PRODUCTION & INDUSTRIAL ENGINEERING _ MOCK - D __ Solutions

01. Ans: (D)

Sol: For wax pattern draft allowance is not required. It is used where very small quantity of job is to be cast or only one (or) two casting is required. This pattern provides high degree of surface finish and dimensional accuracy. If the pattern is made by wax, mercury or polystyrene it is not required to provide draft allowance.

02. Ans: (B)

Sol: $\frac{n_d}{n_{dr}} = 2$

$n_d - n_{dr} = 2$

$2n_{dr} - n_{dr} = 2 \Rightarrow n_{dr} = 2$

$n_d = 2\times2 = 4$

So, number of pairs of friction surface in contact,

$n = n_d + n_{dr} - 1$

$n = 4 + 2 - 1 = 5$

03. Ans: (D)

Sol: Mean tardiness is to be minimized. Hence EDD rule will be used.

04. Ans: (B)

Sol: Applying continuity equation (before and after the nozzle), we can write

$A_1V_1 = A_2V_2$

where the suffix 2 stands for the exit of the nozzle

So, the ratio of the two velocities,

$$\frac{V_1}{V_2} = \frac{A_2}{A_1} = \frac{d^2}{D^2} = \left(\frac{0.5\times10^{-2}}{10^{-2}}\right)^2 = \frac{1}{4}$$

05. Ans: (A)

Sol: HCP has the fewest slip directions, BCC the most and FCC falls in between. HCP metals shows poor ductility and are generally difficult to deform at room temperature.

06. Ans: 2 [No Range]

Sol: The probability density function of uniform distribution is

$$f(x) = \begin{cases} 1, & 0 < x < 1 \\ 0, & otherwise \end{cases}$$

E(y) = $E[-2\log_e x]$

$$= \int_0^1 -2\log_e x \; f(x)\,dx$$

$$= -2\int_0^1 \log_e x \, dx$$

$= -2\{x\log_e x - x\}_0^1$

$= -2\{(0-1)-(0)\}$

$= 2$

07. Ans: 8 [Range 7.9 to 8.1]

Sol: Observed time (OT) = T_0 = 8 minutes

R = Rating = 80%

RRA = Rest and Relaxation Allowance

= 0.25%

SR = Standard Rating = 100%

$$\text{Standard time} = \frac{OT\times R}{SR}\left(1+\frac{RRA}{100}\right)$$

$$= \frac{8\times 80}{100}\left(1+\frac{25}{100}\right) = 8\text{ min}$$

08. Ans: (A)

Sol: $T_{H_1} = 1850^\circ C = 2123\ K$

$T_{L_1} = 500^\circ C = 773\ K$

$T_{H_2} = 1500^\circ C = 1773\ K$

$T_{L_2} = 750^\circ C = 1023\ K$

Radiative heat transfer,

$Q_1 = A\sigma\left(T_{H_1}^4 - T_{L_1}^4\right)$ --------(1)

$Q_2 = A\sigma\left(T_{H_2}^4 - T_{L_2}^4\right)$ --------(2)

Equation (1) ÷ (2)

$$\frac{Q_1}{Q_2} = \frac{T_{H_1}^4 - T_{L_1}^4}{T_{H_2}^4 - T_{L_2}^4}$$

$$\frac{25}{Q_2} = \frac{2123^4 - 773^4}{1773^4 - 1023^4}$$

Q_2 = 11.006 W

09. Ans: (D)

Sol: We know that,

$$\varepsilon_{long} \propto \frac{1}{E}(\text{for same level of stress})$$

$E_{steel} > E_{brass} > E_{glass} > E_{rubber}$.

Elasticity is measured by parameter that how fast the material regains its original shape after removal of stress. So strain is steel is above, hence it is more elastic.

10. Ans: 2450 [Range: 2448 to 2452]

Sol: Basic Length unit (BLU) = $\frac{1}{100}\times\frac{1}{4}\times 4$

= 0.01 mm = 10 μm

The required number of pulses for traveling 24.50 mm = ?

Number of pulses = $\frac{24.5}{0.01}$ = 2450

11. Ans: 0.27 [Range 0.26 to 0.28]

Sol: d_0 = 10 mm; l_0 = 100 mm;

P = 50 kN; Δl = 1 mm; G = 25 GPa

Using Hook's law, $\sigma = E.\varepsilon$

$$\therefore \frac{P}{A} = E.\frac{\Delta\ell}{\ell_0}$$

$$\therefore \frac{50\times10^{3}}{\frac{\pi}{4}\times(10)^{2}} = E\times\frac{1}{100}$$

$\therefore$ E = 66.66 GPa

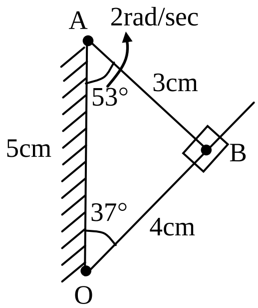
Now, E = 2G(1+μ)

$\therefore$ 66.66 = (2 × 25) × (1 + μ)

