

# GATE EE · Set 3: Questions

20 questions · 30 marks · 45 minutes

|                       |                                                                                     |
|-----------------------|-------------------------------------------------------------------------------------|
| <b>Question types</b> | MCQ: one correct option. MSQ: one or more correct options. NAT: numerical answer.   |
| <b>Marking</b>        | MCQ wrong answer: -1/3 (1-mark) or -2/3 (2-mark). No negative marks for MSQ or NAT. |
| <b>Time</b>           | 45 minutes. The answer key and worked solutions start on a new page.                |

## General Aptitude

**Q1.** [MCQ, 1 mark] Doctor : Hospital :: Teacher : ?

- (A) School
- (B) Book
- (C) Student
- (D) Chalk

**Q2.** [NAT, 2 marks] The average of five numbers is 20. When one number is removed, the average of the remaining four becomes 18. The number removed is \_\_\_\_\_.

## Engineering Mathematics

**Q3.** [MCQ, 1 mark] The value of  $\lim_{x \rightarrow 0} \sin(3x)/x$  is

- (A) 0
- (B) 1
- (C) 3
- (D)  $\infty$

**Q4.** [NAT, 2 marks] A box contains 4 red and 6 blue balls. Two balls are drawn at random without replacement. The probability that both are red is \_\_\_\_\_ (rounded to three decimal places).

## Electric Circuits

**Q5.** [NAT, 1 mark] A voltage  $v(t) = 100 \sin(\omega t)$  V is applied across an impedance  $Z = 10 \angle 60^\circ \Omega$ . The average power absorbed is \_\_\_\_\_ W.

**Q6.** [NAT, 2 marks] A T-network has series arms of  $2 \Omega$  (port 1 side) and  $3 \Omega$  (port 2 side) and a shunt arm of  $5 \Omega$ . The value of  $\Delta z = z_{11}z_{22} - z_{12}z_{21}$  is \_\_\_\_\_  $\Omega^2$ .

## Electromagnetic Fields

**Q7.** [MCQ, 1 mark] The SI unit of magnetic flux density is

- (A) Wb
- (B)  $\text{Wb/m}^2$
- (C) A/m
- (D) H/m

**Q8.** [NAT, 1 mark] An air-cored solenoid has 500 turns, length 0.5 m and cross-sectional area  $10 \text{ cm}^2$ . Its inductance is \_\_\_\_\_ mH (rounded to three decimal places).

## Signals and Systems

**Q9.** [NAT, 2 marks] For  $x[n] = \{1, 2, 3\}$  and  $h[n] = \{1, 1\}$ , both starting at  $n = 0$ , the value of the convolution  $y[n] = x[n] * h[n]$  at  $n = 2$  is \_\_\_\_\_.

**Q10.** [MCQ, 1 mark] The Laplace transform of  $e^{-2t}u(t)$  is

- (A)  $1/(s + 2)$ ,  $\text{Re}(s) > -2$
- (B)  $1/(s - 2)$ ,  $\text{Re}(s) > 2$
- (C)  $1/(s + 2)$ ,  $\text{Re}(s) < -2$
- (D)  $s/(s + 2)$ ,  $\text{Re}(s) > -2$

## Electrical Machines

**Q11.** [MCQ, 1 mark] In a three-phase induction motor, the maximum torque is independent of

- (A) rotor resistance
- (B) supply voltage
- (C) rotor reactance
- (D) supply frequency

**Q12.** [NAT, 2 marks] A 20 kVA transformer has iron loss 300 W and full-load copper loss 600 W. Its efficiency at half load and unity power factor is \_\_\_\_\_ % (rounded to one decimal place).

## Power Systems

**Q13.** [NAT, 2 marks] Two generators have incremental costs  $IC_1 = 0.02P_1 + 10$  and  $IC_2 = 0.03P_2 + 8$  (Rs/MWh, P in MW). For a total load of 300 MW, neglecting losses, the economic output of generator 1 is \_\_\_\_\_ MW.

**Q14.** [MCQ, 1 mark] A Buchholz relay is used to protect

- (A) oil-immersed transformers
- (B) alternators
- (C) transmission lines
- (D) busbars

## Control Systems

**Q15.** [MCQ, 2 marks] A second-order system has  $\zeta = 0.6$  and  $\omega_n = 10 \text{ rad/s}$ . Its peak overshoot for a step input is approximately

- (A) 9.5%
- (B) 25%
- (C) 1.5%
- (D) 16.3%

**Q16.** [NAT, 2 marks] For  $G(s)H(s) = 3 / [s(s + 1)(s + 2)]$ , the gain margin (as a ratio, not in dB) is \_\_\_\_\_.

## Electrical & Electronic Measurements

**Q17.** [MCQ, 1 mark] A megger is used to measure

- (A) insulation resistance
- (B) low resistance
- (C) inductance
- (D) earth current

## Analog and Digital Electronics

**Q18.** [NAT, 2 marks] An 8-bit DAC has a full-scale output of 10.2 V for input 11111111. The output for input 10010110 is \_\_\_\_\_ V.

**Q19.** [MSQ, 1 mark] Which of the following are universal gates?

- (A) AND
- (B) NAND
- (C) NOR
- (D) XOR

## Power Electronics

**Q20.** [NAT, 2 marks] An ideal buck converter has  $V_{in} = 48$  V,  $V_o = 12$  V, switching frequency 20 kHz and  $L = 1$  mH. The peak-to-peak inductor current ripple is \_\_\_\_\_ A.

