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Engineering Academy
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MECHANICAL ENGINEERING _ MOCK - F __ Solutions

01. Ans: (B)

Sol: All quantitative techniques (Regression and moving average analysis) are well suited for the short range planning, whereas all qualitative techniques (Market survey, collective opinion and Delphi method) are suitable for medium and long range planning.

02. Ans: 13.09 (Range: 13.0 to 13.2)

Sol: The expression for torque being a function of 2θ, the cycle is repeated every 180° of the crank rotation.

$$T_{mean} = \frac{1}{\pi}\int_0^{\pi} T d\theta$$

$$= \frac{1}{\pi}\int_0^{\pi} (500 + 200\sin 2\theta - 300\cos 2\theta) d\theta$$

$$= \frac{1}{\pi}\left[500\theta - \frac{200}{2}\cos 2\theta - \frac{300}{2}\sin 2\theta\right]_0^{\pi}$$

$$= \frac{1}{\pi}[(500\pi - 0) - (0)] = 500 \text{ N.m}$$

$$P = T\omega$$

$$= 500 \times \frac{2\pi \times 250}{60}$$

= 13.089 W or 13.09 kW

03. Ans: (C)

Sol: The bulk mean temperature T_m at a given cross-section is defined on the basis of the thermal energy transported by the fluid stream which passes through that cross-section, as

$$T_m = \frac{\int_A \rho c_p u T dA}{\int_A \rho c_p u dA}$$

For flow through a circular pipe, the above expression reduces to

$$T_m = \frac{\int_0^R u(r)T(r)rdr}{\int_0^R u(r)rdr}$$

04. Ans: 53 NO RANGE

Sol: $V(2x + 3y) = 2^2 V(x) + 3^2 V(y)$

$= (4 \times 2) + (9 \times 5) = 53$

05. Ans: (D)

Sol:

- Quick-Return mechanism is used to maintain cutting and reverse strokes. So, (A) is incorrect.

- Rack and pinion mechanism provides the bi-directional continuous feed which is not the requirement of intermittent table feed in shaping or planning. So, (B) is incorrect.
- Cam mechanism is not used because of its high cost relative to alternative mechanisms. So, (C) is incorrect.
- A Ratchet is a device that allows linear or rotary motion in only one direction. So, (D) is correct.

06. Ans: 74.94 (Range 74 to 76)

Sol: Given $T_E = 70, \quad \sigma^2 = 9$

$$\therefore \sigma = \sqrt{9} = 3, \quad Z = 1.647$$

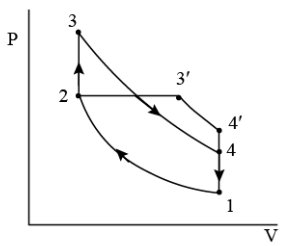
$$Z = \frac{T_S - T_E}{\sigma}$$

$$1.647 = \frac{T_S - 70}{3}$$

$$T_S = 74.94 \text{ weeks}$$

07. Ans: (D)

Sol:



Heat rejected in Otto = $c_V (T_4 - T_1)$

Heat rejected in diesel = $c_v (T_4' - T_1)$

Heat rejected in Otto is less where as heat supplied is same. Hence, efficiency is more for Otto than diesel.

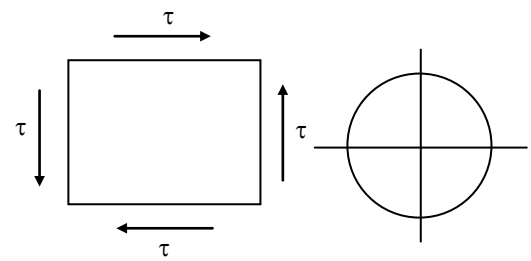
08. Ans: (C)

Sol: Options (A), (B) and (D) are correct pairs.

However, unit power $P_u = \frac{P}{H^{\frac{3}{2}}}$.

09. Ans: (C)

Sol: For pure shear at the centroidal axis of the beam element is shown in figure below



The corresponding Mohr circle should be concentric with origin.

10. Ans: 509 MPa (Range 507 to 511)

Sol: The maximum torsion on the shaft

$$T = 100 \text{ N-m} = 100 \times 10^3 \text{ N. mm}$$

From Torsion equation $\frac{T}{J} = \frac{\tau}{r}$

$$\tau_{max} = \frac{T}{J} r_{max} = \frac{T}{Z_p} = \frac{100 \times 10^3}{\frac{\pi}{16}\left(10^3\right)}$$

$$\therefore \tau_{max} = 509 \text{ MPa}$$

11. Ans: (C)

Sol: Initially when the steel rod is in the boat, it must be resulting in a water displacement such that weight of the water displaced equals the total weight. Since the density of the anchor material is several times than that of water, the volume of water displaced is several times more than the volume of the steel rod.

Now when the steel rod is thrown into the water, it would displace just the volume of water equals to its own volume and this is much less than before. Thus the level of water in the bath tub must go down.

