

ESE 2021

Paper-2

Mechanical Engineering

► Questions & Solutions



ESE 2021 PYSP

1. Consider the following statements regarding mechatronics systems:

1. The anti-lock brakes on a car are a simple example of a real time computing system.
2. The completion of an operation after its deadline is considered useless in soft real time system.
3. The hard real time system tolerates lateness and may respond with decreased service quality.

Which of the above statements is/are correct?

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

Ans. D

Sol. 1. ABC in car is example of real time computing system

2. Soft real time system is a system whose operation is degrade if result is not produced in specified timing

1,2 & 3 are correct

2. Which one of the following materials has least piezoelectric charge sensitivity?

- A. Quartz
B. Barium Titanate
C. PZT
D. PVDF

Ans. D

Sol. **Material Piezoelectric change sensitivity**

PZT (Thin film)	-	60 to 130
ZnO	-	12.4
PVDF	-	-33
Quartz(SiO ₂)	-	2.3
BaTiO ₃	-	190

So, Ans is PVDF.

3. The ideal hydraulic rotary actuator provides shaft torque, T, which is

A. equal to displaced volume measured.

B. inversely proportional to the displaced volume measured.

C. proportional to the differential pressure.

D. inversely proportional to the differential pressure.

Ans. C

Sol. In ideal hydraulic rotary actuator

- Their functionality is just the reverse of a pump.
 - Principle: Instead of pushing the fluid as pumps, pressurized fluid pushes the internal surface area, developing torque and rotation.
 - Thus, both input and output are pressurized.
- Option C is correct.

4. An ammeter requires a change of 3 A in its coil to produce a change in deflection of the pointer by 12 mm. What is the static sensitivity?

- A. 36 mm/A B. 9 mm/A
C. 4 mm/A D. 15 mm/A

Ans. C

Sol. Static sensitivity =

$$\frac{\text{Infinitesimal change in output}}{\text{Infinitesimal change input}}$$

$$= \frac{12}{3}$$

$$= 4 \frac{\text{mm}}{\text{A}}$$

5. What is the force needed to apply to a piston of 2 cm radius in order to result a force of 6000 N at the working piston of radius 6 cm?

- A. 1334 N B. 333 N
C. 1050 N D. 667 N

Ans. D

Sol. Given,

Radius of piston where force is needed to be applied (r_1) = 2cm

Force on working system (F_2) = 6000 N
 working piston radius (r_2) = 6 cm by i' as Cal's law, we have

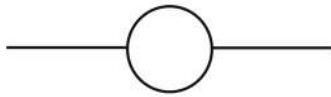
$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Where A_1 is the area where force is needed to be applied and A_2 is area of the working piston.

$$\frac{F_1}{\pi \times 2^2} = \frac{F_2}{\pi \times 6^2} \text{ or } F_1 = \frac{6000 \times 4}{36}$$

$$= 666.67 \text{ N}$$

6. The following symbol in the ladder logic represents:



- A. Normally open contacts
- B. Normally closed contacts
- C. Output loads
- D. Special instruction

Ans. C

Sol. Normally open contacts \Rightarrow



Normally closed contact \Rightarrow



Output loads \Rightarrow



Ladder logic: - ladder logic is a programming language that creates and represent a progression through ladder diagram.

It is mainly used in developing programs for PLC's

7. The settling time for a unit step response of a second-order system is

- A. proportional to the natural frequency.
- B. inversely proportional to the natural frequency.
- C. equal to the damping ratio.
- D. proportional to the damping ratio.

Ans. B

Sol. The settling time t_s is used as a measure of the time taken for the oscillations to die away. It in the time taken for the response to fall within and remain within so me specified percentage. e.g. 2% of steady state (n_{ss}).

This means that the amplitude of the oscillation should be less than 2% of n_{ss} .

$$\text{And } t_s = \frac{4}{\xi \omega_n}$$

ω_n = natural frequency

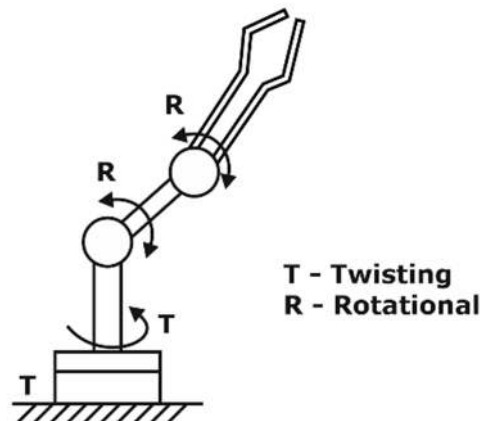
ξ = damping ratio

8. A typical wrist mechanism with three rotational joints would be indicated by

- A. TRL
- B. TRL
- C. LLL
- D. TRR

Ans. D

Sol. TRR stands for torsional, revolute, revolute. Hence, mechanism with three rotational joints would be indicated by TRR.



9. The Analog-to-Digital conversion process involves:

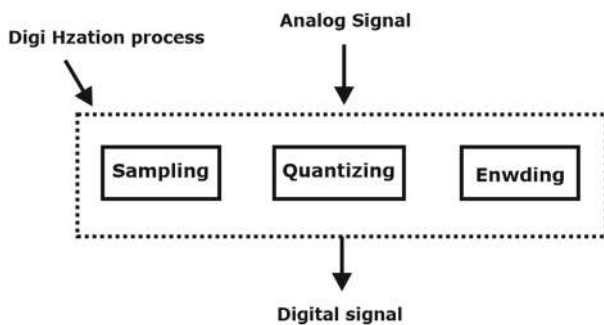
1. Quantizing
2. Sampling
3. Encoding

What is the correct sequence?

- A. 2-1-3
- B. 2-3-1
- C. 3-1-2
- D. 3-2-1

Ans. A

Sol.



(sampling, Quantizing, encoding)

10. Statement (I): Gravity is the driving force behind flows through open channels.

Statement (II) : Gravity stands to reason that the ratio of inertial to gravitational forces will play a major role in open channel flow analysis.

- 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.

Ans. A

Sol. For open channel flow since the liquid has a free surface at atmospheric pressure the driving force is gravitational force.

$$\text{Froude number} = \frac{\text{Inertia force}}{\text{Gravitational force}}$$

In open channel flow Froude number plays an important role

11. Statement (I):

The viscosity of liquids decreases with the increase of temperature while the viscosity of gases increases with the increase of temperature.

Statement (II):

The viscous forces in a fluid are due to cohesive forces and molecular momentum transfer.

- 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.

Ans. A

Sol. Viscosity of liquids decreases with increase in temperature while the viscosity of gases increases with the increase of temperature. Cohesive force and molecular momentum transfer are responsible for viscous forces. In liquids cohesive force dominates which decreases with temperature and in gases, momentum transfer dominates which increases with temperature.

