

ESE 2022 Prelims

Mechanical Engineering

Paper-2

Questions with
Detailed Solution

1. Solar thermal water pumps work on
- A. Rankine cycle
 - B. Otto cycle
 - C. Carnot cycle
 - D. Diesel cycle

Ans. A

Sol. A solar thermal pump works on Rankine cycle. Solar thermal pump consists of flat plate collectors, non focusing type collectors. Water is used as heat transport fluid and yield its heat to a low boiling point organic fluid (from R-113, R-12, isobutane) in a heat exchanger. The high pressure vapour expands in a turbine, condense in condenser and return in heat exchanger (boiler).

2. 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

Ans. D

Sol. Concentration ratio = $\frac{\text{Area of aperture}}{\text{Area of Receiver}}$

For central tower receiver concentration ratio is 3000.

3. 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

Ans. A

Sol. Angle between sun's ray and its projection on horizontal surface is known as inclination angle

4. 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

Ans. C

Sol. Total solar radiation received at any point on earth's surface is the sum of direct and diffuse radiation and is referred as total or global radiation

5. 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

Ans. C

Sol. Rate at which solar energy arrives at top of atmosphere is extraterrestrial radiation. Solar constant is the rate at which solar energy reaches the earth surface from the sun per unit area per unit time

6. 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

Ans. B

Sol. It is possible to produce electricity from solar pond by organic Rankine cycle which uses low temperature fluids like butane or pentane to convert heat into power.

7. 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

Ans. A

Sol. Darrieus type wind mill is vertical axis wind mill used for electricity generation

8. 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. Pyrheliometer 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.

Ans. B

Sol. Pyranometer does not measure beam radiation.

Pyranometer measured beam & diffuse radiation.

Pyrheliometer measures beam radiation.

9. 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

Ans. A

Sol. Copper is the best material used for heat collection in parabolic trough plants of solar receiver system due to high thermal conductivity and resistance to corrosion.

Direction:

Each of the next six (06) item 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 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

10. 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.

Ans. A

Sol. Centre of pressure is calculated by using the principle of moments

The moment of the resultant force about an axis is equal to the sum of moments of the components about the same axis

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

11. 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.

Ans. B

Sol. Both heat and work transfer are boundary phenomenon and they are observed at the boundaries of the system. Heat and work depends on the path followed by the system

during a process because they are transit form of energy .

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

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

Ans. B

Sol. 1. The vapour absorption system uses heat energy to change the condition of the refrigerant from the evaporator

2. The load variations do not affect the coefficient of performance of a vapour absorption system

Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)

13. 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.

Ans. C

Sol. Friction is independent on extent of area but dependent on normal reaction

$F = \mu N$ where N = normal reaction

Hence statement (ii) is incorrect

14. 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 % brittleness.

Ans. B

Sol. The percent elongation is assumed to be based on a gage length of 2.00 in unless some other gage length is specifically indicated.

Theoretically a material is considered ductile if its percent elongation is greater than 5 % brittleness.

Hence both statement are individually true

15. 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.

Ans. D

Sol. Mechanization means something is done or operated by machinery.

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.

16. 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

Ans. D

Sol. In Rankine cycle, for the pump the ideal process would be the reversible adiabatic compression of the liquid

17. 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

Ans. B

Sol. Vacuum efficiency is the ratio of gauge (actual vacuum) to ideal vacuum

18. 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 meter of gas at standard temperature and pressure

Ans. C

Sol. Proximate analysis: To determine the moisture, ash, volatile matter and fixed carbon.

Ultimate analysis: To determine the elemental composition of the fuel such as carbon, hydrogen, sulphur, oxygen, nitrogen and ash.

Calorific value of a fuel is the total quantity of heat liberated when one unit of fuel is burnt completely.

19. 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

Ans. B

Sol.

- Orsat apparatus is used to volumetric analysis of dry flue gases like oxygen, CO, CO₂ etc.

- Calorific values of solid and liquid fuels are generally determined by bomb calorimeter at constant volume.

- In orsat apparatus most common absorbents are

Potassium hydroxide for CO₂

Pyrogallol for O₂

Cuprous chloride for CO

20. 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

Ans. D

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

Fire tube boiler are Cochran, Lancashire, Cornish, locomotive, scotch marine boilers etc.

21. Which one of the following statements is correct?

A. In water tube boiler, water 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

Ans. D

Sol.

- In water tube boiler, hot gases surround the tubes and waters are inside the tubes.
- The boiler which produces steam above 80 bar called high pressure boiler.
- Stirling boilers are externally fired boiler.
- Lancashire boilers are internally fired boiler.

22. 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 %

Ans. C

Sol. Overall point efficiency = 0.33

$$\eta_o = \eta_g \times \eta_t \times \eta_b \times \eta_c \times (1 - \eta_{aux})$$

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

$$(1 - \eta_{aux})$$

$$(1 - \eta_{aux}) = 0.9267$$

$$\eta_{aux} = 0.07321$$

$$\eta_{aux} = 7.32 \%$$

23. An ideal cycle is impracticable 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

Ans. B

Sol. An ideal cycle is impracticable because it is not possible to transfer heat of expanding steam to the fluid in the turbine itself

24. Match the following:

List I (Boiler Type)	List II (Pressure kg/cm²)
a. La Mont Boiler	1. 84
b. Loeffler Boiler	2. 170
c. Loeffler 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

Ans. C

Sol.

Boilers	Pressure range
La Mont boiler	150 to 180 kg/cm ²
Loeffler boiler	120 to 140 kg/cm ²
Benson boiler	200 to 500 kg/cm ²

- 25.** 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 %, H₂ = 30% ?
- A. 16.54 Kg
 B. 17.54 Kg
 C. 18.54 Kg
 D. 19.54 Kg

Ans. C

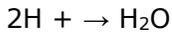
Sol. C + O₂ → CO₂



$$\text{For 1 kg of carbon, O}_2 \text{ required} = \frac{32}{12} = \frac{8}{3} \text{ kg}$$

$$\text{For 0.7 kg of carbon, O}_2 \text{ req} = \frac{8}{3} \times 0.7$$

$$= 1.86 \text{ kg O}_2$$



$$\text{For 1kg of hydrogen, O}_2 \text{ required} = 8\text{kg}$$

$$\text{For 0.3 kg of H}_2, \text{ O}_2 \text{ required} = 2.4 \text{ kg of O}_2$$

$$\text{Total O}_2 \text{ required} = 1.86 + 2.4$$

$$= 4.26 \text{ kg of O}_2.$$

$$\text{Air required} = \frac{4.26}{0.23} \approx 18.52\text{kg}$$

- 26.** 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's 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

Ans. B

Sol. The Rankine cycle efficiency can be improved by decreasing or reducing the temperature at which heat rejected

$$\eta = 1 - \frac{(T_{\text{rej}})_{\text{mean}}}{(T_{\text{add}})_{\text{mean}}}$$

As mean T_{rej} is decreases efficiency increases

27. Match the following

List I	List II
a. Boiler to Turbine process	1. Reversible adiabatic expansion in the turbine
b. Turbine to condenser process	2. Constant pressure transfer of heat in the condenser
c. Condenser to pump process	3. Reversible adiabatic pumping process in the feed pump
d. Pump to boiler process	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

