ESE 2019

PRELIMINARY EXAMINATION

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ELECTRICAL ENGINEERING

ESE TOPICWISE OBJECTIVE
SOLVED PAPER-II

Detailed Solution | Topicwise Description | Fully Revised & Updated

UPSC Engineering Service Examination 2019

ELECTRICAL ENGINEERING

ESE TOPICWISE OBJECTIVE
SOLVED PAPER-II

From (1992 – 2018)

IES MASTER PUBLICATION

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Web : iesmasterpublications.com, iesmaster.org

First Edition : 2017

Second Edition : 2018

Typeset at : IES Master Publication, New Delhi-110016

PREFACE

It is an immense pleasure to present topic wise previous years solved paper of Engineering Services Exam. This booklet has come out after long observation and detailed interaction with the students preparing for Engineering Services Exam and includes detailed explanation to all questions. The approach has been to provide explanation in such a way that just by going through the solutions, students will be able to understand the basic concepts and will apply these concepts in solving other questions that might be asked in future exams.

Engineering Services Exam is a gateway to a immensly satisfying and high exposure job in engineering sector. The exposure to challenges and opportunities of leading the diverse field of engineering has been the main reason for students opting for this service as compared to others. To facilitate selection into these services, availability of arithmetic solution to previous year paper is the need of the day. Towards this end this book becomes indispensable.

Mr. Kanchan Kumar Thakur
Director–IES Master

Note: Direction of all **Assertion Reasoning (A–R)** type of questions covered in this booklet is as follows:

DIRECTIONS:

The following four items consist of two statements, one labelled as **'Assertion A'** and the other labelled as **'Reason R'.** You are to examine these two statements carefully and select the answer to these two statements carefully and select the answer to these items using the codes given below:

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

(b) Both A and R are individually 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.

Note: Direction of all **Statement-I** and **Statement-II** type of questions covered in this booklet is as follows:

DIRECTION:

Following items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the code given below:

(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.

CONTENTS

Unit 1 Electrical Machines and Power Transformers

SYLLABUS

Magnetic Circuits-Analysis and Design of Power transformers. Construction and testing. Equivalent circuits. Losses and efficiency. Regulation. Auto-transformer, 3-phase transformer. Parallel operation.

Basic concepts in rotating machines. EMF, torque, basic machine types. Construction and operation, leakage losses and efficiency.

D.C. Machines. Construction, Excitation methods. Circuit models. Armature reaction and commutation. Characteristics and performance analysis. Generators and motors. Starting and speed control. Testing, Losses and efficiency.

Synchronous Machines. Construction. Circuit model. Operating characteristics and performance analysis. Synchronous reactance. Efficiency. Voltage regulation. Salient-pole machine, Parallel operation. Hunting. Short circuit transients.

Induction Machines. Construction. Principle of operation. Rotating fields. Characteristics and performance analysis. Determination of circuit model. Circle diagram. Starting and speed control.

Fractional KW motors. Single-phase synchronous and induction motors.

Contents

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CHAPTER 1

Transformers

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1. The desirable properties of transformer core material are

(a) low permeability and low hyteresis loss

(b) high permeability and high hysteresis loss

(c) high permeability and low hysteresis loss

(d) low permeability and high hysteresis loss

2. Which of the following acts as a protection against high voltage surges due to lightening and switching?

(a) Breather

(b) Conservator

(c) Horn gaps

(d) Thermal overload relays

3. The efficiency of two identical transformers under load conditions can be determined by

(a) back to back test

(b) open circuit test

(c) short circuit test

(d) any of the above

4. For an ideal transformer the windings should have

(a) maximum resistance on primary side and least resistance on secondary side

(b) least resistance on primary and secondary side

(c) equal resistance on primary and secondary side

(d) no ohmic resistance on either side

5. Two single phase 100 kVA transformers, each having different leakage impedance are connected in parallel. When a load of 150 kVA at 0.8 p.f. lagging is applied

(a) both transformer will operate at power factor more than 0.8 lagging

(b) both transformer will operate at power factor less than 0.8 lagging

(c) one of the transformers will operate at p.f. more than 0.8 lagging and other will operate at p.f. less than 0.8 lagging

(d) both transformers will operate at identical power factors

6. Scott connections are used for

(a) single phase to three phase transformation

(b) three phase to single phase transformation

(c) three phase to two phase transformation

(d) any of the above

7. Two single phase transformers with equal turns have impedance of (0.5 + j0.3) ohms and (0.6 + j1) ohms with respect to the secondary. If they operate in parallel, how will they share a load of 100 kw at 0.8 p.f. lagging?

