

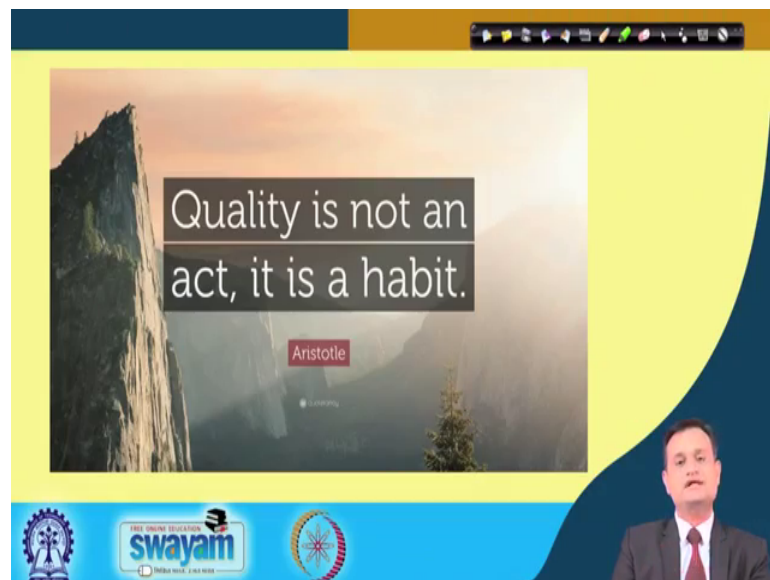
Six Sigma
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Lecture – 63
Six Sigma: Summary of Key Concepts

Hello friends, we have gone through a long and marathon journey of six sigma. We have discussed the various topics in greater detail; many complicated topics as well as interesting topics we have seen critically. Now you would be extremely happy as a student if I say this is the last lecture of the course. So, a student would always be happy when a teacher says, this is the last lecture and I will close the course with this particular lecture, so this is where we are.

So, lecture 63, we will just have a quick revision what we achieved. Try to have a sense of accomplishment, because again it is a kind of six sigma project, executing an online course and we must derive a pride in learning, executing our interest and knowledge on various topics of six sigma.

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So, let me give you a beautiful inspiration, quality is not an act it is a habit; Aristotle. I have specifically preserved this statement for the last lecture, the reason is, you cannot understand six sigma just by listening the video lectures, you have to revise this video lectures, you also have to refer the books suggested and most importantly you must

execute some sigma project, maybe hypothetical data set or maybe the real data set in industry and then only you can make six sigma as your habit.

So, quality is not an act, you just learn once and then you say that I am a six sigma it never happens, it is a continuous journey and you must create a habit of achieving, acquiring, implementing the knowledge and this is where we are at the last lecture of the course.

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Quality Obsession

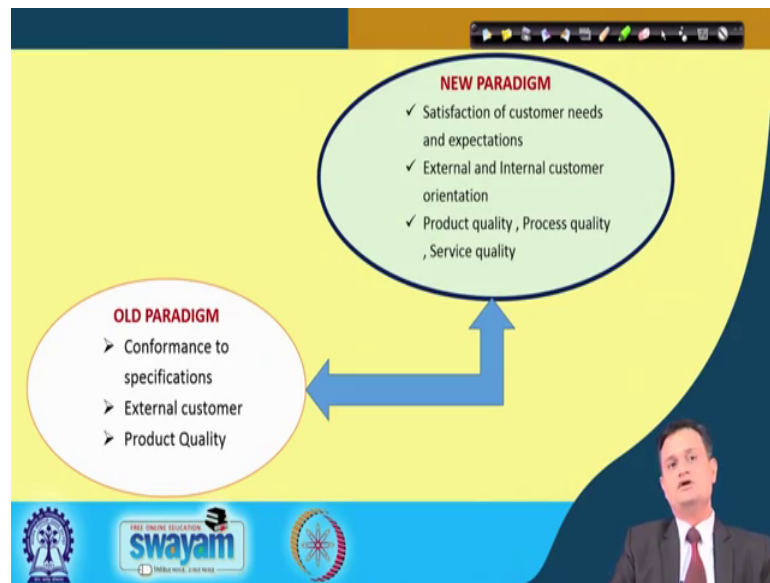
- ❑ Quality is a compulsion. No more a choice!
- ❑ Strategic weapon to differentiate in competition.
- ❑ In the global economy, quality is just the entry ticket.

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So, I would just like to remind you that we had started this journey and we were interested to study six sigma, because quality is an obsession, it is a compulsion. If you have to survive then quality is basically a qualifying factor, it is not a winning factor. If I tell somebody that I purchase the product, because it is quality product, nobody will be interested. People will say what is that extraordinary this product offers, because every product should be a quality product.

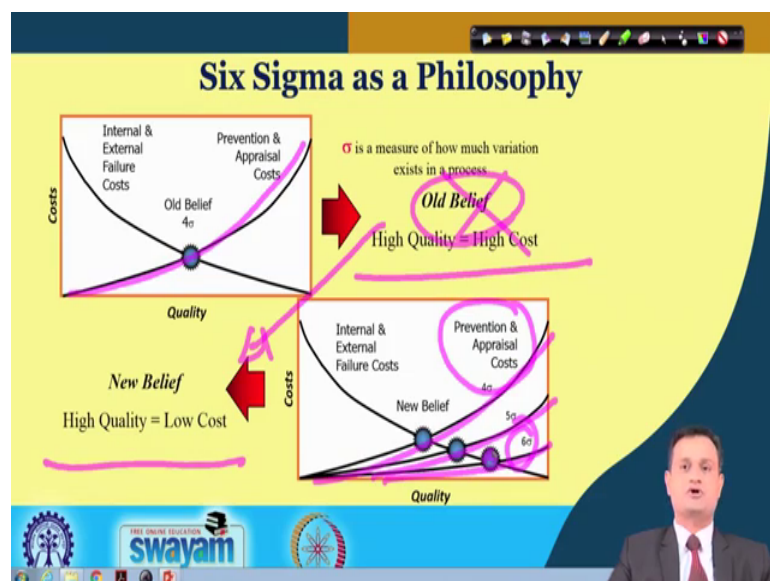
So, quality has become a qualifying criteria and you must ensure the competitive quality standard and hence it is an obsession. Global economy will not exempt you if you do not operate at 4 sigma, 5 sigma, 6 sigma which is the benchmark international standard and you will miserably fail in your business.

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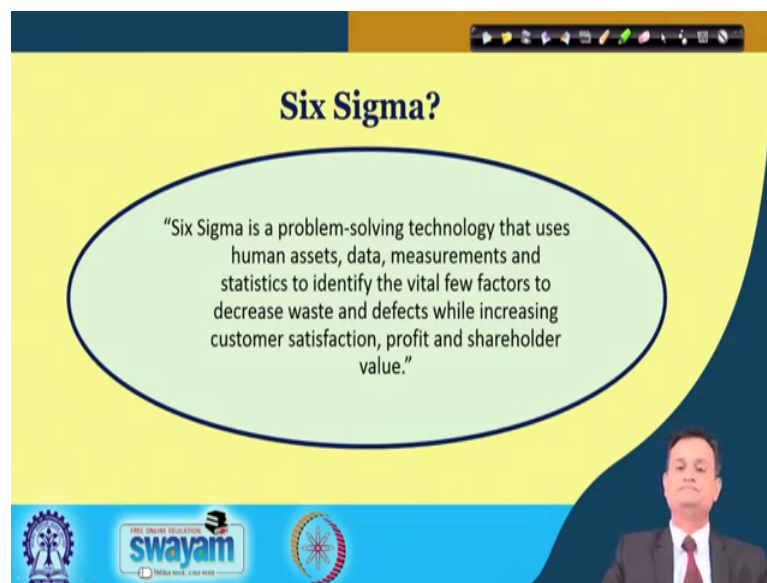
You have seen the shift in the paradigm, old paradigm concentrated on specifications, external customer product quality. New paradigm says talk about satisfaction of customer needs and expectation, capture the voice of customer. Do not only think about external, your internal customers are equally important and product quality process quality and service quality, all these three must be appropriately integrated then only you can say that I am a world class company.

