ESE- 2020 (Prelims) - Offline Test Series Test - 13

MECHANICAL ENGINEERING

Subject: Fluid Mechanics + Turbomachinery + Thermodynamics and Heat Transfer — SOLUTIONS

01. Ans: (d)

Sol: Applying principle of linear momentum in the direction along the inclined plate,

$$F_t = \rho\alpha QV - \rho(1-\alpha)QV - \rho QV\cos\theta$$

$= 0$ [No friction]

Thus, simplifying

$\rho\alpha QV - \rho QV + \rho\alpha QV - \rho QV\cos\theta = 0$

$2\rho\alpha QV = \rho QV(1+\cos\theta)$

$$\Rightarrow \alpha = \frac{1}{2}(1+\cos\theta)$$

02. Ans: (d)

Sol: $$\oint\frac{\delta Q}{T} = \frac{Q_H}{T_H} - \frac{Q_L}{T_L} = \frac{325}{1000} - \frac{125}{400}$$

$= 0.0125 > 0$

03. Ans: (a)

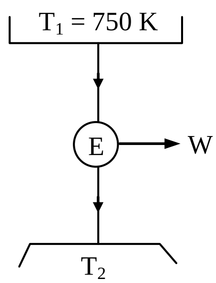
Sol: Fouling factor increases with increasing temperature and decreasing velocity.

04. Ans: (b)

Sol: When the flow is irrotational, one can apply Bernoulli's equation between points 1 and 2 event though these points are on different streamlines.

05. Ans: (c)

Sol: $$\eta_{carnot} = \frac{T_1 - T_2}{T_1} = \frac{750 - T_2}{750}$$



$$\eta_{2nd\ law} = \frac{\eta_E}{\eta_{carnot}}$$

$$0.6 = \frac{0.36}{\frac{750 - T_2}{750}}$$

$$\Rightarrow T_2 = 300\,K$$

06. Ans: (b)

Sol: $u = x-4y$; $v = -(y+4x)$

$$\frac{\partial u}{\partial x} = 1 \quad ; \quad \frac{\partial v}{\partial y} = -1$$

$$\frac{\partial u}{\partial y} = -4 \quad ; \quad \frac{\partial v}{\partial x} = -4$$

Now, $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=1-1=0;$

$\Rightarrow$ Continuity equation for incompressible flow is satisfied.

Also, $\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}=-4-(-4)=0$

$\Rightarrow$ Irrotational condition is also satisfied.

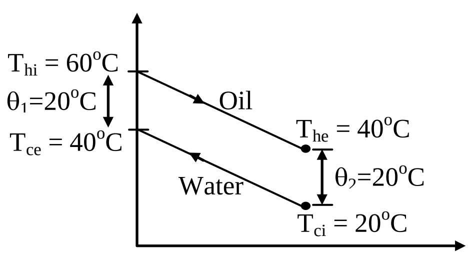
07. Ans: (a)

Sol: Given;

m_h = 10 kg/s

c_h = 2200 J/kgK

$Q = m_h c_h \Delta T$ = 10×2200×20 = 440 kW



LMTD = 20°C

Q = UA(LMTD)

$440\times10^3 = 300\times A\times20$

$A \approx 75\ m^2$

08. Ans: (b)

Sol: For perfect intercooling , $\frac{P_2}{P_1}=\frac{P_3}{P_2}$

where P_2 is the intermediate pressure for the two state compressor

$\Rightarrow P_2=\sqrt{P_1P_3}$

09. Ans: (b)

Sol: From S.F.E.E

$$h_1+\frac{V_1^2}{2000}+\frac{dQ}{dm}=h_2+\frac{V_2^2}{2000}+\frac{dW}{dm}$$

$$h_1+\frac{150^2}{2000}=120+\frac{200^2}{2000}$$

$\therefore$ h_1 = 128.75 kJ/kg

10. Ans: (b)

Sol: Given data : $(NPSH)_{min}$ = 6.5 m,

$Q = 0.3\ m^3/s$, h_s = 1.25 m,

$P_{atm} = 98.7\ kN/m^2$, h_{fs} = 1.2 m,

$P_v = 2.34\ kN/m^2$ and $\gamma = 9.78\ kN/m^3$

NPSH is mathematically expressed as :

$$NPSH=\frac{P_{atm}}{\gamma}-h_s-h_{fs}-\frac{P_v}{\gamma}$$

$$=\frac{(98.7-2.34)}{9.78}-1.25-1.2$$

= 9.85 – 2.45 = 7.4 m

Since NPSH value of 7.4 m is greater than the minimum recommended value of 6.5, the pump is safe from cavitation effects.

11. Ans: (a)

Sol: For phase change process, effectiveness of both counterflow and parallel flow heat exchangers is same.

