Q. No. 1 – 25 Carry One Mark Each

1. The partial differential equation $\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = \frac{\partial^2 u}{\partial x^2}$ is a

(A) Linear equation of order 2 (B) Non-linear equation of order 1
(C) Linear equation of order 1 (D) Non-linear equation of order 2

Answer: (D)

2. The eigen values of symmetric matrix are all
(A) Complex with non-zero positive imaginary part
(B) Complex with non-zero negative imaginary part
(C) Real
(D) Pure imaginary

Answer: (C)

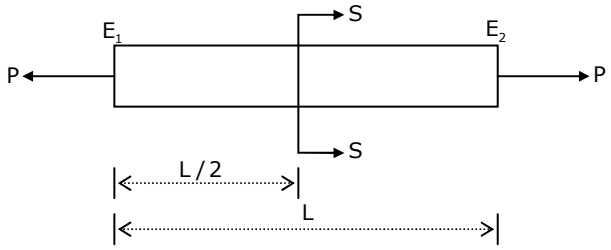
3. Match the CORRECT pairs:

Numerical Integration Scheme	**Order of Fitting Polynomial**
P. Simpson's 3/8 Rule	1. First
Q. Trapezoidal Rule	2. Second
R. Simpson's 1/3 Rule	3. Third

(A) P-2; Q-1; R-3 (B) P-3; Q-2; R-1 (C) P-1; Q-2; R-3 (D) P-3; Q-1; R-2

Answer: (D)

4. A rod of length L having uniform cross-sectional area A is subjected to a tensile force P as shown in the figure below. If the Young's modulus of the material varies linearly from E_1 to E_2 along the length of the rod, the normal stress developed at the section-SS is



(A) $\frac{P}{A}$ (B) $\frac{P(E_1 - E_2)}{A(E_1 + E_2)}$ (C) $\frac{PE_2}{AE_1}$ (D) $\frac{PE_1}{AE_2}$

Answer: (A)

Stress depends on area.

5. The threaded bolts A and B of same material and length are subjected to identical tensile load. If the elastic strain energy stored in bolt A is 4 times that of the bolt B and the mean diameter of bolt A is 12mm, the mean diameter of bolt B in mm is

(A) 16 (B) 24 (C) 36 (D) 48

Answer: (B)

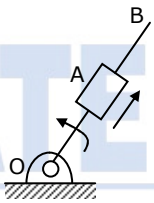
Explanation:

$$\frac{E_1}{E_2}=\frac{\left(\frac{P^2l}{2AE}\right)_1}{\left(\frac{P^2l}{2AE}\right)_2}=\frac{A_2}{A_1}$$

$$4=\frac{d_2^2}{d_1^2}$$

$$d_2=12\times d_1=24$$

6. A link OB is rotating with a constant angular velocity of 2 rad/s in counter clockwise direction and a block is sliding radially outward on it with an uniform velocity of 0.75 m/s with respect to the rod, as shown in the figure below. If OA = 1m, the magnitude of the absolute acceleration of the block at location A in m/s^2 is



(A) 3 (B) 4 (C) 5 (D) 6

Answer: (C)

Explanation:

$$\alpha_t=2v\omega=2\times0.75\times2=3$$

$$\alpha_r=\frac{v^2}{r}=4$$

$$\therefore \text{Resultant } \alpha=\sqrt{3^2+4^2}=5$$

7. For steady, fully developed flow inside a straight pipe of diameter D, neglecting gravity effects, the pressure drop Δp over a length L and the wall shear stress τ_w are related by

(A) $\tau_w=\frac{\Delta pD}{4L}$ (B) $\tau_w=\frac{\Delta pD^2}{4L^2}$ (C) $\tau_w=\frac{\Delta pD}{2L}$ (D) $\tau_w=\frac{4\Delta pL}{D}$

Answer: (A)

Explanation:

$$\tau_\omega(\pi DL)=\frac{\pi}{4}D^2\cdot\Delta p\Rightarrow\tau_\omega=\frac{\Delta pD}{4L}$$

8. The pressure, dry bulb temperature, and relative humidity of air in a room are 1bar, 30ºC and 70% respectively. If the saturated steam pressure at 30ºC is 4.25kPa, the specific humidity of the room air in kg water vapour / kg dry air is

(A) 0.0083 (B) 0.0101 (C) 0.0191 (D) 0.0232

Answer: (C)

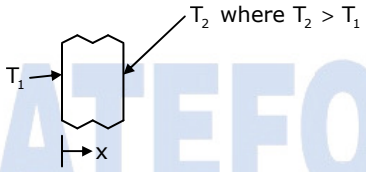
Explanation:

$$P = 1 \text{ bar} = 10^5 \text{ Pa} = 100 \text{ KPa}$$

$$P_{sat} = 4.25 \text{ KPa}$$

$$S_p.\text{humidity} = \frac{0.622 \times 0.7 \times 4.25}{(100 - 4.25)} = 0.019$$

9. Consider one-dimensional steady state heat conduction, without heat generation, in a plane wall; with boundary conditions as shown in the figure below. The conductivity of the wall is given by $k = k_0 + bT$; where k_0 and b are positive constants and T is temperature.



