SSC-JE

Staff Selection Commission

Junior Engineer

Electrical Engineering

Topicwise Objective Solved Questions

Previous Years Solved Papers : 2007-2023

Also useful for ***RRB-JE Mains*** *as well as various* **public sector examinations** and other competitive examinations

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Preface

B. Singh (Ex. IES)

Staff Selection Commission-Junior Engineer has always been preferred by Engineers due to job stability. SSC-Junior Engineer examination is conducted every year. MADE EASY team has deeply analyzed the previous exam papers and observed that a good percentage of questions are repetitive in nature, therefore it is advisable to solve previous years papers before a candidate takes the exam.

The SSC JE exam is conducted in two stages as shown in table given below.

Papers	Subject	Maximum Marks	Duration
Stage 1: Paper-I : Objective type	(i) General Intelligence & Reasoning (ii) General Awareness (iii) General Engineering : Electrical	50 Marks 50 Marks 100 Marks	2 hours
Stage 2: Paper-II : Objective Type	General Engineering : Electrical	300 Marks	2 hours
Note: In Paper-I, every question carry one mark and there is negative marking of ¼ marks for every wrong answer. Candidates shortlisted in Stage 1 are called for Stage 2. On the basis of combined score in Stage 1 and Stage 2, final merit list gets prepared.			

MADE EASY has taken due care to provide complete solution with accuracy. Apart from Staff Selection Commission-Junior Engineer, this book is also useful for Public Sector Examinations and other competitive examinations for engineering graduates.

I have true desire to serve student community by providing good source of study and quality guidance. Any suggestion from the readers for improvement of this book is most welcome.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

Syllabus of Engineering Subjects

(For both Objective and Conventional Type Papers)

Electrical Engineering

Basic concepts: Concepts of resistance, inductance, capacitance, and various factors affecting them. Concepts of current, voltage, power, energy and their units.

Circuit law: Kirchhoff's law, Simple Circuit solution using network theorems.

Magnetic Circuit: Concepts of flux, mmf, reluctance, Different kinds of magnetic materials, Magnetic calculations for conductors of different configuration e.g. straight, circular, solenoidal, etc. Electromagnetic induction, self and mutual induction.

AC Fundamentals: Instantaneous, peak, R.M.S. and average values of alternating waves, Representation of sinusoidal wave form, simple series and parallel AC Circuits consisting of R, L and C, Resonance, Tank Circuit. Poly Phase system – star and delta connection, 3-phase power, DC and sinusoidal response of R-Land R-C circuit.

Measurement and Measuring Instruments: Measurement of power (1 phase and 3-phase, both active and re-active) and energy, 2 wattmeter method of 3-phase power measurement. Measurement of frequency and phase angle. Ammeter and voltmeter (both moving oil and moving iron type), extension of range wattmeter, Multimeters, Megger, Energy meter AC Bridges. Use of CRO, Signal Generator, CT, PT and their uses. Earth fault detection.

Electrical Machines: (a) D.C. Machine – Construction, Basic Principles of D.C. motors and generators, their characteristics, speed control and starting of D.C. Motors. Method of braking motor, Losses and efficiency of D.C. Machines. (b) 1 phase and 3 phase transformers – Construction, Principles of operation, equivalent circuit, voltage regulation, O.C. and S.C. Tests, Losses and efficiency. Effect of voltage, frequency and wave form on losses. Parallel operation of 1 phase /3 phase transformers. Auto transformers. (c) 3 phase induction motors, rotating magnetic field, principle of operation, equivalent circuit, torque-speed characteristics, starting and speed control of 3 phase induction motors. Methods of braking, effect of voltage and frequency variation on torque speed characteristics. Fractional Kilowatt Motors and Single Phase Induction Motors: Characteristics and applications.

Synchronous Machines: Generation of 3-phase e.m.f. armature reaction, voltage regulation, parallel operation of two alternators, synchronizing, control of active and reactive power. Starting and applications of synchronous motors.

Generation, Transmission and Distribution: Different types of power stations, Load factor, diversity factor, demand factor, cost of generation, inter-connection of power stations. Power factor improvement, various types of tariffs, types of faults, short circuit current for symmetrical faults. Switchgears – rating of circuit breakers, Principles of arc extinction by oil and air, H.R.C. Fuses, Protection against earth leakage/over current, etc. Buchholtz relay, Merz-Price system of protection of generators & transformers, protection of feeders and bus bars. Lightning arresters, various transmission and distribution system, comparison of conductor materials, efficiency of different system. Cable – Different type of cables, cable rating and derating factor.

Estimation and Costing: Estimation of lighting scheme, electric installation of machines and relevant IE rules. Earthing practices and IE Rules.

Utilization of Electrical Energy: Illumination, Electric heating, Electric welding, Electroplating, Electric drives and motors.

Basic Electronics: Working of various electronic devices e.g. P N Junction diodes, Transistors (NPN and PNP type), BJT and JFET. Simple circuits using these devices.

■■■■

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SSC-JE

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CHAPTER 1

Paper - I : Objective

Electric Circuits and Magnetic Circuits

1. Basics

1.1 A circuit component that opposes the change in circuit voltage is
(a) resistance (b) capacitance
(c) inductance (d) all the above
[SSC-JE : 2008]

1.2 Two heaters rated at 1000 W, 250 V each are connected in series across a 250 V, 50 Hz AC mains. The total power drawn from the supply would be
(a) 1000 watts (b) 500 watts
(c) 250 watts (d) 2000 watts
[SSC-JE : 2008]

1.3 Specific resistance of a conductor depends upon
(a) dimension of the conductor
(b) composition of conductor material
(c) resistance of the conductor
(d) both (a) and (b)
[SSC-JE : 2009]

1.4 A wire has a resistance 10 Ω. It is stretched by one-tenth of the original length. Then its resistance will be
(a) 10 Ω (b) 12.1 Ω
(c) 9 Ω (d) 11 Ω
[SSC-JE : 2010]

1.5 The ratio of resistances of a 100 W, 220 V lamp to that of a 100 W, 110 V lamp will be equal to
(a) 4 (b) 2
(c) $\frac{1}{2}$ (d) $\frac{1}{4}$
[SSC-JE : 2010]

1.6 If four 10 μF capacitors are connected in parallel the net capacitance is
(a) 2.5 μF (b) 40 μF
(c) 20 μF (d) 115 μF
[SSC-JE : 2010]

1.7 Three resistances 5 Ω each are connected in star. Values of equivalent delta resistances are
(a) 1.5 Ω each (b) 2.5 Ω each
(c) 5/3 Ω each (d) 15 Ω each
[SSC-JE : 2012]

1.8 Match the items given in **List-I** and those in **List-II (Temperature coefficient of Resistance)**. Select your answer using codes given in the lists:

List-I	List-II
(a) Aluminium	P. Negligibly small
(b) Manganin	Q. Positive
(c) Carbon	R. Negative

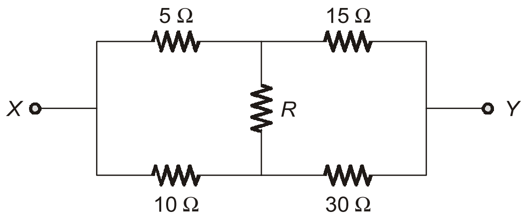
(a) $a \to R$, $b \to Q$, $c \to P$
(b) $a \to Q$, $b \to P$, $c \to R$
(c) $a \to P$, $b \to Q$, $c \to R$
(d) $a \to R$, $b \to P$, $c \to Q$
[SSC-JE : 2012]

1.9 The resistance of insulation, in general, _____ with temperature rise.
(a) decreases (b) increases rapidly
(c) increases slowly (d) does not change
[SSC-JE : 2012]

1.10 Which of the following materials possesses the least resistivity?
(a) Iron (b) Manganin
(c) Aluminium (d) Copper
[SSC-JE : 2012]

1.11 The wires *A* and *B* of the same material but of different lengths *L* and 2*L* have the radius *r* and 2*r* respectively. The ratio of specific resistance will be
(a) 1 : 4 (b) 1 : 8
(c) 1 : 1 (d) 1 : 2
[SSC-JE : 2012]

1.12 The equivalent resistance between terminals X and Y of the network shown is



(a) 8 Ω (b) $\frac{100}{3}\Omega$

(c) $\frac{40}{3}\Omega$ (d) $\frac{20}{9}\Omega$

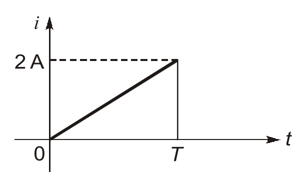
[SSC-JE : 2012]

1.13 A 10 μF and a 20 μF capacitor are in series. The combination is supplied at 150 V from a sinusoidal voltage source. The voltage across the 20 μF capacitor is then

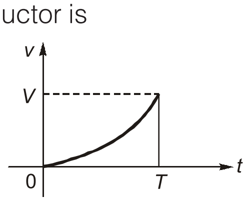
(a) 75 V (b) 125 V
(c) 100 V (d) 50 V

[SSC-JE : 2012]

1.14 The wave shape of current flowing through an inductor is



The wave shape of voltage drop (v) across the inductor is

(a)


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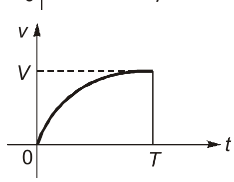

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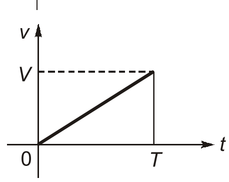
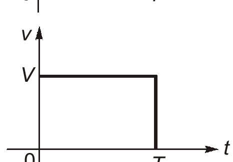


(d)


[SSC-JE : 2012]

1.15 A 20 micro farad capacitor is connected across an ideal voltage source. The current in the capacitor

(a) will be very high at first, then exponentially decay and at steady state will become zero.
(b) none of these are true.
(c) will be zero at first, then exponentially rise.
(d) will be very high at first, then exponentially decay.

