MECHANICAL ENGINEERING MOCK - C __ Solutions

01. Ans: (c)

Sol: Velocity Ratio, $VR = \frac{1}{3} = \frac{N_2}{N_1} = \frac{z_1}{z_2}$

$$\Rightarrow z_2 = 3\,z_1$$
$$\Rightarrow 60 = 3\,z_1$$
$$\Rightarrow z_1 = 20$$

02. Ans: (b)

Sol: Given data:

$\tau_1 = 120$ MPa

$d_2 = 2d_1$

$$\tau = \frac{16T}{\pi d^3}$$

$$\therefore \tau \;\alpha\; \frac{1}{d^3}$$

$$\therefore \frac{\tau_2}{\tau_1} = \left(\frac{d_1}{d_2}\right)^3$$

$$\therefore \tau_2 = \left(\frac{d_1}{2d_1}\right)^3 .\tau_1 \;= \frac{1}{8}\times 120 = 15\,\text{MPa}$$

03. Ans: (b)

Sol:

- In multiplate clutch as number of contacting surface increases, the torque transmitting capacity also increases. So for a given torque capacity size of multiplate clutch is smaller than that of single plate clutch resulting in compact construction that is required for two wheelers.
- Single plate clutch is used where large radial space is available such as trucks and car.

04. Ans: (d)

Sol: Force vector will be same also moment of force $(\vec{F})$ about origin is $\vec{r}\times\vec{F}$

$$= (\hat{i}+2\hat{j})\times(2\hat{i}+\hat{j}) = -3\hat{k}$$

Net moment = $3\hat{k} - 3\hat{k} = 0$

05. Ans: (d)

Sol: Given data:

L = 5 days

$d = \frac{10000}{300}$ = 33.3 units per day

ROP = d × L

= (33.3 units per day) (5 days)

= 166.7 units

Thus, the reorder point is 167 units

06. Ans: (d)

Sol: f(x, y, z) = 2y +z

Directional derivate = (∇f)p. $\frac{\bar{a}}{|\bar{a}|}$

$$\nabla f = j\frac{\partial f}{\partial y} + k\frac{\partial f}{\partial z} = j.2 + \bar{k}.1 = 2\,\bar{j} + \bar{k}$$

$$\therefore \text{ Directional derivate } = \left(2\,\bar{j} + \bar{k}\right).\frac{\left(\bar{j} + \bar{k}\right)}{\sqrt{2}}$$

$$= \frac{2+1}{\sqrt{2}} = \frac{3}{\sqrt{2}} = 2.21$$

07. Ans: 1.33 (Range 1.3 to 1.4)

Sol: Given data:

λ = 2 bikes arriving per hour

μ = 3 bikes serviced per hour

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{2^2}{3(3-2)} = \frac{4}{3} = 1.33$$

Thus, 1.33 bikes waiting in line, on average.

08. Ans: (a)

Sol:

- Counter sinking involves enlarging the rim of a pilot hole. So (a) is incorrect.
- Trepanning is the operation of producing large size hole without drilling. So (b) is incorrect.
- Reaming is the operation used for sizing and finishing of the hole to get exact dimension of the hole. With reamer, very less amount of material is removed. So (c) is correct.
- Spot facing is the operation used for removing the chips present at the ends of the hole. So (d) is incorrect.

09. Ans: 1.22 No range

Sol: $\frac{dy}{dx} = y + x$

$x_o = 0$, $y_o = 1$

$x_1 = x_o + h = 0.1$

$x_2 = x_o + 2h = 0.2$

$y_1 = y_o + h\,f(x_o, y_o)$

$= 1 + (0.1)(1) = 1.1$

$y_2 = y_1 + h\,f(x_1, y_1)$

$= 1.1 + 0.1\,[0.1 + 1.1]$

$= 1.1 + 0.12 = 1.22$

10. Ans: (a)

Sol: For pure substance at triple point 3 phases are in equilibrium

∴ C = 1, P = 3

According to Gibb's phase rule

F + P = C + 2

F = 1 + 2 – 3 = 0

11. Ans: (d)

Sol: Applying energy equation between A & D

$H_A = H_D + h_{fAD} \rightarrow (1)$

Then applying energy equation between D & B

$H_D = H_B + h_{fDB} \rightarrow (2)$

Eliminating H_D between (1) and (2)

$H_A = (H_B + h_{fDB}) + h_{fAD}$

i.e. $H_A = H_B + h_{fAD} + h_{fDB}$

12. Ans: (c)

Sol:

- In free vortex flow velocity is inversely proportional to the distance r

$$V_\theta = \frac{\text{circulation constant}}{r} = \frac{K}{r}$$

For purely circular motion we can write

$V_r = 0$

$$\omega_Z = \frac{1}{2r}\left(\frac{\partial}{\partial r}(rV_\theta) - \frac{\partial V_r}{\partial \theta}\right)$$

$$= \frac{1}{2r}\left(\frac{\partial}{\partial r}\left(r \times \frac{K}{r}\right) - 0\right)$$

$= 0$

- Turbulent flow is non uniform and it is unsteady flow.
- Potential function does not exist for rotational flow but stream function is non zero for rotational fluid.

