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ESE - 2020

PRELIMINARY EXAMINATION

Questions with Detailed Solutions

MECHANICAL ENGINEERING

(SET-A)

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01. A stone weighs 400 N in air and when immersed in water it weighs 225 N. If the specific weight of water is 9810 N/m^3, the relative density of the stone will be nearly

(a) 5.9 (b) 4.7 (c) 3.5 (d) 2.3

01. Ans: (d)

Sol: $\frac{(W_{air})_{stone}}{(W_{water})_{stone}} = \frac{\rho \forall g}{(\rho - \rho_w)\forall g} = \frac{\rho}{\rho - \rho_w}$

where $\forall$ is the volume of stone having density ρ.

$$\frac{400}{225} = \frac{\rho/\rho_w}{\frac{\rho}{\rho_w} - 1} = \frac{S}{S-1}$$

where S is the specific gravity of stone.

$$\frac{16}{9} = \frac{S}{S-1}$$

$16S - 16 = 9S$

$7S = 16$

$$S = \frac{16}{7} = 2.29 \approx 2.3$$

02. A flat plate 0.1 m^2 area is pulled at 30 cm/s relative to another plate located at a distance of 0.01 cm from it, the fluid separating them being water with viscosity of 0.001 Ns/m^2. The power required to maintain velocity will be

(a) 0.05 W (b) 0.07 W (c) 0.09 W (d) 0.11 W

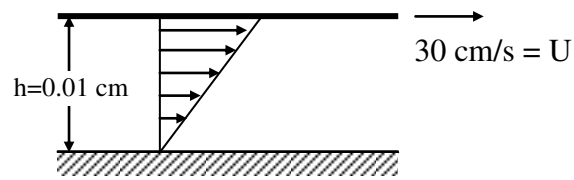
02. Ans: (c)

Sol: $F = \tau A = \mu \frac{du}{dy} A$

For linear velocity profile,

$$\frac{du}{dy} = \frac{\Delta u}{\Delta y} = \frac{U}{h}$$

$$F = \mu \frac{U}{h}.A$$



$$\text{Power} = F \times U = \mu \frac{U^2}{h} A$$

$$= 0.001 \times \frac{0.3^2}{0.01 \times 10^{-2}} \times 0.1$$

$$= 0.09 \text{ W}$$

03. When the pressure of liquid is increased from 3 MN/m^2 to 6 MN/m^2, its volume is decreased by 0.1%. The bulk modulus of elasticity of the liquid will be

(a) 3×10^{12} N/m^2 (b) 3×10^{9} N/m^2 (c) 3×10^{8} N/m^2 (d) 3×10^{4} N/m^2

03. Ans: (b)

Sol: Bulk modulus of elasticity of a liquid is defined as:

$$K = -\frac{dp}{(dv/v)}$$

$$= -\frac{(6-3)\times10^6}{(0.1/100)}$$

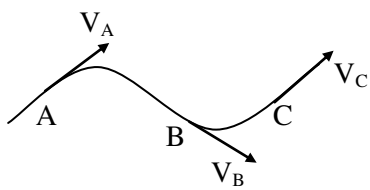
$$= 3 \times 10^9 \text{ N/m}^2$$

04. A curve that is everywhere tangent to the instantaneous local velocity vector, is

(a) Streak line (b) Path line (c) Normal line (d) Streamline

04. Ans: (d)

Sol: As per definition of streamline velocity at any point on streamline is tangential to the streamline at that instant.



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05. A 120 mm diameter jet of water is discharging from a nozzle into the air at a velocity of 40 m/s. The power in the jet with respect to a datum at the jet will be

(a) 380 kW (b) 360 kW (c) 340 kW (d) 320 kW

05. Ans: (b)

Sol: $\text{Power} = \frac{1}{2}\dot{m}v^2 = \frac{1}{2}(\rho av).v^2$

$= \frac{1}{2}\rho av^3$

$= \frac{1}{2} \times 1000 \times \left(\frac{\pi}{4} \times 0.12^2\right) \times 40^3$

$= 362$ kW

06. Which of the following applications regarding Navier-Stokes equations are correct?

1. Laminar unidirectional flow between stationary parallel plates.
2. Laminar unidirectional flow between parallel plates having no relative motion.
3. Laminar flow in circuit pipes.
4. Laminar flow between concentric rotating cylinders.

(a) 1, 2 and 3 only (b) 1, 3 and 4 only (c) 1, 2 and 4 only (d) 2, 3 and 4 only

06. Ans: (*)

Sol: Navier - Stokes equation is applicable for all types of flow given in the question.

07. A crude oil having a specific gravity of 0.9 flows through a pipe of diameter 0.15 m at the rate of 8 lps. If the value of μ is 0.3 Ns/m^2, the Reynolds number will be nearly

(a) 295 (b) 235 (c) 205 (d) 165

07. Ans: (c)

Sol: $V = \frac{Q}{A} = \frac{8 \times 10^{-3}}{\frac{\pi}{4} \times 0.15^2} = 0.453$ m/s

$\text{Re} = \frac{\rho VD}{\mu} = \frac{900 \times 0.453 \times 0.15}{0.3}$

$= 203.8$

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08. Two pipes of lengths 2500 m each and diameters 80 cm and 60 cm respectively, are connected in parallel. The coefficient of friction for each pipe is 0.006 and the total flow is 250 litres/s. The rates of flow in the pipes are nearly

(a) 0.17 m^3/s and 0.1 m^3/s (b) 0.23 m^3/s and 0.1 m^3/s

(c) 0.17 m^3/s and 0.4 m^3/s (d) 0.23 m^3/s and 0.4 m^3/s

08. Ans: (a)

Sol: For pipes in parallel:

$$hf_1 = hf_2$$

i.e. $$\frac{f_1 L_1 Q_1^2}{12.1 d_1^5} = \frac{f_2 L_2 Q_2^2}{12.1 d_2^5}$$

$$\frac{Q_1}{Q_2} = \left(\frac{d_1}{d_2}\right)^{\frac{5}{2}} = \left(\frac{80}{60}\right)^{2.5}$$

$$= 2.05$$

Thus, $Q_1 = 2.05 Q_2$

But, $Q_1 + Q_2 = 0.25$ (given)

Thus, $2.05Q_2 + Q_2 = 0.25$

$\therefore Q_2 = 0.082\ m^3/s$

$Q_1 = 2.05\ Q_2 = 0.168\ m^3/s$

Option (a) is the nearest answer.

Note: Sum of discharge in each pipe must be 0.25 m^3/s. All other options can be eliminated.

09. A fluid of mass density 1790 kg/m^3 and viscosity 2.1 Ns/m^2 flows at a velocity of 3 m/s in a 6 cm diameter pipe. The head loss over a length of 12 m pipe will be nearly

(a) 62.0 m (b) 54.0 m (c) 46.5 m (d) 38.5 m

09. Ans: (d)

Sol : $$Re = \frac{\rho V D}{\mu} = \frac{1790 \times 3 \times 0.06}{2.1}$$

$$= 153.4$$

$\Rightarrow$ Flow is laminar.

For laminar flow:

$$\Delta P = 32\frac{\mu VL}{D^2}$$

$$\therefore h_f = \frac{\Delta P}{\rho g} = \frac{32\mu VL}{\rho g D^2}$$

$$= \frac{32 \times 2.1 \times 3 \times 12}{1790 \times 9.81 \times 0.06^2}$$

$$= 38.3 \text{ m}$$

10. Which of the following characteristics regarding fluid kinematics is/are correct?
    1. Streamline represents an imaginary curve in the flow field so that the tangent to the curve at any point represents the direction of instantaneous velocity at that point.
    2. Path lines, streamlines and streak lines are identical in steady flow.

    (a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

10. Ans: (c)

Sol: Statement (I) is the definition of streamline. It can be shown that for steady flow all the three lines, i.e., pathlines, streamlines and streak lines, are same.

11. To maintain 0.08 m^3/s flow of petrol with a specific gravity of 0.7, through a steel pipe of 0.3 m diameter and 800 m length, with coefficient of friction of 0.0025 in the Darcy relation, the power required will be nearly

    (a) 0.6 kW (b) 1.0 kW (c) 2.6 kW (d) 3.0 kW

11. Ans: (b)

Sol: $$\text{Power} = \rho g Q h_f = \rho g Q\left(\frac{4fLQ^2}{12.1d^5}\right)$$

$$= \frac{700 \times 9.81 \times 0.08 \times 4 \times 0.0025 \times 800 \times 0.08^2}{12.1 \times 0.3^5}$$

$$= 0.96 \text{ kW}$$

12. The diameter of a nozzle d for maximum transmission of power through it, is

(a) $\left[\frac{D^5}{8fL}\right]^{\frac{1}{4}}$ (b) $\left[\frac{D^5}{8fL}\right]^{\frac{1}{2}}$ (c) $\left[\frac{8D^5}{fL}\right]^{\frac{1}{4}}$ (d) $\left[\frac{8D^5}{fL}\right]^{\frac{1}{2}}$

where :

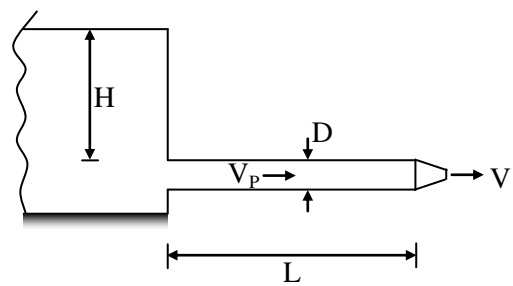
D = Diameter of pipe

f = Coefficient of friction

L = Length of pipe

12. Ans: (a)

Sol: The condition for maximum power transmission is:



$H = 3h_f$

But $H = \frac{V^2}{2g} + h_f$

$3h_f = \frac{V^2}{2g} + h_f$

$2h_f = \frac{V^2}{2g}$

$2 \times \left(\frac{4fLV_p^2}{2gD}\right) = \frac{V^2}{2g}$

$\left(\frac{V_P}{V}\right)^2 = \frac{D}{8fL}$

$\left(\frac{a}{A}\right)^2 = \frac{D}{8fL}$ $(\because\ aV = AV_p)$

$\left(\frac{\frac{\pi}{4}d^2}{\frac{\pi}{4}D^2}\right)^2 = \frac{D}{8fL}$

$d^4 = \frac{D^5}{8fL}$

$\therefore\ d = \left(\frac{D^5}{8fL}\right)^{\frac{1}{4}}$

13. A piston-cylinder device with air at an initial temperature of 30°C undergoes an expansion process for which pressure and volume are related as given below:

p(kPa)	100	37.9	14.4
V (m^3)	0.1	0.2	0.4

The work done by the system for n = 1.4 will be

(a) 4.8 kJ (b) 6.8 kJ (c) 8.4 kJ (d) 10.6 kJ

13. Ans: (d)

Sol: The process followed by the system

$$PV^n = C$$

$$PV^{1.4} = C$$

work transfer is given as

$$W = \frac{P_1V_1 - P_3V_3}{n-1}$$

$$= \frac{100\times0.1 - 14.4\times0.4}{1.4-1}$$

$$= 10.6 \text{ kJ}$$

14. A domestic food freezer maintains a temperature of –15°C. The ambient air temperature is 30°C. If heat leaks into the freezer at the continuous rate of 1.75 kJ/s, the least power necessary to pump this heat out continuously will be nearly

(a) 0.1 kW (b) 0.2 kW (c) 0.3 kW (d) 0.4 kW

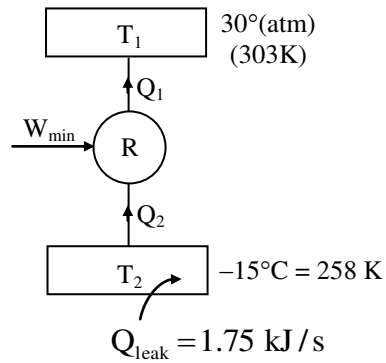
14. Ans: (c)