Ans. D

Sol. Turbine process → Reversible adiabatic expansion in the turbine
 Condenser process → Constant pressure transfer of heat in the condenser
 Pump process → Reversible adiabatic pumping process in the feed pump
 Boiler process → Constant pressure transfer of heat in the boiler

- 28.** Which one of the following fuel cells has lowest operating temperature ?
 A. PEMFC B. MCFC
 C. PAFC D. SOFC

Ans. A

Sol. Polymer exchange membrane fuel cell (PEMFC) has lowest operating temperature around 40-60°C MCFC has temperature (600 – 700°C)
 PADC (150 – 20°C)
 SOFC (600 – 1000°C)

- 29.** 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

Ans. D

Sol. Yaw control in horizontal axis wind turbine issued to adjust nacelle about vertical axis to bring the rotor facing

- 30.** 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
 C. 150 atm pressure
 C. 100 atm pressure
 D. 40 atm pressure

Ans. A

Sol. In distributed collector solar thermal electric power plant, heat collected in collectors is used to dissociate ammonia into hydrogen and nitrogen at approximately 300 atm pressure

- 31.** 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

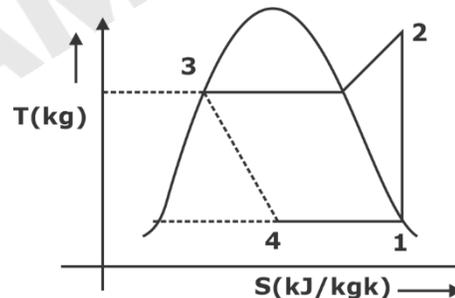
Ans. A

Sol. Given,

Condenser pressure = 14 bar
 Evaporator pressure = 1.4 bar
 Properties

Enthalpy $h_1 = 545 \text{ kJ/kg}$
 $h_2 = 661 \text{ kJ/kg}$
 $h_3 = 341.15 \text{ kJ/kg}$
 $h_4 = 341.15 \text{ kJ/kg}$
 entropy $S_1 = 2.47 \text{ kJ/kgk}$
 $S_2 = 2.47 \text{ kJ/kgk}$

Temperature $T_2 = 63^\circ\text{C}$



Refrigeration effect (R.E) = $h_1 - h_4$
 $R.E = 545 - 341.15$

$R.E = 203.85 \text{ kJ/kg}$

Work (W_c) = $h_2 - h_1$
 $W_c = 661 - 546$
 $W_c = 116 \text{ kJ/kg}$

$COP = \frac{R.E}{W_c}$

$COP = 1.787$

$COP = 1.8$

Correct option A

32. 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

Ans. D

Sol. Limitations of single refrigerant in a simple VCRC in producing low temperatures are

- (i) Solidification temperature of the refrigerant
- (ii) Extremely low pressures in the evaporator and large suction volumes if a high-boiling refrigerant is selected
- (iii) Very high-pressure ratio, therefore a low coefficient of performance

33. 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 kgs)

- A. 13.41 kg.s⁻¹.m⁻¹ B. 16.42 kg.s⁻¹.m⁻¹
C. 19.42 kg.s⁻¹.m⁻¹ D. 22.46 kg.s⁻¹.m⁻¹

Ans. A

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

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

Mass velocity,

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

$$\dot{m} = \rho A u$$

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

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

Z = Length of capillary tube

$$Z = G D = \frac{\dot{m}}{A} (D) = 5.83 \times 10^3 \times (0.0023)$$

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

34. 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

Ans. B

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

35. 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 statements is/are correct.?

- A. 1 only B. 2 only
C. Both 1 and 2 D. Neither 1 nor 2

Ans. A

Sol. (i) A torque converter is a modified form of fluid coupling.

(ii) A combination of rotary pump and turbine is used in a torque converter.

36. 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

Ans. B

Sol. $\left(\frac{H}{D^2N^2}\right)_m = \left(\frac{H}{D^2N^2}\right)_p$

$$D_m = \frac{D_p}{4}$$

$$\frac{16 \times 7}{(1000)^2} = \frac{36}{N^2}$$

37. 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

Ans. C

Sol. The tangential force only can cause rotation of the runner and produce work.

The radial component produces a bending of the shaft which is taken by the journal bearing.

38. 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

Ans. B

Sol. Medium head Range [60m - 300m] turbine is Francis turbine

39. Match the following :

List I (Turbine type)	List II (Flow directions)
a. Deriaz turbine	1. Mixed flow
b. Propeller turbine	2. Tangential flow
c. Francis turbine	3. Axial flow
d. Pelton turbine	4. Diagonal flow

Select the correct matching using the code given below:

	A	b	c	d
A	4	3	1	2
B	3	4	2	1
C	2	1	4	3
D	1	2	3	4

Ans. A

Sol. Deriaz turbine-Diagonal flow
Propeller turbine-Axial flow
Francis turbine-Mixed flow
Pelton turbine-Tangential flow

- 40.** 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

Ans. D

Sol. P = 2000 kW

$$H = 8 \text{ m}$$

$$N = 100 \text{ rpm}$$

$$Q = 250 \text{ m}^3/\text{s}$$

$$D_{\text{TIP}} = 6.5 \text{ m}$$

$$D_{\text{Hub}} = 6.5 \times 0.43 = 2.795 \text{ m}$$

$$4 = \frac{\pi D_{\text{TIP}}^2 N}{60} = \frac{\pi \times 6.5^2 \times 100}{60}$$

$$4 = 34.0339 \text{ m/s}$$

$$A_f = \frac{\pi}{4} [D_{\text{TIP}}^2 - D_{\text{Hub}}^2] = \frac{\pi}{4} [6.5^2 - 2.795^2]$$

$$A_f = 27.0475 \text{ m}^2$$

$$Q = A_f V_f$$

$$V_f = \frac{Q}{A_f} = \frac{250}{27.0475} = 9.2429 \text{ m/s}$$

$$\text{Flow ratio } A_f = \frac{V_{f1}}{\sqrt{2gH}}$$

$$= \frac{9.2429}{\sqrt{2 \times 9.81 \times 8}}$$

$$\text{Flow ratio} = 0.7377$$

- 41.** 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%

Ans. C

Sol. Given,

v = Absolute velocity of discharge 15 m/s

u = velocity of boat = 30 km/hr = 8.33 m/s

$$\eta_{\text{propulsive}} = \frac{2(vu)}{(v+u)^2} = \frac{2 \times 15 \times 8.33}{(15 + 8.33)^2}$$

$$\eta_p = 0.45913 = 45.9\%$$

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

Ans. B

Sol. Surging is a reversal flow that occurs when the process restricts the compressor flow a section value. This will occur when we work beyond the stable limit of operation.

- 43.** Consider the following statements regarding stalling in axial compressor:
1. The flow separation occurring on the suction side of the blade is called negative stalling.
 2. The flow separation occurring on the pressure side of the blade is called positive stalling.
 3. The rotating stall decreases the effectiveness of the compressor.

4. The delivery pressure significantly drops with large stalling leading to flow reversal.

Which of the above statements are correct ?

- A. 1 and 2 only B. 2 and 3 only
C. 3 and 4 only D. 1 and 4 only

Ans. C

Sol.

