

OJEE MTech Mechanical Sample Paper 01

A) Mode and Time: The exam is a Computer Based Test (CBT) lasting 120 minutes.

B) Total Questions: The exam contains 90 questions.

C) Marking Scheme & Rules:

- +4 marks for each correct answer; -1 mark for each incorrect answer.

Q1. In a reversible isothermal expansion of an ideal gas, which of the following thermodynamic properties remains strictly constant?

- A. Enthalpy
- B. Entropy
- C. Internal Energy
- D. Both Enthalpy and Internal Energy

Q2. A Carnot heat engine operates between 1000 K and 300 K. If the engine receives 1000 kJ of heat, what is the maximum possible theoretical work output?

- A. 300 kJ
- B. 700 kJ
- C. 1000 kJ
- D. 1300 kJ

Q3. In fluid mechanics, the Navier-Stokes equations are derived strictly based on the conservation of which fundamental physical quantity?

- A. Mass
- B. Energy
- C. Momentum
- D. Angular Momentum

Q4. For a completely fully developed laminar flow through a circular pipe, the Darcy friction factor f depends solely on which dimensionless parameter?

- A. Froude Number
- B. Reynolds Number
- C. Mach Number

D. Weber Number

Q5. According to the lumped capacitance model for transient heat conduction, the Biot number must be strictly less than what value for the approximation to be valid?

A. 0.01

B. 0.1

C. 1.0

D. 10.0

Q6. In a counter-flow heat exchanger, the log mean temperature difference (LMTD) is theoretically compared to a parallel-flow heat exchanger operating under identical terminal temperatures. The LMTD of the counter-flow exchanger is:

A. Always less

B. Always greater

C. Exactly equal

D. Cannot be determined

Q7. According to the maximum shear stress theory (Tresca criterion), yielding in a ductile material strictly occurs when the maximum shear stress reaches what fraction of the yield stress in simple tension?

A. 0.5

B. 0.577

C. 0.707

D. 1.0

Q8. A simply supported beam of length L carries a concentrated load W exactly at its mid-span. What is the maximum bending moment in the beam?

A. $WL/2$

B. $WL/4$

C. $WL/8$

D. $WL^2/8$

Q9. In the kinematics of machinery, the Coriolis component of acceleration exists strictly when a link has:

A. Translational motion only

- B. Rotational motion only
- C. Simultaneous translation and rotation
- D. Zero velocity

Q10. The primary functional purpose of a flywheel in an internal combustion engine is strictly to:

- A. Govern the engine speed
- B. Reduce the cyclic fluctuation of energy
- C. Maintain constant fuel supply
- D. Prevent engine knocking

Q11. During orthogonal metal cutting, a continuous chip is produced with a chip thickness ratio of 0.5. If the uncut chip thickness is 0.2 mm, what is the final thickness of the chip?

- A. 0.1 mm
- B. 0.2 mm
- C. 0.4 mm
- D. 0.5 mm

Q12. Which specific welding process fundamentally utilizes a non-consumable tungsten electrode to produce the weld?

- A. MIG Welding
- B. TIG Welding
- C. Submerged Arc Welding
- D. Shielded Metal Arc Welding

Q13. In a standard vapor compression refrigeration cycle, the refrigerant explicitly enters the compressor as a:

- A. Subcooled liquid
- B. Saturated liquid
- C. Wet vapor
- D. Saturated or superheated vapor

Q14. Which dimensionless number fundamentally represents the ratio of kinematic viscosity to thermal diffusivity in convective heat transfer?

- A. Nusselt Number
- B. Prandtl Number
- C. Grashof Number
- D. Stanton Number

Q15. According to Euler's formula, the critical buckling load of a perfectly straight column with both ends hinged is proportional to:

- A. L
- B. L^2
- C. $1/L$
- D. $1/L^2$

Q16. A solid circular shaft is subjected to a pure twisting moment T . The maximum shear stress induced at the surface of the shaft is strictly proportional to:

- A. $1/d$
- B. $1/d^2$
- C. $1/d^3$
- D. $1/d^4$

Q17. In the context of gear design, the phenomenon of "interference" can be physically eliminated by:

- A. Decreasing the pressure angle
- B. Increasing the number of teeth on the pinion
- C. Decreasing the center distance
- D. Using a smaller module

Q18. The degree of freedom of a planar mechanism with n links, j lower pairs, and h higher pairs is mathematically given by which criterion?

- A. Gruebler's criterion
- B. Kutzbach criterion
- C. Euler's equation
- D. Grashof's law

Q19. Which advanced manufacturing process removes material strictly by vaporizing it using a highly focused, high-intensity monochromatic light beam?

- A. EDM
- B. ECM
- C. LBM
- D. USM

Q20. In a psychrometric chart, the lines representing constant wet-bulb temperature are approximately parallel to the lines of constant:

- A. Relative Humidity
- B. Enthalpy
- C. Specific Volume
- D. Dew Point Temperature

Q21. An ideal Otto cycle consists of which specific set of thermodynamic processes?

