ACE
Engineering Academy

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ESE- 2018 (Prelims) - Offline Test Series Test - 24

MECHANICAL ENGINEERING

FULL LENGTH MOCK TEST – 2 (PAPER – II)
SOLUTIONS

01. Ans: (a)

Sol:

- Let the temperature of the surroundings be T_∞. From the Stefan-Boltzmann law, the energy of thermal radiation emitted per unit time by a blackbody of surface area A is given by $E = \sigma A T^4$

  Here, σ is Stephen's constant. Also, the energy absorbed per unit time by the body is given by $E = \varepsilon\sigma A\, T_\infty^4$

  As the two spheres have equal radii and temperatures, their rate of absorption and emission will be equal in the beginning.

- *Energy balance:*

  Net radiative heat transfer by sphere = Rate of change of internal energy of sphere.

  $$\varepsilon\sigma\left(T_S^4 - T_\infty^4\right) = -mc\frac{dT}{dt}$$

  $$\frac{dT}{dt} \propto \frac{1}{m}$$

  ∵ Masses of both the spheres are different, (since, one is solid sphere and other is hollow sphere with same material and radii) initial rate of cooling will be different. So, statement (3) is incorrect.

- As cooling rates are different therefore, temperature at any instant will be different. So statement (4) is incorrect.

02. Ans: (b)

Sol: Mean arrival rate (λ) = 4/hr

Mean service time = 10min

Mean service rate (μ) = $\frac{1}{10} \times 60 = 6/\text{hr}$

$$\rho = \frac{\lambda}{\mu} = \frac{4}{6}$$

$$L_s = \frac{\rho}{1-\rho} = \frac{4/6}{1-4/6} = \frac{4/6}{2/6} = 2$$

$L_q = \rho.L_s = 4/6\times2 = 1.33$

03. Ans: (c)

Sol:

- The long term deformation due to constant load with time is called creep.
- The ability of the material to absorb energy without fracturing is called toughness.
- Resistance of a material against repeated load is called fatigue strength.
- The strain energy density when the material is stressed to the proportional limit known as modulus of resilience.

04. Ans: (a)

Sol: According to principal strain theory,

$$\sigma_1 - \mu(\sigma_2 + \sigma_3) = S_{yt}$$

For determining shear strength, consider the material to be in pure shear.

$\sigma_1 = \tau$, $\sigma_2 = -\tau$, $\sigma_3 = 0$

$\tau - \mu(-\tau) = S_{yt}$

$\tau = S_{ys}$

$$S_{ys} = \frac{S_{yt}}{1+\mu}$$

05. Ans: (b)

Sol: Equation of motion of vertical lever based problem is

$$I_0\ddot{\theta} + k_t\theta + kL^2\theta - mg\times\frac{L}{2}\theta = 0$$

For a rod I_0 about one end is $\frac{mL^2}{3}$

$$\frac{mL^2}{3}\ddot{\theta} + \left(kL^2 + k_t - \frac{mgL}{2}\right)\theta = 0,$$

$$\omega_n = \sqrt{\frac{k_{eq}}{m}}$$

$$\omega_n = \sqrt{\frac{kL^2 + k_t - \frac{mgL}{2}}{\frac{mL^2}{3}}}$$

$$= \sqrt{\frac{3k}{m} + \frac{3k_t}{mL^2} - \frac{3g}{2L}}$$

06. Ans: (b)

Sol: Machining time, $T = \frac{D_2 - D_1}{2f_m}$

$$= \frac{200-100}{2\times 25} = 2\text{ min}$$

07. Ans: (b)

Sol: Statements (1) are incorrect, in Mechatronics system the approach is concurrent (or) simultaneous design used.

08. Ans: (a)

Sol: The efficiency of the hydraulic coupling is defined as

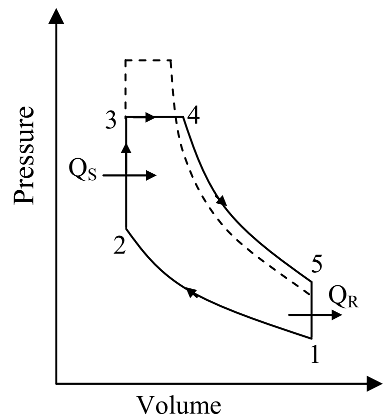
$$\eta = \frac{\text{Output Power}}{\text{Input Power}} = \frac{T_2\omega_2}{T_1\omega_1}$$

$$= \frac{\omega_2}{\omega_1} \quad (\because T_1 = T_2 \text{ for hydraulic coupling})$$

$$= \frac{N_2}{N_1} \quad \left(\because \omega = \frac{2\pi N}{60}\right)$$

09. Ans: (b)

Sol:



Increase in r_p leads to decrease in cutoff ratio. It also decreases the heat rejection which increases the thermal efficiency.

10. Ans: (b)

Sol: Conversion efficiency

$$= \frac{\text{Electric energy output}}{\text{Energy insolation on cell}} \times 100$$

Single crystal $\rightarrow$ 10 % – 17 %

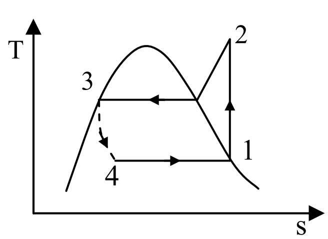
Dye sensitized $\rightarrow$ 7 % – 8 %

Gallium arsenide $\rightarrow$ 18 % – 30 %

Poly crystalline $\rightarrow$ 10 % – 13 %

11. Ans: (a)

Sol:



$h_1 = 1600$ kJ/kg , $h_2 = 2000$ kJ/kg

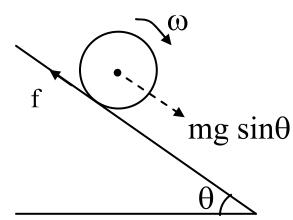
$h_3 = h_4 = 600$ kJ/kg

$$\text{Heat rejection ratio} = \frac{Q_{\text{condenser}}}{Q_{\text{evaporator}}} = \frac{\dot{m}(h_2 - h_3)}{\dot{m}(h_1 - h_4)}$$

$$= \frac{2000 - 600}{1600 - 600} = 1.4$$

12. Ans: (d)

Sol:



- Since there is no slip so friction force is non dissipative.
- Friction force is the only force which can rotate the cylinder as shown in the figure above. So, friction force will aid rotation but hinder translation.

13. Ans: (b)

Sol:

- Deaerator is a contact type open heater.
- The presence of dissolved gases like oxygen and carbon dioxide in water makes water corrosive as they react with metal to form iron oxide. The purpose of deaerator is to remove these gases from feed water. The solubility of these gases decrease with increase in temperature and becomes zero at the boiling or saturation temperature.

- To neutralise the effect of residual dissolved oxygen and carbon dioxide gases in water, sodium sulphite (Na_2SO_3) and hydrazine (N_2H_4) is injected into the feed water at the suction of boiler feed pump.

14. Ans: (b)

Sol: • $S_2 - S_1 = c_p \ell n \frac{T_2}{T_1} - R\ell n \frac{P_2}{P_1}$

$= R\ell n \frac{P_1}{P_2}$ $(\because T_1 = T_2)$

$= R\ell n \frac{10}{5} = R\ell n 2 > 0$

• $S_2 - S_1 = c_p \ell n \frac{V_2}{V_1} + c_v \ell n \frac{P_2}{P_1} = c_p \ell n \frac{1}{4}$

• $ds = \frac{dQ}{T} > 0$

• $S_1 = S_2$

15. Ans: (c)

Sol: Peritetic reaction

$$L + \delta - Fe \leftrightharpoons \gamma - Fe$$

At Peritectic point

$P = 3$ (L, δ, γ)

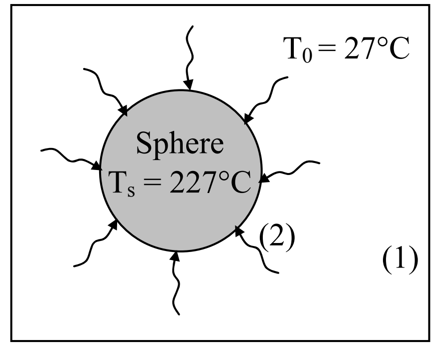
$C = 2$ (Fe, C)

$F = C - P + 1$

$F = 0$

16. Ans: (c)

Sol:



Closed Box

Amount of radiation falling on it

$= A_1F_{1-2}\,\sigma.T_\infty^4$ $[\because A_1F_{1-2} = A_2F_{2-1}]$

$[\because F_{2-1} = 1$, so $A_1F_{2-1} = A_2]$

$= 20\times10^{-4}\times6\times10^{-8}\times(27+273)^4$

$= 20\times10^{-4}\times6\times10^{-8}\times300^4$

$= 20\times10^{-4}\times6\times81$

$= 9720\times10^{-4}$

$= 0.972$ W

17. Ans: (b)

Sol: Self weight elongation of the bar due to its weight density 'γ' is given by,

$$\delta = \frac{\gamma L^2}{2E}$$

where, L = Length of the bar,

E = Young's modulus

Thus, for a same material,

$$\delta \propto L^2$$

As the elongation is independent of cross-sectional area, bar-2 also elongates by δ only.

