DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Bhubaneswar, Pune, Kolkata

ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

MECHANICAL ENGINEERING

Test 8

Section A : Heat Transfer + IC Engines
Section B : Fluid Mechanics and Turbo Machinery-1
Section C : Production Engineering & Material Science-2

ANSWER KEY

1.	(c)	**16.**	(c)	**31.**	(b)	**46.**	(b)	**61.**	(b)
2.	(b)	**17.**	(b)	**32.**	(c)	**47.**	(c)	**62.**	(d)
3.	(d)	**18.**	(b)	**33.**	(a)	**48.**	(d)	**63.**	(c)
4.	(d)	**19.**	(a)	**34.**	(a)	**49.**	(a)	**64.**	(c)
5.	(c)	**20.**	(d)	**35.**	(d)	**50.**	(c)	**65.**	(a)
6.	(a)	**21.**	(a)	**36.**	(c)	**51.**	(b)	**66.**	(a)
7.	(b)	**22.**	(a)	**37.**	(d)	**52.**	(d)	**67.**	(b)
8.	(d)	**23.**	(c)	**38.**	(c)	**53.**	(d)	**68.**	(c)
9.	(c)	**24.**	(a)	**39.**	(d)	**54.**	(b)	**69.**	(c)
10.	(b)	**25.**	(b)	**40.**	(c)	**55.**	(c)	**70.**	(b)
11.	(d)	**26.**	(c)	**41.**	(d)	**56.**	(c)	**71.**	(a)
12.	(a)	**27.**	(d)	**42.**	(d)	**57.**	(d)	**72.**	(d)
13.	(c)	**28.**	(d)	**43.**	(b)	**58.**	(d)	**73.**	(b)
14.	(a)	**29.**	(c)	**44.**	(d)	**59.**	(c)	**74.**	(b)
15.	(c)	**30.**	(b)	**45.**	(c)	**60.**	(b)	**75.**	(d)

DETAILED EXPLANATIONS

1. (c)

Average piston speed, $\bar{V} = 2LN$

$$= 2 \times 0.15 \times \frac{3000}{60} = 15 \text{ m/s}$$

2. (b)

Swept volume, $V_s = \frac{\pi}{4} D^2 \cdot L$

$$= \frac{\pi}{4} D^2 \cdot D \qquad [\because L = D]$$

$$= \frac{\pi}{4} \times 0.15^3 = 2.65 \times 10^{-3} \text{m}^3$$

$\therefore$ Clearance volume, $V_c = \frac{V_s}{r-1} = \frac{2.65 \times 10^{-3}}{8-1} = 3.787 \times 10^{-4} \text{m}^3 = 378.7 \text{ cm}^3$

3. (d)

Given : $BP = 50$ kW, $\eta_{\text{Bth}} = 0.3$, $CV = 42000$ kJ/kg, $\frac{A}{F} = 21$

Brake thermal efficiency is given by

$$\eta_{\text{Bth}} = \frac{BP}{\dot{m}_f \times CV}$$

$$\Rightarrow \quad \dot{m}_f = \frac{BP}{\eta_{Bth} \times CV}$$

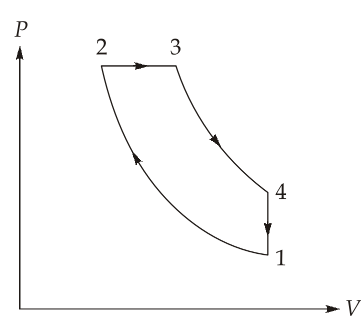
$$\therefore \quad \dot{m}_f = \frac{50}{0.3 \times 42000} = 3.97 \times 10^{-3} \text{kg/s}$$

$$\therefore \quad \dot{m}_{exh} = \dot{m}_a + \dot{m}_f = \dot{m}_f \left(\frac{A}{F} + 1\right)$$

$$= 3.97 \times 10^{-3}[21 + 1]$$

$$= 87.3 \times 10^{-3} \text{ kg/s}$$

5. (c)



