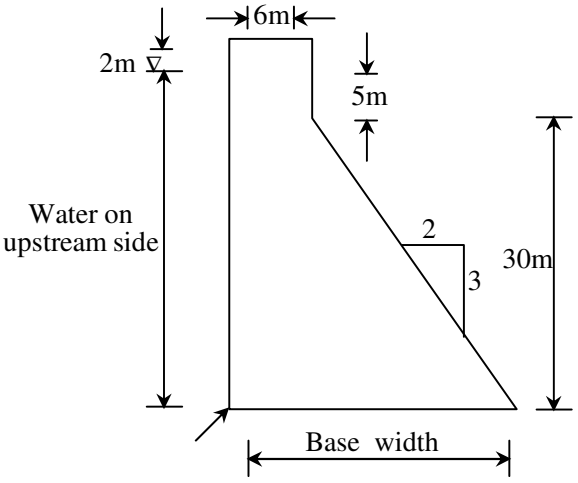
Each question carries two marks

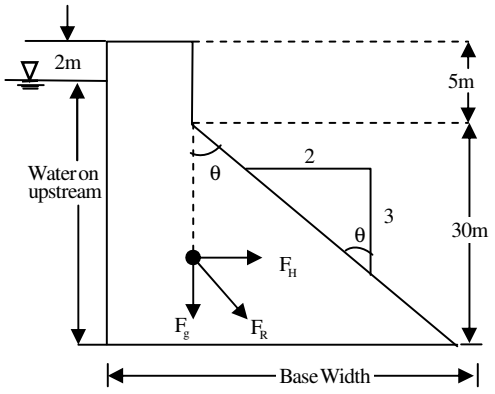
1. A section of a dam made of concrete, $\rho = 2.6$, total height = 35m, with top walkway width of 6m, is shown. The upstream bottommost point is called the Heel of the dam. The sloped part on downstream side is 3 vertical on 2 horizontal. Water stands till 2 m short of the top of the dam section. The net resultant force acting on the base level of the dam is nearly.



(A) 1370 k kgf (B) 1385 k kgf
(C) 1400 k kgf (D) 1433 k kgf

Key: (D)

Sol: Horizontal force act on vertical surface



$F_H = \rho g \bar{h} A$

$= 1000 \times 9.81 \times 16.5 \times (33 \times 1)$

$F_H = 544.5K\,kgf \quad [\because 1kgf = 9.81N]$

Weight of dam $(F_g) = mg$

$F_g = \rho . \forall . g$

$\forall = (6 \times 35) + \left(\frac{1}{2} \times 20 \times 30\right)$

$\forall = 510 m^3$

So $F_g = 2600 \times 510 \times 9.81 = 1326K\,kgf$

$F_R = \sqrt{F_g^2 + F_H^2} = \sqrt{(1326)^2 + (544.5)^2}$

$= 1433K\,kgf$

2. A Spherical waterdrop of 1 mm in diameter splits up in air incvbto 64 smaller drops of equal size. The surface tension coefficient of water in air is 0.073 N/m. The work required in splitting up the drop is

(A) 0.96×10^{-6} J (B) 0.69×10^{-6} J
(C) 0.32×10^{-6} J (D) 0.23×10^{-6} J

Key: (B)

Sol: Given,

$D = 1mm \Rightarrow R = 1/2\,mm$

$n = 64$

$\sigma = 0.073$

Volume before splitting = volume after splitting

$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$

$R^3 = n \times r^3$

$So, n = \left(\frac{R}{r}\right)^3 \Rightarrow r = \frac{R}{n^{1/3}} = \frac{(1/2)}{(64)^{1/3}}$

$r = 1/8\,mm$

Surface Energy before splitting, $E_1 = \sigma . 4\pi R^2$

Surface Energy after splitting, $E_2 = 64 \times (\sigma . 4\pi r^2)$

So, work require in splitting = $E_2 - E_1$

So, work require in splitting $= E_2 - E_1$

$= \sigma \times 4\pi \left[64r^2 - R^2 \right]$

$= 0.073 \times 4 \times 3.14$

$\left[-(1/2)^2 + 64(1/8)^2 \right] \times (10^{-3})^2$

$= 0.68 \times 10^{-6} \text{ J}$

3. Consider the following statements pertaining to stability of floating bodies:

1. A floating body will be stable when the centre of gravity is above the centre of buoyancy.
2. The positions of metacentres corresponding to different axes of rotation are generally different for the same floating object.
3. For cargo ships, the metacentric height varies with loading.

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only

(C) 1 and 3 only (D) 2 and 3 only

Key: (D)

Sol: Statement 1 is incorrect because stability of floating body is measured by metacenter w.r.t center of gravity.

4. Water is coming out from a tap and falls vertically downwards. At the tap opening, the stream diameter is 20 mm with uniform velocity of 2 m/s. Assuming steady inviscid flow, constant pressure atmosphere everywhere, and neglecting curvature and surface tension effects, the diameter of the stream 0.5m below the tap opening is nearly.

(A) 11.7 mm (B) 14.6 mm

(C) 17.5 mm (D) 20.4 mm

Key: (B)

Sol: Apply Bernoulli's equation between (1) & (2)

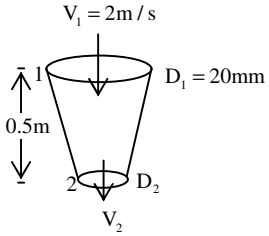
$$\frac{P_1}{\rho g} + \frac{V_1^2}{\rho g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{\rho g} + Z_2$$

$P_1 = P_2 = P_{atm}, V_1 = 2 \text{ m/s}, Z_1 - Z_2 = 0.5 \text{m}$

$$\left(\frac{V_2^2}{2 \times 10}\right) = \left(\frac{4}{2 \times 10}\right) + (0.5)$$

$V_2 = 3.74 \text{ m/s}$

apply continuity equation between (1) & (2)



$A_1 V_1 = A_2 V_2$

$D_1^2 V_1 = D_2^2 V_2$

$$D_2 = D_1 \sqrt{\frac{V_1}{V_2}} = 20 \sqrt{\frac{2}{3.74}}$$

$D_2 = 14.6 \text{mm}$

5. Consider the following statements regarding Bernoulli's equation:

1. It is assumed that no energy has been supplied.
2. The velocity of a steady stream of fluid flow will depend on the cross-sectional area of the stream.
3. Consider two sections 1 and 2 along a flow stream. In this reach, if q is work done by a pump, w is work absorbed by turbine, ρ is density of water and g is acceleration of gravity, with p, v and z carrying standard meanings, Bernoulli's equation will read

$$\frac{p_1}{\rho} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho} + \frac{v_2^2}{2g} + z_2 + w + g$$

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Sol: Given that q is work done by a pump & also in third statement Bernoulli equation is wrong.

6. An oil flows through a pipe at a velocity of 1.0 m/s. The pipe is 45m long and has 150mm diameter. What is the head loss due to friction, if $\rho = 869\,kg/m^3$ and $\mu = 0.0814\,kg/m\,s$?

(A) 0.61 m (B) 0.51 m
(C) 0.41 m (D) 0.31 m

Key: (A)

Sol: $\text{Reynolds no.}(Re) = \frac{V\rho D}{\mu} = \frac{869\times1\times0.15}{0.0814}$

$= 1601 < 2000$ so laminar flow

Head loss due to fluid friction inpipe

$(h_f) = \frac{32\mu\bar{u}L}{D^2.\rho.g}$

$h_f = \frac{32\times0.0814\times1\times45}{(0.15)^2\times869\times9.81} = 0.61m$

$h_f = 0.61m$

7. Consider the following statements:

1. At low Reynolds numbers of any flow, viscous forces dominate over inertial forces.
2. Transition from laminar to turbulent flow occurs over a range of Reynolds numbers depending on the surface presented to the flow.

Which of the above statements is/are correct?

(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (C)

Sol: ∵ At low Reynold no. flow is laminar & depending upon the surface of flow, flow changes from laminar to Turbulent for higher Reynold no.

8. In a steady laminar flow of a given discharge through a circular pipe of diameter D, the head loss is proportional to

(A) D^{-1} (B) D^{-2} (C) D^{-3} (D) D^{-4}

Key: (D)

Sol: Head loss, in a steady laminar flow, for a given discharge

$h_f = \frac{128\mu QL}{\pi D^4}$

$\text{So}, h_f \propto D^{-4}$

9. A two dimensional flow field is defined as $\vec{V} = \vec{i}x - \vec{j}y$. The equation of the stream line passing through the point (1, 2) is

(A) xy + 2 =0 (B) $x^2y+2=0$
(C) xy–2=0 (D) $x^2y-2=0$

Key: (C)

Sol: Given,

$\vec{v} = x\hat{i} - y\hat{j}$

So, $u = x$

$v = -y$

$\text{Streamline equation}, \frac{dx}{u} = \frac{dy}{v}$

$\frac{dx}{x} = \frac{dy}{(-y)}$

$\text{Intergrate equation}, \ln x = -\ln y + \ln c$

$xy = c$

$\text{given } x = 1, y = 2$

$\text{so}, c = 2 \text{ or } xy = 2$

so equation is $xy - 2 = 0$

10. The centre – line velocity in a pipe flow is 2m/s. What is the average flow velocity in the pipe if the Reynolds number of the flow is 800?

(A) 2 m/s (B) 1.5 m/s
(C) 1 m/s (D) 0.5 m/s.

Key: (C)

Sol: Given that centerline velocity = 2m/sec

$\text{i.e.}, v_{max} = 2m/sec$

$\because Re = 800 < 2000 (\therefore \text{Laminar flow})$

So, mean velocity $\bar{v} = \frac{v_{max}}{2} = \frac{2}{2}$

$\bar{v} = 1 m/sec$

11. During a constant pressure expansion of a gas, 33.3% heat is converted into work while the temperature rises by 20K. The specific heat of the gas at constant pressure as a proportion of work, W is

(A) 8% (B) 10% (C) 12% (D) 15%

Key: (D)

Sol: Given,

$\text{Work}(W) = 0.33Q$

$\text{Temperatura rise}(\Delta T) = 20K$

So $Q = C_p(\Delta T)$

$\frac{W}{0.33} = C_p(20)$

$C_p = 0.15W$

i.e., specific heat of the gas at constant pressure is 15% of the work.

12. A cylinder contains $10m^3$ of an ideal gas at a pressure of 2 bar. This gas is compressed in a reversible isothermal process till its pressure increases to 15 bar. What quantum of work will be required for this process? (You can use the table given herewith.)

Number	2	2.5	3	5	7
Log_{10}	0.301	0.397	0.475	0.698	0.845

(A) 4500 kJ (B) 4030 kJ

(C) 450 kJ (D) 403 kJ

Key: (B)

Sol: Given, $V_1 = 10m^3$

$P_1 = 2bar$

$P_2 = 15bar$

Isothermal work $= P_1V_1 \ell n(P_1/P_2)$

$= 2.3 \times 2 \times 10^5 \times 10 \times \log_{10}(2/15)$

$= 2.3 \times 2 \times 10^5 \times 10[\log_{10} 2 - \log_{10} 5 - \log_{10} 3]$

$= 2.3 \times 2 \times 10^5 \times 10[0.301 - 0.698 - 0.475]$

$= 4030kJ$

13. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3kJ/kg K to 0.4 kJ/kg K. At the same time, the entropy of the surroundings decreases from 80kJ/kg K to 75 kJ /kg K. The process is

(A) reversible and isothermal

(B) irreversible

(C) reversible only

(D) isothermal only

Key: (B)

Sol: Given, $m = 100kg$

Entropy of process

$s_1 = 0.3 kJ/kg K, s_2 = 0.4 kJ/kg K$

Entropy of surrounding

$s_1 = 80kJ / kg.K, s_2 = 75kJ / kg.K$

So, for a process $(\Delta S)_{process}$

$= (\Delta S)_{sys} + (\Delta S)_{surr}$

$= (s_1 - s_2)_{sys} + (s_1 - s_2)_{Surr}$

$= (0.3 - 0.4) + (80 - 75)$

$= 5 - 0.1 = 49 kJ/kgK$

$(\Delta S)_{process} > 0$

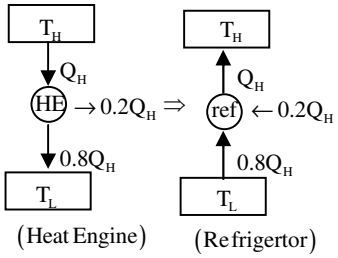
i.e., irreversible process

14. A reversible heat engine rejects 80% of the heat supplied during a cycle of operation. If the engine is reversed and operates as a refrigerator, then its coefficient of performance shall be

(A) 6 (B) 5 (C) 4 (D) 3

Key: (C)

Sol:



$$C.O.P = \frac{Q_L}{W_{in}} = \frac{Q_L}{Q_H - Q_L}$$

$$= \frac{(0.8)Q_H}{(0.2)Q_H}$$

$$C.O.P = 4$$

15. For the same efficiency of the Brayton cycle and the Carnot cycle working between temperature limits of T_{max} and T_{min}, the power contribution of the Brayton cycle will be

(A) zero

(B) maximum

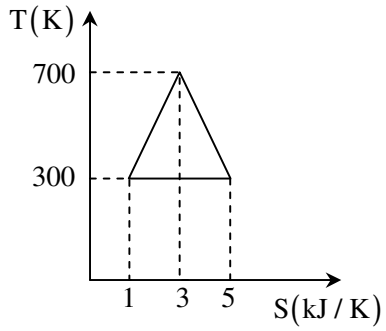
(C) minimum

(D) 50% of the Carnot cycle

Key: (A)

Sol: If efficiency is same then power contribution of Brayton cycle will be zero.