18. Ans: (d)

Sol: Given data:

n_1 = 10 hours, n_2 = 9.6 hours,

N_1 = ? , N_2 = 10 hours

From Miner's equation,

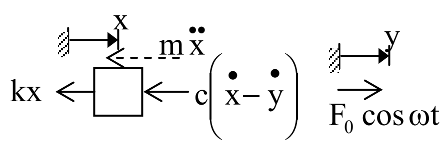
$$\frac{n_1}{N_1}+\frac{n_2}{N_2}=1$$

$$\frac{10}{N_1}+\frac{9.6}{10}=1$$

$$N_1=\frac{10}{0.04}=250\,\text{hours}$$

19. Ans (b)

Sol:



Let the displacement of the mass from its static equilibrium position be x and the displacement of the free end of the damper where the force is applied be y the free body diagram will be as follows

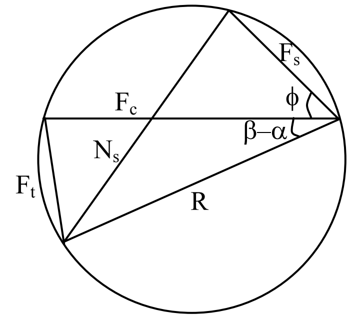
The equations of motion are

$$m\ddot{x}+c\left(\dot{x}-\dot{y}\right)+kx=F_0\cos\omega t$$

20. Ans: (d)

21. Ans: (b)

Sol: From Merchant's circle diagram,



$F_c = R\cos(\beta-\alpha)$

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

$$\frac{F_c}{N_s}=\frac{\cos(\beta-\alpha)}{\sin(\phi+\beta-\alpha)}$$

22. Ans: (a)

23. Ans: (d)

Sol: Ceramic materials possess high melting point temperature with more hardness. But low carbon steels are low hard materials.

24. Ans: (b)

Sol: The slip in reciprocating pump defined as

$$\text{slip}=\frac{Q_{th}-Q_{act}}{Q_{th}}$$

If acceleration head in suction pipe is large then the delivery valve is opened before the start of delivery stroke due to inertia of liquid in suction pipe. This causes the higher actual discharge than the theoretical discharge. i.e., negative slip. The above effect is aggravated under following circumstances.

1. Long suction pipe (increases inertia of liquid in suction pipe)
2. Higher crank speed (increases inertia of liquid in suction pipe)
3. Shorter delivery pipe (decreases the resistance to open delivery valve)

25. Ans: (c)

Sol: A catalytic converter consists of a stainless steel cover and alumina inside it. Alumina contains 3 types of catalyst

(1) Rhodium (R_h) → used for increasing the rate of reducing No_x

(2) Platinum (P_f) → used to convert HC to H_2O & CO_2

(3) Palladium (P_a) → used to convert CO to CO_2

26. Ans: (c)

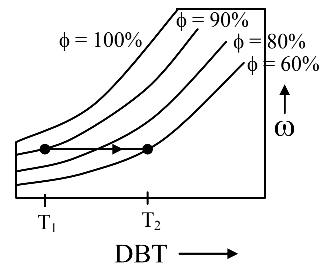
Sol:

- Electrostatic precipitator is used to separate the dust and particulate matters from the gases.
- Electrodes are supplied with the DC voltage which is converted by Rectifier.
- Corona discharge is observed with increase in voltage at which luminous blue glow is observed around the discharge electrode.
- Collector electrode is a positively charge electrode.

27. Ans: (b)

Sol:

- Relative humidity decreases during sensible heating as shown in figure. So statement (1) is incorrect.

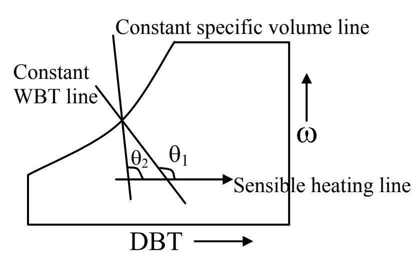


At (1), T = T_1 and ϕ = 90 %

At (2), T = T_2 and ϕ = 60 %

$$T_2 > T_1 , \phi_2 < \phi_1$$

- Angle of constant specific volume line is less as compared to constant wet bulb temperature line, when it is measured anticlockwise from sensible heating line as shown in figure. So, Statement (2) is correct.



$\therefore\ \theta_1 > \theta_2$

28. Ans: (a)

Sol: Since, force is always perpendicular to the velocity of the particle so particle will perform circular motion. Hence velocity and acceleration will change but speed will remain constant. Thus the kinetic energy of the particle is constant.

29. Ans: (c)

Sol: Advantages of a gas turbine power plant are:

1. Less installation cost
2. Less installation time
3. Quick starting and stopping
4. Fast response to load changes

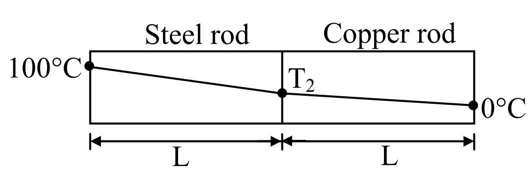
30. Ans: (c)

Sol:

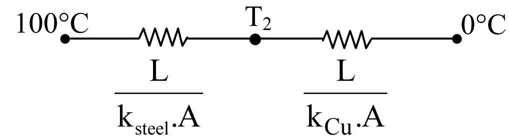
- Heat transfer through infinitesimal temperature difference is closed to reversible process.
- Free expansion and mixing of two fluids are highly irreversible.

31. Ans: (a)

Sol:



Thermal circuit:



$$\text{Heat transfer rate} = \frac{100-0}{\frac{L}{k_{steel}.A}+\frac{L}{k_{Cu}.A}}$$

$$= \frac{T_2-0}{\frac{L}{k_{Cu}.A}}$$

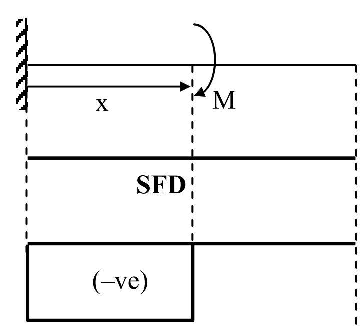
$$T_2 = \frac{100}{\frac{360}{45}+1} = \frac{100}{8+1}$$

$$T_2 = \frac{100}{9} = 11.11°C$$

32. Ans: (b)

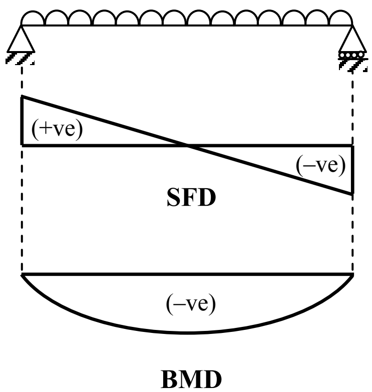
Sol:

- When a cantilever beam is subjected to a couple at a section within its span, shear force and bending moment diagram can be drawn as shown below.



Thus, statement (1) is correct.

- In a simply supported beam subjected to a uniformly distributed load over its entire span, shear force and bending moment diagram can be drawn as shown below.



As bending moment does not change its sign over its entire span, there will not be any point of contra flexure. Thus statement (2) is incorrect.

- Shear force is the first derivative of bending moment.

Shear force, $F = \frac{dM}{dx}$

(where, F = shear force

and M = Bending moment)

Thus, statement (3) is also incorrect.

33. Ans: (c)

Sol: We know that,

$$\sigma = \frac{S_{yt}}{N}$$

N = factor of safety

S_{yt} is tensile strength of material and it is constant.

$N \propto \frac{1}{\sigma}$ [where, σ = induced stress]

$N \propto \text{Area} \propto D^2$ [where, D = diameter]

If N↑ D↑ means size increases

⇒ N↑ σ↓

34. Ans: (d)

Sol: Hunting is caused by high sensitivity, Isochronism means range of speed is zero, Stability means speed fluctuates less which is opposite to sensitivity.

