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Comprehension

The pharmaceutical company Sun Pharma is manufacturing a new batch of painkiller medications, 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 medicine to show effects) as well as quality assurance (which tells you whether the medicine was able to do a satisfactory job).

Question 1:

Quality assurance checks on the previous batches of medications found that it is four times more likely that a medicine is able to produce a satisfactory result than not.

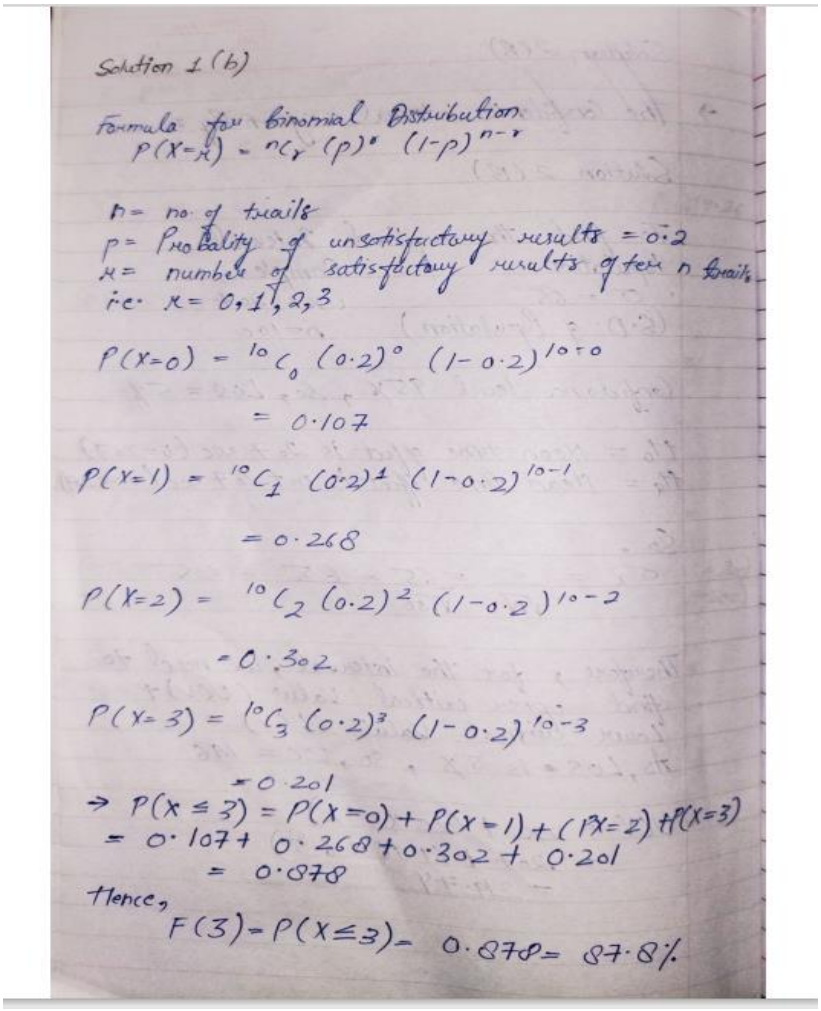
Given a small sample of 10 medicines, you are required to find the theoretical probability that, at most, 3 medicines are unable to do a satisfactory job:

1. Propose the type of probability distribution that would accurately portray the above-mentioned scenario, and list out the three conditions that this distribution follows.
2. Calculate the required probability.

Solution 1.

1. The Binomial Theorem would accurately portray the above-mentioned scenario. Three conditions that this distribution follows:
   a. The total number of trials should be fixed or considered as (n)
   b. Each trial binary, has only two outcomes Success and failure
   c. Probability of Success should be denoted by P, should be the same in all the one
   $^{n}C_{r}(p)^{r} * (1-p)^{n-r}$ **:- Formula of Binomial Theorem**

2. Solution Below



Solution 1 (b)

Formula for binomial Distribution

$P(X=x) = {}^{n}C_{r}\,(p)^{x}\,(1-p)^{n-x}$

n = no of trails
p = Probality of unsatisfactory results = 0.2
x = number of satisfactory results of ten n trails
i.e. $x = 0, 1, 2, 3$

$P(X=0) = {}^{10}C_{0}\,(0.2)^{0}\,(1-0.2)^{10-0}$

$= 0.107$

$P(X=1) = {}^{10}C_{1}\,(0.2)^{1}\,(1-0.2)^{10-1}$

$= 0.268$

$P(X=2) = {}^{10}C_{2}\,(0.2)^{2}\,(1-0.2)^{10-2}$

$= 0.302$

$P(X=3) = {}^{10}C_{3}\,(0.2)^{3}\,(1-0.2)^{10-3}$

$= 0.201$

$\rightarrow P(X \leq 3) = P(X=0) + P(X=1) + P(X=2) + P(X=3)$
$= 0.107 + 0.268 + 0.302 + 0.201$
$= 0.878$

Hence,
$F(3) = P(X \leq 3) = 0.878 = 87.8\%$

Question 2:

For the effectiveness test, a sample of 100 medicines 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 interval in which the population mean might lie – with a 95% confidence level:

1. 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.
2. Find the required interval.

