Grade 12 Computing

Unit 5 · Data, Evidence and Decisions

ANSWER KEY · FOR TEACHERS

Full marks 31

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. population
2. biased
3. bootstrap
4. residual
5. overfitting
6. confounder
7. null hypothesis
8. p-hacking

K · 4

Each carries 0.5 mark.

2 Multiple choice

i. **b.** The people who answered chose themselves: readers of that site, with internet, who cared enough to click. U · 1

A self-selected sample speaks for the kind of people who chose to answer, not for everyone. 15,000 would be plenty if they had been chosen at random: the size of the population hardly matters.

ii. **c.** 400 A · 1

The error shrinks in proportion to 1 ÷ √(sample size). To halve it, the square root must double, so the sample must be four times bigger: 400.

iii. **b.** On average, each extra year of age goes with a price about Rs. 12,000 lower. U · 1

The slope is the change in the prediction for each 1 more across: −12,000 rupees for each year. "On average" matters: real bikes sit above and below the line. A new bike, age 0, is the intercept, Rs. 180,000, and only if bikes that new were in the data.

iv. **c.** A third factor, more people and more traffic, brings both more towers and more accidents. U · 1

Busy districts with more people need more towers and also have more vehicles on the road. The correlation is real, but the towers don't cause the accidents, and removing towers wouldn't prevent any.

v. **b.** Were the green tea drinkers different in other ways, such as being richer or healthier already? U · 1

This sounds like an observational study: people chose whether to drink green tea. Those who do may differ in money, diet, exercise and health, any of which could explain living longer. 20,000 is plenty of people; size can't fix a hidden third factor.

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3 Fit a line by hand

ANSWER **A · 5**

Hours x	Marks y	x − 6	y − 63	(x − 6)(y − 63)	$(x - 6)^2$
2	50	−4	−13	52	16
4	58	−2	−5	10	4
6	61	0	−2	0	0
8	70	2	7	14	4
10	76	4	13	52	16
Total				**128**	**40**

i. Slope = 128 ÷ 40 = **3.2** marks per hour; intercept = 63 − 3.2 × 6 = **43.8**. So marks = 43.8 + 3.2 × hours.

ii. 43.8 + 3.2 × 7 = **66.2 marks**.

iii. **On average, each extra hour a week goes with about 3.2 more marks**, for these five students. It doesn't show cause: students who study more may differ in other ways (interest, help at home, a quiet room), and five students chose their own hours. Only an experiment, with chance deciding who studies more, could show that the hours themselves raise marks.

MARKING SCHEME

✓ The products 52, 10, 0, 14, 52 (total 128) and the squares 16, 4, 0, 4, 16 (total 40).
✓ Slope 3.2 and intercept 43.8.
✓ 66.2 marks for 7 hours.
✓ The slope in words, with "on average": about 3.2 marks more for each extra hour.
✓ Not cause: a correlation in data where students chose their hours; a confounder could explain it.

4 Reading a fitted line

ANSWER **A · 3**

i. 25.45 − 0.00487 × 827 = 25.45 − 4.03 ≈ **21.4 °C**. Residual = real − predicted = 21.5 − 21.4 = **+0.1 °C**: Pokhara is a little warmer than the line says.

ii. 25.45 − 0.00487 × 6,000 = 25.45 − 29.22 ≈ **−3.8 °C**. That is an **extrapolation**, far beyond the highest station (2,363 m): nothing was measured that high, and the slope may change with height, so the data can't show it.

MARKING SCHEME

✓ About 21.4 °C predicted for Pokhara.
✓ Residual about +0.1 °C (real minus predicted).
✓ About −3.8 °C at 6,000 m, an extrapolation beyond the data, not to be trusted.

5 How sure is the estimate?

ANSWER **U · 3**

i. The households spend about **Rs. 612** a month on mobile data (**95% interval Rs. 518 to Rs. 710**, from 40 households chosen at random).

ii. The width shrinks as 1 ÷ √(the sample size), so halving it needs four times as many: about **160 households**.

iii. No. People on the ward's Facebook page who choose to answer are a **self-selected** sample: they all have internet and may spend more on data than the ward as a whole. Their estimate would be biased, and bias doesn't shrink when the sample grows.

MARKING SCHEME

✓ The estimate with its 95% interval, the sample size and how it was chosen.
✓ Four times the sample, about 160 households.
✓ No: a self-selected (biased) sample; size doesn't cure bias.

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6 What does it print?

ANSWER **A · 4**

```
OUTPUT
before 100 18.0
after 100 21.6
```

i. Both shifts' waits went **down**: the morning from 30 to 25 minutes, the afternoon from 10 to 8. The average for the whole day went **up**, from 18.0 to 21.6, because after the change many more of the patients came in the busy morning (80 of 100 instead of 40), when every wait is longer. This is **Simpson's paradox**: the mix of groups changed, so the overall average hides what happened in each group.

MARKING SCHEME

- ✓ `before 100 18.0`: (40 × 30 + 60 × 10) ÷ 100.
- ✓ `after 100 21.6`: (80 × 25 + 20 × 8) ÷ 100.
- ✓ Both shifts' waits fell.
- ✓ The overall average rose because more patients came in the morning, when waits are longest (Simpson's paradox).

7 Find and fix the bug

ANSWER **A · 3**

i. `random.sample` picks **without replacement**: 10 picks from 10 values take every value exactly once, only in a different order, so every resample has the same average. A bootstrap resample must pick **with replacement**, so that some households come up twice and others not at all, as a new random sample from the ward would.

ii. Line 9: `again = random.choices(spend, k=len(spend))`. It then prints an interval of about Rs. 395 to Rs. 815.

MARKING SCHEME

- ✓ `random.sample` picks without replacement, so each resample is the same 10 values reordered.
- ✓ A bootstrap needs picks with replacement.
- ✓ `random.choices(spend, k=len(spend))` on line 9.

8 Could chance do it?

MARKING SCHEME **U · 2**

- ✓ The p-value is how often chance, with no real difference, would give a difference this big: not the chance the buttons are the same.
- ✓ 60% means chance easily explains it: no evidence either way (a small test can find only big differences).

9 Think

ANSWER **HA · 2**

Students who choose the app may already differ: keener, with a phone and data at home, with parents who push them. Any of these confounders could raise their marks with no app at all. A fairer test is a **randomized controlled experiment**: let chance decide which students (or which classes) get the app and which don't, measure the same test for both groups at the end, decided in advance, and check with a shuffle test whether the difference is bigger than chance would give.

MARKING SCHEME

- ✓ Students who choose it differ in other ways (a confounder), so the comparison can't show cause.
- ✓ Chance decides who gets the app (random groups), with the measure decided in advance and the difference compared with what chance gives.

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10 Activity: A survey of one ward

(not marked)

WHAT STUDENTS SHOULD FIND

- At random, the estimates scatter on both sides of 40%: with 10 households from about 10% to 70%; with 40, mostly between about 28% and 52%; with 160, between about 34% and 46%. Each fourfold increase halves the scatter.
- Along the road, every estimate is far too high, near 75%, and a bigger sample only makes the wrong answer steadier: size cures chance, not bias.

Marks by level	Knowledge	Understanding	Application	Higher ability	**Total**
Marks	4	9	16	2	**31**

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