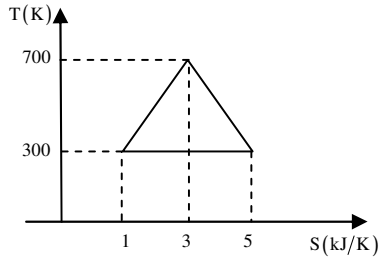
16. The thermal efficiency of the hypothetical cycle shown is



(A) 0.6 (B) 0.5 (C) 0.4 (D) 0.3

Key: (C)

Sol:



W_{net} = area enclosed by curve

$= 1/2 \times 4 \times 400 = 800kJ$

Incycle $W_{net} = Q_{net} = Q_{in} - Q_{out}$

Q_{out} = Heat rejection at lowest temperature in cycle

$= T(\Delta S)$

$Q_{out} = 300(5-1) = 1200kJ$

So, $Q_{in} = Q_{out} + W_{net} = (1200 + 300)kJ$

$Q_{in} = 1500kJ$

$$\text{So, Efficiency of cycle}(\eta) = \frac{W_{net}}{Q_{in}}$$

$$= \frac{300}{2000} = 0.4$$

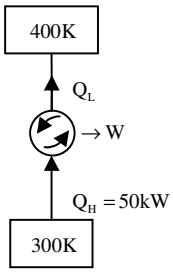
17. A heat engine working on the Carnot cycle receives heat at the rate of 50 kW from a source at 1300K and rejects it to a sink at 400K. The heat rejected is

(A) 20.3 kW (B) 15.4 kW

(C) 12.4 kW (D) 10.8 kW

Key: (B)

Sol: Given, Carnot cycle



$$\eta_{carnot} = 1 - \frac{T_L}{T_H} = \frac{W_{net}}{Q_H}$$

$$= 1 - \frac{400}{1300} = \frac{W_{net}}{50kW}$$

$$W_{net} = 34.6kW$$

$$W_{net} = Q_H - Q_L$$

$$34.6 = 50 - Q_L$$

$$Q_L = (50 - 34.6)kW = 15.4kW$$

$$Q_L = 15.4kW$$

18. An ideal gas is flowing through an insulated pipe at the rate of 3.3 kg. There is a pressure drop of 15% from the inlet to the outlet of the pipe. What is the rate of energy loss because of this pressure drop due to friction, given that R_{gas}=0.287 kJ/kg K and the reference temperature T_0 is 300K?

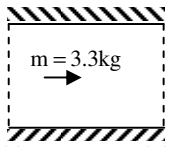
(A) 42.62 kW (B) 40.26 kW
(C) 38.14 kW (D) 35.13 kW

Key: (A)

Sol: Given,

$R_{gas}=287\,J/Kg\,K$

$T_o=300K$



$$\text{Work done} = V(\Delta P)$$
$$= V(P_1 - P_2)$$
$$= \frac{mRT}{P}(0.25)P$$
$$= 0.25\times3.3\times287\times300 = 42.62kW$$

19. A furnace is provided with an insulating refractory lining. The overall thermal conductivity of the material is 0.03W/m K. The thickness of the lining is 100mm. The inner and outer temperatures are 250°C and 50°C, respectively. The heat loss the the surroundings will be

(A) 30 J/m^2/s (B) 60 J/m^2/s
(C) 60 J/s (D) 30 J/s

Key: (B)

Sol: $\text{Conductivity}(K)=0.03\,W/mK$

$\text{Thickness}(L)=100mm$

$T_i=250°C, T_o=50°C$

$$\text{heat loss to surrounding } Q_{loss}=\frac{\Delta T}{(L/K)}$$

$$=\frac{200}{\left(\frac{100\times10^{-3}}{0.03}\right)}$$

$$Q_{loss}=60\,J/(m^2/s)$$

20. A wall of 0.6m thickness has normal area of 1.5m^2 and is made up of material of thermal conductivity 0.4W/m K. If the temperatures on the two sides of the wall are 800°C and 1000°C, the thermal resistance of the wall is

(A) 1.8 K/W (B) 1.8 W/K
(C) 1 K/W (D) 1 W/K

Key: (D)

Sol: Given,

$\text{Thickness}(L)=0.6m$

$\text{Area}(A)=1.5m^2$

$\text{Conductivity}(K)=0.4\,W/mK$

$\text{Temperature difference}(\Delta T)=200$

$$\text{Thermal resistance of wall}(R_{th})=L/AK$$
$$=\frac{0.6}{1.5\times0.4}=1W/K$$

21. Heat is lost from a 100mm diameter steam pipe placed horizontally in ambient air at 30°C. If the Nusselt number is 25 and the thermal conductivity of the air is 0.03W/m K, then the heat transfer coefficient will be.

(A) 7.5 W/m^{2}K (B) 15 W/m^{2}K
(C) 25 W/m^{2}K (D) 35 W/m^{2}K

Key: (A)

Sol: Given,

$D=100mm$

$\text{ambient temperature}(T_\infty)=30°C$

$N_v=25$

$\text{Thermal conductivity}(K)=0.03\,W/mK$

$\text{So, } N_v=h\,L_c/K\,(\text{here } L_c=D)$

$$25=\frac{h(0.1)}{0.03}$$

$$h=7.5\,W/m^2K$$

22. Air at 1 atmospheric pressure and 27°C blows across a 12mm diameter sphere at a free stream velocity of 4 m/s. A small heater

inside the sphere maintains the surface temperature at 77°C. With k = 0. 0.026 W/m (Kelvin) and with (Nu) = 31.4, the heat loss by the sphere would be

(A) 1.93J/s (B) 1.76J/s
(C) 1.65J/s (D) 1.54J/s

Key: (D)

Sol: Given,

$T_\infty = 27°C, K = 0.026\,W/mK$

$D = 12mm, N_v = 31.4$

$V_\infty = 4\,m/s$

$T_s = 77°C$

$Q_{loss} = h.A_s(\Delta T)$

$\because N_v = \frac{hL_c}{K}(\text{here } L_c = D)$

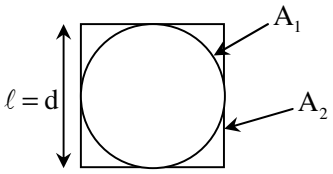
$h = \frac{N_v.K}{D} = \frac{31.4\times0.026}{0.012}$

$h = 68.03\,W/m^2K$

$Q_{loss} = 68.03\times4\times3.14\times(6\times10^{-3})^2\times(77-27)$

$Q_{loss} = 1.54\,J/sec$

23. The view factors F_{12} and F_{21}, for the sphere of diameter d and a cubical box of length l = d as shown in the figure, respectively, are



(A) 1 and $\frac{\pi}{3}$ (B) $\frac{\pi}{3}$ and 1
(C) 1 and $\frac{\pi}{6}$ (D) $\frac{\pi}{6}$ and 1

Key: (C)

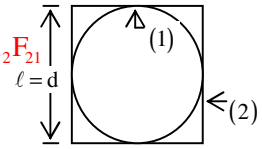
Sol:

$F_{12} = 1$

by reciprocal theorm $A_1F_{12} = A_2F_{21}$

$4\pi(d/2)^2 1 = 6.d^2.F_{21}$

$[F_{21} = \pi/6]$



24. Knocking in a spark ignition engine can be reduced by

1. retarding the spark
2. supercharging
3. increasing the engine speed
4. using a fuel of long straight chain structure

Select the correct answer using the code given below.

(A) 1 and 4 (B) 1 and 3
(C) 2 and 3 (D) 2 and 4

Key: (B)

Sol: To reduce knocking in spark ignition engine we need to reduce the combustion chamber temperature.

So, retarding the spark and increasing the engine speed helps to reduce combustion chamber temperature.

25. A 4-cylinder diesel engine running at 1200 r.p.m. developed 18.6 kW. The average torque when one cylinder was cut out was 105 Nm. If the calorific value of the fuel was 42000 kJ/kg and the engine used 0.34 kg of diesel/kW hr, the indicated thermal efficiency was nearly.

(A) 29% (B) 26% (C) 31% (D) 23%

Key: (A)

Sol: 4 cylinders:

N = 1200RPM, C.V = 42000 kJ/kg

P =18.6 kW, bsfc = 0.34kg/kWhr

T_{avg}=105N-m

$B.P/\text{cylinder} = \frac{18.6}{4} = 4.65kW$

$$\text{B.P when one cylinder is cut off} = \frac{2\pi NT}{60}$$

$$= \frac{2\times 3.14\times 1200\times 105}{60} = 13.188\text{kW}$$

$$\text{So, } (\text{I.P})_{1\text{cylinder}} = (\text{B.P})_{4\text{cylinder}} - (\text{B.P})_{1\text{cylinder}}$$

$$= (18.6 - 13.18)\text{kW}$$

$$(\text{I.P})_{1\text{cylinder}} = 5.412\text{kW}$$

$$(\text{I.P})_{1\text{cylinder}} = 4\times 5.412 = 21.648\text{kW}$$

$$\text{So, bsfc} = 0.34 = \frac{m_f\ (\text{kg/hr})}{\text{B.P(kW)}}$$

$$0.34 = \frac{mf}{(18.6)}$$

$$m_f = 6.324\,\text{kg/hr}$$

$$\text{S, } \eta_{i\,th} = \frac{\text{I.P}}{m_f \times \text{C.V}}$$

$$= \frac{21.6\times \cancel{10^3}}{\frac{6.3}{3600}\times 42000\times \cancel{10^3}} = 0.2938$$

$$\eta_{i\,th} \approx 29.38\%$$

26. In a Morse test on a 2-cylinder, 2-stroke SI engine, the brake power is 9kW and the BHP of individual cylinders with spark cutoff are 4.25kW and 3.75kW, respectively. The mechanical efficiency of the engine is

(A) 90% (B) 80%

(C) 52.5% (D) 45.5%

Key: (A)

Sol: Given, Morse Test

2cylinder, 2stroke SI engine

B.P = 9kW

$(B.P)_I = 4.25\text{kW}$

$(B.P)_{II} = 3.75\text{kW}$

$I.P = (n \times B.P) - [(B.P)_I + (B.P)_{II}]$

$= [(2 \times 9) - (4.25+3.75)]\text{kW}$

$I.P = 10\text{kW}$

$$\eta_m = \frac{\text{B.P}}{\text{I.P}} = \frac{9\text{kW}}{10\text{kW}} = 0.9$$

$$\eta_m = 90\%$$

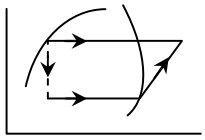
27. The ordinates and abscissae of the diagram given for the vapour-compression refrigeration cycle represent

(A) pressure and volume

(B) temperature and entropy

(C) enthalpy and entropy

(D) pressure and enthalpy



Key: (D)

28. Consider the following statements for refrigeration and air-conditioning :

1. In a refrigerating machine, the heat exchanger that absorbs heat is connected to a conditioned space.
2. A refrigerating cycle operating reversibly between two heat reservoirs has the highest coefficient of performance.
3. The lower the refrigeration required and the higher the temperature of heat rejection to the surroundings, the larger the power consumption.

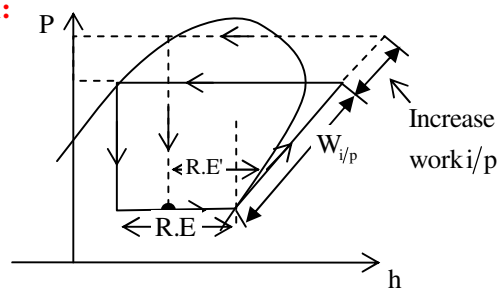
Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

Sol:



All three statements are correct.

Statements -3

$[R.E > R.E']$

So, Power requirement will increase if temperature of heat rejection increases.