$\therefore$ μ = 0.27

12. Ans: (C)

Sol:



From the figure it is clear that

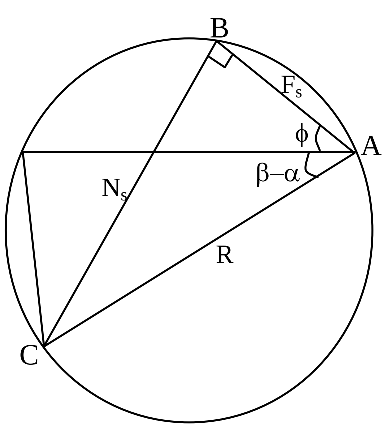
AB ⊥ OB

velocity of sliding block is V = ωr

$V_s = \omega r = 2\times3 = 6$ cm/sec

13. Ans: (C)

Sol:



From the triangle ABC,

$N_s = R \sin(\phi + \beta - \alpha)$

14. Ans: (C)

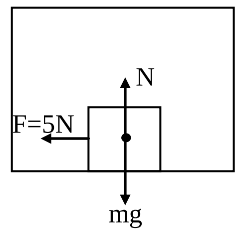
Sol: $\because \underset{x\to0}{Lt} \dfrac{\tan(ax)}{x} = a$

Now, $\underset{x\to0}{\text{Lt}} \dfrac{\tan(4x)}{4x} = \dfrac{1}{4} \underset{x\to0}{\text{Lt}} \dfrac{\tan(4x)}{x}$

$\therefore \underset{x\to0}{\text{Lt}} \dfrac{\tan(4x)}{4x} = \dfrac{1}{4}(4) = 1$

15. Ans: (A)

Sol:



For block :

mg – N = mg

⇒ N = 0

Frictional force = μN = 0

16. Ans: (B)

Sol: Given

$$\int_0^x f(t)\,dt = -2 + \frac{x^2}{2} + 4x\sin(2x) + 2\cos(2x)$$

Differentiating both sides of above w.r.t 'x', we get

$$\frac{d}{dx}\left[\int_0^x f(t)\,dt\right] = -0 + \frac{2x}{2} + 4\sin(2x) + 8x\cos(2x) - 4\sin(2x)$$

$$\Rightarrow \left(\frac{d}{dx}(x)\right)[f(x)] - \left(\frac{d}{dx}(0)\right).[f(0)] = x + 8x\cos(2x)$$

⇒ f(x) = x + 8x.cos(2x)

$$\therefore \frac{1}{\pi} f\left(\frac{\pi}{4}\right) = \frac{1}{\pi}\left[\frac{\pi}{4} + 8\left(\frac{\pi}{4}\right).\cos\left(\frac{2\pi}{4}\right)\right]$$

$$= \frac{1}{4} = 0.25$$

17. Ans: (B)

Sol: Characteristic length for natural convection over horizontal flat plate

$$= \frac{\text{Area}}{\text{Perimeter}} = \frac{A_S}{P}$$

$$= \frac{a \times b}{2a + 2b} = \frac{ab}{2(a+b)}$$

18. Ans: 1.832 (range 1.55 to 1.95

Sol: True strain = $ln(A_0/A_1)$

$= 2\,ln\,(d_0/d_1)$

$= 2\,ln(5/2) = 1.83258$

19. Ans: (B)

Sol: Travel time in X-axis is (6-1)/12 =0.41 sec, in Y-axis is (3-1)/12 = 0.166 sec.

Travel time = 0.41 sec

Resolution = BLU = 0.00254 mm

20. Ans: 1280 [No range]

Sol: Given that $|A_{4\times4}| = 5$

$\because |K\,A_{n\times n}| = K^n\,|A_{n\times n}|$

$\Rightarrow |(-4)\,A| = (-4)^4\,|A_{4\times4}|$ for n = 4

$\Rightarrow |(-4)\,A_{4\times4}| = (256)\,(5)$

$\therefore |(-4)\,A_{4\times4}| = 1280$

21. Ans: (D)

Sol: The typical effect of temperature on the strength and elastic modulus of thermoplastics is similar to those for metals; with increasing temperature, the strength and the modulus of elasticity decreases and toughness increases.

22. Ans: (C)

23. Ans: (B)

Sol: Variables corresponding to unit matrix are called the solution to the problem.

24. Ans: (d)

Sol: Advantages of ultrasonic machining process are:

(i) The process can machine electrically conductive as well as non-conducting hard and brittle materials.

(ii) There is no direct contact between tool and workpiece therefore, the machined surface is free from excess stress and mechanical damages.

(iii) There is no thermal damage such as thermal cracks and heat affected zone on the machined surface as the water abrasive slurry is used during machining.

(iv) It can produce rough as well as finish surface with good structural integrity.

(v) It can produce burr-free surface.

(vi) It can machine chemically active as well as inert materials.

(vii) It can create any shape depending upon tool shape on very hard and brittle materials, such as glass, silicon, quartz crystal, sapphire, nitride, ferrite and optics.