13. Ans: (a)

Sol: $$\frac{Nu}{Bi} = \frac{\left(\frac{\text{conductive resistance of fluid}}{\text{convective resistance of fluid}}\right)}{\left(\frac{\text{conductive resistance of solid}}{\text{convective resistance of fluid}}\right)}$$

$$\frac{Nu}{Bi} = \left(\frac{\text{conductive resistance of fluid}}{\text{conductive resistance of solid}}\right)$$

14. Ans: (b)

Sol: Curtis turbine is a velocity compounded steam turbine and the direction of flow is axial. In Pelton turbine, jet velocity is tangential to the Pelton wheel. In Francis turbine flow enters radially and in Kaplan turbine the flow is parallel to the hub. i.e. axial.

15. Ans: (b)

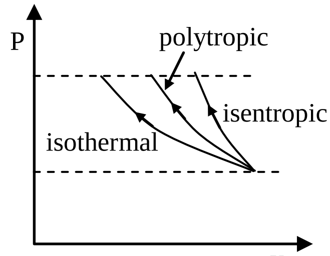
16. Ans: (a)

Sol:

- Annealing is a process of heating the steel slightly above the critical temperature of steel (723°C) and allowing it to cool down very slowly. So statement 2 is incorrect.
- Typically in steels, annealing is used to reduce hardness, increase ductility and help eliminate internal stresses. So statement 4 is also incorrect. Hence option(a) is Correct.

17. Ans: (b)

Sol:



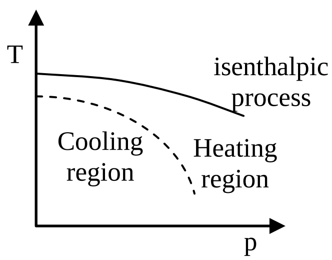
Flow work, $W = -\int vdP$

In the figure shown above area under the curve for isothermal process is minimum and maximum for isentropic process.

$\therefore \quad W_{isothermal} < W_{polytropic} < W_{isentropic}$

18. Ans: (a)

Sol:



Within the inversion curve lies cooling region and outside the curve lies heating region. If initial temperature of gas is above maximum inversion temperature then the gas lies on heating region and on throttling will undergo heating.

19. Ans: (d)

Sol: In orthogonal rake system, the tool is designated as

$$i - \alpha - \theta_s' - \theta_e' - C_e - \lambda - R$$

where, i = inclination angle,

α = orthogonal rake,

θ_s' = side relief,

θ_e' = end relief

C_e = end cutting edge angle

λ = principle cutting edge angle

r = nose radius

$\therefore$ Orthogonal rake angle = 10° and principal cutting edge angle = 60°

20. Ans: (d)

Sol: When the brass is used as filler rod material, if oxidizing flame is used then because of presence of excess amount of oxygen in the flame, the excess oxygen combines with some quantity of zinc present in the brass material and forms zinc oxide which floats on the weld pool and does not allow remaining zinc to evaporate.

21. Ans: 5 No range

Sol: Let X = Amount the player wins in rupees

The probability distribution for X is given below.

Number of heads	0	1	2
X	x	1	3
P(X)	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{1}{4}$

For the game to be fair we have to find x, so that E(X) = 0

$$\Rightarrow x.\left(\frac{1}{4}\right) + 1.\left(\frac{2}{4}\right) + 3.\left(\frac{1}{4}\right) = 0$$

$\Rightarrow x = 5$

$\therefore$ Number of rupees, the player has to lose if no head occur = 5.

22. Ans: 24 No range

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

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

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

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

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

23. Ans: (d)

Sol:

- Earing → Deep drawing
- Bamboo defect → Extrusion
- Alligatoring → Rolling
- Cold shut → Forging

24. Ans: (b)

Sol: Stress invariant,

$$I_1 = \frac{\sigma_x + \sigma_y}{2} = \frac{\sigma_1 + \sigma_2}{2}$$

$$\therefore \sigma_2 = \sigma_x + \sigma_y - \sigma_1$$

$$= 32 - 10 - 40 = -18\ \text{MN/m}^2$$

25. Ans: 4 No range

Sol: The constant term in the characteristic equation of a matrix is equal to the determinant of a matrix

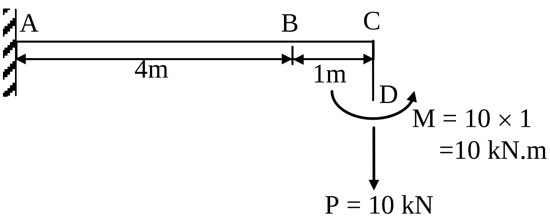
$\therefore$ det(A) = 4

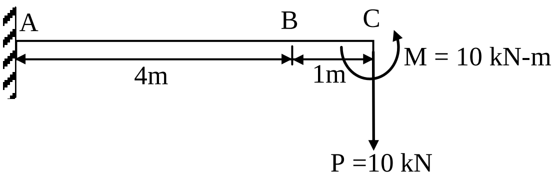
26. Ans: (b)

