Six Sigma

Prof. Jitesh J Thakkar
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

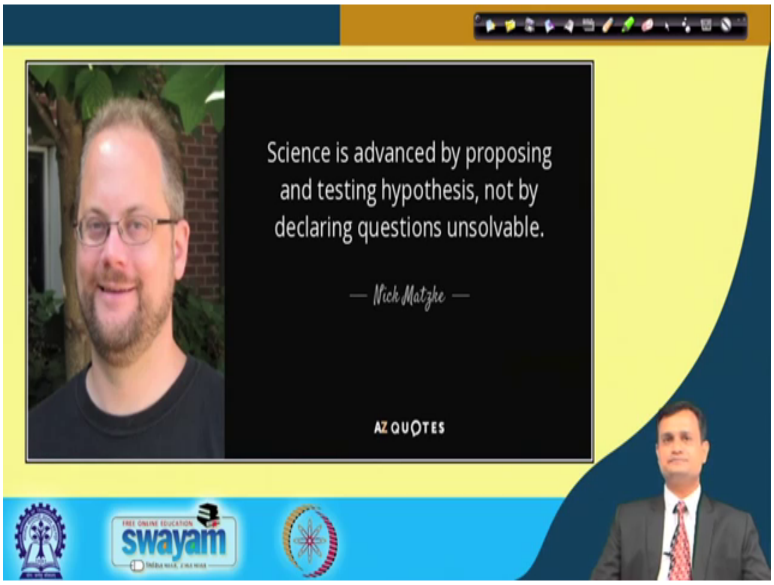
Lecture - 28
Hypothesis Testing: Fundamentals

Hello friends, welcoming you to the ongoing journey of Six Sigma. And we had a long discussion on process capability analysis almost we have spent 4 lectures discussing normal and non-normal process capability analysis with its application in minitab. And this lecture 28 we will focus on a very very important topic that is Hypothesis Testing Fundamentals.

So, if you recall when I talked about the basics of statistics. Then, we have divided the statistics into 2 parts; descriptive statistics and inferential statistics. We have seen that there are various ways and means like finding measures of central tendency, dispersion, shape, plotting the histogram, box and whisker plot many other ways to describe my data in more descriptive manner to enable the practicing people researchers for making the decision.

The another domain which typically deals with inferential statistic this domain we have not discussed so far. So, this is mainly dealing with hypothesis testing and we would like to say begin with our analyse phase in the DMAIC cycle with this lecture 28 that is hypothesis testing fundamentals.

(Refer Slide Time: 02:06)

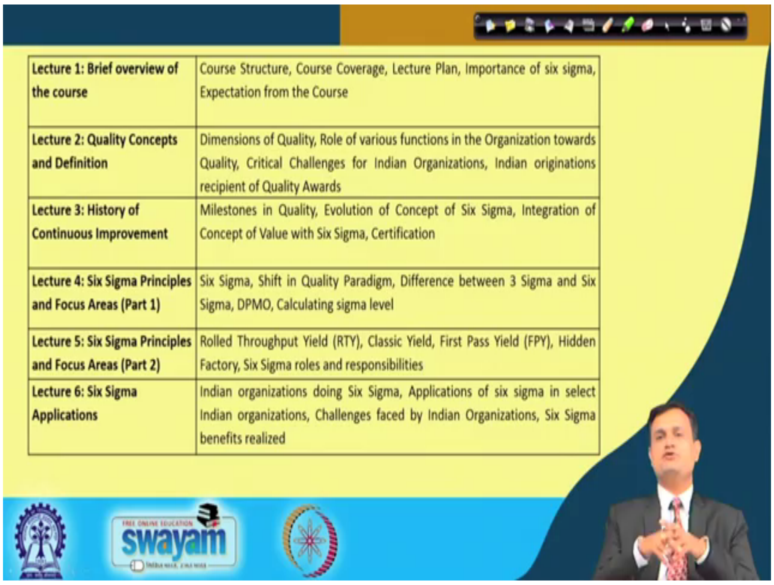


So, let us begin with a very interesting quote given by Nick Matzke and he says, that science is advanced by proposing and testing hypothesis not that by just declaring questions and solvable. You have to prove the theory, you have to test the theory. You have to check your assumptions. And in order to do so, you have to check your claim, you have to test your claim and your claim is basically they scientifically designed hypotheses which can really open a new direction for research, business or policy and practice.

(Refer Slide Time: 02:52)

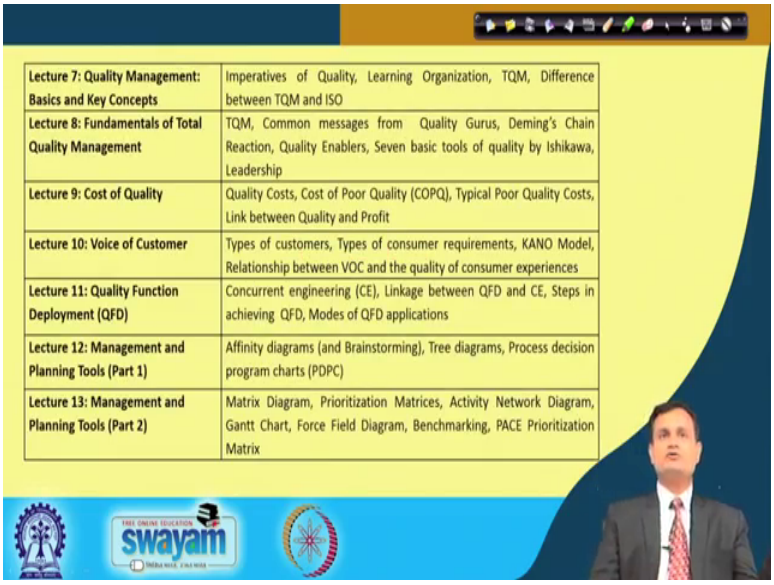
So, before we really enter into the hypothesis testing fundamentals as we are beginning with a new phase in DMAIC cycle that is analyse, let me just give you a brief recap what we have done so far and where are we in our six sigma journey. So, quality fundamentals and key concepts we have discussed in week 1 and 2.

(Refer Slide Time: 03:18)



Week 1; basically gave you the overview of the course quality concepts and definitions, history of continuous improvement, six sigma principles and focus areas. Lecture 4and 5 part 1 and part 2 and then six sigma applications typically in some of the Indian organizations.

(Refer Slide Time: 03:39)

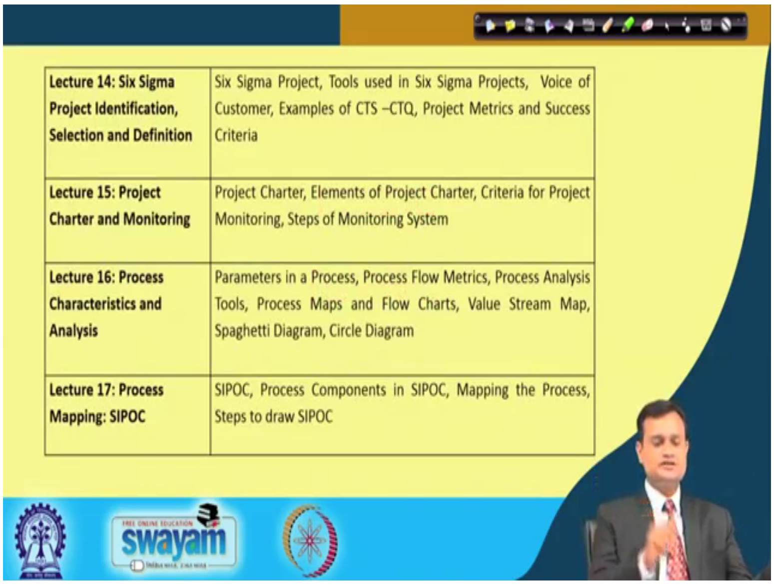


Lecture 7: Quality Management: Basics and Key Concepts	Imperatives of Quality, Learning Organization, TQM, Difference between TQM and ISO
Lecture 8: Fundamentals of Total Quality Management	TQM, Common messages from Quality Gurus, Deming's Chain Reaction, Quality Enablers, Seven basic tools of quality by Ishikawa, Leadership
Lecture 9: Cost of Quality	Quality Costs, Cost of Poor Quality (COPQ), Typical Poor Quality Costs, Link between Quality and Profit
Lecture 10: Voice of Customer	Types of customers, Types of consumer requirements, KANO Model, Relationship between VOC and the quality of consumer experiences
Lecture 11: Quality Function Deployment (QFD)	Concurrent engineering (CE), Linkage between QFD and CE, Steps in achieving QFD, Modes of QFD applications
Lecture 12: Management and Planning Tools (Part 1)	Affinity diagrams (and Brainstorming), Tree diagrams, Process decision program charts (PDPC)
Lecture 13: Management and Planning Tools (Part 2)	Matrix Diagram, Prioritization Matrices, Activity Network Diagram, Gantt Chart, Force Field Diagram, Benchmarking, PACE Prioritization Matrix

Week 2; we have talked about say quality management key concepts and fundamentals we have talked about fundamentals of TQM. Then lecture 8 cost of quality, lecture 9 cost of quality, lecture 10 voice of customer, lecture 11 QFD, 12 management and planning tools part 1, 13 management and planning tools part 2.

And we discussed many plan management and planning tools like benchmarking, affinity diagram, brainstorming metrics diagram, prioritization matrices, activity network diagram, force field diagram and so on. Then we entered in to define phase that is the first phase of DMAIC cycle and that was our week 3.

(Refer Slide Time: 04:33)

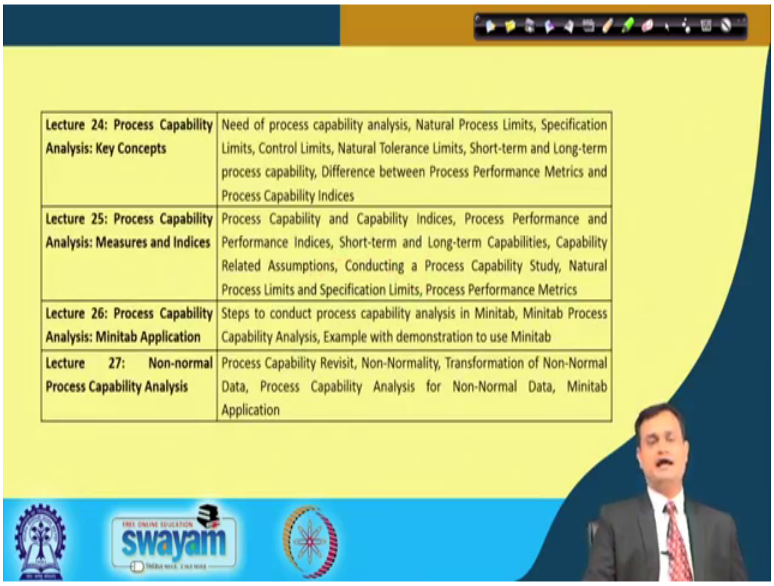


So in this phase, we talked about six sigma project identification, selection and definition. Lecture 15 project charter and monitoring that is the blueprint of the project, 16 process characteristic and analysis, 17 process mapping typically using a very important diagrammatic representation SIPOC. Then we have discussed in detail the measure phase we devoted week 4 and week 5.