Sol: $Q_{leak} = 1.75$ kJ/s

$$COP_{max} = \frac{T_2}{T_1 - T_2} = \frac{Q_2}{W_{min}}$$

$$\frac{258}{303-258} = \frac{1.75}{\dot{W}_{min}}$$

$$\dot{W}_{min} = 0.305\,kW$$

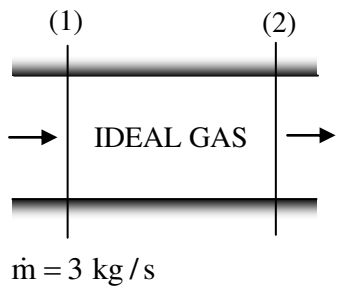


15. An ideal gas is flowing through an insulated pipe at the rate of 3 kg/s. There is a 10% pressure drop from an inlet to exit of the pipe. The values of R = 0.287 kJ/kg.K and T_0 = 300 K. The rate of energy loss for the pressure drop due to friction, will be nearly

(a) 34 kW (b) 30 kW (c) 26 kW (d) 22 kW

15. Ans: (c)

Sol: **Sol:** $\dot{m} = 3\ kg/s$



Pressure drop = 10%

$$R = 0.287\left(\frac{kJ}{kg.K}\right)$$

$T_0 = 300\ K$

$$\dot{I} = T_0 \dot{m} R \ln\left(\frac{\Delta P}{P}\right)(KW)$$

$$= 300 \times 3 \times 0.287\left(\frac{0.1}{1}\right)$$

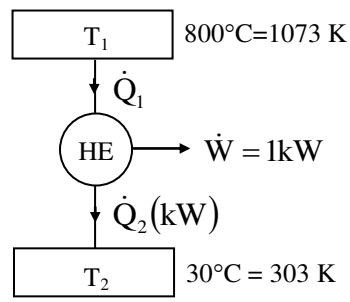
$$\dot{I} = 25.83(KW)$$

16. A cyclic heat engine operates between a source temperature of 800°C and a sink temperature of 30°C. The least rate of heat rejection per kW net output of engine will be nearly

(a) 0.2 kW (b) 0.4 kW (c) 0.6 kW (d) 0.8 kW

16. Ans: (b)

Sol: $$\eta_{max} = \eta_{carnot} = 1 - \frac{T_2}{T_1} = \frac{\dot{W}}{\dot{Q}_1}$$



$$1 - \frac{303}{1073} = \frac{1}{\dot{Q}_1}$$

$$\dot{Q}_1 = 1.39\,kW$$

$$\dot{W} = \dot{Q}_1 - \dot{Q}_2$$

$$1 = 1.39 - \dot{Q}_2$$

$$\dot{Q}_2 = 0.39\,KW$$

17. A fictitious pressure that, if it acted on the piston during the entire power stroke, would produce the same amount of net work as that produced during the actual cycle is called

(a) Quasi equivalent pressure (b) Mean equivalent pressure

(c) Mean effective pressure (d) Quasi static pressure

17. Ans: (c)

18. An ideal cycle based on the concept of combination of two heat transfer processes, one at constant volume and the other at constant pressure, is called

(a) Otto cycle (b) Dual cycle (c) Diesel cycle (d) Carnot cycle

18. Ans: (b)

19. The ideal thermodynamic cycle for the development of gas-turbine engine is

(a) Otto (b) Stirling (c) Ericsson (d) Brayton

19. Ans: (d)

20. If the pressure at exhaust from the turbine is the saturation pressure corresponding to the temperature desired in the process heater, such a turbine is called

(a) Condensing turbine (b) Extraction turbine

(c) Pass out turbine (d) Back pressure turbine

20. Ans: (b)

21. The purpose of providing fins on heat transfer surface is to increase

(a) Temperature gradient so as to enhance heat transfer by convection

(b) Effective surface area to promote rate of heat transfer by convection

(c) Turbulence in flow for enhancing heat transfer by convection

(d) Pressure drop of the fluid

21. Ans: (b)

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22. For fully developed laminar pipe flow, the average velocity is

(a) One-half of the maximum velocity

(b) One-third of the maximum velocity

(c) One-fourth of the maximum velocity

(d) Two-third of the maximum velocity

22. Ans: (a)

Sol: For fully developed laminar flow through a circular pipe, the average velocity,

$$V = \frac{u_{max}}{2}$$

23. The overall heat transfer coefficient due to convection and radiation for a steam maintained at 200°C running in a large room at 30°C is 17.95 W/m^{2}K. If the emissivity of the pipe surface is 0.8; the value of $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4; the heat transfer coefficient due to radiation will be nearly

(a) 17 W/m^{2}K (b) 14 W/m^{2}K (c) 11 W/m^{2}K (d) 8 W/m^{2}K

23. Ans: (c)

Sol: $Q_{Radiation} = \in A\sigma\left(T_S^4 - T_\infty^4\right) = h_{rad}A\left(T_s - T_\infty\right)$

$$\in \sigma\left(T_S^2 - T_\infty^2\right)\left(T_s^2 + T_\infty^2\right) = h_{rad}\left(T_s - T_\infty\right)$$

$$\in \sigma\left(T_S - T_\infty\right)\left(T_s + T_\infty\right)\left(T_s^2 + T_\infty^2\right) = h_{rad}\left(T_s - T_\infty\right)$$

$$h_{rad} = \in \sigma\left(T_s + T_\infty\right)\left(T_s^2 + T_\infty^2\right)$$

$$h_{rad} = 0.8 \times 5.67 \times 10^{-8}(473 + 303)(473^2 + 303^2)$$

$$h_{rad} \cong 11 \text{ W/m}^2\text{K}$$

24. Large heat transfer coefficients for vapour condensation can be achieved by promoting

(a) Film condensation (b) Dropwise condensation

(c) Cloud condensation (d) Dew condensation

24. Ans: (b)

Sol: Dropwise condensation gives almost ten times more condensation rate than film wise condensation.

25. Which one of the following valves is provided for starting the engine manually, during cold weather conditions?

(a) Starting jet valve (b) Compensating jet valve

(c) Choke valve (d) Auxiliary air valve

25. Ans: (c)

26. A 4-cylinder, 4-stroke single acting petrol engine consumes 6 kg of fuel per minute at 800 rpm when the air-fuel ratio of the mixture supplied is 9 : 1. The temperature is 650 K and pressure is 12.5 bar at the end of compression stroke. Take R = 300 Nm/kg.K, diameter of cylinder as 8 cm, stroke of cylinder as 10 cm. The compression ratio will be nearly

(a) 6.2 (b) 5.7 (c) 5.2 (d) 4.6

26. Ans: (*)

Sol: K = 4

4 – stroke S.I engine (Otto cycle)

$\dot{m}_f = 6(kg/min)$; N = 800 RPM

$\frac{A}{F} = 9:1$; $T_2 = 650$ K

$P_2 = 12.5$ bar ; $R = 300(N-m/kg.K)$

D = 8 cm ; L = 10 cm

C.R (r) ?

$$r = \frac{V_1}{V_2} = \frac{V_s}{V_c} + 1$$

$$\frac{A}{F} = \frac{\dot{m}_a}{\dot{m}_f} = 9$$

$$\dot{m}_a = 9 \times 6 = 54 \text{ kg/min}$$

27. Ice is formed at 0°C from water at 20°C. The temperature of the brine is –8°C. The refrigeration cycle used is perfect reversed Carnot cycle. Latent heat of ice = 335 kJ/kg, and c_{pw} = 4.18. The ice formed per kWh will be nearly

(a) 81.4 kg (b) 76.4 kg (c) 71.8 kg (d) 68.8 kg

27. Ans: (a)

Sol: Let m kg of Ice is formed

Refrigeration effect is given as –

$RE = m[4.18 \times 20 + 335]$

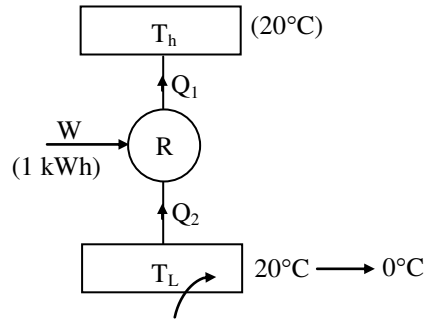
$W_{in} = 1\ kW.hr = 3600\ kJ$

For reversed carnot cycle

$$(COP)_R = \frac{T_L}{T_h - T_L} = \frac{273-8}{28} = \frac{RE}{W_{in}}$$

$$\frac{265}{28} = \frac{m[4.18 \times 20 + 335]}{3600}$$

$m = 81.4$ kgs



28. A Freon 12 simple saturation cycle operates at temperatures of 35°C and –15°C for the condenser and evaporator. If the refrigeration effect produced by the cycle is 111.5 kJ/kg and the work required by the compressor is 27.2 kJ/kg, the value of COP will be nearly

(a) 4.1 (b) 3.6 (c) 3.1 (d) 2.6

28. Ans: (a)

Sol: $$COP = \frac{NRE}{W_C} = \frac{111.5}{27.2} = 4.1$$

29. A cold storage is to be maintained at –5°C while the surroundings are at 35°C. The heat leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual COP of the refrigeration plant used is one-third of an ideal plant working between the same temperatures. The power required to drive the plant will be

(a) 10 kW (b) 11 kW (c) 12 kW (d) 13 kW

29. Ans: (d)

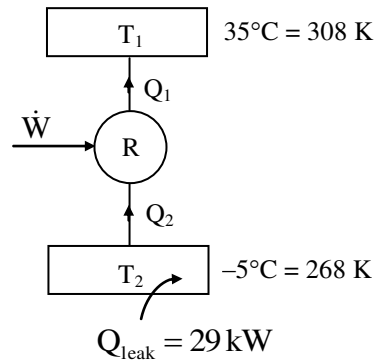
Sol: $Q_{leak} = 29$ kW

$$COP_{act} = \frac{COP_{ideal}}{3}$$

$$\frac{Q_2}{\dot{W}} = \left[\frac{T_2}{T_1 - T_2}\right] \times \frac{1}{3}$$

$$\frac{29}{\dot{W}} = \left[\frac{268}{308 - 268}\right] \times \frac{1}{3}$$

$$\dot{W} = 12.98 \text{ kW}$$



30. A single acting two-stage air compressor deals with 4 m^3/min of air at 1.013 bar and 15°C with a speed of 250 rpm. The delivery pressure is 80 bar. If the inter cooling is complete, the intermittent pressure after first stage will be

(a) 9 bar (b) 8 bar (c) 7 bar (d) 6 bar

30. Ans: (a)

Sol: $P_i = \sqrt{P_d \times P_s} = \sqrt{80 \times 1.013} = 9$ bar

31. The ideal gas-refrigeration cycle is the same as the

(a) Brayton cycle

(b) Reversed Brayton cycle

(c) Vapour compression refrigeration cycle

(d) Vapour absorption refrigeration cycle

31. Ans: (b)

32. If the atmospheric conditions are 20°C, 1.013 bar and specific humidity of 0.0095 kg/kg of dry air, the partial pressure of vapour will be nearly

(a) 0.076 bar (b) 0.056 bar

(c) 0.036 bar (d) 0.016 bar

32. Ans: (d)

Sol: $T_{atm} = 20°C$; $P_{atm} = 1.013$ bar

$\omega = 0.0095$ kg/kg.da ; Pv (bar) = ?

$$\omega = 0.622\left(\frac{Pv}{Pt - Pv}\right)$$

$$0.0095 = 0.622\left(\frac{Pv}{101.3 - Pv}\right)$$

$Pv = 0.0152\ (101.3 - Pv)$

$Pv = 0.0152 \times 101.3 - 0.0152\ Pv$

$Pv = 1.516$ kPa $= 0.01516$ bar

33. In air-conditioning systems air may be cooled and dehumidified by

1. Spraying chilled water to air in the form of fine mist.
2. Circulating chilled water or brine in a tube placed across the air flow.
3. Placing the evaporator coil across the air flow.

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

33. Ans: (d)

Sol: Using air washer or placing evaporator coil or circulating chilled water or brine we can do cooling and dehumidification.