Sol: Given data:

d = 300 mm, b = 150 mm, P = 10 kN

The given force P = 10 kN can be transfer to point 'C' as shown in the given figure below:





Maximum bending moment at point 'A' is given by,

$$M_A = P \times (4 + 1) - M$$

$$= 10 \times (5) - 10 = 40\ \text{kN.m}$$

Maximum bending stress,

$$\sigma_b = \frac{M_A.y}{I}$$

$$= \frac{40 \times 10^6 \times \left(\frac{300}{2}\right)}{\frac{150 \times (300)^3}{12}} = 17.78\ \text{MPa}$$

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27. Ans: 120 (Range 118 to 122)

Sol: $V_C = 60^3\ mm^3$

$$V_{SC} = \frac{2.3}{100}\times V_C = 4968\ mm^3$$

Riser height = 30 mm

$V_r = 4\ V_{Sc}$

$$\frac{\pi}{4}D^2H = 4\times 4968$$

$\Rightarrow$ D = 29.04 mm

According to sufficient condition

$\tau_r \geq \tau_C$ (should be)

but in this case $M_r < M_C$

$\therefore$ Equating $M_r = M_c$

Hence D_r = 120 mm

28. Ans: (d)

Sol: Displacement of $B = \overline{BC} = \overline{x}$

$$\tan\theta = \frac{x}{y}$$

y = constant = 0.5 m

$\dot{\theta} = \omega_{AB}$, $\dot{x} = V_B$ = 5 m/s = Constant

x= y tanθ

$$\Rightarrow \dot{x} = y\sec^2\theta\dot{\theta}$$

$$\dot{\theta} = \frac{\dot{x}}{y}\cos^2\theta$$

$$\alpha_{AB} = \ddot{\theta} = \frac{\dot{x}}{y}2\cos\theta(-\sin\theta)\dot{\theta}$$

$$(\alpha_{AB}) = 2\frac{\dot{x}^2}{y^2}\sin\theta\cos^3\theta$$

$$= 2\times\frac{5^2}{0.5^2}\sin 30\cos^3 30 = 64.95\ \text{rad/s}^2$$

29. Ans: 8.9 (Range: 8.1 to 9.4)

Sol: Total heat supplied to water

= 1 × 4.2 × [90 – 25] = 273 kJ

Increase in availability = $(h_2 – h_1) – T_0(s_2 – s_1)$

$$= 1\times c_p\times[90-25] - T_0\times 1\times c_p\times \ell n\left[\frac{273+90}{273+25}\right]$$

$$= 1\times 4.2\times 65 - (300)\times 4.2\times \ell n\left[\frac{363}{298}\right]$$

= 273 – 248.6 = 24.4 kJ

$$\eta_{IIndLaw} = \frac{\text{Increase in availability of water}}{\text{Total heat supplied to water}} = \frac{24.4}{273} \approx 8.9\%$$

30. Ans: 7.5 (Range 7 to 8)

Sol: Given,

h_o = 10 mm, h_1 = 9 mm, b = 150 mm

V = 20 m/min, p = 150 MPa

$$L = \sqrt{R\,\Delta h} = \sqrt{200\times 1} = 14.142\ \text{mm}$$

Now, F_{avg} = p × (bL)

= 150 × 150 × 14.142

= 318.195 kN

T = F_{avg} × a

[Where, a = moment arm = $\frac{L}{2}$]

$$= 318.195\times\frac{14.142}{2} = 2249.95\ \text{N-m}$$

Power required,

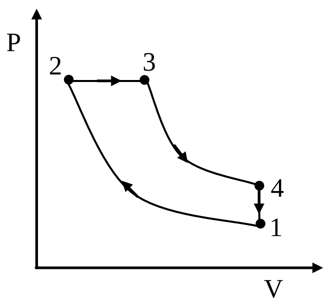
$$P = 2\,T\omega = 2T\frac{V}{R}$$

$$= 2 \times 2249.95 \times \frac{20 \times 1000}{60 \times 200}$$

$P = 7.5$ kW

31. Ans: 60.52 (Range 58.55 to 61.55)

Sol:



The piston displacement (swept volume)

$V_s = (\pi/4)\, d^2L$

$= (\pi/4) \times (25)^2 \times (37.5) = 18408$ cc

Total volume $V_1 = V_s + V_c$

$= 18408 + 1500 = 19908$ cc

Compression ratio, $r = \frac{V_1}{V_2} = \frac{19908}{1500} = 13.27$

Since $V_3 = 1500 + 0.05 \times 18408 = 2420.5$

Cut-off ratio $\rho = \frac{V_3}{V_2} = \frac{2420.4}{1500} = 1.613$

The air standard efficiency of the cycle is

$$\eta_{Diesel} = 1 - \frac{1}{r^{\gamma-1}}\left(\frac{(\rho^{\gamma}-1)}{\gamma(\rho-1)}\right)$$