35. Ans: (c)

Sol: Cycle time = max {station time} = 12

$$\eta_{line} = \frac{\text{total work control}}{\text{no of stations} \times \text{cycle time}} \times 100$$

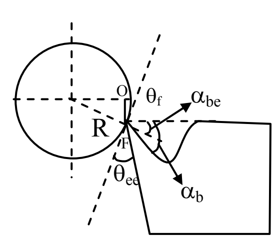
$$= \frac{9+12+8+10+7}{5 \times 12} \times 100$$

$$= \frac{46}{60} \times 100 = 76.66\%$$

Balance delay = 100–η_{line} (%) = 23.33%

36. Ans: (a)

Sol:



- As clearly seen in the figure, if the tool is set below the centre line, the effective rake angle decreases which increases the cutting force. Hence option (b) and (c) are incorrect.
- On setting the tool below the centre line, clearance angle increases which decreases the rubbing action. So, (a) is correct.

37. Ans: (c)

Sol: In addition to the machining processes to the material if the machine is also capable of handling of the material around the machine is called transfer machine. Hence, first option is incorrect.

General purpose machine (GPM): If a machine is capable of carrying out many number of operations in one machine itself it is called as General purpose machine. Hence, second option is incorrect.

Machining center: If CNC is implemented in GPM this called as machining center at general purpose CNC machine tool capable of carrying many number of operations is called as machining center. Hence third option is correct.

- If each and every axis of a machine tool is controlled by numbers or numerals is called as numerical control machine tools. Hence fourth option is incorrect.

38. Ans: (c)

Sol: Discharge (Q) = A × V

Q = 120 LPM

$$= 120\times\frac{10^{-3}\,m^3}{60\,sec} = 2\times10^{-3}\,m^3/sec$$

$$\Rightarrow\ 2\times10^{-3} = \frac{\pi}{4}D^2\times1.5$$

$$\Rightarrow\ D = 41.2\ mm$$

39. Ans: (c)

Sol: Shortest distance between two atoms in face centred cubic structure = $2R == \frac{\sqrt{2}a}{2} = \frac{a}{\sqrt{2}}$

40. Ans: (b)

Sol: $u\ \alpha\ \sqrt{H}$

i.e., $DN\ \alpha\ \sqrt{H}$ $\left(\because u = \frac{\pi DN}{60}\right)$

$Q \propto A_f V_f$

$\propto D^2\left(\sqrt{H}\right)$ $\left(\because A_f \propto D^2, V_f \propto \sqrt{H}\right)$

$\propto D^2(DN)$ $\left(\because DN \propto \sqrt{H}\right)$

$\therefore\ Q \propto D^3N$

$$\frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

$$\therefore\ Q_2 = 200\times\frac{900}{1500} = 120\text{lit/s}$$

41. Ans: (c)

Sol: $I = nB - (B_I + B_{II})$

$= 2\times 15 - (7 + 9) = 14$ kW

$$\eta_{IP} = \frac{IP(kW)\times 3600}{\dot{m}_f(kg/h)\times CV\ (kJ/kg)}$$

$$\frac{25}{100} = \frac{14\times 3600}{\dot{m}_f \times 42000}$$

$$\dot{m}_f = 4.8\,kg/hr$$

42. Ans: (c)

Sol: Local apparent time = Standard Time – 4 (Standard time longitude – longitude location)min + (Time correction) min

= 13.5 hours – 4[82.5–77.2] min – 4 min

= 13.5 – 25.2 min

= (13.5 – 0.42) hours

= 13.08 hours

= 13 hours 4 minutes 48 seconds

(minute angle is converted to degrees)

43. Ans: (c)

Sol: $T_e = 250$ K, $T_g = 400$ K, $T_o = 300$ K

$$(COP)_{max} = \frac{T_e(T_g - T_o)}{T_G(T_o - T_e)}$$

$$= \frac{250\times 100}{400\times 50} = 1.25$$

$$(COP)_{max} = \frac{\text{Refrigeration effect}}{\text{heat input in generator}(Q_g)} = 1.25$$

$$Q_g = \frac{100}{1.25} = 80\,W$$

44. Ans: (b)

Sol: Since, force passes through centre so torque of this force is zero. As torque is zero the angular momentum is constant.

45. Ans: (b)

Sol: For a Rateau staging, Optimum velocity ratio for maximum blading efficiency is given by

$$\frac{V_b}{V_1} = \frac{\cos\alpha}{2}$$

Where, V_b = blade velocity

and V_1 = absolute velocity at inlet.

46. Ans: (d)

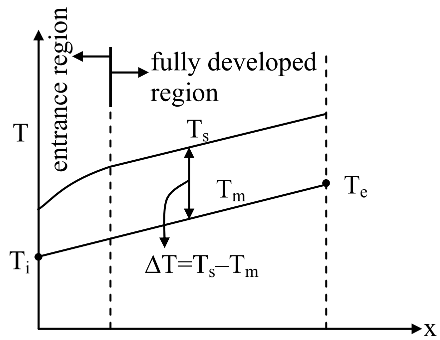
Sol: Available energy added = Maximum work attainable

$$= 500\times\left[\frac{(227+273)-(27+273)}{(227+273)}\right]$$

= 200 kJ

47. Ans: (b)

Sol: For fully developed flow, Nusselt number and heat transfer coefficient remains constant along the length of tube. As heat flux is also constant, the difference between wall temperature and bulk mean temperature of the fluid remains constant at each section.



$$\text{Nusselt No. }(Nu)=\frac{hD}{k}$$

$$60=\frac{h\times 0.1}{0.025}$$

$$\frac{60\times 0.025}{0.1}=h$$

h = 15 W/m^2.K

Heat transfer rate = hAΔT

$= 15\times\pi DL\times 50$

$= 15\times\pi\times 0.1\times 7\times 50$

$= 15\times\frac{22}{7}\times 0.1\times 7\times 50$

$= 15 \times 110$

$= 1650$ W

48. Ans: (a)

Sol:

- An element in plane stress that is oriented to the principal directions of stress has no shear stresses acting on its faces. Therefore, the shear strain for this element is zero. It follows that the normal strains in this element are the principal strains. Thus, statement (1) is true.
- Principal strains exist on perpendicular planes with the principal angles (θ_P) calculated from the equation, $\tan 2\theta_P=\frac{\gamma_{xy}}{\varepsilon_x-\varepsilon_y}$. Thus, statement (2) is false.

49. Ans: (b)

Sol: Pivot bearing support vertical shaft subjected to thrust load.

50. Ans: (a)

Sol: We know that the displacement of cycloidal (s) as a function of cam rotation angle (θ) is given by

$$s=\frac{h\theta}{\phi}-\frac{h}{2\pi}\sin\frac{2\pi\theta}{\phi}$$

$$V=\frac{dS}{dt}=\frac{h\omega}{\phi}\left(1-\cos\frac{2\pi\theta}{\phi}\right)$$

$$a=\frac{dV}{dt}=\frac{2h\pi\omega^2}{\phi^2}\sin\frac{2\pi\theta}{\phi}$$

At $\theta=0,\ \ a=0$.

51. Ans: (c)

52. Ans: (a)

Sol: Drawing stress, $\sigma_d=\sigma_y\,\ell n\left(\frac{A_0}{A_1}\right)$

$$=\sigma_y\,\ell n\left(\frac{\ell_1}{\ell_0}\right)\quad [\because A_0 l_0 = A_1 l_1]$$

$$\Rightarrow 1000 = \sigma_y \ell n\left(\frac{\ell_0 + 3\ell_0}{\ell_0}\right)$$

$\Rightarrow 1000 = \sigma_y\ ln\ (4)$

$\Rightarrow 1000 = 2\ \sigma_y\ ln\ (2)$

$$\Rightarrow \sigma_y = \frac{500}{\ell n(2)} = \frac{500}{0.693} = 721 \text{ MPa}$$

53. Ans: (d)

Sol:

- In Carburizing flame because of lower average temperature, high melting point material can not be joined. This is mostly used for joining of cast iron (high carbon steels). So, statement 1 is correct.
- In Oxidising flame, during joining brass work pieces, the excess oxygen present in flame, which combines with some quantity of zinc present in the brass and produces zinc oxide which also called as 'tennous oxide'. This floats on the weld pool and that does not allow further evaporation of zinc. So, statement 2 also correct.

54. Ans: (b)

Sol: For tolerance grade IT7, the value of tolerance is 16i, where 'i' is the standard tolerance unit.

55. Ans: (b)

Sol: Type of Actuator decides force/torque only, not work volume. Hence option (a), (c) and (d) are wrong.