(viii) Using micro-tool, it can generate micro complex shaped cavity or hole on workpiece.

(ix) Power consumption is less.

25. Ans: (B)

Sol: The condition for exactness of a differential equation

$M(x, y)\,dx + N(x, y)\,dy = 0$ is $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

Given that $M(x, y) = 3xy^2 + k^2 x^2 y$

and $N(x, y) = kx^3 + 3x^2y$

Consider $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

$\Rightarrow 6xy + k^2x^2 = 3kx^2 + 6xy$

$\Rightarrow k^2 = 3k$ (or) $k^2 - 3k = 0$

$\Rightarrow k = 0, 3$

$\therefore$ The non zero value of k is 3

26. Ans: (B)

Sol: Since the spherical bubble is rising upwards, it will be in equilibrium under the condition

$$F_D + W = F_B$$

where, F_B is the buoyancy force. Since Re << 1, the flow is a creeping flow and in this case, $F_D = 3\pi\mu DU$.

Hence,

$$3\pi\mu DU + \frac{4}{3}\pi r^3 \times \rho_a \times g = \frac{4}{3}\pi r^3 \times \rho_w \times g$$

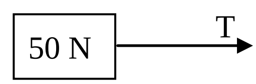
or, $$\frac{4}{3}\pi r^3 g\rho_W\left(1 - \frac{\rho_a}{\rho_w}\right) = 3\pi\mu \times 2 \times r \times U$$

Since ρ_a/ρ_W <<1, we neglect it

$$\Rightarrow \rho_w = \frac{9}{2}\frac{\mu U}{gr^2}$$

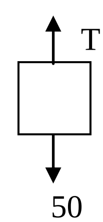
27. Ans: (B)

Sol: F.B.D of A



$T = \frac{50}{g} a_A$ ------(1)

F.B.D of B

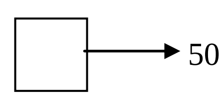


$50 - T = \frac{50}{g}\, a_A$

$50 - \frac{50}{g} a_A = \frac{50}{g} a_A$

$a_A = \frac{g}{2} m/s^2$

F.B.D of C



$50 = \frac{50}{g} a_c$

$a_c = g \;\; m/s^2$

28. Ans: (C)

Sol: Given: $Q = (1 + 0.1t)\ m^3/hr$

Or, $A\dfrac{dh}{dt} = (1+0.1t)$ -------(i)

Where, A is the area of the base of the reservoir, 'h' is the water level from base at any time 't', dh is the elemental increase in water level in time dt.

From equation (i)

$$dh = \frac{(1+0.1t)}{0.5}dt$$

Integrating the above equation

$$h = \int_0^1 (2+0.2t)dt$$

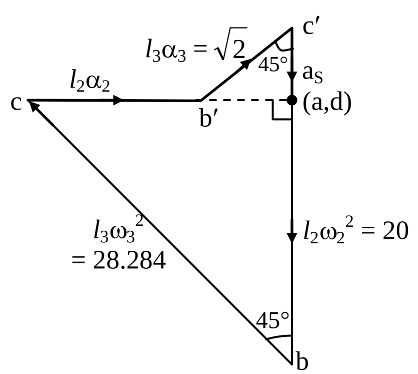
$$= 2[t]_0^1 + \frac{0.2}{2}[t^2]_0^1$$

$= 2(1 – 0) + 0.1(1^2 – 0)$

$= 2.1$ m

29. Ans: (D)

Sol:



(acceleration diagram)

(i) Centripetal acceleration of rod AB = $l_2\,\omega_{AB}^2 = 0.2\times10^2 = 20\ m/s^2$ (parallel to AB sense from b to a)

(ii) Tangential acceleration of rod AB = $l_2\,\alpha_2$ = (unknown) (perpendicular to AB)

(iii) Centripetal acceleration of rod BC = $l_3\,\omega_{BC}^2 = 0.2828 \times 10^2 = 28.284\ m/s^2$ (parallel to BC sense from c to b)

(iv) Tangential acceleration of rod BC = $l_3\,\alpha_3$ = (unknown) (perpendicular to BC)

(v) Acceleration of the slider, $a_s = 1\ m/s^2$ (downward) (parallel to CD)

$BC = \sqrt{0.2^2 + 0.2^2} = 0.2828\,m$

From the acceleration diagram,

$$b'c' = \frac{1}{\cos 45} = \sqrt{2}\,m/s^2$$

$$l_2\alpha_2 = 20 – 1 = 19\ m/s^2$$

$$\alpha_2 = \frac{19}{0.2} = 95\ rad/s^2$$

30. Ans: (B)

Sol: Given that $A = (a_{ij})_{n\times n}$,

where $a_{ij} = \begin{cases} (n+1)^2 - i, & \forall\ i = j \\ 0 & ,\ \forall\, i \neq j \end{cases}$

$$\Rightarrow A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$= \begin{bmatrix} 15 & 0 & 0 \\ 0 & 14 & 0 \\ 0 & 0 & 13 \end{bmatrix}_{3\times3} \quad \text{for } n = 3$$

$\Rightarrow A_{3\times3}$ is a diagonal matrix & its eigen values are its diagonal elements 15, 14, 13.

