MECHANICAL ENGINEERING

Q. No. 1 – 25 Carry One Mark Each

1. A mass m of a perfect gas at pressure p_1 and volume V_1 undergoes an isothermal process. The final pressure is p_2 and volume is V_2. The work done on the system is considered positive. If R is the gas constant and T is the temperature, then the work done in the process is

(A) $p_1V_1 \ln \frac{V_2}{V_1}$ (B) $-p_1V_1 \ln \frac{p_1}{p_2}$ (C) $RT \ln \frac{V_2}{V_1}$ (D) $-mRT \ln \frac{p_2}{p_1}$

Answer: (B)

2. Which one of the following statements is TRUE for the ultrasonic machining (USM) process?

(A) In USM, the tool vibrates at subsonic frequency.

(B) USM does not employ magnetostrictive transducer.

(C) USM is an excellent process for machining ductile materials.

(D) USM often uses a slurry comprising abrasive-particles and water.

Answer: (D)

3. The standard deviation of linear dimensions P and Q are $3\,\mu m$ and $4\,\mu m$, respectively. When assembled, the standard deviation (in μm) of the resulting linear dimension (P+Q) is _____

Answer: (5 to 5)

4. The emissive power of a blackbody is P. If its absolute temperature is doubled, the emissive power becomes.

(A) 2P (B) 4P (C) 8P (D) 16P

Answer: (D)

5. The state of stress at a point is $\sigma_x = \sigma_y = \sigma_z = \tau_{xz} = \tau_{zx} = \tau_{yz} = \tau_{zy} = 0$ and $\tau_{xy} = \tau_{yx} = 50\text{MPa}$. The maximum normal stress (in MPa) at that point is _____

Answer: (49.9 to 50.1)

6. The determinant of a 2×2 matrix is 50. If one eigenvalue of the matrix is 10, the other eigenvalue is _____

Answer: (5 to 5)

7. Which one of the following statement is TRUE?

(A) Both Pelton and Francis turbines are impulse turbines.

(B) Francis turbine is a reaction turbine but Kaplan turbine is an impulse turbine.

(C) Francis turbine is an axial – flow reaction turbine.

(D) Kaplan turbine is an axial – flow reaction turbine.

Answer: (D)

8. Two coins are tossed simultaneously. The probability (upto two decimal points accuracy) of getting at least one head is _____

Answer: (0.75 to 0.75)

9. A cantilever beam of length L and flexural modulus EI is subjected to a point load P at the free end. The elastic strain energy stored in the beam due to bending (neglecting transverse shear)

(A) $\frac{P^2L^3}{6EI}$ (B) $\frac{P^2L^3}{3EI}$ (C) $\frac{PL^3}{3EI}$ (D) $\frac{PL^3}{6EI}$

Answer: (A)

10. It is desired to make a product having T-shaped cross-section from a rectangular aluminium block. Which one of the following processes is expected to provide the highest strength of the product?

(A) Welding (B) Casting (C) Metal Forming (D) Machining

Answer: (C)

11. The heat loss from a fin is 6W. The effectiveness and efficiency of the fin are 3 and 0.75, respectively. The heat loss (in W) from the fin, keeping the entire fin surface at base temperature, is _____.

Answer: (7.9 to 8.1)

12. For a single server with Poisson arrival and exponential service time, the arrival rate is 12 per hour. Which one of the following service rates will provide a steady state finite queue length?

(A) 6 per hour (B) 10 per hour (C) 12 per hour (D) 24 per hour

Answer: (D)

13. For the stability of a floating body the

(A) centre of buoyancy must coincide with the centre of gravity

(B) centre of buoyancy must be above the centre of gravity

(C) centre of gravity must be above the centre of buoyancy

(D) metacentre must be above the centre of gravity

Answer: (D)

14. The divergence of the vector $-yi + xj$ _____

Answer: (0 to 0)

15. For a loaded cantilever beam of uniform cross-section, the bending moment (in N.mm) along the length is $M(x) = 5x^2+10x$, where x is the distance (in mm) measured from the free end of the beam. The magnitude of shear force (in N) in the cross-section at x =10 mm is _____.