34. A duct of rectangular cross-section 600 mm × 400 mm carries 90 m^3/min of air having density of 1.2 kg/m^3. When the quantity of air in both cases is same, the equivalent diameter of a circular duct will be nearly

(a) 0.86 m (b) 0.76 m (c) 0.64 m (d) 0.54 m

34. Ans: (d)

Sol : $$D = \frac{1.3(ab)^{0.625}}{(a+b)^{0.25}} = \frac{1.3(0.6\times 0.4)^{0.625}}{(0.6+0.4)^{0.25}} = 0.53 \text{ m}$$

$$\left[\text{OR},\ D = \frac{2ab}{a+b} = \frac{2\times 0.6\times 0.4}{1} = 0.48 \text{ m}\right]$$

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35. A room having dimensions of 5 m × 5 m × 3 m contains air at 25°C and 100 kPa at a relative humidity of 75%. The corresponding value of p_s is 3.169 kPa. The partial pressure of dry air will be nearly

(a) 106 kPa (b) 98 kPa (c) 86 kPa (d) 78 kPa

35. Ans: (b)

Sol: $\phi = \dfrac{P_v}{\rho_{sat}}$

$0.75 = \dfrac{P_v}{3.169}$

$P_v = 2.38$ kPa

$P_a = P_{atm} - P_v$

$= 100 - 2.38 = 97.62$ kPa ≈ 98 kPa

36. A measure of feeling warmth or coolness by the human body in response to the air temperature, moisture content and air motion is called

(a) Dry bulb temperature (b) Effective temperature

(c) Wet bulb temperature (d) Dew point temperature

36. Ans: (b)

Sol: Effective temperature takes into account DBT, moisture content, air motion and purity into account and is a measure of warmth or coolness.

37. While designing a Pelton wheel, the velocity of wheel 'u' is

(a) $K_u\sqrt{gH}$ (b) $2K_u\sqrt{gH}$ (c) $K_u\sqrt{2gH}$ (d) $2K_u\sqrt{2gH}$

where: K_u = Speed ratio, H = Net head on turbine, g = Gravity

37. Ans: (c)

Sol: For Pelton wheel, speed ratio (K_u) is defined as:

$K_u = \dfrac{u}{\sqrt{2gH}}$

$\therefore u = K_u\sqrt{2gH}$

38. The turbines of the same shape will have the same

(a) Thomas number (b) Reynolds number (c) Specific speed (d) Rotational speed

38. Ans: (c)

Sol: Specific speed depends only upon geometric shape of hydraulic machines. Hence, it is also called shape number.

39. A centrifugal pump is required to lift 0.0125 m^3/s of water from a well with depth 30 m. If rating of the pump motor is 5 kW, and the density of water is 1000 kg/m^3, the efficiency of the pump will be nearly

(a) 82% (b) 74% (c) 66% (d) 58%

39. Ans: (b)

Sol: $\eta_o = \dfrac{\rho g Q H_m}{\text{Shaft Power}}$

$$= \frac{1000 \times 9.81 \times 0.0125 \times 30}{5 \times 10^3}$$

$$= 0.735$$

Note: Manometric head is equal to static head (elevation difference) only when frictional losses are ignored.

40. An inward flow reaction turbine has an external diameter of 1 m and its breadth at inlet is 250 mm. If the velocity of flow at inlet is 2 m/s and 10% of the area of flow is blocked by blade thickness, the weight of water passing through the turbine will be nearly

(a) 10 kN/s (b) 14 kN/s (c) 18 kN/s (d) 22 kN/s

40. Ans: (b)

Sol: Weight flow rate $\left(\dot{W}\right) = \dot{m}g = \rho Q g$

$$= \rho g \times k\pi D_1 B_1 V_{f_1}$$

$$= 1000 \times 9.81 \times 0.9 \times \pi \times 1 \times 0.25 \times 2$$

$$= 13.9 \text{ kN/s}$$

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41. The process of abstracting steam at a certain section of the turbine and subsequently using it for heating feed water supplied to the boiler is called

(a) Reheating (b) Regeneration (c) Bleeding (d) Binary vapour cycle

41. Ans: (c)

Sol: The process of extracting steam from turbine at a certain section is bleeding.

42. When blade speed ratio is zero, no work is done because the distance travelled by the blade is zero even if the torque on the blade

(a) is minimum (b) is zero (c) is maximum (d) remains the same

42. Ans: (c)

43. In an axial flow turbine, the utilization factor has an absolute maximum value of unity, for any degree of reaction if the value of nozzle angle α is

(a) 270° (b) 180° (c) 90° (d) 0°

43. Ans: (d)

Sol: Utilization factor $= \dfrac{2\cos^2\alpha}{1+\cos^2\alpha} = \dfrac{2\times 1}{1+1} = 1 \qquad [\because\ \alpha = 0]$

44. Which of the following are essential for a good combustion chamber of turbojet engine?

1. It should allow complete combustion of fuel.
2. It should maintain sufficiently high temperature in the zone of combustion in addition to proper atomization of fuel thus leading to continuous combustion.
3. It should not have high rate of combustion.
4. The pressure drop should be as small as possible.

(a) 1, 2 and 4 only (b) 1, 2 and 3 only (c) 1, 3 and 4 only (d) 2, 3 and 4 only

44. Ans: (c)

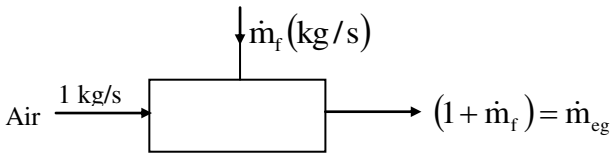
Sol: Because of turbine material limitation, only a limited amount of fuel can be burnt in the combustion chamber. The exhaust products downstream of the turbine still contain a considerable amount of excess oxygen. Hence, excess air is used and temperatures are low. If the temperatures are high it may lead to dissociation reactions which will reduce efficiency.

45. If m_f is the mass of fuel supplied per kg of air in one second, then the mass of gases leaving the nozzle of turbojet will be

(a) $(1-m_f)$ kg/s (b) $\frac{1}{(1+m_f)}$ kg/s (c) $(1+m_f)$ kg/s (d) $\frac{1}{(1-m_f)}$ kg/s

45. Ans: (c)

Sol:



46. Which one of the following may be considered as a single cylinder two-stroke reciprocating engine running at 2400 rpm to 2700 rpm for rapid chain of impulses?

(a) Turbo jet (b) Pulse jet (c) Ram jet (d) Athodyd jet

46. Ans: (b)

Sol: Pulse jet is intermittent flow engine similar to a reciprocating engine and pulse jet operates similar to Otto cycle. Hence, it can be called as a reciprocating engine.

47. In jet propulsion of ships, when the inlet orifices are at right angles to the direction of motion of the ships, the efficiency of propulsion η is

(a) $\frac{2u^2}{V+u}$ (b) $\frac{2Vu}{(V+u)^2}$ (c) $\frac{2u}{(V+u)^2}$ (d) $\frac{2Vu}{V+2u}$

where: V = Absolute velocity of the issuing jet

u = Velocity of the moving ship

47. Ans: (b)

Sol: The efficiency of propulsion η, in jet propulsion of ships, when the inlet orifices are at right angles to the direction of motion of the ships is $\frac{2Vu}{(V+u)^2}$.

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Analog Electronics	4 Q	Analog Electronics	5 Q	Computer Networks	5 Q	Geo Technical Engg.	7 Q	TOM	6 Q
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Power System	7 Q	EDC & VLSI	5 Q	Theory of Computation	6 Q	RCC& STEEL	6 Q	Heat Mass Transfer	4 Q
Power Electronics	6 Q	Communications	8 Q	Digital Electronics	4 Q	Surveying	6 Q	Production	8 Q
Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q	Engg. Maths	5 Q
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48. 0.8 kg of air flows through a compressor under steady state conditions. The properties of air at entry are : pressure 1 bar, velocity 10 m/s, specific volume 0.95 m^3/kg and internal energy 30 kJ/kg. The corresponding values at exit are 8 bar, 6 m/s, 0.2 m^3/kg and 124 kJ/kg. Neglecting change in potential energy, the power input will be

(a) 117 kW (b) 127 kW (c) 137 kW (d) 147 kW

48. Ans: (b)

Sol: Power (kW) $= \dot{m}\left[\left(u_2 + p_2v_2 + \frac{V_2^2}{2000}\right) - \left(u_1 + p_1v_1 + \frac{V_1^2}{2000}\right)\right]$

$$= 0.8\left[\left(124 + 800 \times 0.2 + \frac{6^2}{2000}\right) - \left(30 + 100 \times 0.95 + \frac{10^2}{2000}\right)\right]$$

$$= 0.8[(124 + 160 + 0.018) - (30 + 95 + 0.05)]$$

$$= 0.8[158.968] = 127.17 \text{ kW}$$

49. In a power plant, the efficiency of the electric generator, turbine, boiler, cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. In the generated electricity, the auxiliaries will consume nearly

(a) 7.3% (b) 6.5% (c) 5.7% (d) 4.9%

49. Ans: (a)

Sol: $\eta_o = \eta_b \times \eta_T \times \eta_e \times \eta_g \times \eta_A$

$0.33 = 0.92 \times 0.95 \times 0.42 \times 0.97 \times \eta_A$

$$\eta_A = \frac{0.33}{0.92 \times 0.95 \times 0.42 \times 0.97} = 0.9267$$

Power consumed (%) = $1 - \eta_A = 1 - 0.9267 = 0.0733$ Or, 7.33%

50. The higher power requirements for compression in a steam power plant working on Carnot vapour cycle

(a) Increases the plant efficiency as well as work ratio

(b) Reduces the plant efficiency as well as work ratio

(c) Does not affect the plant efficiency as well as work ratio

(d) Increases the plant efficiency and reduces work ratio

50. Ans: (c)

Sol: By supplying more steam the power output can be increased in case of high power requirements without changing the existing setting. Hence, it will not affect plant efficiency or work ratio.

51. For the same compression ratio, the Brayton cycle efficiency is

(a) Same as the Diesel cycle efficiency (b) Equal to the Otto cycle efficiency

(c) More than the Diesel cycle efficiency (d) Less than the Otto cycle efficiency

51. Ans: (b)

Sol: $\eta_o = 1 - \left(\frac{1}{r_k}\right)^{r-1}$

$$\eta_B = 1 - \left(\frac{1}{r_p}\right)^{\frac{r-1}{r}} = 1 - \left(\frac{1}{r_R}\right)^{r-1} \quad \text{for } r_p = r_k$$

52. An economizer in a steam generator performs the function of preheating the

(a) Combustion air (b) Feed water

(c) Input fuel (d) Combustion air as well as input fuel

52. Ans: (b)

Sol: The flue gases from the super heater enter the economizer and heat up the feed water. Economizer serves as a heat recovery system for the boiler.

53. Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar and 27°C. The pressure ratio in the cycle is 6. If the relation between the turbine work W_T and compressor work W_C is $W_T = 3W_C$ and $\gamma = 1.4$, the cycle efficiency will be nearly

(a) 40% (b) 50% (c) 60% (d) 70%

53. Ans: (a)

Sol: $\eta_{Th} = 1 - \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}}$

$$= 1 - \left(\frac{1}{6}\right)^{\frac{0.4}{1.4}} = 0.4 = 40\%$$

54. A fluidized bed combustion system having an output of 35 MW at 80% efficiency when using a coal of heating valve 26 MJ/kg with a sulphur content of 3.6% requires a particular limestone to be fed to it at a calcium-sulphur molar ratio of 3.0 so as to limit emissions of SO_2 adequately. The limestone used contains 85% $CaCO_3$. The required flow rate of limestone will be

(a) 2405 kg/h (b) 2805 kg/h (c) 3205 kg/h (d) 3605 kg/h

54. Ans: (a)

Sol: Power produced = 35 MW

η = 80%

C.V of fuel = 26 MJ/kg

Sulphur content = 3.6%

Heat supplied, $Q_s = \frac{\text{Power}(MW)}{\eta} = \frac{35}{0.8} = 43.75$ MW

Coal supplied to boiler, $\dot{m}_f = \frac{Q_s}{C_v} = \frac{43.75}{26} = 1.6827$ kg/sec

$= 1.6827 \times 3600$ kg/hr

$= 6057.7$ kg/hr

Sulphur content in coal, $\dot{m}_S = 6057.7 \times \frac{3.6}{100} = 218.07$ kg/hr

No. of moles of Sulphur $= \frac{\dot{m}_S}{\text{Mol.weight of Sulphur}} = \frac{218.07}{32} = 6.815$ kmols

$\frac{\text{Moles of Calcium}}{\text{Moles of Sulphur}} = \frac{n_{Ca}}{n_S} = 3$

$n_{ca} = 3n_S = 3 \times 6.815 = 20.444$ kmol/hr

Calcium requirement in kg/hr = $n_{Ca} \times$ Mol weight of Calcium $= 20.444 \times 40$ kg/hr

$\dot{m}_{Ca} = 817.79$ kg/hr

Calcium content in limestone (molecular weight of $CaCO_3$ = 100) $= \frac{40}{100} = 0.4$

Lime stone requirement to supply necessary Calcium, $\dot{m}_{Lime} = \frac{\dot{m}_{Ca}}{0.4} = \frac{817.79}{0.4} = 2044.47$ kg/hr

Actual lime stone requirement $= \frac{\dot{m}_{Lime}}{\%CaCO_3 \text{ in lim estone}} = \frac{2044.47}{0.85} = 2405.26$ kg/hr

55. In Orsat apparatus, when the percentage of carbon dioxide, oxygen and carbon monoxide are known, the remaining gas is assumed to be

(a) Hydrogen (b) Sulphur dioxide (c) Nitrogen (d) Air

55. Ans: (c)

Sol: Orsat apparatus gives dry analysis of flue gases and in the flasks CO_2, O_2 and CO are absorbed. The remaining gas is Nitrogen.