If $\lambda_1, \lambda_2, \lambda_3$ are the eigen values of $A_{3\times3}$ matrix then the eigen values of matrix $A^2_{3\times3}$ are λ_1^2, λ_2^2 *and* λ_3^2.

$\therefore$ The eigen values of a required matrix A^2 are $(15)^2$, $(14)^2$ and $(13)^2$ (i.e., 225, 196, 169)

31. Ans: 11.5 [Range 10.5 to 12.5]

Sol: Casting size$_1$ = 500×400×200 → t_1 = 30 min

Casting size$_2$ = 500×300×100 → t_2 = ?

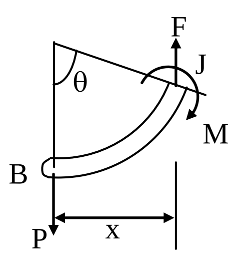
$$t_2 = t_1\left(\frac{M_2}{M_1}\right)^2$$

$$= 30\left[\left(\frac{500\times300\times100}{500\times400\times200}\right)\times\left(\frac{2((500\times400)+(400\times200)\times(500\times200))}{2((500\times300)+(300\times100)+(500\times100))}\right)\right]^2$$

$$t_2 = 11.5\,\text{min}$$

32. Ans: (C)

Sol:



$$\circlearrowright + \sum M_J = 0 \Rightarrow Px - M = 0$$

$$M = Px = PR\sin\theta \quad (\because x = R\sin\theta)$$

Strain energy, $U = \int_0^L \frac{M^2}{2EI}dx$

We know that, $x = R\sin\theta$.

For a small angle θ, $\sin\theta \approx \theta$.

$\Rightarrow dx = R.d\theta$

$$U = \int_o^\pi \frac{(PR\sin\theta)^2}{2EI}(Rd\theta) = \frac{P^2R^3}{2EI}\int_o^\pi \sin^2\theta d\theta$$

$$= \frac{P^2R^3}{2EI}\int_o^\pi \frac{1-\cos2\theta}{2}d\theta$$

$$= \frac{P^2R^3}{2EI}\left(\frac{1}{2}\theta\Big|_o^\pi - \frac{1}{4}\sin2\theta\Big|_o^\pi\right) = \frac{\pi P^2R^3}{4EI}$$

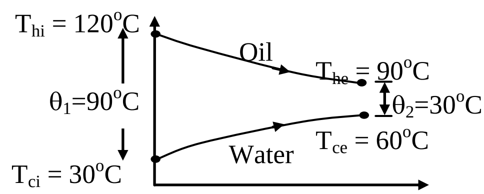
By Castingliano's theorem,

$$\delta = \frac{\partial U}{\partial P} = \frac{\pi PR^3}{2EI} \qquad \textit{(Downward)}$$

33. Ans: 1.098 [Range: 1.09 to 1.1]

Sol: Case-I:

For co-current (parallel flow) heat exchanger.



$$LMTD = \frac{\theta_1 - \theta_2}{\ell n\left(\frac{\theta_1}{\theta_2}\right)} = \frac{90-30}{\ell n\left(\frac{90}{30}\right)} = \frac{60}{\ell n 3}$$

$$LMTD\ (\theta_m) = 54.61^\circ C$$

Net heat transfer = $\dot{m}_o Cp_o (T_{hi} - T_{he})$

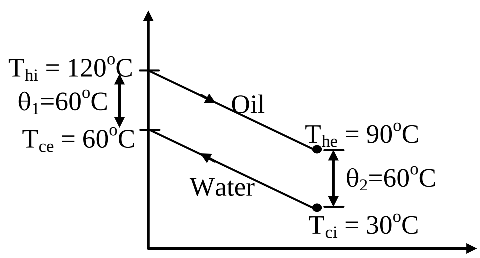
$U \times S_1 \times \theta_m = \dot{m}_o Cp_o (120 - 90)$

$$S_1 = \frac{\dot{m}_o \times Cp_o \times 30}{U \times \theta_m}$$

$$S_1 = \frac{30 \times \dot{m}_o \times Cp_o}{54.61 \times U} ....(1)$$

Case -II:

For counter-current heat exchanger



$\theta_1 = \theta_2 = 60^oC$

$\therefore LMTD(\theta_m) = 60^oC$

Net heat transfer = $\dot{m}_o Cp_o (T_{hi} - T_{he})$

$U \times S_2 \times \theta_m = \dot{m}_o Cp_o (120 - 90)$

$$S_2 = \frac{\dot{m}_o \times Cp_o \times 30}{U \times \theta_m}$$

$$S_2 = \frac{30 \times \dot{m}_o \times Cp_o}{60 \times U} ....(2)$$

From Equation (1) ÷ (2)

$$\frac{S_1}{S_2} = \frac{60}{54.61} = 1.0986$$

34. Ans: 1.33 [Range 1.2 to 1.5]

Sol: $N = \frac{1000V}{\pi D} = \frac{1000 \times 30}{\pi \times 30} = 318.3 rev/min$

