TEST ID: 311

ACE
Engineering Academy

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ESE- 2020 (Prelims) - Offline Test Series Test - 22

MECHANICAL ENGINEERING

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

01. Ans: (b)

Sol: By applying S.F.E.E. at entry and exit of turbine

$$\dot{m}h_1 + \dot{Q} = \dot{m}h_2 + \dot{W}$$

$$\dot{m}(h_1 - h_2) = \dot{W} - \dot{Q}$$

$$\Rightarrow \quad \dot{m}c_p \times (T_1 - T_2) = \dot{W} - \dot{Q}$$

$$\Rightarrow \quad 20 \times 1.005 \times (1000 - 300) = \dot{W} + 300$$

$$\Rightarrow \quad \dot{W} = 13770\ \text{kW}$$

02. Ans: (d)

Sol: Acceleration, $a = g\sin\theta - \mu g\cos\theta$

where, g = acceleration due to gravity,

θ = angle of inclined plane,

μ = coefficient of friction.

$\therefore$ a is same for all

$\therefore$ time will be same.

03. Ans: (b)

Sol: $F_3 = F_2 + \alpha (D_2 - F_2)$

$= 300 + 0.2 \times (250 - 300)$

$= 290$

04. Ans: (c)

Sol:

- For torsional pendulum time period, $T = 2\pi\sqrt{\frac{I}{k}}$ which is independent of acceleration due to gravity.
- For spring mass system time period, $T = 2\pi\sqrt{\frac{m}{k}}$ which is also independent of acceleration due to gravity.

05. Ans: (b)

Sol: If specific heat at constant volume increases for air in SI engine, then efficiency decreases.

06. Ans: (d)

Sol: In a vapour compression refrigeration cycle for making ice, the condensing temperature for higher COP should be much below the critical temperature of the refrigerant.

07. Ans: (b)

Sol: Heat flux through plane wall $(q) = -k\dfrac{dT}{dx}$

$= 50 \times 100$

$= 5000\ W/m^2$

$q = 5000\ W/m^2$

08. Ans: (b)

Sol: $r_1 = 30$ mm ; $r_2 = 50$ mm

$F_1 = 60$ N ; $F_2 = 100$ N

$$K = 2\left(\frac{a}{b}\right)^2 \frac{F_2 - F_1}{r_2 - r_1}$$

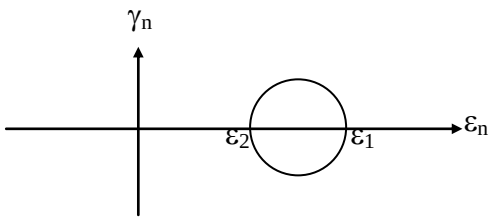
$$K = 2\left[\frac{100 - 60}{50 - 30}\right]$$

$$= 2\left(\frac{40}{20}\right)$$

$K = 4$ N/mm

09. Ans: (b)

Sol: As $\varepsilon_x > \varepsilon_y$ the radius of Mohr's circle for strain will not be zero



10. Ans: (d)

Sol: At low pressure ratio mass flow rate is high for the compressor. Higher mass flow rate causes higher velocity and when velocity exceeds sonic speed choking can occur. The surging occurs when pressure ratio across the compressor is higher than maximum pressure ratio.

11. Ans: (d)

Sol: Volume of cube = Volume of slab

$$a^3 = 1\times 2\times 4 = 8$$

$$a = \sqrt[3]{8} = 2 = \text{side of cube}$$

$$M_{cube} = \frac{a^3}{6a^2} = \frac{a}{6} = \frac{2}{6} = \frac{1}{3}$$

$$M_{slab} = \frac{V}{A_s}$$

$$= \frac{1\times 2\times 4}{2(1\times 2 + 2\times 4 + 4\times 1)} = \frac{8}{28} = \frac{2}{7}$$

$$\frac{\tau_{cube}}{\tau_{Slab}} = \left(\frac{M_{cube}}{M_{Slab}}\right)^2 = \left(\frac{1/3}{2/7}\right)^2 = \left(\frac{1}{3}\times\frac{7}{2}\right)^2$$

$$= \left(\frac{7}{6}\right)^2 = 1.36$$

12. Ans: (a)

Sol: Annealing carried out for the following:

- To soften the steel,
- To relieve the internal stresses, and
- To refine the grains and reduce the hardness

13. Ans: (d)

Sol: The correct relationship between reliability R(t), probability of failure F(t) and failure density function f(t) is, which is not given in three options. Hence, option (d) is correct.

14. Ans: (c)

15. Ans: (b)

Sol: Increasing the pressure inside a biogas plant decreases the gas production.

16. Ans: (b)

Sol:

1. On principal planes shear stress is zero (true)
2. Shear stress on any two mutually perpendicular planes must be the same (true)

3. $\tau_{max} = \frac{\sigma_1 + \sigma_2}{2}$ (false)

True value is, $\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$

17. Ans: (d)

Sol: The heat transfer to air at constant pressure

$Q_H = C_p(T_2 - T_1)$

$= 1\times(175 - 25) = 150$ kJ/kg

Available energy,

$$Q_{max} = Q_H \times \left(1 - \frac{T_0}{T_H}\right)$$

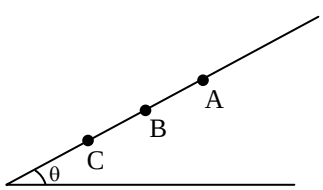
$$= 150 \times \left(1 - \frac{300}{900}\right) = 100 \text{ kJ/kg}$$

Percentage of heat added as available energy = $\frac{Q_{max}}{Q_H} \times 100$

$$= \frac{100}{150} \times 100 = 66.67\%$$

18. Ans: (c)

Sol:



For the first half metre from A to B :

$$S = u\,t + \frac{1}{2} a\,t^2$$

$$\frac{1}{2} = \frac{1}{2} \times g\sin\theta \times \left(\frac{1}{2}\right)^2$$

$\therefore\ g \sin\theta = 4$

$v_B = at = \frac{g\sin\theta}{2} = 2$ m/s

For next half metre from B to C :

$$S = u\,t + \frac{1}{2} a\,t^2$$

$$\frac{1}{2} = 2t + \frac{1}{2} \times 4 \times (t)^2$$

$\therefore\ 4t^2 + 4t - 1 = 0$

$\therefore\ t = 0.21$ sec

19. Ans: (d)

Sol: A freely falling elevator experiences zero gravity.

