Metrology and Machine Tools (ME503PC)

COURSE PLANNER

COURSE OBJECTIVE AND RELEVANCE:

1. To understand the basic parameters of metal cutting operation.
2. Understand different components of Machine Tools and their functions.
3. Understand the basic structure of Lathe machines.
4. Understand the features of Milling process, milling machines, Milling operations and different types of indexing.
5. Understand the basics of Metrology like Surface roughness, surface finish,limits and tolerances etc.

COURSE PURPOSE:

1. Machine tool is fundamental subject for mechanical, automobile and aeronautical engineering branches. The purpose of this course is to learn about the machines like lathe, shaping, slotting, planning, drilling, grinding, etc. In this subject, the students have to learn how to operate the machines and how to do machining for different applications. Students will come to know about metal cutting theory, different cutting tools and tool angles also. In metrology student have to learn basics of Metrology like Surface roughness, surface finish, limits and tolerances etc.

COURSE OUTCOME:

At the end of the course the student will be in a position to,

1. Describe the basics of Machines
2. Explain about metal cutting
3. Use various machines and tools to make the different objects.
4. Describe the basics of Metrology.

PRE-REQUISITES

1. Production Technology
2. Kinematics of Machinery
3. Machine drawing
4. Engineering Physics

JNTU SYLLABUS

UNIT – I

Metal cutting: Introduction, elements of cutting process – Geometry of single point tools. Chip formation and types of chips. Engine lathe – Principle of working, types of lathe, specifications. Taper turning,– Lathe attachments. Capstan and Turret lathe – Single spindle and multi-spindle automatic lathes – tool layouts.

UNIT – II

Drilling and Boring Machines – Principles of working, specifications, types, operations performed; twist drill. Types of Boring machines and applications. Shaping, slotting and planing machines –Principles of working – machining time calculations.

UNIT – III

Milling machines – Principles of working – Types of milling machines – Geometry of milling cutters methods of indexing. Grinding – theory of grinding – classification of grinding machines. Types of abrasives, bonds. Selection of a grinding wheel. Lapping, honing and broaching machines, comparison and Constructional features, machining time calculations

UNIT – IV

Limits, fits and tolerances- Unilateral and bilateral tolerance system, hole and shaft basis system. Interchangeability and selective assembly. Limit Gauges: Taylor's principle, Design of GO and NO GO gauges Measurement of angles, Bevel protractor, and Sine bar. Measurement of flat surfaces, straight edges, surface plates, optical flat and auto collimator.

UNIT –V

Surface Roughness Measurement: Roughness, Waviness. CLA, RMS, Rz Values. Methods of measurement of surface finish, Talysurf. Screw thread measurement, Gear measurement; Machine Tool Alignment Tests on lathe, milling and drilling machines. Coordinate Measuring Machines: Types and Applications of CMM.

GATE SYLLABUS:

Machining and Machine Tool Operations: Mechanics of machining, single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, principles of design of jigs and fixtures, Limits, fits and tolerances, Design of GO and NO GO gauges, Surface Roughness Measurements.

IES SYLLABUS:

Metal Cutting: Turning, Methods of Screw Production, Drilling, Boring, Milling, Gear Manufacturing, Production of flat surfaces, Grinding & Finishing Processes. Computer Controlled Manufacturing Systems-CNC, DNC, FMS, Automation and Robotics.

Cutting Tools Materials, Tool Geometry, Mechanism of Tool Wear, Tool Life & Machinability; Measurement of cutting forces. Economics of Machining. Unconventional Machining Processes. Jigs and Fixtures. Fits and tolerances, Measurement of surface texture, Comparators Alignment tests and reconditioning of Machine Tools

LESSON PLAN-COURSE SCHEDULE:

Lecture No.	Unit No.	Topics to be covered	Content to be covered under . 0each topic	Link for PPT	Link for PDF	Course Learning Outcomes(CLO's)	References
1	1	Introduction to Machine Tools	Introduction and Concept	https://drive.google.com/drive/folders/1EpbfXBlT9LT-pYtyEqEX7GVnGNykfp-H?usp=sharing	https://drive.google.com/drive/folders/1TDR3x0L49g-5ZgYYB8-pQFkL8JC9NrhT?usp=sharing	CLO1	T1
2		Elementary treatment of metal cutting theory	Methods of Metal cutting			CLO1	T1
3		Element of cutting process – Geometry of single point tool	Methods of Metal cutting, Types of Tools, Concept of single point cutting tool			CLO1	T1
4		Tool angles, chip formation and types of chips	Types of chips Effects of chip formation. Concepts of Chip formation Concepts of Tool angles			CLO1	T1
5		Built up edge and its effects chip breakers.	Concepts of Built up Edges Effects of Chips			CLO1	T1