56. Ans: (c)

Sol: In grey cast iron, graphite is present in flakes from. Due to the presence of graphite flakes, it possess high damping coefficient. It can resist high vibration and impact loads.

57. Ans: (c)

Sol: In order to minimize kinetic energy loss at exit the Francis turbine blades are designed in such way that at designed operating condition velocity whirl is zero at exit.

i.e., $V_{w_2} = 0$, $V_2 = V_{f_2}$ and $\alpha_2 = 90°$

58. Ans : (d)

Sol: In constant choke carburetors, area of air flow and fuel flow are constant. Air fuel ratio is changed based on the pressure difference created between the choke and Venturi.

59. Ans: (c)

Sol:

- Specific volume of refrigerants at the inlet of compressor must be small. If it is large it results in larger size of compressor. R-11 and R-113 are used in centrifugal compressor because their specific volume are very high and centrifugal compressor can handel large volume.
- Freons leak detection can be done by halide torch method. In the presence of freons, a hydrocarbon flame which is blue in colour turns bluish green.

60. Ans: (c)

Sol: At highest point velocity is perpendicular to the acceleration.

61. Ans: (a)

Sol: Condenser by lowering the back pressure at turbine exhaust

1. increases specific turbine output.
2. increases cycle efficiency.
3. reduces steam flow for given output.

62. Ans: (b)

Sol: pv = constant

$\ell np + \ell nv = \ell nc$

$$\frac{dp}{p} + \frac{dv}{v} = 0$$

$$\frac{dp}{p} = -\frac{dv}{v}$$

$$0.5 = -\frac{dv}{v} \Rightarrow \frac{dv}{v} = -0.5\%$$

63. Ans: (c)

Sol: Efficiency of the fin $(\eta) = \frac{1}{mL}$

$$\eta = \frac{1}{\sqrt{\frac{Ph}{kA_c}}.L} = \sqrt{\frac{kA_c}{Ph}} \times \frac{1}{L}$$

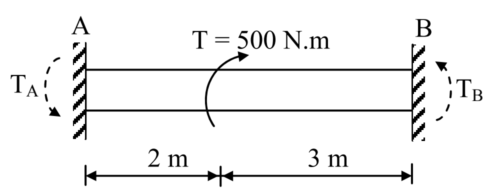
If $k \uparrow \Rightarrow \eta \uparrow$

If $h \uparrow \Rightarrow \eta \downarrow$

If $\frac{P}{A_c} \uparrow \Rightarrow \eta \downarrow$

64. Ans: (d)

Sol: When the bar is fixed at both the ends A and B and it is subjected to torque at any section in between A and B, leads to the parallel connection of shafts.



For such case, let T_A and T_B are reaction (fixing) torques.

$\theta_A = \theta_B$ and $T = T_A + T_B$

$$\therefore \frac{T_A L_A}{GJ} = \frac{T_B L_B}{GJ}$$

$\therefore$ $T_A \times 2 = (T - T_A) \times 3$

$\therefore$ $2T_A = 3T - 3T_A$

$$\therefore T_A = \frac{3T}{5} = \frac{3 \times 500}{5} = 300 \text{ N.m}$$

Also, $T_B = T - T_A = 500 - 300 = 200$ N.m

Shortcut method:

$$T_A = \frac{TL_B}{L_A + L_B} = \frac{T \times 3}{2+3} = \frac{3T}{5}$$

65. Ans: (c)

Sol: Attitude (z) = $\frac{2}{c}\left(\frac{c}{2} - h_o\right)$

c = 0.01 mm, h_0 = 0.002 mm

$$z = \frac{2}{0.01}\left(\frac{0.01}{2} - 0.002\right)$$

z = 0.6

66. Ans: (a)

Sol:

- In undercutting process, a portion of teeth below the base circle is cut off. Due to which the tip of one tooth of a gear will not contact the non-involute portion of the tooth of other gear. Hence, elimination of interference.
- Interference can be avoided by using more number of teeth. If number of teeth is increased then size of the gear will be increased which is desirable to avoid interference.
- Larger pressure angle creates smaller base circle, so that a greater portion of the tooth profile has an involute shape. In this case, the tip of the tooth of one gear will not have a chance to contact the flank of the other gear on its non-involute portion.

67. Ans: (b)

Sol:

- Flash is the excess material that flows outwards. It encourages the filling of the die cavity. So, (1) and (2) are correct.
- In closed-die forging, the volume of raw material is taken 10 to 20 % higher than the volume of the final finished products. So, (3) is incorrect.

68. Ans: (c)

Sol:

- The magnetic forces created by the electric current tend to draw the arc from its shortest line of action and make the arc flame flutter, this is known as magnetic arc blow and mainly occurs in DC arc. So, statement 1 is correct
- No filler rod is used in welding of mild steel plates using gas metal arc welding. So, statement 2 is incorrect.
- Argon is the most widely used inert gas in gas tungsten arc welding, because it requires a lower arc voltage and allows for easier arc starting and also provides a smooth arc action. So, statement 3 is correct.

69. Ans: (c)

70. Ans: (b)

Sol: Inter planar distance (d)

$$= \frac{1}{\sqrt{\left(\frac{h}{a}\right)^2 + \left(\frac{k}{b}\right)^2 + \left(\frac{\ell}{c}\right)^2}}$$

71. Ans: (a)

Sol: The coefficient of compressibility is defined as the reciprocal of the bulk modulus.

i.e., $\alpha = \frac{1}{K} = \frac{1}{-\left(\frac{dp}{dV/V}\right)} = -\frac{dV/V}{dp}$

For fluid, ρV = mass = const.

$\therefore \rho dV + Vds = 0$

Or $\frac{dV}{V} = -\frac{d\rho}{\rho}$

$$\therefore \alpha = -\frac{\left(-\frac{d\rho}{\rho}\right)}{dp}$$

$$= \frac{1}{\rho}.\frac{\partial \rho}{\partial p}$$

Note: Generally the compressibility is defined at constant temperature hence partial derivative is considered.

72. Ans: (c)

Sol: Flame ionisation detector – HC emissions

Non-dispersive infrared analyzer – CO emissions

Chemical luminescence analyzer – NO_x emissions

73. Ans: (b)

Sol: The phenomenon of surging implies unsteady, periodic and reversed flow. This instability will be severe in compressors producing high pressure ratios. It leads to physical damage of compressor due to impact loads and high frequency vibrations.

74. Ans: (b)

Sol: As the piston of the metallic cylinder containing gas is moved to compress the gas, the volume reduces, leading to increase in pressure and temperature. When the time elapses, the heat transfer occurs through metallic cylinder as metals are good conductors of heat. Thus, there is a decrease in pressure as temperature decreases.

75. Ans: (c)

Sol: Nucleate boiling is of most importance in boiling heat transfer. Film boiling is always to be avoided. Nucleate boiling involves two separate processes – the formation of bubbles (nucleation) and the subsequent growth and motion of these bubbles.

Two conditions are required to be fulfilled for bubbles to form:

1. The liquid at the heating surface must be superheated.
2. There must be dissolved gases present to form the nuclei of bubbles.

76. Ans: (a)

Sol: Given data:

$L = 50$ cm

$\theta = 0.04$ radian

For a cantilever beam subjected to uniformly distributed load over its entire length,

Slope at free end, $\theta = \dfrac{wL^3}{6EI}$

Deflection at free end, $\delta = \dfrac{wL^4}{8EI}$

where, EI = Flexural rigidity of the beam

w = Intensity of the load

Thus, $\dfrac{\delta}{\theta} = \dfrac{\frac{wL^4}{8EI}}{\frac{wL^3}{6EI}} = \dfrac{3L}{4}$

$\therefore \delta = \dfrac{3 \times 500}{4} \times 0.04 = 15 \text{ mm}$

77. Ans: (a)

Sol: Average life (L_{50}) = 5 × nominal life (L_{90})

$L_{50} = 5 \times 10 = 50$ million revolutions

(OR)

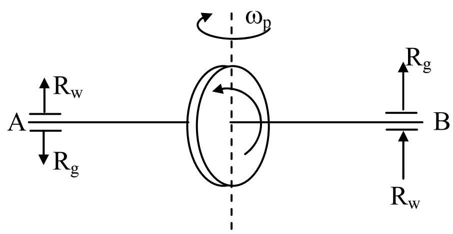
$$\frac{L_{50}}{L_{90}} = \left(\frac{\ell n\left(\frac{1}{R_{50}}\right)}{\ell n\left(\frac{1}{R_{90}}\right)} \right)^{\frac{1}{1.17}}$$

$$\frac{L_{50}}{L_{90}} = \left(\frac{\ell n\left(\frac{1}{0.5}\right)}{\ell n\left(\frac{1}{0.9}\right)}\right)^{\frac{1}{1.17}} = 5$$

$L_{50} = 5 \times L_{90} = 50$ million revolutions

78. Ans (a)

Sol:



Reaction at bearing B due to gyroscopic couple = $\frac{C}{\ell}$ (upwards)

[Where C = gyroscopic couple]

Reaction at each bearing due to weight of the disc = $\frac{mg}{2}$ (upwards)

So net reaction at B will increase

79. Ans: (c)

Sol: Perimeter, $P = 2\,(30 + 20) = 100$ mm

Thickness, $t = 3$ mm

Shear strength, $\tau_u = 150$ MPa

Blanking force, $F = P \times t \times \tau_u$

$= 100 \times 3 \times 150 = 45$ kN

80. Ans: (c)

Sol: Pelton turbine → Flow is tangential to the wheel

Francis turbine → Flow enters in radially inward direction.

