Comprehension: The pharmaceutical company Sun Pharma is manufacturing a new batch of painkiller drugs, which are due for testing. Around 80,000 new products are created and need to be tested for their time of effect (which is measured as the time taken for the drug to completely cure the pain), as well as the quality assurance (which tells you whether the drug was able to do a satisfactory job or not).

Question 1: The quality assurance checks on the previous batches of drugs found that — it is 4 times more likely that a drug is able to produce a satisfactory result than not.Given a small sample of 10 drugs, you are required to find the theoretical probability that at most, 3 drugs are not able to do a satisfactory job.

a.) Propose the type of probability distribution that would accurately portray the above scenario and list out the three conditions that this distribution follows.

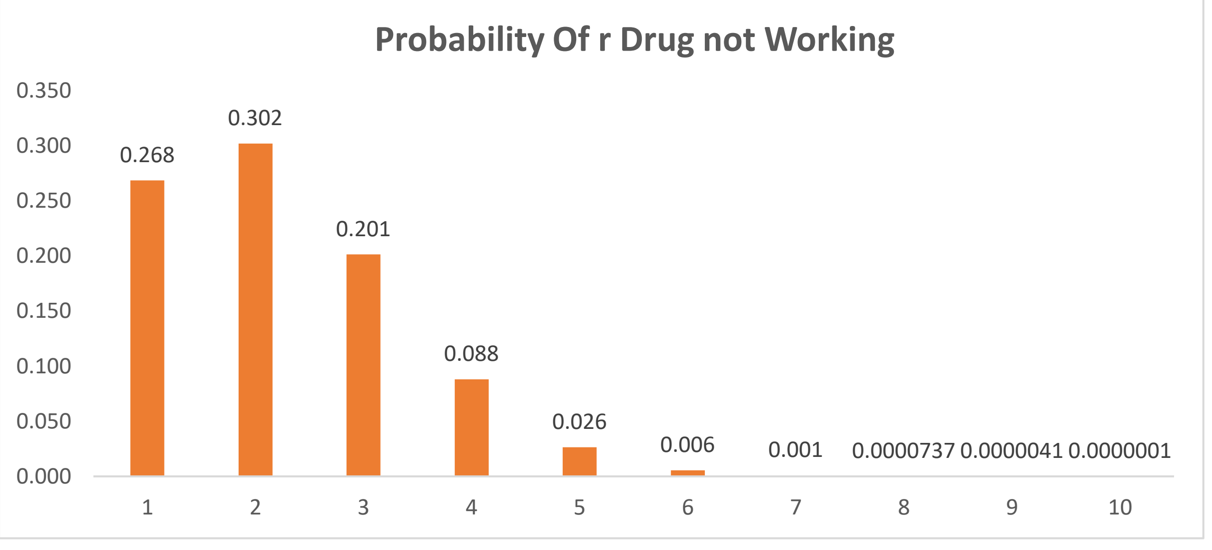
b.) Calculate the required probability.

Ans1 a: The binomial distribution can be used to calculate the probability of an event, if it follows the following conditions

Each trial's outcome is pass or fail / binary (drug will work or not work)

Probability of not working/being ineffective = 1/5 =0.20 (Fixed for each trail)

Total number of trails = 10 (Fixed)



Ans 1b: 0.77

r	Probability of r Drug not working	n=10	P (Drug Not Working) =0.20=1/5	Probability of at most 3 drugs not working (Cum of 1,2 and 3)
1	0.268			
2	0.302			
3	0.201			0.772
4	0.088			
5	0.026			
6	0.006			
7	0.001			
8	0.0000737			
9	0.0000041			
10	0.0000001			

Question 2: For the effectiveness test, a sample of 100 drugs was taken. The mean time of effect was 207 seconds, with the standard deviation coming to 65 seconds. Using this information, you are required to estimate the range in which the population mean might lie — with a 95% confidence level.

a.) Discuss the main methodology using which you will approach this problem. State all the properties of the required method. Limit your answer to 150 words.

b.) Find the required range.

Ans 2a: CLT (Central Limit Theorem) helps us estimate the population mean from the sample mean and sample standard deviation given.

Sample mean = 207 seconds

Sample Standard Deviation = S = 65 seconds

n = 100 (greater than 30 hence hence sampling distribution is a normal distribution)

Below general principal holds good to estimate population mean which follows from CLT (Central Limit Theorem)

For a sample with sample of size **n**, mean ***X* bar** and standard deviation **S**.

