RRB-JE 2024

Railway Recruitment Board

Junior Engineer Examination

Electronics Engineering

Electronic Measurements

Well Illustrated **Theory** *with*

Solved Examples and **Practice Questions**

MADE EASY PUBLICATIONS

Electronic Measurements

Contents

Chapter 1

Basic Measuring Instruments

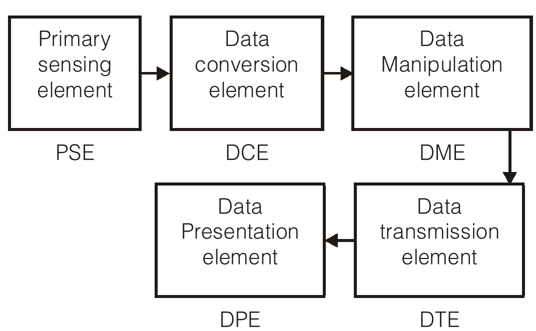
The measurement of a given quantity is an act or the result of comparison between the quantity and predefined standard.

Measurement is a process of gathering information from a physical world and comparing this information with agreed standards.

Instrumentation is the use of measuring instruments to monitor and control process. It is a science of measurement and control of process variables within a production, laboratory or manufacturing area.

- Elements of measurement:
  - (i) Primary sensing element
  - (ii) Data conversion element
  - (iii) Data presentation element

1.1 Generalized Measuring Instrument



PSE: This stage is in direct contact with the quantity under measurement. It consists of various sensing elements like transducers or other sensors.

DCE: This stage may convert one form of data into another but the basic information carried over by the data is preserved. It may consists of voltage to frequency converter V to I, I to V, etc.

DME: This stage changes the level of the signal but nature of the signal remains same, it may consists of an amplitude modulator, attenuators etc.

DTE: This stage consist of transmission media such as optical fibre, cables, Transmission lines etc.

DPE: This stage may consists of various display recorders or storage devices.

1.2 Method of Measurement

Direct Measurement

- In this method, the measured or the unknown quantity is directly compared against a standard.
- This type of measurement sometimes produces human error and hence gives inaccurate results.

Indirect Measurement

- This method of measurement is more accurate and more sensitive.
- These are more preferred over direct measurement.

1.3 Characteristics of Instrument and Measurement Systems

Accuracy

- Closeness with which an instrument reading approaches the true value of the variable being measured.
- The accuracy can be specified in terms of limit of error.
- The accuracy of a measurement means conformity to truth.

Precision

- A measure of the reproducibility of the measurements; i.e., given a fixed value of a variable, precision is a measure of the degree to which successive measurements differ from one another.

NOTE:

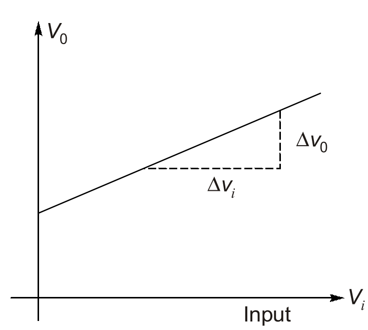
The high precision does not mean high accuracy. A highly precise instrument can be inaccurate.

Resolution

- The smallest change in measured value to which the instrument will respond.
- If the input is slowly increased from some orbitrory (non-zero) input value, it will be found that output doesn't change at all until a certain increment is executed. This increment is called resolution.

Sensitivity

- The ratio of output signal or response of the instrument to a change in input or measured variable. It is a design time characteristic.



$$\text{Sensitivity} = \frac{\text{Small change in output}}{\text{Small change in input}} = \frac{\Delta V_0}{\Delta V_i}$$

- The sensitivity of an instrument should be high.

Reproducibility

- It is the measure of repeatability of reading of a instrument taken over a period of time.

Repeatability

- It is the repetition of reading of an instrument from a given set of reading.

Linearity

- If the output is proportional to input, then the instrument is said to be linear.
- Nonlinear behavior of an instrument doesn't essentially lead to inaccuracy.

Dead time

- The time required for the measurement to begin to respond to the changes in the measurand is known as dead time. It is the time after which the instrument begin to respond after the measured quantity has been changed.

Dead zone

- Dead zone is the largest change of input quantity for which there is no output of the instrument.