56. The partial vacuum created by the fan in the furnace and flues, draws the products of the combustion from the main flue and allows them to pass up to the chimney. Such a draught is called

(a) Balanced draught (b) Forced draught

(c) Induced draught (d) Artificial draught

56. Ans: (c)

Sol: A negative pressure on the top of the furnace is caused by induced draught.

57. Which of the following are applied (used) ways of compounding steam turbines?

1. Pressure compounding
2. Temperature compounding
3. Velocity compounding

(a) 1, 2 and 3 (b) 1 and 2 only (c) 2 and 3 only (d) 1 and 3 only

57. Ans: (d)

Sol: For reducing high speeds of the turbine to speeds that can be used for power generation, the method used are pressure compounding, velocity compounding and pressure and velocity compounding.

58. A steam ejector which removes air and other non-condensable gases from the condenser is known as

(a) Wet air pump (b) Dry air pump (c) Centrifugal pump (d) Circulating pump

58. Ans: (a)

Sol: In a steam ejector along with air some amount of moisture is also removed though negligible in quantity. Hence, it is appropriately called as wet air pump.

59. In a heat exchanger, 50 kg of water is heated per minute from 50°C to 110°C by hot gases which enter the heat exchanger at 250°C. The value of C_p for water is 4.186 kJ/kg.K and for air is 1 kJ/kg.K. If the flow rate of gases is 100 kg/min, the net change of enthalpy of air will be nearly

(a) 17.6 MJ/min (b) 15.0 MJ/min (c) 12.6 MJ/min (d) 10.0 MJ/min

59. Ans: (c)

Sol: $m_w c_{p_w}(T_2 - T_1) = \dot{m}_{air}(\Delta h)_{air}$ = Enthalpy change of air

Enthalpy change of air $= \dfrac{50 \times 4.186 \times 60}{1000} = 12.558$ MJ/min ≈ 12.6 MJ/min

60. The phenomenon that enables cooling towers to cool water to a temperature below the dry bulb temperature of air is termed as

(a) Chemical dehumidification (b) Adiabatic evaporative cooling

(c) Cooling and dehumidification (d) Sensible cooling

60. Ans: (b)

Sol: Water cools due to evaporation and air gets heated and humidified and the phenomenon is called adiabatic evaporative water cooling.

61. The angle through which the Earth must turn to bring the meridian of a point directly in line with the Sun's rays is called

(a) Altitude angle (b) Hour angle (c) Solar azimuth angle (d) Zenith angle

61. Ans: (b)

62. In which type of collector is solar radiation focused into the absorber from the top, rather than from the bottom?

(a) Fresnel lens (b) Paraboloidal (c) Concentrating (d) Compound parabolic

62. Ans: (d)

63. A flat plate collector is 150 cm wide and 180 cm high and is oriented such that it is perpendicular to the sun rays. Its active area is 90% of the panel size. If it is in a location that receives solar insolation of 1000 W/m^2 peak, the peak power delivered to the area of the collector will be

(a) 1.23 kW (b) 2.43 kW (c) 4.46 kW (d) 6.26 kW

63. Ans: (b)

Sol: Power = $I_T.A_C$

$$= 1000 \times \left(\frac{150}{100} \times \frac{180}{100}\right) \times 0.9$$

P = 2.43 kW

64. A surface having high absorptance for short-wave radiation (less than 2.5 μm) and a low emittance of long-wave radiation (more than 2.5 μm), is called

(a) Absorber (b) Emitter (c) Selective (d) Black

64. Ans: (c)

65. In a solar tower power system, each mirror is mounted on a system called

(a) Regenerator (b) Linear Fresnel (c) Dish (d) Heliostat

65. Ans: (d)

66. The ratio of PV cell's actual maximum power output to its theoretical power output is called

(a) Quantum factor (b) Fill factor (c) Quantum efficiency (d) PV factor

66. Ans: (b)

67. With respect to the wind turbine blades, TSR means

(a) Tip Swift Ratio (b) Tip Sharp Ratio (c) Tip Speed Ratio (d) Tip Swing Ratio

67. Ans: (c)

68. For a wind turbine 10 m long running at 20 rpm in 12.9 kmph wind, the TSR will be nearly

(a) 3.6 (b) 5.8 (c) 7.6 (d) 9.8

68. Ans: (b)

Sol: $\omega = \frac{2\pi N}{60} = 2\pi \times \frac{20}{60} = \frac{2\pi}{3}$ rad/sec

$$\text{TSR} = \lambda = \frac{R\omega}{u_0} = \frac{10 \times 2\pi/3}{12.9 \times 5/18} = 5.8$$

69. Which one of the following is an enclosure or housing for the generator, gear box and any other parts of the wind turbine that are on the top of the tower?

(a) Turbine blade (b) Nacelle (c) Turbine head (d) Gear box

69. Ans: (b)

70. The force required for producing tides in the ocean is

(a) 70% due to Moon and 30% due to Sun (b) 30% due to Moon and 70% due to Sun

(d) 45% due to Moon and 55% due to Sun (d) 55% due to Moon and 45% due to Sun

70. Ans: (a)

Sol: Moon is having 2.21 times more tidal force than sun.

71. Which of the following are related to the Proton Exchange Membrane Fuel Cell (PEMFC)?

1. Polymer electrolyte
2. Hydrogen fuel and oxygen
3. Pure water and small amount of electricity
4. Nitrogen gas

(a) 1 and 3 only (b) 2 and 4 only (c) 1 and 2 only (d) 3 and 4 only

71. Ans: (c)

72. Which of the following are the essential functions of fuel cells?

1. The charging (or electrolyser) function in which the chemical AB is decomposed to A and B.
2. The storage function in which A and B are held apart.
3. The charge function in which A and B are charged with the simultaneous generation of electricity.

(a) 1 and 3 only (b) 2 and 3 only (c) 1 and 2 only (d) 1, 2 and 3

72. Ans: (c)

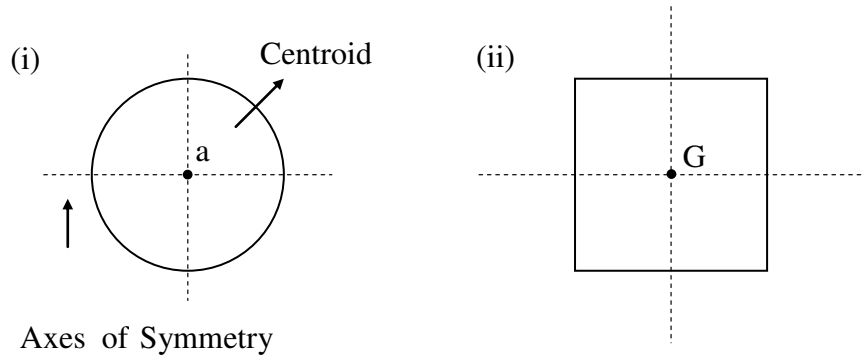
73. The position of centroid can be determined by inspection, if an area has

(a) Single axis of symmetry (b) Two axes of symmetry

(c) An irregular shape (d) Centre axes of symmetry

73. Ans: (b)

Sol:



74. Which of the following statements of D'Alembert's principle are correct?

1. The net external force F actually acting on the body and the inertia force F_1 together keep the body in a state of fictitious equilibrium.
2. The equation of motion may be written as F + (–ma) = 0 and the fictitious force (–ma) is called an inertia force.
3. It tends to give solution of a static problem an appearance akin to that of a dynamic problem.

(a) 1 and 3 only (b) 1 and 2 only (c) 2 and 3 only (d) 1, 2 and 3

74. Ans: (d)

75. The linear relationship between stress and strain for a bar in simple tension or compression is expressed with standard notations by the equation

(a) $\sigma = E\varepsilon$ (b) $\sigma = E\nu$ (c) $\sigma = G\nu$ (d) $\sigma = G\varepsilon$

75. Ans: (a)

Sol: According to Hook's law,

When the material is linear elastic homogeneous and isotropic, stress varies linearly with reference to (w.r.t) strain.

$\therefore \sigma = E\varepsilon$

76. A punch is used for making holes in steel plates with thickness 8 mm. If the punch diameter is 20 mm and force required for creating a hole is 110 kN, the average shear stress in the plate will be nearly

(a) 139 MPa (b) 219 MPa (c) 336 MPa (d) 416 MPa

76. Ans: (b)

Sol: Given, Thickness (t) = 8 mm

Diameter (d) = 20 mm

Force (F) = 110 kN

$F = \tau\pi dt$

$$\tau = \frac{F}{\pi dt} = \frac{110\times10^3\,N}{\pi\times20\times8\,mm^2} = 218.83\,MPa$$

77. A rod of length 2 m and diameter 50 mm is elongated by 5 mm when an axial force of 400 kN is applied. The modulus of elasticity of the material of the rod will be nearly

(a) 66 GPa (b) 72 GPa (c) 82 GPa (d) 96 GPa

77. Ans: (c)

Sol: Axial deformation

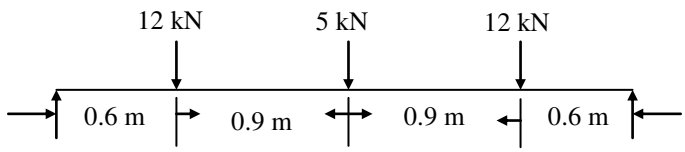
$$8 = \frac{P.\ell}{E.A}$$

$$5 = \frac{400\times10^3\times2000}{E\times\frac{\pi}{4}\times50^2}$$

E = 81487.3 MPa

= 81.5 GPa

78. A beam of span 3 m and width 90 mm is loaded as shown in the figure. If the allowable bending stress is 12 MPa, the minimum depth required for the beam will be



(a) 218 mm (b) 246 mm (c) 318 mm (d) 346 mm

78. Ans: (b)

Sol: Bending stress $\sigma_b = \dfrac{6M_{max}}{b.d^2}$

$M_{max} = 14.5 \times 1.5 - 12 \times 0.9$

$= 10.95$ kN.m

$= 10.95 \times 10^6$ N.mm.