Substituting the values, we get

$\eta_{Diesel} = 60.52$ %

32. Ans: (c)

Sol: $\frac{T_1}{T_2} = 3$, $P_{max} = 0.2$ MPa, $P = 20$ kW

$V = 10$m/s, $D = 500$mm

$(T_1 - T_2)V = 20000$

$T_1 - T_2 = 2000$………..(a)

$\frac{T_1}{T_2} = 3$……….(b)

From equation (a) and (b)

$T_1 = 3000$ N,

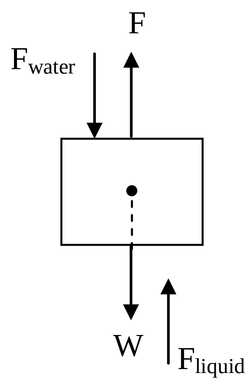
$T_2 = 1000$ N

$$P_{max} = \frac{2T_{max}}{D \times W} = \frac{2T_1}{D \times W}$$

$$W = \frac{2 \times 3000}{0.2 \times 300} = 60\text{mm}$$

33. Ans: (b)

Sol:



Considering the concrete block and the forces acting on it, we have for equilibrium condition.

$\Sigma F_y = 0$

Or, $F - F_{water} + F_{liquid} - W_{block} = 0$

$F = 10^4 \times 5 \times 0.8 - 1.5 \times 10^4 \times 3 \times 0.8$

$+ 25 \times 10^3 \times 0.5 \times 0.8$

$F = (40 - 36 + 10) \times 10^3$ N

= 14 kN

34. Ans: (c)

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

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

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

Consider $du = (u_x)\,dx + (u_y)\,dy$

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

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

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

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

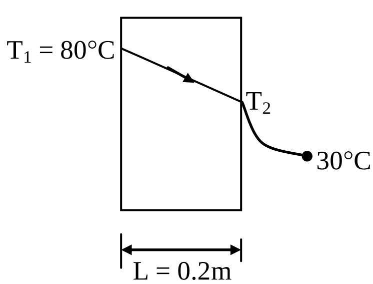
Now, the required analytic function f(z) is given by $f(z) = u + iv$

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

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

35. Ans: (a)

Sol:



$h = 10$ W/m^2-K

$k = 1.2$ W/m-K

$T_1 = 80°C$

$T_2 = T$

$T_\infty = 30°C$

$L = 0.2$ m

$$\text{Heat flux (q)} = \frac{T_1 - T_\infty}{\left(\frac{L}{k}\right) + \frac{1}{h}}$$

$$= \frac{80 - 30}{\frac{0.2}{1.2} + \frac{1}{10}} = 187.5\,\text{W/m}^2$$

Heat flux (q) = $h\,(T_2 - T_\infty)$

$187.5 = 10\,(T - 30)$

$\Rightarrow T = 48.75°C$

36. Ans: (a)

Sol: Initial velocity, $u = 9$ m/s,

Acceleration, $a = -2$ m/s^2

To calculate the time when velocity is zero, we use, $v = u + at$

$0 = 9 - 2\times t \Rightarrow t = 4.5$ sec

Let us calculate displacement (s_1) from t = 4 sec to 4.5 sec

$v^2 = u^2 + 2\,a\,s_1$

$0 = 1^2 - 2 \times 2 \times s_1$

[$\because v|_{at\ t = 4\ sec} = u + at = 9 - 2\times4 = 1$m/s]

$$\Rightarrow s_1 = \frac{1}{4}\text{m}$$

Let us calculate displacement (s_2) from t = 4.5 sec to 5 sec

$$s_2 = ut + \frac{1}{2}at^2$$

$$s_2 = 0 \times 0.5 - \frac{1}{2} \times 2 \times \frac{1}{4} = -\frac{1}{4}\text{m}$$

Total distance = $|s_1| + |s_2| = \frac{1}{2}$m = 0.5 m

37. Ans: (a)

Sol: Given data:

Width = depth = d,

$L = 1.57$ m,

$E = 200\times10^3$ MPa,

$\sigma_y = 240$ MPa

The column has to be designed such that it buckles at the same instant as it yields.

$\therefore$ Critical buckling load = Load at which column starts yielding

$$\therefore \frac{\pi^2 EI}{L_e^2} = \sigma_y \times A$$

where,

L_e = Equivalent length of the beam = L

A = Cross sectional area of the beam

$$\therefore \frac{\pi^2 \times 200\times10^3 \times \left(\frac{d\times d^3}{12}\right)}{\left(1.57\times10^3\right)^2} = 240\times(d\times d)$$