29. In a refrigerator, the evaporator and condenser coil temperatures are -33°C and 27°C, respectively. Assuming that the maximum COP is realized, the required power input for a refrigerating effect of 4 kW is

(A) 8 kW (B) 4 kW (C) 2 kW (D) 1 kW

Key: (D)

Sol: Given,

TL=240K, TH=300K and R.E=4kW.

$$C.O.P = \frac{T_L}{T_H - T_L} = \frac{240}{300-240} = 4$$

$$\text{also } C.O.P = \frac{R.E}{W_{in}}$$

$$\text{so } W_{in} = \frac{R.E}{C.O.P} = \frac{4kW}{4} = 1kW.$$

30. Consider the following statements:

The volumetric efficiency of a reciprocating compressor can be improved by

1. decreasing the clearance volume
2. cooling the intake air
3. heating the intake air

Which of the above statements is / are correct?

(A) 2 only (B) 3 only

(C) 1 and 2 (D) 1 and 3

Key: (C)

Sol: $\eta_v \propto \frac{1}{C} \propto \frac{1}{(Pr.ratio)}$

If clearance volume $(C)\downarrow, \eta_v(\uparrow)$

If cooling of air is done. It increase the density of air due to that large amount of air in small volume enters in compressor. So η_v increases.

31. Consider the following statements:

The presence of air inside condensers

1. remains as a non-condensable gas
2. reduces the condensing coefficient
3. tends to cling to the surface
4. introduces large thermal resistance

Which of the above statements are correct?

(A) 1, 2, 3 and 4 (B) 1, 2 and 3 only

(C) 3 and 4 only (D) 1, 2 and 4 only

Key: (A)

32. The refrigeration system of an ice plant working between temperatures of -5°C and 25°C produces 20kg of ice per minute from water at 20°C. The specific heat of water is 4.2 kJ/kg and latent heat of ice is 335 kJ/kg. The refrigeration capacity of the refrigeration plant is

(A) 9040 kJ/min (B) 8750 kJ/min

(C) 8380 kJ/min (D) 8010 kJ/min

Key: (C)

Sol: $T_H = 25°C, T_L = -5°C$

$\dot{m}_{ice} = 20 kg/min$

$T_{initial} = 20°C$

$(C_p)_{water} = 4.2 kJ/kg$

$L = 335 kJ/kg$

Refrigeration Capacity

$$Q = \dot{m} C_p W \left(T_{initial} - T_{0°C}\right) + \dot{m} L$$

$$= \left[20 \times 4.2 \times (20 - 0°C)\right] + (20 \times 335)$$

$$Q = 8380 kJ/min$$

33. Consider the following statements in respect of a vapour – absorption refrigeration cycle:

1. The absorption refrigeration cycle is generally used when waste heat is available from an existing source or when free energy like solar energy is to be used.

2. There are no moving parts in the absorption refrigeration plant except a small liquid pump.
3. The value of the coefficient of performance is nearly the same in both vapour – absorption and vapour – compression refrigeration plants.

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only
(C) 1 and 3 only (D) 2 and 3 only

Key: (B)

Sol: Statement '3' is not correct because

$(C.O.P)_{\text{vapour absorption}} \approx 1$

$(C.O.P)_{\text{vapour compression}} > 1$

34. Air at 30°C and 1 bar has a specific humidity of 0.016 kg/kg of dry air. By considering the saturation pressure of water vapour at 30°C as 4.246kPa, the relative humidity of the air will be

(A) 66.1% (B) 60.2%
(C) 58.8% (D) 56.8%

Key: (C)

Sol: Given,

$\omega = 0.016\,kg/kg\ of\ Dry\ air$

$P_s = 4.246kPa$

$Relative\ density\ \phi = \frac{P_V}{P_S}$

$\therefore We\ known\ \omega = 0.622\left(\frac{P_V}{P - P_V}\right)$

$0.016 = 0.622\left(\frac{P_V}{1 - P_V}\right)$

$P_V = 0.025bar$

$So, Relative\ humidity\ \phi = \frac{0.025 \times 10^5}{4.246 \times 10^3}$

$= 0.59 \approx 59.14\%$

35. Consider the following statements in respect of an evaporative cooling process:

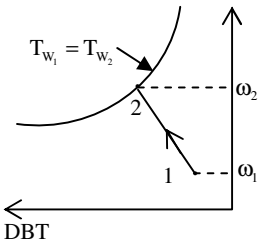
1. The wet-bulb temperature remains constant.
2. The dew-point temperature remains constant.
3. The enthalpy remains constant.

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only
(C) 2 and 3 only (D) 1 and 3 only

Key: (D)

Sol:



For process 1 to 2

Cooling and humidification

$T_{W1} = T_{W2}$ (Wet bulb temperature)

$h_1 = h_2$

$\because$ Dew point Temperature $\propto \omega$

$\therefore \omega \uparrow DPT \uparrow$

36. For a steady process, the conditions at stage 1 and stage 2 are, respectively, h_1=300 kJ/kg, h_2=150 kJ/kg, S_1=1.25 kJ/kg K and S_2=0.8 kJ/kg K. The 'availability' at the ambient temperature 300K will be

(A) 15 kJ (B) 20 kJ (C) 25 kJ (D) 35 kJ

Key: (A)

Sol: Given,

$h_1 = 300\,kJ/kg$

$h_2 = 150\,kJ/kg$

$S_1 = 1.25\,kJ/kg.K$

$S_2 = 0.8\,kJ/kg.K$

$T_o = 300K$

$$\text{Availability} = (h_1 - h_2) - T_o(S_1 - S_2)$$
$$= (300 - 150) - 300(1.25 - 0.8)$$
$$= 15\text{kJ}$$

37. If the maximum pressure in both air standard Otto and Diesel cycles is the same, then the relations for compression ratio r and the efficiency η between the two cycles are

(A) $r_{Diesel} > r_{Otto}$ and $\eta_{Diesel} > \eta_{Otto}$

(B) $r_{Otto} > r_{Diesel}$ and $\eta_{Diesel} > \eta_{Otto}$

(C) $r_{Diesel} > r_{Otto}$ and $\eta_{Otto} > \eta_{Diesel}$

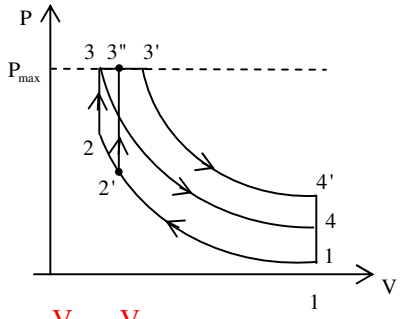
(D) $r_{Otto} > r_{Diesel}$ and $\eta_{Otto} > \eta_{Diesel}$

Key: (A)

Sol: For same maximum pressure

1 – 2 – 3 – 4 – Otto cycle

1 – 2'– 3' – 4' – Diesel cycle



$$\text{So, } \frac{V_1}{V_2} < \frac{V_1}{V'_2}$$

$$r_{otto} < r_{Diesel}$$

$$\because \eta_{Diesel} > \eta_{otto}$$

$$\because (\text{Heat rejection})_{Diesel} > (\text{Heat rejection})_{otto}$$

$$\text{W.D} = \text{H.A} - \text{H.R} = \text{const}$$

$$\text{H.A} = \text{Const} + \text{H.R}$$

$$\text{if H.R} \uparrow \text{ so H.A} \uparrow$$

$$(\downarrow)\eta = \frac{\text{W.D}}{\text{H.A}(\uparrow)}$$

38. Which of the following statements are correct?

1. The specific speed of a turbine is the speed at which a homologous turbine develops 1 mhp under unit head at its maximum efficiency.
2. The specific speed is a dimensionless parameter used for the selection of turbines.
3. The function of guide vanes in reaction turbines is to minimize shock at entry of the fluid onto the runner blades.

Select the correct answer using the code given below.

(A) 1, 2 and 3 (B) 2 and 3 only

(C) 1 and 2 only (D) 1 and 3 only

Key: (A)

39. A centrifugal pump lifts 0.0125 m^3/s of water from a well with a static lift of 30m. If the brake power of the driving electric motor is 5 kW, what is the overall efficiency of the pump-set?

(A) 57.6% (B) 63.9%

(C) 65.3% (D) 73.6%

Key: (D)

Sol: Given,

$$\text{Discharge}(Q) = 0.0125\,\text{m}^3/\text{sec}$$
$$H_m = 30\text{m}$$
$$\text{S.P} = 5\text{kW}$$

$$\text{Overall efficiency}(\eta_o) = \frac{\rho.g.Q.H_m}{\text{S.P}}$$
$$= \frac{1000 \times 9.81 \times 0.0125 \times 30}{5 \times 10^3}$$
$$\eta_o = 0.736 \approx 73.6\%$$

40. Two rods, one of length *l* and the other of length 2*l*, are made of the same material and have same diameter. Both ends of the longer rod are maintained at 100°C. One end of the shorter rod is maintained at 100°C while the other end is insulated. Both rods are exposed

to the same environment at 40°C. The temperature at the insulated end is measured to be 55°C. The temperature at the midpoint of the longer rod would be.

(A) 45°C (B) 50°C (C) 55°C (D) 60°C

Key: (C)

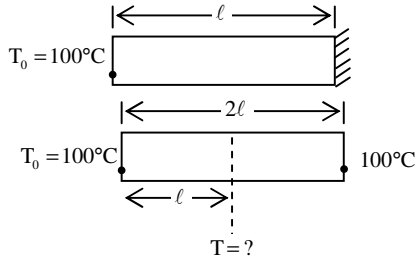
Sol: For insulated tip temperature distribution

$$\theta/\theta_0 = \frac{\text{Cosh}\, m(L-x)}{\text{Cosh}\, mL}$$

$$\text{at } x = L, T = 55°C \text{(given)}$$

$$\text{So}, \frac{1}{\text{Cosh}\, mL} = \frac{T_L - T_\infty}{T_0 - T_\infty}$$

$$= \frac{55-40}{100-40} \Rightarrow (\text{Cosh}\, mL = 4)$$



For second case

$$\frac{T-40}{100-40} = \frac{1}{\cosh mL} = \frac{1}{4}$$

$$T = 55°C$$

41. Consider the following statements in respect of ideal and practical gas turbine cycles:

1. In the ideal cycle case, the cycle efficiency depends on the pressure ratio only.
2. In the practical cycle case (with irreversibilities in the compression and expansion processes), the cycle efficiency depends on the maximum temperature as well as on the pressure ratio.
3. In the practical cycle case, at a given maximum temperature, the maximum efficiency and the maximum work done occur at a same pressure ratio.

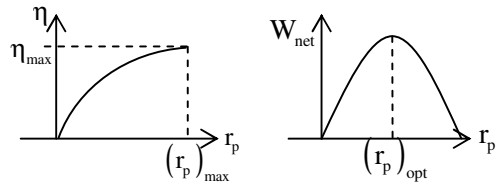
Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Sol: Statement '3' is wrong because maximum efficiency occurs at $(r_p)_{max}$, and maximum work done occurs at $(r_p)_{opt}$

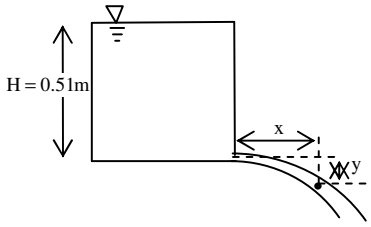


42. A jet of water issues from a sharp-edged vertical orifice under a constant head of 0.51m. At a certain point of the issuing jet, the horizontal and vertical coordinates measured from vena contracta are 0.406 m and 0.085m, respectively. What is the value of the coefficient of velocity?

(A) 0.975 (B) 0.925 (C) 0.875 (D) 0.825

Key: (A)

Sol:



$$\text{Coefficient of velocity } C_V = \frac{V_{act}}{V_{th}}$$

$$V_{th} = \sqrt{2gH} = \sqrt{2 \times 9.81 \times 0.51} = 3.16\, m/s$$

$$V_{act} = x\sqrt{\frac{g}{2y}} = (0.406)\sqrt{\left(\frac{9.81}{2 \times 0.085}\right)}$$

$$= 3.08\, m/s$$

$$\text{So}, C_V = \frac{3.08}{3.16} = 0.974$$

43. In the working of a vapour-compression refrigeration plant, the following enthalpies are recorded at salient points in the cycle:

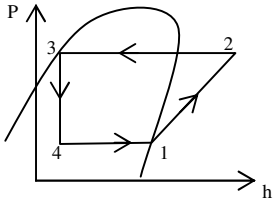
1. Enthalpy at inlet to compressor (saturated vapour), h_1=300kJ/kg.
2. Enthalpy at outlet of compressor (after isentropic compression), h_2=330kJ/kg.
3. Enthalpy at exit of condenser (saturated liquid), h_3=150 kJ/kg.

What is the COP of the plant?

