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# 1

## CHAPTER

# Electrical and Electronic Measurements

## EXERCISE - I

- The dimension of force in SI system are  
(a)  $\text{LMT}^{-1}$  (b)  $\text{LMT}^{-2}$   
(c)  $\text{LMT}$  (d)  $\text{LMT}^2$
- The dimension of power is  
(a)  $\text{ML}^2\text{T}^{-2}$  (b)  $\text{ML}^2\text{T}^{-3}$   
(c)  $\text{M}^2\text{LT}^{-3}$  (d)  $\text{M}^2\text{LT}^{-2}$
- The dimension of torque in SI unit is  
(a)  $\text{ML}^2\text{T}^2$  (b)  $\text{ML}^2\text{T}^{-2}$   
(c)  $\text{ML}^{-2}\text{T}^{-2}$  (d)  $\text{M}^2\text{L}^2\text{T}^{-2}$
- For defining standard metre, wave length of which material is considered  
(a) Helium (b) Neon  
(c) Xenon (d) Krypton
- The number of basic SI units is  
(a) 4 (b) 5  
(c) 6 (d) 7
- Supplementary units added to the basic SI units are  
(a) 2 (b) 3  
(c) 4 (d) 7
- Farad is the unit of  
(a) inductance  
(b) voltage  
(c) current  
(d) capacitance
- The unit newton/coulomb is the unit of  
(a) electric field intensity  
(b) electric flux density  
(c) electro-motive force  
(d) capacitance
- The dimension of magnetic flux density is  
(a)  $\text{IMT}^2$  (b)  $\text{I}^{-1}\text{MT}^2$   
(c)  $\text{IMT}^{-1}$  (d)  $\text{I}^{-1}\text{MT}^{-1}$
- Electrolyte solution in a standard saturated weston cell is  
(a) cadmium sulphite  
(b) potassium sulphate  
(c) magnesium sulphate  
(d) zinc sulphate
- The emf of a saturated Weston cell drops by increase in temperature at a rate of  
(a)  $4\mu\text{Vm}^\circ\text{C}$  (b)  $40\mu\text{Vm}^\circ\text{C}$   
(c)  $4\text{mVm}^\circ\text{C}$  (d)  $40\text{mVm}^\circ\text{C}$
- The internal resistance of a saturated Weston standard cell is of the order of  
(a) a fraction of ohm  
(b) a few ohm  
(c) practically zero ohm  
(d) a few kilo-ohm
- Purely mechanical instruments can be used for dynamic measurements because they have  
(a) high inertia  
(b) large time constant  
(c) high response time  
(d) all of these
- The span of a zero = centered voltmeter having a scale from 10 V to 10 V is  
(a) 0V (b) -10 V  
(c) 10V (d) 20V
- The resolution of an indicating instrument is  
(a) the smallest change in the output reading due to drifting of pointer  
(b) the smallest change in the applied stimulators that will indicate the detectable change in the deflection  
(c) the difference between various readings for the same applied stimulus  
(d) none of these
- In which part of the scale does the pointer indicate most accurately  
(a) In the first third of the scale  
(b) In the first half of the scale  
(c) In about middle of the scale  
(d) In last third of the scale
- The desirable static characteristics of a measuring system is/are  
(a) accuracy (b) sensitivity  
(c) reproducibility (d) all of these

