ACE Engineering Academy

Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.

Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437

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ESE- 2019 (Prelims) - Offline Test Series — Test – 24

MECHANICAL ENGINEERING

MOCK TEST – 2 (PAPER – II) — SOLUTIONS

01. Ans: (d)

Sol: Given data:

$\nu = 0.0004\ m^2/s$, S.G = 0.9

$d_{ram} = 280$ mm, $d_{cyl} = 280.2$ mm

$L_{ram} = \frac{5}{\pi} m$,

Travel of the ram = 0.2 m/s

Dynamic viscosity, $\mu = \rho \times \nu = 900 \times 0.0004$

$= 0.36$ Pa.s

Shear stress, $\tau = \mu \frac{dv}{dy}$

$$= 0.36 \times \left[\frac{0.2}{\left(\frac{280.2 - 280}{2 \times 1000}\right)}\right]$$

$$= 0.36 \times \frac{0.2 \times 2 \times 1000}{0.2}$$

$= 720\ N/m^2$

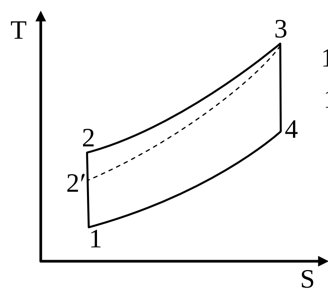
Thus, friction force = $\tau \times A$

$= 720 \times (\pi \times 0.28 \times \frac{5}{\pi})$

$= 720 \times 1.4$ N = 1008 N

02. Ans: (c)

Sol:



1-2-3-4 →Diesel cycle

1-2′-3-4 → Otto cycle

$\eta_{diesel} > \eta_{otto}$ [∵ Heat supplied is more]

$\therefore\ T_2 > T_2'$

03. Ans: (d)

Sol: Twin spark plug reduces flame quenching. Hence, less HC emissions.

04. Ans: (b)

Sol:

- Due to higher fluid velocity in the impulse stage the energy loss due to friction is higher than that in the reaction stage.
- For good efficiency blade height should vary with diameter. For this reason, twisted or wrapped blades are used in later stages of the turbine.

05. Ans: (a)

Sol: $P_t = 90$ kPa

$\phi = 0.75$,

$\omega = 6.22$ gm of wv/kgda

$$\omega = 0.622\frac{P_v}{P_t - P_v}$$

$$0.00622 = 0.622\frac{P_v}{P_a} \quad [\because P_a + P_v = P_t]$$

$$\frac{1}{100} = \frac{90 - P_a}{P_a}$$

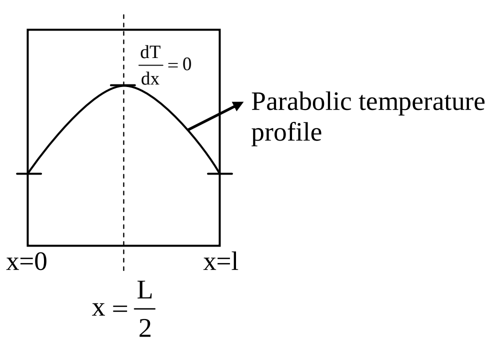
$P_a = 9000 - 100$ Pa

101 Pa = 9000

$\Rightarrow \quad P_a = 89.1$ kPa

06. Ans: (c)

Sol: Temperature profile for 1-D, steady heat conduction with internal heat generation, inside the plane wall is shown below.



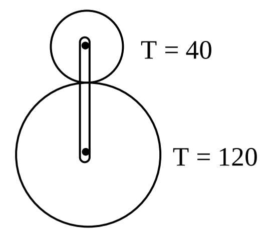
$\text{At}\, x = \frac{L}{2}, \frac{dT}{dx} = 0$ and temperature is maximum.

07. Ans: (b)

Sol: High cost is considered to be the major disadvantage when solar cells are used for power generation.

08. Ans: (d)

Sol:



$$\frac{N_g - N_a}{N_p - N_a} = -\frac{T_p}{T_g}$$

$$\frac{N_g - 1}{N_p - 1} = -\frac{40}{120} = -\frac{1}{3}$$

$3N_g - 3 = -N_p + 1$

$\therefore \quad N_p = 4 \qquad (\because \; N_g = 0)$

09. Ans: (a)

10. Ans: (d)

Sol: Rate of production (k) = 500/month

Rate of consumption (d) = 300/month

Lot size of production (Q) = 1000 units

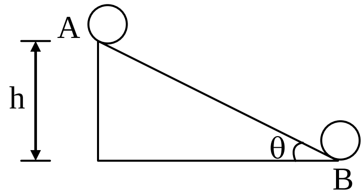
Max. inventory (Q_{max}) = $Q\left(\frac{k-d}{k}\right)$

$= 1000\left(\frac{500-300}{500}\right)$

$= 400$

11. Ans: (c)

Sol:



By using conservation of mechanical energy at top and bottom of incline.

$$mgh = \frac{1}{2}I_{c.m}\omega^2 + \frac{1}{2}\times m\times V_{c.m}^2 \text{ ---------(1)}$$

Where, h = height of incline

$I_{c.m}$ = Moment of inertia of sphere about its centre of mass.

ω = Angular velocity of sphere at the bottom of incline.

$V_{c.m}$ = Velocity of centre of mass of sphere at bottom of incline.

$V_{c.m} = \omega R$ ----------(2) (for pure rolling)

From (1) and (2)

$$V_{c.m} = \sqrt{\frac{10gh}{7}}$$

Thus, $V_{c.m}$ is same for both sphere.

Now, let 't' be the time taken by sphere to reach the bottom.

$V_{c.m.} = g\sin\theta\times t$

$$t = \frac{V_{c.m}}{g\sin\theta}$$

Thus, time taken is same for both the sphere.

12. Ans: (a)

13. Ans: (c)

Sol: The common alloying elements added to steel for improving its oxidation resistance are chromium, aluminium and nickel.

14. Ans: (c)

Sol: Two basic type of die-casting machines are used; hot-chamber and cold-chamber die casting. *Hot-chamber die casting, used for low-melting-point metals such as Sn and Zn, has a melting pot as a part of the die-casting machine*, whereas cold-chamber die casting, used for Al and Mg alloys, has the melting furnace separate from the die-casting unit, and requires metal to be transported from the furnace to the die-casting unit.