1.4 Errors in Measurements and their Analysis

Measurements done in a laboratory or at some other place always involve errors. No measurement is free from errors. If the precision of the equipment is adequate, no matter what it's accuracy is, a discrepancy will always be observed between two measured results.

True Value

The true value of quantity to be measured may be defined as the average of an infinite number of measured values when the average deviation due to various contributing factors tends to zero.

Limiting Errors (Guarantee Errors)

The accuracy and precision of an instrument depends upon it's design, the material used and the work manship that goes into making the instrument. Components are guaranteed to be within a certain percentage of the rated value. Thus, the manufacturer has to specify the deviations from the "nominal value" of a particular quantity. The limits of these deviations from the specified value are defined as ***"Limiting Errors"*** or ***"Guarantee Errors"***.

For example, the magnitude of a resistor is 200 Ω with a limiting error of ±10 Ω. The magnitude of the resistance will be between the limits

$$R = 200 \pm 10\ \Omega$$

or $$R \geq 190\ \Omega$$

and $$R \leq 210\ \Omega$$

Hence, the manufacturer guarantees that the value of the resistor lies between 190 Ω and 210 Ω.

Absolute (Relative) Limiting Error

The relative (fractional) error is defined as the ratio of the error to the specified (nominal) magnitude of a quantity.

$$\text{Relative limiting error, } \varepsilon_r = \left(\frac{\text{Measured value} - \text{True value}}{\text{True value}}\right) \times 100$$

or, $$\% \varepsilon_r = \left(\frac{\text{Actual value} - \text{True value}}{\text{True Value}}\right) \times 100$$

or, $$\% \varepsilon_r = \left(\frac{A_m - A_T}{A_T}\right) \times 100 \qquad \begin{cases} A_m = \text{Measured value} \\ A_T = \text{True value} \end{cases}$$

Now, $$\% \varepsilon_r = \frac{A_m - A_T}{A_T} \quad \text{or} \quad \frac{A_m}{A_T} = 1 + \varepsilon_r \quad \text{or} \quad \boxed{\frac{A_T}{A_m} = \frac{1}{1+\varepsilon_r}}$$

$$A_T = \left(\frac{1}{1+\varepsilon_r}\right) A_m$$

Here, $$\frac{1}{1+\varepsilon_r} = \text{Correction factor}$$

NOTE:

Nominal value = True value and Actual value = Measured value

Example - 1.1 A resistance has nominal value of 50 Ω. When it is measured it's actual value is found to be 60 Ω. Find the percentage limiting error.

Solution:

$$\% \text{ error}, \varepsilon_r = \left(\frac{A_m - A_T}{A_T}\right) \times 100 = \left(\frac{60-50}{50}\right) \times 100 = 20\%$$

$$\boxed{\% \text{ error} = 20\%}$$

Example - 1.2 The measured value of a resistor is 100 Ω and it's relative error is ±10% then, it's true value and the range is

Solution:

$$\varepsilon_r = \pm 10\% \text{ of } 100 = \pm 10\ \Omega$$

Range, $$A_T = (100 - 10) \text{ to } (100 + 10) = 90\ \Omega \text{ to } 110\ \Omega$$

Example - 1.3 The dead zone in a certain pyrometer is 0.125 percent of span. The calibration is 400°C to 1000°C. What temperature change might occur before it is detected?

(a) 0.25°C
(b) –0.50°
(c) 1.25°C
(d) 0.75°C

Solution: (d)

$$\text{Span} = 4000 - 400 = 600° \text{ C}$$

∴ $$\text{Dead zone} = 0.125\% \text{ of span} = \frac{0.125}{100} \times 600 = 0.75°\text{C}$$

Hence, a change of 0.75°C must occur before it is detected.

Combination of Quantities with Limiting Errors

When two or more quantities, each having a limiting error, are combined, it is advantageous to be able to compute the limiting error of the combination.