For phase change process $(C_{max}) \to \infty$

Capacity ratio = $\frac{C_{min}}{C_{max}}=0$

$\therefore\ \epsilon_p=\epsilon_c$

12. Ans: (b)

Sol: In a reaction turbine, the point of minimum pressure is usually at the outlet end of a blade on its convex side. Since cavitation begins when the pressure reaches too low a value ($\le P_{vapour}$), it is likely to occur at points where the velocity or elevation is high and particularly at such points where high velocity and high elevation are combined.

13. Ans: (c)

Sol: $\dot{m} = \frac{P_1V_1}{RT_1} = \frac{500\times17.22}{0.287\times600} = 50$ kg/s

$$s_2 - s_1 = c_p\,\ell n\left(\frac{T_2}{T_1}\right) - R\,\ell n\left(\frac{P_2}{P_1}\right)$$

$$= 1\,\ell n\left(\frac{450}{600}\right) - 0.287\,\ell n\left(\frac{100}{500}\right)$$

$$= 1\times(-0.287) - 0.287\times(-1.61)$$

$$= 0.175 \text{ kJ/kgK}$$

Rate of change of entropy = 50 × 0.175

= 8.75 kW/K

14. Ans: (a)

Sol: Guide vane converts a part of the pressure energy of the fluid at its entrance to the kinetic energy. It also directs the fluid on the runner blades at the angle appropriate to the design. Guide vane does not convert a part of the kinetic energy of the fluid rejected at the runner outlet into useful pressure energy.

15. Ans: (b)

Sol: $T_{max} - T_s = \frac{qR^2}{4K}$

$q = 4\times10^7$ W/m^3

$T_s = 220°$C

R = 0.005 m

K = 30 W/mK

$$T_{max} - 220 = \frac{4\times10^7\times0.005^2}{4\times30}$$

$\Rightarrow T_{max} \approx 228°$C

16. Ans: (d)

Sol: $n = 15 + \frac{1}{2}\left(\frac{D}{d}\right) = 15 + \frac{5}{2} = 17.5$

Given that if $\frac{D}{d_1} = 5\times\frac{D}{d}$;

$n_1 = 2$ n

Thus, $15 + \frac{1}{2}\frac{D_1}{d_1} = 2\left[15 + \frac{1}{2}\frac{D}{d}\right]$

$$15 + \frac{5}{2}\frac{D}{d} = 30 + \frac{D}{d}$$

$$2.5\frac{D}{d} - \frac{D}{d} = 15$$

$$1.5\frac{D}{d} = 15$$

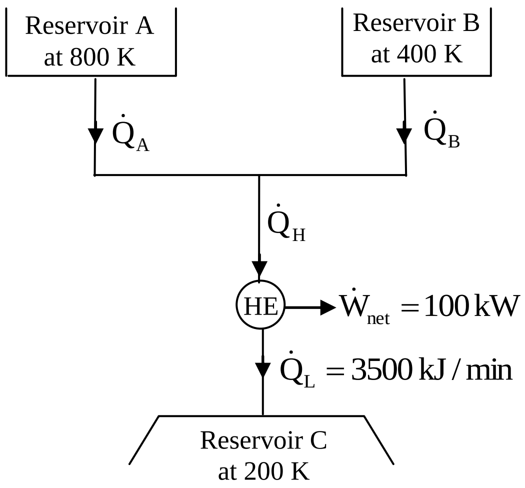
D = 10 d

Pitch diameter required

= 10×0.15 = 1.5 m

17. Ans: (b)

Sol:



$$\dot{Q}_A + \dot{Q}_B = \dot{Q}_H = \dot{W}_{net} + \dot{Q}_L$$

$= 100 \times 60 + 3500$

$= 9500$ kJ/min .... (i)

$$\frac{\dot{Q}_A}{800} + \frac{\dot{Q}_B}{400} = \frac{3500}{200}$$

or $\dot{Q}_A + 2\dot{Q}_B = 14000$ .... (ii)

Solving equation (i) and (ii), we get

$\dot{Q}_A = 5000$ kJ/min and $\dot{Q}_B = 4500$ kJ/min

Thermal efficiency of the reversible heat engine,

$$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_H} = \frac{6000\,\text{kJ/min}}{9500\,\text{kJ/min}}$$

$= 0.631$ or 63.1 %

18. Ans: (d)

Sol: $$\eta_h = \frac{H_e}{H} = \frac{36}{40}$$

and $\eta_o = \eta_m \times \eta_h = \frac{36}{40} \times 0.9 = 0.81$

$$\eta_0 = \frac{P}{\rho g Q H}$$

$$Q = \frac{P}{\eta_0 \rho g H} = \frac{45 \times 10^3}{0.81 \times 10^3 \times 10 \times 40}$$

$$= \frac{1}{0.9 \times 8} = \frac{1}{7.2} = 0.1389\,\text{m}^3/\text{s} = 138.9\,\text{lit/s}$$