12. Statement (I):

If two systems are in thermal equilibrium with a third system, then they are not in thermal equilibrium with each other.

Statement (II):

Zeroth law of thermodynamics is the basis for temperature.

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.

Ans. D

Sol. The zeroth law of thermodynamics states that if two bodies are each in thermal equilibrium with some third body, then they are also in equilibrium with each other. Hence statement I is incorrect

13. Statement (I):

A thermal energy reservoir is a system that always remains at constant temperature even though the heat is added to or removed from it.

Statement (II) :

A thermal reservoir that supplies heat energy is called sink and one that absorbs the heat energy is called source.

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.

Ans. C

Sol. Statement II is incorrect as the thermal reservoir that supplies heat energy is known as Source while the thermal reservoir that absorbs heat energy is known as Sink.

14. Statement (I): Wear is an issue whenever two components operate with relative motion between them or when liquids or solids impinge on a surface at high velocity.

Statement (II): Wear is often cumulative and can eventually render the components incapable of delivering their expected performance.

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.

Ans. B

Sol.

- Erosive wear is caused by the impact of particles of solid or liquid against the surface of an object.
- The impacting particles gradually remove material from the surface through repeated deformations and cutting actions.
- It is a widely encountered mechanism in industry.

Both statements against the wear is true, but statement 2 is not correct explanation for causing of wear.

15. Statement (1):

Increased productivity, reduced cost of labour and improved quality can be achieved by automation.

Statement (II):

Due to automation in process inventory, dependence on operator skills may be increased.

- 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.

Ans. C

Sol.

- In automation the production rate is high, skill of the worker is not required more, and variation is very less so the quality is also high so Statement 1 is right (True).
- In automation operator skill is not required much and his skills is also not improved.
- In job production and batch production only skills of the worker will be improved. In batch production only working processes inventory levels will be more in case of automation the work in process inventory levels will be zero. So this statement (II) is wrong. (False)

So Correct answer as 'C'.

16. Which one of the following lubricants is used in forward hot extrusion of steel?

- A. Molten glass
- B. Soap solution
- C. Copper sulphate
- D. Vegetable oil

Ans. A

Sol. Molten Glass is used as a lubricant in hot extrusion for extrusion of steels. It reduces the friction and also provides effective thermal insulation between the billet and the extrusion container.

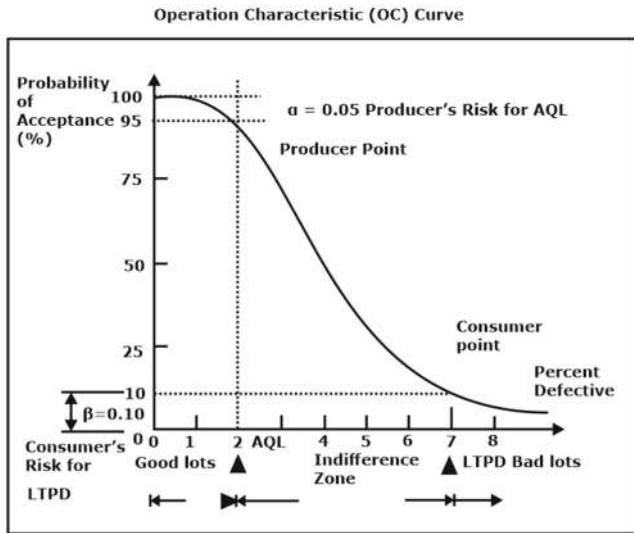
17. Which one of the following statements is not the correct statement regarding operating characteristics (OC) curve for sampling plan?

- A. It shows ability to distinguish between good and bad lots.
- B. No sampling plans can give complete protection against acceptance of defectives.
- C. Larger the sample size, steeper is the slope of the curve.
- D. Acceptance number is zero for ideal sampling plan.

Ans. D

Sol. Operating characteristics (OC) curve for sampling plan,

- (i) OC curve is a plot between percentage of defective and probability of acceptance.
- (ii) OC curve shows ability to distinguish between good and bad lots.
- (iii) In OC curve no sampling plans can give complete protection against acceptance of defectives. Risk is always present in the form of Producer's Risk & Consumer's Risk.
- (iv) Larger the sample size (n) steeper is the OC curve.
- (v) Acceptance number is not zero for ideal sampling plan.

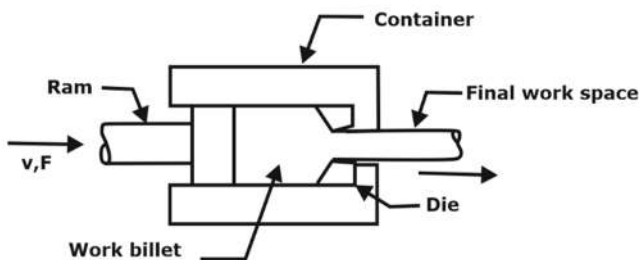


- 18.** Which one of the following statements is not correct for forward or direct extrusion process?
- High friction forces must be overcome.
 - High extrusion forces are required but mechanically simple and uncomplicated.
 - Low scrap or material waste only 5-6 % of billet weight.
 - Simple, but the material must slide along the chamber wall.

Ans. C

Sol. **Direct or Forward extrusion:**

- One of the main disadvantages of direct extrusion is the significant friction between the work surface and the walls of the container as the billet which result in a substantial increase in the ram force required for extrusion.



Material moves with the ram as force is applied.

- 19.** Consider the following statements regarding defects in forgings:
- Flakes are internal breaks or ruptures occurring in some grades of alloy steel.
 - Die shift is caused by misalignment between the top and bottom forging dies.
 - Fins and rags are small projections or loose metal driven into the surface of the forging.
- Which of the above statements are correct?
- 1 and 2 only
 - 1 and 3 only
 - 2 and 3 only
 - 1, 2 and 3

Ans. D

Sol. **Defects in forgings:**

- Internal fissures seen in large forgings are due to hydrogen pick up which are termed as Flakes.
- Die shift is caused when both these dies are not properly aligned i.e., there is misalignment between dies.
- Fins and rags are small projections of loose metal into the forging surface.
- Cold shut.
- Surface cracking.
- Incomplete forging penetration.

- 20.** Consider the following statements regarding desirable properties of cutting fluid:
- It should get oxidized when left in air.
 - It should react with the materials of machine tool parts.
 - It should wet the surface of cutting tool and workpiece.

Which of the above statements is/are correct?

