ESE 2021

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

Electrical Engineering

Topicwise **Objective** Solved Questions

Volume-I

Topicwise Presentation   *Thoroughly Revised and Updated*

Also useful for State Engineering Services Examinations, Public Sector Examinations

& Other Competitive Examinations

ESE-2021 : Preliminary Examination
Electrical Engineering : Volume-1 | Topicwise Objective Solved Questions : (2001-2020)

Director's Message

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a carrier option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

B. Singh (Ex. IES)

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power".* To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Electrical Engineering

Volume-I

Objective Solved Questions
of UPSC Engineering Services Examination

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UNIT

III

Electrical & Electronic Measurements

Syllabus

Principles of measurement, accuracy, precision and standards; Bridges and potentiometers; moving coil, moving iron, dynamometer and induction type instruments, measurement of voltage, current, power, energy and power factor, instrument transformers, digital voltmeters and multi-meters, phase, time and frequency measurement, Q-meters, oscilloscopes, potentiometric recorders, error analysis, Basics of sensors, Transducers, basics of data acquisition systems.

Contents

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1 Characteristics of Instruments and Measurement Systems

1.1 Match **List-I** with **List-II** and select the correct answer:

List-I
- **A.** Precision
- **B.** Accuracy
- **C.** Resolution
- **D.** Static

List-II
1. The smallest change in the input quantity which can be detected with its certainty
2. Closeness of the reading with its true value
3. Measure of reproductibility of the measurements
4. Ratio of infinitesimal change sensitivity in output to infinitesimal change in input

Codes:

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

[ESE-2001]

1.2 Match **List-I** (Error parameters) with **List-II** (Values) and select the correct answer : (σ is the standard deviation of Gaussian error):

List-I	List-II
A. Precision index	1. $0.67\,\sigma$
B. Probable error	2. 3σ
C. Error limit	3. $0.39/\sigma$
D. Peak probability density of error	4. $0.71/\sigma$

Codes:

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

[ESE-2001]

1.3 Which of the following are the characteristics of a thermocouple type of indicating instrument?
1. Its accuracy is very high, as high as about 1 percent.
2. It has linear scale because a d'Arsonval movement is used for measuring the output.
3. It is an RF instrument and can be used for frequency up to about 50 MHz.
4. It cannot be damaged by overloads.

(a) 1 and 2   (b) 2 and 3
(c) 3 and 4   (d) 1 and 3

[ESE-2001]

1.4 An ac voltmeter using full-wave rectification and having a sinusoidal input has an ac sensitivity equal to
(a) 1.414 times dc sensitivity
(b) dc sensitivity
(c) 0.90 times dc sensitivity
(d) 0.707 times dc sensitivity

[ESE-2001]

1.5 Consider the following statements about the D'Arsonval Movement :
1. It is best suited for d.c. current measurement.
2. It responds to the average value of current.
3. It measures the r.m.s. value of a.c. currents.
4. It could be used for power measurements.

Which of these statements is/are correct?
(a) Only 1   (b) 1 and 2
(c) 2 and 3   (d) 1, 2 3 and 4

[ESE-2002]

1.6 Two meters X and Y require 40 mA and 50 mA, respectively, to give full-scale deflection, then
(a) sensitivity can not be judged with given information.
(b) both are equally sensitive.
(c) X is more sensitive.
(d) Y is more sensitive.

[ESE-2002]

1.7 What is the correct sequence of the following types of ammeters and voltmeters with increasing accuracy?
1.   Moving iron
2.   Moving-coil permanent magnet
3.   Induction

Select the correct answer using the codes given below:
(a) 1, 3, 2   (b) 1, 2, 3
(c) 3, 1, 2   (d) 2, 1, 3

[ESE-2002]

1.8 The total current $I = I_1 + I_2$ in a circuit is measured as $I_1 = 150 \pm 1$ A, $I_2 = 250 \pm 2$ A, where the limits of error are given as standard deviations. I is measured as
(a) (400 ± 3) A   (b) (400 ± 2.24) A
(c) $(400 \pm 1/5)$ A   (d) (400 ± 1) A

