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ESE-2022

(PRELIMINARY EXAMINATION)

QUESTIONS WITH DETAILED SOLUTIONS

MECHANICAL ENGINEERING

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ESE - 2022

MECHANICAL ENGINEERING

Questions with Detailed Solutions

SET - D
20/02/22

SUBJECTWISE WEIGHTAGE

S. No.	NAME OF THE SUBJECT	Number of Questions
01	Fluid Mechanics & Turbo-machinery	23
02	Heat Transfer	11
03	Machine Design	11
04	Strength of Material	9
05	Renewable Sources of Energy	12
06	Basic Thermodynamics	5
07	Refrigeration & Air Conditioning	11
08	IC Engines	3
09	Power plant	11
10	Engineering Mechanics	4
11	Production Engineering	7
12	Material Science	13
13	Theory of Machines	13
14	IM & OR	3
15	Mechatronics and Robotics	13
16	Maintenance Engineering	1
Total No. of Questions		150



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TIMING

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- No. of Questions: 50
(25Q: 1 Mark, 25Q: 2 Marks)
- Duration: 90 Mins.
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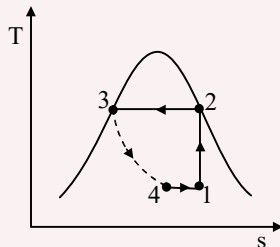
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01. A hydrocarbon refrigerator operating on equal proportions of propane and isobutane by mass works on simple saturation cycle. The condenser and evaporator pressure are 14 bar and 1.4 bar. What is the approximate theoretical COP of the system ? (Take properties : $h_1 = 545 \text{ kJ/kg}$; $h_3 = 341.15 \text{ kJ/kg} = h_4$; $S_1 = 2.47 \text{ kJ/kgK} = S_2$; $h_2 = 661 \text{ kJ/kg}$ and $T_2 = 63^\circ\text{C}$)

- (a) 1.8 (b) 5.4
(c) 3.6 (d) 2.7

01. Ans: (a)

Sol:



$$h_1 = 545 \text{ kJ/kg}$$

$$h_2 = 661 \text{ kJ/kg}$$

$$h_3 = h_4 = 341.15 \text{ kJ/kg}$$

$$\text{COP} = \frac{\text{Net refrigerating effect}}{\text{Compressor work}} = \frac{\text{NRE}}{W_c}$$

$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{545 - 341.15}{661 - 545} = 1.757$$

$$\therefore \text{COP} \cong 1.8$$

02. The use of a single refrigerant in a simple vapor compression cycle for the production of low temperatures is limited by which of the following reasons?

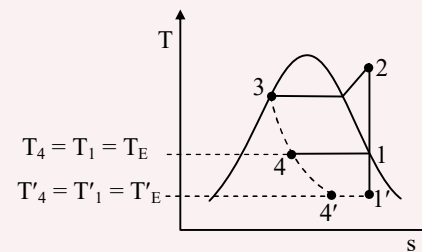
1. Solidification temperature of the refrigerant.
2. Extremely low pressures in the evaporator and large suction volumes if a high-boiling refrigerant is selected.
3. Very high-pressure ratio, therefore a low coefficient of performance.

Select the correct answer using the code given below:

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

02. Ans: (d)

Sol:



For production of low temperatures, evaporator temperature needs to be very low and hence pressure ratio increases, work of compressor increases, work of compressor increases and refrigerating effect decreases and COP also decreases.

1. If this evaporator temperature falls below freezing temperature of refrigerant then it is of no use.
2. At very low pressure specific volume will be very high and hence suction volume is also high.

3. Here as pressure ratio is increasing, performance will be decreasing.

∴ All three statements are correct.

03. A capillary tube in a one-ton R22 air conditioner has a bore of 2.3 mm. Saturated liquid from the condenser enters at a temperature of 48°C and flows adiabatically through the tube until its temperature is 5°C. The friction factor is given as $f = 0.32/Re^{0.25}$. What is the length of the capillary tube? (Take intermediate sections at 40°C, 30°C, 20°C and 10°C and the mass flow rate of the refrigerant as 0.02417 kg/s)

- (a) $13.41 \text{ kg}\cdot\text{s}^{-1}\cdot\text{m}^{-1}$ (b) $16.42 \text{ kg}\cdot\text{s}^{-1}\cdot\text{m}^{-1}$
 (c) $19.42 \text{ kg}\cdot\text{s}^{-1}\cdot\text{m}^{-1}$ (d) $22.46 \text{ kg}\cdot\text{s}^{-1}\cdot\text{m}^{-1}$

03. Ans: (a)

Sol: $\dot{m} = 0.02417 \text{ kg/s}$

$$A = \frac{\pi}{4} d^2$$

$$= \frac{\pi}{4} (0.0023)^2 = 4.15 \times 10^{-6} \text{ m}^2$$

$$G = \frac{\dot{m}}{A} = \frac{0.02417}{4.15 \times 10^{-6}} = 5.83 \times 10^3 \text{ kg/s m}^2$$

$$\dot{m} = \rho AU$$

$$\frac{\dot{m}}{A} = \rho U$$

$$(dP)_f = \frac{\rho f \Delta L U^2}{2D} = \frac{\rho U f (\Delta L) U}{2D}$$

$$= \frac{G f (\Delta L) U}{2D} \quad \left[\text{Let } y = \frac{G}{2D} \right]$$

$$= y f (\Delta L) U$$

$$Re = \frac{\rho U D}{\mu} = \frac{G D}{\mu} = \frac{z}{\mu}$$

$$Z = G D$$

$$= \frac{\dot{m}}{A} (D)$$

$$= 5.83 \times 10^3 (0.0023)$$

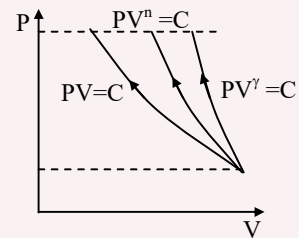
$$= 13.409 \text{ kg s}^{-1} \text{ m}^{-1}$$

04. The work required for compressing one kg of air is minimum if the compression is carried out

- (a) adiabatically (b) isothermally
 (c) isentropically (d) isochorically

04. Ans: (b)

Sol: Isothermal: As the area is work done on P-V diagram, P_2 for isothermal area is less.



05. Consider the following statements regarding torque converter :

1. A torque converter is a modified form of fluid coupling.
2. A reciprocating pump is used in a torque converter.

Which of the above statement is/are correct?

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

05. Ans: (a)

Sol: Torque converter is modified form of fluid coupling. In fluid coupling torque transmitted remains same where as in torque converter torque can be modified. The torque converter has additional component called stator (or reactor) in addition to pump & turbine.

In torque converter as well as fluid coupling centrifugal type pump impeller is used

06. A one fourth scale model of a pump was tested in a laboratory at 1000 rpm. The head developed and power input at the best efficiency point were found to be 7 m and 25 kW respectively. What is the speed of the prototype if the prototype pump has to operate against a head of 36 m ?

- (a) 467 rpm (b) 567 rpm
(c) 667 rpm (d) 767 rpm

06. Ans: (b)

Sol: Given data:

$$\frac{D_m}{D_p} = \frac{1}{4}, \quad N_m = 1000 \text{ rpm}, \quad H_m = 7 \text{ m},$$

$$P_m = 25 \text{ kW}$$

By similarity law, $ND \propto \sqrt{H_m}$

$$\therefore \frac{N_m}{N_p} \times \frac{D_m}{D_p} = \sqrt{\frac{H_m}{H_p}}$$

$$\frac{1000}{N_p} \times \frac{1}{4} = \sqrt{\frac{7}{36}}$$

$$\Rightarrow N_p = 567 \text{ rpm}$$

07. Consider the following statements regarding Euler turbine equation :

1. The axial component produces a bending of the shaft which is taken by the journal bearings.
2. The axial force only can cause the rotation of the runner and produce work.
3. The tangential force only can cause the rotation of the runner and produce work.
4. The radial component produces a bending of the shaft which is taken by the journal bearings.

Which of the above statements are correct ?

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

07. Ans: (c)

Sol:

- Axial component of force causes axial thrust on the bearing.
- Radial component of force causes bending of the shaft
- Tangential component of velocity causes rotation of the rotor and it is responsible for the rotation.

08. Which one of the following turbines is the most popularly used one in the medium head range of 60 m – 300 m ?

- (a) Kaplan turbine (b) Francis turbine
(c) Pelton turbine (d) Deriaz turbine

08. Ans: (b)

Sol: Francis turbine is suitable for the medium head

09. Match the following :

List – I (Turbine types)

- A. Deriaz turbine
- B. Propeller turbine
- C. Francis turbine
- D. Pelton turbine

List – II (Flow directions)

- 1. Mixed flow
- 2. Tangential flow
- 3. Axial flow
- 4. Diagonal flow

Select the correct matching using the code given below :

Codes:	A	B	C	D
(a)	4	3	1	2
(b)	3	4	2	1
(c)	2	1	4	3
(d)	1	2	3	4

09. Ans: (a)

Sol:

- Deriaz turbine → diagonal flow
- Propeller turbine → axial flow
- Francis turbine → mixed flow
- Pelton turbine → tangential flow

10. A Kaplan turbine plant develops 2000 kW under a head of 8 m while running at 100 rpm. The discharge is 250 m³/s. The tip diameter of the runner is 6.5 m and the hub to tip ratio is 0.43. What is the flow ratio based on tip speed ? (Take acceleration due to gravity as 9.81 m/s²?)

- (a) 0.43
- (b) 0.58
- (c) 0.62
- (d) 0.73

10. Ans: (d)

Sol: The flow ratio is defined as,

$$k_f = \frac{V_f}{\sqrt{2gH}}$$

$$V_f = \frac{Q}{A_f} = \frac{4Q}{\pi(D_t^2 - D_h^2)}$$

$$\therefore V_f = \frac{4 \times 250}{\pi \times (6.5^2 - 0.43^2 \times 6.5^2)} = 9.24 \text{ m/s}$$

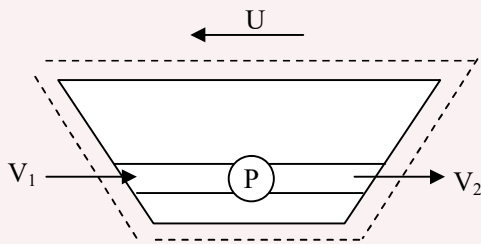
$$\therefore k_f = \frac{9.24}{\sqrt{2 \times 9.81 \times 8}} = 0.737$$

11. The water in a jet-propelled boat is drawn amid-ship and discharged at the back with an absolute velocity of 15 m/s. The boat speed is 30 km/hr. The cross-sectional area of the jet at the back is 0.03 m². What is the efficiency of the jet propulsion ?

- (a) 68.5%
- (b) 51.3%
- (c) 45.9%
- (d) 39.4%

11. Ans: (b)

Sol: Consider the control volume moving along with the boat.



The thrust force is produced due to change in momentum and it is given by

$$T = \dot{m}(V_2 - V_1)$$

Where V_1 , V_2 are velocities at inlet and exit w.r.t. boat

The propulsive efficiency is defined as,

$$\begin{aligned} \eta_p &= \frac{\text{Propulsive power}}{\text{Change in K.E}} \\ &= \frac{T \times u}{\frac{1}{2} \dot{m}(V_2^2 - V_1^2)} \\ &= \frac{\dot{m}(V_2 - V_1)u}{\frac{1}{2} \dot{m}(V_2^2 - V_1^2)} = \frac{2u}{V_1 + V_2} \end{aligned}$$

$$\text{Now, } V_1 = u = 30 \times \frac{5}{8} = 8.33 \text{ m/s}$$

$$V_2 = 8.33 + 15 = 23.33 \text{ m/s}$$

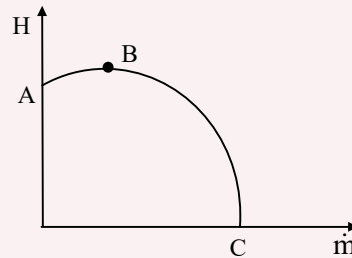
($\because V_1$ and V_2 are velocities w.r.t boat)

$$\therefore \eta_p = \frac{2 \times 8.33}{8.33 + 23.33} = 0.526$$

12. Surge is a condition which occurs
- in forward movement of aircraft
 - beyond the stable limit of operation
 - in forward motion of aircraft with speed above sonic velocity
 - due to the blast of air produced in a compressor

12. Ans: (b)

Sol:



The unsteady, periodic and reversal of flow manifests the phenomenon of surging.

A \rightarrow B is the surging region.

The compressor is suffering by surging beyond the stable limit of operation.

13. Consider the following statements regarding stalling in axial compressor :

- The flow separation occurring on the suction side of the blade is called negative stalling.
- The flow separation occurring on the pressure side of the blade is called positive stalling.
- The rotating stall decreases the effectiveness of the compressor.
- The delivery pressure significantly drops with large stalling leading to flow reversal.

Which of the above statements are correct ?

- 1 and 2 only
- 2 and 3 only
- 3 and 4 only
- 1 and 4 only

13. Ans: (c)

Sol: The flow separation on the suction side is called positive stalling.



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14. In a double acting pump, the work saved by fitting air vessels is about

- (a) 19.2% (b) 29.2%
(c) 39.2% (d) 50.2%

14. Ans: (c)

Sol: Work is saved by using air vessel in reciprocating pump due to reduction in frictional loss in pipe. It can be shown that for double acting pump saving in work is 39.2% and for single acting pump it is 84.8%

15. A single acting reciprocating pump has a bore of 200 mm and a stroke of 350 mm and runs at 45 rpm. The suction head is 8 m and the delivery head is 20 m. What is the theoretical discharge of water if slip is 12%? (Take acceleration due to gravity as 9.81 m/s²)

- (a) 7.260 l/s (b) 6.956 l/s
(c) 3.456 l/s (d) 4.586 l/s

15. Ans: (a)

Sol: For single acting pump, the theoretical discharge is given by,

$$Q_{th} = \frac{A_p LN}{60} = \frac{\pi}{4} \times 0.2^2 \times 0.35 \times \frac{45}{60}$$

$$= 8.25 \times 10^{-3} \text{ m}^3 / \text{s}$$

$$= 8.25 \text{ lit/s (This option is not present)}$$

The actual discharge is given by

$$Q_{act} = (1 - S) \times Q_{th} = (1 - 0.12) \times 8.25 \\ = 7.25 \text{ lit/s}$$

Note: In the question theoretical discharge is asked actual discharge is given in option

16. Lumped system analysis assumes a uniform temperature distribution throughout the body, which will be the case only when the thermal resistance of the body to heat conduction is

- (a) 3 (b) 2
(c) 1 (d) 0

16. Ans: (d)

Sol: For lumped body temperature varies only with respect to time it means at any instant temperature is same everywhere it means for a lumped body internal thermal resistance for heat conduction is zero.

17. Which one of the following is NOT a fluid property for convection heat transfer coefficient ?

- (a) Dynamic viscosity
(b) Thermal conductivity
(c) Density
(d) Rate of convection

17. Ans: (d)

Sol: In convection heat transfer,

$$Nu = \frac{h_{Lc}}{k} = c [Re]^m Pr^n$$

Where, c, m, n are constant

$$\frac{h_{Lc}}{k} = c \left[\frac{\rho \mu L_c}{\mu} \right]^m \left[\frac{\mu C_p}{K} \right]^n$$

$$h = f(k, m, \rho)$$

h is not considered rate of convection as a fluid property.

