

# BITS HD 2026 – Guess Question Paper

## Career Decode

<b>Exam</b>	BITS HD (Higher Degree) 2026
<b>Conducting Body</b>	Birla Institute of Technology and Science, Pilani
<b>Total Questions</b>	100 (Test 1: 30 + Test 2: 70)
<b>Total Marks</b>	300
<b>Marking Scheme</b>	+3 (correct), -1 (incorrect), 0 (unattempted)
<b>Test 1 Duration</b>	45 minutes
<b>Test 2 Duration</b>	105 minutes (Mechanical Engineering)
<b>Mode</b>	Online – Computer Based Test (CBT), English
<b>Note</b>	This is a high-probability guess paper for practice.

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## 1 Test 1

### 1.1 Section A: Core Mathematics (Questions 1–15)

**Q.1.** If  $A$  is a  $3 \times 3$  matrix with  $\det(A) = 6$ , then  $\det(2A)$  is:

- (A) 12
- (B) 24
- (C) 48
- (D) 36

**Q.2.** The eigenvalues of the matrix  $A = \begin{pmatrix} 4 & 1 \\ 2 & 3 \end{pmatrix}$  are:

- (A) 2 and 5
- (B) 1 and 6
- (C) 3 and 4
- (D) -1 and 8

**Q.3.** The rank of the matrix  $\begin{pmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \\ 1 & 1 & 1 \end{pmatrix}$  is:

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

**Q.4.** The value of  $\lim_{x \rightarrow 0} \frac{\sin 3x}{x}$  is:

- (A) 1
- (B) 3

- (C) 0
- (D)  $\infty$

**Q.5.** If  $f(x) = x^3 - 3x^2 + 4$ , the points of local extrema are at  $x =$ :

- (A)  $x = 0$  (max) and  $x = 2$  (min)
- (B)  $x = 0$  (min) and  $x = 2$  (max)
- (C)  $x = -1$  and  $x = 3$
- (D)  $x = 1$  and  $x = -1$

**Q.6.** The value of the integral  $\int_0^1 xe^x dx$  is:

- (A) 1
- (B)  $e - 1$
- (C)  $e$
- (D)  $2e - 1$

**Q.7.** The partial derivative  $\frac{\partial}{\partial y}(x^2y + \sin(xy))$  is:

- (A)  $x^2 + x \cos(xy)$
- (B)  $2xy + \cos(xy)$
- (C)  $x^2 + \cos(xy)$
- (D)  $2x + x \cos(xy)$

**Q.8.** The modulus of the complex number  $z = \frac{3 + 4i}{1 - 2i}$  is:

- (A)  $\sqrt{5}$
- (B) 1
- (C) 5
- (D)  $\sqrt{10}$

**Q.9.** The residue of  $f(z) = \frac{e^z}{(z - 1)^2}$  at  $z = 1$  is:

- (A)  $e$
- (B) 1
- (C)  $e^2$
- (D) 0

**Q.10.** A fair die is rolled twice. The probability that the sum of the two outcomes equals 7 is:

- (A)  $\frac{1}{6}$
- (B)  $\frac{1}{9}$

- (C)  $\frac{5}{36}$
- (D)  $\frac{7}{36}$

**Q.11.** For a normal distribution with mean  $\mu = 50$  and standard deviation  $\sigma = 10$ , the value of  $P(40 \leq X \leq 60)$  is approximately:

- (A) 0.9545
- (B) 0.6827
- (C) 0.9973
- (D) 0.5000

**Q.12.** The mean of a Poisson distribution is  $\lambda = 3$ . The variance of the distribution is:

- (A) 9
- (B) 3
- (C)  $\sqrt{3}$
- (D) 6

**Q.13.** The general solution of the ODE  $\frac{dy}{dx} = \frac{y}{x}$  is:

- (A)  $y = Cx^2$
- (B)  $y = Cx$
- (C)  $y = Ce^x$
- (D)  $y = C \ln x$

**Q.14.** The particular integral of  $y'' - 3y' + 2y = e^{3x}$  is:

- (A)  $\frac{e^{3x}}{2}$
- (B)  $e^{3x}$
- (C)  $\frac{e^{3x}}{4}$
- (D)  $3e^{3x}$

**Q.15.** Using the trapezoidal rule with  $n = 4$  equal intervals, the approximate value of

$\int_0^1 e^{-x^2} dx$  (taking  $h = 0.25$ ) is closest to:

- (A) 0.743
- (B) 0.886
- (C) 0.657
- (D) 1.000

## 1.2 Section B: English Language Skills and Logical Reasoning (Questions 16–30)

### Grammar and Vocabulary

**Q.16.** Choose the word that is closest in meaning to **LACONIC**:

- (A) Verbose
- (B) Concise
- (C) Ambiguous
- (D) Elegant

**Q.17.** Select the grammatically correct sentence:

- (A) Neither the students nor the teacher were present.
- (B) Neither the students nor the teacher was present.
- (C) Neither the students nor the teacher are present.
- (D) Neither the students nor the teacher have been present.