Given : $\frac{\dot{m}_a}{\dot{m}_f} = 20$, $T_1 = 300$ K, $CV = 42000$ kJ/kg, $T_2 = 900$ K

$$\text{Heat supplied} = \dot{m}_a C_p (T_3 - T_2) = \dot{m}_f \times CV$$

Now,

$$T_3 - T_2 = \frac{\dot{m}_f}{\dot{m}_a} \times \frac{CV}{C_p}$$

$$T_3 - T_2 = \frac{1}{20} \times \frac{42000}{1.005}$$

or

$$\rho - 1 = \frac{1}{20} \times \frac{42000}{1.005} \times \frac{1}{900}$$

$$\therefore \quad \rho - 1 = 2.32 \qquad \left[\because \frac{T_3}{T_2} = \frac{V_3}{V_2} = \rho\right]$$

$$\therefore \quad \rho = 3.32$$

6. (a)

The Stoichiometric equation can be written as

$$C_8H_{18} + 12.5(O_2 + 3.76N_2) \rightarrow 8CO_2 + 9H_2O + 47N_2$$

$$\therefore \quad \left(\frac{A}{F}\right)_{\text{Stochiometric}} = \frac{12.5(32 + 3.76 \times 28)}{12 \times 8 + 18 \times 1}$$

$$= 15.05$$

8. (d)

The general principles governing an efficient combustion chamber design is as follows:

- High volumetric efficiency
- Minimum path of flame travel
- Reduced rate of pressure rise
- Maximum thermal efficiency
- Exhaust valve location
- Maximum output
- Scavenging of the exhaust gas
- Materials for cylinder head

9. (c)

$N = 1200$ rpm, $d = 12$ cm

Flame travel distance, ftd = 6 + 0.5 = 6.5 cm

Spark position = 18° bTDC

Ignition lag = 6°

Combustion starts at an angle = 18 – 6 = 12° bTDC

Flame speed, v_f = 20 m/s

$$\therefore \quad \text{Time} = \frac{ftd}{v_f} = \frac{6.5}{20 \times 100} = 3.25 \times 10^{-3} \text{ sec}$$

10. (b)

$$N = 1200 \text{ rpm} = \frac{1200 \times 360^\circ}{60} = 7200 \text{ degree/sec}$$

Rotational angle during flame propagation = $7200 \times 3.25 \times 10^{-3}$

= 23.4°

$\therefore$ Crank angle position at the end of combustion = $23.4^\circ - 12^\circ = 11.4^\circ$ aTDC

11. (d)

Time required for the flame to travel across the combustion space would longer in the larger engines. The delay period is not much affected by size. The larger cylinders will therefore be more likely to knock. SI engine is generally limited to the size of 150 mm bore.

14. (a)

The main advantage of the Pintaux nozzle is that it provides better cold starting performance. The main disadvantage of this type of nozzle is the tendency for the auxiliary hole to choke.

15. (c)

$$\text{Fuel consumption per cycle} = \frac{bsfc \times kW}{\text{Number of cycle per hour}}$$

$$= \frac{0.3 \times 100}{\left(\frac{2500}{2}\right) \times 60} = 4 \times 10^{-4} \text{kg}$$

$$\text{Fuel consumption per cylinder per cycle} = \frac{4 \times 10^{-4}}{4} = 10^{-4} \text{kg/cycle}$$

16. (c)

Given : $k = 6$, 4-stroke, $D = 0.1$ m, $L = 0.15$ m, $N = 3000$ rpm, $T = 500$ N.m, $\eta_{mech} = 0.85$

$$\text{Brake power, BP} = \frac{2\pi NT}{60} = \frac{2\pi \times 3000 \times 500}{60} = 157 \text{ kW}$$

17. (b)

$$\text{Indicated power, I.P} = \frac{B.P}{\eta_{mech}} = \frac{157}{0.85} = 184.8 \text{ kW}$$

18. (b)

$$\text{Brake power, B.P} = \frac{P_{bmep} \times LAN \cdot k}{60 \times 2}$$

$$\therefore \quad P_{b\,mep} = \frac{60 \times B.P \times 2}{LAN \cdot k}$$

$$\text{or} \quad P_{b\,mep} = \frac{60 \times 157 \times 10^3 \times 2}{0.15 \times \frac{\pi}{4} \times 0.1^2 \times 3000 \times 6}$$

$$\therefore \quad P_{b\,mep} = 8.88 \text{ bar}$$

19. (a)

Fourier's law is a vector expression indicating that heat flow rate is in the direction of decreasing temperature and is normal to an isotherm.