1. Sum or Difference of Two or more quantities

Let, $x_1 = a \pm \varepsilon_{r1}$

$x_2 = b \pm \varepsilon_{r2}$

$x_3 = c \pm \varepsilon_{r3}$

$\therefore \quad x = x_1 + x_2 + x_3$

or, $x = -x_1 - x_2 - x_3$

So, $x = \pm(x_1 + x_2 + x_3)$

Relative limiting error in x is given by

$$\boxed{\varepsilon_x = \pm\left(\frac{a}{a+b+c}\cdot\varepsilon_{r1} + \frac{b}{a+b+c}\cdot\varepsilon_{r2} + \frac{c}{a+b+c}\varepsilon_{r3}\right)}$$

(ε_x = worst possible error)

Example - 1.4 Three resistances R_1 = 10 ± 2%, R_2 = 20 ± 5%, R_3 = 50 ± 3% are connected in series. Find the % limiting error for the series combination.

Solution:

$$\varepsilon_R = \pm\left(\frac{10}{10+20+50}\times 2 + \frac{20}{10+20+50}\times 5 + \frac{50}{10+20+50}\times 3\right)$$

or, $\varepsilon_R = \pm 3.375\%$

$$\boxed{\%\text{ Limiting error} = \pm 3.375\%}$$

Given, $R_T = 10 + 20 + 50 = 80\Omega$

$$\boxed{R_{\text{measured}} = 80 \pm 3.375\%}$$

2. Multiplication or Division Terms

Let, $x = \frac{x_1\, x_2}{x_3}$ or $\frac{x_2\, x_3}{x_1}$ or $x_1 x_2 x_3$ or $\frac{x_1}{x_1 x_3}$

Then, relative limiting error is

$$\boxed{\varepsilon_x = \pm(\varepsilon_{r1} + \varepsilon_{r1} + \varepsilon_{r3})}$$

NOTE

- When, $x = \frac{x_1\, x_2}{x_2 + x_3}$ or $\frac{x_1}{x_2 + x_3}$ or $\frac{x_1\, x_2}{x_2 - x_1}$
- Then, multiplication or division form is not applicable for finding relative limiting error.

3. Power of a Factor

Let, $x = x_1^m \cdot x_2^n \cdot x_3^p$ or $\frac{x_1^m x_2^n}{x_3^p}$ or $\frac{x_1^m}{x_1^n x_3^p}$

Then, Relative limiting error is $\varepsilon_r = \pm(m\,\varepsilon_{r1} + n\,\varepsilon_{r2} + p\,\varepsilon_{r3})$

NOTE

When x is of the form $\frac{x_1^m}{x_2^n + x_3^p}$ or $\frac{x_1^m + x_2^n}{x_3^p}$

then, above method is not applicable for finding relative limiting error.

Example - 1.5 The power is measured in a resistor by passing current through the ammeter and ammeter measures $I = (5 \pm 4\%)$ A across the resistance of $R = (10 \pm 2\%)\ \Omega$. Find the power consumed by the resistor and it's limiting error.

Solution:

Power consumed, $P = I^2R = 5^2 \times 10 = 250$ watts

and limiting error, $\varepsilon_p = \pm(2\varepsilon_I + \varepsilon_R) = \pm(2 \times 4 + 2) = 10\%$

$\therefore$ $P = (250 \pm 10\%)$ watt

4. Special Case

Resistance in parallel:

Let, $R_1 = 10 \pm 10\%$ (Range = 9 Ω to 11 Ω)

and $R_2 = 20 \pm 5\%$ (Range = 19 Ω to 21 Ω)

Equivalent resistance of parallel combination is $R = \frac{R_1 R_2}{R_1 + R_2}$

True value; $R = \frac{10 \times 20}{10 + 20} = 6.66\,\Omega = R_T$

Resistance in lower range; $R_L = \frac{R_1 R_2}{R_1 + R_2} = \frac{9 \times 19}{9 + 19} = 6.107\ \Omega$ Measured value in low range = L_m

Resistance in higher range; $R_H = \frac{11 \times 21}{11 + 21} = 7.21875\ \Omega$ Measured value for high range = H_m

Error in low range (for low value) = $\%\ \varepsilon_r = \left(\frac{L_m - R_T}{R_T}\right) \times 100$

Error in high range (for high value) = $\%\ \varepsilon_r = \left(\frac{H_m - R_T}{R_T}\right) \times 100$

For present case,

Error in low range; $\%\varepsilon_r = \left(\frac{6.10 - 6.66}{6.66}\right) \times 100 = -8.4\ \%$

Error in high range; $\%\varepsilon_r = \left(\frac{7.2187 - 6.66}{6.66}\right) \times 100 = 8.38\ \%$

1.5 Types of Errors

Error: Deviation of the measured value from the true value of the quantity being measured is called an error.

