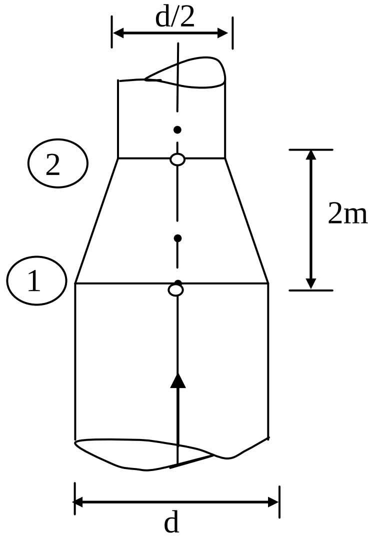
MECHANICAL ENGINEERING MOCK-A – Solutions

01. Ans: (B)

Sol:



By continuity equation:

$$Q = A_1V_1 = A_2V_2$$

$$\frac{\pi}{4}d^2.V_1 = \frac{\pi}{4}\left(\frac{d}{2}\right)^2.V_2$$

$$V_2 = 4V_1 = 4 \times 2 = 8\ m/s$$

By Bernoulli's equation:

$$\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g}$$

(By neglecting the losses),

$V_2 = 4V_1$ from continuity equation.

Thus, $\frac{200 \times 10^3}{1000 \times 9.81} + 0 + \frac{2^2}{2 \times 9.81}$

$$= \frac{P_2}{1000 \times 9.81} + 2 + \frac{8^2}{2 \times 9.81}$$

On simplification,

$\Rightarrow P_2 = 150\ kN/m^2$

02. Ans: (B)

Sol: For 'n' radiation shields inserted,

increase in space resistances = n

Total no. of space resistances = n + 1

= 11 + 1 = 12

and increase in surface resistances = 2n

Total number of surface resistances

= 2n + 2

= 2 × 11 + 2

= 24

03. Ans: 0 (Range: 0 to 0)

Sol: Since there is no external force acting on the block so the value of frictional force will be 0 N.

04. Ans: (A)

Sol: The given function is odd function since

$$f(-x) = -f(x).$$

For odd function $\int_{-1}^{1} f(x) = 0$

05. Ans: (C)

Sol: For a state of pure shear,

$\sigma_x = 0$

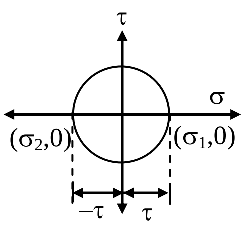
$\sigma_y = 0$

$\tau_{xy} = \tau$

Principal stresses for given state are,

$\sigma_1 = \tau$ and $\sigma_2 = -\tau$

For these principal stresses, Mohr's Circle can be drawn as shown in the figure below.



06. Ans: (B)

Sol: If the clearance provided is greater than the optimum clearance, no shearing action takes place and the sheet is simply pulled into the die.

07. Ans: (C)

Sol: Shear strain, $\gamma = \tan(\phi - \alpha) + \cot\phi$

$\gamma = \gamma_{min}$,

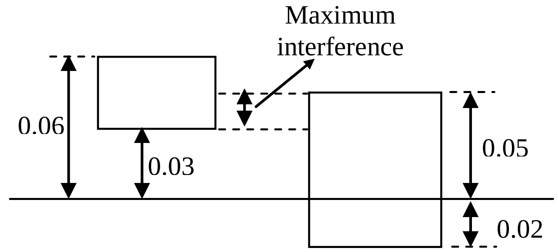
when $2\phi - \alpha = 90°$

Now, if $\alpha = 0$, then $\phi = 45°$

$\therefore \gamma_{min} = \tan 45 + \cot 45 = 2$

08. Ans: (A)

Sol:



Maximum interference

$= (U.L)_{shaft} - (L.L)_{hole}$

$= 0.05 - 0.03 = 0.02mm$

09. Ans: (C)

Sol: In a gas turbine engines combustion is carried out isobarically.

10. Ans: (D)

Sol: P (x = 1) = 0.5 P (x = 2)

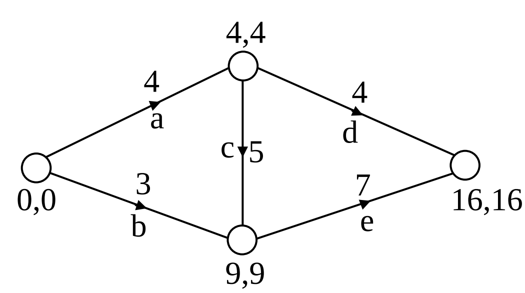
$$\frac{\lambda e^{-\lambda}}{1!} = \frac{1}{2}\frac{\lambda^2 e^{-\lambda}}{2!}$$

$\Rightarrow \lambda = 4$

$$P(x=4) = \frac{\lambda^4 e^{-\lambda}}{4!} = \frac{4^4 e^{-4}}{24} = \frac{32}{3}e^{-4}$$

11. Ans: (B)

Sol:



In project management, float or slack is the amount of time that a task in a project network can be delayed to:

- Subsequent tasks ("free float")
- Project completion date ("total float")

Here,

Slack for activity 'b' in months = Total float

$= L_j - E_i - t_{ij} = 9 - 0 - 3 = 6$

12. Ans: (A)

Sol:

- Area of cross-section of threaded portion is less than that of the shank, so stress induced in threaded portion is higher. We know that strain energy is,

$$U \propto \sigma^2$$

Hence, threaded portion has higher energy absorbing capacity.

