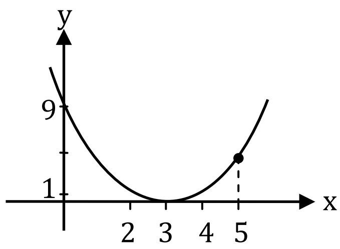
# Full Length Test
# Mechanical Engineering

## Answer Keys and Explanations

1. **[Ans. *] Range: 5 to 5**
$y = x^2 - 6x + 9 = (x-3)^2$
$y(2) = 1$
$y(5) = 4$




$\therefore$ Maximum value of y over the interval 2 to 5 will be at x = 5

2. **[Ans. A]**
We know that for matrix if $\lambda$ is Eigenvalue and x is Eigenvector then $Ax = \lambda x$ and $A^m x = \lambda^m x$
i.e., x is also Eigenvector of $A^m$ corresponding Eigenvalue $\lambda^m$

3. **[Ans. A]**
$PQRS = I$
$P^{-1}\,PQRSS^{-1} = P^{-1}IS^{-1}$
$QR = P^{-1}S^{-1}$
$Q^{-1}QR = Q^{-1}P^{-1}S^{-1}$
$R = Q^{-1}P^{-1}S^{-1}$
$R^{-1} = (Q^{-1}P^{-1}S^{-1})^{-1}$
$= SPQ$

4. **[Ans. A]**
Green's theorem and stokes theorem convert line integral to surface integral and vice versa.
Whereas Gauss's Divergence theorem converts from surface to volume and vice versa.

5. **[Ans. A]**
$$\text{Let } S = \sum_{r=0}^{n-1} \frac{1}{\sqrt{4n^2 - r^2}} = \frac{1}{n}\sum_{r=0}^{n-1} \frac{1}{\sqrt{4 - \left(\frac{r}{n}\right)^2}}$$
$$= \int_0^1 \frac{dx}{\sqrt{4 - x^2}}$$

$$= \sin^{-1}\frac{x}{2}\Big|_0^1 = \frac{\pi}{6}$$

**6.** **[Ans. D]**

$$U = \frac{P^2L}{2AE}$$

Strain energy = Average resistance × Elongation

$$= \frac{1}{2} \times P \times \delta L$$

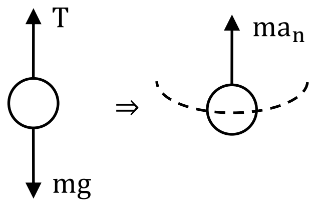
$$= \frac{1}{2} \times \sigma A \times \varepsilon \times AL$$

$$= \frac{1}{2}\frac{\sigma^2}{E} \times AL$$

$$= \frac{1}{2} \times \frac{P^2}{A^2} \times \frac{AL}{E}$$

$$= \frac{P^2L}{2\,AE}$$

**7.** **[Ans. C]**




$$T - mg = ma_n$$

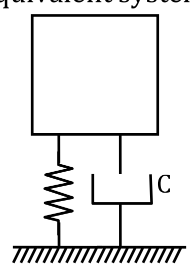
$$T = mg + \frac{mv^2}{R}$$

$$= 0.1 \times 9.81 + \frac{0.1 \times (1.4)^2}{1}$$

$$= 1.17\ \text{N}$$

**8.** **[Ans. *] Range: 3.0 to 3.3**

Equivalent system is




$K_{eq} = 2K$(Parallel sysem of springs)

$$C = 2\xi M\omega_n$$

$$C = 2(1)M\sqrt{\frac{K_{eq}}{M}}$$

$$C = 2M\sqrt{\frac{2K}{M}}$$

$$C = 2(36)\sqrt{\frac{2(35\times10^3)}{36}}$$

$$C = 3174.90\,\text{Ns/m} \approx 3175\,\text{Ns/m} = 3.175\,\text{KNs/m}$$

**9. [Ans. *] Range: 600 to 600.5**

$$\Delta E = \frac{1}{2}Iw_{max}^2 - \frac{1}{2}I\,w_{min}^2$$

$$\Delta E = \frac{1}{2}I(w_{max}+w_{min})(w_{max}-w_{min})$$

$$\Delta E = I\,w_{mean}(w_{max}-w_{min})$$

$$1936 = 9.8\times w_{mean}\frac{(2\pi)}{60}(\Delta N)$$

$$1936 = 9.8\,w_{mean}\frac{2\pi}{60}(30)$$

$$62.883 = w_{mean}$$

$$62.883 = \frac{2\pi N}{60}$$

$$N = 600.4\text{ rpm}$$

**10. [Ans. *] Range: 15 to 15**

| Arm(C) | A | B |
|---|---|---|
| 0 | x | $\frac{-x\times T_A}{T_B}$ |
| y | x + y | $y - \frac{xT_A}{T_B}$ |

$N_A = x + y = 0$

$N_c = y = 10$

$\Rightarrow x = -y = -10$

$$N_B = y - x\frac{T_A}{T_B} = 10 + (10)\times\frac{20}{40} = 15$$

**11. [Ans. *] Range 4 to 4**

$\left.\begin{matrix}DE, & DC\\ AF, & AB\end{matrix}\right\}$ Total No = 4 zero force member.