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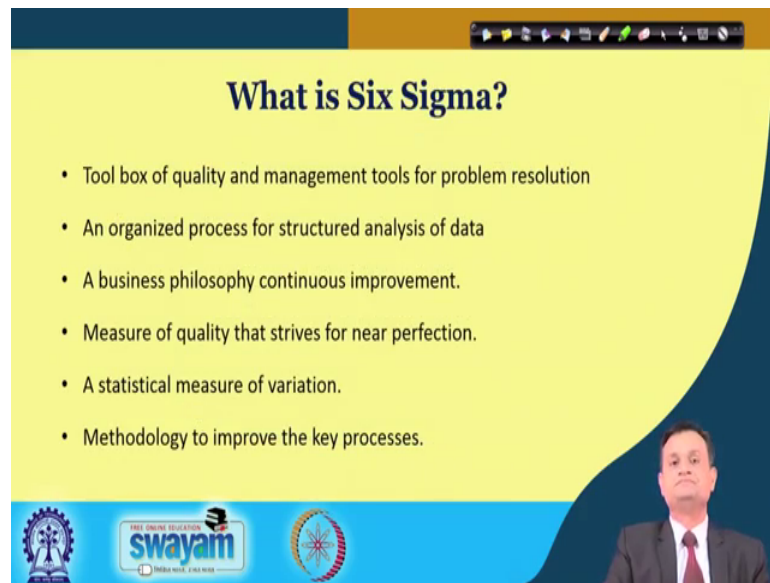
The philosophy we have seen is like this, this is the old belief which says that high quality is high cost, I will put a cross. The new says that high quality is low cost and the reason is very simple, you can just say how this particular curve shifts. So, this is basically prevents on an appraisal cost. If you have better control over your processes variability has gone down, then your prevention and appraisal cost will definitely go down; when you are at six sigma you can see that your cost has, break even cost has shifted to a very very low level and you can really achieve a best quality at a low cost.

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So, this is what we have appreciated by discussing the various phases of six sigma. So, you should not forget the definition, the spirit of six sigma. Six sigma is a problem solving technology that uses human assets, data, measurements and statistics to identify the vital few factors to decrease waste and defects while increasing customer satisfaction profit and shareholders' value. So, it has a very big perspective to address, it is not only about applying DMAIC, but with a very bigger perspective we try to execute the six sigma project.

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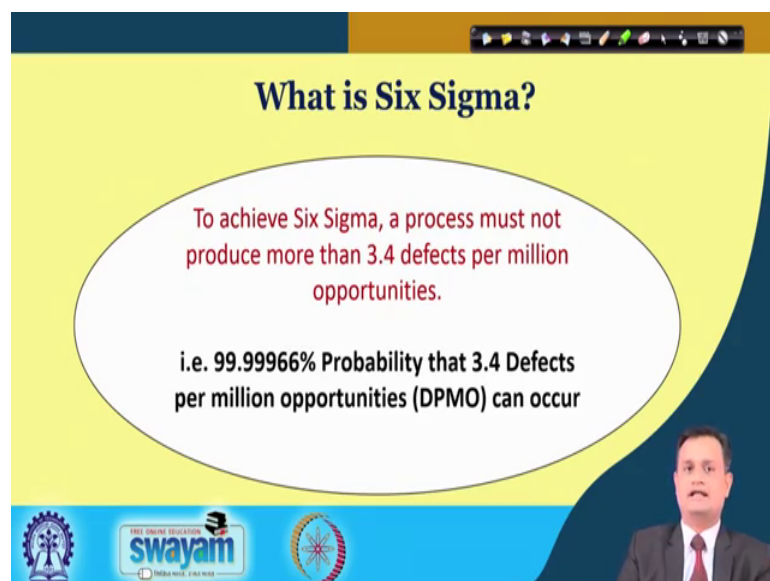
What is Six Sigma?

- Tool box of quality and management tools for problem resolution
- An organized process for structured analysis of data
- A business philosophy continuous improvement.
- Measure of quality that strives for near perfection.
- A statistical measure of variation.
- Methodology to improve the key processes.

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So, what is six sigma? It is a philosophy introduced by Motorola in 1986. General Electric has reaped the extraordinary advantages in 1995. Many Indian organizations as I mentioned Maruti, Tata Steel, Tata Motors L and T. So, all these are the organizations located in India as well as global presence. They have realized the immense benefit of six sigma and typically it is a methodology which is heavily driven on fact based management, statistical variability, control and the use of statistic is extraordinary.

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What is Six Sigma?

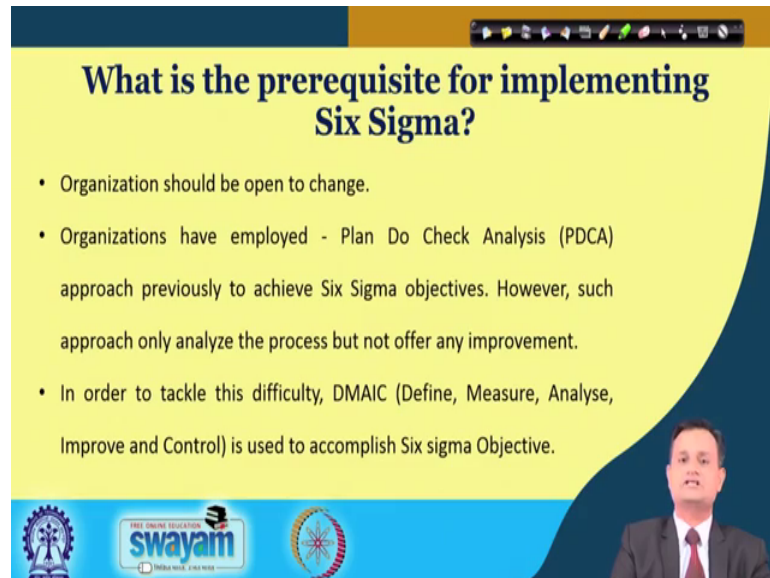
To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities.

i.e. 99.99966% Probability that 3.4 Defects per million opportunities (DPMO) can occur

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So, six sigma in a more technical term I would say that I want to achieve a six sigma and a process must not produce more than 3.4 defects per million opportunity. When I achieve this I will say that my process has reached to the six sigma and 3.4 defects per million is just like, so 99.99996 percent probability that only 3.4 defects will be produced which is almost 0.

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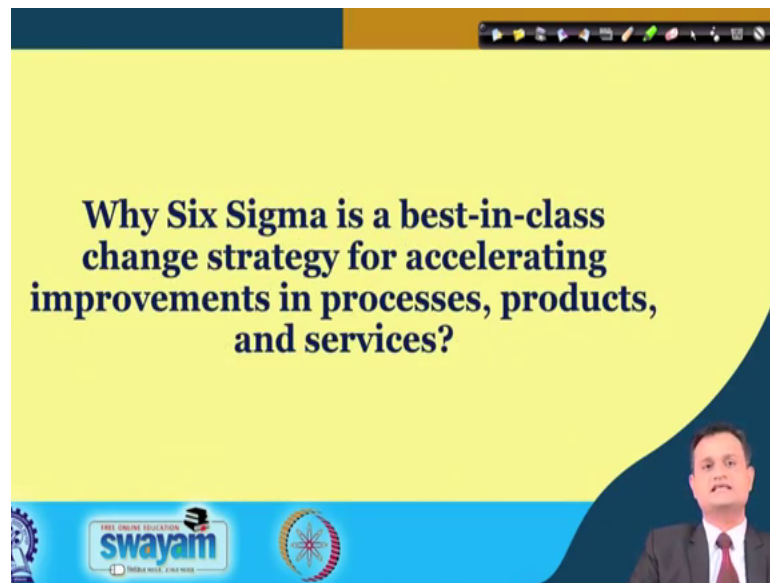
What is the prerequisite for implementing Six Sigma?

- Organization should be open to change.
- Organizations have employed - Plan Do Check Analysis (PDCA) approach previously to achieve Six Sigma objectives. However, such approach only analyze the process but not offer any improvement.
- In order to tackle this difficulty, DMAIC (Define, Measure, Analyse, Improve and Control) is used to accomplish Six sigma Objective.