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

But, h = 20 cm (given)

$\therefore$ Therefore, the height of the water column will remain at a maximum of 20 cm.

[$\because$ Beyond this (20 cm) surface tension is zero thus contact angle will become 90° at 20 cm length]

20. Ans: (d)

Sol:

- Internal irreversibility of Rankine cycle is caused by fluid friction, throttling and mixing.
- External irreversibility of the Rankine cycle is caused due to the temperature differences

between the combustion gases and the working fluid on the source side, and the temperature differences between the condensing working fluid and the condenser cooling water on the sink side.

21. Ans: (c)

Sol: The correct sequence of emissions in ***decreasing order*** of their ppm is HC emissions→ NO_x emissions →CO emissions.

22. Ans: (a)

Sol:

- Compared to natural convection type, forced convection type condensers have smaller weight per unit capacity....CORRECT.
- Evaporative condensers are normally used in small capacity systems.....WRONG.

23. Ans: (c)

Sol: Air is usually employed as a refrigerant for refrigeration in aeroplanes.

24. Ans: (d)

Sol: As per distortion shear energy theory.

$$\left(\sigma_1^2+\sigma_2^2-\sigma_1\sigma_2\right)=\left(\frac{\sigma_y}{FOS}\right)^2 \text{ [For 2D case]}$$

Where σ_1 , σ_2 are principal stresses

$\sigma_1 = 2P$

$\sigma_2 = P$

and $\sigma_y = f_y$ (yielding stress)

$$(2P)^2+(P)^2-(2P)P=\left(\frac{f_y}{FOS}\right)^2$$

$$3(P)^2=\left(\frac{f_y}{FOS}\right)^2 y^2$$

$$P=\frac{f_y}{1.732\times\sqrt{3}}=0.33f_y$$

∴ Maximum magnitude of P before material reaches yield stress is $0.33f_y$

25. Ans: (b)

Sol: $N_u=\frac{N}{\sqrt{H}}$

$$P_u=\frac{P}{H^{3/2}}$$

$$N_s=\frac{N\sqrt{P}}{H^{5/4}}=\frac{N}{\sqrt{H}}\times\sqrt{\frac{P}{H^{3/2}}}=N_u\sqrt{P_u}$$

$$=50\times\sqrt{122}=600$$

For $300 < N_s < 900$, Kaplan turbine is used.

26. Ans: (b)

Sol: $\alpha = 5^o$, F_T = 450 N, F_C = 900 N

$$\beta=\alpha+\tan^{-1}\left(\frac{F_T}{F_C}\right)$$

$$=5+\tan^{-1}\left(\frac{450}{900}\right)=31.6^o$$

Using merchant theory

$$2\phi + \beta - \alpha = 90$$

$$\phi = \frac{90 + \alpha - \beta}{2}$$

$$= \frac{90 + 5 - 31.6}{2} = 31.7^{o}$$

27. Ans: (c)

Sol: Increasing the temperature generally has the following effects on stress-strain curves:

- The ductility and toughness increase
- The yield strength and modulus of elasticity decrease

28. Ans: (d)

29. Ans: (a)

Sol: The declination angle will be zero on September 21.

30. Ans: (c)

Sol: BPF + CF = 1

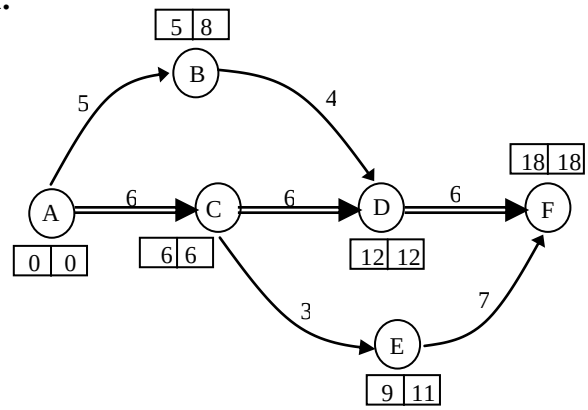
CF = 1- BPF

Low bypass factor signifies high contact factor (CF). Hence high efficiency.

Bypass factor signifies air not coming in contact with coil. It also indirectly indicates efficiency.

31. Ans: (d)

Sol:



Total float on AB = (8 – 0) – 5 = 3

Total float on CE = (11 – 6) – 3 = 2

Free float on EF = (18 – 9 – 7) – (18-11–7)

= 2

32. Ans: (c)

Sol: Following are some ideal conditions that enhance the promotion of continuous chips without BUE formation.

- high cutting speed
- low feed rate
- large back rake angle
- less friction in tool-chip interface

33. Ans: (d)

Sol: Factors affecting the hardenability are :

- Carbon content in the steel: carbon steels are usually quenched in water and alloy steels are quenched in oil. The sudden cooling is called Quenching.

High carbon steels are easily hardenable compared to low carbon steels.

- Rate of cooling: To obtain martensitic structure the cooling rate should be higher than the critical rate.
- Type of quench medium: based on the nature of quench medium like water, oil, polymer quench etc.

34. Ans: (a)

35. Ans: (c)

Sol: The speed of sound depends on the elasticity and density of the medium through which it is travelling.

36. Ans: (c)

37. Ans: (a)

Sol: Reheat factor = $\frac{h_E - h_{2s} + h_F - h_{3s'}}{(h_E - h_{3s})}$

$$= \frac{(30-27)+(28-20.2)}{(30-20)}$$

$$= \frac{3+7.8}{10} = \frac{10.8}{10} = 1.08$$

38. Ans: (c)

Sol:

- By applying force on the lattice along the line of defect the lattice can break or crack easily known as *edge dislocation.*
- *Schott key defect:* Pair of vacancy existing with different charges in a lattice, so that the whole change of the material will be balanced.
- If the lattice atom occupy the interstitial position by creating vacancy in lattice is called *Frenkel defect.*
- If the defect is confined to more number of atoms in a lattice is known as line defect. Ex; Crack formation in a material, where along the line of crack, the atoms are missing. Hence it is a *line defect.*

39. Ans: (a)

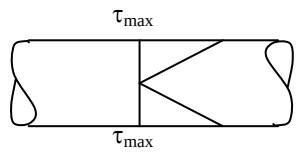
Sol:

- Erosion – Ultrasonic machining
- Ion displacement – Electron chemical machining
- Corrosive reaction – Chemical Machining
- Fusion and Vaporisation – Electron Beam Machining

40. Ans: (a)

Sol: The resistance against Laminar flow is due to viscosity. Further, this resistance is maximum at pipe boundary.