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

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

- A. 19.2% B. 29.3%
C. 39.2% D. 50.2%

Ans. C

Sol. In a double acting pump, the work saved by fitting air vessel is about 39.2%.

In single acting pump, the work saved by fitting air vessels is about 84.8%.

45. 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

Ans. A

Sol. Given:

Theoretical discharge

$$Q_{th} = \frac{ALN}{60}$$

$$d = 200 \text{ mm} = 0.2 \text{ m}$$

$$L = 350 \text{ mm} = 0.35 \text{ m}$$

$$N = 45 \text{ rpm}$$

$$Q_{th} = \frac{\pi}{4} (0.2)^2 \times 0.35 \times \frac{45}{60} \text{ m}^3 / \text{s}$$

$$Q_{th} = 8.2466 \text{ litre/s}$$

$$C_d = \frac{Q_{act}}{Q_{th}}$$

$$C_d = 1 - \% \text{ Slip}$$

$$= 1 - 0.12 = 0.88$$

$$Q_{actual} = 0.88 Q_{th} = 7.260 \text{ litre/s}$$

Note:- In Question Q_{th} is asked but option will match with Q_{actual}

46. 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

Ans. D

Sol. In lumped analysis, there is no temperature gradient within the body, thus there will be zero thermal resistance offered by the body.

47. 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

Ans. D

Sol. For convection heat transfer coefficient.

$h = f(\delta, \nu, d, \mu, C_p, k)$ is all parameters are fluid properties thus rate of convection is not a fluid properties.

48. In friction coefficient, the boundary layer thickness (δ), the local friction coefficient (C_f) at location x and Reynolds (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. $\delta = \frac{5x}{Re_x^{1/5}}; C_f = \frac{0.664}{Re_x^{1/5}}$

Ans. C

Sol. For turbulent flow over flat plate

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

49. The region from the tube inlet to the point at which the boundary layer merges at the centreline, is called.

- A. Hydrodynamic entry length
- B. Thermal entrance region
- C. Hydrodynamic entrance region
- D. Thermal entry length

Ans. C

Sol. The region from the tube inlet to the point at which the boundary layer merges at center line, is called hydrodynamic entry length.

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

Ans. A

Sol. Heat transfer in fully developed turbulent flow in smooth tubes that recommended by Dittus Boelter

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

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

- A. Sea water
- B. Refrigerating liquid
- C. Fuel oil
- D. Industrial air

Ans. C

Sol. Fuel oil has the highest value of fouling factor fouling factor for liquid gasoline is 0.0008.

52. 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 - 4 L/s; rate
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. 45.7 TR
C. 52.6 TR D. 48.6 TR

Ans. A

Sol. Given,

cooling water flow rate = 4 L/S

inlet water temperature $T_i = 303$ K

outlet water temperature $T_o = 313$ K

power input to motor = 48 kW

motor efficiency = 95%

specific heat of water $C_w = 4.1868$

mass flow rate = $\rho \dot{V}$

$$= 10^3 \times 4 \times 10^{-3}$$

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

Heat rejection to atmosphere in condenser

$$= \dot{m} C_{pw} (T_o - T_i)$$

$$= 4 \times 4.1868 \times (10)$$

$$= 167.472 \text{ kW}$$

Heat rejection to atmosphere in condenser = refrigerating capacity + actual power input to motor

$$167.472 = \text{refrigerating capacity} + 48 \times 0.95$$

$$\text{refrigerating capacity} = 121.872 \text{ kW}$$

$$\text{or refrigerating capacity} = \frac{121.872}{3.51}$$

$$= 34.7 \text{ TR}$$

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

- A. Pressure
B. Enthalpy.
C. Internal energy
D. Entropy

Ans. A

Sol. Intensive property are those properties which is independent of mass or it's value is same even after partition. For example, Pressure, Temperature, Specific enthalpy, Conductivity, etc.

54. 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; 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

Ans. A

Sol. Cooling effect = Sensible heating of ice upto 0°C + latent heat of fusion at 0°C + Sensible heating of water upto 10°C .

$$= m C_i (0 - (-5)) + m(\text{LH}) + m C_w (10 - 0)$$

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

$$= 38656.8 \text{ kJ}$$

Cooling effect in

$$\text{kJ/h} = \frac{38656.8}{24} = 1610.7 \approx 1611 \text{ kJ/hr}$$

55. 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

Ans. D

Sol. Some methods of production of low temperatures:

- Adiabatic demagnetization
- Thermoelectric Refrigeration (cooling)
- Expansion of gases by throttling (irreversible adiabatic)
- Expansion of gases through turbine (reversible adiabatic)
- Sensible cooling by cold medium
- Endothermic mixing of substances
- Phase change processes

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

- A. Vapor compression cycle refrigeration
- B. Gas cycle refrigeration
- C. Vapor absorption cycle refrigeration
- D. Steam ejector cycle refrigeration

Ans. B

Sol. Gas cycle refrigeration is used in aircraft refrigeration.

57. 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 a 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

Ans. A

Sol. Given,

Condenser temperature = 35°C

Evaporator temperature = -15°C

Mass = 10 tons

Water temperature = 30°C

Ice temperature = -5°C

Specific heat of ice (C_{pi}) = 1.94 kJ/kgK

Specific heat of water (C_{pw}) = 4.1868 kJ/kgK

Latent heat of fusion of ice = 335 kJ/kg

$$\text{mass flow rate } \dot{m} = \frac{10 \times 1000}{24 \times 60 \times 60}$$

$$\dot{m} = 0.11574 \text{ kg/s}$$

Refrigeration effect

$$(R.E) = [C_{pw} (30 - 0) + 335 + C_{pi} (0 - (-0.5))]$$

$$R.E = [4.1868 \times 30 + 335 + 1.94 \times 5]$$

$$R.E. = (470.309)$$

Capacity of the refrigeration plant

$$= \dot{m} \times RE$$

$$= 0.11574 \times 470.309$$

$$= 54.43 \text{ kW}$$

58. 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

Ans. C

Sol. Increase in condenser pressure results in

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

59. Which one of the following is the designation for dichloro-tetrafluoroethane refrigerant used in refrigeration system ?

- A. R114 B. R116
C. R113 D. R118

Ans. A

Sol. Given,

Dichloro-terafluoro-ethane = $C_2F_4Cl_2$
refrigerant $\rightarrow C_m H_n F_p Cl_q$

$$\begin{aligned} m &= 2 \\ n &= 0 \\ p &= 4 \\ q &= 2 \end{aligned}$$

Refrigerant designation

$$\begin{aligned} &= R - (m - 1) (n + 1) P \\ &= R - 114 \text{ or } R114 \end{aligned}$$

60. 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

Ans. B

Sol. Methane & Butane are highly explosive & flammable

61. A body of dimensions 1.5 m \times 1.0 m \times 2 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

Ans. A

Sol. weight of body in water = 1962 N

Weight of body in water = weight of body in air - Buoyant force

Weight of body in air = Weight of body in + F_B water

$$= 1962 + \rho_w Vg$$

$$= 1962 + 10^3 \times (1.5 \times 1 \times 2) \times 9.81$$

Weight of body in air = 31392 N

62. 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. $-4xy - 3x^2y + f(y, z)$