With   y% confidence level we can say μ /population mean will lie in the range of:

(X bar− $Z*S$ √n, X bar+ $Z*S$ √n)

Where, Z* is the Z-score associated with a y% confidence level.

Ans 2b:

Sample mean = 207 seconds

Sample Standard Deviation = S = 65 seconds

n = 100

Z for 95% confidence level = 1.96

Interval in μ / population mean will lie (207-1.96 * 65 / 10, 207-1.96 * 65 / 10) = (194.26,219.74) seconds

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Question 3:

a) The painkiller drug needs to have a time of effect of at most 200 seconds to be considered as having done a satisfactory job. Given the same sample data (size, mean, and standard deviation) of the previous question, test the claim that the newer batch produces a satisfactory result and passes the quality assurance test. Utilize 2 hypothesis testing methods to make your decision. Take the significance level at 5 %. Clearly specify the hypotheses, the calculated test statistics, and the final decision that should be made for each method.

b) You know that two types of errors can occur during hypothesis testing — namely Type-I and Type-II errors — whose probabilities are denoted by α and β respectively. For the current sample conditions (sample size, mean, and standard deviation), the value of α and β come out to be 0.05 and 0.45 respectively.

Now, a different sampling procedure (with different sample size, mean, and standard deviation) is proposed so that when the same hypothesis test is conducted, the values of α and β are controlled at 0.15 each. Explain under what conditions would either method be more preferred than the other, i.e. give an example of a situation where conducting a hypothesis test having α and β as 0.05 and 0.45 respectively would be preferred over having them both at 0.15. Similarly, give an example for the reverse scenario - a situation where conducting the hypothesis test with both α and β values fixed at 0.15 would be preferred over having them at 0.05 and 0.45 respectively. Also, provide suitable reasons for your choice (Assume that only the values of α and β as mentioned above are provided to you and no other information is available).

Ans 3a

Critical Value method

Null hypothesis H_0 : $\mu \leq 200$ Seconds

Alternate hypothesis H_1 : $\mu > 200$

Need to conduct Upper-tailed test: Since the alternate hypothesis contains the > sign

Sample mean = 207 seconds

Sample Standard Deviation = S = 65 seconds

n = 100

Z for 95% confidence level in right/upper tailed test = 1.65

UCV = 200 + 1.65 * 65 / 10 = 210.72

Sample Mean (207) is lesser than UCV (210.72) **we fail to reject null hypothesis** H_0 : $\mu \leq 200$ Sec

P Value method

Sample Mean =207

Population Mean = 200

Sigma X bar of sampling distribution () = 65 / 10

Z score of sample mean (207) = (207-200) / (65/10) = 1.076

P value for one tailed test = 1 – 0.8599 = 0.14 (greater than 0.05 i.e. 5%) **we fail to reject null hypothesis** H_0: $\mu \leq 200$ Sec

Ans 3b

α = Probability of Rejecting H_0: $\mu \leq 200$ when it is true = 0.05

β = Probability that null hypothesis is false (i.e. $\mu > 200$) but we fail to reject = 0.45

Case I	The Null Hypothesis is True	The Null Hypothesis is False
We Decide to Reject Null Hypothesis	α = 0.05	
We Fail to Reject Null Hypothesis		β = 0.45

Case I is ideal for the situation where $\mu \leq 200$ like banning a food company for average lead content more than threshold value decision is to be made since we want to be very sure before punishing the company

Case II	The Null Hypothesis is True	The Null Hypothesis is False
We Decide to Reject Null Hypothesis	$\alpha = 0.15$	
We Fail to Reject Null Hypothesis		$\beta = 0.15$

α = Probability of Rejecting H_0: $\mu \leq 200$ when it is true = 0.15

β = Probability that null hypothesis is false (i.e. $\mu > 200$) but we fail to reject = 0.15

Case II is favourable for the situation where $\mu > 200$ will create severe problem or side effect in patient since probability of making this error is less 15 % than compared to 45 % in case I

Question 4:

Now, once the batch has passed all the quality tests and is ready to be launched in the market, the marketing team needs to plan an effective online ad campaign to attract new customers. Two taglines were proposed for the campaign, and the team is currently divided on which option to use.

Explain why and how A/B testing can be used to decide which option is more effective. Give a stepwise procedure for the test that needs to be conducted.