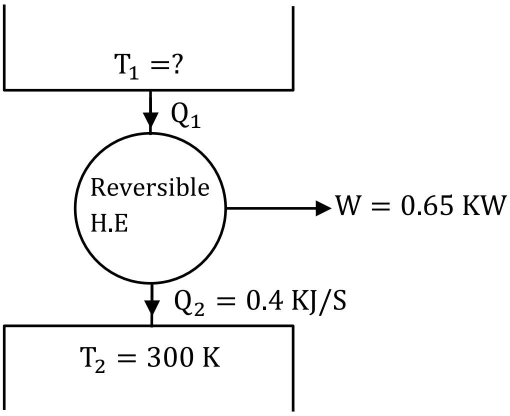
**12. [Ans. *] Range: 2 to 3**

Since Copper is a very good conductor, $T_w = T_c$, for Copper

$\therefore I^2R = hA(T_c - T_\infty)$

$I = 2.67$ A

**13. [Ans. *] Range 787.4 to 787.6**




For a reversible heat engine,

$$W = Q_1 - Q_2$$

$$\therefore Q_1 = Q_2 + W$$

$$= 0.65 + 0.4$$

$$= 1.05 \text{ KJ/s}$$

Efficiency of heat engine expressed as,

$$\eta = \frac{W}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\Rightarrow \frac{0.65}{1.05} = 1 - \frac{300}{T_1} \Rightarrow T_1 = 787.4 \text{ K}$$

**14. [Ans. *] Range: 15 to 15.5**

$$\frac{T - T_\infty}{T_o - T_\infty} = e^{\frac{-hAt}{\rho VC}}$$

$$\frac{T - 100}{450 - 100} = e^{-\frac{10 \times 3 \times 60 \times 60}{8000 \times (0.25) \times 0.45 \times 10^3}}$$

$$T = 389.68$$

$$Q = mc(T_o - T) \ldots\ldots (1)$$

$$m = \rho V$$

$$= 8000 \times \frac{4}{3} \times \pi \times (0.25)^3$$

$$m = 523.6$$

$\therefore$ substitute in equation (1)

$$\therefore Q = 15.25 \text{ MJ}$$

**15. [Ans. D]**

In control section given all holds. As per Bernoulli's equation, energy is conserved. As per continuity, mass or discharge is conserved. As per impulse, momentum is conserved

**16. [Ans. *] Range $-31$ to $-30$**

$$ds = \frac{\delta Q}{T} = \frac{mC\,dt}{T}$$

Take both side integration

$\therefore S_2 - S_1 = mC_p \ln\left(\frac{T_2}{T_1}\right)$

$= -30.57 \text{ J/K}$

**17. [Ans. *] Range: 3.1 to 3.2**

Let $h_1$ & $h_2$ be the states at the beginning and end of the compressor

$0.8 = \frac{h_2 - 185}{229 - 185}$

$\therefore h_2 = 220.2 \text{ kJ/kg}$

$\text{COP} = \frac{185 - 74.5}{220.2 - 185} = 3.14$

**18. [Ans. *] Range 5 to 5**

At the break-even point, the total overheads of both the point must be equal. Let x be the break-even quantity between the two alternatives. Thus by break even analysis

$F_1 + x\,v_1 = F_2 + x\,v_2$

$200 + 20x = 150 + 30x$

$30x - 20x = 200 - 150$

$10x = 50$

$x = 5$

**19. [Ans. B]**

The complete model is given by

Maximize $z = 5x_1 + 4x_2$

Subject to $6x_1 + 4x_2 \leq 24 \ldots\ldots\ldots$ ①

$x_1 + 2x_2 \leq 6 \ldots\ldots\ldots$ ②

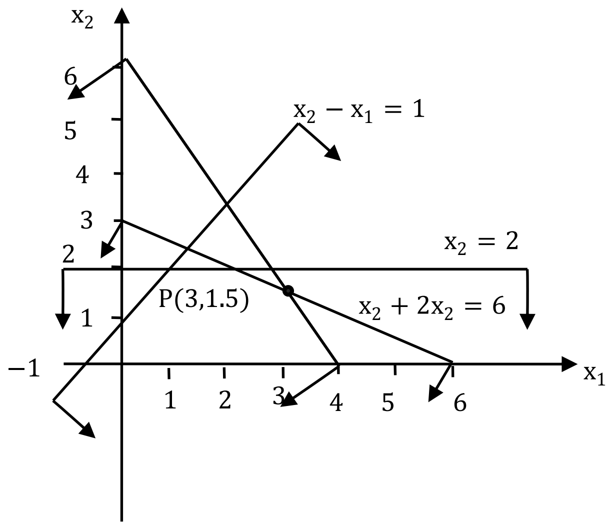
$-x_1 + x_2 \leq 1 \ldots\ldots\ldots$ ③

