MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)

Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

MKC

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Must Know Concepts (MKC)

2020-21

Subject		19RAC10 - Metrology and Measurement		
S.No	**Term**	**Notation (Symbol)**	**Concept/Definition/Meaning/Units/Equation/ Expression**	**Units**
Unit-I Basics of Metrology				
1	Metrology		Science of Measurement	
2	Metrology types		Fundamental Metrology, Industrial Metrology, and Legal Metrology.	
3	Uses of Metrology		Measurements are used in manufacturing and other processes	
4	Units		Meter (m), Kilogram (kg), Second (S), Kelvin (K), Ampere (A), Mole (mol), and Candela (cd)	
5	Measurement		Assigning a number to a characteristic of an Object	
6	Measurement System		It is used to compare the physical quantity with the Standard value. 1. MKS System 2. CGS System 3. FPS System 4. SI System	
7	Measuring tools		1. Vernier Caliper 2. Thread gauge 3. Feeler gauge 4. Micrometer 5. Dial Indicator 6. Torque Wrench 7. Torque Angle Gauge	
8	Need of Measurements		Measurement is needed to find 1. True dimensions of a part 2. Physical Parameters 3. Performance of a system	
9	Methods of Measurements		1. Direct Method 2. Indirect Method 3. Absolute Method 4. Comparison method 5. Transposition Method 6. Substitution Method 7. Coincidence Method	
10	Elements of Measurements		1. Primary sensing elements 2. Variable Conversion Element 3. Variable Manipulation Element 4. Data Transmission Element 5. Data Presentation Element	

11	Elements of Metrology		1. Standard 2. Work piece 3. Instrument 4. Person 5. Environment	
12	Standard		A known accurate measure of physical quantity is termed as Standard.	
13	Instrument		Measuring Devices that transform the measured quantity into an indication	
14	Environment		The surroundings or conditions in which an instrument operates	
15	Accuracy		The degree to which the result of a measurement confirms to the correct value	
16	Precision		The closeness of two or more measurements	
17	Repeatability		Closeness of the agreement between the results of successive measurements of the same measure	
18	Reproducibility		The extent to which consistent results are obtained when an experiment is repeated.	
19	Calibration		Evaluating and adjusting the precision and accuracy of measurement equipment	
20	Calibration Types		1. Transducer Calibration 2. Data system calibration 3. Physical end-to-end calibration	
21	Errors		The difference between a measured value of a quantity and its true value	
22	Types of Error		1. Systematic Error 2. Random Error 3. Gross Error	
23	Types of Standard		1. Line standard 2. End standard 3. Wavelength standard	
24	Line standard		Distance between two parallel lines or two surfaces	
25	End standard		Distance between two flat parallel faces	

Unit-II Linear and Angular Measurements				
1	Linear Measuring		Instruments are designed to measure the distance between two surfaces or points like Vernier Caliper, Micrometer	
2	Linear Measurement		Measurements of length, diameter, height and thickness	
3	Types of Linear Measuring Instruments		Vernier Caliper Micrometer Vernier Depth Gauge Vernier Height Gauge Comparator	
4	Vernier Caliper		It is a visual aid to take an accurate measurement reading between two graduation markings on a linear scale by using mechanical interpolation	
5	Types of Vernier Caliper		1. A Type Vernier Caliper 2. B Type Vernier Caliper 3. C Type Vernier Caliper	
6	Parts of Vernier Caliper		1. Main Scale 2. Vernier Scale 3. External Measuring faces 4. Internal Measuring Faces 5. Depth Measuring Balance	
7	Least Count of Vernier		0.02mm	
8	Parts of Vernier Height Gauge		1. Base 2. Beam 3. Measuring Jaw 4. Scriber 5. Slider	
9	Least Count of Micrometer		0.01mm	
10	Micrometer		It is a device incorporating a calibrated screw widely used for accurate measurement of components	
11	Classification of Micrometer		1. Outside Micrometer 2. Inside Micrometer	
12	Criteria for selecting materials for Slip Gauges		1. High Hardness 2. Temperature Stability 3. Corrosion Resistance 4. High Quality Finish	
13	Angular Measurement		Includes the measurement of angles or tapers	
14	Gauge Materials		Basic metals, Glass, Plastics, Aluminum, Brass, Steel, Polycarbonate and Polypropylene	
15	Purpose of gauge		A gauge is a device used for Inspection Purposes	
16	Limit gauge		Method of checking dimensions using fixed gauge to determine whether a given	

