The numbers go from 1 to 480. Explain how the manager could take a systematic sample of size 30 from these workers.

Solution:

$$k = \frac{480}{30} = 16$$

Randomly select a number between 1 and 16. Starting with the worker with this clock number select the workers that have every 16th clock number after this.

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Exercise C, Question 1

Question:

Using the random numbers on page 139, and starting at the top of the 11th column with the number 88 and working down, a simple random sample (without replacement) of size 10 was taken of numbers between 0 and 75 inclusive. The first two numbers were 17 and 52.

- a Find the other eight numbers in the sample.
- b Explain, with the aid of a practical situation, how this set of random numbers could be used to take a sample of size 10.

Solution:

- a 12, 60, 73, 9, 41, 20, 04, 36
- b Say the population was a school year of size 76, each member of this population is written down in alphabetical order and numbered. Students whose numbers correspond to the numbers from the table are selected. Repeats are ignored.

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Exercise C, Question 2

Question:

- a Give one advantage and one disadvantage of using
- a census,
 - a sample survey.
- b It is decided to take a sample of 100 from a population consisting of 500 elements. Explain how you would obtain a simple random sample without replacement from this population.

Solution:

- a i Advantage: very accurate; disadvantage: expensive (time consuming).
- ii Advantage: easier data collection (quick, cheap); disadvantage: possible bias.
- b Assign unique 3-digit identifiers 000, 001, ..., 499 to each member of the population. Work along rows of random number tables generating 3-digit numbers. If these correspond to an identifier then include the corresponding member in the sample; ignore repeats and numbers greater than 499. Repeat this process until the sample contains 100 members.

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Exercise C, Question 3

Question:

- a Explain briefly what you understand by
- i a population,
 - ii a sampling frame.
- b A market research organisation wants to take a sample of
- i owners of diesel motor cars in the UK,
 - ii persons living in Oxford who suffered from injuries to the back during July 1996.
- Suggest a suitable sampling frame in each case.

Solution:

- a i Collection of individual items.
- ii List of sampling units.
- b i List of registered owners from DVLA.
- ii List of people visiting a doctor's clinic in Oxford in July 1996.

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Exercise C, Question 4

Question:

A gym keeps a numbered alphabetical list of their 200 clients.
Explain how you would choose a simple random sample of 40 clients.

Solution:

Assign unique 3-digit identifiers 000, 001, ..., 199 to the clients. Work along random tables rows generating 3-digit numbers – include the members corresponding to these numbers in the sample, ignoring repeats and numbers larger than 199. Repeat this until the sample includes 40 members.

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Exercise C, Question 5

Question:

Write down one advantage and one disadvantage of using:

- a stratified sampling,
- b simple random sampling.

Solution:

- a Advantage – the results are the most representative of the population since the structure of the sample reflects the structure of the population.
Disadvantage – you need to know the structure of the population before you can take a stratified sample.
- b Advantage – quick and cheap.
Disadvantage – can introduce bias (e.g. if the sample, by chance, only includes very tall people in an investigation into heights of students).

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Exercise C, Question 6

Question:

The managing director of a factory wants to know what the workers think about the factory canteen facilities. One hundred people work in the offices and 200 work on the shop floor.

He decides to ask the people who work in the offices.

- a Suggest reasons why this is likely to produce a biased sample.
- b Explain briefly how the factory manager could select a sample of 30 workers using:
 - i systematic sampling,
 - ii stratified sampling,
 - iii quota sampling.

Solution:

- a People not in office not represented.
- b
 - i Get a list of the 300 workers at the factory. $\frac{300}{30} = 10$ so choose one of the first ten workers on the list at random and every subsequent 10th worker on the list, e.g. if person 7 is chosen, then the sample includes workers 7, 17, 27, ..., 297.
 - ii The population contains 100 office workers ($\frac{1}{3}$ of population) and 200 shop floor workers ($\frac{2}{3}$ of population).
The sample should contain $\frac{1}{3} \times 30 = 10$ office workers and $\frac{2}{3} \times 30 = 20$ shop floor workers. The 10 office workers in the sample should be a simple random sample of the 100 office workers. The 20 shop floor workers should be a simple random sample of the 200 shop floor workers.
 - iii Decide the categories e.g. age, gender, office/non-office and set a quota for each in proportion to their numbers in the population. Interview workers until quotas are full.

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Exercise C, Question 7

Question:

A garden centre employs 150 workers. Sixty-five of the workers are women and 85 are men. Explain briefly how you would take a random sample of 30 workers using stratified sampling.

Solution:

List separately men and women. take a simple sample of $\frac{65 \times 30}{150} = 13$ women and 17 men.

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Exercise C, Question 8

Question:

The 240 members of a bowling club are listed alphabetically in the club's membership book. The committee wishes to select a sample of 30 members to fill in a questionnaire about the facilities the club has to offer.

- a Explain how the committee could use a table of random numbers to take a systematic sample.
- b Give one advantage of this method over taking a simple random sample.

Solution:

- a Label members 1 \rightarrow 240. Use random numbers to select first from 1–8. Select every 8th member (e.g. 6, 14, 22, ...)
- b For example: more convenient, efficient, faster, simpler to carry out etc.

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Exercise C, Question 9

Question:

- a Explain briefly what you understand by:
- i a population,
 - ii a sample.
- b Give one advantage and one disadvantage of taking a sample.

Solution:

- a i The group of all the individuals or items of interest in the investigation.
ii A selection of individual members of the population.
- b Advantage: reduction in the amount of data to be analysed; disadvantage: loss of reliability and accuracy (relative to whole population).

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Exercise C, Question 10

Question:

A college of 3000 students has students registered in four departments: arts, science, education and crafts. The principal wishes to take a sample from the student population to gain information about the likely student response to a rearrangement of the college timetable in order to hold lectures on Wednesday, previously reserved for sports.

What sampling method would you advise the principal to use? Give reasons to justify your choice.

Solution:

Stratified – gives all groups an equal chance to give their views.

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Exercise C, Question 11

Question:

As part of her statistics project, Deepa decided to estimate the amount of time A-level students at her school spent on private study each week. She took a random sample of students from those studying arts subjects, science subjects and a mixture of arts and science subjects. Each student kept a record of the time they spent on private study during the third week of term.

- a Write down the name of the sampling method used by Deepa.
- b Give a reason for using this method and give one advantage this method has over simple random sampling.

Solution:

- a Stratified sampling
- b Uses naturally occurring (strata) groupings. The results are more likely to represent the views of the population since the sample reflects its structure.
e.g. variance of estimator of population mean is usually reduced, either individual strata estimates available.

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Exercise C, Question 12

Question:

There are 64 girls and 56 boys in a school.

Explain briefly how you could take a random sample of 15 pupils using

- a a simple random sample,
- b a stratified sample.

Solution:

- a Allocate a number between 1 and 120 to each pupil.
Use random number tables, computer or calculator to select 15 different numbers between 1 and 120 (or equivalent).

Pupils corresponding to these numbers become the sample.

- b Allocate numbers 1–64 to girls and 65–120 to boys. Idea of different sets for boys and girls

Select $\frac{64}{120} \times 15 = 8$ different random numbers between 1–64 for girls

Select 7 different random numbers between 65–120 for boys.

Include the corresponding boys and girls in the sample.