Ans4: A/B testing is used to find the best approach / method based on the which approach is improving our metric or bottom line.

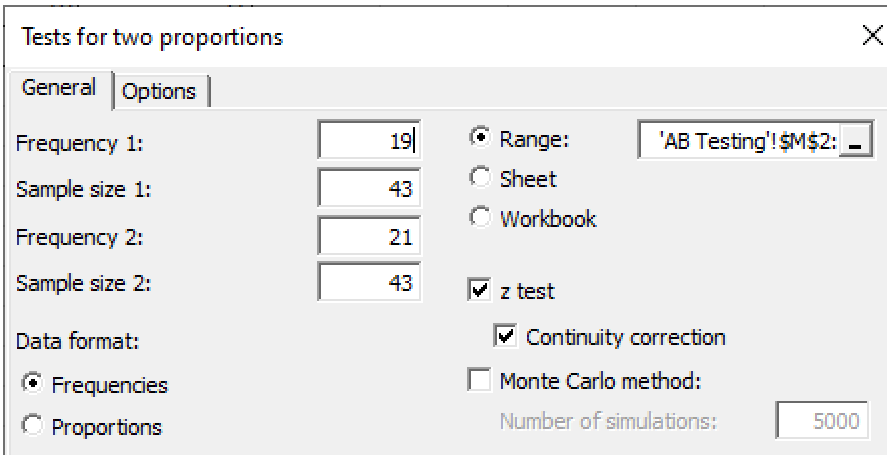
A/B testing is entirely based on the two-sample proportion test, as the two-sample proportion test is used when you want to compare the proportions of two different samples.

Old Feature	New Feature
0	1
0	1
0	1
0	1
1	0
0	1
0	0
0	0
1	1
1	1
0	0
0	1
1	1
1	1
0	1
0	0
0	1
1	0
1	0
0	1
0	0
0	1
0	0
1	1
1	0
1	1
0	0
0	1
0	1
1	0
0	0
1	0
1	1
0	0
0	0
1	1
1	0
0	0
1	0
0	0
1	0
1	0
1	1

In above case we are testing for conversion rate which is denoted by 1 for Old Feature and New Feature introduced on Web page.

We calculate the frequency and sample size for old and new feature as below

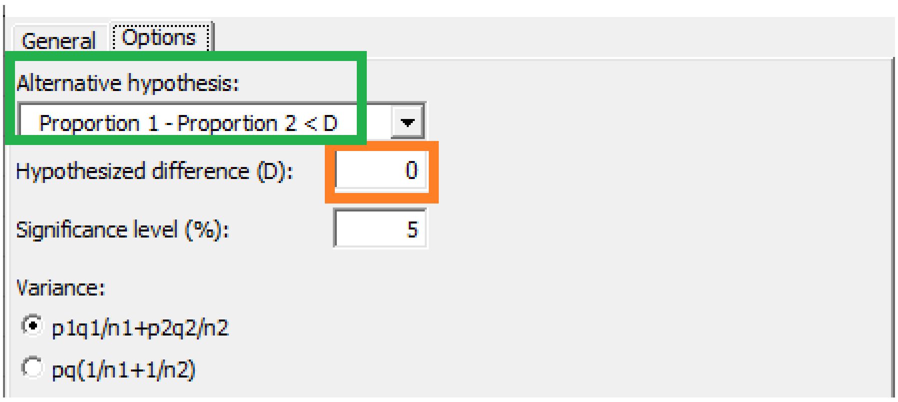
	Old Feature	New Feature
Frequency	19	21
Sample Size	43	43



H0: Our null hypothesis is Old Feature is as good as New Feature

H1: And our alternate hypothesis is new feature is better than old one

We could use feed H0 and H1 in XLSTAT to test for these two features for significance level alpha which is normally 5%



In turn we get the p value as output to compare with alpha

Case p value > alpha H0 could not be rejected means both old and new version have same impact on conversion rate

Case p value < alpha H1 is true (New feature is better than old feature)

------------Result of the A/B testing using XLSTAT----------------------

Difference	-0.047
z (Observed value)	-0.216
z (Critical value)	-1.645
p-value (one-tailed)	0.414
alpha	0.05

Test interpretation:

H0: The difference between the proportions is equal to 0.

Ha: The difference between the proportions is lower than 0.

As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.

Conclusion—To further substantiate our result we are supposed to collect some more data and run the test again to see if both feature have same impact or one is significantly better than another.