15. Ans: (a)

16. Ans: (a)

Sol: Given data : $P_A - P_B = 27$ kPa

$$\frac{P_A}{\gamma} - \frac{P_B}{\gamma} = 1.5 + (1.6 - 1.0)R_m$$

[when CCl_4 is used]

or $$\frac{27\times10^3}{10^4} - 1.5 = 0.6\,R_m$$

$\Rightarrow R_m = 2.0$ m of CCl_4

17. Ans: (a)

Sol: $\eta_{th} = \frac{W_{net}}{Q_s} = \frac{900}{1800} = 0.5$

$$\eta_{carnot} = \frac{600 - 300}{600} = 0.5$$

∴ Engine is reversible and irreversibility is zero.

18. Ans: (d) **19. Ans: (c)**

20. Ans: (b)

Sol: Desirable properties of refrigerant:

- Latent heat of vaporization at evaporator pressure is responsible for heat absorption.
- Critical pressure of refrigerant should be as high as possible.

21. Ans: (d)

Sol: In the lumped capacitance method for transient heat conduction problem we consider that the temperature of solid is not varying with position. This is possible only when conduction resistance in the solid is much less than the resistance to convection across the fluid boundary layer. Such assumptions are valid under the following consideration.

- The physical size of the body is very small.
- Thermal conductivity of the material is very large.
- Heat transfer coefficient is very small.

22. Ans: (a)

Sol: Bulb turbines are low head turbines used to produce power from tidal energy.

23. Ans: (d)

Sol: Any distributed mass can be replaced by two point masses to have same dynamic properties if

- The sum of the two masses is equal to total mass.
- The combined centre of mass coincides with that of the rod.
- The moment of inertia of the two point masses about the perpendicular axis through their combined centre of mass is equal to that of the rod.

24. Ans: (b)

25. Ans: (b)

Sol: Sequencing is systematic procedure for assigning priorities to waiting jobs.

The establishing the quantity of load to each work ceter should carry during specific planned period is called loading.

It is the study of the relation between the load and capacity work centers.

26. Ans: (c)

Sol: Linear momentum must remain constant. Hence, speed must be equal (as masses are equal) and should be in opposite direction.

27. Ans: (a)

28. Ans: (d)

Sol:

- The most common copper alloys are the **brasses,** for which zinc, as a substitutional impurity, is the predominant alloying element.
- Some of the common uses for brass alloys include costume jewelry, cartridge casings, automotive radiators, musical instruments, electronic packaging, and coins. Hence, given statement is incorrect.
- The **bronzes** are alloys of copper and several other elements, including tin, aluminum, silicon, and nickel. These alloys are somewhat stronger than the brasses, yet they still have a high degree of corrosion resistance.
- Applications include jet aircraft landing gear bearings and bushings, springs, and surgical and dental instruments.

29. Ans: (c)

Sol: It is orthogonal cutting, therefore MCD is valid.

Since, $\phi = 90°$ and $P_x = P_{xy}\sin\phi$

$P_{xy} = P_x = 400$ N

We know from MCD that when the rake angle γ_o is 0°.

The friction force is (F) = P_{xy} = 400 N

Normal force is N = P_z = 800 N

Coefficient of friction $(\mu_s) = \frac{F}{N}$

$= \frac{400}{800} = 0.5$

30. Ans: (c)

31. Ans: (b)

Sol: Given data :

$(F_R)_{water}$ = 32.4 kN acting at a distance of 1.9 m from the free liquid surface.

$\Sigma M_{hinge} = 0$

$$(F_R)_{water} \times (h_{cp} - 1.2) = F_{gas} \times \frac{1.8}{3}$$

$$32.4\,(1.9 - 1.2) = F_{gas} \times 0.6$$

$$F_{gas} = \frac{32.4 \times 0.7}{0.6} = 54 \times 0.7$$

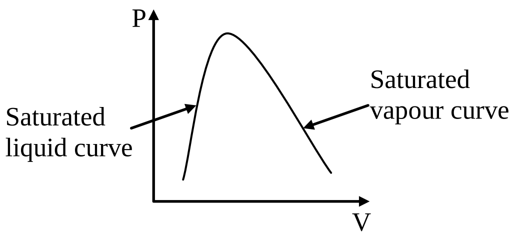
$$\text{or } P_{gas} \times \frac{1}{2} \times 2 \times 1.8 = 54 \times 0.7$$

$$\Rightarrow P_{gas} = \frac{54 \times 0.7}{1.8} = 21 \text{ kPa}$$

32. Ans: (b)

Sol:

- As pressure increases enthalpy of vaporization decreases and at critical point enthalpy of vaporization is zero.



33. Ans: (a)

34. Ans: (d)

Sol:

- If vapour bubbles flow along with saturated water from drum to down comer then this will reduce density difference and pressure head for natural circulation.
- Steam is separated in steam drum and is taken to super heater. Water from the economizer is continuously entering the drum. So the solid content of water in the drum goes on increasing. Thus, blow down is necessary to maintain a certain ppm of solid contents (TDS) in the drum.

35. Ans: (d)

Sol: Ammonia is non-corrosive to steel.

36. Ans: (b)

Sol: In a laminar, incompressible, thermally fully developed flow through a circular tube, the Nusselt number must be constant.

Nu = 4.36 (for constant heat flux condition)

Nu = 3.66 (for constant wall temperature condition)

37. Ans: (b)

Sol: Power from wind is being extracted since olden days. However, it does not provide a constant uninterrupted sources of energy. Thus, statement (b) is wrong. All other statements are correct.

38. Ans: (a)

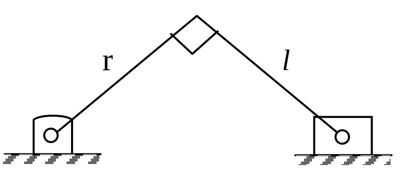
Sol: $\omega_d = \sqrt{1-\xi^2}\,\omega_n$

$= \sqrt{1-(0.8)^2} \times 100$

= 60 rad/sec

39. Ans: (a)

Sol:



Turning moment for this position = $F_c \times r$

$2\times10^3 = F_c \times 200$

$\Rightarrow \quad F_c = 10$ N

40. Ans: (d)

Sol:

- **Dispatching** is used in Production Planning Control.
- Bucket refers to an individual period indicated by MRP list.
- **Time bucket:** The time period used for planning purposes in MRP.
- **Master production Schedule :** It dictates gross or projected requirements for end items to the MRP system.
- **Bill of materials** (BOM) or Product structure file what components and sub assemblies go into each end product of MRP.

41. Ans: (d)

42. Ans: (a)

Sol: *Hardenability* is a term that is used to describe the ability of an alloy to be hardened by the formation of martensite as a result of a given heat treatment. Hardenability is not "hardness," which is the resistance to indentation; rather, hardenability is a qualitative measure of the rate at which hardness drops off with distance into the interior of a specimen as a result of diminished martensite content.