18. In friction coefficient, the boundary layer thickness (δ), the local friction coefficient (C_f) at location x and Reynolds number (Re) at location x for turbulent flow over a flat plate are

$$(a) \delta = \frac{5x}{Re_x^{0.5}}; C_f = \frac{0.664}{Re_x^{0.5}}$$

$$(b) \delta = \frac{0.382x}{Re_x^{0.5}}; C_f = \frac{0.0592}{Re_x^{0.5}}$$

$$(c) \delta = \frac{0.382x}{Re_x^{1/5}}; C_f = \frac{0.0592}{Re_x^{1/5}}$$

$$(d) \delta = \frac{5x}{Re_x^{1/5}}; C_f = \frac{0.664}{Re_x^{1/5}}$$

18. Ans: (c)

Sol: Option (a) represents expression for $\delta(x)$ and C_f for laminar boundary layer where as option (c) represents $\delta(x)$ and C_f to turbulent flow.

19. The region from the tube inlet to the point at which the boundary layer merges at the centre line, is called
- Hydrodynamic entry length
 - Thermal entrance region
 - Hydrodynamic entrance region
 - Thermal entry length

19. Ans: (c)

Sol: The given statement is definition of hydrodynamic entrance region.

20. What is the traditional expression for calculation of heat transfer in fully developed turbulent flow in smooth tubes that recommended by Dittus Boelter?

$$(a) Nu_d = 0.023 (Re_d^{0.8}) (Pr)^n$$

$$(b) Nu_d = 0.023 (Re_d^{0.4}) (Pr)^{2n}$$

$$(c) Nu_d = 0.023 (Re_d^{0.8}) (Pr)^{2n}$$

$$(d) Nu_d = 0.023 (Re_d^{0.4}) (Pr)^n$$

20. Ans: (a)

Sol: Dittus Boelter equation for turbulent flow

$$Nu = 0.023 R_c^{0.8} Pr^n$$

$n = 0.3$ for cooling of fluid

$n = 0.4$ for heating of fluid

21. Which one of the following is having the highest value of fouling factor ?

- Sea water
- Refrigerating liquid
- Fuel oil
- Industrial air

21. Ans: (c)

Sol: Sea water :

$$\text{Below } 325 \text{ K} \rightarrow 0.00009 \text{ m}^2\text{K/W}$$

$$\text{Above } 325 \text{ K} \rightarrow 0.0002 \text{ m}^2\text{K/W}$$

$$\text{Refrigeration liquid} \rightarrow 0.0002 \text{ m}^2\text{K/W}$$

$$\text{Fuel oil} \rightarrow 0.0010 \text{ m}^2\text{K/W}$$

$$\text{Industrial air} \rightarrow 0.0004 \text{ m}^2\text{K/W}$$

22. The performance test of an air conditioning unit rated as 140.7 kW (40 TR) seems to be indicating poor cooling. The test on heat rejection to atmosphere in its condenser shows the following :

Cooling water flow rate = 4 L/s;

Water temperature = inlet 30°C and outlet 40°C ;

Power input to motor = 48 kW (95% efficiency) ;

What is the actual refrigerating capacity of the unit ? (Take $C_w = 4.1868$)

- (a) 34.7 TR (b) 45.6 TR
(c) 52.6 TR (d) 48.6 TR

22. Ans: (a)

Sol: Given data,

$$\dot{m}_w = 4 \text{ kg/s},$$

$$(\Delta T)_w = T_o - T_i = 40 - 30 = 10^\circ\text{C}$$

$$\dot{m}_w = \rho \times V = 1000 \times 4 \times 10^{-3} = 4 \text{ kg/s}$$

$$c_{pw} = 4.1868 \text{ kJ/kgK}$$

$$\text{Power input} = 48 \text{ kW}$$

$$\eta = 95 \% = 0.95$$

Net refrigerating effect

$$= \text{Heat rejection} - \text{Power}$$

$$= \dot{m}_w c_{pw} (\Delta T)_w - \frac{P}{\eta}$$

$$= 4 \times 4.1868 \times 10 - \frac{48}{0.95}$$

$$= 117 \text{ kW}$$

$$= \frac{117}{3.5} = 34.7 \text{ TR}$$

23. Which one of the following is the intensive property in thermodynamic system ?

- (a) Pressure (b) Enthalpy
(c) Internal energy (d) Entropy

23. Ans: (a)

Sol: Pressure is intensive property.

24. 100 kg of ice at -5°C is placed in a bunker to cool some vegetables. 24 hours later, the ice has melted into water at 10°C . What is the average rate of cooling in kJ/h provided by the ice ? (Take specific heat of ice is 1.94 kJ/kg.K; Specific heat of water is 4.1868 kJ/kg.K; latent heat of fusion of ice at 0°C is 335 kJ/kg)

- (a) 1611 kJ/h (b) 1811 kJ/h
(c) 1711 kJ/h (d) 1911 kJ/h

24. Ans: (a)

Sol: $m_{\text{ice}} = 100 \text{ kg}, \quad t = 24 \text{ hr}$

$$Q_a = (\text{kJ/hr})$$

$$(c_p)_{\text{ice}} = 1.94 \text{ kJ/kg.K}$$

$$(c_p)_w = 4.1868 \text{ kJ/kg.K}$$

$$\text{L.H} = 335 \text{ kJ/kg}$$

$$\text{Ice } (-3^\circ\text{C}) \rightarrow \text{H}_2\text{O } (10^\circ\text{C})$$

$$Q_a = Q_1 + Q_2 + Q_3 \quad -5 \rightarrow 0^\circ\text{C}$$

$$0^\circ\text{C} \rightarrow 0^\circ\text{C}$$

$$0^\circ\text{C} \rightarrow 10^\circ\text{C}$$

$$= m[(c_{p_{\text{ice}}} \Delta T) + \text{LH} + c_{p_w} (\Delta T)]$$

$$= 100[(1.94 \times 5) + 335 + 4.1868(10)]$$

$$= \frac{38.65 \times 10^3 (\text{kJ})}{24} = 1610.41 \text{ kJ/hr}$$

25. Which of the following principles and processes involved in the production of low temperatures are correct ?

1. Adiabatic demagnetization
2. Thermoelectric cooling
3. Reversible adiabatic expansion of a gas
4. Irreversible adiabatic expansion of a real gas

Select the correct answer using the code given below :

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

25. Ans: (d)

Sol:

1. **Adiabatic demagnetization:** Magnetic field decreases and hence energy decreases and temperature decreases and produces very low temperature.
2. **Thermo electric cooling:** Works on peltier effect and produces low temperature.
3. Reversible adiabatic expansion always gives cooling effect.
4. Irreversible adiabatic expansion also gives cooling effect such as throttling in VCR cycle.

26. Which one of the following is used in aircraft refrigeration ?

- (a) Vapour compression cycle refrigeration
- (b) Gas cycle refrigeration
- (c) Vapour absorption cycle refrigeration
- (d) Steam ejector cycle refrigeration

26. Ans: (b)

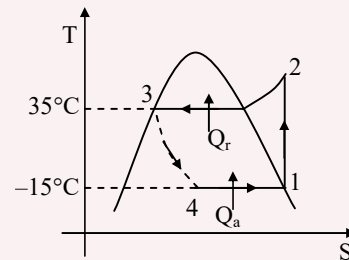
Sol: In aircraft refrigeration reversed Brayton cycle i.e., Bell coleman cycle is used which is air cycle.

27. An ammonia ice plant operates between a condenser temperature of 35°C and an evaporator temperature of -15°C . It produces 10 tons of ice per day from water at 30°C to ice at -5°C . Assume simple saturation cycle, what is the capacity of the refrigeration plant ? (Take Specific heat of ice is 1.94 kJ/kg.K ; Specific heat of water is 4.1868 kJ/kg.K ; latent heat of fusion of ice at 0°C is 335 kJ/kg)

- (a) 54.43 kW (b) 64.32 kW
 (c) 74.52 kW (d) 84.23 kW

27. Ans: (a)

Sol:



$$\text{R.C} = 10 \text{ Tons/day} = 416.66 \text{ (kg/hr)}$$

Water (30°C) \rightarrow ICE (-5°C)

$$m = (10 \times 10^3) / 24 \text{ hr}$$

$$Q_a = m(c_{\text{pice}} \Delta T + L.H + c_{\text{pw}} \Delta T)$$

$$= \frac{416.66}{3600} (1.94 \times 5 + 335 + 4.1868 \times 30)$$

$$Q_a = 54.34 \text{ kW}$$

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26th FEB-2022

13th MAR-2022

27th MAR-2022

11th APR-2022

25th APR-2022

08th & 22nd MAY

11th JUN-2022

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28. Consider the following statements in a vapor compression refrigeration system :

It is observed that an increase in condenser pressure, similarly results in

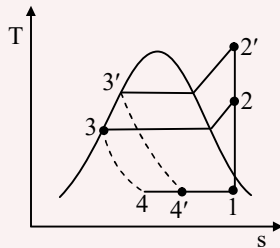
1. a decrease in the refrigerating capacity
2. an increase in power consumption
3. an increase in volumetric efficiency

Which of the above statements are correct ?

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

28. Ans: (c)

Sol:



As condenser pressure increases :

1. Work of compressor increases.
2. Net refrigerating effect decreases.
3. COP decreases.
4. Volumetric efficiency decreases due to increase in pressure ratio.

∴ 1 and 2 are only correct.

29. Which one of the following is the designation for dichloro-tetrafluoro-ethane refrigerant used in refrigeration system ?

- (a) R114 (b) R116
 (c) R113 (d) R118

29. Ans: (a)

Sol: Dichloro – tetrafluoro – ethane \Rightarrow $C_2F_4Cl_2$

Chemical formula is

$$C_m H_n F_p Cl_q = C_2 F_4 Cl_2$$

$$\therefore m = 2, n = 0, p = 4, q = 2$$

Designation is $\Rightarrow R(m-1)(n+1)P$

$$\therefore R(2-1)(0+1)4$$

$$C_2F_4Cl_2 = R114$$

30. Which of the following are highly explosive and flammable in a refrigeration system ?

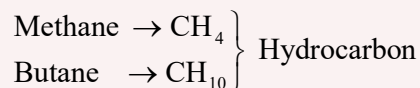
1. Methane
2. Butane
3. R134a

Select the correct answer using the code given below :

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

30. Ans: (b)

Sol: Generally hydrocarbons are more explosive and flammable due to more hydrogen atoms



$R1344 \rightarrow C_2H_2F_4$ is environment friendly

31. Which one of the following statements is NOT correct regarding Rankine cycle ?

- (a) For the steam boiler, the ideal process would be a reversible constant pressure heating process of water to form steam.

- (b) For the turbine, the ideal process would be a reversible adiabatic expansion of steam.
- (c) For the condenser, it would be a reversible constant pressure heat rejection as the steam condenses till it becomes saturated liquid.
- (d) For the pump, the ideal process would be the reversible adiabatic expansion of the liquid ending at the final pressure.

31. Ans: (d)

Sol: During the pumping process, the pressure of the liquid increases, therefore this process is considered as pressure boosting process (compression) not expansion process.

32. Which one of the following statements is NOT correct ?
- (a) In surface condensers, the cooling water and exhaust steam do not come in direct contact with each other.
- (b) The vacuum efficiency is the ratio of ideal vacuum to actual vacuum.
- (c) The Hot well is a sump between the condenser and the boiler where the condensate coming from the condenser is collected.
- (d) Condenser is a closed vessel heat exchanger in which the steam coming from turbine is condensed using a supply of cooling water at atmospheric temperature.

32. Ans: (b)

Sol:
$$\eta_{\text{vacuum}} = \frac{\text{Actual vacuum}}{\text{Ideal vacuum}}$$

33. Which one of the following statements is correct ?
- (a) Ultimate analysis is the determination of the percentages of fixed carbon, volatile matter, moisture and ash in fuel
- (b) The percentage of each constituent element in the fuel such as carbon, hydrogen, sulphur, oxygen, nitrogen, and ash, is determined by proximate analysis
- (c) Calorific value of solid or liquid fuel is defined as the heat evolved by the complete combustion of unit mass of fuel
- (d) Proximate analysis value of gaseous fuel is expressed as heat developed by the complete combustion of one cubic metre of gas at standard temperature and pressure

33. Ans: (c)

Sol: Ultimate analysis is for elemental composition whereas proximate analysis is for fixed carbon.

Calorific value is heat evolved by complete combustion of unit mass of solid or liquid fuels.

34. Which one of the following statements is NOT correct ?

- (a) A simple and convenient apparatus used for the volumetric analysis of dry flue gases is known as Orsat apparatus
- (b) The calorific values of liquid fuels are generally determined by using an Orsat apparatus
- (c) The calorific values of solid and liquid fuels are generally determined by using a bomb calorimeter
- (d) In Orsat apparatus, potassium hydroxide used as absorbent to absorb carbon dioxide

34. Ans: (b)

Sol:

- Orsat's apparatus is used for composition of dry flue gases.
- The calorific values of liquid fuels are generally determined by bomb calorimeter.

35. Which one of the following statements is NOT correct ?

- (a) Grate is the platform in the furnace of boiler upon which fuel is burnt and it is made of cast iron bars
- (b) The removal of the mud and other impurities of water from the lowest part of the boiler is termed as blowing off
- (c) Cochran boiler is one of the best types of vertical multi-tubular boiler.

(d) Babcock and Wilcox boiler is a fire tube boiler

35. Ans: (d)

Sol: Babcock and Wilcox boiler is a water tube boiler.

36. Which one of the following statements is correct ?

- (a) In water tube boiler, water surrounds the tubes and hot gases are inside the tubes
- (b) The boilers which produce steam at pressures of 10 bar and below are called high pressure boiler
- (c) Lancashire boilers are externally fired boiler
- (d) Stirling boilers are externally fired boiler

36. Ans: (c)

Sol: Lancashire boilers are externally fired boiler

37. In a power plant, the efficiencies of the electric generator, turbine. (mechanical), boiler, cycle and overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries ?

- (a) 9.29%
- (b) 8.50%
- (c) 7.32%
- (d) 6.76%

37. Ans: (c)

Sol: $\eta_o = \eta_b \times \eta_{th} \times \eta_T \times \eta_G \times \eta_A$
 $0.33 = 0.92 \times 0.42 \times 0.97 \times 0.95 \times \eta_A$

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

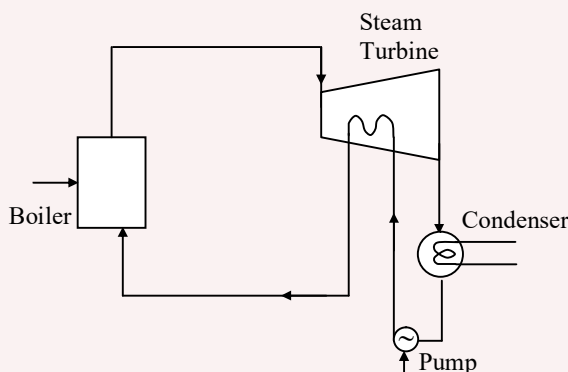
$$= 0.92679$$
 % of energy consumed by auxiliaries
 $= 1 - 0.92679$
 $= 0.0732 = 7.32\%$

38. An ideal cycle is impracticably because

- (a) there is an ideal fluid available which is considered as working fluid
- (b) it is not possible to transfer heat of expanding steam to the fluid in the turbine itself
- (c) it is always possible to transfer heat of expanding steam to the fluid in the turbine itself
- (d) there is no possibility of excessive humidity in low pressure stages of the turbine

38. Ans: (b)

Sol:



39. Match the following:

List – I (Boiler Type)	List – II (Pressure (kg/cm ²))
A. La Mont Boiler	1. 84
B. Loeffler Boiler	2. 170
C. Benson Boiler	3. 135
D. Velox Boiler	4. 230

Select the correct matching using the code given below:

	A	B	C	D
(a)	2	1	3	4
(b)	1	2	4	3
(c)	2	3	4	1
(d)	3	2	1	4

39. Ans: (c)

Sol: La Mont boiler $\Rightarrow \approx 170 \text{ kg/cm}^2$
 Loeffler boiler $\Rightarrow \approx 135 \text{ kg/cm}^2$
 Benson boiler $\Rightarrow \approx 230 \text{ kg/cm}^2$
 Velox boiler $\Rightarrow \approx 84 \text{ kg/cm}^2$

40. What is the amount of air required to burn one kg of fuel and product of combustion for a fuel the percentage composition of which is given as $C = 70\%$, $H_2 = 30\%$?