As x increases, the temperature gradient (dT/dx) will

(A) Remain constant (B) Be zero (C) Increase (D) Decrease

Answer: (D)

10. In a rolling process, the state of stress of the material undergoing deformation is

(A) Pure compression (B) Pure shear

(C) Compression and shear (D) Tension and shear

Answer: (C)

11. Match the CORRECT pairs.

Processes		Characteristics / Application	
P.	Friction Welding	1.	Non-consumable electrode
Q.	Gas Metal Arc Welding	2.	Joining of thick plates
R.	Tungsten Inert Gas Welding	3.	Consumable electrode wire
S.	Electroslag Welding	4.	Joining of cylindrical dissimilar materials

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

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

Answer: (A)

12. A metric thread of pitch 2mm and thread angle 60º is inspected for its pitch diameter using 3-wire method. The diameter of the best size wire in mm is

(A) 0.866 (B) 1.000 (C) 1.154 (D) 2.000

Answer: (C)

Explanations:- For 60^{o} thread angle, best wire size =0.57135xP=1.154

13. Customers arrive at a ticket counter at a rate of 50 per hour and tickets are issued in the order of their arrival. The average time taken for issuing a ticket is 1min. Assuming that customer arrivals form a Poisson process and service times are exponentially distributed, the average waiting time in queue in minutes is:

(A) 3 (B) 4 (C) 5 (D) 6

Answer: (C)

Explanation:

$$\lambda = 50/\text{hr} \quad \mu = 60/\text{hr} \quad \text{W.T} = \frac{\lambda}{\mu(\mu-\lambda)} = 0.083\text{hr} = 5\,\text{min}$$

14. In simple exponential smoothing forecasting, to give higher weightage to recent demand information, the smoothing constant must be close to

(A) -1 (B) zero (C) 0.5 (D) 1

Answer: (D)

Explanations:- Value of α close to one have less of a smoothing effect and give greater weight to recent changes in the data.

15. A steel bar 200 mm in diameter is turned at a feed of 0.25 mm/rev with a depth of cut of 4 mm. The rotational speed of the workpiece is 160 rpm. The material removal rate in mm^3/s is

(A) 160 (B) 167.6 (C) 1600 (D) 1675.5

Answer: (D)

Explanations:- $f \times d \times v$

$$= (0.25)(4) \times \frac{\pi \times 200 \times 160}{60} = 1675.5$$

16. A cube shaped casting solidifies in 5 minutes. The solidification time in minutes for a cube of the same material, which is 8 times heavier than the original casting will be

(A) 10 (B) 20 (C) 24 (D) 40

Answer: (B)

Explanations:- $t = C\left(\frac{V}{A}\right)^2$; $t_1 = 5 = C\left(\frac{V_1}{A_1}\right)^2$

Now $V_2 = 8V_1$

Which implies each ride is getting doubled. So $A_2 = 4A_1$

$$t_2 = c\left(\frac{V_2}{A_2}\right)^2 = c\left(\frac{V_1}{4A_2}\right)^2 = 4 \times t_1 = 4 \times 5 = 20\,\text{min}$$

17. For a ductile material, toughness is a measure of

(A) Resistance to scratching

(B) Ability to absorb energy up to fracture

(C) Ability to absorb energy till elastic limit

(D) Resistance to indentation

Answer: (B)

Explanations:- Since, toughness has ability to absorb energy up to fracture.

18. In order to have maximum power from a Pelton turbine, the bucket speed must be

(A) Equal to the jet speed (B) Equal to half the jet speed

(C) Equal to twice the jet speed (D) Independent of the jet speed

Answer: (B)

Explanation: Since, velocity of bucket = ½ times the velocity of jet.

19. Consider one-dimensional steady state heat conduction along x-axis $(0 \le x \le L)$, through a plane wall with the boundary surfaces $(x = 0$ and $x = L)$ maintained at temperatures $0^{o}C$ and $100^{o}C$. Heat is generated uniformly throughout the wall. Choose the CORRECT statement.

(A) The direction of heat transfer will be from the surface at $100^{o}C$ to surface at $0^{o}C$.

(B) The maximum temperature inside the wall must be greater than $100^{o}C$

(C) The temperature distribution is linear within the wall

(D) The temperature distribution is symmetric about the mid-plane of the wall

Answer: (B)

20. A cylinder contains $5m^3$ of ideal gas at a pressure of 1 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 5 bar. The work in kJ required for this process is

(A) 804.7 (B) 953.2 (C) 981.7 (D) 1012.2

Answer: (A)

Explanations:- $P_1V_1 \ln \frac{P_2}{P_1} = wD$

$\Rightarrow wD = 10^5 \times 5 \ln\left(\frac{5}{1}\right) = 804718.95 = 804.71$ kJ

21. A long thin walled cylindrical shell, closed at both ends, is subjected to an internal pressure. The ratio of the hoop stress (circumferential stress) to longitudinal stress developed in the shell is

(A) 0.5 (B) 1.0 (C) 2.0 (D) 4.0

Answer: (C)

Explanations:- $\sigma_{hoop} = \frac{Pd}{2t}$

$\sigma_{ong} = \frac{Pd}{4t}$

$\frac{\sigma_{hoop}}{\sigma_{long}} = 2$

22. If two nodes are observed at a frequency of 1800 rpm during whirling of a simply supported long slender rotating shaft, the first critical speed of the shaft in rpm is

(A) 200 (B) 450 (C) 600 (D) 900

Answer: (D)

Explanations:- Since it is simply supported critical speed will be half

23. A planar closed kinematic chain is formed with rigid links PQ = 2.0m, QR = 3.0m, RS = 2.5m and SP = 2.7m with all revolute joints. The link to be fixed to obtain a double rocker (rocker-rocker) mechanism is

(A) PQ (B) QR (C) RS (D) SP

Answer: (C)

Explanations:- Since for Rocker – Rocker mechanism the link opposite to smaller link must be fixed