43. Ans: (c)

Sol: When clearance angle increases, the tool life increases at first. This is because for same amount flank wear, h_f reduces. However with further increase in clearance angle, the tool becomes thinner and the tool life decreases due to the higher temperature.

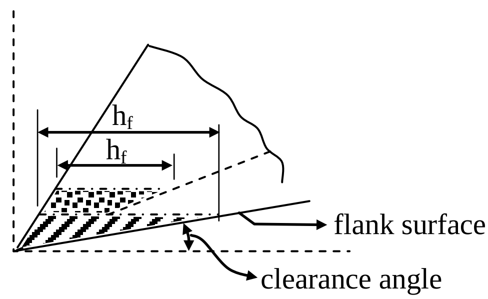
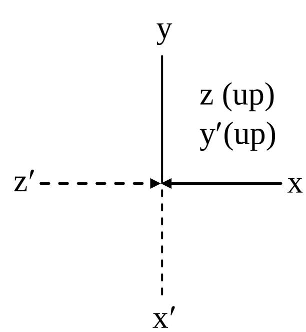


Figure: Dependence of flank wear on clearance angle.

44. Ans: (a)

Sol: Angles between two frames, cosine values

	x′	y′	z′
x	90	*	180
y	180	*	90
z	90	*	90



Co-ordinate frames xyz, x′y′z′ drawn based on right hand rule and angles between y′ with x, y, z computed as 90°, 90°, 0°.

Cosine values 0, 0, 1.

So $(0\ \ 0\ \ 1)^T$.

45. Ans: (d)

Sol: For a thin cylinder Hoop stress, $\sigma_\theta = \frac{Pd}{2t}$,

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

Shear stress, $\tau_{x\theta} = \frac{T}{Z} = \frac{T}{(\pi d^2 t/2)} = \frac{2T}{\pi d^2 t}$

46. Ans: (a)

Sol:

- The continual motion of a movable device in absence of friction does not violates the second law of thermodynamics.
- Entropy change of a truly incompressible substance depends on temperature only and is independent of pressure.

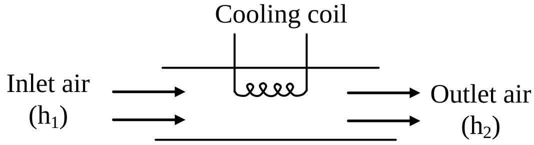
47. Ans: (d)

48. Ans: (a)

Sol: In Rankine cycle work ratio is close to unity.

49. Ans: (b)

Sol:



Cooling load = 48 TR = 48×3.5 kW

h_2 = 50 kJ/kg, $\dot{m}$ = 360 kg/min

Energy balance :

Cooling load = $\dot{m}(h_1 - h_2)$

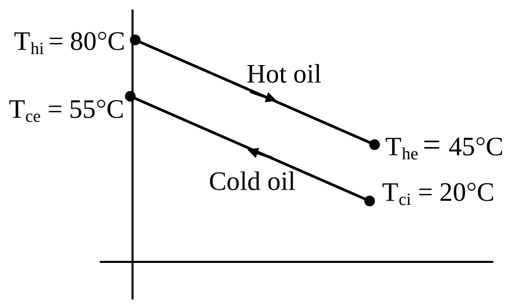
$$48\times3.5 = \frac{360}{60}(h_1 - 50)$$

$$\frac{48\times3.5}{60} = (h_1 - 50)$$

$\Rightarrow$ h_1 = 78 kJ/kg

50. Ans: (b)

Sol: Exit temperature of cold fluid is more than that of hot fluid. Therefore, it is a case of counter flow heat exchanger.



$\because$ Mass flow rates of both the fluids are same.

$$\therefore\ C = \frac{c_{min}}{c_{max}} = 1$$

$$\text{Effectiveness } (\varepsilon) = \frac{c_{min}(T_{ce} - T_{ci})}{c_{min}(T_{hi} - T_{ci})}$$

$$= \frac{55-20}{80-20} = \frac{35}{60} = 0.5833$$

51. Ans: (c)

Sol: Given m = 4 kg, k = 400 N/m

For critically damping,

$c_c = 2\sqrt{mk} = 2\sqrt{4\times400}$ = 2×40 = 80 N-s/m

52. Ans: (b)

Sol: Inertia force, $F_i = mr\omega^2\left(\cos\theta + \frac{\cos(2\theta)}{n}\right)$

Piston effort, $F_p = F_g \pm F_i$

At $\theta < 90°$, $F_P = F_g - F_i$

At $\theta > 90°$, $F_P = F_g + F_i$

where F_g = Gas force, F_i = Inertia force.

53. Ans: (a)

54. Ans: (c)

Sol: Transferring units to zero evaluated cells after reaching optimality gives an alternative solution with the same transportation cost to the problem.

55. Ans: (c)

Sol: Apply the law of vector addition to get

$$\vec{S} = \vec{P} + \overrightarrow{PS} = \vec{P} + b|\vec{R}|\left(\frac{\vec{R}}{|\vec{R}|}\right) = \vec{P} + b\vec{R}$$

$$= \vec{P} + b(\vec{Q} - \vec{P})$$

$$= (1-b)\vec{P} + b\vec{Q}$$

56. Ans: (d)

Sol: The lever rule cannot be applied at the eutectic or the peritectic temperature, where there are three phases in equilibrium and an isothermal reaction, changing the relative amounts of the phases, can occur. It can be applied just above or just below the invariant temperature. By using the lever rule, it is possible to estimate

1. The fraction of a pro-eutectic phase,
2. The fraction of the eutectic mixture, and
3. The fraction of a phase that forms part of the eutectic mixture.

57. Ans: (c)

Sol: In any machine tool operation, the principal parameters are cutting velocity and feed. In most of the machine tools such as lathe, drilling machine, boring machine, milling machine and hobbing machine either or the cutting tool rotates and thus imparts cutting velocity V_c (m/min) as

$$V_c = \frac{\pi DN}{1000} \text{ m/min}$$

Where 'D' is the diameter of the job (as in lathes, etc) or the cutter (as in drilling, milling etc) and

'N' is speed of rotation in rpm.

Therefore,

$$N = \frac{1000 V_c}{\pi D}$$

Hence, 'N' is decided based on the desired value of V_c and the diameter of the job or the tool.

58. Ans: (b)

Sol: Grabuler's criteria

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

n = movable links = 4

m = joints = 5, each joints with DOF = 1 and constraints = 2 (due to planar robot).