- Tensile, shear and compressive stresses are induced on the bolt without preloading.

13. Ans: (A)

Sol: The overdamped system under free vibration condition is non-oscillatory.

14. Ans: (C)

Sol: If runner blades of propeller turbine are adjustable then it is called Kaplan turbine.

15. Ans: (C)

Sol:

- Alligatoring $\rightarrow$ Rolling
- Lap $\rightarrow$ Forging
- Bamboo defect $\rightarrow$ Extrusion
- Blister $\rightarrow$ Casting

16. Ans: (A)

Sol: $(COP)_R = \dfrac{T_1}{T_2 - T_1}$

$T_1 = -3 + 273 = 270$ K

$T_2 = 27 + 273 = 300$ K.

$$(COP)_R = \frac{270}{(300-270)} = 9$$

$$\Rightarrow \quad \frac{5}{P} = 9$$

$$\Rightarrow \quad P = 0.55 \text{ kW}$$

17. Ans: (B)

Sol: The given differential equation

$$4y''' + 4y'' + y' = 0$$

$$\Rightarrow 4D^3 + 4D^2 + D = 0$$

$$\Rightarrow D(2D + 1)^2 = 0$$

$$D = 0, \frac{-1}{2}, \frac{-1}{2}$$

$$\therefore\ y_c = C_1 + (C_2 + C_3x)\, e^{-x/2}$$

18. Ans: (D)

Sol: $P_{buckling} = \frac{n\pi^2 EI}{L^2}$

$P_{buckling} \propto n$

For both ends fixed, $n_1 = 4$

For one end free, $n_2 = 0.25$

$\frac{P_2}{P_1} = \frac{n_2}{n_1}$

$P_2 = P \times \frac{0.25}{4} = \frac{P}{16}$

19. Ans: 12.56 [Range: 12 to 13]

Sol: Given: $\phi = 150°$, h = 20 mm

$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 100}{60} = 10.47$ rad/sec

$V_{max} = \frac{h}{2} \times \frac{\pi\omega}{\phi_a}$

$V_{max} = \frac{0.02}{2} \times \frac{\pi \times 10.47}{150 \times \frac{\pi}{180}}$

= 0.1256 m/s = 12.56 cm/sec

20. Ans: (A)

Sol: Fe is face centered cubic structure at 1000°C

$\therefore\ 4R = \sqrt{2}a$

$a = \frac{4R}{\sqrt{2}} = 2\sqrt{2}R = 2 \times \sqrt{2} \times 0.15\,\text{nm}$

= 0.42 nm

21. Ans: 0.9 [Range: 0.88 to 0.92]

Sol: $\lambda = \frac{1}{4}$

$\mu = \frac{2}{3}$

$W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{\frac{1}{4}}{\frac{2}{3}\left(\frac{2}{3} - \frac{1}{4}\right)}$ = 0.9 minutes

22. Ans: (B)

Sol:

$\text{Biot number}(Bi) = \frac{\text{conductive resistance inside the solid body}}{\text{convective resistance on the solid surface}}$

$[\because Bi \to 0]$

$\therefore$ Conductive resistance inside the solid body $\approx$ 0 (Uniform temperature inside solid body)

$\therefore$ Lumped capacity analysis can be used.

23. Ans: (C)

Sol: $\frac{dy}{dx} = 4x^3 e^{-y}$

Using variable separable method

$e^y = x^4 + c$

at x = 1, y = 0,

$\Rightarrow c = 0$

$\Rightarrow e^y = x^4$

24. Ans: 16 (Range: 16 to 16)

Sol: Given:

$\psi = 2x^2y + (3 + t)y^2$

The flow rate per unit width across the face AB is $= \psi_B - \psi_A$

$= \psi(0, 2) - \psi(3, 0)$

$= 2(0)^2(2) + (3 + t)(2)^2 - 2(3)^2(0) - (3 + t)\times 0$

$= 0 + (3 + 1)2^2 - 0 - 0$ (t = 1s)

= 16 units

25. Ans: (D)

Sol: $z^2 + 9 = 0 \Rightarrow z = \pm 3i$

$z_0 = 3i$ lies inside the circle.

$$\therefore I = 2\pi i \lim_{z\to 3i} \frac{(z-3i)}{(z+3i)(z-3i)}$$

$$= 2\pi i . \frac{1}{6i} = \frac{\pi}{3}$$

26. Ans: (D)

Sol: Given:

$T = xy + z + 3t$ and $\vec{V} = xy\vec{i} + z\vec{j} + 5t\vec{k}$

u = xy,

v = z, w = 5t

Rate of change of temperature of a particle at time t is given by

$$\frac{DT}{dt} = \frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} + w\frac{\partial T}{\partial z}$$

$$= 3 + (xy)(y) + (z)(x) + (5t)(1)$$

$$= 3 + xy^2 + xz + 5t$$

Thus, at (2, –2, 1) and t = 2s, we get

$$\frac{DT}{Dt} = 3 + (2)(-2)^2 + (2)(1) + 5(2) = 23 \text{ K/s}$$

27. Ans: (B)

Sol: Given data:

Uncut chip thickness, $t_1 = 0.25$ mm

Feed rate, f = 0.50 mm

Inclination angle, i = 1.5°

Side rake, $\alpha_s = 10°$

$$\Rightarrow \sin\lambda = \frac{t_1}{f} = \frac{0.25}{0.50} = 0.5$$

$\lambda = 30°$

Now, $\tan i = \sin\lambda \tan\alpha_b - \cos\lambda \tan\alpha_s$

$$\Rightarrow \tan 15 = 0.5 \tan\alpha_b - \frac{\sqrt{3}}{2}\tan 10$$

$\Rightarrow \alpha_b = 40°$

28. Ans: 14.28 [Range 14 to 15]

Sol: Shaping time, $T = \frac{LW(1+m)}{fv_c}$

Where, L = length of stroke

W = width of workpiece

m = quick return ratio

f = feed in mm/double stroke

v_c = cutting velocity

$\Rightarrow T \propto 1 + m$ [under similar conditions]

$$\frac{T_2}{T_1} = \frac{1+m_2}{1+m_1} = \frac{1.6}{1.4} = 1.14$$

Percentage increase

$$= \frac{1.14 - 1}{1} \times 100 = 14.28\%$$

29. Ans: 20.4 [Range 20.0 to 21.0]

Sol: Maintaining volume constancy:

Volume before cutting = volume after cutting

$\Rightarrow$ $b_o \times h_o \times v_o = b_1 \times h_1 \times v_1$

$\Rightarrow$ $b_o \times h_o \times 15 = (1.05b_o) \times (0.7h_o) \times v_1$

$\Rightarrow$ $15 = 1.05 \times 0.7 v_1$

$\Rightarrow$ $v_1 = 20.4$ m/min

30. Ans: 43.17 [Range: 42 to 44]

Sol: $m_1\left[h_1 + \frac{V_1^2}{2}\right] + Q = m_2\left[h_2 + \frac{V_2^2}{2}\right] - P$

$$m_1\left[C_pT_1 + \frac{V_1^2}{2000}\right] = m_2\left[C_pT_2 + \frac{V_2^2}{2000}\right] - P$$

$m_1 = 1$ kg/s, $T_1 = 300$ K, $V_1 = 50$ m/s,

$V_2 = 100$ m/s, $P = 20$ kW

$$1\left[1.005 \times 300 + \frac{50^2}{2000} - \frac{100^2}{2000}\right] + 20 = 1.005\,T_2$$

$T_2 = 316.17$ K

$T_2 = 43.17°C$

31. Ans: (D)

Sol: The Characteristic equation is

$$|A - \lambda I| = 0$$

$$\Rightarrow \begin{vmatrix} 4-\lambda & 1 \\ -1 & 2-\lambda \end{vmatrix} = 0$$

$\Rightarrow \lambda^2 - 6\lambda + 9 = 0$

$\Rightarrow \lambda = 3, 3$

The eigen vectors for $\lambda = 3$ are given by the equation $[A - 3I]X = 0$ where $X = \begin{bmatrix} x \\ y \end{bmatrix}$

$\Rightarrow x + y = 0$

$\therefore$ (x, y) = (2, –2) is an eigen vector

32. Ans: (A)

Sol: Given data:

$\Delta T = 50$ °C,

$\alpha = 17.5 \times 10^{-6}$ /°C,

$E = 120$ GPa

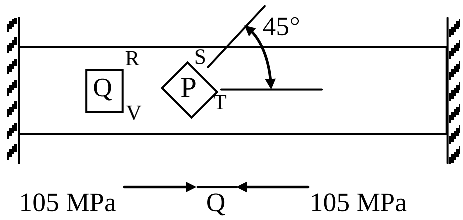
Stress due to temperature increase is given by,

$\sigma_x = E\alpha(\Delta T)$

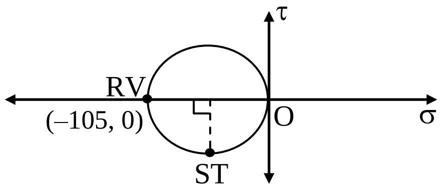
$= 120 \times 10^3 \times 17.5 \times 10^{-6} \times 50$

$= 105$ MPa (compression)

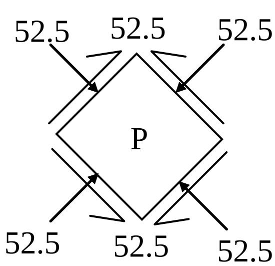
- As the temperature of the bar increases, the bar tries to expand. Due to rigid supports at the ends, expansion of the bar is restricted. Thus, compressive stress is induced in the bar.
- State of stress of an element Q, which is in the direction of longitudinal axis, is shown below.