19. Ans: (b)

Sol: For cylinder $(A_{eq}) = \dfrac{A_2 - A_1}{\ln\left(\dfrac{A_2}{A_1}\right)} = \dfrac{10-5}{\ln(2)}$

$= 7.2134\ \text{m}^2$

20. Ans: (a)

Sol: Given data: H = 25 m, Q = 10 m^3/s

N = 4 rps; $\eta_o = 90\%$

$$P = \eta_o \rho g Q H = 0.9 \times 10 \times 10 \times 10 \times 25$$

$= 2250$ kW

The dimensional specific speed,

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

$$= \frac{4 \times 60\sqrt{2250}}{(25)^{5/4}}$$

$$= \frac{240 \times 15\sqrt{10}}{5^2 \times 5^{1/2}}$$

$$= 240 \times 0.6\sqrt{\frac{10}{5}}$$

$$= 144\sqrt{2}$$

21. Ans: (a)

Sol: Entropy change of metal block = ΔS_1

$$= 100 \times 0.3 \times \ell n\left(\frac{300}{600}\right) = -20.8 \text{ kJ/K}$$

Heat gained by atmospheric air

$= 100 \times 0.3 \times (600 - 300)$

$= 9000$ kJ

Entropy change of atmospheric air

$$= \frac{9000}{300} = 30 \ \frac{\text{kJ}}{\text{K}}$$

Entropy generation = –20.8 + 30 = 9.2 kJ/K.

Irreversibilty = $T_o \times 9.2$

$= 300 \times 9.2 = 2760$ kJ

22. Ans: (c)

Sol: Spiral casing, guide vanes and draft tube are among the main components of Kaplan turbine.

23. Ans: (c)

Sol: According to Lambert's cosine law Energy radiated by diffused body in a particular direction follows Cosine law from the normal.

24. Ans: (c)

Sol: Given data: $H_m = 16$ m;

$D_2 = 0.5$ m, $D_1 = 0.3$ m

Minimum speed of the pump to just start delivering water,

$$N_{min} = \frac{60}{\pi} \times \frac{1}{\sqrt{D_2^2 - D_1^2}} \times \sqrt{2gH_m}$$

$$= \frac{60}{\pi} \times \frac{1}{\sqrt{0.5^2 - 0.3^2}} \times \sqrt{2 \times 10 \times 16}$$

= 854 rpm

25. Ans: (b)

Sol: Clapeyron equation is

$$\left(\frac{dP}{dT}\right) = \frac{h_{fg}}{T_{sat}(v_g - v_f)}$$

$$\left(\frac{dP}{dT}\right)_{sat} = 0.2 \text{ bar / k} = 20 \text{ kPa / K}$$

$v_g - v_f = (0.351 - 0.001)$ m^3/kg = 0.35 m^3/kg

$T_{sat} = 300$ K

$$\therefore h_{fg} = T_{sat}(v_g - v_f)\left(\frac{dP}{dT}\right)_{sat}$$

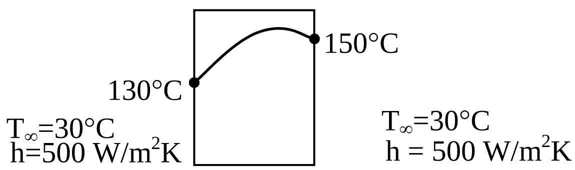
$$= 300 \times 0.35 \times 20 = 2100 \text{ kJ / kg}$$

26. Ans: (b)

Sol: The change in static head consists of both change in centrifugal head and that in pressure head. For axial flow machines the inlet and outlet points of the flow do not vary in their radial locations from the axis of rotation and hence there is no change in centrifugal head. As a result, the change in the static head in the rotor of an axial flow machine is only due to the change in pressure head of the fluid while flowing through the variable area passage in the rotor.

27. Ans: (b)

Sol:



q_g = heat generation in plane wall

$q_g \times A \times 1 = Q_{left} + Q_{right}$

$q_g \times A = h \times A(130 - 30) + hA(150\text{-}30)$

$q_g = 500 \times 100 + 500 \times 120$

$q_g = 1.1 \times 10^5 \text{ W/m}^3$

28. Ans: (c)

Sol: Reynolds transport theorem applies to both conditions given in the problem.

29. Ans: (c)

Sol: According to first law of thermodynamics, the energy of an isolated system is always conserved.

30. Ans: (d)

Sol: The capillary depression is given by:

$$h = \frac{4\sigma \cos\theta}{\gamma_{Hg} \times d}$$

$$\Rightarrow h \,\alpha\, \frac{1}{d} \text{ if } \sigma, \theta \text{ remain same}$$

$$\text{Thus, } \frac{h_2}{h_1} = \frac{d_1}{d_2} = \frac{3}{2} = 1.5$$

Percentage increases in capillary depression is

$$= \left(\frac{h_2}{h_1} - 1\right) \times 100$$

$$= (1.5 - 1) \times 100 = 50\ \%$$

31. Ans: (b)

Sol: Efficiency of fin decreases with increasing length.