So, $m_{(DOF)} = 3\times4 - \sum_{i=1}^{5}(3-1)$ = 12–(5×2) = 2

59. Ans: (c)

Sol: From the conservation of mass,

$$\forall_{initial} + (\dot{\forall}_{cold})_{in}\times30 + (\dot{\forall}_{hot})_{in}\times30 - (\dot{\forall}_{warm})_{out}\times30 = \forall_{final}$$

Since $\dot{\forall}_{cold} = \dot{\forall}_{hot}$

$$140 + 2\times(\dot{\forall}_{hot})_{in}\times30 - 25\times30 = 50$$

$\Rightarrow$ $(\dot{\forall}_{hot})_{in} = 11\ L/min$

60. Ans: (c)

Sol: Loss of available energy = $T_0 \times s_{gen}$

$$= 300\left[\frac{-1000}{750} + \frac{1000}{500}\right] = 200\,kJ$$

61. Ans: (d)

62. Ans: (b)

Sol: $R = \dfrac{\Delta h_{mb}}{\Delta h_{mb} + \Delta h_{fb}}$

$\Delta h_{stage} = \Delta h_{mb} + \Delta h_{fb}$ = 20 kJ/kg

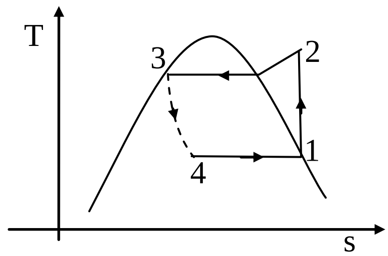
Δh_{fb} = 12 kJ/kg and

Δh_{mb} = 20 – 12 = 8 kJ/kg

$R = \dfrac{8}{20} = 0.4$ or 40%

63. Ans: (b)

Sol:



h_1 = 1500 kJ/kg, h_2 = 2000 kJ/kg

$h_3 = h_4$ = 500 kJ/kg

$$COP = \frac{\text{Refrigerating capacity}}{\text{Power input}}$$

$$COP = \frac{2TR}{P_{in}} = \frac{h_1 - h_4}{h_2 - h_1}$$

$$\frac{2TR}{P_{in}} = \frac{(1500-500)}{2000-1500} = 2$$

$\Rightarrow$ P_{in} = 1 TR = 3.5 kW

64. Ans: (b)

Sol: Given data,

d_i = 13 mm, d_o = 26 mm,

k_{cu} = 350 W/m-K, L = 1 m

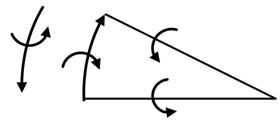
$$\text{Thermal resistance} = \frac{\ell n\left(\frac{r_o}{r_i}\right)}{2\pi k L}$$

$$= \frac{\ell n\left(\frac{26}{13}\right)}{2\times\frac{22}{7}\times350\times1}$$

$$= \frac{\ell n(2)}{22 \times 100} = \frac{0.693}{22 \times 100} = 3.15 \times 10^{-4} \text{ K/W}$$

65. Ans: (b)

Sol:



The gyroscopic couple is shown above assuming the anticlockwise direction when viewed from the front. So it tends to raise the nose and depress the tail.

66. Ans: (c)

Sol: Cycle time = Maximum (station time) = 12

$$\eta_{line} = \frac{\text{Total work content}}{\text{No. of stations} \times \text{cycle time}} \times 100$$

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

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

= 76.66 %

Balance delay = $100 - \eta_{line}(\%)$

= 23.33 %

67. Ans: (a)

Sol: Low temperature that causes a ductile to brittle transition in BCC steels. So option (a) is correct. The transition temperature depends on the chemical composition, heat treatment, processing and microstructure of the material. *FCC metals usually do not exhibit a DBTT*. So options (b), (c) and (d) are incorrect.

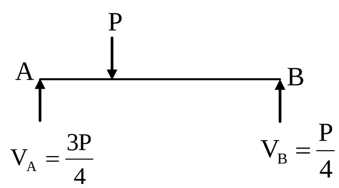
68. Ans: (d)

Sol: The deformation of metals, which is caused by the displacement of atoms, is achieved by one or both of the processes called *slip and twinning.*

69. Ans: (d)

70. Ans: (b)

Sol:



$$\therefore\ V_{max} = \frac{3P}{4}$$

$$\therefore\ \tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2} \times \frac{\frac{3P}{4}}{bh} = \frac{9P}{8bh}$$

71. Ans: (d)

Sol: **For path iaf :**

$Q_{iaf} = W_{iaf} + \Delta U_{iaf}$

$\Rightarrow 500 = 200 + \Delta U_{iaf}$

$U_f - U_i = 300$

$\Rightarrow U_f = 300 + 100 = 400$ J

For path ib :

$Q_{ib} = W_{ib} + \Delta U_{ib}$

$= 50 + (200 - 100) = 150$ J

For path bf :

$Q_{bf} = W_{bf} + \Delta U_{bf}$

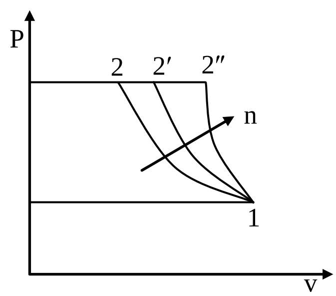
$= 100 + (400 - 200) = 300\text{ J}$

$\therefore \dfrac{Q_{bf}}{Q_{ib}} = 2$

72. Ans: (c)

73. Ans: (a)

Sol:



From the above figure, we can see that as n increases area under Pv diagram increases. Therefore work of compression increases.

74. Ans: (b)

Sol: $\eta_m = \dfrac{B.P}{I.P}$

$0.75 = \dfrac{9}{I.P}$

$I.P = \dfrac{9}{\frac{3}{4}} = 12\,kW$

Indicated thermal efficiency = $\dfrac{I.P.}{\dot{m}_f \times CV}$

$0.4 = \dfrac{12}{\dot{m} \times 44000}$

$\dot{m}_f = \dfrac{12}{44000 \times 0.4}\,kg/s$

$= \dfrac{12 \times 3600}{4400 \times 4} = 2.45\text{ kg/hr}$

75. Ans: (b)

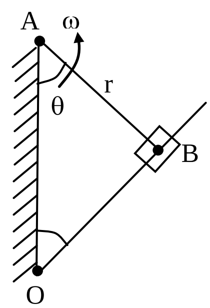
Sol: Dissolved gases are required to form the nuclei of the bubbles in nucleate boiling.

76. Ans: (c)

Sol: Mixing biomass with fossil fuel in conventional power plants is known as co-firing.

77. Ans: (b)

Sol:



When crank becomes perpendicular to slotted lever the velocity of sliding block B is the velocity of point B on the crank. i.e., ωr.