21. (a)

$r_2 = \frac{1.6}{2} = 0.8$ m, $r_1 = 0.8 - 0.08 = 0.72$ m, k = 0.09 W/m°C, $\Delta t = t_1 - t_2 = 250$°C

∴ The rate of heat transfer through the spherical shaped vessel,

$$Q = \frac{(t_1 - t_2)}{\frac{(r_2 - r_1)}{4\pi k r_1 r_2}} = \frac{250 \times 4 \times \pi \times 0.09 \times 0.8 \times 0.72}{0.8 - 0.72}$$

$$= 2035.75 \text{ W}$$

22. (a)

For an insulation to be effective: $r_0 \geq r_c$

$$\Rightarrow \quad \frac{D_0}{2} \geq \frac{k_{insulation}}{h_0}$$

$$\Rightarrow \quad \frac{0.032}{2} \geq \frac{k_{insulation}}{15}$$

$$\Rightarrow \quad k_{\text{insulation}} \leq 0.24 \text{ W/m°C}$$

24. (a)

The amount of heat loss is given by,

$$Q = \sqrt{h \times P \times k \times A} \times (T_w - T_0)$$

$$= \sqrt{9 \times \pi \times 0.35 \times 10^{-2} \times 361 \times \frac{\pi}{4} \times 0.35^2 \times 10^{-4}} \times (97 - 32)$$

$$= 3 \times \pi \times 10^{-3} \times \frac{19}{2} \times \sqrt{0.35^3} \times 65 = 1.205 \text{ W}$$

25. (b)

$$\text{Peclet number} = \text{Re} \cdot \text{Pr}, \text{ Stanton number} = \frac{Nu}{\text{Re} \cdot \text{Pr}} = \frac{h}{\rho V c_p}$$

26. (c)

- For forced convection over flat plate
  1. Laminar flow: $\bar{h} = 2h_x$
  2. Turbulent flow: $\bar{h} = \frac{5}{4}h_x$
- For free convection over flat plate
  1. Laminar flow: $\bar{h} = \frac{4}{3}h_x$
  2. Turbulent flow: $\bar{h} = \text{Constant}$

27. (d)

The relative magnitude of the dimensionless parameter $\frac{Gr}{\text{Re}^2}$ governs the relative importance of natural convection in relation to forced convection where,

$$\frac{Gr}{\text{Re}^2} = \frac{g\beta(T_w - T_\infty)L}{U_0^2}$$

which represents the ratio of the buoyancy forces to inertia forces.

28. (d)

$$\text{Reynolds number, Re} = \frac{\rho \cdot V \cdot D}{\mu} = \frac{VD}{\nu} = \frac{4\dot{m}}{\pi\mu D} \qquad \left[\because \nu = \frac{\mu}{\rho}\right]$$

$$\text{Re} = \frac{4 \times 5}{\pi \times (7700 \times 8 \times 10^{-8}) \times 0.10}$$

$$= 103347.36$$

29. (c)

$$\text{Nu}_d = 12.73$$

$$\Rightarrow \quad \frac{\bar{h} \cdot D}{k} = 12.73$$

$$\Rightarrow \quad \bar{h} = \frac{12.73 \times k}{D} = \frac{12.73 \times 12.32}{0.10}$$

$$= 1568 \text{ W/m}^2\text{K}$$

30. (b)

$$Q = \dot{m}C_p\Delta T$$

$$= 5 \times 110 \times 28 = 15400 \text{ W}$$

$$Q = h \times A \times (T_w - T_b)$$

$$= h \times \pi \times D \times L \times (T_w - T_b)$$

$$\Rightarrow \quad L = \frac{Q}{h \times \pi \times D \times (T_w - T_b)}$$

$$\Rightarrow \quad L = \frac{15400}{1568 \times \pi \times 0.10 \times 40}$$

$$\Rightarrow \quad L = 0.78 \text{ m}$$

31. (b)

The highly conducting liquids such as water and liquid metals give much higher value of heat transfer coefficient and overall heat transfer coefficient.

32. (c)

The correction factor (F) is always less than unity as no arrangement can be more effective than the conventional counter flow.