[ESE-2002]

1.9 Torque/Weight ratio of an instrument indicates
(a) Selectivity   (b) Accuracy
(c) Fidelity   (d) Sensitivity

[ESE-2003]

1.10 A first order instrument is characterized by
(a) Time constant only
(b) Static sensitivity and time constant
(c) Static sensitivity and damping coefficient
(d) Static sensitivity, damping coefficient and natural frequency of oscillations

[ESE-2003]

1.11 Decibel scale is useful while measuring voltages covering
(a) Wide frequency ratio
(b) Wide voltage ratio
(c) Narrow frequency range
(d) Narrow voltage range

[ESE-2003]

1.12 For time and frequency, the working standard is
(a) Microwave oscillator
(b) Crystal controlled oscillator
(c) Laser
(d) ARF oscillator

[ESE-2003]

1.13 The difference between the indicated value and the true value of a quantity is

(a) Gross error   (b) Absolute error
(c) Dynamic error   (d) Relative error

[ESE-2003]

1.14 Integrating principle in the digital measurement is the conversion of
(a) Voltage to time
(b) Voltage to frequency
(c) Voltage to current
(d) Current to voltage   [ESE-2003]

1.15 Match **List-I** (Accuracy) with **List-II** (Type of the standard) and select the correct answer:

List-I	List-II
A. Least accurate	1. Primary
B. More accurate	2. Secondary
C. Much more accurate	3. Working
D. Highest possible accurate	4. International

Codes:

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

[ESE-2004]

1.16 Which one of the following statements is correct? The application of the instrument in wrong manner in the procedure of measurement results in a/an
(a) systematic error   (b) random error
(c) gross error   (d) instrument error

[ESE-2004]

1.17 Which one of the following statements correctly represents the systematic errors?
(a) These errors can be calculated from the details of the instruments.
(b) These are the residual errors.
(c) These errors may occur under controlled conditions.
(d) These are the errors committed by the experiments.

[ESE-2004]

1.18 Which one of the following is basically a current sensitive instrument ?
(a) Permanent magnet moving coil instrument
(b) Cathode ray oscilloscope
(c) Electrostatic instrument
(d) FET input electronic voltmeter

[ESE-2004]

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

                        [ESE-2006]

1.27 A rectifier instrument is used to measure an alternating square wave of amplitude 100 V. What is the meter reading?

(a) 100 V   (b) 70.7 V

(c) 111 V   (d) None of these

                        [ESE-2006]

1.28 When reading is taken at half scale in the instrument, the error is

(a) exactly equal to half of full-scale error

(b) equal to full-scale error

(c) less than full-scale error

(d) more than full-scale error

                        [ESE-2006]

1.29 Match **List-I** (Instrument) with **List-II** (Error) and select the correct answer using the code given below the lists:

    List-I

A. PMMC voltmeter

B. AC ammeter

C. Current transformer

D. Energy meter

    List-II

1. Eddy current error

2. Phase angle error

3. Braking system error

4. Temperature error

Codes:

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

                        [ESE-2006]

1.30 For defining the standard meter, wavelength of which material is considered?

(a) Neon   (b) Krypton

(c) Helium   (d) Xenon

                        [ESE-2006]

1.31 **Assertion (A):** The precision instruments are always accurate.

Reason (R): Precision indicates the degree of agreement within a set of measurements of the same quantity by the instrument, and accuracy refers to the degree of closeness to the true value of the quantity to be measured.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

                        [ESE-2007]

1.32 Match **List-I** (Name of Instrument) with **List-II** (Classification) and select the correct answer using the code given below the lists:

List I		List II
A. Ohmmeter	**1.**	Absolute
B. Watt hour meter	**2.**	Indicating
C. Null balance	**3.**	Recording recorders
D. Rayleigh current	**4.**	Integrating balance

Codes:

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

                        [ESE-2007]

1.33 Match **List-I** (Property) with **List-II** (Type of the Instrument) and select the correct answer using the code given below the lists:

    List-I

A. Linear scale

B. True r.m.s. up to RF range

C. r.m.s. only for sinusoidal input

D. Reads r.m.s. value using square law scale

    List-II

1. Thermocouple type

2. Rectifier type

3. Moving iron type

4. Permanent magnet moving coil type

Codes:

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

                        [ESE-2007]

1.34 **Assertion (A):** A precision instrument is always accurate.