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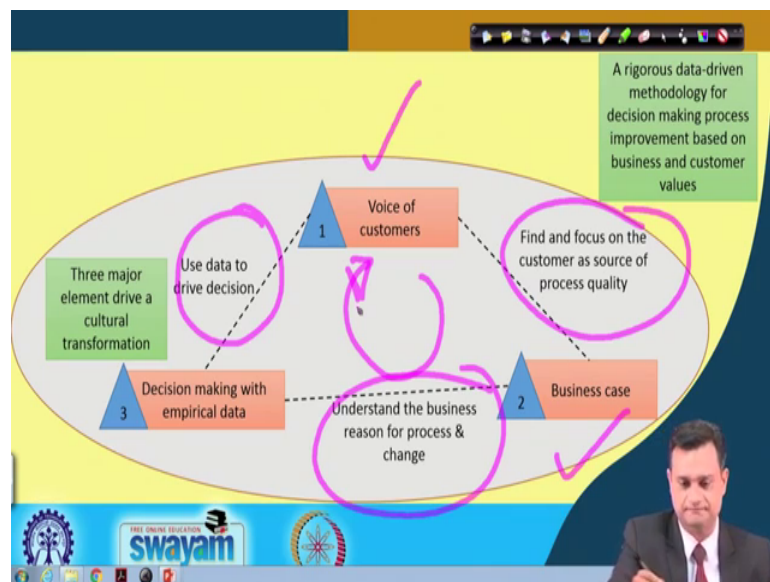
So, there are certain prerequisite and if you recall we discussed as a part of our first two week discussion that you must have an open culture, you must have an organization ready to change and you must have a specific structure like DMAIC to operate with.

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So, why six sigma is a best in class, say change strategy for accelerating improvement in process and products and services.

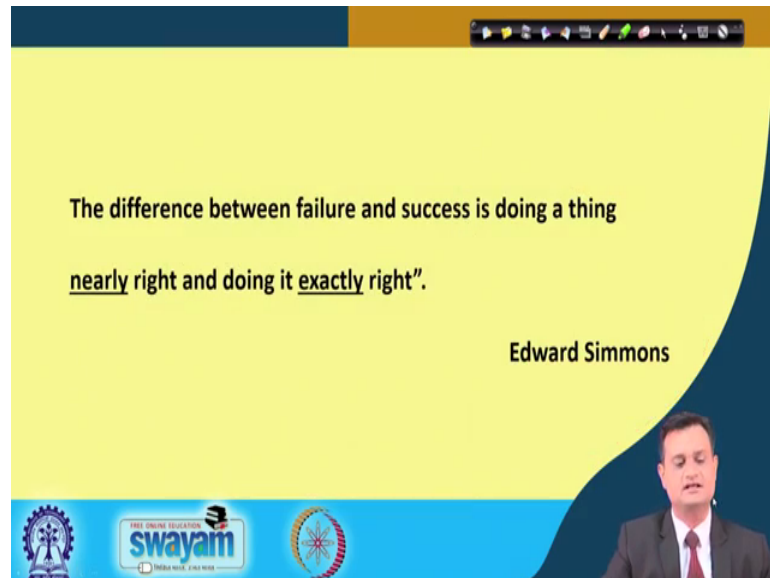
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So, this figure which we discussed right at the beginning, I would like to remind you that you have the voice of customer, you have the business case. Find the focus on the customer a source of process quality and understand the business reasons for process and change, and use data to drive decision. When you complete this particular spiral you will

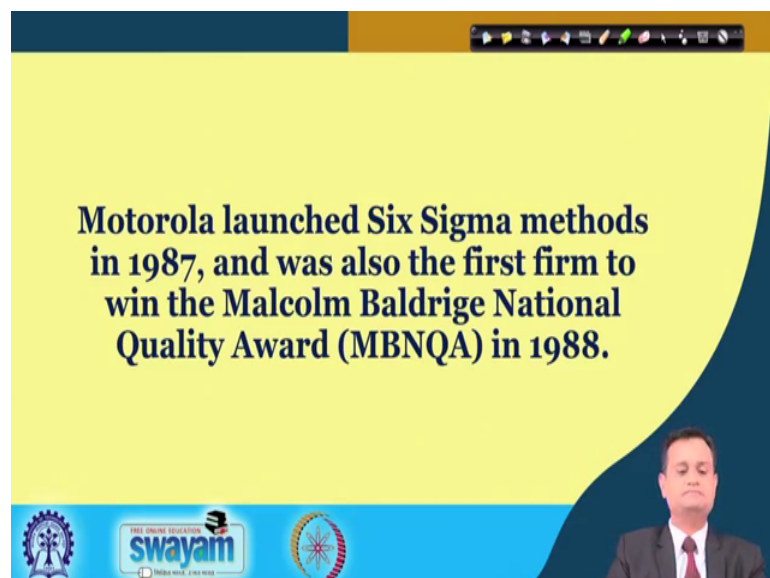
say that six sigma is really a strategy to bring significant improvement and change in the existing processes of the organization.

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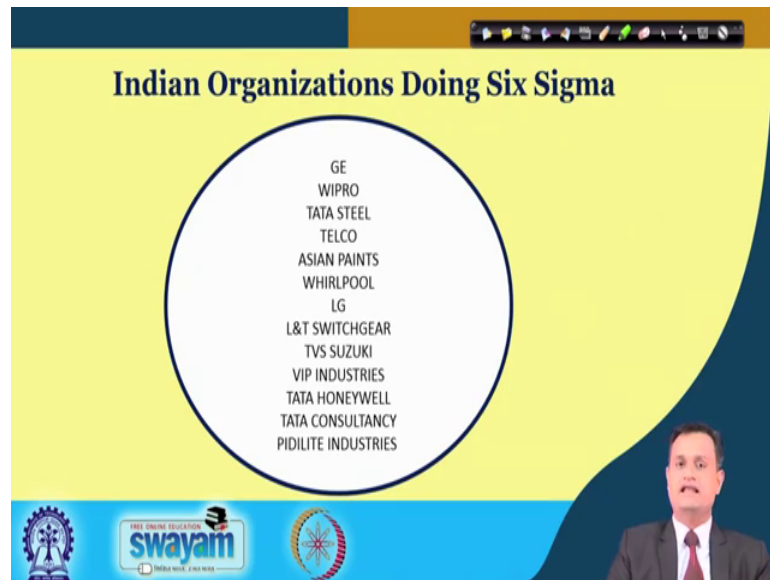
So, this is the change strategy which addresses the three pillars. So, the difference between failure and success is doing a thing nearly right and doing exactly right, and this is what Edward Simmons says. So, when I talked about six sigma, I talked about perfection, I talked about doing the things exactly right not the nearly right. So, this is about six sigma.

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So, Motorola launched six sigma method in 1986-1987 and also the first firm to win the Malcolm Baldrige award in 1988. So, you can see that it can bring, six sigma can bring many laurels to your company by having the excellent control over your processes.

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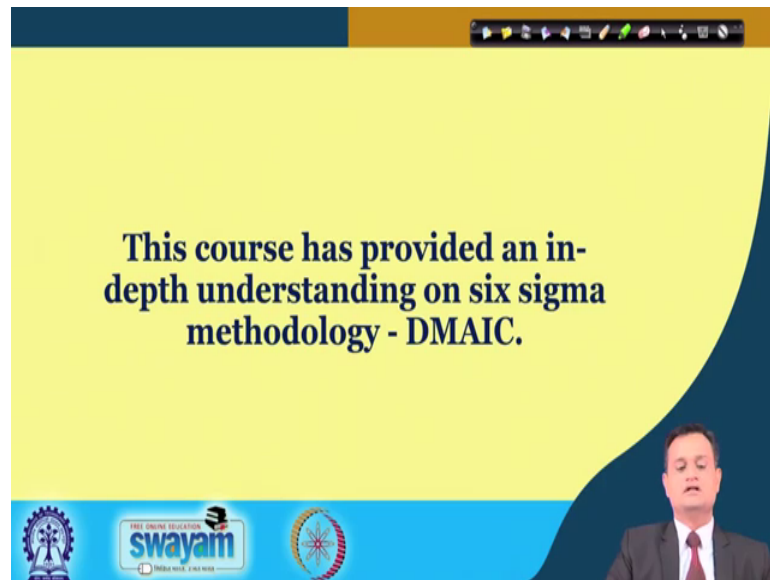
Many organizations in India GE, Wipro, Tata Steel, Telco, Asian paints, Whirlpool, LG and VIP, Tata Honeywell, Tata Consultancy, Pidilite, they have reaped the huge trending benefits of six sigma.