33. (a)

$$\text{Effectiveness, } \in = \frac{Q_{act}}{Q_{\max}}$$

$$\Rightarrow \quad Q_{act} = \in \cdot Q_{\max} = \in \times C_{\min}\left(t_{h_1} - t_{c_1}\right)$$

$$= 0.80 \times 1 \times (450 - 25)$$

$$= 340 \text{ kJ}$$

34. (a)

$$Q = m_c \cdot C_{pc} \cdot \left(t_{c_2} - t_{c_1}\right)$$

$$340 = 4 \times \left(t_{c_2} - 25\right)$$

$$\Rightarrow \quad t_{c_2} = \frac{340}{4} + 25 = 110°\text{C}$$

35. (d)

Nusselt's analysis of film condensation on a vertical plate:

1. The film of the liquid formed flows under the action of gravity.
2. The condensate flow is laminar and the fluid properties are constant.
3. The liquid film is in good thermal contact with the cooling surface and, therefore, temperature at the inside of the film is taken equal to the surface temperature t_s. Further, the temperature at the liquid-vapour interface is equal to the saturation temperature t_{sat} at the prevailing pressure.
4. Viscous shear and gravitational forces are assumed to act on the fluid; thus normal viscous force and inertia forces are neglected.
5. The shear stress at the liquid-vapour interface is negligible. This means there is no velocity gradient at the liquid-vapour interface $\left[i.e., \left(\frac{\partial u}{\partial y}\right)_{y=\delta} = 0\right]$.
6. The heat transfer across the condensate layer is by pure conduction and temperature distribution is linear.
7. The condensing vapour is entirely clean and free from gases, air and non-condensing impurities.

37. (d)

$$T = 2727°\text{C} = 2727 + 273 = 3000 \text{ K}$$

The maximum emissive power,

$$(E_{\lambda b})_{\max} = 1.285 \times 10^{-5} T^5$$

$$= 1.285 \times 10^{-5} \times (3000)^5$$

$$= 3.12255 \times 10^{12} \text{ W/m}^2 \text{ per meter length}$$

38. (c)

Given : $D = 0.2$, $L = 0.4$ m, $N = 60$ rpm

Theoretical discharge is given by,

$$Q_{th} = \frac{ALN}{60} = \frac{\pi}{4}D^2 \times \frac{LN}{60}$$

$$= \frac{\pi}{4} \times 0.2^2 \times \frac{0.4 \times 60}{60}$$

$$= 0.0125 \text{ m}^3/\text{s}$$

39. (d)

Given : $Q_a = 0.011$ m^3/s

$\therefore$ The percentage slip, $\%\text{slip} = \frac{Q_t - Q_a}{Q_t} \times 100$

$$= \frac{0.0125 - 0.011}{0.0125} \times 100 = 12\%$$

40. (c)

$$P_{th} = \rho g Q_{th} \cdot H$$

We have, $H = 30$ m (given)

$\therefore$ $P_{th} = 10^3 \times 9.81 \times 0.0125 \times 30 = 3.67$ kW

41. (d)

In mixed flow, the water enters the runner in the radial direction and leaves in the axial direction.

Example : Francis turbine

42. (d)

Velocity of wheel is given by, $U = \text{Speed ratio} \times \sqrt{2gH}$

$$U = 0.45 \times \sqrt{2 \times 9.81 \times 450} = 42.28 \text{ m/s}$$

$$= 42.28 \text{ m/s}$$

or $\frac{\pi DN}{60} = 42.28$

$\therefore$ $D = \frac{60 \times 42.28}{\pi \times 600} = 1.34$ m

43. (b)

Given : $D_2 = 1.5$ m, $D_1 = 0.5$ m, $V_{f_1} = V_{f_2}$, $B_2 = 250$ mm $= 0.25$ m

Using the relation for discharge,

$$Q = \pi D_1 B_1 V_{f_1} = \pi D_2 B_2 V_{f_2}$$

or $B_1 = \frac{D_2 B_2}{D_1} = \frac{1.5 \times 0.25}{0.5}$ $\quad (\because V_{f_1} = V_{f_2})$

or $B_1 = 0.75$ m

44. (d)

Draft tube is an integral part of a pressure or reaction turbine. In case of pressure turbines, the energy that is not extracted by the runner appears as exit velocity energy, it helps to convert the exit velocity head into pressure or potential head. By providing draft tube, we can install the turbine above the tail race level without any loss in the static head.