24. Let X be a nominal variable with mean 1 and variance 4. The probability $P(X < 0)$ is

(A) 0.5

(B) Greater than zero and less than 0.5

(C) Greater than 0.5 and less than 1

(D) 1.0

Answer: (B)

Explanations:- $P(x < 0) = P\left(\frac{x-\mu}{\sigma} < \frac{0-\mu}{\sigma}\right) - P(Z < -0.5)$

$= P(Z > 0.5) = 0.5 - P(0 < Z < 0.5)$,

which is greater than zero and less than 0.5

25. Choose the CORRECT set of functions, which are linearly dependent.

(A) $\sin x$, $\sin^2 x$ and $\cos^2 x$ (B) cosx, sinx and tan x

(C) $\cos 2x$, $\sin^2 x$ and $\cos^2 x$ (D) cos2x, sinx and cosx

Answer: (C)

Explanations:- (C)

$\because \cos^2 x = \cos^2 x - \sin^2 x$

$\therefore \cos^2 x$ is the linear combination of the functions $\therefore \cos^2 x, \sin^2 x$

$\therefore$ The functions $\cos^2 x, \sin^2 x$ and $\cos^2 x$ are linearly dependent

Q. No. 26 – 55 Carry Two Marks Each

26. The following surface integral is to be evaluated over a sphere for the given steady velocity vector field, $F = xi + yj + zk$ defined with respect to a Cartesian coordinate system having i, j, and k as unit base vectors.

$$\iint_S \frac{1}{4}(F.n)dA$$

Where S is the sphere, $x^2 + y^2 + z^2 = 1$ and n is the outward unit normal vector to the sphere. The value of the surface integral is

(A) π (B) 2π (C) $3\frac{\pi}{4}$ (D) 4π

Answer: (A)

Explanations:- $\frac{1}{4}\iiint_v \text{div}\bar{F}\, dv$ (Using divergence theorem)

$$= \frac{1}{4}\iiint_v 3\,dv = \frac{3}{4} \times \text{volume of the sphere}$$

$$= \frac{3}{4} \times \frac{4}{3} \times (1)^3 = \pi \text{ as radius} = 1$$

27. The function $f(t)$ satisfies the differential equation $\frac{d^2f}{dt^2} + f = 0$ and the auxiliary conditions, $f(0) = 0, \frac{df}{dt}(0) = 4$. The Laplace transform of $f(t)$ is given by

(A) $\frac{2}{s+1}$ (B) $\frac{4}{s+1}$ (C) $\frac{4}{s^2+1}$ (D) $\frac{2}{s^4+1}$

Answer: (C)

Explanations:-

Given E_q is $f''(t) + f(t) = 0$

$$L[f''(t)] + L[f(t)] = L(0)$$

$$s^2F(s) - sf(0) - f'(0) + F(s) = 0$$

$$(s^2+1)F(s) = 4$$

$$f(s) = \frac{4}{s^2+1}$$

28. Specific enthalpy and velocity of steam at inlet and exit of a steam turbine, running under steady state, are as given below:

	Specific enthalpy (kJ/kg)	Velocity(m/s)
Inlet steam condition	3250	180
Exit steam condition	2360	5

The rate of heat loss from the turbine per kg of steam flow rate is 5 kW. Neglecting changes in potential energy of steam, the power developed in kW by the steam turbine per kg of steam flow rate, is

(A) 901.2 (B) 911.2 (C) 17072.5 (D) 17082.5

Answer: (C)
Explanation:

$$h_1 + \frac{V_1^2}{2} + dQ = h_2 + \frac{V_2^2}{2} + dw$$

$$dw = (3250 - 2360) + \frac{(180^2 - 5^2)}{2} + 5$$

$$= 17072.5 \text{ kW}$$

29. Water is coming out from a tap and falls vertically downwards. At the tap opening, the stream diameter is 20mm with uniform velocity of 2 m/s. Acceleration due to gravity is $9.81\,m/s^2$. Assuming steady, inviscid flow, constant atmospheric pressure everywhere and neglecting curvature and surface tension effects, the diameter is mm of the stream 0.5m below the tap is approximately

(A) 10 (B) 15 (C) 20 (D) 25

Answer: (B)

30. A steel ball of diameter 60 mm is initially in thermal equilibrium at $1030°C$ in a furnace. It is suddenly removed from the furnace and cooled in ambient air at $30°C$, with convective heat transfer coefficient h=20 W/m^2K. The thermo-physical properties of steel are: density $\rho = 7800\ kg/m^3$, conductivity $k = 40\ \frac{W}{mK}$ and specific heat c=600 J/kgK. The time required in seconds to cool the steel ball in air from $1030°C$ to $430°C$ is

(A) 519 (B) 931 (C) 1195 (D) 2144

Answer: (D)
Explanations:-

$$\frac{T - T_{co}}{T_i - T_{co}} = e^{-\left(\frac{LAt}{SC_pV}\right)} \qquad 0.01 = \frac{V}{A}$$

$$\frac{430 - 30}{1030 - 30} = e^{-\left(\frac{20 \times L}{7100 \times 0.01 \times 600}\right)}$$

$$t = 2144$$

31. A flywheel connected to a punching machine has to supply energy of 400 Nm while running at a mean angular speed of 20 radians/s. If the total fluctuation of speed is not to exceed $\pm 2\%$, the mass moment of inertia of the flywheel in $kg - m^2$ is