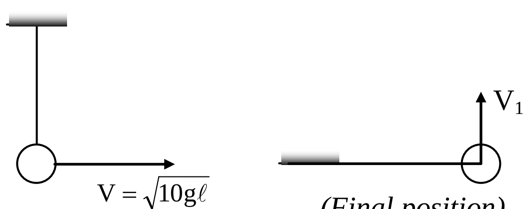
78. Ans: (c)

Sol: The following assumptions are made in basic EOQ model :

- Demand is known, constant and independent
- Lead time - that is, the time between placement and receipt of the order- is known and constant
- Instantaneous replenishment i.e. the receipt of inventory is instantaneous and complete.
- No shortage is permitted
- No safety stock is provided
- Quantity discounts are not possible.

79. Ans: (b)

Sol:



(Initial position) *(Final position)*

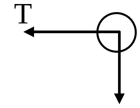
Let, V_1 be the speed of the bob at horizontal (final) position.

By writing conservation of mechanical energy.

$$\Rightarrow \frac{1}{2}\times m\times\left(\sqrt{10g\ell}\right)^2 = mg\ell+\frac{1}{2}mV_1^2$$

$$\Rightarrow V_1^2 = 8g\ell$$

F.B.D of bob in final position is shown below,



$$T = \frac{m\times V_1^2}{\ell} = \frac{m\times 8g\ell}{\ell} = 8\text{ mg}$$

80. Ans: (a)

Sol:

Dominant Characteristics	**Crystal structure**
High strength	BCC
High ductility	FCC
Tend to be brittle	HCP

81. Ans: (a)

Sol: In ironing, the objective is only to reduce the wall thickness of the cup and hence, no blank holding is required because the punch is fitted closely inside the cup.

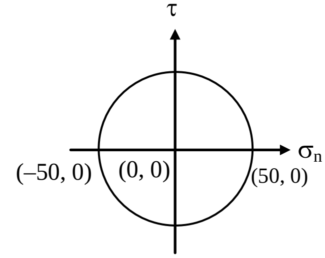
82. Ans: (a) **83. Ans: (a)**

84. Ans: (d)

Sol: For the given state of stress

$\sigma_x = 50$

$\sigma_y = -50$



85. Ans: (d)

Sol: At low speeds weak spark.

86. Ans: (b)

Sol: $\eta_v = 1 - C\left[\left(\frac{P_d}{P_s}\right)^{\frac{1}{n}} - 1\right]$

As delivery pressure increases the volumetric efficiency decreases.

87. Ans: (d)

Sol: In reduced ambient system this is possible due to expansion turbine after ram compression.

88. Ans: (b)

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

$$Q = kA\frac{T_1 - T_2}{L} = \frac{T_1 - T_2}{\frac{L}{kA}}$$

where T_1 and T_2 are the temperatures on the two sides of the wall and $\frac{L}{kA}$ is the thermal resistance of the wall.

Substituting, L = 0.6 m, A = 1.5 m^2

and k = 0.4 W/m°C,

we get, $\frac{L}{kA} = \frac{0.6}{1.5 \times 0.4} = 1\ ^{o}C/W$

89. Ans: (a)

Sol: Pressure angle represents the angle between the normal to pitch curve at a point and direction of the follower motion. A high value of pressure angle causes jamming of follower in the bearing.

90. Ans: (c)

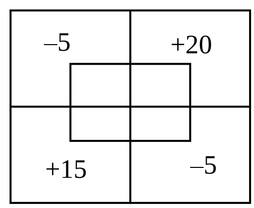
Sol: Total supply = 15 + 15 = 30

Total demand = 10 + 20 = 30

Total supply = Total demand

It is a balanced transportation model.

To check the optimality we have to do the empty cell evaluation (S_2, D_1).



Cell evaluation = 15 – 5 + 20 – 5 = 25

As it is positive, further improvement is not possible. So it is optimal solution.

91. Ans: (d)

Sol: If the dimension of the shaft is lower than the dimension of the hole then there will be clearance. Such a fit is termed *clearance fit.*

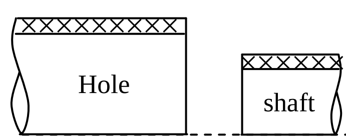


Fig: *clearance fit.*

92. Ans: (b)

Sol: XYZ frame is rotated clockwise by angle θ with ref to Z so angle (–θ).

Then matrix is $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

93. Ans: (b)

Sol: Program counter keep track of next instruction to be fetched

94. Ans: (c)

Sol:

- Larger pump power is needed for a liquid of higher density to flow at a specified velocity through a given pipe.
- The given continuity equation $\frac{\partial \rho}{\partial t} + \vec{\nabla}.(\rho \vec{V}) = 0$ is for compressible flow.

95. Ans: (b)

Sol: High temperatures are required for NO_x emission and in idling we have low temperature.

96. Ans: (a)

Sol: For maximum network output the optimum pressure ratio is given by

$$r_p = \left[\eta_T \times \eta_C \times \left(\frac{T_{max}}{T_{min}}\right)\right]^{\frac{\gamma}{2(\gamma-1)}}$$

$$= \left[0.8 \times 0.8 \times \left(\frac{1200}{300}\right)\right]^{\left(\frac{1.5}{1}\right)}$$

$$= (0.8^2 \times 4)^{3/2} = (0.8 \times 2)^3 = 4.096$$

97. Ans: (c)

Sol: As static regain method is a balanced system, no dampers are required.

98. Ans: (b)

Sol: Maximum fluctuation of energy in flywheel is given by

$$\Delta E_{max} = \frac{1}{2} I(\omega_{max}^2 - \omega_{min}^2)$$

$$= I\left(\frac{\omega_{max} + \omega_{min}}{2}\right)(\omega_{max} - \omega_{min})$$

$$\Delta E = I\, \omega_{mean} \times \Delta\omega = I\omega_{mean}^2 \times \frac{\Delta\omega}{\omega_{mean}}$$

$$= I\,\omega_{mean}^2 \times C_s$$

$$E = \frac{1}{2} I \omega_{mean}^2$$

$$\Delta E = 2\, E \times C_s$$

$$10 = 2 \times 100 \times C_s$$

$$\Rightarrow C_s = 0.05$$

99. Ans: (d)

Sol: The address of the next instruction to be fetched will be stored in program counter.


INDIA

100. Ans: (d)

Sol:

- Kaplan turbine runner blades are warped and twisted.
- In general, the shafts of a reaction turbine is kept vertical.
- Discharge of water is being controlled in a reaction turbine using movable wicket gates.

101. Ans: (b)

Sol: Thrust power = F × c_i

$F \times 500 = 2000$ kW

$\Rightarrow \quad F = 4$ kN

102. Ans: (c)

103. And: (a)

Sol: $2\ddot{X} + 8\pi^2 X = 0$

On comparing with equation $\ddot{X} + \omega^2 X = 0$.