Reason (R): A precision instrument is one where the degree of reproducibility of the measurements is very good.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true   [ESE-2008]

1.35 What is the prefix tera equivalent to?

(a) 10^3 (b) 10^6
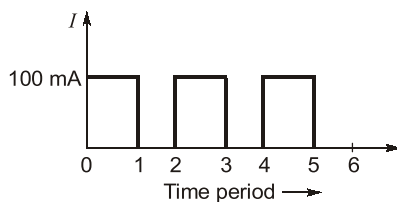
(c) 10^9 (d) 10^{12}

[ESE-2008]

1.36 The errors introduced by an instrument fall in which category?

(a) Systematic errors

(b) Random errors

(c) Gross errors

(d) Environmental errors   [ESE-2008]

1.37 A waveform shown in the figure below, is fed to a a.c. ammeter. What is the reading shown by the meter?

(a) zero   (b) 50 mA

(c) 75 mA   (d) 100 mA

[ESE-2008]

1.38 The instrumentation amplifiers are used principally to amplify signals from which of the following?

(a) Transducers   (b) Active filters

(c) Choppers   (d) D/A converters

[ESE-2008]

1.39 A 0 to 300 V voltmeter has an error of ± 2% of fsd. What is the range of readings if true voltage is 30 V?

(a) 24 V – 36 V   (b) 20 V – 40 V

(c) 29.4 V – 30.6 V (d) 20 V – 30 V

[ESE-2009]

1.40 Consider the following:

1.   Human errors

2.   Improper application of instruments

3.   Error due to worn parts of an instrument

4.   Errors due to effects of environment

Which of the above come under the type of systematic errors?

(a) 1 and 2   (b) 2 and 3

(c) 3 and 4   (d) 1 and 4

[ESE-2009]

1.41 **Assertion (A):** Random errors can be minimized by statistical methods.

Reason (R): These are caused by arithmetic error while taking readings.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2009]

1.42 Match **List-I** (Type of Instrument) with **List-II** (Example) and select the correct answer using the code given below the lists:

List-I	List-II
A. Indicating	1. Wattmeter
B. Absolute	2. Tangent galvanometer
C. Recording	3. Aneroid barometer
D. Integrating	4. Energy meter

Codes:

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

[ESE-2009]

1.43 Match **List-I (Meter)** with **List-II (Type)** and answer using the select the correct code given below the lists:

List-I	List-II
A. Reed frequency meter	1. Moving iron
B. Weston frequency meter	2. Vibrating
C. Weston Synchroscope	3. Moving coil
D. Ohm meter	4. Electro-dynamic

1.53 Match **List-I** (Excitation) with **List-II** (Two-port parameters) and select the correct answer using the code given below the lists:

List-I
A. Moving iron and hot wire type
B. Galvanometer
C. PMMC type
D. Electrostatic type

List-II
1. Air friction
2. Electromagnetic
3. Fluid friction
4. Eddy current

Codes:

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

[ESE-2011]

1.54 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I
A. Average value of current
B. Frequency of a waveform
C. Strain-gauge resistance

List-II
1. Self-balancing bridge
2. Wein's bridge
3. PMMC ammeter

Codes:

	A	B	C
(a)	2	1	3
(b)	3	1	2
(c)	1	2	3
(d)	3	2	1

[ESE-2011]

1.55 Assertion (A): It is always desirable to take measurements as close to the full-scale as possible.

Reason (R): The magnitude of the limiting error is a fixed quantity based on the full-scale reading of the meter and error increases as reading decreases.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE-2011]

1.56 A 0-100 V voltmeter has an accuracy of 1 percent at full-scale reading. What will be the error if it reads 50 V?

(a) 1 percent   (b) 2 percent
(c) 0.5 percent   (d) 4 percent

[ESE-2011]