12. Ans: 1 NO RANGE

Sol: Let $A = \begin{bmatrix} 1 & 2 & 0 \\ 0 & 1 & 3 \\ 0 & 0 & 1 \end{bmatrix}$

A is the upper triangular matrix eigen value is 1 only

Consider $(A - I) = \begin{bmatrix} 0 & 2 & 0 \\ 0 & 0 & 3 \\ 0 & 0 & 0 \end{bmatrix}$

Clearly earth of (A – I) = 2

Geometric multiplicity of eigen value 1 = No. of linearly independent eigen vectors

= n – r

= 3 – 2 = 1

13. Ans: 150 (Range: 150 to 150)

Sol: Given: 3V + I = 300

I = 300 – 3V

Power (P) = VI = V (300 – 3V)

$= 300V - 3V^2$

For optimum power

$$\frac{dP}{dV} = 0 \Rightarrow 300 - 6V = 0$$

V = 50 V

I = 300 – (3×50) = 150 Amp

14. Ans: (A)

Sol: Given data:

S_{yt} = 420 MPa, S_e = 270 MPa,

σ_{max} = 100 MPa, σ_{min} = 40 MPa

$$\sigma_a = \frac{100 - 40}{2} = 30 \text{ MPa}$$

$$\sigma_m = \frac{100 + 40}{2} = 70 \text{ MPa}$$

According to Soderberg's theory

$$\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{yt}} = \frac{1}{FS}$$

$$\therefore \frac{30}{270} + \frac{70}{420} = \frac{1}{FS}$$

$$\therefore \frac{1}{9} + \frac{1}{6} = \frac{1}{FS}$$

$$\therefore FS = \frac{18}{5} = 3.6$$

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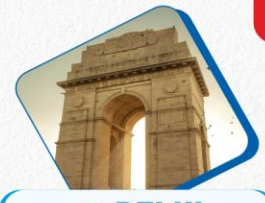

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15. Ans: 96 NO RANGE

Sol: Characteristic equation is $|A - \lambda I| = 0$

$$\begin{vmatrix} 1-\lambda & 0 & 0 \\ 0 & 2-\lambda & 1 \\ 2 & 0 & 3-\lambda \end{vmatrix} = 0$$

$\Rightarrow (1-\lambda)(2-\lambda)(3-\lambda) = 0$

$\therefore \lambda = 1,2,3$ are eigen values

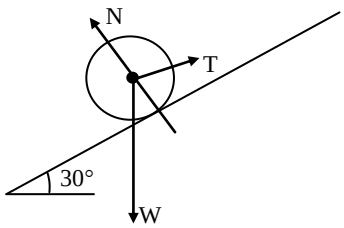
Eigen values of A	Eigen values of $A^2 - 3A + 6I$
1	$1 - 3 + 6 = 4$
2	$4 - 6 + 6 = 4$
3	$9 - 9 + 6 = 6$

Determinate of $A^2 - 3A + 6I = 4 \times 4 \times 6$

$= 96$

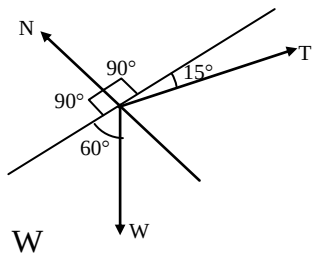
16. Ans: 10.35 (Range 10.1 to 10.5)

Sol: Free body diagram of Roller :



For equilibrium, all the forces should form concurrent force system.

Applying Lami's theorem,



$$\frac{T}{\sin 150^\circ} = \frac{W}{\sin 105^\circ}$$

$T = 10.35$ kN

17. Ans: 3.75 (Range: 3.50 to 4.00)

Sol: Given data: n = 0.4, T_c = 2.5 min

For maximum production rate

Optimum tool life (T) = $\frac{1-n}{n} \times T_c$

$= \frac{1-0.4}{0.4} \times 2.5 = 3.75$ min

18. Ans: (D)

Sol:

Bag -1	**Bag- 2**
5 Red	4 Red
7 Green	8 Green

By total probability $= \frac{1}{2} \times \frac{7}{12} + \frac{1}{2} \times \frac{8}{12}$

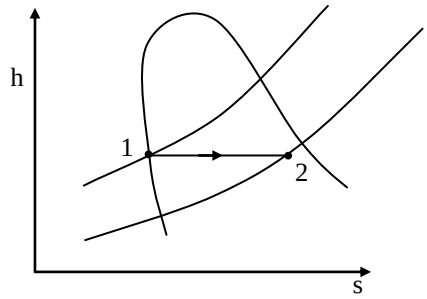
$= \frac{15}{24}$

19. Ans: (A)

Sol: *Tempering of Steel Martensite*: Martensite is not an equilibrium phase. This is why it does not appear on the Fe-Fe_3C phase diagram. When martensite in a steel is heated below the eutectoid temperature, the thermodynamically stable α and Fe_3C phases precipitate. This process is called **tempering**. The decomposition of martensite in steels causes the strength and hardness of the steel to decrease while the ductility and impact properties are improved.

20. Ans: (A)

Sol:



$h_1 = 123.49$ kJ/kg , $s_1 = 0.4418$ kJ/kg

Throttling process

$h_1 = h_2 = 123.49$ kJ/kg < 243.3 kJ/kg, i.e. h_g at –12°C

Hence after throttling it is in wet state

$$h_1 = h_2 = h_{f_2} + x_2(h_{g_2} - h_{f_2})$$

$$123.49 = 35.92 + x_2\,(243.3 - 35.92)$$

$$x_2 = \frac{123.49 - 35.92}{243.3 - 35.92} = \frac{87.57}{207.38} = 0.422$$

$$s_2 = s_{f_2} + x_2(s_{g_2} - s_{f_2})$$

$$= 0.14504 + 0.422\,(0.93911 - 0.14504)$$

$$= 0.4801 \text{ kJ/kg.K}$$

21. Ans: –1 NO RANGE

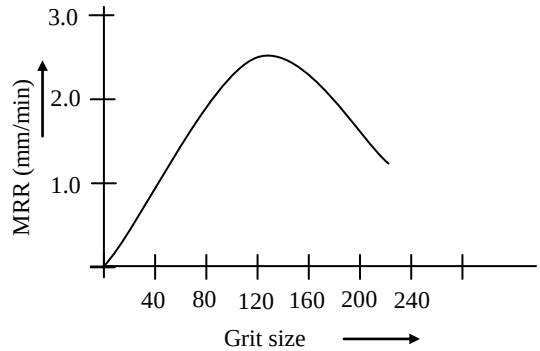
Sol: $$\lim_{x\to 0} \frac{\sin x}{x(x-1)} = \lim_{x\to 0} \frac{1}{x-1} . \lim_{x\to 0} \frac{\sin x}{x}$$

$$= -1 \times 1$$

$$= -1$$

22. Ans: (D)

Sol: The grit size of the abrasive affects both the machining rate and surface roughness of the machined surface. Increase in the grit size increases machining rate till the grit size be come nearly equal to amplitude of vibration. Beyond this, the increase in grit size decreases the machining rate. This is illustrated in figure below.



