XE : Engineering Sciences

Maximum Marks: 150

Duration: Three Hours

Read the following instructions carefully

1. This question paper contains 64 printed pages including pages for rough work. Please check all pages and report discrepancy, if any.
2. Write your registration number, your name and name of the examination centre at the specified location on the right half of the ORS.
3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
4. All the questions in this question paper are of objective type.
5. Questions must be answered on Objective Response Sheet (ORS) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. Each question has only one correct answer. If you wish to change an answer, erase the old one completely. More than one answer bubbled against a question will be treated as wrong answer.
6. This question paper contains nine sections as listed below. **Section A is compulsory.** Choose any two sections from the remaining Sections B through H.

Table 1

Section	**Section Name**	**Page**
A	Engineering Mathematics	03
B	Computational Science	08
C	Electrical Sciences	18
D	Fluid Mechanics	32
E	Materials Science	44
F	Solid Mechanics	52
G	Thermodynamics	64
H	Polymer Science and Engineering	73
I	Food Technology	81

7. The XE Engineering Mathematics section (A), which is compulsory, carries 30 marks. Questions 1 through 8 are 2-mark questions. Questions 9 through 18 are 1-mark questions.

8. Each of the other XE sections (B through I) carry 70 marks. Questions 1 through 8 are 1-mark questions; questions 9 through 32 (except Q32 and Q34) are 2-mark questions. Questions 32 and 34 are matching type with 2 marks each. Some of the questions may be linked.

9. Un-attempted questions will carry zero marks.

NEGATIVE MARKING:

- **Section A:** For Q.1 to Q.6, 0.25 mark will be deducted for each wrong answer. For Q.7 to Q.18, 0.5 mark will be deducted for each wrong answer.
- **Sections B through I:** For Q.1 to Q.8, 0.25 mark will be deducted for each wrong answer. For Q.9 to Q.30, 0.66 mark will be deducted for each wrong answer. For linked questions, there will be negative marks only for the first question. For Q.31 and Q.34, 0.34 mark will be deducted. No negative marking for Q.32.

11. Calculator **without data connectivity** is allowed in the examination hall.

12. Charts, graph sheets and tables are **NOT** allowed in the examination hall.

13. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

A: ENGINEERING MATHEMATICS (*Compulsary*)

Q1-Q6 carry one mark each

Q1. If the characteristic equation of a 3x3 matrix is $\lambda^3 - \lambda^2 + \lambda - 1 = 0$, then the matrix should be

(A) Hermitian
(B) Unitary
(C) Skew symmetric
(D) Identity

GATE XE 2008

Q2. $\lim_{(x,y)\to(0,0)} \frac{x^4+xy}{x^3-y^3}$ is

(A) 0
(B) 1
(C) -1
(D) does not exist

GATE XE 2008

Q3. If $f(z) = u + iv$ is an analytic function and $u - v = (x-y)^3 + kxy(x-y)$, then k is

(A) 2
(B) -4
(C) 6
(D) -8

GATE XE 2008

Q4. The directional derivative at the point $P(1,2,3)$ to the surface $x^2 + \frac{y^2}{4} + \frac{z^2}{9} = 3$ in the direction of the vector $\overrightarrow{OP}$,where O denotes the origin is

(A) 0
(B) $\frac{2}{\sqrt{14}}$
(C) $\frac{3}{\sqrt{14}}$
(D) $\frac{6}{\sqrt{14}}$

GATE XE 2008

Q5. If the solution of the differential equation $\frac{dy}{dx} + P(x)y = xy^3$ is $y^2(1 + ce^{x^2}$, c being an arbitary constant, then $P(x)$ is

(A) $-x$

(B) $\frac{x}{2}$

(C) x

(D) $2x$

GATE XE 2008

Q6. The system of equations
$ax + by + a^2 = 0$
$bx + ay - b^2 = 0$
$x + y + a - b = 0$

(A) admits unique solution if $a = b \neq 0$

(B) admits unique solution if $a = -b \neq 0$

(C) admits unique solution if $a = b = 0$

(D) does not admit unique solution

GATE XE 2008

Q7 to Q18 carry two marks each

Q7. The matrix $\begin{pmatrix} l & 0 & \sin\theta \\ 0 & 1 & m \\ n & 0 & \cos\theta \end{pmatrix}$ is orthogonal, if

(A) $l = -\sin\theta, m = -\cos\theta, n = 0$

(B) $l = -\sin\theta, m = 0, n = \cos\theta$

(C) $l = \cos\theta, m = \sin\theta, n = 0$

(D) $l = -\cos\theta, m = 0, n = \sin\theta$

GATE XE 2008

Q8. The radius of convergence of the real power series $\sum_{m=0}^{\infty} \frac{(m!)^2}{(2m+1)!} x^m$ is

(A) 4

(B) 3

(C) 2

(D) 1

GATE XE 2008

Q9. The value of
$(\int_0^{\frac{\pi}{2}} (\sin\theta)^{\frac{3}{4}}\, d\theta)x(\int_0^{\frac{\pi}{2}} (\sin\theta)^{\frac{-3}{4}}\, d\theta)$ is

(A) $\frac{2\pi}{3}(\sqrt{2}+1)$

(B) $\frac{2\pi}{3}(\sqrt{2}-1)$

(C) $\frac{\pi}{2}(\sqrt{3})$

(D) $\frac{-\pi}{2}(\sqrt{3})$

GATE XE 2008

Q10. If $f(z) = y(1+x^2) + x^2 + i(y^2+2y)x$ is differentiable at a point $z = z_0$, then $f'(z_0)$ is

(A) 0

(B) 1

(C) i

(D) $-i$

GATE XE 2008

Q11. The value of the integral $\oint_{|z|=2} \frac{e^{1/z}}{(z-1)^2}\, dz$ is

(A) 0

(B) $(2e\pi)i$

(C) $(4e\pi)i$

(D) $(4\pi)i$

GATE XE 2008

Q12. The absolute value of the integral $\oint_C (-zdx + xdy + ydz)$, where c is the curve obtained by the intersection of $x^2 + y^2 = a^2$and $y = z$, is

(A) $\frac{\pi a^2}{\sqrt{2}}$

(B) $\frac{\pi a^2}{\sqrt{3}}$

(C) $\pi a^2 \sqrt{2}$

(D) $2\pi a^2$

GATE XE 2008

Q13. One of the values of $\frac{1}{(4x^2D^2+8xD+1)}(\ln x)$where $D \equiv \frac{d}{dx}$ is

(A) $\ln x + 4$

(B) $\ln x - 4$
(C) $4\ln x - 4$
(D) $4\ln x + 4$

GATE XE 2008

Q14. A particular integral of the differential equation $\frac{d^2y}{dx^2} - y = sec\ h\ x$ is

(A) $-(coshx)(lncoshx) + xsinhx$
(B) $-(sinhx)(Incoshx) + xcoshx$
(C) $(coshx)(Insinhx) + xsinhx$
(D) $(sinhx)(lncoshx) - xcoshx$

GATE XE 2008

Q15. If $u = u(x,t)$ is such that $\frac{\partial^2 u}{\partial t^2} = 4\frac{\partial^2 u}{\partial x^2}$, $0 \le x \le \pi$, $t \ge 0$,
$u(0,t) = u(\pi,t) = 0,$
$u(x,0) = 0,$
$\frac{\partial u}{\partial t}(x,0) = \sin x,$
then $u(\frac{\pi}{3}, \frac{\pi}{6})$ is

(A) $\frac{3}{4}$
(B) $\frac{\sqrt{3}}{4}$
(C) $\frac{\sqrt{3}}{4}$
(D) $\frac{\sqrt{3}}{8}$

GATE XE 2008

Q16. The two lines of regression of the variables x and y are $4x+2.4y = 20$ and $1.6x+4y = 12$. The coefficient of correlation between x and y is

(A) 0.49
(B) -0.49
(C) 0.35
(D) -0.35

GATE XE 2008

Q17. While solving the initial value problem
$\frac{dy}{dx} + ky = 0$, $y(0) = 1$
at $x = h$ by fourth order Runge-Kutta method, the expression for k_3 is

(A) $-kh + \frac{(kh)^2}{2!} - \frac{(kh)^3}{3!}$
(B) $-kh + \frac{(kh)^2}{2} - \frac{(kh)^3}{3}$
(C) $-kh + \frac{(kh)^2}{2} - \frac{(kh)^3}{4}$

(D) $-k(1 + \frac{h}{2} - \frac{h^2}{3})$

GATE XE 2008

Q18. On solving the system of equations
$4x + z = 5$
$x + 2y + 3z = 1$
$-y - 4z = 3,$
by LU - decomposition with $u_{ii} = 1$ for i =1,2,3; the values of u_{23} and l_{33} are respectively

(A) 1.375 and -4.250
(B) 2.750 and -3.625
(C) 1.375 and -2.625
(D) 2.750 and -4.250

GATE XE 2008

END OF SECTION - A

B:COMPUTATIONAL SCIENCE

Q1-Q8 carry one mark each

Q1. Which one of the following is not a physical component of a computer ?

(A) CPU
(B) RAM
(C) Assembler
(D) Motherboard

GATE XE 2008

Q2. A number whose representation in base *b* is 64, is equal to 100 in the decimal representation. The value of the base *b* is

(A) 4 (B) 8 (C) 12 (D) 16

GATE XE 2008

Q3. Evaluation of the integral
$\int_1^2 \frac{dx}{\sqrt{1+x^2}}$
using 2 segment trapezoidal rule with equal intervals gives the result

(A) 0.566 (B) 0.564 (C) 0.562 (D) 0.560

GATE XE 2008

Q4. A continuous function $f(x)$ defined in interval [a,b] is such that $f(a)f(b) < 0$.A possible number of simple roots of the equation $f(x) = 0$ in this interval is

(A) 0 (B) 1 (C) 2 (D) 4

GATE XE 2008

Q5. The function e^x is expanded about the point $x = 0$ in a Taylor polynomial $P_n(x)$ of degree n. The value of n necessary to approximate e^x to an accuracy of 10^{-5} in [0,0.5] is

(A) 5 (B) 6 (C) 7 (D) 8

GATE XE 2008

Q6. The eigenvalues of the matrix $\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$ are

(A) 1,-1 (C) 1,1
(B) i, i (D) $i, -i$

GATE XE 2008

Q7. Consider the following code segment in Fortran:

```
REAL PARAMETER:: X=10.0, Y=2.0, Z=5.0
REAL:: RESULT
RESULT = X/Y+Y*Z**2
```

The value of the result when this code segment is executed, is

(A) 0.098 (C) 55.0
(B) 0.192 (D) 105.0

GATE XE 2008

Q8. The value of the integral $\int_1^2 \frac{dx}{x}$ obtained by using Simpson's 1/3 rule, with 3 points, is

(A) 0.694 (B) 0.693 (C) 0.692 (D) 0.691

GATE XE 2008

Q9 to Q30 carry two marks each

Q9. The hypotenuse *c* and a side *b* of a right triangle are found by measurement to be 13 cm and 5 cm respectively. The possible error in the measurement of the hypotenuse is 0.2 cm and that in the side *b* is 0.1 cm. The maximum possible error (in cm) in the calculation of the third side is

(A) 0.26 (B) 0.22 (C) 0.17 (D) 0.10

GATE XE 2008

Q10. One of the eigenvalues of a 3×3 matrix M is 3. If the determinant of the matrix M is 24 and the trace is 9, then the smallest eigenvalue of the matrix M^{-1} is

(A) 1/8 (B) 1/4 (C) 1/3 (D) 1/2

GATE XE 2008

Q11. A quadrature formula is given by

$$\int_0^1 f(x)\,dx = pf(0) + qf(0.5) + rf(1)$$

where the coefficients p, q and r rare determined by comparing the right hand side of the above formula with the exact value of the integral for a quadratic polynomial. The formula corresponds to

(A) Two segment trapezoidal rule

(B) One segment trapezoidal rule

(C) Simpson's 3/8 rule

(D) Simpson's 1/3 rule

GATE XE 2008

Q12. The set of simultaneous equations

$$4x - y = 15$$
$$x + 5y = 9$$

is to be solved using Jacobi's iterative method. Starting with the initial values x = 2, y =2, the values of x and y after two iterations are, respectively,

(A) 4.25, 0.95 (C) 4.1, 0.95

(B) 4.25, 1.4 (D) 4.1, 1.4

GATE XE 2008

Q13. The lower triangular matrix L in the LU factorization of the matrix $\begin{pmatrix} 25 & 5 & 4 \\ 10 & 8 & 16 \\ 8 & 10 & 22 \end{pmatrix}$ is written as $\begin{pmatrix} 1 & 0 & 0 \\ L_{21} & 1 & 0 \\ L_{31} & L_{32} & 1 \end{pmatrix}$. The element L_{32} is

(A) 1.0 (B) 1.4 (C) 0.4 (D) 0.32

GATE XE 2008

Q14. For a function $f(x)$ whose second derivative $f"(x)$ has a maximum value 12 in the interval [0,1]. The number of segments required to integrate $\int_0^1 f(x)\,dx$ with an accuracy of 0.001 using trapezoidal rule is

(A) 10 (B) 12 (C) 100 (D) 1000

GATE XE 2008

Q15. An approximate solution of the equation $x^3 - 3x + 1 = 0$ is 0.347296. Which of the following iterating functions will converge most rapidly to this root?

(A) $x_{n+1} = \frac{1}{(3-x_n^2)}$

(B) $x_{n+1} = \frac{1}{3}(x_n^3 + 1)$

(C) $x_{n+1} = \frac{1}{5}(x_n^3 + 2x_n + 1)$

(D) $x_{n+1} = \frac{1}{27}(10x_n^3 - 3x_n + 10)$

GATE XE 2008

Q16. A real root of the equation $x^3 - 2x - 5 = 0$ lies between $x = 2$ and $x = 3$. The location of the root obtained after the second iteration using the method of false position is

(A) 2.081 (B) 2.061 (C) 2.059 (D) 2.041

GATE XE 2008

Q17. The solution of the first order differential equation $(0 \le x \le 1)$
$\frac{dy}{dx} - y^2 = 0$ with $y(0) = 1$ is

(A) $\frac{1}{1+x}$

(B) $\frac{1}{1-x}$

(C) $\frac{2}{2+x}$

(D) $\frac{x^3}{3} + 1$

GATE XE 2008

Q18. For the initial value problem
$\frac{dy}{dx} + y = 0, y(0) = 1, y_1$ is the computed value of y at $x = 0.2$ obtained by using Euler's dx method with step size $h = 0.1$. Then,

(A) $y_1 < e^{-0.2}$

(B) $e^{-0.2} < y_1 < 1$

(C) $1 < y_1$

(D) $y_1 = e^{-0.2}$

GATE XE 2008

Q19. Consider the initial value problem
$\frac{dy}{dx} = y + x$ with $y(0) = 2$.
The value of $y(0.1)$ obtained using the fourth order Runge-Kutta method with step size $h = 0.1$ is

(A) 2.20000 (B) 2.21500 (C) 2.21551 (D) 2.21576

GATE XE 2008

Q20. The following table gives a function $f(x)$ vs x

Table 2

x	0	1	2	3	4
$f(x)$	1.0	3.7	6.5	9.3	12.1

The best fit of a straight line for the above data points, using a least square error method is

(A) 2.75x+0.55 (C) 3.10x+0.85

(B) 2.80x+0.80 (D) 2.78x+0.96

GATE XE 2008

Q21. Consider the following part of a Fortran 90 function

```
INTEGER FUNCTION RESULT (X)
    INTEGER::X
    VALUE =1
    DO
        IF (X == 0) EXIT
        TERM = MOD (X,10)
        VALUE = VALUE*TERM
        X = X/10
    END DO
    RESULT = VALUE
END FUNCTION RESULT
```

If the above function is called with an integer $X = 123$, the value returned by the function will be

(A) 0 (B) 6 (C) 9 (D) 321

GATE XE 2008

Q22. A portion of a Fortran 90 program is reproduced below:

```
PROGRAM CHECK_CYCLE
    DO I =1, 10, 2
        IF (MOD(I, 3) == 0 ) CYCLE
        PRINT *, I
    END DO
END PROGRAM CHECK_CYCLE
```

The result displayed by the program is

Table 3

(A) 1, 5, 7

(B) 1, 3, 5

(C) 1, 3, 7

(D) 3, 5, 7

GATE XE 2008

Q23. (P), (Q), (R) and (S) are separate segments of Fortran 90 code.

```
(P) IF (A > B) P=Q
(Q) SUBROUTINE SWAP(A, B)
    INTEGER, INTENT(IN):: A, B
    TEMP = A
    A = B
    B = TEMP
    END SUBROUTINE SWAP
(R) IF (A /= B) X = Y-Z
    ELSE
      X=Y+Z
    ENDIF
(S) DO I = 1, N, 3
      C(I) = A(I) + B(I)
    END DO
```

Which segments have syntax errors?

(A) P, Q (B) Q, R (C) R, S (D) P,S

GATE XE 2008

Q24. A Fortran-90 subroutine for Gauss-Siedel Method to solve a set of N simultaneous equations $[A][X] = [C]$ is given below.

```
SUBROUTINE SIEDEL(A, C, X, N,
IMAX)
REAL:: SUM
REAL, DIMENSION(N,N):: A
REAL, DIMENSION(N):: C, X
 DO K = 1, IMAX
   DO I = 1, N
       SUM = 0.0
       DO J = 1, N
           IF ( I / = J ) THEN
             SUM=SUM+A(I,J)*X(J)
           ENDIF
       ENDDO
       ******
   ENDDO
 ENDDO
END SUBROUTINE SIEDEL
```

The missing statement in the program, indicated by ******, is

(A) `X(I) C(I) + SUM`

(B) `X(I) = C(I) - SUM`

(C) `X(I) = (C(I) + SUM)/A(I,I)`

(D) `X(I) = (C(I) - SUM)/A(I,I)`

GATE XE 2008

Q25. What is the result of the following C program?

```c
int main()
{
   int i, sum=0;
   for (i = 0; i < 25; i++ ) {
      if (i > 10 ) continue;
      sum += i;
   }
   printf("%d\n", sum);
   return 1;
}
```

(A) 25 (B) 45 (C) 55 (D) 325

GATE XE 2008

Q26. Consider the following C code.

```
int x = 1, y = 5, z;
z = x++<<--y;
```

The values of x,y and z after the execution are

(A) 2,4,16 (B) 2,4,32 (C) 2,4,64 (D) 1,5,32

GATE XE 2008

Q27. A two dimensional array is declared as `int num[3] [3]`. Then the result of the expression `* (num+1)` is

(A) The value of `num[1][0]`
(B) The value of `num[0][1]`
(C) The address of `num[1][0]`
(D) The address of `num[0][1]`

GATE XE 2008

Q28. A C function named `func` is defined as follows:

```
int func(int a, int b) {
    if ( (a == 1)||(b == 0)||
         (a == b) ) return 1;
    return func(a-1,b)+func(a-1,b-1);
}
```

What is the result of `func (4,2)`?

(A) 12 (B) 6 (C) 3 (D) 1

GATE XE 2008

Common Data Questions

Common data for questions 29 and 30:

The following table gives the values of a function f at three discrete points.