$\therefore$ In laminar flow shear stresses varies linearly with zero at centre and maximum at pipe wall



41. Ans: (c)

Sol: For spherical pressure vessels circumferential stress

$$\sigma_\ell = \sigma_c = \frac{pd}{4t}$$

For cylindrical pressure vessel

$$\sigma_c = 2\sigma_\ell = \frac{pd}{2t}$$

Thus, spherical pressure vessels have lower circumferential stress.

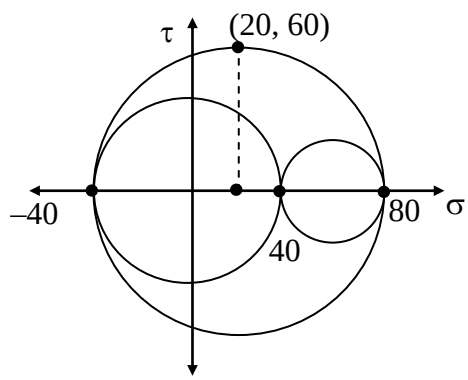
42. Ans: (c)

Sol: Given data:

σ_1 = 80 MPa,

σ_2 = 40 MPa,

σ_3 = –40 MPa



Largest Mohr's circle is considered to calculate maximum shear stress.

The normal stress on maximum shear stress plane is centre of the largest Mohr's circle.

i.e., $\frac{80+(-40)}{2}$ = 20 MPa

43. Ans: (a)

Sol: $a = \frac{h}{2}\left(\frac{\pi w}{\phi}\right)^2 \cos\left(\frac{\pi\theta}{\phi}\right)$

at start of stroke, $\theta = 0$

$$a = \frac{h}{2}\left(\frac{\pi w}{\phi}\right)^2 \rightarrow \text{maximum}$$

at mid stroke, $\theta = \frac{\phi}{2}$

a = 0.

44. Ans: (c)

Sol: In saturated nucleate boiling the rate of heat removal from a heated surface is highest.

45. Ans: (b)

Sol: The materials used in thermo electric refrigeration systems should have high electrical conductivity and low thermal conductivity.

46. Ans: (b)

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47. Ans: (d)

Sol: All the following combinations given are possible cycle plants:

Gas turbine - Steam turbine plant

MHD - Steam plant

Thermionic-Steam plant

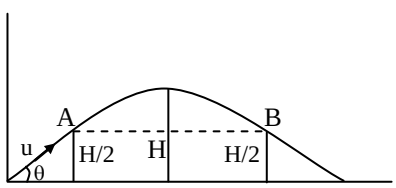
Thermoelectric-Steam plant

48. Ans: (b)

Sol: In meshing gears with involute gear teeth, the contact begins at the intersection of the line of action and the addendum circle of the driven gear.

49. Ans: (b)

Sol:



Let the time taken by projectile from A to B be t,

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{u\cos\theta \times t}{t} = u\cos\theta$$

50. Ans: (b)

Sol: First Law:

$\Sigma Q = \Sigma W$

$Q_C + Q_H - Q_A = 0$

Second Law:

$$\oint \frac{dQ}{T} = 0$$

$$\frac{Q_C}{200} + \frac{Q_H}{400} - \frac{Q_A}{300} = 0$$

$$\frac{Q_C}{200} + \frac{Q_H}{400} - \frac{Q_C + Q_H}{300} = 0$$

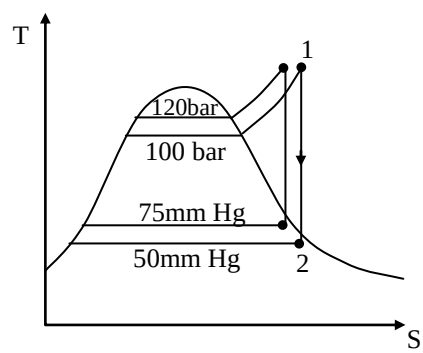
$$Q_C\left[\frac{1}{200} - \frac{1}{300}\right] = Q_H\left[\frac{1}{300} - \frac{1}{400}\right]$$

$$Q_C\left[\frac{1}{600}\right] = Q_H\left[\frac{1}{1200}\right]$$

$$\frac{Q_H}{Q_C} = 2$$

51. Ans: (b)

Sol:



With the increase in condenser pressure from 50 mm Hg to 75 mm Hg and also increase in turbine inlet pressure, it can be seen from the T-S diagram that work output decreases and heat supplied may also increase. This results in decrease in thermal efficiency of a Rankine cycle.

52. Ans: (d)

Sol: Harmful surface ignition results in the following:

- runaway condition
- run on condition
- wild ping
- rumble

53. Ans: (b)

Sol: $T_\infty = 20°C$

$T_s = 100°C$

$T = 20 + 80e^{-y}$

$$\left.\frac{dT}{dy}\right|_{y=0} = -80$$

$k = 10$ W/mK

at surface, conduction heat transfer equal to convective heat transfer

$$-KA\left.\frac{dT}{dy}\right|_{y=0} = hA(\Delta T)$$

$$-10\times(-80) = h(80)$$

$h = 10$ W/m^{2}K

54. Ans: (c)

Sol: Both the following statements are CORRECT.

- The enthalpy of refrigerant remains constant as it flows through a capillary tube.
- The refrigerant mass flow rate through a capillary tube increases as condenser pressure increases and evaporator pressure decreases.

55. Ans: (c)

Sol: Support reactions are due to forces and couple both and need to be zero.

56. Ans: (a)

Sol: Modulus of resilience is defined as elastic strain energy per unit volume of metal.

$\therefore$ 100 J = 100 Nm

Volume of square steel bar

$= (50\text{ mm} \times 50\text{ mm}) \times 5\text{ m}$

$= 2500\text{ mm}^2 \times 5000\text{ mm}$

$\therefore$ Modulus of resilience

$$= \frac{100\,\text{Nm}}{(2500\times5000)\,\text{mm}^3}$$

$$= \frac{100\times10^3}{125\times10^5}\,\text{Nmm/mm}^3$$

$$= \frac{1}{125}\,\text{Nmm/mm}^3$$

57. Ans: (b)

Sol: The static thrust is the thrust developed at starting of take off.

