TEST ID: 311

# ACE
## Engineering Academy

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**ESE- 2018 (Prelims) - Offline Test Series Test - 22**

**MECHANICAL ENGINEERING**

## FULL LENGTH MOCK TEST – 1 (PAPER – II)
## SOLUTIONS

**01. Ans: (b)**

**Sol:** $F_m = 0 \Rightarrow (1 - C)\,P - F_i = 0$

$$C = \frac{K_b}{K_b + K_m} = \frac{K_b}{K_b + 3K_b} = 0.25$$

$$\frac{P}{F_i} = \frac{1}{1-c} = \frac{1}{1-0.25} = \frac{1}{0.75} = 1.33$$

**02. Ans: (a)**

**Sol:** Fe is face centered cubic structure at 1000°C

$$\therefore\ 4R = \sqrt{2}a$$

$$a = \frac{4R}{\sqrt{2}} = 2\sqrt{2}R = 2\times\sqrt{2}\times 0.15\,\text{nm}$$

$$= 0.42\text{ nm}$$

**03. Ans: (c)**

**Sol:** Generalised heat conduction equation for 1-D, steady state without heat generation:

$$\frac{1}{r^n}\frac{\partial}{\partial r}\left(r^n\frac{\partial T}{\partial r}\right) = 0$$

for spherical coordinate, n = 2

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{dT}{dr}\right) = 0$$

Note: For Cartesian co-ordinate, n = 0

For cylindrical co-ordinate, n = 1

**04. Ans: (d)**

**Sol:** $P = 0.707\times S\times L\times\dfrac{S_{sy}}{FS}$

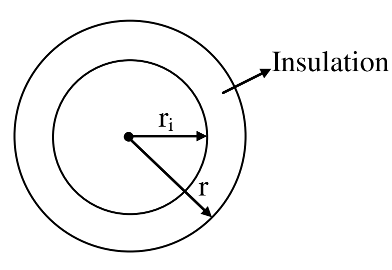
$$P = 0.707\times 5\sqrt{2}\times 10\times 80$$

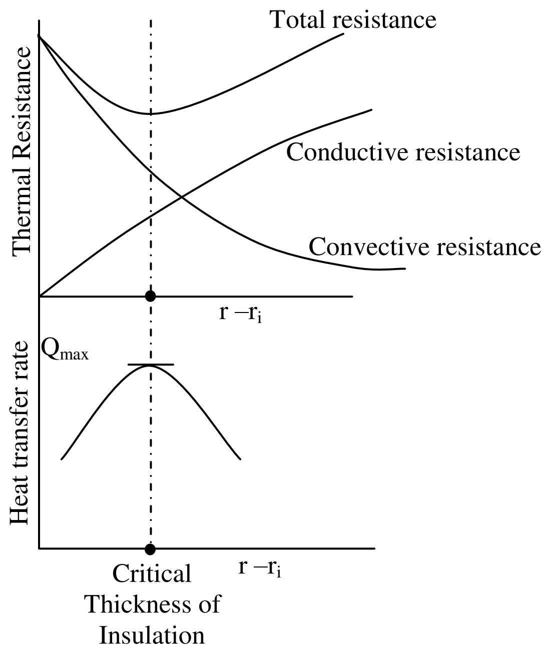
$$= 4000\text{ N}$$

$$= 4\text{ kN}$$

**05. Ans: (c)**

**Sol:** In radial heat conduction system.






Total resistance for hollow cylinder = conductive resistance ($R_{cond.}$) + Convective

$$\text{resistance}(R_{conv}) = \frac{\ln\left(\frac{r}{r_i}\right)}{2\pi kL} + \frac{1}{2\pi rL}$$

If $r \uparrow \Rightarrow R_{cond} \uparrow$ and $R_{conv} \downarrow$

$$\Rightarrow \begin{cases} R_{total} \downarrow (\text{upto critical thickness of insulation}) \\ R_{total} \uparrow (\text{after critical thickness of insulation}) \end{cases}$$

*For plane wall:*

$R_{total}$ = Conductive resistance ($R_{cond}$) + Convective resistance ($R_{conv}$)

$$= \frac{L}{kA} + \frac{1}{hA}$$

If $L\uparrow \Rightarrow R_{cond} \uparrow$ and $R_{conv}$ is constant

$\Rightarrow R_{total} \uparrow$

L = Insulation thickness

∴ Critical thickness of insulation concept is not applicable in plane wall.

**06. Ans: (b)**

**Sol:** VCRS – R-12, R-134, R-$NH_3$ etc.

VTRS – Air

VJRS – Water

VARS – $H_2O$ – $NH_3$, LiBr – $H_2O$ etc.

**07. Ans: (c)**

**Sol:** The hydraulic ram is a pump which transfers water from lower elevation to higher elevation without help of external power. It works on principal of water hammer.

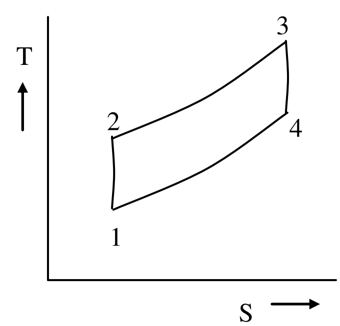
**08. Ans: (b)**

**Sol:** Ideal Brayton cycle is shown

$T_3 = T_{max} = 1225$ K

$T_1 = T_{min} = 400$ K

For maximum work




$$W_{max} = c_p\left[\sqrt{T_{max}} - \sqrt{T_{min}}\right]^2$$

$$= c_p\left[\sqrt{1225} - \sqrt{400}\right]^2$$

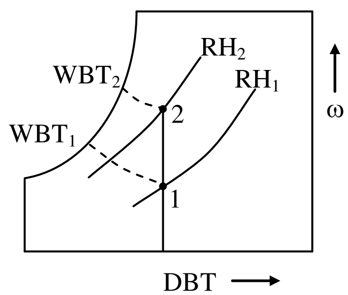
$= 225\ c_p$ kJ/kg

**09. Ans: (a)**

**Sol:**

1. When relative humidity is 100%, Air is saturated. At this condition. Dry bulb temperature, wet bulb temperature and dew point temperature are same. Therefore wet bulb depression is zero.

2.

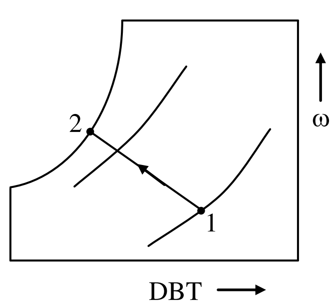



$RH_2 > RH_1$

$WBT_2 > WBT_1$

From the figure shown above, DBT is constant. As relative humidity increases the wet bulb temperature also increases.

3. In adiabatic saturation of air, enthalpy of moist air remains constant. Relative humidity of the air increases.




**10. Ans: (d)**

**Sol:** We know that

Angular impulse $J = \int_{t_1}^{t_2} \tau dt$

Angular impulse about centre of mass

$$= \int_0^t F \times \frac{L}{2} \times dt = \frac{FLt}{2}$$

Now, Angular impulse = Change in angular momentum

$$\frac{FLt}{2} = I\omega$$

$$\frac{FLt}{2} = \frac{mL^2}{12} \times \omega$$

$$\omega = \frac{6Ft}{mL}$$

**11. Ans: (c)**

**Sol:** There should not be any over flow of fuel into the cylinder when vehicle is switched off. So to avoid this level of main nozzle tip is always higher than the float chamber in fuel tank

**12. Ans: (c)**

**Sol:** $l = 11$, s = 3, p = 5, q = 7

Where, $l$ = longest link, s = shortest link

$l + s > p + q \rightarrow$ Non Grashof's chain.

A Non-Grashof chain generates only one distinct inversion namely rocker-rocker mechanism.

