COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE **Course Code :**

Programme Name/s : **Mechatronics**
Programme Code : **MK**
Semester : **Sixth**
Course Title : **COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE**
Course Code :

I. RATIONALE

This course equips diploma engineers with the essential knowledge and skills for modern inspection and quality assurance integrating computer aided technologies. It covers foundational methodology, advance measurements with CMM's ,machine vision for automated inspection, Quality management principles including auditing, six sigma, and statistical tools for process control

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Apply computer aided inspection and quality control techniques for assuring quality of products and services.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Select relevant measuring instrument for given situation.
- CO2 - Measure common features using coordinate measuring machine.
- CO3 - Identify various elements of machine vision system in context of inspection.
- CO4 - Prepare a plan for quality audit considering the quality standard for a given simple process
- CO5 - Apply various SQC tools to ensure Quality assurance for a given data

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
	COMPUTER AIDED INSPECTION AND QUALITY ASSURANCE	IQA	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

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Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe working principle of Linear measuring instruments. TLO 1.2 Explain the use of gauges for given job with justification. TLO 1.3 State the advantages and disadvantages of Computer Aided Inspection (CAI) TLO 1.4 Explain method of laser-based inspection . TLO 1.5 Compare traditional inspection with laser-based inspection.	**Unit - I Introduction to Metrology and Computer aided inspection** 1.1 Definition of Metrology, objective and types of metrologies, need of inspection, methods of measurements. 1.2 Linear measuring Instruments: Working principle of Vernier caliper, micrometer, height gauge and depth gauge. 1.3 Gauges: Limit gauges. Taylor's principle of Gauge design, Plug gauges , Ring Gauges, Snap gauges. 1.4 Computer-Aided Inspection (CAI):Introduction, need, advantages and disadvantages. Comparison between Traditional Inspection and Computer-Aided Inspection (CAI). 1.5 Laser Metrology in Computer-Aided Inspection (CAI):Introduction, need, method of laser based inspection, advantages and disadvantages . 1.6 Applications of Laser Metrology in Industries, Aerospace & Automotive: High-accuracy component inspection	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the principle of working of CMM. TLO 2.2 List the components of CMM. TLO 2.3 Explain the types of CMM. TLO 2.4 List the specifications of CMM. TLO 2.5 Explain procedure for Measurement by CMM.	**Unit - II Co-ordinate measuring machine** 2.1 Introduction to Coordinate Measurement Machine (CMM). 2.2 Contact type CMM – Configurations, parts and its features, types of probes, probe compensation and specifications. 2.3 Non-Contact type CMM –Features, probes, specifications. 2.4 Merits and demerits of CMM. 2.5 Applications of CMM for dimensional and form measurements.	Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Case Study Flipped Classroom
3	TLO 3.1 Select the alignment test for the given machine tool with justification. TLO 3.2 Explain the procedure of flatness testing for the given job. TLO 3.3 Explain the procedure for measuring complex dimensions of the given job using machine vision . TLO 3.4 Explain the role of AI in machine vision inspection. TLO 3.5 List the components of automated inspection system	**Unit - III Introduction to Machine Vision Metrology** 3.1 Machine tool metrology: parallelism, flatness, straightness, squareness, roundness, run out alignment tests of Lathe and machine tools (as per IS standard.) using gauges and measuring devices . 3.2 Introduction to Machine Vision Metrology: Machine vision system – Methods for sensing objects. 3.3 Applications of machine vison in metrology. 3.4 AI-Based machine vision techniques. 3.5 Automated Inspection Systems: Computers power automated inspection systems, including machine vision and optical inspection.	Lecture Using Chalk-Board Presentations Model Demonstration Video Demonstrations Site/Industry Visit Hands-on