(a) 50 kW, 50 kW

(b) 62 kW, 38 kW

(c) 78.2 kW, 21.8 kW

(d) 85.5 kW, 14.5 kW

8. The losses on a transformer are

I. Copper losses

II. Eddy current losses

III. Hysteresis losses

The constant power loss of a transformer loss is given by

(a) I only (b) I and II only

(c) II and III only (d) I, II and III

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

(a) Transformer oil of high break down voltage

(b) High reluctance magnetic core

(c) Winding material of high resistivity

(d) Low reluctance magnetic core

10. The secondary of a current transformer under operating conditions is short-circuited to avoid

(a) break in primary winding

(b) insulation break-down

(c) core saturation and high voltage induction

(d) high voltage surge

11. The inductive reactance of a transformer depends on

(a) electromotive force

(b) magneto motive force

(c) magnetic flux

(d) leakage flux

12. Which of the following connection of transformer will give the highest secondary voltage?

(a) Delta primary, delta secondary

(b) Delta primary, star secondary

(c) Star primary, star secondary

(d) Star primary, delta secondary

IES – 1993

13. In a transformer, if the iron losses and copper losses are 40.5 kW and 50 kW respectively, then at what fraction of load will the efficiency be maximum?

(a) 0.8 (b) 0.57

(c) 0.70 (d) 0.9

14. Can a 50Hz transformer be used as 25Hz, if the input voltage is maintained constant at the rated value corresponding to 50Hz?

(a) Yes since the voltage is constant, current levels will not change

(b) No, flux will be doubled which will drive the core to execessive saturation

(c) No, owing to decreased reactance of transformer, input current will be doubled at load

(d) Yes, at constant voltage, insulation will not be overstressed

15. Short-circuit test is performed on a transformer with a certain impressed voltage at rated frequency. If the short-circuit test is now performed with the same magnitude impressed voltage, but at a frequency higher than the rated frequency, then

(a) the magnitude of current and power factor will both increase

(b) the magnitude of current will decrease but the power factor will increase

(c) the magnitude of current will increase but the power factor will decrease

(d) the magnitude of current as well as the power factor will decrease

16. While performing the open-circuit and short-circuit tests on a transformer to determine its parameters, the status of the low voltage (L.V) and high voltage (H.V) winding will be such that

(a) in O.C., L.V. is open and in S.C., H.V. is shorted

(b) in O.C., H.V. is open and in S.C., L.V. is shorted

(c) in O.C., L.V. is open and in S.C., L.V. is shorted

(d) in O.C., H.V. is open and in S.C., H.V. is shorted

IES – 1994

17. A 2kVA transformer has iron loss of 150 watts and full-load copper loss of 250 watts. The maximum efficiency of the transformer would occur when the total loss is

ANSWER KEY

1.	(c)	32.	(d)	63.	(d)	94.	(c)
2.	(c)	33.	(b)	64.	(b)	95.	(a)
3.	(a)	34.	(a)	65.	(a)	96.	(b)
4.	(d)	35.	(c)	66.	(d)	97.	(b)
5.	(c)	36.	(c)	67.	(b)	98.	(c)
6.	(c)	37.	(d)	68.	(d)	99.	(d)
7.	(c)	38.	(c)	69.	(a)	100.	(d)
8.	(c)	39.	(a)	70.	(a)	101.	(b)
9.	(d)	40.	(b)	71.	(a)	102.	(c)
10.	(c)	41.	(b)	72.	(a)	103.	(a)
11.	(b)	42.	(b)	73.	(c)	104.	(d)
12.	(b)	43.	(d)	74.	(d)	105.	(d)
13.	(d)	44.	(c)	75.	(d)	106.	(b)
14.	(b)	45.	(b)	76.	(c)	107.	(d)
15.	(d)	46.	(a)	77.	(b)	108.	(b)
16.	(b)	47.	(b)	78.	(b)	109.	(a)
17.	(c)	48.	(d)	79.	(b)	110.	(c)
18.	(d)	49.	(b)	80.	(d)	111.	(d)
19.	(c)	50.	(d)	81.	(b)	112.	(b)
20.	(b)	51.	(c)	82.	(a)	113.	(a)
21.	(a)	52.	(b)	83.	(a)	114.	(b)
22.	(d)	53.	(a)	84.	(a)	115.	(a)
23.	(b)	54.	(d)	85.	(a)	116.	(a)
24.	(b)	55.	(a)	86.	(c)	117.	(c)
25.	(a)	56.	(b)	87.	(c)	118.	(b)
26.	(c)	57.	(c)	88.	(b)	119.	(b)
27.	(a)	58.	(b)	89.	(a)	120.	(c)
28.	(a)	59.	(d)	90.	(d)	121.	(b)
29.	(d)	60.	(a)	91.	(d)	122.	(d)
30.	(b)	61.	(b)	92.	(d)	123.	(b)
31.	(a)	62.	(c)	93.	(c)	124.	(b)

125. (none)	141. (d)	157. (a)	173. (a)
126. (b)	142. (d)	158. (d)	174. (none)
127. (b)	143. (none)	159. (b)	175. (a)
128. (c)	144. (b)	160. (c)	176. (b)
129. (b)	145. (b)	161. (a)	177. (c)
130. (c)	146. (c)	162. (b)	178. (a)
131. (c)	147. (a)	163. (b)	179. (a)
132. (c)	148. (c)	164. (d)	180. (c)
133. (b)	149. (c)	165. (c)	181. (b)
134. (a)	150. (b)	166. (c)	182. (b)
135. (b)	151. (d)	167. (a)	183. (a)
136. (d)	152. (d)	168. (c)	184. (b)
137. (b)	153. (d)	169. (d)	185. (a)
138. (a)	154. (d)	170. (c)	186. (b)
139. (d)	155. (d)	171. (a)	
140. (d)	156. (a)	172. (a)	

SOLUTION...