1.57 If a high frequency AC signal, whose rms value is $\sqrt{2}$ V, is applied to a PMMC instrument, then the reading of the instrument will be

(a) 2 V   (b) $\sqrt{2}$ V
(c) 1 V   (d) zero

[ESE-2012]

1.58 The following is not essential for the working of an indicating instrument

(a) deflecting torque   (b) braking torque
(c) damping torque   (d) controlling torques

[ESE-2012]

1.59 Systematic error of an instrument for measurement can be minimized by

(a) selecting a proper measuring device for the particular application.

(b) calibrating the measuring device against a standard device.

(c) applying correction factors for change of ambient conditions.

(d) carrying out all of the above.

[ESE-2012]

1.60 Two resistances $R_1 = 100 \pm 10\%$ Ω and $R_2 = 300 \pm 5\%$ Ω are connected in series. The resulting limiting error of the series combination is

(a) 5 Ω   (b) 15 Ω
(c) 25 Ω   (d) 30 Ω

[ESE-2012]

1.61 Statement (I): A hot-wire instrument gives the rms value of the current measured.

Statement (II): The heat generated is dependent on the average value of the current.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).

(c) Statement (I) is true but Statement (II) is false.

(d) Statement (I) is false but Statement (II) is true.

[ESE-2012]

1.62 Consider the following statements:

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

1. Self heating
2. Poor sensitivity
3. Non-linear characteristics

Which of these statements are correct?

(a) 1, 2 and 3   (b) 1 and 2 only

(c) 2 and 3 only   (d) 1 and 3 only

[ESE-2013]

1.63 Five observers have taken a set of independent voltage measurements and recorded as 110.10 V, 110.20 V, 110.15 V, 110.30 V and 110.25 V. Under the situation mentioned above, the range of error is

(a) ±0.3   (b) ±0.1

(c) ±0.2   (d) ±1.0   [ESE-2013]

1.64 The technique used to check quantitatively whether the given data distribution is close to Gaussian distribution is

(a) curve fitting

(b) method of least squares

(c) Chi-square test

(d) standard deviation of mean   [ESE-2013]

1.65 The unknown resistance R_4 measured in a Wheatstone bridge by the formula $R_4 = \dfrac{(R_2 R_3)}{R_1}$

with

$R_1 = 100 \pm 0.5\% \ \Omega$,

$R_2 = 1000 \pm 0.5\% \ \Omega$,

$R_3 = 842 \pm 0.5\% \ \Omega$

resulting in R_4

(a) $8420 \pm 0.5\% \ \Omega$ (b) $8420 \pm 1.0\% \ \Omega$

(c) $8420 \pm 1.5\% \ \Omega$ (d) $8420 \pm 0.125\% \ \Omega$

[ESE-2013]

1.66 A current $i = 5 + 14.14 \sin(314t + 45°)$ is passed through a centre-zero PMMC, hot-wire, and moving iron instrument, the respective readings are

(a) $-5, 15$ and $\sqrt{125}$

(b) $5, \sqrt{125}$ and $\sqrt{125}$

(c) $-5, \sqrt{125}$ and 19.14

(d) 5, 10 and 10   [ESE-2013]

1.67 A frequency counter needs to measure a frequency of 15 Hz. Its signal geting time is 2s. What is the percentage accuracy of the counter, taking into account the gating error?

(a) 3.33%   (b) 13.33%

(c) 98.67%   (d) 96.67%

[ESE-2013]

1.68 Which of the following instrument will be used to measure a small current of very high frequency?

(a) Electrodynamic ammeter

(b) Moving coil galvanometer

(c) Thermocouple type instrument

(d) Induction type instrument

[ESE-2013]

1.69 **Statement (I):** For random error with normal distribution, probable error = $\pm 0.6745 \ \sigma$, where σ is the standard deviation.

Statement (II): Probable error ξ_ρ is that error value where there is a 50% chance that any observation has a random error no greater than $\pm \xi_\rho$.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).