32. Ans: (a)

Sol: Stone weight in air = 392.4 N

Stone weight in water = Stone weight in air – Buoyancy force

$$196.2 = 392.4 - \rho_w \forall_{stone} \times g$$

or,

$$\forall_{stone} = \frac{392.4 - 196.2}{10^3 \times 9.81} = \frac{196.2}{10^3 \times 9.81} = 0.02\,\text{m}^3$$

$$\rho_{stone} = \left(\frac{\text{mass}}{\forall}\right)_{stone} = \frac{392.4}{9.81 \times 0.02} = 2000 \ \ \text{kg/m}^3$$

$$\text{Thus, } (S.G)_{stone} = \frac{2000}{10^3} = 2$$

33. Ans: (b)

Sol: $Q_1 = m_a \times c_p \times 10$

$Q_2 = m_a \times c_v \times 10$

$Q_1 - Q_2 = m \times (c_p - c_v) \times 10 = m_a \times R \times 10$

$28.7 = m_a \times 0.287 \times 10$

$\Rightarrow \ m_a = 10 \text{ kg}$

34. Ans: (b)

Sol: Piezometric head $= \frac{P}{\rho g} + z$

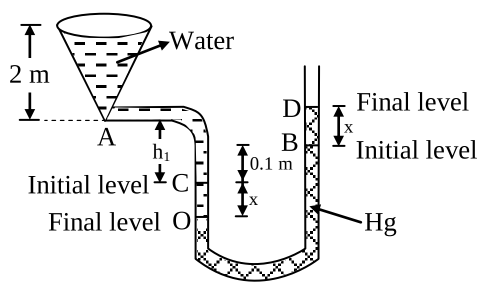
$$= \frac{29.43}{10^{-4}} \times \frac{1}{10^3 \times 9.81} + 5 = 30 + 5 = 35\,\text{m}$$

35. Ans: (a)

Sol: LMTD method is applicable for only constant wall temperature condition.

36. Ans: (c)

Sol:



- When the vessel is empty , let C and B be the levels of mercury in the manometer and A be the bottom of the vessel at height h_1 from C. Then

$$P_{atm} + \gamma_w h_1 = P_{atm} + \gamma_{Hg} \times 0.1$$

$$h_1 = \frac{\gamma_{Hg}}{\gamma_w} \times 0.1 = 13.6 \times 0.1 = 1.36\,\text{m}$$

- When the vessel is completely filled with water, let the level of mercury go down by 'x' m to point O. Consequently the mercury in right limb rises by same amount 'x' to point D. Hence,

$$P_{atm} + \gamma_w (2 + h_1 + x) = P_{atm} + \gamma_{Hg}(x + 0.1 + x)$$

or, $\gamma_w(2 + 1.36 + x) = \gamma_{Hg}(2x + 0.1)$

$$3.36 + x = \frac{\gamma_{Hg}}{\gamma_w}(2x + 0.1) = 13.6(2x + 0.1)$$

or, $3.36 + x = 27.2x + 1.36$

or, $26.2x = 2$

$$x = \frac{2}{26.2} = 0.076\,\text{m}$$

Hence, the manometer reading is

$= 0.1 + 2x = 0.1 + 2 \times 0.076$

$= 0.252$ m $= 252$ mm

37. Ans: (c)

Sol: For process A-B,

$$\frac{T}{V} = \text{constant}$$

$$PV = mRT \Rightarrow P = \frac{mRT}{V} = \text{constant}$$

Thus A–B is an isobaric process

Now for cyclic process :

$\Sigma Q = \Sigma W$

$-12 = W_{AB} + W_{BC} + W_{CA}$

$= mR[T_B - T_A] + W_{BC} + 0$

$-12 = 1 \times 0.287 \times 200 + W_{BC}$

$\Rightarrow W_{BC} = -69.4$ kJ

38. Ans: (d)

Sol: Given data:

$Q = 0.2\ m^3/s$, $A_A = 0.05\ m^2$

$A_B = 0.1 m^2$, $P_A = 100 \times 10^3\ N/m^2$

$$P_B = 60\times10^3\ \ N/m^2,\quad \gamma_w = 10^4\ N/m^3$$

$$V_A = \frac{0.2}{0.05} = 4\,m/s^2$$

$$V_B = \frac{0.2}{0.1} = 2\,m/s^2$$

Total energy at A:

$$E_A = \frac{P_A}{\gamma_w} + \frac{V_A^2}{2g} + Z_A = \frac{100\times10^3}{10^4} + \frac{16}{2\times10} + 0$$

$$= 10 + 0.8 = 10.8$$

Total energy at B:

$$\frac{P_B}{\gamma_w} + \frac{V^2}{2g} + z_B = \frac{60\times10^3}{10^4} + \frac{4}{2\times10} + 5$$