Ans. A

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

$$\frac{\partial u}{\partial x} + xy + wxy = 0$$

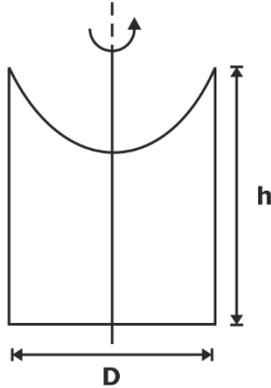
$$u = -4xy - x^2y + f(y, z)$$

63. 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 9.81m/s²)

- A. 50.28 cm B. 55.28 cm
C. 65.36 cm D. 69.36 cm

Ans. A

Sol.



$$D = 0.2, R = 0.1 \text{ m}$$

$$L = 1 \text{ m}$$

$$\mu = 0.6 \text{ m}$$

$$N = 300 \text{ rpm } \omega = \frac{2\pi N}{60}$$

$$\omega = 31.416 \text{ rad/s}$$

$$h = \frac{(31.416)^2 (0.1)^2}{2 \times 9.81} = 0.503 \text{ m}$$

$$h = 50.30 \text{ cm}$$

64. 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 $12 \text{ m}^2/\text{s}$?

- A. 9.55 m/s B. 4.77 m/s
C. 2.38 m/s D. 5.62 m/s

Ans. C

Sol. Velocity at a distance 'r' from the source of strength 'q' is equal to

$$U_r = \frac{q}{2\pi r} = \frac{12}{2\pi \times 0.8} = 2.38 \text{ m/s}$$

65. 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

Ans. D

Sol. $H_{\text{stag}} = 6 \text{ m}$

$$H_{\text{static}} = 5 \text{ m}$$

$$\frac{V^2}{2g} + H_{\text{static}} = H_{\text{stag}}$$

$$V = \sqrt{2g \times 1} \times C_d$$

$$V = 4.34 \text{ m/s}$$

66. A fluid of viscosity 0.7 N/sm^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

Ans. B

Sol. $\tau_w = \frac{-R}{2} \left(\frac{dp}{dx} \right)$

$$196.2 = \frac{0.1}{2 \times 2} \left(\frac{dp}{dx} \right)$$

$$\frac{dp}{dx} = -7848 \text{ N/m}^2 \text{ per m.}$$

67. 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

Ans. D

Sol. $\mu = 10 \text{ poise} = 1 \text{ Ns/m}^2$

$$h = 50 \text{ mm} = 0.05 \text{ m}$$

$$P_1 - P_2 = 0.3 \text{ N/cm}^2 = 0.3 \times 10^4 \text{ N/m}^2$$

$$L = 1.2 \text{ m}$$

$$w = 0.2 \text{ m}$$

$$P_1 - P_2 = \frac{12\mu v L}{h^2}$$

$$0.3 \times 10^4 = \frac{12 \times 1 \times v \times 1.2}{(0.05)^2}$$

$$v = 0.5208$$

$$Q = h \times w \times v$$

$$= 0.05 \times 0.2 \times 0.5208 \times 10^3$$

$$Q = 5.2 \text{ liter/s}$$

68. 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

Ans. A

Sol. $D = 0.35 \text{ m}$

$$N = 200 \text{ rpm}$$

$$\text{Length } L = 100 \text{ mm} = 0.1 \text{ m}$$

$$\mu = 0.8 \frac{\text{NS}}{\text{m}^2}, y = 2 \text{ mm} = 0.002 \text{ m}$$

$$P = \mu \frac{v}{y} (A) V$$

$$P = \mu \frac{Av^2}{y} = \frac{\mu \pi D L v^2}{y}$$

$$v = \frac{\pi D N}{60} = \frac{\pi \times 0.35 \times 200}{60} = 3.665 \text{ m/s}$$

$$P = \frac{0.8\pi \times 0.35 \times 0.1 \times (3.665)^2}{0.002}$$

$$P = 0.59 \text{ kW}$$

69. A sphere of diameter 2 mm falls 150 mm in 20 seconds in a viscous liquid. The density of the sphere is 7500 kg/m^3 and of liquid is 900 kg/m^3 . What is the coefficient of viscosity of the liquid ? (Take acceleration due to gravity as 9.81 m/s^2)

A. 22.31 poise

B. 25.62 poise

C. 19.17 poise

D. 32.21 poise

Ans. C

$$\text{Sol. } v = \frac{D^2}{18\mu} (\rho_s - \rho_{liq}) g$$

$$\mu = \frac{(2 \times 10^{-3})^2}{18 \times \left(\frac{0.15}{20}\right)} [7500 - 900] \times 9.81$$

$$\mu = 19.17 \text{ poise}$$

70. 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/cm^3

B. 312 W/cm^3

C. 512 W/cm^3

D. 412 W/cm^3

Ans. A

Sol. Given,

$$\text{Hair dryer length } l = 80 \text{ cm}$$

$$\text{Diameter } d = 0.3 \text{ cm}$$

$$\text{Power } (P) = 1200 \text{ w}$$

Heat generation in the wire per unit volume

$$= \frac{\text{Power}}{\text{Volume}}$$

$$= \frac{1200}{\frac{\pi}{4} \times 0.3^2 \times 80}$$

$$= 212 \text{ W/cm}^3$$

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

Ans. A

Sol. Heat generation takes place in wire differential equation (study operation)

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

72. 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 W B. 32.39 W
C. 42.39 W D. 52.36 W

Ans. A

Sol. Given,

Wire diameter, d = 1 mm

Wire length , l = 10 cm

Heat transfer

Coefficient h = 5000 W/m²°C

Initial water temperature T_i = 100°C

Wire temperature to be maintain T_s = 114°C

At steady state

Electric power

$$\begin{aligned} &= hA (T_s - T_i) \\ &= 5000 \times \pi \times 1 \times 10 \times 10^{-5} \times (114 - 100) \\ &= 21.99 \text{ W} \end{aligned}$$

73. 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

Ans. B

Sol. Given,

Power = 2 kW

Thermal conductivity k = 15 w/m

Diameter d = 4 mm

Outer surface temperature T = 105°

Heat generation per unit volume (q_g)

$$\begin{aligned} &= \frac{2000}{\frac{\pi}{4} \times 4^2 \times 0.5} \\ &= 318.30 \times 10^6 \text{ w/m}^3 \end{aligned}$$

As

$$T_{\max} - T_w = \frac{q_g R^2}{4k}$$

$$T_c - 105 = 21.22$$

$$T_c = 126^\circ\text{C}$$

74. The thermal contact conductance at the interface of two 1-cm-thick aluminum plates is measured to be 11,000 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

Ans. D

Sol. Given,

Thermal contact conductance

$$= 11,000 \text{ w/m}^2\text{°C}$$

Thermal conductivity (k) = 237 W/m°C

Thermal resistance =

$$\frac{L}{kA} = \frac{1}{h_c A}$$

$$\Rightarrow L = \frac{k}{h_c} = \frac{237}{11000} = 0.0215 \text{ m}$$

75. 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. $\frac{hk}{\delta} < 2$

Ans. A

Sol. In the design of fin, the error in involved in one dimensional fin analysis is negligible

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

76. 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

Ans. C

Sol. Following statements are correct regarding micro-controller and microprocessor.