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

Ans. B

Sol. **Desirable properties of cutting fluids:**

- (i). High thermal conductivity for cooling.
- (ii). Good lubricating qualities and must not produce a gummy or solid precipitate.
- (iii). Be stable against oxidation.
- (iv). Should have high specific heat and good metal-wetting properties to be a better coolant.
- (v). Should not react with the tool and workpiece material.

21. Consider the following statements regarding limits and fits:

- 1. Actual size is the standard size for the part and is the same both for the hole and its shaft.
- 2. Basic size is the dimension as measured on the manufactured part.
- 3. Deviation is the algebraic difference between a size and the corresponding basic size.

Which of the above statements is/are correct?

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

Ans. A

Sol. **Basic Size (nominal size):** The size with reference to which the limits of size are fixed. It is the exact theoretical size arrived at by design.

Actual Size: Actual measured dimension of the part is the actual size and it is different for both the shaft and hole.

Deviation: The algebraic difference between a size (actual, maximum, etc.) and the corresponding basic size.

22. Which of the following statements is not correct about PERT?

- A. Network is constructed based on the events.
- B. It does not take uncertainties involved in the estimation of times.
- C. Network deals with uncertainties and hence three time estimations are considered.
- D. As there is no certainty of time, activity duration cannot be reduced.

Ans. B

Sol. Program elevation and review technique is probabilistic so it has the uncertainty, so statement b is not related to PERT.

23. Parallel misalignment is present when

- A. two shafts are parallel to each other but are not in the same plane.
- B. two shafts are parallel to each other and are in the same plane.
- C. the shafts are not parallel to each other.
- D. the shafts are aligned with each other.

Ans. B

Sol. Parallel misalignment is present when two shafts are parallel to each other and are in the same plane. When shafts are parallel but present in different planes, they are skew shafts. Parallel shafts having lateral misalignment are connected by Oldham's coupling.

24. The major limitation with displacement or proximity probes is

- A. Size
- B. Time
- C. Accuracy
- D. Cost

Ans. A

Sol. The shape and size are important parameters for the design of proximity probe. Time, accuracy and cost are the secondary factors while designing the proximity probe. Thus, proximity probes have limitations of size.

25. Which one of the following contains design data on all products, e.g., their constituent components and parts?

- A. Engineering data master file
- B. Process data master file
- C. Inventory master file
- D. Sales master file

Ans. A

Sol. Engineering data master file contains design data on all products, e.g., their constituent components and parts.

26. Which one of the following is the cutter with a curved tooth outline of the same shape as the profile of the workpiece?

- A. Plain milling cutter
- B. Face milling cutter
- C. End milling cutter
- D. Profile milling cutter

Ans. D

Sol. **Profile milling** cutters have a special curved tooth outline and are used for milling contours of the various shapes. Profile Milling Cutters find use in transferring specific profile onto workpiece where this cutter in required profile assists in cutting material from work piece as well as transferring profile onto it.

27. Which one of the following is a joining process that may employ acetylene, natural gas, butane in combination with oxygen to supply the heat required to melt the filler rod and diffuse it into the surface of the base metal?

- A. Furnace brazing B. Torch brazing
- C. Induction brazing D. Dip brazing

Ans. B

Sol. **Types of brazing:**

Torch brazing: A reducing flame (oxy-acetylene or propane or butane) is generally

used to inhibit oxidation. It requires considerable skills for operating brazing successfully in sound manner.

Furnace brazing: A furnace with a controlled atmosphere, which is either neutral or reducing, is used. The assemblies to be joined enter the furnace on a conveyor and will pass through the various heating and cooling portions of the furnace to make the joint.

Dip brazing: A molten salt bath or metal bath is used to supply heat to the base metal. A brazing joint is prepared and dipped into the bath for quick melting of the brazing alloy. When the assembly is taken out of the bath, the joint cools and joint strength is obtained. It is a faster method for preparing brazing joints.

Induction brazing: Heat is obtained from the high frequency current induced in the work by means of the electrical coils.

28. Consider the following statements regarding modulation:

1. The modulation is essential in communication systems, where a weak signal is transmitted by the use of a carrier signal.
2. When the frequency of the high frequency signal is varied in accordance with the intensity of the low-frequency weak signal, the modulation is said to be frequency modulation.
3. The process of recovering original baseband signal from the modulated signal is called phase modulation.

Which of the above statements are correct?

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

Ans. B

Sol.

- **Modulation:** Modulation is defined as the process of varying some characteristics (amplitude, frequency or phase) of a carrier wave in accordance with given signal. Modulators convert low frequency signal to a high frequency signal.
 - **Analog frequency modulation:**
 - (i). **Frequency modulation:** The frequency of the carrier wave is altered in accordance with the instantaneous amplitude of the modulating signal, keeping phase and amplitude constant. Modulation index is always over 1.
 - (ii). **Amplitude modulation:** Here, the amplitude of the carrier wave is altered in accordance with the instantaneous amplitude of the modulating signal, keeping phase and frequency constant. Modulation index ranges from 0 to 1.
 - (iii). **Phase modulation:** Phase modulation works by modulating the phase of the signal, i.e., changing the rate at which the point moves around the circle.
 - The process of recovering the original signal from the modulated wave is known as demodulation or detection.
- 29.** Consider the situation where a microprocessor gives an output of an 8-bit word. This is fed through an 8-bit digital-to-analog converter to a control valve. The control valve requires 6.0 V to be fully open. If the fully open state is indicated by 11111111, then what is the output to the valve for a change of 1 bit?
- A. 0.033 V B. 0.053 V
C. 0.043 V D. 0.023 V

Ans. D

Sol. No. of bits: $n = 8$

Full scale output voltage = 6 V

The change in output voltage for the change of 1 unit:

$$\text{Change in output for 1 bit} = \frac{6}{2^8} = 0.0234 \text{ V}$$

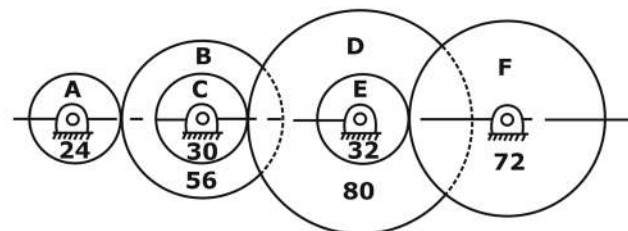
30. Which one of the following is not an application of Hall effect sensor?

- A. Magnetic switch for electric transducer
- B. Measurement of current
- C. Measurement of acceleration
- D. Measurement of power

Ans. A

Sol. Hall effect sensor is used to measure current, power and it is used in accelerometers. Magnetic switch for electric transducer is not an application for Hall Effect Sensor. Therefore, correct option is A.