- (a) 16.54 kg
- (b) 17.54 kg
- (c) 18.54 kg
- (d) 19.54 kg

40. Ans: (c)

$$\begin{aligned}
 \text{Sol: AF/ratio} &= \frac{100}{23} \left[\frac{8}{3} C + 8H_2 \right] \\
 &= \frac{100}{23} \left[\frac{8}{3} \times 0.7 + 8 \times 0.3 \right] \\
 &= \frac{100}{23} \left[\frac{5.6}{3} + 2.4 \right] \\
 &= \frac{100}{23} [1.87 + 2.4] = \frac{427}{23} \\
 &= \frac{460 - 33}{23} = 20 - \frac{33}{23} = 20 - (0.15) \\
 &= 18.55 \text{ kg}
 \end{aligned}$$

41. Which one of the following statements is correct?

- (a) The Rankine cycle efficiency can be improved by increasing the average temperature at which heat is rejected
- (b) The Rankine cycle efficiency can be improved by decreasing/ reducing the temperature at which heat is rejected
- (c) If the steam is superheated before allowing it to expand the Rankine cycle efficiency may be decreased
- (d) The thermal efficiency of the Rankine cycle can be amply improved by increasing the condenser pressure

41. Ans: (b)

$$\text{Sol: } \eta_R = 1 - \frac{T_{m2}}{T_{m1}}$$

where,

T_{m2} = Mean temperature of heat rejection

T_{m1} = Mean temperature of heat supplied

In Rankine cycle the efficiency can be increased by increasing the mean temperature of heat addition or by decreasing the mean temperature of heat rejection.

By using the super heated steam in Rankine cycle increases efficiency.

42. Match the following:

List – I

- A. Boiler to turbine process
- B. Turbine to Condenser process
- C. Condenser to pump process
- D. Pump to Boiler process

List – II

- 1. Reversible adiabatic expansion in the turbine
- 2. Constant pressure transfer of heat in the condenser
- 3. Reversible adiabatic pumping process in the feed pump
- 4. Constant pressure transfer of heat in the boiler

Select the correct matching using the code given below:

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	2	1
(c)	2	1	4	3
(d)	1	2	3	4

42. **Ans: (d)**

Sol:

- Turbine → Reversible adiabatic expansion
- Condenser → Constant pressure heat rejection
- Pump → Reversible adiabatic pumping
- Boiler → Heat supplied at constant pressure

43. Which one of the following fuel cells has lowest operating temperature ?

- (a) PEMFC (b) MCFC
(c) PAFC (d) SOFC

43. **Ans: (a)**

Sol: Operating temperature of various fuel cells are

$$\text{PEMFC} = 60 - 80^\circ\text{C (lowest)}$$

$$\text{PAFC} = 150 - 200^\circ\text{C}$$

$$\text{AFC} = 180 - 200^\circ\text{C}$$

$$\text{MCFC} = 650^\circ\text{C}$$

$$\text{SOFC} = 650 - 1000^\circ\text{C}$$

44. Adjusting the nacelle about the vertical axis to bring the rotor facing wind is known as

- (a) Pitch control (b) Hub control
(c) Rotor control (d) Yaw control

44. **Ans: (d)**

Sol: Yaw control: The direction of wind changes frequently in horizontal and vertical planes. Hence, turbine blades should be oriented such that plane of rotation of blades is

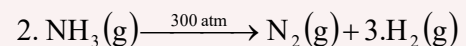
always perpendicular to the wind direction. This is done using nacelle control mechanism.

45. In a distributed collector solar thermal electric power plant, the heat collected in collectors is used to dissociate ammonia into nitrogen and hydrogen at approximately

- (a) 300 atm pressure
(b) 150 atm pressure
(c) 100 atm pressure
(d) 40 atm pressure

45. **Ans: (a)**

Sol: In a distributed collector power generation plant, the heat collected in collectors is used to dissociate ammonia into nitrogen and hydrogen at high pressure. (**approx 300 atm**).



The heat of reaction (46 kJ/mole) of NH_3 is provided by the solar energy. This N_2 and H_2 mixture is transported to central plant where N_2 and H_2 are recombined in a synthesizer using a catalyst. The heat released during the reaction is utilized in a heat engine to generate electric power through an alternator.

46. A body of dimensions $1.5 \text{ m} \times 1.0 \text{ m} \times 2 \text{ m}$, weighs 1962 N in water. What is the weight of the body in air ?

(Take acceleration due to gravity as 9.81 m/s²)

- (a) 31392 N (b) 23392 N
(c) 14392 N (d) 46392 N

46. Ans: (a)

Sol: Weight in water

= actual weight – buoyancy force

$$1962 = W_{\text{actual}} - \rho g \nabla$$

$$\therefore W_{\text{actual}} = 1962 + (1000 \times 9.81 \times 1.5 \times 1 \times 2)$$

$$= 31392 \text{ N}$$

47. The following cases represent the two velocity components, $v = 2y^2$; $w = 2xyz$. What is the third component of velocity such that they satisfy the continuity equation ?

- (a) $-4xy - x^2y + f(y, z)$
(b) $-3xy - x^3y + f(y, z)$
(c) $-5xy - 2x^2y + f(y, z)$
(d) $-4xy - 3x^2y + f(y, z)$

47. Ans: (a)

Sol: Assuming the flow to be incompressible

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$\frac{\partial u}{\partial x} + \frac{\partial}{\partial y}(2y^2) + \frac{\partial}{\partial z}(2xyz) = 0$$

$$\frac{\partial u}{\partial x} + 4y + 2xy = 0$$

Integrating w.r.t x

$$\therefore u = -\int (4y + 2xy) dx + f(y, z)$$

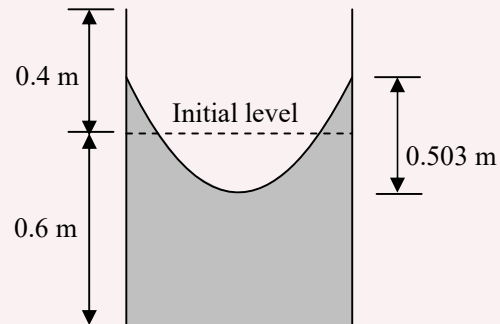
$$= -4xy - x^2y + f(y, z)$$

48. An open circular tank of 20 cm diameter and 100 cm long contains water upto a height of 60 cm. The tank is rotated about its vertical axis at 300 rpm. What is the depth of parabola formed at the free surface of water? (Take acceleration due to gravity as 9.81 m/s²)

- (a) 50.28 cm. (b) 55.28 cm
(c) 65.36 cm (d) 69.36 cm

48. Ans: (a)

Sol:



$$Z = \frac{\omega^2 r^2}{2g} = \frac{\left(\frac{2\pi \times 300}{60}\right)^2 \times 0.1^2}{2 \times 9.81}$$

$$= 0.503 \text{ m}$$

$$= 50.3 \text{ cm}$$

49. What is the velocity of flow at radius of 0.8 m, if the water is flowing radially outward in a horizontal plane from a source at a strength of 12 m²/s ?

- (a) 9.55 m/s (b) 4.77 m/s
(c) 2.38 m/s (d) 5.62 m/s

49. Ans: (c)

Sol: Velocity at a distance 'r' from the source of strength 'q' is given by

$$U_r = \frac{q}{2\pi r} = \frac{12}{2\pi \times 0.8}$$

i.e., $U_r = 2.38 \text{ m/s}$

50. A pitot-static tube is used to measure the velocity of water in a pipe. The stagnation pressure head is 6 m and static pressure head is 5 m. What is the velocity of flow assuming the coefficient of tube equal to 0.98? (Take acceleration due to gravity as 9.81 m/s^2)

- (a) 1.24 m/s (b) 2.68 m/s
(c) 3.56 m/s (d) 4.34 m/s

50. Ans: (d)

Sol: $V = C\sqrt{2gh}$

$$\begin{aligned} &= C\sqrt{2g \times \left(\frac{P_o - P}{\rho g}\right)} \\ &= 0.98 \times \sqrt{2 \times 9.81 \times (6 - 5)} \\ &= 4.34 \text{ m/s} \end{aligned}$$

51. A fluid of viscosity 0.7 N-s/m^2 and specific gravity 1.3 is flowing through a circular pipe of diameter 100 mm.

The maximum shear stress at the pipe wall is given as 196.2 N/m^2 . What is the pressure gradient of the flow?

- (a) 7848 N/m^2 per m
(b) -7848 N/m^2 per m

(c) -9848 N/m^2 per m

(d) 9848 N/m^2 per m

51. Ans: (b)

Sol: $\tau_{\max} = \frac{-dp}{dx} \times \frac{R}{2}$

$$\therefore \frac{dP}{dx} = \frac{-2\tau_{\max}}{R} = \frac{-2 \times 196.2}{0.05} = -7848 \text{ Pa/m}$$

52. An oil of viscosity 10 poise flows between two parallel fixed plates which are kept at a distance of 50 mm apart. What is the rate of flow of oil between the plates if the drop of pressure in a length of 1.2 m be 0.3 N/cm^2 and the width of the plate is 200 mm?

- (a) 6.2 litre/s (b) 3.2 litre/s
(c) 8.2 litre/s (d) 5.2 litre/s

52. Ans: (d)

Sol: $\Delta P = \frac{12\mu VL}{h^2}$

i.e. $0.3 \times 10^4 = \frac{12 \times 1 \times V \times 1.2}{0.05^2}$

$\therefore V = 0.5208 \text{ m/s}$

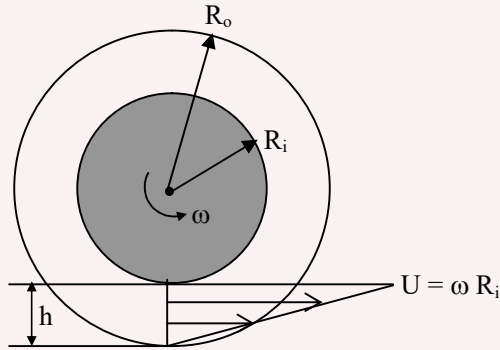
$$\begin{aligned} Q &= A.V = (bh) \times V = 0.2 \times 0.05 \times 0.5208 \\ &= 5.208 \text{ lit/s} \end{aligned}$$

53. A shaft of diameter 0.35 m rotates at 200 rpm inside a sleeve 100 mm long. The dynamic viscosity of lubricating oil in the 2 mm gap between sleeve and shaft is 8 poises. What is the power lost in the bearing?

- (a) 0.59 kW (b) 0.69 kW
(c) 0.88 kW (d) 0.91 kW

53. Ans: (a)

Sol:



$$\begin{aligned}
 P &= T_i \times \omega = F_i \times R_i \times \omega \\
 &= \tau \times (2\pi R_i L) \times R_i \times \omega \\
 &= \mu \times \frac{\omega R_i}{h} \times 2\pi R_i L \times R_i \times \omega \\
 &= \frac{2\pi\mu\omega^2 R_i^3 L}{h} \\
 &= \frac{2\pi \times 0.8 \times \left(\frac{2\pi \times 200}{60}\right)^2 \times 0.175^3 \times 0.1}{2 \times 10^{-3}} \\
 &= 590.8 \text{ W} \\
 &= 0.59 \text{ kW}
 \end{aligned}$$

54. A sphere of diameter 2 mm falls 150 mm in 20 seconds in a viscous liquid. The density of the sphere is 7500 kg/m³ and of liquid is 900 kg/m³. What is the coefficient of viscosity of the liquid ? (Take acceleration due to m gravity as 9.81 m/s²)
- (a) 22.31 poise (b) 25.62 poise
(c) 19.17 poise (d) 32.21 poise

54. Ans: (c)

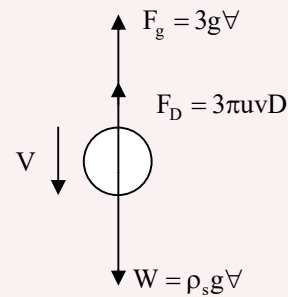
Sol: The velocity of the sphere is given by

$$V = \frac{L}{T} = \frac{150 \times 10^{-3}}{20} = 7.5 \times 10^{-3} \text{ m/s}$$

In steady state, the free body diagram of the sphere will be as shown below,

$$\therefore \Sigma F_y = ma_y = m \times 0 = 0$$

$$\text{i.e. } F_B + F_0 - W = 0$$



$$F_D = W - F_B = \rho_s gV - \rho gV$$

$$3\pi\mu VD = (\rho_s - \rho)g \times \frac{4}{3}\pi \left(\frac{D}{2}\right)^3$$

$$\begin{aligned}
 \mu &= \frac{1}{18} \cdot \frac{(\rho_s - \rho)gD^2}{V} \\
 &= \frac{1}{18} \times \frac{(7500 - 900) \times 9.81 \times 0.002^2}{7.5 \times 10^{-3}} \\
 &= 1.918 \text{ Pa.s} \\
 &= 19.18 \text{ Poise}
 \end{aligned}$$

55. The resistance wire of a 1200 W hair dryer is 80 cm long and has a diameter of 0.3 cm. What is the rate of heat generation in the wire per unit volume ?
- (a) 212 W/cm³ (b) 312 W/cm³
(c) 512 W/cm³ (d) 412 W/cm³

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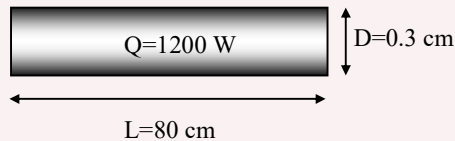
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55. Ans: (a)

Sol:



$$Q_g = 1200 \text{ W}$$

$$q_g = \frac{Q_g}{\text{volume}} = \frac{Q_g}{\frac{\pi}{4} d^2 L}$$

$$= \frac{1200}{\frac{22}{7} \times 4 \times \left(\frac{3}{10}\right)^2 \times 80} = 212 \text{ W/cm}^3$$

$$q_g = \frac{1200 \times 100 \times 7 \times 4}{22 \times 3^2 \times 80} = \frac{1200 \times 100 \times 7 \times 4}{22 \times 9 \times 80}$$

$$q_g = \frac{1200}{80} \times \frac{100}{22} \times \frac{7}{9} \times 4$$

$$q_g = \frac{120}{8} \times \frac{50}{11} \times \frac{7}{9} \times 4 = \frac{120}{2} \times \frac{50}{11} \times \frac{7}{9}$$

$$= 60 \times \frac{50}{11} \times \frac{7}{9} = 212 \text{ W/cm}^3$$

56. A 2 kW resistance heater wire with thermal conductivity 15 W/m°C, diameter 0.4 cm, and length 50 cm is used to boil the water by immersing it in water. Assuming the variation of the thermal conductivity of the wire with temperature to be negligible. What is the differential equation that describes the variation of the temperature in the wire during steady operation ?

$$(a) \frac{1}{r} \frac{d}{dr} \left(r \frac{dT}{dr} \right) + \frac{g}{k} = 0$$

$$(b) \frac{1}{2r} \frac{dT}{dr} \left(r \frac{dT}{dr} \right) + \frac{g}{k} = 0$$

$$(c) \frac{1}{r} \frac{d}{dr} \left(\frac{dT}{dr} \right) + \frac{g}{k} = 0$$

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

56. Ans: (a)

Sol: For wire (cylinder), cylinder co-ordinate is best suitable.