Feed rate (f) = $f_t \times$ number of tooth $\times$ N

= 0.06×5×318.3

= 95.5 mm/min

$$Approach(A) = \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right]$$

$$= 0.5\left(30 - \sqrt{30^2 - 25^2}\right) = 6.7mm$$

$$T_m = \frac{Total\ length}{f} = \frac{120 + 6.7}{95.5} = 1.33 min$$

35. Ans: 2 [No Range]

Sol: Given that $f(x, y) = x^2 + 2y^2$ .... (1)

with $y - x^2 + 1 = 0$ .... (2)

From (2), we write $y = x^2 - 1$ .... (3)

Put (3) in (1), we get

$f(x, y) = x^2 + 2y^2 = x^2 + 2(x^2 - 1)^2$

$= x^2 + 2[x^4 - 2x^2 + 1]$

Let $g(x) = 2x^4 - 3x^2 + 2$

Then $g'(x) = 8x^3 - 6x$ and $g''(x) = 24x^2 - 6$

Consider $g'(x) = 0$

$\Rightarrow 8x^3 - 6x = 0$

$\therefore x = 0, \frac{\sqrt{3}}{2}, \frac{-\sqrt{3}}{2}$ are stationary points.

At x = 0, $g''(0) = -6 < 0$

At $x = \pm\frac{\sqrt{3}}{2}$, $g''\left(\pm\frac{\sqrt{3}}{2}\right) = 12 > 0$

$\therefore$ x = 0 is a local point of maxima.

Hence, the maximum value of the function f(x, y) at x = 0 is

$f(x, y) = f(x, x^2 - 1) = f(0, -1)$

$= 0 + 2[0 - 0 + 1] = 2$

36. Ans: (B)

Sol: t = 2.25 mm

$\tau_u = 420$ MPa , $\sigma_c = 1260$ MPa

FOS = 2 , D_{min} = ?

$$FOS = \frac{\sigma_c}{\sigma_{allowable}} \Rightarrow \frac{1260}{\sigma_{allowable}} = 2$$

$$\sigma_{allowable} = \frac{1260}{2} = 630 \text{ MPa}$$

$$d_{min} = \frac{4t\sigma_u}{\sigma_{allowable}} = \frac{4 \times 2.25 \times 420}{630} = 6 \text{ mm}$$

$\Rightarrow d_{min} = 6$ mm

37. Ans: (A)

Sol: $Z_{max} = 10x + 30y$

Profit on y is 30

Profit on x is 10

1 unit decrease in y is compensated by three units increase in x.

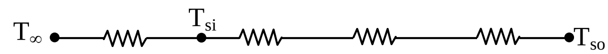
38. Ans: (B)

Sol: Heat transfer (Q) = $h \times A(T_\infty - T_{si})$

$q = h(T_\infty - T_{si})$

$q = 25(200 - 600) = 25 \times 200 = 5000$ W/m^2

Thermal circuit:



$$\frac{1}{hA} \quad \frac{L_A}{k_A \times A} \quad \frac{L_B}{k_B \times A} \quad \frac{L_C}{k_C \times A}$$

$$Q = \frac{T_{Si} - T_{So}}{\frac{L_A}{k_A \times A} + \frac{L_B}{k_B \times B} + \frac{L_C}{k_C \times C}}$$

$$q = \frac{600 - 20}{\frac{0.30}{20} + \frac{0.15}{k_B} + \frac{0.15}{50}}$$

$$5000 = \frac{580}{\frac{0.3}{20} + \frac{0.15}{k_B} + \frac{0.15}{50}}$$

$\Rightarrow k_B = 1.53$ W/m-K

39. Ans: 22.7% [Range: 21% to 23%]

Sol: $m_n = 0.0076 \times \frac{\pi}{4} \times 5^2 \times 4.5 = 0.671$ gm

$H_m = 0.671 \times 1381 = 927.36$ J

$H_s = I^2Rt = 10000^2 \times 120 \times 10^{-6} \times 0.1 = 1200$ J

$$n_m = \frac{927.36}{1200} \times 100 = 77.28\%$$

Percentage of heat lost = 100 – 77.28

= 22.7 %

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40. Ans: 2.35 [Range 2.0 to 2.9]

Sol: To ensure continuous transmission of motion at least one pair of teeth should be in contact.

i.e., contact ratio should be ≥ 1

Path of contact, $\frac{\text{Path of contact}}{\text{Circular pitch} \times \cos\phi} \geq 1$

$$\frac{2\left(\sqrt{R_a^2 - (R\cos\phi)^2} - R\sin\phi\right)}{\frac{2\pi R}{T} \times \cos\phi} \geq 1$$

Given, m = 4 mm, T = 22, $\phi = 20°$

$$R = \frac{mT}{2} = 44$$

$\therefore$ $R_a \geq 46.35$

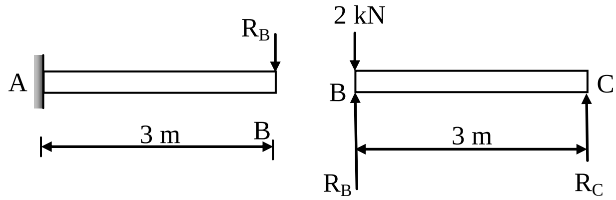
R + addendum ≥ 46.35 mm

Addendum ≥ 2.35mm

Minimum addendum = 2.35 mm

41. Ans: (D)

Sol: The given compound beam can be separated as shown below.



