MECHANICAL ENGINEERING MOCK - B __ Solutions

01. Ans: (D)

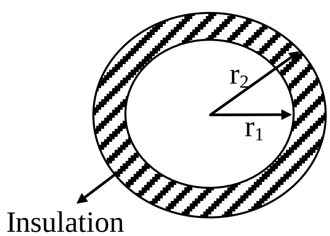
Sol: $a_{cm} = \dfrac{m_1a_1 + m_2a_2}{m_1 + m_2}$

$a_1 = a_2 = g$

$\Rightarrow a_{cm} = g$

02. Ans: (C)

Sol:



$d_1 = 1$ cm

$r_1 = 0.5$ cm $= 5$ mm

$h_o = 12$ W/m^{2}K

$(k)_{insu} = 0.108$ W/mK

For maximum heat transfer,

Critical radius $= r_c = r_2 = \dfrac{k_{insu}}{h_0} = \dfrac{0.108}{12}$

$= 9\times10^{-3}$ m

$r_2 = 9$ mm

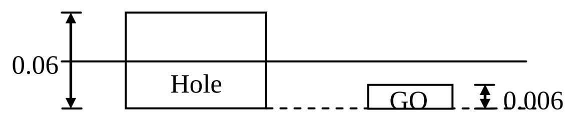
Critical thickness $= r_2 - r_1$

$= 9 - 5 = 4$ mm

03. Ans: (B)

Sol: Work tolerance on hole = 0.06 mm

Gauge tolerance = 0.006 mm



$(\text{Upper limit})_{\text{GO gauge}} = 30 - 0.03 + 0.006$

$= 29.976$ mm

$(\text{Lower limit})_{\text{GO gauge}} = 30 - 0.03$

$= 29.970$ mm

$\therefore$ GO gauge dimensions

$= 29.976^{+0.000}_{-0.006}$ or $29.970^{+0.006}_{-0.000}$

04. Ans: (D)

Sol: Friction at the sleeve of centrifugal governor makes it insensitive over a small range of speed. The position of the sleeve remains unchanged over a range of speed.

05. Ans: 24

Sol: Given that $F(x) = f(g(x))$

$\Rightarrow F^1(x) = f^1(g(x)).\ g^1(x)$ ($\because$ by chain rule)

$\Rightarrow F^1(5) = f^1(g(5)).\ g^1(5)$

$\Rightarrow F^1(5) = f^1(-2)\ .6$

$\therefore F^1(5) = (4)\ (6) = 24$

06. Ans: (C)

Sol: Entropy change of iron block

$$\Delta S_{iron} = \int \frac{\delta Q}{T} = \int mC_{av}\frac{dT}{T}$$

$$= mC_{av}\ell n\left(\frac{T_2}{T_1}\right)$$

$$= 50\times 0.45\times \ell n\left(\frac{285}{500}\right)$$

$$= -12.65 \text{ kJ/K}$$

07. Ans: 390 [Range 390 to 390]

Sol: σ_E = 300 MPa

Engineering strain, $e = \frac{\ell - \ell_0}{\ell_0} = \frac{1.3\ell_0 - \ell_0}{\ell_0}$

$$e = 0.3$$

Now, $\sigma_T = \sigma_E (1 + e)$

$= 300 (1 + 0.3)$

σ_T = 390 MPa

08. Ans: (B)

Sol: $\eta_T = \frac{(P-d)t(\sigma_t)_{per}}{P.t.(\sigma_t)_{per}} = 0.8$

$$\left(1 - \frac{d}{P}\right) = 0.8$$

$$\frac{d}{P} = 0.2 \Rightarrow P = \frac{20}{0.2}$$

P = 100 mm

09. Ans: 10 [Range 10 to 10]

Sol: $Q^* = \sqrt{\frac{2DC_0}{C_c}}$

$$= \sqrt{\frac{2\times 8000\times 300}{30}} = 400 \text{ units}$$

$$N = \frac{D}{Q^*} = \frac{8000}{400} = 20 \text{ orders}$$

Time between orders

$$T = \frac{\text{Number of working days}}{N}$$

$$T = \frac{200}{20} = 10 \text{ working days}$$

With 20 orders placed each year, an order for 400 transistors is placed every 10 working days.

10. Ans: (D)

Sol: We know that,

$P(A \cap B) \le$ min of $\{P(A), P(B)\}$

$\Rightarrow P(A \cap B) \le 0.25$ .... (1)

we have, $P(A \cup B) \le P(S)$

$\Rightarrow \{P(A) + P(B) - P(A \cap B)\} \le 1$

$\Rightarrow \{0.25 + 0.8 - P(A \cap B)\} \le 1$

$\Rightarrow 0.05 \le P(A \cap B)$ .... (2)

From (1) and (2), we have

$0.05 \le P(A \cap B) \le 0.25$

11. Ans: (A)

Sol: A joint produced without a filler metal is called autogenous, and its weld zone is composed of the resolidified base metal. A joint made with a filler metal has a central zone called the weld metal and is composed of a mixture of the base and the filler metals.

