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## HYPOTHESIS TESTING

### 2019 VJC P2 Q9

Exposure to Volatile Organic Compounds (VOCs), which have been identified in indoor air, is suspected as a cause of headaches and respiratory systems. Indoor plants have not only a positive psychological effect on humans, but may also improve the air quality. Certain species of indoor plants were found to be effective removers of VOCs.

A commonly known VOC is Benzene. The following data gives the benzene levels,  $x$  (in ppm) in 40 test chambers containing the indoor plant *Epipremnum aureum*.

$$n = 40, \quad \sum(x - 26.0) = -30.1, \quad \sum(x - 26.0)^2 = 214.61.$$

The initial mean Benzene level (in ppm) without *Epipremnum aureum* was found to be 26.0.

- (i) Test, at the 5% level of significance, the claim that the mean Benzene level,  $\mu$  (in ppm), has decreased as a result of the indoor plant *Epipremnum aureum*. You should state your hypotheses clearly. [5]
- (ii) State, giving a reason, whether there is a need to make any assumptions about the population distribution of the Benzene level in order for the test to be valid. [2]

The Benzene levels of another 50 test chambers containing the indoor plant *Epipremnum aureum* were recorded. The sample mean is  $\bar{x}$  ppm and the sample variance is 8.33 ppm<sup>2</sup>.

- (iii) The acceptance region of a test of the null hypothesis  $\mu = 26.0$  is  $\bar{x} > 25.1$ . State the alternative hypothesis and find the level of significance of the test. [4]
- (iv) If the null hypothesis is  $\mu = \mu_0$ , where  $\mu_0 > 26.0$ , would the significance level of a test with the same acceptance region in part (iii) be larger or smaller than that found in (iii)? Give a reason for your answer. [2]

### 2019 CJC P2 Q9 [MODIFIED]

The security guard of a particular school claims that the average speed of the cars in the school compound is greater than the speed limit of 25 km/h. To investigate the security guard's claim, the traffic police randomly selected 50 cars and the speed was recorded. The total speed and the standard deviation of the 50 cars are found to be 1325 km/h and 7.75 km/h respectively.

- (i) Find the unbiased estimates of the population mean and variance. [2]
- (ii) Test at 5% level of significance whether there is sufficient evidence to support the security guard's claim. [4]
- (iii) Without any further test, state the conclusion if instead the traffic police is testing that the average speed of the cars is not 25 km/h at 20% level of significance [2]

Answers: (i)  $\bar{x} = 26.5$ ,  $\sigma_x^2 = 61.3$

## 2007 IJC P2 Q11

- (b) In general, the marks obtained by students in their Mathematics examination may be assumed to be a random variable with mean 65 and variance 32.

After the introduction of a new program of revision classes, it is found that there are improvements to the marks of the some of the students.

A random sample of the marks of 50 students is taken, and the mean is found to be 66.4. A test is conducted and it shows that there is insufficient evidence that the new program of revision classes is effective. Find an inequality satisfied by the significance level of the test. [3]

- (c) A sample of  $n$  observations is taken from a population with mean 5. The sample mean is found to be 5.1 and sample standard deviation 0.7. A 2-tailed normal test ( $z$ -test) is conducted and the null hypothesis is rejected at the 5% significance level. Find the least value of  $n$ .

Answers: (b)  $\alpha < 4.01$  (c) 190

## 2015 AJC P2 Q10

A farmer claims that the mean weight of the melons grown in his farm is at least 1.2 kg. A random sample of 10 melons is chosen and the weight,  $x$  kg, of each melon is recorded. The results are as follows:

1.037	0.914	1.019	1.234	1.110
1.417	1.008	0.846	1.105	1.331

Assuming the weight of a randomly chosen melon follows a normal distribution, carry out an appropriate test of the farmer's claim at the 10% significance level. [4]

A buyer concludes that the sample could not provide sufficient evidence, at  $\alpha\%$  significance level, that the mean weight differs from 1.2kg. State the range of values of  $\alpha$  for him to draw such a conclusion. [1]

Another random sample of 40 melons is weighed and the results are as follows:

$$\sum x = 45.738 \quad \text{and} \quad \sum x^2 = 72.576$$

- (i) By combining the 2 sets of data, find unbiased estimates of the population mean and population variance of the weight of a melon grown by this farmer. [2]
- (ii) The farmer decides to change the claim to "the mean weight of the melons grown in his farm is at least  $m$  kg". Based on the combined sample of size 50, find the set of values of  $m$  for which the farmer's claim is not rejected at the 5% significance level. [3]

Answers: Reject  $H_0$ ,  $\alpha < 7.85$  (i) 1.13518, 0.42001 (ii)  $0 \leq m < 1.29$

## 2018 EJC P2 Q8

A teacher, Mr. Ku, suspects that the average time a student spends on his or her mobile phone per day is  $\mu_0$  minutes. He selected a random sample of 97 students in the school who own mobile phones and recorded the amount of time each student spent on his or her phone in a randomly selected day. The results are displayed in the table below.

Time spent per day (to nearest minute)	60	65	72	90	110	180
Number of people	11	20	32	18	10	6

- (i) Calculate unbiased estimates of the population mean and variance of the time a student spends on his or her mobile phone per day. [2]

The null hypothesis that the average time a student spends on his or her mobile phone per day is  $\mu_0$  minutes is tested, at 5% level of significance, against the alternative hypothesis that the average time a student spends on his or her mobile phone per day differs from  $\mu_0$  minutes.

- (ii) Determine the range of values of  $\mu_0$  for which the null hypothesis is rejected. [5]
- (iii) Explain, in the context of this question, the meaning of 'at 5% level of significance'. [1]
- (iv) If the null hypothesis in (ii) is rejected at 5% significance level, can we reject the null hypothesis at 1% level of significance? Explain your answer. [1]

Answers: (i) 83.1; 842 (ii)  $\mu_0 > 88.9$  or  $\mu_0 > 77.4$  (iii) 5% level of significance means that there is a 0.05 probability of concluding that the average time a student spent on their mobile phone per day differs from  $\mu_0$  when in actual fact it did not. (iv) Inconclusive.