46. (b)

Following are the characteristics of centrifugal pump :

- Discharge is continuous and smooth
- Starting torque is more
- Maintenance cost is less
- Can run at higher speeds
- Less wear and tear
- Less efficiency
- Cost of centrifugal pump is less
- Needs smaller floor area
- Suction and delivery valve is not necessary
- It can handle any type of liquid
- Priming is necessary

47. (c)

Given : $d = 0.1$ m, $V = 30$ m/s, $u = 10$ m/s

Work done per second is given by

$$= \rho A (V-u)^2 \cdot u$$

$$= 10^3 \times \frac{\pi}{4} \times 0.1^2 (30-10)^2 \times 10$$

$$= 31.4 \text{ kW}$$

48. (d)

Given : $\mu = 8$ poise $= 0.8$ Pa.s, $\rho = 800$ kg/m^3

Velocity distribution, $u = 5y - 4y^2$

$$\Rightarrow \quad \frac{du}{dy} = 5 - 8y$$

At $y = 0.20$ m, $$\left(\frac{du}{dy}\right)_{y=0.20} = 5 - 8(0.20) = 3.4\,\text{s}^{-1}$$

Using Newton's law of viscosity, shear stress is given as

$$\tau_{y\,=\,0.20} = \mu\left(\frac{du}{dy}\right)_{y=0.20} = 0.8 \times 3.4 = 2.72 \text{ Pa}$$

49. (a)

Given : $\theta = 135°$, $r = 1$ mm, $d = 2$ mm, $\sigma = 0.45$ N/m, $\rho_{Hg} = 13600$ kg/m^3

Capillary rise is given as;

$$h = \frac{4\sigma\cos\theta}{\rho g d}$$

$$= \frac{4 \times 0.45 \times \cos(135°)}{13600 \times 9.81 \times (2 \times 10^{-3})}$$

$$= -4.77 \times 10^{-3} \text{ m} \qquad \left[\because \cos 135° = \frac{-1}{\sqrt{2}}\right]$$

$$= -4.77 \text{ mm}$$

$$\simeq -4.8 \text{ mm}$$

Hence, capillary depression is 4.8 mm.

50. (c)

Given : $D = 0.4$ mm, $R = 0.2$ mm, $P_{atm} = 100$ kPa, $\sigma = 0.08$ N/m

Absolute pressure inside the soap bubble is given as;

$$P_{abs} = P_{atm} + \frac{4\sigma}{R}$$

$$= 100 + \frac{4 \times 0.08}{0.0002 \times 1000} = 101.6 \text{ kPa}$$

51. (b)

Given : 0.1 poise = 0.01 Pa.s, $\rho = 800$ kg/m^3, $D = 10$ cm, $v = 0.1$ m/s

$$\text{Reynold's number, Re} = \frac{\rho v D}{\mu} = \frac{800 \times 0.1 \times 0.10}{0.01} = 800$$

As Re < 2000, so it is laminar flow.

Frictional head loss per meter length in laminar flow through circular pipe is given as

$$h_f = \frac{32\mu v}{\rho g D^2} = \frac{32 \times 0.01 \times 0.1}{800 \times 9.81 \times (0.10)^2}$$

$$\simeq 0.407 \times 10^{-3} \text{ m}$$

$$= 0.4 \text{ mm}$$

52. (d)

$$u = 2x^3y^2 + \alpha y^3x^2 \text{ and } v = 6y^4x - 2x^2y^3$$

For steady and incompressible flow, continuity equation is given as,

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\left(6x^2y^2 + 2\alpha y^3 x\right) + \left(24y^3x - 6x^2y^2\right) = 0$$

$$\Rightarrow \quad 2\alpha = -24$$

$$\Rightarrow \quad \alpha = -12$$

53. (d)

Froude number can be interpreted as the ratio of inertia force and gravity force.