			component lies within its limit	
17	Advantages of Limit Gauges		Quicker Inspection Method used in Mass Production	
18	Types of Gauges		1. GO Gauge 2. NOGO Gauge	
19	Interchangability		Ability of components to assemble to form a final Product	
20	Fit		Degree of tightness or looseness between two mating parts	
21	Sine bar		Sine bar is used in conjunction with slip gauge for precise angular measurement	
22	Angle Dekkor		Optical device that uses the principle of Auto collimation for measuring small angles	
23	Bevel Protractor		It is a graduated circular protractor with one pivoted arm to measure angles	
24	Clinometers		Clinometers is an instrument used for measuring angles of slope (or tilt)	
25	Autocollimator		Autocollimator is an optical instrument for non-contact measurement of angles	
Unit-III Advances in Metrology				
1	LASER		Light Amplification by Stimulated Emission of Radiation	
2	Components of Laser		1. Active medium 2. Excitation Mechanism 3. High Reflectance Mirror 4. Partially Transmissive Mirror	
3	Lasers Applications in Measurements		1. Dimensional measurements 2. Surface Inspection	
4	Types of Laser		1. Solid state 2. Gas 3. Semiconductor	
5	Laser in Metrology		Laser is suited in metrology because of its high degree of coherence and monochromatic nature	
6	Alignment test on Machine Tools		The alignment test is carried out to check the Straightness and flatness of guide ways and slide ways of machine tool	
7	CNC		Computer Numerical Control System	
8	CMM		Coordinate Measuring Machine	
9	Types of CMM		1. Cantilever Type 2. Bridge Type 3. Horizontal boring Mill Type 4. Vertical Boring type	
10	Benefits of Using CMM		CMM accurately check multiple features on different planes and angles, and the information is stored for later reference	

11	Advantages of Column Type CMM		1. Quicker Inspection 2. Accurate Measurements 3. Easier to Position 4. More Accurate 5. No need to use GO/NOGO Gauges	
12	Types of Accuracy used for CMM		1. Geometry accuracies 2. Total measuring accuracies 3. Volumetric length measuring accuracies 4. Environmental effects	
13	Causes of Errors in CMM		1. Table of CMM may not have perfect geometric form. 2. The probes may have a degree of run out. 3. Probes should be minimum and rigid	
14	Laser Micrometer		Laser micrometers are the type that uses an encoder to detect the distance and displays the result on a digital screen.	
15	Various Geometrical Checks in Machine Tools		1. Straightness 2. Flatness 3. Parallelism, equidistance and coincidence 4. Rotations	
16	Applications of Laser in Machine Tool Metrology		1. Aircraft production, shipbuilding to check for limits and fits 2. Testing of flatness of machined surfaces	
17	Axial slip of Machine Tool		Machine tools are very sensitive to impact or shock, even heavy casting standards are not always solid and rigid enough to withstand stresses due to falling during transportation	
18	Methods of Dimensional Measurements using Laser		1. Laser telemetric system 2. Laser Triangulation sensors 3. Two frequency laser interference	
19	Laser Interferometer Components		1. Two frequency laser source 2. Optical elements 3. Laser heads measurement receiver 4. Measurement display	
20	Types of Laser Interferometer		1. AC Interferometer 2. DC Interferometer	
21	Types of AC Laser Interferometer		1. Standard Interferometer 2. Single Beam Interferometer	
22	Other Types of Interferometer		1. Michelson Interferometer 2. Twyman green specialization of Michelson Interferometer 3. Dual frequency laser Interferometer	
23	Machine vision		Machine vision is the ability of a computer to employ one or more video cameras, analog-to-digital conversion (ADC) and digital signal processing (DSP). The resulting data goes to a	