**13. Ans: (b)**

**Sol:** Given data:

M = 100 kg, m = 10 kg

k = 20,000 N/m, $\omega$ = 20 rad/sec

X = 1 mm = 0.001 m

$$X = 0.001 = \frac{me\omega^2}{k - M\omega^2}$$

$$\Rightarrow e = \frac{(20000 - 100 \times 20^2) \times (-0.001)}{10 \times 20^2}$$

$= 5$ mm

(X is negative as $\omega > \omega_n$)

**14. Ans: (c)**

**Sol:** Theoretical surface roughness ($R_t$) is given as

$$R_t = \frac{f}{\tan c_s + \cot c_e}$$

[Where f = feed rate in mm/rev,

$c_s$ = Side-cutting angle,

$c_e$ = End cutting angle]

From the tool-signature,

$c_s = 20°$ & $c_e = 25°$

$$\therefore \quad R_t = \frac{f}{\tan 20 + \cot 25}$$

$$\Rightarrow \quad \frac{f}{R_t} = \tan 20 + \cot 25$$

**15. Ans: (c)**

**Sol:** The rotational joint provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input and output links.

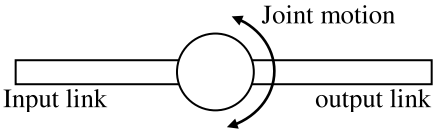



*Fig: Rotational joint*

**16. Ans: (a)**

**Sol:** Given data:

P = 10 kN, A = 500 mm$^2$

Normal stress on a maximum shear stress plane is given by,

$$\sigma_n = \frac{\sigma_1 + \sigma_2}{2}$$

$$= \frac{\frac{P}{A} + 0}{2}$$

$$= \frac{10 \times 10^3}{2 \times 500} = 10\,\text{MPa}$$

**17. Ans: (c)**

**18. Ans: (b)**

**Sol:** $\sigma_1 = 70$ MPa, $\sigma_2 = 120$ MPa

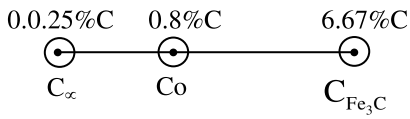
$$\sigma_2 = \frac{S_{yt}}{FS}$$

$$\Rightarrow FS = \frac{240}{120} = 2$$

**19. Ans: (a)**

**Sol:** Percentage carbon in eutectoid composition is 0.8% C.

The lever line is




$$m_\propto = \frac{C_{Fe_3C} - C_o}{C_{Fe_3C} - C_\propto} = \frac{6.67 - 0.8}{6.67 - 0.025}$$

$$= 0.883 = 88.3\%$$

$$m_{Fe_3C} = 1 - m_\propto = 0.117 = 11.7\%$$

**20. Ans: (c)**

**Sol:**

- *Flow through tubes,*

  Nu = f [(Re), (Pr)]

  For fully developed flow

  $$Re = \frac{\rho VD}{\mu} \rightarrow \text{constant along the length}$$

  $$Pr = \frac{\mu C_p}{k} \rightarrow \text{constant}$$

- *Turbulent flow over flat plate.*

  $Nu_x \propto Re_x^{0.8} Pr^{0.4}$

  $Nu_x \propto Re_x^{0.8}$

  [$\because$ Pr is property of fluid and it is constant]

  $$\frac{hx}{k} \propto \left(\frac{\rho V x}{\mu}\right)^{0.8}$$

  $$h \propto x^{-0.2}$$

  as $x\uparrow \Rightarrow h\downarrow$

**21. Ans: (a)**

**Sol:** We know, the temperature profile in cylinder with internal heat generation.

$$T_{max} - T_{wall} = \frac{\dot{q}}{k} \cdot \frac{R^2}{4}$$

$$210 - 40 = \frac{\dot{q}}{3} \times \frac{(0.02)^2}{4}$$

$$170 = \frac{\dot{q}}{3} \times \frac{0.0004}{4}$$

$$\dot{q} = \frac{170 \times 3}{0.0001} = 170 \times 3 \times 10^4 \text{ W/m}^3$$

$$= 510 \times 10^4 \text{ W/mK}$$

$$= 5.10 \text{ MW/m}^3$$

**22. Ans: (a)**

**Sol:** When cold air from atmosphere enters air washer or humidifier, it may freezes the water inside it. So it is better to preheat the incoming cold air before entering humidifier.

**23. Ans: (c)**

**Sol:** $T_{eq} = \sqrt{M^2 + T^2}$

$$\Rightarrow 5 = \sqrt{M^2 + 4^2} \Rightarrow M = 3 \text{ kN} - \text{m}$$

**24. Ans: (a)**

**Sol:** $S_P Y_P = 120 \times 0.09 = 10.8 \text{ N/mm}^2$

$S_G Y_G = 100 \times 0.115 = 11.5 \text{ N/mm}^2$

$S_G Y_G > S_P Y_P$

$\therefore$ Gear is stronger than pinion

**25. Ans: (d)**

**Sol:** During governing of Pelton turbine the discharge is altered by operating the needle valve. During the process the flow area changes but the velocity remains unchanged $\left(V_1 = C_v\sqrt{2gh}\right)$. The efficiency of the turbine which is function of speed ratio ($u/V_1$) also remains constant.

Now, the power developed by the turbine is given by

$$\rho = \eta \rho g Q H$$

$$\propto Q \quad (\because \eta, H \text{ are constant})$$

$$\therefore \frac{P_2}{P_1} = \frac{A_2}{A_1} \times \frac{V_2}{V_1}$$

$$= \frac{2 \times \frac{\pi}{4} d_2^2}{2 \times \frac{\pi}{4} d_1^2}$$

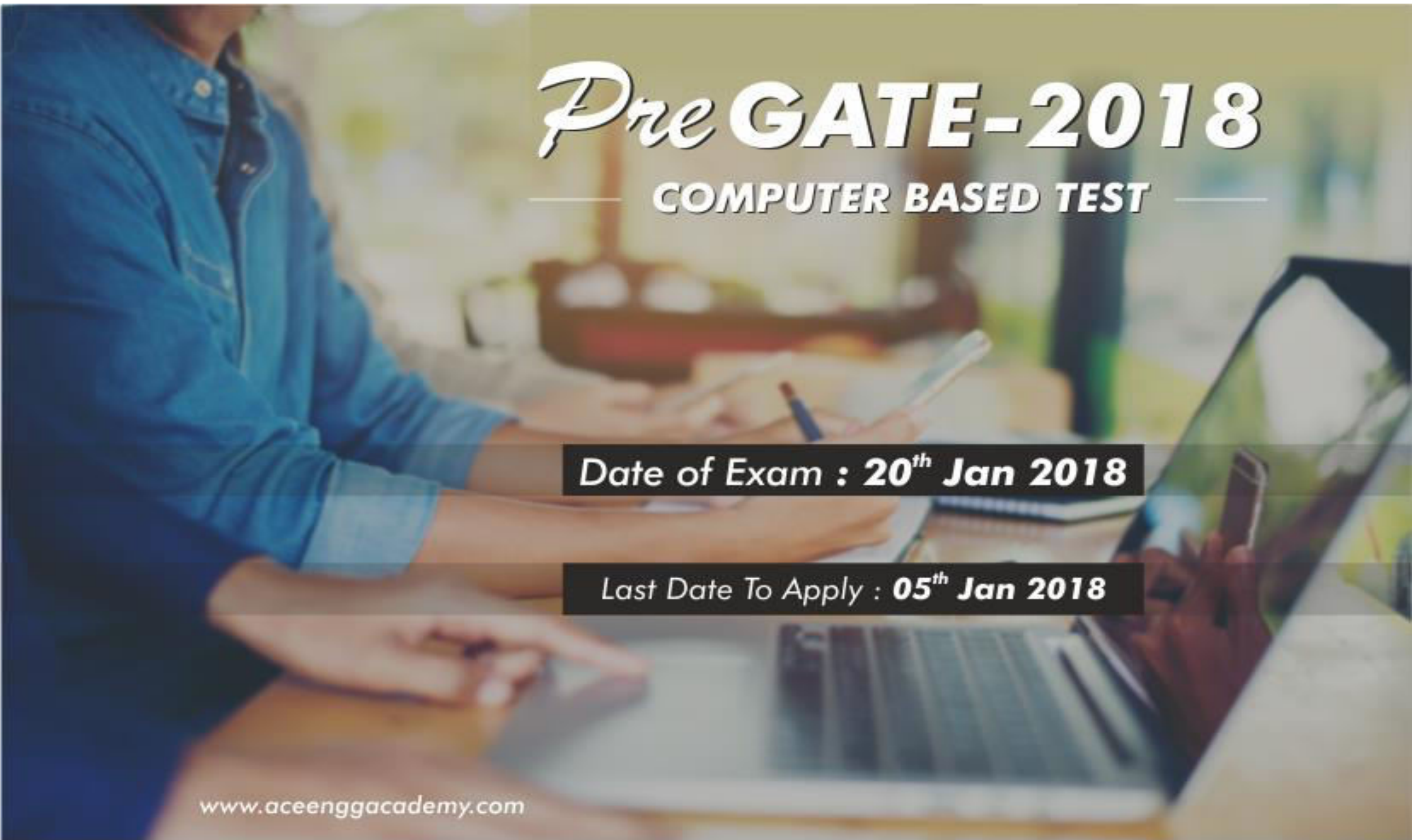
$$(\because V_1 = V_2 = C_v\sqrt{2gH} = \text{const.})$$

$$0.64 = \left(\frac{d_2}{d_1}\right)^2$$

$$\therefore d_2 = 0.8 d_1 = 0.8 \times 10 = 8 \text{ cm}$$

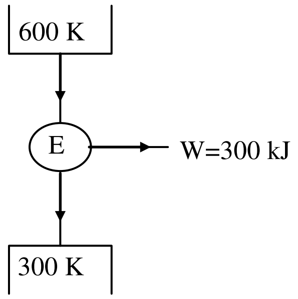
**26. Ans: (b)**

**Sol:** Regeneration is done to improve cycle efficiency. The exhaust gases from turbine are at high temperature. It is used to heat the compressed air before it enters into the combustion chamber. This decreases the heat to be supplied in condenser.