$$= 6 + 0.2 + 5 = 11.2\ m$$

Since $E_B > E_A$, the flow is from B to A and energy loss = 11.2 – 10.8 = 0.4 m

39. Ans: (c)

Sol: if 'Bi' number is less, thermal conductivity is high

$$Bi \propto \frac{1}{k}$$

$$k \propto \frac{1}{\left(\frac{dT}{dx}\right)}$$

$$Bi \propto \left(\frac{dT}{dx}\right)$$

$$\left(\frac{dT}{dx}\right)_1 < \left(\frac{dT}{dx}\right)_2 < \left(\frac{dT}{dx}\right)_3 < \left(\frac{dT}{dx}\right)_4$$

$$(Bi)_1 < (Bi)_2 < (Bi)_3 < (Bi)_4$$

40. Ans: (b)

Sol: Velocity of sound in a medium, $C = \sqrt{kRT}$

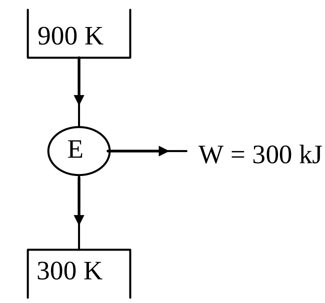
$$C \propto \sqrt{T}$$

$$\frac{C_2}{C_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{600}{400}} = \sqrt{1.5}$$

$$\Rightarrow C_2 = 400 \times \sqrt{1.5} = 490\ m/s$$

41. Ans: (b)

Sol:



$$\eta = \frac{900-300}{900} = 0.67$$

$$\eta = 0.67 = \frac{W}{\text{Heat Supplied}}$$

Heat Supplied = $\dfrac{W}{0.67} = \dfrac{300}{0.67} = 448\,kJ$

Entropy change of source

$$= -\frac{448}{900} = -0.49\,kJ/K$$

42. Ans: (a)

Sol: The discharge of a double acting reciprocating pump

= 2 A L N

$$= 2\times\left(\frac{\pi}{4}\times0.25^2\right)\times0.5\times30\ \ m^3/min$$

$= \pi \times 0.0625 \times 7.5\ m^3/min$

$= \pi \times 62.5 \times 7.5$ lit/min

$$\eta_{vol} = \frac{1375}{\pi \times 62.5 \times 7.5} = 0.934$$

43. Ans: (b)

Sol: Time constant $(\tau) = \frac{\rho vc}{hA}$

$$\tau \propto \frac{1}{hA}$$

$$\frac{\tau_1}{\tau_2} = \frac{h_2 A_2}{h_1 A_1}$$

$$\frac{24}{\tau_2} = \frac{(2h)(1.2A)}{hA}$$

$\Rightarrow \tau_2 = 10$ sec

44. Ans: (c)

Sol: The power required is

$$P = (u_2 V_{w2} - u_1 V_{w1})\ \dot{m}$$

Given that,

$Q = 0.6 \frac{m^3}{min} = 0.01\ m^3/s$, $\omega = 300$ rad/s

$\dot{W}_{in} = 5$ kW, $\eta = 72\%$,

$V_{r2} = 5.4$ m/s , $\beta_2 = 90°$ (radial blade)

$V_{w1} = 0$ (axial inlet)

$\Rightarrow P_{in} = 5 \times 0.72 = 3.6$ kW

From the outlet geometry,

$V_{w2} = u_2 - V_{r2} \cos\beta_2 = u_2$

Hence, $3.6 \times 10^3 = u_2^2 \times \dot{m}$

$3600 = (\omega r_2)^2 \times 10^3 \times 0.01$ (as $\dot{m} = \rho Q$)

or, $(\omega r_2)^2 = 360$

$$r_2 = \frac{\sqrt{360}}{\omega} = \frac{\sqrt{360}}{300}$$

Impeller diameter at exit = 2 r_2

$$= 2 \times \frac{\sqrt{360}}{300} = 0.1265 \text{ m} = 12.65 \text{ cm}$$

45. Ans: (d)

Sol: Throttling process is an irreversible process.

46. Ans: (d)

Sol: All the given statements are correct.

47. Ans: (b)

48. Ans: (b)

Sol: In a reciprocating pump without air vessels the acceleration head and friction head are given by

$$h_a = \frac{\ell}{g} \times \frac{A}{a} \omega^2 r \cos\theta \text{ -------(1) and}$$

$$h_f = f \frac{\ell}{d} \frac{V^2}{2g}, \text{ respectively,}$$

where, V is the velocity of liquid in the pipe.