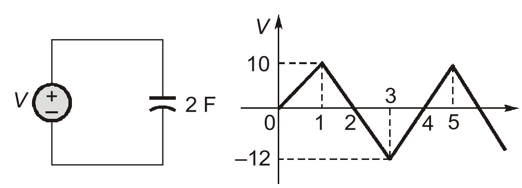
[SSC-JE : 2012]

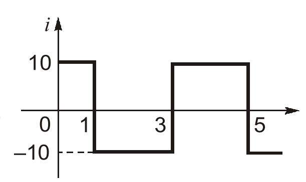
1.16 Three 3 μF capacitor are in series. A 6 μF capacitor is in parallel with this series arrangement. The equivalent capacitance of this combination is

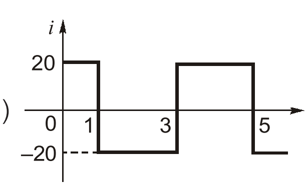
(a) 7 μF (b) 15 μF
(c) 3.6 μF (d) 1 μF

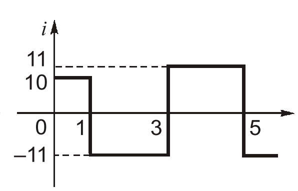
[SSC-JE : 2013]

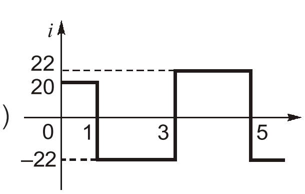
1.17 In the circuit, V is the input voltage applied across the capacitor of 2 F. Current through the capacitor is



(a)


(b)


(c)


(d)


[SSC-JE : 2013]

Answers Electric Circuits and Magnetic Circuits

1. Basics

1.1	(b)	1.2	(b)	1.3	(b)	1.4	(b)	1.5	(a)	1.6	(b)	1.7	(d)	1.8	(b)
1.9	(a)	1.10	(d)	1.11	(c)	1.12	(c)	1.13	(d)	1.14	(d)	1.15	(a)	1.16	(a)
1.17	(d)	1.18	(c)	1.19	(c)	1.20	(b)	1.21	(d)	1.22	(b)	1.23	(b)	1.24	(a)
1.25	(a)	1.26	(b)	1.27	(a)	1.28	(b)	1.29	(b)	1.30	(b)	1.31	(d)	1.32	(a)
1.33	(d)	1.34	(d)	1.35	(a)	1.36	(a)	1.37	(c)	1.38	(a)	1.39	(a)	1.40	(a)
1.41	(d)	1.42	(c)	1.43	(d)	1.44	(b)	1.45	(d)	1.46	(b)	1.47	(b)	1.48	(c)
1.49	(a)	1.50	(b)	1.51	(b)	1.52	(c)	1.53	(b)	1.54	(d)	1.55	(a)	1.56	(b)
1.57	(b)	1.58	(c)	1.59	(d)	1.60	(c)	1.61	(a)	1.62	(b)	1.63	(a)	1.64	(c)
1.65	(c)	1.66	(d)	1.67	(d)	1.68	(b)	1.69	(a)	1.70	(b)	1.71	(c)	1.72	(c)
1.73	(b)	1.74	(b)	1.75	(a)	1.76	(c)	1.77	(d)	1.78	(a)	1.79	(b)	1.80	(b)
1.81	(c)	1.82	(d)	1.83	(d)	1.84	(a)	1.85	(a)	1.86	(c)	1.87	(d)	1.88	(d)
1.89	(d)	1.90	(d)	1.91	(d)	1.92	(a)	1.93	(c)	1.94	(b)	1.95	(c)	1.96	(b)
1.97	(d)	1.98	(a)	1.99	(a)	1.100	(c)	1.101	(a)	1.102	(b)	1.103	(c)	1.104	(d)
1.105	(a)	1.106	(d)	1.107	(b)	1.108	(a)	1.109	(a)	1.110	(c)	1.111	(d)	1.112	(b)
1.113	(b)	1.114	(d)	1.115	(c)	1.116	(c)	1.117	(a)	1.118	(c)	1.119	(a)	1.120	(d)
1.121	(d)	1.122	(a)	1.123	(b)	1.124	(a)	1.125	(a)	1.126	(b)	1.127	(d)	1.128	(a)
1.129	(b)	1.130	(b)	1.131	(d)	1.132	(a)	1.133	(c)	1.134	(a)	1.135	(b)	1.136	(a)
1.137	(*)	1.138	(a)	1.139	(c)	1.140	(c)	1.141	(a)	1.142	(c)	1.143	(a)	1.144	(c)
1.145	(d)	1.146	(a)	1.147	(a)	1.148	(a)	1.149	(c)	1.150	(a)	1.151	(b)	1.152	(a)
1.153	(c)	1.154	(d)	1.155	(d)	1.156	(c)	1.157	(c)	1.158	(b)	1.159	(a)	1.160	(a)
1.161	(a)	1.162	(b)	1.163	(d)	1.164	(c)	1.165	(*)	1.166	(a)	1.167	(c)	1.168	(d)
1.169	(a)	1.170	(c)	1.171	(d)	1.172	(a)	1.173	(c)	1.174	(d)	1.175	(c)	1.176	(c)
1.177	(b)	1.178	(d)	1.179	(a)	1.180	(b)	1.181	(a)	1.182	(b)	1.183	(d)	1.184	(c)
1.185	(c)	1.186	(a)	1.187	(a)	1.188	(a)	1.189	(a)	1.190	(b)	1.191	(b)	1.192	(b)
1.193	(d)	1.194	(c)	1.195	(b)	1.196	(c)	1.197	(d)	1.198	(b)	1.199	(d)	1.200	(a)
1.201	(d)	1.202	(a)	1.203	(b)	1.204	(c)	1.205	(b)	1.206	(c)	1.207	(b)	1.208	(a)
1.209	(b)	1.210	(c)	1.211	(d)	1.212	(a)	1.213	(c)	1.214	(b)	1.215	(d)	1.216	(b)
1.217	(d)	1.218	(c)	1.219	(c)	1.220	(a)	1.221	(a)	1.222	(d)	1.223	(c)	1.224	(b)
1.225	(a)	1.226	(d)	1.227	(b)	1.228	(b)	1.229	(c)	1.230	(b)	1.231	(c)	1.232	(b)
1.233	(b)	1.234	(c)	1.235	(d)	1.236	(d)	1.237	(a)	1.238	(c)	1.239	(a)	1.240	(b)
1.241	(c)	1.242	(b)	1.243	(d)	1.244	(c)	1.245	(d)	1.246	(a)	1.247	(b)	1.248	(c)
1.249	(b)	1.250	(c)	1.251	(d)	1.252	(c)	1.253	(b)	1.254	(b)	1.255	(b)	1.256	(d)
1.257	(c)	1.258	(a)	1.259	(a)	1.260	(a)	1.261	(d)	1.262	(d)	1.263	(b)	1.264	(c)
1.265	(a)	1.266	(b)	1.267	(d)	1.268	(c)	1.269	(d)	1.270	(b)	1.271	(c)	1.272	(d)
1.273	(c)	1.274	(b)	1.275	(b)	1.276	(c)	1.277	(a)	1.278	(d)	1.279	(c)	1.280	(a)
1.281	(b)	1.282	(c)	1.283	(a)	1.284	(d)	1.285	(b)	1.286	(a)	1.287	(c)	1.288	(a)
1.289	(d)	1.290	(a)	1.291	(b)	1.292	(c)	1.293	(a)	1.294	(c)	1.295	(d)	1.296	(a)
1.297	(a)	1.298	(b)	1.299	(a)	1.300	(a)	1.301	(b)	1.302	(d)	1.303	(a)	1.304	(c)
1.305	(a)	1.306	(b)	1.307	(d)	1.308	(d)	1.309	(c)	1.310	(a)	1.311	(c)	1.312	(c)

Explanations **Electric Circuits and Magnetic Circuits**

1. Basics

1.1 (b)

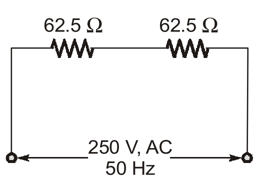
- Capacitor is a device that opposes the sudden change in voltage i.e. it opposes *dV/dt* across it.
- It is not possible to change the voltage across a capacitor by a finite amount in zero time, as this requires an infinite current through the capacitor.

