ESE- 2019 (Prelims) - Offline Test Series Test – 22

MECHANICAL ENGINEERING

MOCK TEST – 1 (PAPER – II) — SOLUTIONS

01. Ans: (c)

Sol: The efficiency of the pump is

$$\eta_{pump} = \frac{\gamma Q H_m}{P_{in}}$$

$$= \frac{10^4 \times 250 \times 10^{-3}(2.5+125)}{435 \times 10^3}$$

$= 0.733$

02. Ans: (a)

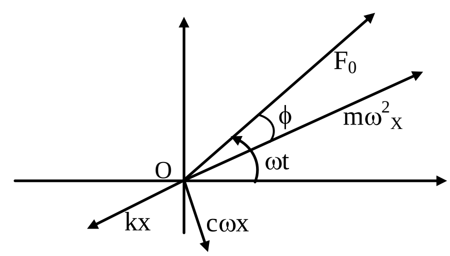
Sol: For unsteady state heat conduction problems, thermal time constant $\left(\frac{\rho c v}{Ah}\right)$ physically signifies the time rate at which the body adopts to a thermal change. Small thermal time constant $\left(\frac{\rho c v}{Ah}\right)$ physically signifies that the temperature of solid will change fast due to a thermal change (i.e. quick response).

03. Ans: (a)

Sol: The output of solar cell is of the order of 1 W.

04. Ans: (a)

Sol:



From the diagram acceleration vector ($m\omega^2x$) leads displacement vector (kx) by π.

05. Ans: (b)

Sol: Friction circle radius is given by:

$x = \mu R$

$$\mu = f\left(\frac{ZN}{P}, \frac{D}{C}, \frac{L}{D}\right)$$

$$x \propto \frac{ZN}{P}, \frac{D}{C}, \frac{L}{D}$$

$\frac{ZN}{P} \rightarrow$ Bearing characteristic number

$N \uparrow \rightarrow x\uparrow$

$P \uparrow \rightarrow \text{Load} \uparrow \rightarrow x \downarrow$

$Z \rightarrow$ viscosity of lubricants

06. Ans: (d)

Sol: The main functions of master production schedule are

- Translate aggegate plans in to specific end items.
- Evaluate alternative schedules.
- Generate material requirement.
- Generate capacity requirement.
- Effective utilization of capacity.

07. Ans: (b)

08. Ans: (b)

Sol:

- *Spheroidizing — Improving Machinability* Steels that contain a large concentration of Fe_3C have poor machining characteristics. It is possible to transform the morphology of Fe_3C using spheroidizing.

09. Ans: (b)

Sol: **Bottom gates:** In the case of bottom gates, usually favoured for large-sized casting, especially those of steel, *molten metal flows down the bottom of the mould cavity in the drag* and enters at the base of the casting.

These are used to keep the turbulence of metal at a minimum while pouring and to prevent mould erosion. Metal is allowed to rise gently in the mould but the filling takes place against gravity. So net head decreases while filling, so time required to fill is more.

10. Ans: (a)

11. Ans: (c)

Sol: Time taken for both the cases = $\sqrt{\frac{2H}{g}}$

where, H is the height of the place above ground.

12. Ans: (a)

Sol: The concept of continuum losses validity when the mean free path of molecules approaches the order of magnitude of the dimensions of the vessel, as, for instance, in high rarefied gases encountered in high vacuum technology, in rocket flights at high altitudes and in electron tubes.

13. Ans: (b)

Sol: In two stroke cycle SI engine :

- Turning moment is more uniform. Hence, lighter fly wheel is needed.
- Due to one power stroke per revolution high cooling requirement and lubrication as well.
- Low volumetric efficiency due to less time for induction.

In ships two stroke cycle SI engine is used due to low weight and compactness.

14. Ans: (a)

Sol: R 152a = $C_2H_4F_2$

There is no chlorine atom in R 152a. Therefore, it has zero ozone depletion potential.

R 600a = Iso-butane (C_4H_{10})

It is a type of hydro Carbon (HCs) refrigerant.

15. Ans: (b)

Sol: Propulsive efficiency, $\eta_e = \frac{2V_a}{(V_j + V_a)}$

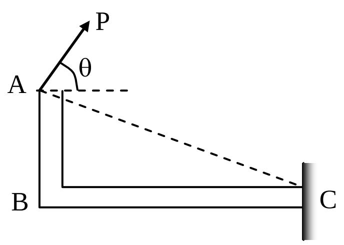
When $V_j = V_a$, $\eta_e = 1$

Thrust power, $T_p = m_a(V_j - V_a)V_a = 0$

(when $V_j = V_a$)

16. Ans: (d)

Sol:



For maximum moment at point 'C' the line of action of 'P' should be perpendicular to AC.

$$\tan\theta = \frac{BC}{AB} = \frac{0.4}{0.3}$$

$$\Rightarrow \theta = \tan^{-1}\left(\frac{4}{3}\right) = 53°$$

17. Ans: (d)

Sol: Euler's equation of turbo machine is given by:

$$H_e = \frac{1}{g}\left(u_1V_{W1} - u_2V_{w2}\right) \quad \text{(for turbine)}$$

$$= \frac{1}{g}\left(u_2V_{W2} - u_1V_{w1}\right) \quad \text{(for pump)}$$

Thus, it is the relation between head and velocities.

18. Ans: (d)

Sol: For steady state one-dimensional heat conduction through the composite wall without generation of thermal energy within the wall, the rate of heat transfer is given by

$$Q = \frac{T_1 - T_2}{\frac{L_1}{k_1A} + \frac{L_2}{k_2A} + \frac{L_3}{k_2A}}$$

Substituting the respective values, we get

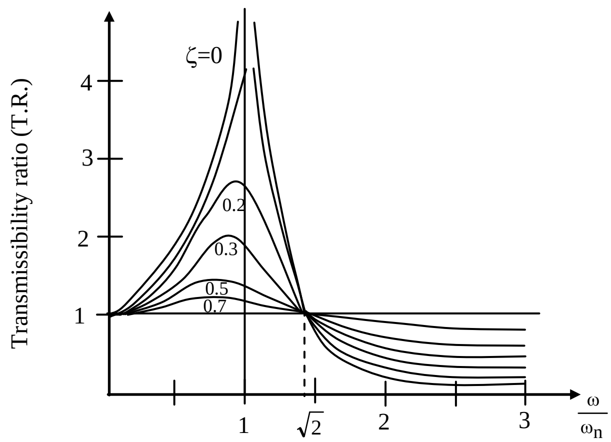
$$Q = \frac{(1840 - 340)\times 2}{\frac{0.3}{0.6} + \frac{0.2}{0.4} + \frac{0.1}{0.1}} = 1500\,W$$

19. Ans: (a)

Sol: Electrical energy is produced in fuel cells by the reaction of hydrogen with oxygen.

20. Ans: (c)

Sol:



Transmissibility versus frequency ratio for different values of ζ

At $\frac{\omega}{\omega_n} < \sqrt{2}$, TR > 1, i.e., the transmitted force is always more than the exciting force.

- TR decreases when $\frac{\omega}{\omega_n}$ increases
- TR decreases when ξ increases

When $\frac{\omega}{\omega_n} > \sqrt{2}$, TR < 1, i.e., the transmitted is always less than the exciting force.