**27. Ans: (a)**

**Sol:**




$$\eta = \frac{600-300}{600} = 0.5$$

$$\eta = 0.5 = \frac{W}{\text{Heat Supplied}}$$

$$\text{Heat Supplied} = \frac{W}{0.5} = \frac{300}{0.5} = 600\text{kJ}$$

Entropy change of source

$$= -\frac{600}{600} = -1\text{kJ/K}$$

$$\text{Entropy change of sink} = \frac{300}{300} = 1\text{kJ/K}$$

**28. Ans: (b)**

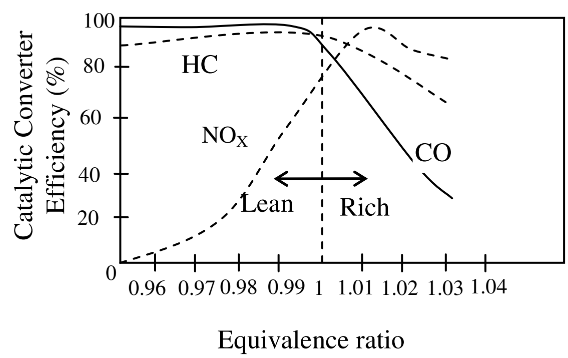
**Sol:**

- Angular momentum = $m(\vec{r}\times\vec{V})$. If the point is on the straight line then, $(\vec{r}\times\vec{V})$ = 0.
- If the point is not on the same straight line then, $(\vec{r}\times\vec{V}) \neq 0$.
- Since, no external torque is applied, So angular momentum about any given point remains constant.

**29. Ans: (c)**

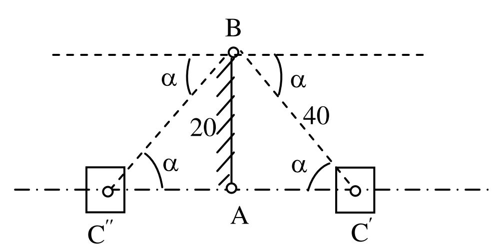
**Sol:** Catalytic converter works efficiently with hydrocarbons and carbon monoxide at lean conditions.

Catalytic converter works efficiently with $NO_x$ at rich conditions.




**30. Ans: (a)**

**Sol:**




$$\sin\alpha = \frac{20}{40} = \frac{1}{2}$$

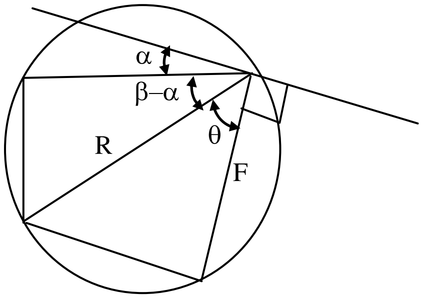
$\alpha = 30°$

$$\text{QRR} = \frac{180+2\alpha}{180-2\alpha} = \frac{240}{120} = 2$$

**31. Ans: (c)**

**32. Ans: (c)**

**Sol:**




From Merchant's circle diagram:

$\theta = 90 - [(\beta - \alpha) + \alpha]$

$\theta = 90 - \beta$

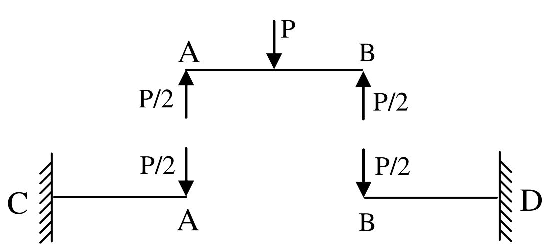
**33. Ans: (d)**

**Sol:** Cartesian coordinate robot is composed of three sliding joints, two of which are orthogonal.

Jointed arm robot manipulator has the general configuration of human arm.

**34. Ans: (c)**

**Sol:** The given beam can be represented by,



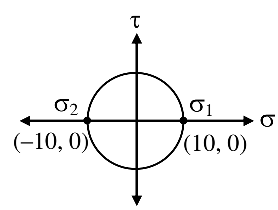

- Bending moment about hinge support is zero. Thus bending moment at A and at B is zero. Hence statement (1) is incorrect.
- Shear force in both the cantilever beams AC and BD is $\frac{P}{2}$. Thus, statement (2) is also incorrect.
- Bending moment at point C is given by

$$M_c = \frac{P}{2} \times L = \frac{PL}{2}$$

Thus, only statement (3) is correct.

**35. Ans: (d)**

**Sol:** Given state of stress is a case of pure shear. For that Mohr's circle can be drawn as shown in the figure below.




Thus principal stresses are 10 MPa and –10 MPa.

**36. Ans: (a)**

**Sol:** The true stress-strain curve is also known as flow curve. The plastic region of the flow curve can be described as

$$\sigma = K\varepsilon^n$$

n = strain hardening component

K = Strength coefficient

The slope of the line is n

For metals n = 0.1 - 0.5

**37. Ans: (c)**

**38. Ans: (b)**

**Sol:** The emissivity of a real surface is not a constant. Rather, it varies with the temperature of the surface as well as the wavelength and the direction of the emitted radiation. Therefore, different emissivities can be defined for a surface, depending on the effects considered. The most elemental emissivity of a surface at a given temperature is the **special directional emissivity,** which is defined as the ratio of the intensity of radiation emitted by the surface at a specified wavelength in a specified direction to the intensity of radiation emitted by a blackbody at the same temperature at the same wavelength. That is

$$\varepsilon_{\lambda,\theta}(\lambda,\theta,\phi,T)=\frac{I_{\lambda,e}(\lambda,\theta,\phi,T)}{I_{b\lambda}(\lambda,T)}$$

**39. Ans: (d)**

**Sol:** $h_y = 75$ kJ/kg, $h_1 = 183$ kJ/kg

$h_2 = 210$ kJ/kg

$$COP == \frac{h_1 - h_4}{h_1 - h_2} = \frac{1836-75}{210-183} = 4$$

$$COP = \frac{\text{Refrigeration Effect}}{W_{I/P}}$$

$$W_{I/P} = \frac{5}{4} = 1.25\text{ kW} = \dot{m}(h_2 - h_1)$$

$$\dot{m} = \frac{1.25}{27}\text{ kg/sec}$$

$h_3 = h_4$

Heat transfer in condenser = $\dot{m}(h_2 - h_3)$

$$Q = \dot{m}(h_2 - h_4)$$

$$Q = \frac{1.25}{27}\times(210-75) = 5 \times 1.25 = 6.25\text{ kW}$$

**40. Ans: (c)**

**Sol:** The specific speed of a turbine depends on geometric shape only. As the shape of two turbines is same their specific speed has to be same irrespective of the operating conditions.

**41. Ans: (a)**

**Sol:** Given data:

$u_2 = 200$ m/s; $\phi = 0.9$

Inlet velocity is axial therefore whirl velocity $V_{w_1} = 0$

$$W = V_{w_2}u_2 - V_{w_1}u_1$$

$$= V_{w_2}u_2 \qquad (\because V_{w_1}u_1 = 0)$$

$\because$ Blades are radial, $V_{w_2}u_2 = \phi u_2$

$\therefore$ Work done per kg, $W = \phi u_2^2$

$$= \frac{0.9\times 200^2}{1000}\frac{kJ}{kg} = 36\frac{kJ}{kg}$$

**42. Ans: (c)**

**Sol:**

- When two bodies at different temperatures are mixed in the calorimeter, heat flows from one body to the other due to the temperature difference. This results in change in the internal energy of the individual bodies.
- There is no exchange of heat with the surrounding in the calorimeter. Thus, the total internal energy of the bodies remain conserved as no external work is done on them.