31. The compound gear train shown in the figure below consists of compound gear B-C and D-E. All gears are mounted on parallel shafts. The motor shaft rotating at 800 rpm is connected to the gear A and the output shaft to the gear F. The number of teeth on gears A, B, C, D, E and F are 24, 56, 30, 80, 32 and 72 respectively. What is the speed of the gear F?



- A. 57.14 rpm
- B. 32.51 rpm
- C. 74.63 rpm
- D. 69.72 rpm

Ans. A

Sol. $\frac{\omega_A}{\omega_f} = \frac{T_B}{T_A} \times \frac{T_D}{T_C} \times \frac{T_F}{T_E}$

$$\frac{800}{\omega_F} = \frac{56}{24} \times \frac{80}{30} \times \frac{72}{32}$$

$$\frac{800}{\omega_F} = 14 \Rightarrow \boxed{\omega_F = 57.14 \text{ rpm}}$$

- 32.** A quick-return mechanism is to be designed, where the outward stroke must consume 1.2 s and the return stroke 0.8 s. If the cycle time is 2.0 s/rev, what is the speed at which the mechanism should be driven?

- A. 10 rev/s B. 30 rev/s
C. 10 rev/min D. 30 rev/min

Ans. D

Sol. Given,

Time consumed by outward stroke = 1.2 sec

Time consumed by return stroke = 0.8 sec

Cycle time = 2 sec/rev

Therefore, number of revolutions in 1 second = 0.5 rev

Therefore, number of revolutions in a minute = $60 \times 0.5 = 30$ rev/min.

- 33.** The following data relate to a single-cylinder reciprocating engine: mass of reciprocating parts = 40 kg, mass of revolving parts = 30 kg at crank radius, speed = 150 rpm, stroke = 350 mm. If 60 % of the reciprocating parts and all the revolving parts are to be balanced, what is the balance mass required at a radius of 320 mm?

- A. 15.27 kg B. 21.43 kg
C. 24.96 kg D. 29.53 kg

Ans. D

Sol. Given,

mass of reciprocating parts (m_r) = 40 kg

mass of revolving parts (m_c) = 30 kg

speed = 150 rpm

stroke = 350 mm

Percentage of reciprocating mass to be balanced (c) = 60%

$$\omega = \frac{2\pi \times 150}{60} = 15.7 \text{ rad/s}$$

$$r = \frac{350}{2} = 175 \text{ mm}$$

Mass to be balanced at the crankpin (m) = m_r

$$+ m_c = 0.6 \times 40 + 30 = 54 \text{ kg}$$

$$m_c r_c = m r$$

$$m_c \times 320 = 54 \times 175$$

$$m_c = 29.53 \text{ kg}$$

- 34.** A leaf spring consists of seven steel plates, each 60 mm wide and 6 mm thick, What is the length of the spring if it is to carry a central load of 3 kN, without the stress exceeding 150 MPa?

- A. 547 mm
B. 498 mm
C. 494 mm
D. 504 mm

Ans. D

Sol. Given,

Thickness $t = 6 \text{ mm} = 6 \times 10^{-3} \text{ m}$

Central load $W = 3 \text{ kN}$,

Width $b = 60 \text{ mm}$

Stress $\sigma_b = 150 \text{ MPa}$

$E = 200 \text{ GPa}$.

Fixed length of spring

$$\sigma_b = \frac{3WL}{2nbt^2}$$

$$150 = \frac{3 \times 3 \times 10^3 \times L}{2 \times 7 \times 60 \times 6^2}$$

$$L = 504 \text{ mm}$$

- 35.** According to maximum shear stress theory, with comparison to yield strength in tension, the yield strength in shear is

- A. half the yield strength in tension.
B. same as that of yield strength in tension.
C. double the yield strength in tension.
D. 1.33 times that of the yield strength in tension.

Ans. A

Sol. According to maximum shear stress theory, with comparison to yield strength in tension, the yield strength in shear is half the yield strength in tension.

- 36.** In curved beams, normally the nature of stress distribution is
- linear
 - circular
 - parabolic
 - hyperbolic

Ans. D

Sol. (i). In Curved beams, the neutral axis does not coincide with the centroidal axis during bending and it shifts towards the center of curvature.

(ii). Bending stress distribution is non-linear and hyperbolic in bending of curved beams.

- 37.** Consider the following statements regarding crack:

- Crack is more likely to occur in the regions of discontinuity such as oil holes.
- Crack is more likely to occur in the regions of irregularities in machining operations such as stamp mark.
- Crack is more likely to occur in the internal cracks due to defects in materials like blow holes.

Which of the above statements are correct?

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

Ans. D

Sol. Fatigue begins with a crack at some point in the material.

The crack is more likely to occur in the following regions:

(i) Regions of discontinuity, such as oil holes, keyways, screw threads etc.

(ii) Regions of irregularities in machining operations, such as scratches on the surface, stamp mark, inspection marks, etc.

(iii) Internal cracks due to defects in materials like blow holes.

- 38.** The yield strength of bolt material is 300 MPa and factor of safety is 2.5. What is the maximum principal stress using maximum principal stress theory?
- 750 MPa
 - 120 MPa
 - 27.38 MPa
 - 10.95 MPa

Ans. B

Sol. Given,
yield strength of bolt = 300MPa,
factor of safety = 2.5
acc. to maximum principal stress theory (MPST),

$$|\sigma_{\max.}| \leq \left| \frac{\sigma_{yt.}}{N} \right|$$

$$|\sigma_{\max.}| \leq \left| \frac{300}{2.5} \right|$$

$$|\sigma_{\max.}| \leq 120\text{MPa}$$

- 39.** Which one of the following theories gives satisfactory results for brittle materials?

- Maximum principal stress theory
- Maximum shear stress theory
- Distortion energy theory
- Shear stress energy theory

Ans. A

Sol. (i) Since brittle materials are weak in tension, maximum principal stress theory is suitable for brittle components.

(ii) Ductile materials may undergo shear failure, thus making this theory not suitable for ductile components.

- 40.** A cast steel bar having an ultimate strength of 120 MPa is subjected to a reversed, repeated, bending load. The bar will be machined to a rectangular cross-section, 150 mm wide × 200 mm high. What is the equivalent diameter?
- A. 14 mm B. 30 mm
C. 140 mm D. 300 mm

Ans. C

Sol. Given,

ultimate strength = 120 MPa,

Rectangular cross-section,

Width (b) = 150 mm,

Height (h) = 200 mm

Equivalent diameter = $0.808\sqrt{bh} = 139.94$
mm \cong 140mm

- 41.** Consider the following statements regarding typical analysis of bolt failure:
1. 15 % failure of bolt occur at the fillet under the head.
 2. 50 % failure of bolt occur at the end of threads on the shank.
 3. 80 % failure of bolt occur in the threads that are in contact with the nut.
- Which of the above statements is/are correct?
- A. 1 only
B. 3 only
C. 2 and 3 only
D. 1, 2 and 3

Ans. A

Sol. A typical analysis of bolt failures indicate that,

(i) 15% failures of bolt occur at the fillet under the head.