12. Ans: (B)

Sol: Dimensions of a unit cell representing a tetragonal unit are:

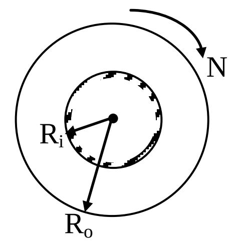
$$a = b \neq c \; ; \; \alpha = \beta = \gamma = 90^{o}.$$

Unit cell:

- A unit cell is a part of the material which explains whole structure of the material.
- A unit cell of three dimensional crystal lattice is formed by intercepts a, b and c along the three axes respectively i.e. x, y and z.
- The three angles α, β and γ are called the inter facial angles of the crystal. The intercepts and interfacial angles constitute the lattice parameter. A 'primitive cell' may be defined as unit cells, which possess lattice points at its corners only.

13. Ans: (B)

Sol:



$$\tau = \frac{F}{A} = \frac{T/R_o}{2\pi R_o L} = \text{constant}$$

$$\frac{du}{dy} = \frac{(2\pi N/60)\times R_o}{R_o - R_i} \propto N$$

Thus, shear stress is constant and shear strain rate increases with respect to time. The apparent viscosity $\left[\mu_a = \frac{\tau}{(du/dy)}\right]$ decreases with respect to time. Hence, the type of fluid is thixotropic.

14. Ans: (C)

Sol: $A_1 = A_2$ (from the figure)

$$F_{1\text{-}2} = F_{2\text{-}1} = 1 - \sin\left(\frac{\alpha}{2}\right)$$

$$F_{1\text{-}2} = 1 - \sin\left(\frac{10}{2}\right) = 1 - \sin 5 = 0.912$$

15. Ans: (A)

Sol: $|\text{adj}A| = |A|^{n-1}$

$\Rightarrow \; -11\,(4-6) + 3\,(4-6) = |A|^2$

$\Rightarrow \; 22 - 6 = |A|^2$

$\therefore \; |A| = \pm 4$

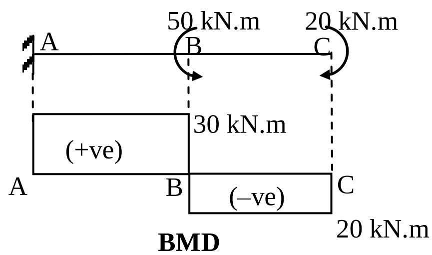
16. Ans: (B)

17. Ans: (D)

Sol:

- For a given cantilever beam, portion BC is subjected to constant (hogging) bending moment of 20 kN.m.
- Portion AB is subjected to constant (sagging) bending moment of (50 – 20) = 30 kN.m.

Thus, the bending moment diagram can be drawn as shown in the figure below.



18. Ans: (C)

Sol: Following are values of hot hardness temperatures of the following tool materials:

- Carbide – 1000^oC
- Stellite – 800^oC
- Ceramic – 1200^oC
- High speed steel – 600^oC

19. Ans: (C)

Sol: $a_x = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + \frac{\partial u}{\partial t}$

$$= \left(\frac{x}{t}\right)\left(\frac{1}{t}\right) + \left(\frac{-y}{t}\right)(0) + \left(\frac{-x}{t^2}\right)$$

$$= 0$$

$$a_y = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + \frac{\partial v}{\partial t}$$

$$= \left(\frac{x}{t}\right)(0) + \left(\frac{-y}{t}\right)\left(\frac{-1}{t}\right) + \left(\frac{y}{t^2}\right)$$

$$= \frac{2y}{t^2}$$

$$\vec{a} = a_x\hat{i} + a_y\hat{j} = 0\hat{i} + \frac{2y}{t^2}\hat{j}$$

$$= \frac{2y}{t^2}\hat{j}$$

20. Ans: (B)

Sol: For N stage reciprocating compressor, the optimum pressure ratio per stage for minimum work is given by

$$r = \left(\frac{P_d}{P_s}\right)^{\frac{1}{N}}$$

Where, P_d = discharge pressure,

P_s = suction pressure

For 4 stage reciprocating compressor, N = 4

$\therefore \quad r = (16)^{1/4} = 2$

21. Ans: 1

Sol: If rank of A is 2, then |A| = 0

$\Rightarrow (x-1)\ (x^2 + x + 1) = 0$

$\Rightarrow x = 1,\ \dfrac{-1 \pm \sqrt{3}\,i}{2}$

$\therefore x = 1$

22. Ans: 75 [Range: 75 to 75]

Sol: Given data:

F = 10 kN, b = 200 mm, τ_{max} = 1 MPa

For a rectangular beam,

$$\tau_{max} = \frac{3}{2} \times \tau_{avg}$$

$$\therefore\ 1 = \frac{3}{2} \times \frac{F}{b.d}$$

$$\therefore\ 1 = \frac{3}{2} \times \frac{10 \times 10^3}{200 \times d}$$

$\therefore$ d = 75 mm

23. Ans: (B)

Sol: $t \propto \left(\dfrac{V}{A}\right)^2$

$t \propto \left(\dfrac{\ell^3}{6\ell^2}\right) \Rightarrow t \propto \ell^2$

V = 8 times

$\ell = \sqrt[3]{8} = 2$ times

$\therefore$ t = 4 times

24. Ans: (D)

Sol: $(1+t)\dfrac{dy}{dt} = 4y$

$$\int \frac{1}{y}\,dy = \int \frac{4}{1+t}\,dt$$

Log y = 4 log (1+t) +logc

$y = c(1+t)^4$

$y(0) = 1 \Rightarrow 1 = c(1+0)^4 \Rightarrow c = 1$

$\Rightarrow y = (1+t)^4$

25. Ans: 3 [Range: 3 to 3]

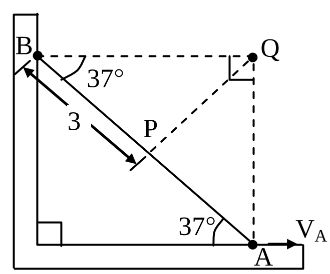
Sol: $Q_2 = \dfrac{Q_1}{2}(1+\cos\theta)$

$$Q_3 = \frac{Q_1}{2}(1-\cos\theta)$$

$$\frac{Q_2}{Q_3} = \frac{1+\cos 60}{1-\cos 60} = 3$$

26. Ans: (B)

Sol:



'Q' is instantaneous centre of link AB with respect to rigid frame

$V_B = BQ.\omega_{AB}$

$$\omega_{AB} = \frac{10}{5\cos 37} = 2.504 \text{ rad/s}$$

$V_P = PQ.\omega_{AB}$

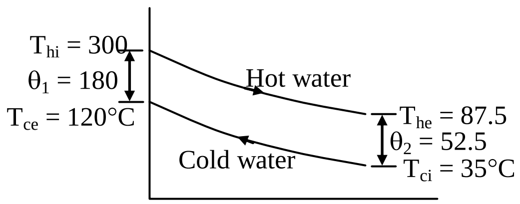
$$PQ = \sqrt{3^2 + (5\cos 37)^2 - 2\times 3\times (5\cos 37).\cos 37}$$

$$= \sqrt{9 - 5\cos^2 37} = 2.41$$

$V_P = 2.41\times 2.504 = 6.034$ m/s

27. Ans: 103.47 [Range: 102 to 105]

Sol: Energy balance:



Heat released by hot water = Heat received by cold water

$$\dot{m}_h C_{ph}(T_{he} - T_{he}) = \dot{m}_c C_{pc}(T_{ce} - T_{ci})$$

($\because$ both fluid is water)

$5000(300 - T_{he}) = 12500(120 - 35)$

$300 - T_{he} = 2.5 \times 85$

$T_{he} = 300 - 212.5 = 87.5$

$\because (T_{ce} = 120^\circ C) > (T_{he} = 87.5^\circ C)$

$\therefore$ It is counter flow type of heat exchanger.

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

$$= \frac{180 - 52.5}{\ell n\left(\frac{180}{52.5}\right)} = 103.47^\circ C$$

28. Ans: (D)

Sol: We know that, natural frequency is given by,

$\delta \rightarrow$ static deflection of mass

$$\delta' = \frac{2mg}{s} = \text{deflection of spring}$$

Deflection of mass,

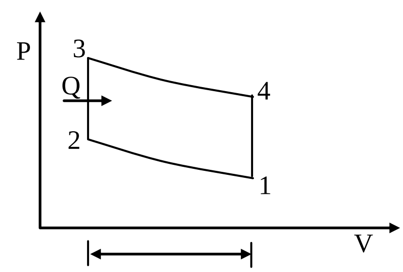
$$\delta = 2\delta' = \frac{4\,mg}{s}$$

$$\omega_n = \sqrt{\frac{g}{4\,mg}\times s} = \sqrt{\frac{s}{4m}}$$

$$\omega_n = \sqrt{\frac{1000}{4\times 5}} = 7.07\ \text{rad/s}$$

29. Ans: 768 [Range: 766 to 769]

Sol:



$V_c = V_3 = V_2 = 120.4$ cc

$$V_s = \frac{\pi}{4}D^2L = \frac{\pi}{4}\times 8^2 \times 12 = 603.2 \text{ cc}$$

$V_1 = V_S + V_c = 723.6$ cc

$$\text{Compression ratio, } r = \frac{V_1}{V_2} = \frac{723.6}{120.4} = 6$$

The efficiency of Otto cycle is given by,

$$\eta = 1-\frac{1}{(r)^{\gamma-1}} = 1-\frac{1}{(6)^{0.4}} = \frac{W}{Q_s}$$

$$0.512 = \frac{W}{1500}$$

$\therefore$ W = 768 kJ/kg

30. Ans: 0.2 [Range: 0.15 to 0.25]

Sol: Given that $\frac{dy}{dx} = x^3 - 2y$ $\left(\because \frac{dy}{dx} = f(x,y)\right)$

with y(0) = 0.25 $(\because y(x_0) = y_0)$

Let $x_0 = 0$, $y_0 = 0.25$ & h = 0.1

Then $x_1 = x_0 + h = 0.1$

The formula for Euler's forward method is

$y(x_1) \simeq y_1 = y_0 + h\, f(x_0, y_0)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\left(x_0^3 - 2y_0\right)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\,[0 - 2(0.25)]$