$x_2 \leq 2 \ldots\ldots\ldots$ ④

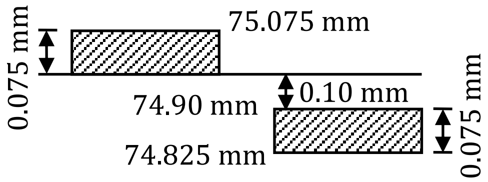
$x_1, x_2 \geq 0 \ldots\ldots\ldots$ ⑤

Solving the above problem we get

$x_1 = 3, x_2 = 1$



20. **[Ans. *] Range: 74.825 to 74.825**




Low limit of hole = 75 mm

High limit of hole = Low limit + Allowance

$= 75 + 0.75 = 75.075$ mm

High limit of shaft = Low limit of hole − Allowance

$= 75 - 0.10 = 74.90$ mm

Low limit of shaft = High limit − Tolerance

$= 74.9 - 0.075 = 74.825$ mm

21. **[Ans. *] Range: 29 to 29.02**

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha}$$

Where

$$r = \frac{0.2}{0.4}$$

$r = 0.5$

$$\tan\phi = \frac{0.5\cos 15}{1 - 0.5\sin 15}$$

$\Rightarrow \phi = 29°$

22. **[Ans. C]**

23. **[Ans. *] Range: 7.2 to 7.2**

Punching force = $Lt\tau$

$= \pi d \times t \times \tau = 6.0$ kN

New punching force = $\pi \times 2d \times 0.6 \times t \times \tau$

$= 1.2 \times \pi dt\tau$

$= 1.2 \times 6.0$

$= 7.2$ kN

24. **[Ans. *] Range: 17.62 to 17.62**

Diameter ever standard cylinder, $D_m = 15.64$ mm

Diameter ever plug screw gauge, $D_s = 15.26$ mm

Standard cylinder diameter, D = 18 mm

Diameter under the wire, $Y = (D_s - D_m) + D$

$= (15.26 - 15.64) + 18$

$Y = 17.62$ mm

25. **[Ans. C]**

If speed is reduced by 75 %, then
$V_2 = 0.25\ V_1$
Tylor's equation for tool wear is given by,
$C = VT^n$
$\therefore 90 = V\sqrt{T}$
and $V_1\sqrt{T_1} = V_2\sqrt{T_2}$
$\Rightarrow V_1\sqrt{T_1} = 0.25\ V_1\sqrt{T_2}$
$$\sqrt{\frac{T_1}{T_2}} = \frac{1}{4}$$
$$\frac{T_1}{T_2} = \frac{1}{16}$$
$\Rightarrow$ Tool life will increase by 1500%

**26. [Ans. *] Range: 0.25 to 0.25**

Let B-boy and G – Girl, C – Cricketer
$P(B) = 60\% = 0.60, P(G) = 40\% = 0.40$
$P(C/B) = 50\% = 0.50, P(C/G) = 25\% = 0.25$
$P(G/C) = ?$
By Bayes theorem
$$P(G/C) = \frac{P(G)P(C/G)}{P(G)P(C/G) + P(B)P(C/B)}$$
$$= \frac{(0.40)(0.25)}{(0.40)(0.25) + (0.60)(0.50)}$$
$$= \frac{0.1}{0.1 + 0.3} = \frac{0.1}{0.4} = 0.25$$

**27. [Ans. A]**

$z^2e^{-z} \Rightarrow (x + iy)^2e^{-(x+iy)}$
$(x^2 - y^2 + 2xy)(e^{-x})(\cos y - i\sin y)$
$(e^{-x})[(x^2 - y^2)\cos y + 2xy\sin y]$

**28. [Ans. D]**

$x^2 - x + I = 0$, Multiplying both sides by $x^{-1}$
$x - I + x^{-1} = 0$
$$\therefore x^{-1} = I - x = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} b^2 & 1 \\ (b^2 + b - 1) & (1 - b) \end{bmatrix} = \begin{bmatrix} (1 - b^2) & -1 \\ (1 - b - b^2) & b \end{bmatrix}$$