In wire there is internally heat generation take place and during steady state there is no change in temperature with respect to time cylindrical co-ordinate system.

$$\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial T}{\partial r} \right) + \frac{g}{k} = \frac{1}{\alpha} \frac{\partial T}{\partial t}$$

$$\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial T}{\partial r} \right) + \frac{g}{k} = 0$$

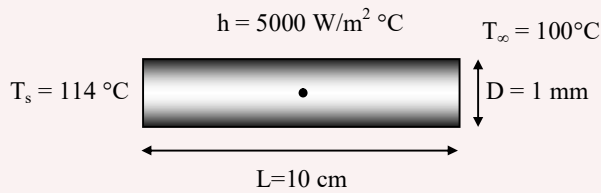
57. An electric current is passed through a wire 1 mm in diameter and 10 cm long. The wire is submerged in liquid water at atmospheric pressure and the current is increased until the water boils. For this situation, h is 5000 W/m²°C and the water temperature will be 100 °C. How much electric power must be supplied to the wire to maintain the wire surface at 114 °C ?

$$(a) 21.99 \text{ W} \qquad (b) 32.39 \text{ W}$$

$$(c) 42.39 \text{ W} \qquad (d) 52.36 \text{ W}$$

57. Ans: (a)

Sol:



To maintain the surface temperature

$$Q_{\text{gen}} = Q_{\text{loss}} = hA_s(T_s - T_\infty) = 5000 \times \pi DL \times (T_s - T_\infty)$$

$$Q = 5000 \times \frac{22}{7} \times \frac{1}{1000} \times \frac{10}{100} \times (114 - 100)$$

$$Q = 5000 \times \frac{22}{7} \times \frac{1}{1000} \times 14$$

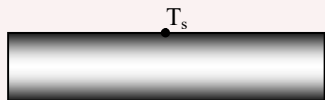
$$Q = \frac{22 \times 2}{2} = 22 \text{ W}$$

58. A 2 kW resistance heater wire whose thermal conductivity is 15 W/m°C has a diameter of 4 mm and a length of 0.5 m, is used to boil the water. If the outer surface temperature of resistance wire is 105°C, what is the temperature at the centre of the wire ?

- (a) 136°C (b) 126°C
(c) 146°C (d) 156°C

58. Ans: (b)

Sol:



$$Q_g = 2 \text{ kW}, \quad T_s = 105^\circ\text{C}$$

$$k = 15 \text{ W/m}^\circ\text{C}, \quad T_{\text{center}} = ?$$

$$D = 4 \text{ mm},$$

$$L = 0.5 \text{ m}$$

$$T_{\text{max}} - T_s = \frac{q_g R^2}{4k} = \frac{Qg}{\pi R^2 L} \cdot R^2$$

$$T_{\text{max}} - T_s = \frac{Qg}{\pi L 4k} = \frac{2000}{\frac{22}{7} \times \frac{1}{2} \times 4 \times 15}$$

$$T_{\text{max}} - 105 = \frac{2000 \times 7}{22 \times 2 \times 15} = \frac{1000}{11} \times \frac{7}{2} \times \frac{1}{15}$$

$$T_{\text{max}} - 105 = \frac{1000}{30} \times \frac{7}{11} = \frac{100}{3} \times \frac{7}{11} \\ = 33.33 \times \frac{7}{11} = 21.21$$

$$T_{\text{max}} = 105 + 21.21 = 126.21^\circ\text{C}$$

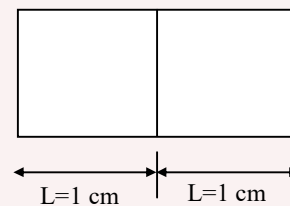
59. The thermal contact conductance at the interface of two 1 cm thick aluminum plates is measured to be 11000 W/m²°C. What is the thickness of the aluminum plate whose thermal resistance is equal to the thermal resistance of the interface between the plates?

(Take the thermal conductivity of aluminum at room temperature as 237 W/m°C)

- (a) 3.15 cm (b) 5.13 cm
(c) 1.28 cm (d) 2.15 cm

59. Ans: (d)

Sol:



$$\text{Thermal resistance} = \frac{1}{\text{Thermal conductance}}$$

$$R_{\text{thermal}} = \frac{1}{11000} \text{m}^2 \frac{^\circ\text{C}}{\text{W}}$$

Resistance offered = Resistance at interface by aluminum

$$\frac{L}{k} = \frac{1}{11000}$$

$$L = \frac{237}{11000} = 0.02154 \text{m} = 2.15 \text{cm}$$

60. In the design of a fin, the error involved in one dimensional fin analysis is negligible (less than about 1%) when

(a) $\frac{h\delta}{k} < 0.2$ (b) $\frac{hk}{\delta} < 0.2$

(c) $\frac{h\delta}{k} < 2$ (d) $\frac{hk}{\delta} < 2$

60. Ans: (a)

Sol: Studies have shown that the error involved in one dimensional fin analysis is negligible (less than about 1 %) when

$$\frac{h\delta}{k} < 0.2$$

δ = characteristic thickness of the fin

61. Solar thermal water pumps work on
 (a) Rankine cycle (b) Otto cycle
 (c) Carnot cycle (d) Diesel cycle

61. Ans: (a)

Sol: It is expected that working of solar thermal water plant (not pump) is asked.

Solar thermal water plant works on Rankine cycle where solar heat is used for steam production and power is obtained by expanding this steam in turbines.

62. The concentration ratio of as high a value as 3000 can be obtained by
 (a) modified flat plate collector
 (b) compound parabolic concentrator
 (c) cylindrical parabolic concentrator
 (d) central tower receiver

62. Ans: (d)

Sol:

Type of collector	C.R
Simple flat plate	1
Modified flat plate	1 to 4
Parabolic trough line focus	2 to 100
Heliostats & Central tower receiver	200 to 3000

63. The angle between the sun's ray and its projection on a horizontal surface is known as
 (a) Inclination angle
 (b) Zenith angle
 (c) Solar azimuth angle
 (d) Hour angle

63. Ans: (a)

Sol: Solar altitude angle / Inclination angle

(α): It is the angle between sun rays and its projection on horizontal plane.

$\alpha = 0$ at sunrise and sunset

$\alpha = \text{Maximum}$ at solar noon

$\alpha = 90^\circ$ on 21st March & 21st Sept noon.

64. The total solar radiation received at any point on the earth's surface is the sum of the direct and diffuse radiation and is referred as

- (a) Total diffuse radiation
- (b) Insolation
- (c) Total radiation
- (d) Total specular radiation

64. Ans: (c)

Sol:

- **Beam/direct radiation:** It is the radiation having parallel rays.
- **Diffuse radiation:** It is the radiation scattered by atmospheric dust, moisture, gases, etc. It has rays in all directions.
- **Global/total radiation:** It is the sum of beam and diffuse radiation.

65. The rate at which solar energy arrives at the top of the atmosphere is called

- (a) Total energy
- (b) Radiation
- (c) Solar constant
- (d) Radiation constant

65. Ans: (c)

Sol: Solar constant:

The solar radiation received outside the earth's atmosphere is called extra-terrestrial solar radiation. It is not affected by atmospheric gases, vapors, dust, etc.

"The solar radiation received per unit area normal to sun rays, in a space outside the earth's atmosphere, at a mean distance between sun and earth is called solar constant (I_{sc})".

$$I_{sc} = 1367 \text{ W/m}^2$$

It is also known as extraterrestrial flux.

66. Consider the following statements regarding solar ponds :

1. It is possible to produce electricity from a solar pond by using a special 'High temperature' heat engine coupled to an electric generator.
2. In a large solar pond, the thermal capacitance and resistance can be made large enough to retain the heat in the bottom layer from summer to winter and the pond can therefore be used for heating buildings in the winter.
3. A solar pond is an ingenious collector, which uses water as its top cover.

Which of the above statements are correct ?

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

66. Ans: (b)

Sol:

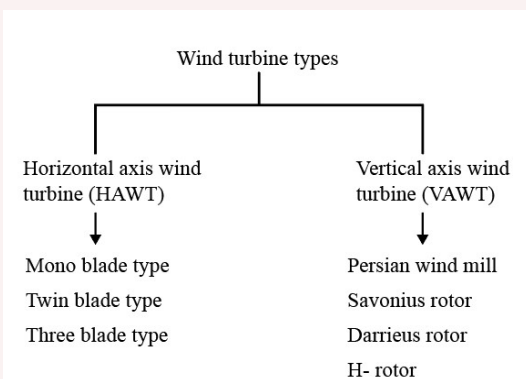
- In Solar pond temperature achieved is in the range of 60 – 100°C. This temperature is not sufficient for power production (electricity generation). Hence this statement is incorrect.
- In a large solar pond, the thermal capacitance and resistance can be made large enough to retain the heat in the bottom layer from summer to winter and the pond can therefore be used for heating buildings in the winter.
- A solar pond is an ingenious (properly planned salt gradient in three layers) collector, which uses water as its top cover.

67. Which one of the following is a vertical axis wind mill ?

- (a) Darrieus type wind mill
- (b) Propellor type wind mill
- (c) Sail type wind mill
- (d) Multi blade type wind mill

67. Ans: (a)

Sol:



68. Consider the following statements regarding solar radiation measurement :

1. Pyranometer collimates the radiation to determine the beam intensity as a function of incident angle.
2. Pyranometer measures the total hemispherical solar radiation.
3. Pyrliometer collimates the radiation to determine the beam intensity as a function of incident angle.

Which of the above statements is/are correct?

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

68. Ans: (b)

Sol: Pyranometer measures total radiations (beam + diffuse).

Pyrliometer measures only beam radiations.

69. Which one of the following materials is used for heat collection element in parabolic trough plants of solar central receiver system?

- (a) Copper
- (b) Mild steel
- (c) Stainless steel
- (d) Aluminum

69. Ans: (a)

Sol: Copper having high thermal conductivity is commonly used material for collector in parabolic trough plants of solar central receiver system.

Directions :

Each of the next Six (06) items consists of two statements, one labelled as the "Statement (I)" and the other 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) is false
- (d) Statement (I) is false but Statement (II) is true

70. **Statement (I):** Centre of pressure is calculated by using the "Principle of Moments".

Statement (II): The moment of the resultant force about an axis is equal to the sum of moments of the components about the same axis.

70. Ans: (a)

Sol: As per Varignon's theorem the moment of resultant force about any axis is equal to the sum of the moments of the components of

the resultant force. This theorem is used to locate the position of centre of pressure in the derivation of formula of depth of centre of pressure.

71. **Statement (I):** Heat and work are boundary phenomenon and recognized only when they cross the boundary of a system.

Statement (II): Heat and work depend on the path followed by the system during a process.

71. Ans: (b)

Sol: Statement (I) and (II) both are correct.

- Heat and work are boundary phenomenon and recognized only when they cross the boundary of a system.
- Heat and work depend on the path followed by the system during a process.

72. **Statement (I):** The vapour absorption system uses heat energy to change the condition of the refrigerant from the evaporator.

Statement (II): The load variations do not affect the performance of a Vapour absorption system.

72. Ans: (d)

Sol: For the vapor absorption refrigeration system, heat energy is the input energy. Heat energy for VAR system is used for improving the thermal properties of

refrigerant in the generator not in the evaporator.

Statement I is wrong, Statement II is correct.

73. **Statement (I):** For moderate speed, the force of friction remains nearly constant and decrease slightly with increase of speed.

Statement (II): Friction is dependent on extent of area but independent on normal reaction.

73. Ans: (c)

Sol: Friction depends on normal reaction but is independent of area of contact.

74. **Statement (I):** The percent elongation is assumed to be based on a gage length of 2.00 in unless some other gage length is specifically indicated.

Statement (II): Theoretically, a material is considered ductile if its percent elongation is greater than 5% (lower values indicate brittleness).

74. Ans: (b)

Sol: Statement (I) and (II) are correct but statement (I) explanation about gauge length and statement (II) is not correct explanation of statement (I).

Percentage elongation $< 5\% \Rightarrow$ Brittleness

Percentage elongation $> 5\% \Rightarrow$ Ductility

75. **Statement (I):** Mechanization means something is done or operated by machinery as well as by hand.

Statement (II): Mechanization of the manufacturing means milestone oriented trend towards minimizing the human efforts to the extent of its possibility, by adopting mechanical and electrical means or methods for automating the different manufacturing processes.

75. Ans: (d)

Sol: Mechanization means something is done or operated by machinery and not by hand. Mechanization of the manufacturing means is milestone oriented trend towards minimizing the human efforts to the extent of its possibility, by adopting mechanical and electrical means or methods for automating the different manufacturing processes. Such a trend may be in the area of automating and mechanizing the processes of material handling, loading and unloading of components, actual operations performed on the job or transportation, etc. But, no feedback is provided by the process, operation or machinery. So given statement (I) is incorrect and statement (I) is CORRECT. Hence the given option (d) is CORRECT.

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76. Centroid of a body coincides with its centre of mass or its centre of gravity only if the material composing the body is
- uniform or homogeneous
 - in equilibrium
 - in static equilibrium
 - translating with constant velocity

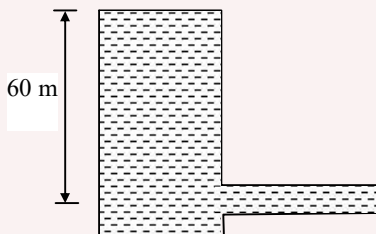
76. Ans: (a)

Sol: Centroid of a body always coincides with COM and centre of gravity if the object is uniform / homogenous (some density).

77. A cast-iron pipe of 750 mm diameter is used to carry water under a head of 60 m. What is the approximate thickness of the pipe if permissible stress is to be 20 MPa ? (Take specific weight of water as 9.81 kN/m^3)
- 22 mm
 - 14 mm
 - 11 mm
 - 7 mm

77. Ans: (c)

Sol:



Given, $\sigma_{\text{allowable}} = 20 \text{ MPa}$

$$d = 750 \text{ mm}$$

$$h = 60 \text{ m}$$

$$\gamma = 9.81 \times 10^3 \text{ N/m}^3$$

Due to head of a water, hoop stress develops in a pipe

$$\sigma_n = \frac{pd}{2t} = 20 \times 10^6 \frac{\text{N}}{\text{m}^2}$$

$$\frac{\gamma h d}{2t} = 20 \times 10^6$$

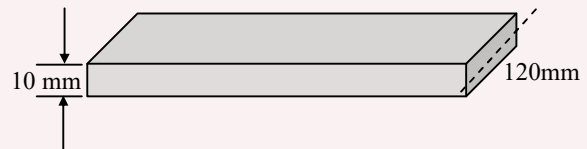
$$\frac{9.81 \times 10^3 \times 60 \times 750}{2 \times t} = 20 \times 10^6$$

$$\Rightarrow t = 11 \text{ mm}$$

78. A 120 mm wide and 10 mm thick steel plate is bent into a circular arc of 8 m radius. What is the bending moment which will produce the maximum stress ? (Take Young's modulus as 200 GPa)
- 250 Nm
 - 212 Nm
 - 200 Nm
 - 172 Nm

78. Ans: (a)

Sol:



$$b = 120,$$

$$h = 10 \text{ mm}$$

$$R = 8 \text{ m} = 8000 \text{ mm}$$

Flexure formula, $\frac{E}{R} = \frac{M}{I} = \frac{\sigma_b}{y}$

$$\sigma_b = \frac{My}{I} = \frac{Ey}{R}$$

$$M = \frac{EI}{R}$$

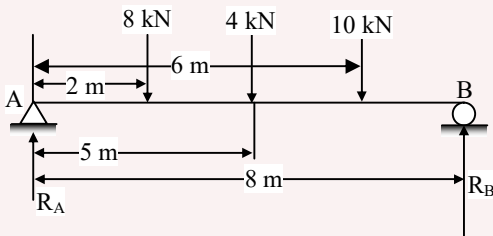
$$M = \frac{200 \times 10^3 \times 120 \times 10^3}{12} \times 10^{-3} \text{ N}$$

$$M = \frac{1000}{4} = 250 \text{ N-m}$$

79. A simply supported beam of 8 m length carries three-point loads of 8 kN, 4 kN and 10 kN at 2 m, 5 m and 6 m respectively from the left end. What are the left and right support reactions respectively?
- (a) 12 kN and 10 kN (b) 9 kN and 11 kN
 (c) 11 kN and 9 kN (d) 10 kN and 12 kN

79. Ans: (d)

Sol:



Find R_A and R_B

$$\Sigma F_y = 0$$

$$R_A + R_B = 22 \text{ kN}$$

$$\Sigma M_A = 0$$

$$R_B \times 8 = 8 \times 2 + 4 \times 5 + 10 \times 6$$

$$= 16 + 20 + 60 = 96$$

$$R_B = 12 \text{ N}$$

$$R_A = 10 \text{ N}$$

80. Which of the following is NOT used as support for beams?
- (a) Roller support
 (b) Hinged support
 (c) Fixed support
 (d) Independent support

80. Ans: (d)

Sol: Independent support is not used in beams.