54. (b)

$$\text{Stream function value at (1, 2)}, \psi_1 = 5(1)(2) = 10 \text{ units}$$

$$\text{Stream function value at (2, 3)}, \psi_2 = 5(2)(3) = 30 \text{ units}$$

$$\text{Discharge per unit depth} = |\psi_1 - \psi_2| = |10 - 30| = |-20| = 20 \text{ units}$$

55. (c)

Given : D_0 = 160 mm, D_c = 140 mm, C_d = 0.80

The coefficient of contraction is given as;

$$C_c = \frac{\text{Actual minimum area}}{\text{Theoretical minimum area}}$$

$$= \frac{\frac{\pi}{4}D_c^2}{\frac{\pi}{4}D_0^2} = \frac{D_c^2}{D_0^2}$$

$$\Rightarrow \quad C_c = \frac{(140)^2}{(160)^2} = 0.765625 \simeq 0.766$$

56. (c)

Euler equation is given as:

$$\vec{F}_{pressure} + \vec{F}_{gravity} = \vec{F}_{inertial}$$

$$\Rightarrow \quad \vec{\nabla}P + \rho\vec{g} = \rho\vec{a}$$

57. (d)

- Toughness is the measure of the "energy" required to break a material, whereas impact strength is a measure of the "stress" required to produce fracture.
- Toughness a dependent upon the material composition as well as the heat treatment given to it.
- Annealed materials generally have better toughness than the corresponding normalised or quenched specimens.
- Coarse grained structures generally have higher ductility compared to fine grain structure and consequently better toughness.

59. (c)

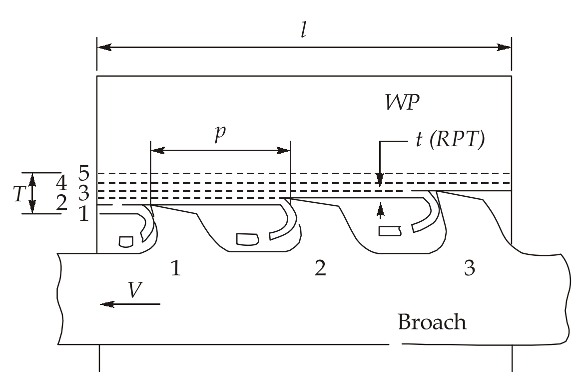
- An ideal cutting tool material should have high thermal conductivity to conduct away heat from the cutting edge efficiently.
- Since cemented carbide tools are very brittle, a small negative rake angle is preferred. The negative rake angle helps the tool tip to become a little bit more stronger.

60. (b)

- Standard grinding wheel designation:
  Abrasive type - grain size - grade - structure - bond
- The wheel grade designates the force holding the grains. It is a measure of strength of the bond. Because strength and hardness are directly related, the grade is also referred to as the hardness of the wheel.
  The grade is designated as follows:
  Very soft : A to G
  Soft : H to K
  Medium hard : L to O
  Hard : P to S
  Very hard : T to Z
- The wheel bond holds the grains together in the wheel with just the right strength that permits each grain of the wheel cutting face to perform its work efficiently. Seven standard bonds are available : Vitrified bond (V), resinoid bond (R), silicate bond (S), rubber bond (R), shellac bond (E), oxychloride bond (O) and metallic bond (M).

61. (b)

Broaching is a cutting process using a multi-toothed tool (broach) having successive cutting edges; each protrudes to a distance further than the preceding one in the direction perpendicular to the broach length. In contrast to all other cutting processes, there is no feeding on the broach or the workpiece. The total depth of the material removed in one stroke T is the sum of rises of teeth of the broach. Broaching is generally used to bore or enlarge through holes of any cross-sectional shape, straight and helical slots, external surfaces of various shapes, and external and internal toothed gears.



62. (d)

In ECM, tool is cathode while work material is anode. ECM is based on electrolysis.
The volumetric MRR in ECM is given by,

$$\text{MRR} = \frac{AI}{ZF\rho_a} \text{mm}^3/\text{s}$$

where, A : Atomic weight of the work material, I = Current, Z = Valency of the work material
F : Faraday's constant = 96540C, ρ_a = Density of work material

Also, the current is inversely related to the gap resistance which is given by,

$$R = \frac{\rho h}{A_{gap}}$$

where, ρ : specific resistance of the electrolyte; h = equilibrium gap; A_{gap} = cross-sectional area of the gap

63. (c)

Cylindrical locator is the best shape for a locator because it is easy to produce and at the same time arrests five degrees of freedom.