1.2 (b)

The heaters of 1000 W, 250 V will have the resistance of

$$R = \frac{V^2}{P} = \frac{(250)^2}{1000} = 62.5\ \Omega$$

So, equivalent circuit will be as shown below.



$\therefore \quad R_{eq} = 62.5 + 62.5 = 125\ \Omega$

$$\therefore \quad P = \frac{V^2}{R_{eq}} = \frac{(250)^2}{125} = 500\text{ W}$$

1.3 (b)

Specific resistance 'ρ' of a material is a property of that material which depends only upon temperature and the composition of material. However, the resistance depends on length, area, temperature.

Resistance, $R \propto \frac{l}{A}$

or, $R = \frac{\rho l}{A}$ (ρ = specific resistance)

where, 'ρ' is constant for constant temperature.

1.4 (b)

As the wire is stretched, the area will decrease and the length will increase but the net conductor volume will remain same.

Since, volumes are equal, therefore

$$A_1 l_1 = A_2 l_2 \quad \text{...(i)}$$

If $l_1 = l$, then

$$l_2 = l + \frac{1}{10}\text{th of } l$$

so, $l_2 = \frac{11l}{10}$

$$\therefore \quad \frac{l_1}{l_2} = \frac{l}{\frac{11l}{10}} = \frac{10}{11}$$

Now from equation (i),

$$\frac{l_1}{l_2} = \frac{A_2}{A_1} = \frac{10}{11}$$

Given, $R_1 = 10\ \Omega$

Now, from $R = \frac{\rho l}{A}$ we have,

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1}$$

or, $\frac{R_1}{R_2} = \frac{100}{121}$

or, $R_2 = \frac{121 R_1}{100} = \frac{121 \times 10}{100} = 12.1\ \Omega$

1.5 (a)

Given: $P_1 = 100\text{ W},\ V_1 = 220\text{ V}$
$P_2 = 100\text{ W},\ V_2 = 110\text{ V}$

Now, $R_1 = \frac{V_1^2}{P_1} = \frac{(220)^2}{100} = 484\ \Omega$

Also, $R_2 = \frac{V_2^2}{P_2} = \frac{(110)^2}{100} = 121\Omega$

$$\therefore \quad \frac{R_1}{R_2} = \frac{484}{121} = \frac{4}{1} = 4$$

1.6 (b)

The equivalent capacitance for parallel connection is equal to sum of the individual capacitance.

$\therefore \quad C_{eq} = C_1 + C_2 + C_3 + C_4$

$C_{eq} = 4 \times C = 4 \times 10\ \mu F$

Hence, $C_{eq} = 40\ \mu F$

(for parallel connection)

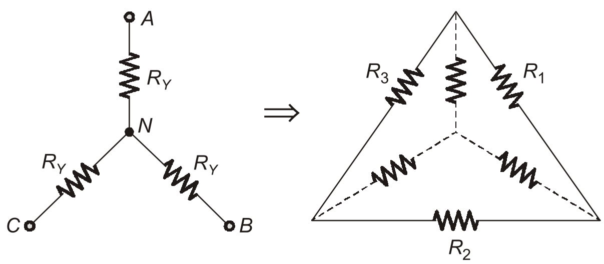
Note: For series connection,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$$

1.7 (d)

Given, in star connection,

$$R_{AN} = R_{BN} = R_{CN} = 5\ \Omega = R_Y \text{ (Say)}$$



(Star) (Delta)

$$R_1 = \frac{R_{AN}R_{BN} + R_{BN}R_{CN} + R_{CN}R_{AN}}{R_{CN}}$$

$$R_2 = \frac{R_{AN}R_{BN} + R_{BN}R_{CN} + R_{CN}R_{AN}}{R_{AN}}$$

$$R_3 = \frac{R_{AN}R_{BN} + R_{BN}R_{CN} + R_{CN}R_{AN}}{R_{BN}}$$

Here as all resistance equal in value.

Hence, $R_1 = R_2 = R_3$

$$= \frac{5\times5+5\times5+5\times5}{5} = 15\ \Omega$$

Note: Also we can find directly using,

$$R_Y = \frac{R_D}{3} \text{ (for equal value of resistance)}$$

1.8 (b)

Aluminium is conductor so, it has positive temperature coefficient of resistance.

Carbon is a semiconductor so, it has negative temperature coefficient of resistance.

Manganin is conductor but its temperature coefficient of resistance is negligible.

1.9 (a)

- Insulators and semiconductors have negative temperature coefficient of resistance. Hence with increase in temperature rise, resistance will decrease,

  $$R_t = R_0(1 + \alpha\Delta T)$$

  where, α = temperature coefficient of resistance.
- If α is negative, R (resistance) will decrease as $T\uparrow$.

1.10 (d)

Resistivity is the resistance per unit length and cross-sectional area. A low resistivity indicates a material that readily allows electric current.

At 20°C, resistivity of material (in Ωm) is

(a) Iron → 1×10^{-7} Ωm

(b) Manganin → 4.2×10^{-7} Ωm

(c) Aluminium → 2.8×10^{-8} Ωm

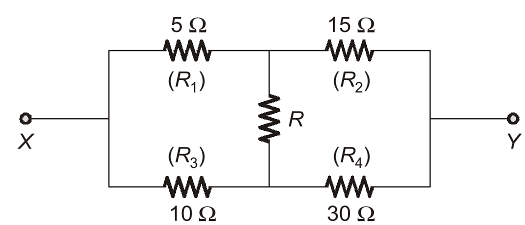
(d) Copper → 1.7×10^{-8} Ωm

Hence, copper has least resistivity.

1.11 (c)

As the wires are of same material, therefore specific resistance of both the wires *A* and *B* will be same (Because specific resistance depends only on type of materials or composition).

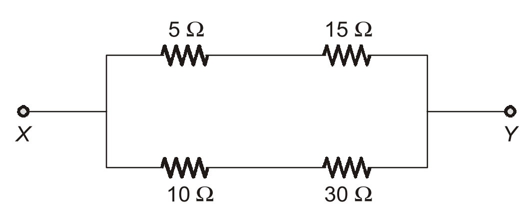
1.12 (c)



Above circuit is a balanced Wheatstone bridge, Hence, no current flows through the resistance *R* since arms ratio is constant.

i.e. $$\frac{R_1}{R_3} = \frac{R_2}{R_4}$$

$$\frac{5}{10} = \frac{15}{30} = \frac{1}{2} = \text{constant}$$



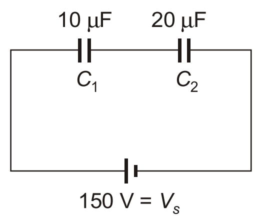
$$\therefore \quad R_{xy} = (5 + 15) \,||\, (10 + 30) = 20 \,||\, 40$$

$$= \frac{20 \times 40}{20 + 40} = \frac{40}{3}\Omega$$

1.13 (d)

We know that,

$$V = \frac{Q}{C} \text{ i.e. } V \propto \frac{1}{C}$$



According to voltage divider rule,

$$V_{C_2} = \frac{VC_1}{C_1 + C_2}$$

$$V_{20\mu F} = \frac{10\ \mu F}{10\ \mu F + 20\ \mu F} \times 150 = 50\ V$$

(In series charge is same and voltage divides).

1.14 (d)

Voltage across an inductor is created to current by the equation,

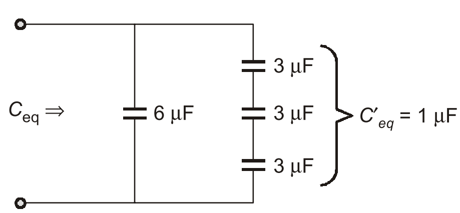
$$V_L = L\frac{di_L}{dt}$$

As current is ramp function of finite duration hence its differentiation leads to a step function of finite duration. Hence option (d) is correct.

1.15 (a)

When capacitor is connected across an ideal voltage source, initially it is short circuited, hence current will be very high, and then it charges to voltage equal to value of voltage source. Hence current will decay exponentially and at steady state will become zero (since capacitor will acts as open-circuit in steady state).

1.16 (a)



Let, $C_1 = C_2 = C_3 = 3\ \mu F$

$$\frac{1}{C'_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

(for series connection)

$$\frac{1}{C'_{eq}} = \frac{3}{C_1}$$

$$\Rightarrow \quad C'_{eq} = \frac{3\ \mu F}{3} = 1\ \mu F$$

Equivalent capacitance of three 3 μF capacitors is

$$\therefore \quad C'_{eq} = 1\ \mu F$$

$$C_{eq} = 6\ \mu F + 1\ \mu F \quad (\because \text{ in parallel})$$

or, $C_{eq} = 7\ \mu F$

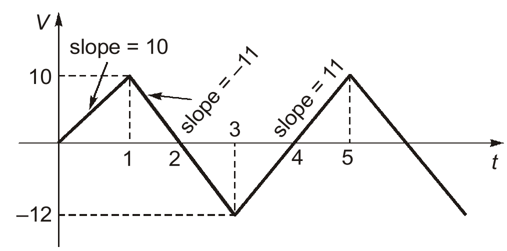
1.17 (d)

Current through the capacitor is

$$i = C\frac{dV}{dt}$$

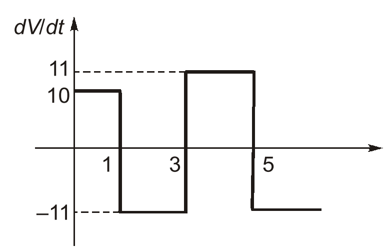
$$i = 2 \cdot \frac{dV}{dt}$$

The input voltage applied across the capacitor is shown below.