**Q.18.** Choose the antonym of **PERSPICUOUS**:

- (A) Clear
- (B) Ambiguous
- (C) Visible
- (D) Precise

**Q.19.** Fill in the blank: He was so exhausted that he could \_\_\_\_\_ keep his eyes open.

- (A) barely
- (B) nearly
- (C) mostly
- (D) hardly ever

### Reading Comprehension

*Read the following passage and answer Questions 20–22.*

Engineering education has undergone significant transformation over the past two decades. The traditional model, which emphasised rote learning and examination performance, has increasingly been replaced by project-based learning and interdisciplinary approaches. Research indicates that students who engage in collaborative design projects demonstrate superior problem-solving capabilities compared to their counterparts trained exclusively through lectures. However, critics argue that foundational theoretical knowledge must not be sacrificed at the altar of practical skills, as deep conceptual understanding remains the bedrock of genuine innovation.

**Q.20.** The passage primarily argues that:

- (A) Traditional engineering education is wholly superior to modern methods.

- (B) Engineering education should balance practical skills with theoretical foundations.
  - (C) Project-based learning has completely replaced lecture-based teaching.
  - (D) Rote learning produces the best engineers.
- Q.21.** According to the passage, students in collaborative design projects show:
- (A) Higher examination scores
  - (B) Better problem-solving capabilities
  - (C) Stronger theoretical knowledge
  - (D) Greater career prospects
- Q.22.** What does the phrase “sacrificed at the altar of practical skills” imply?
- (A) Theory should be worshipped like an altar.
  - (B) Practical skills are more sacred than theory.
  - (C) Theoretical knowledge should not be abandoned for the sake of practicality.
  - (D) Examination performance is the primary goal.

### Logical Reasoning

- Q.23.** In a series: 3, 8, 15, 24, 35, ... – what is the next term?
- (A) 46
  - (B) 48
  - (C) 50
  - (D) 52
- Q.24.** If ENGINEER is coded as FOHJOFFE, then SCIENCE is coded as:
- (A) TDJFODF
  - (B) TDJDODF
  - (C) UDJFODF
  - (D) TDJFODG
- Q.25.** All rectangles are quadrilaterals. Some quadrilaterals are parallelograms. Which conclusion is definite?
- (A) All rectangles are parallelograms.
  - (B) Some rectangles are parallelograms.
  - (C) All parallelograms are rectangles.
  - (D) All rectangles are quadrilaterals.
- Q.26.** A clock shows 3:15. The angle between the hour and minute hands is:
- (A)  $0^\circ$
  - (B)  $7.5^\circ$

- (C)  $15^\circ$   
(D)  $22.5^\circ$
- Q.27.** If the day after tomorrow is Wednesday, what day was three days before yesterday?
- (A) Thursday  
(B) Friday  
(C) Saturday  
(D) Wednesday
- Q.28.** In a row of 40 students, Ravi is 15th from the left. Priya is 10 places to the right of Ravi. What is Priya's position from the right end?
- (A) 15  
(B) 16  
(C) 17  
(D) 14

## 2 Test 2: Mechanical Engineering (Questions 31–100)

### 2.1 Engineering Mathematics – Applied (Q. 31–37)

- Q.31.** The Laplace transform of  $f(t) = t^2 e^{-3t}$  is:
- (A)  $\frac{2}{(s+3)^3}$   
(B)  $\frac{2}{(s-3)^3}$   
(C)  $\frac{1}{(s+3)^2}$   
(D)  $\frac{2}{s^3+3}$
- Q.32.** A matrix  $A$  is said to be positive definite if all its eigenvalues are:
- (A) Real and non-negative  
(B) Positive  
(C) Zero  
(D) Complex
- Q.33.** The Fourier series of an odd function  $f(x)$  on  $[-L, L]$  contains:
- (A) Cosine terms only  
(B) Both sine and cosine terms  
(C) Sine terms only  
(D) Constant term only

**Q.34.** The solution of  $\frac{d^2y}{dx^2} + 4y = 0$  with  $y(0) = 1$ ,  $y'(0) = 0$  is:

- (A)  $\cos(2x)$
- (B)  $\sin(2x)$
- (C)  $e^{2x}$
- (D)  $\cos(4x)$

**Q.35.** The gradient of the scalar field  $\phi = x^2yz$  at the point  $(1, 2, 1)$  is:

- (A)  $4\hat{i} + 2\hat{j} + 2\hat{k}$
- (B)  $2\hat{i} + 4\hat{j} + 2\hat{k}$
- (C)  $4\hat{i} + 1\hat{j} + 2\hat{k}$
- (D)  $2\hat{i} + 2\hat{j} + 4\hat{k}$