- A. Two constant volume and two isentropic
- B. Two constant pressure and two isentropic
- C. Two constant temperature and two constant volume
- D. One constant pressure, one constant volume, and two isentropic

Q22. The absolute critical point of water occurs at a thermodynamic state where the properties of the liquid and vapor phases become identical. What is the approximate critical pressure?

- A. 101.3 kPa
- B. 22.06 MPa
- C. 10.0 MPa
- D. 5.0 MPa

Q23. In hydrodynamics, a Pitot-static tube is fundamentally used to measure:

- A. Static pressure
- B. Dynamic pressure
- C. Total pressure
- D. Stagnation temperature

Q24. For a steady, incompressible boundary layer over a flat plate, the momentum thickness (θ) is mathematically strictly defined as the integral of:

- A. (u/U)
- B. $(1 - u/U)$
- C. $(u/U)(1 - u/U)$
- D. $(u/U)(1 - u^2/U^2)$

Q25. Which mode of heat transfer strictly dominates in the vacuum of outer space?

- A. Conduction
- B. Convection
- C. Radiation
- D. Advection

Q26. The effectiveness of a heat fin is formally defined as the ratio of the actual heat transfer rate from the fin to the:

- A. Heat transfer from a fin of infinite length
- B. Heat transfer if the entire fin were at the base temperature
- C. Heat transfer from the un-finned surface area
- D. Heat transfer if the fin had zero thermal resistance

Q27. When a cantilever beam is subjected to a uniformly distributed load w over its entire length L , the maximum deflection strictly occurs at the free end and is equal to:

- A. $wL^4/8EI$
- B. $wL^4/3EI$
- C. $wL^3/8EI$
- D. $wL^3/3EI$

Q28. Mohr's circle for a state of pure shear fundamentally consists of a circle with its center located exactly at:

- A. The origin (0,0)
- B. The maximum shear stress value
- C. The maximum principal stress value
- D. The average normal stress value

Q29. In vibration analysis, the logarithmic decrement is a dimensionless parameter strictly used to measure:

- A. The natural frequency of the system
- B. The rate of decay of free vibrations
- C. The amplitude of forced vibrations
- D. The magnification factor at resonance

Q30. Which distinct type of gear train allows the first and the last gears to rigorously rotate on the exact same collinear axis?

- A. Simple gear train
- B. Compound gear train
- C. Reverted gear train
- D. Epicyclic gear train

Q31. In casting terminology, a "chaplet" is physically used strictly to:

- A. Provide a path for molten metal
- B. Support the core inside the mold cavity
- C. Prevent shrinkage cavities
- D. Create a hollow cavity in the casting

Q32. The Taylor tool life equation is $VT^n = C$. For High-Speed Steel (HSS) tools, the value of the exponent n strictly falls in the range of:

- A. 0.1 to 0.2
- B. 0.2 to 0.4
- C. 0.5 to 0.7
- D. 0.8 to 1.0

Q33. In a Rankine cycle, the primary purpose of incorporating reheating is strictly to:

- A. Increase the boiler pressure
- B. Increase the condenser temperature
- C. Increase the dryness fraction of steam at the turbine exhaust
- D. Decrease the specific work output

Q34. Which principle rigorously states that the total entropy of an isolated thermodynamic system can never decrease over time?

- A. Zeroth Law of Thermodynamics
- B. First Law of Thermodynamics
- C. Second Law of Thermodynamics
- D. Third Law of Thermodynamics

Q35. In a centrifugal pump, the phenomenon of cavitation is fundamentally initiated when the local absolute fluid pressure strictly falls below the:

- A. Atmospheric pressure
- B. Discharge pressure
- C. Fluid's vapor pressure
- D. Pump's net positive suction head

Q36. For a fully developed turbulent flow in a pipe, the velocity profile is best approximated mathematically by which specific law?

- A. Parabolic law
- B. Logarithmic law
- C. Power law
- D. Linear law

Q37. Stefan-Boltzmann law strictly states that the total emissive power of a black body is proportional to the:

- A. Absolute temperature
- B. Square of the absolute temperature
- C. Cube of the absolute temperature
- D. Fourth power of the absolute temperature

Q38. In a transient heat conduction problem, the Fourier number is a dimensionless parameter strictly representing the ratio of:

- A. Heat conducted to heat stored
- B. Convective heat transfer to conductive heat transfer
- C. Inertial forces to viscous forces
- D. Buoyancy forces to viscous forces

Q39. A thick cylindrical pressure vessel fails fundamentally according to which specific theory of failure?

- A. Maximum principal stress theory
- B. Maximum principal strain theory
- C. Maximum shear stress theory
- D. Distortion energy theory

Q40. In calculating the fatigue life of a component, the strictly defined fatigue limit (endurance limit) for steels is typically observed at approximately how many stress cycles?

- A. 10^3
- B. 10^5
- C. 10^6
- D. 10^8

Q41. In the dynamic analysis of a slider-crank mechanism, the primary unbalanced force is mathematically given by:

- A. $m r \omega^2 \cos \theta$
- B. $m r \omega^2 \sin \theta$
- C. $m r \omega^2 \cos(2\theta)/n$
- D. $m r \omega^2 \sin(2\theta)/n$

Q42. Which type of cam follower strictly experiences the highest rate of wear due to point contact geometry?