$12 = \dfrac{6 \times 10.95 \times 10^6}{90 \times d^2}$

$d = 246.64$ mm

79. A vertical hollow aluminium tube 2.5 m high fixed at the lower end, must support a lateral load of 12 kN at its upper end. If the wall thickness is $\frac{1}{8}$th of the outer diameter and the allowable bending stress is 50 MPa, the inner diameter will be nearly

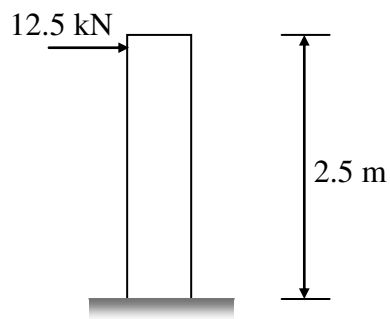
(a) 186 mm (b) 176 mm (c) 166 mm (d) 156 mm

79. Ans: (d)

Sol: $t = \dfrac{1}{8}.d_0$

$d_i = d_0 - 2t$

$= d_0 - 2 \times \dfrac{1}{8} d_0 = \dfrac{3}{4} d_0$



$\dfrac{d_i}{d_0} = \dfrac{3}{4}$

$\sigma_b = \dfrac{32M_{max}}{\pi d_0^3 (1 - K^4)}$

$50 = \dfrac{32 \times 12 \times 10^3 \times 2500}{\pi . d_0^3 \left[1 - \left(\frac{3}{4}\right)^4\right]}$

$d_0 = 207.54$

$d_i = \dfrac{3}{4} \times 207.54 = 155.66$ mm

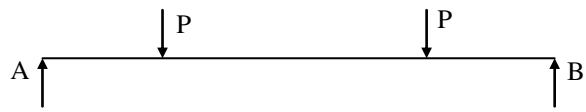
80. A wooden beam AB supporting two concentrated loads P has a rectangular cross-section of width = 100 mm and height = 150 mm. The distance from each end of the beam to the nearest load is 0.5 m. If the allowable stress in bending is 11 MPa and the beam weight is negligible, the maximum permissible load will be nearly

(a) 5.8 kN (b) 6.6 kN (c) 7.4 kN (d) 8.2 kN

80. Ans: (d)

Sol:

$M_{max} = P \times 0.5 = P \times 500$ N.mm



$$\sigma_{max} = \frac{6.M_{max}}{b.d^2}$$

$$11 = \frac{6 \times P \times 500}{100 \times 150^2}$$

P = 8250 N = 8.25 kN

81. Which of the following statements regarding thin and thick cylinders, subjected to internal pressure only, is/are correct?

1. A cylinder is considered thin when the ratio of its inner diameter to the wall thickness is less than 15.
2. In thick cylinders, tangential stress has highest magnitude at the inner surface of the cylinder and gradually decreases towards the outer surface.

(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

81. Ans: (b)

Sol: A cylinder is considered to be thin when the thickness is much smaller than the inner diameter of cylinder.

$\therefore \quad \frac{d_i}{t} > 15$ thin cylinder

$\frac{d_i}{t} < 15$ thick cylinder

When a thick cylinder is subjected to internal pressure, the variation of hoop stress in the direction of radius is represented as

$$\sigma_\theta = \frac{P_i \times r_i^2}{r_o^2 - r_i^2}\left[\frac{r_o^2}{r^2} + 1\right]$$

σ_θ is maximum when $r = r_i$ and minimum when $r = r_o$

82. A cylindrical storage tank has an inner diameter of 600 mm and a wall thickness of 18 mm. The transverse and longitudinal strains induced are 255×10^{-6} mm/mm and 60×10^{-6} mm/mm, and if G is 77 GPa, the gauge pressure inside the tank will be

(a) 2.4 MPa (b) 2.8 MPa (c) 3.2 MPa (d) 3.6 MPa

82. Ans: (d)

Sol : $\frac{d_i}{t} = \frac{600}{18} = 33.33 > 15$

The cylinder is considered to be thin.

Longitudinal strain, $\varepsilon_\ell = \frac{\sigma_\ell}{E} - \mu\frac{\sigma_h}{E}$

Transverse strain, $\varepsilon_h = \frac{\sigma_h}{E} - \mu\frac{\sigma_\ell}{E}$

$\sigma_h = 2\sigma_\ell$

$255 \times 10^{-6} = \frac{\sigma_\ell}{E}[2 - \mu]$-------(1)

$60 \times 10^{-6} = \frac{\sigma_\ell}{E}(1 - 2\mu)$------(2)

(1) – (2)

$(255 - 60)10^{-6} = \frac{\sigma_\ell}{E}(2 - \mu - 1 + 2\mu)$

$195 \times 10^{-6} = \frac{p.d}{4t} \times \frac{1}{2G}$

$P = \frac{195 \times 10^{-6} \times 4 \times 18 \times 2 \times 77 \times 10^3}{600}$

P = 3.6 MPa

83. A compressed air spherical tank having an inner diameter of 450 mm and a wall thickness of 7 mm is formed by welding. If the allowable shear stress is 40 MPa, the maximum permissible air pressure in the tank will be nearly

(a) 3 MPa (b) 5 MPa (c) 7 MPa (d) 9 MPa

83. Ans: (b)

Sol : $\tau_{max} = \max\left(\frac{\sigma_1 - \sigma_2}{2}, \frac{\sigma_1}{2}, \frac{\sigma_2}{2}\right)$

$\sigma_1 = \sigma_2 = \frac{P.d}{4t}$

$\therefore \tau_{max} = \frac{P.d}{8t}$

$40 = \frac{P \times 450}{8 \times 7}$

P = 4.978 MPa

P ≈ 5 MPa

84. A solid bar of circular cross-section having a diameter of 40 mm and length of 1.3 m is subjected to torque of 340 N.m. If the shear modulus of elasticity is 80 GPa, the angle of twist between the ends will be

(a) 1.26° (b) 1.32° (c) 1.38° (d) 1.44°

84. Ans: (a)

Sol: Angle of twist

$\theta = \frac{T.\ell}{G.J}$

$= \frac{340 \times 10^3 \times 1300}{80 \times 10^3 \times \frac{\pi}{32} \times 40^4}$

= 0.02198 rad

θ = 1.26°

85. Which one of the following statements regarding screw dislocation is correct?

(a) It lies parallel to its Burgers vector

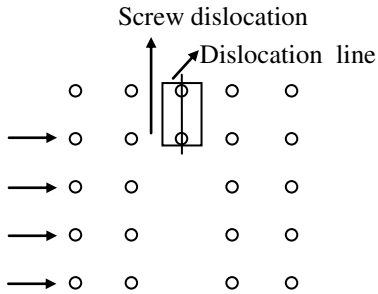
(b) It moves in the direction parallel to its Burgers vector

(c) It initially requires very less force to move

(d) It moves very fast as compared to edge dislocation

85. Ans: (a)

Sol:



Screw distortion:

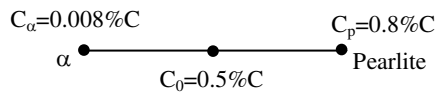
1. Screw dislocation moves perpendicular to the applied force (or) parallel to dislocation line.
2. It initially require more force
3. It lies parallel to the burgers vector and it moves in the perpendicular direction to its Burger's vector.

86. The percentage of pearlite in a slowly cooled melt of 0.5% of carbon steel is

(a) 48.5% (b) 52.5% (c) 58.5% (d) 62.5%

86. Ans: (d)

Sol:



Lever Rule (at Room temperature)

$$m_{pearlite} = \frac{C_o - C_\alpha}{C_p - C_\alpha} = \frac{0.5 - 0.008}{0.8 - 0.008} = 0.6212$$

Percentage of pearlite at 0.5% C is 62.12%

87. In the study of phase diagrams, the rule which helps to calculate the relative proportions of liquid and solid material present in the mixture at any given temperature is known as

(a) Hume-Rothery rule (b) Lever rule

(c) Gibbs phase rule (d) Empirical rule

87. Ans: (b)

Sol: *Lever rule:* This method is used to find mass fractions of solid and liquid in the mixture at a given temperature.

88. The phenomenon that artificially increases the dielectric constant of plastics containing fillers is known as

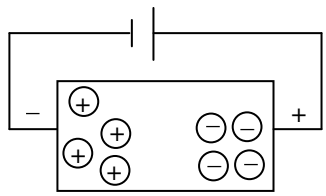
(a) Gamma polarization (b) Interfacial polarization

(c) Post-forming drawing (d) Reinforcement drawing

88. Ans: (b)

Sol: Interfacial polarization: It is a type of polarization mechanism that artificially increases the dielectric strength of plastics containing fillers.

Defects are moving towards opposite terminals of electrodes by applying electric field in plastic and due to that some charges is stored.



89. The addition of alloying element nickel to cast iron will primarily improve

(a) Wear resistance (b) Toughness (c) Carbide formation (d) Machinability

89. Ans: (b)

Sol: Nickel alloying element is added to cast iron to increase toughness without reducing hardness.

90. A unidirectional fibre-epoxy composite contains 65% by volume fibre and 35% epoxy resin. If the relative density of the fibre is 1.48 and of the resin is 1.2, the percentage weight of fibre will be nearly

(a) 70% (b) 75% (c) 80% (d) 85%

90. Ans: (a)

Sol: $\text{Density} = \dfrac{\text{mass}}{\text{volume}}$

Volume fraction of fibre (V_f) = 0.65

Volume fraction of epoxy (V_e) = 0.35

$$\frac{V_f}{V_e} = \frac{\frac{m_f}{\rho_f}}{\frac{m_e}{\rho_e}} \Rightarrow \frac{0.65}{0.35} = \frac{\frac{m_f}{1.48}}{\frac{m_e}{1.2}}$$

$$\frac{m_f}{m_e} = 2.29$$

$m_f + m_e = 100$

$$m_f + \frac{m_f}{2.29} = 100$$

$m_f = 69.6 \cong 70$

91. Which of the following are the advantages of Nano-composite materials?

1. Decreased thermal expansion coefficients.
2. Higher residual stress
3. Reduced gas permeability
4. Increased solvent resistance

(a) 1, 2 and 3 only (b) 1, 3 and 4 only (c) 1, 2 and 3 only (d) 2, 3 and 4 only

91. Ans: (b)

Sol: Advantages of nano composites

(1) High tensile & flexural strength for the same dimensions

(2) Increased dimensional stability

(3) Improved gas barrier properties

(4) Higher electrical conductivity

(5) Low residual stresses

92. A rod of copper originally 305 mm long is pulled in tension with a stress of 276 MPa. If the modulus of elasticity is 110 GPa and the deformation is entirely elastic, the resultant elongation will be nearly

(a) 1.0 mm (b) 0.8 mm (c) 0.6 mm (d) 0.4 mm

92. Ans: (b)

Sol: Axial deformation

$$\delta = \frac{P.\ell}{E.A} = \frac{276 \times 305}{110 \times 10^3}$$

$$= 0.7652 \text{ mm}$$

$$\delta \approx 0.8 \text{ mm}$$

93. A 1.25 cm diameter steel bar is subjected to a load of 2500 kg. The stress induced in the bar will be

(a) 200 MPa (b) 210 MPa (c) 220 MPa (d) 230 MPa

93. Ans: (a)

Sol: $\sigma = \frac{F}{A} = \frac{2500 \times 9.81}{\frac{\pi}{4} \times 12.5^2} = 199.84 \text{ MPa} = 200 \text{ MPa}$

94. The maximum energy which can be stored in a body up to the elastic limit is called

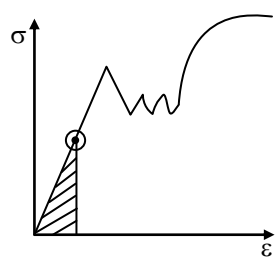
(a) Proof resilience (b) Modulus of resilience

(c) Impact toughness (d) Endurance strength

94. Ans: (a)

Sol: **Proof resilience** is the maximum energy that is stored in the body upto elastic limit.

Modulus of resilience is the maximum strain energy per unit volume that is stored in the body upto elastic limit.