A study of errors is a first step in finding ways to reduce them. Errors may arise from different sources and are classified as under:

1. Gross error
2. Systematic error
3. Random error

Gross Error	Systematic Error	Random Errors
1. These types of error mainly comprises of human mistakes in reading instruments and recording and calculating measurement results. 2. The experimenter is mainly responsible for these errors. 3. Some gross errors are easily detected while some are difficult to detect. 4. These errors can be avoided by taking great care in reading and recording the data. Also, two or three or even more readings should be taken for the quantity under measurement. 5. Computational mistakes, incorrect adjustment and improper application of instruments can lead to gross errors.	1. Systematic errors are classified into three types: (i) **Instrument Errors:** • Occurs due to short coming in the instrument • Misuse of the instrument • Loading effect of the instrument (ii) **Environmental Errors:** • These errors occurs due to external environment factors like humidity, dust, vibrations or external magnetic field etc. (iii) **Observation Errors:** • Different experimenters may produce different results, when sound and light measurements are involved since no two observers possess the same physical response.	1. Random errors are those errors whose causes can't be established because of random variations in the parameters or the system of measurement. 2. The happenings or disturbances about which we are unaware are lumped together and called "Random" or "Residual" and error caused due to these happenings are called "Random" error.

1.6 Standards

Accuracy Decreases ↓

(i) **International standards:** Not available to everyone. These are most accurate.
(ii) **Primary standards:** National standards
(iii) **Secondary standards:** used in industrial labs.
(iv) **Working standards:** Used in general labs.

Standards of EMF

- 'Weston' cell is used for primary and secondary standards of emf.

Primary Standard

- Weston cell **saturated**, normal, weston cell is used as the primary standard of emf.
- The potential of saturated weston cell.

$$E = 1.01864 \text{ volts.}$$

It contains **$CdSO_4$ crystal**, Hg_2SO_4, (Cd + Hg) (Amalgum).

$CdSO_4$ crystal is used in saturated weston cell only.

- Variation in emf with temperature – 40 μv/°C.
- Variation in potential with time –1 μV/Year
- The max. current from saturated weston cell is 100 μA.
- Internal resistance of sat. weston cell. 600-800 Ω.

Secondary Standard

- Unsaturated weston cell is used as secondary. standards.
- The potential of unsaturated weston cell

$$E = 1.0180 \text{ to } 1.0194 \text{ V}$$

- It does not have $CdSO_4$ crystal.
- Porous plug is used to hold electrode in place.
- Variation in potential is –30 μV to –50 μV/year.

Laboratory standard of emf

- The zener diode circuit is used for laboratory standard.

Standards of Resistance

- Manganin is used as the standard resistance.

  Contents of Manganin:

  Ni $\rightarrow$ 4%

  Cu $\rightarrow$ 84%

  Mn $\rightarrow$ 2%

Characteristics of Manganin

- High resistivity
- Low temperature coefficient
- Low thermal expansion with copper

Errors in Resistance Standards

- Skin effect.
- Stray inductances, and capacitances.
- There can be contact resistances.

Bifilar Winding

- The bifilar winding is used to reduce the inductive effect of resistance.

  Primary standards of mutual inductance : (M)

Campbell Type

- Is used as the primary standard. It consists of marble cylinders with screw threads carrying a coils of bare copper, bare copper (without any insulation) wound under tension.

Secondary Standards of Mutual Inductance

- It consists of two coils wound on bobbin of marble and coils are separated, by a flange. Cu is used as a conductor.

Primary Standards of Self Inductance

- It is same as that of mutual inductance. (i.e. Campbell type).

Secondary Standards of Self Inductance

- Silk covered copper wire wound on marble former.

Primary Standards of Time

- Atomic clock is used as primary standard.

Secondary Standard of Time

- Rubidium crystal is used as secondary standard

Primary Standards of Frequency

(a) CAESIUM (Ce) beam is used as primary standard

(b) Hydrogen maser.