(Refer Slide Time: 05:10)

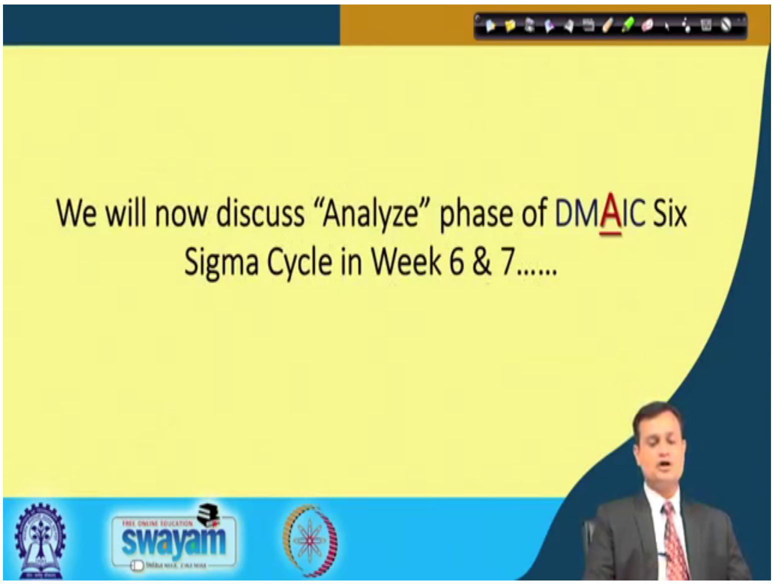
And measure phase week 4, we covered data collection and summarisation part 1 and part 2. Lecture 20 was on measurement system fundamentals, 21 measurement system with gauge R and R study, lecture 22 fundamentals of statistics, 23 probability theory. Subsequently, we picked up few more topics in the measure phase in week 5.

(Refer Slide Time: 05:35)



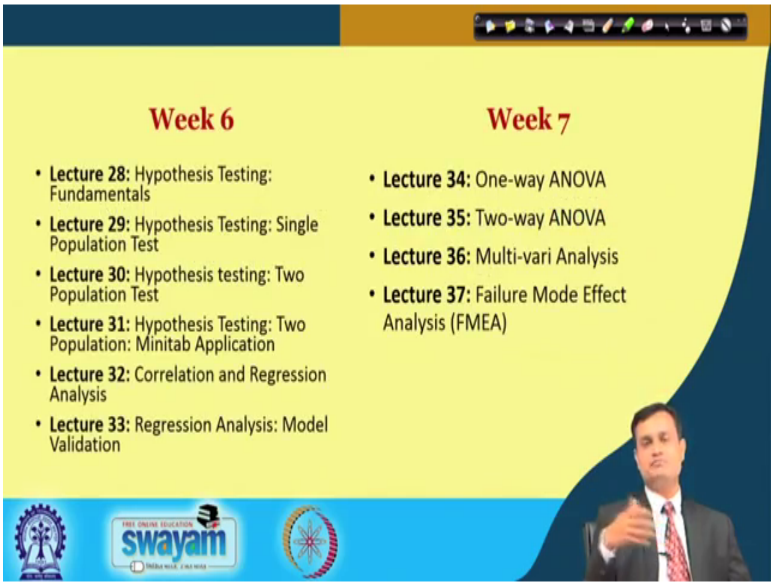
And this has included process capability analysis, some key concepts lecture 24, then lecture 25 process capability analysis measures and indices, lecture 26 process capability analysis with minitab application and lecture 27 non normal process capability analysis also we have included the minitab application.

(Refer Slide Time: 06:03)



So, with this we are now in the analysed phase we will now discuss the analysed phase of DMAIC six sigma cycle in week 6 and 7.

(Refer Slide Time: 06:18)



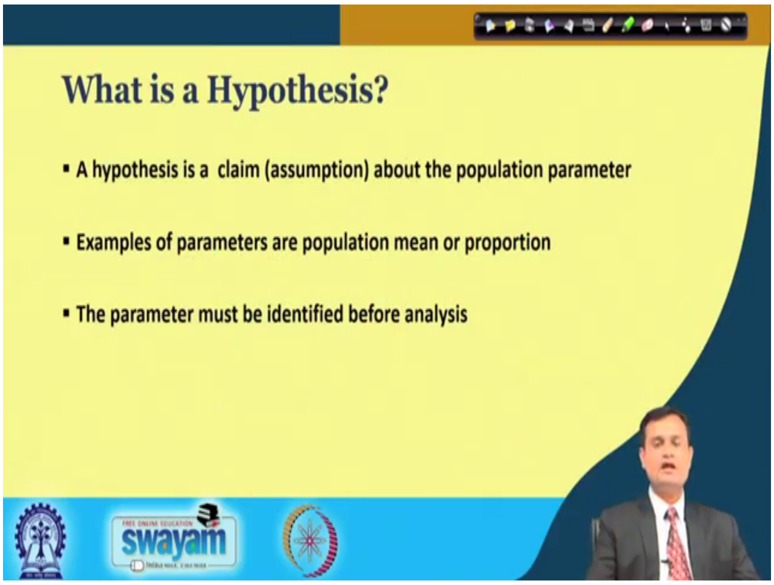
Let me just give you the brief outline that we would be conducting, we would be executing in week 6 and week 7. So, week 6 this lecture 28 will help you to appreciate the concept of hypothesis testing. Lecture 29, hypothesis testing for single population test. Lecture 30, hypothesis testing for 2 population test. 31, hypothesis testing for 2 population test I would like to share the minitab application. Lecture 32, correlation and regression analysis and 33 regression analysis model validation.

Week 7, we will have 4 lectures. Lecture 31 one-way ANOVA, lecture 35, two-way ANOVA, lecture 36, multi-vari analysis and 37, failure mode effect analysis.

(Refer Slide Time: 07:15)

So, with this recap let us try to focus on the important topics of this lecture 28 hypothesis testing fundamentals. So, we will try to see what is statistical hypothesis? What is null and alternative hypothesis? What is type 1 and type 2 error in hypothesis testing? What are the general steps in hypothesis testing? And typically there are three approaches for hypothesis testing approach number 1 critical value, approach number 2 p value, approach number 3 confidence interval.

(Refer Slide Time: 07:55)



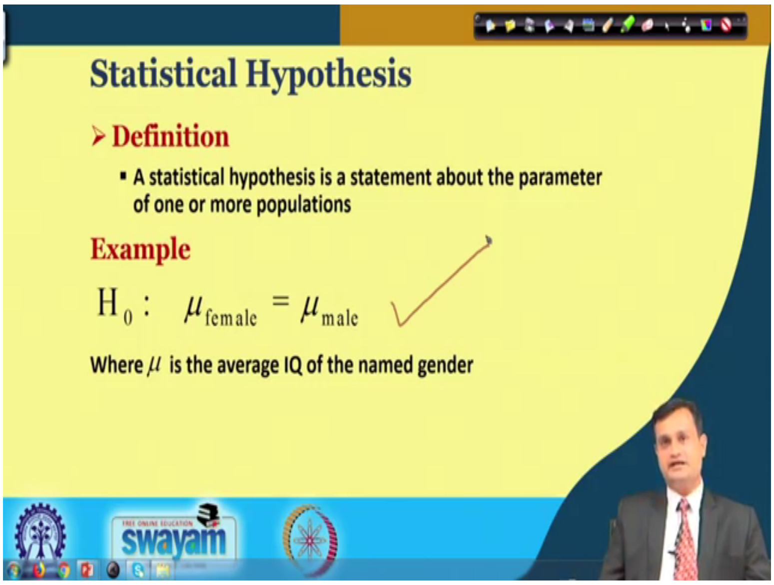
So, what is hypothesis? In a very simple way I would like to say that its your claim about a particular problem or phenomena under investigation and you want to study this particular critical problem in a scientific manner so a hypothesis is basically a claim assumption.

I do not have the theory available, I want to test the theory either existing or propose a new theory and a scientific rigor is necessary to propose any new theory or test the existing theory then I would set a hypothesis about the population parameter. Just for example, I want to investigate the impact of worker morale on the productivity of the organization, its a very interesting phenomena. Now, there could be many factors that can impact the worker morale, it may be compensation, hygiene, incentives, recognition, many other things, transparent working environment.

You have various ways to measure the productivity. It may be labour productivity, it may be equipment productivity, it may be transactional productivity. Now, I want to test the theory for an organization or in general that worker morale or employee morale and the organizational productivity they are positively related. Its my claim, its not yet proven for a typical context fine. It might have been proven for US or UK or other context for some other organization.

I want to check it for my context for my organization then, this claim assumption is my hypothesis and I would like to test it through a systematic scientific procedure. So, examples of parameters are population mean and proportion and the parameters must be identified before we go for the hypothesis testing analysis.

(Refer Slide Time: 10:10)

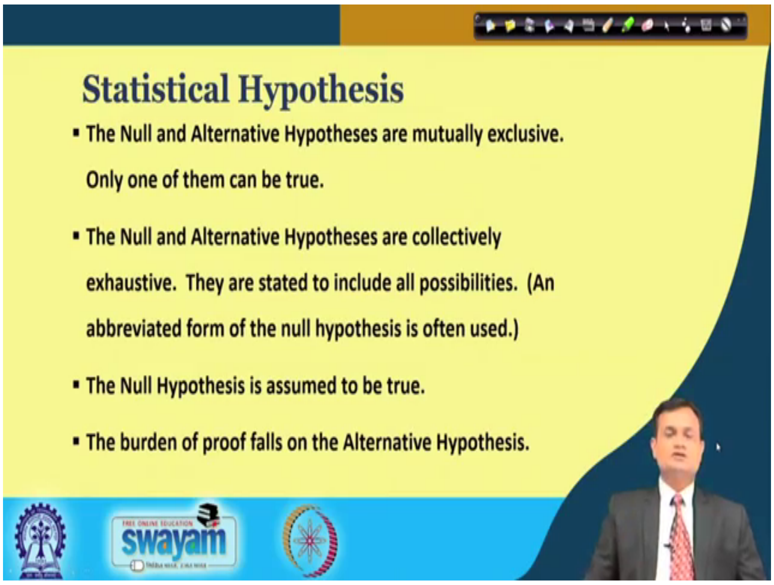


So, just see how we try to figure it out that the definition a statistical hypothesis is a claimed statement about the parameter of one or more population. Here I am citing just a simple, but interesting one that H 0 is typically called as null hypothesis 0 hypothesis null hypothesis. So, always null hypothesis assumes be conformance to the particular requirement and usually it is expressed in terms of equality and I believe that this is possible this can happen.

So, I will say mu of female and mu of male when I am trying to compare the mu for IQ their intelligence, I am trying to say that IQ of mean value of IQ of female and mean value of IQ of male it is equal. Obviously, I will take a sample and for that sample I would like to study because you cannot just take some heterogeneous sample and data and then try to study. Because qualification, upbringing, economic strata, food many things they have an impact on the individual IQ.

So, here for a particular group I want to study that IQ for female and male and I want to state it in a scientific manner null hypothesis that the IQ of female and IQ male mean value they are equal.

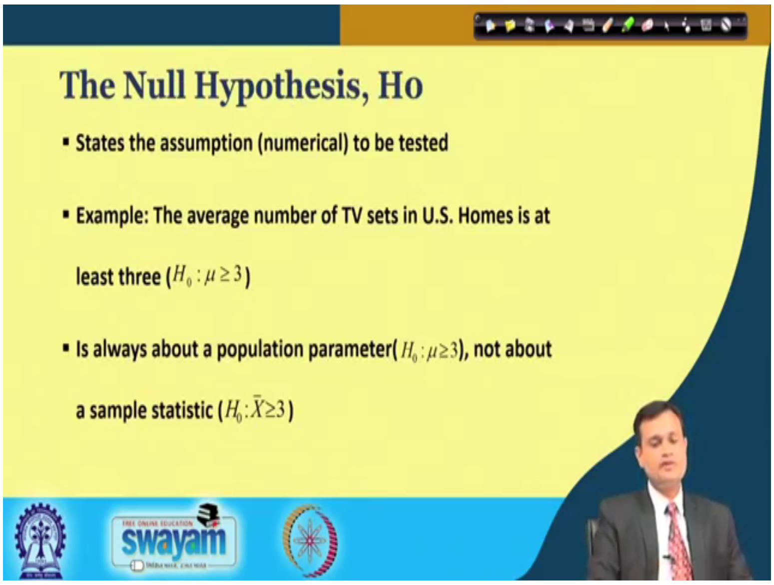
(Refer Slide Time: 11:59)



So, typically my null hypothesis and; obviously, I have null hypothesis when I do not agree with this the other hypothesis I can emerge that is called alternative hypothesis. And I believe that, null hypothesis and alternative hypothesis are mutually exclusive only one of them can occur. So, in this case either mu of that is the IQ mean IQ of female is equal to mean IQ of male or it is not equal. So, I have null hypothesis equal alternate hypothesis alternate claim not equal.