$\therefore\ F_s = \dot{m}(V_o - V_i) = 580 \times 600 = 30$ kN

58. Ans: (b)

Sol: $V = \pi DN$

$$11 = \frac{22}{7} \times \frac{35}{1000} \times N$$

N = 100 rpm

$f_m = f_t \times z \times N$

$= 0.025 \times 20 \times 100$

$f_m = 50$ mm/min

59. Ans: (b)

Sol: If a specimen is first subjected to tension and deformed plastically and then the load is released and a compressive load is applied, the yield stress in compression is found to be lower than that in tension. This behavior is known as the Bauschinger effect; it is exhibited in varying degrees by all metals and alloys. The phenomenon is also called strain softening or work softening, because of the lowered yield stress in the direction opposite that of the original load application.

The higher shear stress required to overcome entanglements and impediments results in an increase in the overall strength and hardness of the metal, and is known as work hardening or strain hardening.

Superplasticity: The term superplasticity refers to the capability of some materials to undergo large uniform elongation prior to necking and fracture in tension.

60. Ans: (b)

61. Ans: (d)

Sol: Dryness fraction, $x = \frac{60}{100} = 0.6$

Specific volume of mixture = $v_f + x(v_g - v_f)$

$= 0.001 + 0.6 \times (0.89 - 0.001)$

$= 0.534\ m^3/kg$

Total mass = $\frac{534}{0.534} \cong 1000$ kg

62. Ans: (d)

Sol: By work energy theorem,

Work done by chain + Work done by gravity = ΔK.E

Work done by chain

$$= \frac{1}{2} \times 30 \times 0.4^2 - 30 \times 10 \times 2$$

$= -597.6$ J

63. Ans: (d)

Sol: $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{10^2}{15(15-10)} = 1.33$

64. Ans: (c)

Sol: Heat to be supplied = Heat rate × Power

$$= 10000 \times 100 \times 10^3$$

$\dot{Q} = 10^9$ kJ/hr

Amount of coal $= \frac{\dot{Q}}{C_v} = \frac{10^9}{40000}$

$$= \frac{10^5}{4} = 25000 \ \text{kg/hr}$$

65. Ans: (d)

Sol: Ignition lag is minimum for SI engine fuels at slightly rich mixture.

66. Ans: (c)

67. Ans: (b)

Sol: Equilibrium equation,

$$T_A + T_B = T \quad \text{----------(1)}$$

Compatibility condition is "angle of twist at the point of application of torque is same for both portion of shaft".

$\therefore \theta_{AC} = \theta_{BC}$

$$\frac{T_A L}{2(2GJ)} = \frac{T_B L}{2GJ}$$

$T_A = 2T_B$ --------(2)

From (1) and (2)

$$T_B = \frac{T}{3}$$

68. Ans: (a)

Sol:

- Turbojet can be used for subsonic as well as supersonic aircrafts.
- Turbofan is suitable only for subsonic aircrafts.
- Ramjet does not use rotating component.
- Rocket does not use external air.

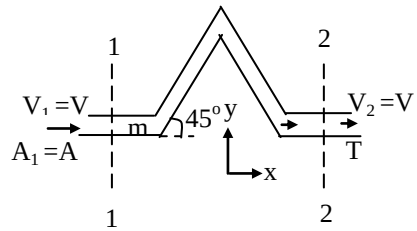
69. Ans: (d)

Sol: Given Data

ρ = mass density of fluid through bend pipe (kg/m^3)

A = cross- section area of pipe (m^2)

V = Velocity of flow in pipe (m/s)



Applying Momentum equation between sections (1) and (2)

In X – direction:

Force exerted by water,

$$\Sigma F_x = \dot{m}(V_{2x} - V_{1x})$$

$$= \dot{m}(V - V)$$

$F_x = 0$

In Y- direction:

Force exerted by water

$$\Sigma F_y = \dot{m}(V_{2y} - V_{1y}) = \dot{m}(0 - 0) = 0$$

$$\Rightarrow \quad F_x = 0 \ \& \ F_y = 0$$

70. Ans: (b)

Sol: $\text{Time/cut} = \frac{B}{f} \times \frac{L}{V}(1 + M)$

$$= \frac{300}{0.1} \times \frac{1200}{45}\left(1 + \frac{1}{4}\right) \times \frac{1}{1000}$$

$$= \frac{300}{0.1} \times \frac{1200}{45} \times \frac{5}{4} \times \frac{1}{1000}$$

$= 100$

71. Ans: (b)

Sol: Some Major Processing Methods for Polymers

Thermoplastics

Injection molding

Blow molding

Extrusion molding

Thermosetting

Transfer molding

Compression molding

72. Ans: (c)

Sol: Given:

r = 50 mm and v = 10 m/s

Volumetric flow rate (m^3/sec) is

$Q(m^3/sec) = \pi r^2.v,$

$= \pi\left(50 \times 10^{-3}\right)^2 \times 10\,m/s$

$= 0.0785\ m^3/sec$

73. Ans: (c)

74. Ans: (b)

Sol: Favourable winds for small-scale applications exist on 75% of the earth's surface.

75. Ans: (d)

Sol: The effects of regenerative feed water heating for the same turbine output may be summarized as given below:

- It significantly increases the cycle efficiency and reduces the heat rate (reducing operating cost).
- It increases the steam flow rate (requiring bigger boiler).
- It reduces the steam flow to the condenser (needing smaller condenser).
- If there is no change of boiler output, the turbine output drops.

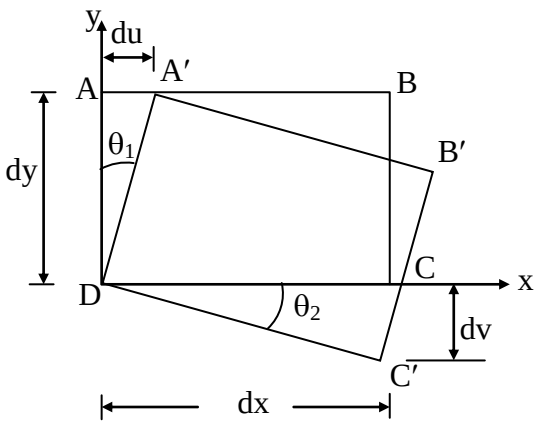
76. Ans: (c)

Sol:

- When the DBT and DPT are equal, the relative humidity of air water mixture is 1.
- The maximum amount of moisture air can hold depends upon its temperature and barometric pressure.