(A) 3 (B) 4 (C) 5 (D) 6

Key: (C)

Sol: Given,



$h_1 = 300\,kJ/kg$

$h_2 = 330\,kJ/kg$

$h_3 = h_4 = 150\,kJ/kg$

$W_c = h_2 - h_1 = 330 - 300 = 30\,kJ/kg$

$R.E = h_1 - h_4 = 300 - 150 = 150\,kJ/kg$

$$C.O.P = \frac{R.E}{W_c} = \frac{150}{30} = 5$$

44. Consider the following statements for single-stage reciprocating compressors:

1. Isothermal process is the most desirable process for compression.
2. The size of clearance volume provided in the compressor has no effect on work done per kg of air delivered.
3. The Volumetric efficiency of the compressor decreases with increasing pressure.

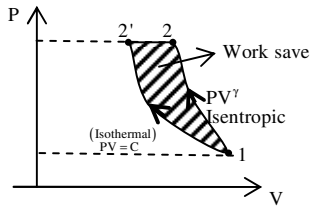
Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

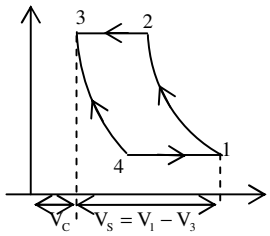
Sol: Isothermal process require less work input



$\because$ W.D/cycle

$$= \frac{\eta}{\eta - 1} P_1 (V_1 - V_4) \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

So work done is independent of clearance volume



$$\because \eta_v \propto \frac{1}{(Pr.ratio)} \left[\because \eta = 1 + C - C(P_2/P_1)^{1/n} \right]$$

So, all three statements are correct.

45. Consider the following statements in respect of regenerative Rankine cycle:

1. Regeneration increases the efficiency of the cycle.
2. The boiler capacity is increased for a given output.
3. The capacity of the condenser is reduced.

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only

(C) 1 and 3 only (D) 2 and 3 only

Key: (D)

Sol: -Due to regeneration efficiency of cycle increases because of increase in mean temperature of heat addition.

-For same power O/P steam flow rate requires bigger boiler.

-Because of steam flow rate to condenser decreases so, small condenser is required.

46. Consider the following statements in respect of (l) the temperature of the medium, (m) the refrigerant and (n) the condenser and absorption system – in a refrigeration unit:

1. Temperature of the medium being cooled must be below that of the evaporator.
2. Refrigerant leaves the condenser as liquid.
3. Any solar thermally operated absorption system is capable only of intermittent operation.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (C)

Sol: Statement '1' is wrong because it is not possible to cool the medium below evaporator temperature i.e., *l* can't be less than m.

47. Volumetric analysis of a certain flue gas gave CO_2 15%, O_2 5% and rest as N_2. The gas was at a temperature of 200°C and a pressure of 5 bar. The partial pressure of N_2 in the flue gas is

(A) 250 kN/m^2 (B) 300 kN/m^2
(C) 350 kN/m^2 (D) 400 kN/m^2

Key: (D)

Sol: $x_{co_2} = 0.15$

$x_{o_2} = 0.05$

$x_{N_2} = 0.8$

$\text{Total pressure}(P) = 5\text{bar}$

$\text{So, Partial pressure of } N_2 \left(P_{N_2}\right) = \frac{x_{N_2}}{x_T}.P$

$= \frac{0.8}{1} \times 5 \times 10^5$

$P_{N_2} = 400\,\text{kN/m}^2$

48. Consider the following statements:

1. The efficiency of heat transfer in a condenser will improve by increase of the overall heat transfer coefficient.
2. The efficiency of heat transfer in a condenser will improve by increase of the velocity of flow of water in the tube.
3. The difference between the temperature of steam entering the condenser and the inlet water temperature should be maximum for maximum efficiency.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Sol: Statement '3' is wrong, because efficiency of condensor

$\eta = \frac{(\Delta T)_{act}}{(\Delta T)_{max}} = \frac{T_{wo} - T_{wi}}{T_S - T_{wi}}$

$\text{if } (T_s - T_{wi}) \uparrow \quad \eta \downarrow$

49. The total power developed by a three-stage velocity compounded impulse steam turbine is 900 kW. The power magnitudes developed in the first and the second stages are, respectively.

(A) 500 kW and 300 kW
(B) 100 kW and 300 kW
(C) 500 kW and 100 kW
(D) 100 kW and 100 kW

Key: (A)

Sol: $\therefore$ for three stage velocity compounded impulse turbine work done is in ratio of 5:3:1 so, in 1st stage 500kW & in 2nd stage 300 kW.

50. Consider the following statements in respect of natural draft cooling towers:

1. Theoretically the water can be cooled to even below the dry – bulb temperature of the induced air flow.
2. Natural – draft cooling towers are 100 m or more in height.
3. The inner and outer surfaces are surfaces of revolution of a segment of a hyperbola about the vertical axis – affording improved strength rather than any thermodynamic augmentation.

Which of the above statements are correct?

(A) 1, 2 and 3 (B) 1 and 2 only
(C) 1 and 3 only (D) 2 and 3 only

Key: (B)

51. Consider the following statements:

1. Wind velocity at about 20m height above the ground is taken as the rated velocity for design of wind mills.
2. The total power of a wind stream is directly proportional to the cube of average velocity.
3. Wind turbine operates with variable load over a narrow range between cut – in and cut – out velocities.
4. Vertical wind machine operates in all wind directions, but it needs yaw adjustment.

Which of the above statements are correct?

(A) 1 and 2 (B) 1 and 4
(C) 3 and 4 (D) 2 and 3

Key: (D)

Sol: $P = \frac{1}{2} c\rho A V^3$

cut in speed – 5m / sec
cut out speed – 25m / sec
} narrow range

52. Which fuel cell is suitable for spacecraft applications?

(A) Direct methanol fuel cell
(B) Proton exchange membrane fuel cell
(C) Alkaline fuel cell
(D) Phosphoric acid fuel cell

Key: (C)

53. A flywheel on a motor speeds up from rest to 1000 r.p.m. in 6 seconds. The number of revolutions made thereby is nearly.

(A) 200 (B) 100 (C) 50 (D) 20

Key: (C)

Sol: Given

$\omega_o = 0 \text{ rad/sec}$

$\omega = \frac{2\pi(1000)}{60} = 104.71 \text{ rad/sec}$

$t = 6 \text{ secs}$

$\omega = \omega_o + \alpha t$

$\alpha = \frac{104.71}{6} = 17.4 \text{ rad/sec}^2$

$\omega^2 - \omega_0^2 = 2\alpha\theta$

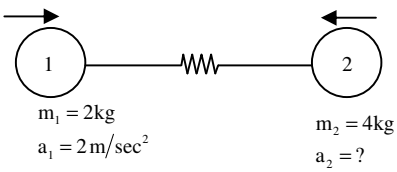
$\theta = \frac{(104.71)^2}{2 \times 17.4} = 49.99 \text{ rev or } 50 \text{ approx}$

54. Two steel balls of 2 kg and 4 kg mass, respectively, are pressed on the two ends of a spring, all pre – placed on a smooth surface. When released, the smaller ball moves with an acceleration of 2 m/s^2. The simultaneous acceleration of the bigger ball will be

(A) 0.5 m/s^2 (B) 1 m/s^2
(C) 2 m/s^2 (D) 4 m/s^2

Key: (B)

Sol: $m_1 = 2\text{kg}$, $m_2 = 4\text{kg}$



Spring force on each mass $F = m_1a_1 = m_2a_2$

$a_2 = \frac{2}{4} \times 2 = 1\,m/sec^2$

55. A bullet of mass 0.03kg moving with a speed of 400 m/s penetrates 12 cm into a fixed block of wood. The average force exerted by the wood on the bullet will be

(A) 30 kN (B) 20 kN (C) 15 kN (D) 10 kN

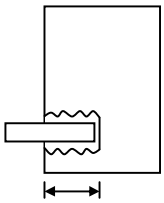
Key: (B)

Sol: $m = 0.03\,kg$

$V = 400\,m/sec$

K.E of bullet = work done

$\frac{1}{2}m(v^2) = Force \times d$



$Force = \frac{1 \times 0.03 \times 400^2}{0.12 \times 2} = 20\,kN$

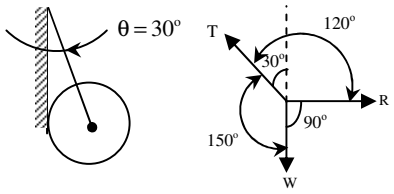
56. A ball of weight 100N is tied to a smooth wall by a cord making an angle of 30° to the wall. The tension in the cord is

(A) 200N (B) $\frac{200}{\sqrt{3}}$ N

(C) 100N (D) $50\sqrt{3}$N

Key: (B)

Sol:



$\frac{T}{\sin 90^\circ} = \frac{W}{\sin 120^\circ} = \frac{R}{\sin 150^\circ}$

$T = \frac{100 \sin 90}{\sin 120} = \frac{100 \times 2}{\sqrt{3}} = \frac{200}{\sqrt{3}}$ N

57. The modulus of rigidity of an elastic material is found to be 38.5% of the value of its Young's modulus. The Poisson's ratio μ of the material is nearly

(A) 0.28 (B) 0.30 (C) 0.33 (D) 0.35

Key: (B)

Sol: $\frac{G}{E} = 0.385$

$E = 2G(1+\nu)$

$\frac{G}{E} = \frac{1}{2(1+\nu)} = 0.385$

$\frac{1}{2 \times 0.385} = (1+\nu)$

$(1+\nu) = 1.297$

$\nu = 1.297 - 1 = 0.297$

58. A bar produces a lateral strain of magnitude 60×10^{-5} m/m when subjected to a tensile stress of magnitude 300 MPa along the axial direction. What is the elastic modulus of the material if the Poisson's ratio is 0.3?

(A) 200 GPa (B) 150 GPa

(C) 125 GPa (D) 100 GPa

Key: (B)

Sol: Lateral strain $= 60 \times 10^{-5}$ m/m

$\sigma = 300$ MPa

$\nu = 0.3$

$\nu = \frac{-\text{lateral strain}}{\text{linear strain}}$

$0.3 = \frac{60 \times 10^{-5}}{\text{linear strain}}$

$\epsilon = \text{linear strain} = 2 \times 10^{-3}$

$E = \frac{\sigma}{\epsilon} = \frac{300}{2 \times 10^{-3}} = 150\,GPa$

59. In the design of beams for a given strength, consider that the conditions of economy of used of the material would avail as follows:

1. Rectangular cross-section is more economical than square section of the same cross-sectional area of the beam.
2. Circular section is more economical than square section.
3. I-section is more economical than a rectangular section of the same depth.

Which of the above are correct?

(A) 1, 2 and 3 (B) 1 and 2 only
(C) 2 and 3 only (D) 1 and 3 only

Key: (D)

Sol:

	Area	M.I
for rectangle	$b \times d$	$I = \frac{bd^3}{12}$
square	a^2	$\frac{a^4}{12}$
circle	$\frac{\pi}{4}d^2$	$\frac{\pi}{64}d^4$

Equating area of rectangle and square.

$a = \sqrt{bd}$

$$\frac{I_{rectangle}}{I_{square}} = \frac{\frac{bd^3}{12}}{\frac{a^4}{12}} = \frac{bd^3}{b^2d^2} = \frac{d}{b} > 1$$

Hence Rectangle is more economical than square cross-section.

$$a^2 = \frac{\pi}{4}d^2,\ a = \frac{\sqrt{\pi}}{2}d$$

$$\frac{I_{square}}{I_{circle}} = \frac{\frac{a^4}{12}}{\frac{\pi}{64}d^4} = \frac{64 \times \left(\frac{\sqrt{\pi}}{2}\right)^4 d^4}{12 \times \pi \times d^4}$$

$$= \frac{64 \times \pi^2}{12 \times \pi \times 16} = \frac{4\pi}{12} > 1$$

Square is economical than circular cross-section.

I-section is more economical than rectangular section.

60. Which one of the following statements is correct?

(A) The strain produced per unit volume is called resilience.
(B) The maximum strain produced per unit volume is called proof resilience.
(C) The least strain energy stored in a unit volume is called proof resilience.
(D) The greatest strain energy stored in a unit volume of a material without permanent deformation is called proof resilience.

Key: (D)

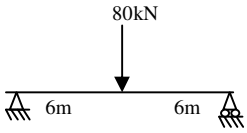
Sol: The greatest strain energy stored in a unit volume of a material with permanent deformation is called proof resilience.

61. A beam of rectangular section (12 cm wide × 20 cm deep) is simply supported over a span of 12 m. It is acted upon by a concentrated load of 80kN at the midspan. The maximum bending stress induced is.