$\therefore y(0.1) \simeq y_1 = 0.25 - (0.1)(0.5)$

$= 0.25 - 0.05 = 0.2$

31. Ans: 105 [Range: 104 to 106]

Sol: Given data:

$\sigma_y = 21$ MN/m^2

$\tau_{xy} = -56$ MN/m^2

$\sigma_{min} = -7$ MN/m^2

Minimum principal stress is given by,

$$\sigma_{min} = \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\therefore -7 = \frac{\sigma_x + 21}{2} - \sqrt{\left(\frac{\sigma_x - 21}{2}\right)^2 + (-56)^2}$$

$$\therefore \left(\frac{\sigma_x - 21}{2}\right)^2 + (56)^2 = \left(\frac{\sigma_x + 21}{2} + 7\right)^2$$

$$\therefore \left(\frac{\sigma_x - 21}{2}\right)^2 - \left(\frac{\sigma_x + 35}{2}\right)^2 = -(56)^2$$

$$\therefore \left(\frac{-21-35}{2}\right)\left(\frac{2\sigma_x + 14}{2}\right) = -(56)^2$$

$$\therefore \sigma_x + 7 = -\frac{(56)^2}{(-56/2)}$$

$\therefore \sigma_x = 105$ MN/m^2

32. Ans: (D)

Sol: $T_P = 25$, $\omega_P = 1200$ rpm,

$\omega_G = 200$ rpm, m = 4 mm

$$\frac{T_G}{T_1} = \frac{\omega_P}{\omega_G}$$

$$T_G = \frac{1200}{200} \times 25 = 150$$

Center distance (c) = $\frac{m}{2}(T_G + T_P)$

$$c = \frac{4}{2}(25 + 150) = 350\text{ mm}$$

33. Ans: (D)

Sol: $\lambda = 6$ customers per hour

$\mu = 10$ customers per hour

Traffic intensity = $\rho = \frac{\lambda}{\mu} = \frac{6}{10} = 0.6$

Expected time a customer spends in the system = $W_s = \frac{1}{\mu - \lambda}$

$$= \frac{1}{(10-6)} = \frac{1}{4}\text{hr} = 15 \text{ min}$$

Expected probability that a customer shall wait for more than t minutes in the queue

$$= W_q(t) = \rho e^{-t/w_s}$$

$$W_q(10) = 0.6 \times e^{-10/15} = 0.31$$

Probability of waiting upto 10 min in the queue = 1 – probability of waiting greater than 10 min.

$$= 1 - 0.31 = 0.69$$

34. Ans: (C)

Sol: d = 100 mm,

t = 3 mm,

τ_u = 50 MPa,

S = 1 mm,

k = 50%

$F_{max} = \pi dt\, \tau_u$

$= \pi \times 100 \times 3 \times 50 = 47.12$ kN

Since, work done with shear = work done without shear

$\therefore$ F (kt + S) = F_{max} kt

$$F = \frac{47.12}{1 + \frac{1}{0.5 \times 3}}$$

F = 28.272 kN

35. Ans: (B)

Sol: Given $v = y + e^{-x}\cos y$

$\Rightarrow$ $v_x = -e^{-x}\cos(y)$

and $v_y = 1 - e^{-x}\sin(y)$

Consider

$du = (u_x)\,dx + (u_y)\,dy = (v_y)\,dx + (-v_x)\,dy$

$\Rightarrow du = (1 - e^{-x}\sin y)\,dx + (e^{-x}\cos y)\,dy$

$\Rightarrow \int du = \int (1 - e^{-x}\sin y)\,dx + \int 0\,dy + k$

$\Rightarrow u = x + e^{-x}\sin y + k$

Now the required analytic function f(z) is given by f(z) = u + i v

$\Rightarrow f(z) = (x + e^{-x}\sin y + k) + i\,(y + e^{-x}\cos y)$

$\therefore f(z) = z + ie^{-z} + k$

36. Ans: (A)

Sol: The four single phases in the iron carbon phase diagram are:

1. *Ferrite (alpha):* Which is the room temperature body centred cubic structure.
2. *Austenite (gamma):* Which is the room temperature body centred cubic phase.
3. *Delta-ferrite (delta):* The high temperature body centred cubic phase.
4. *Cementite (Fe_3C):* The iron carbon intermetallic compound that occurs at 6.67 wt. percent carbon.

37. Ans: (D)

Sol: For the valve to remain closed, the moment due to the buoyant force on the ball must equal the moment due to resultant force on the valve.