**43. Ans: (a)**

**Sol:** $F_1 = \sqrt{F_2^2 + F_3^2}$

($\because$ $F_2$ and $F_3$ are mutually perpendicular and particle is stationary)

Now if $F_1$ is removed then net force

$= \sqrt{F_2^2 + F_3^2}$

$= F_1$

So, acceleration $= \dfrac{F_1}{m}$

**44. Ans: (d)**

**Sol:**

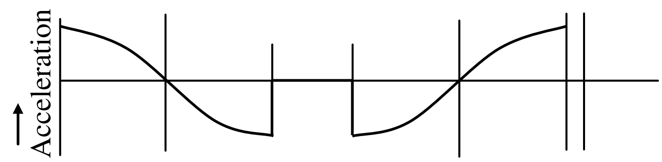
➢ Turbocharged CI engine increases the pressure and temperature of Inlet air. Increase in temperature decreases the ignition delay which decreases tendency to knock.

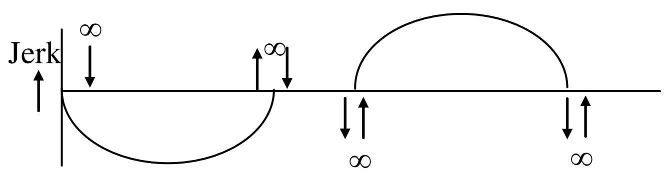
➢ High combustion wall temperature assists in pre-heating of air which decreases tendency to knock.

➢ In case of CI engine increase in speed increases the swirl moment of air which assist in proper mixing of air and fuel.

**45. Ans: (c)**

**Sol:**




*Jerk diagram*

$$\text{Jerk} = \frac{df}{dt}$$

The jerk at the beginning and the end of each of the outstroke and the return stroke is infinity because a finite value of acceleration is to be generated in no time.

**46. Ans: (d)**

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

Rate of consumption (d) = 300/month

Lot size of production (Q) = 1000 units

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

$$=1000\left(\frac{500-300}{500}\right)=400\text{units}$$

**47. Ans: (a)**

**Sol:** Table speed, $f_m = f_t.z.N$

$= 0.3 \times 8 \times 300$

$= 720$ mm/min

Time per pass,

$$T = \frac{L}{f_m} = \frac{360}{720} = 0.5 \text{ min} = 30 \text{ sec}$$

**48. Ans: (a)**

**Sol:** The notation TLR:TR represents a five degree of freedom manipulator whose body and arm is made up of a twisting joint (joint 1=T), a linear joint (joint 2 = L), and a rotational joint (joint 3 = R). The wrist consists of two joints, a twisting joint (joint 4 = T) and a rotational joint (joint 5 = R). A colon separates the body and - arm notation from the wrist notation.

**49. Ans: (a)**

**Sol:** Bending stress is given by,

$$\sigma_b = \frac{M.y}{I}$$

Thus, bending stress does not depend on property of material.

- Curvature of the beam is given by,

$$\kappa = \frac{1}{\rho} = \frac{M}{EI}$$

Thus, curvature of the beam having greater value of E will be smaller.

**50. Ans: (c)**

**51. Ans: (b)**

**Sol:** **Biot Number:** Ratio of internal thermal resistance of solid to the boundary layer thermal resistance

**Fourier Number:** Ratio of heat conduction rate to the rate of thermal energy storage in a solid. It is also known as dimensionless time.

**Grashof Number:** Ratio of buoyancy force to viscous force.

**Colburn j factor:** Dimensionless heat transfer coefficient

**52. Ans: (b)**

**Sol:** In tertiary phase diagram number of components (C) = 3

$$F + P = C + 1$$

At equilibrium point F = 0

$$P = 3 + 1$$

Number of phase = P = 4

**53. Ans: (a)**

**Sol:** $\dot{m}_w = 1.2\text{kg/s}, \; C_{pw} = 4.2\text{kJ/kgK}$

$\dot{m}_a = 2.5\text{kg/s}; \; C_{pa} = 1\text{ kJ/kgK}$

$T_{hi} = 90^\circ C, \quad T_{ci} = 8^\circ C$

$(\dot{m}_w . C_{pw}) = 1.2 \times 4.2 = 5.04$ kW/K

$\dot{m}_a . C_{pa} = 2.5 \times 1 = 2.5$ kW/K

$C_{min} = 2.5$ kW/K

$C_{max} = 5.04$ kW/K

Maximum rate of heat transfer

$= C_{min}(T_{hi} - T_{ci})$

$= 2.5(90 - 8)$

$= 2.5 \times 82$

$= 205.0$ kW

**54. Ans: (b)**

**Sol:** For saturated hydrocarbon,

$C_mH_nF_pCl_q$

$2m + 2 = q + n + p$

$R - (m-1)(n+1)(p)$

$m - 1 = 1, n + 1 = 1, p = 3$

$m = 2, n = 0, p = 3$

$2 \times 2 + 2 = q + 3 + 0$

$q = 3$

$m = 2, n = 0, p = 3, q = 3$

So, chemical formula for R-113 is $C_2F_3Cl_3$

**55. Ans: (b)**

**Sol:** Power transmitted to the plate is given by,

$P = F.u = \rho a(V - u)^2.u$

Maximum transmission of power,

$$\frac{dp}{du} = 0$$

i.e., $\rho a \frac{d}{du}\left[(V-u)^2.u\right] = 0$

i.e. $\frac{d}{du}\left[V^2u - 2u^2V + u^3\right] = 0$

$V^2 - 4uV + 3u^2 = 0$

or $(V-u)(V-3u) = 0$

$\therefore \; u = V \quad$ or $u = V/3$

$u = V$ not possible because force $[\rho a(V-u)^2]$ becomes zero.

$\therefore \; u = \frac{V}{3} = \frac{30}{3} = 10\text{m/s}$

**56. Ans: (a)**

**Sol:** Thermal efficiency,

$$\eta = \frac{m_a W_{net}}{m_f \times CV} \times 100$$

$$= \frac{60}{1} \times \frac{88}{44000} \times 100 = 12\%$$

**57. Ans: (c)**

**Sol:** According to the statement "heat and work are equivalent", heat supplied to the body increases its temperature. Similarly, work done on the body also increases its temperature.

For example: If work is done on rubbing the hands against each other, the temperature of the hands increases. So, we can say that heat and work are equivalent.

When heat is supplied to a body, we do not do work on it. When we are doing work on a body, it does not mean we are supplying heat to the body. Also, a body at rest cannot be set in motion along a line by supplying heat to it. So, these statements do not justify the equivalence of heat and work.

**58. Ans: (a)**

**Sol:** By using equation of motion during one second before it reaches the maximum height

v = u + at

v = 0

a = – g

t = 1 sec

$\Rightarrow 0 = u - gt$

$\Rightarrow u = g \times 1 = 10$ m/s

**59. Ans: (c)**

**Sol:**

| | |
|---|---|
| Flat plate collector | -1 |
| Parabolic through collector | -10 |
| Paraboloid dish Collector | -100 |
| Solar tower | -1000 |

**60. Ans: (b)**

**Sol:** $I_o = \frac{m\ell^2}{3}$

$$I_1 = \frac{m\left(\frac{\ell}{2}\right)^2}{3} = \frac{m\ell^2}{12}$$

$$I_o\ddot{\theta} + mg \times \frac{\ell}{2}\sin\theta = 0$$

$$I_o\ddot{\theta} + mg\frac{\ell}{2}\theta = 0$$

($\sin\theta \approx \theta$ for small oscillations)

$$f_o = \frac{1}{2\pi}\sqrt{\frac{mg\ell}{2I_o}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{mg\ell \times 12}{2 \times m\ell^2}} = \frac{1}{2\pi}\sqrt{\frac{6g}{\ell}}$$

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{mg \times \frac{\ell}{4}}{\left(\frac{m\ell^2}{12}\right)}} = \frac{1}{2\pi}\sqrt{\frac{mg\ell \times 12}{4m\ell^2}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{3g}{\ell}}$$

$\therefore\ f_1 = \sqrt{2}f_o$

**61. Ans: (b)**

**Sol:** Two mating gears should have same modules and same pressure angle $\left(\cos\theta = \frac{r_p}{r_b} = \frac{R_p}{R_b}\right)$

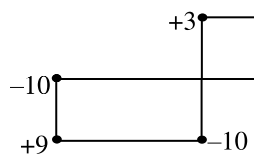
Gear ratio $= \frac{N_1}{N_2} = \frac{T_2}{T_1} = 3$

$\therefore$ From given values $T_2 = 60$, $T_1 = 20$

Gears A, D can be chosen to have gear ratio 3

**62. Ans: (a)**

**Sol:**



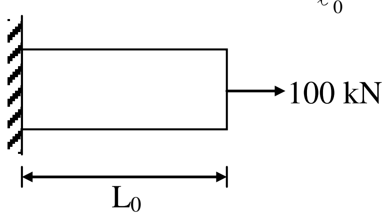

Cell evaluation = +3–9+3–10+9–10 = –14

Cost decreases at 14 per unit

**63. Ans: (c)**

**Sol:** Engineering strain, $\varepsilon_E = \dfrac{\ell - \ell_0}{\ell_0}$

$$= \frac{1.2\ell_0 - \ell_0}{\ell_0} = 0.20$$




Engineering stress,

$$\sigma_E = \frac{10\times10^3}{100} = 100\text{MPa}$$

True stress, $\sigma_T = \sigma_E(1+\varepsilon_E)$

= 100 (1+0.2)

= 120 MPa

**64. Ans: (c)**

**Sol:** Microprocessor does not have interfacing circuits, timers and internal memory. In microprocessor memory is connected externally.