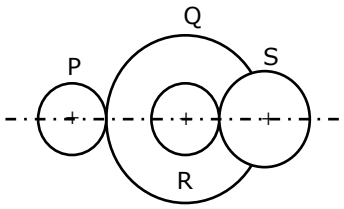
(A) 25 (B) 50 (C) 100 (D) 125

Answer: (A)
Explanations:-

$$E = Iw^2CS$$

$$\Rightarrow I = \frac{400}{20^2 \times 0.04} = 25 kg - m^2$$

32. A compound gear train with gears P, Q, R and S has number of teeth 20, 40, 15 and 20, respectively. Gears Q and R are mounted on the same shaft as shown in the figure below. The diameter of the gear Q is twice that of the gear R. If the module of the gear R is 2 mm, the center distance in mm between gears P and S is



(A) 40
(B) 80
(C) 120
(D) 160

Answer: (B)

Explanations:-

$$d_R = m \times t_R = 2 \times 15 = 30$$

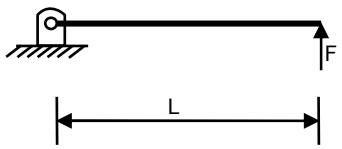
$$dQ = 2dR = 60$$

$$\frac{d_P}{d_Q} = \frac{t_P}{t_Q} \Rightarrow d_P = \frac{20}{40} \times 60 = 30$$

$$\frac{d_R}{d_S} = \frac{t_R}{t_S} \Rightarrow d_s = dR \times \frac{t_S}{t_R} = \frac{30 \times 20}{15} = 40$$

$$\text{centre distance} = \frac{d_P}{2} + \frac{d_Q}{2} + \frac{d_R}{2} + \frac{d_S}{2}$$
$$= 15 + 30 + 15 + 20 = 80$$

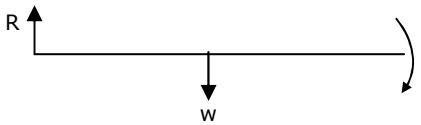
33. A pin jointed uniform rigid rod of weight W and Length L is supported horizontally by an external force F as shown in the figure below. The force F is suddenly removed. At the instant of force removal, the magnitude of vertical reaction developed at the support is



(A) zero (B) $\frac{W}{4}$ (C) $\frac{W}{2}$ (D) W

Answer: (B)

Explanations:-



$$I = \frac{1}{3}\frac{W}{g}L^2; \quad W \times \frac{L}{2} = I\alpha$$

$$\Rightarrow \alpha = \frac{3g}{2L}$$

$\therefore$ Linear accleration at centre $= \alpha \times \frac{L}{2} = \frac{3g}{4}$

$\therefore$ Inertial force at centre $= \frac{3}{4}W$

$\therefore$ Reaction at support $= W - \frac{3W}{4} = \frac{W}{4}$

34. Two cutting tools are being compared for a machining operation. The tool life equations are:

Carbide tool: $VT^{1.6} = 3000$

HSS tool: $VT^{0.6} = 200$

Where V is the cutting speed in m/min and T is the tool life in min. The carbide toll will provide higher tool life if the cutting speed in m/min exceeds

(A) 15.0 (B) 39.4 (C) 49.3 (D)60.0

Answer: (B)

Explanations:-

$$\frac{VT^{1.6}}{VT^{0.6}} = 15$$

$$\Rightarrow T = 15$$

$$V \times (15)^{1.6} = 3000$$

$$\Rightarrow V = 39.4$$

35. In a CAD package, mirror image of a 2D point P(5, 10) is to be obtained about a line which passes through the origin and makes an angle of 45° counterlockwise with the X-axis. The coordinates of the transformed point will be

(A) (7.5, 5) (B) (10, 5) (C) (7.5, -5) (D) (10, -5)

Answer: (B)

36. A linear programming problem is shown below:

Maximize $3x + 7y$

Subject to $3x + 7y \le 10$

$4x + 6y \le 8$

$x, y \ge 0$

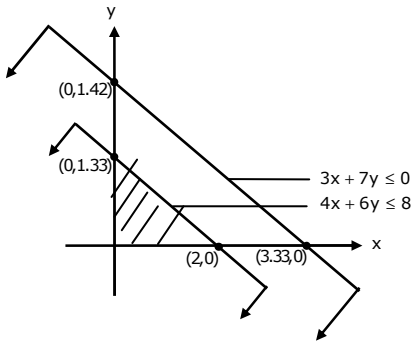
It has

(A) an unbounded objective function (B) exactly one optimal solution

(C) exactly two optimal solutions (D) infinitely many optimal solutions

Answer: (B)

Explanations:-



37. Cylindrical pins of $25^{+0.020}_{+0.010}$ mm diameter are electroplated in a shop. Thickness of the plating is $30^{+2.0}$ micron. Neglecting gage tolerances, the size of the GO gage in mm to inspect the plated components is

(A) 25.042 (B) 25.052 (C) 25.074 (D) 25.084

Answer: (B)

Explanations:- $25^{+0.020}_{+0.010} + 0.03^{\pm 0.002}$

$\left[25.03\right]^{+0.022}_{+0.012}$

Go gauge = max. Limit = 25.052

38. During the electrochemical machining (ECM) of iron (atomic weight=56, valency=2) at current of 1000 A with 90% current efficiency, the material removal rate was observed to be 0.26 gm/s. If Titanium (atomic weight = 48, valency=3) is machined by the ECM process at the current of 2000 A with 90% current efficiency, the expected material removal rate in gm/s will be

(A) 0.11 (B) 0.23 (C) 0.30 (D) 0.52

Answer: (C)