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Now, we want to wrap up this course and let us try to see when we talk about DMAIC at the end we always try to introspect and see that to what extent we have achieved our goals. We had set our goals right at the beginning of this course and in terms of the deliverables of this course how we have achieved this.

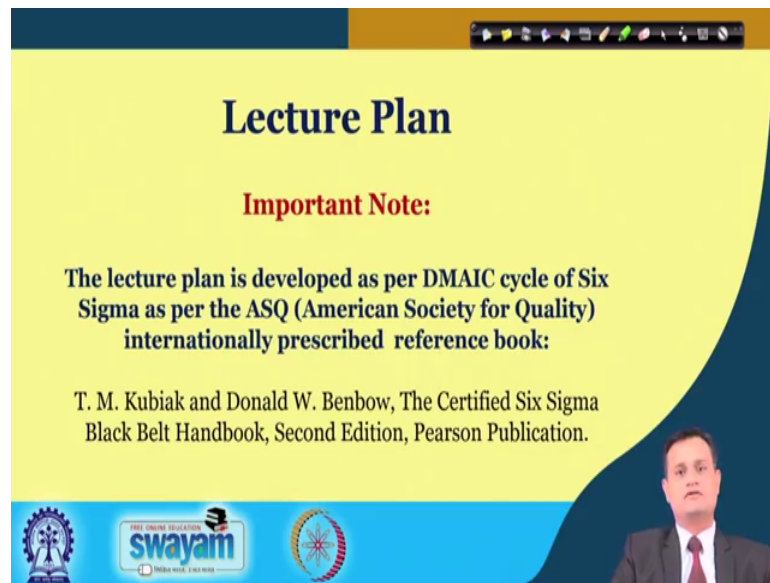
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So, this course has provided an in-depth and critical understanding on six sigma methodology DMAIC. I can assure you that the course is developed based on the ASQ American Society for Quality and international body recommended book, and if you go through this course and satisfy the prerequisite stipulated by ASQ then you can definitely clear the black belt certification for six sigma. Obviously, for that you have to satisfy the prerequisite for two projects, six sigma project and you have to appear in the exam.

So, such exam schedule is available on the net and ASQ they conduct this exam yearly you will have 4 5 slots to appear. And I assure you that the course you have studied is adequate enough to appear and clear this exam. So, this course has included in order to achieve the objectives and as a deliverable.

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Lecture Plan

Important Note:

The lecture plan is developed as per DMAIC cycle of Six Sigma as per the ASQ (American Society for Quality) internationally prescribed reference book:

T. M. Kubiak and Donald W. Benbow, The Certified Six Sigma Black Belt Handbook, Second Edition, Pearson Publication.

Logos at the bottom: Swayam (Free Online Education), NPTEL (National Programme on Technology Enhanced Learning), and a circular logo with a gear and a person.

This is the book which we have followed, which is recommended by American society for quality and it is a Black Belt book TM Kubiak and Donald W, the certified six sigma Black Belt book. I can assure you that the content we have covered is even more than what is being given in this book, but; obviously, we have followed the structure, but we have gone into the greater and greater detail of each topic as a part of this particular course.

So, the course delivered as a part of NPTEL; a government of initiative, India initiative, six sigma can assure you the world class standard in terms of say black belt requirement given by the American society for quality and you can trust and ensure that by going through this course systematically you are well equipped to appear in any such kind of examination.

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So, what we have delivered; quality fundamentals and key concepts week 1, week 2. So, this is all about creating my organization for the six sigma.

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Lecture 1: Brief overview of the course	Course Structure, Course Coverage, Lecture Plan, Importance of six sigma, Expectation from the Course
Lecture 2: Quality concepts and definition	Dimensions of Quality, Role of various functions in the Organization towards Quality, Critical Challenges for Indian Organizations, Indian originations recipient of Quality Awards
Lecture 3: History of continuous improvement	Milestones in Quality, Evolution of Concept of Six Sigma, Integration of Concept of Value with Six Sigma, Certification
Lecture 4: Six Sigma Principles and Focus Areas (Part 1)	Six Sigma, Shift in Quality Paradigm, Difference between 3 Sigma and Six Sigma, DPMO, Calculating sigma level
Lecture 5: Six Sigma Principles and Focus Areas (Part 2)	Rolled Throughput Yield (RTY), Classic Yield, First Pass Yield (FPY), Hidden Factory, Six Sigma roles and responsibilities
Lecture 6: Six Sigma Applications	Indian organizations doing Six Sigma, Applications of six sigma in select Indian organizations, Challenges faced by Indian Organizations, Six Sigma benefits realized

So, week 1 we have talked about lecture 1: brief overview of the course. Then quality concepts as a part of lecture 2, definition of the quality and what are the different imperatives for the organization. Then lecture 3: history of continuous improvement, how it has evolved in last 100 220 years. The lecture 4: six sigma principles and focus

areas part 1 very very important lecture, we talked about the difference between three sigma and six sigma and shift in quality paradigm and so on.

We talked about as a part of lecture 5 six sigma principles part 2, and very important concepts we have discussed rolled throughput yield, classic yield, first pass yield hidden factory six sigma roles and responsibility. Lecture 6 we had seen couple of applications of six sigma so that you feel energetic and motivated to learn this course and many organizations they have implemented this philosophy six sigma and received the immensed benefit in terms of process improvement.

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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 delivered lecture 7 quality management say basics and key concepts. Fundamentals of total quality management we talked in lecture 8. Lecture 9 was very important on cost of quality, unless you made the measure the quality in terms of cost, prevention cost, appraisal cost, internal failure external failure, you cannot really say trigger the thrive or movement for the change and the improvement.

So, this is where you can draw the attention of the top management. Then voice of customer which is the heart of six sigma and that we discussed as a part of lecture 10. Lecture 11 was QFD quality function deployment, you do not only capture the voice of the customer, you try to relate it with the technical requirement, you use it for the benchmark and this is where we had done the lecture 11. Lecture 12 was on management and planning tools part 1 and lecture 13 was management and planning tools part 2. We

have discussed many many tools that can really help us to dig out into the problem and figure out that what is really causing the problem.

So, we have seen various tools like, maybe affinity diagram, tree diagram, process decision program chart, then activity network diagram, pace prioritization matrix, force field analysis and so on.

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Then we entered into the define phase and we delivered say typically the content of defined phase in week 3.

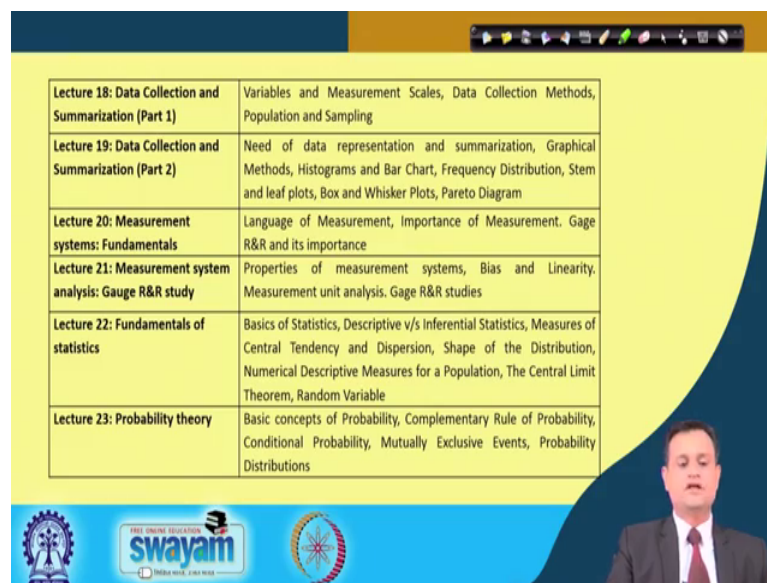
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Lecture 14: Six Sigma Project Identification, Selection and Definition	Six Sigma Project, Tools used in Six Sigma Projects, Voice of Customer, Examples of CTS –CTQ, Project Metrics and Success Criteria
Lecture 15: Project Charter and Monitoring	Project Charter, Elements of Project Charter, Criteria for Project Monitoring, Steps of Monitoring System
Lecture 16: Process characteristics and analysis	Parameters in a Process, Process Flow Metrics, Process Analysis Tools, Process Maps and Flow Charts, Value Stream Map, Spaghetti Diagram, Circle Diagram
Lecture 17: Process Mapping: SIPOC	SIPOC, Process Components in SIPOC, Mapping the Process, Steps to draw SIPOC

So, week 3 we talked about six sigma project identification, selection and definition as a part of lecture 14. Lecture 15 project charter and monitoring you have to define, you have to fix your bible then only you can seek the commitment of the people and the top management. Then lecture 16: process characteristics and analysis. Lecture 17: very important tool for process mapping SIPOC. Then we entered into the second phase that is M stands for measure and we delivered the content specific to measure phase in week 4 and week 5.