## 1.2 Electrical and Electronic Measurements

18. The reliability of an instrument refers to
- (a) measurement of changes due to temperature variation
  - (b) degree to which repeatability continues to remain within specified limits
  - (c) the life of the instrument
  - (d) the extent to which the characteristics remain linear
19. The efficiency of an instrument is defined as the ratio of the measured quantity at full scale of the power taken by the instrument at
- (a) one-fourth scale
  - (b) half scale
  - (c) three-fourth scale
  - (d) full scale
20. To measure 2 volts, if one selects 0 – 100 volts range voltmeter which is accurate within  $\pm 1\%$ , the error in his/her measurement may be upto
- (a)  $\pm 0.02\%$
  - (b)  $\pm 1\%$
  - (c)  $\pm 2\%$
  - (d)  $\pm 50\%$
21. A thermometer is calibrated from  $150^{\circ}\text{C}$  to  $200^{\circ}\text{C}$ . The accuracy specified is  $\pm 0.25\%$ , the maximum static error in the measurement is
- (a)  $\pm 0.5^{\circ}\text{C}$
  - (b)  $0.375^{\circ}\text{C}$
  - (c)  $\pm 0.125^{\circ}\text{C}$
  - (d)  $\pm 0.0125^{\circ}\text{C}$
22. The degree of reproductively among several independent measurements of same true value under reference conditions is known as
- (a) accuracy
  - (b) precision
  - (c) linearity
  - (d) calibration
23. The errors committed by a person in the measurement are
- (a) gross errors
  - (b) random errors
  - (c) instrumental errors
  - (d) environmental errors
24. The current  $I$  through a resistance  $R$  is measured with uncertainties
- $$I = 4\text{A} \pm 0.5\%, R = 100\Omega \pm 0.2\%$$
- The uncertainty in measurement of power is
- (a)  $1600\text{W} \pm 0.1\%$
  - (b)  $1600\text{W} \pm 0.02\%$
  - (c)  $1600\text{W} \pm 0.05\%$
  - (d)  $1600\text{W} \pm 1.2\%$
25. A temperature probe having a first order response with a time constant of 1 second is given a step input from  $50^{\circ}$  to  $0^{\circ}\text{C}$ . The temperature in  $^{\circ}\text{C}$  after 0.6 second is
- (a) 18.4
  - (b) 25
  - (c) 27.4
  - (d) 45
26. Which of the following is absolute instrument?
- (a) Power factor meter
  - (b) Ammeter
  - (c) Wattmeter
  - (d) Tangent galvanometer
27. An instrument which gives total quantity of energy passed through in a given time is called
- (a) integrating instrument
  - (b) indicating instrument
  - (c) recording instrument
  - (d) digital instrument
28. Which of the following types of instrument is an integrating instrument?
- (a) Power factor meter
  - (b) Energy meter
  - (c) Wattmeter
  - (d) Frequency meter
29. The torque produced in an indicating instrument by utilizing magnetic, electrodynamic, thermal, chemical and electrostatic effect is known as
- (a) controlling torque
  - (b) deflecting torque
  - (c) damping torque
  - (d) restoring torque
30. The controlling torque in a spring controlled meter is proportional to
- (a)  $\theta$
  - (b)  $\theta^2$
  - (c)  $1/\theta$
  - (d)  $1/\theta^2$
31. At a steady deflected position of an indicating instrument, the moving system is subjected to
- (a) deflecting torque only
  - (b) deflecting and controlling torque
  - (c) deflecting, controlling and damping torque
  - (d) damping and controlling torque
32. An instrument gives maximum deflection for any amount of quantity passed through it. Which of following pair is present?
- (a) Deflecting and controlling force
  - (b) Deflecting and damping force
  - (c) Damping and controlling force
  - (d) Damping, controlling and deflecting force
33. Which of the following set of torques is provided in deflection galvanometer?
- (a) Deflecting and controlling
  - (b) Controlling and damping
  - (c) Deflecting and damping
  - (d) Deflecting, controlling and damping



34. A hair spring attached to the moving system is used
- damping torque
  - controlling torque
  - balancing torque
  - deflecting torque
35. The movement of the moving element of an electrical indicator is dependent on
- restoring torque
  - number of turns on the coil
  - resistance of the indicator circuit
  - all of these
36. Three force responsible for reduction of oscillations of the pointer in an ammeter is
- controlling force
  - damping force
  - deflecting force
  - none of these
37. If the damping torque is more than the critical damping, the instrument is called
- underdamped
  - overdamped
  - under critically damped
  - over critically damped
38. Air friction damping is used in the instrument which is
- moving iron
  - moving coil
  - induction
  - hot wire
39. The controlling torque in gravity controlled meter is proportional to
- $\cos \theta$
  - $\sin \theta$
  - $\tan \theta$
  - $\theta$
40. The purpose of providing a mirror behind the pointer in a measuring instrument is
- the scale is illuminated through mirror
  - with the help of mirror it can be seen whether the pointer is bend or not
  - The mirror is semi-transparent so as to allow the observation of the interior of the instrument
  - Reading errors due to inclined observations are eliminated by removing parallax between the pointer and its image in the mirror
41. The internal resistance of the milli-ammeter must be very low for
- high sensitivity
  - high accuracy
  - maximum voltage drop across the meter
  - minimum effect on the current in the circuit

42. Consider the following statements.

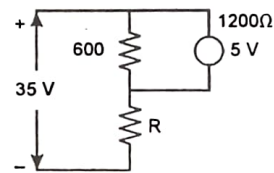
The causes of error in the measurement of temperature using a thermistor are

- selfheating
- poor sensitivity
- non-linear characteristics

Of these statements

- 1, 2 and 3 are correct
- 1 and 2 are correct
- 2 and 3 are correct
- 1 and 3 are correct

43. A 35V dc supply is connected across a combined resistance of 600 ohms and an unknown resistance of R ohms in series. A Voltmeter having a resistance of  $1.2 \mu \Omega$  is connected across 600 ohms resistor and reads 5V. The resistance R will be



- 120 ohms
- 500 ohms
- 1.7 K ohms
- 2.4 K ohms

44. The important characteristics of a frequency counter are given below:

- Time base accuracy
- Least significant bit count
- Gain of the input amplifier.