Explanation:

$$Q = \frac{AI}{F_2} = \frac{0.9 \times 48 \times 2000}{3 \times 96500 \times 3}$$

$$Q = 0.3$$

39. A single degree of freedom system having mass 1 kg and stiffness 10kN/m initially at rest is subjected to an impulse force of magnitude 5 kN for 10^{-4} seconds. The amplitude in mm of the resulting free vibration is

(A) 0.5 (B) 1.0 (C) 5.0 (D) 10.0

Answer: (C)

40. A bar is subjected to fluctuating tensile load from 20 kN to 100 kN. The material has yield strength of 240 MPa and endurance limit in reversed bending is 160 MPa. According to the Soderberg principle, the area of cross-section in mm^2 of the bar for a factor of safety of 2 is

(A) 400 (B) 600 (C) 750 (D) 1000

Answer: (D)

$$\frac{\sigma_m}{\sigma_y}+\frac{\sigma_v}{\sigma_e}=\frac{1}{F.S}$$

$$1000\left[\frac{60}{A\times 240}+\frac{40}{A\times 160}\right]=\frac{1}{2}$$

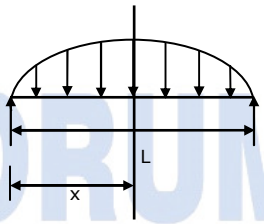
$$A=1000$$

41. A simply supported beam of length L is subjected to a varying distributed load $\sin\left(3\pi\frac{x}{L}\right)Nm^{-1}$, where the distance x is measured from the left support. The magnitude of the vertical force in N at the left support is

(A) zero (B) $\frac{L}{3\pi}$ (C) $\frac{L}{\pi}$ (D) $\frac{2L}{\pi}$

Answer: (B)

Explanations:- $\text{Load}=\sin\left(\frac{3\pi x}{L}\right)\frac{N}{m}$



$$\text{Total Load}=\int_0^L \sin\left(\frac{3\pi x}{L}\right)dx$$

$$=\frac{-L}{3\pi}\left[\cos\left(\frac{3\pi L}{L}\right)-\cos 0\right]=+\frac{2L}{3\pi}$$

Since the load is distributed equally on both supports

$$R_A=R_B=\frac{\text{Total Load}}{2}=\frac{L}{3\pi}$$

42. Two large diffuse gray parallel plates, separated by a small distance, have surface temperatures of 400 K and 300 K. If the emissivities of the surfaces are 0.8 and the Stefan-Boltzmann constant is $5.67\times10^{-8}W/m^2K^4$, the net radiation heat exchange rate in kW/m^2 between the two plates is

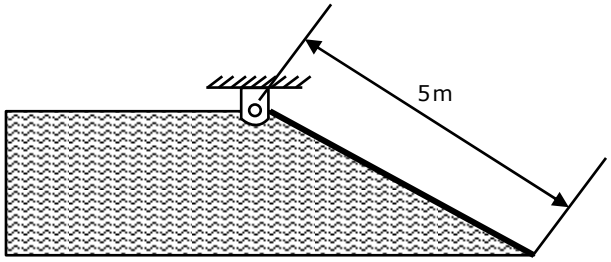
(A) 0.66 (B) 0.79 (C) 0.99 (D) 3.96

Answer: (A)

$$dQ=\frac{\sigma A\left(T_1^4-T_2^4\right)}{\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1};\ \varepsilon_1=\varepsilon_2=0.8$$

$$dQ=0.66\ kW/h^2$$

43. A hinged gate of length 5 m, inclined at $30°$ with the horizontal and with water mass on its left, is shown in figure below. Density of water is 1000 kg/m^2. The minimum mass of the gate in kg per unit width (perpendicular to the plane of paper), required to keep it closed is



(A) 5000 (B) 6600 (C) 7546 (D) 9623

Answer: (D)

Explanation:

An equilibrium moment of weight at '0'= Moment of pressure force at 'O'

Moment at O, $w \times x = F_p \times y$

$F_p = pgA\bar{x}$; A = Area of gate $= 5 \times 1$

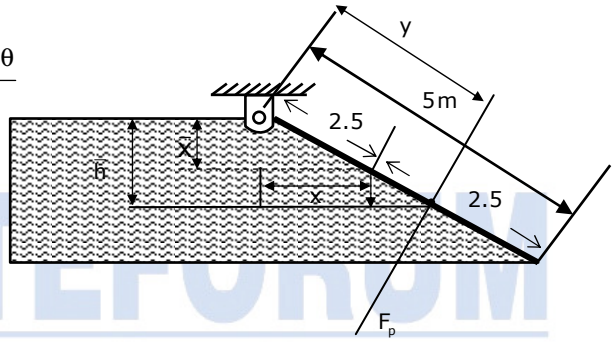
$\bar{x}$ = distance of C.G of Gate from free surface

$\theta = 30°$; $\sin 30° = \dfrac{\bar{x}}{2.5} \Rightarrow \bar{x} = 1.25$

$\bar{h}$ = centre of pressure $= \bar{x} + \dfrac{I_g 8m^2\theta}{A\bar{x}}$

$(I_{a)_{xx}} = \dfrac{bd^3}{12} = \dfrac{1 \times 5^3}{12} = 10.41$

$\bar{h} = 1.25 + \dfrac{10.41 \times \left(\frac{1}{2}\right)^2}{(5 \times 1)1.25} = 1.66$