**65. Ans:(d)**

**Sol:** In torsion of circular section, shear strain is zero at central axis. Thus shear stress is also zero at central axis.

**66. Ans: (c)**

**Sol:** Both above mentioned functions are performed by guide vanes. In addition to this, guide vanes also direct the flow towards runner at proper angle so that the flow enters into the turbine without shock.

**67. Ans: (b)**

**Sol:** Blade erosion in steam turbine takes place due to moisture in the steam. Steam carrying moisture travels with high velocity and strikes the blades which results in its erosion.

**68. Ans: (c)**

**Sol:** Since, $P_B > P_A$ and $\Delta V$ is same in both the cases.

**69. Ans: (a)**

**Sol:** Deceleration = $\mu_k \times g = 6$

$\Rightarrow \quad \mu_k = 0.6$

**70. Ans: (b)**

**Sol:** Psychrometer and hydrometer are used to measure humidity. Rotameter is used to measure flow velocity in closed channels. Anemometer is used to measure the wind velocity.

**71. Ans: (c)**

**Sol:**

- Scott-Russel mechanism-Straight line motion
- Geneva mechanism – Intermittent motion
- Off-set slider crank mechanism-Quick return motion
- Scotch yoke mechanism- Simple Harmonic motion

**72. Ans: (a)**

**Sol:** Let 'D' be the diameter of blank

Then, $\frac{\pi D^2}{4} = 2\pi R^2$

$\Rightarrow \quad \frac{\pi}{4} \times D^2 = 2\pi \times 50^2$

$D = 2\sqrt{2} \times 50 = 100\sqrt{2}$

D = 141 mm

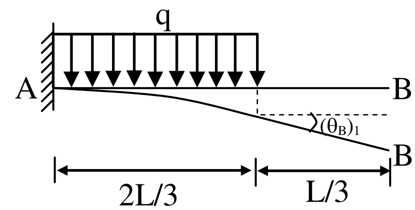
**73. Ans: (c)**

**Sol:** Pneumatic actuators both linear and rotary type are available.

**74. Ans: (a)**

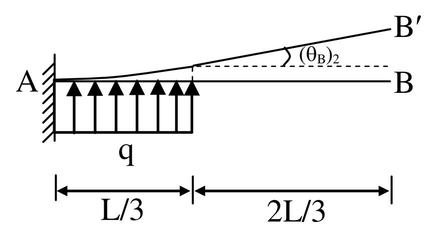
**Sol:** Given beam can be divided into two beams as shown in the figures below.

***Case* (I):**




$$(\theta_B)_1 = \frac{q}{6EI}\left(\frac{2L}{3}\right)^3 = \frac{4qL^3}{81EI} \text{ (clockwise)}$$

***Case* (II):**




$$(\theta_B)_2 = \frac{q}{6EI}\left(\frac{L}{3}\right)^3 = \frac{9qL^3}{162EI} \text{ (Anticlockwise)}$$

By using method of superposition,

$$\theta_B = (\theta_B)_1 - (\theta_B)_2$$

$$= \frac{4qL^3}{81EI} - \frac{qL^3}{162EI} = \frac{7qL^3}{162EI}$$

**75. Ans: (d)**

**Sol:** The net positive suction head for a pump is given as

NPSH = $H_a - H_v - H_s - h_{fs}$

Where $H_a$ = atmospheric pressure head.

$H_v$ = Vapour pressure head.

$H_s$ = Suction head (vertical height of suction pipe)

$H_{fs}$ = frictional head in suction pipe.

- Higher the value of NPSH lower is the possibility of cavitation.
- The minimum permissible value of NPSH is called NPSHR. Hence, first statement is wrong.
- As suction pipe diameter increase, the velocity in suction pipe decreases, head loss in suction pipe decreases and NPSH increases.
- As higher NPSH is desirable, second statement is also wrong.

**76. Ans: (b)**

**Sol:**

- TEL represents the variation of total energy head of fluid $\left(\frac{P}{\rho g}+\frac{V^2}{2g}+Z\right)$ in the direction of flow. The total energy always decreases in the direction of flow due to friction. Hence, second statement is correct.
- HGL represents the variation of piezometric head $\left(\frac{P}{\rho g}+z\right)$ in the direction of flow. The difference between TEL and HGL is $\frac{V^2}{2g}$ which is constant if pipe diameter is same. Hence for constant diameter pipe TEL and HGL are parallel.

**77. Ans: (b)**

**Sol:** The degree of reaction of a Parson's turbine is 50%. The total enthalpy drop in a stage is divided equally between fixed blade and moving blade.

**78. Ans: (a)**

**79. Ans: (d)**

**Sol:** $\Delta Q-\Delta W = \Delta U$ from first law of thermodynamics for closed system.

$\Delta U$ is a point function. So, it is same in both the methods.

**80. Ans: (a)**

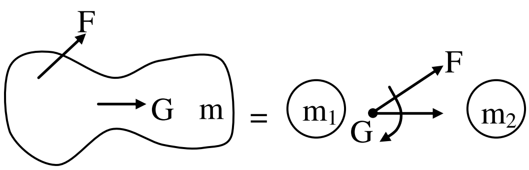
**Sol:** Throttling process is an irreversible process.

**81. Ans: (d)**

**Sol:** Biomass waste from industries is useful for manure and its not harmful to the environment. Bio mass energy requirement increases the plantation which reduces the erosion and increases the soil quality. It does not involve any burning and bio mass crops add oxygen to the atmosphere during photosynthesis.

**82. Ans: (b)**

**Sol:**




Let $r_1$ and $r_2$ respectively be the distance of $m_1$ and $m_2$ from the point C.G.

(i) For dynamically equivalent system acceleration should be same.

$\therefore \; a = \frac{F}{m}$

So the mass of both systems should be same.

$m = m_1 + m_2$

(ii) The moment of both systems should be same otherwise the moment to which the body is subjected will change. i.e., $m_1r_1 = m_2r_2$

(iii) Angular acceleration of equivalent system should same.

$\alpha = \frac{M}{I}$

$\therefore$ I of both systems about centre of gravity should be same.

$I = m_1r_1^2 + m_2r_2^2 = mk^2$

**83. Ans: (b)**

**Sol:** **Flattening:** It is a forging operation used for producing flat surfaces.

**Edgering:** It is a forging method used for collecting the material locally.

**Fullering:** It is a forging method for distributing the material away from the centre.

**Wire drawing:** It is a forging method for distributing the material from centre to outwards uniformly by pulling through a die.