- TR decreases when $\frac{\omega}{\omega_n}$ increases
- TR increases when ξ increases

21. Ans: (b)

Sol: P_{max} = 60 kN, P_{min} = 20 kN,

A = 1000 mm^2

$$P_{mean} = \frac{60+20}{2} = 40 \text{ kN}$$

$$P_{variable} = \frac{60-20}{2} = 20 \text{ kN}$$

According to Soderberg principle,

$$\frac{P_{mean}}{A \times S_{yt}} + \frac{P_{variable}}{A \times S_e} = \frac{1}{N}$$

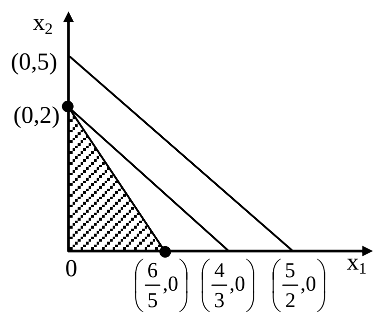
S_{yt} = 100 MPa, S_e = 80 MPa

$$\frac{40000}{1000 \times 100} + \frac{20000}{1000 \times 80} = \frac{1}{F.S}$$

F.S = 1.54

22. Ans: (d)

Sol:



$Z_{max} = 2x_1 + 5x_2$

$Z_{(0,0)} = 0$

$Z_{(0,2)} = 2(0) + 5(2) = 10$

$Z_{(6/5,\,0)} = 2\left(\frac{6}{5}\right) + 5(0) = \frac{12}{5}$

$x_1 = 0$, $x_2 = 2$

$Z_{max} = 10$

Unique optimal solution + One of the basic variable has zero value is called degenerate solutions.

23. Ans: (a)

24. Ans: (d)

Sol:

- Both charpy and *Izod impact* testing are popular methods of determining *impact strength* or toughness.
- The *larson miller parameter* describes the equivalence of time at a temperature steel under the thermally activated *creep* process of stress rupture.
- The *rockwell test* is designed as method of *hardness* testing for rapid comparative analysis.
- A universal testing machine (UTM) is used to test the tensile strength and *compressive strength*.

25. Ans: (b)

Sol: Feed (f) = 0.2 mm/rev,

Rake angle (γ) = 10°

Principal cutting edge angle (ϕ) = 30°,

Chip thickness (t_2) = 0.4 mm

Uncut chip thickness

$(t_1) = f \sin\phi = 0.2\times\sin30°$

$t_1 = 0.2\times0.5 = 0.1$ mm

Chip reduction coefficient (k) = $\frac{t_2}{t_1}$

Chip reduction coefficient (k) = $\frac{0.4}{0.1} = 4$

26. Ans: (c)

27. Ans: (d)

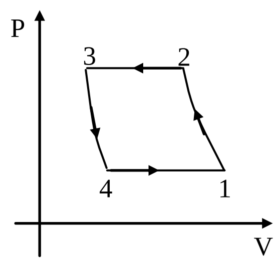
Sol: Friction, turbulence and electrical resistance are internal irreversibility.

28. Ans: (a)

Sol: Surface ignition may lead to knocking but it is not a definite cause.

29. Ans: (d)

Sol: Bell Coleman cycle:



1-2 $\Rightarrow$ Compression process (Compressor work)

3-4 $\Rightarrow$ Expansion process (Turbine work)

For same exponent 'n':

$(W)_{compressor} > (W)_{turbine}$ [where, W = work]

Volumetric efficiency:

$$\eta_v = 1 + c - c\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}$$

If $P_1 \uparrow \Rightarrow \left(\frac{P_2}{P_1}\right)\downarrow \Rightarrow \eta_v \uparrow$

30. Ans: (c)

Sol: $\eta = 1 - \frac{T_{min}}{T_{max}} (r_p)^{\frac{\gamma-1}{\gamma}} = 1 - (r_p)^{\frac{\gamma-1}{\gamma}}$

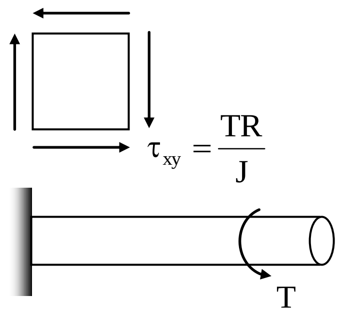
$\Rightarrow 0.4 = 1 - \left(\frac{300}{1000}\right)(r_p)^{\frac{1.5-1}{1.5}}$

$\Rightarrow 0.6 = \left(\frac{3}{10}\right)(r_p)^{\frac{1}{3}}$

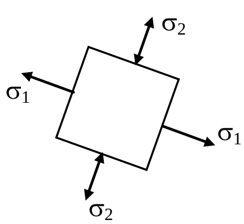
$\Rightarrow r_p = 8$

31. Ans: (c)

Sol: The stresses on critical element (all element on outer surface) are as shown in the figure.



When same stresses are transformed into principal stresses, the



$\sigma_1 = \tau_{xy} = \frac{TR}{J}$

$\sigma_2 = -\tau_{xy} = \frac{-TR}{J}$

The cast iron is a brittle material. Hence, it is weak in tension. Therefore it will fail along plane on which tensile stress is maximum. i.e. (σ_1)

32. Ans: (a)

Sol: $Re_x = \frac{U_\infty x}{\nu} = \frac{1\times1}{2.5\times10^{-5}} = 4\times10^4$

$\Rightarrow$ Flow is laminar

$\frac{y Re_x^{0.5}}{x} = \frac{1\times10^{-3}(4\times10^4)^{0.5}}{1}$

$= 10^{-3}\times2\times10^2 = 0.2$

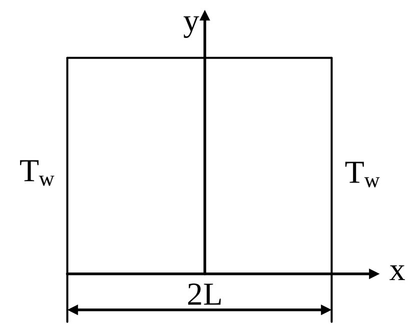
From table, we get $\frac{u}{U_\infty} = 0.067$

corresponding to $\frac{y Re_x^{0.5}}{x} = 0.2$

Thus, u at 1 mm from the surface = 0.067 m/s.

33. Ans: (b)

Sol:



Governing differential equation for one-dimensional steady state heat conduction across the thickness of the wall is given by

$$\frac{d^2T}{dx^2} + \frac{Q''}{k} = 0$$

Integrating with respect to x, we get

$$\frac{dT}{dx} = -\frac{Q''x}{k} + C_1$$

$$T = -\frac{Q''x^2}{2k} + C_1 x + C_2$$

where C_1 and C_2 are arbitrary, independent constants of integration.

The boundary conditions are:

At x = 0, $\frac{dT}{dx} = 0$ and at x = ± L, $T = T_w$

Applying the boundary conditions, the constants of integration are evaluated as

$$C_1 = 0 \text{ and } C_2 = T_w + \frac{Q''L^2}{2k}$$

Therefore, the temperature distribution is

$$T = T_w + \frac{Q''}{2k}\left(L^2 - x^2\right)$$

The temperature at the mid-plane (x = 0) of the wall is $T_o = T_w + \frac{Q''L^2}{2k}$

34. Ans: (b)

Sol: Two pool tidal system is less dependent on tidal fluctuations.