$\cos\theta = \dfrac{x}{2.5} \Rightarrow x = 2.165$

$\sin\theta = \dfrac{\bar{h}}{y} \Rightarrow y = \dfrac{1.666}{\sin 30} = 3.32$

$w \times 2.165 = p \times g \times A\bar{x} \times y = 1000 \times 9.8 \times 5 \times 1 \times 1.25 \times 3.32$

$\Rightarrow w = 94021.9$

$w = mg \Rightarrow 9584 \simeq 9623$

44. The pressure, temperature and velocity of air flowing in a pipe are 5 bar, 500 K and 50 m/s, respectively. The specific heats of air at constant pressure and at constant volume are 1.005 kJ/kgK and 0.718 kJ/kgK, respectively. Neglect potential energy. If the pressure and temperature of the surroundings are 1 bar and 300 K, respectively, the available energy in kJ/kg of the air stream is

(A) 170 (B) 187 (C) 191 (D) 213

Answer: (B)

45. The probability that a student knows the correct answer to a multiple choice question is $\frac{2}{3}$. If the student does not know the answer, then the student guesses the answer. The probability of the guessed answer being correct is $\frac{1}{4}$. Given that the student has answered the question correctly, the conditional probability that the student known the correct answer is

(A) $\frac{2}{3}$ (B) $\frac{3}{4}$ (C) $\frac{5}{6}$ (D) $\frac{8}{9}$

Answer: (D)

A = The student answer the question correctly

E_1 = Student knows the correct answer

E_2 = Student guesses the correct answer

$$p(E_1)=\frac{2}{3},\quad p(E_2)=\frac{1}{3}$$

$$p(A)=p(E_1)\times p\left(\frac{A}{E_1}\right)+p(E_2)\times p\left(\frac{A}{E_2}\right)$$

$$=\frac{2}{3}\times 1+\frac{1}{3}\times\frac{1}{4}=\frac{3}{4}$$

Using Bayes theorem, $p\left(\frac{E_1}{A}\right)$

$$\frac{p(E_1)\times p\left(\frac{A}{E_1}\right)}{p(A)}=\frac{\frac{2}{3}\times 1}{\frac{3}{4}}=\frac{8}{9}$$

46. The solution to the differential equation $\frac{d^2u}{dx^2}-k\frac{du}{dx}=0$ where k is a constant, subjected to the boundary conditions u(0)=0 and u(L)=U, is

(A) $u=U\frac{x}{L}$ (B) $u=U\left(\frac{1-e^{kx}}{1-e^{kL}}\right)$

(C) $u=U\left(\frac{1-e^{-kx}}{1-e^{-kL}}\right)$ (D) $u=U\left(\frac{1+e^{-kx}}{1+e^{-kL}}\right)$

Answer: (B)

$$\frac{d^2u}{dx^2}-K\frac{du}{dx}=0$$

$D^2-kD=0 \quad D(D-K)=0$

$D=0,\ D=K$

$u=C_1e^0+C_2e^{kx}$

$u=C_1+C_2e^{kx}$

$u(0)=0$

$\therefore C_1+C_2=0$.....(1)

$u(L)=u$

$u=C_1+C_2e^{kL}=U$.....(2)

solving (1) and (2)

$C_1=\frac{U}{1-e^{kL}}$, $C_2e^{kx}\ \frac{-U}{1-e^{kL}}$

$u=U\left(\frac{1-e^{kL}}{1-e^{kx}}\right)$

47. The value of the definite integral $\int_1^e \sqrt{x}\ \ln(x)dx$ is

(A) $\frac{4}{9}\sqrt{e^3}+\frac{2}{9}$ (B) $\frac{2}{9}\sqrt{e^3}-\frac{4}{9}$ (C) $\frac{2}{9}\sqrt{e^3}+\frac{4}{9}$ (D) $\frac{4}{9}\sqrt{e^3}-\frac{2}{9}$

Answer: (C)

$$\int_1^e \sqrt{x}\ln(x)dx$$

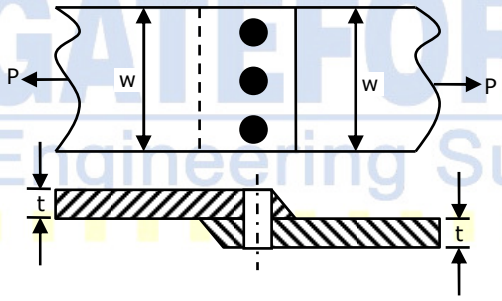
$$=\left[\ln(x)\times\frac{x^{\frac{3}{2}}}{\frac{3}{2}}\right]_1^e-\int\left[\frac{1}{x}\times\frac{x^{\frac{3}{2}}}{\frac{2}{3}}\right]dx$$

$$=\left[\ln(x)\times x^{\frac{3}{2}}\times\frac{2}{3}-\frac{4}{9}\times x^{\frac{3}{2}}\right]_1^e$$

$$=\frac{2}{9}\sqrt{e^3}+\frac{4}{9}$$

Common Data Questions: 48 & 49

A single riveted lap joint of two similar plates as shown in the figure below has the following geometrical and material details:



Width of the plate w=200 mm, thickness of the plate t=5 mm, number of rivets n=3, diameter of the rivet $d_r = 10\,mm$, diameter of the rivet hole $d_h = 11\,mm$, allowable tensile stress of the plate $\sigma_p = 200\,MPa$, allowable shear stress of the rivet $\sigma_s = 100\ MPa$ and allowable bearing stress of the $\sigma_c = 150\ MPa$

48. If the rivets are to be designed to avoid crushing failure, the maximum permissible load P in kN is

(A) 7.50 (B) 15.00 (C) 22.50 (D) 30.00

Answer: (C)

$$p = \sigma_c \times n \times d \times t = 150 \times 3 \times 10 \times 5 = 22.5kN$$

49. If the plates are to be designed to avoid tearing failure, the maximum permissible load P in kN is

(A) 83 (B) 125 (C) 167 (D) 501

Answer: (C)

$$p = \sigma_t \times (w - 3d) \times t = 200 \times (200 - 3 \times 11) \times 5 = 167kN$$

Common Data Questions: 50 & 51

Water (specific heat, $c_p = 4.18\ kJ/kgK$) enters a pipe at a rate of 0.01 kg/s and a temperature of $20°C$. The pipe, of diameter 50 mm and length 3m, is subjected to a wall heat flux q''_w in $\frac{W}{m^2}$.