**29. [Ans. *] Range: 0.5 to 0.5**

1. $P(\text{even}) + P(\text{odd}) = 1$
   $\Rightarrow P(\text{even}) + 2P(\text{even}) = 1 [\because P(\text{even}) = 0.5\ P(\text{odd})]$
   $\Rightarrow P(\text{even}) = \frac{1}{3}$

$P(2) = \frac{1}{3}P(\text{even}) = \frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$

2. $P(2) = P(4) = P(6) = P(1) = \frac{1}{9}$

Now, $P(3 \text{ or } 5) = 1 - [P(1) + P(2) + P(4) + P(6)] = 1 - \frac{4}{9} = \frac{5}{9}$

3. $P\left(\text{even}/x > 3\right) = 0.8$

$\Rightarrow \frac{P(\text{even and } x > 3)}{P(x > 3)} = \frac{P(x = 4 \text{ or } 6)}{P(x = 4 \text{ or } 5 \text{ or } 6)}$

$\Rightarrow \frac{P(4) + P(6)}{P(4) + P(5) + P(6)} = 0.8$

$\Rightarrow \frac{\frac{1}{9} + \frac{1}{9}}{P(5) + \frac{1}{9} + \frac{1}{9}} = 0.8$

$\Rightarrow P(5) = \frac{1}{18}$

$\Rightarrow P(3) = 1 - [P(1) + P(2) + P(4) + P(5) + P(6)]$

$= 1 - \left[\frac{1}{9} + \frac{1}{9} + \frac{1}{9} + \frac{1}{18} + \frac{1}{9}\right] = 0.5$

**30. [Ans. A]**

Loading in CD form a couple (equal and opposite force) and hence shear force just to left of C becomes zero. Bending moment is constant since couple has a constant value.

**31. [Ans. D]**

$F.S = \frac{\text{Yield stress}}{\text{Working stress}}$

$\text{working stress} = \frac{225}{2} = 112.5 \text{ MPa}$

$\tau_{min} = \frac{T}{t \times 2 \times \pi R^2}$

$t = \frac{T}{\tau_{min} \times 2 \times \pi R^2} = 3.96 \text{ mm} \approx 4 \text{ mm}$

**32. [Ans. *] Range: 18 to 22**

| Arm | Sun | Pinion | Ring |
|---|---|---|---|
| 0 | $x$ | $-\frac{x(T_s)}{T_p}$ | $\frac{-xT_s}{T_p} \times \frac{T_p}{T_R}$ |
| $+y$ | $+y$ | $+y$ | $+y$ |
| $y$ | $x + y$ | $y - \frac{xT_s}{T_p}$ | $y - x\frac{T_s}{T_R}$ |

$N_R = 0 \Rightarrow y = x\frac{T_s}{T_p} = x \times \frac{20}{80} = \frac{x}{4}$

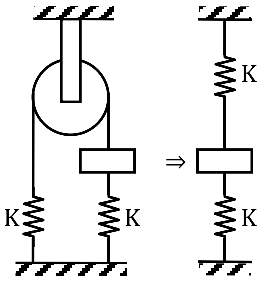
$N_s = 100 \Rightarrow x + y = 100$

$$4y + y = 100$$

$$y = \frac{100}{5} = 20 \text{ rpm}$$

**33. [Ans. C]**

The springs are in parallel. System is equivalent to




Equivalent stiffness is $K + K = 2K$

$$w_n = \sqrt{\frac{2K}{m}}$$

34. **[Ans. B]**

Governing equation is, Viscous force on the element = force of gravity on the element

$$\mu \frac{d^2u}{dy^2} = \rho g$$

$$\text{Or, } \mu \frac{du}{dy} = \rho g y + C_1$$

$$\text{Or, } \frac{du}{dy} = \frac{\rho g y}{\mu} + \frac{C_1}{\mu}$$

$$u = \frac{\rho g y^2}{2\mu} + \frac{C_1}{\mu} y + C_2$$

At $y = 0$

$u = U_0$

So, $C_2 = U_0$

At $y = h$

$\tau = 0$

$$\text{So } \frac{du}{dy} = 0$$

And $C_1 = -\rho g h$

$$u = \frac{\rho g y^2}{2\mu} - \frac{\rho g h y}{\mu} + U_0 = \frac{\rho g}{\mu}\left(\frac{y^2}{2} - hy\right) U_0$$