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Identify quality characteristics for given product TLO 4.2 Explain the parameters of quality economics TLO 4.3 Explain the general procedure to perform the quality audit for the given problem. TLO 4.4 Explain six sigma methodology and tools for quality imporvement TLO 4.5 describe ISO 14000 for environment management system TLO 4.6 describe ISO9001 as a part of QMS TLO 4.7 Explain quality assurance approach for given example	**Unit - IV Quality Control & Quality Assurance** 4.1 Concept and Meaning of Quality Control and Objectives of qualify control. Quality characteristics. 4.2 Quality of design, Quality of conformance and Quality of Performance, 4.3 Quality Economics: Cost of quality, Value of quality, Economics of quality confirmation, Cost of quality appraisal, prevention, external and internal failure cost. 4.4 Quality Audit: functions, Scope of quality audit practices. Difference between inspection & quality control. Role of Quality Inspector and Auditor. Internal and External Quality Audits, 4.5 Six sigma: Methodology, Statistical meaning, six sigma approaches, Introduction to ISO 9001-2008, ISO 14000 and TS 16949 and its implementation. 4.6 Quality Management Systems (QMS): ISO 9001:2015 and Implementing a QMS in an Organization, Documentation and Standard Operating Procedures (SOPs). QMS software ,document management, audit tracking, and non-conformance report. 4.7 Quality Assurance: Definition , Importance, procedure, techniques , Differences Between QC and QA. 4.8 Role of Quality Inspector and Auditor Internal and External Quality Audits, Compliance and Regulatory Requirements	Lecture Using Chalk-Board Presentations Case Study Video Demonstrations Case Study Site/Industry Visit
5	TLO 5.1 Calculate mean, mode and median for the given sample(s) including the frequency histogram, frequency polygon. TLO 5.2 Draw normal distribution curve after calculating the standard deviation (Sigma), variance, range to determine the process capability. TLO 5.3 Draw the control charts (X and R-bar, P-chart and C-chart) for measured data of the given samples. TLO 5.4 Prepare Single/Double sampling plan for the given Lot size (N), Sample size(n), acceptance number(c)	**Unit - V Statistical Quality Control** 5.1 Basics of Statistical concepts, Meaning and importance of SQC. 5.2 Variable and attribute Measurement. Control charts - inherent and assignable sources of variation. Control charts for variables - x bar and R charts, control charts for attributes p, np, C charts. Statistical Process Control (SPC): SPC software to create control charts. 5.3 Process capability of machine (±3sigma or ±6sigma), Cp and Cpk calculations. 5.4 Different types of sampling plans, - sampling methods. 5.5 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve. Merits and demerits of acceptance sampling.	Lecture Using Chalk-Board Presentations Site/Industry Visit Case Study Video Demonstrations Model Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use Vernier caliper, vernier height gauge, micrometer (use both mechanical and digital) to measure dimensions of a given components.	1	*Measurement of Length and Height by using Vernier Calipers and Vernier Height Gauge of a given components.	2	CO1
LLO 2.1 Measure and verify the dimensions and tolerances of workpieces during quality control processes using gauges	2	Inspection using Dial Indicator /Dial Bore Gauge/Snap Gauge for a given component.	2	CO1
LLO 3.1 Use slip gauges combination to set the adjustable snap gauge Go end and No-Go end for a given dimension.	3	*Arrange the adjustable snap gauge Go end and No-Go end for a given dimension.	2	CO1
LLO 4.1 Analyse the application of laser metrology for quality control and dimensional inspection based on given use case	4	*Perform quality control and dimensional inspection by using laser inspection based on given use case	2	CO1
LLO 5.1 Measure the flatness of given flat object using CMM LLO 5.2 Measure the circularity of given cylindrical object using CMM	5	*Measurement of form using CMM	2	CO2
LLO 6.1 Select the type of probe for CMM	6	*List the types of probes for given situtaion	2	CO2
LLO 7.1 Select the appropriate probe and stylus for measurement LLO 7.2 Set up part fixturing to maintain the product orientation LLO 7.3 Align the product coordinate system with the CMM's coordinate system. LLO 7.4 Measure the dimensions using CMM	7	Measurement of product dimension using Coordinate Measuring Machine (CMM) as per standard procedure	2	CO2
LLO 8.1 Identify components of low-cost vision-based automation solutions in the following areas: Inspection (Object recognition and Pose Estimation) Detection (Presence Verification, Counting).	8	*Components identification of low-cost vision-based automation solutions	2	CO3
LLO 9.1 Set up camera ,lens, lighting ,mounting and fixture LLO 9.2 Capture image of the given components LLO 9.3 Apply image processing techniques to enhance the image quality. LLO 9.4 Extract features that are essential for measurement of required dimension	9	*Inspect the given componenet using machine vision system .	2	CO3
LLO 10.1 Draw relevant control chart by observing the variations in a lot of 20 cylindrical jobs with some nominal outside diameter.	10	Preparation of a relevant control chart by observing the variations in a lot of 20 cylindrical jobs with some nominal outside diameter.	2	CO5

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Choose a simple process - (e,g ,ordering food online, barrowing a library book) LLO 11.2 Create a flow chart or a process map of the steps involved LLO 11.3 Identify potential points of failure or non compliance that an auditor would examine. LLO 11.4 Prepare a quality audit checklist .	11	*Mapping a process for quality audit,.	2	CO4 CO5
LLO 12.1 Calculate mean, mode and median for the given data. LLO 12.2 Draw frequency histogram, frequency polygon for the given data.	12	Calculation of mean, mode and median using frequency histogram, frequency polygon for the given sample.	2	CO5
LLO 13.1 Draw normal distribution curve for given data LLO 13.2 Calculate standard deviation (Sigma), variance, range for given data LLO 13.3 Determine the process capability for given data	13	Determintion of process capability for ±3Sigma or ±6Sigma .	2	CO5
LLO 14.1 Draw and interpret X bar chart for the given data LLO 14.2 Draw and interpret R chart for the given data	14	*Inspection of given variable data using Control chart	2	CO5
LLO 15.1 Draw P- chart for given data. LLO 15.2 Draw C - chart for given data.	15	*Inspection of given attribute data using control chart chart	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Prepare a report to interpret effect of errors on the accuracy of instrument and measurement.
- Visit to any nearby shop or industry and list out different gauges used for inspection along with its purpose.
- Visit to any tool room and prepare a report consisting,
  (i)Different advanced measuring instruments.
  (ii)Different measuring standards and calibration process.
  (iii)Care and maintenance of measuring instruments observed.
- Prepare/Download a specification of followings.
  (i)Measuring tools and equipment in metrology laboratory.
  (ii)Machineries in metrology laboratory.