6		Engine lathe – Principle of working,	Specification of lathes Working principal of Lath Types of Lathe			CLO1	T1
7		Taper turning,– Lathe attachments.	Types of lathe, Types attachments			CLO1	T1
8		Capstan and Turret lathe – Single spindle and multi-spindle	working Principle of Lathe Concept of Single and Multi Spindle			CLO1	T1
9		types of lathe, specifications	Specifications of lathe			CLO1	T1
10		tool layouts.	tool layouts.			CLO1	T1
11		CNC & NC LATHE (Beyond Syllabus)	CNC and nc lathes			CLO1	T1
12	2	Introduction to Drilling and Boring	Introduction to Drilling and Boring	https://drive.google.com/drive/folders/1GtGpLfSoty2wL4InzbcHurX9DdNNM_wP?usp=sharing	https://drive.google.com/drive/folders/1ORHTwQlzj8t4axEL6eLmfDO-nBFBIMko?usp=sharing	CLO2	T1
13		specifications, types, operations performed on drilling	specifications, types, operations of drill			CLO2	T1

14		specifications, types, operations performed on boring	Types of Boring, Specifications, Concept and Operation of Boring			CLO2	T1
15		twist drill	Concept and working of Twist drill			CLO2	T1
16		Types of Boring machines and applications	Applications of Boaring Machines			CLO2	T1
17		Principles of working of shaping machine	Principal of Shaping, Main parts of Shaping Working Principal of Shaping			CLO2	T1
18		Principles of working of slotting	Working Principal of Slooting, main parts of Slotting			CLO2	T1
19		Principles of working of planning machines	Working Principal of Planning, main parts of Planning			CLO2	T1

20		types of planning machines	Types of Planning Machines			CLO2	T1
21		Double HousingPlanning Machine	Concept of Double housing machines			CLO2	T2
22	3	Milling machines Introduction	Introduction of Milling machines Types of Milling machines working principal of Milling, Operation of Milling	https://drive.google.com/drive/folders/1TUH_ADhCpYTbmK2GgQLLEnSL4ooW1d7y?usp=sharing	https://drive.google.com/drive/folders/1ELrHPiNf563Fj4GfDR0mGsxAAdOWioXZ?usp=sharing	CLO3	T1
23		Geometry of milling cutters	Concept of Milling Cutters			CLO3	T1
24		methods of indexing	Concept of Indexing			CLO3	T1
25		Grinding Introduction , Principles of working of Grinding machines. Classification of grinding machines	Concept and Introduction of Grinding Machine Working Principal of Grinding, Classification of Grinding			CLO3	T1
26		Types of abrasives, bonds	Types of abrasives, and bonding methods			CLO3	T1

27		Selection of a	concept and			CLO3	T1
28		Introduction to Lapping machines	Introduction Working principal of Lapping, operation of methods			CLO3	T1
29		Honing machines	Concept and Working principal of Honing Machines			CLO3	T1
30		Broaching machines	Concept of Broaching machine, Working principal of Broaching			CLO3	T1
31		Lapping, honing and broaching machines, comparison	Comparison of Different machines			CLO3	T1
32		machining time calculations	Calculation of timings			CLO3	T1
33	4	Limits Introduction	Introduction to Limts and Fits and also Tolerances Problems on Limts and Fits	https://drive.google.com/drive/folders/1Ymbg6VYP5NsaytQG-EVCaAc-ejygmcl9?usp=sharing	https://drive.google.com/drive/folders/190kK6nRLXNUAYByA9xDQLeCy1T2pk7X6?usp=sharing	CLO4	T1

34		Unilateral bilateral tolerance system grinding wheel	Concept of Unilateral bilateral tolerance system selection of grinding wheel			CLO4	T1
35		hole shaft basis system, Interchangeability and selective assembly	Concept of hole shaft basis system, Problems on hole shaft basis system,			CLO4	T1
36		Limit Gauges Introduction , Taylor's principle	Concepts of Taylor's principle, Drivation			CLO4	T1
37		Design of GO and NO GO gauges	Concept and Design of GO and NO GO gauges			CLO4	T1
38		Measurement of angles, Bevel protractor	Concept of Bevel protractor			CLO4	T1
39		Sine bar, surface plates	Concept of Sine bar, surface plates, Working Principal of Sine bar, surface plates,			CLO4	T1

40		Measurement	Concept of flat			CLO4	T1
41	5	Surface Roughness Measurement Introduction	How to measure the surface	https://drive.google.com/drive/folders/12AEYq2dO3B55v1MHkMzDfayAoVjISl6L?usp=sharing	https://drive.google.com/drive/folders/1ddEjXbDieHdxReXpUDuIL6UCqDPDArpw?usp=sharing	CLO5	T1
42		Roughness , Waviness	Concept of Roughness , Concept of Waviness			CLO5	T1
43		CLA, RMS, Rz Values	Various surface measurement values			CLO5	T1
44		Methods of measurement of surface finish.	Methods of measurement of surface finish.			CLO5	T1
45		Gear measurement.	Methods of measurement of Gear Measurement.			CLO5	T1
46		Machine Tool Alignment Tests on lathe.	Machine Tool Alignment Tests			CLO5	T1
47		Machine Tool Alignment Tests on drilling and milling m/cs.	Machine Tool Alignment Tests			CLO5	T1

		of flat surfaces, auto collimator.	surfaces, auto collimator.				
48		Coordinate Measuring Machines: Types	CMM			CLO5	T1
49		Applications of CMM.	CMM			CLO5	T1
50		Talysurf screw thread measurements	Methods of measurement of surface finish.			CLO5	T1