For the beam BC, taking moment about C,

$\Sigma M_C = 0$

$\therefore$ $(2 - R_B) \times 3 = 0$

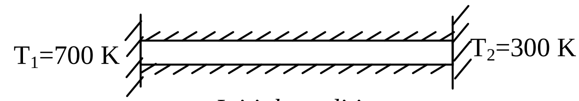
$\Rightarrow$ $R_B = 2$ kN

Now, moment at fixed end A is given by,

$M_A = R_B \times 3 = 2 \times 3 = 6$ kN-m

42. Ans: 500 [Range 500 to 500]

Sol:



Initial condition

Final condition at equilibrium state

From 1st law of thermodynamics

$Q = \Delta U + W$

Q = 0 and W = 0

$\Delta U = 0$

$U_i = U_f$

$dU_i = dm\, CT = \left(\frac{M}{L}dx\right)CT$

$$\int dU_i = \int \frac{MC}{L}\left(700 - \frac{400}{L}x\right)dx$$

$$= \frac{MC}{L}\int_0^L \left(700 - \frac{400}{L}x\right)dx$$

$$U_i = \frac{MC}{L}\left[700x - \frac{400}{2L}x^2\right]_0^L$$

$$= \frac{MC}{L}(700L - 200L) = 500\ MC$$

$U_f = M\,C\,T_f$

$\therefore$ $U_i = U_f$

$\Rightarrow$ 500 MC = MC T_f

$\Rightarrow$ T_f = 500 K

43. Ans: (C)

Sol: Given data:

$P_1 = 200$ kPa, $T_1 = 300$ K, $V_1 = 0.5\ m^3$,

$$m = \frac{P_1V_1}{RT_1} = \frac{200 \times 0.5}{0.287 \times 300} = 1.16\,kg$$

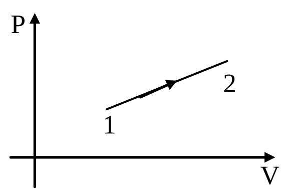
If the piston just touches the stopper the pressure of air becomes, $P_2 = 400$ kPa and volume becomes, $V_2 = 1m^3$

Now, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\Rightarrow \frac{200 \times 0.5}{300} = \frac{400 \times 1}{T_2}$$

$\Rightarrow$ $T_2 = 1200$ K

This process is represented on P-V diagram as shown below.



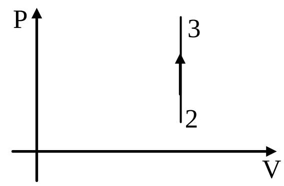
Again as air is heated to 1500 K so pressure will rise further. Let this pressure becomes P_3 .

Now,

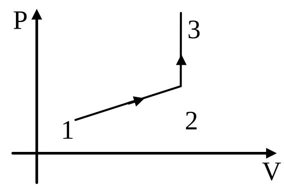
$$\frac{P_2V_2}{T_2} = \frac{P_3V_3}{T_3}$$

$$\frac{200 \times 0.5}{300} = \frac{P_3 \times 1}{1500} \Rightarrow P_3 = 500 \text{ kPa}$$

This process is represented on P-V diagram as shown below.



Complete process is represented on P-V diagram as shown below



Applying first law of thermodynamics for process 1-2-3

$Q - W = \Delta U$ ………… (i)

$$W = \frac{1}{2} \times [P_1 + P_2] \times \Delta V$$

$$= \frac{1}{2} \times [200 + 400] \times 0.5 = 150\,kJ$$

Putting in (i)

$Q - 150 = 1.16 \times C_v \times (1500 - 300)$

$Q = 1148$ kJ

44. Ans: 1.52 [No range]

Sol: Consider

$$\int_C \bar{f}\,.\,d\bar{r} = \int_{(0,0)}^{(1,1)} \left[\sqrt{x}\ dx + \left(x + y^3\right)dy\right] \text{ .... (1)}$$

Given that C: $x = t^2$, $y = t^3$, $0 \le t \le 1$

$\Rightarrow$ $dx = 2t\ dt$, $dy = 3t^2\ dt$ …. (2)

Using (2), (1) becomes

$$\int_C \bar{f}\cdot d\bar{r} = \int_{t=0}^{1} \left[(t)(2t)\,dt + (t^2+t^9)(3t^2)\,dt\right]$$