95. A cast iron bed plate for a pump has a crack length of 100 μm. If the Young's modulus of cast iron is 210 GN/m^2 and the specific surface energy is 10 J/m^2, the fracture strength required will be nearly

(a) 1.0×10^8 N/m^2 (b) 1.2×10^8 N/m^2 (c) 1.4×10^8 N/m^2 (d) 1.6×10^8 N/m^2

95. Ans: (b)

Sol: Crack length (a) = 100×10^{-6} m ; Young's modulus (E) = 210×10^9 N/m^2

Specific surface energy (γ) = 10 J/m^2

$$\text{The fracture strength} = \left(\frac{2E\gamma_s}{\pi a}\right)^{\frac{1}{2}} = \left(\frac{2\times 210\times 10^9\times 10}{\pi\times 100\times 10^{-6}}\right)^{\frac{1}{2}}$$

$$= 1.156\times 10^8\ \text{N/m}^2 \approx 1.2\times 10^8\ \text{N/m}^2$$

96. A 13 mm diameter tensile specimen has 50 mm gauge length. If the load corresponding to the 0.2% offset is 6800 kg, the yield stress will be nearly

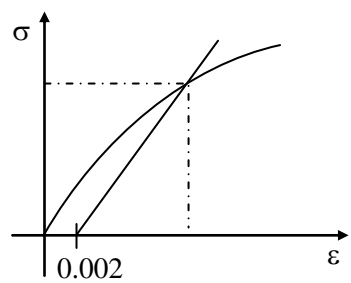
(a) 31 kg/mm^2 (b) 43 kg/mm^2 (c) 51 kg/mm^2 (d) 63 kg/mm^2

96. Ans: (c)

Sol: Yield stress $\sigma_{yt} = \frac{F}{A}$

$$= \frac{6800}{\frac{\pi}{4}\times 13^2}$$

= 51.23 kg/mm^2



97. The magnitude of the velocity of any point on the kinematic link relative to the other point on the same kinematic link is the product of

(a) A square root of an angular velocity of the link and the distance between the two points under consideration

(b) An angular velocity of the link and the square of distance between the two points under consideration

(c) A square of an angular velocity of the link and the distance between the two points under consideration

(d) An angular velocity of the link and the distance between the two points under consideration

97. Ans: (d)

Sol: Since $V = r\omega$

98. In a mechanism, the number of Instantaneous centres (I-centres) N is

(a) $\frac{n(n-1)}{2}$ (b) $\frac{n(2n-1)}{2}$ (c) $\frac{2n(n-1)}{3}$ (d) $\frac{n(2n-1)}{3}$

where: n = Number of links

98. Ans: (a)

Sol: Number of I-centers in mechanism = ${}^{n}C_{2}$

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

99. In cycloidal motion of cam follower, the maximum acceleration of follower motion f_{max} at $\theta = \frac{\varphi}{4}$ is

(a) $\frac{h\pi\omega^2}{2\varphi^2}$ (b) $\frac{3h\pi\omega^2}{2\varphi^2}$ (c) $\frac{2h\pi\omega^2}{\varphi^2}$ (d) $\frac{3h\pi\omega^2}{\varphi^2}$

where:

h = Maximum follower displacement

ω = Angular velocity of cam

φ = Angle for the maximum follower displacement for cam roation.

99. Ans: (c)

Sol : $a = \frac{2\pi h\omega^2}{\beta^2}\sin\left(\frac{2\pi\theta}{\phi_a}\right)$

$$a_{max} = \frac{2\pi hg\omega^2}{\beta^2}$$

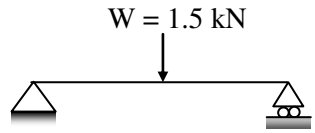
100. A shaft of span 1 m and diameter 25 mm is simply supported at the ends. It carries a 1.5 kN concentrated load at mid-span. If E is 200 GPa, its fundamental frequency will be nearly

(a) 3.5 Hz (b) 4.2 Hz

(c) 4.8 Hz (d) 5.5 Hz

100. Ans: (d)

Sol : Fundamental frequency, $f_n = \frac{1}{2\pi}\sqrt{\frac{48EI}{m\ell^3}}$



$$f_n = \frac{1}{2\pi}\sqrt{\frac{48\times 200\times 10^9 \times \frac{\pi}{64}\left(\frac{25}{1000}\right)^4}{\frac{1.5\times 10^3}{9.81}\times 1^3}}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{48\times 2\times \pi\times (29)^4\times 10^{11}\times 10}{64\times 10^{12}\times 1.5\times 10^3}} \quad (g = 10\ m/s^2)$$

$$= \frac{1}{2\pi}\sqrt{\frac{48\times 2\times \pi\times (25)^4}{64\times 1.5\times 10^3}} = \frac{1}{2\pi}\times\frac{4\times 25^2}{8\times 10}\sqrt{\frac{3\times 2\times \pi}{15}}$$

$$= \frac{1}{2\pi}\times\frac{625}{20}\sqrt{\frac{2\pi}{5}} = 5.57\ rad/s$$

101. A vibrating system consists of mass of 50 kg, a spring with a stiffness of 30 kN/m and a damper. If damping is 20% of the critical value, the natural frequency of damped vibrations will be

(a) 16 rad/s (b) 20 rad/s (c) 24 rad/s (d) 28 rad/s

101. Ans: (c)

Sol: m = 50 kg

K = 30 kN/m

$\zeta = 0.2$

Natural damped frequency, $\omega_d = \omega_n\sqrt{1-\zeta^2}$

$$= \sqrt{\frac{K}{m,}}\sqrt{1-\zeta^2}$$

$$= \sqrt{\frac{30\times 10^3}{50}}\times\sqrt{1-0.2^2}$$

$$= 24\ rad/s$$

102. A refrigerator unit having a mass of 35 kg is to be supported on three springs, each having spring stiffness s. The unit operates at 480 rpm. If only 10% of the shaking force is allowed to transmit to the supporting structure, the value of stiffness will be nearly

(a) 2.7 N/mm (b) 3.2 N/mm (c) 3.7 N/mm (d) 4.2 N/mm

102. Ans: (a)

Sol: m = 35 kg ; No. of springs = 3

Operating speed $\omega = 480$ rpm

$$\omega = \frac{2\pi \times 480}{60} \text{ rad/s}$$

$\varepsilon = 0.1$

S = ?

Since damping is absent

$$\varepsilon = \pm\frac{1}{1-r^2}$$

$$\Rightarrow 1-r^2 = \pm\frac{1}{\varepsilon}$$

$$\Rightarrow 1-r^2 = \pm 10$$

Either $1 - r^2 = +10$ Or, $1 - r^2 = -10$

$r^2 = -9$ Or, $r^2 = 11 \Rightarrow r = \sqrt{11}$

$$\frac{\omega}{\omega_n} = \sqrt{11}$$

$$\omega_n = \frac{2\pi \times 480}{60 \times \sqrt{11}} = 15.15 \text{ rad/s}$$

$$\sqrt{\frac{K}{m}} = 15.15 \Rightarrow K = 8033.28 \text{ N/m}$$

Stiffness of each spring = $\frac{K}{3} = 2677.76$ N/m $= 2.677$ N/mm

103. In which one of the following tooth profiles, does the pressure angle remain constant throughout the engagement of teeth?

(a) Cycloidal (b) Involute (c) Conjugate (d) Epicylcoid

103. Ans: (b)

Sol: In case of involute profile the pressure angle remains constant throughout the engagement.

104. If the axes of the first and last wheels of a compound gear coincide, it is called

(a) Simple gear train (b) Compound gear train

(c) Epicyclic gear train (d) Reverted gear train

104. Ans: (d)

Sol: Reverted gear train.

105. In a reciprocating engine, the force along the connecting rod F_Q is

(a) $\frac{F_P}{\sqrt{n^2-\sin^2\theta}}$ (b) $\frac{F_P}{2\sqrt{n^2-\sin^2\theta}}$ (c) $\frac{nF_P}{2\sqrt{n^2-\sin^2\theta}}$ (d) $\frac{nF_P}{\sqrt{n^2-\sin^2\theta}}$

where:

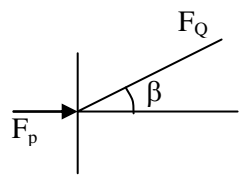
F_P = Force on piston

$n = \frac{L}{r}$

θ = Angle for crank from IDC

105. Ans: (d)

Sol: $F_Q \cos\beta = F_P$



$$F_Q = \frac{F_P}{\cos\beta}$$

$$= \frac{n.F_P}{\sqrt{n^2-\sin^2\theta}}$$

$$\therefore \sin\beta = \frac{\sin\theta}{n}$$

$$\cos\beta = \sqrt{1-\frac{\sin^2\theta}{n^2}}$$

$$= \frac{1}{n}\sqrt{n^2-\sin^2\theta}$$

106. A mass m_1 attached to a shaft at radius r_1, rotating with angular velocity ω rad/s, can be balanced by another single mass m_2 which is attached to the opposite side of the shaft at radius r_2, in the same plane, if

(a) $m_1r_2 = m_2r_1$ (b) $m_1r_1 = m_2r_2$ (c) $m_1r_1\omega_1 = m_2r_2\omega_2$ (d) $m_1r_2\omega_1 = m_2r_1\omega_2$

106. Ans: (b)

Sol: $m_1r_1 = m_2r_2$

107. For a single cylinder reciprocating engine speed is 500 rpm, stroke is 150 mm, mass of reciprocating parts is 21 kg; mass of revolving parts is 15 kg at crank radius. If two-thirds of reciprocating masses and all the revolving masses are balanced, the mass at a radius of 150 mm will be

(a) 7.5 kg (b) 10.5 kg (c) 12.5 kg (d) 14.5 kg

107. Ans: (d)

Sol: speed $(\omega) = \dfrac{2\pi \times 500}{60}$

Stroke = 150 mm

$\Rightarrow$ Crank radius = $\dfrac{\text{stroke}}{2}$ = 75 mm

m_{recip} = 21 kg ; m_{revol} = 15 kg

$c = \dfrac{2}{3}$; b = 150 mm

$B.b = cm_{recip}.r + m_{revol}.r$

$$B \times \frac{150}{1000} = \left[\frac{2}{3} \times 21 \times \frac{75}{1000}\right] + \left[15 \times \frac{75}{1000}\right]$$

B = 14.5 kg

108. If the axes of the rolling of the ship and of the stabilizing rotor are parallel, it will result in

(a) A higher bow and lower stern (b) A lower bow and higher stern

(c) Turning towards left (d) No gyroscopic effect

108. Ans: (d)

Sol: In case of rolling there will be no gyroscopic effect.

109. Coaxing is a process of

(a) Improving the fatigue properties, attained by under-stressing and then raising the stress in small increments.

(b) Decreasing the hardness by full annealing

(c) Increasing the uniaxial tensile strength by heating above recrystallization temperature and quenching in oil media

(d) Maintaining the ductility of the material by chemical treatment

109. Ans: (a)

110. According to the distortion-energy theory, the yield strength in shear is

(a) 0.277 times the yield stress (b) 0.377 times the maximum shear stress

(c) 0.477 times the yield strength in tension (d) 0.577 times the yield strength in tension

110. Ans: (d)

Sol: According to distortion energy theory,

$S_{Sy} = 0.577 \times S_{yt}$

$S_{sy} \Rightarrow$ yield strength in shear

$S_{yt} \Rightarrow$ yield strength in shear

111. For the prediction of ductile yielding, the theory of failure utilized is

(a) Maximum strain energy theory (b) Distortion energy theory

(c) Maximum normal strain theory (d) Mohr theory

111. Ans: (b)

Sol: For ductile materials, following theories of failure are preferred,

1. Maximum shear stress theory
2. Distortion energy theory

112. A steel specimen is subjected to the following principal stresses: 120 MPa tensile, 60 MPa tensile and 30 MPa compressive. If the proportionality limit for the steel specimen is 250 MPa; the factor of safety as per maximum shear stress theory will be nearly

(a) 1.3 (b) 1.7 (c) 2.3 (d) 2.7

112. Ans: (b)

Sol: $\sigma_1 = +120$ MPa, $\sigma_2 = +60$ MPa, $\sigma_3 = -30$ MPa

$$\tau_{12} = \left|\frac{\sigma_1 - \sigma_2}{2}\right| = 30\,\text{MPa} = \left|\frac{120 - 60}{2}\right|$$

$$\tau_{13} = \left|\frac{\sigma_1 - \sigma_3}{2}\right| = \left|\frac{120 - (-30)}{2}\right| = 75$$

$$\tau_{23} = \left|\frac{\sigma_2 - \sigma_3}{2}\right| = \left|\frac{\sigma_0 - (-30)}{2}\right| = 45$$

Maximum shear stress theroy,

$\tau_{max} = \max\times\{\tau_{12}, \tau_{13}, \tau_{23}\} = 75$

$$\tau_{max} = \frac{S_{yt}}{2 \times FOS}$$

$$\therefore\ 75 = \frac{250}{2 \times FOS}$$

$\sigma_{proprotion}$ limit $\approx \sigma$yield point

$$\therefore\ FOS = \frac{250}{2 \times 75} = \frac{250}{150} = \frac{5}{3} = 1.67$$

113. For which one of the following loading conditions is the standard endurance strength multiplied by a load factor, $K_e = 0.9$?