81. The initial frictional resistance of an unloaded pulley block is 2.6 kN. The friction increases at the rate of 1.4 kN per 100 kN load lifted by the block. The velocity ratio is 18. The efficiency of the block at the load of 1200 kN is approximately
- (a) 64 %
 (b) 77 %
 (c) 85 %
 (d) 87 %

81. Ans: (b)

Sol: Frictional resistance = 2.6 kN

Total frictional resistance for overcoming 1200 kN.

$$= F_i + \left(\frac{1.4 \times 1200}{100} \right)$$

$$= 2.6 + \left(\frac{1.4 \times 1200}{100} \right) = 19.4$$

Actual effort required

$$P = P_{\text{ideal}} + P_{\text{frictional}}$$

$$= \frac{\text{load}}{(V.R)} + P_{\text{frictional}}$$

$$= \frac{1200}{18} + 19.4 = 86.06 \text{ kN}$$

$$\text{Efficiency, } \eta = \frac{\text{Load}}{\text{Effort}} \times \frac{1}{V.R}$$

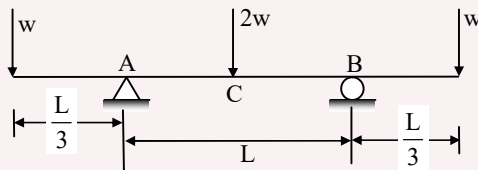
$$= \frac{1200}{86.06} \times \frac{1}{18} = 77.4\%$$

82. The distance between the supports of a simply supported beam is L . The beam has two equal overhangs of length $L/3$ over each support. The beam carries a point load $2W$ at the centre and a point load W at each end. Deflection at the centre is

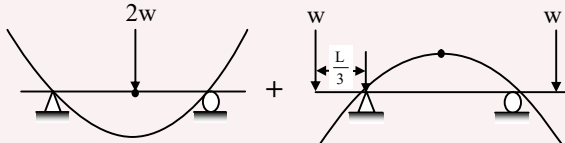
- (a) 1.8 mm (b) 7.2 mm
(c) 0 mm (d) 3.6 mm

82. Ans: (c)

Sol:



Method of superposition:



$$\delta = \frac{ML^2}{8EI} \quad \left(\text{here } M = w \times \frac{L}{3} \right)$$

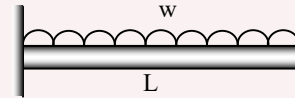
$$\delta_c = \frac{2w \times L^3}{48EI} - \frac{w \times \frac{L}{3} \times L^2}{8EI} = 0$$

83. The maximum bending moment at the fixed end in a cantilever of length L carrying a uniformly distributed load W per unit length across the whole span is

- (a) $WL^2/2$ (b) $WL^2/4$
(c) $WL^3/4$ (d) $WL^3/8$

83. Ans: (a)

Sol:



$$M_{\max} = W_L \times \frac{L}{2} = \frac{WL^2}{2}$$

84. A body of weight 100 N is placed on a rough horizontal plane. If a horizontal force of 60 N just causes the body to slide over the horizontal plane, then the coefficient of friction between the body and the horizontal plane is

- (a) 0.6 (b) 0.3
(c) 0.2 (d) 0.1

84. Ans: (a)

Sol: $F = \mu N = \mu \times 100 = F$

$$\therefore \mu = \frac{60}{100} = 0.6 \text{ N}$$

85. A fire engine raises water at the rate of 6000 litres per minute through a height of 2 m and discharges it at 10 m/s. The H.P. of fire engine is nearly equal to (Take acceleration due to gravity as 9.81 m/s^2)

- (a) 6.5 (b) 7.2
(c) 8.0 (d) 9.5

85. Ans: (d)

Sol: The total energy head imparted to the jet by fire engine is given by,

$$H = \frac{V^2}{2g} + z = \frac{10^2}{2 \times 10} + 2 = 7\text{m}$$

$$\text{Power} = \rho g Q H$$

$$= 1000 \times 10 \times \frac{6000 \times 10^{-3}}{60} \times 7$$

$$= 7000 \text{ W}$$

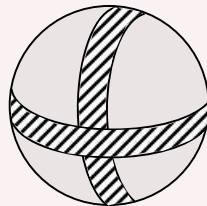
$$= \frac{7000}{746} \text{ hp} = 9.38 \text{ hp}$$

86. A spherical vessel has 1 m diameter. It is subjected to internal pressure of 1.5 N/mm^2 . If maximum stress is not to exceed 200 N/mm^2 and joint efficiency is 80%, then the thickness of the plate required is

- (a) 3.20 mm (b) 4.21 mm
(c) 5.22 mm (d) 2.34 mm

86. Ans: (d)

Sol:



Given: $d = 1 \text{ m}$

$$P = 1.5 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma_{\max} = 200 \text{ MPa}$$

$$\eta_{\text{joint}} = 80 \% = 0.8, \quad t = ?$$

$$\sigma_n = \frac{pd}{4t \eta_{\text{joint}}} = 200 \text{ MPa}$$

$$\frac{1.5 \times 1000}{4 \times t \times 0.8} = 200$$

$$t = \frac{15}{8 \times 0.8} = \frac{15}{6.4} = 2.34 \text{ mm}$$

87. A material has modulus of rigidity equal to $0.4 \times 10^5 \text{ N/mm}^2$ and bulk modulus equal to $0.75 \times 10^5 \text{ N/mm}^2$. The Poisson's ratio is

- (a) 0.2736 (b) 0.1927
(c) 0.3121 (d) 0.4376

87. Ans: (a)

Sol: Given, $G = 0.4 \times 10^5$

$$K = 0.75 \times 10^5$$

$$\nu = ?$$

$$E = 2G(1 + \nu) = 3K(1 - 2\nu)$$

$$2 \times 0.4 \times 10^5 (1 + \nu) = 3 \times 0.75 \times 10^5 (1 - 2\nu)$$

$$\Rightarrow \nu = 0.2736$$

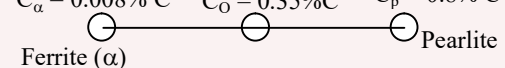
88. For a 99.65 wt% Fe-0.35 wt% C alloy at a temperature just below the eutectoid, the fractions of the proeutectoid ferrite and pearlite are respectively

- (a) 0.44 and 0.56 (b) 0.56 and 0.44
(c) 0.044 and 0.056 (d) 0.056 and 0.044

88. Ans: (b)

Sol: Lever line (at room temperature) (as per options)

$$C_\alpha = 0.008\% \text{ C} \quad C_o = 0.35\% \text{ C} \quad C_p = 0.8\% \text{ C}$$



$$m_{\text{pro-eutectoid-}\alpha} = \frac{C_p - C_o}{C_p - C_\alpha}$$

$$= \frac{0.8 - 0.35}{0.08 - 0.008} = 0.56$$

$$m_{\text{pearlite}} = 1 - m_{\text{pro-eutectoid-}\alpha}$$

$$= 1 - 0.56 = 0.44$$

89. Consider the following statements regarding the mechanical behavior of iron-carbon alloys:

1. Martensitic steels are most ductile.
2. Tempered martensite is relatively brittle.
3. Fine pearlite is more brittle than coarse pearlite.

Which of the above statements is/are correct?

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

89. Ans: (c)

Sol:

1. Martensite steels are brittle in nature, because of rapid cooling hardening strains are generated.
2. Tempered martensite is relatively ductile
3. Fine pearlite is more brittle than coarse pearlite

So, from the options given, only statement 3 correct.

90. Which of the following contain other alloying elements such as copper, vanadium, nickel and molybdenum in combined concentrations as high as 10 wt%, and possess higher strengths than the plain low-carbon steels?

- (a) Alloy steels
(b) Medium carbon steels
(c) Stainless steels
(d) High-strength, low-alloy steels

90. Ans: (d)

Sol: High strength low alloy steel: It is a low alloy steel with alloy content less than 10%. Out other alloying elements Cu, V, Ni, Mo are added to increase strength.

91. Which one of the following is the angle through which the cam turns during the time the follower rises?

- (a) Angle of ascent (b) Angle of dwell
(c) Angle of descent (d) Angle of action

91. Ans: (a)

Sol: Angle of ascent: The angle turned by the cam during which follower rises.

Angle of dwell: The angle turned by the cam during which follower does not move.

Angle of descent: The angle turned by the cam during which follower moves downwards.

Angle of action: Angle of action of cam is defined as the angle moved by the cam from beginning of ascent to the termination of descent.

92. Consider the following statements regarding cams:

1. Base circle is the smallest circle tangent to the cam profile (contour) drawn from the centre of rotation of a radial cam.
2. Pitch curve is the curve drawn by the trace point assuming that the cam is fixed, and the trace point of the follower rotates around the cam.
3. Pitch circle is the circle passing through the pitch point and concentric with the base circle.
4. The smallest circle drawn tangent to the pitch curve is known as the prime circle.

Which of the above statements are correct?

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

92. Ans: (d)

Sol: Base circle :

- It is the smallest circle that can be drawn tangential to the cam profile.
- The base circle decides the overall size of a cam and is, therefore, a fundamental feature of the cam.

Pitch curve :

- It is the curve generated by the trace point as the follower moves relative to the cam.
- For a knife edge follower, the pitch curve and the cam profile are same whereas for a roller follower, they are separated by the radius of the roller.

Prime circle :

- It is the smallest circle that can be drawn from the centre of the cam and tangent to the pitch curve.
- For a knife edge and a flat face follower, the prime circle and the base circle are identical. For a roller follower, the prime circle is larger than the base circle by the radius of the roller.

Pitch circle: It is a circle drawn from the centre of the cam through the pitch points.

93. Consider the following statements regarding acceleration analysis:

1. A graphical method to find the location of the centre of curvature of the locus of a point on a moving body, is known as Bobillier construction.
2. A graphical method by which inflection circle can be drawn without requiring the curvatures of the centrodes, is known as Hartmann construction.
3. Bobillier theorem states that the angle subtended by one of the rays with the centrode tangent is equal to negative of the angle subtended by the other ray with the collineation axis.

Which of the above statements is/are correct?

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

93. Ans: (b)

Sol:

- Hartmann construction is a graphical method to find the location of the centre of curvature of the locus of a point on a moving body.
- Bobillier construction is method by which inflection circle can be drawn without requiring the curvature of centrodes.
- Bobillier theorem states that the angle subtended by one of the rays with the centrode tangent is equal to negative of the angle subtended by the other ray with the collineation axis.

94. Consider the following parameters:

s = length of the shortest link,

l = length of the longest link,

p = length of one of the intermediate length links,

q = length of the other intermediate length links;

According to the Grashof's criteria, if $s + l > p + q$, then the category of four-bar mechanism is

- (a) Double crank (b) Crank-rocker
(c) Change point (d) Triple rocker

94. Ans: (d)

Sol: $s + l > p + q$, it is called as non-Grashof linkage, none of the links will be able to rotate fully, so it will be triple rocker mechanism.

95. A uniform disc of 150 mm diameter has mass of 5 kg. It is mounted centrally in bearings which maintain its axle in a horizontal plane. The disc spins about its axle with a constant speed of 1000 rpm, while the axle precesses uniformly about the vertical at 60 rpm. The gyroscopic couple acting on the disc is approximately

- (a) 6.5 Nm (b) 7.2 Nm
(c) 8.5 Nm (d) 9.2 Nm

95. Ans: (d)

Sol: $d = 150$ mm, $m = 5$ kg
 $N = 1000$ rpm, $N_p = 60$ rpm

Gyroscopic couple,

$$C = I\omega\omega_p$$

$$= \left(\frac{mr^2}{2} \right) \left(\frac{2\pi N}{60} \right) \left(\frac{2\pi N_p}{60} \right)$$

$$= \left(\frac{5 \times (75 \times 10^{-3})^2}{2} \right) \times \left(\frac{2\pi \times 1000}{60} \right) \times \left(\frac{2\pi \times 60}{60} \right)$$

$$= 9.25 \text{ N-m}$$

96. A system of rotating masses is in dynamic balance when

- (a) there does not exist any resultant centrifugal force only
(b) there does not exist any resultant couple only
(c) there does not exist any resultant centrifugal force as well as resultant couple
(d) there exists both resultant centrifugal force and resultant couple

96. Ans: (c)

Sol: For static balancing: Summation of centrifugal forces is zero $\Sigma F = 0$. For dynamic balancing summation of centrifugal forces and moment of centrifugal forces is zero.

$$\Sigma F = 0$$

$$\Sigma M = 0$$

97. Wear rating of a long shoe drum brake is

- (a) directly proportional to friction power
- (b) directly proportional to brake shoe area
- (c) inversely proportional to friction torque on drum
- (d) inversely proportional to friction power

97. Ans: (a)

Sol: Rate of wear $\propto p.v \propto$ torque \propto power

$$\therefore \text{rate of wear} \propto p \propto \frac{1}{A}$$

\therefore more the power transmission, more the wear rate.

98. What is the required basic dynamic load rating, C, for a ball bearing to carry a radial load of 550 kg from a shaft rotating at 500 rpm that is part of an assembly conveyor in a manufacturing plant? (Take the design life as 1×10^9 rev)

- (a) 5000 kg
- (b) 5500 kg
- (c) 4000 kg
- (d) 4500 kg

98. Ans: (b)

Sol: For ball bearing $k = 3$

\therefore From load life relationship

$$L_{10} = \left(\frac{C}{P} \right)^k \times 10^6 \text{ rev}$$

Given design life

$$L_{40} = 1 \times 10^9 \text{ rev}$$

$$\therefore 1 \times 10^9 = \left(\frac{C}{550} \right)^3 \times 10^6$$

$$\frac{C}{550} = 10$$

$$C = 5500 \text{ kg}$$

99. A catalog lists the basic dynamic load rating for a ball bearing to be 8000 kg for a rated life of 1×10^6 rev. What is the expected L_{10} life of the bearing if it is subjected to a load of 4000 kg? (Take $k = 3$ for ball bearing)

- (a) 8×10^6 rev
- (b) 6×10^6 rev
- (c) 4×10^6 rev
- (d) 2×10^6 rev

99. Ans: (a)

Sol: Given $c = 8000$ kg at $L_{10} = 1 \times 10^6$ rev

$$p = 4000 \text{ kg}$$

$$k = 3 \text{ for Ball bearing}$$

$$L_{10} = \left(\frac{c}{p} \right)^k \times 10^6 \text{ rev}$$

$$L_{10} = \left(\frac{8000}{4000} \right)^3 \times 10^6 \text{ rev}$$

$$L_{10} = 8 \times 10^6 \text{ rev}$$

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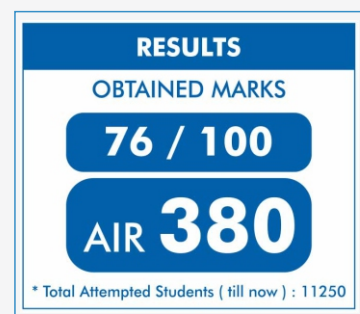
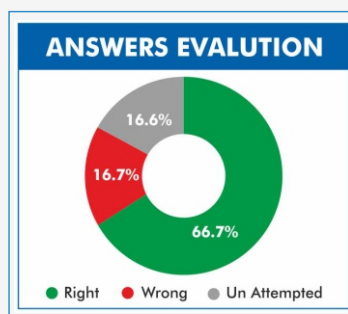
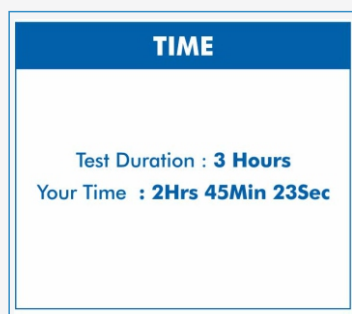
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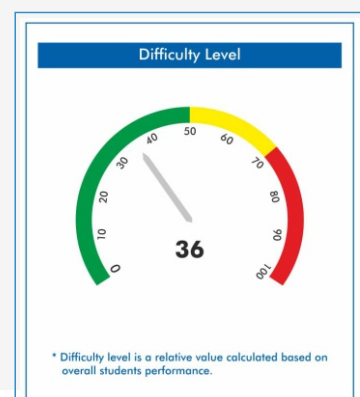
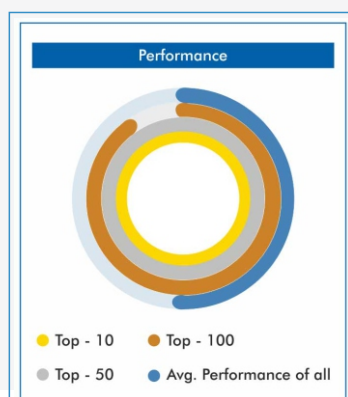
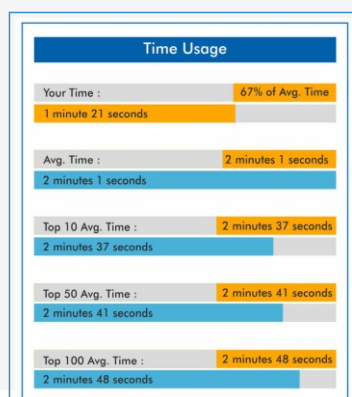
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TEST WISE STATISTICS:



QUESTION WISE STATISTICS:



100. Which of the following static loading failure theories is used for ductile materials?

- (a) Maximum shear stress theory
- (b) Maximum normal stress theory
- (c) Coulomb-mohr theory
- (d) Modified mohr theory

100. Ans: (a)

Sol: Maximum shear stress theory is generally used for Ductile materials and it gives most conservative (safe) results.