77. Ans: (b)

Sol:



Shear strain is defined as change in angle between any two initially perpendicular planes.

$\therefore \gamma_{xy} = \theta_1 + \theta_2$

$= \tan\theta_1 + \tan\theta_2 \quad [\because \theta_1, \theta_2 \to 0]$

$$\gamma_{xy} = \frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}$$

78. Ans: (b)

Sol: For backward vane pump, $\beta_2 < 90°$.

The velocity vectors must satisfy relation,

$$\vec{V} = \vec{V}_{r2} + \vec{u}_2$$

Only option (b) satisfies both the conditions.

79. Ans: (b)

Sol: $\vec{a}_{coriolis} = 2\omega v\,\hat{j}$

$= 2 \times 6 \times 5\,\hat{j} = 60\,\hat{j}$

80. Ans: (d)

Sol: As we know,

Maximum material limit of hole = lower limit of hole

$\therefore$ Maximum material limit of hole = 25.02 mm

Minimum material limit of shaft = lower limit of Shaft

$\therefore$ Maximum material limit of shaft = 25.02 mm

81. Ans: (d)

Sol: Alloying elements can play a dominant role in the susceptibility of cast irons to corrosion attack. The alloying elements generally used to enhance the corrosion resistance of cast irons include Silicon, Nickel, *Chromium*, Copper and Molybdenum.

82. Ans: (d)

Sol: A **mobile robot** is a machine controlled by software that use sensors and other technology to identify its surroundings and move around its environment.

Mobile robots function using a combination of artificial intelligence (AI) and physical **robotic** elements, such as wheels, tracks and legs. So above three types come to the mobile robotics.

83. Ans: (b)

Sol: A vertical surface receives 50% of the reflected component of radiation.

84. Ans: (b)

Sol: In a fuel air cycle actual the maximum mean effective pressure is obtained at a spark advance of 17°.

85. Ans: (b)

Sol: For the condition given, $t_1 < t_2 < t_3$.

86. Ans: (c)

Sol: Let δ_P and δ_b be the compression in plate and elongation in bolt respectively.

The sum of deformation in the bolt and plate must be equal to distance traveled by the nut.

$$\delta_p + \delta_b = \delta$$

$$\frac{P}{k_p} + \frac{P}{k_b} = \delta$$

$$P = \frac{k_p k_b}{k_p + k_b} \times \delta = \frac{400 \times 100}{400 + 100} \times 4 = 320 \text{ kN}$$

87. Ans: (a)

Sol: Volumetric efficiency (η_v) is given by

$$\eta_v = \frac{2 - 0.1}{2} = 0.95$$

The overall efficiency is given by

$$\eta_o = \eta_v \times \eta_h \times \eta_m$$

$$0.75 = 0.95 \times 0.9 \times \eta_m$$

$$\therefore \eta_m = 0.88$$

88. Ans: (d)

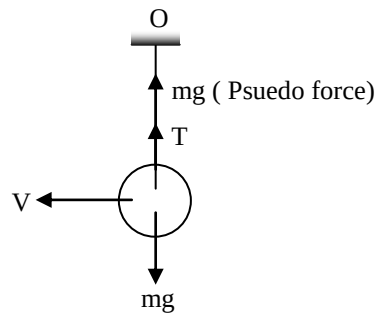
Sol:

List-I (M, G codes)		List-II (function)
M 06	→	Tool change
M 11	→	Vice Close
G 18	→	ZX plane selection
G 19	→	YZ plane selection

89. Ans: (c)

90. Ans: (c)

Sol: F.B.D of bob in box frame,



Thus it has only T(tension force) acting towards its centre of motion (O). Hence, it will undergone circular motion.

91. Ans: (b)

Sol: $EOQ = \sqrt{\frac{2 \times 100 \times 15}{7.5}} = 20$ units

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92. Ans: (a)

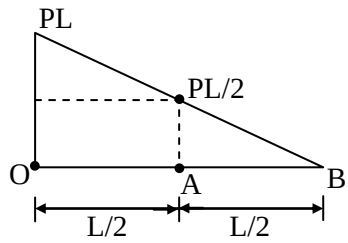
Sol: The polytropic index n is a property of the gas is INCORRECT statement. Hence, correct option is (a).

93. Ans: (d)

Sol: As speed in SI engine increases bsfc decreases and then increases.

94. Ans: (c)

Sol: The deflection at point 'A' can be found from moment area method as given below.



$\delta_{A/O} = \frac{1}{EI}$(Moment of area of BMD between O and A about A)

$$= \frac{1}{EI}\left[\left(\frac{PL}{2}\times\frac{L}{2}\right)\times\left(\frac{L}{4}\right)+\left(\frac{1}{2}\times\frac{PL}{2}\times\frac{L}{2}\right)\times\left(\frac{2}{3}\times\frac{L}{2}\right)\right]$$

$$= \frac{PL^3}{EI}\left(\frac{1}{16}+\frac{1}{24}\right) = \frac{5PL^3}{48EI}$$

95. Ans: (c)

Sol:

- All the turbines have adjustable guide vanes.
- Except Kaplan turbine all the turbine have fixed runner vanes.
- Fourneyron turbine is radially outward flow reaction turbine which is obsolete now.

96. Ans: (d)

Sol: According to Prandtl, mixing length is that distance in the transverse direction which must be covered by a lump of fluid particles traveling with its original mean velocity in order to make the difference between its velocity and the velocity of the new layer equal to the mean transverse fluctuation in turbulent flow.

Also Prandtl maxing length is the distance one has to move normal to the flow so that

$u = u'$

$$\tau_{Turb} = \rho\ell^2\left(\frac{\overline{dv}}{dy}\right)^2$$

Where, l = Prandtl maxing length

For turbulent flow in circular pipes, Prandtl assumed the mixing length 'l' to be linear function of the distance 'y' from the pipe wall, in the nearer region of wall.

i.e., $l \sim y$

or $l = \kappa.y$

Where k (Greek kappa) is the constant of proportionality and is the so called 'Karman universal constant'

The value of $\kappa = 0.4$ (as per Nikuradse)

$\therefore$ The prandtl mixing length near the boundary is zero.