23. Ans: (C)

Sol:

Non-dimensional number	**Ratio of significance**
Froude number	Inertia force / Gravitational force
Euler number	Inertia force / Pressure force
Reynolds number	Inertia force / Viscous force
Mach number	Inertia force / Elastic force

24. Ans: (C)

Sol: *Computer Aided Design (CAD)* uses computers to produce and revise complex engineering drawings on the computer screen. This information produced in making the drawing can also be used to produce the CNC program used on the machine to produce the part. So option (A) is incorrect.

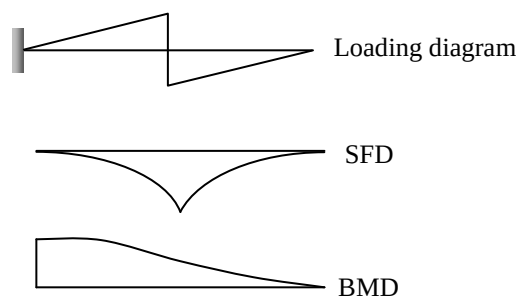
Computer Aided Manufacturing (CAM) uses the technologies of CAD and CAE (Computer aided engineering) to produce a computer model of a manufacturing process. It provides the codes required to control production machines, material handling equipment and control systems. So option (B) is incorrect.

Computer Integrated Manufacturing (CIM) uses a central host computer to control an entire network of computers involved in all phases of manufacturing. The ability of the CIM factory to oversee all aspects of the factory results in a new concept in inventory control and manufacturing scheduling called *Just In Time (JIT) manufacturing.* So option (C) is correct.

Direct Numerical Control (DNC) is used to upload and download CNC programs to one or more CNC machines from the large memory of the machine control unit. In some applications, the DNC system can be combined with part management system, where the CNC operator selects the latest version of a part from the central computer console located in the machine or manufacturing shop. So option (D) is incorrect.

25. Ans: (B)

Sol:

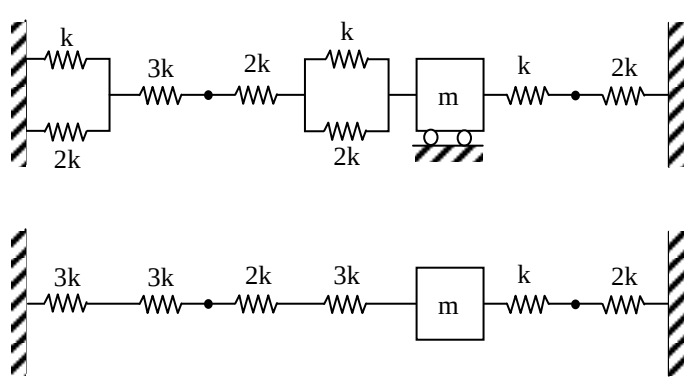


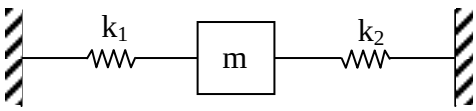
Slope of SFD = rate of loading and

Slope of BMD = shear force value on the beam

26. Ans: (B)

Sol:





$$\Rightarrow \frac{1}{k_1} = \frac{1}{3k} + \frac{1}{3k} + \frac{1}{2k} + \frac{1}{3k} + \frac{1}{k}\left[\frac{2+2+3+2}{6}\right] = \frac{9}{6k}$$

$$\therefore\ k_1 = \frac{2k}{3}$$

$$\Rightarrow \frac{1}{k_2} = \frac{1}{k} + \frac{1}{2k} = \frac{3}{2k}$$

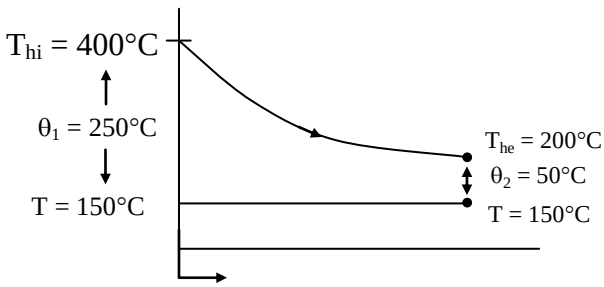
$$\therefore\ k_2 = \frac{2k}{3}$$

$$k_{eq} = k_1 + k_2 = \frac{2k}{3} + \frac{2k}{3} = \frac{4k}{3}$$

$$k_{eq} = \frac{4\times 6000}{3} = 8000\ \text{N/m}$$

27. Ans: (B)

Sol:



$A = 0.64\ m^2$

$\dot{m}_g = 0.4\,kg/s$

$c_{pg} = 1.05\,kg/kg.K$

$T_{he} = 200°C$

$$LMTD = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{250-50}{\ln\left(\frac{250}{50}\right)} = 124.266°C$$