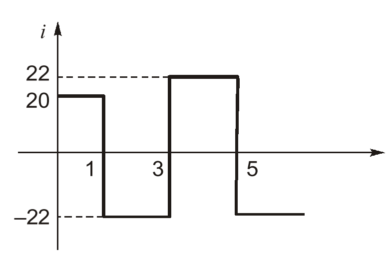
$$\therefore \quad i = C\frac{dV}{dt} = 2\frac{dV}{dt}$$

The waveform for dV/dt is shown below.



The waveform for current is shown below.

$$\left(\text{Using, } i = 2\frac{dV}{dt}\right)$$



1.18 (c)

Ampere-sec is the unit of electric charge.

Current, $i = \frac{Q}{t}$ or $Q = it$

CHAPTER

2

Paper - I : Objective

Measurement and Measuring Instruments

1. Characteristics of Measuring Instruments, Error Analysis

1.1 Which of the following instruments is an integrating type instrument?
(a) Wattmeter
(b) Energy Meter
(c) Power Factor Meter
(d) None of the above **[SSC-JE : 2007]**

1.2 Which of the following meters is an integrating type instrument?
(a) Ammeter (b) Voltmeter
(c) Wattmeter (d) Energy meter
[SSC-JE : 2008]

1.3 The controlling torque in gravity controlled meter is proportional to:
(a) $\cos\theta$ (b) $\sin\theta$
(c) $\tan\theta$ (d) 0
[SSC-JE : 2010]

1.4 In indicating instruments the springs are mainly used to
(a) conduct the current to the coils.
(b) hold the pivot in position.
(c) control the pointer movement.
(d) reduce the vibration of the pointer.
[SSC-JE : 2013]

1.5 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 processes and operations.
(a) A only (b) A and B only
(c) B and C only (d) A, B and C
[SSC-JE (Forenoon) 1.3.2017]

1.6 What is the unit of measure for electrical pressure or electromotive force?
(a) Amperes (A) (b) Ohm (Ω)
(c) Volt (V) (d) Watt (W)
[SSC-JE (Forenoon) 1.3.2017]

1.7 The voltage of a circuit is measured by a voltmeter having input impedance comparable with the output impedance of the circuit thereby causing error in voltage measurement. This error may be called as _______.
(a) gross error
(b) random error
(c) error caused by misuse of instrument
(d) error caused by loading effect
[SSC-JE (Afternoon) 1.3.2017]

1.8 The dead time of an instrument refers to _______.
(a) large change of input quantity for which there is not 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 respond after the quantity has altered.
(d) retardation or delay in the response of an instrument to a change in the input signal.
[SSC-JE (Afternoon) 1.3.2017]

1.9 Systematic errors in bourdon tube pressure gauge may be caused by
(a) friction in the pins and gears of the amplifying mechanism.
(b) incorrect zero setting of the pointer.
(c) variation of atmospheric pressure.
(d) incorrect readings of the scale due to parallax.
[SSC-JE (Afternoon) 3.3.2017]

1.10 Errors which may be variable both in magnitude and nature (positive or negative) are classified as
(a) hysteresis error (b) random error
(c) systematic error (d) interaction error
[SSC-JE (Afternoon) 3.3.2017]

1.11 The measurement of surface temperature in exposed situations where atmospheric variation can interfere with temperature measurement gives rise to
(a) transmission error (b) interaction error
(c) operation error (d) interference error
[SSC-JE (Afternoon) 3.3.2017]

1.12 What represents the departure of the observed reading from the arithmetic mean of the group of readings?
(a) Dispersion (b) Deviation
(c) Variance (d) Median
[SSC-JE (Afternoon) 3.3.2017]

1.13 Dynamometer type moving coil instruments are provided with ________.
(a) eddy current damping
(b) pneumatic damping
(c) fluid friction damping
(d) electrostatic damping
[SSC-JE (Afternoon) 1.3.2017]

1.14 The function of measurement system is/are ___.
(a) indicating function
(b) recording function
(c) controlling function
(d) indicating, recording and controlling function
[SSC-JE (Afternoon) 2.3.2017]

1.15 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
[SSC-JE (Afternoon) 22.1.2018]

1.16 What is the percentage voltage error of a potential transformer with system voltage of 11,000 V and having turns ratio of 100, if the measured secondary side voltage is 105 V?
(a) 2.75 (b) 3.55
(c) 4.54 (d) 9.09
[SSC-JE (Afternoon) 24.01.2018]

1.17 The function of measurement system is/are ___.
(a) Indicating function
(b) Recording function
(c) Controlling function
(d) Indicating, recording and controlling function
[SSC-JE (Forenoon) 25.01.2018]

1.18 Which of the following is a type of recording instrument?
(a) Ammeter (b) Megger
(c) Voltmeter (d) X-Y plotter
[SSC-JE (Afternoon) 25.1.2018]

1.19 Which of the following is the dimensional formula of conductance?
(a) $M^1L^2T^{-3}A^{-1}$ (b) $M^1L^2T^{-3}A^{-2}$
(c) $M^{-1}L^{-2}T^3A^2$ (d) $M^1LT^{-3}A^1$
[SSC-JE (Forenoon) 22.01.2018]

1.20 Which of the following is the dimension of resistance?
(a) $\frac{ML^2}{Q^2T}$ (b) $\frac{Q^2T^2}{ML^2}$
(c) $\frac{ML^2}{QT^2}$ (d) $\frac{ML}{QT^2}$
[SSC-JE (Afternoon) 24.01.2018]

1.21 The type of damping used for moving iron instruments is _____.
(a) air friction damping
(b) gravity friction damping
(c) eddy current damping
(d) fluid friction damping
[SSC-JE : (Afternoon) 26.9.2019]

1.22 In a current measurement exercise the standard deviation is 4 mA. Calculate probable error.
(a) 3.7 mA (b) 3 mA
(c) 4 mA (d) 2.7 mA
[SSC-JE (Forenoon) 28.10.2020]

1.23 The difference between the measured value and the true value of a measurand is called ________.
(a) Sensitivity (b) Threshold
(c) Fidelity (d) Static error
[SSC-JE (Forenoon) 28.10.2020]

Answers Measurement and Measuring Instruments

1. Characteristics of Measuring Instruments, Error Analysis

1.1	(b)	1.2	(d)	1.3	(b)	1.4	(c)	1.5	(d)	1.6	(c)	1.7	(d)	1.8	(c)
1.9	(b)	1.10	(b)	1.11	(d)	1.12	(b)	1.13	(b)	1.14	(d)	1.15	(c)	1.16	(c)
1.17	(d)	1.18	(d)	1.19	(c)	1.20	(a)	1.21	(a)	1.22	(d)	1.23	(d)	1.24	(d)
1.25	(a)	1.26	(b)	1.27	(c)	1.28	(d)								

2. Electromechanical Indicating Instruments

2.1	(c)	2.2	(b)	2.3	(c)	2.4	(a)	2.5	(c)	2.6	(a)	2.7	(d)	2.8	(c)
2.9	(a)	2.10	(c)	2.11	(c)	2.12	(c)	2.13	(d)	2.14	(d)	2.15	(c)	2.16	(b)
2.17	(d)	2.18	(a)	2.19	(a)	2.20	(d)	2.21	(b)	2.22	(a)	2.23	(d)	2.24	(d)
2.25	(c)	2.26	(a)	2.27	(a)	2.28	(d)	2.29	(b)	2.30	(c)	2.31	(c)	2.32	(c)
2.33	(b)	2.34	(b)	2.35	(c)	2.36	(b)	2.37	(a)	2.38	(a)	2.39	(c)	2.40	(a)
2.41	(a)	2.42	(c)	2.43	(a)	2.44	(b)	2.45	(c)	2.46	(d)	2.47	(d)	2.48	(b)
2.49	(a)	2.50	(d)	2.51	(c)	2.52	(a)	2.53	(d)	2.54	(c)	2.55	(a)	2.56	(b)
2.57	(b)	2.58	(a)	2.59	(d)	2.60	(b)	2.61	(b)	2.62	(a)	2.63	(c)	2.64	(c)
2.65	(a)	2.66	(d)	2.67	(d)	2.68	(d)	2.69	(c)	2.70	(a)	2.71	(a)	2.72	(a)
2.73	(a)	2.74	(d)	2.75	(b)	2.76	(d)	2.77	(c)	2.78	(d)	2.79	(d)	2.80	(d)
2.81	(a)	2.82	(b)	2.83	(a)	2.84	(b)	2.85	(d)	2.86	(a)	2.87	(b)	2.88	(c)
2.89	(d)	2.90	(a)	2.91	(b)	2.92	(b)	2.93	(d)	2.94	(a)	2.95	(a)	2.96	(b)
2.97	(b)	2.98	(c)	2.99	(a)	2.100	(d)	2.101	(d)	2.102	(b)	2.103	(a)	2.104	(b)
2.105	(c)	2.106	(b)	2.107	(b)	2.108	(a)	2.109	(b)	2.110	(c)	2.111	(d)		