Solution 2.

1. A sampling Distribution, which is essentially the distribution of the sample mean of a population, has some interesting properties that are collectively called The **Central Limit Theorem**. It states that no matter how the original population is distributed, The sampling follows these three properties:
2. **Sampling Distribution's mean** (μx) = **Population mean** (μ)
3. Sampling Distribution's Standard Deviation **(Standard error)** = $\sigma/\sqrt{n}$, whereas σ is the population's standard deviation and n is the sample size, and
4. **For n> 30,** the Sampling Distribution become a **normal distribution**

Solution 2 (2) given below

Solution 2 (B)

To find the required Interval

Population	Sample
$\sigma = 65$	$\bar{x} = 207$
(S.D. of Population)	$n = 100$

Confidence level 95%, so, LOS = 5%

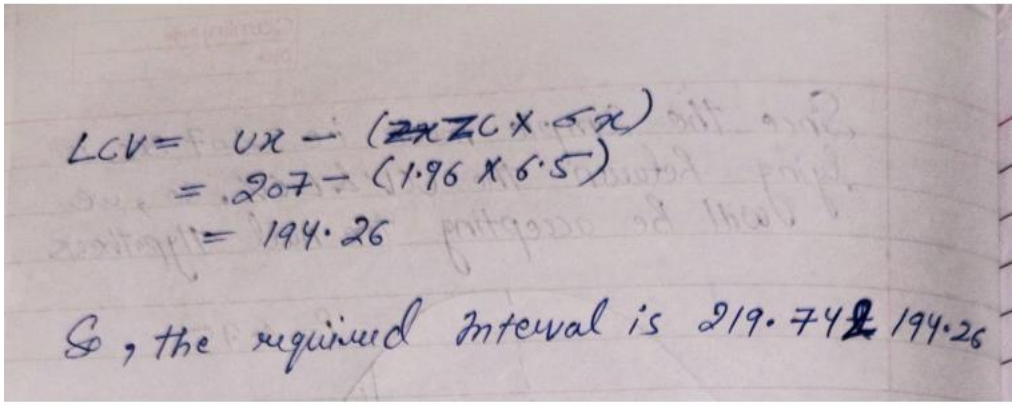
H_0 = Mean time effect is 207 sec ($\mu = 207$)
H_a = Mean time effect is not 207 sec ($\mu \neq 207$)

So,

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{N}} = \frac{65}{\sqrt{100}} = \frac{65}{10} = 6.5$$

Therefore, for the interval, we need to find upper critical value (UCV) + Lower critical Value (LCV)
As, LOS is 5%, so, $Z_c = 1.96$

$$UCV = \bar{x} + (Z_c \times \sigma_{\bar{x}})$$
$$= 207 + (1.96 \times 6.5)$$
$$= 219.74$$



Question 3:

The painkiller 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) as that in the previous question, test the claim that the newer batch produces a satisfactory result and passes the quality assurance test. Utilise two hypothesis testing methods to take a 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.

You know that two types of errors can occur during hypothesis testing – 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 (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.

Under what conditions would either method be more preferred than the other? Give an example of a situation where conducting the hypothesis test with α and β as 0.05 and 0.45, respectively, would be preferred over conducting the same hypothesis test with α and β at 0.15 each. Similarly, give an

example for the reverse scenario, where conducting the same hypothesis test with α and β at 0.15 each would be preferred over having them at 0.05 and 0.45, respectively.

For each example, give suitable reasons for your particular choice using the given values of α and β only. (Assume that no other information is available. Additionally, the hypothesis test that you are conducting is the same as mentioned in the previous question; you need to test whether the newer batch produces satisfactory results.)

Solution 3.

Solution 3 (1)