35. Ans: (d)

Sol: Proell governor is a weight governor.

36. Ans: (b)

Sol:

- Maximum distortion energy theory of failure is suitable to predict the failure of ductile materials.
- Under hydrostatic stress condition, all faces of stress element are subjected to same compressive stress. Under this condition shear stress and distortion become zero.
- Under uniaxial state of stress all the theories of failure converge to same factor of safety value.

37. Ans: (d)

Sol: At EOQ

Carrying cost / year = ordering cost / year

Total inventory cost per annum = carrying cost / year + ordering cost / year

$= 2 \times$ ordering cost /year

$$= 2 \times \frac{10000}{2000} \times 500 = 5000$$

38. Ans: (d)

Sol: A space lattice can be defined as a three dimensional array of points, each of which has identical surroundings.

39. Ans: (c)

Sol: Welding processes with power density in ascending order are shown in below figure.

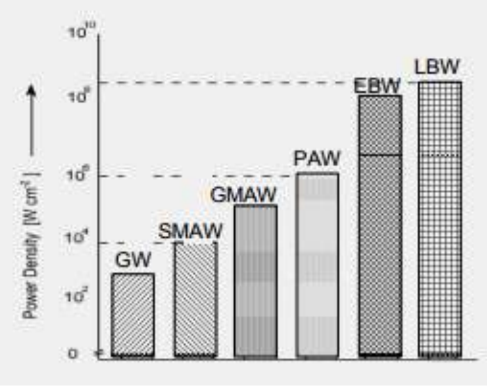


Fig: Power densities of different welding processes

Note: Use of high power density offers many advantages such as deep penetration, high welding speed and improved quality of welding joints.

40. Ans: (a)

41. Ans: (a)

Sol:

- The particles on the surface will have linear acceleration as linear acceleration = $r\alpha$, where r is distance from axis of rotation and α is angular acceleration.
- The particles on the diameter do not have any linear acceleration as r is zero
- Angular speed is same for all the particles.
- Linear speed, $v = r\omega$, where ω is angular velocity. Since, r is different for particles laying on surface.

$\therefore$ All the particles lying on the surface does not have same linear speed.

42. Ans: (b)

Sol: Availability is maximum theoretical work which is lost in irreversibilities. It can be positive or zero.

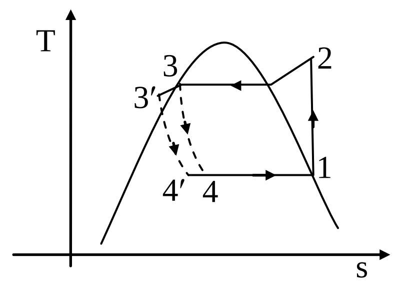
Gibbs function G = H – TS. Useful in chemical reactions.

43. Ans: (a)

Sol: Rhodium is the catalyst to reduce NO_x emission.

44. Ans: (d)

Sol:



COP of V-C cycle can be enhanced by:

1. Increasing evaporator pressure.
2. Decreasing condenser pressure.
3. Sub-cooling of liquid refrigerant etc.

45. Ans: (d)

Sol: In boot strap system two compressors and two heat exchangers are used.

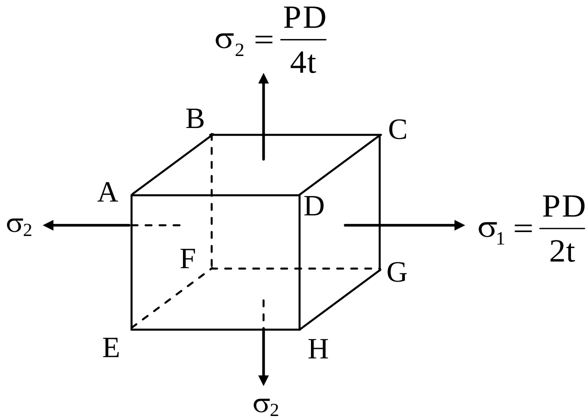
46. Ans: (a)

Sol: Backward curved blades give better efficiency compared to radial and forward curved blades.

Forward curved blades have efficiency lower than those of radial and backward blades.

47. Ans: (b)

Sol:



The principle stresses for the thin walled pressure vessels are

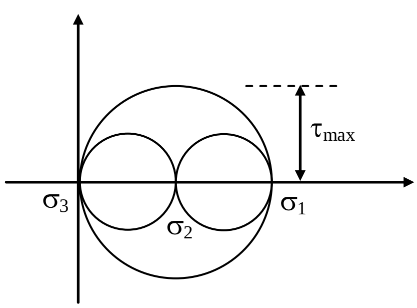
$\sigma_1 = \frac{PD}{2t}$, $\sigma_2 = \frac{PD}{4t}$ and $\sigma_3 = 0$

$$\tau_{max} = \text{max of } \left\{\left|\frac{\sigma_1-\sigma_2}{2}\right|, \left|\frac{\sigma_2-\sigma_3}{2}\right|, \left|\frac{\sigma_3-\sigma_1}{2}\right|\right\}$$

$$= \text{max of } \left\{\left|\frac{\sigma_1-\sigma_2}{2}\right|, \left|\frac{\sigma_2}{2}\right|, \left|\frac{\sigma_1}{2}\right|\right\}$$

$$= \text{max of } \left\{\frac{PD}{8t}, \frac{PD}{8t}, \frac{PD}{4t}\right\}$$

$$= \frac{PD}{4t}$$



Note: Maximum in plane shear stress is $\frac{PD}{8t}$ which occurs along plane ABGH or CDEF but maximum out of plane shear stress is $\frac{PD}{4t}$ which occurs along plane ACGE or BDHF. Hence, maximum over shear stress is $\frac{PD}{4t}$

48. Ans: (a)

Sol: Outside dia of one smaller pipe

$= 2.5 + 0.5 = 3$ cm

Hence, $Q = \frac{\pi}{4}\left[0.08^2 - 3\times 0.03^2\right]\times 10$

$$= \frac{\pi}{4}\left[0.0064 - 3\times 0.0009\right]\times 10$$

$$= \frac{\pi}{4}\left[0.0064 - 0.0027\right]\times 10$$

$$= \frac{\pi}{4}\left[0.0037\right]\times 10$$

$$= \frac{\pi\times 0.037}{4}$$

$= \pi \times 0.00925$ m^3/s $= 9.25\pi$ lit/s

49. Ans: (b)

Sol: It is known that:

$(a_s)_{max} = \left(\frac{A}{A_s}\right)\omega^2 r$, and

$(a_d)_{max} = \left(\frac{A}{A_d}\right)\omega^2 r$

Thus, the ratio

$$\frac{(a_s)_{max}}{(a_d)_{max}} = \left(\frac{A}{A_s}\right)\omega^2 r \times \left(\frac{A_d}{A}\right)\times\frac{1}{\omega^2 r} = \frac{A_d}{A_s}$$

$$= \left(\frac{20}{15}\right)^2 = \left(\frac{4}{3}\right)^2 = \frac{16}{9} = 1.78$$

50. Ans: (d)

Sol: For laminar flow:

Hydrodynamic boundary layer thickness

$$(\delta) = \frac{5x}{\sqrt{Re_x}} \text{ .... (1)}$$

$$\frac{\delta}{\delta_t} = (Pr)^{1/3}$$

From equation (1)

$$\frac{5x}{\sqrt{Re_x}} = \delta_t.(Pr)^{1/3}$$

$$\frac{\delta_t}{x} = 5(Re_x)^{-1/2}(Pr)^{-1/3}$$

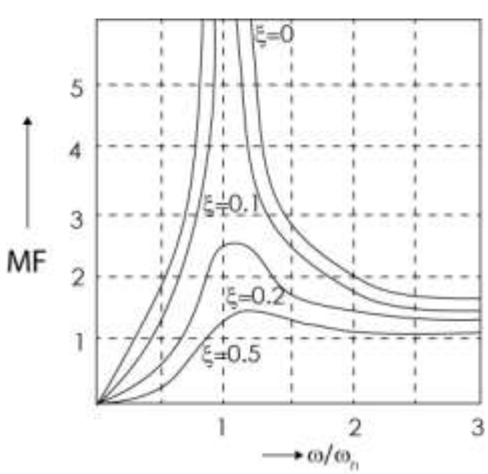
$$\frac{\delta_t}{x} \propto (Re_x)^{-1/2}(Pr)^{-1/3}$$

51. Ans: (a)

Sol: Bio-diesel is made by combining alcohol with vegetable oil, animal fat or recycled cooking grease.

52. Ans: (b)

Sol:



$$MF = \frac{MX}{me} = \frac{r^2}{\sqrt{(1-r^2)^2 + (2\xi r)^2}}$$

$$= \frac{1}{\sqrt{\left[\left(\frac{1}{r^2}\right)-1\right]^2 + \left(\frac{2\xi}{r}\right)^2}}$$

where, $r = \frac{\omega}{\omega_n}$

As $r \to 0$, $\frac{MX}{me} \to 0$ for all values of ξ

As $r = 1$, $\frac{MX}{me} = \frac{1}{2\xi}$

As $r \to \infty$, $\frac{MX}{me} \to 1$ for all the values of ξ

where, M = Total mass of machine

m = unbalanced mass

e = eccentricity

X = Amplitude of steady state response

53. Ans: (c)

Sol: From linear momentum equation, the force required to hold the plate stationary is,

$$F = \rho A_j V_{jet}^2$$

The average pressure on the plate

$$P_{avg} = \frac{F}{A_{plate}} = \frac{\rho A_j V_{jet}^2}{A_{plate}} \text{ ------(1)}$$

The dynamic pressure of the jet is given as:

$$P_{dynamic} = \frac{1}{2}\rho V_{jet}^2 \text{ --------------- (2)}$$

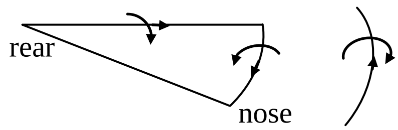
Thus, the required ratio is

$$\frac{P_{avg}}{P_{dynamic}} = \frac{\rho A_j V_{jet}^2}{A_{plate} \times \frac{1}{2}\rho V_{jet}^2}$$

$$= \frac{2A_j}{A_{plate}} = \frac{2\times A_j}{20A_j} = \frac{1}{10}$$

54. Ans: (a)

Sol:



Gyroscopic couple is in clockwise direction when viewed from the front.

So it tends to raise the tail and depress the nose.

55. Ans: (a)

56. Ans: (b)

Sol: Decreasing centre distance decreases pressure angle which increases the chances of interference.

57. Ans: (c)

Sol: In Watt governor

$$h \propto \frac{1}{N^2}$$

At large speed, variation in h becomes small.

In Porter governor

$$h_1 = \frac{g}{\omega_1}\left(1+\frac{M}{m}\right) \quad \text{and} \quad h_2 = \frac{g}{\omega_2}\left(1+\frac{M}{m}\right)$$

If $\omega_1 = \omega_2$ then $h_1 = h_2$ hence two positions of ball at same speed is not possible.

58. Ans: (a)

Sol: $\frac{T_1}{T_2} = 3$,

$P_{max} = 0.2$ MPa,

$P = 40$ kW

$v = 20$ m/s,

$D = 1000$ mm

$(T_1 - T_2)v = 40000$

$T_1 - T_2 = 2000$ .... (a)

$\frac{T_1}{T_2} = 3$

From equation (a)

$T_2 = 1000$ N,

$T_1 = 3000$ N

$$P_{max} = \frac{T_{max}}{R.W} = \frac{T_1}{R.W}$$

$$W = \frac{3000}{500\times 0.2} = 30 \text{ mm}$$

59. Ans: (a)

Sol: New forecast = Forecast + α (forecast error)

Prediction = Forecast

$\Rightarrow F_{feb} = 200$; $D_{feb} = 235$

$F_{t+1} = F_t + \alpha\,(D_t - F_t)$

$F_{mar} = F_{feb} + \alpha\,(D_{feb} - F_{feb})$

$= 200 + 0.4\,(235 - 200) = 214$

60. Ans: (d)

Sol: $Z = C_1x_1 + C_2x_2$

$C_2x_2 = -C_1x_1 + z$

$$\therefore\ x_2 = \left(\frac{-C_1}{C_2}\right)x_1 + z \Rightarrow x_2 = mx_1 + z$$

$$\therefore \text{ Slope, } m = \frac{-C_1}{C_2}$$

Here $C_1 = 3$, $C_2 = 2$

Because given that yarn A is taken on Y-axis, and yarn B taken on X-axis

$$\therefore \qquad m = -\frac{3}{2}$$

The slope of objective function signifies that the decrease of 3 units in A will cause to increase of 2 units in B.

61. Ans: (c)

Sol: On BCC (100) plane number of atoms

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

$$\text{Area} = a \times a = a^2$$

$$\therefore \text{Planar density} = \frac{1}{a^2}$$

62. Ans: (a)

Sol: Conditions of generation of *continuous chips*:

(i) Ductile material

(ii) High cutting speed

(iii) Large rake angle

(iv) Small depth of cut

(v) Small feed rate

(vi) Sharp cutting edge

(vii) Efficient cutting fluid

(viii) Low coefficient of friction at the tool-chip interface

(ix) Polished face of the cutting tool.

Continuous of generation of *continuous chips with built up edge:*

(i) Ductile material

(ii) Coarse feed

(iii) Small rake angle

(iv) Low cutting speed

(v) Dull cutting edge

(vi) Insufficient cutting fluid

(vii) High friction at tool surface interface

Conditions favoring *discontinuous chip formation*:

(i) Brittle and Non-ductile work material such as cast iron, brass, casting etc.

