Q. No. 1 – 25 Carry One Mark Each

1. Which one of the following is NOT a decision taken during the aggregate production planning stage?
   (A) Scheduling of machines
   (B) Amount of labour to be committed
   (C) Rate at which production should happen
   (D) Inventory to be carried forward

Answer: - (B)

2. A CNC vertical milling machine has to cut a straight slot of 10mm width and 2mm depth by a cutter of 10mm diameter between points (0,0) and (100,100) on the XY plane (dimensions in mm). The feed rate used for milling is 50mm/min. milling time for the slot (in seconds) is
   (A) 120 (B) 170 (C) 180 (D) 240

Answer: - (A)

3. A solid cylinder of diameter 100mm and height 50mm is forged between two frictionless flat dies to a height of 25mm. The percentage change in diameter is
   (A) 0 (B) 2.07 (C) 20.7 (D) 41.4

Answer: - (D)

Exp:- From incompressibility we get

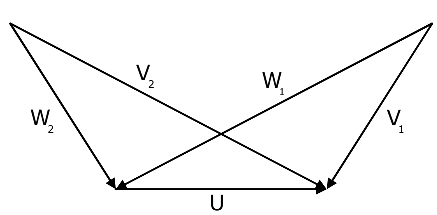
$$\pi d_1^2 h_1 = \pi d_2^2 h_2$$

$$d_2 = d_1 \times \sqrt{\frac{h_1}{h_2}}$$

$$d_2 = 100 \times \sqrt{\frac{50}{25}} = 141.42$$

$$\text{Percentage change in diameter} = \frac{d_2 - d_1}{d_1} \times 100 = 41.42\%$$

4. The velocity triangles at the inlet and exit of the rotor of a turbo machine are shown. V denotes the absolute velocity of the fluid, W denotes the relative velocity of the fluid, and U denotes the blade velocity. Subscripts 1 and 2 refer to inlet and outlet respectively. If $V_2 = W_1$ and $V_1 = W_2$, then the degree of reaction is



   (A) 0 (B) 1 (C) 0.5 (D) 0.25

Answer: - (C)

5. Which one of the following configurations has the highest fin effectiveness?

(A) Thin, closely spaced fins (B) Thin, widely spaced fins

(C) Thick widely spaced fins (D) Thick, closely spaced fins

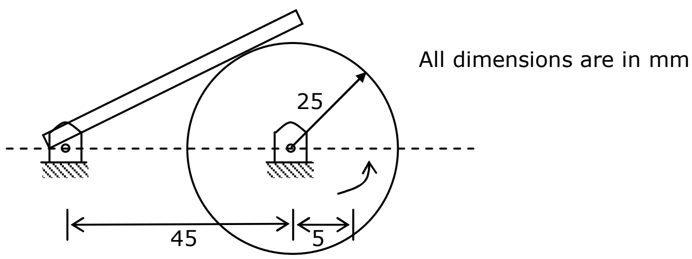
Answer: - (A)

6. An ideal gas of mass m and temperature T_1 undergoes a reversible isothermal process from an initial pressure P_1 to a final pressure P_2. The heat loss during the process is Q. The entropy change ΔS of the gas is

(A) $mR\ln\left(\frac{P_2}{P_1}\right)$ (B) $mR\ln\left(\frac{P_1}{P_2}\right)$ (C) $mR\ln\left(\frac{P_2}{P_1}\right)-\frac{Q}{T_1}$ (D) Zero

Answer: - (B)

7. In the mechanism given below, if the angular velocity of the eccentric circular disc is 1rad/s, the angular velocity (rad/s) of the follower link for the instant shown in the figure is



8. A circular solid disc of uniform thickness 20mm, radius 200mm and mass 20kg, is used as a flywheel. If it rotates at 600rpm, the kinetic energy of the flywheel, in Joules is

(A) 395 (B) 790 (C) 1580 (D) 3160

Answer: - (B)

Exp:- $\text{K.E. of fly wheel} = \frac{1}{2}Iw^2$

$$I = \frac{mR^2}{2} = \frac{20\times0.2^2}{2} = 0.4\ \text{kg}-\text{m}^2$$

$$w = \frac{2\pi N}{60} = \frac{2\times\pi\times600}{60} = 62.83\ \text{rad/s}$$

$$K.E = \frac{1}{2}\times0.4\times62.83^2 = 790\,J$$

9. A cantilever beam of length L is subjected to a moment M at the free end. The moment of inertia of the beam cross section about the neutral axis is I and the Young modulus is E. The magnitude of the maximum deflection is

(A) $\frac{ML^2}{2EI}$ (B) $\frac{ML^2}{EI}$ (C) $\frac{2ML^2}{EI}$ (D) $\frac{4ML^2}{EI}$

Answer: - (A)

Exp:- $E_I \frac{d^2y}{dx^2} = M$

upon intigration,

$EI \frac{dy}{dx} = Mx + C_1$

Once again integrating, weget

$EI\ y = \frac{Mx^2}{2} + C_1x + C_2$

For cantilever beam at x = 0, $\frac{dy}{dx} = 0$ & $x = 0\ y = 0$

From this we get $C_1 = C_1 = 0$, Hence

$y = \frac{Mx^2}{2EI}$; maximum deflection $y_{max} = \frac{ML^2}{2EI}$

10. For a long slender column of uniform cross section, the ratio of critical buckling load for the case with both ends clamped to the case with both ends hinged is

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

Answer: -(C)

Exp:- Critical Buckling load for column fixed at both ends = $\frac{4\pi^2 EI}{L^2}$

Critical Bucking load for a column hinged at both lands $\frac{\pi^2 EI}{L^2}$

Hence, $\frac{P_{cr_1}}{P_{cr_2}} = 4$

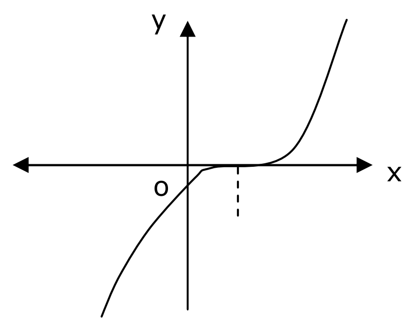
11. At x=0, the function $f(x) = x^3 + 1$ has

(A) A maximum value (B) A minimum value

(C) A singularity (D) A point of inflection

Answer: - (D)

Exp: - The function $f(x) = x^3 + 1$ has a point of inflection at x = 0, since in the graph sign of the curvature (i.e., the concavity) is changed.