**35. [Ans. C]**

Condition for equilibrium

$N_1 = \mu_2 N_2$

$N_2 + \mu_1 N_1 = mg$

$N_2 = \frac{mg}{1+\mu_1\mu_2}$; $N_1 = \frac{\mu_2 mg}{1+\mu_1\mu_2}$

Applying torque equation at B

$(mg)\frac{l}{2}\cos\theta = \mu_2 N_2 l\sin\theta + \mu_1 N_1 l\cos\theta$

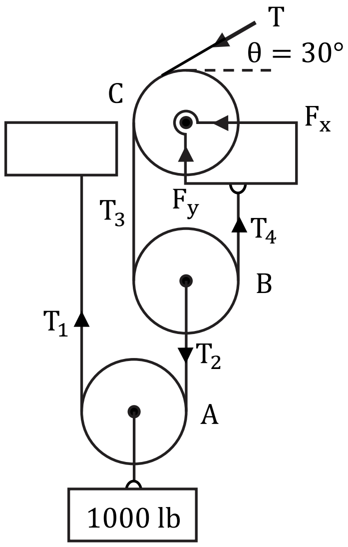
$\mu_2 N_2 \tan\theta + \mu_1 N_1 = \frac{mg}{2}$

$\mu_2\left(\frac{N_1}{\mu_2}\right)\tan\theta + \mu_1 N_1 = \frac{mg}{2}$

$N_1 \tan\theta = \frac{mg}{2}$

Where $\mu_1 = 0$

**36. [Ans. A]**




$\Sigma M_0 = 0;\ T_1 r - T_2 r = 0; T_1 = T_2$

$\Sigma F_y = 0;\quad T_1 + T_2 - 1000 = 0$

$T_1 = T_2 = 500\text{lb}$

And $T_3 = T_4 = T_2/2$

$= 250$ lb

Now force C pulley $T_3 = T$

$T = 250$

$\Sigma F_x = 0;\quad 250\cos 30 = F_x \Rightarrow F_x = 217$

$\Sigma F_y = 0;\quad F_y + 250\sin 30 - 250 = 0$

$F_y = 125$ lb

$F = \sqrt{F_x^2 + F_y^2} = 250$ lb

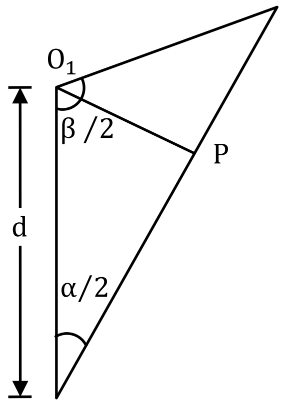
**37. [Ans. *] Range 1 to 1**

We have 7 joints (6 pin + 1 sliding) which restrict 2 DOF

$DOF = 3(n-1) - 2J_1 = 3(6-1) - 2(7)$

$= 15 - 14 = 1$

**38. [Ans. *] Range 250 to 250**




$$\frac{t_{cutting}}{t_{return}} = \frac{360^\circ - \beta}{\beta} = \frac{2}{1}$$

$\Rightarrow 360^\circ - \beta = 2\beta$

$\Rightarrow \beta = 120^\circ$

So, $\alpha = 180^\circ - 120^\circ = 60^\circ$

And, $\frac{\alpha}{2} = 30^\circ$

$$\sin\left(\frac{\alpha}{2}\right) = \frac{O_1P}{d} = \frac{1}{2} = \frac{125}{d}$$

$\Rightarrow d = 250$ mm

**39. [Ans. C]**

$W = 1200 \text{ kg} = 1200 \times 9.81 = 11772 \text{ N}$

$R = \frac{600}{2} = 300 \text{ mm} = 0.3 \text{ m}$

$r = \frac{400}{2} = 200 \text{ mm} = 0.2 \text{ m}$

$\mu = 0.22, \theta = 275^\circ$

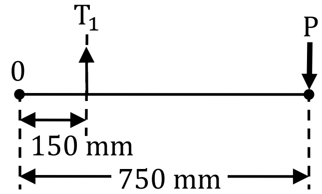
We know, $\frac{T_1}{T_2} = e^{\mu\theta} = e^{\left(0.22 \times 275 \times \frac{\pi}{180}\right)} = 2.8746$

Torque, $T = (T_1 - T_2)R = W \times r$ [For equilibrium]

$(2.8746T_2 - T_2) \times 0.3 = 11772 \times 0.2$

$\Rightarrow T_2 = 4186.493$ N

$\therefore T_1 = 12034.49$ N




Now, $M_o \Rightarrow T_1 \times 150 = P \times 750$

$$\Rightarrow P = \frac{12034.49 \times 150}{750} = 2406.89 \text{ N}$$

**40. [Ans. *] Range: 56 to 56**

$\Delta l_s + \Delta l_a = \text{gap}$

$l_s \alpha_s \Delta T + l_a \alpha_a \Delta T = \text{gap}$

$[0.5(12 \times 10^{-6}) + 0.499 \times 24 \times 10^{-6}]\Delta T = 0.001$

$17.976 \times 10^{-6} \Delta T = 0.001$

$\Delta T = 55.629$

$= 56°C$

**41. [Ans. *] Range: 400 to 400**

$P_1 V_1 = P_2 V_2$, since no change in temperature

$V_2 = 2V_1$

$\therefore P_2 = \frac{800}{2} = 400 \text{ kPa}$

**42. [Ans. *] Range: 136.5 to 137**

$\epsilon = \frac{\text{Actual heat tranfer}}{\text{Max. possible heat transfer}}$