$$\therefore d^2 = \frac{240\times10^6\times12}{(2)^2\times200\times10^3}$$

$\therefore d^2 = 3600$

$\therefore$ d = 60 mm

38. Ans: 0.2 No range

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

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

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

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

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

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

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

$$= 0.25 - 0.05 = 0.2$$

39. Ans: (a)

Sol: h_1(enthalpy at inlet to turbine) = 3400 kJ/kg,

h_2 (enthalpy at outlet to turbine) = 2300 kJ/kg

Heat rejected, $Q_{rej} = 2100$ kJ/kg,

$W_T = h_1 - h_2$

$= 3400 - 2300$ kJ/kg $= 1100$ kJ/kg

Heat supplied,

$Q_{sup} = Q_{rej} + W_T$

$= 2100 + 1100 = 3200$ kJ/kg

$$\eta_{th} = \frac{1100}{3200} = 34.4\%$$

40. Ans: (b)

Sol: line equation of AB is,

Here A = (1 , 1) B = (3 , 2)

$$y - 1 = \frac{1}{2}(x-1) \Rightarrow y = \frac{x+1}{2}$$

$$dy = \frac{dx}{2}$$

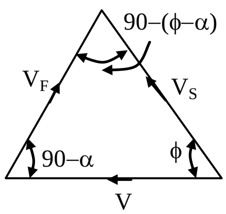
$$\therefore \int_C \text{Re } z\ dz = \int_1^3 x(dx + idy)$$

$$= \int_1^3 x\left(dx + i\frac{dx}{2}\right) = \left(1 + \frac{i}{2}\right)\left[\frac{x^2}{2}\right]_1^3$$

$$= 4 + 2i$$

41. Ans: (b)

Sol:



From the velocity triangle,

$$\frac{V_f}{\sin\phi} = \frac{V}{\cos(\phi - \alpha)}$$

$$V_f = \frac{V\sin\phi}{\cos(\phi-\alpha)}$$

$$= \frac{45 \times \sin 45}{\cos(45 - 10)} = 38.84 \text{ m/min}$$

42. Ans: 100 (Range 99 to 101)

Sol: Maximum uncut chip thickness,

$$t = 2f_t\sqrt{\frac{d}{D}}$$

Where, f_t is the feed per tooth of the cutter that is, the distance the workpiece travels per tooth of the cutter, in mm/tooth

Where, d = depth of cut,

D = cutter diameter

So, $t \propto \sqrt{\frac{d}{D}}$

$$\frac{t_2}{t_1} = \sqrt{\frac{2d}{D/2}} \times \sqrt{\frac{D}{d}} = \sqrt{4}$$

$$\frac{t_2}{t_1} = 2 \Rightarrow t_2 = 2t_1$$

$$\text{Percentage change} = \frac{t_2 - t_1}{t_1} \times 100$$

$$= \frac{2t_1 - t_1}{t_1} \times 100 = 100\ \%$$

43. Ans: (c)

Sol: $$\text{Re}_m = \frac{1000 \times V_m \times L_m}{10^{-3}} = 1000$$

$\therefore V_m L_m = 10^{-3}$ .... (1)

For dynamic similarity of gravity forces

$$\frac{V_m}{\sqrt{L_m}} = \frac{V_p}{\sqrt{L_p}} = \frac{4}{\sqrt{25}}$$

i.e. $V_m = \frac{4}{5}\sqrt{L_m}$ ....(2)

From equation (1) and (2)

$$L_m^{3/2} = \left(\frac{5}{4} \times 10^{-3}\right)$$

i.e. $L_m = 1.16 \times 10^{-2}$

$$L_r = \frac{L_m}{L_p} = \frac{1.16 \times 10^{-2}}{25} = 4.64 \times 10^{-4}$$

44. Ans: 2.47 (range 2.40 to 2.55)

Sol: Given,

$C_p = 846$ J/kgK, $\mu = 1.5\times10^{-5}$ kg/m-s

$\rho = 1$ kg/m^3 , $k = 0.01665$ W/m-K

D = 0.01 m, L = 1m,

V = 0.1 m/s, L = 1m

$$Re = \frac{\rho VD}{\mu}$$

$$= \frac{1\times0.1\times0.01}{1.5\times10^{-5}} = 66.67$$

Re = 66.67 < 2100

$$Pr = \frac{\mu C_p}{k} = \frac{1.5\times10^{-5}\times846}{0.01665} = 0.7621$$

$$Re.Pr.\left(\frac{D}{L}\right) = 66.67\times0.7621\times\frac{0.01}{1}$$

$$= 0.5081 < 10$$

Re < 2100 and

$Re.Pr.\frac{D}{L}$ < 10 indicate that the flow is laminar

For laminar flow

$$Nu = 1.86\left(Re.Pr.\frac{D}{L}\right)^{1/3}$$

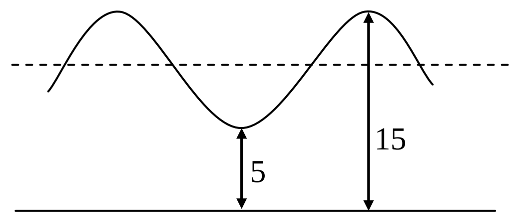
$$= 1.86(0.5081)^{1/3}$$

$$\frac{h\times d}{k} = 1.4842$$

$$h = 1.48\times\frac{0.1665}{0.01} = 2.47 \text{ W/m}^2\text{-K}$$

45. Ans: (d)

Sol: The surface profile is sinusoidal and can be drawn as :