Energy balance:

$UA \times LMTD = \dot{m}_g c_{pg}.(T_{hi} - T_{he})$

$$U \times 0.64 \times 124.26 = 0.4 \times 1050(400-200)$$

$U = 1056.2\ W/m^2\text{-}K$

28. Ans: (A)

Sol: Given $f(D)y = Q(x)$ ……(1)

where $f(D) = D^2 + 4D + 4$

& $Q(x) = x^4 e^{-2x} = e^{-2x}.x^4 = e^x . V(x)$

Now, $y_P = \frac{1}{f(D)}\left[e^{-2x}\, x^4\right]$

$$\Rightarrow y_P = e^{-2x}\left[\frac{1}{f(D-2)}x^4\right]$$

$$\Rightarrow y_P = e^{-2x}\left[\frac{1}{(D-2)^2 + 4(D-2) + 4}x^4\right]$$

$$\Rightarrow y_P = e^{-2x}\left[\frac{1(x^4)}{D^2}\right]$$

$$\therefore y_p = e^{-2x}.\frac{x^6}{30}$$

29. Ans: 1.066 **(Range: 0.9 to 1.2)**

Sol: Data given:

$F_c = 1600$ N, $F_t = 500$ N,

$t_1 = d = 0.3$ mm,

$b = w = 5$ mm, $r = 0.42$,

$\alpha = 10°$, $V_c = 35$ m/min

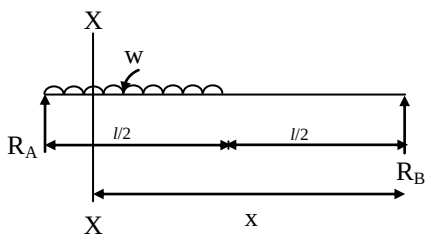
Rate of energy dissipated / per unit volume,

$$= \frac{F_c \times V_c}{t_1 \times b \times V_c}$$

$$= \frac{1600}{0.3\times 5\times 1000}\left(\frac{J}{mm^3}\right) = 1.066\ J/mm^3$$

30. Ans: (B)

Sol:



Using Macauley's double integration method

$$R_B(l) = w\left(\frac{\ell}{2}\right)\left(\frac{\ell}{4}\right)$$

$$R_B = \frac{w\ell}{8}$$

$$EI\frac{d^2y}{dx^2} = R_B(x) - \frac{w\left(x-\frac{\ell}{2}\right)\left(x-\frac{\ell}{2}\right)}{2}$$

$$EI\frac{dy}{dx} = R_B\frac{x^2}{2} - \frac{w\left(x-\frac{\ell}{2}\right)^3}{6} + C_1$$

$$EI(y) = R_B\frac{x^3}{6} - \frac{w\left(x-\frac{\ell}{2}\right)^4}{24} + C_1x + C_2$$

at x = 0 y = 0

$0 = 0 - 0 + C_2 = 0$

at x = l y = 0

$$0 = \left(\frac{w\ell}{8}\right)\frac{\ell^3}{6} - \frac{w\left(\frac{\ell}{2}\right)^4}{24} + C_1(\ell)$$

$$= \frac{w\ell^4}{48} - \frac{w\ell^4}{384} + C_1\ell$$

$$C_1 = \frac{7}{384}w\ell^3$$

at x = $l/2$

$$EI(y) = \frac{w\ell}{8}\left(\frac{\ell^3}{48}\right) - w - \left(\frac{7}{384}w\ell^3\right)\left(\frac{\ell}{2}\right)$$

$$y = \left[\frac{1}{384}(-)\frac{7}{768}\right]w\ell^4 = \frac{5w\ell^4}{768EI}$$

31. Ans: 884.1 (Range: 882.00 to 886.00)

Sol: Given, σ = 1100 MPa, n = 0.35

h_1 = 58 mm,

$$\varepsilon = \ell n\left(\frac{h_o}{h_1}\right)$$

$$\varepsilon = \ell n\left(\frac{75}{58}\right) = l\text{n}\ (1.293) = 0.257$$

Flow stress (Y_f) = $\sigma\ \varepsilon^n$

$Y_f = 1100(0.257)^{0.35} = 683.7$ MPa

Starting volume

$V = 75(1000) = 75{,}000\ mm^3$

At h = 58 mm,

$A = V/L = 75{,}000/58 = 1293.1\ mm^2$

The force required to achieve this compression (F) = 683.7×1293.1

= 884,095 N ≅ 884.1 kN.

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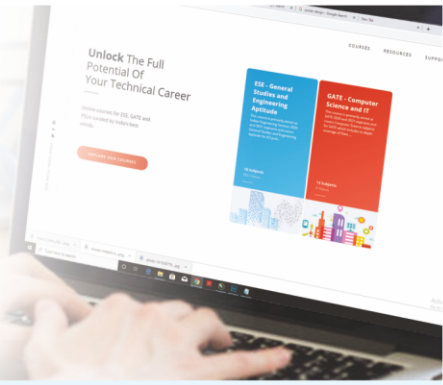