- A. Roller follower
- B. Flat-faced follower
- C. Spherical-faced follower
- D. Knife-edge follower

Q43. In the process of rolling, the physical phenomenon of "forward slip" strictly implies that the exit velocity of the metal strip is:

- A. Equal to the roll surface velocity
- B. Less than the roll surface velocity
- C. Greater than the roll surface velocity
- D. Zero

Q44. In limits and fits, an "interference fit" explicitly guarantees that the maximum size of the hole is always:

- A. Greater than the minimum size of the shaft
- B. Equal to the minimum size of the shaft
- C. Less than the minimum size of the shaft
- D. Equal to the maximum size of the shaft

Q45. In thermodynamics, the strictly defined Joule-Thomson coefficient for an ideal gas is absolutely equal to:

- A. 0
- B. 1
- C. Infinity
- D. Equal to its specific heat capacity

Q46. Which of the following dimensionless numbers is strictly defined as the ratio of buoyancy forces to viscous forces in natural convection?

- A. Prandtl Number
- B. Grashof Number
- C. Reynolds Number
- D. Nusselt Number

Q47. When a fluid flows over a flat plate, the transition from laminar to turbulent flow fundamentally depends primarily on which specific parameter?

- A. Surface roughness
- B. Free-stream velocity
- C. Reynolds number
- D. Fluid temperature

Q48. A material property that strictly measures the ability to absorb energy before macroscopic fracture occurs is called:

- A. Hardness
- B. Toughness
- C. Resilience
- D. Ductility

Q49. In the design of helical springs, the strictly defined Wahl correction factor accounts for both direct shear stress and:

- A. Torsional shear stress
- B. Bending stress
- C. Curvature effect
- D. Buckling effect

Q50. According to the Kennedy theorem of three centers in kinematics, if three bodies have relative motion with respect to one another, their three instantaneous centers must strictly:

- A. Form a triangle
- B. Lie on a circle
- C. Lie on a straight line
- D. Be coincident

Q51. In manufacturing, which specific unconventional machining process is fundamentally driven by the abrasive action of high-velocity fluid jets?

- A. Abrasive Jet Machining (AJM)
- B. Electric Discharge Machining (EDM)
- C. Electrochemical Machining (ECM)
- D. Ultrasonic Machining (USM)

Q52. Which fundamental structural imperfection causes a metal to undergo plastic deformation at shear stresses far below the theoretical shear strength?

- A. Vacancies
- B. Interstitial atoms
- C. Grain boundaries
- D. Dislocations

Q53. In the analysis of planar trusses, a "zero-force member" is strictly defined as a structural member that:

- A. Is unnecessary for structural stability
- B. Carries absolutely no axial load under the given loading conditions
- C. Resists only bending moments
- D. Is made of infinitely rigid material

Q54. For a completely incompressible fluid, the strictly defined mathematical divergence of the velocity vector field is identically equal to:

- A. 1
- B. 0
- C. Infinity
- D. The fluid density

Q55. In the field of heat transfer, "black body" radiation strictly relies on the assumption that the absorptivity of the surface is precisely equal to:

- A. 0
- B. 0.5
- C. 1.0
- D. Infinity

Q56. The fundamental purpose of a draft angle in a casting pattern is strictly to:

- A. Prevent internal voids
- B. Allow easy removal of the pattern from the sand mold
- C. Control the cooling rate
- D. Increase the casting strength

Q57. A universal joint (Hooke's joint) is used to physically connect two intersecting shafts. The angular velocity ratio between the input and output shafts is strictly:

- A. Constant at all times
- B. Variable during rotation
- C. Zero
- D. Exactly equal to the intersection angle

Q58. In an ideal Brayton cycle for a gas turbine, the heat rejection phase strictly occurs at constant:

- A. Pressure
- B. Volume
- C. Temperature
- D. Entropy

Q59. The fundamental concept of a boundary layer in fluid mechanics was first mathematically introduced by:

- A. Isaac Newton
- B. Daniel Bernoulli
- C. Osborne Reynolds
- D. Ludwig Prandtl

Q60. In a simple tension test, the strictly defined physical point at which the material first begins to yield with virtually no increase in load is the:

- A. Proportional limit
- B. Elastic limit
- C. Upper yield point
- D. Ultimate tensile strength

Q61. Given the 2×2 matrix $A = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$, what are the strictly calculated eigenvalues?

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

Q62. What is the exact definite integral $\int_0^\pi \sin(x) dx$?

- A. 0
- B. 1
- C. 2
- D. π

Q63. For a differential equation $\frac{dy}{dx} = y$, with the initial condition $y(0) = 1$, the strictly analytical solution for $y(x)$ is:

- A. x^2
- B. e^x
- C. $\ln(x)$
- D. $\cos(x)$

Q64. What is the mathematical limit $\lim_{x \rightarrow \infty} \frac{2x^2+3x}{5x^2-x}$?

- A. 0
- B. 0.4
- C. 2.5
- D. Infinity

Q65. A strictly fair coin is tossed exactly 4 times. What is the precise probability of obtaining exactly 2 heads?