			computer or robot controller.	
24	Various stages of Machine vision		1. Image Formation 2. Image Processing 3. Image Analysis 4. Image Interpretation	
25	Applications of Machine vision		1. Measurements of Dimensions and Tolerance 2. Guidance and Control 3. Identification of Surface Defects 4. Flatness Measurement 5. Inspection of Printed Circuit Boards (PCB)	
Unit-IV Form Measurement				
1	Straightness		Condition where an element of a surface or an edge is in a straight line	
2	Straight edge		Measuring tool which consists of length on steel of narrow and deep section	
3	Screw thread		Helical ridge produced by forming a continuous helical groove of a uniform section on the external or internal surface of a cylinder	
4	Types of Thread		1. External Threads 2. Internal Threads	
5	Flank		Surface between crest and root	
6	Pitch		Distance measured parallel to the axis from a point on a thread to the corresponding point	
7	Types of Pitch Errors		1. Progressive error 2. Drunken error 3. Periodic error 4. Irregular errors	
8	Wire Methods		1. One wire method 2. Two wire method 3. Three wire method	
9	Instruments for Measuring Pitch Diameter		1. Pitch measuring machine 2. Tool maker 3. Screw pitch gauge	
10	Drunken Thread		The advance of the helix is irregular in one complete revolution of thread	
11	Velocity ratio		To calculate the speed of the driven gear - multiply the speed of the driver gear by the velocity ratio.	
12	Types of Gear		1. Spur Gear 2. Helical Gear 3. Gear Rack 4. Internal Gear	
13	Circular Pitch		The distance along the pitch circle or pitch line between corresponding profiles of adjacent teeth	

14	Force ratio		Ratio of the output force (load) of a machine to the input force (effort)	
15	Runout		Runout is an inaccuracy of rotating mechanical systems, specifically that the tool or shaft does not rotate exactly in line with the main axis	
16	Roundness ratio		The ratio of the polar diameter to the equatorial diameter of a sphere	
17	Addendum		The distance between the reference line and the tooth tip.	
18	Dedendum		The distance between the reference line and the tooth root	
19	Pitch point		The point of contact of the pitch lines of two gears or of a rack and pinion when in mesh.	
20	Diametrical pitch		The number of teeth divided by the pitch diameter.	
21	Types of Thread Gauge		1. Plug Screw Gauge 2. Ring Screw Gauge 3. Caliper Gauges	
22	Flatness		It is defined as minimum distance between two planes.	
23	GD&T		Geometrical Dimensioning and Tolerance	
24	Tolerances types		1. Limit Dimensions 2. Unilateral 3. Bilateral Tolerances	
25	Gears		Gears are used to transmit power	
Unit-V Measurement of Power, Flow and Temperature				
1	Measurement Process		1. Establishing Performance Standards. 2. Measuring the Actual Performance. 3. Comparing Actual Performance to the Standards. 4. Taking Corrective Action	
2	Flow area		Flow may be measured by measuring the velocity of fluid over a known area	
3	Flow Measurement		The quantification of movement of a fluid	
4	Venturimeter		Device used to measure the flow rates of all incompressible fluids	
5	Orificemeter		Device used for measure the flow rate of liquid	
6	Flow Nozzle		When a flow nozzle is placed in a pipe it causes a pressure drop which varies with flow rate	
7	Temperatures measurement		1. Thermocouple, 2. Electrical thermal resistance 3. Thermostats 4. Pyrometers	
8	Types of Strain Gauges		1. Non Bonded strain gauge 2. Bonded strain gauge 3. Fine wire strain gauge	

			4. Metal foil strain gauge 5. Piezo –resistive strain gauge	
9	Types of Flow Meter		1. Venturimeter 2. Orificemeter 3. Rotometer 4. Pitot tube	
10	Thermistor		Defined as a type of resistor whose electrical resistance varies with changes in temperature.	
11	Types of Thermistor		1. Bead type 2. Water type 3. Rod type 4. Washer type	
12	Thermopile		When thermocouples are connected in series it is called as thermopiles	
13	Thermocouple Materials		1. Chrome 2. Alumel 3. Copper 4. Iron 5. Platinum 6. Rhenium	
14	Thermocouple		A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals.	
15	Laws of thermo couple		1. Law of intermediate metals 2. Law of intermediate temperature	
16	Pyrometer		Type of remote-sensing thermometer used to measure the temperature of a surface.	
17	Types of Pyrometers		1. Total Radiation Pyrometer 2. Optical Radiation Pyrometer	
18	Materials for Bimetallic strips		1. Invar 2. Brass 3. Nickel – iron alloy	
19	Force		Mechanical force is a force that needs a physical contact between the system which applies the force and the system on which the force is applied.	
20	Types of Forces		1. Applied Force 2. Gravitational Force 3. Normal Force 4. Frictional Force 5. Air Resistance Force 6. Tension Force. 7. Spring Force	
21	Force measurement methods		1. Direct Comparison 2. Indirect Comparison	
22	Devices used for Measuring Force		1. Scale and Balance 2. Elastic Force meter Proving Ring 3. Load Cell	