(ii) Small or Negative rake angle

(iii) Low cutting speed

(iv) Dry cutting

(v) Large chip thickness

63. Ans: (b)

Sol: Piston velocity $= \dfrac{Q_{in}}{A_c} = \dfrac{96 \times 10^{-3}}{\frac{\pi}{4}(0.04)^2}$

$$= \frac{1.6 \times 10^{-3}}{\frac{\pi}{4}(0.04)^2} = 1.273 \text{ m/sec}$$

64. Ans: (c)

Sol: By work energy theorem,

Work done by all the forces = Change in kinetic energy

Work done by gravity + work done by friction force of tube = ΔK.E

$0.1\times10\times0.2 + (W.D)_f = 0-\frac{1}{2}\times0.1\times5^2$

$\Rightarrow (W.D)_f = -1.45$ J

65. Ans: (a)

Sol: $\oint\frac{\delta Q}{T}=0$ for Reversible cycle

$\oint\frac{\delta Q}{T}<0$ for Irreversible cycle

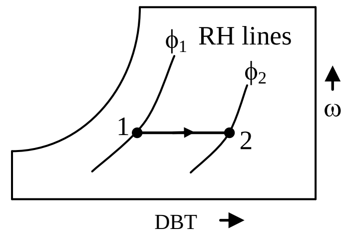
66. Ans: (b)

Sol:

- Engine size has no effect on flame speed in SI engine.
- As large engines have longer stroke length, engine speed will be less.
- Small engines have shorter stroke length, engine speed will be high.
- In both cases piston speed remains constant hence no effect on flame speed.

67. Ans: (d)

Sol: Heating of air in closed chamber is the process of sensible heating.



Process 1-2 ⇒ Sensible heating

$\phi_1 > \phi_2$ (Relative humidity decreases)

- In desert cooler the process which takes place is evaporative cooling.

68. Ans: (a)

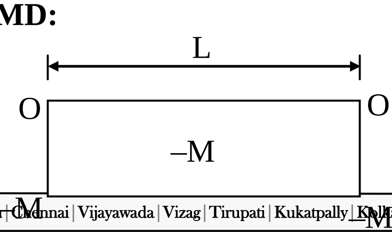
Sol:

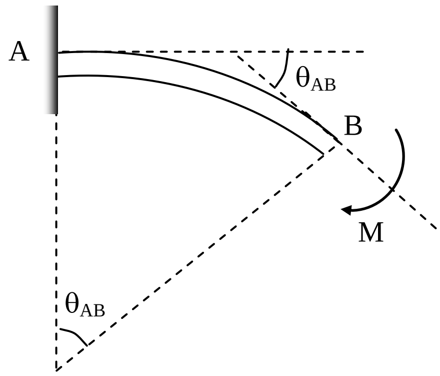
- It occupies smaller length compared to axial flow compressor.
- It operates efficiently over a wide range of mass flow rate at any particular rotational speed.
- It is not liable to loss of performance by built up deposit on surface of air channels.
- It can work reasonably well in contaminated atmosphere compared to an axial flow compressor.

69. Ans: (a)

Sol:

BMD:





By moment area method

$$\theta_{AB} = (\text{Area of moment diagram}) \times \frac{1}{EI}$$

$$= -\frac{ML}{EI}$$

$$|\theta_{AB}| = \frac{ML}{EI}$$

70. Ans: (c)

Sol: Power input, $P_1 = T_1\omega_1 = 50\times250$ W

Power output, $P_2 = T_2\omega_2 = 110\times95$ W

Efficiency of torque converter, $\eta_{TC} = \frac{P_2}{P_1}$

$$\eta_{TC} = \frac{110\times95}{50\times250} = \frac{11\times19}{250}$$

$$= 0.836 \approx 84\%$$

71. Ans: (d)

Sol: The effectiveness of fin with negligible heat loss from the tip is given by

$$\varepsilon = \sqrt{\frac{Pk}{hA}}\tanh mL$$

It can be concluded that in order to increase the fin effectiveness:

1. Thermal conductivity of fin material should be large.
2. The ratio of fin perimeter to the cross-sectional area should be increased. That means the thin and short fins should be used.
3. Fins should be used on the side where heat transfer coefficient is small.

72. Ans: (b)

Sol: Mass to be balanced at crank pin,

$m = 0.6 \times 50 + 30 = 60$ kg

$m_c r_c = mr$

$m_c \times 360 = 60 \times 150$

$\Rightarrow m_c = 25$ kg

73. Ans: (a)

Sol: In multi plate clutch, as number of contacting surface increases, the torque transmitting capacity also increases. So, for a given torque capacity, the size of multi plate clutch is smaller than that of single plate clutch resulting in compact construction that is suitable for two wheelers. In multi-plate clutches heat dissipation is a serious problem.

74. Ans: (c)

Sol: M = Poisson Arrivals

M = Exponential service time

c = Servers in parallel

75. Ans: (b)

Sol:

- If we refer to below figure, we find that atoms touch along the edge of the cube in an *SC* structure. The corner atoms are centered on the corners of the cube, so:

  $a_0 = 2r$

- In a *BCC structure*, atoms touch along the body diagonal, which is $\sqrt{3}\,a_0$ in length. There are two atomic radii from the center atom and one atomic radius from each of the corner atoms on the body diagonal, so

  $$a_0 = \frac{4r}{\sqrt{3}}$$

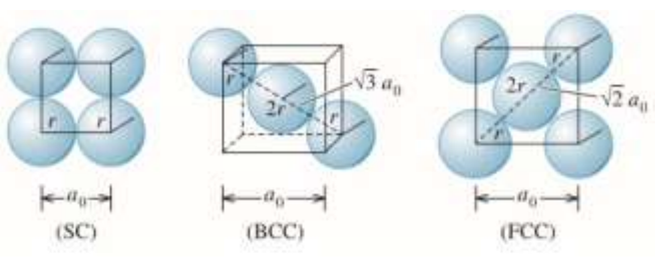


Fig: *The relationships between the atomic radius and the lattice parameter in cubic systems*

- In an *FCC structure*, atoms touch along the face diagonal of the cube, which is $\sqrt{2}\,a_0$ in length. There are four atomic radii along these length two radii from the face-cantered atom and one radius from each corner, so $a_0 = \frac{4r}{\sqrt{2}}$

76. Ans: (b)

Sol: The long parallel T-slots, Vee and inverted Vee type guide ways are machined in planing machines.

77. Ans: (c)

Sol: F(vs) x relationship is :

$$F = mx'' + Bx' + kx$$

Or, $F(s) = ms^2 \times (s) + Bs \times (s) + kx(s)$

$$F(s) = x(s)[ms^2 + Bs + k]$$

For same force, if m, B, k double, output (x) becomes half.

78. Ans: (d)

Sol: Suppose after the collision the block of mass 5 kg moves at a velocity u_1 and the block of mass 10 kg moves at a velocity u_2.

By conservation of linear momentum,

$$5\times10 = 5u_1 + 10u_2 \text{..........(i)}$$

$$e = \frac{1}{2} = \frac{u_2 - u_1}{10} \text{..............(ii)}$$

From (i) and (ii)

$\Rightarrow\ u_1 = 0$

79. Ans: (a)

Sol:

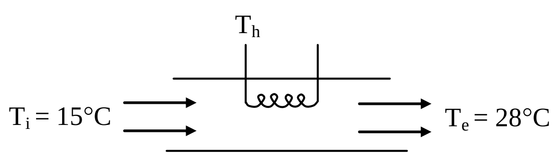
- Only reversible adiabatic process is isentropic.
- An adiabatic process may have internal irreversibilities like friction.

80. Ans: (d)

Sol: Swinging field electric dynamometer can be reversed cranked and made to run as a motor.