Also, $V = \frac{A}{a} r\omega \sin\theta$

$$\text{Therefore, } h_f = f \frac{\ell}{d} \times \frac{\left(\frac{A}{a} r\omega \sin\theta\right)^2}{2g} \text{ -----(2)}$$

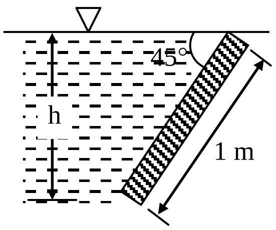
From equations (1) and (2), it is evident that h_a and h_f are maximum when crank angles are 0° and 90°.

49. Ans: (b)

Sol: $ds = \frac{Pt}{T} = \frac{5 \times 3600}{273+27} = 60\,kJ/K$

50. Ans: (c)

Sol:



From the figure, height of liquid from the lower edge of the door,

$$h = 1 \times \sin 45^o = \frac{1}{\sqrt{2}}\,m$$

The resultant hydrostatic force on the submerged door due to the liquid of density ρ, is

$$F_R = P_cA = \rho g \bar{h}(1\times 1)$$

$$= \rho g \times \frac{h}{2} = \rho g \times \frac{1}{2\sqrt{2}}$$

51. Ans: (c)

Sol: Characteristic length of vertical cylinder is its length while for horizontal cylinder is its diameter.

52. Ans: (d)

Sol: Applying Bernoulli's equation between sections (1) and (2), we write

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_L$$

But $P_1 = P_2$ (Given), $V_1 = V_2$ (as $d_1 = d_2$)

Thus, $h_L = Z_1 - Z_2$

$$\frac{f\,L\,V^2}{2gd} = (Z_1 - Z_2) = 3 \times \sin 30^o = 1.5$$

$$\frac{f\,L\,V^2}{2gd} = 1.5$$

$$\frac{8f\,L\,Q^2}{\pi^2\,g\,d^5} = 1.5$$

$$\frac{Q^2}{\pi^2} = \frac{1.5 \times g \times d^5}{8\,f\,L}$$

$$= \frac{1.5 \times 10 \times 2^5 \times 10^{-10}}{8 \times 0.02 \times 3}$$

$$= \frac{20}{0.02} \times 10^{-10}$$

$$= 1000 \times 10^{-10}$$

$$= 10^{-7} = \frac{10^{-6}}{10}$$

$$\frac{Q}{\pi} = \frac{10^{-3}}{\sqrt{10}}$$

$$Q = \frac{\pi}{\sqrt{10}} \times 10^{-3}\ m^3/s$$

$$= \frac{\pi}{\sqrt{10}}\,lit/s \cong 1\ lit/s$$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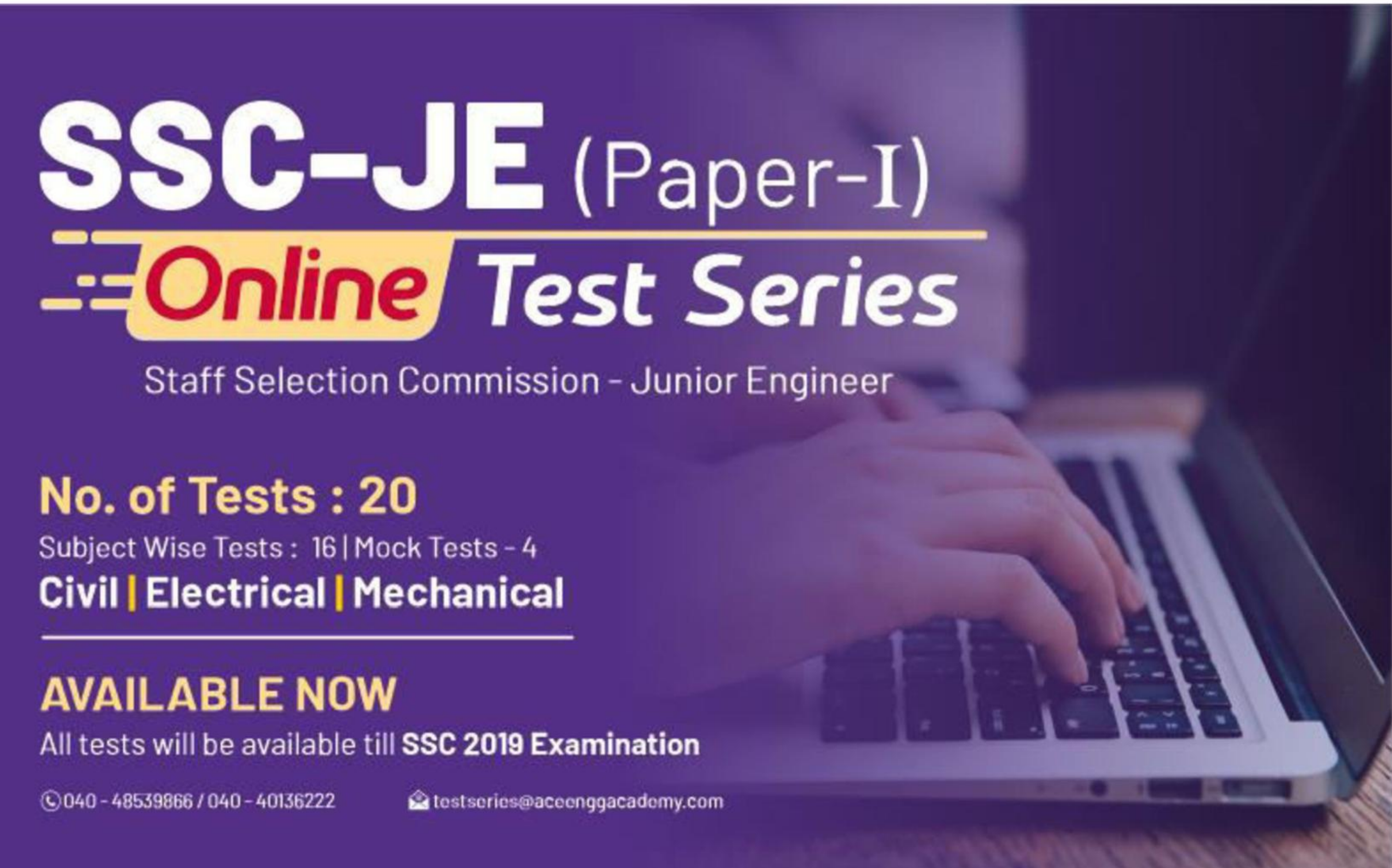
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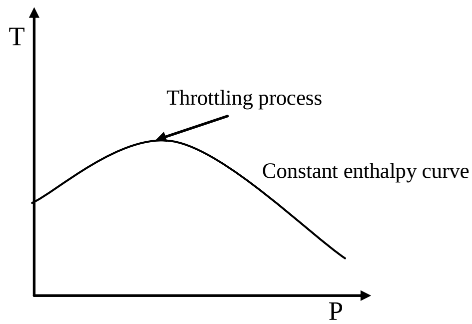
53. Ans: (d)