Answer: (110 to 110)

16. A sample of 15 data is a follows: 17, 18, 17, 17, 13, 18, 5, 5, 6, 7, 8, 9, 20, 17, 3. The mode of the data is

(A) 4 (B) 13 (C) 17 (D) 20

Answer: (C)

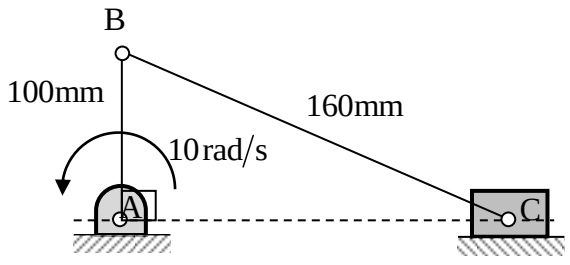
17. If a mass of moist air contained in a closed metallic vessel is heated, then its

(A) relative humidity decreases (B) relative humidity increases

(C) specific humidity increases (D) specific humidity decreases

Answer: (A)

18. In a slider-crank mechanism, the lengths of the crank and the connecting rod are 100mm and 160mm, respectively. The crank is rotating with an angular velocity of 10 radian/s counter- clockwise. The magnitude of linear velocity (in m/s) of the piston at the instant corresponding to the configuration shown in the figure is _____



Answer: (0.99 to 1.01)

19. A machine component made of a ductile material is subjected to a variable loading with $\sigma_{min} = -50$ MPa and $\sigma_{max} = 50$ MPa. If the corrected endurance limit and the yield strength for the material are $\sigma_e^{'} = 100$ MPa and $\sigma_y = 300$MPa, the factor of safety is _____

Answer: **1.99 to 2.01**

20. The crystal structure of aluminium is

(A) body-centred cubic (B) face-centred cubic

(C) close-packed hexagonal (D) body-centred tetragonal

Answer: **(B)**

21. A steel bar is held by two fixed supports as shown in the figure and is subjected to an increases of temperature $\Delta T = 100°C.$ and 200GPa, respectively, the magnitude of thermal stress (in MPa) induced in the bar is _____.

Answer: **(218 to 222)**

22. The Laplace transform of te^t is

(A) $\frac{s}{(s+1)^2}$ (B) $\frac{1}{(s-1)^2}$ (C) $\frac{1}{(s+1)^2}$ (D) $\frac{s}{s-1}$

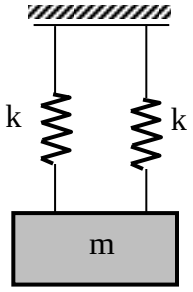
Answer: **(B)**

23. Consider a laminar flow at zero incidence over a flat plate. The shear stress at the wall is denoted by τ_w. The axial positions x_1 and x_2 on the plate are measured from the leading edge in the direction of flow. If $x_2 > x_1$, then

(A) $\tau_w\big|_{x_1} = \tau_w\big|_{x_2} = 0$ (B) $\tau_w\big|_{x_1} = \tau_w\big|_{x_2} \neq 0$ (C) $\tau_w\big|_{x_1} > \tau_w\big|_{x_2}$ (D) $\tau_w\big|_{x_1} < \tau_w\big|_{x_2}$

Answer: (C)

24. A mass m is attached to two identical springs having spring constant k as shown in the figure. The natural frequency ω of this single degree of freedom system is



(A) $\sqrt{\frac{2k}{m}}$ (B) $\sqrt{\frac{k}{m}}$

(C) $\sqrt{\frac{k}{2m}}$ (D) $\sqrt{\frac{4k}{m}}$

Answer: (A)

25. Given the atomic weight of Fe is 56 and that of C is 12, the weight percentage of carbon in cementite (Fe_3C) is _____.