Critical Value Method

Population	Sample
$u = 200$	$ux = 207$
$\sigma = 65$	$\sigma x = 6.5$
	$n = 100$

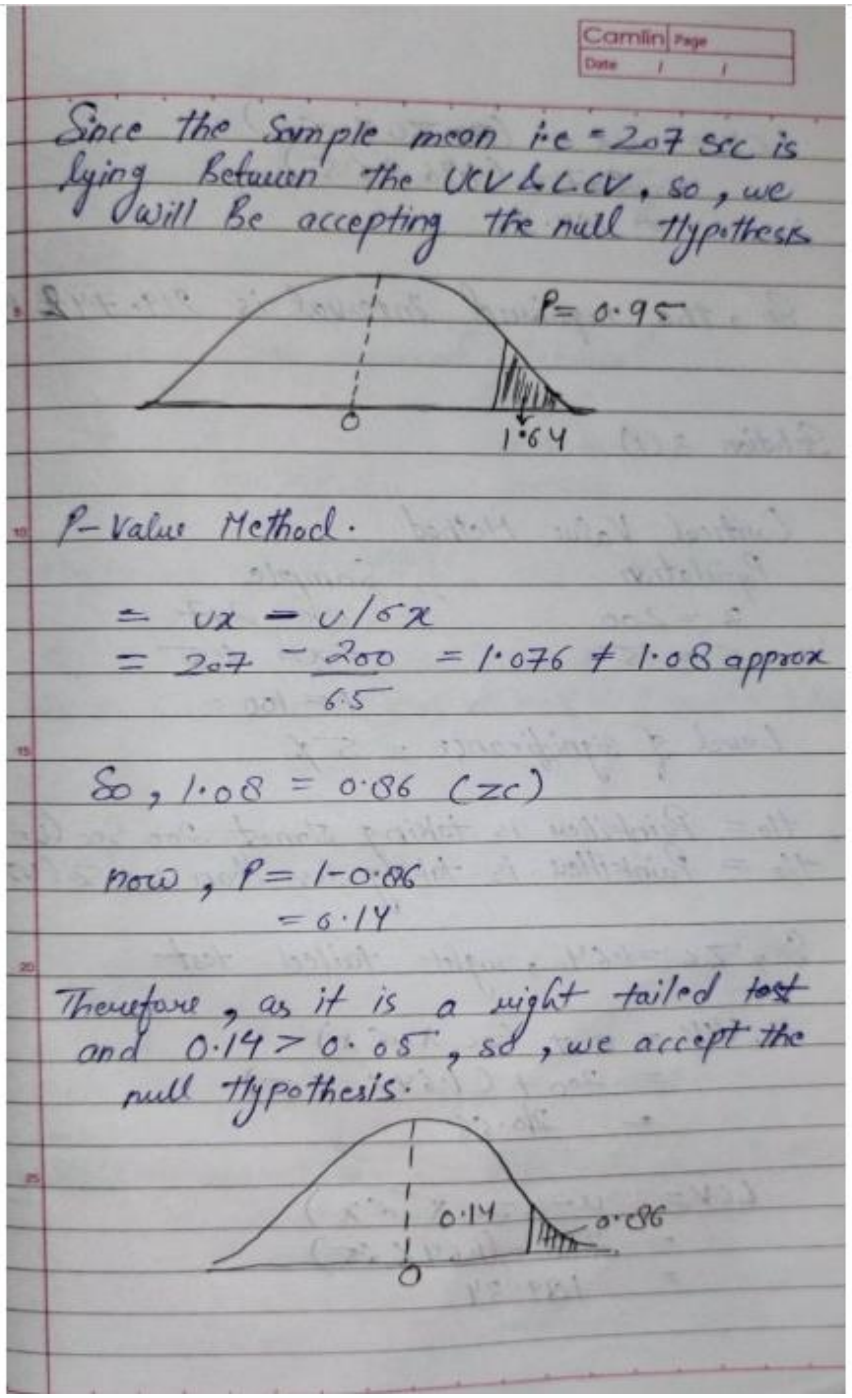
Level of significance = 5%

H_0 = Painkiller is taking almost 200 Sec ($U = < 200$)
H_a = Painkiller is taking less than 200 Sec ($U < 200$)

So, $Zc = 1.64$, right tailed test

$$UCV = u + (Zc \times \sigma x)$$
$$= 200 + (1.64 \times 6.5)$$
$$= 210.66$$

$$LCV = u - (Zc \times \sigma x)$$
$$= 200 - (1.64 \times 6.5)$$
$$= 189.34$$



2. In the hypothesis testing:

Type-1 (α) error refers to the scenario where we decided to reject the NULL hypothesis even though it was TRUE.

Type-2 (β) error refers to the scenario where we failed to reject the NULL hypothesis even though it was FALSE.

There are two possible scenarios:

- **Scenario-1**: The values of a and ß come out to be 0.05 and 0.45 respectively.

- **Scenario-2**: The values of a and ß are controlled at 0.15 each.

We try to keep the error limited to a very low value when there are side effects related to the acceptance of the alternate hypothesis. From the scenario stated in the question, if there are any side effects related to the overdosage of the painkiller drug, we need to keep the error to a minimum i.e., we are conservative in rejecting the null hypothesis.

So, if the painkiller drug has significant side effects, we would like to keep the value of a and ß come out to be 0.05 and 0.45 respectively.

On the other contrary, we tend to be relaxed with the error if there were no major side effects in the painkiller drug. This would mean that we can be aggressive about changing the status quo and establish an alternate hypothesis. In such cases, our ß error limit would be very restricted.

Question 4:

Once one 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 subscribers. 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.

Solution 4.

A/B testing is a direct industry: ect industry application of the two-sample proportion test. It is a widely used process in digital companies in the e-commerce, manufacturing and advertising domains. It provides a way to test two different versions of the same element and see which one performs better.

Steps to perform A/B testing:

1. Two groups of people are chosen and each of them is exposed to only one type of ad.

2. Their conversion rates are considered.

3. The Null Hypothesis and Alternate Hypothesis are defined accordingly:-

a. HO: The ad1 is more effective than the ad2

b. Ha: the ad2 is more effective than the ad1.

3. Decide the value of alpha (LOS)

4. We will perform the statistical test and calculate the p-value.

5. Make the decision whether to accept/ reject the null hypothesis (HO)

p-value > LOS Accept the HO

p-value < LOS Reject the HO