Kaplan turbine → Flow enters in axial direction

Fourneyron turbine → Flow enters in radially outward direction. (Currently obsolete)

81. Ans: (c)

Sol: In a cubic system planes and directions having same indices are perpendicular to each other i.e. if [u v w] direction is perpendicular to $(h k \ell)$ plane then $h = u$, $k = v$ and $\ell = w$.

82. Ans: (d)

Sol: Blow down loss is due to the escape of exhaust gas during the power stroke. Exhaust valve is made to open before BDC for complete removal of exhaust gas. The optimum timing for minimizing the exhaust blow down loss is 40° - 70° bBDC.

83. Ans: (d)

Sol: Temperature rise occur due to ram effect.

$$\frac{T_1}{T_0} = 1 + \frac{\gamma - 1}{2} M^2$$

M = 2, γ = 1.4 , T_0 = 250 K

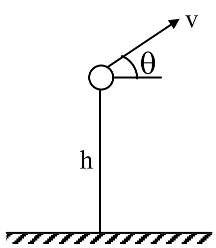
$$\frac{T_1}{250} = 1 + \frac{1.4-1}{2}\times 2^2 = 1 + 0.2 \times 4$$

T_1 = 250 × 1.8 = 450 K

T_1 = 177°C

84. Ans: (d)

Sol:



Let stone be projected from a building of height h with a speed of v at an angle θ.

By using conservation of mechanical energy between initial and final condition.

$$mgh + \frac{1}{2}mv^2 = \frac{1}{2}mv'^2 \text{ .... (i)}$$

(Where v' is the velocity with which stone hit the ground).

Thus from equation (i) it is clear that v' is independent of θ.

85. Ans: (a)

Sol: Critical buckling load is given by,

$$P_{Cr} = \frac{\pi^2 EI}{L_e^2}$$

$\therefore P_{Cr} \propto I \qquad (\because E \text{ and } L_e \text{ are constant})$

***Case: I Square section*:**

$$I = \frac{b^4}{12}$$

$$= \frac{A^2}{12} \quad (\because A = \text{Area} = b^2)$$

***Case: II Equilateral triangle section*:**

$$I = \frac{bh^3}{36}$$

$$= \frac{b^4\sqrt{3}}{96} \quad \left(\because h = \frac{\sqrt{3}}{2}b\right)$$

$$= \frac{A^2\sqrt{3}}{18} \quad \left(\because A = \frac{b^2\sqrt{3}}{4}\right)$$

Now,

$$\frac{(P_{Cr})_1}{(P_{Cr})_2} = \frac{I_1}{I_2} = \frac{A^2/12}{A^2\sqrt{3}/18} = \frac{18}{\sqrt{3}\times 12} = \frac{\sqrt{3}}{2}$$

86. Ans: (d)

Sol:

- For a given torque or power transmission capacity the size of multiplate is smaller than the single plate clutch. So multi-plate clutches are used where size is a constraint like in scooter, motor cycle etc.
- We know that, torque transmission capacity

$$T \propto \operatorname{cosec}\alpha \propto \frac{1}{\sin\alpha}$$

Where, $\alpha\uparrow$, $\sin\alpha\uparrow$ and hence $T\downarrow$

87. Ans: (b)

Sol:

- The direction of the Coriolis acceleration is obtained by rotating the radial velocity vector through 90^0 in the direction of rotation of link.
- Velocity of slider, $V_p = r\omega\left[\sin\theta + \frac{\sin 2\theta}{2n}\right]$

When crank is perpendicular to the line of stroke, then the velocity of piston = velocity of crank i.e., V_p = rω and angular velocity of connecting rod is zero.

To find the location of maximum velocity,

$$\frac{dV_p}{d\theta} = 0 \Rightarrow \frac{d}{d\theta}\left(\sin\theta + \frac{\sin 2\theta}{2n}\right) = 0$$

$$\Rightarrow \cos\theta = -n \pm \frac{\sqrt{n^2+8}}{4}$$

When n = 3, $\theta \approx 74°$ for $V_p = V_{max}$

- Dead center position occurs when crank angle is at 0° and 180°. At these position slider velocity becomes zero and as slider changes its direction so acceleration is maximum.

88. Ans: (c)

Sol: According to Modulus method, $m_R = 1.2\ m_c$

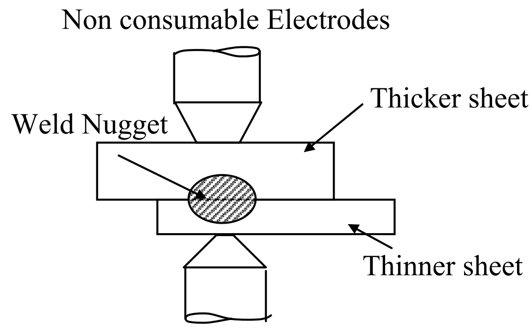
$$\frac{d}{6} = 1.2\,m_c \quad \text{(d = diameter of cylindrical riser)}$$

$$\Rightarrow d = 7.2\ m_c$$

$$\Rightarrow \frac{d}{m_c} = 7.2$$

89. Ans:(a)

Sol:



Thicker sheet has higher resistance (R) or lower conductivity (α), (α = 1/ρ), and the nugget tends to penetrate deeper into it. Therefore use bigger diameter electrode on the side of the thicker sheet. Heat balance can thus be achieved by decreasing the current density in the thicker sheet.

90. Ans: (b)

Sol: The general continuity equation for 2D flow is

$$\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial \rho}{\partial t} = 0$$

For incompressible fluid, the density is constant. Therefore irrespective of wheather flow is steady or unsteady $\frac{\partial \rho}{\partial t} = 0$ ($\because$ ρ = const.)

Thus, for steady or unsteady flow of incompressible fluid above equation reduces to $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

91. Ans: (a)

Sol: Flame speed increases with compression ratio and turbulence. Flame speed increases with slight rich mixture and it decreases after equivalence ratio 1.1.

92. Ans: (d)

Sol:

- For maximum cycle efficiency, temperature rise in each feed water heater is equal.

  Total temperature rise in n feed water heater Δt_{fw} due to regeneration for maximum cycle efficiency is given by

  $$\Delta t_{fw} = \frac{n}{n+1}\Delta t$$

  where, Δt = difference between boiler saturation temperature and condenser temperature

  If $n = 0, \ \Delta t_{fw_0} = 0$

  If $n = 1, \ \Delta t_{fw_1} = \frac{\Delta t}{2}$

  If $n = 2, \ \Delta t_{fw_2} = \frac{2}{3}\Delta t$

  If $n = 3, \ \Delta t_{fw_3} = \frac{3}{4}\Delta t$

  If $n = 4, \ \Delta t_{fw_4} = \frac{4}{5}\Delta t$

  By use of first heater, the gain is

  $$\Delta t_{fw_1} - \Delta t_{fw_0} = \frac{1}{2}\Delta t$$

  By use of second heater, the gain over first heater is

  $$\Delta t_{fw_2} - \Delta t_{fw_1} = \frac{1}{6}\Delta t$$

  By use of third heater, the gain over second heater is

  $$\Delta t_{fw_3} - \Delta t_{fw_2} = \frac{1}{12}\Delta t$$

  By use of fourth heater, the gain over second heater is

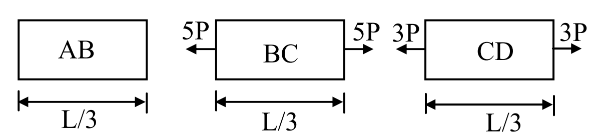
  $$\Delta t_{fw_4} - \Delta t_{fw_3} = \frac{1}{20}\Delta t$$

  We observe that with increase in number of feed water heater, gain in feed water temperature decreases.

