GATE XE 2007

AI25BTECH11003 - Bhavesh Gaikwad

Section A: Engineering Mathematics (Compulsory)

1) Let $M = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{pmatrix}$. Then the maximum number of linearly independent eigenvectors of M is:

(GATE 2007 XE)

a) 0
b) 1
c) 2
d) 3

2) Let $lim_{x \to \frac{\pi}{2}} \frac{\sin^2(2x)}{\left(x-\frac{\pi}{2}\right)^2}$. Then L is equal to :

(GATE 2007 XE)

a) -4
b) 0
c) 2
d) 4

3) Let $f(z) = \frac{1}{1-z^2}$. The coefficient of $f(z) = \frac{1}{z-1}$ in the Laurent expansion of f(z) about z=1 is:

(GATE 2007 XE)

a) -1
b) $-\frac{1}{2}$
c) $\frac{1}{2}$
d) 1

4) Let u(x,t) be the solution of the initial value problem $\frac{\partial^2 u}{\partial t^2} = 9, \frac{\partial^2 u}{\partial x^2}, ; t > 0, ; -\infty < x < \infty$ $u(x,0) = x + 5, ; \left.\frac{\partial u}{\partial t}\right| (x,0) = 0$. Then u(2,2) is:

(GATE 2007 XE)

a) 7
b) 13
c) 14
d) 26

5) Two students take a test consisting of five TRUE/FALSE questions. To pass the test the students have to answer at least three questions correctly. Both of them know the correct answers to two questions and guess the answers to the remaining three. The probability that only one student passes the test is equal to:

(GATE 2007 XE)

a) $\frac{6}{32}$
b) $\frac{7}{32}$
c) $\frac{1}{4}$
d) $\frac{3}{4}$

6) The equation g(x) = x is solved by Newton-Raphson iteration method, starting with an initial approximation x_n near the simple root a. If x_{n+1} is the approximation to a at the (n+1)th iteration, then:

(GATE 2007 XE)

a) $x_{n+1} = \frac{x_n g'(x_n) - g(x_n)}{1 - g'(x_n)}$
b) $x_{n+1} = \frac{x_n, g'(x_n) - g(x_n)}{g'(x_n) - 1}$
c) $x_{n+1} = g(x_n)$
d) $x_{n+1} = \frac{x_n, g'(x_n) - g(x_n) + 2x_n}{g'(x_n) + 1}$

7) Let Ax = b be a system of m linear equations in n unknowns with m ¡ n and $b \neq 0$. Then the system has:

(GATE 2007 XE)

a) n - m solutions
b) either zero or infinitely many solutions
c) exactly one solution
d) n solutions

8) Let R be an $n \times n$ nonsingular matrix. Let P and Q be two $n \times n$ matrices such that $Q = R^{-1}PR$. If x is an eigenvector of P corresponding to a nonzero eigenvalue λ of P, then:

(GATE 2007 XE)

a) Rx is an eigenvector of Q corresponding to eigenvalue λ of Q
b) Rx is an eigenvector of Q corresponding to eigenvalue $\frac{1}{\lambda}$ of Q
c) $R^{-1}x$ is an eigenvector of Q corresponding to eigenvalue λ of Q
d) $R^{-1}x$ is an eigenvector of Q corresponding to eigenvalue $\frac{1}{\lambda}$ of Q

9) Let M be a 2×2 matrix with eigenvalues 1 and 2. Then M^{-1} is:

(GATE 2007 XE)

a) $M - 3I$
b) $3I - M$
c) $2I - M$
d) $M^{-1} - 3I$

10) The number of $n \times n$ matrices that are simultaneously Hermitian, unitary and diagonal is:

(GATE 2007 XE)

a) 2^n
b) n^2
c) $2n$
d) 2

11) Let $M = \begin{pmatrix} 1 & b & a \\ 0 & 2 & c \\ 0 & 0 & 1 \end{pmatrix}$, where a, b, c are real numbers. Then M is diagonalizable:

(GATE 2007 XE)

a) for all values of a, b, c
b) only when $bc \neq a$
c) only when b + c = a
d) only when bc = a

12) The maximum value of the function 2x + 3y + 4z on the ellipsoid $2x^2 + 3y^2 + 4z^2 = 1$ is:

(GATE 2007 XE)

a) 2
b) 3
c) 6
d) 9

13) Let $f : \mathbb{R} \to \mathbb{R}$ be a twice differentiable real valued function such that $f\left(\frac{1}{n}\right) = 1$ for $n = 1, 2, 3, \ldots$. Then:

(GATE 2007 XE)

a) $f'(0) = 0$
b) $f'(0) = 1$
c) $0 < f'(0) < 1$
d) $f'(0) > 1$

14) Let $f(x) = \int_0^{\sqrt{x}} \sin t \, dt$ for $x \geq 0$. Then $f'\left(\frac{x}{2}\right)$ is equal to:

(GATE 2007 XE)

a) 0
b) π
c) 1
d) $\frac{\pi}{2}$

15) The value of the contour integral $\oint_{|z|=1} \frac{4z^2+1}{\cosh z} \, dz$ is equal to:

(GATE 2007 XE)

a) $2\pi i \cosh(i/2)$
b) $\pi \cosh(i/2)$
c) 0
d) $2\pi i$

16) Let $f(x+iy) = u(x,y) + iv(x,y)$ be an analytic function defined on the complex plane satisfying $2u^2 + 3v^2 = 1$. Then:

(GATE 2007 XE)

a) f is a constant
b) f(z) = kz for some nonzero real k
c) $u(x,y) = \frac{\cos(x+y)}{\sqrt{2}}$
d) $v(x,y) = \frac{\sin(x-y)}{\sqrt{3}}$

17) The value of $\oint_C \left(xy^2 + 2x\right) dx + \left(x^2 y + 4x\right) dy$ along the circle $C : x^2 + y^2 = 4$ in the anticlockwise direction is:

(GATE 2007 XE)

a) -16π
b) -4π
c) 4π
d) 16π

18) The volume of the prism whose base is the triangle in the xy-plane bounded by the x-axis and the lines y = x and x = 2 , and whose top lies in the plane z = 5 - x - y is:

(GATE 2007 XE)

a) 2
b) 4
c) 6
d) 10

19) The general solution of $x\frac{\partial z}{\partial x}(z^2-y^2)+(x-2)\frac{\partial z}{\partial y}=(-x)\frac{\partial z}{\partial z}$ is:
(GATE 2007 XE)

a) $F(x^2+y^2+z^2, xyz)=0$
b) $F(x^2+y^2-z^2, xyz)=0$
c) $F(x^2-y^2+z^2, xyz)=0$
d) $F(-x^2+y^2+z^2, xyz)=0$

20) Choose a point uniformly at random on the disc $x^2+y^2\leq 1$. Let the random variable X denote the distance of this point from the center of the disc. Then the variance of X is:
(GATE 2007 XE)

a) $\frac{1}{16}$
b) $\frac{1}{17}$
c) $\frac{1}{18}$
d) $\frac{1}{19}$

21) If Runge–Kutta method of order 4 is used to solve the differential equation $\frac{dy}{dx}=f(x)$, y(0) = 0, in the interval [0,h] with step size h, then:
(GATE 2007 XE)

a) $y(h)=\frac{h}{6}[f(0)+4f(h/2)+f(h)]$
b) $y(h)=\frac{h}{6}[f(0)+f(h)]$
c) $y(h)=h[f(0)+f(h)]$
d) $y(h)=\frac{h}{6}[f(0)+2f(h/2)+f(h)]$