Secondary standards of frequency

(a) Rubidium crystal

(b) Quartz crystal

1.7 Unit and Dimensions

Unit: The standard measure of each kind of physical quantity is called a "unit" measurement mean comparison with a standard value. Magnitude of a physical = (Numerical ratio) × (Unit)

Dimension: Dimensions of a physical quantity are the powers to which the fundamental units are raised to obtain one unit of that quantity. It is written in a characteristic notation, [ ].

The 7 fundamental units:

S. No.	Physical Quantity	SI Base unit	Dimension
1.	Length	metre (m)	L
2.	Mass	kilogram (kg)	M
3.	Time	second (s)	T
4.	Electric current	Ampere (A)	I
5.	Temperature	Kelvin (K)	K
6.	Amount of substance	Moll (mol)	N
7.	Luminous Intensity	Candela (d)	J

Example - 1.6 Derive the dimensional equations for

(a) e.m.f.
(b) magnetic flux density
(c) electric flux density
(d) current density
(e) permeability
(f) permittivity
(g) resistivity and
(h) conductivity in *L*, *M*, *T*, *I* systems of dimensions.

Solution:

(a)
$$\text{Emf} = \frac{\text{Work done}}{\text{Charge}}$$

So,
$$[E] = \frac{[ML^2T^{-2}]}{[IT]} = [I^{-1}ML^2T^{-3}]$$

(b) Magnetic flux density,
$$B = \frac{\text{Flux}}{\text{Area}} = \frac{\phi}{A}$$

As, emf,
$$e = \frac{Nd\phi}{dt}$$

$$\therefore \quad \text{Flux}\,[\phi] = [\text{emf}]\,[\text{time}]$$

$$\therefore \quad [B] = \frac{[\phi]}{[A]} = \frac{[\text{emf}]\,[\text{time}]}{[\text{area}]} = \frac{[I^{-1}ML^2T^{-3}]\,[T]}{[L^2]} = [I^{-1}MT^{-2}]$$

(c) Electric flux density $= \frac{\text{Electric flux}}{\text{Area}} = \frac{\text{Charge}}{\text{Area}}$

$\therefore$ $[D] = \frac{[IT]}{[L^2]} = [IL^{-2}T]$

(d) Current density, $J = \frac{\text{Current}}{\text{Area}}$

$\therefore$ $[J] = \frac{[I]}{[L^2]} = [IL^{-2}]$

(e) Flux $=$ Flux density $\times$ Area

$\therefore$ $[\phi] = [I^{-1}MT^{-2}]\,[L^2] = [I^{-1}\,ML^2\,T^{-2}]$

Also, mmf $=$ Turns $\times$ current

$\therefore$ $[\text{mmf}] = [I]$

Also, Reluctance $= \left(\frac{\text{mmf}}{\text{flux}}\right)$

$\therefore$ $[RI] = \frac{[I]}{[I^{-1}ML^2T^{-2}]} = [I^2M^{-1}L^{-2}T^2]$

We have, reluctance $= \left(\frac{\text{Length}}{\text{Permeability} \times \text{Area}}\right)$

$\therefore$ Permeability, $\mu = \left(\frac{\text{Length}}{\text{Reluctance} \times \text{Area}}\right)$

Thus, $[\mu] = \frac{[L]}{[I^2M^{-1}L^{-2}T^2]\,[L^2]} = [I^{-2}MLT^{-2}]$

(f) Force $= \frac{Q_1 Q_2}{\varepsilon d^2}$ (where, $\varepsilon =$ permittivity)

$\therefore$ $[\varepsilon] = \frac{[\text{charge}^2]}{[\text{force}]\,[\text{distance}]} = \frac{[\text{current}^2]\,[\text{time}^2]}{[\text{force}]\,[\text{distance}^2]} = \frac{[I^2\,T^2]}{[MLT^{-2}][L^2]}$

$= [I^2\,M^{-1}\,L^{-3}\,T^4]$

(g) Resistance, $R = \left(\frac{\text{emf}}{\text{current}}\right)$

$\therefore$ $[R] = \frac{[I^{-1}ML^2T^{-3}]}{[I]} = [I^{-2}ML^2T^{-3}]$

$\therefore$ Resistance $= \left(\frac{\text{Resistivity} \times \text{Length}}{\text{Area}}\right)$