Table 4

x	0.5	0.6	0.7
$f(x)$	0.4794	0.5646	0.4662

Q29. The value of $f'(x)$ at $x = 0.5$ accurate upto two decimal places, is

(A) 0.82
(B) 0.85
(C) 0.88
(D) 0.91

GATE XE 2008

Q30. The value of $f'(x)$ at $x = 0.55$ obtained using Newton's interpolation formula, is

(A) 0.5626
(B) 0.5227
(C) 0.4847
(D) 0.4749

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Linked Answer Questions: Q31 to Q34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

A modified Newton-Raphson method is used to find the roots of an equation $f(x) = 0$ which has multiple zeros at some point $x = p$ in the interval $[a, b]$. If the multiplicity M of the root is known in advance, an iterative procedure for determining p is given by

$p_{k+1} = p_k - M\frac{f(p_k)}{f'(p_k)}$ for $k = 0, 1, 2, ...$

Q31. The equation $f(x) = x^2 - 1.8x^2 - 1.35x + 2.7 = 0$ is known to have a multiple root in the interval $[1, 2]$. Starting with an initial guess $x = 1.0$ in modified Newton-Raphson method, the root, correct up to three decimal places, is

(A) 1.500
(B) 1.200
(C) 1.578
(D) 1.495

GATE XE 2008

Q32. The root of the derivative of $f(x)$ in the same interval is

(A) 1.500
(B) 1.200
(C) 1.578
(D) 1.495

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

The values of a function $f(x)$ at four discrete points are as follows:

Table 5

x	0	1	2	4
$f(x)$	-12	0	6	12

Q33. The function may be represented by a polynomial $P(x) = (x - a)R(x)$, where $R(x)$ is a polynomial of degree 2, obtained by Lagrange's interpolation and a is a real constant. The polynomial $R(x)$ is

(A) $x^2 + 6x + 12$

(B) $x^2 + 6x - 12$

(C) $x^2 - 6x - 12$

(D) $x^2 - 6x + 12$

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Q34. The value of the derivative of the interpolated polynomial $P(x)$ at the position of its real root is

(A) -6 (B) -4 (C) 6 (D) 7

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END OF SECTION-B

C:ELECTRICAL SCIENCES

Q1 - Q8 carry one mark each

Q1. An LC circuit is shown in the figure. The inductor current, i, when the switch S is opened at t = 0 is best represented by

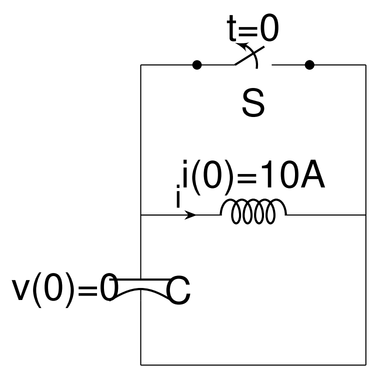

Figure 1

(A)

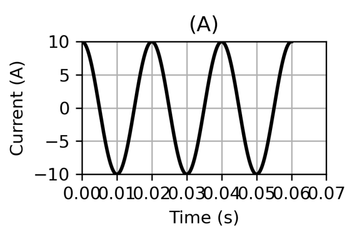

Figure 2

(B)

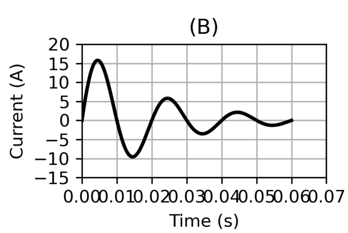

Figure 3

(C)

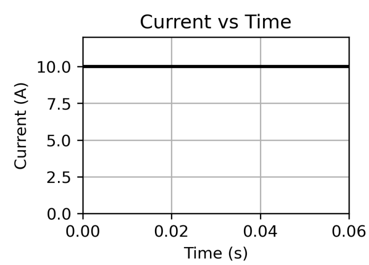

Figure 4

(D)

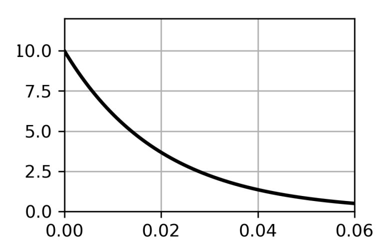

Figure 5

Q2. In the figure shown, power supplied by the current source is

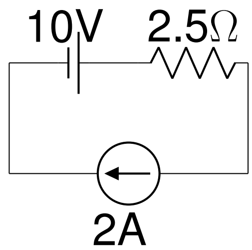

Figure 6

(A) $0.0W$
(B) $5.0W$, delivered
(C) $10.0W$, delivered
(D) $10.0W$, absorbed

GATE XE 2008

Q3. An inductor of 0.4 H was constructed with 20 turns on an iron core. If 10 additional turns in the same sense are added to the coil on the same core, the new inductance will be

(A) $0.9H$ (B) $0.8H$ (C) $0.7H$ (D) $0.6H$

GATE XE 2008

Q4. A three-phase star-connected, slip-ring induction motor has per-phase standstill rotor resistance, $r_2 = 0.01$ and reactance, $x_2 = 0.05$. To achieve maximum torque at starting, the external perphase resistance to be connected at the slip-rings is

(A) 0.01Ω (B) 0.02Ω (C) 0.03Ω (D) 0.04Ω

GATE XE 2008

Q5. The device structure shown in the figure is that of a

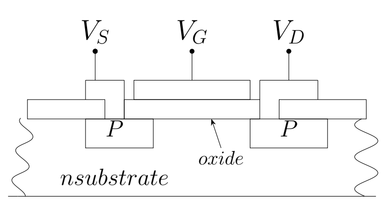

Figure 7

(A) pnp BJT
(B) p-channel MOSFET
(C) npn BJT
(D) n-channel MOSFET

GATE XE 2008

Q6. The input voltage applied to the rectifier circuit shown in the figure is $V_{in} = V_m sin(2\pi 50t)$. The steady state output voltage V_o of the rectifier, under no-load condition, is

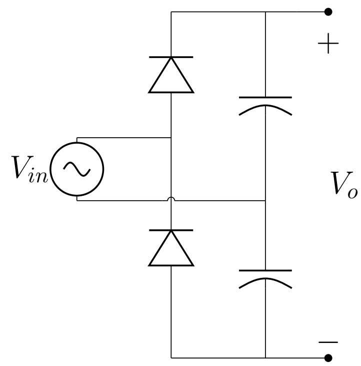

Figure 8

(A) V_m (B) $\sqrt{2}V_m$ (C) $2V_m$ (D) $2\sqrt{2}V_m$

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Q7. In the figure shown, the diode is ideal and the zener voltage is $10V$. The input voltage, $v_{in} = 10\sqrt{2}(100\pi t)V$. The wave-shape of the current through the resistor, R is represented by

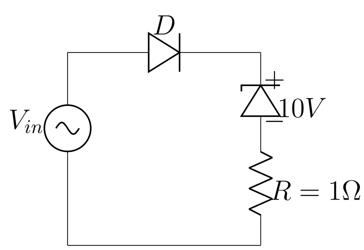

Figure 9

(A)

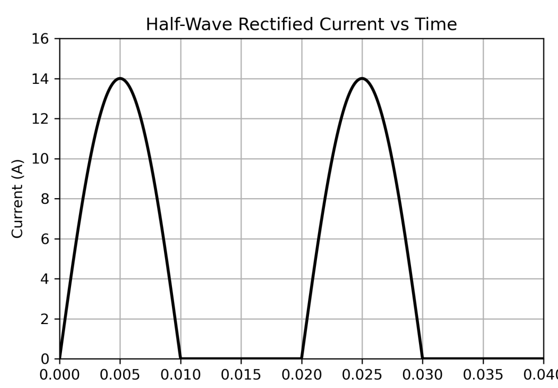

Figure 10

(B)

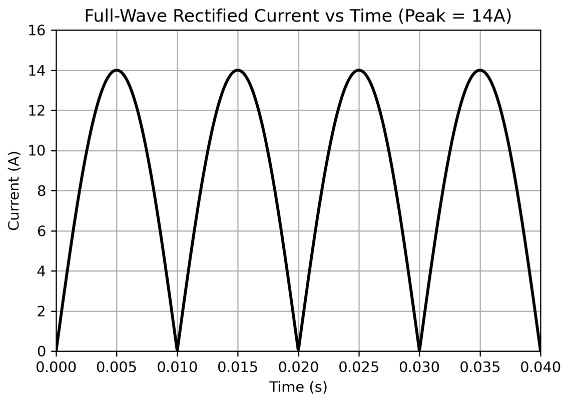

Figure 11

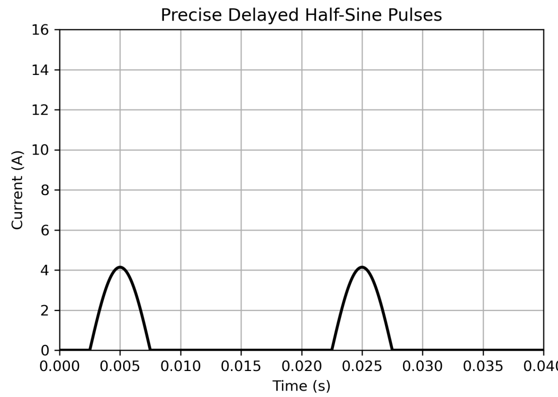

Figure 12

(D)

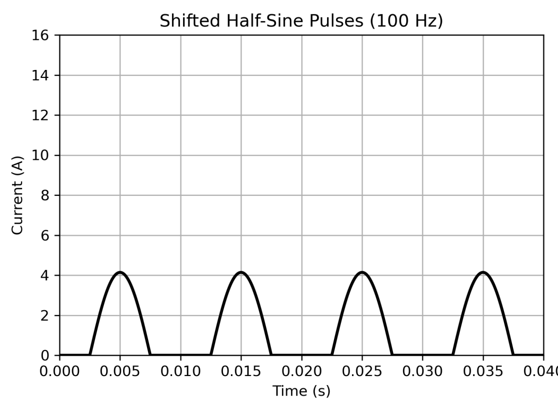

Figure 13

(C)

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Q8. For the counter shown in figure, the present count, $Q_1Q_2Q_3Q_4$ is 0100. The count after two clock pulses will be

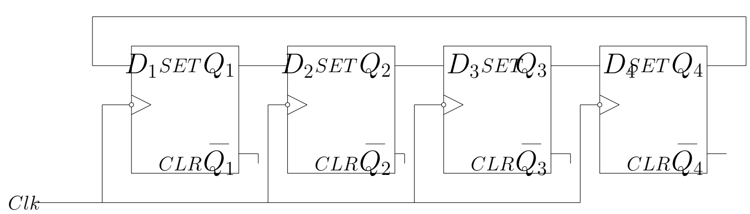

Figure 14

(A) 0100 (B) 0001 (C) 0010 (D) 1000

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Q9 to Q30 carry two marks each

Q9. An incandescent lamp is rated for $200V$, $100W$. Neglect temperature effects. When the lamp consumes $121W$, the supply voltage is

(A) $242V$ (B) $220V$ (C) $180V$ (D) $165V$

GATE XE 2008

Q10. In the circuit shown in the figure, the load resistance, R_1 draws 15 A when it is 10Ω and 20 A when it is 5Ω. The open circuit voltage across XY is

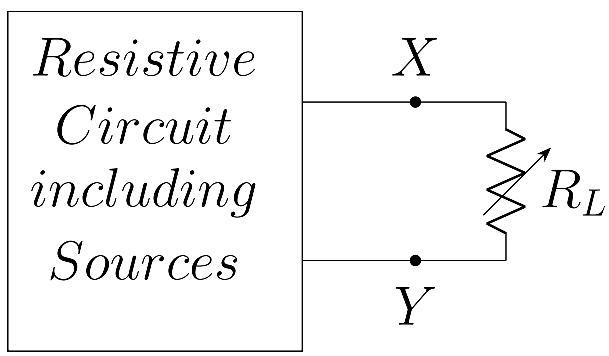

Figure 15

(A) $100V$ (B) $150V$ (C) $200V$ (D) $300V$

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Q11. Three 15V batteries are connected to a resistive network as shown in the figure. The current in each resistor is

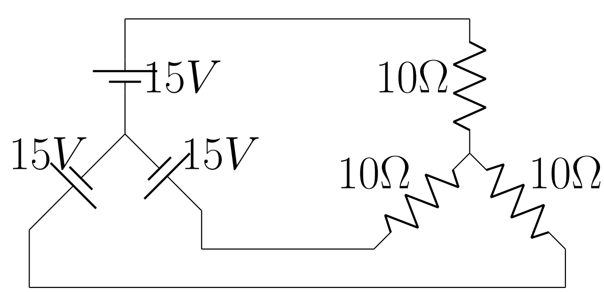

Figure 16

(A) $0.0A$ (B) $0.667A$ (C) $1.0A$ (D) $1.5A$

GATE XE 2008

Q12. At a particular frequency, the impedance across terminals AB in the figure shown is $(6.0 + j0.0)$ ohms. If $R_1 = 12\Omega$, $C_1 = 10\mu F$, $L_1 = 0.2H$, $R_2 = 12\Omega$,$L_2 = 0.1H$, then C_2 is

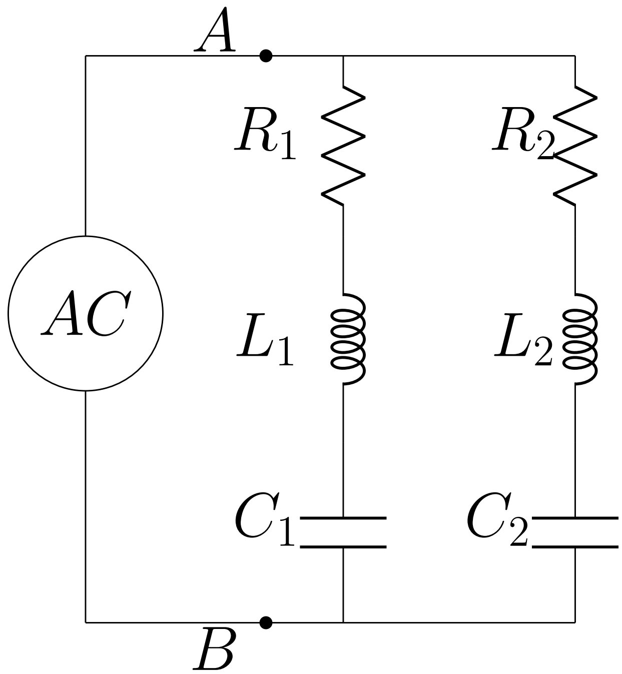

Figure 17

(A) $1.414\mu F$ (B) $5\mu F$ (C) $12\mu F$ (D) $20\mu F$

GATE XE 2008

Q13. A transformer is feeding a 2.5 kVA load at 0.8 pf (lag). If its efficiency is 95% and the copper losses equal 55 W, the core loss is

(A) $25.13W$ (B) $50.26W$ (C) $100.54W$ (D) $125.26W$

GATE XE 2008

Q14. The total winding resistance of a single-phase, two-winding transformer is half the magnitude of total impedance of the winding, both referred to the primary side. Considering the input and output voltages to be practically in-phase, the transformer will have zero regulation when the load power factor is

(A) 60° lagging (B) 60° leading (C) 30° leading (D) 30° lagging

GATE XE 2008

Q15. A 220 V dc shunt motor having an armature resistance, $r_a = 0.5\Omega$ draws an armature current of 40A when running at 1400rpm. If the load torque is halved at the same field current and maintaining the same terminal voltage, then (neglecting armature reaction) the speed of the motor will be

(A) 1510 rpm (B) 1485 rpm (C) 1470 rpm (D) 1370 rpm

GATE XE 2008

Q16. A 230 V separately excited dc motor has armature resistance, $r_a = 2.0\Omega$. It draws 15 A when running at a speed N_1. If the supply to the armature is disconnected, the field excitation and speed remaining unchanged, the voltage at the armature terminals will be

(A) $0V$ (B) $200V$ (C) $210V$ (D) $240V$

GATE XE 2008

Q17. In an induction motor the phase-difference,ϕ between the voltage applied at the stator terminals and the magnetizing current is

(A) $\phi = 0^\circ$ (B) $0^\circ < \phi < 90^\circ$ (C) $\phi = 90^\circ$ (D) $90^\circ < \phi < 180^\circ$

GATE XE 2008

Q18. A voltage of $+5$ V is applied (with respect to ground) to both the inputs V_1 and V_2 of an operational amplifier circuit shown in the figure. $R_1 = 20k\Omega$ and $R_2 = 10k\Omega$. The output voltage, V_o is

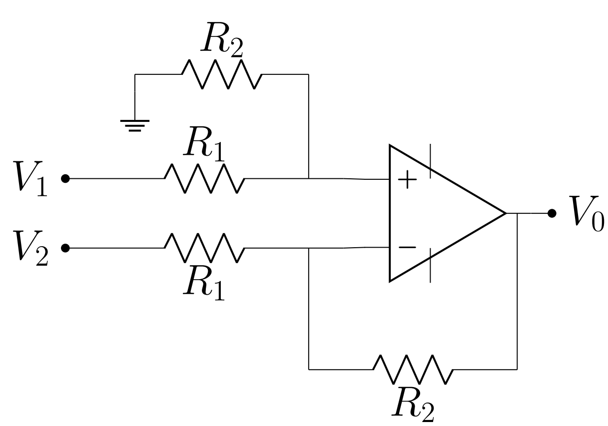

Figure 18

(A) $-5V$ (B) $0V$ (C) $5V$ (D) $20V$

GATE XE 2008

Q19. A pair of zener diodes each with a drop of $0.7V$ and a zener voltage of $4.7V$ is connected as shown in the figure. The input voltage is $v_{in} = 10\sin(2t)$. The peak-to-peak output voltage, v_o is

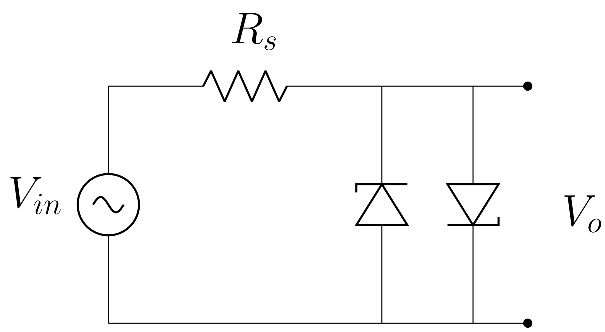

Figure 19

(A) $5.4V$ (B) $4.7V$ (C) $1.4V$ (D) $0.7V$

GATE XE 2008

Q20. The npn transistor shown in figure has $h_{fe} = 99$ and $V_{BE} = 0.7V$. Under quiescent condition, $V_{EG} = 4.3V$ and $I_g = 1mA$, and the current in R_2 is $0.1mA$. The value of R, required for biasing the circuit is

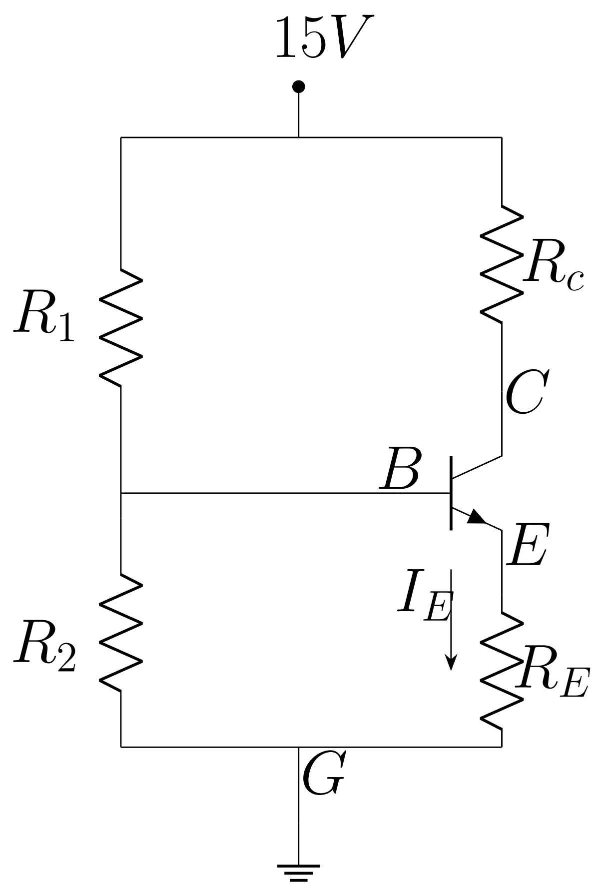

Figure 20

(A) $10.1k\Omega$ (B) $90.9k\Omega$ (C) $100.1k\Omega$ (D) $150.2k\Omega$

GATE XE 2008

Q21. The forward characteristics of a p-n diode is given by $i = I_s e^{v/(nV_T)}$ with $n = 2$ and $V_T = 25mV$. If the diode current is measured to be $100mA$ at $0.7V$ drop, the diode power dissipation at a diode current of $200mA$ is

(A) $70mW$ (B) $140mW$ (C) $143mW$ (D) $147mW$

GATE XE 2008

Q22. For the n-channel JFET shown in the figure the pinch-off voltage, $V_p = -5V$, and gate source voltage, $V_{GS} = -3V$. The minimum required drain to source voltage, V_{DS} to operate at pinch-off condition is