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32. Ans 4.48

Sol: Wall shear stress:

$$\tau_o = -\frac{dP}{dx}\frac{R}{2}$$

In laminar flow through a pipe, the velocity distribution is,

$$u = 1.4\left[1-\left(\frac{r}{R}\right)^2\right]$$

$$u = U_{max}\left[1-\left(\frac{r}{R}\right)^2\right]$$

and,

$$U_{max} = \frac{R^2}{4\mu}\left(\frac{-dP}{dx}\right)$$

$$\frac{-dP}{dx} = \frac{4\mu U_{max}}{R^2}$$

$$\tau_o = \frac{4\mu U_{max}}{R^2}\times\frac{R}{2} = \frac{2\mu U_{max}}{R}$$

$$= \frac{2\times 0.08\times 1.4}{50\times 10^{-3}}$$

$$\tau_o = 4.48\,N/m^2$$

33. Ans: (C)

Sol: Given

$$f(x) = \frac{\pi^2}{3} - 4\left(\frac{\cos x}{1^2} - \frac{\cos 2x}{2^2} + ...\right)$$

clearly f(x) is continuous at x = 0

($\because \lim_{x\to 0} f(x) = 0$) the four series converges to f(0)

$$\frac{\pi^2}{3} - 4\left(\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - .....\right) = 0$$

$$\frac{\pi^2}{3} - 4\left(\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - .....\right) = 0$$

$$\frac{1}{1^2} + \frac{1}{2^2} - \frac{1}{3^2} + ... = \frac{\pi^2}{12}$$

34. Ans: (B)

Sol: We know that, Torque = Rate of change of angular momentum

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

$$\Rightarrow d\vec{L} = \vec{\tau}\,dt$$

$$\Rightarrow \Delta\vec{L} = \vec{\tau}\,\Delta t$$

$$\Rightarrow I\Delta\vec{\omega} = \vec{\tau}\,\Delta t$$

$$\Rightarrow |\Delta\vec{\omega}| = \frac{\tau\Delta t}{I} = \frac{100\times 0.1}{1} = 10\,rad/s$$

35. Ans: 87.72 (Range 86.5 to 88.3)

Sol: Stroke length = 400 mm,

$$n = \frac{\ell}{r} = 4.5$$

$$\omega_{crank} = \frac{2\pi\times 200}{60} = 20.94\,rad/s$$

a_{crank} = ?

2r = 400 mm

$\Rightarrow$ r = 200 mm

$a_{crank} = r\,\omega^2 = 87.72\ m/s^2$

36. Ans: (D)

Sol: Initial volume = $0.033 \times 2 = 0.066\ m^3$

Finally pressure becomes 500 kPa

Final volume = $0.042 \times 1 = 0.042\ m^3$

It is constant pressure process

So,

Work done = $500 \times [0.066 - 0.042] = 12$ kJ

37. Ans: (B)

Sol: Given f(D) y = Q(x) .....(1)

where $f(D) = D^2+3D+2$

and Q(x) = cos(x)

C.F: Consider A.E, f(m) = 0

$\Rightarrow m^2+3m+2=0$

$\Rightarrow m = -1, -2$

$\therefore y_c = c_1e^{-x} + c_2e^{-2x}$

P.I: Here, Q(x) = cos(x) = cos(ax+b)

and $f(D) = \phi(D^2) = \phi(-a^2) = \phi(-1)$

$= (-1) + 3D + 2 = 1 + 3D \neq 0$

Now,

$$y_p = \frac{1}{1+3D} \times \frac{1-3D}{1-3D}\cos(x) = \frac{1-3D}{1-9D^2}\cos(x)$$

$$\Rightarrow y_p = (1-3D)\left[\frac{1}{1-9(-1)}\cos x)\right] = (1-3D)\left(\frac{1}{10}\cos(x)\right)$$

$$\therefore y_p = \frac{\cos(x)}{10} + \frac{3}{10}\sin x$$

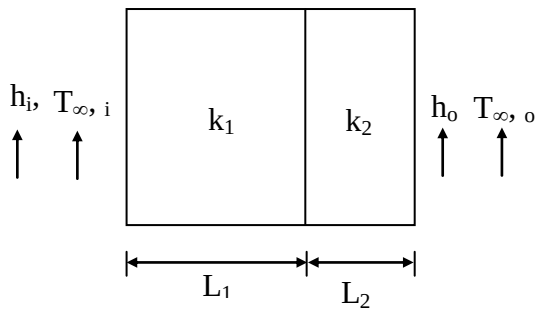
Hence, the general solution of (1) is

$$y = y_c + y_p$$

$$\text{i.e., } y = c_1e^{-x} + c_2e^{-2x} + \frac{\cos(x)}{10} + \frac{3}{10}\sin x$$

38. Ans: 13.40 (Range: 13.1 to 13.7)

Sol:



Let the interface temperature (in °C) of the two sections be T.

For steady state one-dimensional heat conduction, the rate of heat flux is given by

$$q = \frac{T_{\infty,i} - T_{\infty,o}}{\frac{1}{h_i} + \frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{1}{h_o}} = \frac{T_{\infty,i} - T}{\frac{1}{h_i} + \frac{L_1}{k_1}}$$

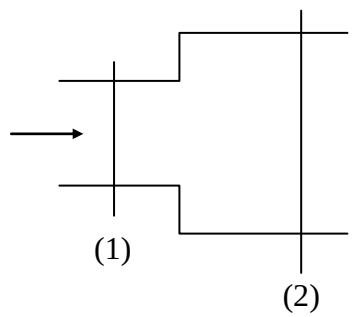
Substituting the respective values, we get

$$\frac{40-4}{\frac{1}{20} + \frac{0.3}{20} + \frac{0.15}{50} + \frac{1}{50}} = \frac{40-T}{\frac{1}{20} + \frac{0.3}{20}}$$

$\Rightarrow$ T = 13.40°C

39. Ans: 30 (Range 29 to 31)

Sol:



$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_{Le}$$

$$\Rightarrow \frac{P_2}{\gamma}-\frac{P_1}{\gamma}=\frac{V_1^2-V_2^2}{2g}-h_{Le}$$