12. For the spherical surface, $x^2+y^2+z^2-1$, the unit outward normal vector at the point $\left(\frac{1}{\sqrt{2}},\frac{1}{\sqrt{2}},0\right)$ is given by

(A) $\frac{1}{\sqrt{2}}\hat{i}+\frac{1}{\sqrt{2}}\hat{j}$ (B) $\frac{1}{\sqrt{2}}\hat{i}-\frac{1}{\sqrt{2}}\hat{j}$ (C) $\hat{k}$ (D) $\frac{1}{\sqrt{3}}\hat{i}+\frac{1}{\sqrt{3}}\hat{j}+\frac{1}{\sqrt{3}}\hat{k}$

Answer: - (A)

Exp: - Given spherical surface is $x^2+y^2+z^2=1$ and point is $\left(\frac{1}{\sqrt{2}},\frac{1}{\sqrt{2}},0\right)$

Normal vector outward to $x^2+y^2+z^2-1=0$ at $\left(\frac{1}{\sqrt{2}},\frac{1}{\sqrt{2}},0\right)$ is

$$\frac{1}{\sqrt{2}}i+\frac{1}{\sqrt{2}}j+0.k=\frac{1}{\sqrt{2}}i+\frac{1}{\sqrt{2}}j$$

Hence the outward unit normal vector $=\dfrac{\frac{1}{\sqrt{2}}\,i+\frac{1}{\sqrt{2}}\,i}{\left(\frac{1}{\sqrt{2}}\right)^2+\left(\frac{1}{\sqrt{2}}\right)^2}=\frac{1}{\sqrt{2}}i+\frac{1}{\sqrt{2}}j$

13. Match the following metal forming processes with their associated stresses in the workpiece.

List I		List II	
P	Coining	1	Tensile
Q	Wire Drawing	2	Shear
R	Blanking	3	Tensile and compressive
S	Deep drawing	4	Compressive

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

Answer: - (A)

14. In abrasive jet machining, as the distance between the nozzle tip and the work surface increases, the material removal rate

(A) Increases continuously
(B) Decreases continuously
(C) Decreases, becomes stable and then increases
(D) Increases, becomes stable and then decreases

Answer: - (D)

15. In an interchangeable assembly, shafts of size $25.000^{+0.040}_{-0.010}$ mm mate with holes of size $25.000^{+0.030}_{+0.020}$ mm. The maximum interference (in microns) in the assembly is

(A) 40 (B) 30 (C) 20 (D) 10

Answer: - (C)

Maximum interference = maximum size of shaft – minimum size of hole

= 25.040-25.020 =20μm

16. During normalizing process of steel, the specimen is heated

(A) Between the upper and lower critical temperature and cooled in still air

(B) Above the upper critical temperature and cooled in furnace

(C) Above the upper critical temperature and cooled in still air

(D) Between the upper and lower critical temperature and cooled in furnace

Answer: - (C)

17. Oil flows through a 200mm diameter horizontal cast iron pipe (friction factor, f=0.0225) of length 500m. The volumetric flow rate is $0.2m^3/s$. The head loss (in m) due to friction is (assume $g=9.81m/s^2$)

(A) 116.18 (B) 0.116 (C) 18.22 (D) 232.36

Answer: - (A)

Exp:- $$H = \frac{fLV^2}{2gD} = \frac{0.0225 \times 500 \times \left(\frac{0.2}{\Pi \times 0.2^2/4}\right)^2}{2 \times 9.81 \times 0.4} = 116.18\,m$$

18. For an opaque surface, the absorptivity (α), transitivity (τ) and reflectivity (ρ) are related by the equation

(A) $\alpha + \rho = \tau$ (B) $\rho + \alpha + \tau = 0$ (C) $\alpha + \rho = 1$ (D) $\alpha + \rho = 0$

Answer: - (C)

19. Steam enters an adiabatic turbine operating at steady state with an enthalpy of 3251.0kJ/kg and leaves as a saturated mixture at 15kPa with quality (dryness fraction) 0.9. The enthalpies of the saturated liquid and vapour at 15kPa are h_f=225.94kJ/kg and h_g=2598.3kJ/kg respectively. The mass flow rate of steam is 10kg/s. Kinetic and potential energy changes are negligible. The power output of the turbine in MW is:

(A) 6.5 (B) 8.9 (C) 9.1 (D) 27.0

Answer: - (B)

Exp:- $$Power = \dot{m}_r \times (h_1 - h_2) = 10 \times (3251 - (225.94 + 0.9 \times (2598.3 - 225.94))$$

$$= 8900\,KJ/S = 8.9\,MW$$

20. The following are the data for two crossed helical gears used for speed reduction:

Gear I: Pitch circle diameter in the plane of rotation 80mm and helix angle 30º.

Gear II: Pitch circle diameter in the plane of rotation 120mm and helix angle 22.5º.