Sol: In a throttling process for ideal gases temperature remains constant.

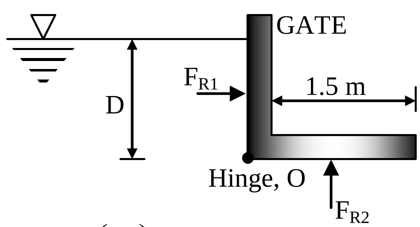
For real gases temperature may increase or decrease or remain constant.

Temperature decreases if slope is positive and vice versa



54. Ans: (a)

Sol: F.B.D of the rectangular gate is shown as :



$$F_{R1} = \gamma_w\left(\frac{D}{2}\right)(D\times b)$$

where b is the width of the gate

$$F_{R1} = \gamma_w\frac{D^2b}{2}$$

$$h_{cp1} = \frac{D}{3} \text{ from the hinge O.}$$

$F_{R2} = \gamma_w \times D \times 1.5 \times b$

$= 1.5\ \gamma_w Db$ acting 0.75 m from O.

Taking moments above the hinge, O, we get

$$F_{R1}\times h_{cp1} = F_{R2}\times 0.75$$

$$\gamma_w\frac{D^2b}{2}\times\frac{D}{3} = 1.5\gamma_w Db\times 0.75$$

$$\frac{D^2}{6} = 1.5\times 0.75$$

$D^2 = 6\times1.5\times0.75$

$D = 2.598$ m ≈ 2.6 m

55. Ans: (d)

Sol: $$\text{Error}(T_G - T_C) = \frac{(T_C^4 - T_W^4)\times\in}{h}$$

$T_G \rightarrow$ gas temperature

$T_C \rightarrow$ thermocouple temperature

$T_W \rightarrow$ wall temperature

$h \rightarrow$ heat transfer coefficient

$\in \rightarrow$ emissivity of thermocouple

$$\text{Error} \propto \frac{1}{h}$$

$\text{Error} \propto \in$

$$\text{Error} \propto \frac{1}{T_w}$$

56. Ans: (b)

Sol: The velocity field of a flow indicates the velocity at a point in the flow field.

57. Ans: (d)

Sol: A system has only energy in different forms. A system will not have any heat when energy transfer occurs. It may become heat or work.