- (i) A microcontroller is a single chip that contains programmable electronic component, they are small scale integrated chips.
- (ii) Address bus carries a memory address
- (iii) A micro-computer consists of a central processing unit, I/O interface and memory block.

77. 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

Ans. B

Sol.

- Jumps instruction changes the sequence in which the program.
- Decrement instruction subtracts 1 from the contents of a specified location.
- Compare instruction compare with accumulator and compare intermediate with accumulator. It compares the data byte in the register or memory with the contents of accumulator.

78. 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.

Ans. B

Sol.

- Span is the arithmetic difference between the highest and lowest values of input that being sensed.
- Precision is defined as the degree of exactness for which an instrument is intended to perform.
- Sensitivity of a sensor is defined as the change in output for a given change in input.
- Hysteresis is the deviation approached from two different directions.

79. Consider the following statement 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 over shoot.
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

Ans. D

Sol.

- The maximum amount by which the moving parts move beyond the steady state is known as over shoot.
- An output whose magnitude does not repeat with time is known as over shoot.
- An output whose magnitude has a definite repeating time cycle is called steady state periodic.

80. 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

Ans. D

Sol. An encoder is a device that provides a digital output in response to a linear or angular displacement.

A digital optical encoder is a device that converts motion into a sequence of digital pulses.

An incremental encoder produces equally spaced pulses from one or more concentric tracks on the code disk.

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

A. In displacement seismic accelerometer, the displacement of seismic mass is measured by displacement transducer itself

B. in strain gauge accelerometer, the seismic mass is placed on a cantilever beam placed inside the housing

C. In potentiometric accelerometer, in a spring-mass-damper system, the mass is connected with the wiper arm of the potentiometer

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

Ans. D

Sol. The LVDT accelerometer consist of one primary and one secondary winding which are placed on either side of a central core.

82. 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

Ans. A

Sol. Check valve restricts or throttles the fluid in a particular direction to influence the volumetric flow of fluid. They are one-way valves.

83. 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. Communication instruction

C. Control instruction

D. Arithmetic instruction

Ans. C

Sol. Control instructions is conditional instruction which allow the uses to change the order is which the processor scans the program.

84. 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

Ans. A

Sol. Controlled signals, Disturbance signals & Setpoint signals does not exists. Control signals are external commands signals provided to the controller

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

A. Spatial resolution of robot

B. Accuracy of robot

C. Repeatability of a robot

D. Compliance of a robot

Ans. A

Sol. Spatial resolution of robot is the smallest increment of movement into which the robot can divide its work volume.

86. Which one of the following sensors is a special type of force sensor composed to a matrix of force-sensing elements?

- A. Touch sensor
- B. Tactile array sensor
- C. Range sensor
- D. Proximity sensor

Ans. B

Sol. Tactile array sensor is a special type of force sensor composed of matrix of force sensing elements. It measures information arising from physical interaction with its environment. They are generally modeled after the biological sense of cutaneous touch which is capable of detecting stimuli from environment.

87. 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 material 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

Ans. D

Sol. Following statements are correct regarding robot and 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 material in liquid or powder form.

88. 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

Ans. A

Sol. Given,

$$A = 1.5 \times 10^6 \text{ mm}^2 = 1.5 \text{ m}^2$$

$$v = 0.4 \text{ m/s}$$

$$y = 0.15 \text{ mm}$$

$$\mu = 1 \text{ poise} = 0.1 \frac{\text{Ns}}{\text{m}^2}$$

$$\text{Power} = ?$$

$$P = \mu \frac{du}{dy} A \times v$$

$$= \mu \frac{v}{y} A v$$

$$\frac{0.1(0.4)^2}{0.15 \times 10^{-3}} \times 1.5 = 160 \text{ W}$$

- 89.** A gas weighs 16 N/m³ at 25°C and at an absolute pressure 0.25 N/mm². What is the gas constant approximately? (Take acceleration due to gravity as 9.81 m/s²)
- A. 514.68 Nmkg⁻¹ K⁻¹
 B. 542.55 Nmkg⁻¹ K⁻¹
 C. 562.68 Nmkg⁻¹ K⁻¹
 D. 592.55 Nmkg⁻¹ K⁻¹

Ans. A

Sol. For ideal gas

$$PV = n\bar{R}T$$

And

$$PV = m\left(\frac{\bar{R}}{M}\right)T \quad \left(\text{Here, } \frac{\bar{R}}{M} = \text{gas constant}\right)$$

Given

$$P = 0.25 \text{ N/mm}^2 = 25 \times 10^4 \text{ N/m}^2$$

And $T = 25^\circ\text{C}$

$$\text{Specific weight} = \frac{mg}{V} = 16$$

$$\frac{m}{V} = \frac{16}{8} = \frac{16}{9.81} = 1.631 \text{ kg/m}^3$$

$$p = \frac{P}{T} \times \left(\frac{V}{m}\right) = \frac{\bar{R}}{M} = \text{Gas constant}$$

$$R = \frac{\bar{R}}{M} = \frac{25 \times 10^4}{(25 + 273)} \times \left(\frac{1}{1.631}\right)$$

$$= 514.68 \text{ Nmkg}^{-1} \text{ K}^{-1}$$

- 90.** A pipe contains an oil of specific gravity 0.9. A differential manometer connected at 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/s², specific gravity of mercury as 13.6 and density of water as 1000 kg/m³)
- A. 18688 N/m² B. 19688 N/m²
 C. 15688 N/m² D. 17866 N/m²

Ans. A

Sol. $h = \left(\frac{\rho_{\text{Hg}}}{\rho_{\text{gas}}} - 1\right) x = \left(\frac{13.6}{0.9} - 1\right) 0.15 = 2.12$

$$\frac{P_2 - P_1}{\rho g} = h$$

$$P_2 - P_1 = 0.9 \times 10^3 \times 9.81 \times 2.12$$

$$P_2 - P_1 = 18688.05 \text{ N/m}^2$$

- 91.** 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

Ans. A

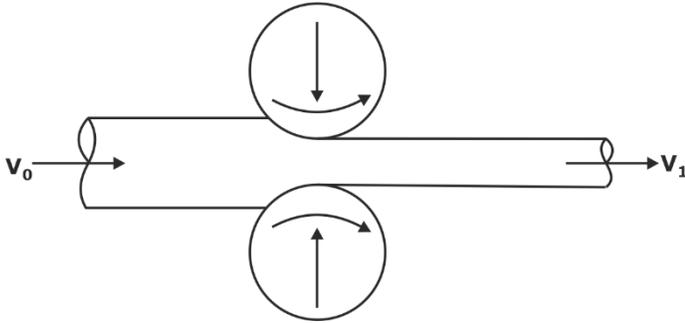
Sol. In overrunning clutches, clutches spin freely majority of time when the machine is being driven in the intended direction. A common application of overrunning clutches is a two speed drive.

- 92.** In a band brake, the tension in the band decreases from the 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. $(P_1 + P_2)r$

Ans. B

Sol. The construction of a simple band brake is shown in figure. It consists of a flexible steel strip line with friction material, which is pressed against the rotating brake drum. When one end of the steel band passes through the fulcrum of the actuating lever, the brake is called the simple band brake.

Sol.