If the input speed is 1440rpm, the output speed in rpm is

(A) 1200 (B) 900 (C) 875 (D) 720

Answer: - (B)

Exp: - For helical gears

$$\text{Velocity ratio} = \frac{d_1 \cos\varphi}{d_2 \cos\varphi} = \frac{80\cos 30^o}{120COS22.5} = \frac{N_2}{N_1}$$

$$N_2 = 1440 \times 0.625 = 900 \text{ rpm}$$

21. A solid disc of radius r rolls without slipping on the horizontal floor with angular velocity ω and angular acceleration α. The magnitude of acceleration of the point of contact on the disc is

(A) Zero (B) $r\alpha$ (C) $\sqrt{(r\alpha)^2 + (r\omega^2)^2}$ (D) $r\omega^2$

Answer: - (A)

22. A thin walled spherical shell is subjected to an internal pressure. If the radius of the shell is increased by 1% and the thickness is reduced by 1%, with the internal pressure remaining the same, the percentage change in the circumferential (hoop) stress is

(A) 0 (B) 1 (C) 1.08 (D) 2.02

Answer: - (D)

Exp:- Hoop stress for a thin spherical shell $(\sigma_h) = \frac{Pr}{2t}$

By applying logarithm on both sides, we get, $\log(\sigma_h) = \log(\frac{P}{2}) + \log(r) - \log(t)$

Differentiating the above equation, $f(t) = \sin t$ and it is given that $\frac{dr}{r} = 0.01$ and $\frac{dt}{t} = -0.01$

Up on substituting we get, $\frac{d\sigma_h}{\sigma_h} = 0.02$, $\therefore$ percentage increase will be 2%.

23. The area enclosed between the straight line y=x and the parabola $y = x^2$ in the x-y plane is

(A) 1/6 (B) 1/4 (C) 1/3 (D) 1/2

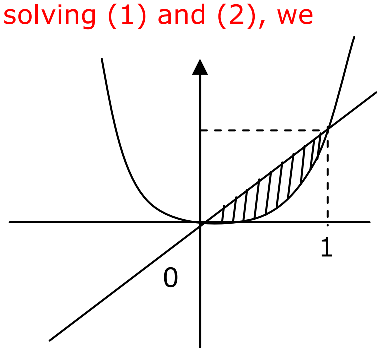
Answer: - (A)

Exp:- The given curves are y = x and y = x2 solving (1) and (2), we Have x = 0, x = 1

$$\text{Area} = \int_0^1 (x - x^2)dx$$

$$= \left(\frac{x^2}{2} - \frac{x^3}{3}\right)_0^1 = \frac{1}{2} - \frac{1}{3}$$

$$= \frac{1}{6} \text{ sq units}$$



24. Consider the function $f(x) = |x|$ in the interval $-1 \le x \le 1$. At the point x=0, $f(x)$ is

(A) Continuous and differentiable (B) Non-continuous and differentiable
(C) Continuous and non-differentiable (D) Neither continuous nor differentiable

Answer: - (C)

Exp:- Given function is f(x) = |x|`
|x| is continues at x = 0 but not differentiable

25. $\lim_{x\to 0}\left(\frac{1-\cos x}{x^2}\right)$ is

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

Answer: - (B)

Exp:- $\underset{x\to 0}{\text{lt}} \frac{1-\cos^x}{x^2} = \underset{x\to 0}{\text{lt}} \frac{2\sin^2\left(\frac{x}{2}\right)}{x^2} = 2 \underset{x\to 0}{\text{lt}} \frac{\sin^2\left(\frac{x}{2}\right)}{\left(\frac{x^2}{2}\right)\times 4} = 2\times\frac{1}{4} = \frac{1}{2}$

Q. No. 26 – 55 Carry Two Marks Each

26. Calculate the punch size in mm, for a circular blanking operation for which details are given below:

Size of the blank	25mm
Thickness of the sheet	2mm
Radial clearance between punch and die	0.06mm
Die allowance	0.05mm

(A) 24.83 (B) 24.89 (C) 25.01 (D) 25.17

Answer: - (A)

Exp:- Diameter of punch = Diameter of Blank – 2 x radial clearance- die allowance
$= 25 - 2\times 0.06 - 0.05 = 24.83$ mm

27. In a single pass rolling process using 410mm diameter steel rollers, a strip of width 140mm and thickness 8mm undergoes 10% reduction of thickness. The angle of bite in radians is

(A) 0.006 (B) 0.031 (C) 0.062 (D) 0.600

Answer: - (C)

Exp:- $\Delta H = D(1-\cos\alpha)$

$\cos\alpha = 1 - \frac{\Delta H}{D} = 1 - \frac{0.1\times 8}{410}$

$\boxed{\alpha = 3.57^{O}}$

$\alpha = 3.57\times\frac{\pi}{180}$ radians

$\boxed{\alpha = 0.062 \text{ radians}}$

28. In a DC arc welding operation, the voltage-arc length characteristic was obtained as $V_{arc} = 20 + 5l$ where the arc length l was varied between 5mm and 7mm. Here V_{arc} denotes the arc voltage in Volts. The arc current was varied from 400A to 500A. Assuming linear power source characteristic, the open circuit voltage and short circuit current for the welding operation are:

(A) 45V, 450A (B) 75V, 550A (C) 95V, 950A (D) 150V, 1500A

Answer: - (C)

Exp:- $V_{arc} = 20 + 5l$

$l = 5mm,\ V_{arch} = 45\ V$

$l = 7mm,\ V_{arch} = 55\ V$

$V = V_0 - \frac{V_0}{I_S} I$ (where V_0 is open circuit voltage and I_S is short circuit current)

$45 = V_0 - \frac{V_0}{I_S} \times 500$

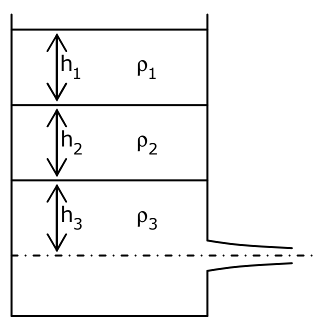
$55 = V_0 - \frac{V_0}{I_S} \times 400$

Upon solving (1) and (2) we get

$V_O = 95$ volts

$I_S = 950A$

29. A large tank with a nozzle attached contains three immiscible inviscid fluids as shown. Assuming that the changes in h_1, h_2 and h_3 are negligible, the instantaneous discharge velocity is:



(A) $\sqrt{2gh_3\left(1 + \frac{\rho_1 h_1}{\rho_3 h_3} + \frac{\rho_2 h_2}{\rho_3 h_3}\right)}$

(B) $\sqrt{2g(h_1 + h_2 + h_3)}$

(C) $\sqrt{2g\left(\frac{\rho_1 h_1 + \rho_2 h_2 + \rho_3 h_3}{\rho_1 + \rho_2 + \rho_3}\right)}$

(D) $\sqrt{2g\left(\frac{\rho_1 h_2 h_3 + \rho_2 h_3 h_1 + \rho_3 h_1 h_2}{\rho_1 h_1 + \rho_2 h_2 + \rho_3 h_3}\right)}$

Answer: - (A)

Exp:- Applying Bernoulli's equation, at exit we get,

$$\frac{P_1}{\rho_3} + gz_1 + \frac{V_1^2}{2} = \frac{P_2}{\rho_3} + gz_2 + \frac{V_2^2}{2}$$

We know that $Z_1 = Z_2$, $V_1 = 0$ & $P_2 = P_{atm}$

Hence it reduce to

$$\frac{P_1}{\rho_3} = \frac{V_2^2}{2}$$

$$V_2 = \sqrt{\frac{2P_1}{\rho_3}}$$

But $P_1 = \rho_1 gh_1 + \rho_2 gh_2 + \rho_3 gh_3$

Upon substituting we get,

$$V_2 = \sqrt{2gh_3\left[1 + \frac{\rho_1 h_1}{\rho_2 h_3} + \frac{\rho_2 h_2}{\rho_3 h_3}\right]}$$

30. Water $\left(C_p = 4.18 kJ/kg \cdot K\right)$ at 80ºC enters a counter flow heat exchanger with a mass flow rate of 0.5kg/s. Air $\left(C_p = 1kJ/kg \cdot K\right)$ enters at 30ºC with a mass flow rate of 2.09kg/s. If the effectiveness of the heat exchanger is 0.8, the LMTD (in ºC) is

Exp:- $\varepsilon = \frac{C_h}{C_{min}} \times \frac{(t_{h_1} - t_{h_2})}{(t_{h_1} - t_{c_1})}$

$$0.8 = \frac{4.18 \times 0.5}{2.09 \times 1} \times \frac{(80 - t_{h_2})}{(80 - 30)}$$

$$t_{h_2} = 40^{\circ}C$$

$$m_h c_{p_h}(t_{h_1} - t_{h_2}) = m_c c_{p_c}(t_{c_2} - t_{c_1})$$

$$0.5 \times 4.18 \times 40 = 2.09 \times 1 \times (t_{c_2} - 30)$$

$$t_{c_2} = 70^{\circ}C$$

$$\theta_1 = \theta_2 = 10^{\circ}C \therefore LMTD = 10^{\circ}C$$

31. A solid steel cube constrained on all six faces is heated so that the temperature rises uniformly by ΔT. If the thermal coefficient of the material is α, Young's modulus is E and the Poisson's ratio is v, the thermal stress developed in the cube due to heating is

(A) $-\frac{\alpha(\Delta T)E}{(1-2v)}$ (B) $-\frac{2\alpha(\Delta T)E}{(1-2v)}$ (C) $-\frac{3\alpha(\Delta T)E}{(1-2v)}$ (D) $-\frac{\alpha(\Delta T)E}{3(1-2v)}$

Answer: - (A)

32. A solid circular shaft needs to be designed to transmit a torque of 50Nm. If the allowable shear stress of the material is 140MPa, assuming a factor of safety of 2, the minimum allowable design diameter in mm is

(A) 8 (B) 16 (C) 24 (D) 32

Answer: - (B)

Exp:- $T = 50N - n;\quad \tau_{allowable} = 140MPa$

$f o.S = 2;\qquad \tau_{safe} = \frac{\tau_{allowable}}{f_{O.S}} = 70MPa$

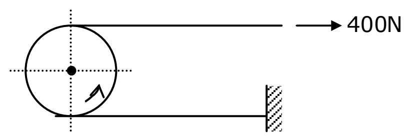
We know, $\frac{T}{Z_P} = \tau_{safe}$

$Z_P = \frac{\pi d^3}{16} \Rightarrow d^3 = \frac{16\,T}{\pi\,\tau_{safe}}$

$d = \sqrt{\frac{16 \times 50 \times 10^3}{\pi \times 70}}$

$d = 15.38\,mm \approx 16mm$

33. A force of 400N is applied to the brake drum of 0.5m diameter in a band brake system as shown in the figure, where the wrapping angle is 180º. If the coefficient of friction between the drum and the band is 0.25, the braking torque applied, in Nm is



(A) 100.6 (B) 54.4 (C) 22.1 (D) 15.7

Answer: - (B)

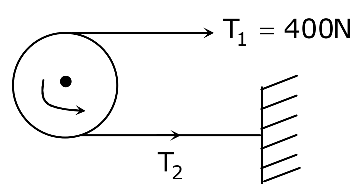
Exp:- As the drum is rotating in anti clock wise direction, T1 will be tight side & T2 will be clack side.