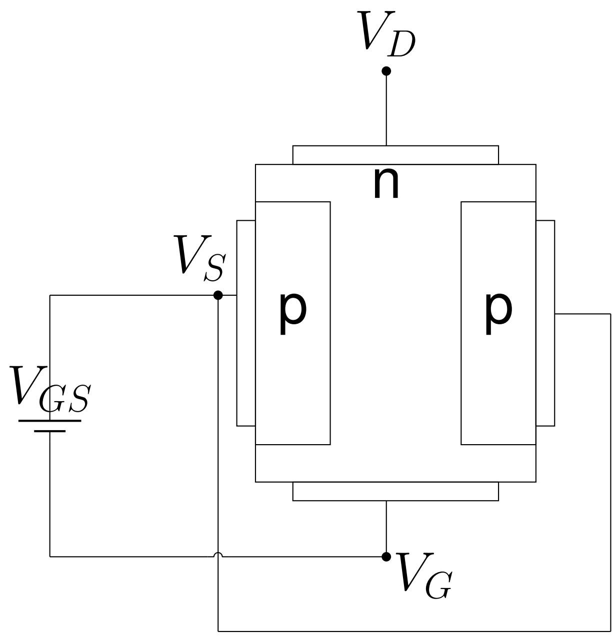

Figure 21

(A) $0V$ (B) $2V$ (C) $5V$ (D) $8V$

GATE XE 2008

Q23. The Boolean function corresponding to the truth table shown is

Table 6

A	B	C	**F**
0	0	0	**1**
0	0	1	**1**
0	1	0	**0**
0	1	1	**1**
1	0	0	**0**
1	0	1	**1**
1	1	0	**0**
1	1	1	**0**

(A) $F = A\bar{B}C + \bar{A}BC + \bar{A}\bar{B}C + \bar{A}\bar{B}\bar{C}$

(B) $F = ABC + AB\bar{C} + \bar{A}BC$

(C) $F = ABC + AB\bar{C} + A\bar{B}\bar{C} + \bar{A}B\bar{C}$

(D) $F = A\bar{B}C + \bar{A}BC + \bar{A}\bar{B}C + \bar{A}BC$

GATE XE 2008

Q24. The decimal number 328 when converted to the base of 9 is equivalent to

(A) $(434)_9$ (B) $(424)_9$ (C) $(404)_9$ (D) $(304)_9$

GATE XE 2008

Q25. The following logic circuit can be represented by the Boolean expression

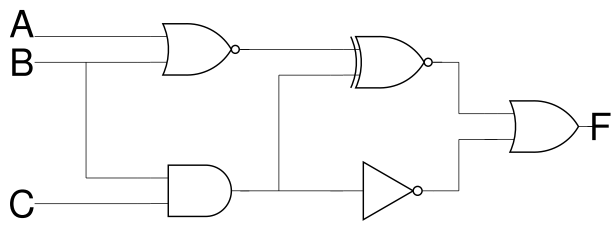

Figure 22

(A) $F = \bar{B} + BC + \bar{C}$

(B) $F = \bar{B} + \bar{C}$

(C) $F = \overline{(B + C)}$

(D) $F = \bar{A} + \bar{B} + \bar{C}$

GATE XE 2008

Q26. A 4-bit resistor network based D/A converter is shown in the figure. The output corresponding to the number 1010 is

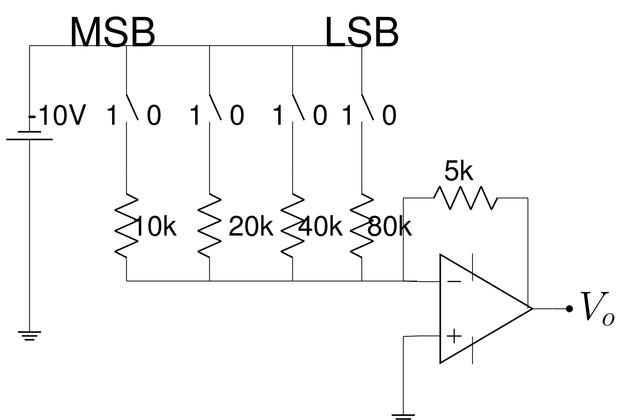

Figure 23

(A) $5.0V$ (B) $6.25V$ (C) $7.25V$ (D) $10.0V$

GATE XE 2008

Q27. Two $10V$ square waves of same frequency but $90°$ out-of-phase to each other are applied to X and Y deflecting plates of a CRO. Both channels are set at $5V$/division and the CRO is operating in the X-Y mode. The display on CRO will be

(A) A bright circle

(B) A bright ellipse

(C) Two bright spots at the diagonal of a faint square

(D) Four bright spots at the corners of a faint square

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Q28. A CRO that is used in X-Y mode displays a line inclined at an angle of $135°$. The X-channel gain is $5V$/division and the Y-channel gain is $10V$/division. If the display point at a given instant corresponds to $+3$ divisions on the X-axis, the input voltage to the Y-channel at that instant is

(A) $-30V$ (B) $-15V$ (C) $+15V$ (D) $+30V$

GATE XE 2008

Common Data Questions

Common Data for Questions 29 and 30

A $1.0kW$ induction motor has 15 pole-pairs and is supplied from a $60Hz$ source. The motor runs at 0.05 slip. The stator loss is $80W$.

Q29. The speed of the rotating magnetic field in the motor and the frequency of the rotor induced voltage are

(A) $120rpm, 1.5Hz$

(B) $120rpm, 28.5Hz$

(C) $240rpm, 3.0Hz$

(D) $240rpm, 57.0Hz$

GATE XE 2008

Q30. The rotor copper loss of this induction motor is

(A) $4.6W$ (B) $42W$ (C) $46W$ (D) $54W$

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

A practical de voltage source is represented as an ideal dc voltage source in series with an internal resistance. The V-I characteristics of two such sources, E_1 and E_2, are shown in the figure.

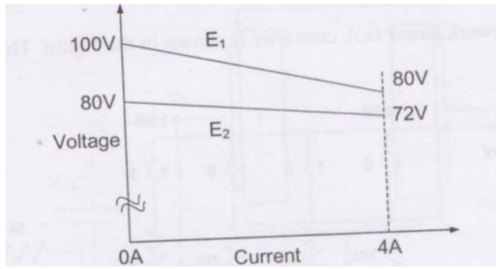

Figure 24

Q31. The respective internal resistances of E_1 and E_2 are

(A) $20\Omega, 8\Omega$ (B) $5\Omega, 2\Omega$ (C) $8\Omega, 20\Omega$ (D) $2\Omega, 5\Omega$

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Q32. If the two sources, E_1 and E_2, in question Q.31 are connected in parallel to feed a load of 200Ω resistance, then the load current is in the range

(A) $0.0A$ to $0.5A$
(C) $2.0A$ to $4.0A$
(B) $0.5A$ to $2.0A$
(D) $4.0A$ to $8.0A$

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Statement for Linked Answer Questions 33 and 34:

A function F, in "Sum of Product (SOP)" form is described by $F = \sum m(0, 1, 3, 4, 5, 6, 7, 13, 15)$

Q33. The Karnaugh Map for F is given by (X being don't care)

Table 7

AB \ CD	00	01	11	10
00	X	X	X	1
01	X	X	X	X
11	1	X	X	1
10	1	1	1	1

(A)

Table 8

AB \ CD	00	01	11	10
00	1	1	1	X
01	1	1	1	1
11	X	1	1	X
10	X	X	X	X

(B)

Table 9

AB \ CD	00	01	11	10
00	1	X	1	X
01	X	1	X	1
11	1	X	X	X
10	X	1	X	1

(C)

Table 10

AB \ CD	00	01	11	10
00	1	1	X	X
01	X	X	X	X
11	X	1	1	1
10	X	1	1	X

(D)

GATE XE 2008

Q34. Using the Karnaugh Map obtained in question Q.33, the function, F reduces to

(A) $F = \bar{A}\bar{C} + \bar{A}D + AB + BD$

(B) $F = AC + AD + \bar{A}\bar{B} + \bar{B}\bar{D}$

(C) $F = AC + \bar{A}D + \bar{A}\bar{B} + \bar{B}\bar{D}$

(D) $F = \bar{A}\bar{C} + \bar{A}D + \bar{A}B + BD$

GATE XE 2008

END OF SECTION-C

D : FLUID MECHANICS

Useful data:

Acceleration due to gravity, $g = 10m/s^2$
Density of water $\rho_w = 1000kg/m^3$
Density of air (unless otherwise specified),$\rho_o = 1.2kg/m^3$

Q1 - Q8 carry one mark each

Q1. A potential function can be defined for a flow if and only if it is

(A) laminar (B) incompressible (C) steady (D) irrotational

GATE XE 2008

Q2. The momentum equation (Euler),
$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial x}$,
is valid if and only if the flow is

(A) unsteady (B) laminar (C) steady (D) inviscid

GATE XE 2008

Q3. Which of the following statements is true for two kinematically similar flows?

(A) They must be geometrically similar but may or may not be dynamically similar
(B) They must be dynamically similar but may or may not be geometrically similar
(C) They must be neither geometrically similar nor dynamically similar
(D) They must be both geometrically similar and dynamically similar

GATE XE 2008

Q4. The Darcy-Weisbach equation for head loss is valid

(A) only for laminar flow through smooth pipes
(B) only for turbulent flow through rough pipes
(C) for laminar or turbulent flows through smooth pipes only
(D) for laminar or turbulent flow through smooth or rough pipes

GATE XE 2008

Q5. A ceiling fan of diameter, D, and weight, W, is suspended at a distance, L, below the ceiling by a support rod. When the fan spins at high speed and creates a downward flow the force exerted by the fan on the support rod is

(A) greater than W

(B) less than W

(C) equal to W

(D) greater than or less than W depending on the value of D/L

GATE XE 2008

Q6. Logs of the following cross-section are fully submerged horizontally in water

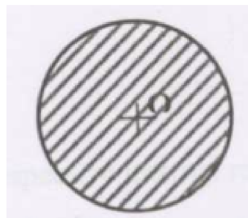

Figure 25: Solid Cylinder

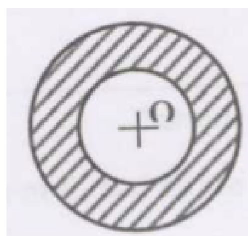

Figure 26: Hollow Cylinder

Figure 27: Solid Square

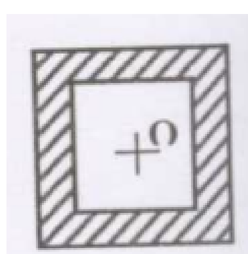

Figure 28: Hollow square

The buoyancy force passes through the point 'O' for which of the following cross-sections?

(A) Solid cylinder only

(B) Solid cylinder and hollow cylinder only

(C) All the cross sections except hollow square

(D) All the cross sections

GATE XE 2008

Q7. A fluid particle can accelerate

(A) in a steady non-uniform flow-field

(B) only if the flow field is both unsteady and non-uniform

(C) only in an unsteady flow-field

(D) in a steady uniform flow-field if the viscous forces are large enough

GATE XE 2008

Q8. A fluid element is said to have vorticity with respect to a reference frame if in that reference frame

(A) it travels along a circular streamline

(B) it travels along a circular pathline

(C) it revolves about any arbitrary point in the flow-field

(D) it rotates about its own centre of mass as it moves

GATE XE 2008

Q. 9 to Q.30 carry two marks each.

Q9. A cubical block of melting ice ($20cmx20cmx20cm$) rests on a smooth horizontal floor over a layer of water of $0.1mm$ thickness. To pull the block at a speed of $1m/s$ a force of $1N$ is required. What is the force required to pull the block at a speed of $2m/s$?

(A) $0.5N$ (B) $1N$ (C) $2N$ (D) $4N$

GATE XE 2008

Q10. Which of the following statements is true?

(A) Eulerian description of fluid motion follows individual fluid particles

(B) Lagrangian description of fluid motion is a field description

(C) Both Eulerian and Lagrangian descriptions follow individual fluid particles but in different reference frames

(D) Eulerian description is a field description while Lagrangian description follows individual fluid particles

GATE XE 2008

Q11. The velocity in a wind tunnel is being measured using a Pitot-static tube connected to a vertical U- tube manometer. The density of air is $1.2kg/m^3$ and the deflection of the manometer is $24mm$. The manometric fluid is water. The velocity measured by the Pitot-static tube is:

(A) $14.1m/s$ (B) $20.0m/s$ (C) $22.0m/s$ (D) $400m/s$

GATE XE 2008

Q12. The stream function for a potential flow around a corner is given by $y(x, y) = kxy$, where k is a constant. The slopes of the streamline and the potential line passing through the point $(1, 1)$ are respectively

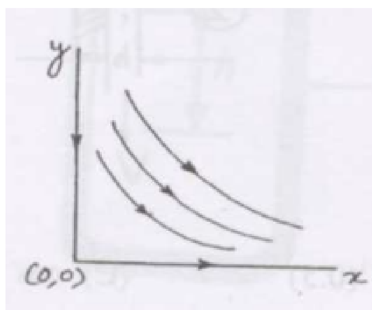

Figure 29

(A) 1 and-1 (B) -1 and (C) 1 and 1 (D) -1 and-1

GATE XE 2008

Q13. The non-dimensional numbers shown in column 1 relate the inertial force with another force shown in column 2. Match the dimensionless number with the corresponding force.

Table 11

Column 1	Column 2
R: Reynolds number	P: Pressure
F: Froude number	G: Gravity
E: Euler number	S: Surface tension
W: Weber number	V: Viscous

(A) R-G, F-P, E-S, W-V
(B) R-V, F-G, E-S, W-P
(C) R-G, F-V, E-S, W-P
(D) R-V, F-G, E-P, W-S

GATE XE 2008

Q14. Consider the aerofoil of the dimensions shown. The lift coefficient Ct is measured to be 1.4 (based on the largest projected area). If air of density $1.2kg/m^3$ flows over the aerofoil at $50m/s$ the lift force is:

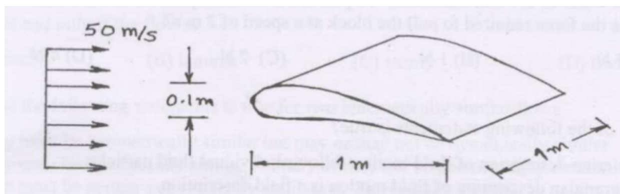

Figure 30

(A) $2.1kN$
(B) $1.5kN$
(C) $0.21kN$
(D) $0.042kN$

GATE XE 2008

Q15. A two-dimensional water jet hits a splitter plate as shown. The velocities at sections 1,2 and 3 may be taken as uniform and equal to V. The weight of the water and the friction along the plate may be neglected. For the data shown what is θ?

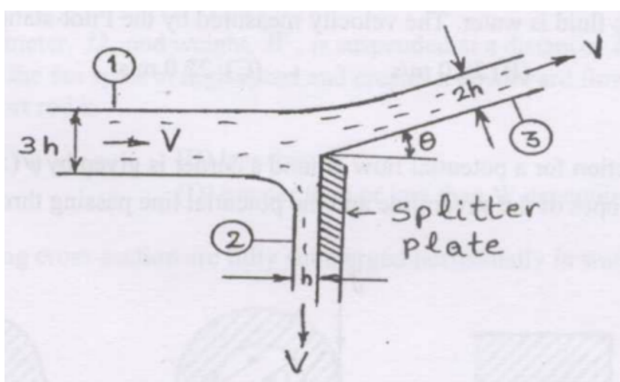

Figure 31

(A) 0
(B) $\tan^{-1}(0.5)$
(C) $\cos^{-1}(0.5)$
(D) $\sin^{-1}(0.5)$

GATE XE 2008

Q16. Find the vertical hydrostatic force, f_z, on the surface P-Q due to the water in the tank. Note, f_z is the force per unit width along y. The surface P-Q is shaped like a quarter-cylinder of radius R.. The atmospheric pressure is P_o.

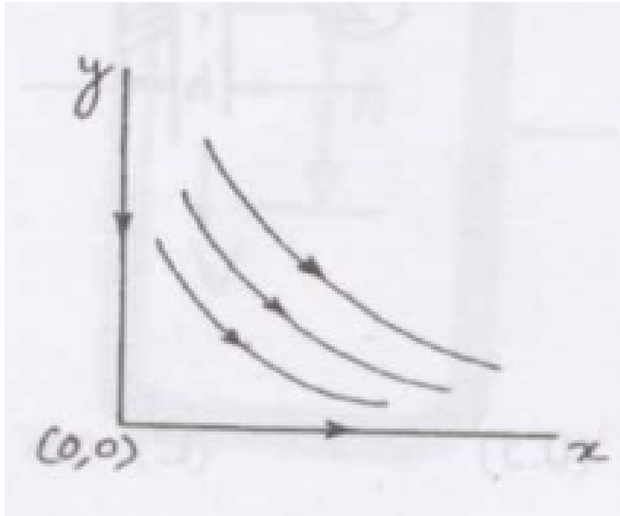

Figure 32

(A) $\rho_w(R^2 + \frac{\pi}{4}R^2)$
(B) $P_oR + \rho_w g(R^2 + \frac{\pi}{4}R^2)$
(C) $\rho_w g(\frac{\pi}{4}R^2)$
(D) $P_oR + \rho_w g(\frac{\pi}{4}R^2)$

GATE XE 2008

Q17. For a given location in a flow, the rate of change of density following a fluid particle $(\frac{D\rho}{Dt} = \frac{\partial \rho}{\partial t} + u\frac{\partial \rho}{\partial x} + v\frac{\partial \rho}{\partial y} + w\frac{\partial \rho}{\partial z})$, is $2.4kg/(m^3s)$.I the denst at that poin is $1.2kg/m^3$, then the divergence of the velocity field $(\nabla \cdot \mathbf{V})$ at that point is:

(A) $0.5s^{-1}$ (B) $-0.5s^{-1}$ (C) $-2s^{-1}$ (D) $2s^{-1}$

GATE XE 2008

Q18. Water is flowing with volume flow rate Q through a pipe whose diameter reduces to half across a reducer. If the flow is frictionless, compare the manometer reading h_1,h_2 and h_3, corresponding to the three different inclinations of the pipe $\theta_1 = 30°$, $\theta_2 = 0°$and $\theta_3 = -30°$. Note that only the pipe tilts, while the manometer always stays vertical.

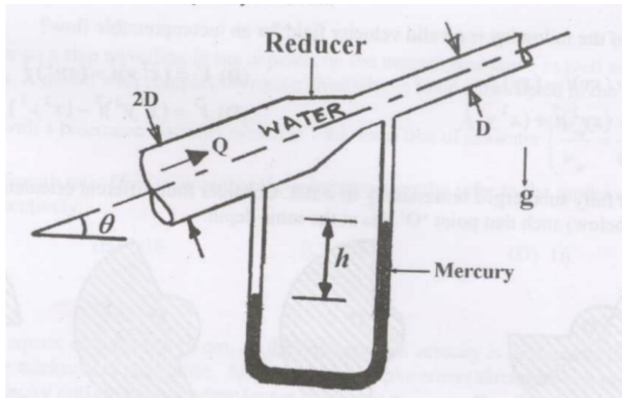

Figure 33

(A) $h_1 > h_2 > h_3$ (B) $h_1 < h_2 < h_3$ (C) $h_1 = h_2 = h_3$ (D) $h_1 = h_3$ and $h_1 > h_2$

GATE XE 2008

Q19. A $4m$ wide canal is modelled using a $1m$ wide dynamically similar model in the laboratory. A wooden block was observed to travel between two points in the model in 8 seconds. How long will it take to travel between the corresponding points in the actual canal?

(A) $4s$ (B) $8s$ (C) $16s$ (D) $32s$

GATE XE 2008

Q20. Water (dynamic viscosity $\mu = 0.001Ns/m^2$) flows under pressure through a pipe of $1cm$ diameter at a velocity of $1cm/s$. What would be the head loss per km length of the pipe?

(A) $0.08m$ (B) $0.16m$ (C) $0.32m$ (D) $1.28m$

GATE XE 2008

Q21. Air with free stream velocity $10m/s$ flows over three different bluff bodies P, Q and R as shown below, with a hemisphere of radius $1m$ forming the nose.

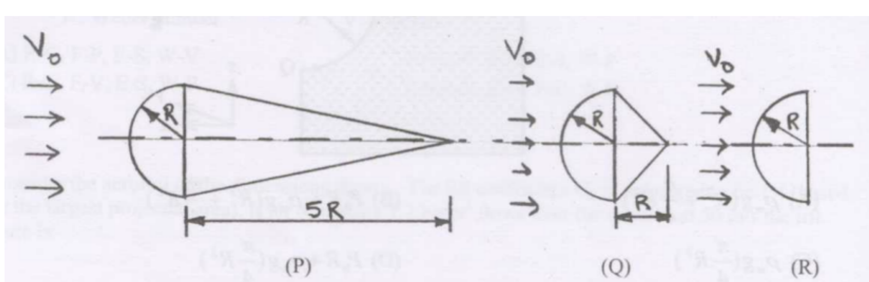

Figure 34

Comparing the total drag force F on the three bodies, state which of the following is true.