$\frac{P_2-P_1}{\gamma}$ represents rise in HGL (as $Z_1 = Z_2$)

$$\Rightarrow 0.02=\frac{V_1^2-V_2^2}{2g}-\frac{(V_1-V_2)^2}{2g}$$

By continuity equation $V_1 = 4V_2$

$$\Rightarrow 0.02=\frac{16V_2^2-V_2^2}{2g}-\frac{9V_2^2}{2g}$$

$$\Rightarrow 0.02=\frac{6V_2^2}{2g}$$

$$\Rightarrow \frac{V_2^2}{2g}=\frac{0.02}{6}$$

Since, $h_{Le}=\frac{9V^2}{2g}=\frac{9\times0.02}{6}=0.03$ m

$\therefore$ Energy grade line drops down by 30 mm

40. Ans: 35.3 (Range 34.5 to 36.5)

Sol: d = 12.7 mm

$T_i = 66°C$, $\tau = 69$ s

$T_\infty = 27°C$, $\rho = 8933$ kg/m^3

$T = 55°C$, $c = 389$ J/kg.K

Temperature distribution

$$\frac{T_i-T_\infty}{T-T_\infty}=e^{\left(\frac{hA}{\rho VC}\times\tau\right)}$$

$$\frac{66-27}{55-27}=e^{\left(\frac{h\times6}{59.33\times0.0127\times389}\times69\right)}$$

(for sphere, $\frac{V}{A}=\frac{d}{6}$)

$$\frac{39}{28}=e^{(0.00938\times h)}$$

h = 35.32 W/m^2.K

41. Ans: 0.026 (Range : 0.026 to 0.026)

Sol: Allowance = difference between maximum material limits

= higher limit shaft – lower limit of hole

= [(41.996 + 0.015) – (42.000 – 0.015)]

= 42.011 – 41.985

= 0.026 mm

42. Ans: (C)

Sol: Given data:

$\mu_1 = 0.15$ Pa.s, $\mu_2 = 0.5$ Pa.s, $\mu_3 = 0.2$ Pa.s

$h_1 = 0.5$ mm, $h_2 = 0.25$ mm, $h_3 = 0.2$ mm,

$V_{12}=\frac{1}{3}$m/s,

Shear stress at the top plate = $\frac{F}{A}$

$$=\frac{100}{1}=100\ \text{N/m}^2$$

For the problem given, the shear stress will be same everywhere because of the linear velocity profiles given.

$$100=\mu_2\frac{V_{23}-V_{12}}{h_2}$$

$$V_{23}=\frac{100\times0.25\times10^{-3}}{0.5}+\frac{1}{3}$$

= 0.05 + 0.333 = 0.383 m/s

Also, $100 = \mu_3 \dfrac{V - V_{23}}{h_3}$

$$100 = \frac{0.2(V - 0.383)}{0.2 \times 10^{-3}}$$

$\Rightarrow$ V = 0.1 + 0.383 = 0.483 m/s

Hence, the required ratio,

$$\frac{V_{23}}{V} = \frac{0.383}{0.483} = 0.793$$

43. Ans: (A)

Sol: Casting size = 100 mm × 100 mm × 50 mm

Riser, D = H

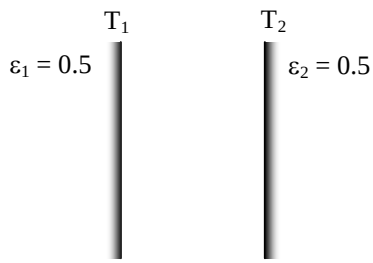
$$\left(\frac{V}{A_s}\right)_c = \frac{100 \times 100 \times 50}{2(50 \times 100 + 50 \times 100)} = 25$$

$$\left(\frac{V}{A_s}\right)_r = \frac{D}{6}$$

$$\text{Freezing ratio} = \frac{(V/A_s)_r}{(V/A_s)_c} = \frac{D/6}{25} = \frac{D}{150}$$

44. Ans: (C)

Sol:



Net heat exchange

$$(Q_1) = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A} + \frac{1}{AF_{1-2}} + \frac{1-\varepsilon_2}{\varepsilon_2 A}}$$

$$= \frac{\sigma A(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} \qquad (\text{as } F_{12} = 1)$$

Considering new emissivity of second plate $(\varepsilon_2') = 0.25$

$$Q_2 = \frac{\sigma A(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2'} - 1}$$

$$\frac{Q_2}{Q_1} = \frac{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2'} - 1} = \frac{\frac{1}{0.5} + \frac{1}{0.5} - 1}{\frac{1}{0.5} + \frac{1}{0.25} - 1}$$

$$= \frac{2 + 2 - 1}{2 + 4 - 1} = \frac{3}{5} = 0.6$$

Percentage decrease in heat exchange

$$= \frac{Q_1 - Q_2}{Q_1} \times 100\%$$

$$= \left(1 - \frac{Q_2}{Q_1}\right) \times 100\%$$

$$= (1 - 0.6) \times 100\% = 40\ \%$$

45. Ans: 300 (Range 300 to 300)

Sol: FC = Rs. 15000, SP = Rs. 90/unit,

VC = Rs. 30/unit, Profit = Rs. 3000

Profit = Total revenue – Total cost

$\Rightarrow 3000 = q \times SP - (FC + q \times VC)$

$$\Rightarrow q = \frac{18000}{60} = 300 \text{ units}$$

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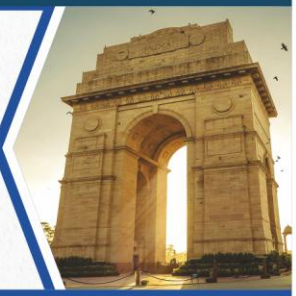

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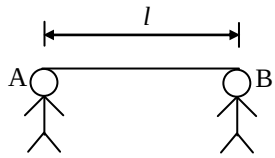
46. Ans: (C)

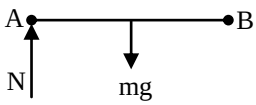
Sol:



When the beam is supported at A and B, the force exerted on each man = $\frac{mg}{2}$

Where 'm' is the mass of the beam.