$\omega_n = \sqrt{\dfrac{8\pi^2}{2}} = 2\pi$ rad/sec

$\omega_n = 2\pi f \Rightarrow f = \dfrac{\omega_n}{2\pi} = \dfrac{2\pi}{2\pi} = 1$ Hz

104. Ans: (d)

Sol: The construction of a resolver is similar to that of a two phase, two pole, round induction motor. The stator windings are identical and are housed in magnetic structure, with the axis of two windings 90° to each other. Similarly, the two rotor winding are placed in a magnetic structure and are mutually perpendicular to each other.

105. Ans: (a)

Sol: For homologous turbine, we can use the following formula :

$$\left(\frac{1-\eta_m}{1-\eta_p}\right) = \left(\frac{D_p}{D_m}\right)^{1/5}$$

or $\dfrac{1-0.9}{1-\eta_p} = \left(\dfrac{180}{60}\right)^{1/5} = 3^{0.2} = 1.246$

or $1-\eta_p = \dfrac{0.1}{1.246}$

or $\eta_p = 1 - \dfrac{0.1}{1.246} = \dfrac{1.146}{1.246} \cong 0.92$

106. Ans: (b)

Sol: Since the disc is rolling with slip, the pair is considered to be a lower pair.

N = 4, j = 4, h = 0

F = 3(N – 1) – 2j – h

= 3(4 – 1) – 2 × 4 – 0 = 1

107. Ans: (d)

Sol: Rack and pinion converts rotary motion to translating motion.

108. Ans: (c)

109. Ans: (c)

Sol: Spring is used to provide restoring force to mass when device is displaced.

110. Ans: (d)

Sol: Given data :

$P_d = 240$ kPa,

$P_s = 60$ kPa,

$V_d = 6$ m/s,

$V_s = 4$ m/s ,

Q = 45 lit/s,

$\eta_{pump} = 0.8125$

Applying energy equation between inlet and exit of the pump, we get

$$\frac{P_s}{\gamma}+\frac{V_s^2}{2g}+z_s h_{pump}=\frac{P_d}{\gamma}+\frac{V_d^2}{2g}+z_d$$

$$\text{or}\quad h_{pump}=\frac{P_d-P_s}{\gamma}+\frac{V_d^2-V_s^2}{2g}+z_d-z_s$$

$$=\frac{(240-60)\times10^3}{10^4}+\frac{6^2-4^2}{2\times10}+0.5$$

= 18 + 1.0 + 0.5 = 19.5 m

Power delivered to the pump = $\dfrac{\gamma Q h_{pump}}{\eta_{pump}}$

$$=\frac{10^4\times15\pi\times10^{-3}\times19.5}{0.8125}\text{W}$$

= $150\pi\times24$ = 3600 π W

= 3.6 π kW

111. Ans: (c)

Sol:

- Work done by gas = Increase in potential energy of spring $=\frac{1}{2}Kx_0^2$
- By first law of thermodynamics

$$Q - W = \Delta U$$

$$-W = \Delta U$$

$$\Rightarrow \Delta U = -\frac{1}{2}Kx_0^2$$

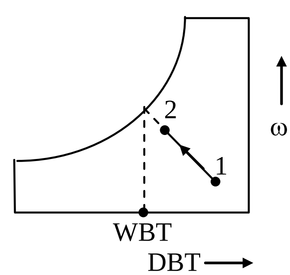
- $\Delta U < 0$

$\Rightarrow U_f < U_i$

$\Rightarrow T_f < T_i$

112. Ans: (b)

Sol: Evaporating cooling on psychrometric chart:



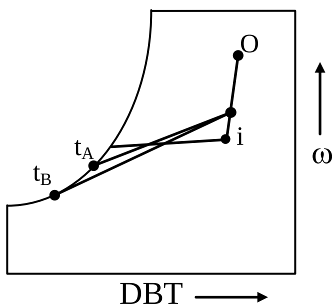
The Lowest temperature of air stream can be achieved during evaporative cooling is wet bulb temperature.

113. Ans: (c)

Sol: Both supersonic and subsonic diffusers convert the kinetic energy of entering air into pressure rise. Air from the atmosphere enters the engine at very high speed and its velocity gets reduced first in supersonic diffuser. The air then enters subsonic diffuser wherein there is further pressure rise.

114. Ans: (d)

Sol:



t_A = higher ADP has less BPF.

As evaporator temperature is high, small machine with high COP.

115. Ans: (a)

Sol: When the spring is inclined to the direction of oscillation at an angle α. The equivalent stiffness is $k\cos^2\alpha = \frac{k}{2}$ ($\alpha = 45°$).

The four springs are parallel

$$\therefore k_{eq} = 4\times\frac{k}{2} = 2k$$

Natural frequency = $\sqrt{\frac{2k}{2m}} = \sqrt{\frac{k}{m}}$

116. Ans: (d)

117. Ans: (b)

Sol: They are not called general purpose because they are not meant to do a single work at a time.

118. Ans: (b)

Sol: From the relation

$E = 3K(1-2\mu)$

If $\mu = \frac{1}{3} : E = 3K\left(1-2\left(\frac{1}{3}\right)\right)$

$E = K$

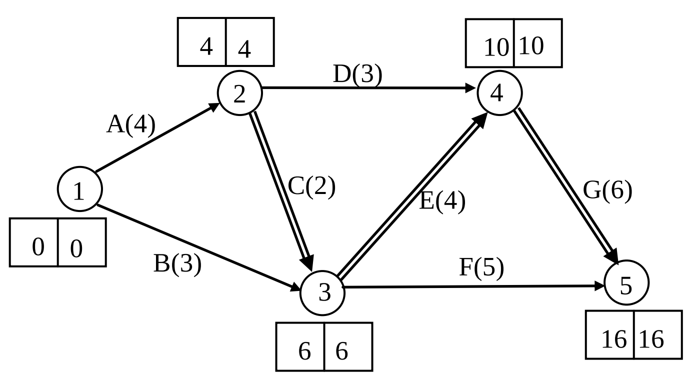
If $\mu = \frac{1}{4} : E = \frac{3}{2}K$

i.e if $\mu < \frac{1}{3} \Rightarrow E > K$

and if $\mu > \frac{1}{3} \Rightarrow E < K$

119. Ans (a)

Sol:



Total float for 'B' = (6 – 0) – 3 = 3

Total float for 'D' = (10 – 4) – 3 = 3

120. Ans: (d)

Sol:

- In ultrasonic welding (USW), the faying surfaces of the two components are subjected to a static normal force and oscillating shearing (tangential) stresses. The shearing stresses are applied by the tip of a transducer, which is similar to that used for ultrasonic machining.
- In resistance spot welding (RSW), the tips of two opposing solid, cylindrical electrodes touch a lap joint of two sheet metals, and *resistance heating* produces a spot weld.
- Shielded metal-arc welding (SMAW): The *electric arc* is generated by touching the tip of a coated electrode against the work piece and withdrawing it quickly to a distance sufficient to maintain the arc.
- The two main thermo chemical welding processes are thermit welding and atomic hydrogen welding.