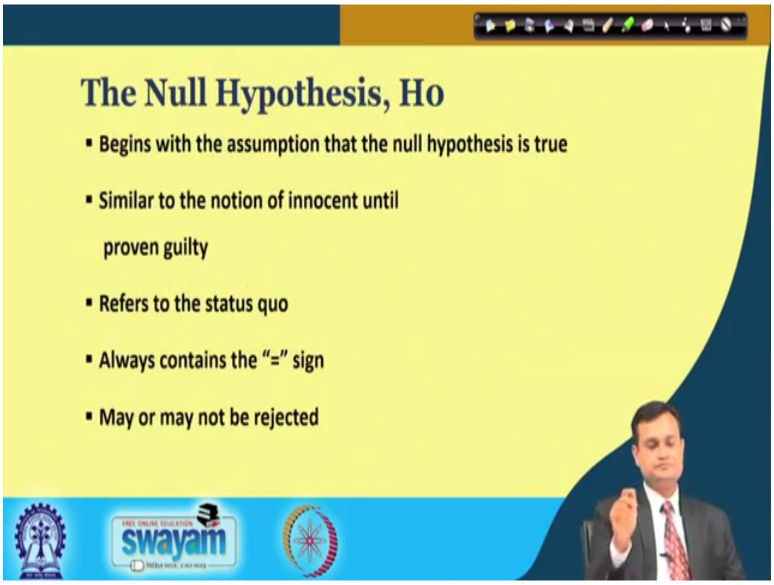
So, null hypothesis and alternative hypothesis are collectively exhaustive, they are stated to include all possibilities and abbreviation from null hypothesis is often used. So, null hypothesis is assumed to be true the burden of proof falls on the alternative hypothesis. So, here if I have null hypothesis true; obviously, alternate is false if I say I fail to accept my null hypothesis or in simple word it is rejected then I will say alternate hypothesis is true.

(Refer Slide Time: 13:20)



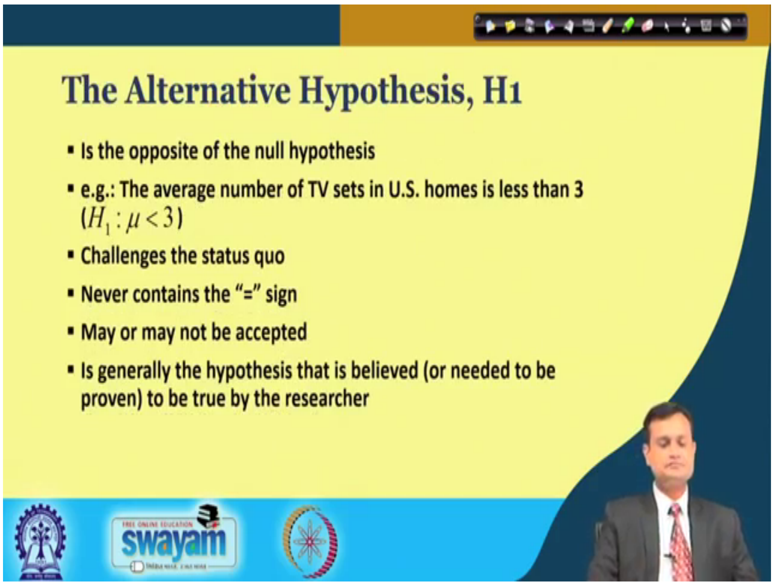
Now, just a little bit more idea on null hypothesis with example that, it is the assumption to be tested. And as I said usually, but not necessarily that it is expressed in terms of equality you can also have inequality just see the example the average number of TV sets in US homes is at least 3, this is my null hypothesis. It is 3 or greater than 3; it is always about a population parameter not about the sample statistic so H 0 mu is greater than equal to 3 is my claim that I want to check, test scientifically.

(Refer Slide Time: 14:05)



So, my null hypothesis is something which begins with the assumption refers to the status quo that yes this will prevail or this is prevailing and usually as I said contains equal to sign, but not necessary and may or may not be rejected.

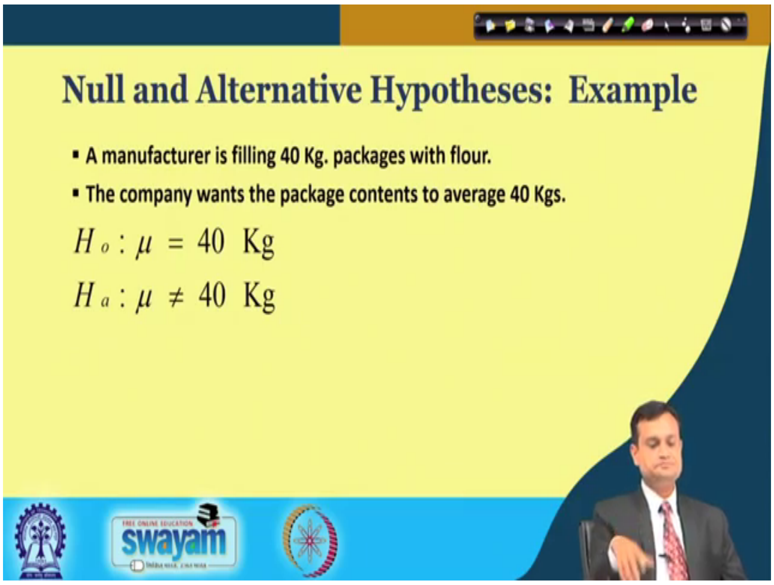
(Refer Slide Time: 14:25)



So, alternative hypothesis; obviously, when you say number of TVs in a home alternate hypothesis would be less than 3 if it is equal to or greater than 3, its null hypothesis. When I say alternate hypothesis, it is less than 3. So, alternate hypothesis typically is designated as H 1.

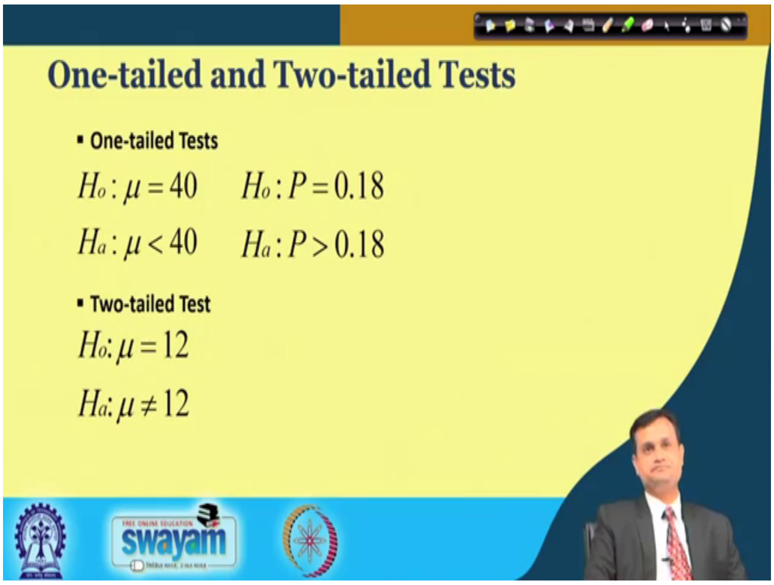
So, H 0 is my null H 1 is my alternate and typically this hypothesis never contains equal to sign either it is in inequality form or it is non-equal to and this is the generally the hypothesis that is believed to be true by the researcher or needed to be proven.

(Refer Slide Time: 15:14)



So, we can see the example of null and hypothesis together that, you have a manufacturing company and is filling 40 kg packages with flour now, company wants to package that contained the average of 40 kg so, I will say null hypothesis I want to check. I have collected the data, measured the package and now I want to prove that statistically really I am filling 40 kg. So, mu is equal to 40 kg alternate, so H 1 or H a both is ok, you can express it as H 1 or H a mu is not equal to 40 kg.

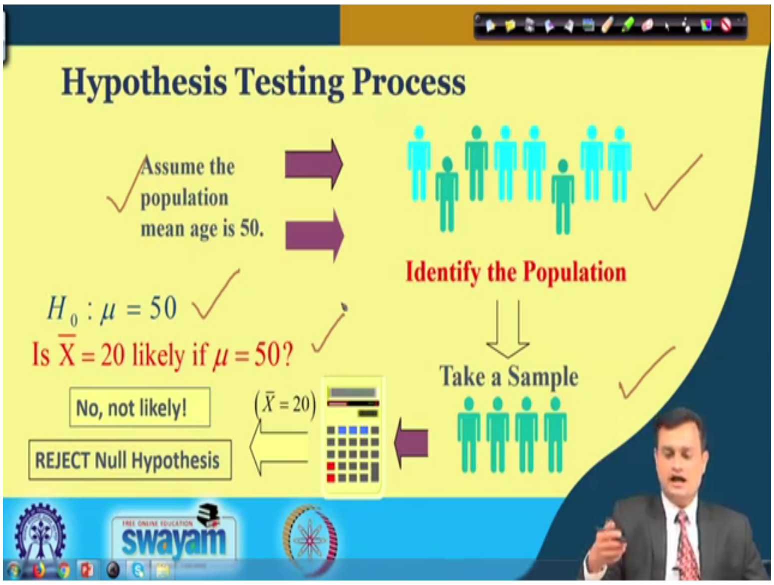
(Refer Slide Time: 15:57)



I can have one-tailed test, I can have two-tailed test, you have seen the distribution, normal distribution typically and I can have one-tailed test two-tailed test. So, when I follow the one-tailed test it means, I am only bothered about either higher side or lower side just see here H 0 is mu is equal to 40 and H a that is my alternative hypothesis that is mu is less than 40.

So, I would say that if it is less than 40 not acceptable, but if it is equal to 40 then I would prove that my claim about filling the bag with 40 kg is true. Two-tailed, I would say mu is equal to 12 mu is not equal to tail. So, I would like to explore both the sides of the distribution and I will conduct the two-tailed test.

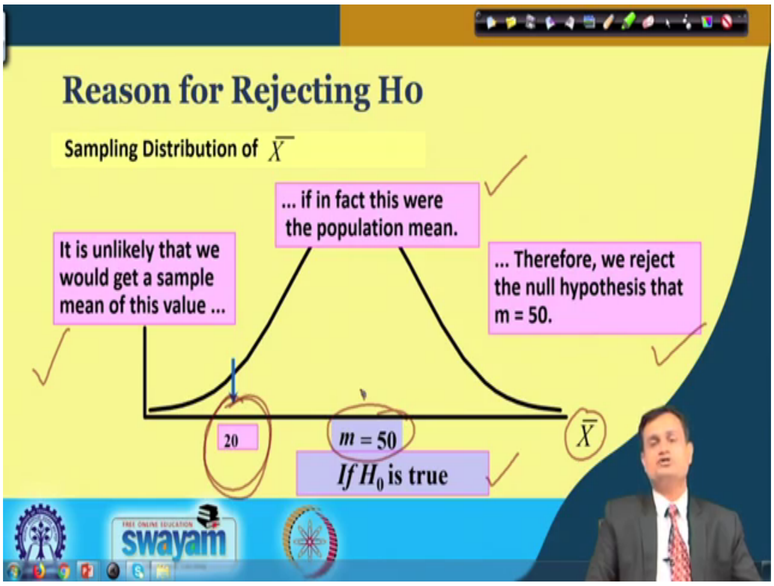
(Refer Slide Time: 16:56)



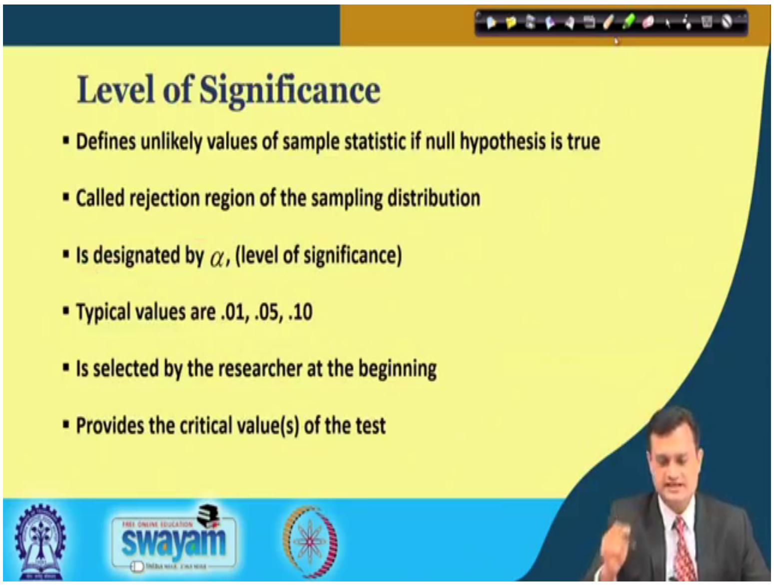
So, just see this to make your idea on hypothesis the word may sound little bit more difficult, but its a scientific and it is the simplest way to say its my claim about the population. So, you have the population on about which you want to test some of the claim may be average expectancy of the life, height, weight of the population, their socio-cultural values many a times. Now you take a sample and here I am assuming the population with mean age 50 and you can see that my H 0 says mu is equal to 50, so on an average life is 50 is X bar 20 likely if mu is equal to 50, so this is what I want to check.