- Since, gain in efficiency is proportional to gain in feed water temperature, the increment in efficiency with each successive heater diminishes. Thus gain in efficiency follows law of diminishing return.

93. Ans: (c)

Sol: Free body diagram of each section is shown below:



Total strain energy stored in bar decrease AD is given by,

$$U = \sum \frac{F^2 L}{2AE}$$

$$= 0 + \frac{(5P)^2(L/3)}{2AE} + \frac{(3P)^2(L/3)}{2AE}$$

$$= \frac{17P^2L}{3AE}$$

94. Ans: (a)

Sol: Cycloidal motion

$$y = \frac{h}{2\pi}\left(\frac{2\pi\theta}{\phi} - \sin\left(\frac{2\pi}{\phi}\theta\right)\right)$$

$$\dot{y}_{max} = \frac{2h\omega}{\phi}$$

Simple harmonic motion :

$$\dot{y}_{max} = \left(\frac{\pi}{2}\frac{h\omega}{\phi}\right)$$

Uniform velocity :

$$\dot{y} = \frac{h\omega}{\phi}$$

As $2 > \frac{\pi}{2} > 1$

$V_{cyclodial} > V_{SHM} > V_{UV}$

95. Ans: (d)

Sol: For Venturi meter:

$$Q_v = C_{dv}\frac{a_1a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh_v},$$

For orifice meter:

$$Q_o = C_{do}\frac{a_1a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh_o}$$

But, $Q_v = Q_o$

$$\therefore C_{dv}\sqrt{h_v} = C_{do}\sqrt{h_o}$$

$$\therefore \frac{h_v}{h_o} = \left(\frac{C_{do}}{C_{dv}}\right)^2$$

The pressure head difference (h) and the reading of manometer are related as,

$$h = x\left(\frac{\rho_m}{\rho} - 1\right)$$

$$\therefore \frac{x_v}{x_o} = \frac{h_v}{h_o} = \left(\frac{C_{do}}{C_{dv}}\right)^2 = \frac{0.65^2}{0.98^2} = 0.44$$

96. Ans: (a)

Sol: C_{pw} = 4.2 kJ/kg.K, $C_{p_a} = 1\,kJ/kg.K$,

$\dot{m}_w = 1\ kg/s$, $\dot{m}_a = 5\ kg/s$

$\dot{m}C_{p_w} = 4.2 \times 1 = 4.2$ kW/kg,

$\dot{m}_a.c_a = 5 \times 1 = 5\ kW/kg$

C_{min} = 4.2 kW/kg, C_{max} = 5 kW/kg

$$NTU = \frac{UA}{C_{min}} = \frac{200 \times 32}{4200} = 1.52$$

97. Ans: (a)

Sol: $$(COP)_{max} = \frac{(-23 + 273)}{(273 + 27) - (273 - 23)} = 5$$

Minimum power required

$$= \frac{120/60}{5} = 0.4\,kW$$

Irreversibility

= Actual power – Minimum power

= 0.5 – 0.4 = 0.1 kW

98. Ans: (b)

Sol:

- When we cut a plane through the centre of the sphere in any direction whatsoever, from the symmetry of a spherical shell we obtain the same tensile stress (σ) in the wall.

$$\text{Tesile stress}, \sigma = \frac{Pd}{4t}$$

where, P = Internal pressure,
d = Internal diameter of the sphere,
t = Thickness of the sphere

Thus, statement (1) is correct.

- For a thin cylindrical pressure vessel, subjected to internal pressure 'P',

Longitudinal stress, $\sigma_L = \frac{Pd}{4t}$

Circumferential (Hoop) stress, $\sigma_C = \frac{Pd}{2t}$

Thus, $\sigma_L = \frac{1}{2} \times \sigma_C$

Therefore, statement (2) is incorrect

- For a thin cylindrical pressure vessel,

Volume, $V = \frac{\pi}{4} D^2 L$

$$\therefore \frac{dV}{V} = 2\frac{dD}{d} + \frac{dL}{L}$$

$$\therefore \varepsilon_V = 2\varepsilon_C + \varepsilon_L$$

Thus, statement (3) is correct.

99. Ans: (d)

Sol: Given data:

n = 25, d = 10 mm,

D = 150 mm, W = 200 N

Shear stress is given by,

$$\tau = \frac{8WD}{\pi d^3} = \frac{8\times 200\times 150}{\pi\times(10)^3} = \frac{240}{\pi}\text{MPa}$$

100. Ans: (a)

101. Ans: (b)

Sol:

- Strainer is a filter for separating the impurities present in molten metal. So, (a) is incorrect.
- Splash core is used to avoid sand erosion. So, (b) is correct.
- Skim bob is used for separating heavier and lighter impurities. So, (c) is incorrect.
- Sprue well is used to reduce the turbulence caused by the flow of molten metal. So, (d) is incorrect.

102. Ans: (a)

Sol: Hall Pitch equation

$$\sigma = \sigma_0 + \frac{K}{\sqrt{d}}$$

σ = Strength of material at a grain size (d)

σ_0 and K are constant.

1. $250 = \sigma_0 + \frac{K}{\sqrt{36}}$

2. $150 = \sigma_0 + \frac{K}{\sqrt{64}}$

By solving 1 and 2 equations σ_0, K values are determined. Then strength at 49 μm

$$\sigma = \sigma_0 + \frac{K}{\sqrt{49}} = 192\,\text{MPa}$$

103. Ans: (b)

Sol: *Newtonian:* μ_a is constant $\left(\because \tau \propto \frac{du}{dy}\right)$

Pseudo plastic: μ_a decreases with respect to shear stress or shear strain rate.

Dilatant: μ_a increases with respect to shear stress or shear strain rate.

Thixotropic: μ_a increases with respect to time at constant shear stress or shear strain rate.

Rheopectic: μ_a increases with respect to time at constant shear stress or shear strain rate.

104. Ans (d)

Sol: Primary circuit consist of the battery, ignition switch, primary coil winding and breaker points.

Secondary circuit consist of Secondary coil winding, distributor, spark plug.

105. Ans: (a)

Sol:

- Compounding is done to reduce turbine speed. If entire enthalpy drop occurs in single stage, they would have very high rotational speed (N). Such high speeds cannot be properly utilised and entails large frictional losses. Centrifugal stress also becomes very large.
- In pressure compounding entire enthalpy drop does not occur in single row of nozzles but in row of nozzles at each stage. It is equally divided among the stages.
- Curtis staging is less efficient than Rateau stages because velocity of steam in Curtis staging is high. Thus frictional losses are more.

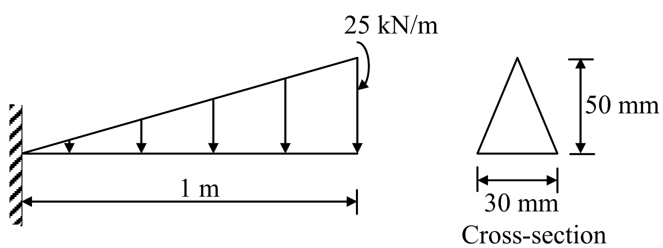
106. Ans: (b)

Sol: Given data:

b = 30 mm

h = 50 mm

L = 1 m



Maximum shear force (F_{max}) occur at the fixed end of the beam.

$$F_{max} = \frac{1}{2} \times w \times L$$

$$= \frac{1}{2} \times 25 \times 1 = 12.5 \text{ kN}$$

Maximum shear stress for a triangular cross-section is given by,

$$\tau_{max} = \frac{3}{2}\tau_{avg}$$

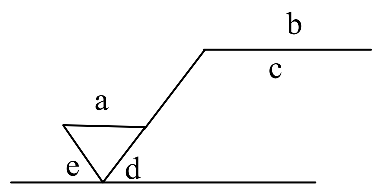
$$= \frac{3}{2} \times \frac{F_{max}}{A} = \frac{3}{2} \times \frac{12.5 \times 1000}{\frac{1}{2} \times 30 \times 50} = 25 \text{ MPa}$$

107. Ans: (d)

Sol: For very low speeds, centrifugal governors will not able to generate the required governing forces, hence inertial governors are used. Hence pickering governor, an inertial governor is used

108. Ans: (a)

Sol: *Specification of surface texture:*



a = Roughness Value (R_a) ,

b = Production method,

c = sampling length

d = Direction of lay,

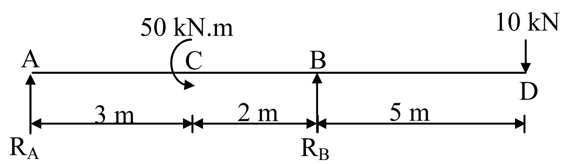
e = Machining allowance

109. Ans: (c)

Sol: Sudden closure or opening valve causes very high pressure due to water hammer effect. The primary function of surge tank is to reduce water hammer effect.