So, $[\text{Resistivity}] = \frac{[\text{Resistance} \times \text{Area}]}{[\text{Length}]}$

or, $[\rho] = \frac{[I^{-2}ML^2T^{-3}]\,[L^2]}{[L]} = [I^{-2}ML^3T^{-3}]$

(h) Conductivity $= \left(\frac{1}{\text{Resitivity}}\right)$

$\therefore$ $[\sigma] = [\rho^{-1}] = [I^2M^{-1}L^{-3}T^3]$

Example - 1.9 Air friction damping should not be used where the deflecting torque in the instrument is produced due to

(a) magnetic field
(b) electrostatic field
(c) thermoelectric emf
(d) all of the above

Solution: (b)

Example - 1.10 Fluid friction damping can be used in

(a) Horizontally mounted instruments
(b) Vertically mounted instruments
(c) both in horizontally and vertically mounted instruments
(d) None of these

Solution: (b)

In fluid friction damping, oil is used in place of air and as the viscosity of oil is greater, the damping force is also correspondingly greater. This type of damping is suitable for vertically mounted instruments and gives a greater damping torque.

Student's Assignments

Q.1 The errors introduced by an instrument fall in which category?
(a) Systematic
(b) Random errors
(c) Gross errors
(d) Environmental error

Q.2 Due to which one of the following reasons bearings of PMMC instrument are made of Jewel?
(a) To avoid wear and tear of the moving system
(b) To provide a small support
(c) It can be easily replaced
(d) To make the system robust

Q.3 What is a differential transformer?
(a) constant pressure transducer
(b) variable pressure transducer
(c) constant displacement transducer
(d) variable inductance transducer

Q.4 Which amplifier is used in an electronic multimeter?
(a) Power amplifier
(b) Buffer amplifier
(c) Differential amplifier
(d) Wideband amplifier

Q.5 Five students made the following readings on a very accurate voltmeter which reads 3.12 V, 3.15 V, 2.97 V, 3.10 V and 2.99 V. What is the most probable value of the voltage?
(a) 3.066 V
(b) 3.12 V
(c) 2.99 V
(d) 2.97 V

Q.6 In indicating instruments, the springs are mainly used to
(a) conduct the current to the coils
(b) hold the pirot in position
(c) control the pointer movement
(d) reduce the vibration of the pointer.

Q.7 Watt-hour is classified as
(a) deflecting instrument
(b) Indicating instrument
(c) Recording instrument
(d) Integrating instrument

Q.8 Zero drift or bias describes the effect
(a) Where the zero reading of an instrument is modified by a change in ambient conditions.
(b) Where the zero reading is achieved by increasing sensitivity.
(c) Where the zero reading is achieved by increasing linearity.
(d) None of the above

Q.9 The restoring torque in a spring controlled indicating instrument is
(a) directly proportional to the angle of deflection of moving system
(b) dierctly proportional to the sine of angle of deflection of moving system.
(c) inversely proportional to the angle of deflection of moving system.
(d) directly proportional to the square of the angle of deflection of moving system.

Q.10 As the deflection of the moving system increases, the controlling torque of an indicating instrument
(a) remains unchanged
(b) decreases
(c) increases
(d) None of the above

Q.11 In which of the following do the measurements find their application?
A. Automatic control of processes and operations.
B. Engineering experimental analysis.
C. Monitoring of process and operations.
(a) A only (b) A and B only
(c) B and C only (d) A, B and C

Q.12 Which of the following is the dimensional formula for mutual inductance?
(a) $ML^2T^2A^2$ (b) MLT^2A^2
(c) $ML^3T^{-2}A^{-2}$ (d) $ML^2T^2A^{-2}$

Q.13 "The current internationally recognized unit of time and frequency is based on the cesium clock, which gives an accuracy better than 1 μs per day." This statement is related to
(a) working standards
(b) International standards
(c) Primay standard
(d) Secondary standard

Q.14 The mean deviation $\bar{D}$ in terms of deviations from the mean value of n readings is
(a) $\frac{\Sigma|d|}{n}$ (b) $\frac{\Sigma d}{n}$
(c) $\frac{\sqrt{\Sigma d^2}}{n}$ (d) $\sqrt{\frac{\Sigma d^2}{n}}$

Q.15 The following are the desirable dynamic characteristics of a measurement system
(a) Fast response, fidelity, measuring lag and dynamic error.
(b) Fast response and measuring lag.
(c) Fidelity and measureing lag.
(d) Fast response and fidelity.