& $\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25\times\pi} = 2.19$

$T_2 = 182.375\ N$

Breaking torque = $(T_1 - T_2)\ r$

$= 54.4\ N - m$



34. A box contains 4 red balls and 6 black balls. Three balls are selected randomly from the box one after another without replacement. The probability that the selected set contains one red ball and two black balls is

(A) $\frac{1}{20}$ (B) $\frac{1}{12}$ (C) $\frac{3}{10}$ (D) $\frac{1}{2}$

Answer: - (D)

Exp:- Given, $\frac{\text{Red}}{4}$ $\frac{\text{Black}}{6}$

The selection will be RBB or BBR of BRB

Probability of selecting RBB = $\frac{4}{10}\times\frac{6}{9}\times\frac{5}{8}$

Probability of selecting BBR = $\frac{6}{10}\times\frac{5}{9}\times\frac{4}{8}$

Probability of selecting BRB = $\frac{6}{10}\times\frac{4}{9}\times\frac{5}{8}$

P (Red=1) =sum of above three probabilities= 0.5

35. Consider the differential equation $x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}-4y=0$ with the boundary conditions of $y(0)=0$ and $y(1)=1$. The complete solution of the differential equation is

(A) x^2 (B) $\sin\left(\frac{\pi x}{2}\right)$ (C) $e^x\sin\left(\frac{\pi x}{2}\right)$ (D) $e^{-x}\sin\left(\frac{\pi x}{2}\right)$

Answer: - (A)

Exp:- $x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}-4y=0$ $y(0)=0$

$y(1)=1$

Cauchy's D.E

$y=x^2$ $\frac{dy}{dx}=2x$ $\frac{d^2y}{dx^2}=2$

$y=x^{-2}$ $dy/dx=-2x^{-3}$ $dy/dx^2=+6x^{-4}$

$y=x^{-2}$ $dy/dx=-2x^{-3}$ $dy/dx^2=+6x^{-4}$

$x^2\left(6/x^4\right)+\left(-2/x^3\right)-4\left(1/x^2\right)=0$

m^2 $4=0$ $m^2=4$

$m=\pm2$

$\therefore$ The required solution is $C_1x^2+C_2x^2+C_2x^2$

Hence the answer is x^2.

36. The system of algebraic equations given below has

$x+2y+z=4$
$2x+y+2z=5$
$x-y+z=1$

(A) A unique solution of x=1, y=1 and z=1

(B) Only the two solutions of (x=1, y=1 and z=1) and (x=2, y=1 and z=0)

(C) Infinite number of solutions

(D) No feasible solution

Answer: - (C)

Exp:- The given equations are

$x + 2y + z = 4 \quad -(1)$

$2x + y + 2z = 5 \quad -(2)$

$x + y + z = 1 \quad -(3)$

Eliminating n from (1) & (2), we have

y = 1 -(4)

Eliminating x form (2) & (3), we have

y = 1 -(5)

Lines (4) and (5) are coincident

Hence the given equation has infinite solutions

37. The homogeneous state of stress for a metal part undergoing plastic deformation is

$$T = \begin{bmatrix} 10 & 5 & 0 \\ 5 & 20 & 0 \\ 0 & 0 & -10 \end{bmatrix}$$

Where the stress component values are in MPa. Using von Mises yield criterion, the value of estimated shear yield stress, in MPa is

(A) 9.50 (B) 16.07 (C) 28.52 (D) 49.41

Answer: - (B)

Exp:- $\sigma_{eq} = \sqrt{\frac{1}{2}\left\{(\sigma_{11} - \sigma_{22})^2 + (\sigma_{11} - \sigma_{22})^2 + 6\left[\sigma_{12}^2 + \sigma_{23}^2 + \sigma_{13}^2\right]\right\}}$

We know, $\sigma_{11} = 10,\ \sigma_{22} = 20,$

$\sigma_{33} = -10;\ \sigma_{12} = 5;\ \sigma_{23} = \sigma_{13} = 0$

$\therefore\ \sigma_{eq} = 27.839\,\text{MPa}$

Shear stress at yield $\tau_y = \frac{\sigma_{eq}}{\sqrt{3}} = 16.07\,\text{MPa}$

38. Details pertaining to an orthogonal metal cutting process are given below

Chip thickness ratio	0.4
Unreformed thickness	0.6mm
Rake angle	+10º
Cutting speed	2.5m/s
Mean thickness of primary shear zone	25 microns

The shear strain rate in s^{-1} during the process is

(A) 0.1781×10^5 (B) 0.7754×10^5

(C) 1.0104×10^5 (D) 4.397×10^5

Answer: - (C)

Exp:- $r = 0.4$

$t_1 = 0.6\,mm$

$\alpha = 10^O$

$V_C = 2.5 m/s$

$t_m = 25\mu m$

$$\tan\phi = \frac{r\cos\alpha}{1-r\sin\alpha} = 0.4233 \Rightarrow \phi = 22.9^O$$

$$\text{Shear strain rate} = \frac{V_C\cos\alpha}{\cos(\phi-\alpha)\times t_m} = \frac{2.5\times\cos 10}{\cos 12.9\times 25\times10^{-6}} = 1.010^4\times10^5\,/\,S$$

39. In a single pass drilling operation, a through hole of 15mm diameter is to be drilled in a steel plate of 50mm thickness. Drill spindle speed is 500rpm, feed is 0.2mm/rev and drill point angle is 118º. Assuming 2mm clearance at approach and exit, the total drill time in seconds is

(A) 35.1 (B) 32.4 (C) 31.2 (D) 30.1

Answer: - (A)

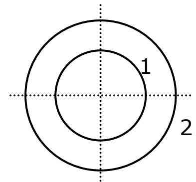
Exp:- $$T_c = \frac{(L_h + A + O + C)}{Nf}$$

$$L_h = 50mm; A = O = 2mm; C = \frac{D}{2}\cot(\frac{\beta}{2}) = 7.5\times\cot(59) = 4.5mm$$

$N = 500\,rpm;\ f = 0.2\,mm/rev$

$T_c = 0.585\,min$ or 35.1 Seconds

40. Consider two infinitely long thin concentric tubes of circular cross section as shown in the figure. If D_1 and D_2 are the diameters of the inner and outer tubes respectively, then the view factor F_{22} is given by



(A) $\left(\frac{D_2}{D_1}\right)-1$ (B) Zero (C) $\left(\frac{D_1}{D_2}\right)$ (D) $1-\left(\frac{D_1}{D_2}\right)$