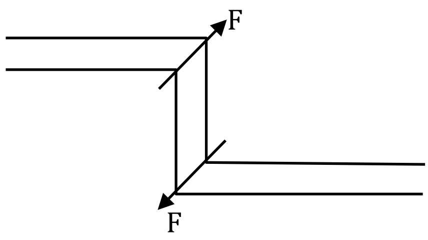
$0.62 = \frac{Q_{actual}}{2.826\,(116 - 38)}$

$\therefore \text{Qactual} = 136.7 \text{ kW}$

**43. [Ans. B]**

$F = \rho A = (dgH)\, A = gdHA$

**44. [Ans. C]**




**45. [Ans. *] Range 1.8 to 2.2**

$Q = AV = \text{constant}$

$V_{nozzle} = \frac{AV}{A_{nozzle}}$

$= \frac{D^2}{d^2} v$

$= \left(\frac{8}{2}\right)^2 \times 0.25$

$V_{nozzle} = 4 \text{ m/s}$

$R = vt \ldots\ldots\ldots \text{①}$

But, $h = \frac{1}{2} gt^2$

$$t^2 = \frac{2h}{g}$$

$$t = \sqrt{\frac{2h}{g}}$$

Apply t and v value in equation ①

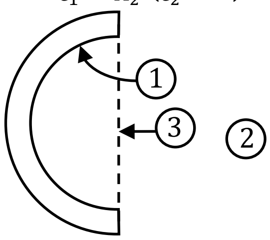
$$R = 4 \times \sqrt{\frac{2 \times 1.25}{10}}$$

$$R = 2 \text{ m}$$

**46. [Ans. B]**

We have,

$$q = \frac{\sigma A_1(T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{A_1}{A_2}\left(\frac{1}{\epsilon_2} - 1\right)}$$




$$\frac{1-\epsilon_1}{\epsilon_1 A_1} = \frac{0.6}{0.4 \times 0.1414} = 10.61$$

$$\frac{1-\epsilon_2}{\epsilon_2 A_2} = 0, A_2 \to \infty$$

③ is a imaginary surface, with $f_{12} = f_{13}$ using $A_1F_{13} = A_3F_{31}$

$$\therefore f_{13} = \frac{\pi r^2}{2\pi r^2} = 0.5$$

$$\frac{1}{A_1F_{12}} = \frac{1}{0.1414 \times 0.5} = 14.14$$

$$\therefore q = \frac{\sigma(973^4 - 298^4)}{10.61 + 14.14} = 2035\text{W}$$

**47. [Ans. *] Range 1.71 to 1.77**

$$\text{Cut off ratio} = \gamma = \frac{V_3}{V_2} = \frac{T_3}{T_2}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 957.52 \text{ K}$$