3. Measurement of Resistance and Potentiometers

3.1	(b)	3.2	(a)	3.3	(a)	3.4	(c)	3.5	(a)	3.6	(b)	3.7	(a)	3.8	(a)
3.9	(b)	3.10	(a)	3.11	(a)	3.12	(d)	3.13	(a)	3.14	(b)	3.15	(b)	3.16	(c)
3.17	(b)	3.18	(a)	3.19	(c)	3.20	(c)	3.21	(b)	3.22	(d)	3.23	(c)	3.24	(a)
3.25	(a)	3.26	(d)	3.27	(c)	3.28	(d)	3.29	(c)	3.30	(c)	3.31	(d)	3.32	(b)

4. AC Bridges

4.1	(a)	4.2	(b)	4.3	(a)	4.4	(a)	4.5	(a)	4.6	(c)	4.7	(a)	4.8	(d)
4.9	(b)	4.10	(c)	4.11	(a)	4.12	(b)	4.13	(d)	4.14	(c)	4.15	(c)	4.16	(a)
4.17	(d)	4.18	(a)	4.19	(d)	4.20	(b)	4.21	(c)	4.22	(d)	4.23	(a)	4.24	(d)
4.25	(b)	4.26	(a)	4.27	(a)	4.28	(c)	4.29	(b)	4.30	(c)	4.31	(b)		

Explanations **Measurement and Measuring Instruments**

1. Characteristics of Measuring Instruments, Error Analysis

1.1 (b)

Integrating type instruments are those instruments which first measure the quantity then integrate (sum) it over a time period.

Energy meter reads the kW-hr reading and integrates if for a time period.

1.2 (d)

- Integrating instruments totalises the events over a specified period of time. The output is product of time and an electrical quantity. **e.g.:** Amp-hr meter, Energy meter etc.
- Indicating instruments indicate the magnitude of quantity being measured. Ammeter, voltmeter, wattmeter are examples of indicating type instruments.

1.3 (b)

In gravity controlled instruments, a small weight is attached to the moving system in such a way that it produces a controlling torque, when the moving system is in deflection. Another adjustable weight is there for balancing purpose.

Controlling torque, T_c is given by

$$T_c = Wl\sin\theta \text{ or } K_g\cdot\sin\theta$$

where, W = Control weight

l = distance of control weight from axis of rotation

K_g = gravity constant

Clearly, $T_c \propto \sin\theta$

Hence, in gravity controlled meters, scale is not uniform and it is cramped for lower readings.

1.4 (c)

Controlling torque is in opposite to the deflecting torque. This can be done by two ways. One is gravity control and other is spring control. A spring made up of phosphorous bronze provides the required controlling torque.

1.5 (d)

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

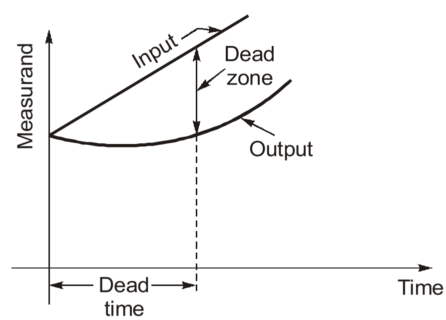
1.6 (c)

Emf is measured in volt. Emf is difference in potential which give rise to current difference is measured in volt, so is emf.

1.7 (d)

If a low sensitivity voltmeter is used to measure the voltage across the low resistance, some of the current will pass through the meter and hence, meter will read error value due to the own loading. This is called loading effect. To reduce the loading effect, high sensitivity voltmeters are used. Loading effect of the instrument is a kind of instrument error.

1.8 (c)



Dead time is the time required for the measurement to begin to respond to the changes in the measurand. It is the time before which instrument begins to respond after the measurand quantity has altered.

1.9 (b)

In systematic error there are three types of error:

- Instrumental errors
- Environmental errors
- Observation errors

In instrumental error there can be

1. Inherent shortcoming of instrument
2. Misuse of instrument – Zero setting, poor initial adjustment
3. Loading effect

1.10 (b)

Random errors are those errors whose causes can't be known because of random variations. These errors are variable and are caused by the happenings or disturbances about which we are unaware. These errors are also called residual errors.

1.11 (d)

It is the interference of the environment within the measurement process.

1.12 (b)

$x_1, x_2 \ldots\ldots x_n \rightarrow$ reading

$$\bar{x} = \frac{x_1 + x_2 + \ldots\ldots + x_n}{N}$$

Deviations,

$$d_1 = x_1 - \bar{x}$$
$$d_2 = x_2 - \bar{x}$$
$$\vdots$$
$$d_n = x_n - \bar{x}$$

1.13 (b)

- Air friction damping or pneumatic damping is employed in electrodynamometer type instruments. This is due to the fact that operating magnetic field in such instruments is weak. Hence using eddy current damping may led to distortion and hence may leads to error.
- Air friction damping is preferred where low value of magnetic field is used (e.g. MI instrument, EDM type).

1.14 (d)

- Measurement is the result of comparison between the quantity (unknown) and a predefined.
- There are four main functions performed by a measuring system:
  - (i) Indicating function: to supply information as deflection of pointer of measuring instrument.
  - (ii) Recording function: instrument make a written record of the quantity under measurement.
  - (iii) Controlling function: information used by system to control the original measured quantity eg: in food processing industries.
  - (iv) Signal processing: to modify the signal to facilitate control.

1.15 (c)

Resolution is the ability of measurement system to detect and indicate small change in the measurement. The small measurable input change that can be measured by instruments is called resolution.

1.16 (c)

V_t = True secondary voltage obtained using potential transformer,

Turns ratio = 100

Hence, $$V_t = \frac{11000}{100} = 110 \text{ V}$$

= Nominal voltage/true voltage

V_m = Measured secondary voltage = 105 V

$$\% V_e = \frac{V_t - V_m}{V_t} = \frac{110 - 105}{110} \times 100$$

% error in voltage = 4.54%

1.17 (d)

Instruments in measurement system can be classified according to their functions as well. So, these are indicating functions (e.g. PMMC, wattmeters), recording functions (e.g. XY plotter, ECG machine) and also controlling functions using gravity control or spring control.

1.18 (d)

X-Y plotter is a recording instrument which records on graph paper while voltmeter, ammeter and megger are type of indicating instruments.

1.19 (c)

$$P = I^2 R$$

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$
$$= \frac{\text{Force} \times \text{Distance}}{\text{Time}}$$
$$= \frac{\text{Mass} \times \text{Acceleration} \times \text{Distance}}{\text{Time}}$$

$$\because \text{Acceleration} = \frac{\text{Distance}}{(\text{Time})^2}$$

Dimensions:

$$[\text{Power}] = \frac{[MLT^{-2}L]}{[T]} = [ML^2T^{-3}]$$

$\because$ Conductance $= G = \frac{1}{R} = \frac{I^2}{P} = \frac{[A]^2}{[ML^2T^{-3}]}$

Hence, $[G] = M^{-1}L^{-2}T^3A^2$

1.20 (a)

$\because$ Resistance $[R] = \frac{[V]}{[I]}$

$[V]$ = [Electric field] × [distance]

But, [Electric field] $= \frac{[\text{Force}]}{[\text{Charge}]} = \frac{MLT^{-2}}{Q}$

$$[R] = \frac{\left[\frac{[MLT^{-2}]}{[Q]}\right]\times[L]}{[QT^{-1}]}$$

$$\{\because [I] = [QT^{-1}]\}$$

$$[R] = \frac{ML^2}{Q^2T}$$

1.21 (a)

- Air friction damping is preferred where low value of magnetic field is used.
  eg.: Moving iron instruments and electrodynamometer type instruments.
- Electrostatic instruments uses fluid friction damping.
- Eddy current damping is preferred in PMMC instruments.

1.22 (d)

Probable error (PE) $= 0.6745\,\sigma$

$= 0.6745 \times 4$

PE $= 2.7$ mA

1.24 (d)

$$\text{Precision} = \frac{\text{true value}}{\text{actual mean}} = \frac{99}{100} = 0.99$$

1.25 (a)

$$\%\text{ error} = \frac{50-48}{50}\times 100 = \frac{2}{50}\times 100 = 4\%$$

1.26 (b)

$$\text{Sensitivity,}\quad S = \frac{\Delta V_o}{\Delta V_i} = \frac{0.18}{0.2} = 0.9$$

1.27 (c)

Errors are introduced in the measurement by wattmeter due to mutual inductance between current coil and pressure coil.