110. Ans: (a)

Sol: Free body diagram of a given beam is shown below:



The reactions are assumed to be in upward direction.

By taking moment about point A,

$(R_B \times 5) - 10 \times 10 + 50 = 0$

$\therefore \quad R_B = 10$ kN (upward)

111. Ans: (b)

Sol: The average velocity $(V = Q/A)$ remains same because discharge is same. Hence, statement (1) is wrong. As flow enters into pipe velocity near to pipe surface decreases due to no slip condition hence flow velocity must increase near to surface in order to satisfy conservation of mass. Thus, statement (2) is correct.

112. Ans: (d)

113. Ans: (a)

Sol: $P_{xyz} = R(z, 60) \times P_{u\,v\,w}$

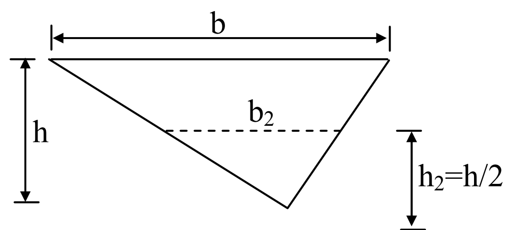
$$= \begin{bmatrix} \text{Cos}\,60° & -\text{Sin}\,60° & 0 \\ \text{Sin}\,60° & \text{Cos}\,60° & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 3 \\ 2 \end{bmatrix} = \begin{bmatrix} -0.598 \\ 4.964 \\ 2 \end{bmatrix}$$

114. Ans: (a)

Sol: Since volume is continuously increasing ($dV > 0$) so work done ($W = P.dV$) by the system continuously increases.

115. Ans: (a)

Sol:



Let F = Force on bigger triangle.

By similarity of triangles

$$\frac{b_1}{b} = \frac{h/2}{h}$$

$$b_1 = \frac{b}{2}$$

$F = P_{C.G.}A$

$$= \rho g \frac{h}{3} \times \frac{bh}{2}$$

i.e., $F = \dfrac{\rho g b h^2}{6}$ ------------(1)

$$F_2 = (P_{C.G.}A)_2 = \rho g\left(\frac{h}{2}+\frac{1}{3}\times\frac{h}{2}\right)\times\frac{1}{2}\left(b_2\times\frac{h}{2}\right)$$

$$= \rho g\left(\frac{2}{3}h\right)\times\frac{1}{2}\times\left(\frac{b}{2}\right)\times\left(\frac{h}{2}\right)$$

i.e., $F_2 = \frac{\rho g b h^2}{12}$ ---------(2)

$F_1 + F_2 = F$

$$\therefore\ F_1 = F - F_2 = \frac{\rho g b h^2}{6} - \frac{\rho g b h^2}{12} = \frac{\rho g b h^2}{12}$$

$$\therefore\ \frac{F_1}{F_2} = \frac{\left(\frac{\rho g b h^2}{12}\right)}{\left(\frac{\rho g b h^2}{12}\right)} = 1$$

116. Ans: (d)

Sol: The volumetric efficiency of a well designed SI engine is in the range of 70 % to 90%.

117. Ans: (b)

Sol: At maximum Coefficient of performance,

$$u_1 = \frac{2}{3}u_0 = \frac{2}{3}\times 12 = 8 \text{ m/s}$$

118. Ans: (b)

Sol: Adiabatic saturation temperature or thermodynamic wet bulb temperature is the temperature at which water by evaporating into air can bring the air to saturation state adiabatically at same water temperature.

119. Ans: (c)

Sol: For linear variation of velocity inside boundary layer

$$\frac{u}{U_\infty} = \frac{y}{\delta}$$

Now, $\theta = \int_0^\delta \frac{u}{U_\infty}\left(1-\frac{u}{U_\infty}\right)dy$

$$= \int_0^\delta \left(\frac{y}{\delta}-\frac{y^2}{\delta^2}\right)dy$$

$$= \left[\frac{y^2}{2\delta}-\frac{y^3}{3\delta^2}\right]_0^\delta$$

$$= \frac{\delta}{2}-\frac{\delta}{3}$$

$$= \frac{\delta}{6}$$

$$\therefore\ \frac{\delta}{\theta} = 6$$

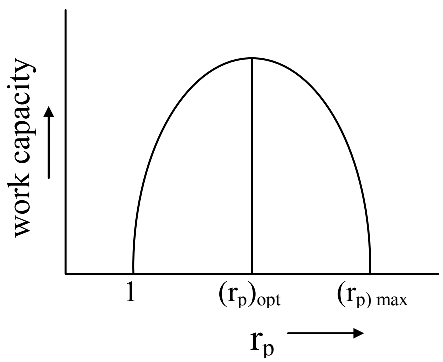
120. Ans: (b)

Sol: Efficiency of gas turbine cycle reaches Carnot efficiency when pressure ratio becomes

$$(r_p) = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{\gamma-1}}$$

Work capacity is zero when r_p is unity; becomes maximum when $(r_p)_{opt}$ = $\left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}}$, and again becomes zero when

$(r_p)_{max} = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{(\gamma-1)}}$ as shown in the figure below.



121. Ans: (d)

Sol:

- *In turbulent flow over flat plate :*

  Hydrodynamic boundary layer thickness = thermal boundary thickness

  $\therefore \delta_h = \delta_T$

  Boundary layer development does not depend on the Prandtl number in turbulent flow.

- *Prandtl number :*

$$= \frac{\text{momentum diffusivity}}{\text{thermal diffusivity}} = \frac{\nu}{\alpha}$$

122. Ans: (b)

Sol:

- Thrust produce in turbojet

$$= \dot{m}(V_{exit} - V_{inlet})$$

  $\dot{m} =$ mass flow rate of air

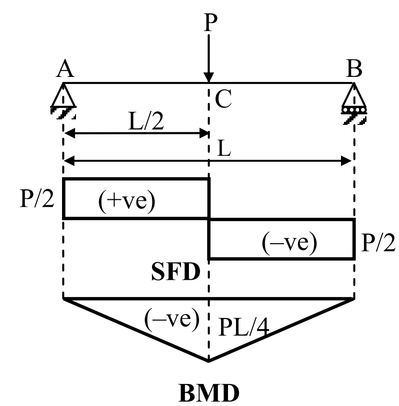
  V_{exit} = velocity of gases leaving engine.

  V_{inlet} = velocity of air entering engine

- Commercial air planes save fuel by flying at high altitude, since air at higher altitudes is of less density and exert smaller drag force on aircraft.

123. Ans: (a)

Sol: For a simply supported beam subjected to concentrated load at its mid-span:



- From above it is concluded that the bending moment varies throughout its span. Thus it is an example of non uniform bending.
- The shear force is also present on entire span of beam, which is responsible for non uniform bending as per the equation given below:

  Shear force, $F = \frac{dM}{dx}$

  Thus, both the statements are true and statement (II) is the correct explanation of statement (I).

124. Ans: (a)

Sol: In real beam at an intermediate support, there is an identical slope on both the sides of the support but deflection is zero. So, in the conjugate beam, there should be identical shear force on both the sides and also zero bending moment, which is possible in case of intermediate hinge.

Thus, both the statements are true and statement (II) is the correct explanation of statement (I).

125. Ans: (c)

Sol:

- Merchant's criteria is valid for the minimum work required in machining. So, it gives a criteria of optimum shear angle relation for minimum energy. So, statement (I) is correct.
- $2\phi + \beta - \alpha = C_m$ (Merchant's equation)

  In Merchant's equation, the machinability constant, C_m depends on the energy utilization efficiency. $C_m = 90°$ only when the efficiency is 100 %. So, statement (II) is incorrect.

126. Ans: (a)

Sol: The pressure difference across the impeller due to centrifugal force is given by,

$$P_2 - P_1 = \frac{\rho\omega^2}{2}\left(r_2^2 - r_1^2\right)$$

If air is present instead of water the centrifugal pump produces less pressure rise due to much lesser density of air. This pressure difference will not be sufficient to lift the water.

127. Ans: (a)

Sol: Dissociation is disintegration of combustion products at high temperatures. It is reverse of combustion. Dissociation effect is more pronounced in SI engine than CI engine due to heterogeneous combustion and lean air fuel mixture in CI engine which results in lowering of peak temperature.

128. Ans: (c)

Sol:

- Temperature profile with heat generation for different geometries.