The more important characteristic(s) responsible for the overall accuracy of frequency measurement using the counter would include

- 1 and 2
- 2 and 3
- 1 and 3
- 2 alone

45. Which of the following will improve the mutual coupling between primary and secondary circuits?

- Transformer oil of high break down voltage
- High reluctance magnetic core
- Winding material of high resistivity
- Low reluctance magnetic core

46. In a dual beam oscilloscope

- there are two separate vertical input and two separate horizontal inputs
- there are two separate vertical inputs and there is only one set of horizontal deflection plates
- there is only one vertical input but there are two separate horizontal deflection plates
- there is only one vertical and one horizontal input

406. Galvanometer type recorders use

- vibration galvanometer
- ballistic galvanometer
- D'Arsonval galvanometer
- tangent galvanometer

407. In a telemetry system used for measuring inaccessible non-electrical quantity, the following sub-systems are used at the measuring end:

- Transmitter
- Transducer
- Amplifier
- Modulator

- 2, 3, 1, 4
- 2, 3, 4, 1
- 3, 2, 1, 4
- 3, 2, 4, 1

408. The power delivered to a three-phase load can be measured by the use of 2 wattmeter only when the

- load is balanced
- load is unbalanced
- 3-phase load is connected to the source through 3 wires
- 3-phase load is connected to the source through 4 wires

409. Which of the following are the features of a charge amplifier?

- Its output voltage is proportional to charge
- Its sensitivity is independent of the capacitance of the crystal and connecting cable
- Its signal to noise ratio tends to be small
- Its time constant is low

Select the correct answer using the codes given below:

**Codes:**

- 1, 2 and 3
- 2, 3 and 4
- 1, 3 and 4
- 1, 2 and 4

410. Match List-I (Measurements) with List-II (Transduction principles) and select the correct answer using the codes given below the lists:

**List-I**

- Rpm
- Temperature
- Static pressure
- Current

**List-II**

- Variable resistance
- Hall effect
- Piezoelectric effect
- Variable reluctance
- Variable capacitance

**Codes:**

- |     | A | B | C | D |
|-----|---|---|---|---|
| (a) | 4 | 1 | 5 | 2 |
| (b) | 1 | 4 | 5 | 2 |
| (c) | 2 | 1 | 3 | 5 |
| (d) | 4 | 1 | 2 | 3 |

411. Which of the following features determine the precision of an integrating type digital voltmeter?

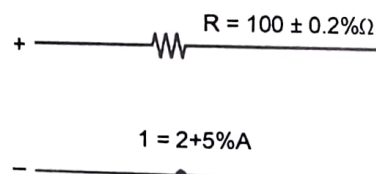
- Time constant of the integrator
- Input impedance of the integrator
- Reference voltage of the comparator
- Opening time of the gate before counter

Select the correct answer using the codes given below:

**Codes:**

- 1, 2 and 3
- 1, 2 and 4
- 1, 3 and 4
- 2, 3 and 4

412. In the circuit given in the figure, the limiting error in the power dissipation ' $I^2 R$ ' in the resistor R is



- 1.2%
- 5.2%
- 10.2%
- 25.2%

413. In a digital voltmeter, 'over-ranging' implies that

- the next four digits are switched on
- 1/2 digit is switched off
- 1/2 digit is switched on
- an over-range indicator starts glowing

414. Two voltmeters A and B are connected in series across dc line. A reads 100 volts and has a resistance 100 ohms/volt. B has a total resistance of 15,000 ohms. What is the line voltage?

- 220 V
- 400 V
- 250 V
- 230 V

415. The rotor of a synchro-transmitter

- uses a salient pole type of construction
- uses a cylindrical pole type of construction
- may use either salient pole or cylindrical type of construction
- none of these

416. It is found that 10A current passes through a resistor of 10 ohms value. The resistor has 5% tolerance. The error in measurement of current can be as high as 5%. What is the maximum error in measurement of power, calculated from the measured value of I and the nominal value of resistor?