22) If a polynomial of degree three interpolates a function f(x) at the points (0,3), (1,13), (3,99), (4,187), then f(2) is:
(GATE 2007 XE)

a) 20
b) 36
c) 43
d) 58

23) Let $f(x)=x^2$ for $-\pi\leq x\leq\pi$ and f(x+2π) = f(x). The Fourier series of f in $[-\pi,\pi]$ is:
(GATE 2007 XE)

a) $\frac{\pi^2}{3}+4\sum_{n=1}^{\infty}\frac{\cos nx}{n^2}$
b) $\frac{\pi^2}{3}+4(-1)^n\sum_{n=1}^{\infty}\frac{\cos nx}{n^2}$
c) $\frac{\pi^2}{3}+4(-1)^n\sum_{n=1}^{\infty}\frac{\cos nx}{n^2}$
d) $\frac{\pi^2}{3}+\sum_{n=1}^{\infty}\frac{\cos nx}{n^2}$

24) The sum of the absolute values of the Fourier coefficients of f is:

(GATE 2007 XE)

a) $\frac{\pi^2}{6}$
b) $\frac{\pi^2}{3}$
c) $\frac{2\pi^2}{3}$
d) π^2

25) Let $y(x) = \sum_{n=0}^{\infty} a_n x^n$ be a solution of $\frac{d^2y}{dx^2} + xy = 0$. The value of a_n is:

(GATE 2007 XE)

a) 0
b) 1
c) 2
d) 3

26) The solution of the above differential equation satisfying y(0) = 1 and y'(0) = 0 is:

(GATE 2007 XE)

a) $y(x) = 1 + \frac{x^2}{2! \cdot 3} - \frac{x^4}{2 \cdot 3 \cdot 5 \cdot 6} + \dots$
b) $y(x) = 1 - \frac{2 \cdot 3x^2}{1} + \dots$
c) $y(x) = 1 + \dots$
d) $y(x) = 1 - \dots$

27) The potential u(x,y) satisfies $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ in $0 \leq x \leq \pi$, $0 \leq y \leq \pi$, with u = 0 on x = 0 , $x = \pi$, y = 0 and nonzero at $y = \pi$. The potential is:

(GATE 2007 XE)

a) $u = \sum A_n \cosh(nx) \sin(ny)$
b) $u = \sum A_n \sin(nx) \cosh(ny)$
c) $u = \sum A_n \sinh(nx) \sin(ny)$
d) $u = \sum A_n \sin(nx) \sinh(ny)$

28) If $y = \pi$ edge is at potential sin(x), then:

(GATE 2007 XE)

a) $u = \frac{\sin(nx)\sinh(ny)}{\sinh(n\pi)}$
b) $u = \frac{\sin x \sinh y}{\sinh \pi}$
c) $u = \frac{\sin x \cosh y}{\cosh \pi}$
d) $u = \frac{\cosh(nx)\sin(ny)}{\cosh(n\pi)}$

—END OF SECTION—

Section B: Computational Science

1) If the 7-base representation of a number is 123, then its octal representation is:

(GATE 2007 XE)

a) 102
b) 103
c) 111
d) 112

2) Consider the following four FORTRAN statements:
S1: X = 5**3
S2: X = (-5)**3.0
S3: X = 5**-3
S4: X = 5**3.0
Which of the following sets contains the valid statements from above?:

(GATE 2007 XE)

a) {S1, S3}
b) {S1, S4}
c) {S2, S3}
d) {S2, S4}

3) Which of the following sets contains the set of the basic data types in C?:

(GATE 2007 XE)

a) {char, int, float, logical}
b) {char, boolean, int, float}
c) {char, int, long, short, float, double}
d) {char, int, float, void}

4) If a root of $f(x) = x^2 - 2x + 1 = 0$ is obtained by using iteration $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$ with $x_0 = 0.5$, the convergence rate is:

(GATE 2007 XE)

a) 1
b) 1.62
c) 1.84
d) 2

5) Let S_1 be the sum of the eigenvalues of a 2×2 matrix P and S_2 the sum of eigenvalues of another 2×2 matrix Q. If $S_1 = S_2$, then P and Q are:

(GATE 2007 XE)

a) $\begin{pmatrix} 4 & 1 \\ 3 & 5 \end{pmatrix}$ and $\begin{pmatrix} 3 & 2 \\ 3 & 5 \end{pmatrix}$

b) $\begin{pmatrix} 3 & 4 \\ 5 & 1 \end{pmatrix}$ and $\begin{pmatrix} 3 & 4 \\ 5 & 1 \end{pmatrix}$

c) $\begin{pmatrix} 4 & 1 \\ 3 & 5 \end{pmatrix}$ and $\begin{pmatrix} 3 & 1 \\ 5 & 1 \end{pmatrix}$

d) $\begin{pmatrix} 4 & 3 \\ 5 & 5 \end{pmatrix}$ and $\begin{pmatrix} 4 & 3 \\ 5 & 5 \end{pmatrix}$

6) If y_i denotes the value of y(x) at x = x_i in $x_0 < x_1 < \cdots < x_n$, $x_i - x_{i-1} = h$ for $1 \leq i \leq n$, then $\frac{d^2y}{dx^2}$ at $x = x_i$ is approximated using finite differences by:

(GATE 2007 XE)

a) $\frac{y_{i+1}-2y_i+y_{i-1}}{h^2}$
b) $\frac{y_{i+1}-y_i+y_{i-1}}{h^2}$
c) $\frac{y_{i+1}-2y_i+y_{i-1}}{2h}$
d) $\frac{y_{i+1}-y_i+y_{i-1}}{2h^2}$

7) The minimum number of terms required in e^x series expansion to evaluate at x = 1 correct up to 3 decimal places is:

(GATE 2007 XE)

a) 8
b) 7
c) 6
d) 5

8) The iteration $x_{n+1} = \frac{1}{1+x_n^2}$ converges to a real number x in the interval (0,1) with $x_0 = 0.5$. The value of x correct up to 2 decimal places is:

(GATE 2007 XE)

a) 0.65
b) 0.68
c) 0.73
d) 0.80

9) If the diagonal elements of a lower triangular square matrix A are all $\neq 0$, then A will always be:

(GATE 2007 XE)

a) symmetric
b) non-symmetric
c) singular
d) non-singular

10) If two eigenvalues of the matrix $M = \begin{pmatrix} 2 & 6 & 0 \\ 1 & p & 0 \\ 0 & 0 & 3 \end{pmatrix}$ are -1 and 4, then p is:

(GATE 2007 XE)

a) 4
b) 2
c) 1
d) -1

11) Consider the system:
x + 10y = 5
y + 5z = 1
10x - y + z = 0
On applying Gauss–Seidel method, x correct up to 4 decimal places is:

(GATE 2007 XE)

a) 0.0385
b) 0.0395
c) 0.0405
d) 0.0410

12) The graph y = f(x) passes through (0,-3), (1,-1), (2,3). Using Lagrange interpolation, the x-value where y = 0 is:

(GATE 2007 XE)

a) 1.375
b) 1.475
c) 1.575
d) 1.675

13) The equation of the best fit line (least squares) for: x : 1 2 3 4 5, y : 14 13 9 5 2 is:

(GATE 2007 XE)

a) y = 18 - 3x
b) y = 18.1 - 3.1x
c) y = 18.2 - 3.2x
d) y = 18.3 - 3.3x

14) Solve $\frac{dy}{dx} = xy^2$, y(1) = 1 by Euler's method, step h = 0.1, find y(1.2):

(GATE 2007 XE)

a) 1.1000
b) 1.1232
c) 1.2210
d) 1.2331

15) The local error of scheme: $y_{n+1} = y_n + \frac{h}{12}(5y_{n+1} + 8y_n - y_{n-1})$ by comparison with Taylor series is:

(GATE 2007 XE)

a) O(h)
b) $O(h^2)$
c) $O(h^3)$
d) $O(h^4)$

16) The area between $y = 1 - x^2$ and x-axis from x = -1 to x = 1 using Trapezoidal rule with h = 0.5 is:

(GATE 2007 XE)

a) 1.20
b) 1.23
c) 1.25
d) 1.33

17) Iteration: $x_{n+1} = \sqrt{a}\left(1 + \frac{1}{3a^2}\right)$, $a > 0$ converges to:

(GATE 2007 XE)

a) $\sqrt{a}$
b) a
c) $\sqrt[3]{a}$
d) a^2

18) If $m = 01001101_2$, $n = 00101011_2$, then $m - n$ in binary is:

(GATE 2007 XE)

a) 00010010
b) 00100010
c) 00111101
d) 00100001

19) Which of the following C-program statements are true?
P: Local variable is used only within its block and sub-blocks.
Q: Global variables are declared outside all blocks.
R: Extern variables are used for sharing between compilation units.
S: Default all global variables are extern.:

(GATE 2007 XE)

a) P, Q
b) P, Q, R
c) P, Q, S
d) P, Q, R, S

20) Recursive function:

```
integer function g(m,n)
if (n == 0) then
r = m
else if (m ¡= 0) then
r = n + 1
else if ((n - n/2*2) == 1) then
r = g(m-1, n+1)
else
r = g(m-2, n/2)
end if
```

If called with (6,6), returns:

(GATE 2007 XE)

a) 2
b) 4
c) 6
d) 8

21) Function:

```
real function print_value(x)
i = 0; sum = 2.0; term = 1.0
do while (term > 0.00001)
term = x * term / (i+1)
sum = sum + term
i = i + 1
end do
```

Called with x = 1 outputs close to:

(GATE 2007 XE)

a) ln2
b) ln3
c) 1 + e
d) e

22) C-program:

```
char s[80], *p;
int sum = 0;
p = s;
gets(s);
while (*p)
if (*p == '1') sum = 2*sum + 1;
else if (*p == '0') sum = sum * 2;
else printf("invalid string");
p++;
printf("%d", sum);
```

Input 10110 outputs:

(GATE 2007 XE)

a) 31
b) 28
c) 25
d) 22

23) Given:

```
int m[3] =  1,3,5, 7,9,11, 13,15,17 ;
sum=0;
for (i=0; i<3; i++)
for (j=2; j>1; j–)
```

```
sum += m[i][j]*m[i][j-1];
prints sum = ?:
```

(GATE 2007 XE)

a) 369
b) 361
c) 303
d) 261

24) Values printed after calling:

```
void print_mat(int mat[][3]) {
int (*p) = &mat[1];
printf(”%d and %d”, (*p)[1], (*p)); } :
```

(GATE 2007 XE)

a) 3 and 5
b) 7 and 9
c) 9 and 11
d) 13 and 15

25) Quadrature formula: $\int_0^1 f(x)\,dx \approx \frac{1}{8}\left[f(0) + 2bf(0.25) + 2f(0.5) + 2df(0.75) + f(1)\right]$. If used as Simpson's $\frac{1}{3}$ rule:

(GATE 2007 XE)

a) b = d = 1
b) b = d = 2
c) b = 2d = 1
d) b = 2d = 2

26) Using b, d from Q25, $\int_0^1 \frac{dx}{1+x}$ correct to 4 decimal places is:

(GATE 2007 XE)

a) 0.3091
b) 0.3121
c) 0.3151
d) 0.3191

27) Solve $\frac{dy}{dx} = f(x, y) = 2xy$, y(0) = 1, y(0.2) = 1.0408 , y(0.4) = 1.1735, y(0.6) = 1.4333. Predictor scheme:

(GATE 2007 XE)

a) $y_{n+1} = y_n + \frac{4h}{3}(2f_{n-1} - f_{n-2} + 2f_{n-3})$
b) $y_{n+1} = y_{n-3} + 3\frac{h}{4}(2f_{n-2} - f_{n-1} + 2f_n)$
c) $y_{n+1} = y_{n-1} + \frac{h}{3}(4f_n - 5f_{n-1} + 4f_{n+1})$
d) $y_{n+1} = y_{n-3} + \frac{h}{4}(2f_{n-1} - f_{n-2} + 2f_{n-3})$

28) Using correct predictor from Q27, y(0.8) =:

(GATE 2007 XE)

a) 1.8680
b) 1.8750
c) 1.8890
d) 1.9055

—END OF SECTION—

1) Assuming all components are ideal, the average power delivered by the DC voltage source in the network is:

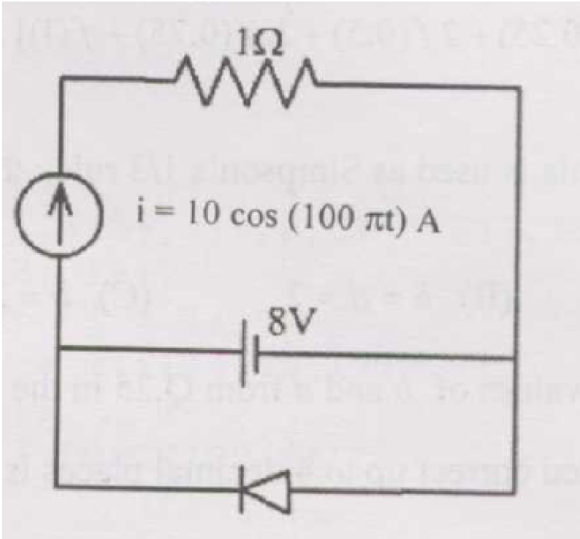


Fig. 1).1: Circuit

(GATE 2007 XE)

a) -28W
b) 0W
c) 64W
d) 80W

2) An ideal transformer with 10 turns in primary and 30 turns in secondary has its primary connected to external circuits as shown. The current provided from the sinusoidal voltage source is:

(GATE 2007 XE)

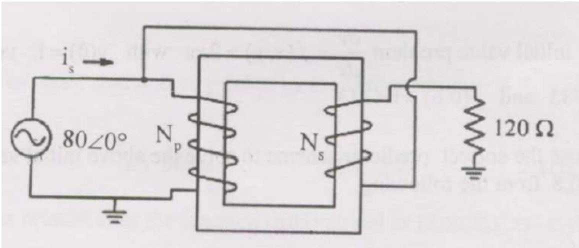


Fig. 2).1: Transformer

a) $0.67\angle 0°$
b) $2.0\angle 0°$
c) $2.67\angle 0°$
d) $10.67\angle 0°$

3) In a three-phase, Y-connected squirrel cage induction motor, if N_s is synchronous speed, N_r is rotor speed and s is slip, then speeds of airgap field and rotor field w.r.t. stator structure will be respectively:

(GATE 2007 XE)

a) N_s, N_s
b) N_r, N_s
c) N_r, N_r
d) N_s, N_r

4) The equivalent conductance of a forward biased diode at room temperature is:

(GATE 2007 XE)

a) constant
b) proportional to V
c) proportional to V^2
d) proportional to $\exp(KV)$

5) An 8-bit signed magnitude number $(10101010)_2$ represents the decimal:

(GATE 2007 XE)

a) -42
b) -85
c) -86
d) -176

6) A 10-bit DAC with full-scale $5\,V$ has resolution and step size respectively:

(GATE 2007 XE)

a) 0.0978%, 500 mV
b) 0.0978%, 4.88 mV
c) 0.195%, 9.76 mV
d) 0.195%, 500 mV

7) A power source has open circuit voltage 24 V and short circuit current 16 A. Terminal characteristics shown below: (GATE 2007 XE)

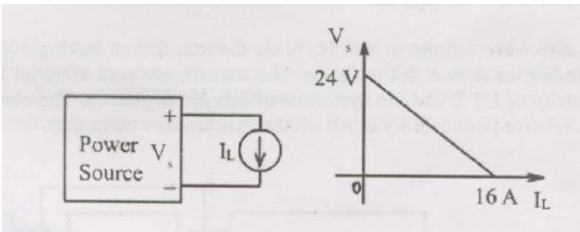


Fig. 7).1: Circuit

a) Load current = 16 A
b) Source voltage = 24 V
c) Load power = 96 W
d) Load power = 384 W

8) A 100 kVA, 11 kV/415 V transformer with 2% winding resistance and 4% leakage reactance. Voltage regulation at rated KVA, 0.8 pf lagging load is:

(GATE 2007 XE)

a) 2%
b) 4%
c) 4.8%
d) 6%

9) Source voltage of three-phase network is 11 kV. Line voltage at load end and phase angle w.r.t source voltage:

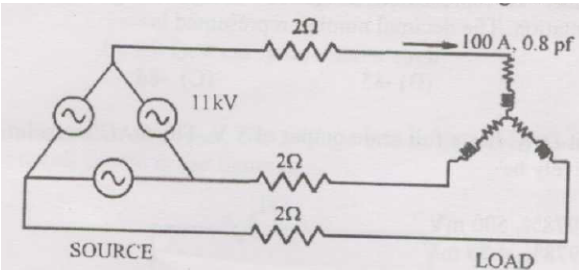


Fig. 9).1: Network

(GATE 2007 XE)

a) 10.7 kV, 0°
b) 10.7 kV, 1.08° lagging
c) 10.7 kV, 1.08° leading
d) 11 kV, 1.08° lagging

10) A sine-wave voltage at 400 Hz feeds a transformer with 50 primary turns, core saturation flux density 1.2 T, core area 10 cm^2, relative permeability 1000. Max amplitude without saturation is: (GATE 2007 XE)

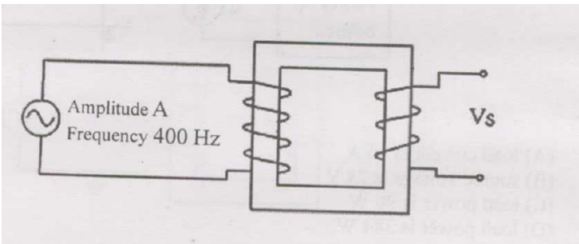


Fig. 10).1: Transformer

a) 24 V
b) 48 V
c) 75.4 V
d) 150.8 V

11) A 415 V/240 V, 1 kVA, 50 Hz transformer has leakage reactance 4%. Leakage inductance of secondary winding is: (GATE XE 2007)

a) 7.3 mH
b) 21.9 mH
c) 183 mH
d) 2300 mH

12) Transformer with 100 turns primary and 50 turns secondary on C core with 1.0 mm airgap, core area 1.0 cm^2, primary connected to $v_p = 10\cos(2000\pi t)$V. Peak MMF of primary winding is: (GATE 2007 XE)

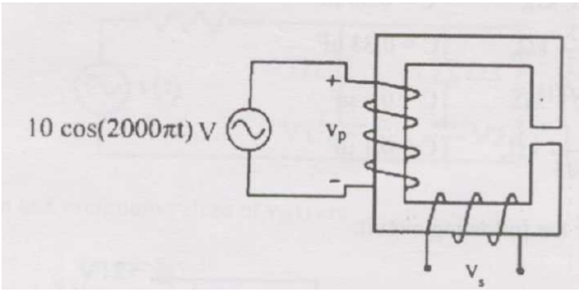


Fig. 12).1: Transformer

a) 126.65 AT
b) 253.3 AT
c) 314 AT
d) 1000 AT

13) PMDC generator armature resistance 0.5 Ω, speed 600 rpm, voltage 60 V. When armature connected to 150 V DC source, starting current and line current at 1200 rpm are:

(GATE 2007 XE)

a) 120 A, 60 A
b) 300 A, 60 A
c) 120 A, 120 A
d) 300 A, 120 A

14) 4-pole DC machine with lap wound armature radius 14.2 cm, length 26.3 cm, poles cover 80% armature, 39 coils 5 turns each, flux per pole is:

(GATE 2007 XE)

a) 15.95 mWb
b) 31.9 mWb
c) 39.9 mWb
d) 63.8 mWb

15) DC shunt motor at 1400 rpm fed by 220 V DC, line current 101 A, field resistance 220 Ω, armature resistance 0.2 Ω. Mechanical power developed:

(GATE 2007 XE)

a) 22.22 kW
b) 22 kW
c) 20 kW
d) 2 kW

16) A transistor oscillator uses a 3-section RC phase shift circuit. Oscillation frequency 10 k rad/s, suitable R and C values are:

(GATE 2007 XE)

a) $R = 3\,k\Omega,\ C = 0.33\,\mu F$
b) $R = 1\,k\Omega,\ C = 0.33\,\mu F$
c) $R = \frac{1}{\sqrt{3}}\,k\Omega,\ C = 0.1\,\mu F$
d) $R = 1\,k\Omega/\sqrt{3},\ C = 0.1\,\mu F$

17) For transistor circuit given, $\beta = 50$, $C \to \infty$. The quiescent collector current I_{CQ} is:

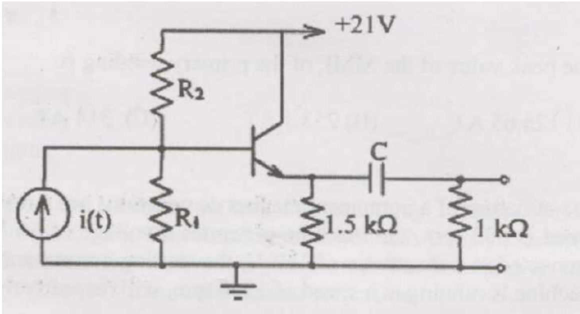


Fig. 17).1: Transistor Circuit

(GATE 2007 XE)

a) 7 mA
b) 10 mA
c) 14 mA
d) 35 mA

18) The CMOS circuit shown below represents: (GATE 2007 XE)