Or, $F_R \times 1 = F_B \times 5$

$$\gamma_{water} \times 8.0 \times \frac{\pi}{4} \times 0.01^2 \times 1 = \gamma_{water} \times \forall_{submerged} \times 5$$

Or, $\forall_{submerged} = 8.0 \times \frac{\pi}{4} \times 0.01^2 \times \frac{1}{5}$

$= 0.4\pi \times 0.01^2 \text{ m}^3$

$= 40\pi \text{ cm}^3$

38. Ans: 5 [Range: 5 to 5]

Sol: Torque about hinge, $\tau = 10 \times 1 = 10$ N-m

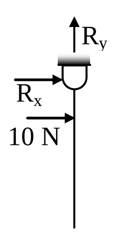
$\tau = I\alpha$

$$10 = \frac{10 \times 3^2}{3 \times 3} \times \alpha \Rightarrow \alpha = 1 \text{rad/s}^2$$

Tangential acceleration of centre of mass,

$$(a_t)_{cm} = \frac{L}{2} \times \alpha = \frac{3}{2} \times 1 = \frac{3}{2} \text{m/s}^2$$

F.B.D of rod is shown below:



Net force along horizontal direction = Mass × Acceleration of centre of mass along horizontal direction

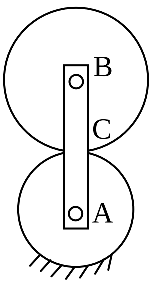
$$R_x + 10 = \frac{10}{3} \times \frac{3}{2}$$

$R_x = -5$ N

39. Ans: (B)

Sol: $T_A = 130$, $T_B = 55$

$N_B = 95$ rpm



$$\frac{N_B - N_C}{N_A - N_C} = -\frac{T_A}{T_B}$$

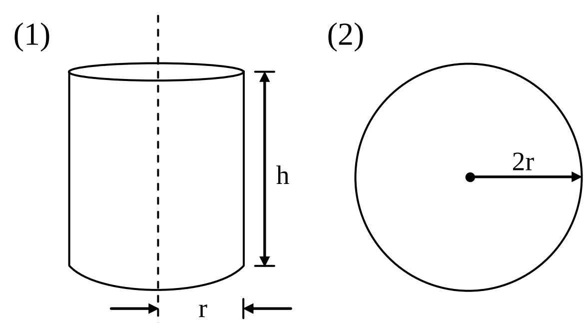
$$\frac{95 - N_C}{-N_C} = -\frac{130}{55}$$

$95 \times 55 - 55N_C = 130N_C$

$$N_C = \frac{95 \times 55}{185} = 28.24 \text{ rpm}$$

40. Ans: (A)

Sol:



Modulus of casting 1,

$$m_1 = \frac{\pi r^2 h}{2\pi rh + 2\pi r^2}$$

$$= \frac{\pi r^3}{4\pi r^2} = \frac{r}{4}$$

Modulus of casting 2,

$$m_2 = \frac{\frac{4}{3}\pi(2r)^3}{4\pi(2r)^2} = \frac{2r}{3}$$

$$\frac{\tau_1}{\tau_2} = \left(\frac{m_1}{m_2}\right)^2 = \left(\frac{r}{4\times 2r}\times 3\right)^2 = \left(\frac{3}{8}\right)^2 = 0.14$$

41. Ans: (A)

Sol: Given $(2xy - 9x^2)dx + (2y + x^2+1)dy = 0$

Here, $M = 2xy - 9x^2$

and $N = 2y + x^2 + 1$

Now, $\frac{\partial M}{\partial y} = 2x = \frac{\partial N}{\partial x}$

$\therefore$ The given D.E is exact

Now the general solution of the given D.E is

$\int(2xy - 9x^2)\,dx + \int(2y + 0 + 1)\,dy = C$

$\Rightarrow x^2y - 9\frac{x^3}{3} + y^2 + y = C$ .... (1)

but $y = -3$ at $x = 0$

Now (1) becomes

$0 - 0 + 9 - 3 = C$

$\Rightarrow C = 6$

$\therefore$ The solution of a given D.E is

$$x^2y - 3x^3 + y^2 + y = 6$$

42. Ans: 1140.9 [Range: 1138 to 1142]

Sol: Given: $T_1 = 50 + 273 = 423$ K,

$T_2 = 60 + 273 = 333$ K

Final temperature, $T = \frac{m_1T_1 + m_2T_2}{(m_1 + m_2)}$

$= \frac{100\times 150 + 50\times 60}{(100+50)} = 120°C$

Change in entropy (ΔS)

$$\Delta S = m_1 c\ell n\frac{T}{T_1} + m_2 c\ell n\frac{T}{T_2}$$

$$= 100\times 4.2\ell n\frac{393}{423} + 50\times 4.2\ell n\frac{393}{333}$$

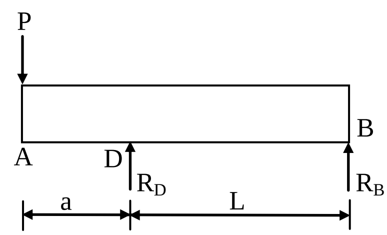
$= 3.894$ kJ/K

Decrease in availability $= T_o\Delta S$

$= 293 \times 3.894 = 1140.9$ kJ/kg

43. Ans: (C)

Sol:



By taking moment about point D,

$\Sigma M_D = 0$

$\therefore aP + LR_B = 0$

$\therefore R_B = -\frac{aP}{L}$ (downward)

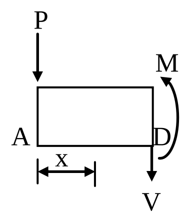
***Over the portion* AD:**

Bending moment at distance x from A,

$M = -Px$

Strain energy is given by,

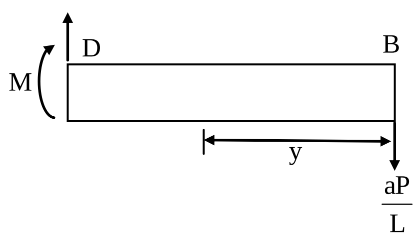
$$U_{AD} = \int_0^a \frac{M^2 dx}{2EI}$$



$$= \frac{1}{2EI}\int_0^a P^2 x^2 dx$$

$$= \frac{P^2}{2EI}\left[\frac{x^3}{3}\right]_0^a = \frac{P^2 a^3}{6EI}$$

Over the portion **DB:**



Bending moment at distance y from B,

$$M = -\frac{aP}{L}y$$

Strain energy,

$$U_{DB} = \int_0^L \frac{M^2}{2EI}dy = \frac{1}{2EI}\int_0^L \frac{a^2P^2}{L^2}y^2.dy$$

$$= \frac{a^2P^2}{2EIL^2}\left[\frac{y^3}{3}\right]_0^L$$

$$= \frac{a^2P^2L}{6EI}$$

Total strain energy of beam AB,

$$U = U_{AD} + U_{DB}$$

$$= \frac{P^2a^3}{6EI} + \frac{a^2P^2L}{6EI}$$

$$= \frac{P^2a^2}{6EI}(a + L)$$

44. Ans: 54 [Range: 53 to 55]

Sol: L = 576 mm, D = 100 mm,

N = 144 rpm, f = 0.2 mm/rev

Then, V = πDN

$= \pi \times 0.1 \times 144$

$= 45.24$ m/min

According to Taylor's equation,

$VT^{0.75} = 75$

$45.25 \times T^{0.75} = 75$

$\Rightarrow T = 2$ min

Time for turning one bar = $\dfrac{576}{0.2\times144}$

= 20 min

$\therefore$ Total number of tools required = $\dfrac{20}{2} = 10$

Hence, the total time required for one bar

= 10 (2 + 3) + 4 = 54 min

45. Ans: (B)

Sol: From the definition of the stream function,

$$v_r = -\frac{1}{r}\frac{\partial\psi}{\partial\theta} \quad \text{and} \quad v_\theta = \frac{\partial\psi}{\partial r}$$

We write

$$\frac{1}{r}\frac{\partial\psi}{\partial\theta} = -Ar^{-1} - Br^{-2}\cos\theta$$

Or, $$\frac{\partial\psi}{\partial\theta} = -A - Br^{-1}\cos\theta$$

Integrating with respect to θ, we get

$$\psi = -A\theta - Br^{-1}\sin\theta + f_1(r)$$

Differentiating with respect to r , we get

$$\frac{\partial\psi}{\partial r} = Br^{-2}\sin\theta + f_1'(r)$$

But $\frac{\partial\psi}{\partial r} = v_\theta = Br^{-2}\sin\theta + f_1'(r) = Br^{-2}\sin\theta$

or, $f_1'(r) = 0$

Integrating with respect to r,

$f_1(r) = C$

Then, $\psi = -A\theta - Br^{-1}\sin\theta + C$

where, C is an arbitrary constant.

Given that $\theta = 0, \psi = 0 \Rightarrow C = 0$

Hence, $\psi = -\left(A\theta + \frac{B\sin\theta}{r}\right)$

46. Ans: (D)

Sol: The steady flow energy equation per unit mass of air-fuel mixture between start and end of combustion chamber can be written as:

$$h_1 + \frac{V_1^2}{2} + Q = h_2$$

$$C_pT_1 + \frac{V_1^2}{2} + Q = C_p \times T_2$$

$Q = 1000 \times 10^3$ J/kg

$$1000\times300 + \frac{100^2}{2} + 1000\times10^3 = 1000\times T_2$$

$T_2 = 1305$ K

47. Ans: (D)

Sol: Given curve 'C' is a closed curve.

So, we have to evaluate the integral by using Green's theorem.

