

GATE EE · Set 1: Questions

20 questions · 30 marks · 45 minutes

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

General Aptitude

Q1. [MCQ, 1 mark] Choose the word that is most nearly OPPOSITE in meaning to EPHEMERAL.

- (A) Transient
- (B) Permanent
- (C) Fleeting
- (D) Brief

Q2. [NAT, 2 marks] Pipe A can fill a tank in 12 hours and pipe B in 15 hours. Pipe C can empty the full tank in 20 hours. If all three pipes are opened together on an empty tank, the time taken to fill it is _____ hours.

Engineering Mathematics

Q3. [MCQ, 1 mark] The eigenvalues of the matrix $A = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$ are

- (A) 2 and 5
- (B) 1 and 6
- (C) -2 and -5
- (D) 3 and 4

Q4. [NAT, 2 marks] The value of $(1/2\pi j) \oint_C z / [(z - 1)(z - 3)] dz$, where the contour is the circle $|z| = 2$ traversed anticlockwise, is _____.

Electric Circuits

Q5. [NAT, 2 marks] A 12 V ideal DC source in series with a 4Ω resistor feeds terminals a-b, across which a 12Ω resistor is connected. A variable load resistor R_L is connected across a-b. The maximum power that can be delivered to R_L is _____ W.

Q6. [MCQ, 1 mark] A series RLC circuit has $R = 10 \Omega$, $L = 10 \text{ mH}$ and $C = 100 \mu\text{F}$. Its resonant frequency and quality factor are

- (A) 159.2 Hz, $Q = 1$
- (B) 1000 Hz, $Q = 1$
- (C) 159.2 Hz, $Q = 10$
- (D) 1000 Hz, $Q = 0.1$

Electromagnetic Fields

Q7. [NAT, 1 mark] A parallel-plate capacitor has plate area 0.01 m^2 , plate separation 1 mm and a dielectric of relative permittivity 5. Taking $\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$, its capacitance is _____ pF.

Q8. [MSQ, 1 mark] Which of the following are valid Maxwell's equations (in point form) for time-varying fields?

- (A) $\nabla \cdot \mathbf{B} = 0$
- (B) $\nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$
- (C) $\nabla \cdot \mathbf{D} = 0$ in all regions
- (D) $\nabla \times \mathbf{H} = \mathbf{J} + \partial \mathbf{D} / \partial t$

Signals and Systems

Q9. [MCQ, 2 marks] The Nyquist sampling rate for the signal $x(t) = \cos(200\pi t) \cdot \cos(300\pi t)$ is

- (A) 300 Hz
- (B) 500 Hz
- (C) 250 Hz
- (D) 1000 Hz

Q10. [NAT, 1 mark] The Laplace transform of a signal $x(t)$ is $X(s) = (5s + 10) / [s(s + 1)(s + 2)]$. The final value of $x(t)$ as $t \rightarrow \infty$ is _____.

Electrical Machines

Q11. [NAT, 1 mark] A 4-pole, 50 Hz, three-phase induction motor runs at 1440 rpm. If the air-gap power is 10 kW, the rotor copper loss is _____ W.

Q12. [NAT, 2 marks] A 10 kVA single-phase transformer has an iron loss of 200 W and full-load copper loss of 400 W. The load at which maximum efficiency occurs is _____ kVA (rounded to two decimal places).

Power Systems

Q13. [NAT, 1 mark] A generator rated 50 MVA, 11 kV has a reactance of 0.2 pu on its own rating. On a base of 100 MVA, 12 kV its reactance is _____ pu (rounded to three decimal places).

Q14. [MCQ, 2 marks] An unloaded generator with $E = 1.0 \text{ pu}$ has $Z_1 = Z_2 = j0.2 \text{ pu}$ and $Z_0 = j0.1 \text{ pu}$ (neutral solidly grounded). The magnitude of fault current for a bolted single line-to-ground fault at its terminals is

- (A) 5.0 pu
- (B) 6.0 pu
- (C) 2.0 pu
- (D) 3.33 pu

Control Systems

Q15. [NAT, 2 marks] A unity-feedback system has open-loop transfer function $G(s) = K / [s(s + 4)]$. The value of K for which the closed-loop damping ratio is 0.5 is _____.

Q16. [MCQ, 1 mark] The system with characteristic equation $s^3 + 2s^2 + Ks + 8 = 0$ is stable for

- (A) $K > 4$
- (B) $K > 2$
- (C) $0 < K < 4$
- (D) $K > 8$

Electrical & Electronic Measurements

Q17. [NAT, 2 marks] In the two-wattmeter method of measuring power in a balanced three-phase load, the readings are $W_1 = 10$ kW and $W_2 = 5$ kW. The power factor of the load is _____ (rounded to three decimal places).

Analog and Digital Electronics

Q18. [NAT, 1 mark] An ideal op-amp is used as a non-inverting amplifier with $R_f = 90$ k Ω and $R_1 = 10$ k Ω . It is powered from ± 12 V supplies and its output saturates at the supply rails. For a DC input of 1.5 V, the output voltage is _____ V.

Q19. [MSQ, 2 marks] A Boolean function is given by $F(A, B, C) = \sum m(1, 3, 5, 7)$. Which of the following statements is/are correct?

- (A) $F = C$
- (B) F is independent of A and B
- (C) $F = A + C$
- (D) $F' = \sum m(0, 2, 4, 6)$

Power Electronics

Q20. [NAT, 2 marks] A single-phase fully-controlled thyristor bridge rectifier is fed from 230 V (rms), 50 Hz. The load current is continuous and ripple-free. For a firing angle of 60° , the average output voltage is _____ V.