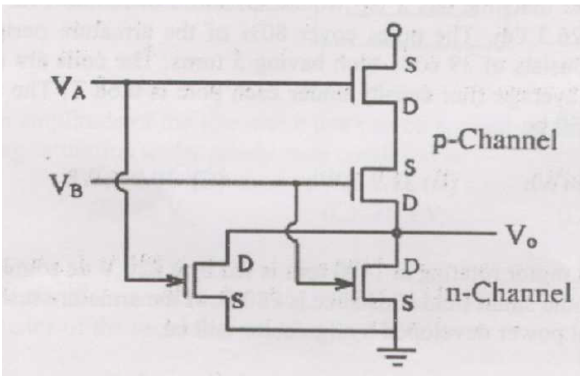


Fig. 18).1: CMOS circuit

a) AND gate
b) NAND gate
c) OR gate
d) NOR gate

19) In the circuit below, $v(t) = 3\cos\omega t$, diode cut-in voltage 0.7 V, $V_1 = 2V$, $V_2 = 1V$. Max and min values of $v_o(t)$ are: (GATE 2007 XE)

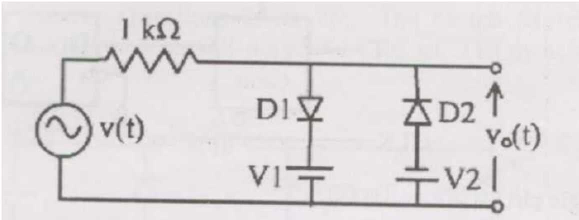


Fig. 19).1: Circuit

a) +2.3 V, -1.7 V
b) +2.7 V, -1.7 V
c) +1.3 V, -0.3 V
d) +2.3 V, -1.3 V

20) Given $v(t) = 2\cos 2000\pi t$ and ideal op-amp as shown, current $i_x(t)$ in 5 kΩ resistor is: (GATE 2007 XE)

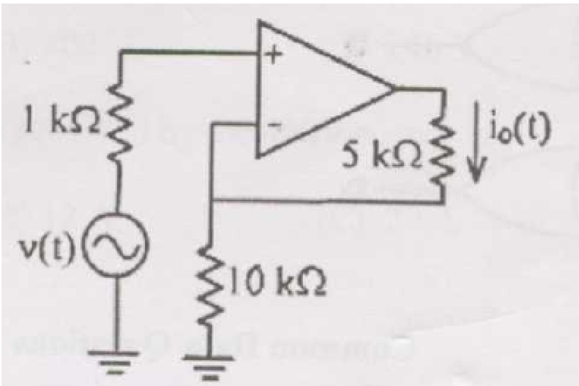


Fig. 20).1: Circuit

a) 0.66 mA $\cos 2000\pi t$
b) 0.33 mA $\cos 2000\pi t$
c) 0.2 mA $\cos 2000\pi t$
d) 0.1 mA $\cos 2000\pi t$

21) Simplified logic expression of circuit shown is: (GATE 2007 XE)

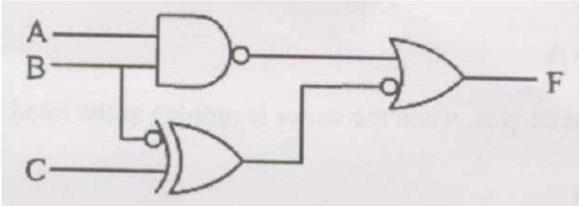


Fig. 21).1: Logic Gate

a) AB + BC
b) AB + C
c) A + B + C
d) $\overline{A + B + C}$

22) A D flip-flop is converted to T flip-flop by a logic circuit shown. The logic circuit is: (GATE 2007 XE)

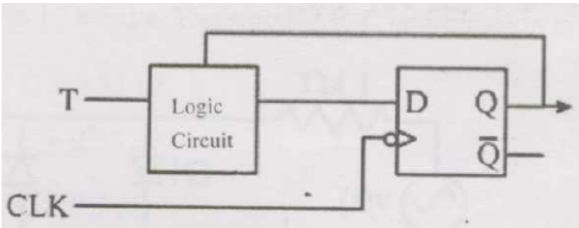
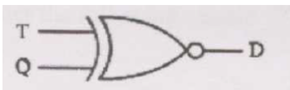
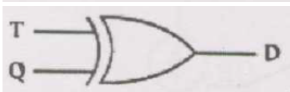
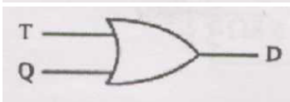


Fig. 22).1: Logic Circuit

a) 

b) 

c) 

d) 

23) Three-phase, 4-pole, 400 V, 50 Hz, Y-connected induction motor with parameters $R_2 = 0.35\Omega$, $X_2 = 0.25\Omega$, $X_m = 25\Omega$. Stator impedance and iron loss neglected. Starting current for direct-on-line start is:

(GATE 2007 XE)

a) 542.36 A
b) 659.83 A
c) 939.4 A
d) 1142.85 A

24) Full load current at rated speed is:

(GATE 2007 XE)

a) 13.88 A
b) 24.04 A
c) 33.99 A
d) 41.64 A

25) The switch S_1 turns on/off repeatedly at 20 kHz, with ON duration 20 μs. Switch & diode ideal. The average load voltage V_o is: (GATE 2007 XE)

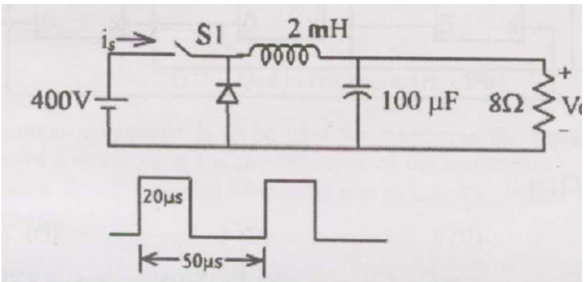


Fig. 25).1: Circuit

a) 667 V
b) 400 V
c) 240 V
d) 160 V

26) Average source current I_s provided by 400 V source is: (GATE 2007 XE)

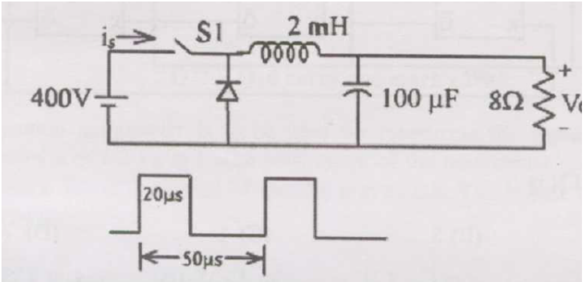


Fig. 26).1: Circuit

a) 8 A
b) 12 A
c) 20 A
d) 160 A

27) Divide by N counter using J-K flip-flops shown below. The value of N is:

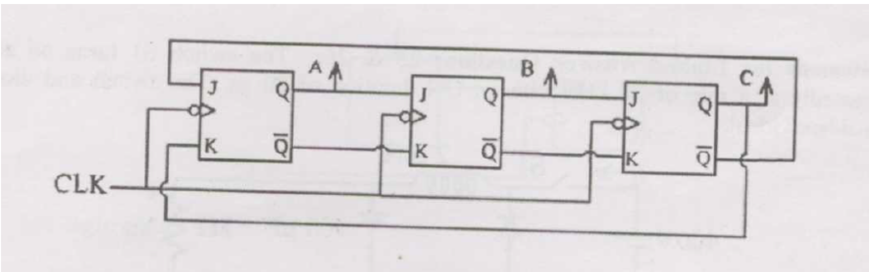


Fig. 27).1: Circuit

(GATE 2007 XE)
a) 4
b) 5
c) 6
d) 7

28) Counter output (Q27) goes to 3-to-8 decoder, LEDs as shown. LEDs that never glow are:

(GATE 2007 XE)

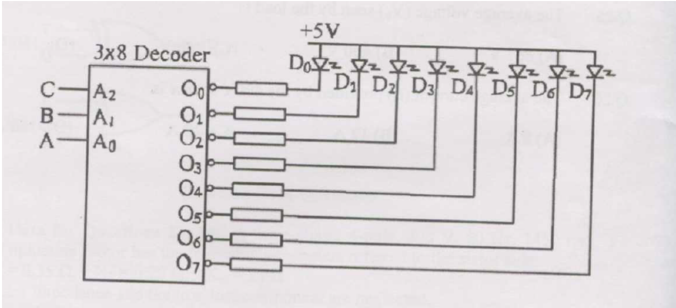


Fig. 28).1: LED Circuit

a) D_0 and D_7
b) D_0 and D_2
c) D_2 and D_5
d) D_5 and D_7

—END OF SECTION—

SECTION D: FLUID MECHANICS

1) A projection manometer measures the dynamic pressure of an airstream (ρ = $1.2\,\text{kg/m}^3$). The manometric liquid is alcohol (specific gravity 0.8), least count 0.1 mm, $g = 10\,\text{m/s}^2$, water density $\rho = 1000\,\text{kg/m}^3$. The lowest measurable velocity is:

(GATE 2007 XE)

a) $\sqrt{3}/2\,\text{m/s}$
b) $2/\sqrt{3}\,\text{m/s}$
c) $\sqrt{3}\,\text{m/s}$
d) $2\,\text{m/s}$

2) The velocity of sound:

(GATE 2007 XE)

a) is a thermodynamic state variable
b) is constant for a particular fluid
c) depends on the velocity field
d) depends on laminar or turbulent flow

3) The mass balance equation
$\frac{\partial\rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} = 0$ holds for:

(GATE 2007 XE)

a) steady/unsteady, compressible/incompressible
b) steady/unsteady, compressible only
c) steady/unsteady, incompressible only
d) steady, compressible or incompressible

4) The non-dimensional number from specific heat c, thermal conductivity k, and viscosity μ is:

(GATE 2007 XE)

a) $\frac{kc_p}{\mu}$
b) $\sqrt{\frac{ku}{c_p}}$
c) $\frac{k\mu}{c_p}$
d) $\frac{\mu c}{k}$

5) In a turbulent boundary layer, wall shear stress is $\tau_w = \mu \left.\frac{du}{dy}\right|_{\text{wall}}$, where u is velocity parallel to the wall, y is perpendicular. Here, μ denotes:

(GATE 2007 XE)

a) molecular viscosity
b) turbulent eddy viscosity
c) effective viscosity greater than molecular
d) effective viscosity less than molecular

6) Flow separation may occur if the flow is:

(GATE 2007 XE)

a) viscous, positive streamwise pressure gradient
b) viscous, negative streamwise pressure gradient
c) inviscid, positive streamwise pressure gradient
d) inviscid, negative streamwise pressure gradient

7) A solid sphere and hollow cube have the same surface area. The buoyancy force ratio (sphere:cube), fully submerged, is:

(GATE 2007 XE)

a) $\frac{\pi^2}{4}$
b) $\frac{\pi}{6}$
c) $\frac{\pi}{8}$
d) $\frac{\pi}{67}$

8) For steady 2D incompressible flow, if temperature $T(x, y)$ is constant along a streamline, the streamline equation is:

(GATE 2007 XE)

a) $\frac{\partial T}{\partial x} = \frac{\partial T}{\partial y} \cdot \frac{dy}{dx}$
b) $\frac{\partial T}{\partial x} \cdot \frac{dy}{dx} = \frac{\partial T}{\partial y}$
c) $\frac{\partial T}{\partial y} \cdot \frac{dy}{dx} = \frac{\partial T}{\partial x}$
d) $\frac{\partial T}{\partial y} = \frac{\partial T}{\partial x} \cdot \frac{dy}{dx}$

9) In a 2D laminar boundary layer with constant free-stream velocity, the signs of material acceleration (parallel, perpendicular to wall) near the wall are:
(GATE 2007 XE)

a) +, −
b) −, +
c) +, +
d) −, −

10) Water enters a pipe (area A) and branches into sections (areas A_2, A_3). Velocities at one instant: $V_1 = 2\,\text{m/s}$, $V_2 = 3\,\text{m/s}$, $V_3 = 5\,\text{m/s}$. At another, $V_1 = 3\,\text{m/s}$, $V_2 = 4\,\text{m/s}$. Find V_3:
(GATE 2007 XE)

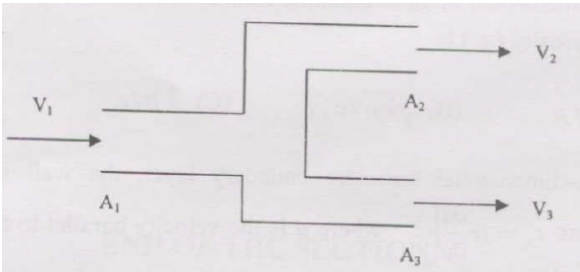


Fig. 10).1: Pipe Diagram

a) 5 m/s
b) 6 m/s
c) 7 m/s
d) 8 m/s

11) In 2D incompressible irrotational flow, $u = 2x + 3y$. The y-component of velocity is:

(GATE 2007 XE)
a) $2y - 3x$
b) $2y + 3x$
c) $-2y + 3x$
d) $-2y - 3x$

12) For steady 2D flow with $u = 6y$, $v = 0$ (y is vertical distance), the angular velocity and shear strain rate are:
(GATE 2007 XE)

a) −3, 3
b) 3, −3
c) 3, −6
d) −6, 3

13) In steady 2D incompressible flow, the stream function ψ obeys: $\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} = 4$. A solution is:

(GATE 2007 XE)

a) $\psi = x^2 + y^2$
b) $\psi = y^2 - x^2$
c) $\psi = xy$
d) $\psi = x + y$

14) A uniform stream of ideal fluid (velocity U, pressure p) flows past a circular cylinder. Wall velocity is $V = 2U \sin\theta$. Pressure coefficient $C_p = \frac{P-P_\infty}{0.5\rho U^2}$. The minimum C_p on the cylinder is:

(GATE 2007 XE)

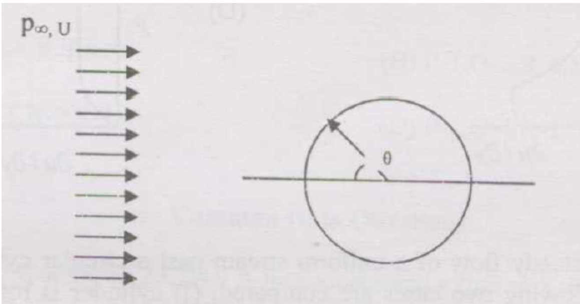


Fig. 14).1: Circular Cylinder

a) 1
b) -1
c) -3
d) -4

15) A model (length 20 cm) studies water flow ($\nu = 10^{-6}\,\mathrm{m^2/s}$) in a 5 m channel. The model's kinematic viscosity should be:

(GATE 2007 XE)

a) 4×10^{-6}
b) 8×10^{-6}
c) 4×10^{-7}
d) 8×10^{-7}

16) Water flows through a 5 cm diameter tube at π kg/s, $\mu = 0.001\,\mathrm{Ns/m^2}$, $\rho = 1000\,\mathrm{kg/m^3}$. Darcy friction factor: $f = 64/\mathrm{Re}$ (laminar), $f = 0.316\mathrm{Re}^{-0.25}$ (turbulent). Approximate pressure drop per unit length is:

(GATE 2007 XE)

a) $20\,\mathrm{Pa/m}$
b) $120\,\mathrm{Pa/m}$

c) 480 Pa/m
d) 960 Pa/m

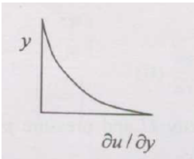
17) Constant pressure boundary layer over a 3 m plate, $U = 60\,\text{m/s}$, $\rho = 1.23\,\text{kg/m}^3$, $\mu = 1.79 \times 10^{-5}\,\text{Ns/m}^2$. Transition at $x_{cr} = 0.1\,\text{m}$. If $U = 120\,\text{m/s}$, new x_{cr} is:

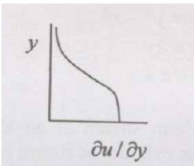
(GATE 2007 XE)

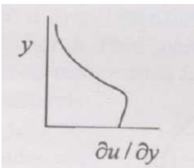
a) 0.2 m
b) 0.1 m
c) 0.05 m
d) 0.005 m

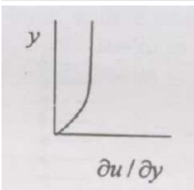
18) For a laminar boundary layer with constant free-stream velocity ($\frac{dp}{dx}$=0), the variation of $\partial u/\partial y$ with y is:

(GATE 2007 XE)

a) 

b) 

c) 

d) 

19) Steady viscous flow past a cylinder: (I) slow rotation, (II) no rotation. Which is true?
P: Lift force zero in (I) Q: Lift force zero in (II)
R: Drag force non-zero in (I) S: Drag force zero in (II)

(GATE 2007 XE)

a) P, Q, R
b) P, R, S
c) P, S
d) Q, R

20) Orifice plate (60 mm diameter, discharge coefficient 0.6) measures air flow ($\rho = 1.2\,\text{kg/m}^3$, $\mu = 1.8\times10^{-5}\,\text{kg m}^{-1}\text{s}^{-1}$) in a 100 mm pipe. Manometer reading 180 mm of water. Air flow rate is:

(GATE 2007 XE)

a) $0.3\,\text{m}^3/\text{s}$
b) $0.1\,\text{m}^3/\text{s}$
c) $0.01\,\text{m}^3/\text{s}$
d) $0.003\,\text{m}^3/\text{s}$

21) Airstream velocity ($\rho = 1.0\,\text{kg/m}^3$) measured with a Pitot-static tube, manometer difference 2 cm of water. Velocity is:

(GATE 2007 XE)

a) $0.02\,\text{m/s}$
b) $2.0\,\text{m/s}$
c) $10\,\text{m/s}$
d) $20\,\text{m/s}$

22) Match the following columns using the most appropriate combinations:

TABLE 22): Table-1

P. Volume flow rate	1. Quality
Q. Lift	2. Variable density atmosphere
R. Stream function	3. Mach number
S. Compressibility	4. Circulation
	5. Reynolds number

Correct matching is:

(GATE 2007 XE)

a) P-3, Q-4, R-1, S-5
b) P-1, Q-2, R-4, S-3
c) P-4, Q-5, R-2, S-3
d) P-2, Q-4, R-1, S-3

23) A line source and sink of unit strength at $x = -1$ and $x = +1$. Velocity at (0,1) in Cartesian unit vectors $\mathbf{i}$, $\mathbf{j}$ is:

(GATE 2007 XE)

a) $0\mathbf{i} + 0\mathbf{j}$
b) $\frac{1}{2\pi}\mathbf{i} + 0\mathbf{j}$
c) $0\mathbf{i} + \frac{1}{2\pi}\mathbf{j}$
d) $\frac{1}{\pi}\mathbf{i} + 0\mathbf{j}$

24) Source and sink in a uniform stream correspond to:

(GATE 2007 XE)

a) doublet
b) flow over circular cylinder
c) flow over Rankine half-body
d) flow over Rankine oval

25) A motorboat cruises at 10 m/s. A 180 kW pump sucks water at 1 m^3/s and ejects it at 10 m/s relative to the lake. Total drag on the boat is:

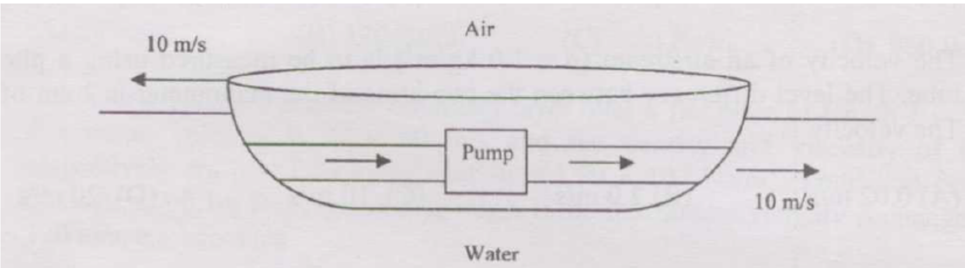


Fig. 25).1: Motor Boat

(GATE 2007 XE)

a) 30 kN
b) 20 kN
c) 10 kN
d) 0 kN

26) From Q25, Power utilized for propelling the boat is:

(GATE 2007 XE)

a) 130 kW
b) 100 kW
c) 80 kW
d) 30 kW

27) Fully developed laminar flow in a pipe (radius R) with axial velocity:

$$u(r) = \frac{-R^2}{4\mu}\frac{dp}{dx}\left(1 - \frac{r^2}{R^2}\right).$$

Wall shear stress magnitude τ_{wall} is:

(GATE 2007 XE)

a) $\frac{4\mu U_m}{R}$
b) $\rho u R$
c) $\frac{\mu U_m}{R}$
d) $-\frac{R}{2}\frac{dp}{dx}$

28) Local friction factor C_f with $y = \frac{dp}{dx}$ is: (GATE 2007 XE)

a) $\frac{16\mu^2}{\rho^2 R^3 y}$
b) $\frac{24\mu^2}{\rho^2 R^3 y}$
c) $\frac{64\mu^2}{\rho^2 R^3 y}$
d) $\frac{2\mu y}{\rho R}$

—END OF SECTION—

Section E: Material Science

1) High bond energy in a crystal leads to:

(GATE 2007 XE)

a) high elastic modulus, low melting point, high coefficient of thermal expansion
b) low elastic modulus, high melting point, low coefficient of thermal expansion
c) high elastic modulus, high melting point, low coefficient of thermal expansion
d) low elastic modulus, low melting point, high coefficient of thermal expansion

2) Which oxide does NOT form glass by itself?