(ii) 20% failure of bolt occur at the end of threads on the shank.

(iii) 65% failures of bolt occur in the threads that are in contact with the nut.

- 42.** Which of the following are the functions of lubrication in a bearing unit?
1. To protect the bearing components from corrosion.
 2. To absorb heat from the bearing unit.
 3. To carry heat away from the bearing unit.
- 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. D

Sol. Functions of lubrication in a bearing are given below:

- (i). To protect the bearing components from corrosion.
- (ii). To absorb heat from the bearing unit.
- (iii). To carry heat away from the bearing unit.

- 43.** Consider the following statements regarding clutches:
- 1 Dry clutch has higher coefficient of friction compared to wet clutch.
 2. The torque capacity of wet clutch is high compared to dry clutch.
 3. The engagement in a dry clutch is smoother than in case of wet clutch.
- Which of the above statements is/are correct?
- A. 1 only
B. 1 and 3 only
C. 2 only
D. 1, 2 and 3

Ans. A

Sol. 1 Dry clutch has higher coefficient of friction compared to wet clutch.

2. The torque capacity of wet clutch is low compared to dry clutch.

3. The engagement in a wet clutch is smoother than that of dry clutch.

- 44.** Which of the following factors can cause misalignment of the teeth on the pinion relative to those on the gear?
1. Inaccurate gear teeth
 2. Misalignment of the axes of shafts carrying gears
 3. Thermal distortions during operation
- 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. D

Sol. Following are the factors cause misalignment of the teeth on the pinion relative to those on the gear,

- (i). Inaccurate gear teeth.
- (ii). Misalignment of the axes of shafts carrying gears.
- (iii). Thermal distortions during operation.

- 45.** Consider the following statements regarding welded and riveted joints:
1. Welded assemblies are tight and leak proof as compared with riveted assemblies.
 2. Single-welded V-joint is less reliable than square butt joint.
 3. Welding results in a thermal distortion of the parts, thereby inducing residual stresses.
- Which of the above statements is/are correct?
- A. 1 only
B. 1 and 3 only
C. 2 only
D. 1, 2 and 3

Ans. D

Sol. Following statements regarding welded and riveted joints,

- (i). Welded assemblies are tight and leak proof as compared with riveted assemblies.
- (ii). Single-welded V-joint is less reliable than square butt joint.

(iii). Welding results in a thermal distortion of the parts, thereby inducing residual stresses.

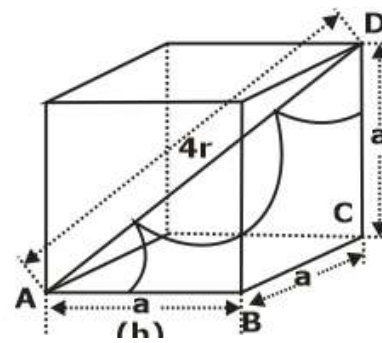
- 46.** Iron at 20°C is BCC with atoms of atomic radius 0.124 nm. What is the lattice constant 'a' for the cube edge of the iron unit cell?
- A. 0.2864 nm B. 0.1496 nm
C. 0.2173 nm D. 0.1756 nm

Ans. A

Sol. Given:

Atomic radius: $r = 0.124 \text{ nm}$

For BCC:



$$4r = \sqrt{3}a$$

$$\therefore a = \frac{4}{\sqrt{3}} \times r = \frac{4}{\sqrt{3}} \times 0.124$$

$$a = 0.2863 \text{ nm}$$

- 47.** Copper has the FCC crystal structure and a unit cell with a lattice constant of 0.361 nm. What is the interplanar spacing d_{220} ?
- A. 0.085 nm B. 0.174 nm
C. 0.206 nm D. 0.128 nm

Ans. D

Sol. Given:

Lattice constant: $a = 0.361 \text{ nm}$

For FCC:

Interplanar spacing is given as:

$$d_{(h \ k \ l)} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

$$d_{220} = \frac{0.361}{\sqrt{(2)^2 + (2)^2 + 0}}$$

$$d_{220} = 0.1276 \text{ nm.}$$

- 48.** Which one of the following is not a step of lever rule of determination of phase amounts ?
- A. A tie line is constructed across the two-phase region at the temperature of the alloy.
- B. The overall alloy composition is located on the tie line.
- C. Perpendiculars are dropped from these intersections to the horizontal composition axis, from which the composition of each of the respective phases is read.
- D. The fraction of one-phase is computed by taking the length of tie line from the overall alloy composition to the phase boundary for the other phase and dividing by the total tie line length.

Ans. C

Sol. Procedure to find equilibrium concentrations of phases:

Step-1: A tie-line or isotherm (UV) is drawn across two-phase region to intersect the boundaries of the region.

Step-2: Perpendiculars are dropped from these intersections to the composition axis, from which each of each phase is read (i.e., liquid phase and solid phase).

Step-3: Now, the relative amount of a phase is computed by taking the length of tie line from overall composition to the phase boundary for the other phase, and dividing by the total tie line length.

3rd statement is related to tie line not the lever rule, where we can find the compositions on horizontal axis.

So, correct answer will be C.

- 49.** Consider the following statements regarding polymeric materials:
1. A plastic material that requires heat to make it formable (plastic) and upon cooling,

retains its shape is known as thermosetting plastic.

2. The chemical reaction in which high molecular mass molecules are formed from two or more monomers is called chain polymerization.

3. A polymer chain consisting of two or more types of monomeric units is called copolymer. Which of the above statements is/are correct?

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

Ans. B

Sol.

- Thermoset is a material that strengthens (not become plastic) when heated but cannot be remoulded or heated after the initial forming, while thermoplastics can be reheated, remoulded.
- A 'chain polymerization' is a chain reaction in which the growth of a polymer chain proceeds exclusively by reaction between monomer and active site on the polymer chain with the regeneration of the active site(s) at the end of each growth step.

Chain polymers can be of two types:

(i). Homopolymer: When all the repeating units along a chain are of the same type, the resulting polymer is called a **homopolymer**.

(ii). Copolymer is a polymer formed when two (or more) different types of monomers are linked in the same polymer chain.

- 50.** As per mechanical properties, which one of the following microconstituents is soft and ductile?
- A. Bainite
B. Martensite
C. Spheroidite
D. Tempered martensite

Ans. C

Sol. **Spheroidite:** Spheroidite steel has spherical particles are less conducive to stress concentration because of their rounded shapes. Thus, this structure has higher toughness and lower hardness than the pearlite structure. Spheroidite is known as the most ductile and machinable form of steel.