Answer: (6.3 to 7.0)

Q. No. 26 – 55 Carry Two Marks Each

26. In an orthogonal machining with a tool of 9° orthogonal rake angle, the uncut chip thickness is 0.2mm. The chip thickness fluctuates between 0.25 mm and 0.4 mm. The ratio of the maximum shear angle to the minimum shear angle during machining is _____

Answer: (1.45 to 1.53)

27. A cylindrical pin of $25^{+0.020}_{+0.010}$ mm diameter is electroplated. Plating thickness is $2.0^{\pm 0.005}$ mm. Neglecting the gauge tolerance, the diameter (in mm, up to 3 decimal points accuracy) of the GO ring gauge to inspect the plated pin is _____.

Answer: (29.030 to 29.030)

28. A helical compression spring made of wire of circular cross-section is subjected to a compressive load. The maximum shear stress induced in the cross-section of the wire is 24 MPa. For the same compressive load, if both the wire diameter and the mean coil diameter are doubled, the maximum shear stress (in MPa) induced in the cross-section of the wire is _____.

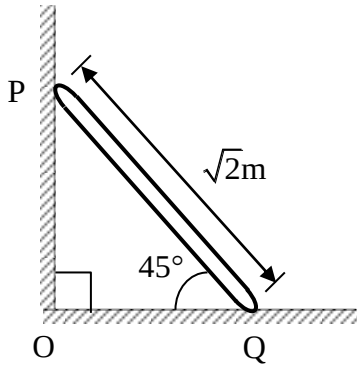
Answer: (6 to 6)

29. In a counter-flow heat exchanger, water is heated at the rate of 1.5kg/s from 40°C to 80°C by an oil entering at 120°C and leaving at 60°C. The specific heats of water and oil are 4.2kJ/kg.K and 2kJ/kg.K respectively. The overall heat transfer coefficient is 400 W/m^2.K. The required heat transfer surface area (in m^2) is

(A) 0.104 (B) 0.022 (C) 10.4 (D) 21.84

Answer: (D)

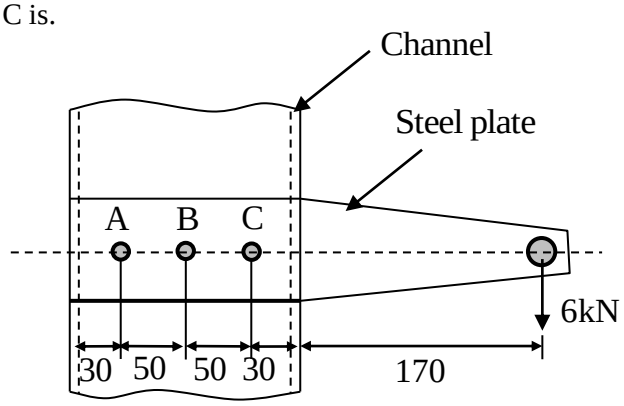
30. The rod PQ of length L = $\sqrt{2}$ m, and uniformly distributed mass of M = 10 kg, is released from rest at the position shown in the figure.



The ends slide along the frictionless faces OP and OQ. Assume acceleration due to gravity, g = 10 m/s^2. The mass moment of inertia of the rod about its centre of mass and an axis perpendicular to the plane of the figure is (ML^2/12). At this instant, the magnitude of angular acceleration (in radian/s^2) of the rod is _____

Answer: (7.25 to 7.75)

31. A steel plate, connected to a fixed channel using three identical bolts A, B and C, carries a load of 6kN as shown in the figure. Considering the effect of direct load and moment, the magnitude of resultant shear force (in kN) on bolt C is.