81. Ans: (c)

Sol:



$$BPF = \frac{T_h - T_e}{T_h - T_i} = \frac{41-28}{41-15}$$

$$= \frac{13}{26} = 0.5 = 50\%$$

82. Ans: (d)

Sol: If swirl component is zero, the inlet velocity is axial.

$$W = \phi u^2 = \frac{0.90 \times (200)^2}{1000} = 36 \text{ kJ}$$

83. Ans: (d)

Sol: The deflection in all the spring is equal hence all the springs are parallel to each other

$K_{eq} = K + K + K = 3K$

$$\delta = \frac{P}{K_{eq}} = \frac{P}{3K}$$

84. Ans: (a)

Sol: Atmospheric pressure head,

$$H_a = \frac{P_a}{\gamma} = \frac{100}{10} = 10 \text{ m (absolute)}$$

Vapour pressure head,

$$H_v = \frac{P_v}{\gamma} = \frac{3.5}{10} = 0.35 \text{ m (absolute)}$$

Critical cavitation coefficient,

$$\sigma_c = \frac{H_a - H_v - H_s}{H}$$

Hence, net head, $H = \frac{10 - 0.35 - (-1.5)}{0.9}$

$$= \frac{11.15}{0.9} = 12.39 \approx 12.4 \text{ m}$$

85. Ans: (c)

Sol:

- Variation in temperature difference is less along the length in the counter flow heat exchanger as compared to parallel flow heat exchanger.

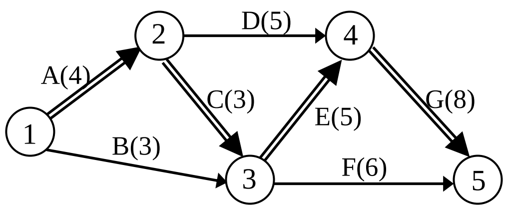
  Therefore, irreversibility is less.
- $(LMTD)_{\text{counter flow}} > (LMTD)_{\text{parallel flow}}$

86. Ans: (a)

Sol: The difference between the greatest and the least speed of the engine over one revolution is known as fluctuation of speed.

87. Ans: (b)

Sol:



Path	Duration (days)
A – D – G	4 + 5 + 8 = 17
A – C – E – G	4 + 3 + 5 + 8 = 20
B – E – G	3 + 5 + 8 = 16
B – F	3 + 6 = 9
A – C – F	4 + 3 + 6 = 13

Minimum time required to complete the project = 20 days

88. Ans: (d)

Sol: Peritectoid: $\gamma + \beta \Leftrightarrow \alpha$

(Cooling $\rightarrow$, Heating $\leftarrow$)

89. Ans: (d)

Sol: Given data :

Drill diameter (D) = 25 mm,

Plate thickness (L_W) = 60 mm

Cutting (V_c) = 55 m/min,

Feed (f) = 0.24 mm/rev,

Conical angle (2β) = 120°

$$T_C = \frac{L_c}{f\ N}$$

$$N = \frac{1000 v_c}{\pi D} = \frac{1000 \times 55}{\pi \times 25} = 700 \text{ rpm}$$

$L_c = L_w + A + O + C$

$= 60 + 2 + 3 + 7.25 = 72.25$

$$C = \frac{D}{2}\cot(\beta) = \frac{25}{2}\cot 60^\circ$$

$$= \frac{25}{2}(0.58) = 7.25$$

$$T_c = \frac{72.25}{700 \times 0.24} = 0.43 \text{ min}$$

90. Ans: (b)

91. Ans: (a)

Sol: $$\eta_{th} = 1 - \left(\frac{1}{r}\right)^{\gamma-1} = 1 - \left(\frac{1}{7}\right)^{0.4} \approx 0.55$$

$$\eta_{th} = \frac{W_{net}}{Q_s} = \frac{W_{net}}{W_{net} + Q_R}$$

$$0.55 = \frac{W_{net}}{W_{net} + 200}$$

$0.55W_{net} + 110 = W_{net}$

$\Rightarrow W_{net} \approx 244.44$ kJ

92. Ans: (c)

Sol: Economiser or power enrichment device supplies rich mixtures at high loads.

93. Ans: (a)

Sol: Specific enthalpy decreases during sensible cooling process.

94. Ans: (b)

Sol: The range of PH (8.5 to 9.5) is used in boilers. In this range of corrosion is least.

95. Ans: (b)

Sol: Given data:

E = 300 GPa

G = 150 GPa

We know that,

$$E = \frac{9\ KG}{3K + G}$$

$$\therefore\ 300 = \frac{9K \times 150}{3K + 150}$$

$$\therefore\ 3K + 150 = \frac{9}{2}K$$

$$\therefore\ \frac{3}{2}K = 150$$

$\therefore$ K = 100 GPa = 100 GN/m^2

96. Ans: (c)

Sol: Francis turbine - For maximum efficiency, the velocity of whirl at outlet is zero.

Kaplan turbine - Low head and high discharge

Impulse turbine - $N_s < 30$

Draft tube - Recovery of lost head

97. Ans: (c)

Sol: $K_{eq} = K + \left(\frac{K}{2} + \frac{K}{2}\right) = 2K$

$$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{2K}{m}}$$

98. Ans: (d)

Sol: *n* jobs and n persons

First job allotted to a person in n ways.

Second job allotted to a person in (n –1) ways and so on.

Total number of solutions = n(n –1)....1 = n!

99. Ans: (a)

Sol: The three polymer categories:

Behaviour	**General Structure**	**Example**
Thermoplastic	Flexible linear chains (straight or branched)	Polyethylene
Thermosetting	Rigid three-dimensional network (chains may be linear or branched)	Polyurethanes
Elastomers	Thermoplastics or lightly cross-linked thermosets, consist of spring-like molecules	Natural rubber

100. Ans: (a)

Sol: When the ratio of depth of the product to its diameter is greater than 1/2, the process is known as *deep drawing.* Whereas when the ratio is less than 1/2, it is considered as *shallow drawing*.

101. Ans: (d)

102. Ans: (b)

Sol: $$(COP)_{H.P} = \frac{T_H}{T_H - T_L} = \frac{1}{1-\frac{T_L}{T_H}} = 5$$

$$\Rightarrow 1-\frac{T_L}{T_H} = \frac{1}{5}$$

$$\Rightarrow \frac{T_L}{T_H} = \frac{4}{5} \Rightarrow \frac{T_H}{T_L} = \frac{5}{4}$$

103. Ans: (c)

Sol: Frost formation on evaporator tubes but no cooling effect in room, indicates choked filters.

104. Ans: (c)

Sol: If atmospheric temperature increases, density of outside air decreases. Hence, natural draught is less.