SUGGESTED BOOKS:

A) TEXT BOOKS:

1. Production Technology by R.K. Jain and S.C. Gupta.
2. Production Technology /H.M.T./Tata McGraw Hill.
3. **Engineering Metrology / R. K. Jain / Khanna Publishers**
4. **Engineering Metrology / I C Gupta / Dhanpath Rai.**

B) REFERENCES:

5. Principles of machine tools/ Bhattacharyya A and Sen G.C. /New central book agency
6. Elements of Workshop Technology-Vol-II/Hazra Chowdhury/Media promoters
7. Manufacturing Technology/R.K Rajput/ Laxmi Publications.
8. Metal Cutting and Machine Tool Engineering/ Pakirappa/Durga publishing house.
9. Workshop Technology by B.S.RAGHVAMSHI.
10. Fundamentals of Dimensional Metrology / Connie Dotson / Thomson
11. Principles of Engineering Metrology / Rega Rajendra / Jaico Publications.
12. Engineering Metrology / Kenneth John Hume / Mc Donald.

QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS:

UNIT-I

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Define cutting speed; feed and depth of cut with respect to turning process also state the units of measurements	L1	CO1
2	Draw the merchant's circle diagram and derive the expression for showing relationship between cutting force and thrust force	L2	CO1
3	Explain about Discontinuous chip, Continuous chip, and continuous chip with built up edge? Explain the conditions favoring their formation.	L2	CO1
4	With a neat sketch explain the formation of a built-up-edge. Explain the conditions which promote the growth of built-up-edge along with its consequences	L1	CO1
5	When the use of positive rake angle and negative rake angle is recommended?	L1	CO1
6	What are the conditions that would allow a continuous chip to be formed in metal cutting?	L1	CO1
7	Differentiate between Orthogonal cutting and Oblique cutting?	L2	CO1
8	What are the various types of automatic lathe? Explain their differences and applications.	L1	CO1
9	List the common tools and attachments used on turret and capstan lathe	L1	CO1
10	Discuss various methods to obtain taper turning in lathe.	L1	CO1
11	What is the significance of capstan, turret and automatic lathes in production shop?	L1	CO1

UNIT-II

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	A mild steel plate 780 × 460 × 30 mm is to be shaped on a shaper along its wider face. Feed is 1.6 mm/cycle, tool over-travel and tool approach is 40mm, cutting speed is 24 m/min and ratio of return time to cutting time is 2:3. The allowance on sides is 5 mm. Determine the machining time	L2	CO2
2	What are vertical boring machines? Where are they preferred and why?	L1	CO2

3	What is a jig boring machine? Describe its construction and working detail.	L1	CO2
4	Describe in brief the working principle of a boring machine.	L2	CO2
5	Differentiate between shaper, planer and slotter as regards to relative tool and work motions.	L2	CO2
6	Describe a tapping attachment in drilling machine	L2	CO2
7	State the differences between honing and lapping.	L1	CO2
8	Write the principle of working of shaper with neat sketch.	L1	CO2
9	Write the differences between shaping and slotting.	L1	CO2
10	Write the differences between single housing and double housing planning machine.	L1	CO2

UNIT-III

Sl No	**Question**	**Blooms Taxonomy Level**	**Course Outcome**
1	What are the common milling methods? Compare their relative merits and Demerits	L1	CO3
2	Explain the applications and differences with neat sketches, the following with reference to milling: (a) Straddle milling (b) Gang milling	L2	CO3
3	Describe the set up that can be used for milling cams in a milling machine. Explain neatly with a sketch, the various attachments that one needs to use for such milling.	L2	CO3
4	Explain the characteristics that distinguish a milling process from other machining processes.	L2	CO3
5	Classify and explain the various centre type cylindrical grinding machine. Discuss procedure involved in selection of a g7rinding wheel. Illustrate with an example.	L1	CO3
6	How is the abrasive selected for a grinding operation? Explain the reasons for selection.	L1	CO3
7	What are the differences between 'rough' grinding and 'precision' grinding?	L2	CO3
8	What is meant by 'grade' and 'structure' of a grinding wheel?	L1	CO3
9	Mention the various types of bonds used in the making of grinding wheels. Also mention their applications.	L2	CO3