97. Ans: (a)

Sol: A wind turbine extracts maximum power from wind, when the downstream wind speed reduces to one-third that of upstream wind.

98. Ans: (a)

Sol: The transverse shear stress is present at neutral axis, its value is maximum at support where shear force is maximum

$$(\tau_{max})_{N.A} = \frac{3}{2}(\tau_{avg})$$

$$= \frac{3}{2} \times \frac{wL}{A}$$

$$= \frac{3}{2} \times \left[\frac{5 \times 10^3 \times 2}{0.05 \times 0.08}\right] = 3.75 \text{ MPa}$$

99. Ans: (d)

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

$$= 1 \times 10^{-3}\left(\frac{800}{1.2} - 1\right)$$

$$= 0.665 \text{ m}$$

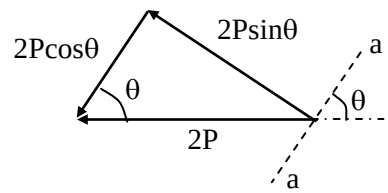
$$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.665}$$

$$= 3.614 \text{ m/s}$$

$$= 3.614 \times 10^{-3} \times 3600 \text{ km/hr} = 13 \text{ km/hr}$$

100. Ans: (b)

Sol: The force in section a-a is 2P which can be resolved into normal and tangential components as,



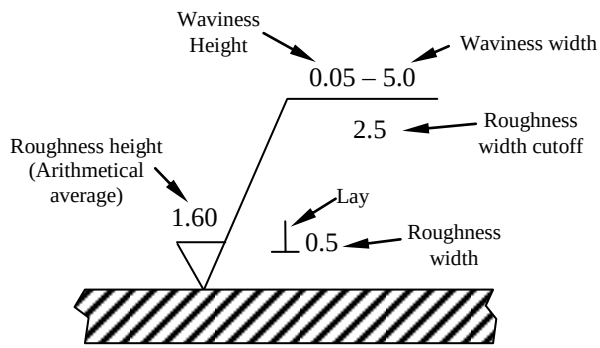
The resisting area along a-a is $\frac{A}{\sin\theta}$.

$$\sigma_n = \frac{\text{Normal force}}{\text{Resisting area}}$$

$$= \frac{(2P\sin\theta)}{(A/\sin\theta)} = \frac{2P}{A}\sin^2\theta$$

101. Ans: (b)

Sol: From the below figure, the waviness width is 5.0 in microns.



102. Ans: (a)

Sol: $P_1 + \gamma_1 (1.5 - 1) + \gamma_2 (1) - \gamma_w (0.5) = 0$

$\Rightarrow P_1 = 0.5\,\gamma_w - 0.5\,\gamma_1 - \gamma_2$

$= \gamma_w (0.5 - 0.5S_1 - S_2)$

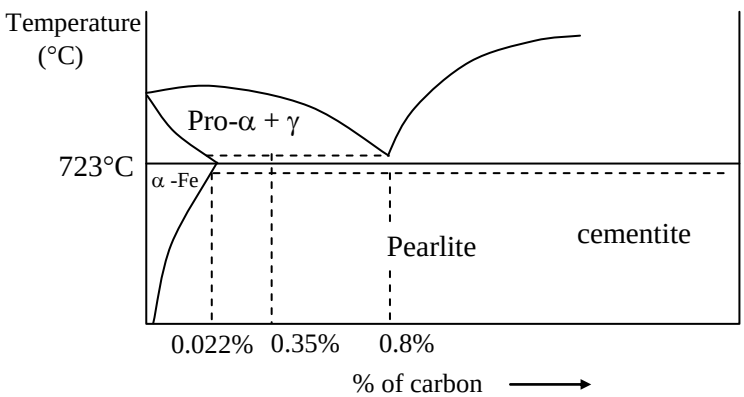
$= 9.81 (0.5 - 0.5 (0.88) - 0.95)$

$= 9.81 (- 0.89) = - 8.7309$ kPa

103. Ans: (a)

Sol: Fraction of total ferrite and cementite phase:

Applying lever rule between 0.022% and 6.67% carbon with fulcrum at 0.35% carbon, just below 723°C.



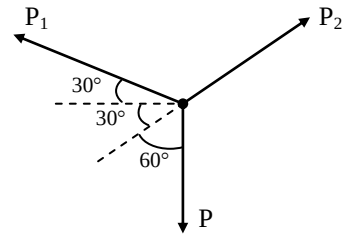
$$f_\alpha = \frac{6.67 - 0.35}{6.67 - 0.022} = 0.95$$

$$f_{Fe_3C} = \frac{0.35 - 0.022}{6.67 - 0.02} = 0.05$$

104. Ans: (c)

105. Ans: (a)

Sol: Due to applied load 'P' the rod 'OM' is under tension and the rod 'ON' is under compression. The free body diagram of joint 'O' is



By Lame's theorem,

$$\frac{P_1}{\sin 120^o} = \frac{P_2}{\sin 120^o} = \frac{P}{\sin 120^o}$$

$\Rightarrow P_1 = P$ (Tension)

$\Rightarrow P_2 = P$ (Compression)

The strain energy (U) stored in the bars is given by

$$U = \frac{P_1^2 L}{2AE} + \frac{P_2^2 L}{2AE} = \frac{P^2 L}{AE}$$

$[\because P_1^2 = P_2^2 = P^2]$

By Castigliano's second theorem,

$$y_o = \frac{\partial U}{\partial P} = \frac{2PL}{AE}$$

106. Ans: (c)

Sol: $C_d = \frac{Q}{Q_{th}} = \frac{a.V}{a_{th} V_{th}} = \frac{a}{a_{th}} \times \frac{V}{V_{th}}$

$C_d = C_c \times C_v$

$0.88 = C_c \times 0.96$

$C_c = 0.92$

107. Ans: (b)

108. Ans: (a)

Sol: $F = P_{CG} A$

$= (100\times10^3 + 1000\times10\times1) \times (2\times4)$

$= 880$ kN

Note: In order to get net force P_{atm} should be first subtracted from both sides.