(A) 400 MPa (B) 300 MPa
(C) 200 MPa (D) 100 MPa

Key: (B)

Sol: b = 12 cm = 120 mm
d = 20cm = 200 mm



$$M_{max} = \frac{WL}{L_p} = \frac{80 \times 10^3 \times 12 \times 10^3}{4}$$

$$= 240 \times 10^6\ N - mm$$

$$I = \frac{bd^3}{12} = \frac{120 \times 200^3}{12} = 80 \times 10^6$$

$$y = \frac{d}{2} = \frac{200}{2} = 100\ mm$$

$$\sigma = \frac{240 \times 10^6}{80 \times 10^6} \times 100 = 300\ MPa$$

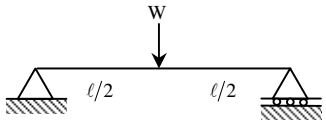
62. A uniform bar, simply supported at the ends, carries a concentrated load P at mid-span. If the same load be, alternatively, uniformly

distributed over the full length of the bar the maximum deflection of the bar will decrease by.

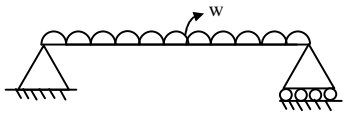
(A) 25.5% (B) 31.5%
(C) 37.5% (D) 50.0%

Key: (C)

Sol:



$$\delta_A = \frac{WL^3}{48EI}$$



$$\delta_B = \frac{5WL^4}{384EI} = \frac{5(WL)L^3}{384EI} = \frac{5}{384}\frac{W}{E}$$

% of decrease

$$= \frac{\delta_A - \delta_B}{\delta_A} \times 100$$

$$= \left(\frac{\frac{1}{48} - \frac{5}{384}}{\frac{1}{48}}\right) \times \frac{\frac{WL^3}{EI}}{\frac{WL^2}{EI}} = \frac{\frac{1}{128}}{\frac{1}{48}}$$

$$= 0.375 = 37.5\%$$

63. A thin cylindrical pressure vessel and a thin spherical pressure vessel have the same mean radius, same wall thickness and are subjected to same internal pressure. The hoop stresses set up in these vessels (cylinder in relation to sphere) will be in the ratio.

(A) 1 : 2 (B) 1 : 1 (C) 2 : 1 (D) 4 : 1

Key: (C)

Sol: Cylindrical vessel

$$\sigma_{h_1} = \frac{pD}{2t}$$

Spherical vessel

$$\sigma_{h_2} = \frac{pD}{4t}$$

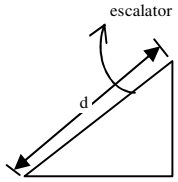
$$\frac{\sigma_{h_1}}{\sigma_{h_2}} = \frac{\frac{pD}{2t}}{\frac{pD}{4t}} = 2$$

64. A boy walks up a stalled escalator in 90 seconds. When the same escalator moves, he is carried up in 60 seconds. How much time would it take him to walk up the moving escalator?

(A) 48 seconds (B) 36 seconds
(C) 30 seconds (D) 24 seconds

Key: (B)

Sol: Escalation at rest



$$v_1 = d/t_1$$

$$v_1 = d/90 = 0.011d$$

Escalator during running

$$v_2 = \frac{d}{t_2} = \frac{d}{60} = 0.01667d$$

Walking on moving escalator

$$v_1 + v_2 = \frac{d}{90} + \frac{d}{60} = 0.011d + 0.01667d$$

$$v = 0.02767\ d = \frac{d}{36}$$

$$t = 36\,sec$$

65. A 10 mm diameter bar of mild steel of elastic modulus 200×10^9 Pa is subjected to a tensile load of 50000N, taking it just beyond its yield point. The elastic recovery of strain that would occur upon removal of tensile load will be

(A) 1.38×10^{-3} (B) 2.68×10^{-3}
(C) 3.18×10^{-3} (D) 4.62×10^{-3}

Key: (C)

Sol: E = 200 GPa = 200×10^3 MPa

P = 50000 N = 50kN

d =10 mm

$$\sigma = \frac{P}{A} = \frac{50\times10^3}{\frac{\pi}{4}\times10^2} = 636.94\ \text{MPa}$$

$$\sigma = E\epsilon$$

$$\epsilon = \frac{\sigma}{E} = \frac{636.94}{200\times10^3} = 3.14\times10^{-3}$$

66. On completion of heat treatment, the austenite structure would be retained if

(A) The rate of cooling is greater than the critical cooling rate.

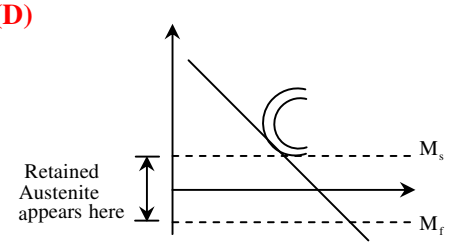
(B) The rate of cooling is less than the critical cooling rate

(C) The initiating temperature of martensite formation is above the room temperature

(D) The finishing temperature of martensite formation is below the room temperature.

Key: (D)

Sol:



If the finishing Temperature is below the room temperature total Austenite will not be corrected to martensite there will be refined Austenite.

67. Which one of the following statements is correct?

(A) Iron – carbon and TTT diagrams are both equilibrium diagrams.

(B) Iron – carbon and TTT diagrams are both non-equilibrium diagrams.

(C) Iron – carbon diagram is an equilibrium diagram but TTT diagram is a non-equilibrium diagram.

(D) Iron – carbon diagram is a non equilibrium diagram but TTT diagram is an equilibrium diagram.

Key: (C)

Sol: In iron carbon phase diagram, addition of carbon to iron produced various phases and it is infinite slow cooling where as in T – T – T curve if do not produce a distinct phase. Based on its rate of cooling the phase formation will change w. r. t time.

68. The correct order of increasing resistivity among the following materials is

(A) nickel, doped silicon, sodium silicate, pure silica

(B) doped silicon, nickel, pure silica, sodium silicate

(C) nickel, pure silica, sodium silicate, doped silicon.

(D) sodium silicate, nickel, pure silica, doped silicon.

Key: (A)

Sol: Nickel – Doped silicon – sodium – pure silicate silica

$10^{-7} - 10^{-4} - 2 - 10^{4} \rightarrow$ Resistivity

69. Consider the following statements:

On heating an elastomer under tensile load, its shrinkage

1. maximizes the enthalpy
2. maximizes the entropy
3. minimizes the free energy
4. avoids breaking

Which of the above statements are correct?

(A) 1 and 2 (B) 2 and 3

(C) 3 and 4 (D) 1 and 4

Key: (D)

70. Which of the following properties will be the meaningful indicator / indicators of uniform rate of elongation of a test piece of a structural material before necking happens in the test piece?

1. Ductility 2. Toughness
3. Hardness

Select the correct answer using the code given below.

(A) 1 only (B) 2 only
(C) 3 only (D) 1, 2 and 3

Key: (A)

71. Which one of the following alloying elements increases the corrosion resistance of steel?

(A) Vanadium (B) Chromium
(C) Nickel (D) Copper

Key: (B)

Sol: Chromium when alloyed with steel increases corrosion resistance.

72. Which of the following mechanisms are examples of forced closed kinematic pairs?

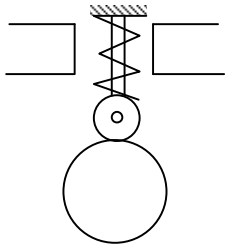
1. Cam and roller mechanism
2. Door – closing mechanism
3. Slider – crank mechanism

Select the correct answer using the code given below.

(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Sol: Cam and roller mechanism



Door-closing mechanism consist of Torsional spring.

73. A planer mechanism has 10 links and 12 rotary joints. Using Grubler's criterion, the number of degrees of freedom of the mechanism is

(A) 1 (B) 3 (C) 2 (D) 4

Key: (B)

Sol: $n = 10$

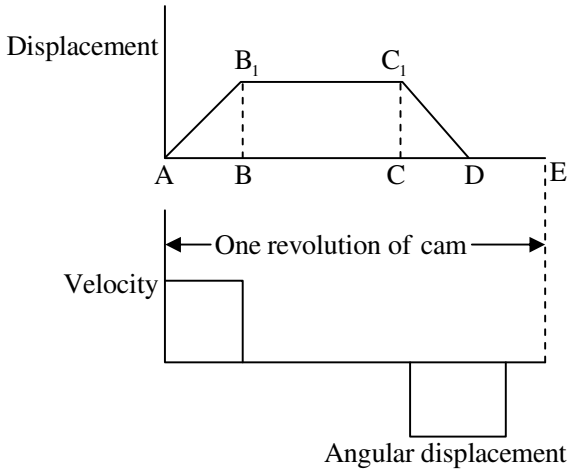
$j_1 = 12$

$j_2 = 0$

$DOF = 3(n-1) - 2j_1 - j_2$

$= 3(10-1) - 2(12) = 27 - 24 = 3$

74. The displacement and velocity diagrams of a cam and follower mechanism are shown:



Which of the following statements is / are correct?

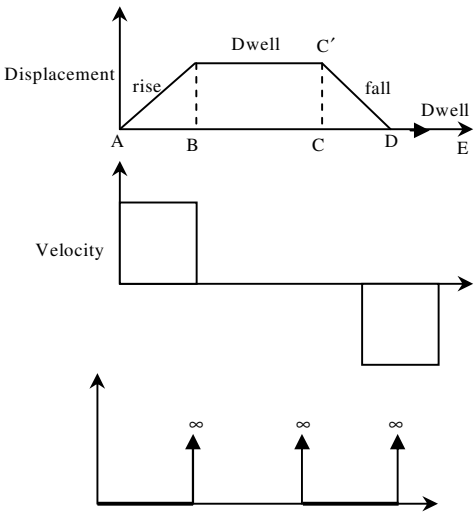
1. The acceleration of the follower at the beginning and at the end of each stroke will be zero.
2. The follower remains at rest in the dwell period.
3. During period DE, the motion of the follower is retarding.

Select the correct answer using the code given below.

(A) 1, 2 and 3 (B) 1 only
(C) 2 only (D) 3 only

Key: (C)

Sol:



Follower remains at rest in the dwell period.

75. The number of instantaneous centers of rotation in a slider-crank quick-return mechanism is

(A) 10 (B) 8 (C) 6 (D) 4

Key: (C)

Sol: No. of instantaneous centres

$$=\frac{n(n-1)}{2}$$

$$=\frac{4(4-1)}{2}=\frac{12}{2}=6$$

76. A simple spring-mass vibrating system has a natural frequency of N. If the spring stiffness is halved and the mass doubled, then the natural frequency will be

(A) 0.5N (B) N (C) 2N (D) 4N

Key: (A)

Sol: $N=\sqrt{\frac{k}{m}}$ $k=\frac{k}{2}, m=2m.$

$$N=\sqrt{\frac{(k/2)}{(2m)}}=\frac{1}{2}\sqrt{\frac{k}{m}}=\frac{1}{2}\omega_n=0.5N$$

77. A car of mass 1450 Kg is constructed on a chassis supported by four springs. Each spring has a force constant of 40000 N m. The combined mass of the two people occupying the car is 150 kg. What is the period of execution of two complete vibrations?

(A) 0.63 s (B) 1.59 s

(C) 4.96 s (D) 1.26 s

Key: (D)

Sol: m = 1450 kg, K = 40000 N/m

$$k_{Total}=4\times40000=160000\ N/m$$

$$m_{Total}=1450+150=1600\ kg$$

$$\omega_n=\sqrt{\frac{k}{m}}=\sqrt{\frac{160000}{1600}}=\sqrt{100}=10\ rad/sec$$

$$\omega_n=2\pi f=\frac{2\pi}{T},\ f=\frac{1}{T}$$

$$T=\frac{2\pi}{\omega_n}=\frac{2\times\pi}{10}=\frac{6.28}{10}=0.628\ sec$$

For 2 oscillation = 2 × 0.628 = 1.26 sec.

78. Consider the following statements:

Artefacts to prevent harmful effects resulting from vibrations of an unbalanced machine fixed on its foundation include.

1. mounting the machine on springs thereby minimizing the transmission of forces
2. using vibration isolating materials to prevent or reduce the transmission of forces
3. moving the foundation so as to have only one degree of freedom towards reducing the transmission of forces.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

79. Two heavy rotors are mounted on a single shaft. Considering each of the rotors separately, the transverse natural frequencies are 100 cycles/s and 200 cycles/s, respectively. The lower critical speed will be

(A) 12000 r.p.m. (B) 9360 r.p.m

(C) 8465 r.p.m (D) 5367 r.p.m.

Key: (D)

Sol: $\frac{1}{\omega^2}=\frac{1}{\omega_1^2}+\frac{1}{\omega_2^2}$

$\frac{1}{f}=\frac{1}{f_1^2}+\frac{1}{f_2^2}$

$\frac{1}{f^2}=\frac{1}{100^2}+\frac{1}{200^2}$

$f=\sqrt{8000}=89.44$

$N=89.44\times 60=5366.6\ \text{rpm}$

80. Consider the following statements:

In the case of gears of involute profiles, increase in the centre to centre distances between the mounting shafts

1. increases the pressure angle
2. will not affect the law of gearing
3. shortens the path of contact
4. increases the contact ratio

Which of the above statements are correct?