- 100 W
- 150 W
- 50 W
- 200 W

417. Different damping systems are mentioned. Choose the best for PMMC meter.

- oil
- air
- eddy current
- electrodynamic



## EXERCISE – II

1. The deflection depends on the average value in
  - (a) Moving-iron meter
  - (b) Rectifier meter
  - (c) Hot-wire meter
  - (d) Moving-coil meter [NTPC]
2. Some wire-wound resistors have bifilar winding. This type of winding is used to
  - (a) increase the thermal stability
  - (b) reduce the tolerance
  - (c) reduce the inductance of winding
  - (d) double the power rating of the resistors [NTPC]
3. The practical unit of energy is kWh. The unit of energy in the SI is the joule. The number of joules in kWh is
  - (a) 3.6
  - (b)  $3.6 \times 10^6$
  - (c)  $3.6 \times 10^{-6}$
  - (d) none of these [BHEL]
4. The secondary winding of a current transformer is open when current is flowing in the primary. Then,
  - (a) there will be high current in primary
  - (b) there will be very high secondary voltage
  - (c) the transformer will burn out immediately
  - (d) the meter will burn out [NTPC]
5. Ionic wind voltmeter is used for measuring
  - (a) low voltage
  - (b) interwinding capacitance
  - (c) leakage inductance
  - (d) high voltage [BHEL]
6. Consider the following statements regarding an electromagnetic flowmeter;
  1. A.C. excitation is used to avoid polarisation of the fluid.
  2. The meter calibration is changed as the viscosity of the fluid changes.
  3. Stainless steel pipes can be used for measuring the flow of fluids of high conductivity.
 Of these statements,
  - (a) 1, 2 and 3 are correct
  - (b) 1 and 2 are correct
  - (c) 2 and 3 are correct
  - (d) 1 and 3 are correct [NTPC]
7. A Hall-effect transducer with Hall coefficient  $K_H = -1 \times 10^{-8}$  is required to measure a magnetic field of 10,000 gauss. A 2 mm bismuth slab is used as the transducer with a current of 3 A. The output voltage of the transducer will be
  - (a)  $-15 \times 10^{-6}$  V
  - (b)  $-7.5 \times 10^{-6}$  V
  - (c)  $-20 \times 10^{-6}$  V
  - (d)  $-22.5 \times 10^{-6}$  V [BHEL]
8. Schering bridge is used to
  - (a) determine dielectric loss
  - (b) determine the inductance
  - (c) measure low resistance
  - (d) measure mutual inductance [NTPC]
9. Which of the following instruments can be used for measurement of alternating current only?
  - (a) Permanent magnet type ammeter
  - (b) Induction type ammeter
  - (c) Moving-iron voltmeter
  - (d) Moving-iron ammeter [NTPC]
10. Electrodynamicometer can be used also to measure
  - (a) Time, frequency, flux
  - (b) Flux, power, voltage
  - (c) Power, power factor, reactive power
  - (d) Power, power factor, reactive power, frequency [BHEL]
11. A single pulse has a
  - (a) single frequency component
  - (b) continuous frequency spectrum
  - (c) spectrum of even harmonics
  - (d) spectrum of odd harmonics [BHEL]
12.  $V_{RN}$ ,  $V_{YN}$  and  $V_{BN}$  are the instantaneous line to neutral voltages and  $i_R$ ,  $i_Y$  and  $i_B$  are instantaneous line currents in a balanced three-phase circuit the computation
 
$$V_{RN}(i_Y - i_B) - (V_{YN} - V_{BN})i_R$$
 will yield a quantity proportional to
  - (a) active power
  - (b) power factor
  - (c) reactive power
  - (d) complex power [GATE]
13. A milliammeter can be used as
  - (a) voltmeter and ammeter
  - (b) wattmeter
  - (c) ohmmeter
  - (d) frequency meter [NTPC]