- A. $1/2$
- B. $3/8$
- C. $1/4$
- D. $5/16$

Q66. Which vector calculus operation strictly converts a scalar field into a vector field?

- A. Divergence
- B. Curl
- C. Gradient
- D. Laplacian

Q67. What is the strictly calculated determinant of the 3×3 identity matrix?

- A. 0
- B. 1
- C. 3
- D. 9

Q68. The mathematical function $f(x) = x^3 - 3x$ has a strictly defined local minimum at which specific value of x ?

- A. -1
- B. 0
- C. 1
- D. 3

Q69. In numerical methods, Simpson's $1/3$ Rule fundamentally approximates the integral curve using polynomials of which specific degree?

- A. First degree (Linear)
- B. Second degree (Quadratic)
- C. Third degree (Cubic)
- D. Fourth degree

Q70. What is the exact Laplace transform of the function $f(t) = e^{at}$?

- A. $1/(s - a)$
- B. $1/(s + a)$
- C. $a/(s^2 + a^2)$
- D. $s/(s^2 + a^2)$

Q71. In probability theory, if two events A and B are strictly independent, then $P(A \cap B)$ mathematically equals:

- A. $P(A) + P(B)$
- B. $P(A) - P(B)$
- C. $P(A) \times P(B)$
- D. $P(A)/P(B)$

Q72. What is the strictly calculated mathematical curl of the gradient of any scalar field ϕ ?

- A. 1
- B. 0
- C. $\nabla^2 \phi$
- D. ϕ

Q73. The Taylor series expansion of $\cos(x)$ strictly contains terms featuring only:

- A. Odd powers of x
- B. Even powers of x
- C. Both even and odd powers
- D. Exponential functions

Q74. For a continuously differentiable function $f(x, y)$, the fundamental Clairaut's theorem strictly dictates that:

- A. $f_{xy} = f_{yx}$
- B. $f_{xx} = f_{yy}$
- C. $f_x = f_y$
- D. $\nabla f = 0$

Q75. If a random variable X strictly follows a standard normal distribution $N(0, 1)$, what is its exact mathematical variance?

- A. 0
- B. 0.5
- C. 1
- D. Infinity

Q76. What is the explicit geometric meaning of the first derivative of a function evaluated at a specific point?

- A. The area under the curve
- B. The exact slope of the tangent line
- C. The rate of change of curvature
- D. The inflection point

Q77. A linear system of equations $Ax = b$ strictly has a unique solution if and only if the determinant of the square matrix A is:

- A. Exactly zero
- B. Less than zero
- C. Greater than zero
- D. Non-zero

Q78. In the context of complex variables, the strictly formulated Cauchy-Riemann equations for an analytic function $f(z) = u + iv$ are:

- A. $u_x = v_y$ and $u_y = v_x$
- B. $u_x = v_y$ and $u_y = -v_x$
- C. $u_x = -v_y$ and $u_y = v_x$
- D. $u_x = -v_y$ and $u_y = -v_x$

Q79. Which classic differential equation strictly represents simple harmonic motion?

- A. $\frac{d^2y}{dx^2} - k^2y = 0$
- B. $\frac{d^2y}{dx^2} + k^2y = 0$
- C. $\frac{dy}{dx} + ky = 0$
- D. $\frac{d^2y}{dx^2} + \frac{dy}{dx} + y = 0$

Q80. What is the specific dot product of two strictly orthogonal, non-zero vectors in a Cartesian plane?

- A. -1
- B. 0
- C. 1
- D. Infinity

Q81. If the word "ENGINE" is strictly coded in a secret language as "FOHJOF", how will the word "MOTOR" be similarly coded?

- A. NPUPS
- B. NPTPS
- C. OPUPS
- D. NPUPR

Q82. A mechanical engineer walks strictly 8 km North, turns directly Right and walks 6 km. What is the exact straight-line distance from the starting point?

- A. 10 km
- B. 14 km
- C. 2 km
- D. 100 km

Q83. Identify the logically missing number in this specific mathematical sequence: 2, 6, 12, 20, 30, ?

- A. 40
- B. 42
- C. 44
- D. 46

Q84. Pointing exactly to a man, a woman strictly says, "His mother is the only daughter of my mother." How is the woman related to the man?

- A. Aunt
- B. Sister
- C. Mother
- D. Grandmother

Q85. Logical Statements: 1. All machines are complex. 2. Some complex things are useful. Conclusion: Some machines are useful. Does this conclusion strictly follow?

- A. Yes
- B. No
- C. Cannot be determined
- D. Data is contradictory

Q86. If 5 automated robots can strictly assemble 5 parts in exactly 5 minutes, how many minutes will it logically take for 50 robots to assemble 50 parts?

- A. 1
- B. 5
- C. 50
- D. 250

Q87. Select the strictly odd word out from the following logical grouping of engineering materials:

- A. Steel
- B. Iron
- C. Aluminium
- D. Concrete

Q88. In an office, A is strictly older than B. C is strictly older than A. D is strictly older than C. Who is the absolute youngest among them?