10	What are the advantages and limitations of using centre less grinding	L2	CO3

UNIT-IV

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Define and explain about interchangeability and selective assembly	L2	CO4
2	Determine and sketch the limits of tolerance and allowance for a 45mm shaft and hole pair designated H7−d8. The basic size lies in the range of 30-50mm. The multipliers for grades 7 and 8 are 16 and 25 respectively. The fundamental deviation for'd' shaft is (-16 D0.44) microns.	L2	CO4
3	Mention the materials used for the manufacture of GO and NOGO gauges. Explain the disposition of tolerance on GO and NO GO gauges by taking reference to work tolerances	L1	CO4
4	Why is a Sine bar not used for generating angles greater than 450 , if high accuracy is needed? Explain it with a suitable graph. Explain the different sources of errors in Sine Bars	L2	CO4
5	With a sketch, explain the construction of autocollimator. What are its applications	L1	CO4
6	Determine limit dimensions for a clearance fit between mating parts of diameter 40 mm, providing a minimum clearance of 0.10 mm with a tolerance on the hole equal to 0.025mm and on shaft 0.05mm using both systems.	L2	CO4
7	Distinguish between line and end standards. How are end standards derived from line standards? Give examples	L2	CO4
8	Explain briefly different types of fits with necessary sketches	L1	CO4
9	Explain the following in connection with gauge design: (i) Gauge tolerance (ii) Wear allowance	L2	CO4
10	Explain with the help of a diagram the principle of working of a sine bar for angular measurement. List the advantages and limitations of sine bar.	L2	CO4
11	What are the essential considerations in selection of materials for gauges and what are the common materials used for gauges	L2	CO4
12	Explain the need for limit system.	L1	CO4
13	With the help of suitable diagrams explain minimum and aximum metal condition of Shaft and Hole?	L2	CO4

14	Do you think interchangeability reduces the number of rejects? Justify your answer	L2	CO4
15	Differentiate between Hole basis system and Shaft basis system	L2	CO4
16	Explain about allowances, Deviations and types of fits	L1	CO4
17	Explain about Indian standard system?	L1	CO4
18	What is the Fit and Explain about different types fits with neat diagrams	L2	CO4
19	Explain about Unilateral system and Bi lateral tolerance system for different Fits	L1	CO4
20	Explain about international standard system for plane and screwed Work	L1	CO4
21	Write the differences between the Interchangeability and selective assembly	L2	CO4
22	Explain the construction and working of optical bevel protractor?	L1	CO4
23	Explain the construction and working of Tool Makers Microscope?	L1	CO4
24	Explain the construction and working of Auto collimator?	L2	CO4
25	What are different types Interferometers and explain them?	L1	CO4
26	Explain the procedure of use of straight edges to check straightness	L2	CO4
27	Describe the construction and Working of Micrometer?	L2	CO4
28	What is mean by flatness and explain any one method to measure flatness?	L1	CO4
29	Explain about the surface plates and optical flats to measure flatness?	L2	CO4

UNIT-V

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Write the applications and feature of CMM	L1	CO5
2	Write the differences between surface roughness and surface waviness	L2	CO5
3	Make a comparative study of CLA, RMS and Ten point height method of Measurement of surface finish with the help of an example	L2	CO5
4	Explain about Profilograph	L1	CO5
5	With the help of neat sketch explain about Talysurf method for measuring surface finish?	L1	CO5

6	What are the methods of measurement of surface finish and explain any one	L1	CO5
7	Derive the expression for 'Best size of wire' in screw thread measurement	L2	CO5
8	What is the importance of surface roughness? Mention the geometrical characteristics of a surface	L1	CO5
9	What are differences between surface roughness and surface waviness	L1	CO5
10	Derive the expression for 'Best size of wire' in screw thread measurement	L2	CO5

OBJECTIVE QUESTIONS:

JNTUH

UNIT-1

1. Tool signature means:
   a) The impression of the tool taken on a paper for any reference
   b) A numerical method of identification of tool
   c) The plan of tool
   d) the signature of operator using the tool.
2. A built –up-edge is formed while machining:
   (a) Ductile materials at high speed (b) Ductile materials at low speed
   (c) Brittle materials at high speeds (d) brittle materials at low speeds
3. A single point tool has the following specifications in ASA system 8°, 7°, 5°, 6°, 10°, 9°, 1.5. The number 1.5 represents _____.
   (a) Back rake angle (b) End relief angle (c) Side relief angle (d) nose radius
4. Chip breakers are used to:
   (a) Increase tool life (b) remove chips from bed
   (c) Break the chips short segments (d) to minimize heat generation.
5. Tool life is affected by ____. a) Depth of cut b) cutting speed c) feed d) all of these
6. Cutting speed is calculated by the formulae _____.
7. Factors effecting tool life are _____.
8. For turning aluminum components, the coolant used is _____.
9. Machinablity index (%) calculated by the formulae _____.
10. Taylor's tool life equation is _____.
11. HSS cutting tools are generally provided with _____ rake angle.
12. In orthogonal cutting shear angle and rake angle are related by the equation _____.
13. Capstan and turret lathes are usually used:
    a) To make small components b) To make large components c) For ordinary work d) for mass production
14. Tail stock set over method of taper Turning is preferred for:
    (a) Internal tapers (b) small tapers (c) long slender tapers (d) step tapers
15. Half nut mechanism is employed while performing _____operation in lathe.