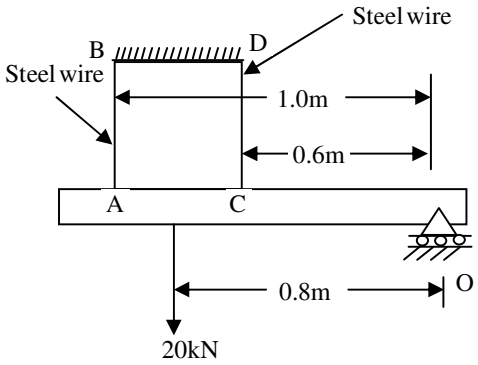
(A) 1, 2 and 4 (B) 1, 2 and 3

(C) 1, 3 and 4 (D) 2, 3 and 4

Key: (B)

Sol: If the distance between centre is increased then pressure angle also increases and path of contact decreases and law of gearing will be unaffected.

81. A rigid bar ACO as shown is hinged at O and is held in a horizontal position by two identical vertical steel wires AB and CD. A point load of 20 kN is hung at the position shown. The tensions in wires AB and CD are



(A) 15.2 kN and 7.1 kN

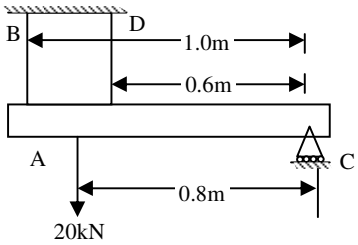
(B) 11.8 kN and 7.1 kN

(C) 15.2 kN and 5.0 kN

(D) 11.8 kN and 5.0 kN

Key: (D)

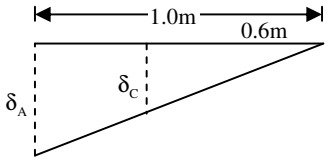
Sol:



$\Sigma M_C=0$

$T_A(1)+T_C(0.6)=20(0.8)$

$T_A+0.6T_C=16 \quad ...(1)$



$\frac{\delta_A}{1}=\frac{\delta_C}{0.6}$

$\frac{T_A.\ell_A}{E_A.A_A}=\frac{1}{0.6}\times\frac{T_C\ell_B}{E_B.A_B}$

$0.6T_A=T_B \quad ...(2)$

$T_A+(0.6)(0.6T_A)=16$

$T_A=\frac{16}{1.36}=11.76\ \text{kN}$

$T_B=4.24\ \text{kN}$

82. An epicyclic gear train has 3 shafts A, B and C. A is the input shaft running at 100 r.p.m.

clockwise. B is the output shaft running at 250 r.p.m. clockwise. The torque on A is 50 kNm (clockwise), C is a fixed shaft. The torque needed to fix C is

(A) 20 kN m (anti-clockwise)
(B) 20 kN m (clockwise)
(C) 30 kN m (anti-clockwise)
(D) 30 kN m (clockwise)

Key: (C)

Sol: $T_A = 50\text{kN} - \text{m}(\text{CW})$

$N_B = 250\ \text{rpm}(\text{C.W})$

$N_A = 100\text{rpm}(\text{C.W})$

$N_C = 0$

$T_A.N_A + T_B.N_B + T_C.N_C = 0$

$(50)(100) + (T_B)(250) + (T_C)(0) = 0$

$T_B = -20\text{kN} - \text{N}(\text{A.C.W})$

$T_A + T_B + T_C = 0 \Rightarrow T_C$

$= -T_A - T_B = -50 - (-20)$

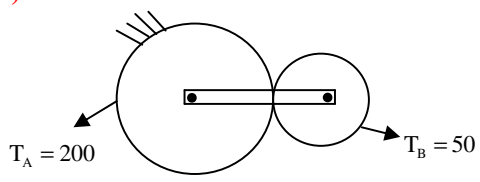
$= -30\ \text{kN} - \text{m}(\text{A.C.W})$

83. A fixed gear having 200 teeth is meshed with a smaller gear having 50 teeth. The two gears are connected by an arm. The number of turns made by the smaller gear for one revolution of the arm about the centre of the bigger gear is

(A) 1 (B) 2 (C) 3 (D) 5

Key: (D)

Sol:



$N_{arm} = 1\ \text{rpm}$

$N_p = ?$

S.No	Arm	Gear A	Gear B
1	0	+1	
2			
3			
4			

$N_B = y + x.\dfrac{\overline{R}_A}{T_B}$

$N_A = y - x\dfrac{T_B}{T_A} = 0$

$y - 0.25x = 0$

$y = 1\ \text{rpm}$

$x = 4\ \text{rpm}$

$N_B = 1 + 4 = 5\text{rpm}$

84. Consider the following statements:

1. Balancing of several masses rotating in the same plane can be effected by a single mass.
2. Balancing of several masses in different planes can be done by 2 masses in 2 planes on either side of the reference plane or on the same side.
3. Reciprocating masses cannot be completely balanced by rotating masses.
4. Secondary unbalanced forces will be negligible compared to primary imbalance forces.

Which of the above statements are correct?

(A) 1, 2, 3 and 4 (B) 1, 2 and 3 only
(C) 3 and 4 only (D) 1, 2 and 4 only

Key: (A)

85. A body of mass 10 kg with its CG 200 mm from the axis of rotation is to be completely balanced by another mass B of 5 kg placed in the same plane. The radius at which the CG of mass B should be is

(A) 500 mm (B) 400 mm
(C) 300 mm (D) 200 mm

Key: (B)

Sol: $m_A = 10\ kg$

$r_A = 200\ mm$

$m_B = 5\ kg$

$r_B = ?$

$m_A r_A = m_B r_B$

$10 \times 200 = 5 \times r_B$

$r_B = \dfrac{10^2 \times 200}{5} = 400$

86. Consider the following statements:

1. In stationary constant speed engines, the spring-loaded governor mechanism is fitted on the cam-shaft of the engine.
2. Hunting occurs when the governor is not sensitive.
3. Isochronous governors have the same speed over a wide range of governor action.
4. A governor is said to be unstable if the radius of rotation falls as the speed increases.

Which of the above statements are correct?

(A) 1, 2, 3 and 4 (B) 1, 2 and 4 only

(C) 1, 3 and 4 only (D) 2 and 3 only

Key: (C)

87. An aircraft cruising at 360 kmph takes a right turn on an arc of 100 m radius. The turbines and propellers have a total mass of 500 kg with radius of gyration of 25 cm. The engine rotates at 2000 r.p.m. The magnitude of the gyroscopic couple generated is

(A) 6.55 kN m (B) 7.65 kN m

(C) 9.81 kN m (D) 13.1 kN m

Key: (A)

Sol: $V = 360\ kmph$

$r = 100\ m$

$m = 500\ kg$

$K = 25cm = 0.25\ m$

$N = 2000\ rpm$

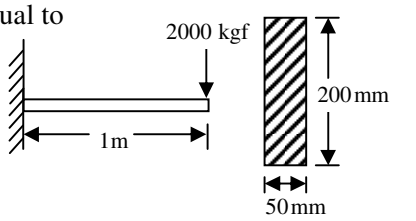
$\omega_p = \dfrac{V}{R} = \dfrac{360 \times \frac{5}{18}}{100} = 1\ rad/sec$

$C = I\omega\omega_p$

$C = (500)(0.25)^2 \times \left(\dfrac{2\pi \times 2000}{60}\right) \times (0.1)$

$= 6.55\ kN - m$

88. The maximum shearing stress induced in the beam section at any layer at any position along the beam length (shown in the figure) is equal to



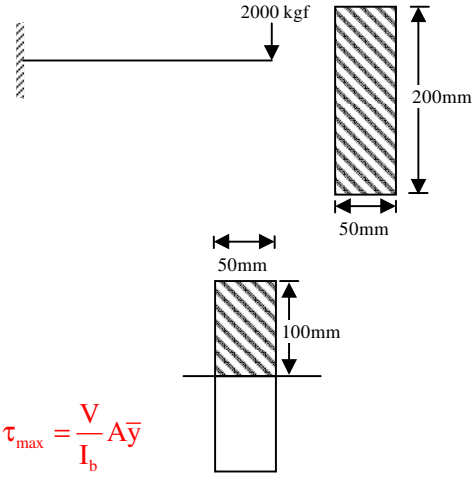
Cross – section of beam

(A) 30 kgf/cm^2 (B) 40 kgf/cm^2

(C) 50 kgf/cm^2 (D) 60 kgf/cm^2

Key: (A)

Sol:



$\tau_{max} = \dfrac{V}{I_b} A\bar{y}$

$$V = 200\ \text{kgf}$$

$$I = \frac{5\times 20^3}{12} = 3333.33\ \text{cm}^4$$

$$A\bar{y} = (100\times 50)\left(\frac{100}{2}\right)$$

$$= 250000\text{mm}^3 = 250\text{cm}^3$$

$$\tau = \frac{2000\times 25}{(3333.33)\times 5} = 30\text{kgf}/\text{cm}^2$$

89. Consider the following statements:
For a component Made of ductile material, the failure criterion will be
1. endurance limit, if the external force is fluctuating.
2. fatigue, if the external force is fluctuating.
3. yield stress, if the external force is static.

Which of the above statements are correct?
(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (*)

Sol: 3. Ductile material fails by yielding if the load is static
2. Fatigue is failure of material when subjected to cyclic load.
1. Ability of material to withstand maximum stress when subjected to cycle loading is called endurance limit.

90. A machine component is subjected to a flexural stress, which fluctuates between 300 MN/m^2 and -150 MN/m^2. Taking the yield strength = 0.55 of the ultimate strength, endurance strength = 0.50 of the ultimate strength and factor of safety to be 2, the value of the minimum ultimate strength according to modified Goodman relation will be
(A) 1100 MN/m^2 (B) 1075 MN/m^2
(C) 1050 MN/m^2 (D) 1025 MN/m^2

Key: (C)

Sol: $\sigma_{max} = 300\ \text{MPa}$

$\sigma_{min} = -150\ \text{MPa}$

$$\sigma_{min} = \frac{\sigma_{max}+\sigma_{min}}{2} = \frac{300-150}{2} = 75\ \text{MPa}$$

$$\sigma_v = \frac{\sigma_{max}-\sigma_{min}}{2} = \frac{300-(-150)}{2} = 225\ \text{MPa}$$

$$\frac{\sigma_m}{\sigma_{ut}} + \frac{\sigma_v}{\sigma_e} = \frac{1}{(F.S)}$$

$$\frac{\sigma_m}{\sigma_{ut}} + \frac{\sigma_v}{\sigma_e} = \frac{1}{F.S}$$

$$\frac{75}{\sigma_{ut}} + \frac{225}{0.5\,\sigma_{ut}} = \frac{1}{2}$$

$$\frac{1}{\sigma_{ut}}(75+450) = \frac{1}{2}$$

$$\sigma_{ut} = 2\times(525) = 1050\ \text{MPa}$$

91. In a Hartnell governor, the mass of each bell is 4 kg. The maximum and minimum centrifugal forces on the balls are 1800 N and 100 N at radii 25 cm and 20 cm, respectively. The lengths of vertical and horizontal arms of the bell-crank levers are the same. What is the spring stiffness?
(A) 780 N/cm (B) 740 N/cm
(C) 720 N/cm (D) 680 N/cm

Key: (D)

Sol: Given that, for a Hartnell governor,
Mass of each ball (m) = 4kg
Maximum centrifugal force (f_2) = 1800N
Minimum centrifugal force (f_1) = 100N
Max. radius of ball (r_2) = 25cm
Min. radius of ball (r_1) = 20cm
and lengths of vertical and horizontal arms of the bell-crank levers are the same i.e., a=b

Spring stiffness (K) for a Hartnell governor is $= 2\left(\frac{a}{b}\right)^2\left(\frac{f_2 - f_1}{r_2 - r_1}\right)$

$= 2(1)^2\left(\frac{1800-100}{25-20}\right)$

$= 2\left(\frac{1700}{5}\right) = 680 N/cm$

92. Consider the following statements regarding the ends of the pressure vessels flanged by pre-tensioned bolts:

1. Pre-tensioning helps to seal the pressure vessel.
2. Pre-tensioning reduces the maximum tensile stress in the bolts.
3. Pre-tensioning countermands the fatigue life of the bolts.
4. Pre-tensioning helps to reduce the deleterious effect of pressure pulsations in the pressure vessel.

Which of the above statements are correct?

(A) 1, 2 and 3 only
(B) 1, 3 and 4 only
(C) 2 and 4 only
(D) 1, 2, 3 and 4

Key: (B)

Sol: Statement 2 is incorrect.
1, 3, 4 are correct.