- A. A
- B. B
- C. C

D. D

Q89. If the day before yesterday was strictly a Thursday, what exact day of the week will it be tomorrow?

- A. Sunday
- B. Monday
- C. Tuesday
- D. Saturday

Q90. A standard analog clock physically shows 3:15. What is the exact angle in degrees strictly measured between the hour hand and the minute hand?

- A. 0 degrees
- B. 7.5 degrees
- C. 15 degrees
- D. 22.5 degrees

Solutions

1. D

Explanation: For an ideal gas, both enthalpy and internal energy are strictly functions of temperature alone. In an isothermal process, the temperature is absolutely constant, hence both remain strictly constant.

2. B

Explanation: The Carnot efficiency is $\eta = 1 - (T_{cold}/T_{hot}) = 1 - (300/1000) = 0.70$. The maximum theoretical work output is exactly $\eta \times Q_{in} = 0.70 \times 1000 = 700$ kJ.

3. C

Explanation: The Navier-Stokes equations are fundamental partial differential equations in fluid mechanics derived strictly by applying Newton's second law of motion, which is the conservation of momentum, to a fluid parcel.

4. B

Explanation: For a fully developed, strictly laminar flow in a circular pipe, the Darcy friction factor is mathematically defined exactly as $f = 64/Re$, demonstrating its sole dependence on the Reynolds number.

5. B

Explanation: The lumped capacitance method assumes uniform temperature distribution within a body. This approximation is strictly considered valid in engineering when the Biot number (Bi) is strictly less than 0.1.

6. B

Explanation: For any given set of identical fluid inlet and outlet temperatures, mathematical analysis strictly proves that the LMTD for a counter-flow arrangement is always fundamentally greater than that of a parallel-flow arrangement.

7. A

Explanation: The Tresca criterion mathematically asserts that yielding occurs when the maximum shear stress equals the maximum shear stress at yielding in a simple tension test, which is exactly half (0.5) of the uniaxial yield stress.

8. B

Explanation: For a simply supported beam with a central concentrated load, structural statics mathematically proves the maximum bending moment occurs strictly at the mid-span and is precisely equal to $WL/4$.

9. C

Explanation: In kinematic analysis, the Coriolis acceleration component physically emerges strictly when a point slides radially along a link that is concurrently rotating with a specific angular velocity.

10. B

Explanation: While a governor regulates mean speed over extended cycles, a flywheel possesses significant mass moment of inertia strictly to absorb and release energy within a single cycle, reducing cyclic speed fluctuations.

11. C

Explanation: The chip thickness ratio (r) is strictly defined as the uncut chip thickness (t_1) divided by the final chip thickness (t_2). Thus, $0.5 = 0.2/t_2$, strictly

yielding $t_2 = 0.4$ mm.

12. B

Explanation: Tungsten Inert Gas (TIG) welding, also formally known as Gas Tungsten Arc Welding (GTAW), is fundamentally unique as it generates an electric arc utilizing a strictly non-consumable tungsten electrode.

13. D

Explanation: To strictly prevent severe mechanical damage to the compressor valves due to liquid slugging, standard refrigeration cycles ensure the refrigerant is completely vaporized (saturated or slightly superheated) before entering the compressor.

14. B

Explanation: The Prandtl Number (Pr) is a strictly defined dimensionless fluid property representing the formal ratio of momentum diffusivity (kinematic viscosity) to thermal diffusivity.

15. D

Explanation: Euler's critical buckling load formula is $P = \pi^2 EI / L_{eff}^2$. For a perfectly straight column pinned at both ends, $L_{eff} = L$, making the load strictly proportional to $1/L^2$.

16. C

Explanation: From the standard torsion equation, the maximum shear stress is $\tau = 16T/(\pi d^3)$. Therefore, the stress is strictly inversely proportional to the cube of the shaft diameter ($1/d^3$).

17. B

Explanation: In gear kinematics, "interference" occurs when a gear tooth tip digs into the non-involute flank of the mating gear. It is practically eliminated by strictly increasing the number of teeth on the pinion.

18. B

Explanation: The Kutzbach criterion mathematically provides the degree of freedom (F) for planar mechanisms through the strictly defined formula $F = 3(n - 1) - 2j - h$.

19. C

Explanation: Laser Beam Machining (LBM) is a highly precise thermal process that removes material strictly by utilizing a focused, monochromatic laser beam to instantly melt and vaporize the workpiece.

20. B

Explanation: On a standard psychrometric chart, the diagonal lines representing constant wet-bulb temperature are nearly identical and strictly parallel to the lines of constant thermodynamic enthalpy.

21. A

Explanation: The theoretical Otto cycle, which strictly models ideal spark-ignition engines, fundamentally consists of two reversible isentropic (adiabatic) processes and two constant-volume (isochoric) heat transfer processes.

22. B

Explanation: The thermodynamic critical point of water, where the distinction

between liquid and vapor completely vanishes, occurs strictly at an absolute pressure of approximately 22.06 MPa and 374°C.

23. B

Explanation: A Pitot-static tube physically measures both stagnation (total) pressure and static pressure simultaneously. The differential reading strictly yields the dynamic pressure, allowing fluid velocity calculation.