64. (c)

Given, thread angle, $\theta = 60°$

best wire diameter, $d_w = 2$ mm

Using three-wire method,

$$d_w = \frac{P}{2}\sec\frac{\theta}{2}$$

$$2 = \frac{P}{2}\sec 30° = \frac{P}{2} \times \frac{2}{\sqrt{3}}$$

$$P = \sqrt{3} \times 2 \simeq 3.5 \text{ mm}$$

65. (a)

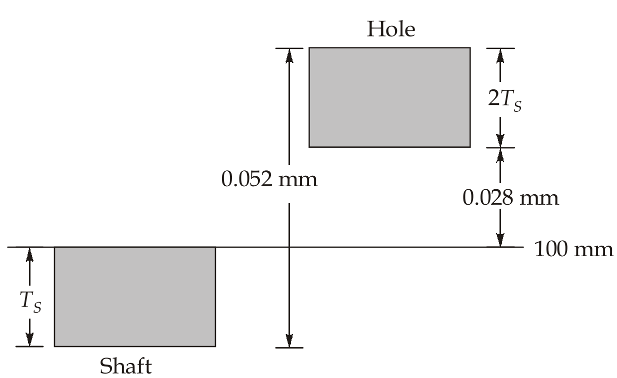
Given, average clearance = 0.04 mm

Since clearance must not exceed ±0.012 mm from average value,

Maximum clearance = 0.04 + 0.012 = 0.052 mm

Minimum clearance = 0.04 – 0.012 = 0.028 mm

The fit is shown schematically below, where shaft basic size is 100 mm and T_S is tolerance on shaft.



From diagram, $2T_S + 0.028 + T_S = 0.052$

$$3T_S = 0.024$$

$$T_S = 0.008 \text{ mm}$$

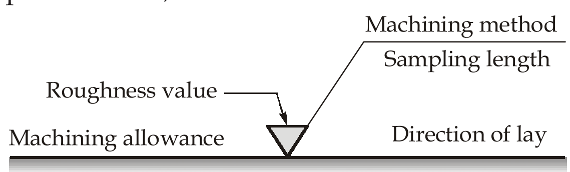
Thus, tolerance on hole, $T_H = 2T_S = 2 \times 0.008 = 0.016$ mm

Thus, upper limit of hole = 100 mm + 0.028 mm + 0.016 mm

= 100.044 mm

67. (b)

Surface roughness is represented as,



68. (c)

- Inhibitors form a protective layer on the metal surface and prevent corrosion. Small uncovered areas may lead to severe localized corrosion known as pitting.
- Metallic coatings are used for corrosion prevention. If a metal coating is noble with respect to the underlying metal, it is necessary to avoid flaws in the coating such as cracks and pores. As the exposed part of the anode at a crack or pore is very small, corrosion takes the form of a localized attack known as pinhole attack.

69. (c)

- Fully recoverable deformation, which is virtually time independent, is called elastic deformation.
- Fully recoverable but time dependent deformation is called anelastic deformation.
- When both recoverable and permanent deformation occur together and are time dependent, the phenomenon is called viscoelastic deformation.
- Permanent deformation which is time independent is called plastic deformation.

70. (b)

- Pearlite is the eutectoid mixture of ferrite and cementite.
- Ledeburite is the eutectic mixture of austenite and cementite.
- Ferrite, austenite and cementite are single phases while pearlite and ledeburite are micro constituents but not a single phase.

71. (a)

The ultrasonic-inspection method has high penetrating power and sensitivity. It can be used from various directions to inspect flaws in large parts, such as railroad wheels, pressure vessels and die blocks.

73. (b)

- In tension, fracture takes place along the crystallographic plane on which the normal tensile stress is maximum.
- Brittle fracture of a specimen in compression is more complex, and fracture may even follow a path that is theoretically at an angle of 45° to the direction of the applied force.
- Fatigue fracture typically occurs in a brittle manner. Minute external or internal cracks develop at pre-existing flaws or defects in the material; these cracks then propagate over time and eventually lead to total and sudden failure of the part.

74. (b)

Above 1400°C, the crystal structure of iron changes to BCC from FCC which is called δ-iron. This iron is the same phase as α-iron except for its temperature range, and so it is commonly called δ-ferrite. The solubility of carbon in δ-ferrite is small (0.1 wt%), but it is appreciably larger than α-ferrite (0.022 wt%), because of higher temperature.

75. (d)

The area under the stress-strain curve indicates the toughness (i.e., energy which can be absorbed by the material upto the point of rupture). Although the engineering stress-strain curve is often used for this computation, a more realistic result in obtained from a true-stress-strain curve.

❍❍❍❍