Answer: - (D)

Exp:- $$F_{22} = 1 - F_{21} = 1 - \frac{A_1}{A_1} = 1 - \frac{D_1}{D_2}$$

41. An incompressible fluid flows over a flat plate with zero pressure gradient. The boundary layer thickness is 1mm at a location where the Reynolds number is 1000. If the velocity of the fluid alone is increased by a factor of 4, then the boundary layer thickness at the same location, in mm will be

(A) 4 (B) 2 (C) 0.5 (D) 0.25

Answer: - (C)

Exp:- Boundary layer thickness $(\delta)\ \alpha\ \frac{1}{\sqrt{R_e}}$

$R_e\ \alpha\ V \Rightarrow \delta\ \alpha\ \frac{1}{\sqrt{V}}$

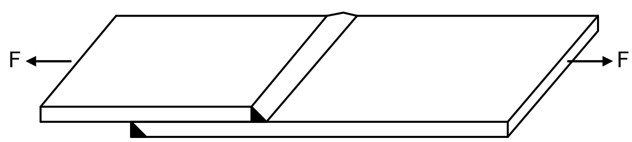
If velocity of fluid is increased by 4 times then boundary layer thickness reduces by half

42. A room contains 35kg of dry air and 0.5g of water vapour. The total pressure and temperature of air in the room are 100kPa and 25ºC respectively. Given that the saturation pressure for water at 25ºC is 3.17kPa, the relative humidity of the air in the room is

(A) 67% (B) 55% (C) 83% (D) 71%

Answer: - (D)

43. A fillet-welded joint is subjected to transverse loading F as shown in the figure. Both legs of the fillets are of 10mm size and the weld length is 30mm. If the allowable shear stress of the weld is 94MPa, considering the minimum throat area of the weld, the maximum allowable transverse load in kN is



Exp:- $P = 0.707\,sl.\ \tau_{allowable}$

$P = 0.707 \times 10 \times 30 \times 94 = 19937.4N$

$P = 19.934\,kM$

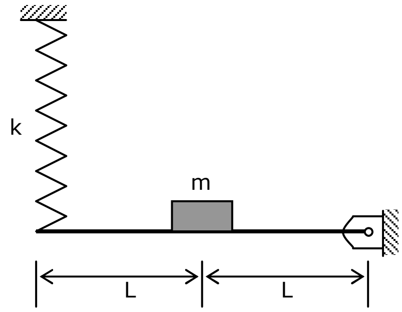
44. A concentrated mass m is attached at the centre of a rod of length 2L as shown in the figure. The rod is kept in a horizontal equilibrium position by a spring of stiffness k. For very small amplitude of vibration, neglecting the weights of the rod and spring, the undamped natural frequency of th system is:

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

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

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

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



Answer: - (D)

45. The state of stress at a point under plane stress condition is

$\sigma_{xx} = 40\text{MPa}; \ \sigma_{yy} = 100\text{MPa}$ and $\tau_{xy} = 40\text{MPa}$

The radius of the Mohr's circle representing the given state of stress in MPa is

(A) 40 (B) 50 (C) 60 (D) 100

Answer: - (B)

Exp:- $\sigma_{xx} = 40\,\text{MPa}; \ \sigma_{yy} = 100\,\text{MPa}, \ \tau_{xy} = 40\text{MPa}$

$$\text{Radius of Mohr's circle} = \sqrt{\left[\frac{\sigma_{xx} - \sigma_{yy}}{2}\right]^2 + \tau_{xy}^2} = \sqrt{30^2 + 40^2} = 50 \text{ MPa}$$

46. The inverse Laplace transform of the function $F(s) = \dfrac{1}{s(s+1)}$ is given by

(A) $f(t) = \sin t$ (B) $f(t) = e^{-t}\sin t$ (C) $f(t) = e^{-t}$ (D) $f(t) = 1 - e^{-t}$

Answer: - (D)

Exp:- $L^{-1}\left(\dfrac{1}{S(S+1)}\right) = \dfrac{1}{S} - \dfrac{1}{S+1}$

$L^{-1}\left(\dfrac{1}{S} - \dfrac{1}{s+1}\right) = 1 - e^{-t}$

47. For the matrix $A = \begin{bmatrix} 5 & 3 \\ 1 & 3 \end{bmatrix}$, ONE of the normalized eigen vectors is given as

(A) $\begin{pmatrix} \frac{1}{2} \\ \frac{\sqrt{3}}{2} \end{pmatrix}$ (B) $\begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{-1}{\sqrt{2}} \end{pmatrix}$ (C) $\begin{pmatrix} \frac{3}{\sqrt{10}} \\ \frac{-1}{\sqrt{10}} \end{pmatrix}$ (D) $\begin{pmatrix} \frac{1}{\sqrt{5}} \\ \frac{2}{\sqrt{5}} \end{pmatrix}$

Answer: - (B)

Exp:- $|A - \lambda I| = 0 \Rightarrow \begin{vmatrix} 5-\lambda & 3 \\ 1 & 3-\lambda \end{vmatrix} = 0 \Rightarrow (5-\lambda)(3-\lambda) = 3 = 0$

$\Rightarrow \lambda^2 - 8\lambda + 15 - 3 = 0 \Rightarrow \lambda^2 - 8\lambda + 12 = 0 \Rightarrow \lambda = 2, \ \lambda = 6$

$(A - 2I) \times X = 0$

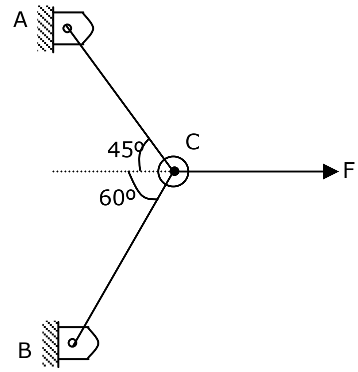
At, $\lambda = 2$

$\begin{pmatrix} 3 & 3 \\ 1 & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}; \quad \begin{matrix} x_1 + x_2 = 0 \\ x_1 = x_2 \end{matrix}$

Hence the required vector is $\begin{bmatrix} \frac{1}{\sqrt{2}} \\ \frac{-1}{\sqrt{2}} \end{bmatrix}$

Common Data Questions: 48 & 49

Two steel truss members AC and BC, each having cross sectional area of $100mm^2$, are subjected to a horizontal force F as shown in the figure. All the joints are hinged.