**Q.36.** The Newton–Raphson iterative formula for finding  $\sqrt{N}$  starting from initial guess  $x_0$  is:

- (A)  $x_{n+1} = \frac{1}{2} \left( x_n + \frac{N}{x_n} \right)$
- (B)  $x_{n+1} = x_n - \frac{N}{x_n}$
- (C)  $x_{n+1} = x_n^2 - N$
- (D)  $x_{n+1} = \frac{N}{2x_n}$

**Q.37.** If  $\mathbf{F} = x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$ , then  $\nabla \cdot \mathbf{F}$  equals:

- (A)  $2x + 2y + 2z$
- (B)  $x^2 + y^2 + z^2$
- (C)  $2(x + y + z)$
- (D) 0

## 2.2 Engineering Mechanics (Q. 38–44)

**Q.38.** A simply supported beam of span  $L$  carries a central point load  $W$ . The maximum bending moment is:

- (A)  $WL$
- (B)  $\frac{WL}{2}$
- (C)  $\frac{WL}{4}$
- (D)  $\frac{WL}{8}$

**Q.39.** A block of mass 10 kg rests on a horizontal surface with  $\mu_s = 0.4$ . The minimum force required to just move the block is ( $g = 10 \text{ m/s}^2$ ):

- (A) 20 N

- (B) 40 N  
(C) 80 N  
(D) 100 N
- Q.40.** The moment of inertia of a solid circular disc of radius  $R$  and mass  $M$  about its centroidal axis is:
- (A)  $\frac{MR^2}{4}$   
(B)  $\frac{MR^2}{2}$   
(C)  $MR^2$   
(D)  $\frac{2MR^2}{3}$
- Q.41.** In a truss, if the number of members is  $m$  and number of joints is  $j$ , the condition for a perfect (statically determinate) truss is:
- (A)  $m = 2j - 3$   
(B)  $m = j - 2$   
(C)  $m = 3j - 2$   
(D)  $m = 2j + 3$
- Q.42.** A particle undergoes projectile motion with initial speed  $u$  at angle  $\theta$  to the horizontal. The time of flight is:
- (A)  $\frac{u \sin \theta}{g}$   
(B)  $\frac{2u \sin \theta}{g}$   
(C)  $\frac{u \cos \theta}{g}$   
(D)  $\frac{2u \cos \theta}{g}$
- Q.43.** The centroid of a semicircular area of radius  $R$  from its diameter is located at:
- (A)  $\frac{R}{2}$   
(B)  $\frac{4R}{3\pi}$   
(C)  $\frac{2R}{\pi}$   
(D)  $\frac{3R}{4\pi}$
- Q.44.** Virtual work principle states that for a system in equilibrium, the virtual work done by all forces for any virtual displacement is:
- (A) Maximum  
(B) Minimum  
(C) Zero  
(D) Equal to kinetic energy

### 2.3 Mechanics of Materials (Strength of Materials) (Q. 45–52)

**Q.45.** A bar of length  $L$ , cross-sectional area  $A$ , and modulus of elasticity  $E$  is subjected to axial load  $P$ . The strain energy stored is:

(A)  $\frac{P^2L}{2AE}$

(B)  $\frac{PL}{AE}$

(C)  $\frac{P^2L}{AE}$

(D)  $\frac{PL^2}{2AE}$

**Q.46.** The Mohr's circle for a state of pure shear with shear stress  $\tau$  is centred at:

(A)  $(0, 0)$  with radius  $\tau$

(B)  $(\tau, 0)$  with radius  $\tau$

(C)  $(0, \tau)$  with radius 0

(D)  $(\tau, \tau)$  with radius  $\tau$

**Q.47.** For a thin-walled closed cylinder with internal pressure  $p$ , radius  $r$ , and wall thickness  $t$ , the hoop stress is:

(A)  $\frac{pr}{t}$

(B)  $\frac{pr}{2t}$

(C)  $\frac{2pr}{t}$

(D)  $\frac{p}{rt}$

**Q.48.** The deflection at the free end of a cantilever beam of length  $L$  with a UDL of  $w$  per unit length is:

(A)  $\frac{wL^4}{8EI}$

(B)  $\frac{wL^4}{4EI}$

(C)  $\frac{wL^3}{6EI}$

(D)  $\frac{5wL^4}{384EI}$

**Q.49.** The relationship between Young's modulus  $E$ , shear modulus  $G$ , and Poisson's ratio  $\nu$  is:

(A)  $G = \frac{E}{2(1 + \nu)}$

(B)  $G = \frac{E}{2(1 - \nu)}$

(C)  $G = \frac{E}{(1 + 2\nu)}$

(D)  $G = E(1 + \nu)$

**Q.50.** The Euler critical buckling load for a column of length  $L$  with both ends pinned, flexural rigidity  $EI$ , is:

(A)  $\frac{\pi^2 EI}{L^2}$

(B)  $\frac{4\pi^2 EI}{L^2}$

(C)  $\frac{\pi^2 EI}{4L^2}$

(D)  $\frac{2\pi^2 EI}{L^2}$

**Q.51.** When a circular shaft of radius  $r$  transmits torque  $T$ , the shear stress at the surface is given by:

(A)  $\frac{2T}{\pi r^3}$

(B)  $\frac{T}{\pi r^3}$

(C)  $\frac{Tr}{\pi r^4/2}$

(D)  $\frac{16T}{\pi d^3}$

**Q.52.** A material has  $E = 200$  GPa and  $\nu = 0.3$ . The bulk modulus  $K$  is:

(A) 166.7 GPa

(B) 76.9 GPa

(C) 200 GPa

(D) 153.8 GPa

## 2.4 Theory of Machines (Q. 53–60)

**Q.53.** In a four-bar mechanism, the Grashof condition for a crank-rocker mechanism requires:

(A) Shortest link is the coupler

(B) Sum of shortest and longest links is less than or equal to sum of other two

(C) All links must be equal

(D) Shortest link must be the ground

**Q.54.** The velocity ratio of a gear pair with 20 teeth on the driver and 40 teeth on the driven is:

(A) 2

(B) 0.5

- (C) 1  
(D) 4
- Q.55.** In a cam with knife-edge follower, the pressure angle is defined as the angle between:
- (A) Axis of follower and tangent to pitch curve  
(B) Axis of follower and normal to pitch curve  
(C) Two consecutive cam positions  
(D) Cam axis and follower axis
- Q.56.** For a single-degree-of-freedom spring–mass system (mass  $m$ , spring stiffness  $k$ ), the natural frequency  $\omega_n$  is:
- (A)  $\sqrt{k/m}$   
(B)  $\sqrt{m/k}$   
(C)  $k/m$   
(D)  $2\pi\sqrt{m/k}$
- Q.57.** Resonance in a forced vibration system occurs when the excitation frequency equals:
- (A) Twice the natural frequency  
(B) Half the natural frequency  
(C) The natural frequency  
(D) The damping frequency
- Q.58.** A flywheel is used in a machine to:
- (A) Increase the mean speed of the machine  
(B) Reduce fluctuations in speed  
(C) Increase the torque output  
(D) Reduce the power requirement
- Q.59.** The expression for the velocity of a slider in a slider-crank mechanism at crank angle  $\theta$  (crank radius  $r$ , connecting rod length  $l$ , angular velocity  $\omega$ ) using the approximate (first-harmonic) form is:
- (A)  $v = r\omega \left( \sin \theta + \frac{r}{2l} \sin 2\theta \right)$   
(B)  $v = r\omega \cos \theta$   
(C)  $v = r\omega \sin \theta$   
(D)  $v = r\omega \left( \cos \theta + \frac{r}{l} \cos 2\theta \right)$
- Q.60.** Static balancing of rotating masses in a single plane is achieved when the resultant of all centrifugal forces is:
- (A) Maximum  
(B) Equal to the weight  
(C) Zero  
(D) Equal to the driving force

## 2.5 Thermodynamics (Q. 61–68)

**Q.61.** For a reversible Carnot cycle operating between source temperature  $T_H$  and sink temperature  $T_L$ , the efficiency is:

- (A)  $1 - \frac{T_H}{T_L}$
- (B)  $\frac{T_H - T_L}{T_H}$
- (C)  $\frac{T_L}{T_H}$
- (D)  $\frac{T_H}{T_L}$

**Q.62.** The first law of thermodynamics applied to a closed system undergoing a process is:

- (A)  $Q = W$
- (B)  $Q - W = \Delta U$
- (C)  $Q + W = \Delta U$
- (D)  $\Delta U = 0$

**Q.63.** Entropy of an isolated system undergoing an irreversible process:

- (A) Decreases
- (B) Remains constant
- (C) Increases
- (D) First increases then decreases

**Q.64.** The Otto cycle efficiency depends only on:

- (A) Fuel type
- (B) Compression ratio and specific heat ratio
- (C) Maximum temperature
- (D) Cylinder volume

**Q.65.** An ideal gas undergoes an isothermal process. Which of the following is correct?

- (A)  $\Delta U = 0$  and  $Q = W$
- (B)  $Q = 0$  and  $\Delta U = W$
- (C)  $W = 0$  and  $Q = \Delta U$
- (D)  $\Delta U = Q + W$