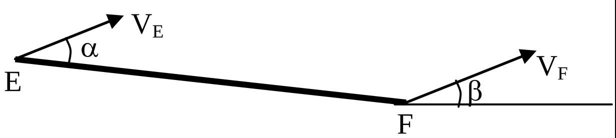
$$\Rightarrow \int_C \bar{f}\cdot d\bar{r} = \int_{t=0}^{1} \left[2t^2+3t^4+3t^{11}\right]dt$$

$$\Rightarrow \int_C \bar{f}\cdot d\bar{r} = \left(\frac{2t^3}{3}+\frac{3t^5}{5}+\frac{3t^{12}}{12}\right)_0^1$$

$$\therefore \int_C \bar{f}\cdot d\bar{r} = \left(\frac{2}{3}+\frac{3}{5}+\frac{3}{12}\right) = 1.52$$

45. Ans: (C)

Sol:



If velocity V_E is not perpendicular to V_F

Then, $V_E\cos\alpha = V_F\cos\beta$

[∵ Rod is rigid]

$\alpha = \beta$

$V_E = V_F$

So, $V_E \sin\alpha = V_F \sin\beta$

$$\Rightarrow \omega_{EF} = \frac{V_E\sin\alpha - V_F\sin\beta}{\text{length of EF}} = 0$$

46. Ans: 35.82 [Range 35 to 36]

Sol: For peripheral milling

Approach = $\sqrt{d(D-d)}$

$= \sqrt{15(200-15)} = 52.678$ mm

Total tool travel

= 52.678 + 400 + 10 = 462.678 mm

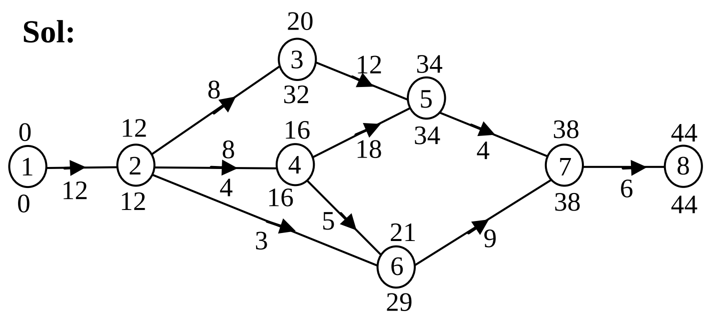
$$\text{Time/cut} = \frac{L}{f\,N} = \frac{L}{f_t \times Z \times N}$$

$$= \frac{462.678}{0.38\times 16\times \dfrac{1000V}{\pi D}}$$

= 0.597 min = 35.82 sec

47. Ans: (C)

Sol:



Activity (2 – 6)

TF = $L_j - E_i - T_{ij}$ = 29 – 12 –3 = 14

FF = $E_j - E_j - T_{ij}$ = 21 – 12 – 3 – 6

FF = TF – (Head event slack)

= 14 – (29 – 21) = 6

48. Ans: (A)

Sol: $\lambda = 3\text{ day}^{-1}$; $\mu = 6\text{ day}^{-1}$

$$P_n = \left(1-\frac{\lambda}{\mu}\right)\left(\frac{\lambda}{\mu}\right)^n = \left(1-\frac{3}{6}\right)\left(\frac{3}{6}\right)^2 = 0.125$$

49. Ans: (D)

Sol: m = 4 mm, $\phi = 20°$,

t = 22, N = 900 rpm

P = 10 kW, T = 60,

$b = 38$ mm, $y = 0.59$,

$c_v = 0.32$

$$\text{Power} = F_t \times V = F_t \times \frac{\pi \times DN}{60}$$

$$= F_t \times \pi \times \frac{4 \times 22}{1000} \times \frac{900}{60}$$

$F_t = 2.411$ kN

$2411\text{ N} = \sigma_b \times m \times b \times y \times c_v$

$2411 = \sigma_b \times 4 \times 38 \times 0.59 \times 0.32$

$\sigma_b = 84$ MPa

50. Ans: (B)

Sol: AB is subjected to pure torsion and bending moment

$T = 10 \times 10^3 \times 1 = 10000$ N-m

Bending moment at point A

$M = 10 \times 2 \times 10^3 = 20000$ N-m

$$M_{eq} = \frac{1}{2}\left\{M + \sqrt{M^2 + T^2}\right\}$$

$$M_{eq} = \frac{1}{2}\left\{20000 + \sqrt{(10000)^2 + (20000)^2}\right\}$$

$M_{eq} = 21180.33$ N-m

$$\sigma = \frac{32M_{eq}}{\pi d^3} = 215.85\,\text{MPa}$$

51. Ans: (B)

Sol: For maximum production rate criteria

$$T_{opt} = \left(\frac{C}{V_{opt}}\right)^{1/n} = \left[\frac{1-n}{n}T_C\right]$$

where, T_c = tool changing time

Here, $T_c = 3.5$ minutes

$$T_{opt} = \left[\frac{1-0.13}{0.13} \times 3.5\right] = 23.42 \text{ min}$$

$$V_{opt} = \frac{C}{(T_{opt})^n} = \frac{75}{(23.42)^{0.13}} = 49.77 \text{ m/min}$$