30. Among the measuring instruments for current and voltage the instrument that can be used as a secondary standard is  
 (a) Thermocouple (b) Electrodynamometer  
 (c) Moving iron (d) Electrostatic [NTPC]
31. The full-scale deflection current of an ammeter is 1 mA and its internal resistance is 100 ohms. If this meter is to have full deflection at 5 A, what is the value of the shunt resistance to be used?  
 (a) 49.99 ohms (b) 1/49.99 ohm  
 (c) 1 ohm (d) 2 ohms [BHEL]
32. In a moving-iron meter, the deflecting torque is proportional to  
 (a) square of the current through the coil  
 (b) current through the coil  
 (c) sine the measurand  
 (d) square-root of the measurand [BHEL]
33. An oscilloscope indicates  
 (a) peak to peak value of voltage  
 (b) d.c. value of voltage  
 (c) r.m.s value  
 (d) average value [BHEL]
34. The resistance of a 125 ohm strain gauge changes by one ohm for 4000 micro strain. The gauge factor of the strain gauge is  
 (a) 1.5 (b) 2.0  
 (c) 2.5 (d) 3 [BEL]
35. In a dynamometer, wattmeter used for polyphase measurement, the two power readings are equal and opposite,  
 (a) The load is reactive  
 (b) The load is resistive  
 (c) The load is inductive  
 (d) The load is capacitive [BEL]
36. When using ohmmeter, applied voltage is to be disconnected from the circuit because  
 (a) voltage source will increase resistance  
 (b) current will decrease resistance  
 (c) the ohmmeter has its own internal battery  
 (d) none of these [BEL]
37. When ac voltage is connected to a PMMC meter, then  
 (a) meter will get damaged  
 (b) reading is zero  
 (c) pointer will oscillate to and fro  
 (d) pointer will not move at all [NTPC]
38. The advantage of Hay's bridge over Maxwell's inductance-capacitance bridge is because  
 (a) its equations for balance do not contain any frequency term  
 (b) it can be used for measurement of inductance of high Q coils  
 (c) it can be used for measurement of inductance of low Q coils  
 (d) none of these [NTPC]
39. Sensitivity inaccuracy of a recording instrument means  
 (a) the amount of input required to produce unit pen deflection  
 (b) the smallest signal required to produce detectable output  
 (c) the maximum error in sensitivity displayed by a pen  
 (d) degree to which the instrument is not sensitive enough to repeat readings [PGCIL]
40. The value of resistance of an earthing electrode depends upon  
 (a) shape and material of electrode  
 (b) depth to which electrode is driven into earth  
 (c) specific resistance of soil  
 (d) all of these [PGCIL]
41. A Merz Price Maximum Demand Inducto Indicates  
 (a) maximum demand  
 (b) average maximum demand over a specified period of time  
 (c) maximum energy consumption  
 (d) all of these [PGCIL]
42. The power in a 3 phase four wire circuit can be measured by using  
 (a) 2 wattmeters (b) 4 wattmeters  
 (c) 3 wattmeters (d) 1 wattmeter [IOCL]
43. Thermocouple instruments can be used for a frequency range  
 (a) upto 100 Hz  
 (b) upto 5000 Hz  
 (c) upto 1 MHz  
 (d) 50 MHz and above [IOCL]
44. A metal strain gauge factor of two, its nominal resistance is 120 ohms. If it undergoes a strain of  $10^{-5}$ , the value of change of resistance in response to the strain is  
 (a) 240 ohms  
 (b)  $2 \times 10^{-5}$   
 (c)  $2.4 \times 10^{-3}$  ohms  
 (d)  $1.2 \times 10^{-3}$  ohms [GATE]

## EXPLANATIONS

## EXERCISE - I

1. Force = mass  $\times$  acceleration  
 $= MLT^{-2}$

2. Power =  $\frac{\text{Work}}{\text{Time}} = \frac{ML^2T^{-2}}{T}$   
 $= ML^2T^{-3}$

3. Torque = force  $\times$  distance  
 $= MLT^{-2} \times L$   
 $= ML^2T^{-2}$

9. We have charge,  $Q = IT$   
 emf,  $E = \frac{\text{Work done}}{\text{Charge}}$   
 $= ML^2T^{-3}I^{-1}$

Flux is given by,  $E = N \frac{d\phi}{dt}$   
 $\therefore [\phi] = ML^2T^{-3}I^{-1}$

Now, flux density,  $B = \frac{\text{Flux}}{\text{Area}} = [MT^{-2}I^{-1}]$

20. Error =  $100 \times \frac{1}{100}$   
 $= \pm 1V$

When measuring 2V,

Relative error =  $\pm \frac{1}{2} \times 100$   
 $= \pm 50\%$

21. Maximum static error =  $\pm \frac{0.25 \times 200}{100}$   
 $= \pm 0.5^\circ C$

24.  $P = I^2 R$   
 $\therefore \frac{dP}{P} = 2 \frac{dI}{I} + \frac{dR}{R}$   
 $= \left( 2 \times \frac{0.5}{100} + \frac{0.2}{100} \right) \times 100$   
 $\frac{dP}{P} = \pm 1.2\%$

And  $P = 4 \times 4 \times 100 = 1600W$

25.  $\theta = \theta_0 + (\theta_c - \theta_0) \exp(-t/\tau)$   
 $= 0 + (50 - 0) e^{-(0.6/1)}$   
 $= 27.4$