(A) $F_P > F_Q > F_R$ (B) $F_P = F_Q = F_R$ (C) $F_P < F_Q < F_R$ (D) $F_P = F_Q and F_R > F_P$

GATE XE 2008

Q22. A single engine jet aircraft is in a steady level flight at speed V_a with respect to ground. Assume that the engine intake area (A_{in}) is much larger than the engine exhaust area (A_e). If the density of the exhaust gas is ρ_e and the exhaust velocity relative to the aircraft is V_e, the thrust generated by the engine is

(A) $\rho_e V_e^2 A_e$ (B) $\rho_e (V_a + V_e)^2 A_e$ (C) $\rho_e (V_a - V_e)^2 A_e$ (D) $\rho_e (V_a + V_e) V_e A_e$

GATE XE 2008

Q23. Which of the following is a valid velocity field for an incompressible flow?

(A) $\mathbf{V} = (xy)\hat{i} - (xy)\hat{j}$
(B) $\mathbf{V} = (x^2y)\hat{i} - (xy^2)\hat{j}$
(C) $\mathbf{V} = (xy^2)\hat{i} + (x^2y)\hat{j}$
(D) $\mathbf{V} = (x^2y^2)\hat{i} - (x^2y^2)\hat{j}$

GATE XE 2008

Q24. A log is fully submerged horizontally in water. Consider four different orientations (cross-sections shown below) such that point 'O' lies at the same depth.

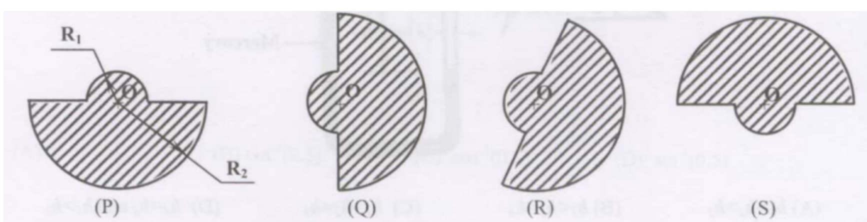

Figure 35

Which orientation(s) will give the maximum moment about point O?

(A) P (B) Q (C) R (D) Pand S

GATE XE 2008

Q25. A closed cylindrical container of diameter D and length L is completely filled with a liquid of density ρ. The axis of the cylinder makes an angle with the vertical.

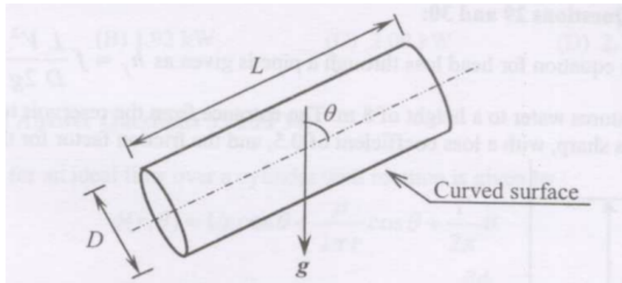

Figure 36

The total force on the curved surface is

(A) $\frac{\pi D^2 L}{4}\rho g \sin\theta$
(B) $\frac{\pi D^2 L}{4}\rho g \cos\theta$
(C) $\frac{3\pi D^2 L}{4}\rho g \sin\theta$
(D) $\frac{3\pi D^2 L}{4}\rho g \cos\theta$

GATE XE 2008

Q26. Air flowing over a smooth cylinder of diameter $30cm$ in a wind tunnel produces a two-dimensional laminar boundary layer that separates from the surface ofthe cylinder. The surface of the cylinder is then roughened with sand paper so that the boundary layer turns turbulent. The location of the point of separation will

(A) shift upstream
(B) shift downstream
(C) not shift
(D) shift upstream or downstream depending on the roughness height

GATE XE 2008

Q27. The drag force on a ship travelling in sea depends on the viscous resistance as well as the effect of surface waves. A model with complete dynamic similarity is to be constructed in the laboratory using a fluid with a kinematic viscosity which is $\frac{\nu_m}{\nu_p} = \frac{1}{64}$ times that of seawater. What should be the length ratio $\left(\frac{l_m}{l_p}\right)$? Note that the subscripts m and p refer to the model and the prototype respectively.

(A) $\frac{1}{64}$
(B) $\frac{1}{16}$
(C) $\frac{1}{8}$
(D) 16

GATE XE 2008

Q28. Air flows in a square duct of side 10 cm. At the entrance, the velocity is uniform at 10 m/s and the boundary layer thickness is negligible. At the exit, the displacement thickness is 5 mm (on each wall). The velocity outside the boundary layers at the exit is:

(A) 12.35 m/s (B) 11.08 m/s (C) 10 m/s (D) 9 m/s

GATE XE 2008

Common Data questions

Common Data for Questions 29 and 30:

The Darcy–Weisbach equation for head loss through a pipe is given as $h_f = f\frac{L}{D}\frac{V^2}{2g}$. A reservoir, as shown in the figure, stores water to a height of 8 m. The entrance from the reservoir to the pipe (length 50 m, diameter 10 cm) is sharp, with a loss coefficient of 0.5, and the friction factor for the pipe is 0.017.

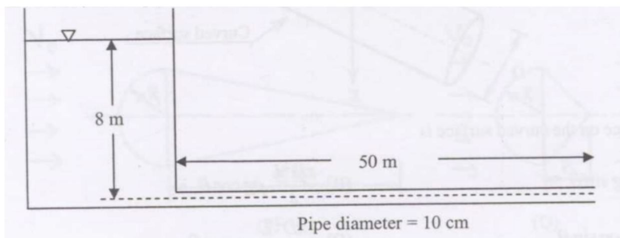

Figure 37

Q29. What would be the discharge through the pipe?

(A) 0.0314 m^3/s (B) 0.0322 m^3/s (C) 0.0331 m^3/s (D) 0.0341 m^3/s

GATE XE 2008

Q30. If it is desired to increase the discharge, the following four options are available:

1. Increase the pipe length, keeping everything else the same
2. Increase the pipe diameter, keeping everything else the same
3. Add a valve at the end of the pipe, keeping everything else the same
4. Replace the sharp entrance by a rounded entrance, keeping everything else the same

Only two of these options serve our purpose. Which are they?

(A) 1, 2 (B) 1, 3 (C) 2, 4 (D) 3, 4

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

A pump draws water from a reservoir and discharges it to an overhead tank as shown. The area of the outlet pipe is 20 cm^2 and the average velocity in the outlet pipe is 3 m/s. Neglect the minor and major losses in the piping.

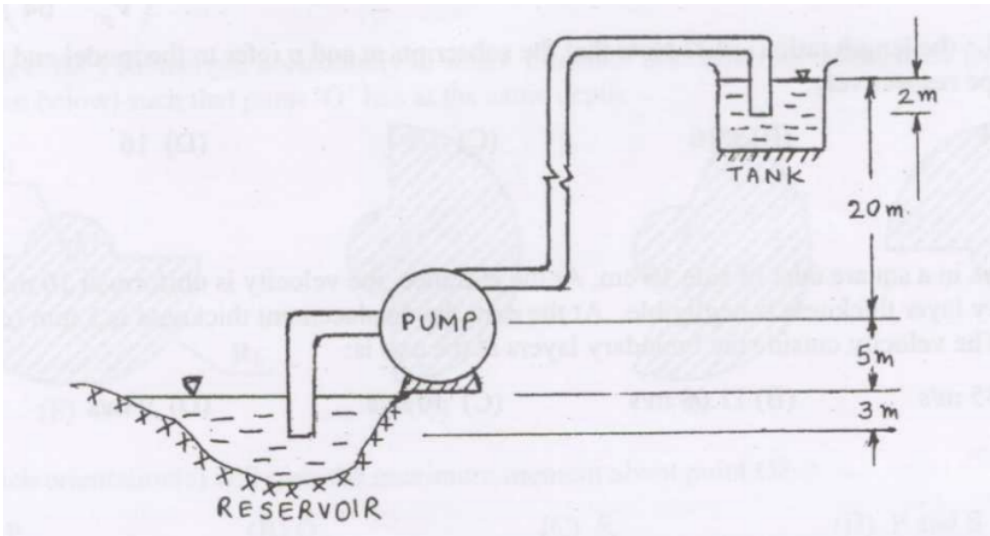

Figure 38

Q31. The total head developed by the pump (in metres of water) is:

(A) 27 m (B) 25 m (C) 24 m (D) 22 m

GATE XE 2008

Q32. If the combined efficiency of the pump and motor is 0.75, then the power required to run the pump is:

(A) 1.76 kW (B) 1.92 kW (C) 2.00 kW (D) 2.16 kW

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

The potential function for an ideal flow over a cylinder with rotation is given by $\phi(r,\theta) = Ur\cos\theta + \frac{\mu}{2\pi r}\cos\theta + \frac{\Gamma}{2\pi}\theta$

The velocity components are related to the potential function as $u_r = \frac{\partial\phi}{\partial r}$ and $u_\theta = \frac{1}{r}\frac{\partial\phi}{\partial\theta}$.

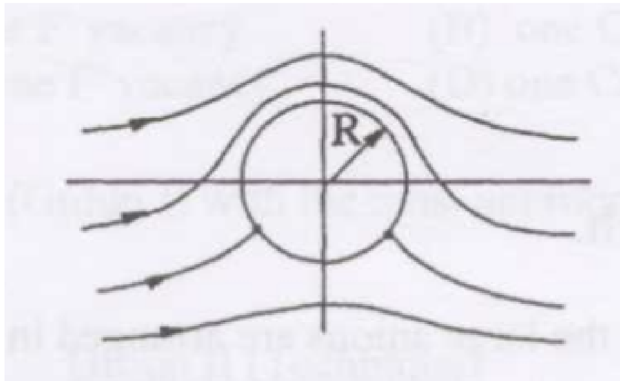

Figure 39

Q33. What is the radius of the cylinder?

(A) $R = \sqrt{\frac{\mu}{2\pi U}}$ (B) $R = \sqrt{\frac{2\pi U}{\mu}}$ (C) $R = \sqrt{\frac{\mu}{\Gamma - 2\pi U}}$ (D) $R = \sqrt{\frac{\Gamma - 2\pi U}{\mu}}$

GATE XE 2008

Q34. Where are the stagnation points located?

(A) $\theta = 0$ and $\theta = \pi$

(B) $\theta = \sin^{-1}\left(\frac{\Gamma}{4\pi UR}\right)$ and $\theta = \pi - \sin^{-1}\left(\frac{\Gamma}{4\pi UR}\right)$

(C) $\theta = \frac{\pi}{2}$ and $\theta = -\frac{\pi}{2}$

(D) $\theta = \cos^{-1}\left(\frac{\Gamma}{4\pi UR}\right)$ and $\theta = 2\pi - \cos^{-1}\left(\frac{\Gamma}{4\pi UR}\right)$

GATE XE 2008

END OF SECTION - D

E : MATERIALS SCIENCE

Useful Data

Table 12

Avogadro's number	6.023×10^{23} mol^{-1}
Boltzmann's constant	1.38×10^{-23} J K^{-1}
Electron charge	1.6×10^{-19} C
Gas constant	8.314 J mol^{-1}K^{-1}
Electron rest mass	9.1×10^{-31} kg
Free space permittivity (ε_0)	8.854×10^{-12} F m^{-1} or C V^{-1} m^{-1}
Free space magnetic permeability (μ_0)	$4\pi \times 10^{-7}$ H m^{-1}
Speed of light (c)	3×10^8 m s^{-1}
Planck's constant (h)	6.62×10^{-34} J s
Bohr magneton, μ_B	9.27×10^{-24} A m^2

1 eV $= 1.6 \times 10^{-19}$ J
1 cal $= 4.2$ J

Q1 - Q8 carry one mark each

Q1. In the rocksalt-type structure, the large anions are arranged in a cubic close-packed manner. The cations occupy

(A) all the octahedral interstitial sites

(B) half of the octahedral interstitial sites and quarter of the tetrahedral interstitial sites

(C) all the tetrahedral interstitial sites

(D) 50% of the tetrahedral interstitial sites

GATE XE 2008

Q2. Which of the following is **NOT** a Bravais lattice?

(A) Body-centered tetragonal
(B) Face-centered tetragonal
(C) Body-centered orthorhombic
(D) Face-centered orthorhombic

GATE XE 2008

Q3. The characteristic diffusion distance in a material with diffusivity D in time t is proportional to

(A) $Dt^{1/2}$ (B) $D^{1/2}t$ (C) $D^{1/2}t^{1/2}$ (D) Dt

GATE XE 2008

Q4. At constant pressure, the maximum degrees of freedom in a binary phase diagram are

(A) 0 (B) 1 (C) 2 (D) 3

GATE XE 2008

Q5. When the particle size decreases, the surface-to-volume ratio

(A) increases
(B) decreases
(C) remains constant
(D) is material-dependent

GATE XE 2008

Q6. A material in the superconducting state is

(A) paramagnetic (B) diamagnetic (C) ferromagnetic (D) antiferromagnetic

GATE XE 2008

Q7. Toughness is a measure of

(A) the stress required to fracture a material
(B) the strain required to fracture a material
(C) the energy required to fracture a material
(D) the energy required to plastically deform a material

GATE XE 2008

Q8. Metals, because of their many available empty electron states, will absorb

(A) X- and γ-ray radiation
(B) visible light of all frequencies
(C) ultra-violet (UV) light
(D) all the frequencies greater than that of UV light

GATE XE 2008

Q. 9 to Q.30 carry two marks each.

Q9. The stacking sequence of the (001) FCC and (0001) HCP planes is

(A) ...ABAB and ABAB...
(B) ...ABCABC and ABCABC...
(C) ...ABAB and ABCABC...
(D) ...ABCABC and ABAB...

GATE XE 2008

Q10. A Schottky defect in CaF_2 is comprised of

(A) one Ca^{2+} vacancy and one F^- vacancy
(B) one Ca^{2+} vacancy and one F^- interstitial
(C) two Ca^{2+} vacancies and one F^- vacancy
(D) one Ca^{2+} vacancy and two F^- vacancies

GATE XE 2008

Q11. Match the materials property (Group I) with the most appropriate characterization technique (Group II).

Table 13

Group I (Property)	**Group II (Technique)**
P)Lattice strain	1) Scanning electron microscope
Q) Band Gap	2) X-ray diffraction
R) Surface topography	3) Optical Absorption Spectroscopy
S) Specific Heat	4) Differential Scanning Calorimetry
	5) Nuclear Magnetic Resonance (NMR) Spectroscopy

(A) P-1, Q-2, R-3, S-4
(B) P-5, Q-1, R-2, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-5, R-1, S-4

GATE XE 2008

Q12. The average degree of polymerization of Polypropylene associated with an average molecular weight of 36000 amu is (atomic masses of C and H are 12 and 1 amu, respectively)

(A) 1286 (B) 857 (C) 360 (D) 346

GATE XE 2008

Q13. In an alloy system, X-Y, three phases α (10), γ (21), and L_{iq} (45) are in equilibrium at $700°$C and γ (21), L_{iq} (68) and β (89) are in equilibrium at $420°$C. (Numbers in the brackets are compositions of the phase in wt% of X). Choose the **INCORRECT** statement:

(A) γ is an intermetallic compound
(B) Equilibrium at $700°$C is peritectic

(C) Equilibrium at $420°$C is eutectic
(D) Equilibrium at $420°$C is eutectoid

GATE XE 2008

Q14. Which one of the following may **NOT** help in resisting the weld decay or intergranular corrosion in austenitic stainless steel?

(A) Heating the stainless steel to $1000°$C followed by quenching to room temperature
(B) Heating the stainless steel to $1000°$C followed by furnace cooling
(C) Lowering the carbon content to 0.03 wt.% in the stainless steel
(D) Alloying the stainless steel with Nb or Ti

GATE XE 2008

Q15. A badminton racquet stem is designed to have a Young's modulus of 230 GPa. The stem is made up of long, oriented carbon fibres parallel to the stem axis in an epoxy matrix. The Young's moduli of carbon fibre and epoxy are 400 GPa and 3 GPa respectively. The volume fraction of the fiber in the composite should be

(A) 0.006 (B) 0.428 (C) 0.572 (D) 0.994

GATE XE 2008

Q16. Match the material (Group I) with its most well known application (Group II).

Table 14

Group I (Material)	**Group II (Application)**
P) Graphite	1) Lubricant
Q) Cermet	2) Cutting tools
R) PbS	3) Infrared detector
S) Quartz	4) Crystal oscillator
	5) Red LED

(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-5, Q-1, R-2, S-3
(D) P-2, Q-5, R-1, S-4

GATE XE 2008

Q17. At constant volume, the energy required to raise the temperature of $1\ \mathrm{g}$ of a monatomic solid (atomic mass: $24\ \mathrm{amu}$) by $1°\mathrm{C}$ at $T \gg \Theta_{\mathrm{Debye}}$ is:

(A) 0.20 cal (B) 0.25 cal (C) 0.30 cal (D) 0.35 cal

GATE XE 2008

Q18. For a hard magnet, the remnant induction (B_r) is 0.5 T and the coercive field (H_c) is $4 \times 10^4 \text{ A m}^{-1}$. The energy loss of the magnet per cycle is:

(A) 2 kJ m^{-3} (B) 20 kJ m^{-3} (C) 40 kJ m^{-3} (D) 80 kJ m^{-3}

GATE XE 2008

Q19. A 1 mm thick sheet of a material having a relative dielectric constant of 4 is subjected to a static voltage of 100 V. The polarization induced in the sheet is:

(A) $3 \times 10^{-6} \text{ C m}^{-2}$ (B) $2.7 \times 10^{-6} \text{ C m}^{-2}$ (C) $4.2 \times 10^{-7} \text{ C m}^{-2}$ (D) $6.8 \times 10^{-5} \text{ C m}^{-2}$

GATE XE 2008

Q20. The refractive index of a window glass is 1.5 in the range of visible wavelengths of light. The value of the reflectivity is:

(A) 0.01 (B) 2 (C) 0.04 (D) 5

GATE XE 2008

Q21. In $BaTiO_3$, the presence of spontaneous polarization is as a result of the

(A) relative displacements of the Ti^{4+} and O^{2-} ions from their symmetrical positions
(B) displacement of only cations from their symmetrical positions
(C) relative displacements of Ba^{2+} and O^{2-} ions from their symmetrical positions
(D) displacement of only O^{2-} ions from their symmetrical positions

GATE XE 2008

Q22. What is the yield strength of a material with a grain size of $10\ \mu$m? The yield strength of a single crystal of this material is 80 MPa and its Hall–Petch constant is $0.6 \text{ MN m}^{-3/2}$.

(A) 80 MPa (B) 86 MPa (C) 140 MPa (D) 270 MPa

GATE XE 2008

Q23. The amount of sulphur (S) required for 5% cross linking in 100 kg of polyisoprene is (atomic masses of H, C, and S are 1, 12, and 32 amu, respectively):

(A) 23.5 g (B) 47 g (C) 2.35 kg (D) 16 kg

GATE XE 2008

Q24. Match the type of laser (Group I) with its lasing medium (Group II).

Table 15

Group I (Laser)	**Group II (Lasing Medium)**
P) CO_2	1) Gas
Q) Ruby	2) Metal vapor
R) Dye	3) Liquid
S) HeCd	4) Solid
	5) Gas-ions

(A) P-1, Q-4, R-3, S-2

(B) P-1, Q-2, R-3, S-4

(C) P-2, Q-4, R-5, S-4

(D) P-5, Q-4, R-3, S-4

GATE XE 2008

Q25. Which of the following is the direction common to $(\bar{1}11)$ and (111) planes?

(A) $[011]$ (B) $[21\bar{1}]$ (C) $[0\bar{1}1]$ (D) $[001]$

GATE XE 2008

Q26. The net magnetic moment of iron (Fe) is $2.22\,\mu_B$ per atom. Calculate the saturation flux density in iron. (Density of iron: $7.87\,\text{g/cm}^3$; Atomic mass of iron: $56\,\text{amu}$)

(A) 2.18×10^{-6} Tesla (B) 2.18×10^{-12} Tesla (C) 2.18×10^{9} Tesla (D) 2.18 Tesla

GATE XE 2008

Common Data Questions

Common Data for Questions 27 and 28:

A hypothetical load–elongation curve for a 13 mm diameter tensile specimen with 50 mm gauge length is as shown.