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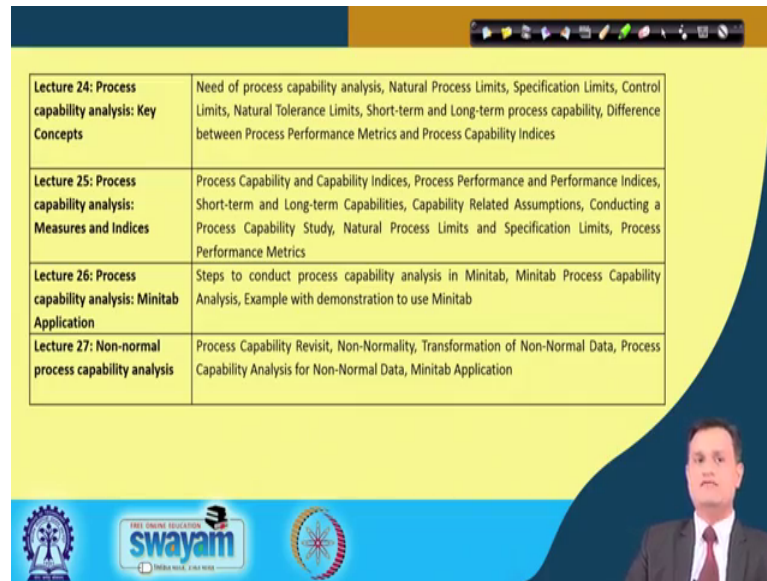


Lecture 18: Data Collection and Summarization (Part 1)	Variables and Measurement Scales, Data Collection Methods, Population and Sampling
Lecture 19: Data Collection and Summarization (Part 2)	Need of data representation and summarization, Graphical Methods, Histograms and Bar Chart, Frequency Distribution, Stem and leaf plots, Box and Whisker Plots, Pareto Diagram
Lecture 20: Measurement systems: Fundamentals	Language of Measurement, Importance of Measurement. Gage R&R and its importance
Lecture 21: Measurement system analysis: Gauge R&R study	Properties of measurement systems, Bias and Linearity. Measurement unit analysis. Gage R&R studies
Lecture 22: Fundamentals of statistics	Basics of Statistics, Descriptive v/s Inferential Statistics, Measures of Central Tendency and Dispersion, Shape of the Distribution, Numerical Descriptive Measures for a Population, The Central Limit Theorem, Random Variable
Lecture 23: Probability theory	Basic concepts of Probability, Complementary Rule of Probability, Conditional Probability, Mutually Exclusive Events, Probability Distributions

So, week 4 we talked about in lecture 18; data collection in summarization part 1, lecture 19 data collection in summarization part 2 and we had seen the various concept like population and sample, Pareto diagram, histogram, bar chart and say box and whisker plot and many other things. Lecture 20: measurement system fundamentals, if your system is not accurate and precise, garbage in garbage out follows. Lecture 21: gage R and R study which is the heart of analyzing the precision of your measurement system.

Lecture 22: fundamentals of statistics and we have talked about the central limit theorem, shape of the distribution and other concepts, and 23 probability theory. I would emphasize that if you really want to appreciate this course, you must have some knowledge of the statistics right at the beginning even though we have covered some of the concepts as a part of lecture 22 23.

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Lecture 24: Process capability analysis: Key Concepts	Need of process capability analysis, Natural Process Limits, Specification Limits, Control Limits, Natural Tolerance Limits, Short-term and Long-term process capability, Difference between Process Performance Metrics and Process Capability Indices
Lecture 25: Process capability analysis: Measures and Indices	Process Capability and Capability Indices, Process Performance and Performance Indices, Short-term and Long-term Capabilities, Capability Related Assumptions, Conducting a Process Capability Study, Natural Process Limits and Specification Limits, Process Performance Metrics
Lecture 26: Process capability analysis: Minitab Application	Steps to conduct process capability analysis in Minitab, Minitab Process Capability Analysis, Example with demonstration to use Minitab
Lecture 27: Non-normal process capability analysis	Process Capability Revisit, Non-Normality, Transformation of Non-Normal Data, Process Capability Analysis for Non-Normal Data, Minitab Application

Now, we have entered into week 5 and then we delivered as a part of lecture 24 process capability analysis. I must know whether my process is capable or not, if I am having a very poor process, very poor capability process then first I need to enhance the capability of the process through necessary adjustment or the up gradation and then I can think about the other measures. We talked about various process capability indices; like C_p , C_{pk} , C_{pm} , P_p , P_{pk} , P_{pm} as a part of lecture 25.

Lecture 26 delivered process capability analysis in Minitab for helping the professionals as well as university students for executing the projects and lecture 27 was on non normal process capability, where we have discussed the concept as well as Minitab application for non-normal process capability. Then we entered into the analyze phase, we delivered the content of analyze phase in week 6 and week 7.

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Lecture 28: Hypothesis testing: Fundamentals	Statistical Hypothesis, Null and Alternative Hypothesis, Type I and Type II Errors in hypothesis testing, General Steps in Hypothesis Testing, Approaches to Hypothesis Testing: Approach 1: Critical Value; Approach 2: p-value; Approach 3: Confidence Interval
Lecture 29: Hypothesis Testing: Single Population Test	Hypothesis testing for a Single Population Mean using - z statistic, t statistic, for Proportion
Lecture 30: Hypothesis Testing: Two Population Test	Hypothesis testing for comparing the difference between a) The means of two independent populations; b) The proportions of two independent populations; c) The variances of two independent populations by testing the ratio of the two variances; d) Dependent (Related) Samples (Same group before vs. after treatment)
Lecture 31: Hypothesis Testing: Two Population: Minitab Application	Minitab applications for a) Pooled-Variance t Test Example; b) Comparison of two population proportions
Lecture 32: Correlation and Regression Analysis	Correlation analysis, Predicting the value of a dependent variable based on an independent variables, Evaluating the assumptions of regression analysis
Lecture 33: Regression Analysis: Model Validation	Autocorrelation, Durbin-Watson statistic, The t-test and F test, Pitfalls of regression analysis

So, week 6 was about hypothesis testing. I want to check my claim on a scientific basis, statistical basis and this was lecture 28. I can do hypothesis testing for one population or single population or two population and I can also have the Minitab application, this part was covered in lecture 29, 30 and 31. Lecture 32 we deliberated on correlation and regression analysis and lecture 33 we went into the various line assumption verification, linearity independence, normality, equal variance for validating my regression model.

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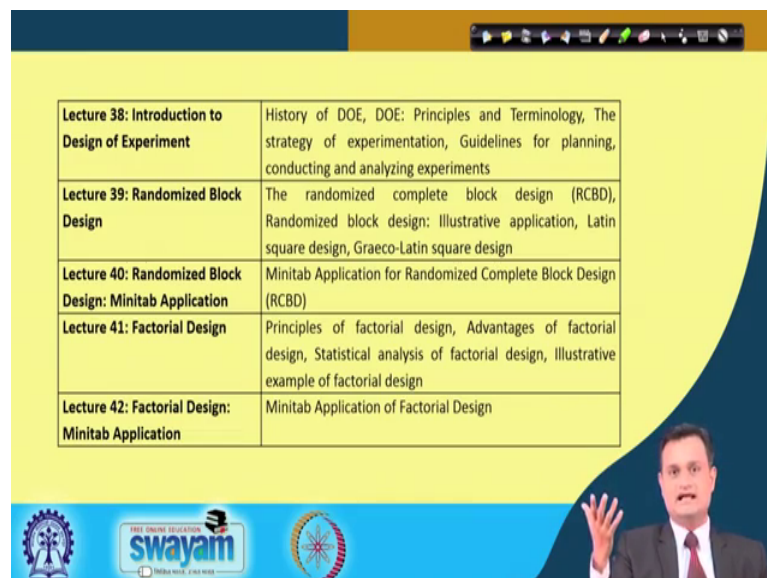
Lecture 34: One-Way ANOVA	Purpose of ANOVA analysis, One-way ANOVA for testing differences among the means of several populations, One-way ANOVA in Minitab
Lecture 35: Two-Way ANOVA	Purpose of Two-way ANOVA, Two-Way ANOVA (Factorial Design), Two Way ANOVA in Minitab
Lecture 36: Multi-vari Analysis	Need of Multi-vari Studies, Concept of Multi-vari Studies, Construction & Interpretation of Multi-vari Charts, MINITAB Exposure: Multi-vari Charts
Lecture 37: Failure Mode Effect Analysis (FMEA)	Need and Advantages of FMEA, Types of FMEA, Failure Mode, Risk Priority Number, Steps in FMEA, Risk Management and Risk Mitigation

Then week 7 we delivered one-way ANOVA, I cannot be happy with the multiple say paired comparison by T test, I need to have a mechanism which can help me to reduce my type 1 error and this is where I will go for ANOVA which can compare more than two or three means simultaneously and I deal with basically the variability within group between group and I discussed the concept of one-way ANOVA.