2. Electromechanical Indicating Instruments

2.1 (c)

Since, *MI* instrument measures RMS value of the quantity therefore *MI* ammeter reading is

$$I_{rms} = \sqrt{(10)^2 + \left(\frac{10}{\sqrt{2}}\right)^2}\ \text{A}$$

$$= \sqrt{100 + \frac{100}{2}}\ \text{A} = \sqrt{100+50}\ \text{A}$$

$$I_{rms} = \sqrt{150}\ \text{A}$$

2.2 (b)

Since the torque equation of MI instrument is

$$T_d = I^2\frac{dL}{d\theta} \quad\text{or}\quad T_d \propto I^2$$

In a MI instrument, to get a linear scale at lower value of θ, very high value of $dL/d\theta$ is required. Which is not possible practically due to which the scale is cramped at the lower end of the scale. Similarly, at higher value of θ, $dL/d\theta$ is minimum due to which deflecting torque is minimum. Hence, the scale is cramped to read this minimum torque at high scale range.

2.3 (c)

Given, $I = 500$ A, $I_m = 100$ A and $R_m = 0.1\ \Omega$.
For ammeter shunt, a low value of resistance is connected in parallel with the meter whose value is

$$R_{sh} = \frac{R_m}{m-1}$$

Here, m = Multiplication factor given as

$$m = \frac{I}{I_m} = \frac{500}{100} = 5$$

Hence, $R_{sh} = \frac{0.1}{5-1} = \frac{0.1}{4} = 0.025\ \Omega$

CHAPTER

3

Paper - I : Objective

Electrical Machines

1. Transformers

1.1 A 100 V/10 V, 50 VA transformer is converted to 100 V/ 110 V autotransformer, the rating of the autotransformer will be
(a) 550 VA (b) 500 VA
(c) 110 VA (d) 100 VA
[SSC-JE : 2007]

1.2 A transformer has maximum efficiency at full load, when iron losses are 800 watts, copper losses at half load will be
(a) 1600 W (b) 800 W
(c) 400 W (d) 200 W
[SSC-JE : 2007]

1.3 The purpose of the conservator in a transformer is
(a) to cool the winding.
(b) to prevent moisture in the transformer.
(c) to prevent short circuit of primary and secondary winding.
(d) to take up contraction and expansion of oil.
[SSC-JE : 2008]

1.4 In case of a power transformer, the no load current in terms of rated current is
(a) 10 to 20% (b) 2 to 6%
(c) 15 to 30% (d) 30 to 50%
[SSC-JE : 2008]

1.5 If copper loss of transformer at $\frac{7}{8}$th full load is 4900 W, then its full load copper loss would be
(a) 5600 W (b) 6400 W
(c) 373 W (d) 429 W
[SSC-JE : 2008]

1.6 If a 500 kVA, 200 Hz transformer is operated at 50 Hz, its KVA rating will be
(a) 2000 KVA (b) 125 KVA
(c) 250 KVA (d) 1000 KVA
[SSC-JE : 2009]

1.7 The power factor at which transformer operates
(a) is unity
(b) is 0.8 lag
(c) is 0.8 lead
(d) depends upon the power factor of the load
[SSC-JE : 2009]

1.8 The efficiency at a 100 KVA transformer is 0.98 at full as well as half load. For this transformer at full load the copper loss
(a) is less than core loss.
(b) is equal to core loss.
(c) is more than core loss.
(d) all the above
[SSC-JE : 2009]

1.9 Which of the following will improve the mutual coupling between primary and secondary circuit?
(a) Transformer oil of high breakdown voltage
(b) High reluctance magnetic core
(c) Winding material of high resistivity
(d) Low reluctance magnetic core
[SSC-JE : 2009]

1.10 High leakage transformers are of
(a) small voltage ampere rating
(b) high voltage ampere rating
(c) high voltage rating
(d) low voltage rating [SSC-JE : 2009]

1.11 A transformer is working at its full load and its efficiency is also maximum at which iron loss is 1000 Watts. Then, its copper loss at half of full load will be:
(a) 250 Watts (b) 300 Watts
(c) 400 Watts (d) 500 Watts
[SSC-JE : 2010]

1.12 Distribution transformers are designed to have maximum efficiency nearly at:
(a) 100% of full load (b) 50% of full load
(c) 25% of full load (d) 10% of full load
[SSC-JE : 2010]

1.13 A 2 kVA transformer has iron loss of 150 W and full load copper loss of 250 W. The maximum efficiency of the transformer will occur when the total loss is:
(a) 500 W (b) 400 W
(c) 300 W (d) 275 W
[SSC-JE : 2010]

1.14 A 20 kVA, 2000 V / 200 V, 2-winding transformer, when used as an autotransformer, with constant voltage source of 2000 V, is capable of handling
(a) 20 kVA (b) 220 kVA
(c) 320 kVA (d) None of these
[SSC-JE : 2011]

1.15 Power transformers are designed such that maximum efficiency occurs at
(a) half of the full load
(b) near full load
(c) $1/4^{th}$ of full load
(d) $3/4^{th}$ of full load
[SSC-JE : 2011]

1.16 In a 1-phase transformer, the copper loss at full load is 600 Watts. At half of the full load the copper loss will be
(a) 150 Watts (b) 75 Watts
(c) 600 Watts (d) 300 Watts
[SSC-JE : 2012]

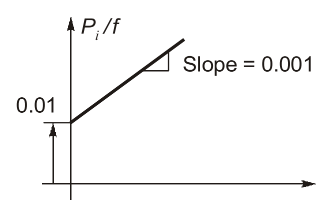
1.17 In autotransformer, the number of turns in primary winding is 210 and in secondary winding is 140. If the input current is 60 A, the currents in output and in common winding are respectively
(a) 40 A, 20 A (b) 40 A, 100 A
(c) 90 A, 30 A (d) 90 A, 150 A
[SSC-JE : 2012]

1.18 A 3-phase transformer has its primary connected in delta and secondary in star. Secondary to primary turns ratio per phase is 6. For a primary voltage of 200 V, the secondary voltage would be
(a) 2078 V (b) 693 V
(c) 1200 V (d) 58 V
[SSC-JE : 2012]

1.19 The iron loss in a 100 KVA transformer is 1 kW and full load copper losses are 2 kW. The maximum efficiency occurs at a load of
(a) 100 KVA (b) 70.7 KVA
(c) 141.4 KVA (d) 50 KVA
[SSC-JE : 2012]

1.20 The iron loss per unit frequency in a ferromagnetic core, when plotted against frequency, is a
(a) Straight line with positive slope
(b) Straight line with negative slope
(c) Parabola
(d) Constant
[SSC-JE : 2012]

1.21 Following graph shows the loss characteristic of a sheet of ferromagnetic material against varying frequency f. P_i is the iron loss at frequency f. Hysteresis and eddy current losses of the sheet at 100 Hz are



(a) 10 W, 100 W (b) 10 W, 50 W
(c) 1 W, 5 W (d) 1 W, 10 W
[SSC-JE : 2012]

1.22 Eddy current loss in ferromagnetic core is proportional to
(a) square of frequency
(b) square root of frequency
(c) frequency
(d) reciprocal of frequency
[SSC-JE : 2012]

1.23 If the frequency of input voltage of a transformer is increased keeping the magnitude of the voltage unchanged, then
(a) both hysteresis loss and eddy current loss in the core will increase.
(b) hysteresis loss will increase but eddy current loss will decrease.
(c) hysteresis loss will decrease but eddy current loss will remain unchanged.
(d) hysteresis loss will decrease but eddy current loss will increase.
[SSC-JE : 2013]