From the figure :

$h_{max} = 15$, $h_{min} = 5$

Maximum peak to valley height,

$R_t = h_{max} - h_{min}$

$R_t = 15 - 5 = 10$

Now, $R_a = \frac{R_t}{4} = \frac{10}{4} = 2.5$ μm

46. Ans: (b)

Sol: For eigen vector, $Ax = \lambda x$

$$\begin{bmatrix} 1 & 1 & 3 \\ 1 & 5 & 1 \\ 3 & 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = (-2)\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

$\Rightarrow x_1 + x_2 + 3x_3 = -2x_1 \rightarrow (1)$

$\Rightarrow x_1 + 5x_2 + x_3 = -2x_2 \rightarrow (2)$

$\Rightarrow 3x_1 + x_2 + x_3 = -2x_3 \rightarrow (3)$

$(1) \Rightarrow 3(x_1 + x_3) = -x_2 \rightarrow (4)$

$(2) \Rightarrow x_1 + x_3 = -7x_2 \rightarrow (5)$

$(3) \Rightarrow 3(x_1 + x_3) = -x_2 \rightarrow (6)$

From (5) $\rightarrow x_1 + x_3 - 7(3(x_1 + x_3)) = 0$

$\Rightarrow x_1 + x_3 = 0$

Suppose $x_1 = k \Rightarrow x_3 = -k$

$\therefore x_2 = -3(x_1 + x_3)$

$= 0$

$$\therefore \text{Eigen vector} \begin{bmatrix} k \\ 0 \\ -k \end{bmatrix}$$

$$\text{For } k = 1 \Rightarrow \text{eigen vector} = \begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

47. Ans: (b)

Sol: $\dot{m} = \rho Q$

$= 10^3 \times 250 \times 10^{-3} = 250$ kg/s

$$V_1 = \frac{Q}{A_1} = \frac{250 \times 10^{-3}}{250 \times 10^{-4}} = 10\,\text{m/s}$$

Applying linear momentum equation to the C.V. surrounding the bend and assuming, the force on the fluid exerted by bend to be F_x towards right.

$$(F_x)_{\text{on fluid}} + P_1A_1 + P_2A_2\cos 60^\circ$$

$$= \dot{m}[-\beta_2 V_2 \cos 60^\circ - \beta_1 \times V_1]$$

$$V_2 = \frac{A_1}{A_2} \times V_1 = 5 \text{ m/s}$$

$$(F_x)_{\text{on fluid}} = -250(1.03 \times 5\cos 60^\circ + 1.01 \times 10) - 76 \times 10^3 \times 0.025 - 60 \times 10^3 \times 0.05\cos 60^\circ$$

$= -[3.17 + 1.9 + 1.5] \times 10^3$

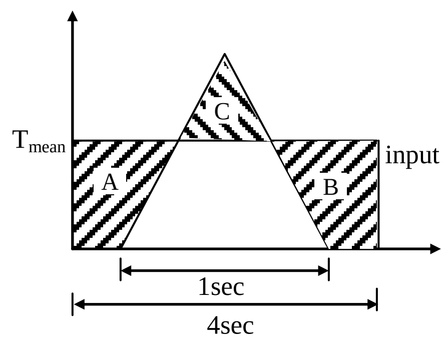
$= -6.57$ kN

$= 6.57$ kN acting towards left

Hence, force acting on the bend by water = 6.57 kN acting towards right

48. Ans: (d)

Sol:



Area, A + B = C

Given,

Energy supplied by motor in 1sec = 250 J

Energy required for 1 rivet operation in 1 sec = 1000 J

Excess energy required

$= 1000 - 250 = 750$ J

Total time required for motor to supply

$$1000 \text{ J} = \frac{1000}{250} = 4\text{sec}$$

So non-machining time = 4 – 1 = 3 sec

Energy supplied by motor in 3sec is stored in flywheel and this energy is released during riveting operation which takes place in 1 sec.

No. of holes closed per hour

$$= \frac{\text{time of execution}}{\text{total time required per hole}}$$

$$= \frac{1 \times 60 \times 60}{4} = 900\,\text{holes}$$

$I = mk^2 = 125 \times 0.7^2 = 61.25$ kgm^2

Now, $\Delta E = \frac{1}{2} I\left(\omega_1^2 - \omega_2^2\right) = 750$

$$= \frac{1}{2} \times 61.25 \times \left(\frac{2\pi}{60}\right)^2 \left(240^2 - N_2^2\right) = 750$$

N_2 = 235.3 rpm

Reduction in speed = 240 – 235.3 = 4.7 rpm

49. Ans: (c)

Sol: Solving problem by linear programming, we get the following equations.