(GATE 2007 XE)

a) SiO_2
b) B_2O_3
c) P_2O_5
d) Al_2O_3

3) Diffusion mechanism with lowest activation energy is:

(GATE 2007 XE)

a) Lattice diffusion
b) Grain boundary diffusion
c) Surface diffusion
d) Diffusion through dislocations

4) In tensile test, necking starts at:

(GATE 2007 XE)

a) lower yield point
b) upper yield point
c) ultimate tensile stress
d) proof stress

5) Si is added to transformer grade steel to:

(GATE 2007 XE)

a) decrease magnetic permeability
b) decrease electrical resistivity
c) improve ductility
d) increase magnetic permeability

6) According to galvanic series, the most active metal among: Mg, Zn, Sn, Al is:

(GATE 2007 XE)

a) Mg
b) Zn
c) Sn
d) Al

7) Enthalpy of vacancy formation in Cu is 120 kJ/mol. Equilibrium fraction of vacant lattice sites in Cu at 1000 K is:

(GATE 2007 XE)

a) 1.35×10^{-8}
b) 5.39×10^{-7}
c) 7.76×10^{-6}
d) 2.58×10^{-9}

8) Metal melting point 1000 K, enthalpy of melting 2.0×10^9 J/m^3, solid-liquid interface energy 0.5 J/m^2. Radius of critical nucleus during solidification at 900 K is:

(GATE 2007 XE)

a) 10.0 nm
b) 5.0 nm
c) 5.0 μm
d) 2.5 nm

9) In binary system A-B at 1 atm, parameters independently varied in two phase $(\alpha+\beta)$ region are:

(GATE 2007 XE)

a) composition of α phase and temperature
b) composition of α and β phases
c) either composition of α or β phase or temperature
d) temperature only

10) Cd^{++} doped NaCl crystal has higher conductivity at room temp due to:

(GATE 2007 XE)

a) lower activation energy for cation movement
b) increase in cation vacancy concentration
c) introduction of holes in crystal
d) increase in anion vacancy concentration

11) Match heat treatments (P, Q, R, S) with microstructure (1-5) in hypoeutectoid steel:

(GATE 2007 XE)

TABLE 11): Table-2

P: Austempering	1. Martensite
Q: Martempering	2. Ferrite + Spheroidized cementite
R: Full annealing	3. Ferrite + coarse pearlite
S: Quench hardening + tempering at 700 °C	4. Bainite
	5. Tempered martensite

a) P-4, Q-1, R-3, S-2
b) P-5, Q-1, R-3, S-2
c) P-1, Q-4, R-2, S-3
d) P-2, Q-5, R-3, S-4

12) Second peak in powder X-ray diffraction pattern of FCC crystal at Bragg angle 23.21° with Cu-Kα wavelength 0.154 nm. Lattice parameter (nm) is:

(GATE 2007 XE)

a) 0.391
b) 0.338
c) 0.276
d) 0.437

13) Which direction lies in (111) plane?

(GATE 2007 XE)

a) (211)
b) (110)
c) (100)
d) (112)

14) Yield strength varies with grain size d as:

(GATE 2007 XE)

a) $d^{-1/2}$
b) d^{-1}
c) d
d) $d^{1/2}$

15) Toughening mechanism NOT contributing in SiC whisker reinforced alumina composite:

(GATE 2007 XE)

a) crack tip deflection

b) transformation toughening
c) bridging across crack face
d) energy absorbed during whisker pull-out

16) Match experimental techniques (P, Q, R, S) with applications (1-5):
(GATE 2007 XE)

TABLE 16): Table-3

P: X-ray diffraction	1. Resistivity determination
Q: Transmitted polarized light microscopy	2. Measurement of crystallite size
R: Four probe technique	3. Observation of inclusions
S: Zone refining	4. Observation of spherulites
	5. Purification of materials

a) P-2, Q-3, R-1, S-5
b) P-4, Q-3, R-5, S-3
c) P-4, Q-3, R-1, S-2
d) P-2, Q-4, R-1, S-5

17) Match polymers (P, Q, R, S) with applications (1-5):
(GATE 2007 XE)

TABLE 17): Table-4

P: Polycarbonates	1. Anti-adhesive coating
Q: Fluorocarbons	2. Packaging film
R: Polyaniline	3. Outdoor light globes
S: Polypropylene	4. Magnetic recording tapes
	5. Polymer LEDs

a) P-2, Q-1, R-4, S-3
b) P-4, Q-1, R-3, S-2
c) P-3, Q-1, R-5, S-4
d) P-3, Q-1, R-5, S-2

18) Match materials (P, Q, R, S) with applications (1-5):

TABLE 18): Table-5

P: $GaAs_{1-x}P_x$	1. Prosthetics
Q: MgB_2	2. Bulletproof jackets
R: Hydroxyapatite	3. LEDs
S: Kevlar^{TM} fibers	4. Abrasives
	5. Superconducting magnets

(GATE 2007 XE)

a) P-3, Q-5, R-1, S-2
b) P-3, Q-5, R-4, S-2
c) P-5, Q-4, R-1, S-2
d) P-3, Q-5, R-4, S-1

19) Optical transparency of a single crystal depends on:

(GATE 2007 XE)

a) Band gap
b) Lattice parameter
c) Crystal structure
d) Work function

20) Drift mobility of electrons in intrinsic region of doped semiconductor as function of temperature:

(GATE 2007 XE)

a) limited by ionized impurity scattering
b) limited by phonon scattering
c) limited by point defects
d) remains unaffected

21) ZnFe_2O_4 has inverse spinel structure. Atomic numbers of Zn, Fe, O are 30, 26, 8 respectively. Net magnetic moment per formula unit in Bohr magnetons (μ_B) is:

(GATE 2007 XE)

a) 2 μ_B
b) 1 μ_B
c) 4 μ_B
d) 0 μ_B

22) Nb_3Sn is widely used in superconducting magnets because:

(GATE 2007 XE)

a) Type I superconductor
b) Type II superconductor with large critical magnetic field
c) T_c above helium boiling point
d) It is an intermetallic

23) Mo has BCC with lattice parameter 0.315 nm, atomic mass 96. Mo–Mo nearest neighbor distance (nm) is:

(GATE 2007 XE)

a) 0.223
b) 0.273
c) 0.136
d) 0.1575

24) Theoretical density of Mo (kg/m^3) is:

(GATE 2007 XE)

a) 20400
b) 2550
c) 10200
d) 5100

25) A continuous carbon fiber reinforced epoxy composite has 40 vol% carbon fibers. Elastic modulus of fibers 400 GPa, epoxy 2.4 GPa. Density of fiber 1800 kg/m^3, epoxy 1200 kg/m^3. Density of composite (kg/m^3) is:

(GATE 2007 XE)

a) 1440
b) 1200
c) 1800
d) 1340

26) Specific modulus of elasticity of composite in longitudinal direction is:

(GATE 2007 XE)

a) 2.76 MPa·m^3/kg
b) 112.11 GPa
c) 161.44 GPa
d) 112.11 MPa·m^3/kg

27) Intrinsic carrier density in Si at 300 K is 1.45×10^{16} m^{-3}. Sample doped with 1 ppm As. Density of Si 2330 kg/m^3, atomic wt 28. Number of As atoms per m^3 is:

(GATE 2007 XE)

a) 5.01×10^{22}
b) 5.01×10^{26}
c) 5.01×10^{19}
d) 3.929×10^{23}

28) Assuming all impurities ionized, hole concentration per m^3 is:

(GATE 2007 XE)

a) 2.894×10^{-7}
b) 4.197×10^{0}
c) 4.197×10^{5}
d) 4.197×10^{12}

—END OF SECTION—