105. Ans: (b)

Sol: Elongation due to temperature rise is given by

$$\delta L_T = L \propto \Delta T$$

$$= 10^3 \times 1.25 \times 10^{-6} \times 100 = 0.125 \text{ mm}$$

Elongation due to axial load is

$$\delta L_P = \frac{PL}{AE} = \frac{10\times10^3\times10^3}{100\times200\times10^3} = 0.5 \text{ mm}$$

Total elongation is

$$\delta L = \Delta L_T + \delta L_P = 0.125 + 0.5 = 0.625 \text{ mm}$$

As the total elongation is less than gap between free end and rigid support, the bar will not touch the support. Hence the thermal stress will not be developed. The stress is developed only due to external load and it is given by

$$\sigma = \frac{P}{A} = \frac{10\times10^3}{100} = 100 \text{ MPa}$$

106. Ans: (d)

Sol: Given data:

$C_{D1} = 0.4$, $C_{D2} = 0.35$

Drag accounts for 20% of fuel consumption (Given)

Hence, % reduction in fuel consumption

$$= 0.2\times\frac{(0.4-0.35)}{0.4}\times100 = 2.5\%$$

107. Ans: (a)

Sol: $\omega_n = \omega_f$

$$\sqrt{\frac{k}{m}} = \frac{2\pi}{\lambda}V$$

(V is velocity of vehicle λ is wavelength of rough road, k is stiffness of spring m is mass of vehicle).

108. Ans: (b)

Sol: The features sizes range from less than 1 nm to 100 nm.

109. Ans: (b)

Sol: **Shrink and Expansion Fits:** These terms refer to the assembly of two parts that have an interference fit at room temperature. The typical case is a cylindrical pin or shaft assembled into a collar.

To assemble by *shrink fitting*, the external part is heated to enlarge it by thermal expansion, and the internal part either remains at room temperature or is cooled to contract its size. The parts are then assembled and brought back to room temperature, so that the external part shrinks, and if previously cooled the internal part expands, to form a strong interference fit. So statement (1) is *correct.*

An *expansion fit* is when only the internal part is cooled to contract it for assembly; once inserted into the mating component, it warms to room temperature, expanding to create the interference assembly. So statement (2) is also *correct. Hence the correct given option is(b).*

These assembly methods are used to fit gears, pulleys, sleeves, and other components onto solid and hollow shafts.

110. Ans: (b)

111. Ans: (b)

Sol: $\oint\left(\frac{\delta Q}{\delta T}\right) = \frac{2000}{1000} - \frac{300}{300} - \frac{250}{200}$

$\oint\left(\frac{\delta Q}{\delta T}\right) < 0$

So, it is an irreversible cycle.

112. Ans: (d)

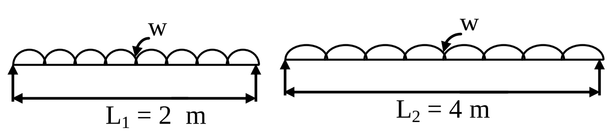
Sol: 10-20% variation in relative humidity is permitted in computer centres.

113. Ans: (b)

Sol: Hydrazine (N_2 H_4) reacts with water acting as scavenger.

114. Ans: (a)

Sol:



$\Delta_1 = 1 \text{ mm} = \frac{5}{384}\frac{wL_1^4}{EI}$

$\Delta_2 = \frac{5}{384}\frac{wL_2^4}{EI}$

$\frac{\Delta_2}{\Delta_1} = \left(\frac{L_2}{L_1}\right)^4 = \left(\frac{4}{2}\right)^4 \Rightarrow \Delta_2 = 16 \text{ mm}$

115. Ans: (b)

Sol: Let r = variable radius

$dA = 2\pi r dr$

and $\tau = \mu \frac{du}{dy} = \mu . \frac{\omega r}{\Delta h}$

$$\text{Torque} = \int r \times \tau dA = \frac{2\pi\mu\omega}{\Delta h}\int_o^{d/2} r^3 dr$$

$$= \frac{2\pi\mu\omega}{\Delta h}\left[\frac{r^4}{4}\right]_o^{d/2}$$

$$= \frac{2\pi\mu\omega}{\Delta h} \times \frac{d^4}{64}$$

$$\text{Torque} = \frac{\pi\mu\omega d^4}{32\Delta h}\text{N.m}$$

116. Ans: (c)

Sol: Maximum possible length of path of contact

$L_{max} = (R+r)\sin\phi$

$R = \frac{mT_G}{2} = \frac{5\times 40}{2} = 100\,\text{mm}$

$r = \frac{mT_P}{2} = \frac{5\times 32}{2} = 80\,\text{cm}$

$L_{max} = 180\sin(14.5) = 45$ mm

117. Ans: (d)

Sol: Ultrasonic machining is best suited for materials that are *hard and brittle*, such as ceramics, carbides, precious stones, and hardened steels.

A special tool is required for each shape to be produced; hence it is also called a *form tool*. The tip of the tool (which is attached to a transducer through the tool holder) usually is made of mild steel.

118. Ans: (b)

119. Ans: (b)

Sol: For critical stability centre of pressure must be at B.

Thus, B will be $\frac{5.4}{3} = 1.8$ m above N.

Now, $F = 10\left(\frac{4}{2}\right)\times 4\times 1$

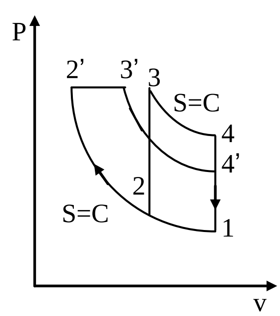
= 80 kN acting at a distance $\frac{4}{3}$m from N.

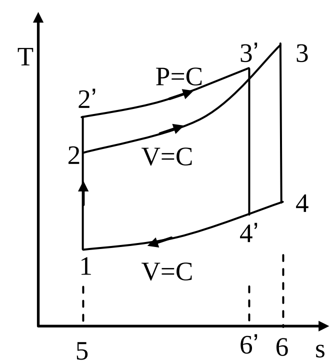
$\sum M_B = 0 = 80\left(1.8 - \frac{4}{3}\right) - N_x \times 1.8$

$\Rightarrow N_x = \frac{80\times 1.4}{3\times 1.8}$ = 20.74 kN

120. Ans: (b)

Sol:





1 – 2– 3– 4 is Otto cycle.

1 – 2′ – 3′– 4′ is Diesel cycle

$(\text{Expansion ratio})_{Otto} < (\text{Expansion ratio})_{Diesel}$

$(\text{Peak temp})_{Otto} > (\text{Peak temp})_{Diesel}$

121. Ans: (b)

Sol: Degree of reaction = $\dfrac{\text{Enthalpy rise in rotor}}{\text{Enthalpy rise in stage}}$

$$= \frac{c_p \Delta T_R}{c_p(\Delta T_R + \Delta T_S)} = \frac{\Delta T_R}{\Delta T_R + \Delta T_S}$$

122. Ans: (b)

Sol: Given data:

b = 10 mm, d = 20 mm, L_e = 1 m

Slenderness ratio,

$$\lambda = \frac{L_e}{k_{min}}$$

here, $k_{min} = \sqrt{\dfrac{I_{min}}{A}} = \sqrt{\dfrac{20\times(10)^3}{12\times 20\times 10}} = \dfrac{5}{\sqrt{3}}$

$$\Rightarrow \quad \lambda = \frac{1000}{5}\times\sqrt{3} \approx 346$$

123. Ans: (c)

Sol:

- The deflection (x) in the mercury manometer is expressed as $h = x\left(\dfrac{\rho_m}{\rho_{water}} - 1\right)$

  Discharge through venturimeter is given by,

  $$Q = C_d \frac{a_1.a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh}$$

  For the same discharge, h will remain same for inclined as well as horizontal venturimeters.