So, my hypothesis basically would help me to structure my problem and then to apply the scientific analysis to see that to what extent my claim about a population based on the sample is really true.

(Refer Slide Time: 18:13)



(Refer Slide Time: 18:19)



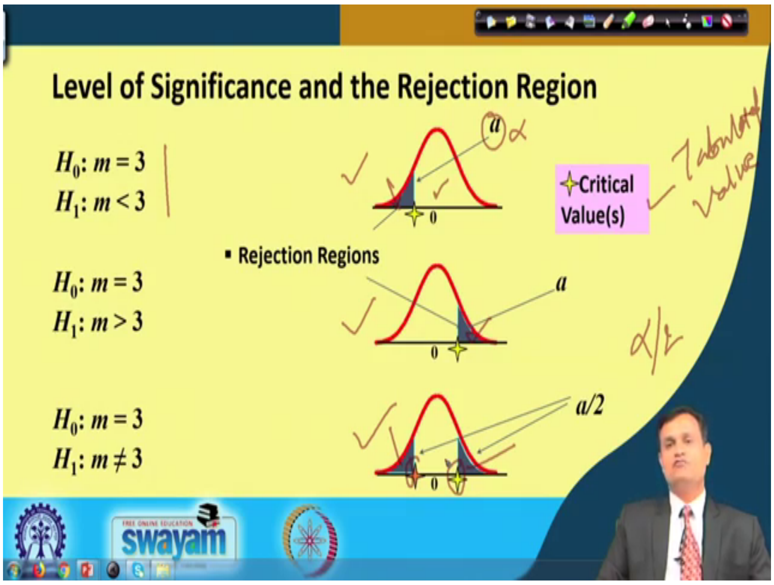
So, just see this reasons for rejecting H 0. And what you can see here that, what you can see here that sampling distribution is X bar. So, I have taken a sample and I refer to the sampling distribution this is my X bar sampling distribution I have taken maybe 100 sample, each sample mean is taken and when I plot X bar instead of let us individual value then, I am plotting the sampling distribution of X bar.

So, it is unlikely that we would get a sample mean of this value that is 20 here and this is my 50 which says that H 0 is true and if in fact, this were the population mean therefore, we reject the null hypothesis that m is equal to 50. I have not done any inferential analysis, just I am trying to show you and visually I am trying to say that you will say that yes this is too far and too far has to be proven statistically, but I would say that this is 20 and this where if this were the population mean then we reject the null hypothesis. But, this is not at all scientific I have to use the inferential statistics to prove that yes my claim about a particular population is true to what extent.

So, you have one term that is called level of significance. We always say that, when we deal with the probability theory and we draw our conclusions based on the sample. We always say that we cannot be 100 percent sure, we always try to check or test the hypothesis at particular level of significance. So, technically this defines unlikely value of sample statistic if null hypothesis is true.

So, this helps us to define the rejection region of my sampling distribution and typically it is denoted in all the textbook you will find; this is denoted as alpha level of significance. Typical values you can choose 0.01, 0.02, 0.05, 0.1 we will discuss what is the real interpretation of higher and lower value, but you can choose conveniently 0.01, 0.05. If this is selected by the researcher and at the beginning then he would be comfortable in checking the critical value finding from the table we had seen the various distributions and the table value. So, then he can prove that whether the null hypothesis is accepted or it is rejected.

(Refer Slide Time: 21:24)



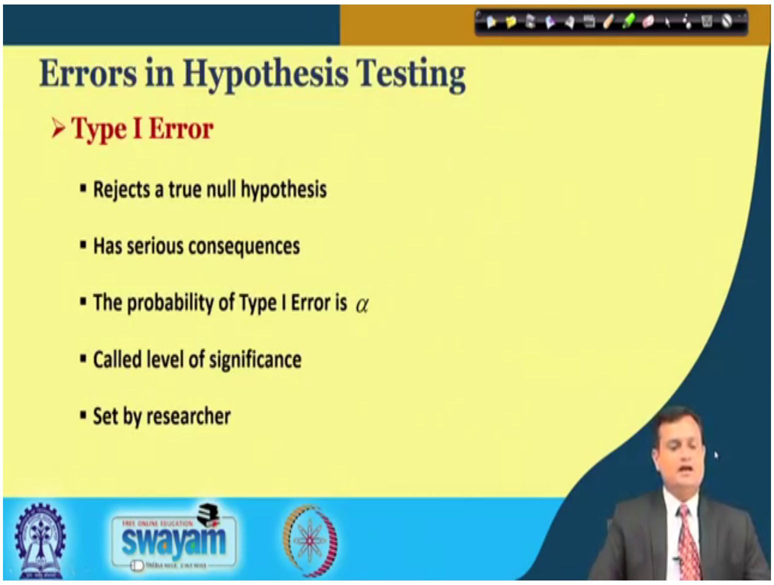
So, just see this will give you a very clear cut idea what I have here say I have null hypothesis m is equal to 3 and alternate hypothesis m less than 3. Now, I have the critical value a corresponding to my say particular claim and I want to this is my alpha rather you say not a, this is alpha I have this alpha and this is the level of significance.

So, this will give me a critical value. So, critical value is basically the tabulated value. So, from this statistical table for a given level of significance alpha you find the critical value and then you check the hypothesis, if it falls in this region particularly this shaded region then it is reject means null hypothesis my null hypothesis claim is reject and I will accept the alternate hypothesis. If it is fall, it falls in the non-shaded region then, I will accept the null hypothesis and alternate hypothesis is rejected.

Same way, you can have the rejection region on this side when you talk about only one site, one-tail test this is one-tail test, this is also one-tailed test and you have here two-tailed test. So, I will divide the alpha into 2 part alpha by 2 so suppose, you have selected 0.05 as the alpha then 0.025 and 0.025 will become alpha by 2; alpha by 2.

So, this region is the rejection region once again I am reminding you. And if, these regions are determined based on the critical values found from the statistical tables for a particular statistics of interest we will see it and if my calculated value falls in this region shaded region then it is reject if it falls in the non-shaded region my null hypothesis is accepted.

(Refer Slide Time: 23:51)

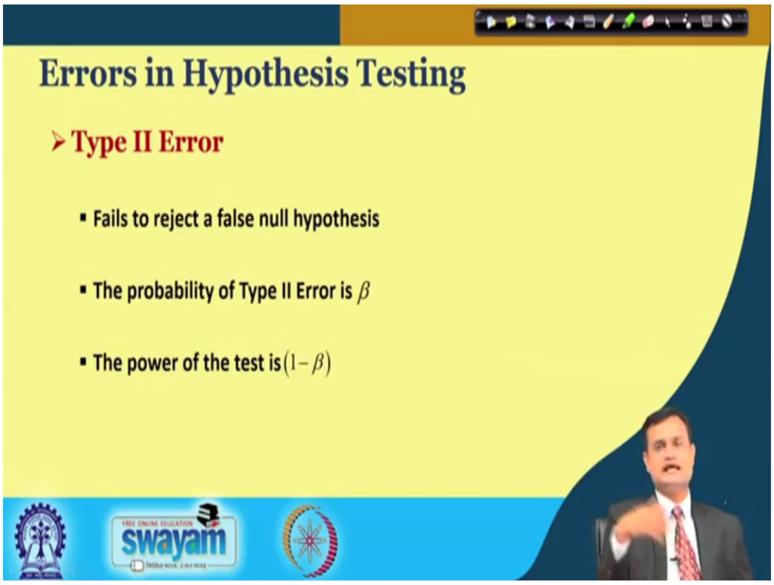


So, there are 2 errors when we deal with the probability and when we talk about the level of significance we should understand that there are 2 types of errors that a researcher, scientist, analyst has to accept and these are typically called as type I and type II error.

So, type I error means reject a true null hypothesis. It means, actually my null hypothesis is true, but for the chosen alpha given level of significance I say that my null hypothesis is rejected. So, if you recall, I gave you the example that suppose you have a person presented in the court against the jury before the jury and the decision is that he is guilty he should be punished, but actually the person is innocent.

Now in this case you are basically rejecting the null hypothesis that person is innocent and punishing him. So, this is your say type I error. So, there are certain serious consequences if you punish an innocent person and if you do not punish let us say, guilty there could not be that much of consequences because this fellow will be caught later on also.

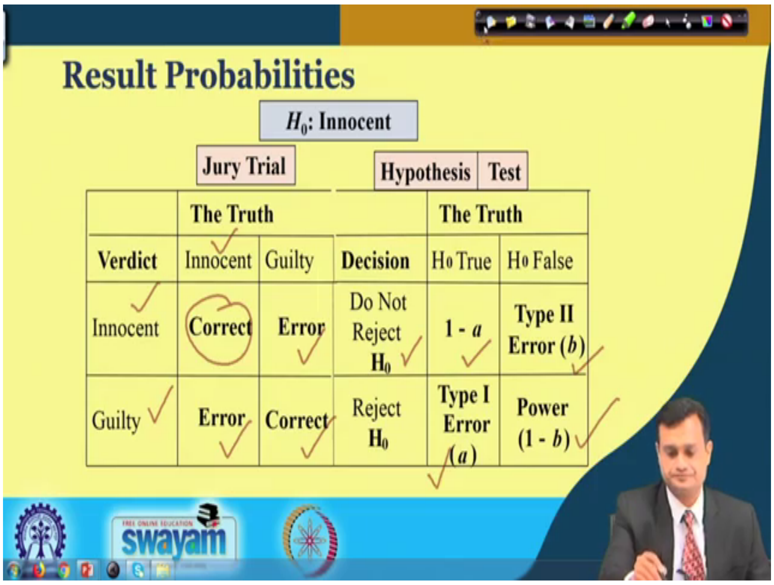
(Refer Slide Time: 25:18)



So, this is alpha is said by the researcher. Type II error is to fail, to reject the false null hypothesis. It is just reverse, I say that null hypothesis is rejected, but here the null hypothesis is accepted, but actually it should be rejected. So, it is just reverse. So, in my way I will say that you are say declaring a guilty; declaring a guilty and innocent means you are not punishing the guilty you are accepting the say null hypothesis, but actually it is of reject.

So, this is something that basically leads to the error in any kind of statistical analysis, but we have to bear and we have to be judicious about deciding the type I and type II error. So, probability of type II error is typically beta and the power of test is 1 minus beta.