- Mohr's circle for an element Q is shown in the figure below.



- In above diagram, it is shown that a plane ST which is at 45° to the longitudinal axis (Plane RV) is at 90° to the plane RV in Mohr's circle.



At plane ST, $\sigma_x = \dfrac{-105}{2} = -52.5$ MPa

$\sigma_y = -52.5$ MPa

$\tau_{xy} = -52.5$ MPa

33. Ans: 780.16 [Range: 775 to 785]

Sol: We know that

$$P_{max} = \frac{T_{max}}{R \times W} = \frac{T_1}{R \times W} = 0.25$$

$T_1 = R \times W \times P_{max}$, W = 60 mm

$T_1 = 250 \times 60 \times 0.25 = 3750$ N

$$\frac{T_1}{T_2} = e^{\mu\theta}, \quad \mu = 0.4,$$

$$\theta = \frac{\pi}{180} \times 225$$

θ = 3.925 radian

$$\frac{T_1}{T_2} = e^{(0.4 \times 3.925)}$$

$T_2 = 780.16$ N

34. Ans: 261.66 [Range 258 to 264]

Sol: T_{mean} = constant

$$W = \int_0^{\pi} T d\theta = \int_0^{\pi} (10000 + 2000 \sin 2\theta - 1800 \cos 2\theta) d\theta$$

W = 10000π J

$$T_{mean} = \frac{W}{\pi} = 10000 \text{ N} - \text{m}$$

Power = $T_{mean} \times \omega$

$$P = 10000 \times 2\pi \times \frac{250}{60}$$

P = 261.66 kW

35. Ans: (B)

Sol: $g(x)=\frac{f(x)}{x+1}$

g(x) in continuous and differentiable in [0, 5].

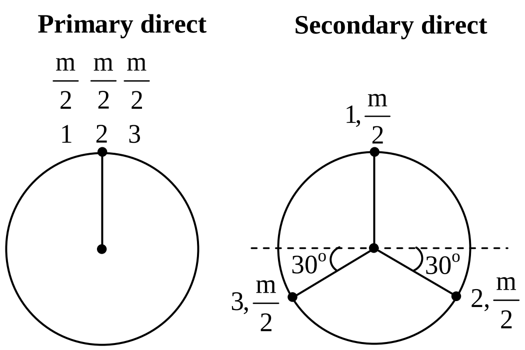
By Lagrange's theorem, there exists a value $c \in (0, 5)$, such that

$$g^1(c)=\frac{g(5)-g(0)}{5-0}$$

$$=\frac{\left(-\frac{1}{6}\right)-4}{5}=\frac{-5}{6}$$

36. Ans: (B)

Sol:



From the secondary direct diagram and resolving the force along x and y direction

$(F_{net})_x = 0$

$(F_{net})_y = 0$

$F_{net} = 0$ N

37. Ans: (D)

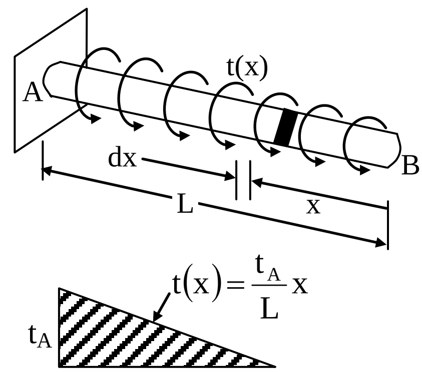
Sol: Given data:

$t(x)$ = Intensity of distributed torque $=\frac{t_A}{L}x$

t_A = Maximum intensity of torque

d = Diameter

G = Shear modulus



Maximum torque which occurs at end A is given by,

$$T_A=\frac{1}{2}t_A L$$

Torque at distance x from end B is given by,

$$T(x) = \frac{1}{2}\times t(x)\times x=\frac{t_A x^2}{2L}$$

Angle of twist for a small strip of length *dx* is given by,

$$d\phi=\frac{T(x)dx}{GI} = \frac{16 t_A x^2 dx}{\pi G L d^4}$$

Now, total tist between ends is given by,

$$\phi=\int_0^L d\phi = \frac{16 t_A}{\pi G L d^4}\int_0^L x^2 dx$$

$$=\frac{16 t_A L^2}{3\pi G d^4}$$

38. Ans: 87 [Range: 85 to 88]

Sol: Forecast for Feb = $F_{Jan} + \alpha\,(D_{Jan} - F_{Jan})$

$= 90 + 0.3\,(100 - 90) = 93$

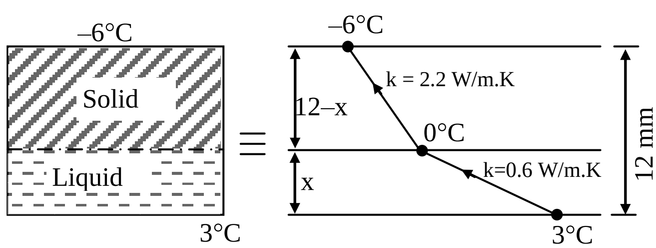
Forecast for March = $F_{Feb} + \alpha\,(D_{Feb} - F_{Feb})$

$= 93 + 0.3\,(70 - 93)$

$= 86.1$

39. Ans: 1.44 mm [Range: 1.4 to 1.5]

Sol:



$$\text{Heat Transfer rate} = \frac{3-0}{\left(\frac{x}{0.6A}\right)} = \frac{0-(-6)}{\left(\frac{12-x}{2.2\,A}\right)}$$

$$\frac{3}{\frac{x}{0.6}} = \frac{6}{\left(\frac{12-x}{2.20}\right)}$$

$0.6(12-x) = 2\times2.2x$

$12 - x = \frac{44}{6}x$

$8.33x = 12$

$x = \frac{12}{8.33}$

$x = 1.44$ mm

40. Ans: (A)

Sol: The common point defects are

- Vacancy - a missing atom in the lattice structure;
- Ion-pair vacancy (Schottky defect) - a missing pair of ions of opposite charge in a compound;
- Interstitialcy - a distortion in the lattice caused by an extra atom present
- Frenkel defect - an ion is removed from a regular position in the lattice and inserted into an interstitial position not normally occupied by such an ion.

41. Ans: (D)

Sol:

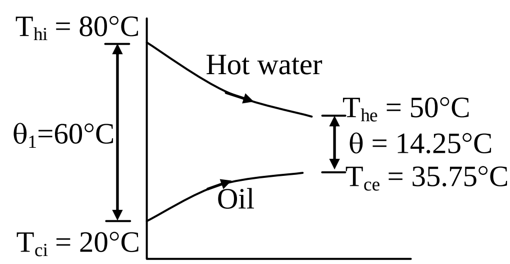
$$[A/B] = \begin{bmatrix} 1 & 2 & 3 & 14 \\ 1 & 4 & 7 & 30 \\ 1 & 1 & 1 & \lambda \end{bmatrix} \sim \begin{bmatrix} 1 & 2 & 3 & 14 \\ 0 & 2 & 4 & 16 \\ 0 & 0 & 0 & 2\lambda-12 \end{bmatrix}$$

To be consistent Rank of augmented matrix ($\rho(A/B)$) and Rank of A matrix should be equal.

$\rho(A/B) = \rho(A) = 2\lambda - 12 = 0 \Rightarrow \lambda = 6$

42. Ans: 31.82 (Range: 31 to 32.5°C)

Sol:



$$(\dot{m})_{water} = \rho \times \dot{v}_{water}$$

(where, $\dot{v}_{water}$ = volume flow rate of hot water)

$= 1000 \times 0.01 = 10$ kg/min

$$(\dot{m})_{oil} = \rho \dot{v}_{oil}$$

(where, $\dot{v}_{oil}$ = volume flow rate of oil)

$= 800 \times 0.05 = 40$ kg/min

$C_{P(water)} = 4.2$ kJ/kgK

$C_{P(oil)} = 2$ kJ/kgK

Energy balance:

Energy released by hot water = Energy received by cold oil

$$(\dot{m})_{water} \times C_{P\,water} \times (T_{hi} - T_{he}) = (\dot{m})_{oil} \times C_{p\,oil} \times (T_{ce} - T_{ci})$$

$$10 \times 4.2 \times (80 - 50) = 40 \times 2 \times (T_{ce} - 20)$$

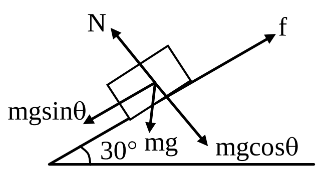
$T_{ce} = 35.75°C$

$$\text{LMTD} = \frac{\theta_1 - \theta_2}{\ell n\left(\frac{\theta_1}{\theta_2}\right)} = \frac{60 - 14.25}{\ell n\left(\frac{60}{14.25}\right)}$$

LMTD = 31. 82°C

43. Ans: 0 **[Range: 0 to 0]**

Sol:



For motion along the incline

Maximum Frictional Force,

$f_{max} = \mu N = \mu mg\cos\theta$

$$= 0.2 \times 2 \times 10 \times \frac{\sqrt{3}}{2} = 3.464 \text{ N}$$

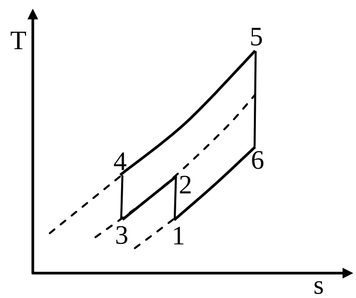
Net force down the incline = mgsinθ

$= 2 \times 10 \times \sin 30 = 10$ N

Since, net force down the incline is greater than f_{max}, so no force is needed to move the block down i.e. it will move by itself.