23	Torque		Turning or twisting action of the force. The SI unit of torque is Nm	
24	Torque Measuring Instruments		1. Mechanical Torsion Meter 2. Optical Torsion Meter 3. Electrical Torsion Meter 4. Strain Gauge Torsion Meter	
25	Types of Dynamometers		Absorption Dynamometers Driving Dynamometers Transmission Dynamometers	
Aptitude Questions and Answers				
S.No	**Term**	**Notation (Symbol)**	**Concept/Definition/Meaning/Units/Equation /Expression**	**Units**
1	A person crosses a 600 m long street in 5 minutes. What is his speed in km per hour?		A. 3.6 **B. 7.2** C. 8.4 D. 10 Explanation: Speed = 600/ 5 x 60 m/sec. = 2 m/sec. = 2 x 18/5km/hr =7.2 km/hr	
2	An express train travelled at an average speed of 100 km/hr, stopping for 3 minutes after every 75 km. How long did it take to reach its destination 600 km from the starting point?		A. 6 hrs 27 min B. 6 hrs 24 min **C. 6 hrs 21 min** D. 6 hrs 30 min Explanation: Time taken to cover 600 km = (600/100)hrs =6 hrs. Number of stoppages = 600/75 - 1 =7. Total Time of stoppages= (3 x 7)min=21 min. Hence, total time taken=6 hrs 21 min.	
3	The ratio between the length and the breadth of a rectangular park is 3: 2. If a man cycling along the boundary of the park at the speed of 12 km/hr completes one round in 8 minutes, then the area of the park (in sq. m) is		A. 15360 **B. 153600** C. 30720 D. 307200 Explanation: Perimeter = Distance covered in 8 min. =12000x 8m = 1600 m. Let length = 3x metres and breadth = 2x metres. Then, 2(3x + 2x) = 1600 or x = 160. Length = 480 m and Breadth = 320 m. Area = (480 x 320) m^2 = 153600 m^2.	

4	If a cost price of a pencil box is Rs.67 and selling price is Rs.70.Is there is profit or loss?		A. Rs.2 **B. Rs.3** C. Rs.4wrong D. RS.5 Explanation: C.P = RS.67 , S.P = Rs.70 As, S.P >C.P it means profit .profit = S.P-C.P = Rs.3	
5	A and B started a business by investing Rs.4000/- and Rs.5000/- respectively. Find the A's share out of a total profit of Rs.1800:		A. Rs.1000/- B. Rs.1800/- **C. Rs.800/-** D. Rs.400/- Explanation: A = Rs.4000/- B = Rs.5000/- A share 4 parts & B share 5 parts Total 9 parts -----> Rs.1800/- ----> 1 part -------> Rs.200/- A share = 4 parts -----> Rs.800/-	
6	Two pipes can fill the cistern in 10hr and 12 hr respectively, while the third empty it in 20hr. If all pipes are opened simultaneously, then the cistern will be filled in		**A. 7.5 hr** B. 8 hr C. 8.5 hr D. 10 hr Explanation: Work done by all the tanks working together in 1 hour. 110+112-120=215 Hence, a tank will be filled in 152 = 7.5 hour	
7	A train running at the speed of 60 km/hr crosses a pole in 9 seconds. What is the length of the train?		A. 120 metres B. 180 meters **C. 150 meters** D. 324 meters Explanation: Speed= 60 x5/18 m/sec= 50/3 m/sec. Length of the train = (Speed x Time). Length of the train = 50/3x 9m = 150 m.	
8	A boat can travel with a speed of 13 km/hr in still water. If the speed of the stream is 4 km/hr, find the time taken by the boat to go		A. 2 hours B. 3 hours **C. 4 hours** D. 5 hours Explanation: Speed downstream = (13 + 4) km/hr = 17 km/hr. Time taken to travel 68 km downstream =68/17hrs = 4 hrs.	