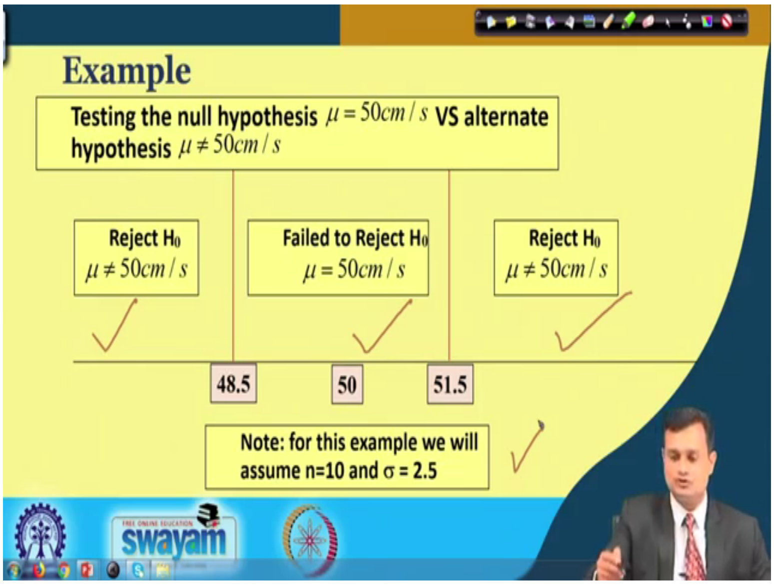
(Refer Slide Time: 26:23)



So, jury trial example I have given is well demonstrated here. Just see this to make it more clear you have innocent and I declare it as the innocent. So, there is a verdict you know and there is innocent correct. When I say, verdict is guilty and I declare it as innocent as a jury error when I say verdict is innocent and guilty error both is guilty this is correct. So, do not reject null hypothesis H 0 is true, I will say 1 minus alpha and if H 0 is 4 false this is type 2 error. If H 0 is rejected, when H 0 is true then this is my type I error and when H 0 is rejected, when H 0 is really false, this is actually the power of my test.

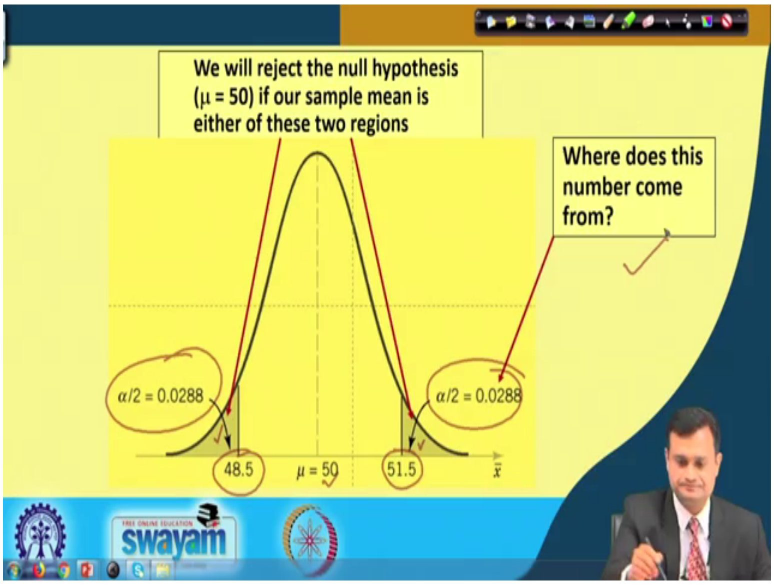
So, to what extent I am able to discriminate the truth from the lie or I am able to discriminate in quality context bad quality from the good quality this is where exactly the power of my statistical test lies.

(Refer Slide Time: 27:44)



So, we can see this through a small example, testing the null hypothesis mu is equal to 50 centimetre by per second versus alternate hypothesis that it is not this much of speed. So, you have these 3 options, 3 regions, reject h 0 mu is not equal to this, fail to reject that is mu is equal to 50 cm per second and reject h 0, mu is not equal to 50 cm per s. So, you are basically trying to say check it with respect to 2 side 2 tail. So, for this example we will assume n is equal to 10 and sigma is equal to let us say 2.5.

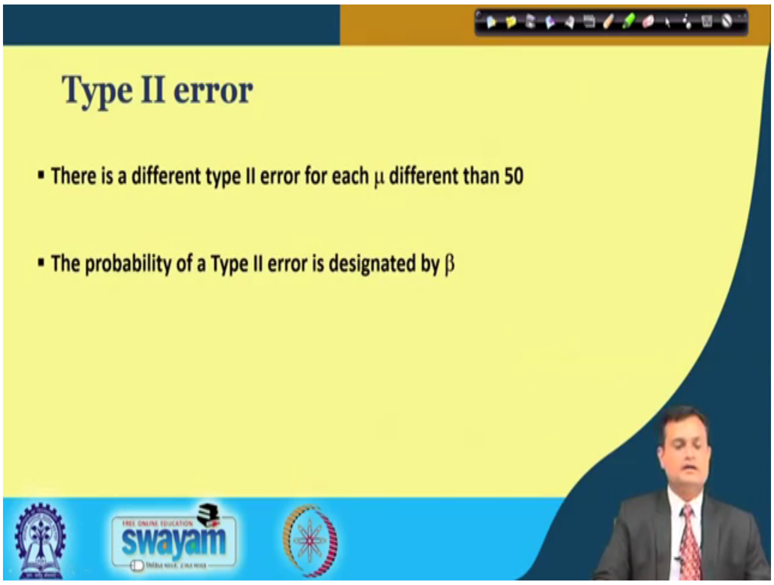
(Refer Slide Time: 28:32)



So, I would say that when I have put the alpha by 2. So, this is my alpha by 2, this is my alpha by 2 for the chosen value of my significance and I have the critical value here, I have the critical value here and I have mu is equal to 50.

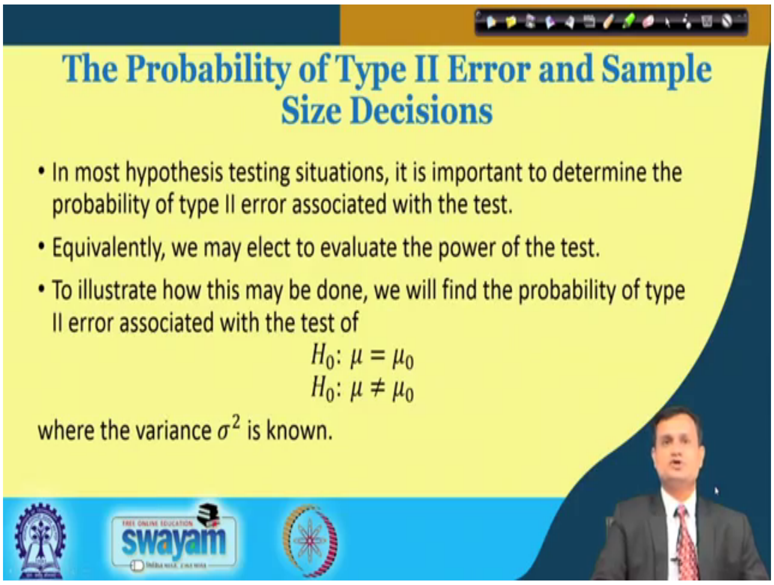
So, we will basically reject the null hypothesis mu is equal to 50, if our sample mean is either of these regions. So, if it falls in this region, I will reject the null hypothesis this shaded region is my reject region. So, this value typically comes from the table your statistical table for the given level of alpha.

(Refer Slide Time: 29:24)



Now, let us try to appreciate the importance of type II error. So, there is a different type II error for each mu different than 50 in this case and the probability of a type II error is designated by beta.

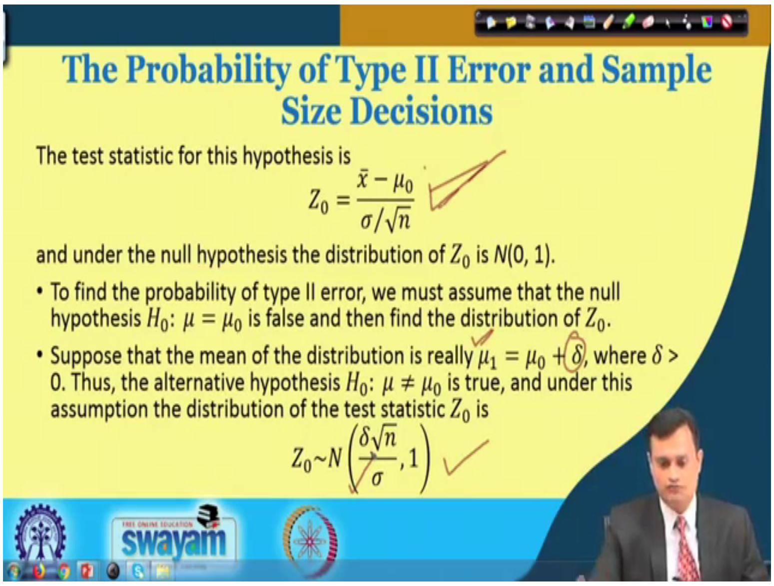
(Refer Slide Time: 29:42)



So, typically if we see then little bit it is difficult complex, but I will make it simple. Then, in most of the hypothesis testing situation it is most important to determine type II error because it also decides the power of my test.

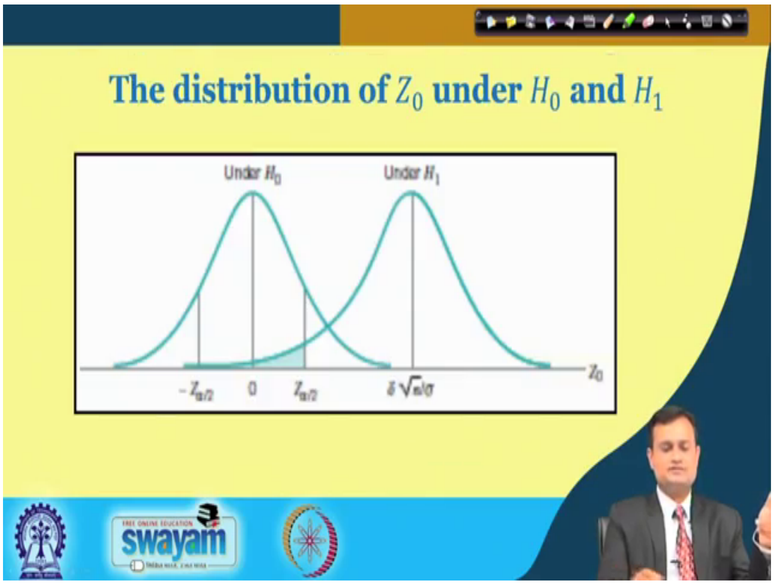
So, here the situation is like this H 0 is equal to is mu is equal to mu 0 and H 0 is mu is not equal to mu 0 and the variance is sigma square which is known let us say.

(Refer Slide Time: 30:16)



Now, what exactly this mu and mu 0 means?

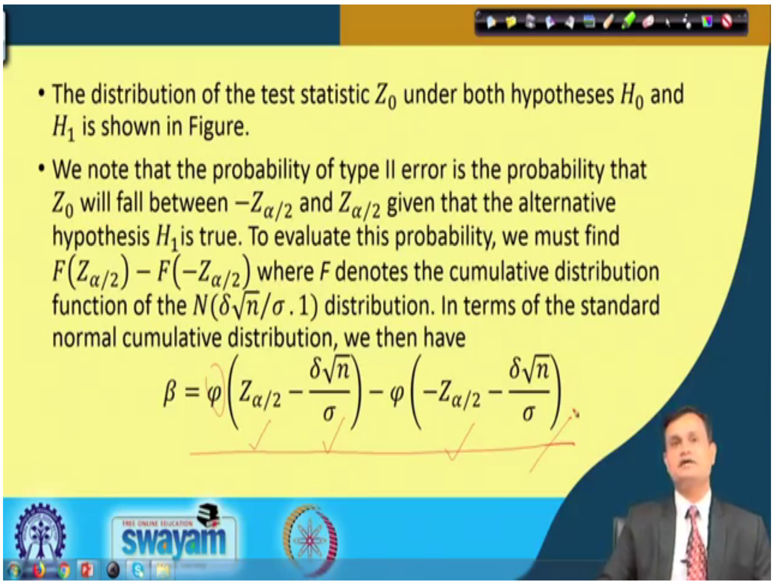
(Refer Slide Time: 30:22)



So, I am just trying to show you the figure first, I am saying that I have H 0 and I have H 1. So, there could be a possibility that my process has shifted and now under this situation what is that region so you can very well see this shaded region this particular shaded region this will typically gives you the type II error. So, when there is a shift in the process what is that region that will prompt me to make the type II error, it means not rejecting the null hypothesis when it is really to be rejected ok or this is something that we can also see through the calculation, so just we can see.