(a) Reversed beam bending loads

(b) Reversed axial loads with no bending

(c) Reversed axial loads with intermediate bending

(d) Reversed torsion loads

113. Ans: (b)

114. A 120 mm wide uniform plate is to be subjected to a tensile load that has a maximum value of 250 kN and a minimum value of 100 kN. The properties of the plate material are: endurance limit stress is 225 MPa, yield point stress is 300 MPa. If the factor of safety based on yield point is 1.5, the thickness of the plate will be nearly

(a) 12 mm (b) 14 mm (c) 16 mm (d) 18 mm

114. Ans: (a)

Sol: $P_{max} = 250\times10^3\ N, P_{min} = 110\times10^3\ N$

$\therefore$ Pm = 175×10^3 N, Pa = 75×10^3 N

$$\sigma_m = \frac{P_m}{b\times t} = \frac{175\times10^3}{120\times t};\ \sigma_a = \frac{75\times10^3}{120\times t}$$

As yield strength only is given,

Using Soderberg theory, $\frac{\sigma_m}{S_{yt}} + \frac{\sigma_a}{S_e} = \frac{1}{FOS}$

$$\frac{10^3}{120\times t}\times\left[\frac{175}{300}+\frac{75}{225}\right] = \frac{1}{1.5}$$

$$\therefore\ t = \frac{1.5\times10^3}{120}\times\left[\frac{175}{300}+\frac{75}{225}\right]$$

$$\therefore\ t = \frac{3}{2}\times\frac{100}{12}\times\left[\frac{7}{12}+\frac{1}{3}\right]$$

$$t = \frac{50}{4}\times\frac{11}{12}$$

$$t = 12.5\times\frac{11}{12} < 12.5\,mm \Rightarrow \quad \therefore\ t = 12\ mm$$

115. A steel connecting rod having S_{ut} = 1000 MN/m^2, S_{yt} = 900 MN/m^2 is subjected to a completely reversed axial load of 50 kN. By neglecting any column action, if the values of k_e = 0.85, k_b = 0.9, k_a = 0.82, k_t = 1.5, q = 0.6 and N = 2, the diameter of the rod will be nearly

(a) 20 mm (b) 23 mm (c) 26 mm (d) 29 mm

115. Ans: (b)

Sol: Reversed axial loading $\Rightarrow P_{max}$ = +50 kN

P_{min} = –50 kN

$\therefore\ P_m = 0;\ P_a = 50$ kN

$$\therefore\ \sigma_m = 0;\ \sigma_a = \frac{P_a}{\frac{\pi}{4}\times d^2} = \frac{4\times50\times10^3}{\pi\times d^2}$$

As, loading is reversed, all theories will give same results.

$$\sigma_a = \frac{S_e}{FOS} = \frac{0.5 \times S_{ut} \times k_a \times k_b \times k_a}{(1 + (k_t - 1) \times a) \times N}$$

$$\therefore \frac{4 \times 50 \times 10^3}{\pi \times d^2} = \frac{0.5 \times 1000 \times 0.85 \times 0.9 \times 0.82}{(1 + 0.6 \times 0.5) \times 2}$$

$\therefore$ d = 22.97 mm

$\Rightarrow$ d = 23 mm

116. During crushing or bearing failure of riveted joints

(a) The holes in the plates become oval shaped and joints become loose

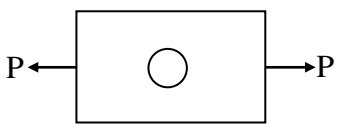
(b) There is tearing of the plate at an edge

(c) The plates will crack in radial directions and joints fail

(d) The rivet heads will shear out by applied stress

116. Ans: (a)

Sol:



Bearing failure

117. The double riveted joint with two cover plates for boiler shell is 1.5 m in diameter subjected to steam pressure of 1 MPa. If the joint efficiency is 75%, allowable tensile stress in the plate is 83 MN/m^2, compressive stress is 138 MN/m^2 and shear stress in the rivet is 55 MN/m^2, the diameter or rivet hole will be nearly

(a) 8 mm (b) 22 mm (c) 36 mm (d) 52 mm

117. Ans: (b)

118. A bearing supports a radial load of 7000 N and a thrust load of 2100 N. The desired life of the ball bearing is 160×10^6 revolutions at 300 rpm. If the load is uniform and steady, service factor is 1, radial factor is 0.65, thrust factor is 3.5, k = 3 and rotational factor is 1, the basic dynamic load rating of a bearing will be nearly

(a) 65 kN (b) 75 kN (c) 85 kN (d) 95 kN

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CE	5	44
ME	6	60
EE	7	71
EC	9	74
CS	5	28
IN	10	74
PI	10	49

118. Ans: (a)

Sol: $F_R = 7000$ N, $F_a = 2100$ N

$L = 160 \times 10^6$ revolutions, $N = 300$ rpm

Service factor, $C_s = 1$, $X = 0.65$, $Y = 3.5$

$V = 1$

Equivalent load $P = Cs \times \{X \times V \times F_R + Y \times F_a\}$

$\therefore$ Load – Life relation

$$L = \left\{\frac{C}{P}\right\}^3 \times 10^6 \text{ revolutions}$$

$$\therefore\ 160 \times 10^6 = \left[\frac{C}{CS \times \left[X.V.F_R + Y + F_a\right]}\right]^3 \times 10^3$$

$$\therefore\ C = \sqrt[3]{160} \times P$$

$$P = 1 \times \{0.65 \times 1 \times 7000 + 3.5 \times 2100\} = \{65 \times 70 + 35 \times 210\}$$

$\therefore$ P = 4550+7350 = 11900

$\Rightarrow$ 53 = 125 and 63 = 216

$$\therefore 5 < \sqrt[3]{160} < 6$$

C<75 kN

$\therefore$ C < 75 kN

119. A solid cast iron disk, 1 m in diameter and 0.2 m thick, is used as a flywheel. It is rotating at 350 rpm. It is brought to rest in 1.5 s by means of a brake. If the mass density of cast iron is 7200 kg/m^3, the torque exerted by the brake will be nearly

(a) 3.5 kN m (b) 4.35 kN m (c) 5.3 kN m (d) 6.3 kN m

119. Ans: (a)

Sol: Energy absorbed by brake = energy lost by flywheel

= work done by braking torque

$$\therefore\ \Delta E = \frac{1}{2} \times I \times \left\{w_o^2 - \omega_f^2\right\} = T \times \theta$$

$$\frac{1}{2} \times \frac{MR^2}{2} \times \left[w_0^2 - w_f^2\right] = T \times \frac{t}{2} \times \left(w_f + w_o\right)$$

$w_f = 0$

$$\therefore \frac{mR^2}{2} \times \frac{w_o}{t} = T$$

$$\therefore T = \frac{\rho \times \frac{\pi}{4} \times D^2 \times L \times \frac{2\pi N}{60}}{2t}$$

$$\therefore T = \frac{7200 \times \pi \times 1^2 \times 0.5^2 \times 0.2 \times 2\pi \times 350}{4 \times 2 \times 1.5 \times 60}$$

$$T = \frac{7200 \times 0.5 \times 0.5}{4 \times 2 \times 1.5} \times \frac{0.2 \times 2 \times \pi^2 \times 350}{60}$$

$$T = 6 \times 5 \times 5 \times \frac{2 \times 2 \times \pi^2 \times 35}{60}$$

$T = 10 \times 35 \times \pi^2 = 350 \times \pi^2 < 3500$

$\therefore$ Ans (a)

$T = 3.5$ kN-m

120. The torque transmitting capacity of friction clutches can be increased by

(a) Use of friction material with a lower coefficient of friction

(b) Decreasing the mean radius of the friction disk

(c) Increasing the mean radius of the friction disk

(d) Decreasing the plate pressure

120. Ans: (c)

Sol: According to uniform wear theory

$$T = \mu \times P_N \times R_{mean} = \pi \times \mu \times p \times R \times \frac{R_2^2 - R_1^2}{2}$$

$\therefore T \propto \mu$

$T \propto R_{mean}$

$T \propto P$

121. The time taken to face a workpiece of 80 mm diameter for the spindle speed of 90 rpm and cross feed of 0.3 mm/rev will be

(a) 4.12 min (b) 3.24 min (c) 2.36 min (d) 1.48 min

121. Ans: (d)

Sol: Given, facing operation

Work piece diameter = 80 mm ; i.e., length of tool travel (L) = $\frac{80}{2} = 40\,\text{mm}$

spindle speed (n) = 90 rpm ; cross feed (f) = 0.3 mm/rev

Time per cut (T_m) = $\frac{L}{f \times N} = \frac{40}{0.3 \times 90} = \frac{40}{27} = 1.48\,\text{min}$

122. A feed for the lathe operation is

(a) $\frac{N}{L \times T_m}\,\text{mm/rev}$ (b) $\frac{L}{N \times T_m}\,\text{mm/rev}$ (c) $\frac{T_m}{N \times L}\,\text{mm/rev}$ (d) $\frac{T_m \times L}{N}\,\text{mm/rev}$

Where: T_m = Machining time in min, N = Speed in rpm, L = Length of cut in mm

122. Ans: (b)

Sol: **Face turning operation** is used for reducing the length of work piece. In this the feed is given in a direction perpendicular to the axis of revolution.

Time per cut (T_m) = $\frac{\text{length of tool travel (mm)}}{\text{feed (mm/rev)} \times \text{velocity (rpm)}} = \frac{L}{f \times N}\,\text{min}$

$\therefore \quad f = \frac{L}{N \times T_m}\,\text{mm/rev}$

123. The main advantages of the radial drilling machine is that

(a) It is very compatible and handy for machining

(b) It is accurate, economical, portable and least time consuming while machining

(c) Heavy workpieces can be machined in any position without moving them

(d) Small workpieces can be machined and it can be used for mass production as well

123. Ans: (c)

Sol: The main advantage of the radial drilling machine is that the drilling can be carried out on heavy workpieces in any position without moving them. This type of drilling machine is used in tool rooms and in large scale die manufacturing units.

124. For the purpose of sampling inspection, the maximum percent defective that can be considered satisfactory as a process average is

(a) Rejectable Quality Level (RQL) (b) Acceptable Quality Level (AQL)

(c) Average Outgoing Quality Limit (AOQL) (d) Lot Tolerance Percent Defective (LTPD)

124. Ans: (b)

Sol: AQL: AQL is the maximum percent defective that is considered satisfactory as a process average by the producer and consumer.

LTPD: The LPTD has the lowest probability of acceptance.

RQL : RQL is the minimum defect rate that not acceptable to ship.

AOQL: The AOQL is the maximum (or) worst possible defective for the average outgoing quality.

125. Hard automation is also called

(a) Selective automation (b) Total automation

(c) Group technology (d) Fixed position automation

125. Ans: (d)

Sol: In hard automation, also called *fixed-position automation*, the production machines are designed to produce a standardized product, such as an engine block, a valve, a gear, or a spindle.

126. The method of CNC programming which enables the programmer to describe part geometry using variables is

(a) Computer assisted part programming (b) Computer aided drafting programming

(c) Conversational programming (d) Parametric programming

126. Ans: (d)

Sol: Parametric programming software systems enable the programmer to describe part geometry using variables. Once described, entering specific values of the variables that uniquely indentify the part generates an actual tool path CNC program.

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127. Revolving joint of the robot is referred to as

(a) L joint (b) O joint (c) T joint (d) V joint

127. Ans: (d)

Sol: Revolving joint of the robot is referred as V-joint.

128. Repairing of a machine consists of 5 steps that must be performed sequentially. Time taken to perform each of the 5 steps is found to have an exponential distribution with a mean of 5 minute and is independent of other steps. If these machines break down in Poisson fashion at an average rate of 2/hour and if there is only one repairman, the average idle time for each machine that has broken down will be.