121. Ans: (a)

Sol: Immediate addressing ----------LXIH, 2050

Implied addressing-------------- RRC

Register addressing--------------MOV A, B

Direct addressing---------------- LDA 30 FF

122. Ans: (a)

Sol: Given,

Rise, h = 20mm = 0.02 m

Angle of ascent, $\phi_a = 60° = \frac{\pi}{3}$ rad with constant acceleration and deceleration

N = 300 rpm,

$$\omega = \frac{2\pi N}{60} = \frac{2\pi(300)}{60} = 10\pi \text{ rad/s}$$

$$V_{max} = \frac{2h\omega}{\phi_a} = \frac{2\times 0.02\times 10\pi}{\frac{\pi}{3}} = 1.2 \text{ m/s}$$

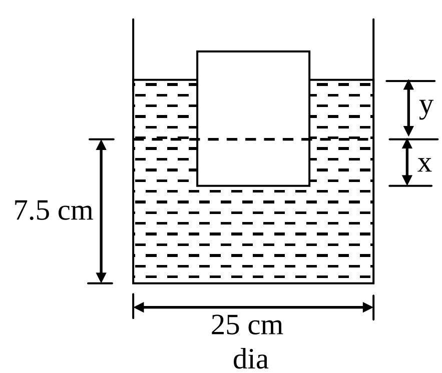
123. Ans: (c)

Sol: Maximum shear stress at that point is given by $= \left|\frac{\sigma_1 - \sigma_3}{2}\right|$

$$\therefore \text{ Absolute } \tau_{max} = \left|\frac{40-0}{2}\right| = 20 \text{ MPa}$$

124. Ans: (a)

Sol: Let x be the height of the solid cylinder below the initial level of the liquid and y be the rise of liquid level.



So, Volume of liquid displaced by solid cylinder = Volume of liquid rise

$\pi \times 10^2 \times x = \pi \times (12.5^2 - 10^2)\, y$

$100\, x = (156.25 - 100)\, y = 56.25\, y$

or $x = 0.5625\, y$ ------(1)

Also, weight of the solid cylinder = Weight of the displaced volume

$$5\pi = 8\times10^3 \pi \times 10^2 \times 10^{-4} \times (x+y) \times 10^{-2}$$

$$x + y = \frac{5\pi\times10}{8\pi} = \frac{50}{8} = 6.25 \text{ cm}$$

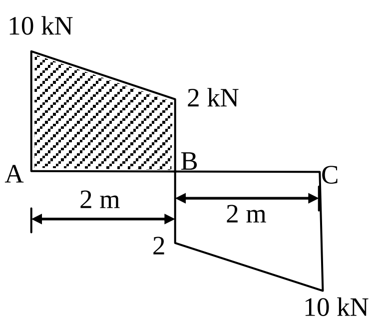
But $x = 0.5625\, y$ from (1)

Thus, $y = \dfrac{6.25}{1.5625} = 4$ cm

Note: ***This question is a bit lengthy. Such questions are asked to trap the students. Students are advised not to attempt such question in the beginning.***

125. Ans: (b)

Sol:



$$\frac{dM}{dx} = F$$

$\Rightarrow dM = Fdx$

$$\int_A^B dM = \int_A^B Fdx$$

$M_B - M_A$ = area of SFD between A and B

$$= \frac{1}{2}\times 2(10-2) + 2\times 2$$

$M_B - 0 = 8+4 = 12$

$M_B = 12$ kN-m

126. Ans: (a)

Sol: Given :

$\psi = x + 2x^2 - 2y^2$

$$u = -\frac{\partial\psi}{\partial y} = +4y$$

and $v = \dfrac{\partial\psi}{\partial x} = 1 + 4x$

Also, $\dfrac{\partial^2\psi}{\partial x^2} + \dfrac{\partial^2\psi}{\partial y^2} = 4 - 4 = 0$

$\Rightarrow$ Flow is irrotational.

Thus, Bernoulli's equation can be applied for any two points in the flow field.

$$V_1 \text{ at } (1,-2) = \sqrt{u_1^2 + v_1^2}$$

$$= \sqrt{(4y_1)^2 + (1+4x_1)^2}$$

$$= \sqrt{64+25} = \sqrt{89} \text{ unit}$$

From Bernoulli's equation the total energy per unit volume is given by the sum

$$= P + \frac{1}{2}\rho V^2 + \rho g z$$

where, $P_1 + \rho g z_1$ = Piezometric head at point (1)

Thus, piezometric head at point (1, –2) is

$$= \text{Total energy / volume} - \frac{1}{2}\rho V_1^2$$

$$= 4853.4 - \frac{1}{2} \times 1.2 \times 89$$

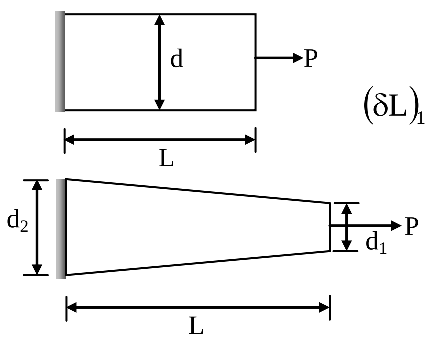
$$= 4853.4 - 53.4$$

$$= 4800 \text{ Pa} = 4.8 \text{ kPa}$$

Note: ***This question is a bit lengthy. Such questions are asked to trap the students. Students are advised not to attempt such question in the beginning.***

127. Ans: (b)

Sol:



$$(\delta L)_1 = \frac{4PL}{\pi d^2 E}$$

$$(\Delta L)_2 = \frac{4PL}{\pi d_1 d_2 E}$$

For $(\delta L)_1 = (\delta L)_2$

$$\frac{1}{d^2} = \frac{1}{d_1 d_2}$$

$d = \sqrt{d_1 d_2}$ (Geometric mean of diameters)