Micro project

- Prepare a report on Quality Management Systems (QMS) for your institute.
- Comparative study of various linear measuring instruments like steel rule, Inside-outside micrometer, Vernier caliper and Digital caliper with proper justification.

- Comparative study of surface finish of various samples machined by various machining / finishing processes using surface roughness tester.
- Prepare a report on calibration procedure of Vernier Caliper and Micrometer followed by NABL Lab.
- Prepare a visit report on measurement systems used in nearby industries / SME / Workshops / Fabrication shops.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Digital/manual Vernier Caliper Range 0-150 mm, L.C. 0.02mm	1
2	Vernier Height Gauge and Depth Gauge (mechanical and digital) 0-300 mm	1
3	Tool Maker's microscope: Dimensions 152 x 152mm, Stage glass size 96 x 96mm, Feeding range 50 x 50 mm, Maximum height 115 mm x 107 mm, Workpiece 5Kg, Light source: 24V, 2W (special bulb), Continuously adjustable light intensity, green filter.	1
4	Display Wall chart showing X bar Chart and R Chart.	11,12,13,14,15
5	Display Wall chart showing "C Chart"	12,13
6	Spirit Level: Base length: 200 mm + 1 mm, Base width: 20 mm + 0 - 1, Height : 25 + 1 mm, Bubble opening : 50 mm x 8 mm (length x width).	4
7	Gauges - plug (3piece) Grade A/X.	5

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Metrology and Computer aided inspection	CO1	10	2	4	6	12
2	II	Co-ordinate measuring machine	CO2	10	2	4	4	10
3	III	Introduction to Machine Vision Metrology	CO3	10	2	4	6	12
4	IV	Quality Control & Quality Assurance	CO4	15	4	6	8	18
5	V	Statistical Quality Control	CO5	15	4	6	8	18
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two-unit tests of 30 marks and the average of two-unit tests. For laboratory learning 25 Marks For Self-Learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning. End semester assessment of 70 marks

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	-	-	-	3	-	-	3			
CO2	-	-	-	3	-	-	3			
CO3	-	-	-	3	-	-	3			
CO4	-	-	-	3	-	-	3			
CO5	-	-	-	3	-	-	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dr. Parthasarathi, Dr. P. Sreenivas	Metrology, Measurements and Computer Aided Inspection	Scientific International Publishing House ISBN: 9789361320309
2	R.K. Rajput	A Textbook of Measurements & Metrology	S.K. Kataria & Sons ISBN 978-93-5014-230-1
3	K Duraivelu and S Karthikeyan	Engineering Metrology and Measurement	Universities Press ISBN 9789386235527
4	Kulkarni V. A.. Bewoor A. K.	Quality Control	Wiley India Pvt. Ltd, New Delhi, 2012. ISBN: 978-81-265-1907-1
5	Ankita Dadwal	Quality Assurance	PharmaMed Press ISBN-10 : 9395039701
6	Mahajan M	Statistical Quality Control	Dhanpat Rai & Co. ISBN-13 : 978-8177000399
7	M.M.M. SARCAR, K. LALIT NARAYAN,	Computer Aided Design and Manufacturing	PHI Learning, ISBN - 9788120333420
8	Sheila Anand	Guide for Machine Vision in Quality Control	Chapman and Hall, ISBN -978-0815349273

XIII . LEARNING WEBSITES & PORTALS

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Sr.No	Link / Portal	Description
1	https://elearn.nptel.ac.in/shop/nptel/engineering-metrology/?v=c86ee0d9d7ed	Engineering Metrology
2	https://youtu.be/4O6mfoJWJGc?si=AZaSdaunYusJr7on	Learning about CMM and Metrology
3	https://youtu.be/BPQI1xMXC04?si=hq33GQJUtlvywUbD	Basics of CMM (Coordinate Measuring Machine)
4	https://youtu.be/6eGwbxHOa-A?si=oF-upNkZ3K0QfWq4	Visual Inspection for Defect Detection
5	https://youtu.be/uqEXP14i3QQ?si=qprSEsfNniQLhXAw	Smart Factory - Vision based quality inspection
6	https://youtu.be/60Sk-mq3Cr8?si=wZvKfYzD9lkY8O7Z	Improve Production Quality with Visual Inspection AI
7	https://youtu.be/9fqygvj-O2s?si=nhcV7NKn4Mn4nYmc	Computer Aided Quality Control

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students