Answers Electrical Machines

1. Transformers

1.1	(a)	1.2	(d)	1.3	(d)	1.4	(b)	1.5	(b)	1.6	(b)	1.7	(d)	1.8	(c)
1.9	(d)	1.10	(a)	1.11	(a)	1.12	(b)	1.13	(c)	1.14	(b)	1.15	(b)	1.16	(a)
1.17	(c)	1.18	(a)	1.19	(b)	1.20	(a)	1.21	(d)	1.22	(a)	1.23	(c)	1.24	(b)
1.25	(c)	1.26	(c)	1.27	(d)	1.28	(b)	1.29	(d)	1.30	(a)	1.31	(d)	1.32	(c)
1.33	(d)	1.34	(c)	1.35	(b)	1.36	(a)	1.37	(a)	1.38	(d)	1.39	(a)	1.40	(d)
1.41	(b)	1.42	(b)	1.43	(c)	1.44	(d)	1.45.	(d)	1.46	(a)	1.47	(d)	1.48	(a)
1.49	(c)	1.50	(b)	1.51	(a)	1.52	(c)	1.53	(b)	1.54	(a)	1.55	(c)	1.56	(b)
1.57	(d)	1.58	(d)	1.59	(a)	1.60	(d)	1.61	(b)	1.62	(a)	1.63	(b)	1.64	(b)
1.65	(c)	1.66	(c)	1.67	(d)	1.68	(b)	1.69	(d)	1.70	(b)	1.71	(a)	1.72	(c)
1.73	(d)	1.74	(b)	1.75	(b)	1.76	(b)	1.77	(c)	1.78	(c)	1.79	(c)	1.80	(d)
1.81	(a)	1.82	(d)	1.83	(b)	1.84	(b)	1.85	(d)	1.86	(a)	1.87	(d)	1.88	(b)
1.89	(a)	1.90	(b)	1.91	(a)	1.92	(a)	1.93	(b)	1.94	(d)	1.95	(c)	1.96	(b)
1.97	(a)	1.98	(a)	1.99	(c)	1.100	(d)	1.101	(c)	1.102	(a)	1.103	(b)	1.104	(c)
1.105.	(a)	1.106	(c)	1.107	(b)	1.108	(a)	1.109	(a)	1.110	(d)	1.111	(c)	1.112	(c)
1.113	(d)	1.114	(d)	1.115	(c)	1.116	(a)	1.117	(d)	1.118	(a)	1.119	(b)	1.120	(b)
1.121	(b)	1.122	(b)	1.123	(b)	1.124	(b)	1.125	(b)	1.126	(a)	1.127	(a)	1.128	(a)
1.129.	(b)	1.130	(c)	1.131	(b)	1.132	(d)	1.133	(d)	1.134	(b)	1.135	(c)	1.136	(b)
1.137	(c)	1.138	(b)	1.139	(b)	1.140	(b)	1.141	(d)	1.142	(c)	1.143	(a)	1.144	(a)
1.145	(b)	1.146	(c)	1.147	(b)	1.148	(a)	1.149	(d)	1.150	(b)	1.151	(a)	1.152	(d)
1.153	(d)	1.154	(a)	1.155	(d)	1.156	(d)	1.157	(d)	1.158	(b)	1.159	(b)	1.160	(c)
1.161	(b)	1.162	(a)	1.163	(c)	1.164	(d)	1.165	(c)	1.166	(c)	1.167	(b)	1.168	(d)
1.169	(b)	1.170	(c)	1.171	(c)	1.172	(d)								

2. DC Machines

2.1	(d)	2.2	(a)	2.3	(a)	2.4	(a)	2.5	(b)	2.6	(c)	2.7	(d)	2.8	(b)
2.9	(b)	2.10	(d)	2.11	(c)	2.12	(d)	2.13	(b)	2.14	(b)	2.15	(b)	2.16	(d)
2.17	(b)	2.18	(a)	2.19	(b)	2.20	(a)	2.21	(c)	2.22	(c)	2.23	(d)	2.24	(c)
2.25	(a)	2.26	(b)	2.27	(b)	2.28	(c)	2.29	(b)	2.30	(b)	2.31	(c)	2.32	(c)
2.33	(d)	2.34	(c)	2.35	(a)	2.36	(a)	2.37	(b)	2.38	(d)	2.39	(d)	2.40	(c)
2.41	(c)	2.42	(c)	2.43	(b)	2.44	(b)	2.45	(c)	2.46	(a)	2.47	(a)	2.48	(a)
2.49	(b)	2.50	(b)	2.51	(c)	2.52	(c)	2.53	(b)	2.54	(d)	2.55	(c)	2.56	(c)
2.57	(d)	2.58	(d)	2.59	(b)	2.60	(b)	2.61	(c)	2.62	(d)	2.63	(a)	2.64	(b)
2.65	(a)	2.66	(b)	2.67	(b)	2.68	(c)	2.69	(b)	2.70	(d)	2.71	(b)	2.72	(d)
2.73	(a)	2.74	(d)	2.75	(b)	2.76	(a)	2.77	(d)	2.78	(d)	2.79	(a)	2.80	(a)
2.81	(c)	2.82	(c)	2.83	(a)	2.84	(a)	2.85	(b)	2.86	(c)	2.87	(b)	2.88	(d)

Explanations **Electrical Machines**

1. Transformers

1.1 (a)

Method 1:

∵ Rating of auto transformer is given as

$$S_{auto} = \left(\frac{a_{auto}}{a_{auto}-1}\right) \times S_{2\,winding}$$

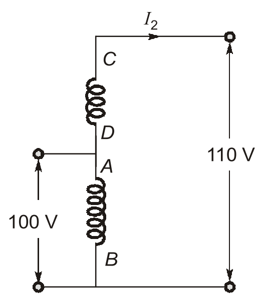
where, $a_{auto} = \frac{V_H}{V_L} = \frac{110}{100} = \frac{11}{10}$

Given, $S_{2wdg} = 50$ VA

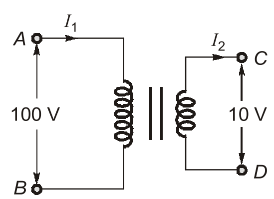
$$S_{auto} = \left[\frac{\frac{11}{10}}{\frac{11}{10}-1}\right] \cdot 50 \text{ VA}$$

$$= 11 \times 50 = 550 \text{ VA}$$

Method 2:



(Auto T/F)



(2 winding T/F)

$$I_2 = \frac{50}{10} = 5 \text{ A}$$

$$S_{auto} = 110 \times I_2 = 110 \times 5 = 550 \text{ VA}$$

1.2 (d)

For maximum efficiency (η_{max}) :

Copper loss (I^2R) = Iron loss (P_i)

So, for η_{max} at full load

$$I_{fl}^2 \cdot R = 800 \text{ W}$$

At half load, $I = \frac{I_{fl}}{2}$

∴ Copper loss at half load

$$P_{cu} = \left(\frac{I_{fl}}{2}\right)^2 \cdot R = \frac{800}{4} = 200 \text{ W}$$

1.3 (d)

Conservator is a tank placed at the top of the transformer. It controls the expansion and contraction of the transformer oil on heating and cooling process respectively.

1.4 (b)

In transformer the no load current is just 2 - 6% of full load/rated current, hence it can be neglected however it is quite considerable in the induction motor about (30-40%) of full load current hence cannot be ignored.

1.5 (b)

Copper loss P_{cu} at full load is

$$P_{cu} = I_{fl}^2 \cdot R$$

At $\frac{7}{8}$th full load, $I = \frac{7}{8} I_{fl}$

Copper loss at this load,

$$\therefore \left(\frac{7}{8} I_{fl}\right)^2 \times R = 4900 \text{ W} \quad \text{(Given)}$$

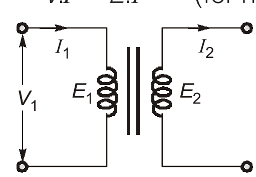
$$\Rightarrow I_{fl}^2 \cdot R = 6400 \text{ Watts}$$

= Full load copper loss

1.6 (b)

The transformer rating is given as:

$$V.I = E.I \quad \text{(for no voltage drop)}$$



$$E_1 I_1 = E_2 I_2$$

(E is induced emf.)

Since loss of voltage is neglected here, therefore

$V = E$ is taken

So, rating is $E \cdot I$ kVA

∵ $E \propto f$ as $(E = \sqrt{2}\pi f \phi N)$

so, kVA $\propto f$

$$\therefore \frac{\text{kVA}_1}{\text{kVA}_2} = \frac{f_1}{f_2}$$

$$\Rightarrow \text{kVA}_2 = \text{kVA}_1 \times \frac{f_2}{f_1} = 500 \times \frac{50}{200}$$

or, $\text{kVA}_2 = 125$ kVA

1.7 (d)

The power factor at which a transformer operates depends upon the power factor of the load. If can be leading pf, lagging pf or unity pf load depending on the load connected on the secondary side of the transformer corresponding to capacitive, inductive or resistive load respectively.

1.8 (c)

Let full load copper loss in $P_{cu} = I_{fl}^2 \cdot R$

$$\text{Full load kVA} = 100 \text{ kVA}$$
$$\text{Half load kVA} = 50 \text{ kVA}$$
$$P_{cu}(\text{half load}) = \frac{P_{cu}}{4} \qquad [\because P_{cu} \propto I^2]$$

Now,
$$\eta = \frac{\text{output}}{\text{output} + P_i + P_{cu}}$$

∴ for full load,
$$0.98 = \frac{100}{100 + P_i + P_{cu}} \qquad ...(i)$$

At half load,
$$0.98 = \frac{50}{50 + P_i + \frac{P_{cu}}{4}} \qquad ...(ii)$$

(as P_i is always constant)

From equation (*i*) and (*ii*),
$$P_i = 0.68 \text{ kW}$$
$$P_{cu} = 1.36 \text{ kW} \quad \text{(full load)}$$
$$\therefore \quad P_{cu} > P_i$$

1.9 (d)

$$\because \quad \text{flux } (\phi) = \frac{\text{mmf}}{\text{Reluctance}}$$

If the reluctance of the path is low in a coupled circuit, then mutual flux will be more hence the mutual coupling will get improved.

Lower the reluctance, lesser will be the opposition to flux through the transformer core. Hence the core is made of high permeability material.

1.10 (a)

- Leakage transformers are those where magnetic flux of secondary is loosely coupled to the flux of primary.
- They are used in extra low voltage applications where short circuit conditions are expected.
  Hence, the VA rating is low.
- These types of transformers are used for some negative resistance applications such as neon signs, are welding sets.