48. The maximum force F in kN that can be applied at C such that the axial stress in any of the truss members DOES NOT exceed 100MPa is

(A) 8.17 (B) 11.15 (C) 14.14 (D) 22.30

Answer: - (B)

Exp: - From Lame's theorem,

$$\frac{F}{\text{Sin}105} = \frac{F_A}{\text{Sin}120} = \frac{F_B}{\text{Sin}135}$$

$$\Rightarrow F_A = 0.8965F\,;\ F_B = 0.732F$$

$$\therefore \text{maximum force is } F_A \text{ and stress} = \frac{F_A}{\text{Area}} = 100\text{MPa}$$

$$\frac{0.8965F}{100} = 100\text{MPa} \Rightarrow F = 11154.48\text{N or } 11.15\text{KN}$$

49. If $F = 1kN$, the magnitude of the vertical reaction force developed at the point B in KN is

(A) 0.63 (B) 0.32 (C) 1.26 (D) 1.46

Answer: - (A)

$$\text{vertical reaction at point B is } R_B = F_B \cos 30 = 0.633F$$

$$F = 1\text{KN} \therefore R_B = 0.633\text{KN}$$

Common Data Questions: 50 & 51

A refrigerator operates between 120kPa and 800kPa in an ideal vapour compression cycle with R-134a as the refrigerant. The refrigerant enters the compressor as saturated vapour and leaves the condenser as saturated liquid. The mass flow rate of the refrigerant is 0.2kg/s. Properties for R-134a are as follows:

Saturated R-134a					
$P\,(kPa)$	$T^{o}C$	$h_f\,(kJ/kg)$	$h_g\,(kJ/kg)$	$s_f\,(kJ/kg\cdot K)$	$s_g\,(kJ/kg\cdot K)$
120	-22.32	22.5	237	0.093	0.95
800	31.31	95.5	267.3	0.354	0.918

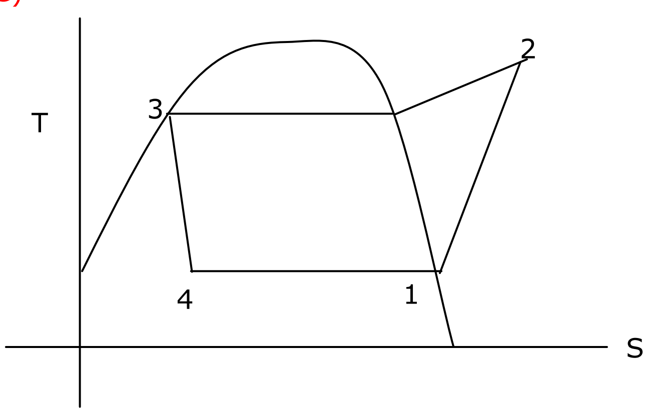
Superheated R-134a			
$P\,(kPa)$	$T^{o}C$	$h\,(kJ/kg)$	$s\,(kJ/kg\cdot K)$
800	40	276.45	0.95

50. The power required for the compressor in kW is

(A) 5.94 (B) 1.83 (C) 7.9 (D) 39.5

Answer: - (C)

Exp:-



Power required for compressor $= m_r\ (h_2 - h_1)$

$= 0.2 \times (276.45 - 237) = 7.9\,kW$

51. The rate at which heat is extracted in kJ/s from the refrigerated space is

(A) 28.3 (B) 42.9 (C) 34.4 (D) 14.6

Answer: - (A)

Exp:- Rate at which heat is extracted $= m_r\ (h_1 - h_4)$

$$= 0.2(237 - 95.5) = 28.3\ \text{kW}$$

Statement for Linked Answer Questions: 52 & 53

For a particular project, eight activities are to be carried out. Their relationships with other activities and expected durations are mentioned in the table below.

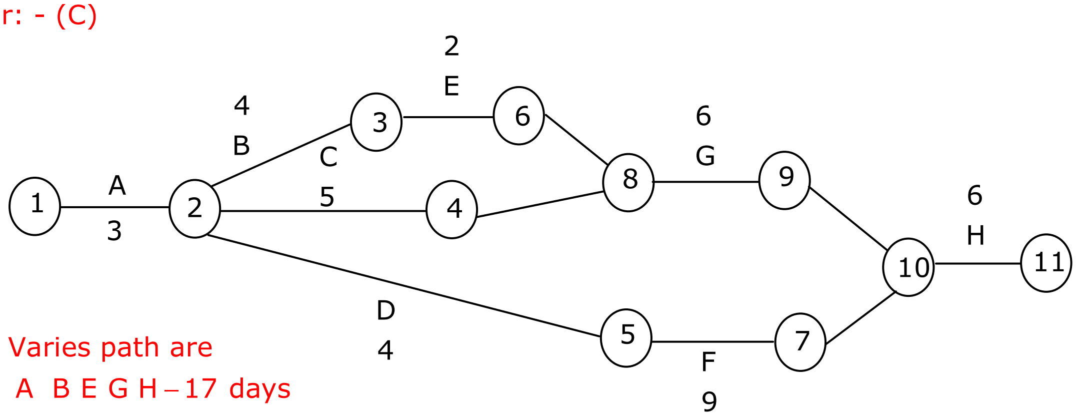
Activity	Predecessors	Duration (days)
A	-	3
B	a	4
C	a	5
D	a	4
E	b	2
F	d	9
G	c.e	6
H	f,g	2

52. The critical path for the project is

(A) a-b-e-g-h (B) a-c-g-h (C) a-d-f-h (D) a-b-c-f-h

Answer: - (C)

Exp:-



Varies path are

A B E G H – 17 days

A C G H – 16 days

A D F H – 18 days ;

$\therefore$ A D F H is critical path

53. If the duration of activity f alone is changed from 9 to 10 days, then the

(A) Critical path remains the same and the total duration to complete the project changes to 19days

(B) Critical path and the total duration to complete the project remain the same

(C) Critical path changes but the total duration to complete the project remains the same

(D) Critical path changes and the total duration to complete the project changes to 17days

Answer: - (A)

Exp:- If duration of activity F has changed to 10 days, critical path remains the same and project duration will increase to 19 days.