	68 km downstream.			
9	Ramya gives 50 times the rent per annum to purchase a plot from L.I.C. Find the rate of interest from the amount paid by him		A. 1% **B. 2%** C. 3% D. 1.5% Explanation : Let the annual rent be Rs. x. I = x; P = 50x, n = 1 The rate of interest =100I/Pn =100x/(50x x 1)%= 2%	
10	Average of all prime numbers between 30 to 50		A. 37 B. 37.8 C. 39 **D. 39.8** Explanation: Prime numbers between 30 and 50 are: 31, 37, 41, 43, 47 Average of prime numbers between 30 to 50 will be ((31+37+41+43+47)/5)=199/5=39.8	
11	Average of 10 matches is 32, How many runs one should score to increase his average by 4 runs.		A. 70 **B. 76** C. 78 D. 80 Explanation: Average after 11 innings should be 36 So, Required score = (11 * 36) - (10 * 32)= 396 - 320 = 76	
12	The greatest number which on dividing 1657 and 2037 leaves remainders 6 and 5 respectively, is:		**A. 127** B. 305 C. 235 D. 123 Explanation: Required number = H.C.F. of (1657 - 6) and (2037 - 5) = H.C.F. of 1651 and 2032 = 127.	
13	Find the number, when 15 is subtracted from 7 times the number, the result is 10 more than twice of the number		**A. 5** B. 15 C. 7.5 D. 4 Explanation: Let the number be x. 7x -15 = 2x + 10 => 5x = 25 => x = 5	
14	Difference between a two-digit number and the number obtained by		A. 2 **B. 4** C. 8 D. 12	

	interchanging the two digits is 36, what is the difference between two numbers		Explanation: Let the ten digit be x, unit digit is y. Then (10x + y) - (10y + x) = 36 => 9x - 9y = 36 => x - y = 4.	
15	Find the odd man out. 1, 3, 9, 12, 19, 29		**A. 12** B. 9 C. 1 D. 3 Explanation : 12 is an even number. All other given numbers are odd	
16	Find the odd man out. Shakespeare		A. Romeo B. Hamlet **C. Novel** D. Play Explanation: Shakespeare was involved in all three forms of literature except NOVEL. Thus, option 3 is correct.	
17	Find the Missing Number 2, 6, 12, 20, 30, 42, 56, __		A. 60 B. 64 **C. 72** D. 70 Explanation: Pattern is 1 * 2, 2 * 3, 3 * 4, 4 * 5, 5 * 6, 6 * 7, 7 * 8 i.e) 8 * 9 = 72	
18	In 100 m race, A covers the distance in 36 seconds and B in 45 seconds. In this race A beats B by:		**A. 20m** B. 25m C. 22.5m D. 9m Explanation: Distance covered by B in 9 sec. = (100/45)*9m = 20m A beats B by 20 meters.	
19	Raju age after 15 years will be 5 times his age 5 years back, What is the present age of Raju		A. 15 B. 14 **C. 10** D. 8 Explanation: Clearly, x+15 = 5(x-5) <=> 4x = 40 => x = 10	
20	Ten years ago, P was half of Q's age. If the ratio of their present ages is 3:4, what will be the total of		A. 45 B. 40 **C. 35** D. 30 Explanation: Let the present age of P and Q be 3x and 4x respectively.	

	their present ages?		Ten years ago, P was half of Q's age (3x-10)=1/2(4x-10)?6x-20=4x-10=> 2x=10=>x=5 Total of their present ages=3x+4x=7x=7×5=35	
21	Solve the equation x+34=82		A. 58 **B. 48** C. 55 D. 60 Explanation: x=82-34=48	
22	Find c, if 5c - 2 = 33		**A. 7** B. 9 C. 11 D. 13 Explanation: We add 2 to both sides and get 5c-2+2=33+2, or 5c=35. We divide both sides by 5 in order to get c=7.	
23	A fires 5 shots to B's 3 but A kills only once in 3 shots while B kills once in 2 shots. When B has missed 27 times, A has killed :		**A. 30 birds** B. 60 birds C. 72 birds D. 90 birds Explanation: Let the no of shots be x. Then, Shots fired by A =(5/8)x Shots fired by B = (3/8)x Killing shots by A = 1/3 of (5/8)x = (5/24)x Shots missed by B = 1/2 of (3/8)x = (3/16)x (3/16)x = 27 ? x =144 Birds killed by A = (5/24)x = (5/24)*144 = 30	
24	f √‾2n =64, then the value of n is:		A. 2 B. 4 C. 6 **D. 12** Explanation: √‾2n =64 => 2n/2 = 64= 26 n/2=6; n=12	
`25	Solve (x + 1) (x – 3) = 0.		**A. –1, 3** B. 2, 3 C. –1, 5 D. –1, 6 Explanation: (x + 1)(x – 3) = 0 x + 1 = 0, x – 3 = 0 x = –1, x = 3 That was quick! And my answer is: x = –1, 3	
Faculty Team Prepares		Dr.T.Yuvaraj, ASP/MECH P.Ramesh, AP/MECH S.Palanisamy, ASP / MECH		

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