109. Ans: (c)

110. Ans: (d)

Sol: $V_1 = \frac{Q}{A_1} = \frac{4000}{20} = 200$ cm/s = 2 m/s

$V_2 = \frac{Q}{A_2} = \frac{4000}{10} = 400$ cm/s = 4 m/s

From Beruoulli's equation,

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

$$P_1 - P_2 = \frac{\rho}{2}\left(V_2^2 - V_1^2\right) + \rho g\left(Z_2 - Z_1\right)$$

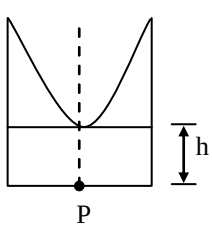
$$= \frac{1000}{2}\left(4^2 - 2^2\right) + 1000\times10\left(-0.5\right)$$

$= 1$ kPa

111. Ans: (b) **112. Ans: (b)**

113. Ans: (b)

Sol:



$P = P_{atm} + \gamma \times h$

$P = \gamma \times h$

$\frac{P}{\gamma} = h = 0.6$ (Given)

Therefore, the required ratio,

$$= \frac{1}{2}\pi R^2\left(1.2 - 0.6\right) \div \pi R^2 \times 1.2$$

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

114. Ans: (b)

Sol: Let the equilibrium temperature be T,

Heat lost by first copper piece = Heat gained by second copper piece

$1 \times c_p \times (400 - T) = 1 \times c_p \times (T - 300)$

$T = 350$ K

Entropy change for the process

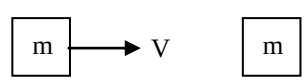
$$= 1\times c_p \times \ell n\left(\frac{350}{400}\right) + 1\times c_p \times \ell n\left(\frac{350}{300}\right)$$

$= 22.6 \times (-0.13) + 22.6 \times 0.15$

$= 0.452$ J/K

115. Ans: (d)

Sol: Before collision



Finally just after collision

Loss in kinetic energy

$$= \frac{1}{4} \times \frac{1}{2} mV^2 = \frac{1}{8} mV^2 \quad \text{------(i)}$$

Loss of kinetic energy

$$= \frac{1}{2} mV^2 - \frac{1}{2} m\left(V_1^2 + V_2^2\right)$$

$$= \frac{1}{2} m\left(V_1 + V_2\right)^2 - \frac{1}{2} m\left(V_1^2 + V_2^2\right) \text{ ---(ii)}$$

$[\because mV = mV_1 + mV_2 \quad \text{or} \quad V = V_1 + V_2]$

From (i) and (ii),

$V^2 = 8\, V_1\, V_2$

Now, $(V_2 - V_1)^2 = (V_1 + V_2)^2 - 4V_1\, V_2$

$$\left(V_2 - V_1\right)^2 = V^2 - \frac{V^2}{2} = \frac{V^2}{2}$$

$$\therefore \; V_2 - V_1 = \frac{V}{\sqrt{2}}$$

$$e = \frac{V_2 - V_1}{V} = \frac{1}{\sqrt{2}}$$

116. Ans: (b)

Sol: $\sigma = \rho V^2$

$$\sigma = \frac{10 \times 10^{-3}}{10^{-6}} \times 60^2 = 3.6 \times 10^7 \text{ N/m}^2$$

117. Ans: (c)

Sol: The value of TTD varies with heater pressure. For L.P. heaters receiving wet steam, the TTD is positive and often of the order of 3°C. Too small a value, although good for plant efficiency, would require a larger heater. Too large a value would reduce the cycle efficiency.

118. Ans: (b)

Sol: Removal of CO_2 and O_2 dissolved in boiler water is necessary to reduce corrosion.

119. Ans: (d)

Sol: Delay period in CI engine decreases due to

- increase in jacket water temperature
- increase in engine size
- increase in swirl rate

120. Ans: (c)

Sol: For comfort chart the following are recommended :

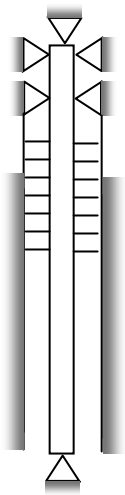
- Lower DBT and lower moisture content are recommended for winter.
- Higher DBT and higher moisture content are recommended for summer.

121. Ans: (b)

Sol: For the same lift and same angle of ascent, a smaller base circle will give a large value of pressure angle.

122. Ans: (b)

Sol:



Slenderness ratio

$$\lambda = \frac{\text{Effective length}}{\text{Radius of gyration}}$$

$$\lambda = \frac{\ell_e}{R_{min}}$$

Since, the column is supported throughout its length, distance between two adjacent points of contra flexure is nearly zero.

$l_e \to 0 \to \lambda = 0$

123. Ans: (c)

Sol: Kinematic similarity is prerequistic for dynamic similarity & geometric similarity is prerequistic for kinematic similarity. Without geometric similarity flow pattern cannot be similar and without similar flow pattern forces cannot be proportional.

However, geometric similarity doesn't guarantee similar flow pattern and similar flow pattern cannot guarantee proportional forces. (For example, flow over a plate in subsonic and supersonic regions has similar streamline pattern but nature of forces is quite different).

124. Ans: (b)

Sol: Find Reciprocals of the intercepts of the plane. Miller indices obtained after taking LCM.

Example: For Fig.1, intercepts are 1,α,α. Their reciprocals are 1, 0, 0. Hence Miller Indices (100). Similarly, for the other planes, (200) (100) (111)

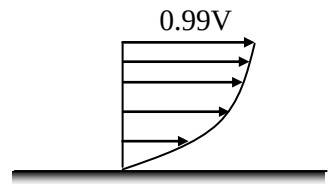
125. Ans: (d)

Sol: The correct statement is given below:

Acoustic emission testing basically works on the principle of measuring the generated elastic waves due to crack initiation.