24. C

Explanation: The momentum thickness (θ) rigorously quantifies the loss of momentum in the boundary layer. Mathematically, it is strictly defined by the integral of the quantity $(u/U)(1 - u/U)dy$.

25. C

Explanation: In the absolute vacuum of space, molecules are absent, strictly nullifying conduction and convection. Thermal energy transfer relies entirely on electromagnetic waves, formally termed thermal radiation.

26. B

Explanation: Fin effectiveness is fundamentally a performance metric strictly defined as the ratio of actual heat transferred by the fin to the ideal heat transfer if the entire fin surface was maintained exactly at the base temperature.

27. A

Explanation: Through successive double integration of the fundamental beam bending equation, the exact maximum deflection of a uniform cantilever beam bearing a uniformly distributed load strictly resolves to $wL^4/8EI$.

28. A

Explanation: A state of pure shear fundamentally implies zero normal stresses on the reference planes. Consequently, the center of Mohr's circle (σ_{avg}) is strictly located at the origin (0,0) on the normal stress axis.

29. B

Explanation: In mechanical vibration, the logarithmic decrement is mathematically defined as the natural logarithm of the ratio of any two successive amplitudes, strictly serving as a precise measure of the system's damping decay rate.

30. C

Explanation: A "reverted" gear train is kinematically distinct because its structural layout explicitly forces the axis of the first driving gear to physically coincide perfectly with the axis of the final driven gear.

31. B

Explanation: In sand casting, a chaplet is a small physical metallic insert placed specifically within the mold cavity strictly to support complex sand cores and prevent them from shifting due to buoyancy forces.

32. A

Explanation: Based on extensive empirical machining data, the strictly formulated exponent n in Taylor's tool life equation for standard High-Speed Steel (HSS) tools fundamentally ranges between 0.1 and 0.2.

33. C

Explanation: In steam power plants, expanding steam entirely in one stage causes

severe moisture formation. Reheating the steam between turbine stages is strictly employed to significantly increase the vapor dryness fraction at the turbine exhaust, protecting the blades.

34. C

Explanation: The Second Law of Thermodynamics conceptually introduces entropy and strictly establishes the principle that the total aggregate entropy of an isolated system (or the universe) is fundamentally irreversible and can never decrease.

35. C

Explanation: Cavitation is an intensely destructive physical phenomenon strictly triggered when the local absolute static pressure of the fluid inside the pump drops precisely below the fluid's specific vapor pressure, forming vapor bubbles.

36. B

Explanation: While laminar flow features a parabolic profile, empirical evidence and fluid dynamics theory rigorously demonstrate that the fully developed turbulent velocity profile in a pipe is best approximated strictly by the Logarithmic law.

37. D

Explanation: The Stefan-Boltzmann law is a fundamental radiation principle strictly declaring that the total emissive thermal power of a perfect black body is directly proportional to the absolute temperature raised precisely to the fourth power.

38. A

Explanation: The Fourier number is a strictly defined dimensionless timescale parameter in transient heat conduction, physically representing the rigorous ratio of the heat conducted through a body to the heat stored within it.

39. D

Explanation: Thick cylindrical pressure vessels are typically manufactured from ductile metals. Advanced mechanics of materials dictates that failure in such ductile components is most accurately predicted strictly by the Distortion Energy Theory (von Mises).

40. C

Explanation: On a standard S-N (Stress-Number of cycles) fatigue curve, ferrous alloys like steel strictly exhibit a distinct physical plateau known as the endurance limit, which typically manifests explicitly at approximately 10^6 stress cycles.

41. A

Explanation: In the strict kinematic analysis of a slider-crank mechanism, the primary unbalanced inertial force associated exclusively with the engine speed (ω) is exactly defined mathematically as $mr\omega^2 \cos \theta$.

42. D

Explanation: The knife-edge cam follower physically interacts with the cam surface via a theoretically sharp, infinitesimal point contact. This highly concentrated stress geometry strictly subjects it to the highest rate of frictional wear.

43. C

Explanation: Due to the strict conservation of mass, as the metal strip's thick-

ness physically decreases while passing through the rolling mill, its exit velocity must strictly become greater than the circumferential velocity of the rolls, termed forward slip.

44. C

Explanation: The strict engineering definition of an "interference fit" demands that the absolute maximum permissible diameter of the hole must remain physically less than the absolute minimum permissible diameter of the corresponding shaft.

45. A

Explanation: The Joule-Thomson coefficient mathematically defines the temperature change of a gas during a purely isenthalpic throttling process. For a strictly ideal gas, enthalpy is independent of pressure, making the coefficient exactly equal to zero.

46. B

Explanation: The Grashof number (Gr) is the fundamental dimensionless parameter strictly dictating natural convection fluid mechanics, mathematically representing the precise ratio of fluid buoyancy forces to internal viscous forces.

47. C

Explanation: Osborne Reynolds fundamentally proved that the transition from smooth laminar to chaotic turbulent fluid flow over a flat surface is strictly mathematically determined by a critical value of the dimensionless Reynolds number.

48. B

Explanation: In material science, toughness is strictly defined physically as the total capacity of a specific material to absorb elastic and plastic strain energy without experiencing catastrophic macroscopic fracture.