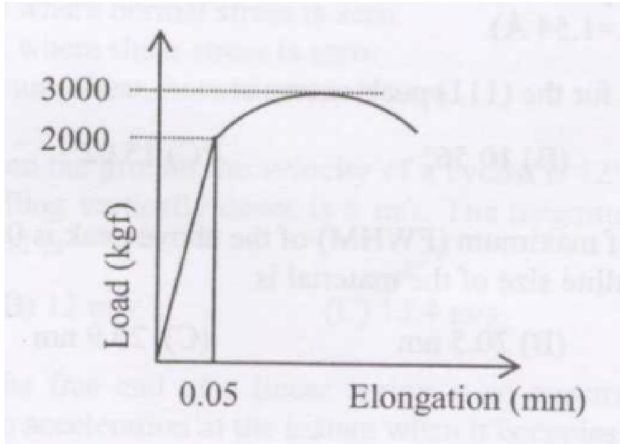

Figure 40

Q27. The Young's modulus is

(A) $101\ \mathrm{GPa}$ (B) $148\ \mathrm{GPa}$ (C) $201\ \mathrm{GPa}$ (D) $301\ \mathrm{GPa}$

GATE XE 2008

Q28. The ultimate tensile strength of the material is

(A) $207\ \mathrm{MPa}$ (B) $247\ \mathrm{MPa}$ (C) $222\ \mathrm{MPa}$ (D) $267\ \mathrm{MPa}$

GATE XE 2008

Common Data for Questions 29 and 30:

A cylindrical well-annealed copper (Cu) specimen having a cross-sectional area of $5 \times 10^{-6}\ \mathrm{m}^2$ and length of $1\ \mathrm{m}$ has a dislocation density of $10^9\ \mathrm{m}^{-2}$ and grain diameter of $40\ \mu\mathrm{m}$. This specimen is reduced to a cross-section of $1 \times 10^{-6}\ \mathrm{m}^2$ by passing through a die and in the process, its dislocation density increases to $10^{13}\ \mathrm{m}^{-2}$. Subsequently, the wire is annealed at $400°\mathrm{C}$ and the just-recrystallized wire has a grain diameter of $10\ \mu\mathrm{m}$. If it is kept at $450°\mathrm{C}$ for a longer duration, grain growth would occur. (Shear modulus of Cu: $44\ \mathrm{GPa}$; Atomic diameter of Cu: $2.56\ \text{Å}$; Specific grain boundary energy of Cu: $0.5\ \mathrm{J/m^2}$)

Q29. What is the strain energy stored in the just-deformed copper specimen?

(A) $72\ \mathrm{J}$ (B) $36\ \mathrm{J}$ (C) $72\ \mathrm{mJ}$ (D) $36\ \mathrm{mJ}$

GATE XE 2008

Q30. What is the driving force for grain growth (stored grain boundary energy) just after recrystallization at $450°\mathrm{C}$ in the given specimen?

(A) $375\ \mathrm{mJ}$ (B) $750\ \mathrm{mJ}$ (C) $1.5\ \mathrm{J}$ (D) $3.0\ \mathrm{J}$

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 (carry two marks each)

Statement for Linked Answer Questions 31 and 32:

For a semiconductor, the electron and hole mobilities are $\mu_e = 0.364\,\mathrm{m}^2\,\mathrm{V}^{-1}\,\mathrm{s}^{-1}$, $\mu_h = 0.19\,\mathrm{m}^2\,\mathrm{V}^{-1}\,\mathrm{s}^{-1}$, and the intrinsic carrier concentrations are $n_e = n_h = 2.3 \times 10^{19}\,\mathrm{m}^{-3}$ at $300\ \mathrm{K}$.

Q31. The electrical conductivity of the semiconductor at $300\ \mathrm{K}$ is

(A) 2.04 $\Omega^{-1}\,\mathrm{m}^{-1}$ (B) 1.34 $\Omega^{-1}\,\mathrm{m}^{-1}$ (C) 0.70 $\Omega^{-1}\,\mathrm{m}^{-1}$ (D) 2.74 $\Omega^{-1}\,\mathrm{m}^{-1}$

GATE XE 2008

Q32. Upon increasing the temperature to $373\ \mathrm{K}$, the electrical conductivity increases to $25.75\ \Omega^{-1}\,\mathrm{m}^{-1}$. The bandgap of the semiconductor is

(A) 1.43 eV (B) 1.11 eV (C) 0.67 eV (D) 0.33 eV

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

The X-ray powder diffraction pattern of a well annealed cubic material (lattice parameter $a = 4.2\ \text{Å}$) is taken using CuK$_\alpha$ radiation ($\lambda = 1.54\ \text{Å}$).

Q33. The Bragg angle (θ_B) for the (111) peak occurs at

(A) $18.55°$ (B) $10.56°$ (C) $15.02°$ (D) $33.37°$

GATE XE 2008

Q34. If the full width at half maximum (FWHM) of the above peak is $0.4°$, ignoring the instrumental broadening, the crystallite size of the material is

(A) 20.2 nm (B) 20.5 nm (C) 20.9 nm (D) 23.7 nm

GATE XE 2008

END OF SECTION - E

F : SOLID MECHANICS

Q1 - Q8 carry one mark each

Q1. Which of the following is true?

(A) In the plane of maximum shear, normal stress is always zero.
(B) In the plane of maximum shear, normal stress may not be always zero.
(C) In a principal plane, shear stress is never zero.
(D) In a principal plane, normal stress is always zero.

GATE XE 2008

Q2. State of stress at a point in a loaded body is given by $\sigma_x = 10$ MPa, $\sigma_y = 0$, $\sigma_z = -5$ MPa and $\tau_{xy} = \tau_{yz} = \tau_{zx} = 0$. Maximum shear stress at that point is

(A) 5 MPa (B) 2.5 MPa (C) 7.5 MPa (D) 0

GATE XE 2008

Q3. State of stress at a point of a body in a plane stress problem is given by $\sigma_x = -6$ MPa, $\sigma_y = 2$ MPa and $\tau_{xy} =$ MPa. Which of the following is true at that point?

(A) There exists at least one plane where normal stress is zero.
(B) There exists no plane where normal stress is zero.
(C) There exists no plane where shear stress is zero.
(D) In the plane of maximum shear, normal stress is zero.

GATE XE 2008

Q4. To an observer standing on the ground the velocity of a cyclist is 12 m/s in the horizontal direction and that of rain drops falling vertically down is 6 m/s. The magnitude of the velocity of the rain drops relative to the cyclist is

(A) 6 m/s (B) 12 m/s (C) 13.4 m/s (D) 18.4 m/s

GATE XE 2008

Q5. If a mass attached to the free end of a linear spring is so constrained that it executes vertical undamped oscillations, its acceleration at the instant when it occupies the static equilibrium position is

(A) vertically upward
(B) vertically downward
(C) the maximum
(D) zero

GATE XE 2008

Q6. If three nonparallel forces are in equilibrium they

(A) must be concurrent but need not be coplanar
(B) must be coplanar but need not be concurrent
(C) must be both concurrent and coplanar
(D) need not have zero as the geometric sum of the force vectors

GATE XE 2008

Q7. A point of contraflexure in a loaded beam is one where

(A) shear force is maximum.
(B) shear force and bending moment are maximum.
(C) bending moment is maximum.
(D) bending moment is zero.

GATE XE 2008

Q8. In a beam of uniform strength, the extreme fibers at every cross section are stressed to the maximum allowable stress. Consider a solid circular beam of uniform strength subjected to bending moment. In this beam, the diameter of the cross-section at any section is proportional

(A) to cube root of the bending moment at that section.
(B) to the square root of the bending moment at that section.
(C) to the bending moment at that section.
(D) inversely to the bending moment at that section.

GATE XE 2008

Q9 to Q30 carry two marks each.

Q9. For a loaded body representing a two dimensional plane problem, the displacement components along x and y at any point (x, y) are $u = x^2 + y^2$, $v = 2xy$ respectively. Principal strains at the point $(3, 1)$ in the body are

(A) $\epsilon_1 = 8, \epsilon_2 = 2$
(B) $\epsilon_1 = 6.24, \epsilon_2 = 1.76$
(C) $\epsilon_1 = 0, \epsilon_2 = 3$
(D) $\epsilon_1 = 5, \epsilon_2 = -3$

GATE XE 2008

Q10. A 9 kN tensile load will be applied to a 50 m length steel wire with $E = 200$ GPa. The normal stress in the wire must not exceed 150 MPa and the increase in the length of the wire should be at most 25 mm. Which among these could be the smallest diameter of the wire so that the wire does not fail?

(A) 5.75 mm (B) 7.75 mm (C) 8.75 mm (D) 10.7 mm

GATE XE 2008

Q11. A uniform circular cross section rod made of a brittle material is subjected to a pure torsion. If d is the diameter of the cross section of the rod and σ_{all} is the maximum allowable normal stress for the material of the rod, then the maximum twisting moment that can be applied to the rod without failure is

(A) $\frac{\sigma_{\text{all}}}{16}\pi d^3$ (C) $\frac{\sigma_{\text{all}}}{8}\pi d^3$

(B) $\frac{\sigma_{\text{all}}}{32}\pi d^3$ (D) $\frac{\sigma_{\text{all}}}{64}\pi d^3$

GATE XE 2008

Q12. A thin walled spherical pressure vessel of mean radius 1000 mm, having a wall thickness of 10 mm is subjected to an internal pressure of 0.8 MPa. The maximum shear stress developed in the wall will be

(A) 0 (B) 20 MPa (C) 40 MPa (D) 80 MPa

GATE XE 2008

Q13. A rectangular cross section beam of width $w = 0.25$ m and depth $d = 0.4$ m is subjected to a bending moment $M = 200$ N·m and a uniform axial load of $P = 200$ N as shown. Measured from the centroidal axis of the beam, normal stress will be zero at a distance of

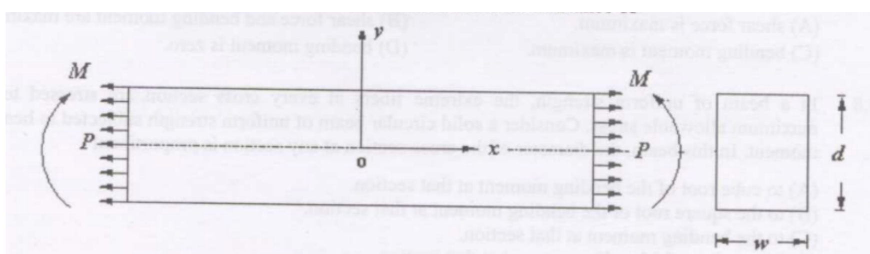

Figure 41

(A) $y = 15$ mm (B) $y = -13.3$ mm (C) $y = -15$ mm (D) $y = 10$ mm

GATE XE 2008

Q14. Three masses M, $2M$ and $3M$ are attached by circular cross section wires and are rotated around a vertical axis on a frictionless plane at 4 Hz as shown in the figure. Consider the masses to be concentrated as points. For equal stresses in wires in all the three segments, the cross sectional areas of the wires in the three segments 1, 2 and 3 should be in the ratio

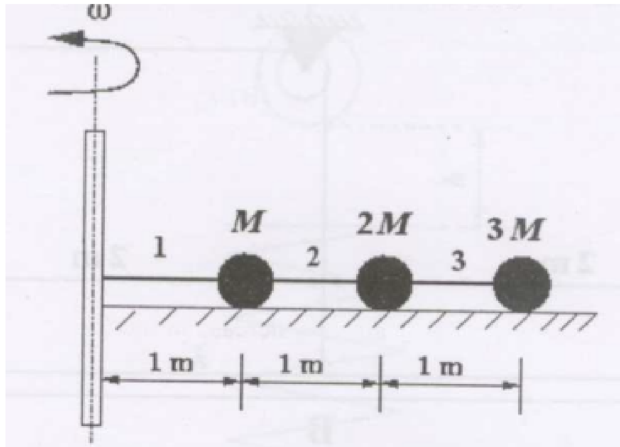

Figure 42

(A) 1:2:3 (B) 3:2:1 (C) 9:4:1 (D) 14:13:9

GATE XE 2008

Q15. Two steel plates of uniform cross section $10 \text{ mm} \times 80 \text{ mm}$ are welded together and subjected to an axial load of $P = 100 \text{ kN}$ as shown in the figure. Allowable normal stress (tension and compression) and allowable shear stress for the material of the weld are 100 MPa and 50 MPa respectively and $\beta = 25°$. Which of the following is true?

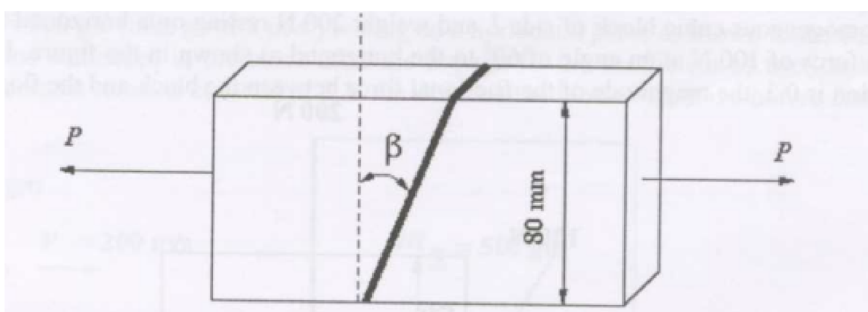

Figure 43

(A) The joint will fail due to normal tensile stress.
(B) The joint will fail due to normal compressive stress.
(C) The joint will fail due to shear stress.
(D) The joint will not fail.

GATE XE 2008

Q16. A plane cantilever truss is loaded as shown in the figure. If a positive sign denotes tension and a negative sign compression, the axial force in the member 1 is

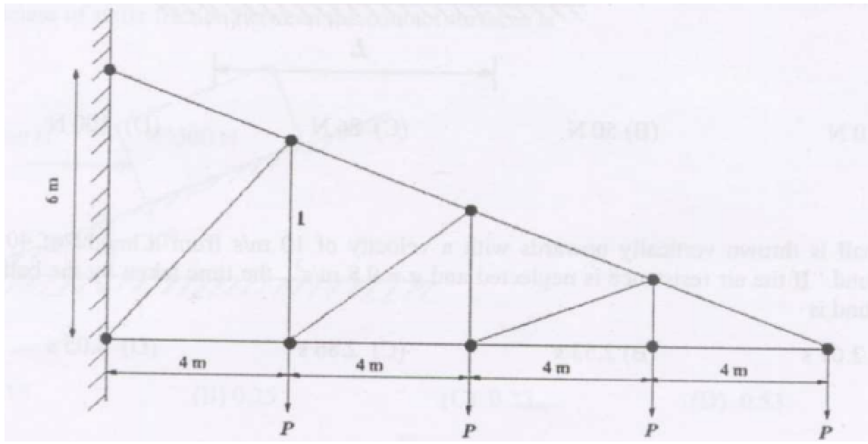

Figure 44

(A) $-5.33P$ (B) $-1.67P$ (C) $+2P$ (D) $+3P$

GATE XE 2008

Q17. A man weighing $600\ \mathrm{N}$ stands on a horizontal beam of negligible weight at C and holds a string passing over two smooth pulleys and attached to point B on the beam as shown in the figure. The tension in the string is

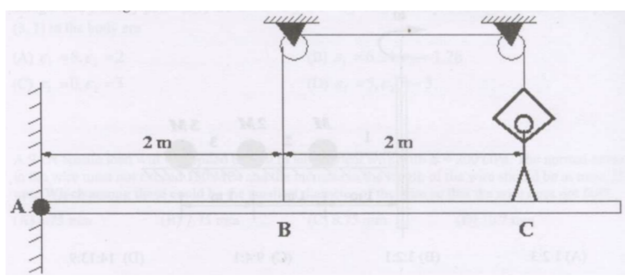

Figure 45

(A) $100\ \mathrm{N}$ (B) $400\ \mathrm{N}$ (C) $600\ \mathrm{N}$ (D) $1200\ \mathrm{N}$

GATE XE 2008

Q18. A homogeneous cubic block of side L and weight $200\ \mathrm{N}$ resting on a horizontal floor is acted upon by a force of $100\ \mathrm{N}$ at an angle of $60°$ to the horizontal as shown in the figure. If the coefficient of friction is 0.3, the magnitude of the frictional force between the block and the floor is

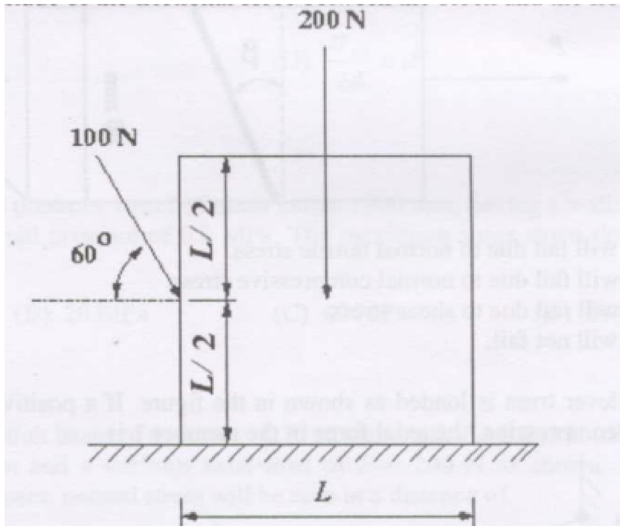

Figure 46

(A) 0 N (B) 50 N (C) 86 N (D) 100 N

GATE XE 2008

Q19. A ball is thrown vertically upwards with a velocity of 10 m/s from a height of 40 m from the ground. If the air resistance is neglected and $g = 9.8 \text{ m/s}^2$, the time taken by the ball to reach the ground is

(A) 2.01 s (B) 2.53 s (C) 2.86 s (D) 4.05 s

GATE XE 2008

Q20. When a ball of weight W rests on a spring of constant k, it produces a static deflection of 3 cm. If the ball is now dropped from a height of $h = 30 \text{ cm}$ as shown in the figure, the spring will get compressed by

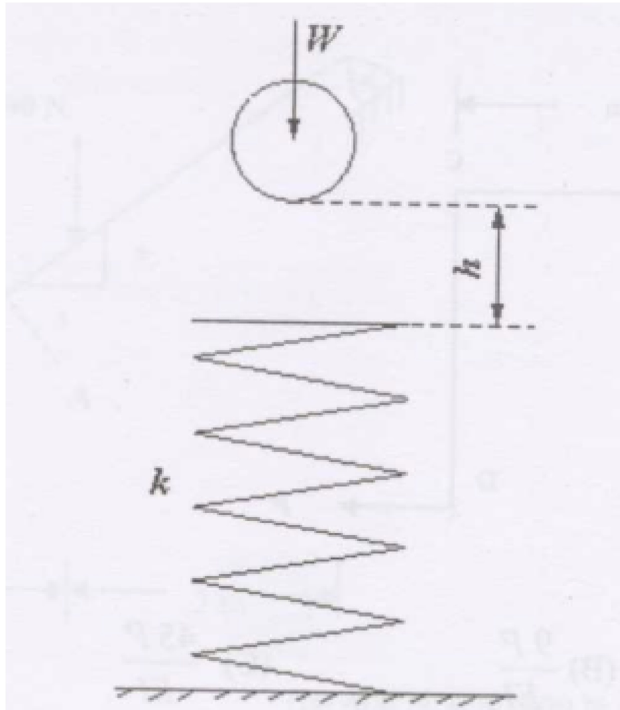

Figure 47

(A) 2.45 cm (B) 14.07 cm (C) 16.75 cm (D) 33 cm

GATE XE 2008

Q21. A bullet of mass $m_1 = 20 \text{ gm}$ fired horizontally with a velocity of $v = 200 \text{ m/s}$ hits a wooden block of mass $m_2 = 500 \text{ gm}$ (take $g = 9.8 \text{ m/s}^2$) resting on a horizontal plane as shown in the figure and the bullet remains embedded in the block after the impact. If the coefficient of friction between the surfaces in contact remains constant at 0.3, the distance the block will move before coming to rest is