126. Ans: (c)

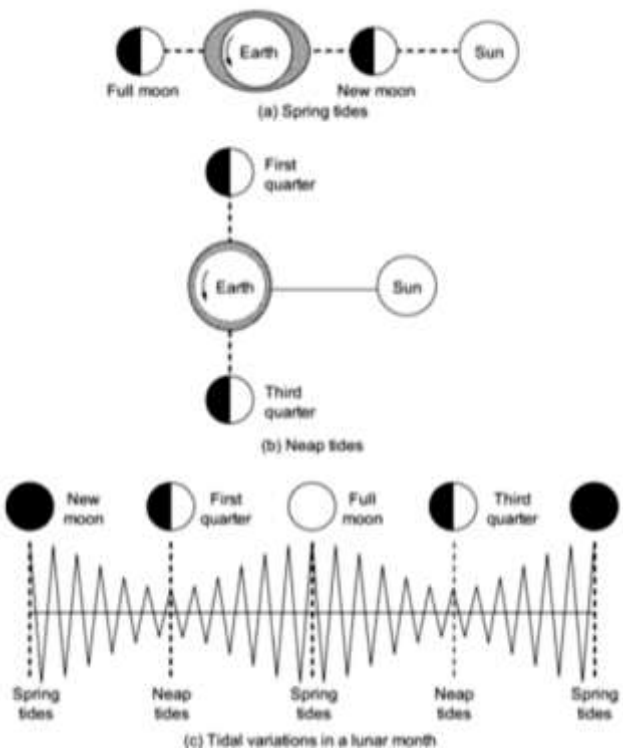
Sol: Within the boundary layer region, the velocity changes form zero to that of 99% of free stream velocity.



It means, the velocity varies from point to point. Velocity changes will occur only if viscous shear forces are considerable.

127. Ans: (d)

Sol: Referring to the figure for nature of tides given below, option (d) is the correct answer.



128. Ans: (a)

Sol: Maximum shear stress theory :

Design condition, $|\sigma_1 - \sigma_2| \le \sigma_{yt}$

But $\sigma_1 = -\sigma_2$ (Pure shear)

$2\sigma_1 \le \sigma_{yt}$

$$\sigma_1 \le \frac{\sigma_{yt}}{2}$$

$$\frac{F}{A} \le \frac{\sigma_{yt}}{2}$$

$$\Rightarrow A_{MSST} \ge \frac{2F}{\sigma_{yt}}$$

Maximum principal stress theory :

$$\sigma_1 \le \sigma_{yt}$$

$$\frac{F}{A} \le \sigma_{yt}$$

$$A_{MPST} \ge \frac{F}{\sigma_{yt}}$$

129. Ans: (a)

Sol: Large generators are cooled with hydrogen. The thermal properties of hydrogen (like specific heat and thermal conductivity) are superior to those of air and allow for reduced windage and better cooling. Windage and ventilating losses are lower because of the low density of hydrogen.

The generator losses may be reduced by using hydrogen at higher pressures, say 2 bar. The specific heat of hydrogen is the highest, since its molecular weight is the least.

130. Ans: (a)

131. Ans: (a)

132. Ans: (b)

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133. Ans: (d)

Sol:

- Statement (II) is true because incase of simply supported beams, bending moment at supports is always zero.
- In case of internal pin supports, bending moment at supports is not zero. Hence, statement (I) is incorrect.

134. Ans: (d)

Sol: As there is no external work added in diffuser, stagnation pressure as well temperature remain constant. However, static pressure increases due to conversion of velocity into pressure.

135. Ans: (c)

Sol: AS/RS is used as material handling system in store for automatic storage limited goods and automatic retrieval of raw material for machining.

136. Ans: (b)

Sol: Graphene is the basic structural element of carbon nano tubes. It is one atom thick planer sheet of (Sp^2 bonded) carbon atoms that are densely packed in honeycomb crystal lattice.

Graphene is stronger and stiffer than diamond. Its surface area is the largest known for its weight. So both statements are correct. But statement (II) is not correct explanation of Statement (I).

137. Ans: (b)

Sol: In general, a measurement system consists of four types of elements: sensing, signal conditioning, signal processing and data presentation elements.

A measurement system is often made a part of the control system. Both Statements are individually correct.

138. Ans: (c)

139. Ans: (b)

Sol: Blades are held at one end with the rotor while the other end is free. So they act as cantilevers with distributed load of steam on them. They are subjected to bending stresses. Since they are rotating at a high rpm, so they are subjected to centrifugal stresses also. As the blade height increases, both bending and centrifugal stresses increase. Due to these stresses, both blade height and blade diameter get restricted.

140. Ans: (a)

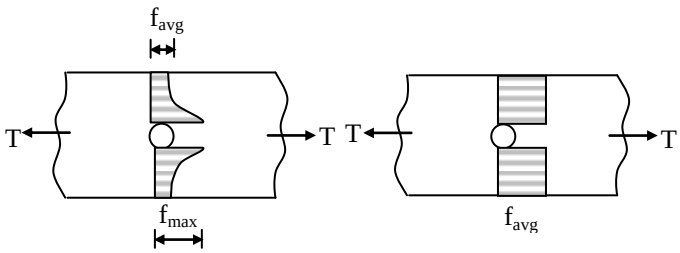
141. Ans: (c)

Sol: Bypass factor of coil indicates inefficiency of the system.

142. Ans: (a) **143. Ans: (a)**

144. Ans: (b)

Sol:



When the component is subjected to fluctuating loading, both ductile and brittle materials fail by brittle fracture. Hence the effect of stress concentration cannot be neglected.

$$\text{Stress concentration factor} = \frac{\text{Maximum Stress at discontinuity}}{\text{Nominal Stress at discontinuity}}$$

145. Ans: (a)

Sol: As Parson's turbine is a reaction turbine. Enthalpy is dropped both in fixed as well as moving blades. As enthalpy decreases pressure also decreases.

146. Ans: (c)

147. Ans: (a)

Sol: Most materials are less dense in their liquid state than in their solid state and denser at lower temperatures in general. Due to this nature, a metal casting undergoing solidification will tend to decrease in volume. During the manufacture of a part by casting this decrease in volume is termed shrinkage.

148. Ans: (b)

Sol:

- Critical path can be calculated by means of forward pass technique i.e. earliest occurrence time of last event will give the project completion time. Hence, statement I is correct.
- Critical path contains zero slack events and zero float activities. Hence, statement II is correct.
- Both the statements are independently correct.

149. Ans: (b)

150. Ans: (c)

Sol: Kengoro, the **Most Advanced Humanoid Robot** Yet. The **most advanced humanoid robot** to date has been **developed** by a team of researchers at the University of Tokyo.