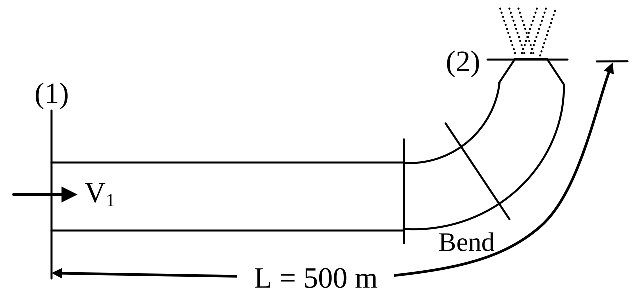
128. Ans: (b)

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

$$= \frac{100}{10} = 10 \text{ m/s}$$

129. Ans: (b)

Sol:



Velocity of jet, $V_j = \sqrt{2gH}$

$V_j = V_2 = \sqrt{2 \times 10 \times 31.25} = 25$ m/s

Applying Bernoulli's equation for sections (1) and (2)

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f$$

where, $\frac{P_1}{\gamma} = \frac{480.5 \times 10^3}{10^4} = 48.05$ m,

$z_1 = 0$, $z_2 = 1$ m, $V_2 = 25$ m/s , $P_2 = 0$

$$48.05 - \frac{V_2^2}{2g} - z_2 = \frac{V_1^2}{2g}\left[\frac{f\,L}{D} - 1\right]$$

$$48.05 - 25 - 1 = \frac{V_1^2}{20}\left[\frac{0.01 \times 500}{0.1} - 1\right]$$

$$\Rightarrow 22.05 \times 20 = V_1^2(49)$$

$$\Rightarrow V_1 = \sqrt{\frac{22.05 \times 20}{49}} = \sqrt{\frac{441}{49}} = 3 \text{ m/s}$$

Note: ***This question is a bit lengthy. Such questions are asked to trap the students. Students are advised not to attempt such question in the beginning.***

130. Ans: (b)

Sol:

- Carbon Nanotubes structure consists of a single sheet of graphite, rolled into a tube, both ends of which are capped with C60 fullerene hemispheres. The *nano* prefix denotes that tube diameters are of the order of a nanometer (i.e., 100 nm or less).
- These nanotubes are extremely strong and stiff and relatively ductile. For single-walled nanotubes, tensile strengths range between 50 and 200 GPa (approximately an order of magnitude greater than for carbon fibers); this is the strongest known material.

131. Ans: (a)

Sol: Wire drawing improves the mechanical properties because of the cold working. The main purpose of cold working is to improve the mechanical properties by strain hardening. Drawing usually increases the strength and hardness of the metal.

132. Ans: (d)

Sol: As $\rho_{oil} < \rho_{water}$ the vapour pressure for oil will be higher than that of water at the same operating temperature. Chances of cavitation increases as vapour pressure increases. Thus, Statement (I) is wrong. However, statement (II) is correct.

133. Ans: (a)

134. Ans: (c)

Sol:

- In the application of the momentum equation, we can disregard the atmospheric pressure and work with gauge pressures only since the atmospheric pressure acts in all directions and its effect cancels out in every direction. Thus, statement (I) is correct.
- Considering an example of flow through a nozzle, we can write nozzle force, $F = P_1A_1 - P_2A_2 - \dot{m}(V_2 - V_1)$. As $A_1 \neq A_2$, subtracting constant pressure from P_1 and P_2, F will change. Thus, statement (II) is wrong.

135. Ans: (b)

Sol:

- The percentage elongation at fracture in a tensile test can be used as a measure of ductility.
- The percentage reduction of cross sectional area can be used as a measure of ductility.
- These two quantities are not directly related to each other since the cross sectional area changes in unknown way in the necked region of tensile specimen loaded to fracture.

136. Ans: (a)

Sol:

- As the pressure increases the density difference between water and steam decreases and so the separating force due to gravity is low.
- At high pressure where the density difference between water and steam diminishes, centrifugal forces much greater than the gravity forces are used. Cyclone separator utilizes centrifugal forces for separation of steam from water-steam flow mixture.

137. Ans: (b)

Sol: Wet bulb depression (WBD) = DBT – WBT

For saturated air, WBD = 0

As WBD increases, moisture absorbing capacity of air increases.

138. Ans: (b)

Sol: Microwave ovens utilize electromagnetic radiation in the microwave region of the spectrum generated by microwave tubes called magnetrons. Microwaves in the range of 10^2-10^5 μm are very suitable for use in cooking since they are reflected by metals, transmitted by glass and plastics and absorbed by food (especially water) molecules. Thus, the electric energy converted to radiation in a microwave over eventually becomes part of the internal energy of the food.

139. Ans: (d)

Sol:

- Irreversible head loss (h_L) is the loss of mechanical energy due to irreversible processes (such as friction) in piping and is expressed as an equivalent column height of fluid.
- h_L is always positive otherwise the second law of thermodynamics will be violated.

140. Ans: (a)

141. Ans: (b)

Sol:

- White iron has a characteristic white, crystalline fracture surface. Large amounts of Fe_3C are formed during casting, giving a hard, brittle material.
- Gray iron has a gray fracture surface with a finely faceted structure. A significant silicon content (2 to 3 wt %) promotes graphite (C) precipitation rather than cementite (Fe_3C). The sharp, pointed graphite flakes contribute to characteristic brittleness in gray iron.

142. Ans: (c)

Sol: The penetration rate of the tool is proportional to the current density.

The material removal rate typically ranges between 1.5 and 4 mm^3 per A-min. Because *the metal-removal rate is a function only of the ion exchange rate*, it is *not affected by the strength, hardness, or toughness of the workpiece.*

143. Ans: (d)

144. Ans: (a)

Sol: Since the air density decreases, more air must be forced into the down draft by helicopter blades to provide the same lift force. Therefore, it takes more power for a helicopter to hover on the top of a high mountain that it does at sea level.

145. Ans: (c)

Sol: The efficiency of all reversible heat engines between the same two temperature reservoirs are same.

146. Ans: (a)

Sol: Since supercritical plants use less fuel for a given power output than a subcritical plants. They produce less Carbon dioxide, other combustion gases and solid waste than subcritical plants.

147. Ans: (b)

Sol: COP of refrigerator is less as compared to that of air conditioning because the difference in working temperature in refrigerator is more as compared to that in air conditioning.

Therefore, statement (II) is not right explanation of statement (I).

148. Ans: (a)

Sol: The value of h is usually much lower at the fin base than it is at the fin tip because the fluid is surrounded by solid surfaces near the base, which seriously disrupt its motion to the point of "suffocating" it, while the fluid near the fin tip has little contact with a solid surface and thus encounters little resistance to flow. Therefore, adding too many fins on a surface may actually decrease the overall heat transfer when the decrease in h offset any gain resulting from the increase in the surface area.

149. Ans: (b)

Sol: Global radiation is measured using pyranometer. Both statements are correct individually.

150. Ans: (c)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