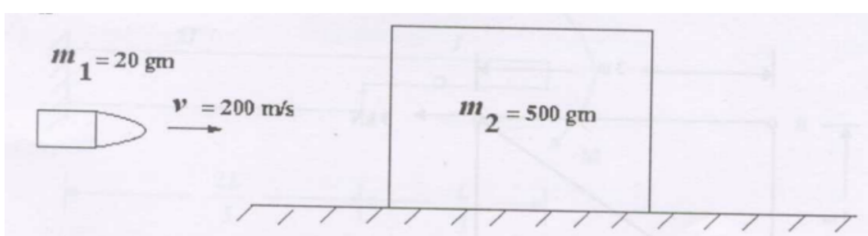

Figure 48

(A) 5.03 m (B) 10.06 m (C) 20.12 m (D) 100 m

GATE XE 2008

Q22. A block of weight 500 N is about to move up the plane due to a horizontal force of 800 N. The coefficient of static friction between the contact surfaces is

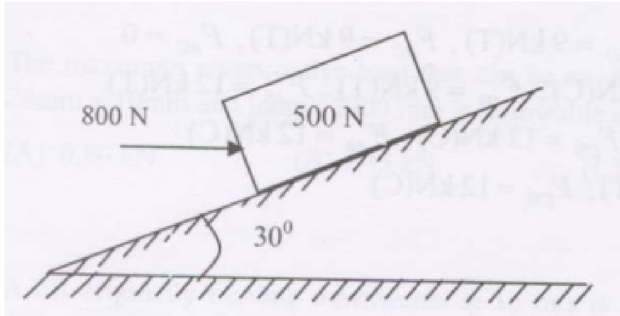

Figure 49

(A) 0.15 (B) 0.25 (C) 0.33 (D) 0.53

GATE XE 2008

Q23. The horizontal displacement at D of the frame shown in figure is (neglect axial strain energy and assume EI to be constant throughout)

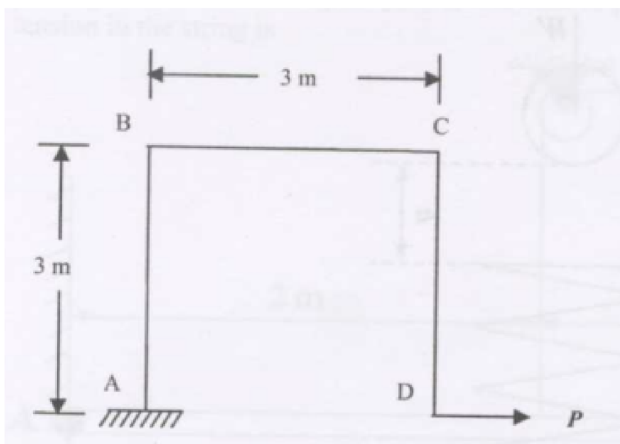

Figure 50

(A) $\frac{6P}{EI}$ (B) $\frac{9P}{EI}$ (C) $\frac{45P}{EI}$ (D) $\frac{729P}{EI}$

GATE XE 2008

Q24. The forces in the members of a truss ABCD as shown in the figure are (T stands for tension and C for compression)

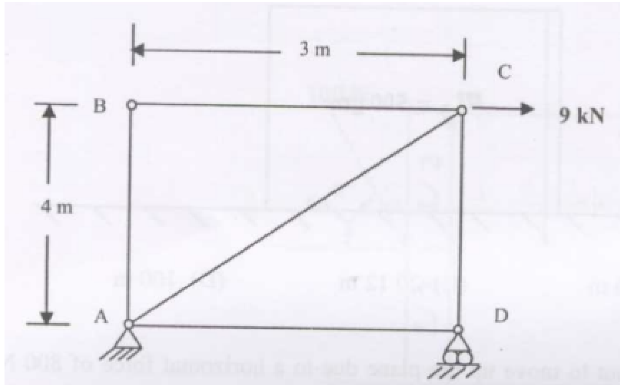

Figure 51

(A) $F_{AB} = 12\ \mathrm{kN(T)},\ F_{CD} = 12\ \mathrm{kN(C)},\ F_{AD} = 9\ \mathrm{kN(T)},\ F_{BC} = 9\ \mathrm{kN(T)},\ F_{AC} = 0$

(B) $F_{BC} = 0,\ F_{AC} = 15\ \mathrm{kN(T)},\ F_{CD} = 12\ \mathrm{kN(C)},\ F_{AD} = 9\ \mathrm{kN(T)},\ F_{AB} = 12\ \mathrm{kN(T)}$

(C) $F_{BC} = 0,\ F_{AC} = 15\ \mathrm{kN(T)},\ F_{CD} = 12\ \mathrm{kN(C)},\ F_{AB} = 12\ \mathrm{kN(C)}$

(D) $F_{AB} = F_{BC} = F_{AD} = 0,\ F_{AC} = 15\ \mathrm{kN(T)},\ F_{CD} = 12\ \mathrm{kN(C)}$

GATE XE 2008

Q25. The axial force, shear force and bending moment at section A-A of beam shown in figure are respectively

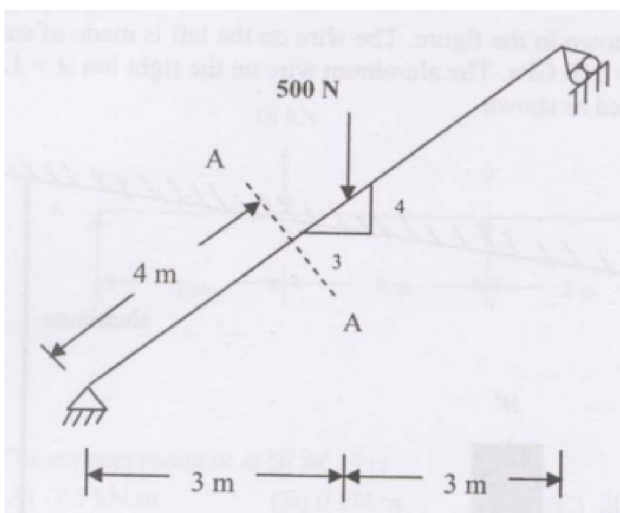

Figure 52

(A) $-400\ \mathrm{N},\ 150\ \mathrm{N},\ 600\ \mathrm{N \cdot m}$

(B) $400\ \mathrm{N},\ 0,\ 600\ \mathrm{N \cdot m}$

(C) $0,\ 250\ \mathrm{N},\ 1000\ \mathrm{N \cdot m}$

(D) $-400\ \mathrm{N},\ 310\ \mathrm{N},\ 1240\ \mathrm{N \cdot m}$

GATE XE 2008

Q26. The slope and deflection at the free end of a variable cross section cantilever beam subjected to a bending moment at the free end as shown in the figure is

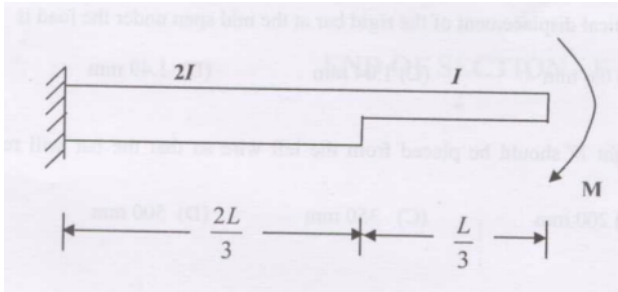

Figure 53

(A) $\frac{2ML}{3EI}, \frac{5ML^2}{18EI}$ (B) $\frac{ML}{EI}, \frac{ML^2}{2EI}$ (C) $\frac{ML}{1.5EI}, \frac{ML^2}{3EI}$ (D) $\frac{ML}{3EI}, \frac{ML^2}{3EI}$

GATE XE 2008

Q27. The maximum compressive load that can be applied on a hinged-hinged column of cross-section $20\ \mathrm{mm} \times 10\ \mathrm{mm}$ and length $2000\ \mathrm{mm}$ is (allowable compressive stress = $250\ \mathrm{MPa}$; $E = 210\ \mathrm{GPa}$)

(A) $0.86\ \mathrm{kN}$ (B) $3.45\ \mathrm{kN}$ (C) $25\ \mathrm{kN}$ (D) $50\ \mathrm{kN}$

GATE XE 2008

Q28. A lift originally moving downwards at $10\ \mathrm{m/s}$ is brought to rest with a constant retardation in a distance of $25\ \mathrm{m}$. The force with which the feet of a passenger of mass $80\ \mathrm{kg}$ (take $g = 9.8\ \mathrm{m/s^2}$) press downwards on the floor of the lift is

(A) $160\ \mathrm{N}$ (B) $784\ \mathrm{N}$ (C) $944\ \mathrm{N}$ (D) $1000\ \mathrm{N}$

GATE XE 2008

Common Data Questions

Common Data for Questions 29 and 30

Two wires are connected to a rigid bar as shown in the figure. The wire on the left is made of steel having an area of cross section $A = 60mm^2$ and $E = 210GPa$. The aluminum wire on the right has $A = 120m^2$ and $E = 70GPa$. The weight $W = 100kN$ is placed as shown

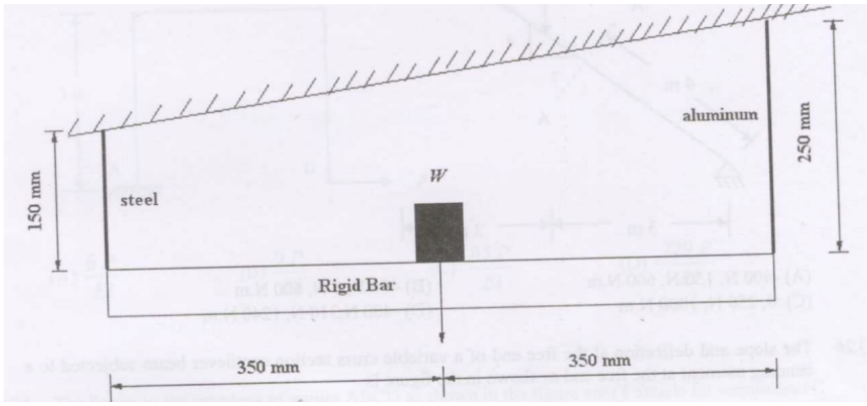

Figure 54

Q29. Due to this loading, the vertical displacement of the rigid bar at the mid span under the load is

(A) 0.45 mm (B) 0.6 mm (C) 1.04 mm (D) 1.49 mm

GATE XE 2008

Q30. At what distance the weight W should be placed from the left wire so that the bar will remain horizontal

(A) 100 mm (B) 200 mm (C) 350 mm (D) 500 mm

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

One end of a linear spring is attached to a fixed support and a mass of $2kg$ hangs from it at the other end. A force of $4N$ causes a displacement of $0.02m$. The mass is pulled down a distance of $0.04m$ from its static equilibrium position and released with zero velocity

Q31. The natural frequency of vibration is

(A) 1 rad/s (B) 1.59 rad/s (C) 5 rad/s (D) 10 rad/s

GATE XE 2008

Q32. The magnitude of velocity when the body has moved half way towards the static equilibrium position from its initial position is

(A) 0.212 m/s (B) 0.346 m/s (C) 0.4 m/s (D) 1.0 m/s

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

A two span variable cross section simply supported beam ABC is carrying two concentrated loads as shown in the figure.

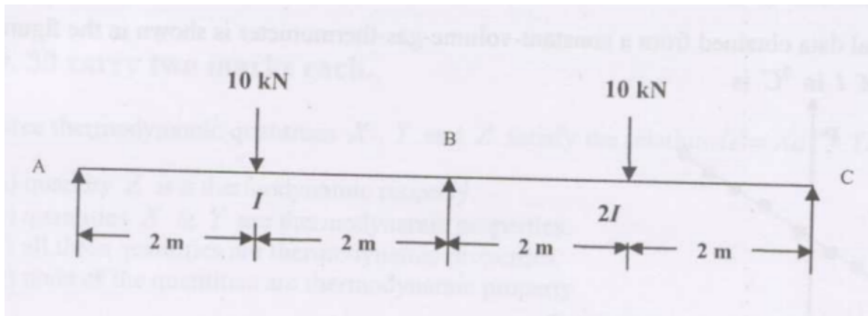

Figure 55

Q33. The support moment at B (M_B) is

(A) -7.5 kN · m (B) 0 kN · m (C) 20 kN · m (D) 80 kN · m

GATE XE 2008

Q34. The support reactions are

(A) $R_A = R_C = 3.125$ kN, $R_B = 13.75$ kN (B) $R_A = R_C = R_B = 6.67$ kN (C) $R_A = R_C = 5$ kN, $R_B = 10$ kN (D) $R_A = R_C = 10$ kN, $R_B = 0$

GATE XE 2008

END OF SECTION - F

G : THERMODYNAMICS

Q1 - Q8 carry one mark each

Q1. Experimental data obtained from a constant-volume gas thermometer is shown in the figure below. The value of t in °C is

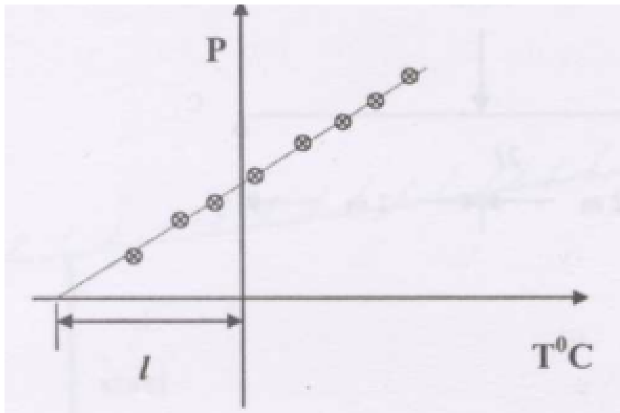

Figure 56

(A) 273.15 (B) 1.0 (C) -100 (D) -273.15

GATE XE 2008

Q2. At constant temperature, pressure of an incompressible fluid is changed from $400\ \mathrm{kPa}$ to $4\ \mathrm{MPa}$. Which of the following set of thermodynamic properties remain unchanged during the process: (u is specific internal energy, v is specific volume, h is specific enthalpy and s is specific entropy)

(A) u, v, h (B) u, s, h (C) u, v, s (D) v, s, h

GATE XE 2008

Q3. The densities of water and ice at $0°$C are $1000\ \mathrm{kg/m^3}$ and $900\ \mathrm{kg/m^3}$, respectively. If ice at $0°$C is allowed to melt into water at the same temperature, then

(A) work is done by ice on the surrounding atmosphere.
(B) work is done by the atmosphere on ice.
(C) there is no work interaction.
(D) nothing can be said about the work interaction.

GATE XE 2008

Q4. The work done in an isentropic process involving ideal gas is equal to

(A) $-\int V\,dP$

(B) Zero

(C) $\dfrac{P_1V_1 - P_2V_2}{\gamma - 1}$

(D) $RT\ln\left(\dfrac{V_2}{V_1}\right)$

GATE XE 2008

Q5. Thermal efficiency of a Diesel cycle can be increased by

(A) increasing both compression ratio and cut-off ratio.
(B) decreasing both compression ratio and cut-off ratio.
(C) decreasing compression ratio and increasing cut-off ratio.
(D) increasing compression ratio and decreasing cut-off ratio.

GATE XE 2008

Q6. In a throttling process

(A) temperature always remains unchanged.
(B) temperature always increases.
(C) temperature always decreases.
(D) temperature may increase, decrease or remain unchanged.

GATE XE 2008

Q7. The COP of a Carnot heat pump operating between $-3°\mathrm{C}$ and $27°\mathrm{C}$ is

(A) 10 (B) 0.1 (C) 9.0 (D) 1.0

GATE XE 2008

Q8. If the moist air is heated at a constant pressure

(A) the specific humidity changes.
(B) the relative humidity does not change.
(C) the relative humidity decreases.
(D) the relative humidity increases.

GATE XE 2008

Q. 9 to Q. 30 carry two marks each.

Q9. Three thermodynamic quantities X, Y and Z satisfy the relation $dZ = X\,dY + Y\,dX$. This implies,

(A) quantity Z is a thermodynamic property.

(B) quantities X and Y are thermodynamic properties.

(C) all three quantities are thermodynamic properties.

(D) none of the quantities are thermodynamic property.

GATE XE 2008

Q10. In a constant temperature process 70 moles of an ideal gas at temperature $354\ \mathrm{K}$ attains a final volume $V_2 = 1\ \mathrm{m}^3$. Work input during this process is $206\ \mathrm{kJ}$. Initial volume V_1 of the gas approximately satisfies the following relation (e is the base of natural logarithm)

(A) $V_1 = V_2$ (B) $V_1 = e\,V_2$ (C) $\ln\left(\frac{V_2}{V_1}\right) = 1$ (D) $V_1 = \ln(V_2)$

GATE XE 2008

Q11. An ideal gas at pressure P_0 and temperature T_0 undergoes a reversible isothermal compression and attains a pressure P_1. The characteristic gas constant is R. Net heat transferred during this process is

(A) zero (B) $RT_0 \ln\left(\frac{P_1}{P_0}\right)$ (C) $-RT_0 \ln\left(\frac{P_1}{P_0}\right)$ (D) $RT_0 \frac{(P_0 - P_1)}{P_0}$

GATE XE 2008

Q12. A person starts a $60\ \mathrm{W}$ table fan in an insulated room of volume $30.4\ \mathrm{m}^3$. The person expects to cool the room from $32°\mathrm{C}$ (pressure = $100\ \mathrm{kPa}$) and allows the fan to rotate for 4 hours. If the specific heat at constant volume of the room air is $0.718\ \mathrm{kJ/(kg\ K)}$ and characteristic gas constant is $287\ \mathrm{J/(kg\ K)}$, after 4 hours, the person will find that the room is

(A) hotter by approximately $12°$C.

(B) cooler by approximately $10°$C.

(C) at the same temperature.

(D) hotter by approximately $8°$C.

GATE XE 2008

Q13. Consider the cycles given below and state which one of the following statements is true

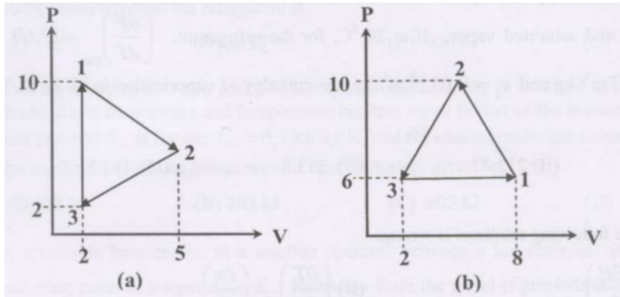

Figure 57

(A) In both (a) and (b) net work done is $+12$ units.

(B) In (b) net work done is more since in (a) no work is produced by the constant volume process.

(C) Magnitudes of net work produced in both (a) and (b) are 12 units but their signs are opposite.

(D) Magnitudes of net work produced in both (a) and (b) are different.

GATE XE 2008

Q14. Steam of quality 0.98 is present in two separate containers A and B at $300\ \mathrm{kPa}$ and $200\ \mathrm{kPa}$, respectively. Specific volumes of steam in containers A and B initially are v_A and v_B, respectively. Steam condenses at a constant pressure in such a way that the final quality of steam in both the containers is 0.01 and specific volumes of steam in containers A and B are v_{A2} and v_{B2}, respectively. Which one of the following statements is true?