101. In shaft rigidity and dynamic considerations, shorter shaft lengths

- (a) increase deflections and reduce critical speeds
- (b) increase deflections and raise critical speeds
- (c) reduce deflections and reduce critical speeds
- (d) reduce deflections and raise critical speeds

101. Ans: (d)

Sol: Flexural rigidity of shaft is given

$$k = (c) \frac{EI}{\ell^3}$$

$c = \text{constant}$

$$k \propto \frac{1}{L^3}$$

Natural frequency / critical speed

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{\delta_{\text{static}}}}$$

$$\omega_n \propto \sqrt{k} \propto \frac{1}{(L^3)^{0.5}}$$

$$\delta_{\text{static}} = \frac{WL^3}{EI} \times \text{constant}$$

$$\delta_{\text{static}} \propto L^3$$

$$\text{As } L \downarrow \delta \downarrow \omega_n \uparrow$$

102. Wear performance of the brakes can be improved to

- (a) keep the pressure between the friction material and the material of the disc or drum as high as practical
- (b) specify friction materials that have low bonding strength between constituent particles
- (c) specify friction materials that have relatively high adhesion when in contact with the disc or drum material
- (d) provide high hardness on the surface of the disc or drum by heat treatment

102. Ans: (a)

Sol: Wear performance of the brakes can be improved to keep the pressure between the friction material and the material of the disc or drum as high as practical.

103. Consider the following statements regarding the parameters involved in the rating of clutches and brakes:

1. Torque required to accelerate or decelerate the system.

2. Time required to accomplish the speed change.
3. The cycling rate is required.

Which of the above statements is/are correct?

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

103. Ans: (b)

Sol: Power rating = $\frac{2\pi N.T}{60}$

∴ Power ∝ torque ∝ angular acceleration

Following statements are correct:

- Torque required to accelerate or decelerate the system.
- Time required to accomplish the speed change.

104. In the design of spur gear, the load-distribution factor can be minimized by specifying which of the following?

1. Accurate teeth
2. Narrow face widths
3. Long shaft spans between bearings

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

104. Ans: (a)

Sol:

- Accurate teeth lead is uniform load distribution.

- Narrow face width also leads to uniform load distribution.
- Long shaft spans leads to deflection and bending of shafts leads is non-uniform stress distribution.

105. Which one of the following fatigue failure criteria's is used in graphical method equation?

- (a) Soderberg fatigue failure criteria
(b) Goodman fatigue failure criteria
(c) Smith diagram fatigue failure criteria
(d) Gerber fatigue failure criteria

105. Ans: (b)

Sol: Goodman fatigue failure criteria is used in graphical method equation.

106. Which one of the following alloys is most suitable for applications in bearings, bushings, piston rings, steam fittings and gears?

- (a) Cartridge brass
(b) Tin bronze
(c) Leaded yellow brass
(d) Beryllium copper

106. Ans: (b)

Sol: Tin Bronze: Copper based alloy with major alloying element is Tin (89% Cu, 11% Tin).

Applications: Bearings, Bushings, Gears, Piston rings etc.

107. In general, annealing is carried out to

- (a) increase softness
- (b) increase stresses
- (c) decrease ductility
- (d) decrease toughness

107. Ans: (a)

Sol: Annealing process is applied to increase the ductility of the material and increases the softness.

108. Consider the following statements related to compute the equilibrium concentrations of the two phases:

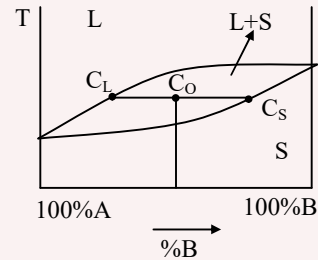
1. A tie line is constructed across the two-phase region at the temperature of the alloy.
2. The intersections of the tie line and the phase boundaries on either side are noted.
3. Perpendiculars are dropped from these intersections to the horizontal composition axis, from which the composition of each of the respective phases is read.

Which of the above statement is/are correct?

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

108. Ans: (d)

Sol: Statement (I), (II) and (III) are correct.



109. In which of the following microconstituents, α -Ferrite + Fe_3C phases are present?

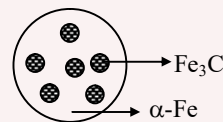
1. Spheroidite
2. Coarse pearlite
3. Fine pearlite

Select the correct answer using the code given below:

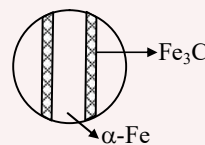
- (a) 1 and 2 only
- (b) 1 and 3 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

109. Ans: (d)

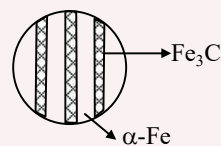
Sol: Spheroidite:



Coarse pearlite:



Fine pearlite:

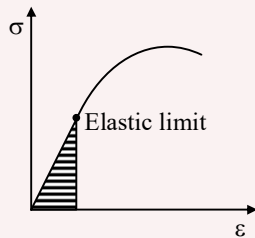


110. Which one of the following is the capacity of a material to absorb energy when it is deformed elastically and then, upon unloading, to have this energy recovered?

- (a) Resilience (b) Ductility
(c) Brittleness (d) Hardness

110. Ans: (a)

Sol: Resilience: It is the ability of the material that can absorb energy upto elastic limit.



Ductility: Ability of a material to be drawn or deformed without fracture.

111. What is the shape of indenter for Vickers microhardness testing technique?

- (a) Sphere
(b) Diamond cone
(c) Diamond pyramid
(d) Cube

111. Ans: (c)

Sol: Vicker's Hardness test: This method is used to measure hardness of very high hard materials.

Indenter tool = Diamond with pyramid shape

Applicable materials = SiC, WC, CBN, Si₃N, TiC, Diamond

Indented tool for Brinell's hardness test = Spherical head.

Rockwell hardness test = Cone shape.

112. Corrosion penetration rate is directly proportional to

- (a) Exposed specimen area
(b) Density
(c) Weight loss after exposure time
(d) Exposure time

112. Ans: (c)

Sol: Corrosion Penetration Rate:

$$CPR = \frac{KW}{\rho At}$$

W = Weight loss

ρ = Density

A = Exposed area

t = Exposed time

CPR ∝ Weight loss

113. Which one of the following measures is correct to reduce the effects of galvanic corrosion?

- (a) It uses cathode area as large as possible
(b) It avoids an unfavorable anode-to-cathode surface area ratio
(c) It uses an anode area as small as possible
(d) It electrically insulates similar metals from each other

113. Ans: (b)

Sol: Use small cathode area.

Use anode area as large as possible.

Avoid unfavourable anode to cathode surface area.

114. Consider the following statements regarding corrosion:

1. The formation of a film of atoms or molecules on the surface of an anode so that corrosion is slowed down, is called passivation.
2. Local corrosion attach resulting from the formation of small anodes on a metal surface, is known as intergranular corrosion.
3. Preferential corrosion occurring at grain boundaries or at regions adjacent to the grain boundaries, is called pitting corrosion.

Which of the above statements is/are correct?

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

114. Ans: (c)

Sol: 2nd and 3rd statements are incorrect.

Inter-granular corrosion occurs at grain boundaries.

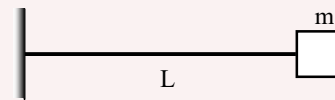
Pitting corrosion only at a point indepth from the surface.

115. A cantilever beam of negligible mass has a mass m at its free end. If the length of the cantilever is halved, what is the factor by which its natural frequency is increased?

- (a) $\sqrt{8}$ times (b) $\sqrt{6}$ times
(c) $\sqrt{5}$ times (d) $\sqrt{3}$ times

115. Ans: (a)

Sol:



$$\omega_{n1} = \sqrt{\frac{k}{m}} = \sqrt{\frac{3EI}{mL^3}}$$

If the length is halved

$$\omega_{n2} = \sqrt{\frac{3EI}{\left(\frac{L}{2}\right)^3}} = \sqrt{8 \cdot \frac{3EI}{mL^3}} = \sqrt{8} \omega_{n1}$$

116. Consider the following statements regarding kinematic pairs:

1. When a pair has a point or line contact between the links, it is known as lower pair.
2. When the elements of a pair are held together mechanically, it is known as closed pair.
3. If two mating links have a turning as well as sliding motion between them, they form a screw pair.
4. When two links of a pair are in contact either due to force of gravity, they constitute an un closed pair.

Which of the above statements are correct?

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

116. Ans: (d)

Sol:

- When a pair has a point or line contact between the links it is known as higher.
- When the elements of a pair are held together mechanically, it is known as closed pair.
- If two mating links have a turning as well as sliding motion between them, they form a screw pair.
- When two links of a pair are in contact either due to force of gravity, they constitute an un closed pair.

117. The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 rpm clockwise when looking from stern. If the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h, then the gyroscopic couple is

- (a) 22.27 kN-m (b) 21.27 kN-m
 (c) 12.47 kN-m (d) 11.47 kN-m

117. Ans: (a)

Sol: $M = 3500 \text{ kg}$

$k = 0.45 \text{ mts}$

$N = 3000 \text{ rpm}$

$V = 36 \text{ kmph} = 10 \text{ m/sec}$

$R = 100 \text{ mts}$

Gyroscopic couple:

$$C = I\omega\omega_p$$

$$= mk^2 \cdot \omega \left(\frac{V}{R} \right)$$

$$= 3500 \times (0.45)^2 \times \left(\frac{2\pi \times 3000}{60} \right) \left(\frac{10}{100} \right)$$

$$= 22.27 \text{ kN-m}$$

118. Consider the following statements regarding governors:

1. A Wilson governor is a spring controlled governor in which the vertical arms of the bell-crank lever are fitted with spring balls.
2. A Hartung governor is a spring-loaded type governor in which two bell-crank levers are pivoted at the ends of two arms which rotate with the spindle.
3. In a spring-controlled gravity governor, two bell-crank levers are pivoted on the moving sleeve.
4. In a Watt governor, a pair of balls (masses) is attached to a spindle with the help of links.

Which of the above statements are correct?

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

118. Ans: (b)

Sol:

- Wilson Hartnell Governor main spring is arranged symmetrically on either side of the axis and it connects two flying balls on the vertical arms of bell crank lever. Statement 1 is correct.
- In Hartung governor the arms are pivoted at the point which is intersection of vertical and horizontal arms. Statement 2 is correct.
- In a spring-controlled gravity governor, two bell-crank levers are pivoted on the moving sleeve. Statement 3 is correct.
- In a Watt governor, a pair of balls (masses) is attached to a spindle with the help of links. Statement 4 is correct.

119. Which one of the following principles states that the inertia forces and couples, and external forces and torques on a body together give statical equilibrium?

- (a) D'Alembert principle
- (b) Paul Ehrlich principle
- (c) David Hibert principle
- (d) Edward Jenner principle

119. Ans: (a)

Sol: D'Alembert principle states that the inertia forces and couples, and external forces and torques on a body together give statical equilibrium.

120. Consider the following statements regarding gears:

1. A cycloid is the locus of a point on the circumference of a circle that rolls without slipping on a fixed straight line.
2. A hypocycloid is the locus of a point on the circumference of a circle that rolls without slipping on the circumference of another circle.
3. An epicycloid is the locus of a point on the circumference of a circle that rolls without slipping inside the circumference of another circle.

Which of the above statements is/are correct?

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

120. Ans: (d)

Sol:

- A cycloid is the locus of a point on the circumference of a circle that rolls without slipping on a fixed straight line.
- A hypocycloid is the locus of a point on the circumference of a circle that rolls without slipping inside the circumference of another circle.
- An epicycloid is the locus of a point on the circumference of a circle that rolls without slipping on the circumference of another circle.

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121. Consider the following statements regarding microprocessors and micro-controllers:

1. A microcontroller is a single, very large-scale integrated chip that contains programmable electronic components.
2. Address bus carries the signals relating to control actions.
3. A microcomputer consists of a central processing unit, I/O interface and a memory block.

Which of the above statements are correct?

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

121. Ans: (c)

Sol: *Control bus* The signals relating to control actions are carried by the control bus.

The address bus carries signals which indicate where data is to be found and so the selection of certain memory locations or input or output ports. So given statement (2) is INCORRECT. By option elimination method the CORRECT option is (c).

Structure of Microcomputer: A microcomputer consists of three sections, a central processing unit (CPU), and I/O interface and a memory block.

So given statement (3) is CORRECT.

122. Consider the following statements regarding microprocessor instructions:

1. Compare instruction reads the contents of a particular memory location and copied to a specific register in the processor.
2. Jumps instruction changes the sequence in which the program is being carried out.
3. Decrement instruction subtracts 1 from the contents of a specified location.

Which of the above statements are correct?

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

122. Ans: (b)

Sol: *Compare instruction* indicates whether the contents of a register are greater than, less than or the same as the contents of a specified memory location.

Load instruction reads the contents of a specified memory location and copies it to a specified register location in the central processing unit (CPU). So given statement (1) is INCORRECT.

Jump or branch instruction changes the sequence in which the program steps are carried out. So given statement (2) is correct.

Decrement instruction subtracts 1 from the contents of a specified location. So given statement (3) is CORRECT. Hence option (b) is correct.

123. Which one of the following statements is correct regarding characteristic parameters used in transducers?

- (a) Span is the deviation of the true value from the desired value
- (b) Precision is defined as the degree of exactness for which an instrument is designed or intended to perform
- (c) Sensitivity is the difference in the output for a given input when the value is approached from the opposite direction
- (d) Hysteresis of an instrument is defining as the ratio of the magnitude of the output signal to the magnitude of the input signal.