43. Equivalent resistance of 600 ohm and 1200 ohm  
 $= \frac{600 \times 1200}{1800} = 400 \text{ ohm}$

We have  $\frac{R}{35-5} = \frac{400}{5}$   
 $\Rightarrow R = 2400 \text{ ohms} = 2.4 \text{ k}\Omega$

48. Under balanced condition, we have

$$R_1 \left( R + \frac{1}{j\omega c} \right) = R_2 \frac{\frac{1}{j\omega c}}{R + \frac{1}{j\omega c}}$$

$$\Rightarrow \frac{R_1(j\omega c R + 1)}{j\omega c} = \frac{R_2 R}{j\omega c R + 1}$$

$$\Rightarrow R_1(-c^2 \omega^2 R^2 + 1 + j\omega c R) = jR_2 c \omega R$$

$$\therefore 2c\omega R R_1 = C\omega R R_2$$

$$\Rightarrow R_1 = \frac{R_2}{2}$$

and  $c^2 \omega^2 R^2 + 1 = 0$

$$\Rightarrow \omega = \frac{1}{Rc}$$

$$\therefore \phi = \frac{1}{2\pi R c}$$

49. Under balanced condition

$$R_1 R_4 = R_2 R_3$$

$$\therefore R_4 = \frac{R_2 R_3}{R_1}$$

$$= \frac{5 \times 100}{10} = 50\Omega$$

Relative limiting error in unknown resistance

$$\frac{dR_4}{R_4} = \pm \left( \frac{dR_2}{R_2} + \frac{dR_1}{R_1} + \frac{dR_3}{R_3} \right)$$

$$= \pm (3 + 5 + 1) = \pm 10\%$$

50. We have,

Gauge factor,  $G = \frac{\Delta R / R}{\text{Strain}}$

$$\therefore \text{Strain} = \frac{0.52}{110 \times 2.03} = 2.32 \times 10^{-3}$$

52. Here,  $i = 1 + 2 \sin \omega t$ ,

$$v = 2 + 3 \sin 2\omega t$$

$$P = Vi$$

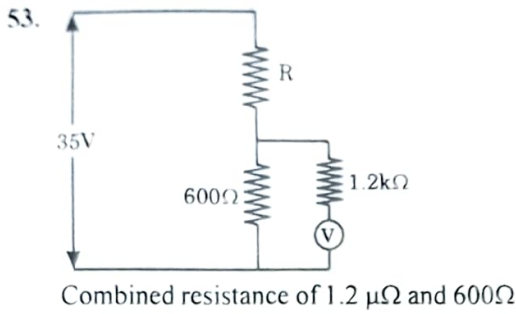
$$= (1 + 2 \sin \omega t)(2 + 3 \sin 2\omega t)$$

$$= 2 + 4 \sin \omega t + 3 \sin 2\omega t + 6 \sin \omega t \sin 2\omega t$$

Wattmeter gives average values of power, hence

$$P = 2W$$





$$= \frac{1200 \times 600}{1800} = 400 \Omega$$

Voltage across combined resistance = 5V

$\therefore$  Voltage across unknown resistance  
 $= 35 - 5 = 30 \text{ V}$

$\therefore$  Unknown resistance,

$$R = \frac{30}{5} \times 400 = 2.4 \text{ k}\Omega$$

54. We have,

$$\text{Power} = VI \cos \phi$$

$$\text{Now, Power} = \frac{\text{Work done}}{\text{Time}} = \frac{ML^2T^{-2}}{T} = ML^2T^{-3}$$

Hence dimension of  $VI \cos \phi = ML^2T^{-3}$

$$56. \quad F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$\therefore q = it$$

$$\therefore [Q] = [AT]$$

$$[F] = MLT^{-2}$$

$$[v] = L$$

$$\therefore [\epsilon] = \frac{A^2 T^2}{MLT^{-2} L^2} = M^{-1} L^{-3} T^{-4} A^2$$

58. To reconstruct original signal, minimum sampling frequency should be atleast twice the original signal frequency.

$\therefore$  Sampling frequency

$$= 2 \times 2 \times 10^6$$

$$= 4 \times 10^6 \text{ samples/s}$$

60. To avoid autoliassing and to limit band width of the analog signal to less than half sampling frequency in order to eliminate frequency folding.