(a) 120 minutes (b) 110 minutes (c) 100 minutes (d) 90 minutes

128. Ans: (c)

Sol: This is a queuing system of Poisson arrivals and Erlang service times (negative exponential) with k phases and a single server.

No. of phases of service = k = 5 ; m/c break down rate (λ) = 2/hr

Service time = 25 min ($5 \times 5 = 25$ min) ; Mean service rate (μ) = $\frac{1}{25} \times 60 = 2.4$/hr

Average idle time of breakdown m/c (W_s) = ?

Waiting time in the system = Idle time of the machine

$$W_s = \frac{k+1}{2k} \times \frac{\lambda}{\mu} \times \frac{1}{\mu - \lambda} + \frac{1}{\mu}$$

$$= \frac{5+1}{2\times 5} \times \frac{2}{2.4} \times \frac{1}{2.4-2} + \frac{1}{2.4} = 5/3 \text{ hours} \cong 100 \text{ min}$$

129. A portion of the total float within which an activity can be delayed for start without affecting the floats of preceding activities is called

(a) Safety float (b) Free float (c) Independent float (d) Interfering float

129. Ans: (c)

Sol: Total float …….. without affecting the project duration

Free float ..... without affecting the occurrence of next activity

Independent float ..... without affecting the occurrence of preceding activity

130. An oil engine manufacturer purchases lubricant cans at the rate of ₹. 42 per piece from a vendor. The requirement of these lubricant cans is 1800 per year. If the cost per placement of an order is ₹. 16 and inventory carrying charges per rupee per year is 20 paise, the order quantity per order will be

(a) 91 cans (b) 83 cans (c) 75 cans (d) 67 cans

130. Ans: (b)

Sol: annual requirement = 1800 cans

Ordering cost = Rs. 16/ order

Carrying cost = Rs. 0.2/ruppe/year

EOQ = ?

$$EOQ = \sqrt{\frac{2DC_0}{C_C}} = \sqrt{\frac{2\times1800\times16}{0.2\times42}} \cong 83 \text{ cans}$$

131. Consider the following data regarding the acceptance sampling process:

N = 10,000, n = 89, c = 2, P = 0.01 and $P_a = 0.9397$

The average Total Inspection (ATI) will be

(a) 795 (b) 687 (c) 595 (d) 487

131. Ans: (b)

Sol: N = 10000; n = 89; c = 2 ; P = 0.01 ; $P_a = 0.9397$

$ATI = n + (1 - P_a)(N - n)$

$= 89 + (1 - 0.9397)[10000 - 89]$

$= 89 + 0.0603 \times 9911 \cong 687$

132. The Non-Destructive Inspection (NDI) technique employed during inspection for castings of tubes and pipes to check the overall strength of a casting in resistance to bursting under hydraulic pressure is

(a) Radiographic inspection (b) Magnetic particle inspection

(c) Fluorescent penetrant (d) Pressure testing

132. Ans: (d)

Sol: Pressure testing: It is employed to locate leaks in a casting or to check the overall strength of a casting in resistance to bursting under hydraulic pressure. It is carried out on tubes and pipes. So, option (d) is correct.

Radiographic inspection is used to test subsurface defects. Magnetic particle inspection and fluorescent penetration is used for fine surface defects. Hence, options (a), (b) and (c) are incorrect.

133. Consider the situation where a microprocessor gives an output of an 8-bit word. This is fed through an 8-bit digital-to-analogue converter to a control valve. The control valve requires 6.0 V being fully open. If the fully open state is indicated by 11111111, the output to the valve for a change of 1-bit will be

(a) 0.061 V (b) 0.042 V (c) 0.023 V (d) 0.014 V

133. Ans: (c)

Sol: for change of 1 bit = Resolution

$$\Rightarrow \frac{6V}{2^8} = \frac{6V}{256} = 0.023V$$

134. Which of the following factors are to be considered while selecting a microcontroller?

1. Memory requirements
2. Processing speed required
3. Number of input/output pins

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

134. Ans: (d)

Sol: Selection of micro controller based on

i. No. of Input/output pins ;

ii. Memory requirements

iii. Processing speed required and some other factors.

135. Which of the following statements regarding interface circuit are correct?

1. Electrical buffering is needed when the peripheral operates at a different voltage or current to that on the microprocessor bus system or there are different ground references.
2. Timing control is needed when the data transfer rates of the peripheral and the microprocessor are different.
3. Changing the number of lines is needed when the codes used by the peripherals differ from those used by the microprocessor.

(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1,2 and 3

135. Ans: (a)

Sol: Statements 1, 2 regarding interface circuits are correct, 3 is incorrect.

136. Alternative paths provided by vertical paths from the main rung of a ladder diagram, that is, paths in parallel, represent

(a) Logical AND operations (b) Logical OR operations

(c) Logical NOT operations (d) Logical NOR operations

136. Ans: (b)

Sol: Logical OR operation has parallel paths.

137. The resolution of a encoder with 10 tracks will be nearly

(a) 0.15 (b) 0.25° (c) 0.35° (d) 0.45°

137. Ans: (c)

Sol: Resolution $= \frac{360}{2^n} = \frac{360}{2^{10}} = \frac{360}{1024} = 0.35°$

138. Which of the following features is/are relevant to variable reluctance stepper motors?

1. Smaller rotor mass; more responsive
2. Step size is small
3. More sluggish

(a) 1 only (b) 2 only (c) 3 only (d) 1, 2 and 3

138. Ans: (a)

139. Which of the following statements regarding hydraulic pumps are correct?

1. The gear pump consists of two close - meshing gear wheels which rotate in opposite directions.
2. In vane pump, as the rotor rotates, the vanes follow the contours of the casing.
3. The leakage is more in vane pump compared to gear pump.

(a) 1, 2 and 3 (b) 1 and 2 only (c) 1 and 3 only (d) 2 and 3 only

139. Ans: (b)

Sol: Vane pump leakage is less than gear pump. Hence, Statements 1, 2 are correct and statement 3 is wrong.

140. The selection of the right controller for the application depends on

1. The degree of control required by the application.
2. The individual characteristics of the plants.
3. The desirable performance level including required response, steady-state deviation and stability.

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

140. Ans: (d)

Sol: The selection of right controller for the application depends on three factors such as

- The degree of control required by the application.
- The individual characteristics of the plants.
- The desirable performance level including required response, steady-state deviation and stability.

141. Consider a system described by

$\dot{x} = Ax + Bu$

$y = Cx + Du$

The system is completely output controllable if and only if

(a) The matrix

$$\left[CB \vdots CBA \vdots CB^2A \vdots \cdots \vdots CB^{n-1}A \vdots D\right]$$

is of rank n

(b) The matrix

$$\left[CB \vdots CAB \vdots CA^2B \vdots \cdots \vdots CA^{n-1}B \vdots D\right]$$

is of rank m

(c) The matrix

$$\left[BC \vdots BAC \vdots BA^2C \vdots \cdots \vdots BA^{n-1}C \vdots D\right]$$

is of rank m

(d) The matrix

$$\left[BC \vdots ABC \vdots CA^2B \vdots \cdots \vdots CB^{n-1}A \vdots D\right]$$

is of rank n

Where: x = State vector (n-vector) ; u = Control vector (r-vector)

y = Output vector (m-vector) ; A = n × n matrix

B = n × r matrix ; C = m × n matrix

D = m × r matrix

141. Ans: (b)

Sol: Matrix $Q_C = [B \quad AB \quad A^2B \quad \ldots\ldots\ldots\ldots \quad A^{n-1}B]$

142. Which one of the following symbols is used as the notation for designating arm and body of a robot with jointed arm configuration?

(a) TRL (b) TLL, LTL, LVL (c) LLL (d) TRR, VVR

142. Ans: (d)

Sol: Jointed arm configuration has all revolute joints, as TRR, VVR can be used.

143. A compliant motion control of robots can be understood by the problem of controlling of

(a) Position and velocity of joints

(b) Position and acceleration of the end-effector

(c) Manipulator motion and its force interactions with the environment

(d) Joint velocities of given end-effector velocity

143. Ans: (c)

Sol: Compliant motion control of robot is by controlling of manipulator motion in contact with its environment by force interaction.

144. For the vector v = 25 i+10 j+20 k, perform a translation by a distance of 8 in the x-direction, 5 in the y-direction and 0 in the z-direction. The translated vector Hv will be

(a) $\begin{bmatrix} 1 \\ 20 \\ 33 \\ 15 \end{bmatrix}$ (b) $\begin{bmatrix} 33 \\ 15 \\ 20 \\ 1 \end{bmatrix}$ (c) $\begin{bmatrix} 15 \\ 33 \\ 1 \\ 20 \end{bmatrix}$ (d) $\begin{bmatrix} 1 \\ 15 \\ 20 \\ 33 \end{bmatrix}$

144. Ans: (b)

Sol: Translation x $\rightarrow$ 8 + 25 = 33

y $\rightarrow$ 5 + 10 = 15

z $\rightarrow$ 0 + 20 = 20

Directions: Each of the next six (06) items consists of two statements, one labelled as 'Statement (I)' and the other labelled as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

(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) false.

(d) Statement (I) is false, but Statement (II) is true.

145. **Statement (I):** The greater the chemical affinity of two metals, the more restricted is their solid solubility and greater is the tendency of formation of compound.

Statement (II): Wider the separation of elements in the periodic table, greater is their chemical affinity.

145. Ans: (a)

Sol: The greater the chemical affinity of two metals, the more restricted is their solid solubility and the greater is the tendency toward compound formation. Generally, the farther apart the elements are in the periodic table, the greater is their chemical affinity.

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146. **Statement (I):** The size of a memory unit is specified in terms of the number of storage locations available; 1 K is 2^{10} = 1024 locations and thus a 4 K memory has 4096 locations.

Statement (II): Erasable and programmable ROM (EPROM) is a form of memory unit used for ROMs that can be programmed and their contents altered.

146. Ans: (b)

Sol: The size of a memory unit is specified in terms of the number of storage locations available; 1K is 210 5 1024 locations and thus a 4K memory has 4096 locations. There are a number of forms of memory unit.

EPROM: The term erasable and programmable ROM (EPROM) is used for ROMs that can be programmed and their contents altered. A typical EPROM chip contains a series of small electronic circuits, cells, which can store charge. Both statements are individually CORRECT. So option (B) is correct.

147. **Statement (I):** Microprocessors which have memory and various input/output arrangements, all on the same chip, are called microcontrollers.

Statement (II): The microcontroller is the integration of a microprocessor with RAM , ROM , EPROM, EEPROM and I/O interfaces, and other peripherals such as timers, on single chip.

147. Ans: (a)

Sol: Statement I, II are correct and statement II is explaining/elaborating about micro controller.

148. **Statement (I):** Capacitive proximity sensor can only be used for the detection of metal objects and is best with ferrous metals.

Statement (II): One form of capacitive proximity sensor consists of a single capacitor plate probe with the other plate being formed by the object, which has to be metallic and earthed.

148. Ans: (d)

Sol: Statement I is wrong as capacitive, proximity sensor can defect any material.

149. **Statement (I):** SCARA configuration provides substantial rigidity for the robot in the vertical direction, but compliance in the horizontal plane.

Statement (II): A special version of the Cartesian coordinate robot is the SCARA, which has a very high lift capacity as it is designed for high rigidity.

149. Ans: (c)

Sol: Statement I is correct and Statement II is wrong.

SCARA is combination of cylindrical and articulated type.

150. **Statement (I):** The stepper motor is a device that produces rotation through equal angles, the so-called steps, for each digital pulse supplied to its input.

Statement (II): Stepper motors can be used to give controlled rotational steps but cannot give continuous rotation, as a result their applications are limited to step angles only.

150. Ans: (c)

Sol: The stepper motor is a device that produces rotation through equal angles, the so-called steps, for each digital pulse supplied to its input. Thus, for example, if with such a motor 1 pulse produces a rotation of 6° then 60 pulses will produce a rotation through 360°. So statement (I) is correct.

Stepper motors can be used to give controlled rotational steps *but also can give continuous rotation* with their rotational speed controlled by controlling the rate at which pulses are applied to it to cause stepping. This gives a very useful controlled variable speed motor which finds many applications. So statement (II) is incorrect. Hence option(c) is correct.

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