## Set 3: Answer Key and Solutions

| Q  | Type | Marks | Answer                                |
|----|------|-------|---------------------------------------|
| 1  | MCQ  | 1     | (A) School                            |
| 2  | NAT  | 2     | 28                                    |
| 3  | MCQ  | 1     | (C) 3                                 |
| 4  | NAT  | 2     | 0.133 (accept 0.13 to 0.14)           |
| 5  | NAT  | 1     | 250                                   |
| 6  | NAT  | 2     | 31                                    |
| 7  | MCQ  | 1     | (B) Wb/m <sup>2</sup>                 |
| 8  | NAT  | 1     | 0.628 (accept 0.62 to 0.64)           |
| 9  | NAT  | 2     | 5                                     |
| 10 | MCQ  | 1     | (A) $1/(s + 2)$ , $\text{Re}(s) > -2$ |
| 11 | MCQ  | 1     | (A) rotor resistance                  |
| 12 | NAT  | 2     | 95.7 (accept 95.6 to 95.8)            |
| 13 | NAT  | 2     | 140                                   |
| 14 | MCQ  | 1     | (A) oil-immersed transformers         |
| 15 | MCQ  | 2     | (A) 9.5%                              |
| 16 | NAT  | 2     | 2                                     |
| 17 | MCQ  | 1     | (A) insulation resistance             |
| 18 | NAT  | 2     | 6                                     |
| 19 | MSQ  | 1     | (B), (C)                              |
| 20 | NAT  | 2     | 0.45                                  |

### Worked solutions

#### Q1. Answer: (A) School

The relation is person : place of work.

#### Q2. Answer: 28

Sum of five = 100; sum of four = 72; removed number = 28.

#### Q3. Answer: (C) 3

$\sin(3x)/x = 3 \times \sin(3x)/(3x)$ , which tends to  $3 \times 1 = 3$ .

#### Q4. Answer: 0.133 (accept 0.13 to 0.14)

$P = (4/10) \times (3/9) = 12/90 = 0.133$ .

#### Q5. Answer: 250

$V_{\text{rms}} = 70.71 \text{ V}$ ;  $I_{\text{rms}} = 7.071 \text{ A}$ .  $P = V_{\text{rms}} I_{\text{rms}} \cos 60^\circ = 500 \times 0.5 = 250 \text{ W}$ .

#### Q6. Answer: 31

$z_{11} = 2 + 5 = 7$ ,  $z_{22} = 3 + 5 = 8$ ,  $z_{12} = z_{21} = 5$ .  $\Delta z = 56 - 25 = 31$ .

**Q7. Answer: (B)  $\text{Wb/m}^2$** 

Magnetic flux density  $B$  is measured in tesla, which equals  $\text{Wb/m}^2$ .

**Q8. Answer: 0.628 (accept 0.62 to 0.64)**

$$L = \mu_0 N^2 A / l = 4\pi \times 10^{-7} \times 250000 \times 10^{-3} / 0.5 = 0.628 \text{ mH.}$$

**Q9. Answer: 5**

$$y[2] = x[2]h[0] + x[1]h[1] = 3 + 2 = 5.$$

**Q10. Answer: (A)  $1/(s + 2)$ ,  $\text{Re}(s) > -2$** 

Standard pair:  $e^{-at}u(t) \leftrightarrow 1/(s + a)$  with ROC  $\text{Re}(s) > -a$ .

**Q11. Answer: (A) rotor resistance**

$T_{\max} \propto V^2 / (2X_2)$ . Rotor resistance changes only the slip at which  $T_{\max}$  occurs.

**Q12. Answer: 95.7 (accept 95.6 to 95.8)**

Output = 10 kW. Copper loss at half load =  $600 \times 0.25 = 150 \text{ W}$ .  $\eta = 10000 / (10000 + 300 + 150) = 95.7\%$ .

**Q13. Answer: 140**

Equal incremental cost:  $0.02P_1 + 10 = 0.03(300 - P_1) + 8$ , so  $0.05P_1 = 7$ ,  $P_1 = 140 \text{ MW}$  ( $P_2 = 160 \text{ MW}$ ).

**Q14. Answer: (A) oil-immersed transformers**

It detects gas produced by internal faults in oil-filled transformers.

**Q15. Answer: (A) 9.5%**

$$M_p = \exp(-\pi\zeta/\sqrt{1 - \zeta^2}) = \exp(-\pi \times 0.6/0.8) = 0.0948.$$

**Q16. Answer: 2**

Phase crossover ( $\angle G = -180^\circ$ ) occurs at  $\omega = \sqrt{2} \text{ rad/s}$ .  $|G|$  there =  $3/(\sqrt{2} \times \sqrt{3} \times \sqrt{6}) = 0.5$ , so  $\text{GM} = 1/0.5 = 2$ .

**Q17. Answer: (A) insulation resistance**

A megger applies a high DC voltage to measure very high (insulation) resistance.

**Q18. Answer: 6**

Resolution =  $10.2/255 = 0.04 \text{ V}$ .  $(10010110)_2 = 150$ , so output =  $150 \times 0.04 = 6.0 \text{ V}$ .

**Q19. Answer: (B), (C)**

Any Boolean function can be built using only NAND or only NOR gates.

**Q20. Answer: 0.45**

$$D = 12/48 = 0.25. \Delta I = (V_{in} - V_o)D/(fL) = 36 \times 0.25/(20000 \times 0.001) = 0.45 \text{ A.}$$