So, I can find out the test static for this that is Z 0 x bar minus mu 0 divided by sigma square root n and I have this statistics, that this Z is equal to x bar minus mu 0 divided by sigma square root n and I believe that this follows the normal distribution. So, here my mu 1 is little shift as I mentioned with delta in mu 0 and this Z 0 typically follows a normal distribution with mu delta square root n that is the shift divided by sigma and 1 has the standard deviation. So, for this suppose if I do the analysis for type II, then I can find this particular beta; I can find this particular beta.

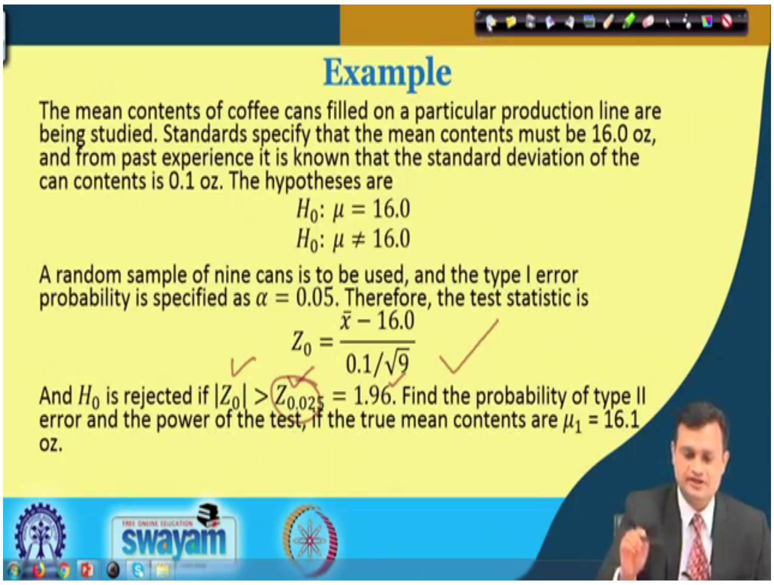
(Refer Slide Time: 32:26)



So, here when I say phi it is cumulative distribution your total probability over a horizon and this is Z alpha by 2 minus delta square root n divided by sigma minus cumulative probability minus Z alpha by 2 minus delta square root n divided by sigma. Its very simple, just see this figure you will have a clear idea.

So, here what I am trying to see that what is the region that I have between my minus Z alpha by 2 and delta square root and this and minus Z alpha by 2 and this so you will end up with this particular region. So, to find the probability of this region basically, I have taken the subtraction of these two which is this one Z alpha by 2 minus delta square root n divided by sigma minus this smaller region.

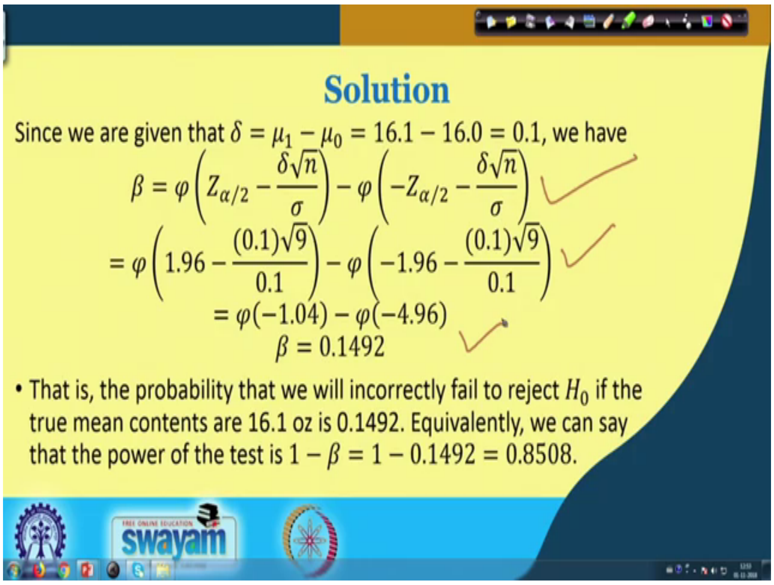
(Refer Slide Time: 33:53)



So, you can find the type II error and just see the example small before we summarize this particular lecture. So, the mean contents of coffee cans filled on a particular production line are being studied and the standard specify that the mean contains must be 16 ozone and from the past experience it is known that the standard deviation of the can content is 0.1. And now I want to set the hypothesis mu is equal to 16 mu is not equal to 16, so I can find my Z statistic we have seen in this probability theory that Z 0 is x bar minus mu x bar minus mu that is 16 divided by sigma divided by square root n because I am dealing with the sample.

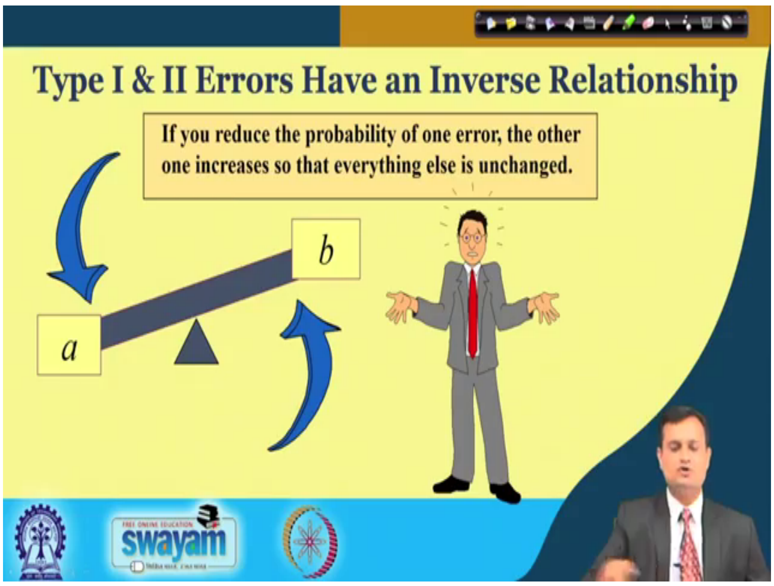
So, as for the central limit theorem sigma divided by square root n my sigma is 0.1 and n is typically the sample size that is 9. So, here you will find that the value you get is Z 0 is basically if you see this Z 0 is basically greater than Z 0.025. So Z 0.025 is the critical value that you have obtained from the table and your value comes out to be greater than this which is 1.96. So you will say that my particular claim needs to be tested for this particular relationship and now find the probability of error and power of the test, if true mean contents our mu 1 16.1 ozone. So, I am now considering that delta part little shift and I want to compute the my type II error.

(Refer Slide Time: 35:54)



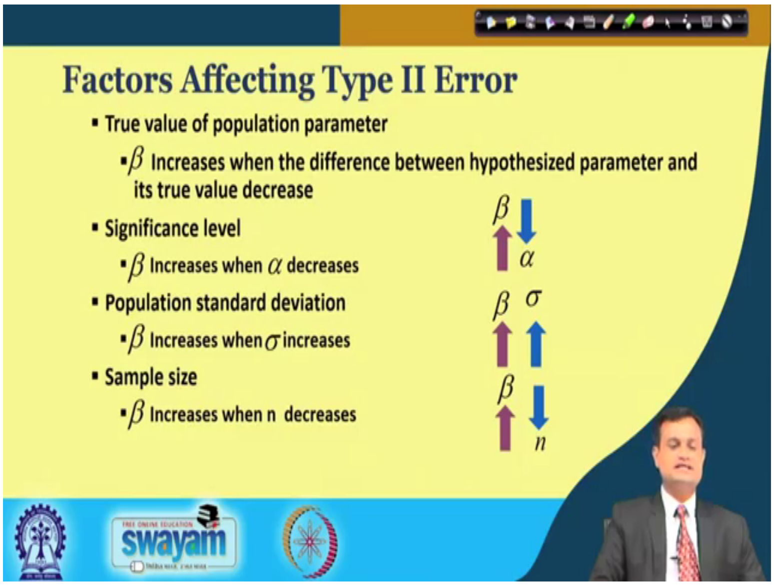
So, just see that how this can be done. So, now, I am using this expression which I have explained. This is typically the finding the shaded region for type II error I am just plugging in the values and what I find that beta is equal to 0.1492. So, 0.1492 is the type II error it means we will incorrectly fail to reject at 0, if the true mean contains are 16.1 is point 1 ozone is 0.1492 that is 14.92 percent or equivalently we can say that the power of test is 85 percent. So, this will help me to appreciate that to what extent I am critical and discriminative in applying my scientific analysis and I am able to make the decision.

(Refer Slide Time: 36:51)



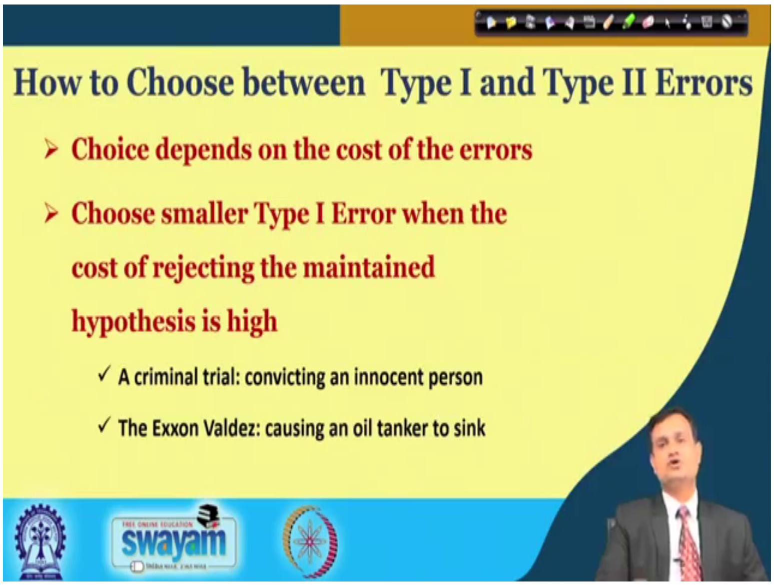
So, now the question comes what is the trade off between type I and type II error?

(Refer Slide Time: 38:59)



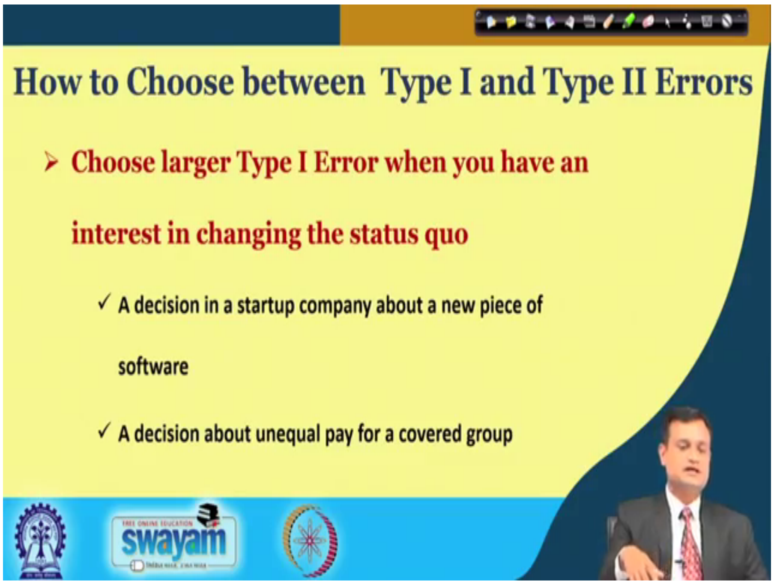
So, just see this when beta increases typically the differences between hypothesis parameter and its true value increases. Significance level when you try to understand with respect to that, beta increases, alpha decreases. Population standard deviation beta increases when sigma increases, sample size beta increases when n decreases. So, there is lot of thing that even you can have in your control in order to set or in order to have a trade off between alpha and beta, but what is the right trade off.