(A) $v_A > v_{A2}$ and $v_{B2} > v_B$

(B) $v_A < v_{A2}$ and $v_{B2} < v_B$

(C) $v_A > v_{A2}$ and $v_{B2} < v_B$

(D) $v_A < v_{A2}$ and $v_{B2} > v_B$

GATE XE 2008

Q15. The approximate entropy change, when $10\ \mathrm{kg}$ of an ideal gas having specific heat at constant volume $c_v = \dfrac{5R}{2}$ (given, $R = 287\ \mathrm{J/(kg\ K)}$) is taken from an initial state of $100\ \mathrm{kPa}$ and $300\ \mathrm{K}$ to the final state of $200\ \mathrm{kPa}$ and $500\ \mathrm{K}$, is

(A) 9.1 (B) 3.14 (C) 91.0 (D) 0.314

GATE XE 2008

Q16. In a thermal power plant operating on a Rankine cycle, steam having enthalpy $h = 2995.1\,\mathrm{kJ/kg}$ and entropy $s = 6.5422\,\mathrm{kJ/(kg\,°C)}$ is produced at $3\,\mathrm{MPa}$ and $300\,°\mathrm{C}$ and is fed to a turbine where it expands to a condenser pressure of $5\,\mathrm{kPa}$. The dryness fraction of steam at the exit of the turbine is $x_t = 0.9761$ and $s_f = 0.4763\,\mathrm{kJ/(kg\,°C)}$ and $s_g = 8.3960\,\mathrm{kJ/(kg\,°C)}$. At the entrance to the condenser, the quality and enthalpy of steam, respectively, are approximately:

(A) $0.89,\ 1994.42$ (B) $0.68,\ 1795.67$ (C) $0.79,\ 2055.02$ (D) $0.77,\ 2004.12$

GATE XE 2008

Q17. For a refrigerant, the slope $\left(\dfrac{dP}{dT}\right)_{\mathrm{sat}}$ of the saturation curve on a P–T diagram is a function of the temperature, the enthalpy of vaporization and the difference between specific volumes of the saturated liquid and saturated vapor. If at $20\ °\mathrm{C}$, for the refrigerant, $\left(\dfrac{dP}{dT}\right)_{\mathrm{sat}} = 17.69\ \mathrm{kPa/K}$, $v_f = 0.0008157\ \mathrm{m^3/kg}$ and $v_g = 0.0358\ \mathrm{m^3/kg}$, the enthalpy of vaporization in $\mathrm{kJ/kg}$ at $20\ °\mathrm{C}$ is approximately:

(A) 12.38 (B) 273.77 (C) 353.8 (D) 181.5

GATE XE 2008

Q18. Which one of the following relations is wrong:

(A) $\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_v$

(B) $\left(\frac{\partial T}{\partial P}\right)_s = \left(\frac{\partial v}{\partial s}\right)_P$

(C) $\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$

(D) $\left(\frac{\partial s}{\partial P}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_P$

GATE XE 2008

Q19. For the same maximum temperature and pressure, an Otto cycle and a Diesel cycle are shown on the same T-s diagram in the following figure. Which one of the following is correct:

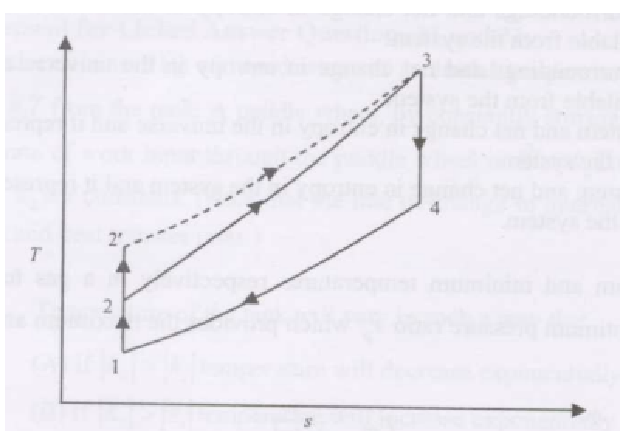

Figure 58

(A) 1-2-3-4 is an Otto cycle and 2-3 is an isobaric process.
(B) 1-2-3-4 is an Otto cycle and 2′-3 is an isobaric process.
(C) 1-2-3-4 is an Otto cycle and 2-3 is an isochoric process.
(D) 1-2-3-4 is a Diesel cycle and 2′-3 is an isochoric process.

GATE XE 2008

Q20. A Carnot engine having efficiency $\eta = 0.5$ drives a Carnot refrigerator with COP = 4. The energy absorbed by the refrigerator from the cold body for each kJ of energy absorbed from the source by the Carnot engine is

(A) $2kJ$ (B) $2.4kJ$ (C) $3kJ$ (D) $4kJ$

GATE XE 2008

Q21. It is proposed that the solar energy be used to heat a large collector plate. The engine in turn transfers heat to a fluid within a heat engine, and the engine would reject energy as heat to the atmosphere. Experiments indicate that 0.5 kW/m^2 of energy can be collected at the operating temperature of the plate and the maximum efficiency of the engine is 0.2. The minimum collector area that would be required for a plant to produce 1 kW of useful shaft power is

(A) 1 m^2 (B) 10 m^2 (C) 100 m^2 (D) 1000 m^2

GATE XE 2008

Q22. A reversible engine operates between temperatures $T_1 = 1000\,\mathrm{K}$ and $T_2 = 400\,\mathrm{K}$. The engine drives a refrigerator which operates between $T_2 = 400\,\mathrm{K}$ and $T_3 = 200\,\mathrm{K}$. The energy transfer to the engine is 2000 kJ and the net work output of the combined engine and refrigerator is 300 kJ. The energy transferred to the refrigerant is

(A) $9kJ$ (B) $90kJ$ (C) $900kJ$ (D) $9000kJ$

GATE XE 2008

Q23. Two kg of air at 500 kPa and 370 K expands adiabatically in a closed system until its volume is doubled and its pressure and temperature become equal to that of the surroundings, which is at 100 kPa and 300 K. If for air, $C_v = 0.7\,\mathrm{kJ/kg\cdot K}$ and the characteristic gas constant $R = 0.287\,\mathrm{kJ/kg\cdot K}$, the maximum work for this process is approximately given by

(A) $105kJ$ (B) $205kJ$ (C) $305kJ$ (D) $405kJ$

GATE XE 2008

Q24. A reversible heat engine in a satellite operates between a hot reservoir at temperature T_r and a radiating panel at temperature T_p. Radiation from the panel is proportional to the area A and T_p^4. The constant of proportionality is the Stefan–Boltzmann constant σ. The ratio of the work output W to the temperature difference $(T_r - T_p)$ is

(A) σAT (B) σAT^2 (C) σAT_p^2 (D) σAT_p^4

GATE XE 2008

Q25. Irreversibility of a given process in a system is equal to

(A) product of temperature of the surroundings and net change in entropy in the universe and it represents loss in total work available from the system.

(B) product of temperature of the surroundings and net change in entropy in the universe and it represents gain in total work available from the system.

(C) product of temperature of the system and net change in entropy in the universe and it represents loss in total work available from the system.

(D) product of temperature of the system and net change in entropy in the system and it represents loss in total work available from the system.

GATE XE 2008

Q26. $T_{\max}$ and $T_{\min}$ represent the maximum and minimum temperatures respectively in a gas turbine working on a Brayton cycle. The optimum pressure ratio r_p which provides the maximum amount of work is given by

(A) $r_p = \left(\frac{T_{\max}}{T_{\min}}\right)^{\frac{2\gamma-1}{\gamma}}$

(B) $r_p = \left(\frac{T_{\max}}{T_{\min}}\right)^{\frac{\gamma}{2\gamma-1}}$

(C) $r_p = \left(\frac{T_{\min}}{T_{\max}}\right)^{\frac{\gamma}{2\gamma-1}}$

(D) $r_p = \left(\frac{T_{\min}}{T_{\max}}\right)^{\frac{2\gamma-1}{\gamma}}$

GATE XE 2008

Q27. A heat engine operates between three reservoirs: R_1 at 550 K, R_2 at 450 K and R_3 at 350 K. For every cycle, the engine accepts 100 kJ from R_1 and rejects 60 kJ into R_2 and 30 kJ into R_3. The engine efficiency is

(A) 0.10 (B) 0.20 (C) 0.30 (D) can not be defined

GATE XE 2008

Q28. Carbon tetrachloride boils at $76°$C at 101 kPa. The latent heat of vaporization of carbon tetrachloride is 195 kJ/kg and for this, the characteristic gas constant is 0.055 kJ/kg K. The boiling point of carbon tetrachloride at 202 kPa is

(A) 274.54 K (B) 374.54 K (C) 474.54 K (D) 574.54 K

GATE XE 2008

Common Data Questions

Common Data for Questions 29 and 30:

Steam at 0.6181 MPa and 160°C (saturated) enters a steady flow device with a velocity of 50 m/s and enthalpy 2756.7 kJ/kg. It leaves at a pressure of 0.1 MPa with a velocity of 600 m/s and enthalpy h_2. The device is perfectly insulated and does not do any work on the surroundings. Neither does it receive any work input. Use the following data table:

Table 16

Pressure P (bar)	**Temperature** (°C)	**Specific enthalpy**		**Specific entropy**	
		h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)
1.5	111.37	467.13	2693.4	1.4336	7.2234

Q29. The quality of the steam at the outlet of the device is

(A) 0.548 (B) 0.648 (C) 0.748 (D) 0.948

GATE XE 2008

Q30. The above mentioned device is a

(A) turbine (B) compressor (C) nozzle (D) diffuser

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

A tank contains $9\ \mathrm{kg}$ of liquid water at an initial temperature $T_0\ ^\circ\mathrm{C}$. A coil removes heat at the rate of $\dot{Q} = k_1 T$ from the tank. A paddle wheel, by constantly stirring, maintains uniform temperature in the tank. The rate of work input through the paddle wheel is $\dot{W} = k_2 T$. Temperature, T is in $^\circ\mathrm{C}$ and k_1 and k_2 are constants. (Note that the rate of change in internal energy inside the tank will be a balance of work and heat transfer rates.)

Q31. Temperature of the tank will vary in such a way that

(A) If $|k_2| > |k_1|$ temperature will decrease exponentially
(B) If $|k_2| > |k_1|$ temperature will increase exponentially
(C) If $|k_2| < |k_1|$ temperature will increase exponentially
(D) If $|k_2| > |k_1|$ temperature will decrease linearly

GATE XE 2008

Q32. If $T_0 = 80\,^\circ\mathrm{C}$, $|k_1| = 0.1$, $|k_2| = 0.01$ and specific heat of the liquid $= 1.0$, the temperature of the tank after $1\ \mathrm{minute}$ will be

(A) $43.9°\mathrm{C}$ (B) $38.4°\mathrm{C}$ (C) $166.6°\mathrm{C}$ (D) $145.7°\mathrm{C}$

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

Air enters a gas turbine at $1.0135\ \mathrm{MPa}$, $1000\ \mathrm{K}$ at the rate of $1\ \mathrm{kg/s}$ and exits at $101.35\ \mathrm{kPa}$ and $600\ \mathrm{K}$. Neglect the changes in potential energy and kinetic energy and assume that air is an ideal gas with $R = 0.287\ \mathrm{kJ/(kg\,K)}$, $c_p = 1.005\ \mathrm{kJ/(kg\,K)}$.

Q33. The net power output of the gas turbine is

(A) $102\ \mathrm{kW}$ (B) $200\ \mathrm{kW}$ (C) $301\ \mathrm{kW}$ (D) $402\ \mathrm{kW}$

GATE XE 2008

Q34. If for the isentropic process $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$ and $\gamma = 1.4$, the isentropic efficiency of the turbine is

(A) 63% (B) 73% (C) 83% (D) 93%

GATE XE 2008

END OF SECTION - G

H : POLYMER SCIENCE AND ENGINEERING

Q1 - Q8 carry one mark each

Q1. Among the polymerization methods listed below, the one that is likely to give a polydispersity close to unity is

(A) Anionic polymerization
(B) Cationic polymerization
(C) Condensation polymerization
(D) Radical polymerization

GATE XE 2008

Q2. The end-groups in a polymer sample prepared by using $\mathrm{ROOH/Fe^{2+}}$ (where R = alkyl) as the initiator system is

(A) $\mathrm{Fe^{2+}}$ (B) $-\mathrm{OR}$ (C) $-\mathrm{OH}$ (D) $\mathrm{Fe^{3+}}$

GATE XE 2008

Q3. Most polymers exhibit Newtonian behaviour at

(A) High temperature
(B) Low shear rate
(C) High molecular weight
(D) Low filler content

GATE XE 2008

Q4. The shear rate of a typical injection molding process is

(A) $1\ \mathrm{s^{-1}}$ (B) $10\ \mathrm{s^{-1}}$ (C) $100\ \mathrm{s^{-1}}$ (D) $1000\ \mathrm{s^{-1}}$

GATE XE 2008

Q5. Which of the following monomers is used in the synthesis of poly(vinyl alcohol) is

(A) $\mathrm{CH_3CH_2OH}$ (B) $\mathrm{CH_2 = CH(OH)}$ (C) $\mathrm{CH_2 = CH - O - COCH_3}$ (D) $\mathrm{CH_2 = CH - CO_2H}$

GATE XE 2008

Q6. The extension ratio of an elastomer deformed to 10 times its original length is

(A) 2 (B) 5 (C) 9 (D) 11

GATE XE 2008

Q7. Most plausible value for the Gibbs free energy change for a miscible blend of two polymers is

(A) $+5\ \mathrm{kJ\,mol^{-1}}$ (B) $+1\ \mathrm{kJ\,mol^{-1}}$ (C) $0\ \mathrm{kJ\,mol^{-1}}$ (D) $-0.01\ \mathrm{kJ\,mol^{-1}}$

GATE XE 2008

Q8. The glass transition temperature of raw natural rubber is

(A) $-70\,^\circ\mathrm{C}$ (B) $-10\,^\circ\mathrm{C}$ (C) $0\,^\circ\mathrm{C}$ (D) $+30\,^\circ\mathrm{C}$

GATE XE 2008

Q. 9 to Q.30 carry two marks each.

Q9. $2,2'$-Azobisisobutyronitrile (AIBN) is an initiator used in the free radical polymerization of methyl methacrylate (MMA). When the concentration of AIBN is doubled maintaining MMA concentration unchanged, the rate of propagation

(A) Is doubled
(B) Increases by a factor of $\sqrt{2}$
(C) Is reduced by half
(D) Decreases by a factor of $\sqrt{2}$

GATE XE 2008

Q10. A polymer sample has 3 molecules with molecular weights 1×10^5, 2×10^5 and $3 \times 10^5\ \mathrm{g\,mol^{-1}}$ respectively. The weight average molecular weight of the sample is

(A) $2.99 \times 10^5\ \mathrm{g\,mol^{-1}}$
(B) $2.66 \times 10^5\ \mathrm{g\,mol^{-1}}$
(C) $2.33 \times 10^5\ \mathrm{g\,mol^{-1}}$
(D) $2.00 \times 10^5\ \mathrm{g\,mol^{-1}}$

GATE XE 2008

Q11. Which of the following reagents is capable of effecting Group Transfer polymerization with methacrylates?

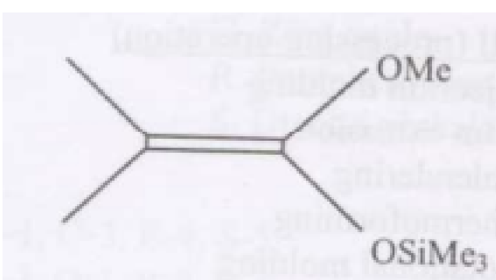

Figure 59: A

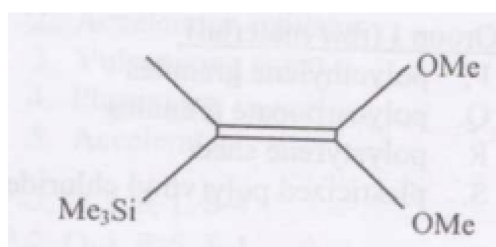

Figure 60: B

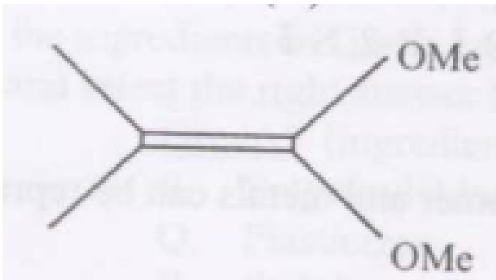

Figure 61: C

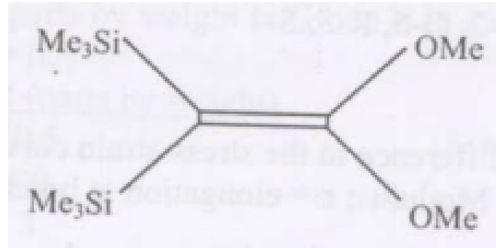

Figure 62: D

GATE XE 2008

Q12. For the copolymerization of MMA with vinyl chloride, the monomer reactivity ratios were found to be 10 and 0.1 respectively. The resulting polymer is most likely to be

(A) an alternating copolymer

(B) an ideal copolymer

(C) a block copolymer

(D) a branched copolymer

GATE XE 2008

Q13. Match the characterization techniques listed in Group I with the applications listed in Group II and select the correct answer from (A), (B), (C) or (D):

Table 17

Group I (Technique)	**Group II (Application)**
P. X-ray Diffraction	1. Functional Groups
Q. Differential Thermal Analysis	2. Crystallinity
R. Infrared Spectroscopy	3. Morphology
S. Microscopy	4. Enthalpy
	5. Power Factor

(A) P-5, Q-4, R-3, S-2

(B) P-2, Q-3, R-1, S-5

(C) P-3, Q-2, R-4, S-5

(D) P-2, Q-4, R-1, S-3

GATE XE 2008

Q14. For a polymer, viscosity at $50\,°\mathrm{C}$ and at $80\,°\mathrm{C}$ was found to be $2.00\ \mathrm{Pa \cdot s}$ and $1.00\ \mathrm{Pa \cdot s}$ respectively. The value of viscosity at $60\,°\mathrm{C}$ is

(A) $1.65\ \mathrm{Pa \cdot s}$ (B) $1.55\ \mathrm{Pa \cdot s}$ (C) $1.45\ \mathrm{Pa \cdot s}$ (D) $1.35\ \mathrm{Pa \cdot s}$

GATE XE 2008

Q15. For a viscoelastic material behaving as Maxwell model, the modulus at its relaxation time under constant strain reduces to

(A) 36.8% of the initial value

(B) 63.2% of the initial value

(C) 66.7% of the initial value

(D) 50.0% of the initial value

GATE XE 2008

Q16. The capacity of an extruder can be maximized by a combination of

(A) higher barrel diameter; higher screw diameter; higher helix angle; higher rpm

(B) higher barrel diameter; higher screw diameter; higher helix angle; lower rpm

(C) higher barrel diameter; higher screw diameter; lower helix angle; higher rpm

(D) higher barrel diameter; lower screw diameter; higher helix angle; higher rpm

GATE XE 2008

Q17. Match the raw materials in Group I with the polymer processing operation in Group II and select the correct answer from (A), (B), (C) or (D).

Table 18

Group I (raw material)	**Group II (processing operation)**
P. polyethylene granules	1. Injection molding
Q. polycarbonate granules	2. Film extrusion
R. polystyrene sheet	3. Calendering
S. plasticized poly(vinyl chloride)	4. Thermoforming
	5. Rotational molding

(A) P-1, Q-2, R-3, S-4

(B) P-2, Q-1, R-4, S-3

(C) P-2, Q-5, R-3, S-1

(D) P-4, Q-3, R-2, S-5

GATE XE 2008

Q18. The difference in the stress-strain curve for plastics, elastomer and metals can be represented by:
(M = Modulus; ε = elongation at break)

(A) $M_{\text{metal}} < M_{\text{plastic}} < M_{\text{elastomer}}$ and $\varepsilon_{\text{metal}} \geq \varepsilon_{\text{plastic}} \geq \varepsilon_{\text{elastomer}}$

(B) $M_{\text{plastic}} < M_{\text{elastomer}} < M_{\text{metal}}$ and $\varepsilon_{\text{plastic}} \geq \varepsilon_{\text{elastomer}} \geq \varepsilon_{\text{metal}}$

(C) $M_{\text{elastomer}} < M_{\text{plastic}} < M_{\text{metal}}$ and $\varepsilon_{\text{elastomer}} \geq \varepsilon_{\text{plastic}} \geq \varepsilon_{\text{metal}}$

(D) $M_{\text{plastic}} > M_{\text{metal}} > M_{\text{elastomer}}$ and $\varepsilon_{\text{plastic}} \geq \varepsilon_{\text{metal}} \geq \varepsilon_{\text{elastomer}}$

GATE XE 2008

Q19. Match the following rubbers in Group I with their applications in Group II and select the correct answer from (A), (B), (C) or (D).

Table 19

Group I (rubbers)	**Group II (applications)**
P. Butyl rubber	1. Gaskets in chemical plants
Q. Fluorocarbon elastomer	2. Petrol hoses
R. Natural rubber	3. Hand gloves
S. Nitrile rubber	4. Roofing membrane
	5. Tire inner liner

(A) P-5, Q-1, R-3, S-2
(B) P-1, Q-3, R-2, S-5
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-5, R-1, S-4

GATE XE 2008

Q20. A carbon fiber-epoxy bar of dimensions ($0.5\,\mathrm{m} \times 0.04\,\mathrm{m} \times 0.04\,\mathrm{m}$) gave a breaking load of $784\,\mathrm{N}$ in a three point bending test. The flexural strength of the material is:

(A) 15.8 MPa (B) 9.2 MPa (C) 0.3 GPa (D) 108.1 GPa

GATE XE 2008

Q21. Match the polymers in Group I with their crystalline melting point (m_p, °C) in Group II and select the correct answer from (A), (B), (C) or (D).