Sol–1: (c)

The desirable properties of transformer core material are:

(i) High permeability, so that a very small magnetising current is needed to establish the required flux in the core.

(ii) The core-loss should be low i.e. hysteresis loss and eddy-current loss should be low. For low hysteresis loss, hysteresis loop of the material should be small and for low eddy-current loss, material should have high electrical resistivity.

Sol–2: (c)

Horn gap is used as a protection against high voltage surges due to lightening and switching. For utmost protection to the terminal apparatus, the horn gap should be located as close to the apparatus.

Horn gap consists of two horn-shaped pieces of metal seperated by a small air gap and connected in shunt between each conductor and earth. The distance between the two electrodes is such that the normal voltage between the line and earth is insufficient to jump the gap, but abnormally high voltages will breakdown the gap and so, find a path to earth.

Sol–3: (a)

In back-to-back test or Sumpner's test, two identical transformers are used to determine the ohmic loss and core loss

both, occuring in the transformers. Considering, ohmic loss and iron-loss are the major losses occuring in the transformer, the efficiency can be determined.

Open-circuit test is used to determine the core-loss only.

Short-circuit test is used to determine the ohmic loss only.

Sol–4: (d)

For an ideal transformer

(i) no ohmic resistance on either side of the transformer, so that there is no ohmic loss.

(ii) no leakage reactance on either side, so that all the flux is confined to the core and links both windings (i.e. leakage flux is assumed neglegible)

(iii) no losses in the core.

(iv) permeability of the core is infinite i.e. negligible exciting mmf is required to establish the flux

Sol–5: (c)

For parallel operation of single phase transformer,

$$\bar{I}_a\bar{Z}_a = \bar{I}_b\bar{Z}_b$$

If $|\bar{Z}_a| \neq |Z_b|$ and $\frac{X_{ea}}{R_{ea}} \neq \frac{X_{eb}}{R_{eb}}$

then both transformer will not share the load, proportionally to their kVA rating. The transformer whose impedance is larger, will share less kVA and the transformer which has smaller impedance will share large kVA of load.

Also, both transformer will operate at different power factor i.e. one will operate at power factor greater than the load pf and other at lesser pf of the load.

If $|\bar{Z}_a| \neq |Z_b|$ but $\frac{X_{ea}}{R_{ea}} = \frac{X_{eb}}{R_{eb}}$

Both transformer will operate at same power factor and it will be equal to load power factor.

Sol–6: (c)

Scott connection is used to convert three phase supply to two phase supply. In scott conection, there are two single phase transformers : one having turns ratio N_1/N_2; called main transformer and other having turns ratio $\frac{\sqrt{3}}{2}(N_1/N_2)$; called Teaser transformer. This type of connection is required in arc furnace.

Sol–7: (c)

Given, load = 100 kW at 0.8 pf lagging

i.e. S_L = 125 kVA at $\phi = -36.87^\circ$

Let $Z_1 = (0.5 + j0.3)\Omega = 0.58\angle 30.96^\circ\Omega$

and $Z_2 = (0.6 + j1)\Omega = 1.16\angle 59^\circ\Omega$

Now, load sharing of transformer-1,

$$S_1 = \frac{Z_2}{Z_1 + Z_2} \times S_L^*$$

$$= \frac{1.16\angle 59^\circ}{0.58\angle 30.96 + 1.16\angle 59^\circ} \times (125\angle +36.87^\circ)$$

$$= 85.6\angle +27.6^\circ \text{ kVA}$$

= 85.6 × cos(+27.6°) kW = 75.85 kW

i.e. 75.85kW at 0.886 pf lagging

and, load sharing of transformer-2,

$$S_2 = \frac{Z_1}{Z_1 + Z_2} \times S_L^*$$

$$= \frac{(0.58\angle 30.96)}{(0.58\angle 30.96) + (1.16\angle 59^\circ)} \times (125\angle +36.87^\circ)$$

$$= 42.8\angle +55.64^\circ \text{ kVA}$$

i.e. 42.8 × cos(+55.64°) kW

= 24.15kW at 0.564pf lagging.

Sol–8: (c)

For electrical machines, the constant loss means the losses which do not vary with load. Copper losses are directly proportional to the square of the current and hence depend on loading condition. But core losses which comprises eddy current losses and hysteresis losses

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ISBN 978-93-86383-77-8