123. Ans: (b)

Sol: Characteristic Parameters Used in Transducers:

Static Characteristics :

The static characteristics of an instrument are considered for instruments that are used to measure unvarying process conditions. All the static performance characteristics are obtained by one form or another of a process called calibration. There are a number of related definitions such as accuracy, precision, repeatability, reproducibility, sensitivity, drift, etc. that are described as follows:

1. Range:

2. Span: It is the difference between the maximum and minimum values of the quantity to be measured.

That is, Span = Maximum value of the input - Minimum value of the input

3. Error:

4. Accuracy :

5. Precision: It is defined as the degree of exactness for which an instrument is designed or intended to perform. It refers to the repeatability or consistency of measurements when the measurements are carried out under identical conditions at short intervals of time. It can also be defined as the ability of the instrument to reproduce a group of measurements of the same measured quantity under the same conditions.

6. Sensitivity: Sensitivity of an instrument is defined as the ratio of the magnitude of the output signal to the magnitude of the input signal. It denotes the smallest change in the measured variable to which the instrument responds. It is the relationship indicating how much output may be obtained per unit input.

$$\text{Sensitivity} = \frac{\text{Output}}{\text{Input}}$$

$$= \frac{\text{Maximum} - \text{Minimum values given}}{\text{Full range}} \times 100$$

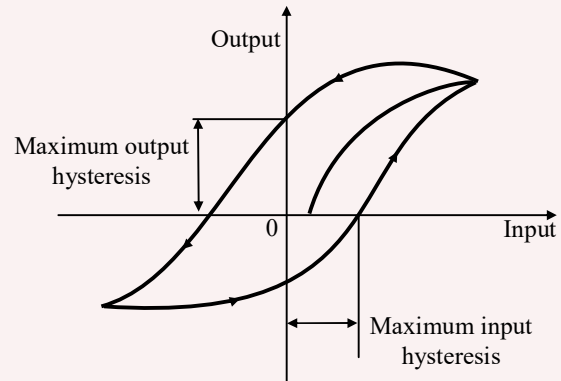
The static sensitivity is defined as the slope of the calibration curve :

Sensitivity

$$= \frac{\text{Infinitesimal change of output signal}}{\text{Infinitesimal change of input signal}}$$

$$= \frac{\Delta q_o}{\Delta q_i}$$

7. **Hysteresis:** Hysteresis defines the difference in the output for a given input when this value is approached from the opposite direction. This phenomenon occurs in many mechanical, electrical, physical and chemical processes. In mechanical terms, hysteresis means that both the loading and unloading curves do not coincide. Hysteresis can be identified while testing an instrument for repeatability. It is often seen that input-output graphs do not coincide for continuously ascending and then descending values of the input. Figure shows the hysteresis effect on an input and output graph. As shown in the figure, we can obtain the two different values of output for the same value of input under increasing and decreasing conditions. The difference between these two output values is called hysteresis. The maximum input hysteresis and maximum output hysteresis are shown in Figure.



So given options (a), (c) and (d) are INCORRECT and option (b) is CORRECT.

124. Consider the following statements regarding dynamic quantities in sensors and transducers:
1. The maximum amount by which the moving parts move beyond the steady state is known as over shoot.
 2. An output whose magnitude does not repeat with time is known as transient.
 3. An output whose magnitude has a definite repeating time cycle is called steady state periodic.

Which of the above statements are correct?

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

124. Ans: (d)

Sol: Dynamic Characteristics:

In many practical cases, the parameters to be measured are time varying, that is, they are dynamic in nature. Thus, the output of an instrument is also time varying. The behavior of an instrument under such time-

varying input-output conditions is called the dynamic response of an instrument. The analysis of such dynamic response is called dynamic analysis of the measurement system.

Dynamic quantities are of two types, namely,

1. **Steady-state periodic:** An output whose magnitude has a definite repeating time cycle is called steady-state periodic.

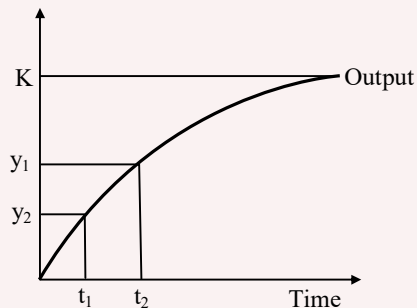


Fig: Step response of the first order system

2. **Transient:** An output whose magnitude does not repeat with time is known as transient.

The system response of first order and second order can be described by following specification parameters.

- **Over shoot:** The maximum amount by which the moving parts move beyond the steady state is known as an over shoot.
- Time constant
- Response time
- Rise time
- Setting time
- Types of input

So given all three statements are CORRECT. Hence (d) option is CORRECT.

125. Consider the following statements regarding encoders:

1. An encoder is a device that provides a digital output in response to a linear or angular displacement.
2. A digital optical encoder is a device that converts motion into a sequence of digital pulses.
3. An incremental encoder produces equally spaced pulses from one or more concentric tracks on the code disk.

Which of the above statements are correct?

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

125. Ans: (d)

Sol: An encoder is a device that provides a digital output in response to a linear or angular displacement. An optical encoder is a suitable transducer for the measurement of angular position and has the added advantage of having a digital output. An optical encoder has four main parts: a light source, a code disk, a light detector and a signal conditioner. Most rotary encoders are composed of a glass or plastic code disk with a photographically deposited radial pattern organized in tracks. A digital optical encoder is a device that converts motion into

a sequence of digital pulses. By counting or decoding these bits, the pulses can be converted into relative or absolute position measurements. Optical encoders are in rotary or linear configurations. The rotary encoders are of two forms: absolute encoder and incremental encoder.

The **absolute encoder** is designed to produce a unique digital word corresponding to each rotational position of the shaft that distinguishes "N" distinct positions of the shaft.

An **incremental encoder** produces equally spaced pulses from one or more concentric tracks on the code disk. Each track has its own light beam. Thus, an encoder with 3 tracks will have three light sources and three light sensors.

So given all three statements are CORRECT. Hence (d) option is CORRECT.

126. Which one of the following statements is NOT correct regarding accelerometers?

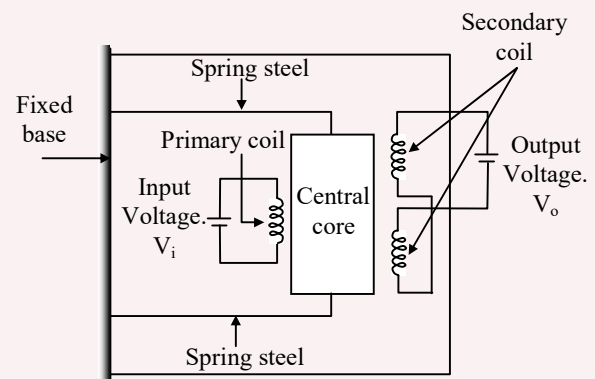
- In displacement seismic accelerometer, the displacement of seismic mass is measured by displacement transducer itself.
- In strain gauge accelerometer, the seismic mass is placed on a cantilever beam placed inside the housing.
- In potentiometric accelerometer, in a spring-mass-damper system, the mass

is connected with the wiper arm of the potentiometer.

- The LVDT accelerometer consist of one primary and four secondary windings which are placed on either side of central core.

126. Ans: (d)

Sol: The LVDT accelerometer (Figure) consists of one primary and two secondary windings which are placed on either side of a central core. The two ends of the core are connected with spring steel but these are already placed in a casing. If the core is exactly placed at the center, the voltage produced between primary and secondary windings will be exactly equal; this voltage is called static field voltage.



Thus this LVDT circuit is nullified. If any vibration occurs on the casing of the LVDT accelerometer, the core placed between the primary and secondary coil will either move upward or downward. Owing to this, the voltage is induced in the secondary coil

according to the movement of the core. Now, the difference in voltage arises in the output terminal. This output voltage is directly proportional to the vibrations or acceleration.

So given options (a), (b) and (c) are CORRECT and option (d) is INCORRECT.

127. Which one of the following valves restricts or throttles the fluid in a particular direction to influence the volumetric flow of the fluid?
- (a) Check valve
 - (b) Flow control valve
 - (c) Quick exhaust valve
 - (d) Sequence valve

127. Ans: (b)

Sol: The check valves allow the flow in one direction and in the other direction the flow is blocked.

The flow control valve restricts or throttles the fluid in a particular direction to influence the volumetric flow of the fluid. The flow control is very important to regulate the speed of hydraulic or pneumatic actuator.

The quick exhaust valve is used to vent a cylinder quickly by providing a shortcut for exhausting air. The sequence valve is used in a pneumatic circuit for switching operation depending upon a preset pressure. The sequence valve opens once its inlet pressure rises above a preset pressure.

So given options (a), (c) and (d) are CORRECT and option (b) is CORRECT.

128. Which one of the following instructions is conditional instruction which allow the user to change the order in which the processor scans the program?
- (a) Sequence instruction
 - (b) Communications instructions
 - (c) Control instruction
 - (d) Arithmetic instruction

128. Ans: (c)

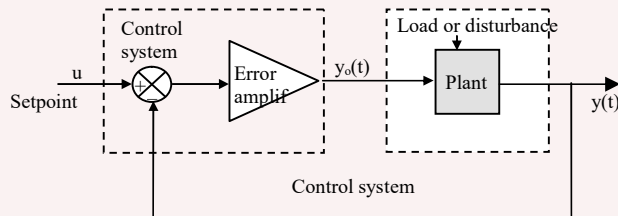
Sol: *Control instruction* are conditional or output instructions which allow the user to change the order in which the processor scans the program.

The purpose of these instructions are to minimize scan time, create a more efficient program and provide diagnostic programming tools to facilitate troubleshooting.

129. Which one of the following signals are external commands signals provided to the controller?
- (a) Control signals
 - (b) Controlled signals
 - (c) Disturbance signals
 - (d) Setpoint signals

129. Ans: (d)

Sol: Setpoint signals are external commands signals provided to the controller.



130. Which one of the following is the smallest increment of movement into which the robot can divide its work volume?

- (a) Spatial resolution of a robot
- (b) Accuracy of a robot
- (c) Repeatability of a robot
- (d) Compliance of a robot

130. Ans: (a)

Sol: The spatial resolution of a robot is the smallest increment of movement into which the robot can divide its work volume. Spatial resolution depends on two factors: the system's control resolution and the robot's mechanical inaccuracies.

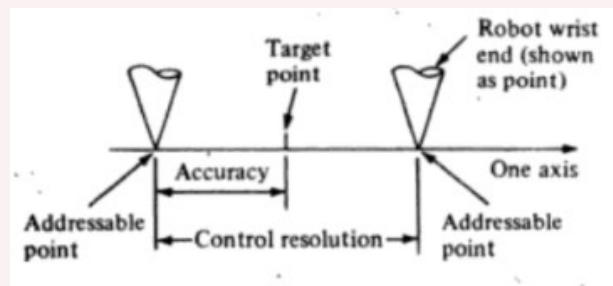


Fig: Illustration of accuracy and control resolution when mechanical inaccuracies are assumed to be zero.

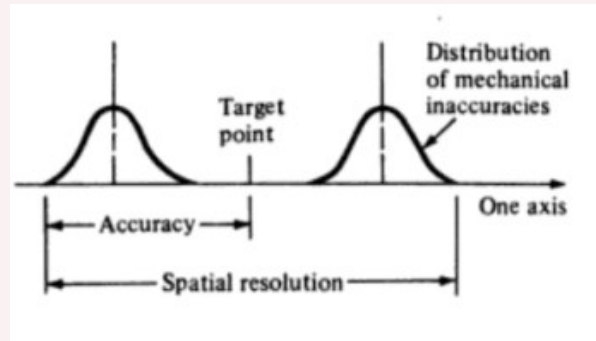
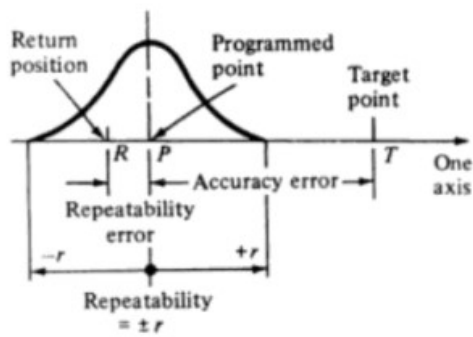


Fig: Illustration of accuracy and spatial resolution in which mechanical inaccuracies are represented by a statistical distribution.

Accuracy refers to a robot's ability to position its wrist end at a desired target point within the work volume.

Repeatability

Repeatability is concerned with the robot's ability to position its wrist or an end effector attached to its wrist at a point in space that had previously been taught to the robot. Repeatability and accuracy refer to two different aspects of the robot's precision. Accuracy relates to the robot's capacity to be programmed to achieve a given target point. The actual programmed point will probably be different from the target point due to limitations of control resolution. Repeatability refers to the robot's ability to return to the programmed point when commanded to do so.



The compliance of the robot manipulator refers to the displacement of the wrist end in response to a force or torque exerted against it. A high compliance means that the wrist is displaced a large amount by a relatively small force. The term "springy" is sometimes used to describe a robot with high compliance. A low compliance means that the manipulator is relatively stiff and is not displaced by a significant amount.

So given options (b), (c) and (d) are INCORRECT and option (a) is CORRECT.

131. Which one of the following sensors is a special type of force sensor composed of a matrix of force-sensing elements?
- (a) Touch sensor
 - (b) Tactile array sensor
 - (c) Range sensor
 - (d) Proximity sensor

131. Ans: (b)

Sol: Touch sensors are used to indicate that contact has been made between two objects

without regard to the magnitude of the contacting force.

Tactile array sensors A tactile array sensor is a special type of force sensor composed of a matrix of force-sensing elements. The force data provided by this type of device may be combined with pattern recognition techniques to describe a number of characteristics about the impression contacting the array sensor surface.

Proximity and Range Sensors: Proximity sensors are devices that indicate when one object is close to another object. How close the object must be in order to activate the sensor is dependent on the particular device. The distances can be anywhere between several millimeters and several feet. Some of these sensors can also be used to measure the distance between the object and the sensor, and these devices are called range sensors. Proximity and range sensors would typically be located on the wrist or end effector since these are the moving parts of the robot.

So given options (a) (c) and (d) are INCORRECT.

Hence (b) option is CORRECT.

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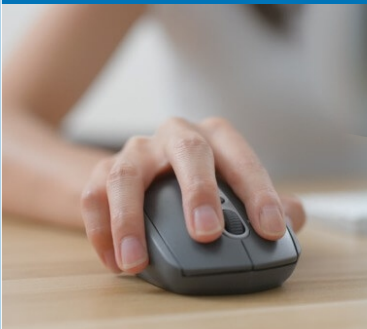
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132. Consider the following statements regarding robot end effectors:

1. Magnetic gripper can be a very feasible means of handling ferrous materials.
2. Hooks can be used as end effectors to handle containers of parts and to load and unload parts hanging from overhead conveyors.
3. Scoops and ladles can be used to handle certain materials in liquid or powder form.

Which of the above statements are correct?

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

132. Ans: (d)

Sol: Magnetic Grippers:

Magnetic grippers can be a very feasible means of handling ferrous materials. The stainless steel plate would not be an appropriate application for a magnetic gripper because 18-8 stainless steel is not attracted by a magnet. Other steels, however, including certain types of stainless steel, would be suitable candidates for this means of handling, especially when the materials are handled in sheet or plate form.

Hooks, Scoops, and Other Miscellaneous Devices

A variety of other devices can be used to grip parts or materials in robotics applications. Hooks can be used as end

effectors to handle containers of parts and to load and unload parts hanging from overhead conveyors. Obviously, the items to be handled by a hook must have some sort of handle to enable the hook to hold it.

Scoops and ladles can be used to handle certain materials in liquid or powder form. Chemicals in liquid or powder form, food materials, granular substances, and molten metals are all examples of materials that can be handled by a robot using this method of holding. One of its limitations is that the amount of material being scooped by the robot is sometimes difficult to control. Spillage during the handling cycle is also a problem.