Bainite: Bainite is a very fine microstructure consisting of ferrite and cementite. Bainite is **harder and stronger than pearlite**, which, in turn, is harder and stronger than spheroidite.

Martensite: is a metastable interstitial solid solution of carbon in iron. It does not have as many slip systems, it is extremely hard and brittle, it lacks toughness, and therefore has limited use.

51. The simultaneous compaction and shaping of a ceramic powder (and binder) by pressure applied uniformly in all directions is known as
- A. Glaze pressing B. Porcelain pressing
C. Slip pressing D. Isostatic pressing

Ans. D

Sol. Isostatic pressing is a powder metallurgy (PM) forming process that applies equal pressure in all directions on a powder compact thus achieving maximum uniformity of density and microstructure.

52. An electric motor drives a punching press. A flywheel fitted to the press has a radius of gyration of 0.5 m and runs at 250 rpm. The press is capable of punching 800 holes per hour with each punching operation taking 1.5 seconds and requiring 12,000 N-m of work. The energy delivered by the motor during punching operation is
- A. 2000 N-m B. 3000 N-m
C. 4000 N-m D. 5000 N-m

Ans. C

Sol. Given:

Radius of gyration of flywheel, $R = 0.5$ m

Speed of flywheel, $N = 250$ rpm

The press is capable of punching 800 holes per hour.

Exact operation time, $t = 1.5$ seconds

Energy required for punching, $E = 12000$ N-m

Power rating of motor

$$= \text{Energy required for punching} \times \frac{\text{No. of holes}}{\text{sec}}$$

$$\text{Power rating of motor} = 12000 \times \frac{800}{3600}$$

$$= 2666.67 \text{ W}$$

Energy delivered by motor during punching

$$= 2666.67 \times 1.5 = 4000 \text{ J} = 4000 \text{ N-m}$$

53. A linkage has 11 links and 4 loops. What is the degree of freedom if it has only single turning pairs ?

- A. 0
B. 1
C. 2
D. 3

Ans. C

Sol. Given:

Number of links: $N = 11$

No. of loops: $L = 4$

Degree of freedom is given as:

$$F = N - (2L + 1)$$

Where $N =$ Number of link,

$L =$ Number of loops

$$\text{DOF} = 11 - (2 \times 4 + 1) = 2$$

54. Which one of the following is the application of first inversion of single-slider-crank chain?
- A. Hand-pump
B. Reciprocating engine
C. Elliptical trammel
D. Whitworth quick-return mechanism

Ans. B

Sol. Inversion of single-slider-crank chain:

1st inversion: when cylinder is fixed.

Example: Reciprocating engine

2nd inversion: Crank is fixed.

Examples: Whitworth Quick Return Motion Mechanism & Rotary Internal Combustion Engine (Gnome Engine).

3rd Inversion: connecting rod is fixed.

Examples: Crank and Slotted lever Quick Return Motion Mechanism & Oscillating Cylinder Engine Mechanism.

4th Inversion: Piston/slider is fixed.

Example: Hand Pump (Pendulum Pump/Bull Engine).

55. Consider the following statements regarding cams:

1. A cam in which the follower moves radially from the center of rotation of the cam is known as a disc cam.
2. A globoidal cam is a double-disc cam, the two discs being keyed together and are in constant touch with the two rollers of a follower.
3. A conjugate cam can have two types of surfaces, convex or concave.
4. In a spherical cam, the follower oscillates about an axis perpendicular to the axis of rotation of the cam.

Which of the above statements are correct?

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

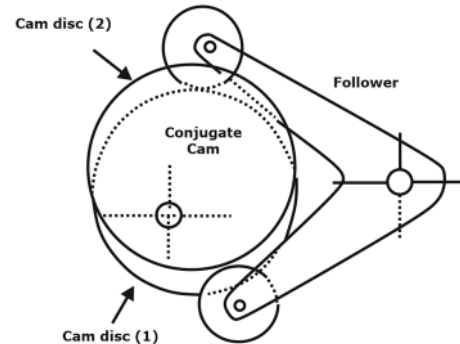
Ans. A

Sol. A cam in which the follower moves radially from the center of rotation of the cam is known as a disc cam.

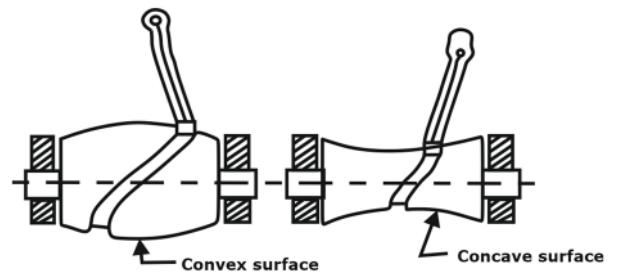
In a spherical cam, the follower oscillates about an axis perpendicular to the axis of rotation of the cam.

Conjugate cams

- A conjugate cam is a double-disc cam, the two discs being keyed together and are in constant touch with the two rollers of a follower (shown in Fig.).
- Thus, the follower has a positive constraint.
- Such a type of cam is preferred when the requirements are low wear, low noise, better control of the follower, high speed, high dynamic loads, etc.



Globoidal cam: A globoidal cam can have two types of surfaces, convex or concave.



Globoidal cam can have convex or concave surface

56. Under which of the following conditions is Coriolis component encountered in the relative acceleration of two points?

1. The two points are coincident, but on different links.
2. The point on one link traces a path on the other link.

3. The link that contains the path rotates.
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. D

Sol. Coriolis component will be present when:

- The two points are coincident, but on different links.
- The point on one link traces a path on the other link.
- The link that contains the path rotates.

57. A mass 'm' attached to a light spring oscillates with a period of 2 seconds. If the mass is increased by 2 kg, the period increases by 1 second. What is the value of the mass?

- A. 0.9 kg B. 1.6 kg
C. 2.1 kg D. 2.7 kg

Ans. B

Sol. Given,

initial time period (T_1) = 2 seconds

Final time period (T_2) = 3 seconds

Let the mass initially be 'm' and 's' be the spring constant, then we have

$$T_1 = 2\pi\sqrt{\frac{m}{s}}$$

$$T_2 = 2\pi\sqrt{\frac{m+2}{s}}$$

On putting the given values and dividing T_1 by T_2 , we get

$$\frac{2}{3} = \sqrt{\frac{m}{m+2}} \Rightarrow \frac{m}{m+2} = \frac{4}{9}$$

$$9m = 4m + 8$$

$$5m = 8$$

$$m = 1.6 \text{ kg}$$

58. What is the critical speed of the shaft if its natural frequency of transverse vibration is 2.85 Hz?

- A. 171 rpm B. 285 rpm
C. 570 rpm D. 142.5 rpm

Ans. A

Sol. Given,

Frequency (f) = 2.85 Hz

$$\omega = 2\pi f = 2\pi \times 2.85$$

$$\text{rpm}(N) = \frac{\omega \times 60}{2\pi} = \frac{2\pi \times 2.85 \times 60}{2\pi} = 171 \text{ rpm}$$

59. Consider the following statements regarding gears:

- The ratio of number of teeth on the gear to that on the pinion is known as gear ratio.
- The circle passing through the tips of teeth is called dedendum circle.
- The circle passing through the roots of teeth is called addendum circle.
- Backlash is the difference between the space width and the tooth thickness along the pitch circle.