(a) Under cutting (b) plain turning (c) thread cutting (d) taper turning

16. Which of the following is lathe accessory?
    (a) Head stock (b) compound rest (c) lathe carrier (d) Tool post.
17. The composition of carbide bits is _____ and _____.
18. Which of the following is not used as driving mechanism for an engine lathe:
    a) Motor b) Gear c) Pulley d) Engine
19. Lathe bed is usually made of:
    a) Structural Steel b) Stainless steel c) Cast iron d) Mild steel
20. For holding irregular work piece on a lathe ____ chuck is used.
21. A lathe bed is generally made of _____.

UNIT-2

1. Normally shaping machine is used for producing:
   (a) Threads (b) Cylindrical surfaces (c) Surfaces composed of straight line elements (d) cylindrical holes.
2. Size of a shaper is given by:
   (a) Stroke length (b) motor power (c) weight of machine (d) table size
3. Which of the following operations cannot be performed by a drilling machine?
   a) Reaming b) Boring c) Drilling d) Slotting
4. In a mechanical shaper the lifting of the tool during idle stroke is ensured by:
   (a) Tool head (b) ratchet and power mechanism
   (c) Ram adjustment (d) clamper box mechanism
5. Enlarging an existing hole with a rotating single point tool is called:
   (a) Boring (b) drilling (c) reaming (d) internal turning
6. In reaming process:
   (a) Metal removal rate is high (b) position of drilled hole is corrected
   (c) High form accuracy is obtained (d) high dimensional accuracy is obtained
7. The type of quick return mechanism employed mostly in shaping machines is _____.
8. The machining operation in which tool is stationary and work piece reciprocates past the tool is _____.
9. The drill used for drilling deep holes is _____.
10. Twist drill is generally made up of _____.

UNIT-3

1. String milling is used for:
   a) Large work pieces b) small work pieces c) heavy work pieces d) all
2. Gang milling is used for:
   a) Large work pieces b) Number of milling cutters is used to cut simultaneously
   c) Small work pieces d) Only one milling cutters is used to cut heavy work pieces
3. _____ is used for machining rectangular slots on a vertical knee and column milling machine.
   a) End mill b) ball end mill c) slitting saw d) side and face cutter
4. Simple or plain indexing, number of rotation of the crank are _____.
   a) 40/N b) 24/N C) 21/N D) ALL

5. INDEXING of 77 divisions:
   (a) 9/21 +3/33= 40/77 (b) 26/39-18/47=40/141 (c) 5/20+1/15=19/60 (d) all
6. The characteristics of the work-piece produced by honing are _____.
7. The characteristics of the work piece produced by lapping are _____.
8. Lapping speed is _____.
9. Lapping pressure applied for soft material _____.
10. The abrasive process that uses a loose abrasive grit is ____.
11. Super finishing tools speeds used are _____.
12. Lapping is a _____operation. a) Machining b) finishing c) Both d) none
13. Broaching is used for _____ type of work pieces. a) Flat b) cone shape c) Cylindrical
14. Grinding is a process used for machining materials ____.
    (a) which are too hard (b) close dimensional accuracy
    (c) high degree of surface smoothness (d) all
15. An abrasive used in grinding wheel selected for grinding ferrous alloys is:
    a) Silicon carbide b) aluminum oxide c) diamond d) CBN
16. Among the conventional machining processes the most inefficient process is:
    a) Turning b) grinding c) drilling d) milling
17. Higher feed rates in grinding causes _____.
    (a) Increased chip size (b) increased wheel wear
    (c) Improve surface finish (d) decreased wheel wear
18. Grinding process used for steel balls of a ball bearing is:
    a) cylindrical grinding b) spherical grinding c) surface grinding d) centre less grinding
19. For grinding flat surfaces we use:
    a) cylindrical grinding b) spherical grinding c) surface grinding d) centre less grinding
20. Grinding operation is used for: a) forming b) sharpening c) dressing d) finishing
21. _____ bond is used in cutoff wheels.
22. The girt and grade of grinding wheel refers to _____.

UNIT-4

1. Tolerance is specified _____.
2. (a) To obtain desired fit (b) because it is not possible to manufacture in size exactly
3. (c) To obtain high accuracy (d) to have proper allowance
4. In this type of fit shaft is always smaller than the hole:
   a) Clearance fit (b) interference fit (c) transition fit (d) push fit
5. Fundamental tolerance grade value in Indian standard limits are_____.
6. (a)17 (b) 18 (c) 22 (d) 12
7. Allowance in limits and fits refers to _____.
   (a) Axiom clearance between shaft and hole
   (b) Minimum clearance between shaft and hole
   (c) Difference between maximum and minimum size of hole
   (d) Difference between maximum and minimum size of shaft
8. The fit on a hole shaft system is specified as 117-s_6. The type of fit is _____.

(a) Clearance fit (b) Transition fit (c) Interference fit (d) Wringing fit

9. _____ System lower deviation of the hole is zero.
10. Engineering metrology is restricted to the measurements of _____.
11. _____ System, the dimension of a part is allowed to vary only on one side of the basic size.
12. Fundamental tolerance unit formula _____.
13. In tail stock which type of fit is used _____.
14. Slip gauges are made of the _____material.
15. The instrument based on the _____ principle that the linear motion of the rack is converted into angular motion of the pointer.
16. The least count of a differential micro meter is _____.
17. When using a micrometer a constant (uniform) measuring pressure can be obtained by using the _____.
18. If a gauge is made as an exact copy of mating part of the component to be checked, it _____.
19. Limit gauges are used in _____.
20. Sine bars are specified by the _____ of the roller
21. Feeler gauge is used for_____.
22. Slip gauges are also called _____.
23. Relief holes are provided to reduce the _____ of the sine bar.
24. Auto collimator is used to check _____.