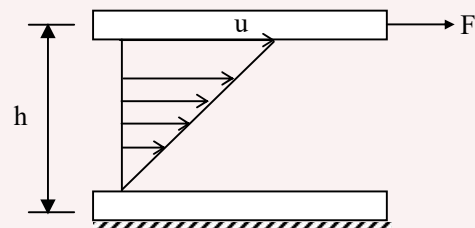
So given all three statements are Correct. Hence (d) option is CORRECT.

133. A flat plate of area $1.5 \times 10^6 \text{ mm}^2$ is pulled with a speed of 0.4 m/s relative to another plate located at a distance of 0.15 mm from it. What is the power required to maintain this speed, if the fluid separating them is having viscosity as 1 poise?

- (a) 160 W (b) 158 W
 (c) 145 W (d) 130 W

133. Ans: (a)

Sol:



$$\begin{aligned}
 \text{Power} &= F \times V \\
 &= \tau \times A \times V \\
 &= \mu \frac{V}{h} A \times V \\
 &= \frac{\mu V^2 A}{h} \\
 &= \frac{0.1 \times 0.4^2 \times 1.5 \times 10^6 \times 10^{-6}}{0.15 \times 10^{-3}} = 160 \text{ W}
 \end{aligned}$$

134. A gas weighs 16 N/m^3 at 25°C and at an absolute pressure 0.25 N/mm^2 . What is the gas constant approximately ? (Take acceleration due to gravity as 9.81 m/s^2)

- (a) $514.68 \text{ Nmkg}^{-1} \text{ K}^{-1}$
- (b) $542.55 \text{ Nmkg}^{-1} \text{ K}^{-1}$
- (c) $562.68 \text{ Nmkg}^{-1} \text{ K}^{-1}$
- (d) $592.55 \text{ Nmkg}^{-1} \text{ K}^{-1}$

134. Ans: (a)

Sol: $w_{\text{gas}} = 16 \text{ N/m}^3 \Rightarrow$ Specific weight

$$P = 0.25 \text{ N/mm}^2; \quad T = 25^\circ\text{C}$$

$$R \text{ (J/kg.K)?}$$

$$g = 9.81 \text{ m/s}^2$$

$$w = \frac{W}{V} = 16 \text{ N/m}^3$$

$$W = mg$$

$$16 = m \times 9.81$$

$$m = 1.630 \text{ kg}$$

$$PV = mRT$$

$$\frac{0.25}{(10^{-3})^2 \times 10^3} \times 1 = 1.630 \times R \times (25 + 273)$$

$$R = 0.5146 \text{ kJ/kg.K}$$

$$R = 514.67 \text{ J/kg.K}$$

Alternate:

$$w = \frac{W}{V}$$

$$w = \frac{mg}{V}$$

$$w = \rho g \Rightarrow \left(\rho = \frac{w}{g} \right)$$

$$P = \rho RT$$

$$P = \frac{wRT}{g}$$

$$Pg = wRT$$

$$R = \frac{Pg}{wT} = \frac{250 \times 9.81}{16 \times 298}$$

$$= \frac{250 \times 10}{16 \times 300} = \frac{2500}{4800} = \frac{25}{48} \approx 0.51$$

$$R = 0.5146 \text{ kJ/kg.K}$$

$$R = 514.67 \text{ J/kg.K}$$

135. A pipe contains an oil of specific gravity 0.9.

A differential manometer connected to the two points A and B shows a difference in mercury level as 15 cm. What is the difference of pressure at the two points?

(Take acceleration due to gravity as 9.81 m/s^2 , specific gravity of mercury as 13.6 and density of water as 1000 kg/m^3)

(a) 18688 N/m^2

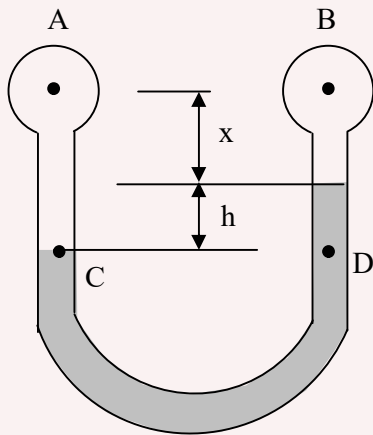
(b) 19688 N/m^2

(c) 15688 N/m^2

(d) 17866 N/m^2

135. Ans: (a)

Sol:



$$P_C = P_D$$

$$P_A + \rho_o gx + \rho_o gh = P_B + \rho_o gx + \rho_m gh$$

$$\therefore P_A - P_B = (\rho_m - \rho)gh$$

$$= (13600 - 900) \times 9.81 \times 0.15$$

$$= 18688 \text{ Pa}$$

136. Which one of the following is used in case in which the clutch runs free when the machine is being driven in the intended direction?

- (a) Overrunning (b) Backstopping
(c) Under running (d) Front stopping

136. Ans: (a)

Sol: **Backstopping:**

In backstop applications, clutches allow the drive shaft to rotate freely in one direction. As soon as torque is reversed, the clutch automatically engages with a fixed frame to prevent any movement in the opposite direction. Backstop clutches are used as a

safety measure to prevent reverse movement of incline conveyors, bucket elevators, or pump systems. They not only help protect critical equipment from damage, they also help ensure worker safety.

Overrunning:

An overrunning clutch or coupling permits the driven member of a machine to “freewheel” or “overrun” because the driver is stopped or because another source of power increases the speed of the driven mechanism. The construction uses rollers or balls mounted between an outer sleeve and an inner member having cam flats machined around the periphery. Driving action is obtained by wedging the rollers between the sleeve and the cam flats. This clutch is therefore equivalent to a pawl and ratchet with an infinite number of teeth.

In many overrunning applications, clutches spin freely the majority of the time, occasionally being called upon to engage and drive. A common application for overrunning clutches is a two-speed drive, where two motors with different output speeds are connected to a single driven shaft through one-way clutches. When the primary motor drives the machine at a low speed, the clutch engages. When the secondary electric motor drives the machine, the clutch overruns, switching from low speed to high speed.

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EE : 4

EC : 09

CS : 03

IN : 08

XE : 06

137. In a band brake, the tension in the band decreases from the value P_1 at the pivot side of the band to P_2 at the lever side. If r is the radius of the drum, then the net torque on the drum is

- (a) $(P_1 - P_2)/r$ (b) $(P_1 - P_2)r$
 (c) $(P_1 + P_2)/r$ (d) $(P_1 + P_2)r$

137. Ans: (b)

Sol: Braking torque, $T_B = \text{frictional force} \times \text{radius}$

Note: In band brake, difference in tension of band is due to frictional force

$$\therefore T_B = (P_1 - P_2)r$$

138. Consider the following statements regarding transmission shafts:

1. Counter shaft is secondary shaft which is driven by the main shaft from which the power is supplied to a machine component.
2. Jack shaft is an intermediate shaft between two shafts that is used in transmission of power.
3. A line shaft consists of a number of shafts, which are connected in an axial direction by means of couplings.

Which of the above statements is/are correct?

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

138. Ans: (d)

Sol:

- Counter shaft is the secondary shaft of gear box which is connected to main shaft (or) power shaft that transmit power to the wheels of an automobile counter shaft rotates in the opposite direction to main shaft.
- Jackshaft is a counter shaft and it is also said to be the intermediate shaft that transmit power from driving shaft to driven shaft.
- A line shaft is a main shaft connected to a power source and transmits power to all the machines. Generally many shafts are coupled together to form a line shaft.

139. In the rolling process, if V_r is the velocity of roll surface, V_0 is the velocity of material at the entrance to the deformation zone and V_1 is the velocity of material at the exit of the rolls, then the forward slip is

- (a) $\frac{V_r}{V_1 - V_r} \times 100$ percent
 (b) $\frac{V_r}{V_r - V_0} \times 100$ percent
 (c) $\frac{V_1 - V_r}{V_r} \times 100$ percent
 (d) $\frac{V_r - V_0}{V_r} \times 100$ percent

139. Ans: (c)

Sol: The maximum percentage slip present in leading zone is called Forward slip.

$$\text{Forward slip} = \frac{V_1 - V_r}{V_r} \times 100\% .$$

The maximum percentage slip present in lagging zone is called Backward slip.

$$\text{Backward slip} = \frac{V_r - V_0}{V_r} \times 100\% .$$

140. Which one of the following fits is used for high-strength assemblies where high resulting pressures are required?

- (a) Light drive fit
- (b) Medium drive fit
- (c) Heavy drive fit
- (d) Force fit

140. Ans: (d)

Sol: For high strength assembly we always need a interference fit. Here we need to apply force between mating components so that there should not be any kind of relative motion present. This component should not give any motion between parts. Hence answer must be a press fit, force fit or interference fit.

141. In PERT , which one of the following is the estimator expects that he may come across some sort of uncertainties and many a time the things will go right?

- (a) Optimistic time

- (b) Pessimistic time

- (c) Likely time

- (d) Unlikely time

141. Ans: (a)

Sol: Optimistic time: It is a shortest possible time by which the activity can be completed and every thing goes right.

142. In which one of the following, the criticality of the item is most important than the cost factor of the item?

- (a) ABC analysis
- (b) VED analysis
- (c) p system
- (d) q system

142. Ans: (b)

Sol: VED analysis is base on criticality of usage.

V → Vital,

E → Essential

D → Desirable

143. Which one of the following is the projections on a pattern that is used to make recesses in the mould to locate the core?

- (a) Sprue
- (b) Core print
- (c) Gate
- (d) Riser

143. Ans: (b)

Sol: Core print: The open space provided in a mould to support the core is called a core print.

The core print is produced by providing the extensions on the pattern. Due to the

presence of projection or extension on the pattern during the removal of pattern it is damaging the mould walls, even it is removed by using wax pattern the placement of the core becomes difficult.

144. Which one of the following is a disadvantage of permanent mold or gravity die casting?
- The surface of casting becomes hard due to chilling effect
 - Good surface finish and surface details are obtained
 - The process requires more labor
 - Fast rate of production can be attained

144. Ans: (a)

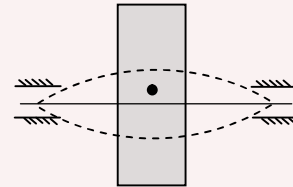
Sol:

- All four are advantages of permanent mould casting. Casting produced by permanent mould casting have hard surface and soft interior. Because of fast cooling sometimes outer surface may be brittle that is disadvantage of permanent mould casting.
- The surface finish produced in the metal mould is excellent.
- The labor cost required in permanent mould casting is less than sand casting.
- Casting produced by permanent casting is faster than sand casting.

145. In critical speed of a light shaft having a single disc without damping, the critical speed of the shaft is
- equal to the natural frequency of the system in longitudinal vibration
 - equal to the natural frequency of the system in torsional vibration
 - equal to the natural frequency of lateral vibration of the shaft.
 - no relationship to any of the natural frequency systems

145. Ans: (c)

Sol:



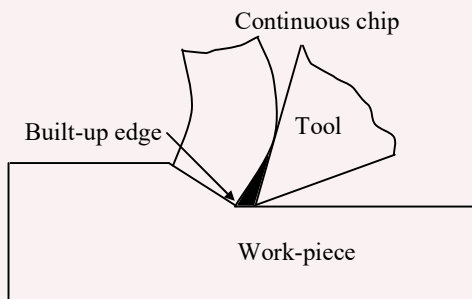
The critical speed is equal to natural frequency of transverse vibration / lateral vibration.

146. Which one of the following is formed due to large friction and stronger adhesion between chips and tool face?
- Continuous chip
 - Discontinuous chip
 - Continuous chip with built-up edge
 - Discontinuous chip with built-up edge

146. Ans: (c)

Sol: Continuous chip with built-up edge: A built-up edge (BUE) consists of layers of

material from the workpiece that are gradually deposited on the tool tip-hence the term built-up. When machining ductile materials at low-to medium cutting speeds, friction between tool and chip tends to cause portions of the work material to adhere to the rake face of the tool near the cutting edge. This formation is called a built-up edge (BUE).



147. Total Quality Management (TQM) and Quality assurance are the responsibility of everyone involved in designing and manufacturing of the product. Who among the following pioneers has NOT been quality control heightened?

- (a) Deming
- (b) Taguchi
- (c) Juran
- (d) B.F Skinner

147. Ans: (d)

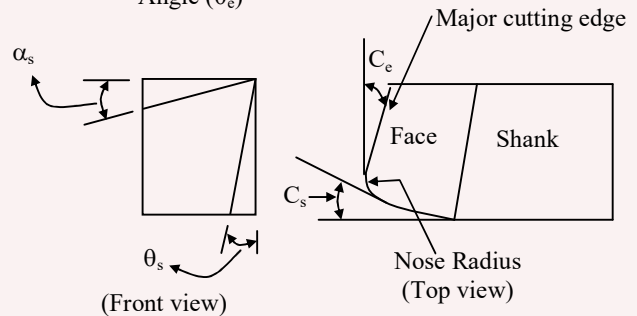
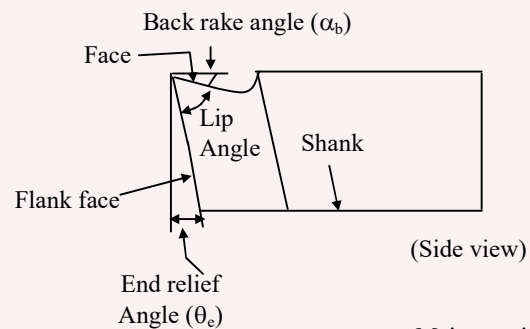
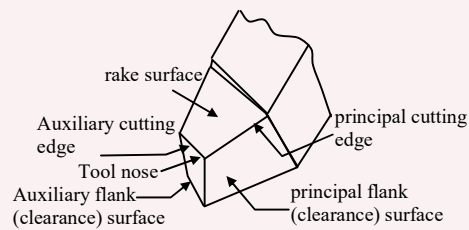
Sol: Deming, Tanuchi, and Juran pioneers is Total Quality Management (TQM). B.F. Skinner has no contributions towards TQM.

148. Which one of the following is the angle between the planes of end flank immediately below the end cutting edge and line perpendicular to the base and right angle to the axis?

- (a) Back rake angle
- (b) Side rake angle
- (c) End relief angle
- (d) Side relief angle

148. Ans: (c)

Sol: Total 6 angles are there and one nose radius. The surface or surface below and adjacent to the cutting edge is called flank of the tool.



149. Consider the following statements related to stepless drive of machine tools:

1. The spindle speeds available are fixed, it is not possible to use optimum cutting speeds with any of the workpiece diameters.
2. Changing the axial distance of the discs will vary the point of contact between the belt and disc.
3. The surface finish achieved will not be uniform.

Which of the above statements are correct?

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

149. Ans: (d)

Sol: Stepless drive systems doesn't provide vibrations, so surface finish achieved will be uniform.

150. Consider the following statements regarding machine vibration:

1. If the mechanical stresses are below the acceptable safe working stress levels of the materials involved, no direct protection methods are required.
2. If the stresses exceed the safe levels, corrective measures such as stiffening,

reduction of inertia and bending moment effects, and incorporation of further support members, as well as possible uses of isolators, may be required.

3. Shock isolators differ from vibration isolators in that shock requires a stiffer spring and a higher natural frequency for the resilient element.

Which of the above statements are correct?

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

150. Ans: (d)

Sol: The given statements are correct.

- If the mechanical stresses are below the acceptable level, no direct protection is required. Otherwise some measure must be taken like stiffening, reduction in inertia and bending moment effects.
- Shock isolators are used to limit the force transmitted to the surroundings of the equipment.
- Vibration isolation is the process of isolating an equipment from the source of vibration.

Hearty Congratulations to our

ESE - 2020 TOP RANKERS



CHARUDATTA S ME



SHASHANK GAUR EE



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GAGAN GHUNAWAT EE



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and many more...

TOTAL 36 RANKS IN TOP 10

ME 10

EE 09

E&T 10

CE 07