(Refer Slide Time: 37:37)



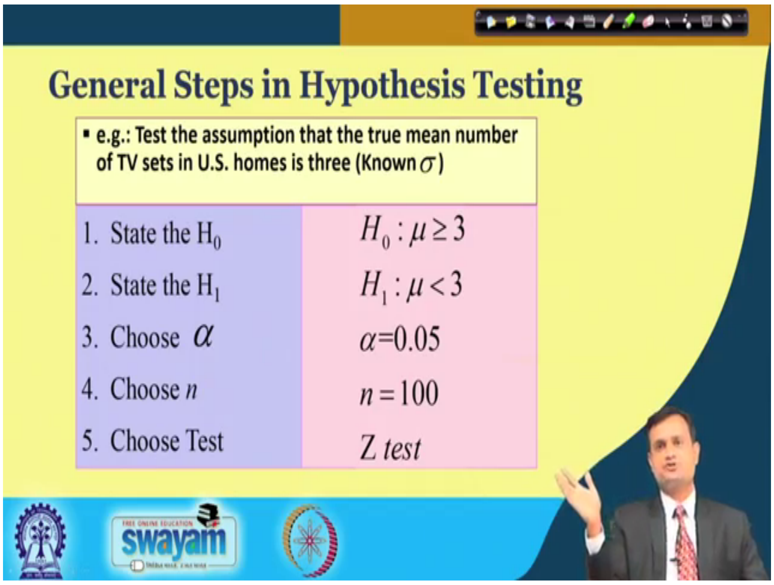
So, you must look at the particular situation and it is the situation problem which you are investigating will help you to decide what is the acceptable alpha level? So, as I mentioned in a criminal trial convicting an innocent person is not acceptable. So, in this case, you try to choose the lesser value of r for type I error level of significance.

(Refer Slide Time: 38:02)



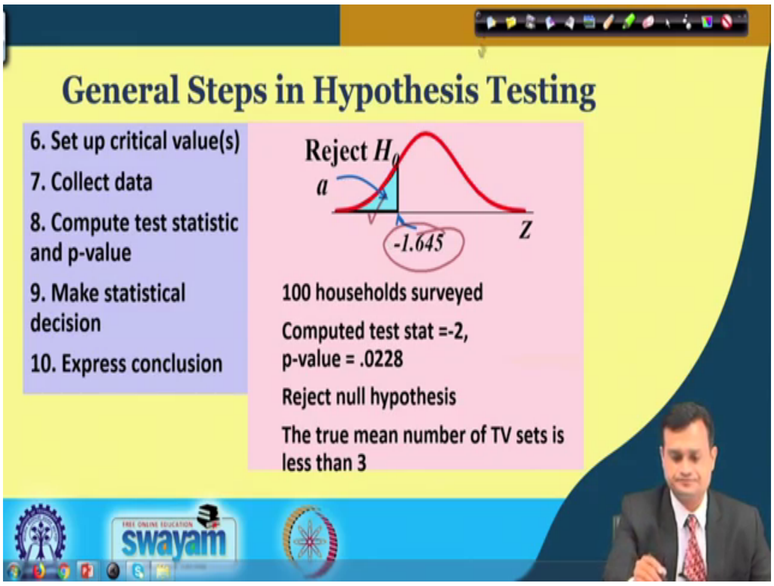
So, choose larger type one error when you and say interest in changing the status queue. You want people to change, you want to have a new startup, you do not want to get discouraged and you want to prove that my business will bring more profit or it would be successful then higher alpha value is acceptable.

(Refer Slide Time: 38:26)



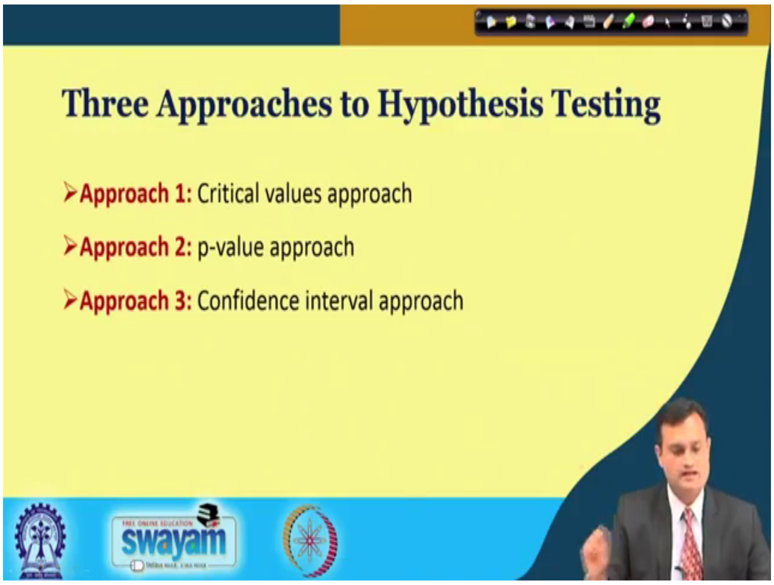
So, general steps to summarize in hypothesis testing state H 0, state H 1, you can parallelly see the green box, choose alpha choose n, choose the test.

(Refer Slide Time: 38:39)



Here, let us say it is Z test decide the say particular region based on the critical value here the blue shaded region is the critical region and this is the critical value which I found from the table for a given. Say alpha setting and then compute these statistics and p value make the statistical decision whether my claim is really true or it is rejected.

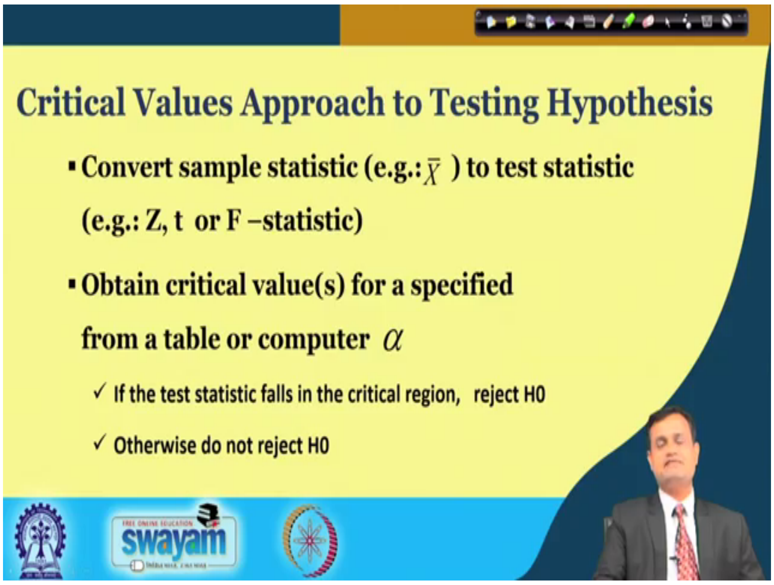
(Refer Slide Time: 39:12)



So, we have three approaches to summarize critical value approach, p value approach, and confidence interval approach to test the hypothesis.

(Refer Slide Time: 39:21)

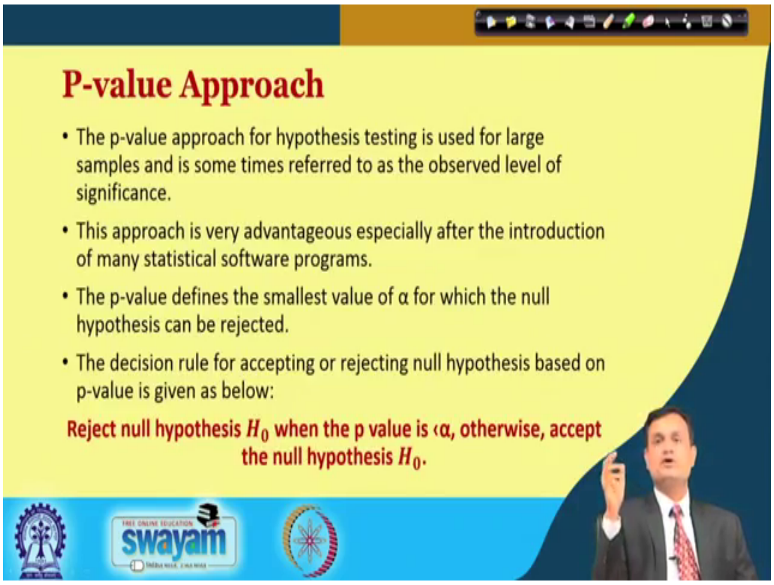
(Refer Slide Time: 39:24)



Critical value approach, I have just discussed that I will find the critical value based on alpha and then I will try to check whether I should reject null hypothesis or I should accept.

(Refer Slide Time: 39:32)

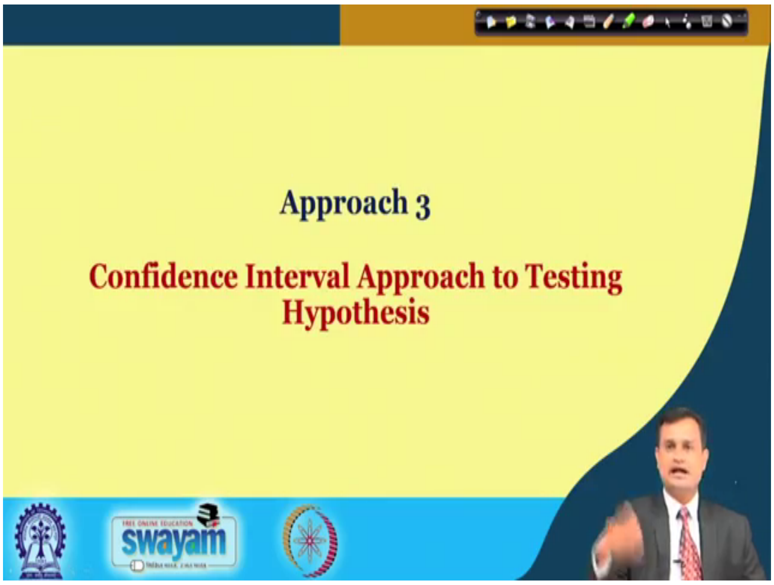
(Refer Slide Time: 39:35)



P value approach, I will try to find the probability value specific to critical value and then I will try to see that I have level of significance, I have observed level of significance that is the computed test statistics. Now you should feel comfortable with this technique or you should little bit revised. So, I have the observed level of significance, I have the critical level of significance, chosen level of significance and if my region is smaller it falls within the critical region. I will say my null hypothesis is reject.

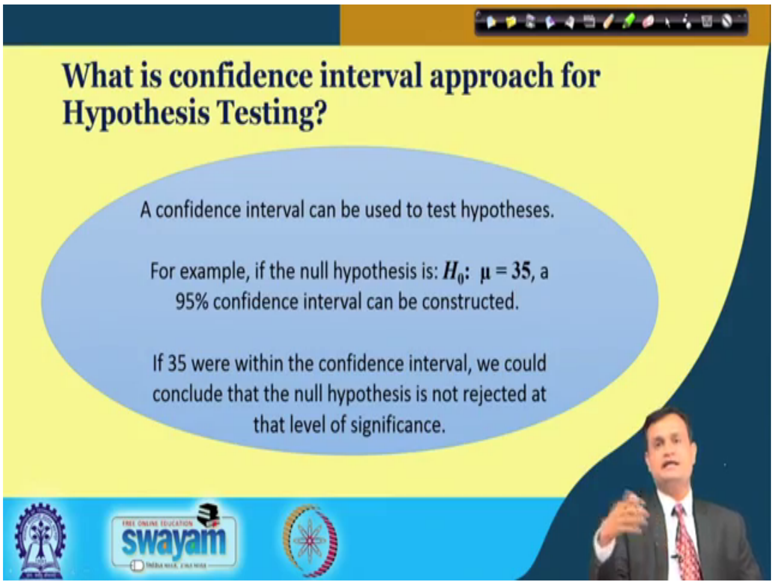
So, many a times softwares many softwares they use p value approach it is more intuitive to the managers because they know that what is the difference in probability at which they are rejecting null hypothesis. So, p value approach is more useful.