(a)Roughness (b) Flatness (c) Angle (d) Automobile balance

25. Interferometer is used for the measurement of _____.

(a)Flatness (b) Length of slip gauge (c) a & b (d) none of these

26. This instrument is used for Measurements of flatness of the work table _____.

(a) Dial indicator (b) Dial gauge (c) spirit level (d) angle plate

27. Universal Measuring machine is a combination of _____.
28. N-P-L Gauge interferometer is also called as _____.
29. A monochromatic light consist of rays of _____ wavelength
30. For Basic shaft _____ is zero
31. In _____ system lower deviation is zero
32. The size of difference between Go and No Go gauge gives _____.
33. Snap gauges are used to measure_____.

UNIT-5

1. The surface irregularities of small wave length are called _____.

(a) Primary texture (b) Secondary texture (c) Waviness (d) Roughness

2. Using _____ methods, the surface roughness is measured as the average deviation from the nominal surface _____.

(a) R M S method (b) Ten point method (c) a & b (d) C L A method

3. The surface roughness on a drawing is represented by _____.

(a) Circles (b) Square (c) Zig-Zag lines (d) Triangles

4. The M and E system in metrology are related with measurement of
   (a) Gears (b) Screw threads (c) Flatness (d) Angularity (e) Surface finish
5. C.L.A. values are expressed in _____.
6. The waviness is also called as _____ texture
7. Profilometer is measuring for _____ in _____ units
8. Surface Roughness value is 1.6 to 8μm then symbol for this_____.
9. Prototype meter is made of _____alloy.
10. Secondary texture is also known as _____.

GATE QUESTIONS:

1. Deep hole drilling of small diameter, say 0.2 mm is done with EDM by selecting the tool material as: (a) Copper wire (b) tungsten wire (c) Brass wire (d) tungsten carbide
2. Thickness ratio was obtained as 0.4. The shear angle (in degrees) evaluated from this data is: (a) 6.53 (b) 20.22 (c) 22.94 (d) 50.00
3. Tool life testing on a lathe under dry cutting conditions gave n and C of Taylor tool life equation as 012 and 130 m/min, respectively. When a coolant was used, C increased by 10%. What is the percent increase in tool life with the use of coolant at a cutting speed of 90 m/min?
4. A lead-screw with half nuts in a lathe, free to rotate in both directions has: (a) V-threads (b) Whitworth threads (c) Buttress threads (d) Acme threads
5. The time taken to drill a hole though a 25 mm thick plate with the drill rotating at 300 rpm and moving at a feed rate of 0.25 mm/revolution is: (a)10 sec (b) 20 sec (c) 60 sec (d) 100 sec
6. In an orthogonal cutting test on mild steel, the following data were obtained: Cutting speed 40 m/min, Depth of cut: 0.3 mm, Tool rake angle: + 5°, Chip thickness: 1.5 mm, Cutting force: 900 N, Thrust force: 450 N. Using Merchant's analysis, the Friction angle during the machining will be: (a) 26.6° (b) 31.5° (c) 45° (d) 63.4°
7. In an orthogonal cutting process the tool used has rake angle of zero degree. The measured cutting force and thrust force are 500 N and 250 N, respectively. The coefficient of friction between the tool and the chip is _____.
8. The tool life equation for HSS tool is the tool life (T) of 30 min is obtained using the following cutting conditions: V = 45 m/min, f = 0.35 mm, d = 2.0 mm. If speed (V), feed (f) and depth of cut (d) are increased individually by 25%, the tool life (in min) is: (a) 0.15 (b) 1.06 (c) 22. 50 (d) 30.0
9. A single point cutting tool with 0° rake angle is used in an orthogonal machining process. At a cutting speed of 180 m/min, the thrust force is 490 N. If the coefficient of friction between the tool and the chip is 0.7, then the power consumption (in kw) for the machining operation is _____.
10. A slot is to be milled centrally on a block with a dimension of 40 x 0.05 mm. A milling cutter of 20 mm width is located with reference to the side of the block within 0.02 mm. The maximum offset in mm between the centre lines of the slot and the block is: (a) 0.070 (b) 0.070 (c) 0.020 (d) 0.045