Statement for Linked Answer Questions: 54 & 55

Air enters an adiabatic nozzle at 300kPa, 500K with a velocity of 10m/s. It leaves the nozzle at 100kPa with a velocity of 180m/s. The inlet area is $80 cm^2$. The specific heat of air C_p is 1008J/kg.K.

54. The exit temperature of the air is

(A) 516K (B) 532K (C) 484K (D) 468K

Answer: - (C)

Exp:- $h_1 + v_1^2 / 2 = h_2 + v_2^2 / 2$

$$\frac{v_2^2 - v_1^2}{2} = h_1 - h_2 = C_p(T_1 - T_2)$$

$$\frac{180^2 - 10^2}{2} = 1008 \times (500 - T_2)$$

$$T_2 = 484K$$

55. The exit area of the nozzle in cm^2 is

(A) 90.1 (B) 56.3 (C) 4.4 (D) 12.9

Answer: - (D)

Exp:- From continuity equation we get,

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

$$\frac{P_1}{RT_1} \times A_1 V_1 = \frac{P_2}{RT_2} \times A_2 V_2 \Rightarrow A_2 = \frac{P_1 T_2}{P_2 T_1} \times \frac{V_1}{V_2} \times A_1$$

$$A_2 = \frac{300 \times 484}{500 \times 100} \times \frac{10}{180} \times 80 = 12.9\,cm^2$$

Q. No. 56 – 60 Carry One Mark Each

56. The cost function for a product in a firm is given by $5q^2$, where q is the amount of production. The firm can sell the product at a market price of Rs.50 per unit. The number of units to be produced by the firm such that the profit is maximized is

(A) 5 (B) 10 (C) 15 (D) 25

Answer: (A)

Exp:- $P = 50q - 5q^2$

$\frac{dp}{dq} = 50 - 10q; \ \frac{d^2p}{dq^2} < 0$

$\therefore$ p is maximum at $50 - 10q = 0$ or, $q = 5$

Else check with options

57. Choose the most appropriate alternative from the options given below to complete the following sentence:

Suresh's dog is the one _________ was hurt in the stampede.

(A) that (B) which (C) who (D) whom

Answer: (A)

58. Choose the grammatically **INCORRECT** sentence:

(A) They gave us the money back less the service charges of Three Hundred rupees.

(B) This country's expenditure is not less than that of Bangladesh.

(C) The committee initially asked for a funding of Fifty Lakh rupees, but later settled for a lesser sum.

(D) This country's expenditure on educational reforms is very less

Answer: (D)

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

Mitigate

(A) Diminish (B) Divulge (C) Dedicate (D) Denote

Answer: (A)

60. Choose the most appropriate alternative from the options given below to complete the following sentence:

Despite several ___________ the mission succeeded in its attempt to resolve the conflict.

(A) attempts (B) setbacks (C) meetings (D) delegations

Answer: (B)

Q. No. 61 – 65 Carry Two Marks Each

61. Wanted Temporary, Part-time persons for the post of Field Interviewer to conduct personal interviews to collect and collate economic data. Requirements: High School-pass, must be available for Day, Evening and Saturday work. Transportation paid, expenses reimbursed.

Which one of the following is the best inference from the above advertisement?

(A) Gender-discriminatory

(B) Xenophobic

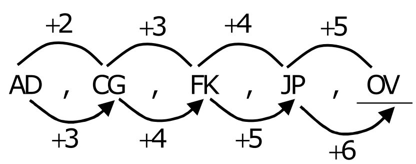
(C) Not designed to make the post attractive

(D) Not gender-discriminatory

Answer: (C)

Exp:- Gender is not mentioned in the advertisement and (B) clearly eliminated

62. Given the sequence of terms, AD CG FK JP, the next term is



64. An automobile plant contracted to buy shock absorbers from two suppliers X and Y. X supplies 60% and Y supplies 40% of the shock absorbers. All shock absorbers are subjected to a quality test. The ones that pass the quality test are considered reliable Of X's shock absorbers, 96% are reliable. Of Y's shock absorbers, 72% are reliable.

The probability that a randomly chosen shock absorber, which is found to be reliable, is made by Y is

(A) 0.288 (B) 0.334 (C) 0.667 (D) 0.720

Answer: (B)

Exp:-

	x	y
Supply	60%	40%
Reliable	96%	72%
Overall	0.576	0.288

$$\therefore P(x) = \frac{0.288}{0.576 + 0.288} = 0.334$$

65. A political party orders an arch for the entrance to the ground in which the annual convention is being held. The profile of the arch follows the equation $y = 2x - 0.1x^2$ where y is the height of the arch in meters. The maximum possible height of the arch is

(A) 8 meters (B) 10 meters (C) 12 meters (D) 14 meters

Answer: (B)

Exp:- $y = 2x - 0.1x^2$

$$\frac{dy}{dx} = 2 - 0.2x$$

$$\frac{d^2y}{dx^2} < 0 \therefore \text{ y maximises at } 2 - 0.2x = 0$$

$$\Rightarrow x = 10$$

$$\therefore \; y = 20 - 10 = 10\,m$$