Which of the above statements are correct?

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

Ans. B

Sol. 1. The ratio of number of teeth on the gear to that on the pinion is known as gear ratio.

2. The circle passing through the tips of teeth is called addendum circle.

3. The circle passing through the roots of teeth is called dedendum circle.

4. Backlash is the difference between the space width and the tooth thickness along the pitch circle.

- 60.** The number of teeth of a spur gear is 30 and it rotates at 200 rpm. What is the pitch line velocity if it has a module of 2 mm?
 A. 341.7 mm/s B. 497.2 mm/s
 C. 628.3 mm/s D. 758.5 mm/s

Ans. C

Sol. Given:

Teeth: $T = 30$

$$m = \frac{D}{T \rightarrow 30}$$

$D = 60 \text{ mm}$

$m = 2 \text{ mm}$

Pitch line velocity is given by:

$u = r\omega$

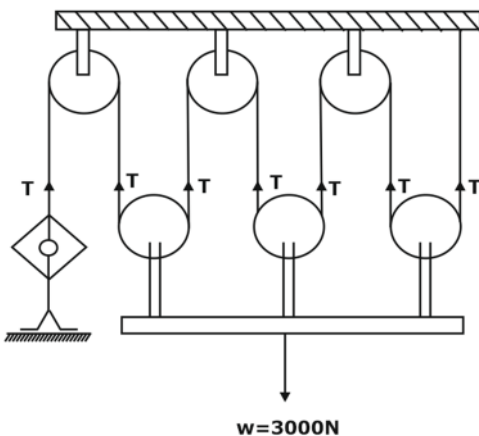
$$u = 30 \times 2\pi \frac{200}{60}$$

$u = 3.14 \times 200 = 628 \text{ mm/s}$

- 61.** A man whose weight is 650 N, standing on the ground, raises a load of 3000 N by means of single string system of pulleys. There are six light pulleys in each block. The thrust of the man on the ground is
 A. 120 N B. 135 N
 C. 150 N D. 175 N

Ans. C

Sol.



$6T = 3000$

$T = 500 \text{ N}$

Axial thrust = $w - T = 650 - 500 = 150 \text{ N}$

- 62.** A particle starts with an initial velocity of 200 cm/s and moves with a uniform retardation of 10 cm/s. If it describes 1500 cm in time, what is/are the possible value(s) of t?
 A. 10 sec only B. 10 sec and 30 sec
 C. 30 sec only D. 5 sec and 10 sec

Ans. B

Sol.



$$s = ut - \frac{1}{2}at^2$$

$$1500 = 200t - \frac{1}{2} \times 10 \times t^2$$

Verify

$5t^2 - 200t + 1500$

$t^2 - 40t + 300 = 0$

$t^2 - 30t - 10t + 300 = 0$

$t(t - 30)(t - 10) = 0$

$(t - 30)(t - 10) = 0$

$t = 30 \quad t = 10$

- 63.** Consider the following statements for system of forces:

1. Two or more forces that act at the same point are called coplanar forces.
2. Two or more forces whose directed arrows lie in same plane are called concurrent forces.
3. Varignon's theorem states that the moment of several concurrent coplanar forces about any point O in their plane equals the moment of their resultant about the point O.
4. Lami's theorem states that if a body is in equilibrium under the action of three forces, each force is proportional to the sine of angle between the other forces. Which of the above statements are correct?

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

Ans. C

Sol.

- **Varignon's theorem** states that the moment of several concurrent coplanar forces about any point O in their plane equals the moment of their resultant about the point O.
 - **Lami's theorem** states that if a body is in equilibrium under the action of three forces, each force is proportional to the sine of angle between the other forces.
 - Two or more forces that act at the same point are called concurrent forces.
 - Two or more forces whose directed arrows lie in same plane are called coplanar forces.
- 64.** Consider the following statements related to stress and strain :
1. Shear stress is always tangential to the area over which it acts.
 2. Shear stresses on the transverse pair of faces are known as complimentary shear stresses.
 3. Shear strain is defined as the change in the right angle of the element measured in radians.
 4. Modulus of rigidity is the ratio of shear strain to shear stress.
- Which of the above statements are correct?
- A. 1, 3 and 4 only
 B. 2 and 4 only
 C. 3 and 4 only
 D. 1, 2 and 3

Ans. D

- Sol. (i). Shear stress is parallel or tangential force per unit area on the surface of object.
- (ii). complimentary shear stress acts in plane perpendicular to the plane acting shear stresses such as it forms another couple in opposite direction.

(iii). The angular changes resulting between two mutually perpendicular planes is known as shear strain and it is measured in radians.

(iv). Modulus of rigidity (G) is given as:

$$G = \tau / \gamma$$

- 65.** Consider the following statements for stress and strain analysis :
1. The stress components on any inclined plane can easily be found with the help of a geometrical construction known as Mohr's stress circle.
 2. The ratio of longitudinal strain to lateral strain is known as Poisson's ratio.
 3. When a body is acted upon by three mutually perpendicular forces, there is change in the volume of the body which is referred to as dilation of the material.
 4. The ratio of original volume to increase in volume is known as volumetric strain.
- Which of the above statements are correct?
- A. 1 and 3 only B. 2 and 4 only
 C. 3 and 4 only D. 1,2,3 and 4

Ans. A

- Sol. (i). Mohr's circle is a graphical representation of a general state of stress at a point and principal stresses, maximum shear stress; normal and tangential stresses on any given plane can be calculated easily from it.
- (ii). Poisson's ratio is given as:

$$\mu = - \frac{\epsilon_{\text{lateral}}}{\epsilon_{\text{longitudinal}}}$$

(iii). Volumetric strain:

$$e_v = \frac{\text{Change in volume}}{\text{original volume}}$$

(iv). When a body is acted upon by three mutually perpendicular forces, there is change in the volume of the body which is referred to as dilation of the material.

Example: Hydrostatic stress condition.