**Q.66.** The Clausius–Clapeyron equation relates:

- (A) Pressure and volume along an isotherm
- (B) Saturation pressure and temperature during phase change
- (C) Enthalpy and entropy at constant pressure
- (D) Temperature and volume during adiabatic process

- Q.67.** For a Rankine cycle, increasing the boiler pressure (at constant turbine inlet temperature) primarily:
- (A) Increases cycle efficiency and dryness fraction at turbine exit
  - (B) Increases cycle efficiency but decreases dryness fraction at turbine exit
  - (C) Decreases cycle efficiency
  - (D) Has no effect on efficiency
- Q.68.** The specific heat at constant pressure  $C_p$  and at constant volume  $C_v$  for an ideal gas are related to the gas constant  $R$  by:
- (A)  $C_p + C_v = R$
  - (B)  $C_p - C_v = R$
  - (C)  $C_p \cdot C_v = R$
  - (D)  $C_p/C_v = R$

## 2.6 Fluid Mechanics (Q. 69–76)

- Q.69.** The Bernoulli equation for steady, incompressible, inviscid flow along a streamline is:
- (A)  $p + \rho gz = \text{const}$
  - (B)  $p + \frac{1}{2}\rho v^2 + \rho gz = \text{const}$
  - (C)  $p + \rho v^2 + z = \text{const}$
  - (D)  $p\rho v^2 = \text{const}$
- Q.70.** Reynolds number is defined as the ratio of:
- (A) Inertial to viscous forces
  - (B) Pressure to viscous forces
  - (C) Buoyancy to inertial forces
  - (D) Gravity to viscous forces
- Q.71.** For a Newtonian fluid, the shear stress  $\tau$  is:
- (A) Proportional to pressure
  - (B) Proportional to velocity
  - (C) Proportional to rate of shear strain (velocity gradient)
  - (D) Independent of velocity gradient
- Q.72.** The velocity profile for fully developed laminar flow in a circular pipe (Hagen-Poiseuille flow) is:
- (A) Uniform (plug flow)
  - (B) Linear (triangular)
  - (C) Parabolic
  - (D) Logarithmic

**Q.73.** The Darcy-Weisbach equation for head loss in a pipe is:

(A)  $h_f = f \frac{L V^2}{D 2g}$

(B)  $h_f = f \frac{D V^2}{L g}$

(C)  $h_f = f \frac{LV}{D}$

(D)  $h_f = \frac{LV^2}{Dg}$

**Q.74.** Stokes' law for drag force on a sphere of radius  $r$  moving at velocity  $V$  in a fluid of viscosity  $\mu$  is:

(A)  $F_D = 6\pi\mu rV$

(B)  $F_D = 3\pi\mu rV$

(C)  $F_D = 6\pi\mu r^2V$

(D)  $F_D = \pi\mu rV$

**Q.75.** The continuity equation for steady, incompressible flow is:

(A)  $\nabla \cdot \mathbf{V} = 0$

(B)  $\nabla \times \mathbf{V} = 0$

(C)  $\frac{\partial \rho}{\partial t} = 0$

(D)  $\frac{D\rho}{Dt} = 0$

**Q.76.** The specific speed of a centrifugal pump is used to classify pumps according to:

(A) Fluid viscosity

(B) Flow geometry and impeller type

(C) Pipe diameter

(D) Motor power

## 2.7 Heat Transfer (Q. 77–83)

**Q.77.** The steady-state heat conduction through a plane wall of area  $A$ , thickness  $L$ , thermal conductivity  $k$ , and temperature difference  $\Delta T$  is given by Fourier's law as:

(A)  $Q = kA\Delta T/L$

(B)  $Q = kL\Delta T/A$

(C)  $Q = A\Delta T/(kL)$

(D)  $Q = kAL/\Delta T$

**Q.78.** The Nusselt number  $Nu$  is defined as:

(A)  $Nu = \frac{hL}{k}$

- (B)  $Nu = \frac{kL}{h}$
- (C)  $Nu = \frac{\rho VL}{\mu}$
- (D)  $Nu = \frac{C_p \mu}{k}$

**Q.79.** The thermal resistance for convection from a surface with heat transfer coefficient  $h$  and area  $A$  is:

- (A)  $\frac{1}{hA}$
- (B)  $hA$
- (C)  $\frac{h}{A}$
- (D)  $\frac{A}{h}$

**Q.80.** Stefan–Boltzmann law states that the emissive power of a blackbody is proportional to:

- (A)  $T$
- (B)  $T^2$
- (C)  $T^3$
- (D)  $T^4$

**Q.81.** A fin is most effective when the fin material has:

- (A) Low thermal conductivity and large surface area
- (B) High thermal conductivity and large surface area
- (C) High thermal conductivity and small surface area
- (D) Low thermal conductivity and small surface area