1.11 (a)

The iron loss at full load is 1000 Watts and maximum efficiency is obtained at full load.
For maximum efficiency
∴ Full load copper loss
$$= I_{fl}^2 \cdot R = 1000 \text{ Watts}$$
$$= \text{iron loss}$$
∴ Half load copper loss
$$= \left(\frac{I_{fl}}{2}\right)^2 \times R$$
$$= \frac{1000}{4} = 250 \text{ Watts}$$

1.12 (b)

A distribution transformer has an average loading of 50-70% of full load and depends on consumer. Hence, these transforms are designed to have maximum efficiency at around 50-70% of full load (strictly at 70-75% of full load).

1.13 (c)

For maximum efficiency
$$P_{cu} = P_i$$
(i.e. variable copper loss = iron loss)

i.e. at η_{max},
$$\text{Total loss} = P_i + P_{cu}$$
$$= P_i + P_i = 2P_i$$
$$\therefore \quad \text{Total loss} = 2 \times 150 \text{ W} = 300 \text{ W}$$

1.14 (b)

Method-1:
For additive polarity connection, the voltage ratio will be equal to $\frac{2000}{2200}$.

Since, $a_{auto} > 1$

So, $a_{auto} = \frac{11}{10}$

∴ Rating of auto transformer is
$$S_{auto} = \left(\frac{a_{auto}}{a_{auto} - 1}\right) \times S_{2W}$$

or,
$$S_{auto} = \left(\frac{11/10}{\frac{11}{10} - 1}\right) \times 20 \text{ kVA} = 220 \text{ kVA}$$

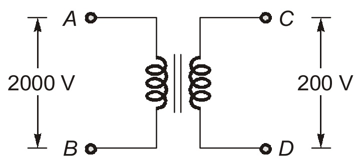
Note: For subtractive polarity $\left(\frac{2000}{1800}\right) = a_{auto}$

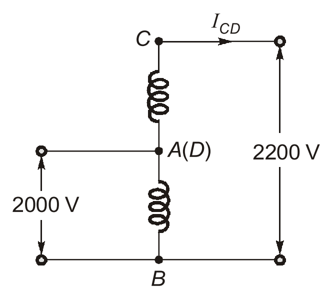
$\therefore \quad a_{auto} = \frac{10}{9} (> 1)$

$$\therefore \quad S_{auto} = \left(\frac{10/9}{\frac{10}{9}-1}\right) \times 20 \text{ kVA} = 200 \text{ kVA}$$

Method-2:

(i) Case-1:





$$I_{CD} = \frac{20 \times 10^3 \text{ VA}}{200 \text{ V}} = 100 \text{ A}$$

$$I_{AB} = \frac{20 \times 10^3 \text{ VA}}{2000 \text{ V}} = 10 \text{ A}$$

S_{auto} = rating of autotransformer

= $(2200) \times I_{CD}$

= 2200×100

= 220 kVA

1.15 (b)

Normally power transformers runs on full load or switched off.

So, it is designed to have maximum efficiency at full load. However for distribution transformer, designing for about 70-75% of full load.

1.16 (a)

Given, $P_{cuFL} = 600 \text{ W} = I_{FL}^2 \cdot R$

$\because$ Copper losses = I^2R losses

i.e., $P_{cu} \ \alpha \ I^2$

At half of full load i.e.,

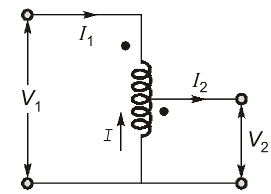
$$I = \frac{I_{FL}}{2}$$

Let, P_{cuHL} = copper loss at half of full load

$$\because \quad \frac{P_{cuFL}}{P_{cuHL}} = \frac{I_{FL}^2 \cdot R}{(I_{FL}/2)^2 \cdot R} = 4$$

$$\Rightarrow \quad P_{cuHL} = \frac{P_{cuFL}}{4} = \frac{600}{4} = 150 \text{ W}$$

1.17 (c)



$$\because \quad \frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{210}{140} = \frac{I_2}{I_1}$$

$\because \quad I_1 = 60 \text{ A}$

$$\therefore \quad I_2 = I_1 \times \frac{210}{140} = 60 \times \frac{210}{140} = 90 \text{ A}$$

So, I (common winding current) = 90 – 60 = 30 A

1.18 (a)

Given, V_1 = 200 V

= phase voltage

= line voltage

($\because$ Δ-connection in primary side)

Δ/Y transformer (Given)

Phase turns ratio:

$$\frac{N_2}{N_1} = 6 = \frac{V_2}{V_1}$$

$$\frac{V_2}{200} = 6 \Rightarrow V_2 = 1200 \text{ V}$$

= phase voltage at secondary

Secondary line voltage

$$= \sqrt{3} V_2 = \sqrt{3} \times 1200 = 2078 \text{ V}$$

1.19 (b)

Given, P_i = 1 kW

P_{cufl} = 2 kW

Load for maximum efficiency,

$$(S_\eta)_{max} = S_{full\ load}\sqrt{\frac{P_i}{P_{cufl}}}$$

$$= 100 \text{ kVA}\sqrt{\frac{1}{2}} = 70.7 \text{ kVA}$$

1.20 (a)

$\because \quad P_i$ = iron loss = $P_h + P_e$

where, P_h = hysteresis loss α fB_m^2

Let, $P_h = A \cdot f$ [A → constant]

P_e = eddy current loss $\alpha\ f^2 B_m^2$

Let, $P_e = B \cdot f^2$ [$B \to$ constant]

Thus, $P_i = Af + Bf^2$

P_i/f = ironless per unit frequency

$= A + Bf$ ...(i)

Equation (i) represents straight line with positive slope since A and B are positive constants.

1.21 (d)

$\because$ $P_h = af$ and $P_e = bf^2$

$P_i = P_h + P_e$

Iron loss is given by

$P_i = af + bf^2$

(where a, b are constants > 0)

$$\frac{P_i}{f} = a + bf = 0.001f + 0.01$$

Since, $a = 0.01$ (Given at $f = 0$)

and $b = 0.001$ = slope

where, P_h = Hysteresis loss

$= af = 0.01 \times 100$

(At $f = 100$ Hz.....Given)

or, P_h = 1 watt

Eddy current loss

$= bf^2 = 0.001 \times (100)^2$

= 10 Watts

1.22 (a)

Eddy current losses are due to circulating currents rise in the iron core,

$$P_e \propto f^2 B_m^2 t^2 \text{ per m}^3$$

where, f = frequency

B_m = maximum flux density

t = thickness of laminations

i.e., $P_e \propto f^2$

1.23 (c)

Hysteresis loss, $P_h \propto f B_m^n$

n = Steinmetz coefficient (> 1)

and eddy current loss, $P_e \propto f^2 B_m^2$

Now, $B_m \propto \phi \propto \dfrac{V}{f}$

(Maximum flux density)

$$\therefore \quad P_h \propto f\left(\frac{V}{f}\right)^n$$

or, $P_h \propto V^n . f^{(1-n)}$

and $P_e \propto f^2 \cdot \dfrac{V^2}{f^2}$

i.e., $P_e \propto V^2$

Thus, if V = constant and f is increased then, hysteresis loss will decrease but eddy current loss will remain unchanged.

1.24 (b)

Given, $r_1 = 0.1\ \Omega$, $r_2 = 0.004\ \Omega$

$$a = \frac{1100}{220} = 5$$

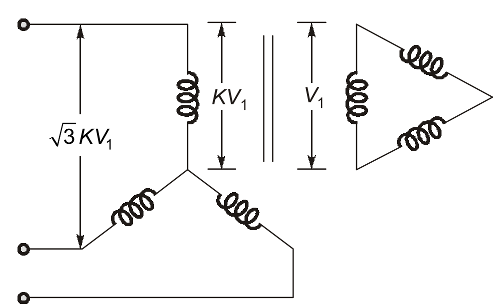
$$(R_{eq})_{HV} = r_1 + a^2 r_2 = 0.1 + (5)^2 \times 0.004 = 0.2\ \Omega$$

and $$(R_{eq})_{LV} = r_2 + \frac{r_1}{a^2} = 0.004 + \frac{0.1}{(5)^2} = 0.008\ \Omega$$

1.25 (c)

Placing HV winding after LV winding is economical as the insulation requirement gets reduced. In other words, LV winding is kept close to the core and HV winding outside to minimise the amount of insulation required.

1.26 (c)



$$\text{Ratio (phase)} = \frac{KV_1}{V_1} = K = \frac{(V_{ph})_Y}{(V_{ph})_\Delta}$$

$$\text{Now,} \quad \frac{(V_{L-L})_Y}{(V_{L-L})_\Delta} = \frac{\sqrt{3}(V_{ph})_Y}{(V_{ph})_\Delta} = \sqrt{3}K$$

1.27 (d)

Auto-transformation ratio,

$$a_A = \frac{V_1}{V_2} = \frac{V_H}{V_L}$$