49. C

Explanation: The Wahl correction factor (K) in helical spring design is a rigorously derived multiplier specifically engineered to account for the simultaneous combination of direct shear stress and the severely localized stress concentration strictly due to wire curvature.

50. C

Explanation: Kennedy's theorem in planar kinematics explicitly and rigorously dictates that if any three rigid bodies are in relative planar motion, their three respective instantaneous centers of rotation must strictly lie on a single straight line.

51. A

Explanation: Abrasive Jet Machining (AJM) strictly utilizes a highly pressurized, high-velocity stream of carrier gas physically laden with microscopic abrasive particles to mechanically erode and machine hard, brittle materials.

52. D

Explanation: Dislocations are highly specific linear crystalline defects inside a metal's lattice structure. Their physical movement requires significantly less energy than shearing entire crystal planes, explaining why actual yield strength is strictly lower than theoretical calculations.

53. B

Explanation: By strict definition in structural mechanics, a "zero-force member"

in a truss explicitly carries absolutely no internal axial load under a highly specific loading condition, though it remains structurally necessary for general geometric stability.

54. B

Explanation: The strict mathematical expression of the continuity equation for a completely incompressible fluid directly mandates that the spatial divergence of its velocity vector field ($\nabla \cdot \vec{V}$) must be identically equal to zero.

55. C

Explanation: A fundamental "black body" is a purely theoretical thermodynamic construct strictly defined by an absolute absorptivity equal exactly to 1.0, meaning it perfectly absorbs all incident thermal radiation regardless of wavelength.

56. B

Explanation: In foundry practices, a draft angle represents a strictly intentional slight physical taper specifically machined onto vertical pattern faces to allow the pattern to be cleanly withdrawn without fracturing the compacted sand mold.

57. B

Explanation: Kinematic analysis of a single standard universal (Hooke's) joint strictly proves that the angular velocity ratio physically fluctuates during a single revolution, causing non-uniform output motion dependent directly on the specific intersection angle.

58. A

Explanation: The strictly ideal theoretical Brayton cycle, which models gas turbine engine performance, explicitly models the heat rejection phase to the environment as an isobaric (constant pressure) thermodynamic process.

59. D

Explanation: The fundamental mathematical and physical theory of the fluid boundary layer, separating fluid flow into a viscous near-wall region and an inviscid outer region, was strictly introduced by Ludwig Prandtl in 1904.

60. C

Explanation: During a standard tensile test, the highly specific point where the metal first explicitly undergoes macroscopic plastic yielding with a sudden, noticeable drop or plateau in the required physical load is strictly termed the upper yield point.

61. B

Explanation: The characteristic equation is $|A - \lambda I| = 0$, giving $(4 - \lambda)(3 - \lambda) - 2 = 0$. Simplifying: $\lambda^2 - 7\lambda + 10 = 0$. Factoring explicitly yields strictly $(\lambda - 2)(\lambda - 5) = 0$, so the eigenvalues are strictly 2 and 5.

62. C

Explanation: The mathematical antiderivative of $\sin(x)$ is strictly $-\cos(x)$. Evaluating this exactly from $x = 0$ to $x = \pi$ yields $[-\cos(\pi)] - [-\cos(0)]$. Since $\cos(\pi) = -1$ and $\cos(0) = 1$, the calculation is strictly $1 - (-1) = 2$.

63. B

Explanation: Separating variables yields $dy/y = dx$. Integrating strictly produces $\ln(y) = x + C$. Exponentiating gives $y = Ae^x$. Applying the precise initial condition

$y(0) = 1$ forces $A = 1$, making the strictly exact solution $y(x) = e^x$.

64. B

Explanation: For limits strictly approaching infinity, divide numerator and denominator by the absolutely highest power of x (which is x^2). The expression strictly simplifies to $(2 + 3/x)/(5 - 1/x)$. As $x \rightarrow \infty$, it evaluates strictly to $2/5 = 0.4$.

65. B

Explanation: Using the precise binomial probability formula: $P(k) = \binom{n}{k} p^k (1 - p)^{n-k}$. Here $n = 4$, $k = 2$, $p = 0.5$. So, $P(2) = 6 \times (0.5)^2 \times (0.5)^2 = 6 \times 0.0625$, which simplifies strictly to the fraction $3/8$.

66. C

Explanation: In vector calculus, the mathematical "gradient" operator (∇) is the specific operation that strictly operates on a scalar field to explicitly produce a corresponding vector field pointing in the direction of maximum change.

67. B

Explanation: The identity matrix is a strictly diagonal matrix where all main diagonal elements are precisely 1 and all others are 0. The mathematical determinant of any diagonal matrix is the direct product of its diagonal elements, explicitly yielding 1.

68. C

Explanation: First derivative $f'(x) = 3x^2 - 3$. Setting to zero gives strictly $x = 1, -1$. Second derivative $f''(x) = 6x$. Testing the roots: $f''(1) = 6 > 0$ (indicating a local minimum), while $f''(-1) = -6 < 0$ (a maximum). The minimum is strictly at $x = 1$.