- $(C_d)_{\text{venturimeter}} > (C_d)_{\text{nozzle meter}} > (C_d)_{\text{orfice meter}}$

124. Ans: (d)

125. Ans: (c)

126. Ans: (a)

Sol: Minimum number of teeth (N) on gear to avail interference

$$= \frac{2f}{\sqrt{1+\frac{1}{G}\left(\frac{1}{G}+2\right)\sin^2\alpha} - 1}$$

For equal gears G = 1

$$N = \frac{2f}{\sqrt{1+3\sin^2\alpha} - 1}$$

$$N\left(\sqrt{1+3\sin^2\alpha}\right) = 2f + N$$

$$N^2\left(1+3\sin^2\alpha\right) = 4f^2 + N^2 + 4fN$$

$$3N^2\sin^2\alpha - 4fN - 4f^2 = 0$$

127. Ans: (c)

Sol: $\dfrac{\tau}{r} = \dfrac{T}{J} = \dfrac{G\theta}{L}$

$$\tau = \left(\frac{G\theta}{L}\right)r \quad \text{------(1)}$$

$$\gamma = \frac{\tau}{G} = \left(\frac{\theta}{L}\right).r \quad \text{----(2)}$$

The angle of twist for hollow and solid shaft remains same.

Hence, from equation (2) shear strain varies linearly and slope must be same for both materials. However, from equation (1) it can be concluded that at interface G value is suddenly increasing hence τ should increase suddenly. The slopes of τ vs r curve are also not same due to difference in material.

128. Ans: (a)

Sol: Grabuler's criterion

$$DOF = 3n - \sum_{i=1}^{m}(3 - c_i)$$

n = movable links = 3

m = Joints = 4

$$DOF = 3\times 3 - \sum_{i=1}^{4}(3-1)$$

$= 9 – (2 + 2 + 2 + 2)$

$= 9 – 8 = 1$ DOF

129. Ans: (b)

Sol: It is based on three fluid system (H_2, H_2O and NH_3)

Circulation is done due to gravity (no pump is required).

130. Ans: (a)

Sol: Due to lower fluid velocity in reaction blading the energy losses due to friction are lower. Hence, reaction blading have higher efficiency than impulse blading.

131. Ans: (b)

Sol: Statement (I) and statement (II) represent castigliano's theorem-I and theorem-II respectively. Both the statements are correct but both are independent of each other.

132. Ans: (b)

Sol:

- To describe shear strain rate completely at a point, nine parameters are required. Because, shear strain rate is a tensor quantity. Mathematically,

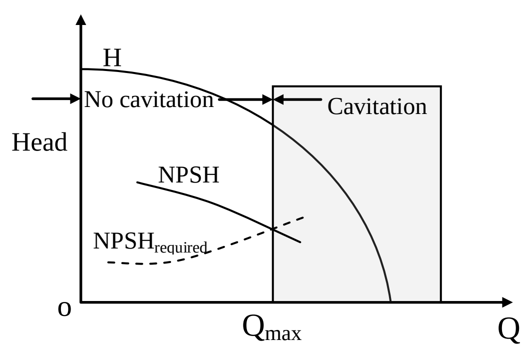
$$\dot{\varepsilon} = \begin{vmatrix} \dot{\varepsilon}_{xx} & \dot{\varepsilon}_{xy} & \dot{\varepsilon}_{xz} \\ \dot{\varepsilon}_{yx} & \dot{\varepsilon}_{yy} & \dot{\varepsilon}_{yz} \\ \dot{\varepsilon}_{zx} & \dot{\varepsilon}_{zy} & \dot{\varepsilon}_{zz} \end{vmatrix}$$

Thus, statement (I) is correct.

- Statement - II is the definition of the shear strain rate at a point. However, it is not the correct explanation of statement - I.

133. Ans: (a)

Sol: Refer to the figure shown below.



It is evident from the above figure that both the statements are correct and statement - II is the correct explanation of statement - I.

134. Ans: (d)

Sol: If all the plates have same emissivities, heat transfer rate will is reduced by 50% due to addition of one shield.

135. Ans: (d)

136. Ans: (c)

Sol: The rolling load can be reduced by applying tensile force to the workpiece in the horizontal direction. This will lower the compressive yield strength of the material. Both *back tension* and *front tension* can be applied.

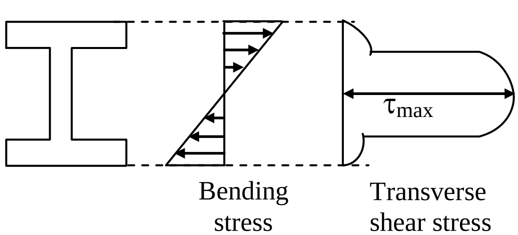
137. Ans: (b)

138. Ans: (c)

Sol: Initially flame spreads slowly and fraction of burned mixture is little. Hence, no appreciable pressure rise.

139. Ans: (d)

Sol:



For 'I' section beam flanges carry maximum bending load where as web carries maximum shear load. The distribution of bending stress and transverse shear stress is shown above.

140. Ans: (d)

Sol: HGL is the sum of pressure head and datum head. It is drawn with reference to some reference line, may be the centre line of the duct. It slopes downwards in the direction of flow except at the abrupt expansion point of the duct. At this point the pressure rise will take place and HGL will be modified accordingly. Hence, the statement - I is wrong. However, the statement - II is correct.

141. Ans: (d)

Sol: Black body is a body which absorbs all the radiation fall on it.

142. Ans: (a)

143. Ans: (a)

Sol: Hammer blow is the maximum unbalanced force in the vertically upward direction caused by the mass provided to balance the reciprocating masses. Hammer blow varies as the square of the speed. At high speed force of hammer blow can lift the wheels of a locomotive off the rails.

144. Ans: (b)

Sol: Tin based alloys are also known as white metal. Generally they contain copper, antimony and lead. The alloying imparts hardness, strength and corrosion resistance.

145. Ans: (a)

Sol:

- Incompressible Navier-Stokes equation is given by

$$\rho\frac{D\vec{V}}{Dt} = -\vec{\nabla}P + \rho\vec{g} + \mu\nabla^2\vec{V}$$

It can be seen that the above equation is an unsteady, nonlinear, second order, partial differential equation.

- The Inertia terms in the Navier-Stokes equation are:

$$\rho\left(\frac{\partial\vec{V}}{\partial t} + \vec{V}.\nabla\vec{V}\right)$$

The first term in the above equation is for unsteady flow while the second term is nonlinear.

Thus statement (II) is correct and it is the correct explanation of statement (I) as well.

146. Ans: (a)

Sol: The dissimilar metal may form a galvanic cell i.e., two electrodes in an electrolyte in corrosive environment including moisture and cause galvanic corrosion. Two phase alloys are more susceptible to galvanic corrosion because of the physical separation of the two different metals involved than are single phase alloys or pure metals.

147. Ans: (d)

148. Ans: (b)

Sol: Supercharging increases the pressure of air at inlet to engine by using compressor. Both statements are individually correct.

149. Ans: (a)

Sol: Encoders become popular with CNC systems because in Encoders digital quality can be readily compared with the pulses generated by the CNC system. Statement (I) is justified by Statement (II).

150. Ans: (a)

Sol: Pre-flame reactions are responsible for knock. In auto ignition theory sudden burning of free radicals and other chemicals cause knock.