(A) 13 (B) 15 (C) 17 (D) 30

Answer: (C)

32. The volume and temperature of air (assumed to be an ideal gas) in a closed vessel is 2.87 m^3 and 300K, respectively. The gauge pressure indicated by a manometer fitted to the wall of the vessel is 0.5bar. If the gas constant of air is R = 287 J/kg. K and the atmospheric pressure is 1 bar, the mass of air (in kg) in the vessel is

(A) 1.67 (B) 3.33 (C) 5.00 (D) 6.66

Answer: (C)

33. For the laminar flow of water over a sphere, the drag coefficient C_F is defined as $C_F = F/\left(\rho U^2 D^2\right)$, where F is the drag force, ρ is the fluid density, U is the fluid velocity and D is the diameter of the sphere. The density of water is 1000 kg/m^3. When the diameter of the sphere is 100mm and the fluid velocity is 2m/s, the drag coefficient is 0.5. If water now flows over another sphere of diameter 200mm under dynamically similar conditions, the drag force (in N) on this sphere is _____

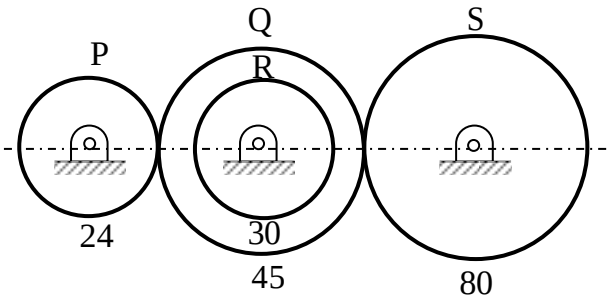
Answer: (19.9 to 20.1)

34. A rod of length 20mm is stretched to make a rod of length 40 mm. Subsequently, it is compressed to make a rod of final length 10mm. Consider the longitudinal tensile strain as positive and compressive strain as negative. The total true longitudinal strain in the rod is

(A) –0.5 (B) –0.69 (C) –0.75 (D) –1.0

Answer: (B)

35. A gear train shown in the figure consists of gears P, Q, R and S. Gear Q and gear R are mounted on the same shaft. All the gears are mounted on parallel shafts and the number of teeth of P, Q, R and S are 24, 45, 30 and 80, respectively.



Gear P is rotating at 400 rpm. The speed (in rpm) of the gear S is _____.

Answer: (120 to 120)

36. In the Rankine cycle for a steam power plant the turbine entry and exit enthalpies are 2803 kJ/kg and 1800 kJ/kg, respectively. The enthalpies of water at pump entry and exit are 121 kJ/kg and 124 kJ/kg, respectively. The specific steam consumption (in kg/k W.h) of the cycle is _____.

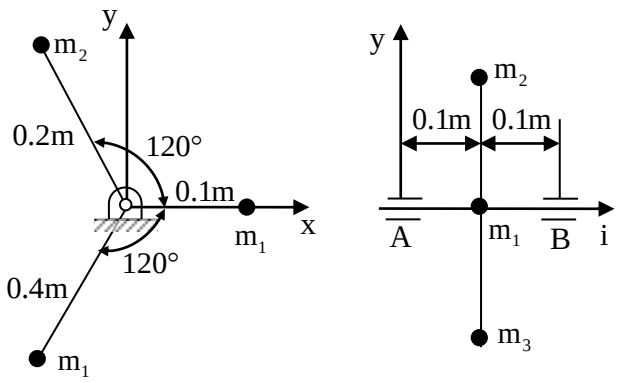
Answer: (3.5 to 3.7)

37. A calorically perfect gas (specific heat at constant pressure 1000 J/kg.K) enters and leaves a gas turbine with the same velocity. The temperatures of the gas at turbine entry and exit are 1100 K and 400 K. respectively. The power produced is 4.6 MW and heat escapes at the rate of 300 kJ/s through the turbine casing. The mass flow rate of the gas (in kg/s) through the turbine is.

(A) 6.14 (B) 7.00 (C) 7.50 (D) 8.00

Answer: (B)

38. Three masses are connected to a rotating shaft supported on bearings A and B as shown in the figure. The system is in a space where the gravitational effect is absent. Neglect the mass of shaft and rods connecting the masses. For $m_1 = 10kg$, $m_2 = 5kg$ and $m_3 = 2.5$ kg and for a shaft angular speed of 1000 radian/s, the magnitude of the bearing reaction (in N) at location B is _____.