When the support at B is withdrawn, the F.B.D of beam is shown below



$$\Sigma\tau_A = mg \times \frac{\ell}{2} = I\alpha = \frac{m\ell^2}{3}\alpha$$

$$\Rightarrow \alpha = \frac{3g}{2\ell}$$

The instantaneous linear acceleration of the centre of mass is

$$a_{cm} = \alpha \times \frac{\ell}{2} = \frac{3g}{2\ell} \times \frac{\ell}{2} = \frac{3g}{4}$$

Now, we know that $(\Sigma F)_{ext} = m \times a_{c.m}$

$$mg - N = m \times \frac{3g}{4}$$

$$\Rightarrow \quad N = \frac{mg}{4}$$

Thus, the force exerted by beam on man decreases.

47. Ans: 3 (Range 2.8 to 3.2)

Sol: $N_g = 300$ rpm,

$$\omega_g = \frac{2\pi \times 300}{60} = 31.4 \text{ rad/s}$$

$V_{s\,max} = 1260$ mm/s

Path of recess = 8.06 mm and

Path of approach = 10.03 mm

Maximum velocity of sliding

$= (\omega_p + \omega_g) \times$ maximum path

$$1260 = \omega_g\left(\frac{\omega_p}{\omega_g} + 1\right) \times 10.03$$

$1260 = 31.4(G + 1) \times 10.03$

$\therefore \quad G = 3$

48. Ans: (B)

Sol: Shear force throughout the beam will be 10 kN and it is constant.

Bending Moment: (*Sign convention : Hogging moment is taken negative*)

$(BM)_C = 0$

$(BM)_{B_{Right}} = -10 \times 1 = -10$ kN.m

$(BM)_{B_{Left}} = -10$ kN.m $- 10$ kN.m

$= -20$ kN.m

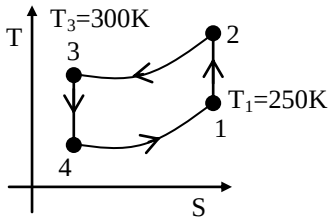
$(BM)_A = -10 \times 2 - 10 = -30$ kN.m

Thus, $|SF_{max}| = 10$ kN

and $|BM_{max}| = 30$ kN.m

49. Ans: 2 (Range: 2 to 2)

Sol:



$T_1 - T_4 = 50$ K

$250 - T_4 = 50$

$T_4 = 200$ K

For Brayton cycle:

$$\frac{T_2}{T_1} = \frac{T_3}{T_4} = \left(r_p\right)^{\frac{\gamma-1}{\gamma}}$$

$$\frac{T_2}{250} = \frac{300}{200} \quad ; \quad T_2 = 375K$$

$W_C = C_p(T_2 - T_1)$

$= 1(375 - 250) = 125$ kJ/kg

$W_E = C_p(T_3 - T_4)$

$= 1(300 - 200) = 100$ kJ/kg

$W_{net} = W_C - W_E$

$= 125 - 100 = 25$ kJ/kg.

$$\text{COP} = \frac{c_p \times (T_1 - T_4)}{25} = \frac{250 - 200}{25} = 2$$

50. Ans: (B)

Sol: $$\int_{-\infty}^{\infty} x e^{-x^2}\, dx$$

Let $f(x) = xe^{-x^2}$

$$f(-x) = -xe^{-x^2} = -f(x)$$

$\therefore$ f(x) is odd function

$\therefore$ The value of given integral is zero.

51. Ans: 5 (Range 5 to 5)

Sol:

	2	3
A	$+\theta$	$10 - \theta$
B	$5 - \theta$	$15 + \theta$

θ = minimum value of $(5 - \theta, 10 - \theta) = 0$

$\theta = 5$ units

The maximum quantity that can be shifted to A-2 cell without changing the supply and demand constraint is 5 units.

52. Ans: (B)

Sol: $$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

$$\Rightarrow \quad P_1 = \rho \frac{V_2^2 - V_1^2}{2} = \frac{15\rho V^2}{2}$$

Just inside the pitot tube

$P_{stag} = \rho (4V)^2/2 = 8\rho V^2$

$P_1 + \gamma_{Hg}.h = P_{stag} + \gamma_{water}.h$

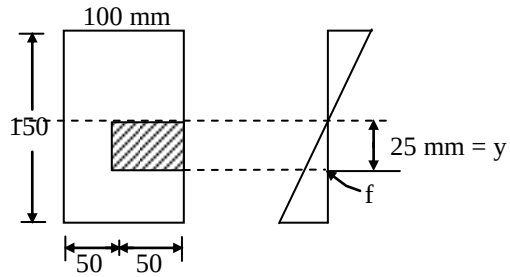
$$\Rightarrow \frac{1}{2}\rho V^2 = h\left(\gamma_{Hg} - \gamma\right)$$

$$\Rightarrow \quad V = \sqrt{\frac{2 \times (0.2 \times 9810)}{1000}(13.6 - 1)}$$

$= 7.03$ m/s

53. Ans: (C)

Sol:



From bending equation

$$f = \frac{M}{I}.y = \frac{16\times10^6}{\left(\frac{100\times150^3}{12}\right)} \quad (25)$$

$$= 14.22\,\text{MPa}$$

Force on hatched surface = average stress on the hatched area × hatched area

$$= \left(\frac{0+14.22}{2}\right)(25\times50) = 8.9\,\text{kN}$$

54. Ans: (A)

Sol: Put $x^3 = t \Rightarrow 3x^2\,dx = dt$

$$\Rightarrow x^2\,dx = \frac{dt}{3}$$

$x = 0 \Rightarrow t = 0$

$x = 2 \Rightarrow t = 8$

$$\therefore \int_0^2 x^2\left[x^3\right]dx = \int_0^8 [t]\frac{dt}{3}$$

$$= \frac{1}{3}\int_0^8 [t]dt$$

$$= \frac{1}{3}\frac{8(8-1)}{2} = \frac{28}{3}$$

55. Ans: 0.7 (Range: 0.62 to 0.75)

Sol: During cooling process of air, entropy decrease of air takes place.

$$\Delta S_1 = mC_p\ell n\left(\frac{T_H}{T_L}\right)$$

$$= 1\times1\times\ell n\left(\frac{300}{280}\right) = 0.069\,\text{kJ/K}$$

And heat removed from the air,

$$Q_L = mC_p(T_H - T_L)$$

$$= 1 \times 1 \times (27–7) = 20\ \text{kJ}$$

Let the work input be, W_{in}

The entropy increase of atmosphere,

$$\Delta S_2 = \frac{W_{in} + mC_p(T_H - T_L)}{T_H} = \frac{W_{in} + 20}{300}$$

$S_{gen} = \Delta S_{system} + \Delta S_{Surrounding}$

$S_{gen} \geq 0$

$\Delta S_1 + \Delta S_2 \geq 0$

$$\therefore \quad \frac{W_{in} + 20}{300} - 0.069 \geq 0$$

So, $W_{min} = 0.7$ kJ

56. Ans: (D)

Sol: ‘Cut out for’ means designed to be so. ‘Cut up’ means ‘to be emotionally upset’. ‘Cut down’ means ‘to kill somebody’ or ‘to make something fall down by cutting it at the base’. ‘Cut off’ means ‘separated from the rest of the world’.

57. Ans: (C)

58. Ans: (A)

59. Ans: (D)

Sol: Let principle be 1. then amount after 10 years = 3 × 1 = 3

$\therefore$ Simple interest = 3 - 1 = 2

$\therefore$ Rate of interest $= \frac{2\times100}{1\times10} = 20\%$

60. Ans: (C)

Sol:

20=2*2*5
25=5*5
35=1*5*7
40=2*2*2*5

Note that 20 – 14 = 6; 25 – 19 = 6;

35 – 29 = 6; 40 – 34 = 6.

Required number

= L.C.M. of (20, 25, 35 and 40) – 6

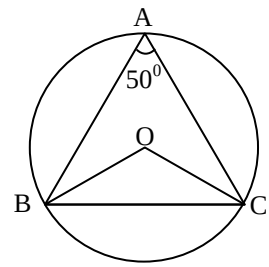
= (2 × 2 × 2 × 5 × 5 × 7) – 6

= 1400 – 6 = 1394

61. Ans: (C)

Sol: The angle subtended by an arc at the centre of the circle is twice the angle subtended by the arc at any point on the remaining part of the circle.

$\therefore \angle BOC = 2\angle BAC = 2 \times 50^0 = 100^0$



Now in ΔBOC

OB = OC [radii of circumcentre]

$\therefore \angle OBC = \angle OCB = x$ (let)

$\therefore$ x + x + 100° = 180°

$\Rightarrow$ 2x = 80°

$\Rightarrow$ x = 40°

62. Ans: (A)

Sol: At 4:10 the hour hand is a head of minute hand

Given that n = 4 and x = 10

Then according to the formula required angle

$$= \left\{30\left(n - \frac{x}{5}\right) + \frac{x}{2}\right\}^0$$

$$= \left\{30\left(4 - \frac{10}{5}\right) + \frac{10}{2}\right\}^0$$

$= \{(30 \times 2) + 5\}^0 = (60 + 5)^0 = 65^0$

63. Ans: (B)

Sol: Total cost (in Rs) of journey to Town A

= 4300 + 3100 + 4000 + 6000 = 17400

Average cost = $\frac{17400}{4}$ = Rs. 4350

64. Ans: (A)

Sol: Maximum cost (in Rs) of journey from Delhi to town A = By Train 4 = Rs. 6000

Similarly, for town B = Rs. 6300

Town C = Rs. 5600 and Town D = Rs. 5700

$\Rightarrow$ Maximum cost = 6000 + 6300 + 5600 = Rs. 23600

65. Ans: (D)

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Networks	5 Q	Networks	6 Q	DS,PL& Algorithm	10 Q	SOM	5 Q	SOM	6 Q
Control System	5 Q	Control System	6 Q	DBMS	5 Q	FM & HM	5 Q	FM & HM	5 Q
Analog Electronics	4 Q	Analog Electronics	5 Q	Computer Networks	5 Q	Geo Technical Engg.	7 Q	TOM	6 Q
Digital Electronics	5 Q	Digital Electronics	5 Q	Operating System	6 Q	Environmental	7 Q	Machine Design	4 Q
Electrical Machines	8 Q	Signal & Systems	5 Q	Computer Organization	4 Q	Transportation	4 Q	Thermal	7 Q
Power System	7 Q	EDC & VLSI	5 Q	Theory of Computation	6 Q	RCC& STEEL	6 Q	Heat Mass Transfer	4 Q
Power Electronics	6 Q	Communications	8 Q	Digital Electronics	4 Q	Surveying	6 Q	Production	8 Q
Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q
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