50. If $q''_w = 2500x$, where x is in m and in the direction of flow (x=0 at the inlet), the bulk mean temperature of the water leaving the pipe in $°C$ is

(A) 42 (B) 62 (C) 74 (D) 104

Answer: (B)

Explanation: $q''_w = 2500x$

$x = 0 \quad q''_{wi} = 0$

$x = 3 \quad q''_{wi} = 2500 \times 3 = 7500$

$$q_{avg} = \frac{0 + 7500}{2} = 3750$$

$q_{avg} \times Area = mcp \times \Delta T$

$3750 \times \pi \times 0.05 \times 3 = 0.01 \times 4.18 \times 10^3 (T - 20)$

$\Rightarrow T = 42.2 + 20 = 62.2°C$

51. If $q''_w = 5000$, and the convection heat transfer coefficient at the pipe outlet is $1000\ W/m^2K$, the temperature in $°C$ at the inner surface of the pipe at the outlet is

(A) 71 (B) 76 (C) 79 (D) 81

Answer: (D)

Explanation: $q''_w = 5000$ consant

$\Rightarrow q''_w \times A = MCP\ \Delta T$

$Q = 5000 \times \pi \times 0.05 \times 3 = 0.01 \times 4.18 \times 10^3 (T_o - 20)$

$\Rightarrow T_0 - 20 = 56.3 \quad = T_o = 76.3°C$

Heat flux between any two sections is same

$Q = hA(T_p - T_o)$

$$But\ \frac{Q}{A} = q''_w = 5000 = h(T_p - T_o)$$

$5000 = 1000(T_p - 76.3)$

$\Rightarrow T_p = 76.3 + 5 = 81.3$

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

In orthogonal turning of a bar of 100 mm diameter with a feed of 0.25 mm/rev, depth of cut of 4 mm and cutting velocity of 90 m/min, it is observed that the main (tangential) cutting force is perpendicular to the friction force acting at the chip-tool interface. The main (tangential) cutting force is 1500 N.

52. The orthogonal rake angle of the cutting tool in degree is

(A) Zero (B) 3.58 (C) 5 (D) 7.16

Answer: (A)

Explanations:- As cutting f is f^{ar} to F – F

Rake angle $\alpha = 0$

53. The normal force acting at the chip-tool interface in N is

(A) 1000 (B) 1500 (C) 2000 (D) 2500

Answer: (B)

Explanations:- Normal force $N = F_H \cos\alpha - F_V \sin\alpha$

$= 1500 \times \cos 0 - F_v \sin 0$

$= 1500$

Statement for Linked Answer Questions: 54 & 55

In a simple Brayton cycle, the pressure ration is 8 and temperatures at the entrance of compressor and turbine are 300 K and 1400 K, respectively. Both compressor and gas turbine have isentropic efficiencies equal to 0.8. For the gas, assume a constant value of c_p (specific heat at constant pressure) equal to 1 kJ/kgK and ratio of specific heats as 1.4. Neglect changes in kinetic and potential energies.

54. The power required by the compressor in kW/kg of gas flow rate is

(A) 194.7 (B) 243.4 (C) 304.3 (D) 378.5

Answer: (C)

Explanations:-

$r_D = 8;\ T_1 = 300K;\ T_3 = 1400K$

$\gamma = 1.4$

$\frac{T_2}{T_1} = (r_P)^{\frac{\gamma-1}{\gamma}} = (r)^{\frac{0.4}{1.4}} \Rightarrow T_2 = 543.43K$

$\eta_C = \frac{T_2 - T_1}{T_2^1 - T_1} \Rightarrow 0.8 = \frac{543.43 - 3w}{T_2^1 - 300}$

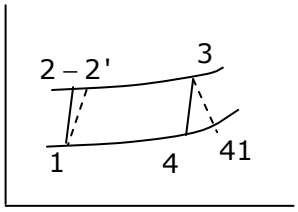
$T_2^1 = 604.29k;\ \frac{T_4}{T_3} = \left(\frac{1}{r_P}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{1}{8}\right)^{\frac{0.4}{1.4}}$

$T_4 = 772.86k$

$\eta_T = \frac{T_3 - T_4^1}{T_3 - T_4} \Rightarrow 0.8 = \frac{14w - T_4^1}{1400 - 772.86}$

$T_4^1 = 898.29$

$w_C = C_P\left(T_2^1 - T_1\right) = 1 \times (604.29 - 300) = 304.3$



55. The thermal efficiency of the cycle in percentage (%) is

(A) 24.8 (B) 38.6 (C) 44.8 (D) 53.1

Answer: (A)