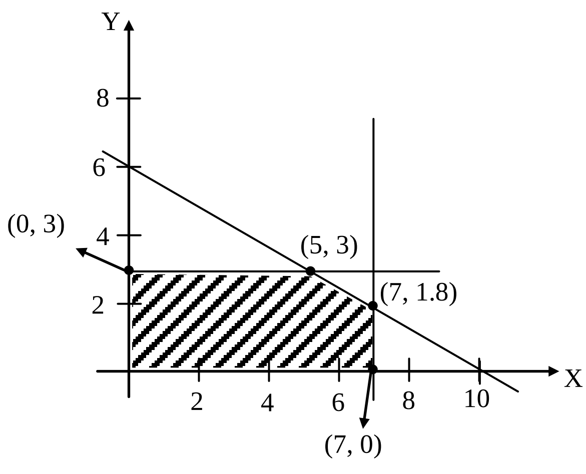
$6X \le 42$; $X \ge 0$

$10Y \le 30$; $Y \ge 0$

$6X + 10Y \le 60$;

And the objective function is to maximize profit, i.e., (Z = X + 8Y)

Solving the above constraints using graphical method, we get the following graph



Point	Value, Z = X + 8Y
(0, 3)	Z = 0 + 8 × 3 = 24
(5, 3)	Z = 5 + 8 × 3 = 29 ← Maximum
(7, 1.8)	Z = 7 + 8 × 1.8 = 21.4
(7, 0)	Z = 7 + 8 × 0 = 7

Therefore, maximum profit per week from manufacturing X and Y is Rs. 29.

50. Ans: (a)

Sol: $\frac{\partial \omega}{\partial y} = \frac{1}{1+\left(\frac{y}{x}\right)^2} \frac{\partial}{\partial y}\left(\frac{y}{x}\right) = \frac{x^2}{x^2+y^2}\frac{1}{x}$

$$= \frac{x}{x^2+y^2}$$

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

$$= \frac{-y}{x^2+y^2}$$

51. Ans: 1.14 (Range: 1.10 – 1.2)

Sol: Water will be in equilibrium with its vapour when the vapour gets saturated. In this case, the pressure of vapour = saturation vapour pressure = 15mm of mercury.

$= (15\times10^{-3}\text{m})(13600\text{kgm}^{-3})(9.8\text{ms}^{-2})$

$= 1999.2\ \text{Nm}^{-2}$

Using gas law, $pV = \frac{m}{M}RT$

$$= \frac{(18\text{g mol}^{-1})(1999.2\text{Nm}^{-2})(76\text{m}^3)}{(8.314\text{JK}^{-1}\text{mol}^{-1})(288\text{K})}$$

$= 1145\text{g} = 1.14\text{kg}$

Thus, 1.14kg of water will evaporate

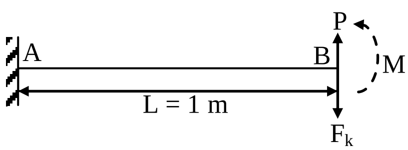
52. Ans: (a)

Sol: Given data:

k = 2000 N/m, P = 1000 N,

L = 1 m, EI = 66000 N.m^2, δ = 1 mm

When the beam is deflected by 1 mm in upward direction, spring force (F_k) is induced in downward direction.



Net upward force at point B is,

$$F = P - F_k = P - k\delta$$

Due to net force F in upward direction,

Deflection, $\delta_1 = \frac{FL^3}{3EI}$ (upward)

Due to an additional sagging moment at point B,

Deflection, $\delta_2 = \frac{ML^2}{2EI}$ (upward)

Net deflection in upward direction,

$\delta = \delta_1 + \delta_2$

$$\therefore \delta = \frac{FL^3}{3EI} + \frac{ML^2}{2EI}$$

$$\therefore \delta = \frac{L^2}{2EI}\left(\frac{2L(P-k\delta)}{3} + M\right)$$

$$\therefore M = \frac{2EI\delta}{L^2} - \frac{2L(P-k\delta)}{3}$$

$$= \frac{2\times 66000 \times 1\times 10^{-3}}{(1)^2} - \frac{2\times 1\times (1000 - 2000 \times 1\times 10^{-3})}{3}$$

$= -533.33$ N.m

53. Ans: 8855 (Range 8850 to 8900)

Sol: H_m = u × volume of weld nugget

$$= 5.2 \times \frac{\pi}{4} \times 8^2 \times 3$$

H_m = 784.14 J

Also $H_m = H_s$ [given]

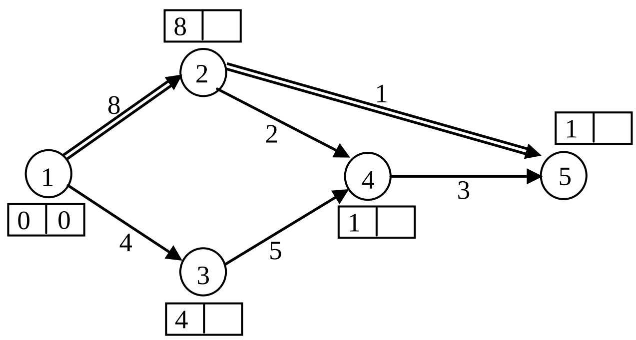
$\therefore$ 784.14 = $I^2 \times 50 \times 10^{-6} \times 0.2$