  For slab, $T = -\frac{\dot{q}}{k}\frac{x^2}{2} + c_1x + c_2$

  For cylinder, $T = -\frac{\dot{q}}{k}\frac{r^2}{4} + c_2$

  For sphere, $T = -\frac{\dot{q}}{k}\frac{r^2}{6} + c_2$
- For parabolic temperature profile, thermal conductivity of material should be constant.

129. Ans: (b)

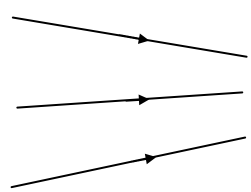
Sol: Cold cracking generally occurs at room temperature after the weld is completely cooled. This can be generally seen in the heat-affected zone. The causes are

- Excessive restraint of the joint which induces very high residual stresses.
- Martensitic transformations make the metal very hard as a result of rapid cooling.

So, statement (I and II) both are correct but statement (II) doesn't justify statement (I).

130. Ans: (c)

Sol:



For converging streamlines, the velocity gradient is non zero along the streamline.

i.e., $\frac{\partial V}{\partial s} \neq 0$

Thus, second statement is not correct.

$a_{convective} = V\frac{\partial V}{\partial s} \neq 0$ for converging flow.

Hence, statement – I is correct.

131. Ans: (a)

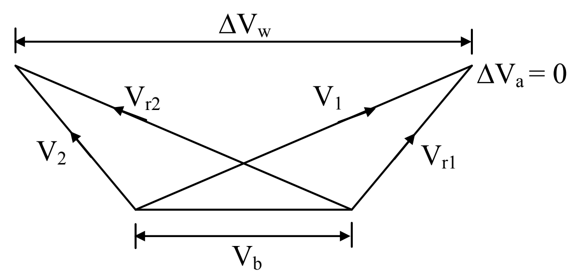
Sol: Nitriding process is a surface hardening heat treatment process. In this process, low carbon steel material is heated up to 1000°C and simultaneously, nitrogen atoms are released and penetrated in to the material. The nitrided component possess high fatigue limit and low wear rate, high corrosion resistance. These materials are used in aeroplane engine parts.

132. Ans: (d)

Sol: Effect of stress concentration can be neglected in ductile material under static loading because the effect of stress concentration is very less. The geometry near the discontinuity is rearranged due to load yielding of ductile material.

133. Ans: (b)

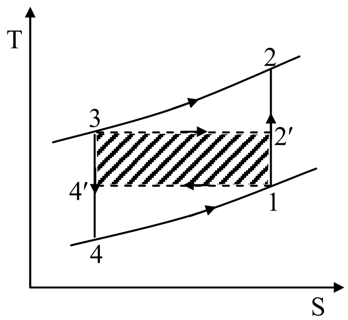
Sol: For a 50% reaction turbine the velocity diagram is shown below.



- The change in axial velocity ΔV_a in a 50% reaction turbine is zero. So the axial thrust imposed on blades due change in axial velocity is zero.
- There is considerable axial thrust produced due to pressure difference across the blades in each rotor disc, since there is a pressure drop of steam across the moving blades.

134. Ans: (d)

Sol:



1-2-3-4-1 → Reversed Brayton cycle

1-2′-3-4′-1 → Reversed Carnot cycle

$$(COP)_{carnot} = \frac{T_L}{T_H - T_L} = \frac{T_1}{T_3 - T_1} = \frac{T_1}{T_2' - T_1} \text{ ---(1)}$$

$$(COP)_{Brayton} = \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}} - 1}$$

$$= \frac{1}{\frac{T_2}{T_1} - 1} = \frac{T_1}{T_2 - T_1} \text{ ---- (2)}$$

As $T_2' - T_1 < T_2 - T_1$ (from diagram)

$(COP)_{carnot} > (COP)_{Brayton}$

- From equation (1), COP of reversed Carnot cycle depends only on rejection temperature and refrigeration temperature.

135. Ans: (b)

136. Ans: (b)

Sol:

➢ In self energizing brake, moment of friction help to apply brake. Moment of friction adds to moment of applied load.

➢ Brake should be self energizing not self locking. No external force needed to apply brake in self locking brakes, but in back stop mechanism self locking brakes are advantages.

137. Ans: (b)

Sol: x = asinωt and $v = \frac{dx}{dt} = a\omega\cos\omega t$. It is clear that phase difference between 'x' and 'v' is π/2.

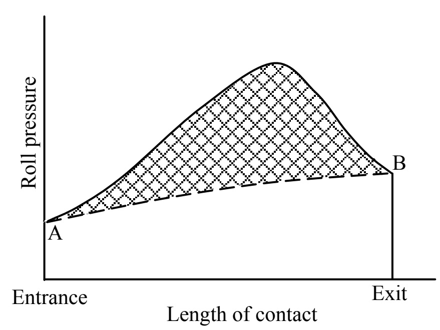
138. Ans: (b)

Sol:

- With reamer, very less amount of material is removed, so surface produced is smooth. So, statement (I) is correct.
- Right hand reamer with right hand helix is used for roughing cuts, since the tool tends to go into the workpiece more efficiently and thereby promotes the material removal. So, statement (II) is correct but doesn't justify statement (I).

139. Ans: (d)

Sol:



- Roll pressure varies inversely with slip between roller and strip. At the neutral plane, the slip becomes zero. Hence, the pressure exerted will be maximum. So, statement (I) is incorrect.
- The velocity of the strip increases in the longitudinal direction and becomes equal to the surface velocity of the roller at neutral plane. So, statement (II) is correct.

140. Ans: (d)

Sol: Statement (II) is correct definition of fanning friction factor.

i.e., $$f' = \frac{\tau_w}{\frac{1}{2}\rho V^2}$$

For laminar flow the Fanning friction factor is independent of surface roughness. $\left(\because f' = \frac{f}{4} = \frac{16}{Re}\right)$. Thus statement (I) is incorrect.

141. Ans: (c)

Sol: Variation of specific heat of working fluid is the main reason for the dip in pressure and temperature. Dissociation also causes in dip in pressure and temperature but its effect is negligible compared to the variation of specific heat.

142. Ans: (b)

Sol: In 4-stroke , 4 cylinder inline engines what ever may be the firing order primary forces are always balanced. Primary couple depends on firing order.

143. Ans: (b)

Sol:

- Pouring temperature is kept higher than the freezing temperature by 150°C to 200°C to increase the degree of superheat. So, Statement (I) is correct.
- The amount of liquid shrinkage depends on the difference between the pouring and freezing temperatures. So, statement (II) is correct but doesn't justify statement (I).

144. Ans: (c)

Sol:

- Linear momentum, $\vec{P} = m\vec{V}_{c.m}$

  $(V_{c.m} = \text{velocity of centre of mass})$

  If $V_{c.m} = 0$

  ⇒ Linear momentum is always zero.
- Suppose a particle is moving with constant velocity, then linear momentum is conserved but centre of mass is not at rest.

145. Ans: (a)

Sol: In an isenthalpic expansion process, enthalpy remains constant. If it is used in air refrigeration cycle, we know that air is an ideal gas.

For ideal gas, $\Delta h = f(T)$

Δh remains constant for isenthalpic process so that the temperature also. So we will not get any refrigeration effect by using isenthalpic expansion in air refrigeration cycle.

146. Ans: (d)

Sol: Incineration of Biomass is complete combustion of Biomass which produces energy and High ash content.

147. Ans: (a)

148. Ans: (b)

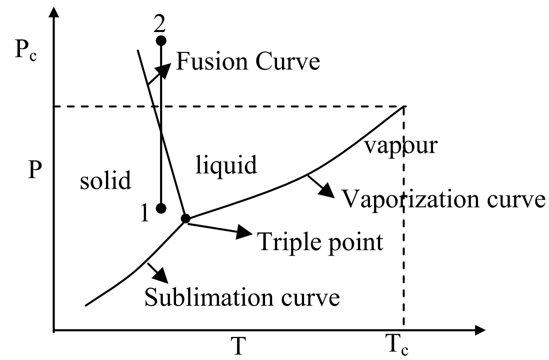
149. Ans: (c)

Sol:

- Caustic soda is used in absorbing carbon dioxide.
- Pyrogalic acid is used in absorbing Carbon dioxide.
- Cuprous chloride is used in absorbing carbon monoxide which reacts reversibly to form carbonyl cuprous chloride solution.

150. Ans: (a)

Sol:



P-T diagram shows that as pressure increases melting point increases. Therefore, ice melts due to pressure rise cause by skate. Solid –solid contact is converted into solid-liquid contact where friction is comparatively less.