**84. Ans: (a)**

**Sol:** A variation in the tractive effort of an engine is caused by the unbalanced portion of primary force which acts along the line of stroke of a locomotive engine (2 cylinders)

**85. Ans: (c)**

**Sol:** Given data:

$\tau = 40$ MPa , G = 80 GPa,

Strain energy per unit volume when a member subjected to torsinoal shear stress is given by,

$$u = \frac{\tau^2}{4G} = \frac{(40)^2}{4 \times 80 \times 10^3}$$

$= 0.005$ N.mm/mm$^3$ = 5 kJ/m$^3$

**Note:** When a member is subjected to pure shear, strain energy density is given by $u = \frac{\tau^2}{2G}$

**86. Ans: (a)**

**Sol:** $h_{L,\,expansion} = \dfrac{(V_1 - V_2)^2}{2g}$

$h_{L,\,contraction} = \left(\dfrac{1}{C_c - 1}\right)^2 \dfrac{V_2^2}{2g}$

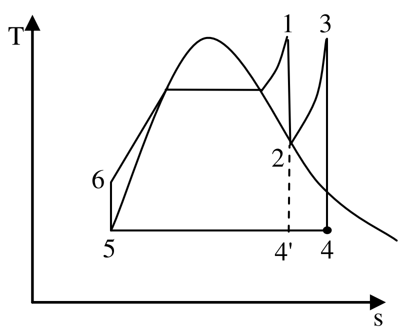
where $C_c$ = contraction coefficient

$h_{L,\,entrance} = 0.5 \times \dfrac{V^2}{2g}$

$h_{L,\,exit} = V^2/2g$

**87. Ans: (b)**

**Sol:** Reheating is mainly adopted to decrease moisture content in low pressure stage to a safe value



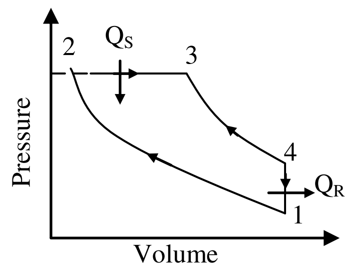

In the figure shown above, the process 2-3 is reheating of steam. If higher pressure is used without reheating the moisture content of steam at the low pressure stage of the turbine would be very high. Reheating reduces moisture in the steam at low pressure stages of turbine. Thus, prevents erosion of blades.

**88. Ans: (b)**

**Sol:** $ds = \dfrac{Pt}{T} = \dfrac{5 \times 3600}{273 + 27} = 60 kJ/K$

**89. Ans: (d)**

**Sol:**




Combustion Process

$T_3 = T_2 \times r_c$ ;

$\dfrac{P_2 V_2}{T_2} = \dfrac{P_1 V_1}{T_1}$

$\Rightarrow \quad P_2 = \dfrac{P_1 V_1}{T_1} \times \dfrac{T_2}{V_2}$

$= P_1 \times \dfrac{r}{r_c} \times \dfrac{T_3}{T_1}$

$= 95 \times \dfrac{15 \times 2400}{1.5 \times 300} = 7600 kPa$

$P_2 = 76$ bar

**90. Ans: (d)**

**Sol:** $T_{min} = \dfrac{2a}{\sin^2 \phi} = \dfrac{2 \times 1}{\sin^2 20} = 18$

**91. Ans: (a)**

**Sol:**

- Allowance is defined as the difference between the maximum material limits of hole and shaft. So, (1) is correct.
- It is equal to the minimum clearance in clearance fit. So, (3) is correct.
- It is equal to the maximum interference in interference fit. So, (4) is incorrect.

**92. Ans: (a)**

**Sol:** Given data:

$n = 10,\quad n_A = 7,\quad n_B = 3$

Deflection of a spring is given by,

$$\delta = \frac{8WD^3n}{Gd^4}$$

$$\therefore \quad \frac{W}{\delta} = \frac{Gd^4}{8D^3n} = k\,(\text{stiffness})$$

$$\therefore \quad k \propto \frac{1}{n}$$

$$\therefore \quad \frac{k_A}{k_B} = \frac{n_B}{n_A} = \frac{3}{7}$$

**93. Ans: (b)**

**Sol:** Hot air balloon is a completely submerged object in a fluid. (Fluid is atmospheric air).

For the stability of completely submerged objects centre of buoyancy (B) must be above centre of gravity (G).

**94. Ans: (d)**

**Sol:** Boiler mountings are used to enhance the performance of boilers.

They are:

1. Water level indicator
2. Pressure Gauge
3. Fusible plug
4. Feed check valve
5. Blow down cock
6. Fusible plug

Boiler accessories are used to increase efficiency of boiler.

They are:

1. Pressure Reducing valve
2. Steam traps
3. Feed pump
4. Injector
5. Economiser
6. Steam separator

**95. Ans: (d)**

**96. Ans: (a)**

**Sol:** $m r\omega^2 \times a = \left(\frac{F_s}{2}\right) \times a$

$F_s = 2mr\omega^2 = 2 \times 1 \times 0.4 \times (20)^2 = 320\text{ N}$

**97. Ans: (c)**

**Sol:**

- A total of 25 fundamental deviations are defined by Indian system of limits, fits and tolerances.

  A, B, C, D, .................... $Z_A$, $Z_B$, $Z_C$

  So, (1) is correct

- Because of the availability of standard drill bits in the market, hole is made first and then shaft. So, (2) is correct

**98. Ans: (b)**

**Sol:**

- The ratio of an equivalent length of the column to the minimum radius of gyration of the cross-sectional area of the column is called slenderness ratio. Thus, statement (1) is incorrect.
- Euler's formula holds good only for long column. Thus, statement (2) is also incorrect.
- For a column with both end fixed, equivalent length is given by, $L_e = \frac{L}{2}$, which is least compare to other end conditions. Thus, statement (3) is correct.

**99. Ans: (b)**

**Sol:** $u = -\frac{\partial \psi}{\partial y} = -2x$

$$v = \frac{\partial \psi}{\partial x} = 2y$$

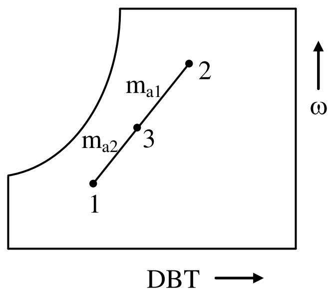
$$a_x = u\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = (-2x)(-2) + (2y)(0)$$

$$= -4x = -4(1) = -4 \text{ m/s}^2$$

Thus, magnitude of the x-component of acceleration at point (1, 1) is 4 m/s$^2$.

**100. Ans: (a)**

**Sol:**




$$\frac{\omega_2-\omega_3}{\omega_3-\omega_1}=\frac{m_{a1}}{m_{a2}}$$

$$\therefore \quad \frac{0.0187-\omega_3}{\omega_3-0.0058}=\frac{1}{2}$$

$\therefore \quad \omega_3 = 0.0144$ kg vap/kg dry air

**101. Ans: (a)**

**Sol:** Centripetal acceleration = $r\omega^2 = 8\ \text{m/s}^2$

r = 0.5 m

$$\omega = \sqrt{\frac{8}{0.5}} = 4 \text{ rad/sec}$$

Coriolis acceleration = $2V \times \omega = 2 \times 2 \times 4$

$= 16\ \text{m/s}^2$

**102. Ans: (b)**

**Sol:** Brake Power = 120 kW

Brake Thermal $\eta$ = 30 %

IP = 150 kW

$$\eta_{mech}=\frac{BP}{IP}=\frac{\text{Break thermal efficiency}}{\text{Indicated thermal efficiency}}$$

$$=\frac{120}{150}=\frac{30}{\text{Indicated thermal efficiency}}$$

Indicate thermal efficiency,

$\eta_{it}$ = 37.5 %

**103. Ans: (c)**

**Sol:** The electrodes should be sufficiently cooled in a protective atmosphere rather than oxidizing in normal atmosphere because tungsten oxide has low melting point, and thus, electrode may be contaminated and consumed.

**104. Ans: (d)**

**Sol:** In case of series connection

$T_1 = T_2 = T = 10$ kN - m

$$\theta=\frac{TL}{GJ} \qquad \theta \propto \frac{1}{d^4}$$

$$\frac{\theta_1}{\theta_2}=\frac{d_2^4}{d_1^4}=\frac{1}{2^4}=\frac{1}{16}$$

**105. Ans: (c)**

**Sol:** Let a = side of the cube

h = depth of the base

$\bar{h}$ = depth of C.G. of wetted area of vertical face.

As the cube is floating,

Buoyancy force = weight of the cube

$\therefore \rho \forall g = \rho_s V_s g$

i.e. $1000 \times h \times a^2 = 500 \times a^3$

i.e. h = a/2

$$\therefore \quad \bar{h}=\frac{h}{2}=\frac{a}{4}$$

$F_{side} = \rho g \bar{h} A_{side}$

$$= \rho g\left(\frac{a}{4}\right)\left(\frac{a}{2}\times a\right) = \frac{\rho g a^3}{8}$$

$F_{base} = \rho g h A_{base}$

$$= \rho g\left(\frac{a}{4}\right)\left(\frac{a^2}{2}\right) = \frac{\rho g a^3}{2}$$

$$\therefore \frac{F_{base}}{F_{side}} = \frac{\rho g a^3/2}{\rho g a^3/8} = 4$$

**106. Ans: (c)**

**Sol:** Equivalence ratio is the ratio of Fuel Air ratio at the given load to the stiochiometric Fuel Air ratio.

Air fuel ratio for SI engine during

| | |
|---|---|
| Cold Starting | - 3 |
| Idling | - 10 |
| Cruising | - 16 |
| Maximum Power | - 13 |

**107. Ans: (c)**

**Sol:** The power sources used are DC with electrode negative for better electrode life. These are normally the constant current or drooper type of power supplies.