58. Ans: (b)

Sol: Irradiation

= Total energy falling on the surface

= Emissive power of surface (2) + Reflected radiation of surface (2)

$G_1 = E_2 + \rho_2 E_1$ [$\because$ $\rho_2 = 1 - \varepsilon_2$]

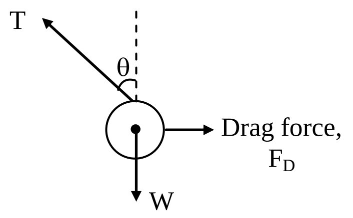
$= \varepsilon_2 \sigma T_2^4 + (1 - \varepsilon_2) \sigma T_1^4$

$= 0.5 \times 5.67 \times 10^{-8} \times 500^4 + 0.5 \times 5.67 \times 10^{-8} \times 1000^4$

$G_1 = 30.12$ kW/m^2

59. Ans: (b)

Sol: F.B.D of sphere is drawn as



Since, the sphere is static, all the forces must balance

ΣF_y gives : $T\cos\theta = W$

Or, $T = \dfrac{W}{\cos\theta}$ -------------(1)

ΣF_x gives : $F_D = T\sin\theta$ -------(2)

$$F_D = \frac{W}{\cos\theta}\sin\theta = W\tan\theta$$

$$C_D \times \frac{1}{2}\rho V_\infty^2 \times A_{projected} = W\tan\theta$$

where,

$A_{projected}$ = Projected surface area = $\dfrac{\pi}{4}D^2$

Hence, $C_D \times \dfrac{1}{2}\rho V_\infty^2 \times \dfrac{\pi}{4}D^2 = W\tan\theta$

$\Rightarrow$ $C_D = \dfrac{8W\tan\theta}{\rho V_\infty^2 \pi D^2}$

60. Ans: (a)

Sol: The volume displaced,

$$\forall = \frac{500 \times 10^6}{10^3 \times 10} = 50000 \text{ m}^3$$

$$I = \frac{1}{12} \times 200 \times 25^3 \times 0.6 = 156,250 \text{ m}^4$$

$$\overline{BM} = \frac{I}{\forall} = \frac{156,250}{50,000} = 3.125 \text{ m}$$

The metacentric height,

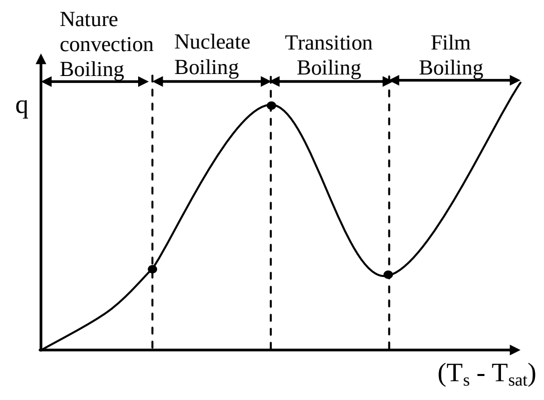
$\overline{GM} = \overline{BM} - \overline{BG}$

$= 3.125 – 2.5 = 0.625$ M

The metacentre is 0.625 m above the centre of gravity and the ocean liner is stable.

61. Ans: (d)

Sol:



62. Ans: (b)

Sol: As the pressure ratio increases the thermal efficiency of gas turbine increases. Hence, curve A is eliminated and curve C and D are of similar nature and hence eliminated. Thus the correct curve is B.

63. Ans: (a)

64. Ans: (b)

65. Ans: (d)

Sol: Turboprop < 800 kmph

Turbojet > 800 kmph.

At high speeds propeller efficiency falls.

66. Ans: (d)

Sol: The extent of irreversibility of any process undergone by a system in a given surroundings is determined by estimating the entropy change of that system as well as surrounding.

67. Ans: (c)

Sol: For compact heat exchangers, surface area to volume is large.

68. Ans: (c)

Sol: Large excess air reduces peak temperature and produces cooling effect.

69. Ans: (c)

70. Ans: (a)

Sol: For maximum efficiency of the collector its surface should have high absorptivity for short wave length (to maximize the heat gain) and low emissivity at low temperatures (to minimize the heat losses).

71. Ans: (a)

Sol: Energy is transferred to the fluid in impeller. Thus, stagnation pressure rise in a centrifugal compressor stage takes place only in the impeller.

72. Ans: (a)

Sol: Work potential (Also called available energy) is a function of both system and surrounding. So if the state of the surrounding is changed work potential will also change.

73. Ans: (a)

Sol: Fins are made with higher thermal conductivity materials, heat transfer rate through fins more. For maximum heat transfer from the fin, the entire fin should be at the base temperature.

74. Ans: (c)

Sol: Variation in maximum speed ratio exists.

$(\Delta h)_{50\%}$: $(\Delta h)_{IS}$: $(\Delta h)_{curtis}$

1 : 2 : 8

75. Ans: (a)

Sol: $K_{gas} \propto \dfrac{1}{\sqrt{M}}$

$M_{H_2},\ M_{He} < M_{O_2},\ M_{N_2}$

$K_{H_2},\ K_{He} > K_{O_2}, K_{N_2}$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AIR 9 ANKIT KUMAR CE
AIR 10 ANKITA SHARMA EE
AIR 10 GAURAV SRIVASTAVA E&T
AIR 10 SUMIT BHAMBOO ME
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(EE: 9, E&T: 8, ME: 9, CE: 7) and many more...


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