11. In an orthogonal machining operation: Uncut thickness = 0.5 mm, Cutting speed = 20 m/min, Width of cut = 5 mm, Chip thickness = 0.7 mm, Thrust force = 200 N, Cutting force = 1200 N, Rake angle = 15°, Assume Merchant's theory to calculate: (A) The values of shear angle and shear strain, respectively, are: (a) 30.3° and 1.98 (b) 30.3° and 4.23 (c) 40.2° and 2.97 (d) 40.2° and 1.65. (B) The coefficient of friction at the tool-chip interface is: 0.23 (b) 0.46 (c) 0.85 (d) 0.95. (C) The percentage of total energy dissipated due to friction at the tool-chip interface is: 30% (b) 42% (c) 58% (d) 70%
12. In order to have interference fit, it is essential that the lower limit of the shaft should be _____.
    (a) Greater than the upper limit of the hole.
    (b) Lesser than the upper limit of the hole.
    (c) Greater than the lower limit of the hole.
    (d) Lesser than the lower limit of the hole.
13. A ring gage is used to measure _____.
    (a) Outside diameter but not roundness.
    (b) Roundness but not outside diameter.
    (c) Both outside diameter and roundness.
    (d) Only external threads.
14. GO and No-GO plug gages are to be designed for a hole Gage tolerances can be taken as 10% of the hole $20.000^{+0.050}_{+0.010}$Following ISO system of gage design, sizes of GO and NO-GO gage will be respectively.
    (a). 20.010 mm and 20.050 mm. (b) 20.014 mm and 20.046 mm
    (c). 20.006 mm and 20.054 mm. (d) 20.014 mm and 20.054 mm
15. Which one of the following instruments is widely used to check and calibrate geometric features of machine tools during their assembly?
    (a) Ultrasonic probe (b) Coordinate Measuring Machine (CMM)
    (c) Laser interferometer (d) Vernier calipers
16. A metric thread of pitch 2 mm and thread angle 60° is inspected for its pitch diameter using 3-wire method. The diameter of the best size wire in mm is_____.
    (a) 0.866 (B) 1.000 (C) 1.154 (D) 2.000
17. The flatness of a machine bed can be measured using_____.
    (a) Vernier calipers (b) Auto collimator
    (c) Height gauge (d) Tool Maker's Microscope.

IES QUESTIONS:

1. A hole of 20 mm diameter is to be drilled in a steel block of 40 mm thickness. The drilling is performed at rotational speed of 400 rpm and feed rate of 0.1 mm/rev. The required approach and over run of the drill together is equal to the radius of drill. The drilling time (in minute) is: (a) 1.00 (b) 1.25 (c) 1.50 (d) 1.75
2. If the Taylor's tool life exponent n is 0.2, and the tool changing time is 1.5 min, then the tool life (in min) for maximum production rate is _____.

3. A steel bar 200 mm in diameter is turned at a feed of 0.25 mm/rev with a depth of cut of 4 mm. The rotational speed of the work piece is 160 rpm. The material removal rate is _____.
4. Two cutting tools are being compared for a machining operation. The tool life equations are: Carbide tool: $VT^{1.6}=3000$, HSS tool: $VT^{0.6}=200$, where V is the cutting speed in m/min and T is the tool life in min. The carbide tool will provide higher tool life if the cutting speed in m/min exceeds: (a) 0 (b) 39.4 (c) 49.3 (d) 60.
5. In a single pass drilling operation, a through hole of 15 mm diameter is to be drilled in a steel plate of 50 mm thickness. Drill spindle speed is 500 rpm, feed is 0.2 mm/rev and drill point angle is 118°. Assuming 2 mm clearance at approach and exit, the total drill time (in seconds) is: (a) 35.1 (b) 32.4 (c) 31.2 (d) 30.1
6. Details pertaining to an orthogonal metal cutting process are given below: Chip thickness ratio 0.4, Unreformed thickness 0.6 mm, Rake angle +10°, Cutting speed 2.5 m/s, Mean thickness of primary shear zone 25 microns. The shear strain rate during the process is: (a) 0.1781×10^5 (b) 0.7754×10^5 (c) 1.0104×10^5 (d) 4.397×10^5
7. A single point cutting tool with 12° rake angle is used to machine a steel work piece. The depth of cut i.e., uncut thickness is 0.81mm.The chip thickness under orthogonal machining condition is 1.8mm. The shear angle is approximately: (a) 22° (b) 26° (c) 56° (d) 76°
8. The usual method of defining mach inability of a material is by an index based on: (a) Hardness of work material (b) Production rate of machined parts (c) Surface finish of machined surfaces (d) Tool life.
9. In Taylor's tool life equation VT= C, the constants n and C depend upon; 1. Work piece material 2.Tool material 3.Coolant: (a) 1, 2 and 3 (b) 1 and 2 only (c) 2 and 3 only (d) 1 and 3 only
10. Tool life increase with increase in: (a) Cutting speed (b) Nose radius (c) Feed (d) Depth of cut
11. The most important function of the cutting fluid is to: (a) Provide lubrication (b) Cool the tool and work piece (c) Wash away the chips (d) Improve surface finish
12. During orthogonal cutting, an increase in cutting speed causes: (a) An increase in longitudinal cutting force (b) An increase in radial cutting force (c) An increase in tangential cutting force (d) Cutting forces to remain unaffected
13. Typical coolants used for machining aluminum are; (1)Kerosene oil (2) Soda water (3) Air (4) Paraffin oil: (a) 1, 2, 3 and 4 (b) 2 and 3 only (c) 1 and 2 only (d) 3 and 4 only
14. In a machining experiment, tool life was found to vary with the cutting speed in the following manner: If the Cutting speed is 60 m/min, then the Tool life is 81 minutes while if the Cutting speed is 90 m/min, then the Tool life is 36 minutes. (A) The exponent (n) and constant (k) of the Taylor's tool life equation are: (a) n=0.5 and k =540 (b) n=1 and k =4860 (c) n=−1 and k =0.74 (d) n=−0.5 and k =1.15585. (B) What is the percentage increase in tool life when the cutting speed is halved?
15. Match List – I with List – II and select the correct answer using the code given below the lists.