I may have two factors say of interest on which I want to analyze the impact and this is where the impact of this two factor I want to analyze on the response variable. So, productivity may be governed by the morale of the employee as well as the state of the technology, I have two factors and I conducted the two-way ANOVA analysis. Then lecture 36 I did multi-vari analysis, this can be used as a screening tool, I cannot handle too many factors in ANOVA.

So, if I have the descriptive tool like multi-vari analysis which basically talks about temporal cyclic and positional factors, I can really reduce my number of factors and then I can conduct the ANOVA analysis. Lecture 37 was on FMEA; failure mode effect analysis, it is all about multiplying severity, detectability and occurrence rate probability. So, I will get RPN and then I can have risk mitigation and management strategies.

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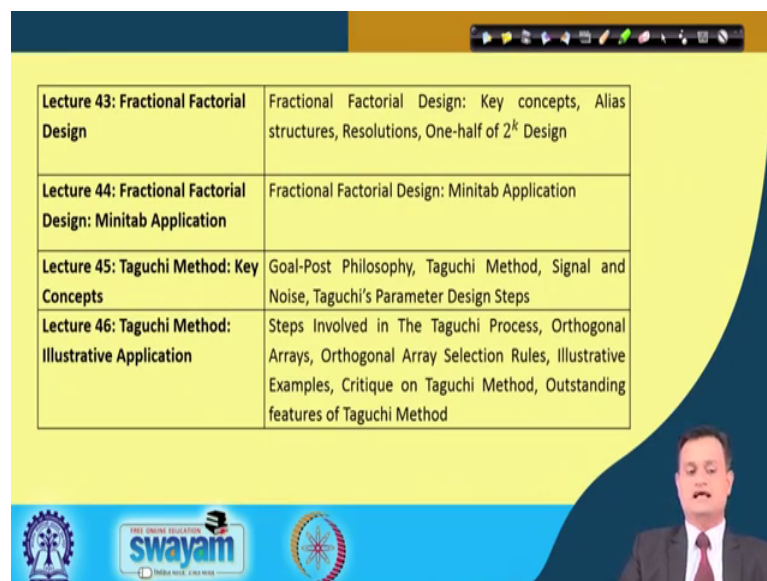


Lecture 38: Introduction to Design of Experiment	History of DOE, DOE: Principles and Terminology, The strategy of experimentation, Guidelines for planning, conducting and analyzing experiments
Lecture 39: Randomized Block Design	The randomized complete block design (RCBD), Randomized block design: Illustrative application, Latin square design, Graeco-Latin square design
Lecture 40: Randomized Block Design: Minitab Application	Minitab Application for Randomized Complete Block Design (RCBD)
Lecture 41: Factorial Design	Principles of factorial design, Advantages of factorial design, Statistical analysis of factorial design, Illustrative example of factorial design
Lecture 42: Factorial Design: Minitab Application	Minitab Application of Factorial Design

Then we entered into the fourth, say fifth phase after DMA; that is the fourth phase improve phase of my DMAIC cycle and we delivered the content in week 8 and week 9.

So, week 8 we delivered introduction to design of experiment and the definition of some of the key terms; like factor, treatment, level, blocking, randomization, replication, repetition. Then we talked about the randomized block design as a part of lecture 39 and we have seen couple of examples also. Lecture 40 I demonstrated the Minitab application for the convenience and focusing more on the interpretation part. Lecture 41 factorial design, I also want to consider the interaction effect and subsequently I demonstrated the Minitab application for factorial design.

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Lecture 43: Fractional Factorial Design	Fractional Factorial Design: Key concepts, Alias structures, Resolutions, One-half of 2^k Design
Lecture 44: Fractional Factorial Design: Minitab Application	Fractional Factorial Design: Minitab Application
Lecture 45: Taguchi Method: Key Concepts	Goal-Post Philosophy, Taguchi Method, Signal and Noise, Taguchi's Parameter Design Steps
Lecture 46: Taguchi Method: Illustrative Application	Steps Involved in The Taguchi Process, Orthogonal Arrays, Orthogonal Array Selection Rules, Illustrative Examples, Critique on Taguchi Method, Outstanding features of Taguchi Method

Week 9, we continued in the phase of improve and we talked about as a part of lecture 43 fractional factorial design. I cannot have the resources to conduct the full factorial and I need to have some mechanism by which I can reduce the size of the experimentation without compromising with the quality of analysis. So, this is possible when I consider the confounding effect and alias structure by defining a generator or relationship, and I can really reduce the number of factors, number of experiments to be considered. So, if I have 2^3 full factorial 8 I can go for half factorial $2^3 - 1$. We have seen the concept of resolution and how it affects my quality of experimentation.

So, that was covered in fractional factorial followed by that lecture 45 gave you the Minitab application. Lecture 45 was on Taguchi method key concepts, lecture 46 demonstrated an application of Taguchi method.

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Finally we entered into the last phase of DMAIC that is the control and we delivered this particular content of control phase in week 10 and 11.

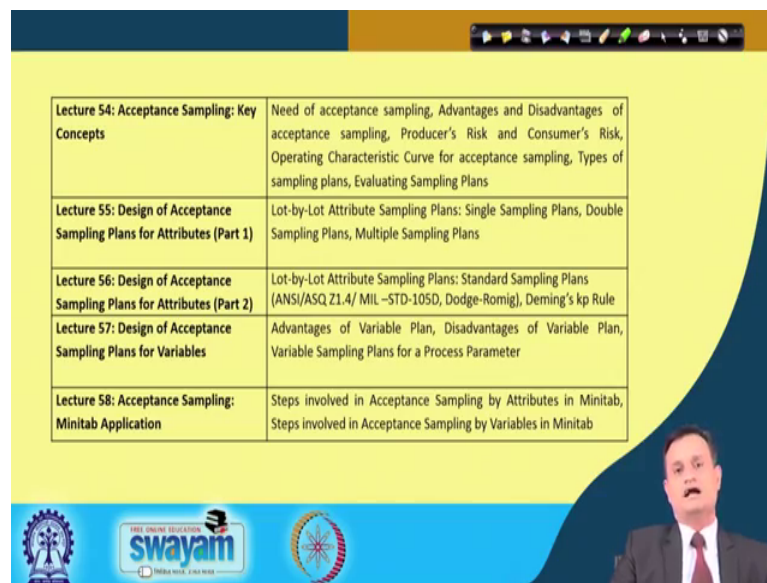
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Lecture 47: Seven QC Tools	Need of QC approach, Benefits of QC approach, Seven QC Tools
Lecture 48: Statistical Process Control: Key Concepts	Common Causes and Assignable Causes of Variations, Objectives of SPC, Type I and Type II errors in control charts, Analysis of Patterns in control charts
Lecture 49: Statistical Process Control: Control Charts for Variables	Need for Control for both Mean and Variability, General procedure for constructing control charts, Control Charts for X-bar, R and S
Lecture 50: Operating Characteristic (OC) Curve for Variable Control charts	Operating-Characteristic (OC) Curve for variable control charts: X-bar and R charts
Lecture 51: Statistical Process Control: Control Charts for Attributes	Chart for Proportion Nonconforming (p-Chart), Construction and Interpretation of p-Chart, Chart for the number of nonconformities (c-Chart), Chart for the number of nonconformities per unit (u-Chart)
Lecture 52: Operating Characteristic (OC) Curve for Attribute Control charts	OC curve for p-chart, OC curve for c-chart
Lecture 53: Statistical Process Control: Minitab Application	Statistical Process Control in Minitab

So, week 10 was on seven QC tool, I have Pareto diagram, histogram, scattered plot and most importantly say I have control chart and others. Lecture 48: we entered into the statistical process control with key concept, what is the chance cause, what is the assignable cause, when I can say that my process has shifted, what is type 1 error, what is type 2 error and so on.