Set 1: Answer Key and Solutions

Q	Type	Marks	Answer
1	MCQ	1	(B) Permanent
2	NAT	2	10
3	MCQ	1	(A) 2 and 5
4	NAT	2	-0.5
5	NAT	2	6.75
6	MCQ	1	(A) 159.2 Hz, $Q = 1$
7	NAT	1	442.7 (accept 442 to 443)
8	MSQ	1	(A), (B), (D)
9	MCQ	2	(B) 500 Hz
10	NAT	1	5
11	NAT	1	400
12	NAT	2	7.07 (accept 7.05 to 7.10)
13	NAT	1	0.336 (accept 0.33 to 0.34)
14	MCQ	2	(B) 6.0 pu
15	NAT	2	16
16	MCQ	1	(A) $K > 4$
17	NAT	2	0.866 (accept 0.86 to 0.87)
18	NAT	1	12
19	MSQ	2	(A), (B), (D)
20	NAT	2	103.5 (accept 103 to 104)

Worked solutions

Q1. Answer: (B) Permanent

Ephemeral means lasting a very short time; its opposite is permanent.

Q2. Answer: 10

Net rate = $1/12 + 1/15 - 1/20 = (5 + 4 - 3)/60 = 1/10$ tank per hour, so 10 hours.

Q3. Answer: (A) 2 and 5

Trace = 7, determinant = $12 - 2 = 10$. Roots of $\lambda^2 - 7\lambda + 10 = 0$ are 2 and 5.

Q4. Answer: -0.5

Only $z = 1$ lies inside $|z| = 2$. Residue at $z = 1$ is $1/(1 - 3) = -0.5$.

Q5. Answer: 6.75

$V_{th} = 12 \times 12/16 = 9$ V; $R_{th} = 4 \parallel 12 = 3$ Ω . $P_{max} = V_{th}^2/(4R_{th}) = 81/12 = 6.75$ W.

Q6. Answer: (A) 159.2 Hz, $Q = 1$

$\omega_0 = 1/\sqrt{LC} = 1/\sqrt{10^{-6}} = 1000$ rad/s, so $f_0 = 159.2$ Hz. $Q = (1/R)\sqrt{L/C} = 0.1 \times \sqrt{100} = 1$.

Q7. Answer: 442.7 (accept 442 to 443)

$$C = \epsilon_0 \epsilon_r A/d = 8.854 \times 10^{-12} \times 5 \times 0.01 / 0.001 = 442.7 \text{ pF.}$$

Q8. Answer: (A), (B), (D)

$\nabla \cdot \mathbf{D} = \rho_v$, which is zero only in charge-free regions, so (C) is not valid in general.

Q9. Answer: (B) 500 Hz

The product equals $\frac{1}{2}[\cos(100\pi t) + \cos(500\pi t)]$, with components at 50 Hz and 250 Hz.

Highest frequency 250 Hz, so Nyquist rate = 500 Hz.

Q10. Answer: 5

Poles of $sX(s)$ are at -1 and -2 (left half-plane), so the final value theorem applies: $\lim_{s \rightarrow 0} sX(s) = 10/2 = 5$.

Q11. Answer: 400

$$N_s = 120 \times 50/4 = 1500 \text{ rpm}; s = (1500 - 1440)/1500 = 0.04. \text{ Rotor copper loss} = s \times P_{ag} = 0.04 \times 10000 = 400 \text{ W.}$$

Q12. Answer: 7.07 (accept 7.05 to 7.10)

Maximum efficiency when copper loss = iron loss: $x = \sqrt{(200/400)} = 0.707$, so load = $0.707 \times 10 = 7.07 \text{ kVA}$.

Q13. Answer: 0.336 (accept 0.33 to 0.34)

$$X_{\text{new}} = 0.2 \times (100/50) \times (11/12)^2 = 0.336 \text{ pu.}$$

Q14. Answer: (B) 6.0 pu

$$I_f = 3E/(Z_1 + Z_2 + Z_0) = 3/0.5 = 6 \text{ pu. (5.0 pu would be the three-phase fault current.)}$$

Q15. Answer: 16

Characteristic equation: $s^2 + 4s + K = 0$. $2\zeta\omega_n = 4$ with $\zeta = 0.5$ gives $\omega_n = 4$, so $K = \omega_n^2 = 16$.

Q16. Answer: (A) $K > 4$

Routh array: s^3 : 1, K; s^2 : 2, 8; s^1 : $(2K - 8)/2$; s^0 : 8. Stability needs $2K - 8 > 0$, so $K > 4$.

Q17. Answer: 0.866 (accept 0.86 to 0.87)

$$\tan \phi = \sqrt{3}(W_1 - W_2)/(W_1 + W_2) = \sqrt{3} \times 5/15 = 0.577, \text{ so } \phi = 30^\circ \text{ and pf} = \cos 30^\circ = 0.866 \text{ (lagging).}$$

Q18. Answer: 12

Gain = $1 + 90/10 = 10$, so the ideal output would be 15 V. This exceeds +12 V, so the output saturates at 12 V.

Q19. Answer: (A), (B), (D)

Minterms 1, 3, 5, 7 are exactly those with $C = 1$, so $F = C$, independent of A and B. The complement contains the remaining minterms 0, 2, 4, 6.

Q20. Answer: 103.5 (accept 103 to 104)

$$V_o = (2V_m/\pi) \cos \alpha = (2 \times 230\sqrt{2}/\pi) \times 0.5 = 207.07 \times 0.5 = 103.5 \text{ V.}$$