Answer: (0 to 0)

39. A strip of 120 mm width and 8mm thickness is rolled between two 300 mm-diameter rolls to get a strip of 120 mm width and 7.2 mm thickness. The speed of the strip at the exit is 30 m/min. There is no front or back tension. Assuming uniform roll pressure of 200 MPa in the roll bite and 100% mechanical efficiency, the minimum total power (in kW) required to drive the two rolls is _____.

Answer: (9.4 to 9.8)

40. A product made in two factories p and Q, is transported to two destinations, R and S. The per unit costs of transportation (in Rupees) from factories to destinations are as per the following matrix:

Factory \ Destination	R	S
P	10	7
Q	3	4

Factory P produces 7 units and factory Q produces 9 units of the product. Each destination requires 8 units. If the north-west corner method provides the total transportation cost as X (in Rupees) and the optimized (the minimum) total transportation cost Y (in Rupees), then (X-Y), in Rupees, is

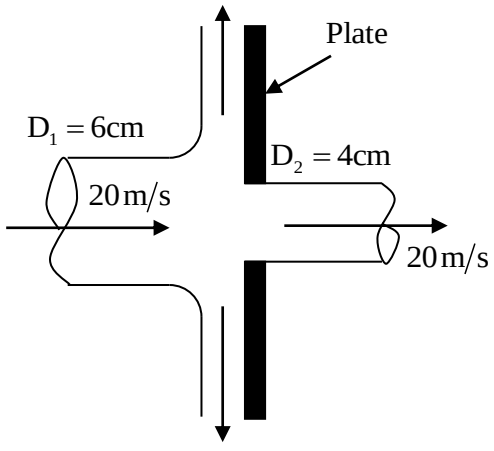
(A) 0 (B) 15 (C) 35 (D) 105

Answer: **Answer is not matched with IIT Key**

41. One kg of an ideal gas (gas constant R = 287 J/kg.K) undergoes an irreversible process from state-1 (1 bar, 300 K) to state -2 (2 bar, 300 K). The change in specific entropy ($s_2 - s_1$) of the gas (in J/kg. K) in the process is _____

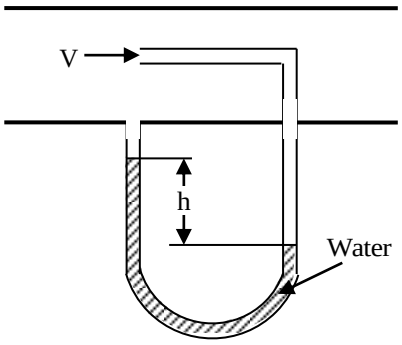
Answer: **(–201 to –197)**

42. A 60 mm-diameter water jet strikes a plate containing a hole of 40mm diameter as shown in the figure. Part of the jet passes through the hole horizontally, and the remaining is deflected vertically. The density of water is 1000 kg/m^3. If velocities are as indicated in the figure, the magnitude of horizontal force (in N) required to hold the plate is _____



Answer: **(627 to 629)**

43. The arrangement shown in the figure measures the velocity V of a gas of density 1 kg/m^3 flowing through a pipe. The acceleration due to gravity is 9.81 m/s^2. If the manometric fluid is water (density 1000 kg/m^3) and the velocity V is 20 m/s, the differential head h (in mm) between the two arms of the manometer is _____



Answer: (19 to 21)

44. A metal ball of diameter 60mm is initially at 220 °C. The ball is suddenly cooled by an air jet of 20°C. The heat transfer coefficient is 200 W/m^2.K and 9000kg/m^3, respectively. The ball temperature (in °C) after 90 seconds will be approximately.