Velocity of material at entrance = V_0

Velocity of material at exit = V_1

Velocity roller = V_r

$V_0 < V_r < V_1$

$$\text{Forward slip} = \frac{(V_1 - V_r)}{V_r} \times 100$$

95. 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

Ans. D

Sol. Force Fit or Shrink is a permanent fit accomplished either by giving heavy blows by hammering or by expanding the hole by heating and after assembly allowing it to contract due to cooling, thus making a firm grip over the shaft.

Force fit is used for high strength assemblies where high resulting pressure are required.

96. 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

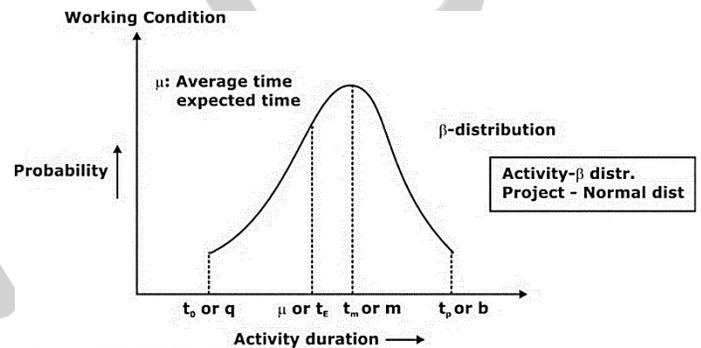
Ans. A

Sol. In PERT

(i). Optimistic time (t_0 or q): It is the minimum time required to complete an activity when everything goes acc. to the plan.

(ii). Pessimistic time (t_p or b): It is the maximum time required to complete an activity when everything goes against the plan.

(iii). Most likely time (t_m or m): It is a time required to complete an activity when executed under normal working condition.



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

- A. ABC analysis B. VED analysis
C. p system D. q system

Ans. B

Sol. (i) ABC Analysis:

In ABC control, inventory items are classified into A, B & C category depending upon their usage value.

	Usage %	Item %	Vital few trivial many
A	50 - 60%	10 - 20%	
B	30 - 40%	30 - 40%	
C	10 - 20%	50 - 60%	

(ii) VED (Vital essential & desirable):

Inventory is classified based on importance of inventory for the production system.

(iii) HML (High Medium & Low)

Inventory are classified based on unit price of inventory.

(iv) SDE (Source difficult & Easy):

Inventory are classified based on availability of inventory for the production system.

98. 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

Ans. B

Sol. Core print:

- Recess provided in the mould for locating, positioning and supporting of cores is called core print.
- The core prints are provided so that the cores are securely and correctly positioned in the mould cavity.
- The design of core prints is such as to take care of the weight of the core before pouring and the upward metallostatic pressure of the molten metal after pouring.
- The core prints should also ensure that the core is not shifted during the entry of the metal into the mould cavity.

99. Which one of the following is a disadvantage of permanent mold or gravity die casting?

- A. The surface of casting becomes hard due to chilling effect

- B. Good surface finish and surface details are obtained
C. The process required more labor
D. Fast rate of production can be attained

Ans. A

Sol. Following are the advantages of gravity die casting:

- (i) Accuracy
(ii) Good surface finish
(iii) Fast rate of production.

100. In critical speed of a light shaft having a single disc damping, the critical speed of the shaft is

- A. equal to the natural frequency of the system in longitudinal vibration
B. equal to the natural frequency of the system in torsional vibration
C. equal to the natural frequency of lateral vibration of the shaft
D. no relationship to any of the natural frequency systems

Ans. C

Sol. In critical speed of a light shaft having a single disc damping, the critical speed of the shaft is equal to the natural frequency of lateral vibration of the shaft.

101. Which one of the following is formed due to large friction and stronger adhesion between chips and tool face?

- A. Continuous chip
B. Discontinuous chip
C. Continuous chip with built-up edge
D. Discontinuous chip with built-up edge

Ans. C

Sol. Large friction between chips and tool face will result in continuous chips and stronger adhesion between chips and tool face will be favorable for built up edge.

102. 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

Ans. D

Sol. B.F. Skinner is not related to TQM and quality assurance.

103. 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

Ans. C

Sol. End relief angle is the angle between portion of the end flank immediately below the end cutting edge and a line perpendicular to the base of tool and measured at the right angle to the end flank.

104. 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 diameter.

2. Changing the axial distance of the discs will vary the point of contact between the belt and disc.

3. The surface finish achieved with 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

Ans. B

Sol.

- Infinite speed ratio is available with stepless drives enabling optimum selection and flexibly automatic control of speeds and feeds.
- Changing the axial distance of discs will vary the point of contact between belt and disc which gives variable speed ratios.
- Surface finish achieved will not be uniform.

105. 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 elements.

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

Ans. D

Sol. Regarding machine vibration:

- If the mechanical stresses are below the acceptable safe working stress levels of the materials involved, no direct protection methods are required.
- 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.
- Shock isolators differ from vibration isolators in that shock requires a stiffer spring and a higher natural frequency for the resilient elements.

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

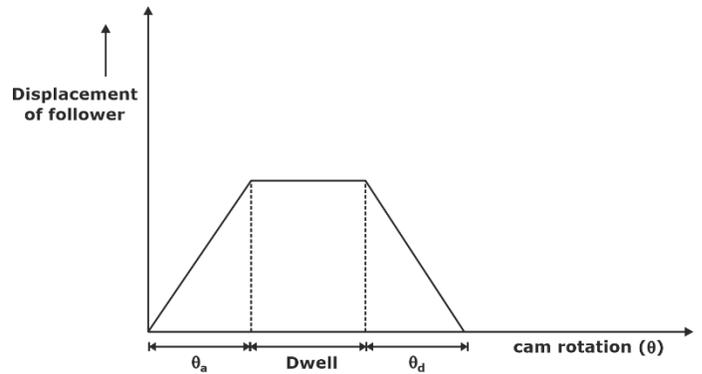
- Angle of ascent
- Angle of dwell
- Angle of descent
- Angle of action

Ans. A

Sol. Angle of Ascent (α): It is the angle through which the cam turns during the follower rises.

Angle of Dwell (δ): It is the angle through which the cam turns while the follower remains stationary.

Angle of Descent (θ_d): It is angle which the cam turns during the time the follower returns to the initial position.



107. 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 statement are correct?

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

Ans. D

Sol. Cam terminology:

1. Base circle: It is the smallest circle tangent to the cam profile drawn from the centre of rotation of radial cam.
2. Pitch curve: 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: Pitch circle is the circle passing through the pitch point and concentric with the base circle.

4. Prime circle: The smallest circle drawn tangent to the pitch curve is known as prime circle.

108. 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 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

Ans. B

Sol.

- 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 Hartmann construction
- A graphical method by which inflection circle can be drawn without requiring the curvatures of the centrodes, is known as Bobillier construction

- Bobillier theorem states that the angle subtended by one of the rays with centrode tangent is equal to negative of the angle subtended by the other ray with the collineation axis.

109. 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

Ans. D

Sol. According to the Grashof's criteria, if $s + l > p + q$ the no link will work like crank. So, all link produce rocker motion.

Hence answer should triple rocker mechanism.