69. B

Explanation: Simpson's $1/3$ numerical integration method physically partitions the area into segments and strictly models the boundary curve connecting any three consecutive data points explicitly using a second-degree (quadratic) polynomial parabola.

70. A

Explanation: The strictly defined mathematical Laplace transform of e^{at} is evaluated as the integral from 0 to infinity of $e^{at} \cdot e^{-st} dt$. This physically converges strictly for $s > a$ to the exact rational expression $1/(s - a)$.

71. C

Explanation: By the strict mathematical definition of statistical independence, the joint probability of two fundamentally independent events occurring simultaneously is identically equal to the exact product of their individual probabilities.

72. B

Explanation: A universally proved fundamental identity in vector calculus mathematically mandates that the curl of the gradient of any twice-differentiable scalar field ($\nabla \times \nabla \phi$) is strictly and identically equal to the zero vector.

73. B

Explanation: The cosine function is mathematically classified strictly as an even function. Consequently, its explicit Taylor (Maclaurin) series expansion around zero exclusively consists of strictly even mathematical powers of x .

74. A

Explanation: Clairaut's theorem is a fundamental calculus principle explicitly stating that if a function has continuous second-order partial derivatives, the mixed partial derivatives must strictly be mathematically equal ($f_{xy} = f_{yx}$).

75. C

Explanation: The strictly defined standard normal distribution is mathematically explicitly normalized to have a precise mathematical mean exactly equal to 0 and a precise variance (and standard deviation) exactly equal to 1.

76. B

Explanation: In geometric calculus, the explicit first derivative $f'(x)$ evaluated exactly at a specific coordinate strictly calculates the precise mathematical slope of the tangent line physically touching the curve at that exact specific point.

77. D

Explanation: A fundamental principle of linear algebra mathematically dictates that a linear system is strictly invertible, guaranteeing exactly one unique mathematical solution, if and only if the absolute determinant of its coefficient matrix is strictly non-zero.

78. B

Explanation: For a complex function to be strictly analytic, it must satisfy the precise mathematical Cauchy-Riemann differential equations, explicitly defined as the simultaneous conditions $u_x = v_y$ and $u_y = -v_x$.

79. B

Explanation: The linear, second-order ordinary differential equation $\frac{d^2y}{dx^2} + k^2y = 0$ is the strict mathematical representation governing pure simple harmonic motion, physically describing a system where acceleration is strictly opposite to displacement.

80. B

Explanation: In Cartesian geometry, if two distinct non-zero vectors are strictly orthogonal (physically perpendicular, intersecting at 90 degrees), their mathematical dot product is explicitly calculated to be exactly zero.

81. A

Explanation: The strictly applied logical coding pattern actively shifts every individual letter physically forward by exactly +1 in the standard alphabet. M(+1)=N, O(+1)=P, T(+1)=U, O(+1)=P, R(+1)=S. The strictly generated output is exactly NPUPS.

82. A

Explanation: The person physically traces out a strictly mathematically perfect right-angled triangle. Applying the strict Pythagorean theorem ($a^2 + b^2 = c^2$), the hypotenuse is exactly $\sqrt{8^2 + 6^2} = \sqrt{64 + 36} = \sqrt{100}$, which strictly yields 10 km.

83. B

Explanation: The logical pattern explicitly features differences between consecutive terms increasing by exactly +2 each time: (+4, +6, +8, +10). The strictly next mathematical difference must be +12. Therefore, exactly $30 + 12 = 42$.

84. C

Explanation: The phrase "the only daughter of my mother" strictly and explicitly refers to the speaking woman herself. Therefore, the sentence simplifies to "His mother is me," strictly confirming she is the man's physical mother.

85. B

Explanation: Logical syllogism states all machines are inside the complex set. The useful set explicitly overlaps with the complex set. However, there is strictly no logical guarantee the useful set explicitly overlaps the internal machine set. It does not strictly follow.

86. B

Explanation: The strict operational rate is exactly 1 robot producing 1 part in exactly 5 minutes. If 50 robots physically operate concurrently, they explicitly produce 50 parts in the exact same strict 5-minute timeframe.

87. D

Explanation: Steel, Iron, and Aluminium are all strictly categorized fundamentally as metallic materials (either pure metals or highly metal-based alloys). Concrete is fundamentally a composite ceramic/stone material, explicitly making it the logical odd category out.

88. B

Explanation: Setting up the strictly logical age hierarchy: $A \prec B$, $C \prec A$, $D \prec C$. Combining these logical statements yields the strict mathematical sequence $D \prec C \prec A \prec B$. Therefore, B is explicitly and strictly the absolute youngest individual.

89. A

Explanation: If the day before yesterday was strictly Thursday, then yesterday was explicitly Friday, making today exactly Saturday. Therefore, the day arriving explicitly tomorrow is logically and strictly Sunday.

90. B

Explanation: At exactly 3:00, the hour hand is physically on 3. In 15 exact minutes, the minute hand physically reaches 3. However, the hour hand strictly moves 0.5° per minute. After 15 minutes, it has strictly advanced $15 \times 0.5 = 7.5^\circ$ away from the 3.