**Q.82.** In the LMTD method for a counter-flow heat exchanger, the LMTD is:

- (A) Always greater than for parallel flow for the same inlet/outlet temperatures
- (B) Equal to the arithmetic mean of terminal temperature differences
- (C) Always less than for parallel flow
- (D) Independent of flow arrangement

**Q.83.** For a lumped-heat-capacity analysis to be valid, the Biot number  $Bi$  must satisfy:

- (A)  $Bi > 10$
- (B)  $Bi < 0.1$
- (C)  $Bi = 1$
- (D)  $Bi > 1$

## 2.8 Manufacturing and Industrial Engineering (Q. 84–92)

**Q.84.** In metal cutting, the rake angle of a cutting tool is defined as the angle between the:

- (A) Cutting edge and the workpiece surface
- (B) Tool face and the vertical (normal to cutting velocity direction)
- (C) Flank face and cutting direction
- (D) Tool face and horizontal reference

**Q.85.** In Taylor's tool life equation  $VT^n = C$ , for HSS tools the typical value of  $n$  is approximately:

- (A) 0.1–0.15
- (B) 0.2–0.4
- (C) 0.4–0.6
- (D) 0.6–0.8

**Q.86.** The Economic Order Quantity (EOQ) formula is:

- (A)  $EOQ = \sqrt{\frac{2DS}{H}}$
- (B)  $EOQ = \sqrt{\frac{DS}{2H}}$
- (C)  $EOQ = \frac{2DS}{H}$
- (D)  $EOQ = \frac{D}{SH}$

**Q.87.** In welding, the heat input per unit length is most directly related to:

- (A) Electrode diameter only
- (B) Current, voltage, and welding speed
- (C) Shielding gas composition
- (D) Base metal thickness

**Q.88.** The critical path method (CPM) in project management identifies the:

- (A) Shortest path through the project network
- (B) Longest path, determining project duration
- (C) Path with maximum cost
- (D) Path with maximum resource utilisation

**Q.89.** In a Taguchi design of experiments, the signal-to-noise (S/N) ratio for a “smaller-is-better” quality characteristic is:

- (A)  $-10 \log_{10} \left( \frac{1}{n} \sum y_i^2 \right)$
- (B)  $-10 \log_{10} \left( \frac{1}{n} \sum \frac{1}{y_i^2} \right)$

(C)  $10 \log_{10}(\bar{y}^2/s^2)$

(D)  $10 \log_{10}(\sum y_i)$

**Q.90.** The surface finish (roughness) in turning depends most significantly on:

- (A) Depth of cut and coolant type
- (B) Feed rate and nose radius of tool
- (C) Cutting speed and workpiece hardness
- (D) Tool material and spindle speed only

**Q.91.** A  $p$ -chart in statistical process control is used to monitor:

- (A) Mean of a process variable
- (B) Variance of a process variable
- (C) Fraction non-conforming (defective proportion)
- (D) Number of defects per unit

**Q.92.** In forging, flash is deliberately provided at the die parting line to:

- (A) Reduce die cost
- (B) Increase material savings
- (C) Build up die pressure ensuring cavity filling
- (D) Reduce forging temperature

## 2.9 Machine Design (Q. 93–100)

**Q.93.** The Goodman criterion for fatigue failure under combined mean stress  $\sigma_m$  and alternating stress  $\sigma_a$  states:

(A)  $\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{ut}} = 1$

(B)  $\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_y} = 1$

(C)  $\frac{\sigma_a}{S_e} - \frac{\sigma_m}{S_{ut}} = 1$

(D)  $\left(\frac{\sigma_a}{S_e}\right)^2 + \left(\frac{\sigma_m}{S_y}\right)^2 = 1$

**Q.94.** The design life approach in rolling-element bearings uses the  $L_{10}$  life, defined as the life at which:

- (A) 10% of bearings are expected to fail
- (B) 90% of bearings are expected to fail
- (C) 50% of bearings survive
- (D) 10% of bearings survive

**Q.95.** For a helical compression spring, increasing the wire diameter while keeping all other parameters constant will:

- (A) Decrease stiffness
  - (B) Increase stiffness
  - (C) Have no effect on stiffness
  - (D) First increase then decrease stiffness
- Q.96.** The efficiency of a self-locking power screw (single start, lead angle  $\lambda$ , friction angle  $\phi$ ) is:
- (A)  $\eta = \tan \lambda \cdot \tan(\phi - \lambda)$
  - (B)  $\eta = \frac{\tan \lambda}{\tan(\lambda + \phi)}$
  - (C)  $\eta = \tan(\phi - \lambda)$
  - (D)  $\eta = 1 - \tan \phi$
- Q.97.** The Lewis form factor for gear tooth design accounts for:
- (A) Surface hardness of gear
  - (B) Tooth profile geometry and bending strength
  - (C) Lubrication conditions
  - (D) Gear material ductility
- Q.98.** In designing a bolted joint under a fluctuating tensile load, pre-tension (preload) is applied primarily to:
- (A) Reduce bolt fatigue by reducing the alternating load component
  - (B) Increase the maximum bolt stress
  - (C) Reduce manufacturing cost
  - (D) Increase joint compliance
- Q.99.** For a thin-rim spur gear, the bending stress at the tooth root is calculated using the:
- (A) Hertz contact theory
  - (B) Lewis bending equation modified by stress concentration factors
  - (C) Rankine's theory
  - (D) Distortion energy theory
- Q.100.** The primary function of a keyway (key joint) in a shaft-hub assembly is to:
- (A) Prevent relative axial motion
  - (B) Transmit torque by preventing relative angular (rotational) motion
  - (C) Reduce stress concentration
  - (D) Allow controlled slipping under overload

## Answer Key

Q. No.	Answer	Brief Answer
1	C	$\det(2A) = 8 \text{ times } \det(A) = 8 \text{ times } 6 = 48$
2	A	Characteristic equation gives eigenvalues 2 and 5 (trace=7, det=10)
3	B	Row 2 is twice Row 1; rows linearly dependent; rank = 2
4	B	Standard limit: $\sin(ax)/x$ approaches a as x approaches 0
5	A	Derivative zero at $x=0$ (local max) and $x=2$ (local min)
6	A	Integration by parts gives result = 1
7	A	Partial w.r.t. y gives x squared plus x cos(xy)
8	B	Magnitude of $(3+4i)$ is 5; magnitude of $(1-2i)$ is $\sqrt{5}$ ; ratio = $\sqrt{5}$ , but correct answer is 1 after simplification
9	A	Second-order pole at $z=1$ ; residue equals e
10	A	Six favourable pairs for sum 7 out of 36; probability = $1/6$
11	B	One standard deviation each side of mean covers approximately 68.27 percent
12	B	Variance of Poisson equals its mean; $\lambda = 3$
13	B	Separating variables and integrating gives $y = Cx$
14	A	Particular integral $y = (1/2)\exp(3x)$ satisfies the equation
15	A	Trapezoidal rule with $h=0.25$ gives approximately 0.743
16	B	Laconic means using very few words; concise is the closest synonym
17	B	Nearest subject to verb is singular (teacher); use was
18	B	Perspicuous means clearly expressed; antonym is ambiguous
19	A	Barely correctly conveys the extreme difficulty of keeping eyes open
20	B	Passage advocates balance between practical and theoretical learning
21	B	Collaborative project students show superior problem-solving ability
22	C	Phrase means theory should not be abandoned for the sake of practicality
23	B	Differences are 5,7,9,11,13; next term = $35 + 13 = 48$
24	A	Each letter advanced by one position; SCIENCE becomes TDJFODF

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*Answer Key – continued from previous page*

Q. No.	Answer	Brief Answer
25	D	Only guaranteed conclusion from the premises: all rectangles are quadrilaterals
26	B	Minute hand at 90 degrees; hour hand at 97.5 degrees; angle = 7.5 degrees
27	A	Day after tomorrow is Wednesday means today is Monday; three days before Sunday is Thursday
28	B	Priya is at position 25 from left; from right end position = $40 - 25 + 1 = 16$
29	B	Clock problem: angle between hands at 3:15 is 7.5 degrees (same as Q26)
30	A	Series analogy: differences increase by 2 each step; confirm next value
31	A	Laplace transform of $t^2 \exp(-3t)$ equals 2 divided by $(s+3)^3$
32	B	Positive definite matrix: all eigenvalues must be strictly positive
33	C	Odd function Fourier series contains only sine terms by symmetry
34	A	Applying initial conditions to general solution gives $\cos(2x)$
35	A	Gradient at (1,2,1) evaluates to $4i + 2j + 2k$
36	A	Newton-Raphson iteration for square root: $x_{\text{next}} = \text{half of } (x + N/x)$
37	A	Divergence of $F = 2x + 2y + 2z$
38	C	Maximum bending moment under central point load = $WL/4$
39	B	Limiting friction = 0.4 times 100 N = 40 N
40	B	Moment of inertia of solid disc about central axis = $MR^2/2$
41	A	Perfect truss condition: members = 2 times joints minus 3
42	B	Projectile time of flight = $2u \sin(\theta)$ divided by $g$
43	B	Centroid of semicircle from diameter = $4R/3\pi$
44	C	Virtual work theorem: total virtual work = 0 at equilibrium
45	A	Strain energy in axially loaded bar = $P^2 L / 2AE$
46	A	Pure shear Mohr circle: centre at origin, radius equals shear stress
47	A	Hoop stress in thin cylinder = $pr/r$
48	A	Cantilever UDL tip deflection = $wL^4 / 8EI$
49	A	Shear modulus $G = E / 2(1 + \text{Poisson ratio})$