$$\therefore \gamma = 1.74$$

**48. [Ans. D]**

Total heat = $(0.8 + 0.12) \times 60 \times 30$

$= 1656$ KJ

According to first law of thermodynamics

$dQ = dU + dW$

Room is well sealed, so $dW = 0$

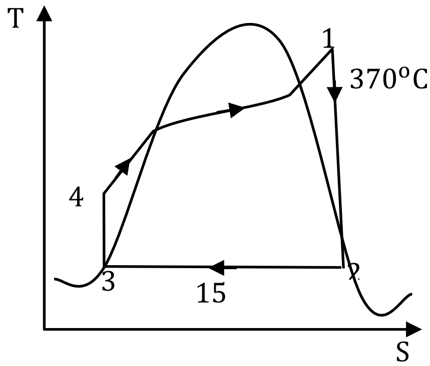
$dU = 1656 = MCvdT$

$$dT = \frac{1656}{60 \times 0.738}$$

$T_2 = 37.4 + 25$

$T_2 = 62.4^oC$

**49. [Ans. *] Range: 30 to 32**




$S_1 = S_2$

$6.5821 = s_f + x(s_g - S_f)$

$x = 0.8$

$h_2 = h_f + x(h_g - h_f)$

$h_2 = 225.94 + 0.8(2599.1 - 225.94)$

$\quad = 2124.46$

$W_T = h_1 - h_2 = 3092.5 - 2124.46$

$W_T = 968$

$W_{actual} = 0.9 \times 968 = 871.2$

$W_P = Vd_P = 0.001014(4000 - 15)$

$W_P = 4.04\ KJ/kg$

$W_{net} = W_{actual} - W_P = 867.16$

$Q_S = h_1 - [h_3 + W_P]$

$\quad = 2862.5\ KJ/kg$

$$\eta = \frac{W_{net}}{Q_s} = 30.30\%$$

**50. [Ans. C]**

The production of company per quarter = 3000 units

Demand in 1st quarter = $0.8 \times 3000 = 2400$ units

Total inventory after 1st quarter = $3000 - 2400 = 600$ units

Demand in 2nd quarter = $1 \times 3000 = 3000$ units

Total inventory after 2nd quarter = $600 + 3000 - 3000 = 600$ units

Demand in 3rd quarter = $0.8 \times 3000 = 2400$ units

Total inventory after 3rd quarter = $600 + 3000 - 2400 = 1200$ units

Demand in 4th quarter = $1.4 \times 3000 = 4200$

Surplus in 4th quarter = 1200 units
Surplus is equal to total demand so inventory at beginning of
1st quarter = 1200 − 1200 = 0

**51. [Ans. *] Range: 26.3 to 26.4**

Reduction in area = 0.3

$\Rightarrow 1 - \dfrac{r^2}{r_0^2} = 0.3$

$\Rightarrow \dfrac{r^2}{r_0^2} = 0.7$

$B = \mu \cot\alpha = 0.10 \times \cot 6° = 0.95$

$\sigma_d = \dfrac{\sigma_0(1+B)}{B}\left[1 - \left(\dfrac{r_1}{r_0}\right)^{2B}\right]$

$\therefore \sigma_d = \sigma_0 \times \dfrac{1.95}{0.95}\,[1 - (0.7)^{0.95}] = 141.60\ \text{N/mm}^2$

Now, $r_1 = \sqrt{0.7} \times 6 = 5.02$ mm

$\therefore$ Drawing load $= 141.60 \times \pi \times (5.02)^2$

$= 11.21$ kN

Power of motor $= \dfrac{11.21 \times 2.3}{\eta} = \dfrac{25.78}{0.98}$ kW

$= 26.31$ kW

**52. [Ans. C]**

For a linear power source,

$V = V_{oc} - \left(\dfrac{V_{oc}}{I_{sc}}\right) \times I$

$= 40 - \dfrac{40}{400} I$

Power, $P = VI = (40 - 0.1I)I$

For maximum power $\dfrac{dP}{dI} = 0$

$\Rightarrow 40 - 0.2I = 0$

$\Rightarrow I = 200A$

$\Rightarrow V = 20$ V

Now, $P_{max} = VI = 200 \times 20$

$= 4000$ W $= 4$ kW

**53. [Ans. C]**

Since necking strain corresponds to the max load and the necking strain of the material is given by,

$\varepsilon = n = 0.5$

Cross – sectional area at the onset of necking is obtained from,

ie., $\ln\left(\dfrac{A_0}{A_{neck}}\right) = 0.5$

$\Rightarrow A_{neck} = e^{-0.5}.A_o$

$\Rightarrow$ Max load, $P = \sigma A_{neck}$

$= \sigma A_o e^{-0.5}$

Where, σ=there ultimate tensile strength,

Now,

$\sigma = 100000\ \varepsilon^{0.5}$

$\sigma = 100000(0.5)^{0.5} = 70710$ Psi

$\Rightarrow P = 70710 \times e^{-0.5} \times A_0$

$= 70710 \times 0.606\ A_0 = 42850\ A_0$

Engineering UTS $= \dfrac{P}{A_0} = \dfrac{42850\ A_0}{A_0}$

Engineering UTS = 42850 Psi

**54. [Ans. *] Range: 51 to 51**

$\in = \text{Cot}\ \phi + \tan(\phi - 12)$

$\dfrac{d\in}{d\phi} = -\text{cosec}^2\ \phi + \sec^2(\phi - 12) = 0$

$\phi = 51^o$

**55. [Ans. B]**

$\tau_{sphere} = k\left(\dfrac{D_s}{6}\right)^2 ; \tau_{cube} = k\left(\dfrac{a}{6}\right)^2$

$\tau_{cylinder} = k\left(\dfrac{D_{cyl}}{6}\right)^2$

$\dfrac{4}{3}\pi r_s^3 = a^3 = \dfrac{\pi}{4}d_c^3 = \dfrac{4}{3}\pi\dfrac{d_s^3}{8}$

$\Rightarrow \dfrac{\pi d_s^3}{6} = a^3 = \dfrac{\pi}{4}d_c^3 \ldots\ldots\ldots (1)$

$\Rightarrow d_s = \left(\dfrac{6a^3}{\pi}\right)^{1/3} \ldots\ldots\ldots (2)$

$\tau_{sphere} = \left[\dfrac{(6a^3/\pi)^{1/3}}{6}\right]^2 = \left[\dfrac{1.24\ a}{6}\right]^2 = [(0.206)a]^2 = 0.0424\ a^2 \ldots\ldots\ldots (3)$