**108. Ans: (d)**

**Sol:** For a process to occur the entropy change of the process can be negative zero or positive. The entropy change of universe must be positive or zero.

**109. Ans: (a)**

**Sol:** $\tau_w = \mu\frac{du}{dy} = \mu\frac{u}{y}$ ($\because$ velocity profile is linear inside laminar sublayer)

$$u^* = \sqrt{\frac{\tau_w}{\rho}} = \sqrt{\frac{\mu}{\rho}\cdot\frac{u}{y}}$$

$$\left(u^*\right)^2 = \upsilon\times\frac{u}{y}$$

$$\upsilon = \frac{\left(u^*\right)^2\times y}{u}$$

$$= \frac{(0.05)^2\times(0.5)\times10^{-3}}{1.25}$$

$$= \frac{0.25\times10^{-2}\times5\times10^{-4}}{1.25}$$

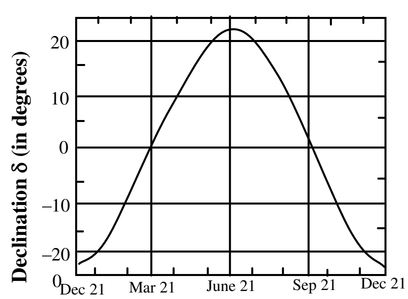
$= 10^{-6}$ m$^2$/s

$= 10^{-2}$ cm$^2$/s

**110. Ans: (b)**

**Sol:** Declination of beam radiation is highest during June 21 and it is 23.45°. On July 1st it should be near to 23.45°.

$$\delta = 23.45\sin\left[\frac{360}{365}(284+n)\right]$$




**Variation of Declination over the year**

**111. Ans: (b)**

**Sol:** Risers are used to compensate shrinkage before during solidification, therefore, the volume of the metal compensated from the riser is 1+2 = 3%.

**112. Ans: (d)**

**Sol:**

- **Rotational Vibrometer:** A rotational LDV is used to measure rotational or angular velocity.
- **Differential Vibrometer:** A differential LDV measures the out-of-plane velocity difference between two locations on the target.
- **Multi-beam Vibrometer:** A multi-beam LDV measures the target velocity at several locations simultaneously.
- **Self-mixing Vibrometer :** Simple LDV configuration with ultra-compact optical head. These are generally based on a laser diode with a built-in photo detector.

**113. Ans: (a)**

**Sol:** The methods of improving efficiency are

1. Providing clearance as small as possible.
2. Maintaining low pressure ratio.
3. Cooling during compression.
4. Reducing pressure drops at the valves by designing a light-weight valve mechanism, minimising the valve overlaps.

**114. Ans: (d)**

**Sol:**

- A scar is a shallow blow which occurs on the flat surface of the castings. so (1) is correct.
- If it is covered by a thin layer of metal, it is called a blister so (2) is correct.

**115. Ans: (b)**

**Sol:** $\Delta P = \rho g h_f = \rho g \times \dfrac{fLV^2}{2g.D}$

$$\therefore \Delta P \propto fV^2$$

$$\therefore \frac{\Delta P_2}{\Delta P_1} = \left(\frac{f_2}{f_1}\right) \times \left(\frac{V_2}{V_1}\right)^2$$

$$\text{Now, } f = \frac{0.316}{Re^{0.25}} = \frac{0.316}{\left(\frac{\rho VD}{\mu}\right)^{0.25}}$$

$$f \propto V^{-0.25}$$

$$\therefore \frac{f_2}{f_1} = \left(\frac{V_2}{V_1}\right)^{-0.25}$$

$$\therefore \frac{\Delta P_2}{\Delta P_1} = \left(\frac{V_2}{V_1}\right)^{-0.25} \times \left(\frac{V_2}{V}\right)^2$$

$$= \left(\frac{V_2}{V_1}\right)^{1.75} = 2^{1.75} = 3.34$$

**116. Ans: (c)**

**Sol:** TC = FC + VC(Q)

$TC_I = 150 + 6(100) = 750$

$TC_{II} = 80 + 10(100) = 1080$

$TC_{III} = 250 + 4(100) = 650$

$TC_{IV} = 100 + 9(100) = 1000$

The most economical process = process III

**117. Ans: (b)**

**Sol:** Control resolution is defined as the distance separating two adjacent control points in the axis movement. Control points are sometimes called addressable points.

**118. Ans: (c)**

**Sol:**

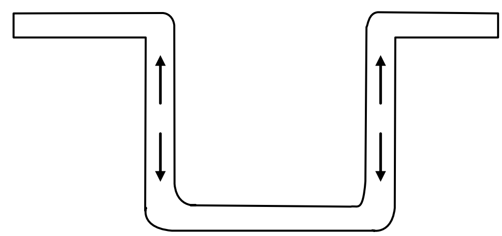
- Elasto – Plastic: The material is assumed to follow Hook's law up to the yield stress, after which is yields under constant stress. (A–3)
- Rigid – Perfectly plastic: When the material yields under constant stress, known as rigidly –perfectly plastic material. (B–4)
- Elastic – Strain hardening: Stress-strain diagram for this type of material is also known as bilinear diagram. In this after linear elastic region, strain hardening also takes place. (C–1)

**119. Ans: (c)**

**Sol:** Scanning laser sensor, ultrasonic sensor and capacitive sensor are non contact proximity sensors, so (a), (b) and (d) options are incorrect.

**120. Ans: (c)**

**Sol:**



The vertical wall zone is also known as deformation zone, because entire deformation happens in this zone. The stresses responsible for this deformation are tensile stresses only.

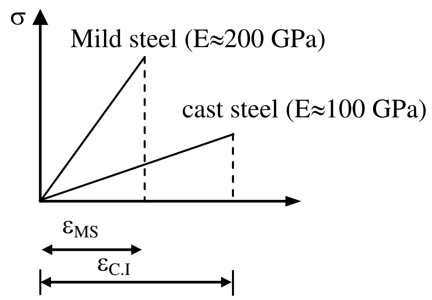
**121. Ans: (b)**

**Sol:** In non-prismatic beam, the section modulus also varies along the axis, so we can not assume that the maximum stresses occur at the cross section with the largest bending moment.

Thus, both the statements are true but statement (2) is not the explanation of statement (1).

**122. Ans: (a)**

**Sol:**




**123. Ans: (a)**

**Sol:** The product of the inertia is given by,

$$I_{x_1y_1} = \frac{I_x - I_y}{2}\sin 2\theta + I_{xy}\cos 2\theta$$

If the product of inertia is zero, then,

$$\frac{I_x - I_y}{2}\sin 2\theta + I_{xy}\cos 2\theta = 0$$

$$\therefore \quad \tan 2\theta = -\frac{2I_{xy}}{I_x - I_y}$$

This equation is same as equation given in statement (I) for orientation ($\theta_p$) of principal axes. Therefore, it is concluded that product of inertia is zero for the principal axes.

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

**124. Ans: (a)**

**Sol:**

- When a small specimen of ductile material is compressed, it begins to bulge outward on the sides and become barrel shaped.
- With increase in load, the specimen is flattened out, thus offering increased resistance to further shortening, which means the stress-strain curve goes upward.
- Thus, both the statements are true and statement (II) is correct explanation of statement (I).

**125. Ans: (a)**

**Sol:** Based on Hall-pitch equation

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

The same material having a finer grain size will have higher strength. Fine grain materials have large grain boundary area per unit volume. As the grain boundaries hinder dislocation motion, stress required to move the dislocations increases in the fine grain material and hence the strength increases.

**126. Ans: (b)**

**Sol:** In DCSP the work is positive and electrode is negative, due to work is positive the heat generated at the work is high, depth of penetration is high. Hence high melting point and high thickness plates can be easily welded but due to lower heat generation at electrode, the melting rate of electrode is low and so deposition rate is low.

By increasing welding current the heat generated will increase and by reducing welding speed more concentration is taking place hence depth of penetration of the weld will increase

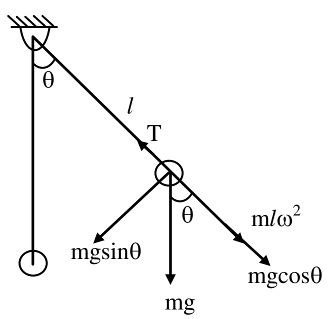
**127. Ans: (a)**

**Sol:** The draft tube minimizes kinetic energy loss at exit of turbine by converting it into pressure.

To convert velocity into pressure the area must increase in the direction of flow. In other words the area must decrease towards turbine. Therefore, both statements are correct and statement II is correct explanation for statement I.