(A) 141 (B) 163 (C) 189 (D) 210

Answer: (A)

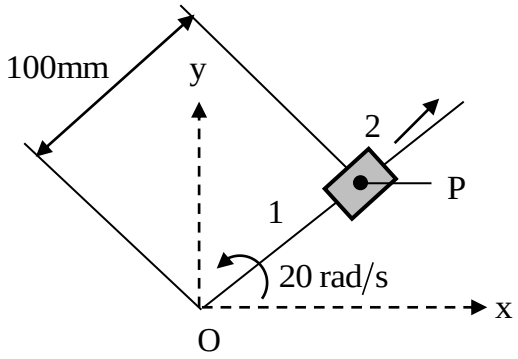
45. A single – plate clutch has a friction disc with inner and outer radii of 20mm and 40 mm, respectively. The friction lining in the disc is made in such a way that the coefficient of friction μ varies radially as $\mu = 0.01r$, where r is in mm. The clutch needs to transmit a friction torque of 18.85kN.mm. As per uniform pressure theory, the pressure (in MPa) on the disc is _____

Answer: 0.49 to 0.51

46. The surface integral $\iint_S F.ndS$ over the surface S of the sphere $x^2 + y^2 + z^2 = 9$, where F=(x+y) i+ (x+z) j+(y+z) k and n is the unit outward surface normal, yields _____.

Answer: 225 to 227

47. Block 2 slides outward on link 1 at a uniform velocity of 6 m/s as shown in the figure. Link 1 is rotating at a constant angular velocity of 20 radian/s counterclockwise. The magnitude of the total acceleration (in m/s^2) of point P of the block with respect to fixed point O is _____



Answer: 243 to 244

48. During the turning of a 20mm-diameter steel bar at a spindle speed of 400 rpm, a tool life of 20 minute is obtained. When the same bar is turned at 200 rpm, the tool life becomes 60 minute. Assume that Taylor's tool life equation is valid. When the bar is turned at 300 rpm, the tool life (in minute) is approximately.

(A) 25 (B) 32 (C) 40 (D) 50

Answer: (B)

49. Consider the matrix $A = \begin{bmatrix} 50 & 70 \\ 70 & 80 \end{bmatrix}$ whose eigenvectors corresponding to eigenvalues $\lambda_{1 \text{ and}} \lambda_2$ are $x_1 = \begin{bmatrix} 70 \\ \lambda_1 - 50 \end{bmatrix}$ and $x_2 = \begin{bmatrix} \lambda_2 - 80 \\ 70 \end{bmatrix}$. respectively. The value of $x_1^T x_2$ is_____

Answer: (0 to 0)

50. The radius of gyration of a compound pendulum about the point of suspension is 100mm. The distance between the point of suspension and the centre of mass is 250mm. Considering the acceleration due to gravity as 9.81 m/s^2, the natural frequency (in radian/s) of the compound pendulum is _____.

Answer: (15 to 16)

51. Consider the differential equation $3y''(x)+27y(x)=0$ with initial conditions y(0) = 0 and $y'(0)=2000$. The value of y at x = 1 is _____.

Answer: (93 to 95)

52. If f(z) = (x^2+ay^2) + ibxy is a complex analytic function of z = x + iy, where i = $\sqrt{-1}$, then

(A) a = –1, b= –1 (B) a = –1, b = 2 (C) a = 1, b = 2 (D) a = 2, b = 2

Answer: (B)

53. A project starts with activity A and ends with activity F. The precedence relation and durations of the activities are as per the following table:

Activity	Immediate Predecessor	Duration (days)
A	-	4
B	A	3
C	A	7
D	B	14
E	C	4
F	D,E	9

The minimum project completion time (in days) is _____

Answer: (30 to 30)

54. Maximize $Z = 5x_1+3x_2$

Subject to

$x_1+2x_2 \leq 10$,

$x_1-x_2 \leq 8$,

$x_1, x_2 \geq 0$.

In the starting Simplex tableau, x_1 and x_2 are non-basic variables and the value of Z is zero. The value of Z in the next Simplex tableau is _____.

Answer: (40 to 40)

55. The principal stresses at a point in a critical section of a machine component are $\sigma_1 = 60\text{MPa}, \sigma_2 = 5\text{MPa}$ and $\sigma_3 = -40$ MPa. For the material of the component, the tensile yield strength is $\sigma_y = 200$ MPa. According to the maximum shear stress theory, the factor of safety is

(A) 1.67 (B) 2.00 (C) 3.60 (D) 4.00

Answer: (B)