$\therefore$  Cut-off frequency of the low pass filter should be

$$\text{less than } \frac{1000}{2} = 500 \text{ Hz}$$

$$62. \quad \frac{f_y}{f_x} = \frac{3f}{f} = 3 = \frac{\text{Number of vertical tangency}}{\text{Number of horizontal tangency}}$$

$$65. \text{ Rms value of current} = \sqrt{\frac{1}{T} \int_0^T I^2(t) dt}$$

$$= \left[ \frac{1}{T} \int_0^{T/2} \left( \frac{20}{T} t \right)^2 dt + \int_{T/2}^T \left( \frac{20t}{T} - 20 \right)^2 dt \right]^{1/2}$$

$$= \left[ \frac{400}{3} + \frac{400}{2} - 300 \right]^{1/2} = 5.77$$

66. At balance we have

$$\frac{z_1}{z_2} = \frac{z_3}{z_x}$$

$$\Rightarrow z_x = \frac{z_2 z_3}{z_1}$$

$$\Rightarrow z_x = \frac{R_2 R_3}{R_1} (R_1 C_1 j\omega + 1)$$

$$\Rightarrow R_x + j\omega L_x = \frac{R_2 R_3}{R_1} + j\omega R_2 R_3 C_1$$

$$\therefore L_x = R_2 R_3 C_1$$

74. To measure 100V, the voltmeter choosen should be such that its rated voltage should be equal to the voltage to be measured and this should have highest possible resistance.

$$77. \text{ Resolution} = \frac{9.999}{9999} = 1 \times 10^{-3} \text{ V} = 1 \text{ mV}$$

80. We have,  $r_{cc} = 0.01\Omega$

$$r_{vc} = 1000\Omega$$

We can connect current coil and voltage coil can be connected. The wattmeter reads high by an amount equal to power loss in current coil in one case and in voltage coil in the other. Hence power loss in two connections are

$$(a) I_c^2 r_{cc} = 20^2 \times 0.01 = 4 \text{ W}$$

$$(b) \frac{V^2}{r_{vc}} = \frac{30^2}{1000} = 0.9 \text{ W}$$

Percentage errors are

$$(i) \frac{4}{600} \times 100 = 0.66$$

$$(ii) \frac{0.9}{600} \times 100 = 0.15$$

$$84. \text{ Gauge factor} = \frac{\Delta R/R}{\Delta L/L}$$

$$\text{But we have } \frac{\Delta L}{L} = \frac{100}{2 \times 10^{-5}}$$

**ANSWERS****EXERCISE - I**

1. (b)	2. (d)	3. (a)	4. (d)	5. (a)	6. (d)	7. (a)	8. (b)	9. (d)	10. (a)
11. (b)	12. (a)	13. (b)	14. (b)	15. (a)	16. (a)	17. (a)	18. (b)	19. (b)	20. (c)
21. (b)	22. (b)	23. (a)	24. (c)	25. (a)	26. (a)	27. (b)	28. (d)	29. (a)	30. (c)
31. (b)	32. (c)	33. (b)	34. (b)	35. (d)	36. (c)	37. (a)	38. (d)	39. (a)	40. (a)
41. (d)	42. (b)	43. (d)	44. (d)	45. (b)	46. (a)	47. (b)	48. (c)	49. (c)	50. (c)
51. (b)	52. (b)	53. (c)	54. (d)	55. (d)	56. (c)	57. (a)	58. (b)	59. (d)	60. (b)
61. (c)	62. (d)	63. (a)	64. (b)	65. (b)	66. (a)	67. (d)	68. (b)	69. (d)	70. (b)
71. (d)	72. (b)	73. (a)	74. (c)	75. (b)	76. (c)	77. (c)	78. (c)	79. (d)	80. (d)
81. (d)	82. (d)	83. (c)	84. (b)	85. (d)	86. (d)	87. (c)	88. (b)	89. (c)	90. (a)
91. (a)	92. (b)	93. (d)	94. (c)	95. (c)	96. (a)	97. (d)	98. (d)	99. (b)	100. (c)
101. (b)	102. (d)	103. (d)	104. (d)	105. (c)	106. (b)	107. (c)	108. (c)	109. (a)	110. (a)
111. (b)	112. (b)	113. (b)	114. (b)	115. (d)	116. (c)	117. (c)	118. (c)	119. (b)	120. (a)
121. (d)	122. (a)	123. (c)	124. (a)	125. (a)	126. (a)	127. (b)	128. (b)	129. (b)	130. (a)
131. (b)	132. (d)	133. (c)	134. (a)	135. (c)	136. (a)	137. (a)	138. (d)	139. (d)	140. (a)
141. (a)	142. (d)	143. (c)	144. (d)	145. (d)	146. (d)	147. (d)	148. (c)	149. (b)	150. (c)
151. (c)	152. (a)	153. (b)	154. (c)	155. (a)	156. (b)	157. (b)	158. (d)	159. (d)	160. (a)
161. (d)	162. (d)	163. (c)	164. (c)	165. (d)	166. (a)	167. (a)	168. (c)	169. (b)	170. (a)
171. (c)	172. (c)	173. (a)	174. (b)	175. (c)	176. (a)	177. (c)	178. (c)	179. (a)	180. (c)
181. (c)	182. (a)	183. (c)	184. (c)	185. (d)	186. (b)	187. (a)	188. (a)	189. (d)	190. (d)
191. (d)	192. (c)	193. (b)	194. (c)	195. (b)	196. (c)	197. (a)	198. (c)	199. (d)	200. (a)
201. (d)	202. (a)	203. (b)	204. (c)	205. (c)	206. (c)	207. (b)	208. (b)	209. (d)	210. (d)
211. (c)	212. (b)	213. (a)	214. (a)	215. (c)	216. (a)	217. (c)	218. (d)	219. (b)	220. (b)
221. (d)	222. (c)	223. (d)	224. (a)	225. (c)	226. (a)	227. (d)	228. (d)	229. (a)	230. (b)
231. (d)	232. (a)	233. (b)	234. (c)	235. (b)					