110. 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

Ans. D

Sol. Gyroscopic couple, $C = I\omega\omega_p$

$$= \left(5 \times \frac{0.075^2}{2}\right) \times \left(\frac{2\pi \times 1000}{60}\right) \times \left(\frac{2\pi \times 60}{60}\right)$$

$$= 9.25 \text{ Nm}$$

111. 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

Ans. C

Sol. A system of rotating masses is in dynamic balance when there does not exist any resultant centrifugal force as well as resultant couple.

112. 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

Ans. A

Sol. Wear is directly proportional to the torque, given frictional force and velocity. So, it is directly proportional to friction power.

Wear \propto work done by friction force.

113. 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

Ans. B

Sol. We know, $\frac{L_{90}}{10^6} = \left(\frac{C}{P_e}\right)^k$

$$L_{90} = 1 \times 10^9 \text{ rev,}$$

$$P_e = 550 \text{ kg \& } k = 3$$

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

$$\therefore C = (10^3 \times P_e^3)^{\frac{1}{3}} = 10 \times 550 = 5500 \text{ kg}$$

114. 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

Ans. A

Sol. $L_{10} = \left(\frac{C}{P}\right)^k$

$$C = 8000 \text{ kg for a rated life of } 10^6 \text{ rev}$$

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

$$k = 3 \text{ (ball bearing)}$$

$$\therefore L_{10} = \left(\frac{8000}{4000}\right)^3 \text{ for } 10^6 \text{ revolutions}$$

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

115. Which one 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

Ans. A

Sol. Maximum shear stress theory is used for ductile materials.

116. 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

Ans. D

Sol. Flexural rigidity of shaft (K)

For short lengths flexural rigidity increases

⇒ K ↑

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

ω_n increases and δ_{static} decreases when ℓ increases.

117. 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

Ans. A

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

118. 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

Ans. B

Sol. Power rating = $\frac{2\pi NT}{60}$

Power ∝ torque ∝ angular acceleration.

Power rating is not dependent upon cycling rate or how frequently the brakes are applied.

119. 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

Ans. A

Sol. In the design of spur gear, the load-distribution factor can be minimized by specifying

- Accurate teeth
Narrow face widths

120. Which one of the following fatigue failure criterion 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

Ans. C

Sol. Smith diagram fatigue failure criteria is used in graphical method equation.

121. 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

Ans. B

Sol. Tin bronze is most suitable for application in bearings, bushings, piston rings, steam fitting and gears. Tin bronze is 89% copper and 11% tin.

122. In general, annealing is carried out to

- A. increase softness
- B. increase stresses
- C. decrease ductility
- D. decrease toughness

Ans. A

Sol. Annealing is carried out to restore ductility i.e., to increase softness.

123. 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 statements is/are correct?

- A. 1 only B. 3 only
C. 1 and, 3 only D. 1,2 and 3

Ans. D

Sol. 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.

124. In which of the following micro constituents, 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

Ans. C

Sol. Pearlite (coarse or fine) is a mixture of ferrite and cementite forming distinct layers or bands in slowly cooled carbon steels.

125. 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

Ans. A

Sol. Resilience is the capacity of a material to absorb energy when it is deformed elastically and then, upon unloading, this is recovered.

126. What is the shape of indenter for vickers microhardness testing technique?

- A. Sphere
- B. Diamond cone
- C. Diamond pyramid
- D. Cube

Ans. C

Sol. The Vickers hardness test uses a 136° pyramidal diamond indenter that forms a square indent.

127. Corrosion penetration rate is directly proportional to

- A. Exposed specimen area
- B. Density
- C. Weight loss after exposure time
- D. Exposure time

Ans. C

Sol. Corrosion penetration rate is the speed at which any metal in a specific environment deteriorates due to chemical reaction.

Corrosion penetration rate \propto Weight loss after exposure time.

128. 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

Ans. D

Sol. Ways to reduce galvanic corrosion

1. Selecting materials with similar corrosion potential.
2. Breaking the electrical connection by insulating the two metals from each other.
3. Separating the two materials by inserting a suitably sized space.
4. Adding corrosion inhibition to the environment.

129. 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 attack 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

Ans. C

Sol.

- Passivation involves creation of an outer layer of shield material that is applied as microcavity.
- Intergranular corrosion is a selective attack in the vicinity of grain boundaries of stainless steel.
- Pitting corrosion is location from of corrosion by which cavities or "holes" are produced in the material.

130. 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

Ans. A

Sol. We know that,

$$\omega_n = \sqrt{\frac{g}{\Delta}}$$



Where, $\Delta = \frac{\omega L^3}{3EI}$

So, $\omega_n = \sqrt{\frac{g \cdot 3EI}{\omega L^3}}$

or $\omega_n \propto \frac{1}{L^{3/2}}$

or $\frac{\omega_{n2}}{\omega_{n1}} = \left(\frac{L_1}{L_2}\right)^{3/2} = \left(\frac{L}{L/2}\right)^{3/2} = \sqrt{8}$

131. 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 unclosed 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

Ans. D

Sol. Kinematic pair:

1. When a pair has a point or line contact between the links, it is known as higher 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 unclosed pair.

- 132.** 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

Ans. A

Sol. $C = I\omega\omega_p$

$$= 3500 \times 0.45^2 \times \frac{2\pi \times 3000}{60} \times \left(\frac{36000}{3600} \frac{1}{100} \right)$$

$$= 22266.0 \text{ Nm}$$

$$= 22.26 \text{ kNm}$$

- 133.** 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

Ans. B

Sol. Regarding Governors:

1. A Hartung governor is a spring-controlled governor in which the vertical arms of the bell-crank lever are fitted with spring balls.
2. A Wilson 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.

- 134.** 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 Hilbert principle
D. Edward Jenner principle

Ans. A

Sol. D' Alembert's principle states that the resultant force acting on a body together with the reversed effective force (i.e., inertia force) are in equilibrium make the body.

- 135.** 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

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.
- A epicycloid is the locus of a point on the circumference of a circle that rolls without slipping outside the circumference of another circle.

136. Centroid of a body coincides with its centre of mass or its centre of gravity only if the material composing the body is

- A. uniform or homogeneous
- B. in equilibrium
- C. in static equilibrium
- D. translating with constant velocity

Ans. A

Sol. For uniform or homogeneous (uniform density), the centroid of body coincides with its centre of mass.