93. Two shafts, one solid and the other hollow, made of the same material, will have the same strength and stiffness, if both are of the same

(A) length as well as weight
(B) length as well as polar modulus
(C) weight as well as polar modulus
(D) length, weight as well as polar modulus

Key: (*)

Sol: $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{\ell}$

$\tau = \frac{T}{J}R = \frac{T}{Z}$

$q = \frac{T}{\theta} = \frac{GJ}{\ell}$

τ, **q** to same then both should have same polar moment of Inertia.

94. A solid shaft is to transmit 20 kW at 200 r.p.m. The ultimate shear stress for the shaft material is 360 MPa and the factor of safety is 8. The diameter of the solid shaft shall be

(A) 42 mm (B) 45 mm
(C) 48 mm (D) 51 mm

Key: (C)

Sol: $P = 20\times10^3 W$

$N = 2000 rpm$

$\tau = 360 MPa$

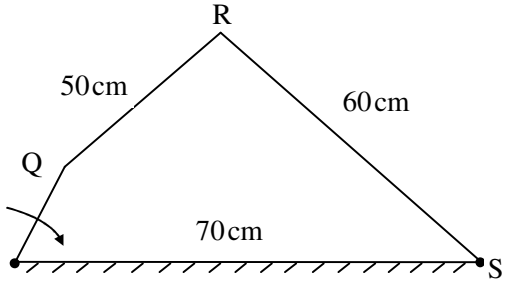
$F.O.S = 8$

$T = \frac{P\times60}{2\pi N} = \frac{20\times10^3\times60}{2\pi\times200} = 954.9 N-m$

$\tau_{safe} = \frac{\tau_{ut}}{F.O.S} = \frac{16T}{\pi d^3} \Rightarrow \frac{360}{8} = \frac{16\times954.9\times10^3}{\pi\times d^3}$

$d = \left[\frac{16\times954.9\times10^3\times8}{\pi\times360}\right]^{1/3} = 48 mm$

95. In the 4-bar mechanism as shown, the link PQ measures 30 cm and rotates uniformly at 100 rev/min. The velocity of point Q on link PQ is nearly



(A) 2.54 m/s (B) 3.14 m/s
(C) 4.60 m/s (D) 5.80 m/s

Key: (B)

Sol: $r_{PQ} = 30cm$

$N = 100$ rpm

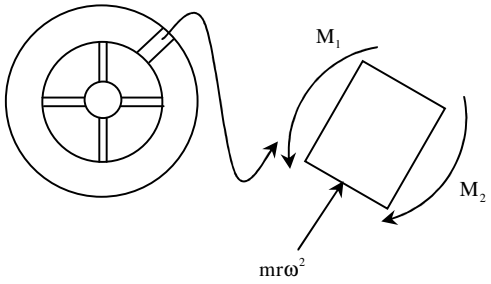
$$V_{PQ} = r_{PQ}.N = 0.3 \times \left(\frac{2 \times \pi \times 100}{60}\right)$$

$= 3.14$ m/sec

96. The rim of a flywheel is subjected to
(A) direct tensile stress and bending stress
(B) torsional shear stress and bending stress
(C) direct shear stress and bending stress
(D) compressive stress and bending stress

Key: (A)

Sol: Due to rotation centrifugal stresses are setup.
Considering the differential element of flywheel.
The bending stresses will be set for the differential element segment.



97. A stockiest has to supply 400 units of a product every Monday to his customers. He gets the product at Rs. 50 per unit from the manufacturer. The cost of ordering and transportation from the manufacturer to the stockist's premises is Rs. 75 per order. The cost of carrying inventory is 7.5% per year of the cost of the product. What are the economic lot size and the total optimal cost (including capital cost) for the stockist?
(A) 989 units/order and Rs. 20,065.80/ week
(B) 912 units/order and Rs. 20,065.80/ week
(C) 989 units/order and Rs. 18,574.50/ week
(D) 912 units/order and Rs. 18,574.50/ week

Key: (B)

Sol: Annual Demand D = 52×400=20800 units
Unit cost = Rs. 50
Ordering cost F = Rs. 75/ order
Unit Carrying cost C = Rs. 50 × 7.5 %
C= Rs. 3.75 /unit/year.

$$EOQ = \sqrt{\frac{2DF}{C}} = \sqrt{\frac{2 \times 20800 \times 75}{3.75}}$$

$EOQ = 912$units

& Total cost $= \sqrt{2DFC} + D \times$ unit cost

$= \sqrt{2 \times 20800 \times 75 \times 3.75} + 20800 \times 50$

$=$ Rs. 20065

98. Consider just only the following parameters:
1. Grinding wheel diameter
2. Regulating wheel diameter
3. Speed of grinding wheel
4. Speed of regulating wheel

Which of the above parameters will influence the axial feed rate in centre-less grinding?
(A) 2 and 4 (B) 2 and 3
(C) 1 and 3 (D) 1 and 4

Key: (A)

99. A metric thread of pitch 2 mm and thread angle 60^o is inspected for its pitch diameter using the 3-wire method. The indicated diameter of the wire will be nearly
(A) 0.85 mm (B) 1.05 mm
(C) 1.15 mm (D) 2.05 mm

Key: (C)

Sol: Wire Diameter $= \frac{P}{2}\sec\left(\frac{Q}{2}\right)$

$= \frac{2}{2}\sec(30°)$

$= 1.15\text{mm}$

100. Consider the following statements with reference to NC machines:

1. Both closed-loop and open-loop systems are used.
2. Papers, tapes, floppy tapes and cassettes are used for data storage.
3. Digitizers may be used as interactive input devices.
4. Post-processor is an item of hardware.

Which of the above statements are correct?

(A) 1, 2 and 4 (B) 1, 3 and 4

(C) 2, 3 and 4 (D) 1, 2 and 3

Key: (D)

Sol: Post processor is used in CNC machines only & not is NC machines.

So, Statement 4 is wrong.

101. Consider the following benefits of CIM:

1. Less direct labour
2. Less scrap and rework
3. Higher machine use

Which of the above are correct?

(A) 1, 2 and 3

(B) 1 and 2 only

(C) 1 and 3 only

(D) 2 and 3 only

Key: (A)

Sol: With CIM, less direct labour & less rework & scrap & utilization of machine is maximum.

102. A firm's inventory turnover of Rs. 8,00,000 is 5 times the cost of goods sold. If the inventory turnover is improved to 8 with the cost of goods sold remaining the same, a substantial amount of fund is either released from, or gets additionally invested in, inventory. Which one of the following statements is correct?

(A) Rs. 1, 60,000 is released.

(B) Rs. 1, 60,000 is additionally invested.

(C) Rs. 60,000 is released.

(D) Rs. 60,000 is additionally invested.

Key: (C)

Sol: Inventory turnover $= \frac{\text{cost of goods sold}}{\text{Avg. inventory cost}}$

Old Avg. inventory cost $= \frac{800000}{5} = 160000.$

New Avg. inventory cost $= \frac{800000}{8} = 100000.$

So, Rs. 60000 fund will be released.

103. An 8-hour measurement study in a plant reveals that 320 number of units were produced. If idle time = 15% and performance rating = 120%, with allowance = 12% of normal time, the standard time per unit produced will be

(A) 1.823 minutes (B) 1.714 minutes

(C) 1.645 minutes (D) 1.286 minutes

Key: (B)

Sol: Observed Time per unite

$\text{OT} = \frac{8\times0.85\times60}{320} = 1.275\,\text{min}$

Normal time, NT=OT× Performance Rating

$= 1.275\times1.2$

$= 1.53\,\text{min}$

Standard time, ST = NT×1.12

=1.72 min.

104. An organization's sales during a financial year is Rs. 6,00,000 with 90% of it on credit. At the end of the year, the receivables turnover was found to be 5. Considering 365 days to a year, the average collection period and receivables are, respectively.

(A) 81 days and Rs. 1, 08,000
(B) 73 days and Rs. 1, 08,000
(C) 81 days and Rs. 1, 20,000
(D) 73 days and Rs. 1, 20,000

Key: (B)

Sol: Inventory cost $= \frac{600000}{5} = \text{Rs.}120000$

Received inventory = 1200000×0.9
$= \text{Rs. } 108000$

Avg. collection period $= \frac{1}{5} \times 365 = 73\text{days}$

105. A particular item has a demand of 9000 units/year. The cost of one procurement is Rs. 108 and the holding cost per unit is Rs. 2.40/year. The replacement is instantaneous and no shortages are allowed. What is the optimum number of orders/year?
(A) 7 orders/year
(B) 8 orders/year
(C) 9 orders/year
(D) 10 orders/year

Key: (D)

Sol: D = 9000 units/year
F = Rs. 108/order
C= Rs. 2.4 / unit/year

$\therefore \text{EOQ} = \sqrt{\frac{2DF}{C}} = \sqrt{\frac{2 \times 9000 \times 108}{2.4}} = 900\text{units}$

Optimum No. of orders per year

$= \frac{D}{EOQ} = \frac{9000}{900} = 10 \text{ orders / year.}$

106. Which one of the following is correct with respect to microcontrollers?
(A) Integration of a microprocessor with I/O interfaces and memory and other peripherals in a single IC chip
(B) A single very large scale integrated (VLSI) chip that contains programmable electronic components that perform control functions.
(C) Digital circuits for data handling and computation.
(D) The primary computation and system control operations.

Key: (A)

107. Which one of the following statements is correct?
Seismic transducer working in the displacement mode should have
(A) weak springs and heavy mass
(B) stiff springs and light mass
(C) weak springs and light mass
(D) stiff springs and heavy mass

Key: (A)

108. What will be the velocity of piston movement for a single-acting hydraulic actuator, when the fluid pressure is 100 bar, the diameter of the piston is 50 mm and the flow rate is 0.3 m^3/min?
(A) 2.41 m/s (B) 2.55 m/s
(C) 2.67 m/s (D) 2.84 m/s

Key: (B)

Sol: Given, D = 0.05m
Q = $0.3 m^3$/min

$\because Q = A.V$

$Q = \frac{\pi}{4} D^2.V$

$\text{so, } V = \frac{4Q}{\pi D^2} = \frac{4 \times 0.3}{3.14 \times (0.05)^2} = 2.55 \text{m/s}$

109. A stepper motor is to be used to drive the linear axis of a certain Mechatronics system. The motor output shaft is connected to a screw thread with a 30 mm pitch. Linear resolution of 0.5 mm is stipulated. What is the needed step angle?
(A) 9^o (B) 8^o (C) 7^o (D) 6^o

Key: (D)

Sol: Pitch on screw thread = 30mm

Linear resolution required = 0.5mm

For one rotation of screw, it advances by 30mm

For getting 0.5mm resolution, the motor shaft has to rotate $= \left(\frac{0.5}{30}\right)$ rotations

$= \frac{1}{60}$ rotations

Step angle

$\Rightarrow \frac{1}{60} \times 360^\circ = 6^\circ (\because 1\,\text{Rotation} = 360^\circ)$

110. Consider the following statements regarding a stepper motor:

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill.
3. Speed and electric control signal of the motor vary mutually linearly.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

111. The following table lists the tasks in a project and the time duration for each task:

Task	Preceding Task	Normal duration (in weeks)
A	--	16
B	--	20
C	A	8
D	A	10
E	B, C	6
F	D, E	12

The critical path, the project duration and the free float for activity A are, respectively.

(A) A-C-E-F; 42 weeks and 0 week

(B) B-E-F; 42 weeks and 1 week

(C) B-C-D-F; 50 weeks and 2 weeks

(D) A-C-E-F; 50 weeks and 0 week

Key: (A)

Sol: $\because$ Critical path is longest path of network & its length is equal to project duration.

So, A – C – E – F is critical path with duration 16 + 8 + 6 + 12 = 42 Weeks

& $\because$ Float for critical Activity is zero.

So, free Float of Activity A is zero.

112. Consider the following statements with reference to SCARA Robot:

1. It has four degrees of freedom.
2. It has only one forward kinematic solution.
3. It has two inverse kinematic solutions.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

113. Consider the following statements regarding the laws of Robotics:

1. A Robot shall not injure a human being or, through inaction, allow a human being harmed.
2. A Robot must obey orders given by humans except when such orders conflict with first law.
3. A Robot must always protect its own existence.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (A)

Sol: The Robot should obey 1 and 2.

114. The number of degrees of freedom in a 3D Robot of TRL : R type configuration is

(A) 4 (B) 3 (C) 2 (D) 1

Key: (A)

115. Which of the following are the basic differences between vibration signature and noise signature?

1. Vibration signature is essentially in the frequency range zero to 100 cps whereas noise signature is in the range 20 cps to 3000 cps.
2. Vibration signature has well-defined peaks whereas the noise signal is smeared.
3. The intensities of noise signatures are much less than that of vibration signatures.
4. Detection of vibration signature calls for a microphone whereas that of noise can do with a pickup.

Select the correct answer using the code given below.