By Green's theorem, we have

$$\oint_C (M\,dx + N\,dy) = \iint_R \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right) dx\,dy$$

Now, $\oint_C [(x-y)dx + (x+3y)\,dy]$

$$= \iint_R \left[\frac{\partial}{\partial x}[x+3y] - \frac{\partial}{\partial y}(x-y)\right] dx\,dy$$

$$= \iint_R [1-(-1)]\,dx\,dy$$

$$= 2\iint_R 1\,dx\,dy = 2(\text{Area of the circle 'C'})$$

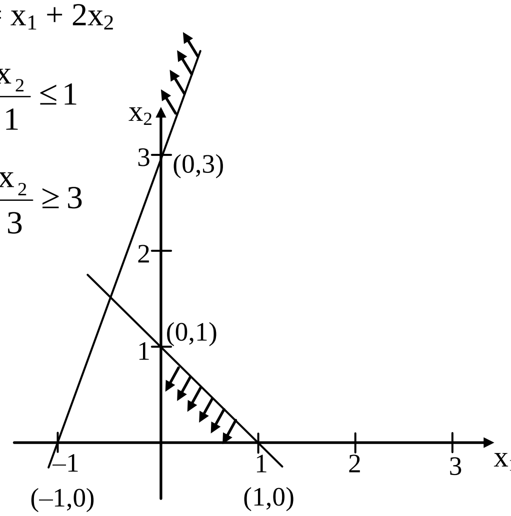
$= 2(\pi r^2)_{r=4} = 32\pi$

48. Ans: (A)

Sol: $Z_{max} = x_1 + 2x_2$

$$\frac{x_1}{1} + \frac{x_2}{1} \le 1$$

$$\frac{x_1}{-1} + \frac{x_2}{3} \ge 3$$

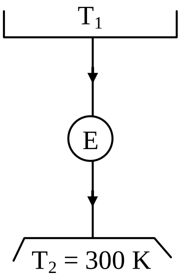


From the graph there is no common feasible solution.

49. Ans: (A)

Sol: $\eta_{carnot} = \dfrac{T_1 - T_2}{T_1} = \dfrac{T_1 - 300}{T_1}$

$\eta_E = 0.36$ or 36%



$$\eta_{2ndlaw} = \frac{\eta_E}{\eta_{carnot}}$$

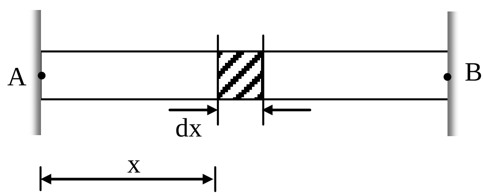
$$0.6 = \frac{0.36}{\frac{T_1 - 300}{T_1}}$$

$$\frac{0.6(T_1 - 300)}{T_1} = 0.36$$

$$\Rightarrow T_1 = 750\,K$$

50. Ans: (C)

Sol:



Let us consider an element of length dx at a distance x from A.

Given, at any distance x

$$\Delta T = \Delta T_B . \frac{x^3}{L^3}$$

dS = elongation of element dx

$= \alpha . \Delta T . dx$

$$= \alpha . \Delta T_B . \frac{x^3}{L^3} dx$$

δ = Total elongation of bar AB under free expansion

$$= \int_0^L \alpha . \Delta T_B . \frac{x^3}{L^3} . dx$$

$$= \frac{1}{4} L . \alpha . \Delta T_B$$

This deformation 'δ' has to be restricted.

$$\therefore \quad \sigma = E . \frac{\delta}{L}$$

$$= \frac{E \times \frac{1}{4} L . \alpha . \Delta T_B}{L}$$

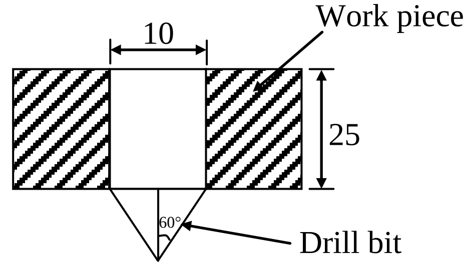
$$= \frac{1}{4} E . \alpha . \Delta T_B$$

$$= \frac{1}{4} \times 100 \times 10^3 \times 21 \times 10^{-6} \times 40$$

= 21 MPa

51. Ans: 15.3 [Range: 15 to 16]

Sol:



Total length travelled by drill bit,

$$= 25 + \frac{10}{2 \tan 60^o} + 4$$

L = 31.88 mm

$$T = \frac{L}{f\,N} = \frac{31.88}{0.5 \times 250} = 15.3 \text{ sec}$$

52. Ans: (B)

Sol: Given data: $I = 10000A$

Time, $\tau = \frac{5}{50} = 0.1sec$

Heat required, $u = 30\ J/mm^3$

Total heat required, $H_m = 30V$

[Where, V = volume of weld nugget]

Contact resistance, $R = 300\times10^{-6}\Omega$

Heat supplied, $H_s = I^2 R \tau$

$= 10000^2\times300\times10^{-6}\times0.1$

$= 3000\ J$

Now, $\eta_m = \frac{H_m}{H_s}$

$\Rightarrow \quad 0.8 = \frac{30V}{3000}$

$\therefore \quad V = 80\ mm^3$

53. Ans: 70 [Range: 69 to 71]

Sol: Applying Bernoulli's equation between point 'A' and the exit (B) of siphon

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B$$

$$P_A = P_B + \frac{\rho}{2}\left(V_A^2 - V_B^2\right) + \rho g\left(Z_B - Z_A\right)$$

As the pipe diameter is constant the velocity remains same by virtue of continuity equation

$\therefore V_A = V_B$

$\therefore P_A = 70\ kPa$

Note: The pressure at point 'A' is not equal to atmospheric pressure even though the elevation of point 'A' is same as that of free surface because the fluid at 'A' is in motion and hydrostatic law is not applicable.