(c) Statement (I) is true but Statement (II) is false.

(d) Statement (I) is false but Statement (II) is true.

[ESE-2013]

1.70 What is the number of turns of wire needed to provide a potentiometer with a resolution of 0.05 percent?

(a) 200 turns   (b) 2000 turns

(c) 20 turns   (d) 20000 turns

[ESE-2014]

Answers	Characteristics of Instruments and Measurement Systems

1.1	(c)	1.2	(b)	1.3	(d)	1.4	(c)	1.5	(b)	1.6	(c)	1.7	(c)	1.8	(b)	1.9	(d)
1.10	(b)	1.11	(a)	1.12	(b)	1.13	(b)	1.14	(b)	1.15	(c)	1.16	(d)	1.17	(a)	1.18	(a)
1.19	(c)	1.20	(c)	1.21	(a)	1.22	(a)	1.23	(c)	1.24	(b)	1.25	(d)	1.26	(a)	1.27	(a)
1.28	(d)	1.29	(b)	1.30	(b)	1.31	(d)	1.32	(b)	1.33	(b)	1.34	(d)	1.35	(d)	1.36	(a)
1.37	(c)	1.38	(a)	1.39	(a)	1.40	(b and c)			1.41	(c)	1.42	(a)	1.43	(a)	1.44	(c)
1.45	(d)	1.46	(a)	1.47	(c)	1.48	(b)	1.49	(a)	1.50	(c)	1.51	(c)	1.52	(a)	1.53	(c)
1.54	(d)	1.55	(a)	1.56	(b)	1.57	(d)	1.58	(b)	1.59	(d)	1.60	(c)	1.61	(c)	1.62	(d)
1.63	(b)	1.64	(d)	1.65	(c)	1.66	(b)	1.67	(d)	1.68	(c)	1.69	(a)	1.70	(b)	1.71	(d)
1.72	(b)	1.73	(d)	1.74	(c)	1.75	(c)										

Explanations	Characteristics of Instruments and Measurement Systems

1.3 (d)
- Thermo-couple instrument has a "square-law response" so it does not have a linear scale.
- Their accuracy can be as high as 1% for frequencies upto 50 MHz and can be classified as RF instruments. Above this frequency the effective resistance of heater wire is increased on account of skin effect, thereby reducing the accuracy. Tubular designs are used for heater wire above 3 A to reduce errors on account of skin effect produced by high frequencies. For small currents upto 3 A, the heater wire is solid and very thin.
- At normal rated current, the heater attains a tempeature of 300° C. If we pass twice the rated current, the heater would give a temperature of nearly 4 times the normal temperature i.e., 1200° C. It is obvious that square law rate will bring the heater to nearly its burn out temperature. Thus it is imperative that the heater be protected against damaging over loads. The fuses do not provide any protection as due to overload the heater wire may burn out before fuse blows out. Thus the overload capacity of thermo-couple instruments is small as compared with other instruments and is about 150 percent of the full scale current.

1.4 (c)
For full-wave rectifier type of instruments
$V_{avg} = 0.9$ V where $V = V_m/\sqrt{2}$.

1.5 (b)
D'Arsonval ammeter is PMMC Ammeter which measures average value.

1.6 (c)
$$S = \frac{\theta}{I_{FS}}$$

1.7 (c)
Induction principle is more generally used for watt-hour meters than for ammeters and voltmeters owing to their comparatively high cost, and inaccuracy of induction instruments of the later types and PMMC is most accurate.

1.8 (b)
$$\sigma_I = \sqrt{\left(\frac{\partial I}{\partial I_1}\right)^2 \sigma_{I_1}^2 + \left(\frac{\partial I}{\partial I_2}\right)^2 \sigma_{I_2}^2}$$

$$\frac{\partial I}{\partial I_1} = \frac{\partial I}{\partial I_2} = 1$$

∴ $\sigma_I = \sqrt{(1)^2(1)^2 + (1)^2(2)^2}$
   = 2.24 A

∴ $I = (400 \pm 2.24)$ A