List – I	List– II
(P) Lathe	(1) Flute
(Q) Shaper	(2) Universal indexing
(R) Drilling machine	(3) Lead screw
(S) Milling machine	(4) Rocker arm

(a) P -2,Q-4,R-1,S-3 (b) P-3,Q-4,R-1,S-2 (c) P -2,Q-1,R-4,S-3 (d) P-3,Q-1,R-4,S-2

WEBSITES:

1. http://www.nptel.ac.in/downloads/112105127/
2. http://users.tamuk.edu/kfldp00/MEIE_Peel_website/Courses/MEEN5301.html
3. http://metalcutting.com/
4. http://www.engineeringarticles.org/lathe-lathe-operations-types-and-cutting-tools/
5. http://www.educationdiscussion.com/various-types-of-operations-performed-in-lathe-machine/
6. http://www.enggpedia.com/mechanical-engineering-encyclopedia/dictionary/machine-design/1643-milling-operation-milling-process-a-types-of-milling
7. https://www.nmri.go.jp/eng/khirata/metalwork/milling/intro/index_e.html
8. http://www.mechengg.net/2015/12/difference-between-shaping-planing-slotting.html.
9. nptel.ac.in/courses/112106138/
10. metrologyindia.org/
11. www.worldscientific.com/worldscibooks/10.1142/9610
12. www.worldmetrologyday.org/
13. http://www.zeiss.com/industrial-metrology/en_de/home.html
14. http://www.nplindia.org/metrology-society-india
15. www.bis.org.in/
16. www.sme.org/manufacturingengineering/

EXPERT DETAILS:

1. Dr. S. Narendranath, Professor, NIT, Suratkal
2. Dr. Sai Kumar, Scientist-G, DRDL, Hyderabad
3. Dr. Manzoor Hussain, Professor, JNTU, Hyderabad
4. B. Sravan Kumar Reddy, Metrology Engineer at Schneider electrical India, Hyderabad.
5. Dr. Arkanti Krishnaiah, Associate Professor, Osmania University.
6. Abhay Sharma, Associate Professor, IIT Hyderabad.
7. Dr. S. Surya Kumar, Assistant Professor, IIT Hyderabad.
8. Dr. N. Venkaiah Assistant Professor, NITW.
9. Mr.Rahul Kumar Chandan, Metrology Engineer at Machine Tools India Limited, Bhopal, Madhya Pradesh.
10. Mr. Vijay Kumar Sharma, CMM programmer/Metrology Engineer, at TE Connectivity Bengaluru, Karnataka.

JOURNALS:

1. Journal of Machinery Manufacture and Reliability
2. International Journal of Machining and Machinability of Materials
3. International journal of pure and applied research in engineering and technology
4. International Journal of Research in Engineering and Technology
5. Machining Science and Technology-An International Journal
6. IEEE-Explore
7. Journal of Machining and Forming Technologies
8. International Journal of Advances in Machining and Forming Operations
9. International Journal of Machine Tools and Manufacturing
10. International Journal of Engineering and Advanced Technology
11. International Journal of Engineering Trends and Technology
12. International Journal of Metrology and Quality Engineering.
13. Development and Calibration of an integrated 3D scanning system for high-accuracy large-scale metrology.
14. International Journal of Metrology and measurement system.
15. MAPAN –Journal of Metrology society of India Impact factor.
16. International journal of Mechanical Engineering Technology.
17. International journal of Mechanical and Mechatronics Engineering.

LIST OF TOPICS FOR STUDENT SEMINARS:

1. Cutting tool materials composition and uses.
2. Types of lathes and specifications.
3. Different types of milling machines and specifications.
4. Grinding machines and specifications.
5. Super finishing operation and super finish produced.
6. Optical Measuring Instruments.
7. Measurement of Angles and Tapers.
8. Surface Roughness Measurement.
9. Screw Thread Measurement.

CASE STUDIES / SMALL PROJECTS:

1. Design and fabrication of mini lathe for pipes.
2. Development of cutting tool inserts using modified tool geometry for thread cutting.
3. Effect of cutting forces and cutting parameters in turning process.
4. Spatial's 3D component software helps Metrology companies rapidly deliver robust solutions and better integrate with the manufacturing design process.
5. Advanced techniques for assessment surface topography: development of a basis for 3D surface texture standards.
6. Statistical case studies for industrial process improvement.