(A) 1 and 4 (B) 2 and 3
(C) 1 and 2 (D) 3 and 4

Key: (B)

116. Consider the following features relating to Robot kinematics with reference to SCARA Robot:

1. Shoulder and elbow rotational axes are vertical.
2. The Robot could perform insertion tasks along the vertical direction.
3. Its general configuration is analogous to that of a human arm.

Which of the above features are correct?

(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

117. A flywheel fitted to a steam engine has a mass of 500 kg and radius of gyration 300mm. The starting torque is 900 N m. What is the kinetic energy after 10 s?

(A) 225 kJ (B) 450 kJ
(C) 900 kJ (D) 1800 kJ

Key: (C)

Sol: $m = 500\ kg$

$k = 300\ mm$

$T = 900\ N-m$

$T = I\alpha$

$900 = 500\times 0.3^2 \times \alpha$

$\alpha = \dfrac{900}{500\times 0.3^2} = 20\ rad/sec^2$

$\omega = \omega_0 + \alpha t$

$\alpha = \dfrac{\omega}{t}$

$\omega = 20\times 10 = 200\ rad/sec^2$

$K.E = \dfrac{1}{2} I\omega^2 = \dfrac{1}{2}\times\left(500\times 0.3^2\right)\times\left(200\right)^2$

$= 900\ kJ$

118. In a counterflow heat exchanger, hot gases enter at 250°C and leave at 100°C. Atmospheric air enters at 50° C and leaves at 80°C. The effectiveness of the heat exchanger will be

(A) 0.20 (B) 0.25
(C) 0.30 (D) 0.35

Key: (*)

Sol: Given, hot gases

$T_{hi} = 250°C$

$T_{ho} = 100°C$

atmospheric air $T_{Ci} = 50°C$

$T_{Co} = 80°C$

$So, \in = \dfrac{Q_{act}}{Q_{max} = C_{min}\left(T_{hi} - T_{ci}\right)}$

here, $C_h < C_c$

$\because$ large temperature variation takes placein hot gases

$$So, C_{min} = C_h$$

$$\in = \frac{C_h (T_{hi} - T_{ho})}{C_h (T_{hi} - T_{Ci})} = \frac{(250-100)}{(250-50)} = 0.75$$

$$\in = 0.75$$

119. Two air streams with mass flow rates of 36 kg/min and 14 kg/min with respective enthalpies of 36 kJ/kg da and 50 kJ/kg da are mixed. The enthalpy of the mixture is nearly

(A) 64 kJ/kg da (B) 55 kJ/kg da

(C) 46 kJ/kg da (D) 40 kJ/kg da

Key: (D)

Sol: Given

$$\dot{m}_1 = 36 kg/min$$

$$\dot{m}_2 = 14 kg/min$$

$$h_1 = 36 kJ/kg$$

$$h_2 = 50 kJ/kg$$

after mixing Enthalpy of mixture

$$(h) = \frac{\dot{m}_1 h_1 + \dot{m}_2 h_2}{(\dot{m}_1 + \dot{m}_2)}$$

$$= \frac{(36\times 36) + (14\times 50)}{36+14}$$

$$h = 40 kJ/kg \text{ D.A}$$

120. Consider the following statements in respect of maximum efficiency of a two-stage reciprocating compressor:

1. The pressure ratios are same for each stage.
2. The work done is same in each stage.
3. The intercooling is perfect.

Which of the above statements are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

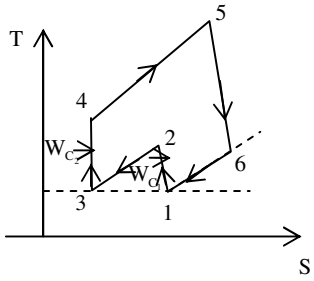
Key: (D)

Sol: In two-stage reciprocating compressor, for maximum efficiency.

$$W_{C_1} = W_{C_2}$$

For perfect intercooling $(T_1 = T_3)$

$$P_2 = P_3 = \sqrt{P_1 P_4}$$



Directions:

Each of the following thirty (30) items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the code given below:

Code:

(A) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(B) Both Statement (I) and Statement (II) are individually true but Statement (II) is **not** the correct explanation of Statement (I).

(C) Statement (I) is true but Statement (II) is false.

(D) Statement (I) is false but Statement (II) is true.

121. Statement (I):

Depth of centre of pressure of any immersed surface is independent of the density of the liquid.

Statement (II):

Centre of area of the immersed body lies below the centre of pressure.

Key: (C)

Sol: ∵ Distance of centre of pressure from free surface is

$$y_{cp} = \bar{y} + \frac{I_{cc_1} \sin^2\theta}{A\bar{y}}$$

So, centre of Pressure is independent of density of liquid & C.P is below centroid of Area.

122. Statement (I):
In flow through a pipeline, the nature of the fluid flow depends on the velocity of the fluid.
Statement (II):
Reynolds number of the flow depends on the velocity, the diameter of the pipe and the kinematic viscosity of the fluid.

Key: (A)

Sol: ∵ Nature of flow depends on Reynolds No. (Re)

$$\& \ Re = \frac{VD}{\nu}$$

Where V = Velocity of fluid
D = Dia. of pipe
ν =Kinematic viscosity.

123. Statement (I):
The specific heat at constant pressure for an ideal gas is always greater than the specific heat at constant volume.
Statement (II):
Heat added at constant volume is not utilized for doing any external work.

Key: (A)

Sol: $C_P > C_V$ (always)

$$\because W = \int P dv$$

If constant volume then, $W = 0 (\because V_1 = V_2)$

124. Statement (I):
A homogeneous mixture of gases that do not react within themselves can be treated as a pure substance.
Statement (II):
Flue gases can be treated as a homogeneous mixture of gases.

Key: (A)

125. Statement (I):
Air-blast injection in diesel engines could reduce engine efficiency.
Statement (II):
Air-blast injection in diesel engines is not instantaneous but happens when the piston moves outward with the injection valve remaining open for whatever reason.

Key: (C)

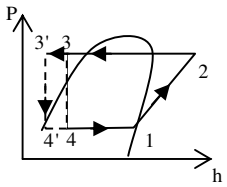
126. Statement (I):
Use of non-azeotropic mixtures used as the refrigerant in a vapour-compression system improves the coefficient of performance.
Statement (II):
The increase in this coefficient is attributable to reduction in volume.

Key: (C)

127. Statement (I):
Sub-cooling of a refrigerant liquid increases the coefficient of performance of a refrigeration cycle.
Statement (II):
Sub-cooling reduces the work requirement of the refrigeration cycle.

Key: (C)

Sol: In sub-cooling it doesn't affect the work requirement
3-3^1-subcooling
1-2-compressor work i/p.



128. Statement (I):
In vapour-absorption system, larger the value of specific solution circulation, more the pump work.
Statement (II):
Higher solution circulation rates of poor as well as rich solutions need larger pressure drops in the system.

Key: (A)

Sol: As circulation rate increases, the pressure drop increase during flow in pipe.

129. Statement (I):
Outward radial flow turbines do race inherently.
Statement (II):
In outward radial flow turbines, the centrifugal head impressed upon the exiting water leads to flow increase.

Key: (A)

130. Statement (I):
Regarding the power transmitted by a clutch, greater the speed, lower the torque to be transmitted for fixed power rating.
Statement (II):
The clutch is placed on the low-speed side to transmit larger torque.

Key: (C)

131. Statement (I):
The volume of air taken into the cylinder of a reciprocating air compressor is less than the stroke volume of the cylinder.
Statement (II):
Air that has been compressed to clearance volume expands to larger volumes during the suction stroke.

Key: (A)

Sol: Statement is correct because of scavenging effect.

132. Statement (I):
Providing reheat in a Rankine cycle would increase the efficiency of the cycle.
Statement (II):
Reheat in Rankine cycle reduces specific steam consumption.

Key: (A)

Sol: $\because$ Specific Steam Rate (S.S.C) $= \frac{1}{W_{net}}$

Due to reheating $W_{net} \uparrow$ so steam consumption decreases.

133. Statement (I):
Heat carried away by hot gases in chimney draught is much greater than the work required for lifting the same gases through the height of the chimney. Yet artificial draught is not preferred.
Statement (II):
Artificial draught involves large initial cost as well as large maintenance cost.

Key: (D)

Sol: In most of power plant artificial draught is use.

134. Statement (I):
The overall combustion efficiency of a fuel oil based plant is less as compared to that of a coal burning plant.
Statement (II):

Fuel oils contain comparatively larger percentage of hydrogen, which produce more moisture per kg of fuel burnt.

Key: (D)

Sol: Due to high ash contain combustion efficiency of coal burning plant is less compared to fuel oil based plant.

135. Statement (I):
Proximate analysis of coal is done to determine its calorific value.
Statement (II):
In proximate analysis of coal, the percentages of moisture, volatile matter, fixed carbon and ash are determined.

Key: (D)

Sol: Calorific value is achieved by calorimetric analysis.

136. Statement (I):
Water entering into a condenser from the cooling tower has much dissolved impurities.
Statement (II):
In a closed cooling system, the water is continuously aerated, therefore, there is abundant dissolved oxygen in this water.

Key: (C)

Sol: In a closed cooling system there are chances of deaeration due to the presence of vaccum.

137. Statement (I):
Pyranometer is used to measure diffuse solar radiation by blocking the direct radiation with a shadow band.
Statement (II):
Pyrheliometer is used to measure diffuse radiation.

Key: (C)

Sol: Pyrheliometer is used to measure direct component of solar radiation.
Diffuse radiation measured by pyrometer.

138. Statement (I):
Directionally solidified materials have good creep resistance.
Statement (II):
Directionally solidified materials may be so loaded that there is no shearing stress along, or tensile stress across, the grain boundaries.

Key: (A)

139. Statement (I):
The ideal material for shafts transmitting power is CI.
Statement (II):
CI resists compression well.

Key: (D)

140. Statement (I):
Hardenability curves are developed based on the fact that any given steel item always develops the same microstructure under a standardized cooling rate.
Statement (II):
Industry employs Jominy hardenability test to measure hardenability.

Key: (B)

141. Statement (I):
Cams used in high-speed application should have displacement, velocity and acceleration curves of the follower in continuity.
Statement (II):
Abrupt changes in these curves will cause high contact stresses at the bearings and make the operation noisy.

Key: (A)

142. Statement (I):
Resonance is a special case of forced vibration in which the natural frequency of the body is the same as the impressed frequency of the external periodic force whereby the amplitude of the forced vibration peaks sharply.
Statement (II):
The amplitude of forced vibration of a body increases with increase in the frequency of the externally impressed periodic force.

Key: (C)

143. Statement (I):
All worm drives (worm and worm wheel) are reversible.
Statement (II):
The worm and worm wheel are made of different materials.

Key: (D)

Sol: Statement-I is incorrect
It cannot be reversible because the drive is used to increase the torque.

144. Statement (I):
There is no balancing methodology in the case of reciprocating engines.
Statement (II):
Balancing of dynamic forces is achieved mostly by resorting to multi-cylinder engine concept.

Key: (C)

145. Statement (I):
Two circular discs of equal masses and thickness made of different materials will have same moment of inertia about their central axes of rotation.
Statement (II):
Moment of inertia depends upon the distribution of mass within the body.

Key: (D)

Sol: Statement-I is incorrect because density is different, masses will be different even though both the disc have same size. Even if the masses are made same then radius of gyration will be different.

$$I = \frac{mR^2}{2}$$

$$m = \rho.v = \rho.A.t$$

$$m_1 = m_2$$

$$I_1 = \rho_1 A_1 t_1 \times \frac{R_1^2}{2} = \rho_1 \frac{\pi}{2} R_1^4 t_1$$

$$I_2 = \rho_2 A_2 t_2 \times \frac{R_2^2}{2} = \rho_2 \frac{\pi}{2} R_2^4 t_2$$

$$t_1 = t_2$$

Say $\rho_1 < \rho_2$ then $R_1 > R_2$

$I_2 > I_1$

146. Statement (I):
The speed of a governed water turbine will remain constant irrespective of load.
Statement (II):
In governing, the water supply is regulated to maintain the speed constant.

Key: (A)

147. Statement (I):
In sugarcane crushing rollers, the fit between the cast roll and the forged steel shaft is of interference type.
Statement (II):
This helps in removing the roll from the shaft whenever not needed.

Key: (A)

148. Statement (I):
Thicker sections of casting take longer to solidify than thinner sections.
Statement (II):
Thicker sections of casting carry residual stresses.

Key: (B)

149. Statement (I):
Sand with grains of uniform round shape is preferred for preparing moulds.
Statement (II):
If grains are large and regular in shape, the air-venting property of the mould prepared with them would be better.

Key: (D)

150. Statement (I):
Bar chart plots in the time dimension the planned performance of various activities of a project.
Statement (II):
One advantage of a bar chart is that the inter sequence and linkage of all activities is indicated there in.

Key: (C)