Then lecture 49 I deliberated on statistical process control chart design for variable quantity. Then control chart operating characteristic curve which is the performance measure of the control chart for variables, we discussed in lecture 50. Subsequently lecture 51 we have seen the design of control chart for attributes and lecture 52 we have seen the operating characteristic curve for attribute control chart. Lecture 53 was Minitab application for SPC, for students doing project or industry professionals.

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Lecture 54: Acceptance Sampling: Key Concepts	Need of acceptance sampling, Advantages and Disadvantages of acceptance sampling, Producer's Risk and Consumer's Risk, Operating Characteristic Curve for acceptance sampling, Types of sampling plans, Evaluating Sampling Plans
Lecture 55: Design of Acceptance Sampling Plans for Attributes (Part 1)	Lot-by-Lot Attribute Sampling Plans: Single Sampling Plans, Double Sampling Plans, Multiple Sampling Plans
Lecture 56: Design of Acceptance Sampling Plans for Attributes (Part 2)	Lot-by-Lot Attribute Sampling Plans: Standard Sampling Plans (ANSI/ASQ Z1.4/ MIL -STD-105D, Dodge-Romig), Deming's kp Rule
Lecture 57: Design of Acceptance Sampling Plans for Variables	Advantages of Variable Plan, Disadvantages of Variable Plan, Variable Sampling Plans for a Process Parameter
Lecture 58: Acceptance Sampling: Minitab Application	Steps involved in Acceptance Sampling by Attributes in Minitab, Steps involved in Acceptance Sampling by Variables in Minitab

Week 11, again was specific to control phase and as I mentioned statistical quality control has two pillars; one is statistical process control other is acceptance sampling. We devoted week 11 and the lecture 54, 55, 6, 57 and 58 on acceptance sampling. 54 provided you the key concepts on producers raise consumers raise, evaluation of sampling plan, advantages disadvantages. 58 was part 1 on design of acceptance sampling plan for attributes.

I talked about the design of single sampling plan, double sampling plan, multiple sampling plan and then we entered into the lecture 56, this is design of attribute sampling plan part 2. So, here we talked about say standard sampling plan and as a part of that we have seen ANSI ASQ military standard and the Deming's kp rule. Lecture 57 was design of acceptance sampling plan for variables and we have talked about the various advantages disadvantages, variable sampling plan for a process parameter. We have considered three cases; case number 1 my say only single specification limit and the

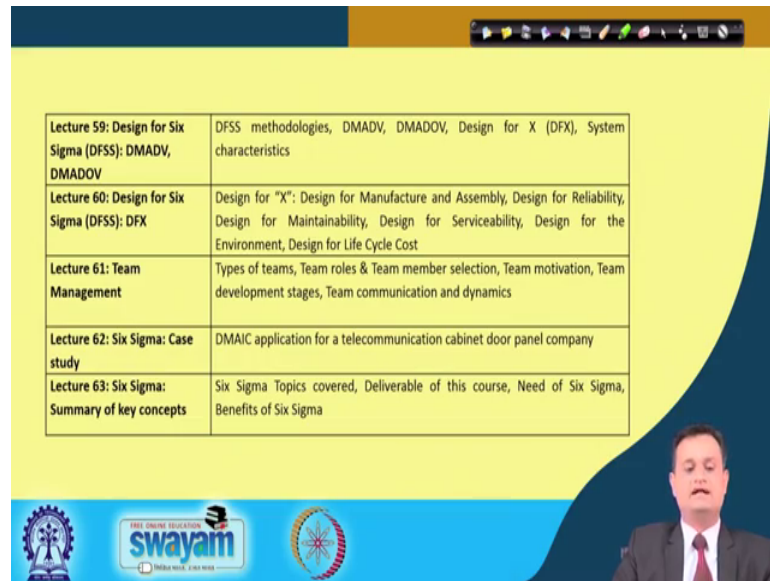
variance or standard deviation is known. Case 2, two specification limit I am considering and the standard deviation or variance of the process is known and third when I am dealing with single specification limit, but my standard deviation of the process is unknown. So, we have discussed these three cases in detail. Lecture 58 was Minitab application for the convenience of the industry people.

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And then we entered into the week 12 that was the final one.; six sigma implementation challenges, and as a part of that we talked about design for six sigma DMADV, DMADOV, DFX, various X, maintainability, reliability, testability, robustness and many more we have seen as has a part of DFX.

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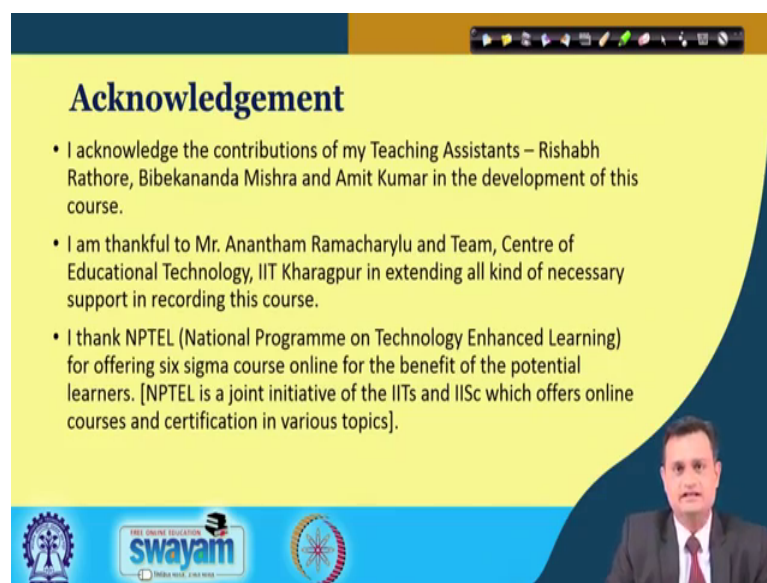
The screenshot shows a presentation slide with a yellow background and a blue header. A table is displayed on the slide, listing lecture topics and their descriptions. In the bottom right corner, there is a small video feed of a man in a suit and tie, who appears to be the speaker. The bottom of the slide features logos for 'swayam' and 'INDIA WIDE, FREE WIDE'.

Lecture 59: Design for Six Sigma (DFSS): DMADV, DMADOV	DFSS methodologies, DMADV, DMADOV, Design for X (DFX), System characteristics
Lecture 60: Design for Six Sigma (DFSS): DFX	Design for "X": Design for Manufacture and Assembly, Design for Reliability, Design for Maintainability, Design for Serviceability, Design for the Environment, Design for Life Cycle Cost
Lecture 61: Team Management	Types of teams, Team roles & Team member selection, Team motivation, Team development stages, Team communication and dynamics
Lecture 62: Six Sigma: Case study	DMAIC application for a telecommunication cabinet door panel company
Lecture 63: Six Sigma: Summary of key concepts	Six Sigma Topics covered, Deliverable of this course, Need of Six Sigma, Benefits of Six Sigma

Then we talked about a very interesting and important issue that is the team management. Six sigma projects are executed in team and you need to understand the team dynamics, formation of the team, roles of the team, communication requirement and so on.

Finally in 62 I have discussed a small case study to give you confidence in executing DMAIC cycle for a chosen company or industry and process. And lecture 63 we are just wrapping up as a part of this and I am giving you the whole idea about the deliverable of this course.

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Acknowledgement

- I acknowledge the contributions of my Teaching Assistants – Rishabh Rathore, Bibekananda Mishra and Amit Kumar in the development of this course.
- I am thankful to Mr. Anantham Ramacharylu and Team, Centre of Educational Technology, IIT Kharagpur in extending all kind of necessary support in recording this course.
- I thank NPTEL (National Programme on Technology Enhanced Learning) for offering six sigma course online for the benefit of the potential learners. [NPTEL is a joint initiative of the IITs and IISc which offers online courses and certification in various topics].