137. 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/m³)

- A. 22 mm
- B. 14 mm
- C. 11 mm
- D. 7 mm

Ans. C

Sol. Given,

$$h = 60 \text{ m} = \frac{P}{\rho g}$$

$$P = 9.81 \times 10^3 \times 60 \\ = 588600 \text{ N/m}^2$$

$$\sigma = \frac{pr}{t}$$

$$t = \frac{588600 \times 375}{20 \times 10^6}$$

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

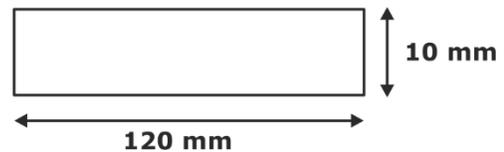
138. A 120 wide and 10 mm thick steel plate is bent into a circular arc of 8 m radius. What is the bending moment which will produce the maximum stress? (Take Young's modulus as 200 GPa)

- A. 250 Nm
- B. 212 Nm
- C. 200 Nm
- D. 172 Nm

Ans. A

Sol. $E = 200 \text{ GPa} = 200 \times 10^3 \text{ MPa}$

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



We know that,

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

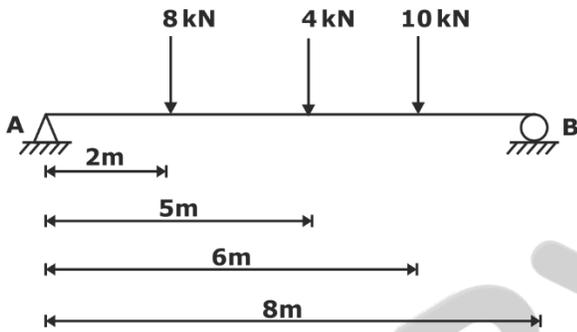
$$M = \frac{EI}{R} = \frac{200 \times 10^3 \times \left(\frac{120 \times 10^3}{12} \right)}{8 \times 10^3} \text{ N.m} \\ = 250 \text{ Nm}$$

139. 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

Ans. D

Sol. Given,



Let the reactions at A & B be R_A and R_B respectively.

$$\sum F_V = 0$$

$$R_A + R_B + (-8) - (4) - 10 = 0$$

$$R_A + R_B = 22 \text{ kN} \quad \dots (1)$$

$$\sum M_A = 0$$

$$R_B \times 8 = 8 \times 2 + 4 \times 5 + 10 \times 6 = 96 \text{ kN-m}$$

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

From equation (1)

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

140. Which one of the following is NOT used as support for beams?

- A. Roller support
- B. Hinged support
- C. Fixed support
- D. Independent support

Ans. D

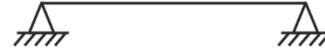
Sol. Roller support



Fixed support



Hinged support



Independent support is not used to support beams and all others are used.

141. 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%

Ans. B

Sol. Initial frictional resistance

$$F_1 = 2.6 \text{ kN}$$

Amount of frictional resistance

$$2.6 + \frac{1.4}{100} \times 1200 = 19.4 \text{ kN}$$

In an ideal machine

$$\eta = 1$$

$$\eta = \frac{W}{P_i \times V.R}$$

Where, P_i = ideal effort

$$P_i = \frac{W}{V.R}$$

$$= \frac{1200}{18} = 66.67 \text{ kN}$$

Effort lost in friction, $F_p = P - P_i$

$$19.4 = P - 66.67$$

$$P = 86.07 \text{ kN}$$

$$\eta = \frac{MA}{VR}$$

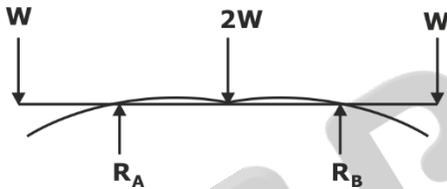
$$= \frac{W}{P} \times \frac{1}{VR} = \frac{1200}{86.07 \times 18} = 77.46\%$$

142. 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

Ans. C

Sol.



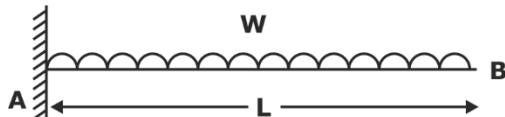
By symmetry deflection at the centre is 0.

143. 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. $WL^3/8$

Ans. A

Sol. Given:



Maximum bending moment will occur at A

$$(BM)_{\max} = (WL) \times \frac{L}{2} = \frac{WL^2}{2}$$

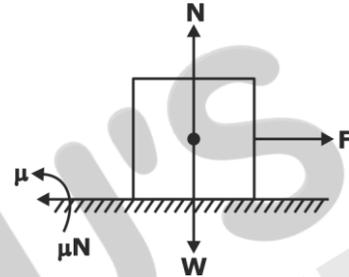
144. A body of weight 100 N is placed on a rough horizontal plane. If a horizontal force of 60 N

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

Ans. A

Sol. $\Sigma F_y = 0$



$$\Rightarrow N = W = 100 \text{ N}$$

$$\Sigma F_x = 0$$

$$\therefore F = \mu N$$

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

145. 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

Ans. D

Sol. Total head imparted by jet is given by

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

$$\text{Power} = \rho gQH = 1000 \times 10 \times \frac{6000 \times 10^{-3}}{60} \times 7$$

$$\text{Power} = 7000 \text{ W}$$

$$\text{Power (hp)} = \frac{7000}{746} = 9.38 \text{ hp} \approx 9.5 \text{ hp}$$

146. A spherical vessel has 1 m diameter. It is subjected to internal pressure of 1.5 N/mm². If maximum stress is not to exceed 200 N/mm² 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

Ans. D

Sol. D = 1 m

$$p = 1.5 \text{ N/mm}^2$$

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

$$\frac{pr}{2t} \leq 200$$

$$\frac{1.5 \times 500}{2t(0.8)} \leq 200$$

$$t \geq \frac{1.5 \times 500}{2 \times 0.8 \times 200}$$

$$t \geq 2.34 \text{ mm}$$

147. A material has modulus of rigidity equal to 0.4×10^5 N/mm² and bulk modulus equal to 0.75×10^5 N/mm². The Poisson's ratio is

- A. 0.2736 B. 0.1927
C. 0.3121 D. 0.4376

Ans. A

Sol. $G = 0.4 \times 10^5$ N/mm²

$$K = 0.75 \times 10^5 \text{ N/mm}^2$$

$$E = \frac{9KG}{3K + G} = \frac{9 \times 0.75 \times 0.4}{3 \times 0.75 + 0.4} = 1.0189$$

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

$$1.0189 = 2 \times 0.4(1 + \mu)$$

$$\mu = 0.2736$$

148. For a 99.65 wt% Fe - 0.35 wt% C alloy at temperature just below the eutectoid, the

fractions of the proeutectoid ferrite and pearlite are respectively

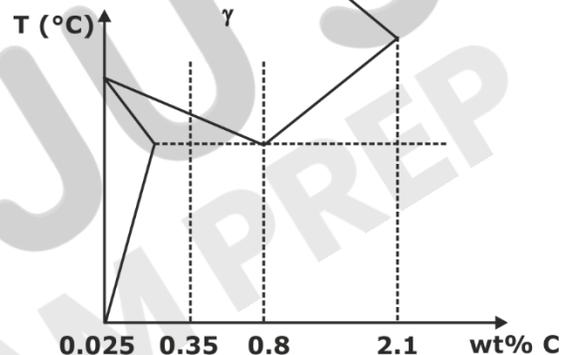
- A. 0.44 and 0.56
B. 0.56 and 0.44
C. 0.044 and 0.056
D. 0.056 and 0.044

Ans. B

Sol.

Fraction of proeutectoid ferrite

$$= \frac{0.8 - 0.35}{0.8 - 0.025} = 0.56$$



Fraction of pearlite

$$= \frac{0.35 - 0.025}{0.8 - 0.025} = 0.44$$

149. 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

Ans. C

Sol. Martensitic steels are most brittle material. Tempered martensite is relatively ductile as compared to martensite. Fine pearlite is more brittle than coarse pearlite.

150. Which one 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

Ans. D

Sol. High-strength, low-alloy steels 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