52. Ans: (B)

Sol: Given $\frac{d}{dx}\left(x\frac{dy}{dx}\right) = x$ .... (1)

With $y(1) = 0$ .... (2)

And $y'(1) = 0$ .... (3)

Now, integrating on both sides of (1), we get

$$x\frac{dy}{dx} = \frac{x^2}{2} + C_1$$

$$\Rightarrow \frac{dy}{dx} = \frac{x}{2} + \frac{C_1}{x} \text{ .... (4)}$$

Using (3), (4) becomes

$$0 = \frac{1}{2} + \frac{C_1}{1} \text{ (or) } C_1 = \frac{-1}{2} \text{ .... (5)}$$

Using (5), (4) becomes

$$\frac{dy}{dx} = \frac{x}{2} - \frac{1}{2x}$$

$$\Rightarrow y = \frac{x^2}{4} - \frac{1}{2}\log x + c \text{ .... (6)}$$

Using (2), (6) becomes

$$0 = \frac{1}{4} - \frac{1}{2}(0) + C \text{ (or) } C = \frac{-1}{4} \text{ .... (7)}$$

$\therefore$ The solution of (1) from (6) and (7) is

$y = y(x) = \frac{x^2}{4} - \frac{1}{2}\log(x) - \frac{1}{4}$

$y(2) = 1 - \frac{1}{2}\log(2) - \frac{1}{4} = \frac{3}{4} - \frac{1}{2}\log(2)$

53. Ans: (A)

Sol: Annual demand = A = 1200 tins

EOQ = Q = 100 tins

Cost per unit = C = 9.85

Order cost = S = 10/-

At EOQ:

Ordering cost = Inventory carrying cost

$$\frac{A}{Q}S = \frac{Q}{2}CI$$

$$\frac{1200}{100}\times 10 = \frac{100}{2}\times CI$$

$CI = \frac{120}{50}$ = 2.4/units/year

54. Ans: 580 Range: (578 to 582)

Sol: $\frac{x}{1.1} + \frac{650}{(1.1)^2} + \frac{x}{(1.1)^3} = 1500$

0.909x + 537.19 + 0.7513x = 1500

1.6603x = 1500 – 537.19

x = 579.9 = 580/-

$$NPV = -I_0 + \frac{F_1}{(1+r)} + \frac{F_2}{(1+r)^2} + \frac{F_3}{(1+r)^3}$$

When NPV is zero corresponding interest is called as IRR.

55. Ans: 0.11 **Range: 0.1 to 0.2**

Sol: Total possible outcomes for both faces even = (2, 2), (2, 4), (2, 6), (4, 2), (4, 4), (4, 6), (6, 2), (6, 4), (6, 6) = 9

Total favorable outcome for sum smaller than 6 = (2, 2)

P (sum is less than 6 given both faces are even) = $\frac{1}{9}$ = 0.11

56. Ans: (B)

Sol: (so) is wrong because they mean the same.

57. Ans: (C) **58. Ans: (A)**

59. Ans: (D)

Sol: Capacity of the tank = (12×13.5)=162 litres

Capacity of each bucket = 9 litres.

Number of buckets needed = 162/9 =18

60. Ans: (D)

Sol: Volume of Cuboid = length × breadth × height

Number of cuboids

$$= \frac{(Volume\ of\ cuboids)\ formed\ from}{(Volume\ of\ cuboids)\ taken}$$

$\frac{18\times 15\times 12}{5\times 3\times 2}$ = 108

61. Ans: (B)

Sol: **At the most case:** Let the numbers be {–45, 1, 1, 1, ……, 1}.

Average is 0. So, at the most 44 numbers may be > 0.

At the least case: Let the numbers be {45, –1, –1, –1, …., –1}.

Average is 0. So, at the least 1 number may be > 0.

62. Ans: (B)

Sol: Perimeter = Distance covered in 8 min.

$$= 12000 \times \frac{8}{60} \text{ m} = 1600 \text{ m.}$$

Let length = 3*x* metres and breadth = 2*x* metres.

Then, $2(3x + 2x) = 1600$ or $x = 160$.

∴ Length = 480 m and Breadth = 320 m

∴ Area = (480 x 320) m^2 = 153600 m^2

63. Ans: (B)

Sol: Consider CP as 100%.

Loss 15% ⇒ So, SP = 85%

Gain 15 % ⇒ So, New SP = 115%

Given 115% – 85% = 30% = 450

$$\frac{100}{30} \times 450 = 1500$$

64. Ans: (A)

Sol: GDP at the beginning of 2013 is equal to the GDP at the end of 2012

⇒ GDP growth rate in 2012 = 7%

GDP at the end of 2011 = GDP at the beginning of 2012 = \$1 trillion

∴ GDP at the beginning of 2013

$$= \frac{100+7}{100} \times 1 \; trillion$$

$$= \frac{107}{100} = \$1.07 \; trillion$$

65. Ans: (A)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