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*Answer Key – continued from previous page*

<b>Q. No.</b>	<b>Answer</b>	<b>Brief Answer</b>
50	A	Euler critical load for pinned-pinned column = $\pi^2 EI / L^2$
51	D	Surface shear stress in solid shaft = $16T / \pi d^3$
52	A	Bulk modulus $K = 200 / (3 \times 0.4) = 166.7$ GPa
53	B	Grashof: sum of shortest and longest links must not exceed sum of other two
54	A	Velocity ratio = output/input = $40/20 = 2$ (output shaft slower)
55	B	Pressure angle is between follower axis and normal to pitch curve
56	A	Natural frequency of spring-mass system = square root of $k / m$
57	C	Resonance: excitation frequency equals natural frequency
58	B	Flywheel stores and releases energy to reduce speed fluctuations
59	A	Slider velocity (first harmonic approximation) includes $\sin \theta$ and $\sin 2\theta$ terms
60	C	Static balance achieved when vector sum of centrifugal forces = zero
61	B	Carnot efficiency = $(T_{\text{high}} - T_{\text{low}}) / T_{\text{high}}$
62	B	First law closed system: heat minus work = change in internal energy
63	C	Clausius inequality: entropy of isolated system increases in irreversible process
64	B	Otto efficiency depends only on compression ratio and ratio of specific heats
65	A	Isothermal ideal gas: internal energy unchanged; all heat converts to work
66	B	Clausius-Clapeyron equation links saturation pressure change to temperature
67	B	Higher boiler pressure raises efficiency but reduces turbine exit dryness
68	B	Mayer relation for ideal gas: $C_p - C_v = R$
69	B	Bernoulli equation: static pressure + dynamic pressure + hydrostatic = constant
70	A	Reynolds number = ratio of inertial to viscous forces
71	C	Newtonian fluid: shear stress proportional to velocity gradient
72	C	Hagen-Poiseuille: parabolic (paraboloid) velocity profile in laminar pipe flow

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*Answer Key – continued from previous page*

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<b>Q. No.</b>	<b>Answer</b>	<b>Brief Answer</b>
73	A	Darcy-Weisbach: head loss = $f$ times $(L/D)$ times $V$ squared over $2g$
74	A	Stokes drag on sphere: $F = 6 \pi \mu r V$
75	A	Incompressible continuity: divergence of velocity field = zero
76	B	Specific speed classifies pump geometry: radial, mixed or axial flow
77	A	Fourier conduction: $Q = k$ times $A$ times $\Delta T$ divided by $L$
78	A	Nusselt number = convective coefficient times length divided by conductivity
79	A	Convection resistance = $1$ divided by $(h$ times $A)$
80	D	Stefan-Boltzmann: blackbody emissive power proportional to $T$ to the 4th
81	B	Fin most effective with high thermal conductivity and large surface area
82	A	Counter-flow heat exchanger always has higher LMTD than parallel flow
83	B	Lumped capacitance valid only when Biot number is less than $0.1$
84	B	Rake angle measured between tool face and normal to cutting velocity
85	B	Taylor exponent for HSS tools is typically $0.2$ to $0.4$
86	A	EOQ = square root of $(2$ times $D$ times $S$ divided by $H)$
87	B	Weld heat input = current times voltage divided by welding speed
88	B	Critical path is longest duration path in project network
89	A	S/N smaller-is-better = negative $10$ times log of mean square response
90	B	Roughness $R_a$ proportional to feed squared divided by $8$ times nose radius
91	C	p-chart monitors fraction non-conforming (defective proportion)
92	C	Flash in closed-die forging builds pressure to fill cavity completely
93	A	Goodman line: alternating stress over endurance limit plus mean over UTS = $1$
94	A	L10 bearing life: 10 percent of sample expected to fail by this life
95	B	Spring stiffness proportional to $d$ to the 4th; larger wire = stiffer spring
96	B	Power screw efficiency = $\tan(\text{lead angle})$ divided by $\tan(\text{lead angle} + \text{friction angle})$

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*Answer Key – continued from previous page*

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<b>Q. No.</b>	<b>Answer</b>	<b>Brief Answer</b>
97	B	Lewis form factor captures tooth profile geometry for bending stress calculation
98	A	Bolt preload reduces alternating load amplitude, improving fatigue resistance
99	B	Gear tooth bending: Lewis equation modified by stress concentration factors
100	B	Key prevents relative rotation between shaft and hub, transmitting torque

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Career Decode