44. Ans: 25.4 **[Range 25.00 to 26.00]**

Sol:



$$r_p = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{2}{3}\left(\frac{\gamma}{\gamma-1}\right)}$$

$$\therefore (r_p) = \left(\frac{1200}{300}\right)^{\frac{2}{3}\left(\frac{\gamma}{\gamma-1}\right)} = 25.4$$

<u>Derivation for the above result</u>

$$W_c = C_p[T_2 - T_1] + C_p[T_4 - T_3] = 2C_p \times T_1\left[(r_p)^{\frac{\gamma-1}{2\gamma}} - 1\right]$$

Because $T_1 = T_3$ and $T_2 = T_4$ & $r_p = r_{p1} \times r_{p2}$

$$W_T = C_p[T_5 - T_6]$$

$$W_{net} = C_p T_5\left[1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}}\right] - 2C_p T_1\left[(r_p)^{\frac{\gamma-1}{2\gamma}} - 1\right]$$

Taking $\frac{\gamma - 1}{\gamma} = x$;

$T_5 = T_{max}$, $T_1 = T_{min}$

$$W_{net} = C_p\left[T_{max}\left(1-\left(\frac{1}{r_p}\right)^x\right)\right] - 2C_p \times T_{min}\left[(r_p)^{\frac{x}{2}} - 1\right]$$

$$\therefore \frac{dW}{d(r_p)} = C_P\left[T_{max}\left(x(r_p)^{-(x+1)}\right) - 2T_{min}\frac{x}{2}(r_p)^{\frac{x}{2}-1} - 0\right]$$

$$T_{max}(r_p)^{-(x+1)} = T_{min}(r_p)^{\left(\frac{x}{2}-1\right)}$$

$$\left(\frac{T_{max}}{T_{min}}\right) = (r_p)^{\frac{x}{2}+x} = (r_p)^{\frac{3x}{2}}$$

45. Ans: 0.917 (Range: 0.914 to 0.920)

Sol: Upward deflection of the tip due to uniformly distributed load 'q_o' is given by,

$$\delta_1 = \frac{q_o \ell^4}{8EI}$$

$$= \frac{10W\ell^3}{8EI} \quad (\because \text{Given that } q_0.l = 10\text{ W})$$

Downward deflection of the tip due to tip mass of weight 'W' is given by,

$$\delta_2 = \frac{W\ell^3}{3EI}$$

Net upward deflection of the tip is given by,

$$\delta = \delta_1 - \delta_2$$

$$\therefore K\frac{W\ell^3}{EI} = \frac{10W\ell^3}{8EI} - \frac{W\ell^3}{3EI}$$

$$\therefore K\frac{W\ell^3}{EI} = \left(\frac{11}{12}\right)\frac{W\ell^3}{EI}$$

$\therefore$ K = 0.917

46. Ans: 1.84 (Range 1.75 to 1.95)

Sol: D_1 = 100 mm, D_2 = 50 mm,

μ = 0.15, P = 3 kW

$P_{max} = P_2$ = 0.3 MPa, n_1 = 5, n_2 = 4

Number of pairs of contact surfaces,

$n = n_1 + n_2 - 1 = 8$

Maximum torque it can transmit,

$$T_{max} = \frac{\mu W}{4}(D_1 + D_2)$$

$$W = \pi C(D_1 - D_2)$$

$$C = P_1R_1 = P_2R_2 = P_{max} \times \frac{D_2}{2}$$

$$= 0.3 \times \frac{50}{2} = 7.5 \text{ N/mm}$$

W = π × 7.5(100 –50)

W = 1177.5 N

$$T_{max} = \frac{0.15 \times 1177.5(50+100) \times 8}{4 \times 1000}$$

T_{max} = 52.96 N-m

Torque transmitted by clutch

$$T = \frac{60P}{2\pi N} = \frac{60 \times 3000}{2\pi \times 1000} = 28.66 \text{ N-m}$$

Factor of safety is,

$$FOS = \frac{T_{max}}{T} = \frac{52.96}{28.66} = 1.84$$

47. Ans: (C)

Sol: Number of ways we can distribute 5 red balls into 3 numbered boxes

= C(3–1+5, 5) = 21

Similarly we can distribute 5 white balls in 21 ways and 5 blue balls in 21 ways.