(Refer Slide Time: 40:28)



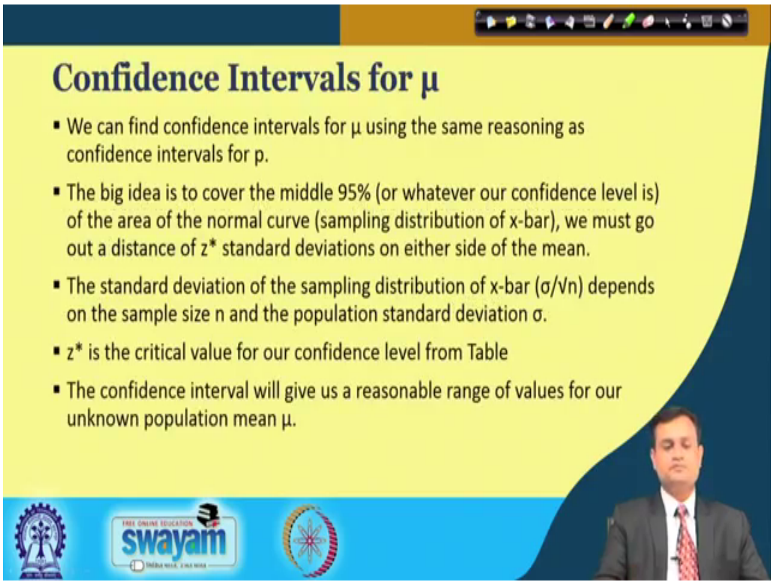
So, you have 3rd approach that is the confidence interval approach,

(Refer Slide Time: 40:32)



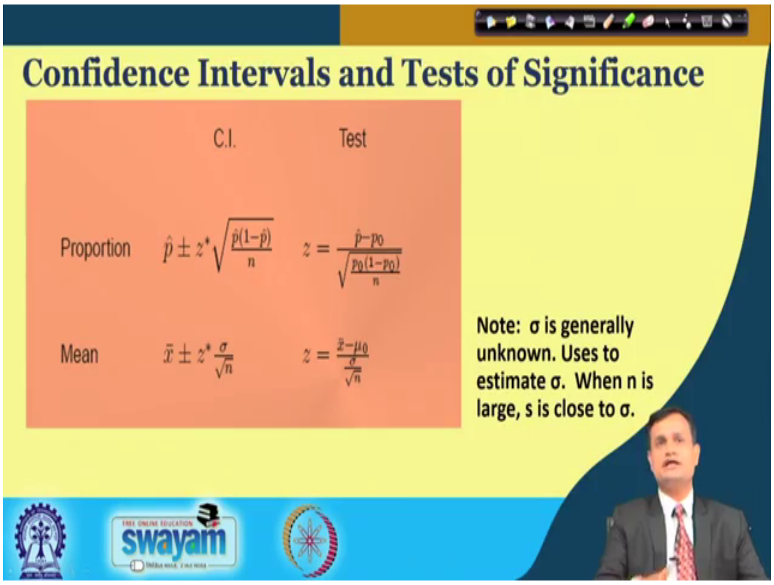
And here, you try to set the confidence interval that within what my value will fall. So, suppose my null hypothesis is 35, mu is equal to 35, I want to check that for a given confidence interval what is that interval within which majority of the time 95 percent of the time this value will fall.

(Refer Slide Time: 40:54)



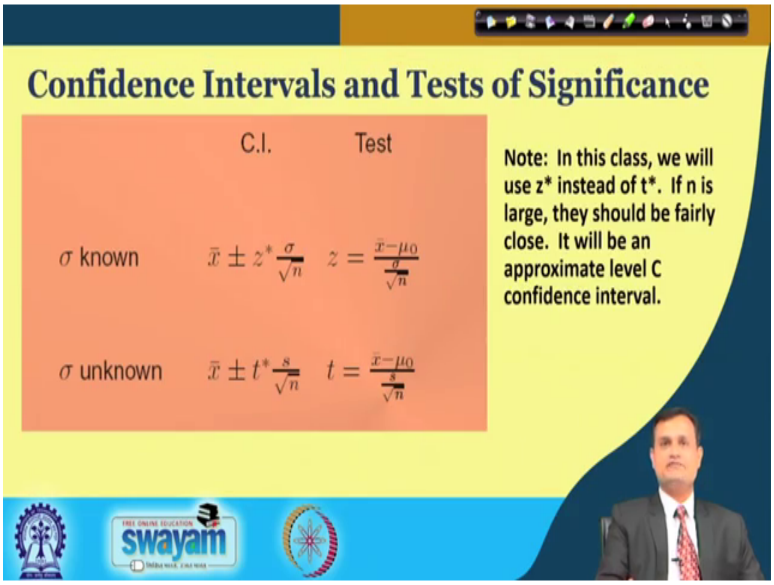
So, you have confidence interval construction using proportion mean.

(Refer Slide Time: 40:57)



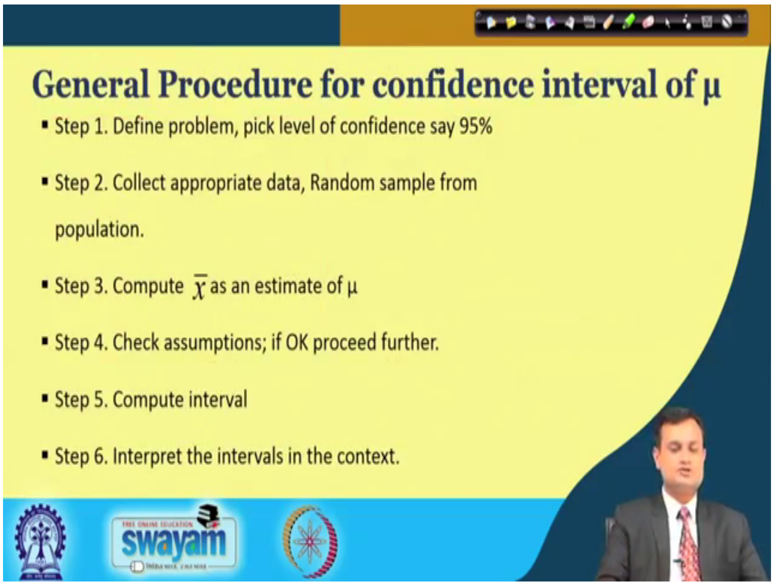
And you can use this mu plus or minus k sigma for proportion it would be p hat plus or minus Z star square root of p hat 1 minus p hat divided by n for mean x bar plus or minus Z sigma divided by square root n it will give you an interval and you need to check within what it falls.

(Refer Slide Time: 41:19)



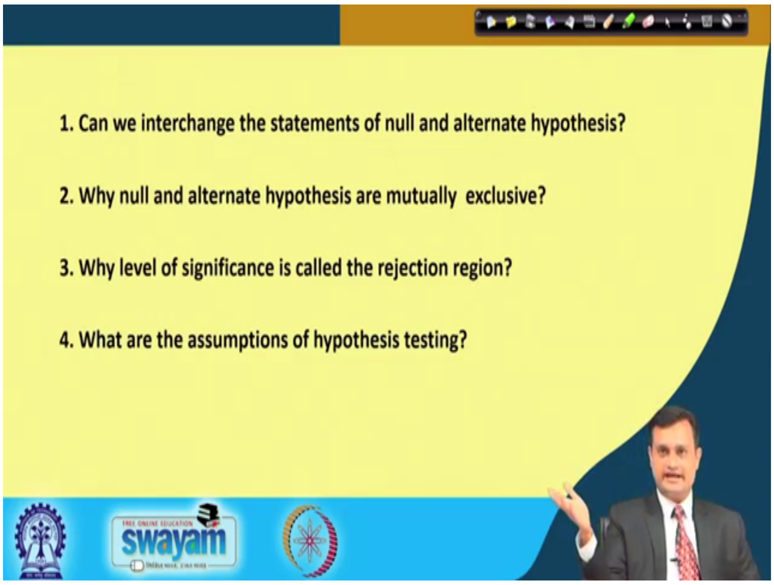
Same way, you have a situation sigma known, sigma unknown you can use the Z distribution or t distribution depending upon your sample size also.

(Refer Slide Time: 41:30)



So, there is a general procedure streps I have outline in the confidence interval. Define the problem, collect the data, compute x bar and mu, check assumption if proceed further, compute interval then interpret the interval in the context and take the decision about accepting or rejecting null hypothesis.

(Refer Slide Time: 41:52)

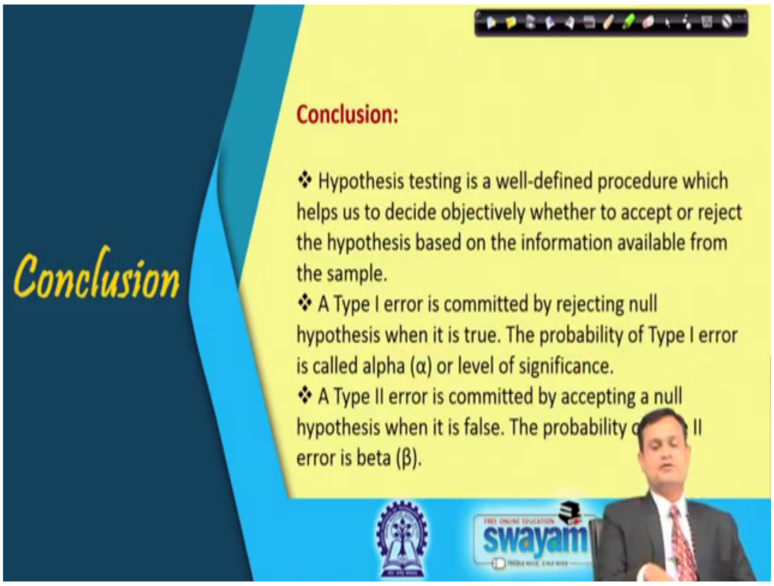


Think it, can be interchange H 0 and H 1 null and alternate. Why null and alternate are mutually exclusive, why level of significance called rejection region and what are the assumption of hypothesis testing.

(Refer Slide Time: 42:06)

Please go through couple of references to strengthen your idea. By the time, you must have developed confidence in understanding some of the vocabulary of hypothesis testing type I error, type II error, null hypothesis, alternate hypothesis, test statistics, confidence interval and I assume that this knowledge this terminology is clear to you. If you have a doubt, please revise this lecture or see the relevant chapter in the reference book suggested so that, you can understand the remaining lectures with comfort.

(Refer Slide Time: 42:48)



So, we have a conclusion that hypothesis is a claim subject to type I and type II error and I want to test existing theory or prove new theory check new theory and hypothesis testing is required alpha is level of significance type 1 error beta is my type II error and 1 minus beta is the power of the test.

So, thank you very much for your patience in learning this particular topic. I would like to say, this is the most important lecture you must understand it thoroughly otherwise, the subsequent lectures you will have some difficulty in understanding when we will try to solve the example or execute the hypothesis testing for various situation.

So, please revise it, internalize it, if required listen this lecture 2 to 3 times or you refer the textbook. So, that your journey becomes comfortable in analysed phase. So, this is the first lecture of analysed phase we will keep discussing enjoy be with me.