**128. Ans: (d)**

**Sol:**




$a_T = g\cos\theta$

$a_r = g\sin\theta$

$a_{net} = \sqrt{a_T^2 + a_r^2} = g$

**129. Ans: (c)**

**Sol:** Lifting of the locomotive wheel above rails at certain speed is due to unbalanced force perpendicular to the line of stroke called Hammer blow.

**130. Ans: (b)**

**Sol:**

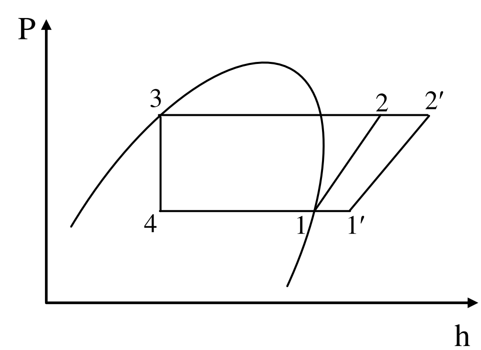
- Lewis equation predicts the static load capacity of gear tooth considering it as cantilever beam of uniform strength.
- For interchangeability the module and pitch of the mating gears should be same.

$P = \frac{\pi D}{T}$,

$m = \frac{D}{T}$

**131. Ans: (d)**

**Sol:**




By superheating $(h_1' - h_4) > (h_1 - h_4)$, refrigeration effect ↑ (increases)

Work input in compressor is a function of inlet temperature.

$$W_{in} = \frac{\gamma R T_i}{\gamma - 1}\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

When inlet temperature ($T_i$) increases (↑) then work input ($W_{in}$) increases (↑)

$$COP = \frac{RE}{W_{in}}$$

So, COP may increase, or decrease and it depends upon the type of refrigerant.

R – 12, R – 134a → COP increases (↑) with superheating inside evaporator.

R – 22, R – $NH_3$ → COP decreases (↓) with superheating inside evaporator.

**132. Ans: (a)**

**Sol:** Dummy job is a virtual activity consuming no resources and time. Statement (I) is correct**.** It is used mainly to specify precedence relationship.

**133. Ans: (d)**

**Sol:** The drag coefficient for an object depends on geometric shape and non-dimensional parameters like Reynolds number, Froude number, Mach number etc which govern the physics of the flow. It is independent of the size of the object. Thus, statement I is wrong.

The drag force is given by

$$F_D = \frac{C_D}{2}\rho A V^2$$

Above equation shows that, the drag force increases with increase in size of the object.

**134. Ans: (c)**

**Sol:** Surface tension (σ) is property of a fluid which is independent of size. Hence second statement is wrong. The surface energy due to surface tension is σA. Therefore, larger the surface area higher is the surface energy.

**135. Ans: (d)**

**Sol:** Nusselt number can not be less than unity.

$$\text{Nusselt number} = \frac{\text{convective heat transfer}}{\text{pure conductive heat transfer}}$$

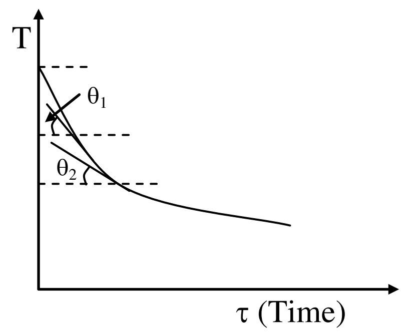
$$= \frac{\text{pure conductive heat transfer} + \text{heat transfer due to advection}}{\text{pure conductive heat transfer}}$$

If heat transfer rate due to advection is zero, then that means there is no macroscopic bulk displacement of the fluid. In this case, heat transfer in fluid is by conduction only (If radiation effect is neglected).

So, the minimum value of Nusselt number is one.

**136. Ans: (d)**

**Sol:**




For unsteady state

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-\left(\frac{hA}{\rho V C_p} \times \tau\right)}$$

$$\theta_1 > \theta_2$$

$$\left(\frac{dT}{d\tau}\right)_1 > \left(\frac{dT}{d\tau}\right)_2$$

$$\left(\frac{65-60}{5}\right) > \left(\frac{60-55}{d\tau}\right)$$

$$\frac{1}{5} > \frac{1}{d\tau}$$

$$d\tau > 5 \text{ min}$$

It will take more than 5 minutes for cooling the same temperature difference.

**137. Ans: (d)**

**Sol:** From second law of thermodynamics there should be a heat interaction with source and sink for production of work. Hence statement I is incorrect.

**138. Ans: (b)**

**Sol:**

- Chips carry around 75% of the heat generated. So, the temperature rise in the chip is maximum. So, statement (I) is correct.
- All the heat zones (Primary, Secondary and Tertiary) meet at one junction called as tool tip. So, the tip of the tool experiences very high temperature. If it goes beyond the hot hardness temperature of tool material, plastic deformation takes place. So, statement (II) is correct but doesn't justify statement (I).

**139. Ans: (d)**

**Sol:** Increase in heat transfer to the coolant across the combustion chamber decreases the temperature and pressure of working substance which reduces the work done during the expansion process.

**140. Ans: (a)**

**Sol:** For a ramjet engine, thrust is maximum at sea level and decreases as the altitude increase because the density of air reduces with altitude.

**141. Ans: (a)**

**Sol:** In vapour compression cycle is an inherently irreversible cycle because in expansion device pressure drop occurs due to throttling which is an irreversible process.

**142. Ans: (b)**

**Sol:** In uniform circular motion speed is constant but velocity is changing and acceleration is non zero.

**143. Ans: (a)**

**Sol:**

- If hard grinding wheels are employed for the machining of hard workpieces, abrasives particles wear out easily but due to the hardness of the wheel, the fresh abrasives don't come out of the wheel and only rubbing takes place. So, statement - I is correct.
- If fresh abrasives don't appear, no self-sharpening takes place. This condition is termed as glazing. So, statement (II) is correct and completely justifies statement (I).

**144. Ans: (d)**

**Sol:** Morse test can only be conducted on multi-cylinder engines. Frictional power is obtained by difference of total power and power produced during short circuit of spark plug.

**145. Ans: (d)**

**Sol:**

- In shell moduling casting process, solid cast product are made but not shell like products. So, statement (I) is incorrect.
- Slush casting is the open casting process in which the liquid molten metal is poured into the cavity, allowing it to solidify for some time, invert the mold so that the un-solidified molten metal will fall down and solidified metal retains in the mold. Now by breaking the mold the casting can be taken out. This is generally used for producing decorative parts like lamp shades and toys.
- In general, in shell molding the phenolic resin is used as mold material, but ceramic slurry can also be used as mold material called as ceramic molding. So, statement (II) is correct.

**146. Ans: (b)**

**Sol:** Capillary tube cannot satisfy the flow requirements with changing condenser and evaporator pressure. It is a constant restriction type device. It is merely a long tube with a narrow diameter bore. Once a capillary tube is selected, it is suitably only for designed pressure drop and flow.

Pressure drop through the capillary is due to following two factors

1. Friction, due to fluid viscosity, resulting in frictional pressure drop.
2. Acceleration due to flashing of liquid refrigerant into vapour resulting in momentum pressure drop.

**147. Ans: (a)**

**Sol:** Higher load results in more charge due to which peak temperature increases. The higher peak temperature increases chances knocking in SI engine.

**148. Ans: (b)**

**Sol:**

- Ultimate analysis is the elemental analysis which determines the percentage composition of carbon, hydrogen, oxygen, nitrogen and sulphur by weight. These elemental compositions are of pure fuel only, which is free of moisture and inorganic compounds.
- Proximate analysis reports moisture, volatile matter, ash and fixed carbon content of a fuel by percentage weight.

**149. Ans: (b)**

**Sol:**

- In hydrostatic extrusion, the direction of extruded component is same as that of the ram movement. So, the physical arrangement is similar to that of forward extrusion. So, statement (I) is correct.
- Hydrostatic extrusion is not preferable for extruding ductile materials because of the difficulty in arresting the leakages. So, statement (II) is correct but doesn't justify statement (I).

**150. Ans: (b)**

**Sol:** Encoders are mostly used position sensors. These are non-contact type devices. It converts linear or angular displacement into digital code or pulse signal.

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