$\tau_{cube} = \left(\dfrac{a}{6}\right)^2 = 0.027\ a^2 \ldots\ldots\ldots (4)$

$\tau_{cyl} = \left(\dfrac{D_{cyl}}{6}\right)^2 = \left[\dfrac{a\left(\frac{4}{\pi}\right)^{1/3}}{6}\right]^2 \quad \ldots\left\{\because D_{cyl} = \left(\dfrac{4a^3}{\pi}\right)^{1/3} = a\left(\dfrac{4}{\pi}\right)^{1/3}\right\}$

$= 0.0326\ a^2$

$\therefore \tau_{sphere} = 0.0424\ a^2$ ... [solidifies last]

$\tau_{cyl} = 0.0326\ a^2$

$\tau_{cube} = 0.027\ a^2$ ... [solidifies first]

**56. [Ans. D]**

They will chime together after the time in minutes equal to LCM of 18, 24, 32.

$18 = 2 \times 3 \times 3$

$24 = 2 \times 2 \times 2 \times 3$

$32 = 2 \times 2 \times 2 \times 2 \times 2$

$\therefore$ LCM $= 2 \times 2 \times 2 \times 3 \times 3 \times 2 \times 2 = 288$

288 min = 4 hrs 48 min.

**57.** **[Ans. C]**

According to the statement, 80% of the total runs were made by spinners. So, conclusion I does not follow. Nothing about the opening batsmen is mentioned in the statement. So, conclusion II also does not follow

**58.** **[Ans. D]**

1 km = 1000 meter

1 min = 60 second

$$\text{Average speed } = \frac{\text{Total distance}}{\text{Total time}}$$

Total distance = 12 km = 12000 meter

Total time = 6 + 6 +12 minute = 24 × 60 = 1440 seconds

$$\text{Average speed } = \frac{12000}{1440} = 8.33 \text{ m/s}$$

**59.** **[Ans. A]**

**60.** **[Ans. C]**

CEPQS - E cannot go with S.

AEPQS - C and P have to be together. E cannot go with S.

ACPRS -It satisfies all the conditions and also there are two boys in the team.

BDPRS - C and P have to be together.

Hence, C

**61.** **[Ans. A]**

$$\text{Number of males in U.P } = \left[\frac{3}{5} \text{ of } (15\% \text{ of N})\right] = \frac{3}{5} \times \frac{15}{100} \times \text{N} = \frac{9\text{N}}{100}$$

Total population, N = 3276000

$$\text{Number of males in M.P } = \left[\frac{3}{4} \text{ of } (20\% \text{ of N})\right] = \frac{3}{4} \times \frac{20}{100} \times \text{N} = \frac{15\text{N}}{100}$$

$$\text{Number of males in Goa } \left[\frac{3}{8} \text{ of } (12\% \text{ of N})\right] = \frac{3}{8} \times \frac{12}{100} \times \text{N} = \frac{4.5\text{N}}{100}$$

$$\text{Total males in these 3 states } = \frac{(9 + 15 + 4.5)\text{N}}{100} = \frac{28.5\text{N}}{100}$$

$$\text{Required \% } = \left(\frac{28.5 \times \frac{\text{N}}{100} \times 100}{\text{N}}\right)\% = 28.5\%$$

62. [Ans. C]
A cube is cut into 125 smaller cubes.
∴ Length of cube $=\sqrt[3]{125}$
∴ l = 5 unit
Let upper face be coloured red.
Then bottom face will be coloured green, two adjacent faces are coloured yellow and blue respectively.
Two faces are uncoloured.
Number of cubes uncoloured on all faces $= (n-2)^3 = (5-2)^3 = 27$
Now there are two surfaces which are not coloured.
∴ There will be 9 cubes at centre on both the uncoloured surfaces each.
3 cubes at the common edge of both uncoloured surfaces.
∴ Total number of uncoloured cubes = 27 + 9 + 9 + 3 = 48

63. [Ans. C]

64. [Ans. B]
The passage clearly states the unawareness of teachers regarding population education. Thus, the teachers should be given a proper orientation on the same.

65. [Ans. C]
In statement I nothing is given about c. Hence it is not enough to answer the question.
In statement II nothing is mentioned about a. Hence this statement alone cannot answer the question.
Combining both the statements we get
a : b : c = 3 : 15 : 10
∴ a : c = 3 :10

$$\frac{a}{c} = \frac{3}{10}$$

$$\frac{a+c}{c} = \frac{3+10}{10} = \frac{13}{10}$$

∴ Question can be answered using both the statements.
Hence, C.