Table 20

Group I (polymers)	**Group II (m_p, °C)**
P. Nylon66	1. 108
Q. PBT	2. 320
R. PP	3. 264
S. LDPE	4. 165
	5. 220

(A) P-1, Q-3, R-5, S-2
(B) P-3, Q-4, R-2, S-5
(C) P-3, Q-5, R-4, S-1
(D) P-5, Q-1, R-3, S-4

GATE XE 2008

Q22. Match the additives listed in Group I below with their function listed in Group II and select the right answer from (A), (B), (C) or (D).

Table 21

Group I (additives)	**Group II (function)**
P. Sulfur	1. Age resistor
Q. Zinc oxide	2. Accelerator activator
R. Paraphenylene diamine	3. Vulcanizing agent
S. Dioctyl phthalate	4. Plasticizer
	5. Accelerator

(A) P-1, Q-3, R-4, S-5
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-4, R-5, S-1
(D) P-2, Q-4, R-5, S-1

GATE XE 2008

Q23. Match the ingredients in Group I with their amount in parts by weight in Group II in a typical recipe and select the right answer from (A), (B), (C) or (D).

Table 22

Group I (ingredients)	**Group II (parts by weight)**
P. Polyvinylchloride	1. 0.5
Q. Plasticizer	2. 40
R. Stabilizer	3. 3
S. Calcium stearate	4. 100

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-2, R-3, S-1

GATE XE 2008

Q24. The heat flow across the thickness to the opposite surface of a plastic slab of dimensions $0.1 \times 0.1 \times 0.05$ m is 19 W. If the temperature difference between the surface of the slab is 10 K, the thermal conductivity of the material will be

(A) 0.3 W K^{-1}m^{-1} (B) 35.1 W K^{-1}m^{-1} (C) 2.1 W K^{-1}m^{-1} (D) 9.5 W K^{-1}m^{-1}

GATE XE 2008

Q25. A miscible polymer blend consisting of 60% of polymer X ($T_g = 208\,^\circ$C) and 40% of polymer Y ($T_g = 100\,^\circ$C) will show a glass transition temperature in the range of

(A) 100–$120\,^\circ$C (B) 145–$165\,^\circ$C (C) 200–$220\,^\circ$C (D) 250–$270\,^\circ$C

GATE XE 2008

Q26. Crystallinity of the three different types of polyethylene (PE) follows the order

(A) HDPE $>$ LLDPE $>$ LDPE
(B) LDPE $>$ HDPE $>$ LLDPE
(C) HDPE $>$ LDPE $>$ LLDPE
(D) LLDPE $>$ HDPE $>$ LDPE

GATE XE 2008

Q27. The notched Izod impact strength of acrylonitrile-butadiene-styrene polymer (ABS), polypropylene (PP), polycarbonate (PC) and phenol-formaldehyde (PF) resin follows the order

(A) PC $<$ ABS $<$ PP $<$ PF
(B) ABS $<$ PF $<$ PC $<$ PP
(C) PC $<$ PP $<$ PC $<$ PF
(D) PF $<$ PC $<$ ABS $<$ PC

GATE XE 2008

Q28. The properties of three polymers are as follows:

Table 23

	Polymer X	**Polymer Y**	**Polymer Z**
Density (kg/m^3)	920	1130	900
Heat Distortion Temp. ($^\circ$C)	40	110	55
Tensile strength (MPa)	10	85	35
Elongation at break (%)	600	200	400

Which of the following is true?

(A) Polymer X is Commodity and Polymer Z is Engineering Plastic
(B) Polymer Y is Commodity and Polymer Z is Engineering Plastic
(C) Polymer Z is Commodity and Polymer Y is Engineering Plastic
(D) Polymer Y is Commodity and Polymer Z is Engineering Plastic

GATE XE 2008

Common Data Questions

Common Data for Questions 29 and 30:

For a polymer which follows the Mark-Houwink equation, the various parameters determined were as follows: $K = 1.2 \times 10^{-4}$; $[\eta] = 2.4$; $a = 0.76$; Huggins' constant $= 0.33$; concentration, $c = 0.3$ g dL^{-1}

Q29. The molecular weight of the polymer is

(A) 4.5×10^5
(B) 6.1×10^4
(C) 3.2×10^6
(D) 7.9×10^5

GATE XE 2008

Q30. The specific viscosity of the above polymer is

(A) 0.73 (B) 1.12 (C) 0.89 (D) 2.30

GATE XE 2008

Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32:

Consider step growth polymerization of two bifunctional monomers with a monomer ratio of 0.99 and the number average degree of polymerization of 66.8.

Q31. The extent of reaction will be

(A) 0.90 (B) 0.95 (C) 0.99 (D) 1.00

GATE XE 2008

Q32. The polydispersity index at stoichiometric conditions would be

(A) 1.90 (B) 1.95 (C) 1.85 (D) 1.99

GATE XE 2008

Statement for Linked Answer Questions 33 and 34:

A polymer composite of mica filled polypropylene contains 60% polymer by mass. Tensile elastic modulus of polypropylene $= 23$ MPa Tensile elastic modulus of mica $= 30$ GPa Density of polypropylene $= 900$ kg m^{-3} Density of mica $= 2800$ kg m^{-3}

Q33. The volume % of mica in the composite is

(A) 25.95 (B) 17.60 (C) 14.83 (D) 39.27

GATE XE 2008

Q34. The modulus of elasticity of the composite is

(A) 12.8 GPa (B) 20.3 GPa (C) 5.3 GPa (D) 31.7 GPa

GATE XE 2008

END OF SECTION - H

I : FOOD TECHNOLOGY

Q1 - Q8 carry one mark each

Q1. The major protein in corn is

(A) Oryzenin (B) Glutenin (C) Zein (D) Hordenin

GATE XE 2008

Q2. Which of the following is NOT a reducing sugar?

(A) Lactose (B) Mannose (C) Maltose (D) Sucrose

GATE XE 2008

Q3. Which of the following is an intrinsic factor influencing microbial growth in food?

(A) Temperature (B) Relative humidity (C) Nutrients (D) Gas composition

GATE XE 2008

Q4. Which of the following combination of starter cultures is mostly used for the production of yoghurt?

(A) *Lactobacillus casei* and *Lactobacillus delbrueckii*
(B) *Lactobacillus delbrueckii* and *Streptococcus thermophilus*
(C) *Lactobacillus acidophilus* and *Leuconostoc mesenteroides*
(D) *Streptococcus thermophilus* and *Leuconostoc mesenteroides*

GATE XE 2008

Q5. Potassium bromate is used to improve the gluten quality of wheat dough by increasing

(A) protein-protein ester linkages
(B) protein-protein disulphide linkages
(C) protein-protein interaction with large number of H-bonds
(D) protein-starch interaction with large number of H-bonds

GATE XE 2008

Q6. Which of the following substances is NOT a Class I preservative in food

(A) Vinegar (B) Sodium benzoate (C) Vegetable oils (D) Citric acid

GATE XE 2008

Q7. Saturated steam at temperature T_s (°C) flows through a pipe and atmospheric air flows over the outer surface of the pipe. If the temperature of the air has increased from T_i to T_o, the effectiveness of the heat exchange can be expressed as

(A) $\dfrac{T_s - T_o}{T_s - T_i}$ (C) $\dfrac{T_o - T_i}{T_s - T_i}$

(B) $\dfrac{T_s - T_i}{T_s - T_o}$ (D) $\dfrac{T_o - T_i}{T_s - T_o}$

GATE XE 2008

Q8. Convective mass transfer coefficient of water vapour diffusing from a water surface to air depends primarily on

(A) velocity of air (C) density of water vapour

(B) viscosity of water vapour (D) specific heat of water vapour

GATE XE 2008

Q.9 to Q.30 carry two maeks each.

Q9. The following was obtained from an analysis of two oil samples A and B

(a) Iodine value of A is greater than iodine value of B

(b) Reichert Meissl value of A is less than Reichert Meissl value of B

Based on the above analysis, the following is the correct statement

(A) Oil A is more unsaturated than oil B and has low molecular weight fatty acids
(B) Oil A is less unsaturated than oil B and has low molecular weight fatty acids
(C) Oil A is less unsaturated than oil B and has high molecular weight fatty acids
(D) Oil A is more unsaturated than oil B and has high molecular weight fatty acids

GATE XE 2008

Q10. Match the items in Group I with the most appropriate items in Group II

Table 24

Group I	**Group II**
P) Iodine	(1) Biotin
Q) Curing salt	(2) Flavour enhancer
R) Avidin	(3) Goitre
S) Mono sodium glutamate	(4) Sausage
	(5) Anemia

(A) P-3, Q-4, R-1, S-2
(B) P-5, Q-4, R-1, S-2
(C) P-3, Q-4, R-5, S-2
(D) P-5, Q-2, R-1, S-4

GATE XE 2008

Q11. Protein denaturation is a phenomenon of change in three dimensional structure of protein, and consequently an alteration of its functionality. Which of the following statement is NOT related to protein denaturation?

(A) Accessibility of proteolytic enzymes to peptide bonds increases
(B) Solubility and enzymatic activity of native protein decrease
(C) Intrinsic viscosity and optical rotation of the protein solution increase
(D) Increase in intrinsic viscosity through formation of amino acids by hydrolysis

GATE XE 2008

Q12. If v is the reaction rate, $V_{\max}$ is the maximum reaction rate, K_m is the Michaelis-Menton constant and $[S]$ is the substrate concentration, the Lineweaver–Burk plot for NO INHIBITION enzymatic reaction can be written as

(A) $\frac{1}{v} = \frac{1}{V_{\max}} + \frac{K_m}{V_{\max}[S]}$
(B) $\frac{1}{v} = \frac{K_m}{V_{\max}[S]} + \frac{1}{V_{\max}}$
(C) $\frac{1}{v} = \frac{K_m}{V_{\max}} + \frac{[S]}{V_{\max}}$
(D) $\frac{1}{v} = \frac{K_m}{V_{\max}[S]^2} + \frac{1}{V_{\max}}$

GATE XE 2008

Q13. Match the items in Group I with the most appropriate items in Group II

Table 25

Group I	**Group II**
P) PER	(1) Jelly
Q) Synerisis	(2) Essential amino acids
R) Soyabean	(3) Nerai
S) Lemon	(4) Saponin
	(5) Lycopene

(A) P-2, Q-1, R-4, S-5
(B) P-2, Q-1, R-5, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-5, Q-1, R-4, S-3

GATE XE 2008

Q14. Which of the following is the structure of flavonol?

(A)

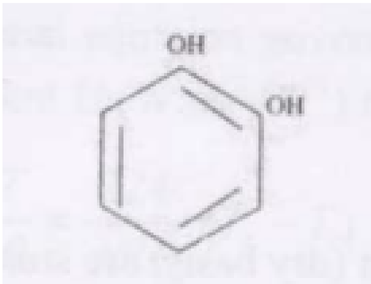

Figure 63

(B)

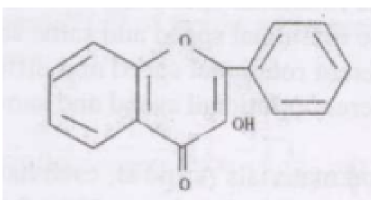

Figure 64

(C)

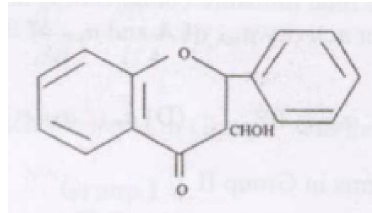

Figure 65

(D)

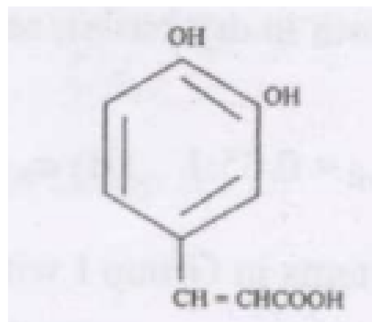

Figure 66

GATE XE 2008

Q15. The specific growth rate of *Bacillus cereus* in a food sample is $0.4\ \mathrm{h}^{-1}$. Doubling time of the cell is

(A) $2.0\ \mathrm{h}$ (B) $1.73\ \mathrm{h}$ (C) $1.25\ \mathrm{h}$ (D) $1.0\ \mathrm{h}$

GATE XE 2008

Q16. Match the items in Group I with the most appropriate items in Group II

Table 26

Group I	**Group II**
(P) Cheese	(1) Hydrogen peroxide
(Q) Enterotoxin B	(2) Nisin
(R) Bacteriocin	(3) *Propionibacterium*
(S) Milk ropiness	(4) *Alcaligenes*
	(5) *Staphylococcus aureus*

(A) P-5, Q-1, R-2, S-4
(B) P-3, Q-1, R-5, S-4
(C) P-3, Q-5, R-2, S-4
(D) P-3, Q-5, R-2, S-1

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Q17. Five grams of cheese was mixed with $45\ \mathrm{ml}$ of sterile diluent. Two successive dilutions of 1:100 each were made and one-tenth milliliter from the last dilution was plated onto each of two plates containing plate count agar (PCA) medium. Following incubation, 56 colonies were counted on one plate and 54 on the other. The average number of colony forming units (CFUs) per gram of cheese is

(A) 5.5×10^5 (B) 5.5×10^6 (C) 5.5×10^7 (D) 5.5×10^8

GATE XE 2008

Q18. Match the items in Group I with the most appropriate items in Group II

Table 27

Group I	**Group II**
(P) Spore former	(1) *Listeria*
(Q) Vinegar	(2) *Shigella*
(R) Psychrotroph	(3) *Lactobacillus*
(S) Dysentery	(4) *Bacillus*
	(5) *Acetobacter*

(A) P-3, Q-5, R-4, S-2
(B) P-4, Q-5, R-1, S-2
(C) P-4, Q-5, R-1, S-3
(D) P-4, Q-3, R-1, S-2

GATE XE 2008

Q19. Development of ‘hot spot’ in high moisture grain during storage in silo is due to

(A) exothermic reaction between moisture and starch present in the endosperm of the grain
(B) microbial growth and respiration of grain
(C) heating of the silo wall during day and cooling during night
(D) exothermic reaction between the moisture present in endosperm and the oil in germ

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Q20. In modern rice mills, the two rubber rolls in the sheller rotate in opposite direction at the

(A) same rotational speed and different surface speed

(B) same rotational speed and same surface speed
(C) different rotational speed and different surface speed
(D) different rotational speed and same surface speed

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Q21. Two food materials A and B, each having 14% moisture content (dry basis) are stored in a constant relative humidity chamber at $30°\mathrm{C}$ for equilibration. The final moisture contents of A and B are 6% and 12% (both in dry basis), respectively. The final water activity a_{wA} of A and a_{wB} of B are related as

(A) $a_{wA} : a_{wB} = 0.65 : 1$
(B) $a_{wA} : a_{wB} = 1 : 1$
(C) $a_{wA} : a_{wB} = 1 : 2$
(D) $a_{wA} : a_{wB} = 2 : 1$

GATE XE 2008

Q22. Match the items in Group I with the most appropriate items in Group II

Table 28

Group I	**Group II**
(P) Disc centrifuge	(1) Separation of solid phase in milk by coagulation
(Q) Multiple effect evaporator	(2) Aseptic packaging of milk
(R) UHT processing	(3) Separation of liquid phases in milk
(S) Homogenization	(4) Dispersion of one of the liquid phases in milk
	(5) Concentration of milk

(A) P-3, Q-5, R-1, S-4
(B) P-1, Q-5, R-2, S-4
(C) P-3, Q-5, R-2, S-1
(D) P-3, Q-5, R-2, S-4

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Q23. Rigor mortis in meat is due to

(A) glycolysis followed by formation of lactic acid
(B) binding of collagen and elastin
(C) action of cathepsin enzyme in meat
(D) binding of myosin and actin

GATE XE 2008

Q24. Following operations are adopted for cleaning in place (CIP) of equipment

P: Cold water rinse; Q: Hot water rinse; R: Alkali cleaning; S: Acid cleaning

The correct sequence of CIP for equipment used in UHT processing of milk is

(A) P – Q – R – S – P
(B) P – Q – R – Q – S – P
(C) P – Q – R – Q – S – P
(D) P – Q – S – P

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Q25. Following operations are adopted for refining of vegetable oils

P: Winterization; Q: Alkali refining; R: Steam deodorization; S: Bleaching; T: Degumming

The correct sequence of operations for the refining is

(A) P – Q – T – R – S
(B) S – R – Q – T – P
(C) Q – T – S – R – P
(D) R – T – Q – S – P

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Q26. A liquid having density ρ and viscosity μ flows under laminar condition through a circular pipe having diameter D and length L against a pressure drop of ΔP. Volume flow rate of the liquid through the pipe will be proportional to

(A) $\frac{D^4 \Delta P}{\mu L}$ (B) $\frac{D^3 \Delta P}{\mu L}$ (C) $\frac{D \Delta P}{\mu L}$ (D) $\frac{\Delta P}{\mu L}$

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Q27. A liquid having mass M (kg), heat capacity C_p (J.kg^{-1} °C^{-1}) is cooled in an agitated vessel having surface area A (m^2). A cooling medium at temperature T_r (°C) is used for cooling the liquid. The differential equation governing the temperature change $\frac{dT}{d\theta}$ of liquid with overall heat transfer coefficient U (W.m^{-2} °C^{-1}) for the vessel is given by

(A) $\frac{dT}{d\theta} = \frac{UA}{MC_p}(T_r - T)$
(B) $\frac{dT}{d\theta} = \frac{MC_p}{UA}(T_r - T)$
(C) $\frac{dT}{d\theta} = \frac{MC_p}{UA}(T_r - T)$
(D) $\frac{dT}{d\theta} = \frac{UA}{MC_p}(T_r - T)$

GATE XE 2008

Q28. Match the items in Group I with the most appropriate items in Group II

Table 29

Group I	Group II
(P) Freezing	(1) Stoke's law
(Q) Fat globules movement in milk	(2) Plank's equation
(R) Flow through packed bed	(3) Ergun's equation
(S) Boiling temperature	(4) Hagen Poiseulli's equation
	(5) Raoult's law

(A) P-4, Q-1, R-3, S-5
(B) P-2, Q-1, R-3, S-4
(C) P-2, Q-1, R-4, S-5
(D) P-2, Q-1, R-3, S-5

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Common Data Questions

Common Data for Questions 29 and 30:

Milk having heat capacity 3900 J.kg^{-1} °C^{-1} and density 1020 kg.m^{-3} is pressurized to 300 atmosphere gauge pressure and allowed to flow through a high pressure homogenizing valve at a rate of 60 liters per min. The diameter of the homogenizing valve through which the milk flows is 6 mm. (1 atmosphere = 101.3 kPa)

Q29. Temperature rise in milk will be

(A) $10.1\,°$C (B) $9.2\,°$C (C) $7.7\,°$C (D) $6.1\,°$C

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Q30. Height of the valve lift will be

(A) 0.06 mm (B) 0.11 mm (C) 0.16 mm (D) 0.22 mm

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Linked Answer Questions: Q.31 to Q.34 carry two marks each.

Statement for Linked Answer Questions 31 and 32: A medium acid food is sterilized at $100°$C in a can to reduce the number of heat resistant organisms ($D_{120} = 2$ min, $z = 10°$C) from an initial count of 10000 per can to a probability of survival of 1 in million.

Q31. D_{100} value of this organism is

(A) 0.4 min (B) 20 min (C) 4 min (D) 10 min

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Q32. The total processing time is

(A) 100 min (B) 40 min (C) 200 min (D) 4 min

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Statement for Linked Answer Questions 33 and 34:

Compressed air at 0.5 atmosphere gauge pressure and 30°C contains 0.01 kg water vapor per kg dry air. Molecular weight of dry air and water vapor are 28.9 and 18 kg.kmol^{-1}, respectively. Saturation vapor pressure of water at 30°C is 4.246 kPa absolute. (1 atmosphere = 101.3 kPa)

Q33. Partial pressure of water vapor inside the compressor is

(A) 2.15 kPa (B) 2.40 kPa (C) 3.12 kPa (D) 3.51 kPa

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Q34. Relative humidity of air inside the compressor is

(A) 40.1% (B) 49.8% (C) 56.5% (D) 57.6%

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END OF SECTION - I