**EXERCISE - II**

1. (c)	2. (d)	3. (b)	4. (b)	5. (c)	6. (b)	7. (b)	8. (b)	9. (c)	10. (a)
11. (d)	12. (c)	13. (c)	14. (a)	15. (a)	16. (c)	17. (c)	18. (d)	19. (b)	20. (c)
21. (c)	22. (b)	23. (d)	24. (b)	25. (d)	26. (d)	27. (c)	28. (a)	29. (c)	30. (b)
31. (a)	32. (c)	33. (a)	34. (d)	35. (a)	36. (c)	37. (c)	38. (c)	39. (b)	40. (c)
41. (a)	42. (b)	43. (d)	44. (a)	45. (c)	46. (b)	47. (a)	48. (d)	49. (a)	50. (d)
51. (c)	52. (d)	53. (d)	54. (b)	55. (c)	56. (b)	57. (a)	58. (b)	59. (b)	60. (a)
61. (c)	62. (a)	63. (a)	64. (a)	65. (c)	66. (b)	67. (a)	68. (c)	69. (b)	70. (a)
71. (a)	72. (a)	73. (b)	74. (d)	75. (c)	76. (c)	77. (a)	78. (b)	79. (c)	80. (a)
81. (a)	82. (b)	83. (a)	84. (c)	85. (b)	86. (d)	87. (c)	88. (a)	89. (d)	90. (a)
91. (d)	92. (a)	93. (c)	94. (a)	95. (b)	96. (b)	97. (a)	98. (b)	99. (b)	100. (b)
101. (b)	102. (a)	103. (b)	104. (b)	105. (b)	106. (d)	107. (c)	108. (c)	109. (a)	110. (a)
111. (a)	112. (a)	113. (b)	114. (a)	115. (a)	116. (d)	117. (b)	118. (c)	119. (c)	120. (d)
121. (d)	122. (c)	123. (d)	124. (a)	125. (c)	126. (a)	127. (c)	128. (b)	129. (b)	130. (c)
131. (d)	132. (a)	133. (b)	134. (c)	135. (a)	136. (b)	137. (c)	138. (b)	139. (c)	140. (b)
141. (d)	142. (b)	143. (d)	144. (d)	145. (d)	146. (a)	147. (d)	148. (d)	149. (c)	150. (a)
151. (b)	152. (b)	153. (d)	154. (a)	155. (d)	156. (d)	157. (a)	158. (a)	159. (b)	160. (b)
161. (d)	162. (b)	163. (b)	164. (a)	165. (c)	166. (c)	167. (a)	168. (c)	169. (a)	170. (b)
171. (a)	172. (d)	173. (c)	174. (c)	175. (a)	176. (a)	177. (d)	178. (d)	179. (d)	180. (d)
181. (a)	182. (c)	183. (c)	184. (b)	185. (d)	186. (d)	187. (c)	188. (b)	189. (a)	190. (a)
191. (a)	192. (d)	193. (d)	194. (d)	195. (a)	196. (b)	197. (c)	198. (c)	199. (a)	200. (a)
201. (b)	202. (c)	203. (d)	204. (a)	205. (d)	206. (a)	207. (a)	208. (a)	209. (c)	210. (c)
211. (a)	212. (b)	213. (c)	214. (a)	215. (c)	216. (c)	217. (a)	218. (a)	219. (b)	220. (c)
221. (c)	222. (d)	223. (b)	224. (a)	225. (a)					