Q.16 Which of the following is the dimensional formula for conductivity?
(a) $M^{-1}L^{-3}T^3A^2$ (b) $ML^3T^3A^2$
(c) $M^2L^{-2}T^3A^{-2}$ (d) $ML^2T^3A^{-2}$

Q.17 The error induced by an instrument fall in which category?
(a) Systematic errors
(b) Random errors
(c) Gross errors
(d) Environmental errors

Q.18 The spiring which is used for producing controlling torque in indicating instruments are made up of materials which is/are
(a) None-magnetic
(b) Not subjected to much fatigue.
(c) Low specific resistance and low temperature resistance coefficient.
(d) All of the above

Q.19 The pointer of an indicating instrument is generally made of
(a) Copper (b) Aluminium
(c) Silver (d) Soft steel

Q.20 In eddy current damping, disc or former is made of a material that is
(a) conductor but non-magnetic
(b) conductor but magnetic
(c) non-conductor and non-magnetic
(d) Non-conductor but magnetic

Q.21 In general, fluid friction damping is not employed in indicating instruments, although one can find its use in
(a) Dynamometer wattmeter
(b) Hot-wire ammeter
(c) Induction type energy meter
(d) Kelving electrostatic voltmeter

Q.22 Which of the following is TRUE about analog multimeter?
(a) It is a type of absolute instrument.
(b) It is a type of indicating instrument.
(c) It is a type of recording instrument.
(d) It is a type of integrating instrument.

Q.23 Illumination is measured using which one of the following:
(a) Millivoltmeter (b) Stroboscope
(c) Luxmeter (d) pH meter

Q.24 A null type of instrument as compared to a deflection type instrument has
(a) high accuracy
(b) a lower sensitivity
(c) a faster response
(d) all of these

Q.25 Fluid friction damping can be used in
(a) horizontally mounted instruments
(b) vertically mounted instruments
(c) both in horizontally and vertically mounted instruments
(d) none of these

Q.26 A set of reading has a wide range and therefore, it has
(a) low precision (b) high precision
(c) low accuracy (d) high accuracy

Q.27 What is the smallest change in the input signal that can be detected by an instrument called?
(a) Accuracy (b) Precision
(c) Resolution (d) Sensitivity

Q.28 The dead time on an instrument refers to
(a) large change of input quanity for which there is no output.
(b) the time encountered when the instrument has to laid for some reactions to take place.
(c) the time before the instrument begins to responds after the quantity has altered.
(d) retardation or delay in the response of an instrument to change in the input signal.

Q.29 Tesla is same as
(a) Weber/meter (b) Weber/(meter)^2
(c) Farad/meter (d) Henry/(meter)^2

STUDENT'S ASSIGNMENTS — ANSWER KEY

1. (a)	**2.** (a)	**3.** (d)	**4.** (c)	**5.** (a)
6. (c)	**7.** (d)	**8.** (a)	**9.** (a)	**10.** (c)
11. (d)	**12.** (c)	**13.** (c)	**14.** (a)	**15.** (d)
16. (a)	**17.** (a)	**18.** (a)	**19.** (b)	**20.** (a)
21. (d)	**22.** (b)	**23.** (b)	**24.** (c)	**25.** (a)
26. (a)	**27.** (c)	**28.** (c)	**29.** (b)	

STUDENT'S ASSIGNMENTS — EXPLANATIONS

5. (a)

Most probable vlaue

$$= \left(\frac{3.12+3.15+2.97+3.1+2.99}{5}\right) = 3.066 \text{ V}$$

6. (c)

In indicating type instrument, spring is mainly used to control the pointer movmement. It mainly provides controlling torque which is opposite to deflecting torque.

7. (d)

The instrument records the consumption of the total quantity of electrical energy over a period of time.

9. (a)

For spring control mechinism,

$$T_c = K\theta$$

$$\Rightarrow \quad T_c \;\alpha\; \theta$$

11. (d)

In automatic control system, measurement is required to control and provide the desired response. In engineering experience mental analysis, measurement is required to find out the response of system to inputs. To monitor a system or process, we require measurement.

12. (c)

Dimension of mutual inductance is same as inductance and we know that units of wL are same