By product rule, required number of ways

= (21) (21) (21) = 9261

48. Ans: 26.69 (range 25.5 to 27.5)

Sol: S = 30.5 mm, d = 2mm

Best wire size, $d = \frac{p}{2}\sec\left(\frac{\alpha}{2}\right)$

$$= \frac{3.5}{2}\sec 30^o = 2.02 \text{ mm} \approx 2 \text{ mm}$$

$\therefore$ The wire used is the best wire.

R_1 = 14.5642 mm,

R_2 = 13.7683 mm

Micrometer reading, $M = S + (R_2 - R_1)$

= 30.5 + (13.7683 – 14.5642)

= 29.7041 mm

Effective diameter = $M - \left(d + \frac{p}{2}\tan\left(\frac{\alpha}{2}\right)\right)$

$$= 29.7041 - \left(2 + \frac{3.5}{2}\tan 30^o\right)$$

= 26.69 mm

49. Ans: 1000 (Range 1000 to 1000)

Sol: Clapeyron equation is

$$\left(\frac{dP}{dT}\right) = \frac{h_{fg}}{T_{sat}(v_g - v_f)}$$

$$= \left(\frac{dP}{dT}\right) = 0.1 \text{bar}/k = 10 \text{kPa}/K$$

$v_g – v_f$ = (0.251–0.001)m^3/kg = 0.250m^3/kg

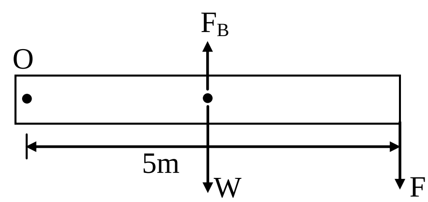
T_{sat} = 400 K

$$\therefore \quad h_{fg} = T_{sat}(v_g - v_f)\left(\frac{dP}{dT}\right)_s$$

$$= 400 \times 0.250 \times 0.1 \times 100 = 1000 \text{kJ/kg}$$

50. Ans: 75 (Range: 75 to 75)

Sol: The F.B.D of the timber block is shown as under:



For the timber block to float horizontally, we consider, $\Sigma M_o = 0$, i.e.,

$$F \times 5 + W \times \frac{5}{2} = F_B \times \frac{5}{2}$$

where W is the weight of the timber block and F_B is the buoyancy force on the timber block.

Thus,

$$F = (F_B - W)\frac{1}{2} = (\gamma_{oil} \times 0.1^2 \times 5 - \gamma_{block} \times 0.1^2 \times 5) \times \frac{1}{2}$$

$$= (900 \times 10 \times 0.1^2 \times 5 - 600 \times 10 \times 0.1^2 \times 5) \times \frac{1}{2}$$

= 75 N

51. Ans: (B)

Sol: Given data:

Welding Process: I

$V_1 = 60$ V ; $I_1 = 50$ A

$N_1 = 150$ mm/min ; $\eta_2 = 90\% = 0.9$

Welding Process: II

$V_2 = 60$ V ; $I_2 = ?$

$N_2 = 120$ mm/min ; $\eta_2 = 88\% = 0.88$

(Heat input per unit length)$_1$ = (Heat input per unit length)$_2$

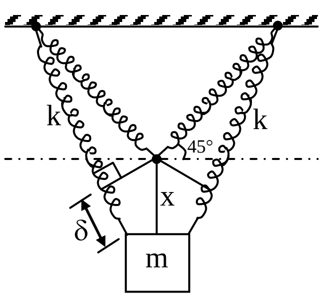
$$\frac{V_1 I_1}{N_1} \times \eta_1 = \frac{V_2 I_2}{N_2} \times \eta_2$$

$$\frac{60 \times 50}{150} \times 0.9 = \frac{60 \times I_2}{120} \times 0.88$$

$\Rightarrow$ $I_2 = 40.9$ Amp

52. Ans: (A)

Sol:



Let the mass moves by a distance x

Elongation in spring, $\delta = x\cos 45$

Force on the mass along x direction = – 2 kxcos45×cos45

$$= -2kx\cos^2 45$$

$$= \frac{-2kx}{2}$$

$$= -kx$$

$\therefore$ Acceleration $= -\omega_n^2\, x = \frac{-kx}{m}$

$$\omega_n = a\sqrt{\frac{k}{m}} = \sqrt{\frac{k}{m}}$$

$\therefore$ a = 1

53. Ans: 3028 (Range: 3020 to 3050)

Sol: Given:

$Q = 0.02\pi$ m^3/s, $d_i = 0.2$ m,

$d_o = 0.21$ m, H = 20 m.

$$V = \frac{Q}{A} = \frac{4Q}{\pi d_i^2} = \frac{4 \times 0.02\pi}{\pi \times 0.2^2} = 2 \text{ m/s}$$

Velocity of sound,

$C = \sqrt{\frac{K}{\rho}}$ for pipe material as rigid.