Explanations:-

$$w_T = C_P\left(T_3 - T_4^1\right) = 1\times(14w - 898.29) = 501.71$$

$$\text{Thermal efficiency} = \frac{w_T - w_C}{\theta_1 501.71}$$

$$= \frac{595.71 - 304.3}{C_P\left(T_3 - T_2^1\right)} = \frac{501.71 - 304.3}{1\times(1400 - 604.29)} = 24.8\%$$

Q. No. 56 – 60 Carry One Mark Each

56. Complete the sentence:

Universalism is to particularism as diffuseness is to _____

(A) specificity (B) neutrality (C) generality (D) adaptation

Answer: (A)

The relation is that of antonyms

57. Were you a bird, you _____ in the sky.

(A) would fly (B) shall fly

(C) should fly (D) shall have flown

Answer: (A)

58. Which one of the following options is the closest in meaning to the word given below?

Nadir

(A) Highest (B) Lowest (C) Medium (D) Integration

Answer: (B)

Nadir in the lowest point on a curve

59. Choose the grammatically INCORRECT sentence:

(A) He is of Asian origin

(B) They belonged to Africa

(C) She is an European

(D) They migrated from India to Australia

Answer: (C)

60. What will be the maximum sum of 44, 42, 40, ... ?

(A) 502 (B) 504 (C) 506 (D) 500

Answer: (C)

The maximum sum is the sum of 44, 42,- - - - -2.

The sum of 'n' terms of an AP

$$=\frac{n}{2}\left[2a+(n-1)d\right]$$

In this case, n = 22, a = 2 and d = 2

$$\therefore \text{Sum} = 11\left[4+21\times 2\right] = 11\times 46 = 506$$

Q. No. 61 – 65 Carry Two Marks Each

61. Out of all the 2-digit integers between 1 and 100, a 2-digit number has to be selected at random. What is the probability that the selected number is not divisible by 7?

(A) 13/90 (B) 12/90 (C) 78/90 (D) 77/90

Answer: (D)

The number of 2 digit multiples of 7 = 13

$\therefore$ Probability of choosing a number

$$\text{Not divisible by } 7 = \frac{90-13}{90} = \frac{77}{90}$$

62. A tourist covers half of his journey by train at 60 km/h, half of the remainder by bus at 30 km/h and the rest by cycle at 10 km/h. The average of the tourist in km/h during his entire journey is

(A) 36 (B) 30 (C) 24 (D) 18

Answer: (C)

Let the total distance covered be 'D'

$$\text{Now, average speed} = \frac{D}{\text{Total time taken}}$$

$$= \frac{D}{\left(\frac{D}{2}\times\frac{1}{6}+\frac{D}{4}\times\frac{1}{30}+\frac{D}{4}\times\frac{1}{10}\right)} = \frac{1}{\frac{1}{120}+\frac{1}{120}+\frac{1}{40}} = \frac{120}{5} = 24\,\text{km/hr}$$

63. Find the sum of the expression

$$\frac{1}{\sqrt{1}+\sqrt{2}}+\frac{1}{\sqrt{2}+\sqrt{3}}+\frac{1}{\sqrt{3}+\sqrt{4}}+\ldots..+\frac{1}{\sqrt{80}+\sqrt{81}}$$

(A) 7 (B) 8 (C) 9 (D) 10

Answer: (B)

The expression can be written as

$$\frac{\left(\sqrt{2}\right)^2-\left(\sqrt{1}\right)^2}{\sqrt{1}+\sqrt{2}}+\frac{\left(\sqrt{3}\right)^2-\left(\sqrt{2}\right)^2}{\sqrt{2}+\sqrt{3}}+-----\frac{\left(\sqrt{81}\right)^2-\left(\sqrt{80}\right)^2}{\sqrt{80}+\sqrt{81}}$$

$$=\frac{\left(\sqrt{2}-\sqrt{1}\right)\left(\sqrt{1}+\sqrt{2}\right)}{\left(\sqrt{1}+\sqrt{2}\right)}+-------+\frac{\left(\sqrt{81}-\sqrt{80}\right)\left(\sqrt{81}+\sqrt{80}\right)}{\sqrt{80}+\sqrt{81}}$$

64. The current erection cost of a structure is Rs. 13,200. If the labour wages per day increase by 1/5 of the current wages and the working hours decrease by 1/24 of the current period, then the new cost of erection in Rs. is

(A) 16,500 (B) 15,180 (C) 11,000 (D) 10,120

Answer: (B)

Let 'W' be the labour wages, and 'T' be the working hours.

Now, total cost is a function of $W \times T$

Increase in wages = 20%

$\therefore$ Revised wages = 1.2 W

Decrease in labour time = $\left(\frac{100}{24}\right)\%$

$\therefore$ Revised time $=\left(1-\frac{1}{24}\right)T=\frac{23}{24}T$

$\therefore$ Revised Total cost $=1.2\times\frac{23}{24}WT=1.15WT$

$=1.15\times13200=15180$

65. After several defeats in wars, Robert Bruce went in exile and wanted to commit suicide. Just before committing suicide, he came across a spider attempting tirelessly to have its net. Time and again the spider failed but that did not deter it to refrain from making attempts. Such attempts by the spider made Bruce curious. Thus, Bruce started observing the near-impossible goal of the spider to have the net. Ultimately, the spider succeeded in having its net despite several failures. Such act of the spider encouraged Bruce not to commit suicide. And then, Bruce went back again and won many a battle, and the rest is history.

Which one of the following assertions is best supported by the above information?

(A) Failure is the pillar of success

(B) Honesty is the best policy

(C) Life begins and ends with adventures

(D) No adversity justifies giving up hope

Answer: (D)