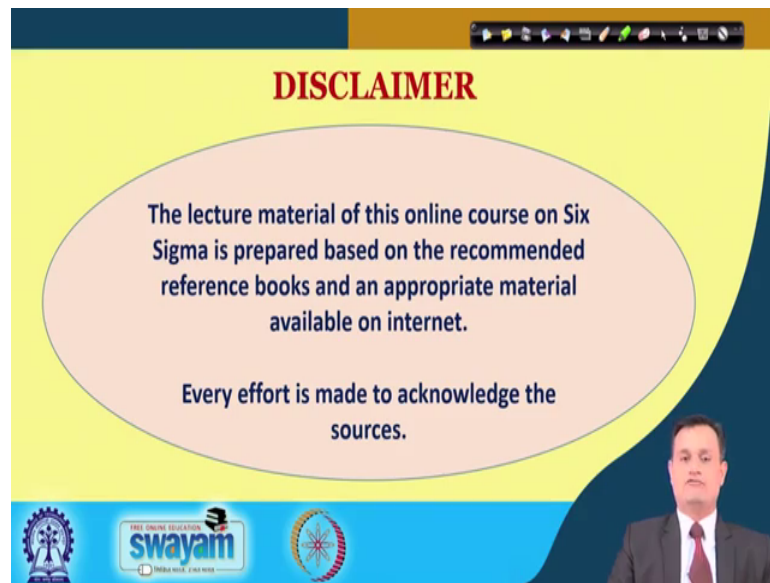
Logos at the bottom: IIT Kharagpur, Swayam, NPTEL. Video inset of a man in a suit.

So, I acknowledge here and I sincerely acknowledge the people who are involved in this particular course who has really helped me for executing this course and extending the content to my students, university student, industry professionals.

So, first I acknowledge the contributions of my teaching Assistants Rishabh Rathore, Bibekananda Mishra and Amit Kumar in the development of this particular course material. I am thankful to Mr. Anantham and team who have extensively supported the video recording in this course, they are part of Centre of Education Technology IIT Kharagpur and they provided sincere extended support. Many a times they had gone beyond and even up to 7 o'clock or 8 o'clock in the night they have helped me to record this course.

I thank NPTEL National Programme on Technology Enhanced Learning for offering the six sigma course for the benefit of the potential university student as well as industry professional and NPTEL, I will just like to mention is a joint initiative of IITS and IISC which offers online courses and certification in various topics.

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DISCLAIMER

The lecture material of this online course on Six Sigma is prepared based on the recommended reference books and an appropriate material available on internet.

Every effort is made to acknowledge the sources.

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MHRD

I would like to present my disclaimer. This course is developed based on the suggested references and textbooks and the concepts written in this textbooks and the references are extensively used. Even some of the examples illustrated in this book are discussed as a part of this online course and every effort is made to acknowledge the sources either from the textbook or internet.

Even if by chance something is forgotten then I acknowledge all the authors who have really contributed in the domain of six sigma and helped me in developing and delivering this course for the benefit of my students which are spread across the country not across the country, internationally.

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Dr. Jitesh J. Thakkar

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Education:
Ph.D (Supply Chain Management) *IIT/D*
M.Tech. (Industrial Engineering) *IIT/D*
B.E. (Mechanical Engineering, Gold Medalist) *BVM, SPU*

Areas of Expertise:
❖ Six Sigma
❖ Project Management
❖ Supply Chain Sustainability
❖ Service Operations Management

CV:
<http://iitkgp.ac.in/cv/im-jt>

Google Scholar:
<https://scholar.google.co.in/citations?user=5ih0yloAAAAJ&hl=en>

So, I would like to share my personal details for any future help if I can exchange or any collaboration we can have for executing the six sigma project. So, I am Dr. Jitesh J Thakkar, I am with department of industrial and systems engineering, Indian Institute of Technology Kharagpur. Kharagpur is located in West Bengal and my educational qualification includes PhD in supply chain management from IIT Delhi, I did my M Tech in industrial engineering from IIT Delhi.

And I did my B.E that is Bachelors of Engineering in Mechanical with gold medal from the oldest Government Engineering College in Gujarat, Birla Vishvakarma Mahavidyalaya associated with Sardar Patel University. My areas of expertise include six sigma project management, supply chain sustainability and service operations management, you can see my CV and my contributions in this field at this particular link. And you can see all my publications, you can also refer this link Google scholar where you will get all my publications with citations and you can also pick the one which is suitable for your requirement or receiving the good citation for your reference.

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So, I can help you in executing the six sigma project and if you have my details we can really collaborate.

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Journal	SCI-IF
Journal of Cleaner Production	5.651
International Journal of Production Economics	4.407
Expert Systems with Applications	3.768
Computers & Industrial Engineering	3.195
Resources Policy	2.695
International Journal of Production Research	2.623
International Journal of Advanced Manufacturing Technology	2.601
Production Planning and Control	2.369
Journal of Manufacturing Technology Management	2.194
Operational Research	1.816
International Journal of Logistics Management	1.776
Asia Pacific Journal of Marketing and Logistics	1.204
International Journal of Quality and Reliability Management	ESCI
International Journal of Productivity and Performance Management	ESCI

This is my brief publication profile, during last say 15 years I tried to publish in the top notch Journals of Operations Management. This includes Journal of Cleaner Production with an impact factor 5.651, International Journal of Production Economics 4.407, Expert System with Applications, Computers and Industrial Engineering Resource Policy, International Journal of Production Research, International Journal of Advanced

Manufacturing Technology, Production Planning and Control and Journal of Manufacturing Technology Management, Operations Research, International Journal of Logistic Management, Asia Pacific Journal of Marketing and Logistics and International Journal of Quality and Reliability Management, and finally, International Journal of Productivity and Performance Management.

So, you will find my articles published in all these journals and you can easily refer them, and mainly I have demonstrated the case based approach, so that would really be beneficial to industry people as well as university students.

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Year	No. of Papers	Discipline	No. of Papers	Industry	No. of Papers	Methodology	No. of Papers
2018	13	Supply Chain Sustainability	21	Manufacturing	19	Multi-criteria Decision Making	21
2017	06	Lean, Six Sigma and Performance Measurement	14				
2016	07	Scheduling	05	SMEs	14	Optimization	12
2015	03						
2014	02	Service Operations Management	04	Agriculture	05	Literature Review/ Conceptual	06
2013	04			Infrastructure	04		
2012	05						
2011	02	Risk Management	05	Automotive	03	Case Study	05
2009	02			Education	03		
2008	06			Healthcare	01	Innovative Frameworks	04
2007	01	Project Management	03	Petroleum	01	Empirical Survey	03
2006	02	E-Business	02	R&D	02	Simulation/ System Dynamics	03

This is just the statistics we work on the fact based management, we are six sigma people. So, this is just the classification of my papers and I evolved as a researcher and I tried to publish, say more number of papers as I advanced from 2006 to 2018, I have addressed supply chain sustainability and published some 21 papers, lean six sigma 14 papers, scheduling 6, service operations management 4, risk management 5, project management 3 and E-business 2. You can also see that I have addressed the industry context like manufacturing, SME, agriculture, infrastructure, automotive, education, healthcare and petroleum.

So, I tried to say analyze the manufacturing as well as service context in order to evolve my research in the different dimensions. And I have used various methodologies, because we are tool driven people, analytic people. So, multi criteria decision making I have

published 21 papers, optimizations integer programming in others, literature review and conceptual couple of papers are there, case study, innovative frameworks have propose like I to NOC is one of the framework, former linkage mechanism you will find, I derived the analogy from the mechanical engineering and empirical survey and simulation and system dynamics.

So, this is my brief publication profile, you can always visit Google scholar or my CV at the suggested link and you can go through in detail the titles of the paper and the context, whatever you might be interested in. So, thank you very much, the departure is always painful even though I am not connected to you directly, but it is an emotional binding I carry and I really feel over blame in delivering this course. And I would certainly like to see that if I can help you in any way during the execution of this course or even after the execution of this course I would be extremely happy.

I wish you all the best for executing six sigma project, for your personal projects, for your professional career and I wish that you all grow well in your personal and professional life. Wish you all the best.