54. Ans: 0.0045 (Range 0.004 TO 0.005)

Sol: Let X = number of accidents between 5 P.M and 6 P.M.

For Poisson distribution,

$\lambda = np = (1000)(0.0001) = 0.1$

$P(X = x) = \frac{e^{-\lambda}.\lambda^x}{\angle x}$ (x = 0, 1, 2,……..)

Required Probability $= P(X \geq 2)$

$= 1 - P(X < 2)$

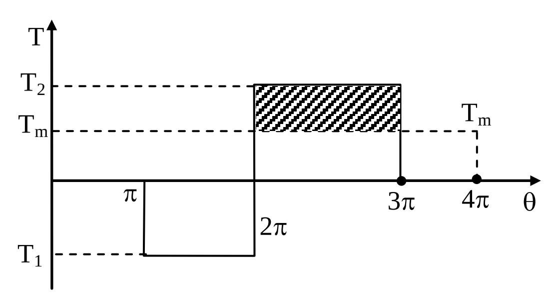
$= 1 - \{P(X = 0) + P(X = 1)\}$

$= 1 - e^{-0.1}(1 + 0.1)$

$= 0.0045$

55. Ans: 1692.33 [Range: 1689 to 1694]

Sol:



Given, $T_2 = 2.8T_1$,

$\omega = \frac{2\times\pi\times250}{60} = 26.18$ rad/sec

$C_s = 0.01$

Let T be the load torque, $T\omega = 18.5kW$

$\frac{2\pi N T_m}{60} = 18.5\times10^3 \Rightarrow T_m = 707N\text{-}m$

$4\pi T_m = -\pi T_1 + \pi T_2 = \pi(1.8T_1)$

$T_1 = 1571.11N\text{-}m$

Energy stored in flywheel

$= \pi(T_2 - T_m)$

$= \pi(2.8 \times 1571.11 - 707)$

$= 11599.099$ N-m

$11599.099 = I\,\omega^2 C_s$

$\therefore\ I = \frac{11599.099}{26.18^2 \times 0.01} = 1692.33$ kg-m^2

56. Ans: (D)

Sol: (PART AND THE WHOLE) A fragment is a piece of broken bone; a shard is a piece of broken pottery.

57. Ans: (A)

58. Ans: (D)

Sol: Irretrievably means impossible to recover or get back, so irrevocably is the correct synonym, which means not capable of being changed : impossible to revoke.

59. Ans: (B)

Sol: Indiscriminate (adj.) means not discriminating or choosing randomly; haphazard; without distinction.

60. Ans: (A)

Sol: $a_0 = 1$; $a_n = 2a_{n-1}$ if n is odd

$a_n = a_{n-1}$ if n is even

$a_{100} = a_{100-1} = a_{99} = 2.a_{99-1}$

$= 2.a_{99} = 2.a_{98-1} = 2a_{97}$

$= 2.2a_{97-1} = 2^2.a_{96}$ ……… $2_{50}.a_0 = 2^{50}$

61. Ans: (C)

Sol: A = 1; B = 1

(a) B = B + 1 = 2

(b) & (c) A = A × B = 1 × 2 = 2

Step 2: B = 2 + 1 = 3; A = A × B = 2 × 3 = 6

Step 3: B = 3 + 1 = 4; A = A × B = 6×4 = 24

Step 4: B = 4 + 1 = 5; A = 24 × 5 = 120

Step 5: B = 5 + 1 = 6; A = 120 × 6 = 720

62. Ans: (A)

Sol: Ratio of efficiency (P & Q) = 2 : 1

Ratio of efficiency (P + Q, R) = 3 : 1

If R does 1 unit work, then P& Q together do 3 units.

Out of 3 units, P does 2 units and Q does 1 unit.

∴ Ratio of efficiency (P, Q & R) = 2 : 1 : 1

Hence, earnings should be divided in the ratio is 2 : 1 : 1

63. Ans: (C)

Sol: In 1972, A was as old as the number formed by the last two digits of his year of birth.

So, A was born in 1936 (as in 1972, he is 36 yrs older also, last two digits of 1936 are 36).

Hence, B was born in 1936 + 15 = 1951

So, he is 21 yrs old in 1972

64. Ans: (B)

Sol: Difference (in thousands) between the numbers of customers in the 2 complexes in:

January:	22 – 20 = 2
February:	25 – 24 = 1
March:	20 – 15 = 5
April:	28 – 25 = 3
May:	20 – 14 = 6 [Max]
June:	20 – 15 = 5

65. Ans: (B)

Sol: The issue is more about punishing criminals, and so punishment is more important than crime prevention (correct answer B).