I = 8855 A

54. Ans: 1800 (Range 1780 to 1820)

Sol:

Activity	Normal Time (days)	Normal Cost (Rs.)	Crash Time (days)	Crash Cost (Rs.)	Crash cost slope $= \frac{C.C - N.C}{N.T - C.T}$	Crash possibility
1-2	8	100	6	200	50	2
1-3	4	150	2	350	100	2
2-4	2	50	1	90	40	1
2-5	10	100	5	400	60	5
3-4	5	100	1	200	25	4
4-5	3	80	1	100	10	2



Path	Days
1-2-5	18 (Critical path)
1-2-4-5	13
1-3-4-5	12

Therefore, crashing along critical path activities by 2 days, we will crash activity 1-2, as cost slope is minimum for 2 days.

Activity	Cost
1-2	**50**
2-5	60

Initial total cost = D.C + I.D.C

= Σ Normal cost + I.D. cost × days

= 580 + 18 × 70 = 1840(Σ Normal cost =100+150+100+100+80 =580)

After crashing activity (1-2) for 2 days

Total cost = D.C + I.D.C

= (580 + 2×50) + 16×70

= Rs. 1800

Therefore, cost for 16 days schedule is Rs. 1800 /-

55. Ans: 34.13 (range : 34 to 34.5)

Sol: $\int_c \left[(x-y)dx + 3xydx\right]$

$$y_1 = \frac{x^2}{4}, \qquad y_2 = 2\sqrt{x}$$

$$x = 0, \qquad x = 4$$

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

(∵ Green theorem)

$$= \iint_R (3y+1)dy\,dx$$

$$= \int_0^4 \int_{\frac{x^2}{4}}^{2\sqrt{x}} (3y+1)dy\,dx = 34.13$$

56. Ans: (a)

Sol: The right choice is 'on'. 'Tell on' means 'to affect'. 'Tell against' means 'to go against'. 'Tell of' means 'to tell about something'.

57. Ans: (c)

Sol: 'is' tired verb must agree with the first subject when 'as well as' is used.

58. Ans: (a)

59. Ans: (d)

Sol: $L = \frac{5}{2}B$

Area = L × B = 1000

$$L \times \frac{2L}{5} = 1000$$

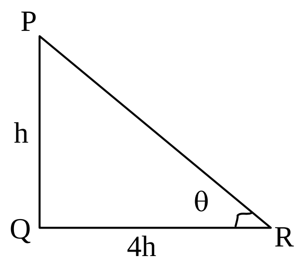
$L^2 = 2500 \Leftrightarrow L = 50$ m

60. Ans: (b)

Sol: Supplement of $80^0 = 180^0 - 80^0 = 100^0$.

61. Ans: (d)

Sol:



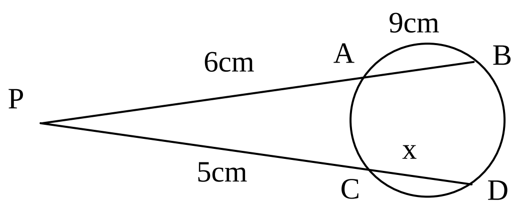
Let the height of tower be 'PQ', 'QR' be the length of shadow to tower in ΔPQR.

$$\tan\theta = \frac{PQ}{QR} = \frac{h}{4h}$$

$$\therefore\ \theta = \tan^{-1}\left(\frac{1}{4}\right)$$

62. Ans: (a)

Sol: If two chords of a circle, intersect inside a circle (outside a circle) at any point. Then,



PA × PB = PC × PD

$\Rightarrow 6 \times 15 = 5 \times (x + 5)$

$\Rightarrow x + 5 = 18 \Rightarrow x = 13$ cm

63. Ans: (a)

Sol: Total time between 10 pm to 6 am = 8 hours

% time spent in Light sleep or in Extreme sleep = 30 + 25 = 55%

$\Rightarrow$ Time spent in Light sleep or in Extreme sleep = $\frac{55}{100} \times 8$

$\Rightarrow \frac{22}{5} = 4.4\,\text{hours}$

64. Ans: (b)

Sol: Total cost of mobiles = 99 × 15000
= Rs. 14,85,000

Total cost of cameras = 53 × 13000
= Rs. 6,89,000

Total cost of TVs = 29 × 59000
= Rs. 17,11,000

Total cost of Refrigerator = 21 × 56000
= Rs. 11,76,000

Total cost of AC = 97 × 25000
= Rs. 24,25,000

Total cost = 14,85,000 + 6,89,000 + 17,11,000 + 11,76,000 + 24,25,000
= Rs. 74,86,000

Total cost in lakhs = Rs. 74.86 lakhs

65. Ans: (a)

Sol: An assumption is an unstated premise. So, we are looking for something that is implied in the argument, and if wrong, will undermine the argument. All that the speaker implies is that Josh is efficient because he has twenty years of practice, and so answer (a) is correct.