$$= \sqrt{\frac{2 \times 10^9}{10^3}} = 10^3\sqrt{2} = 1414 \text{ m/s}$$

$P = \rho VC = 10^3 \times 2 \times 1414 = 2828$ kPa

The maximum pressure near the inlet would be equal to = P + ρgH

$$= 2828(\text{kPa}) + \frac{10^3 \times 10 \times 20}{10^3}(\text{kPa})$$

= 3028 kPa

54. Ans: 1.25 (Range: 1.2 to 1.30)

Sol: Taking its dual we get

minimize $t = x' + 2z'$

$10x' + 2z' \geq 11$

$x' - 2z' \geq 0$

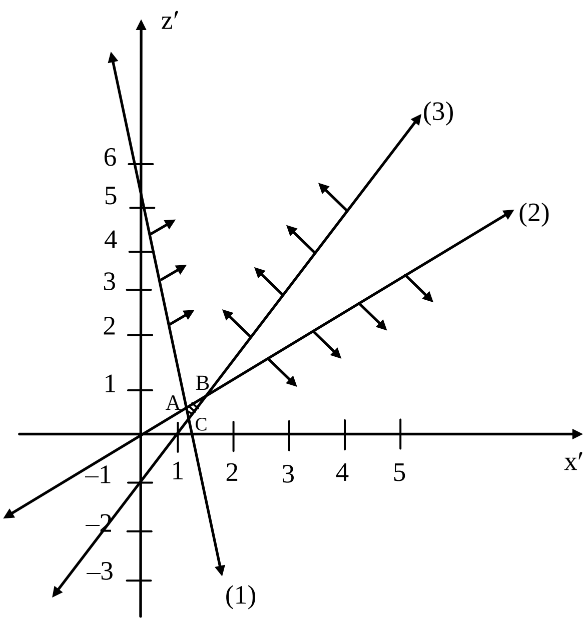
$-x' + z' \geq -1 \Rightarrow x' - z' \leq 1$

or $\dfrac{x'}{11/10} + \dfrac{z'}{11/2} \geq 1$......(1)

$x' = 2z'$.......(2)

$\dfrac{x'}{1} + \dfrac{z'}{-1} \leq 1$.......(3)

Plotting these three equations we get the following graph



Solving equation (1) & (2) we get, point A(1, 1/2)

Similarly solving equation (2) & (3), we get point B (2, 1)

And solving equation (1) & (3) we get point C(13/12,1/12)

Putting these values in new objective function, i.e minimize $t = x' + 2z'$

The values for point

A(1,1/2) = 1 + 2×1/2 = 2

B (2,1) = 2 + 2×1 = 4

C(13/12,1/12) = 13/12 + 2×1/12 = 1.25

The minimum value of dual is 1.25.

Therefore, the maximum value of w i.e. primal objective function is 1.25.

55. Ans: (B)

Sol: Total marbles = 10 + 30 + 20 + 15 = 75

P[both are white]

= P[first is white and second is white]

$= \dfrac{35}{75} \times \dfrac{35}{75} = \dfrac{4}{25}$

56. Ans: (A)

Sol: Vulgarity (n.) means offensive speech or conduct.

57. Ans: (A)

58. Ans: (B)

59. Ans: (A)

Sol: Cylinder volume = $\pi r^2 h$

$$= \frac{22}{7} \times 10 \times 10 \times 14 = 4400 \text{ m}^3$$

60. Ans: (D)

Sol: Speed = 10 kmph

$$= 10 \times \frac{5}{18} m/\sec = \frac{50}{18} m/\sec$$

Man walks 50 m in 18 sec.

61. Ans: (D)

Sol: Rate downstream = (24/2) kmph = 12 kmph.

Rate upstream = (24/4) kmph = 6 kmph.

Therefore, speed in still water

= 1/2* (12 + 6) = 9 kmph.

62. Ans: (B)

Sol: Let principle be 4. Then amount = $4 \times \frac{7}{4} = 7$

Interest = 7 - 4 = 3

Rate of interest $= \frac{3 \times 100}{4 \times 4} = 18\frac{3}{4}\%$

63. Ans: (C)

Sol: Net part filled in 1 hour

$$= \frac{1}{10} + \frac{1}{12} - \frac{1}{20} = \frac{6+5-3}{60}$$

$$= \frac{11-3}{60} = \frac{8}{60} = \frac{2}{15}$$

The tank will be full in $\frac{15}{2}$ hrs

= 7 hrs.30 min.

64. Ans: (A)

Sol: Share of wealth that C gets (in Rs lakhs)

= 20

Tax = 40%

⇒ Wealth tax (in Rs lakhs) that C has to pay

$$= \frac{40}{100} \times 20 = 8$$

65. Ans: (A)

Sol: Note that an assumption is like a premise in that if it is wrong the argument is invalid, and if it is right it supports the conclusion. If the statement in (A) is correct, it supports the idea that point and shoot is not art, but if it is wrong, and choosing what to point the camera at involves art, then the argument is invalid. Hence, (A) is an assumption.