- 66.** The stresses on two perpendicular planes - through a point in a body are 160 MPa and 100 MPa, both compressive, along with a shear stress of 80 MPa. What is the normal stress on a plane inclined at 30° to the plane of 160 MPa stress ?
- A. -42.4 MPa B. -75.7 MPa
C. -59.1 MPa D. -86.3 MPa

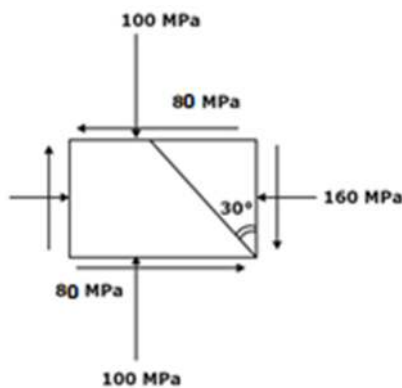
Ans. B

Sol. Given:

$$\sigma_x = -160 \text{ MPa}$$

$$\sigma_y = -100 \text{ MPa}$$

$$\tau_{xy} = 80 \text{ MPa}$$



$$\sigma_{\theta} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\sigma_{30^\circ} = \frac{-160 - 100}{2} + \frac{-160 - (-100)}{2} \cos 60^\circ + 80 \sin 60^\circ$$

$$\sigma_{30^\circ} = -130 - 30 \times \frac{1}{2} + 80 \times \frac{\sqrt{3}}{2}$$

$$\sigma_{30^\circ} = -75.71 \text{ MPa}$$

- 67.** Consider the following statements regarding types of supports and beams:
1. When both supports of beams are roller supports, the beam is known as simply supported beam.
 2. A beam with one end fixed and the other end free is known as fixed beam.
 3. A beam with both ends fixed is known as cantilever beam.

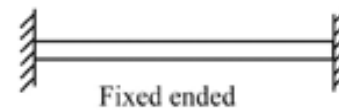
4. A beam with one end fixed and the other simply supported is known as propped cantilever.

Which of the above statements is/are correct?

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

Ans. B

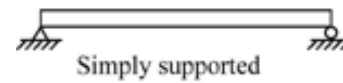
Sol. **Fixed beam:** Both ends Fixed.



Cantilever beam: Beam with one end fixed and another end free.



Simply supported beam: A beam with pin support at one end and roller support on another end.



Propped cantilever: A cantilever beam with fixed support at one end and roller support at another end, is called propped cantilever.

- 68.** Consider the following statements regarding stress in beam:

1. If a member is subjected to equal and opposite couples acting in the same longitudinal planes, the member is said to be in pure bending.
2. The internal stresses developed in the beam are known as flexural stresses.
3. There is an intermediate surface known as neutral surface, at which the stress is zero.
4. An axis obtained by intersection of the neutral surface and a cross-section is known as neutral axis.

Which of the above statements are correct?

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

Ans. D

Sol. The internal stresses developed in the beam are known as flexural stresses.

- A surface in a bent beam along which material is neither compressed nor extended i.e., no stresses, is called neutral surface.
- The line of intersection of the neutral layer, with any normal cross-section of a beam, is known as neutral axis of the section.

- 69.** Consider the following statements for the symmetric beam under pure bending :
1. In the elastic range, the normal stress varies linearly with the distance from the neutral surface.
 2. As long as the stresses remain in the elastic range, the neutral axis passes through the centroid of the section.
 3. If stresses are in the plastic range, the neutral axis passes through the centroid of the section.

Which of the above statements is/are correct?

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

Ans. C

Sol. **For symmetric beam under pure bending:**

- Bending stress is given as:

$$\sigma_b = \frac{E.y}{R} \text{ and } \sigma_b = \frac{M.y}{I_{NA}}$$

$$\sigma_b \propto y$$

Thus, bending stress has the linear variation of stress with the distance (y) from neutral axis.

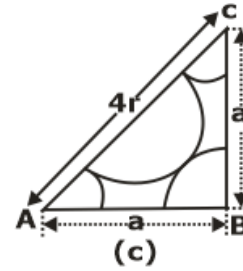
- When the stresses remain in the elastic range, the neutral axis passes through the centroid of the section.

- 70.** The volume of FCC unit cell in terms of the atomic radius R is

- A. $V_c = 16R^3\sqrt{3}$ B. $V_c = 8R^3\sqrt{2}$
C. $V_c = 16R^3\sqrt{2}$ D. $V_c = 8R^3\sqrt{3}$

Ans. C

Sol. For FCC



$$4r = a\sqrt{2}$$

Here, $r = R$

Volume of unit cell:

$$V = a^3$$

$$V = (2\sqrt{2}R)^3 = 16\sqrt{2} R^3$$

- 71.** Which one of the following alloying ingredients increases the hardenability and forms carbides for wear resistance?

- A. Chromium
B. Molybdenum
C. Nickel
D. Manganese

Ans. B

Sol.

- Chromium improves toughness, wear resistance, and high-temperature strength. It increases the corrosion resistance of the steels.
- Molybdenum improves wear resistance, toughness, and high-temperature strength and hardness. In martensitic steels, molybdenum increases the hardness at higher tempering temperatures due to its effect on carbide precipitation.
- Manganese is generally used to improve hot ductility.
- Nickel generally increases ductility and toughness.

- 72.** Which one of the following related to the most stable arrangement of atoms in a crystal is not correct?
- Preserves electrical neutrality
 - Maximizes strong ion-ion repulsion
 - Satisfies discreteness of all covalent bonds
 - Packs the atoms as closely as possible

Ans. B

Sol. Most stable arrangement will be the one that:

- Minimizes energy per unit volume.
- Preserves electrical neutrality.
- Satisfies directionality and discreteness of the covalent bonds.
- Minimizes ion-ion repulsion.
- Packs atoms as closely as possible.

- 73.** The dielectric constant of rubber varies

- 0.5 and 1.0
- 1.0 and 1.5
- 1.5 and 2.0
- 2.5 and 5.0

Ans. D

Sol. Dielectric constant for different materials:

Material	Dielectric constant
Rubber	2 to 4.5
Glass	3.8 to 14.5
Air	1
Quartz	5
Distilled water	34 to 78

- 74.** Consider the following statements for ductile fracture:

- The material undergoes substantial plastic deformation with high energy absorption before fracture.
- Presence of cracks on the surface of material initiates this type of failure.
- Fracture occurs due to necking. Which of the above statements is/are correct?

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

Ans. D

Sol.

- Ductile fracture in occurs after appreciable plastic deformation and fracture occurs due to necking (generally cup and cone fracture).
- Brittle fracture intakes place with little or no preceding plastic deformation and it is generally initiated at the surface cracks. Rock, concrete, glass, and cast-iron exhibit such type of failure.

- 75.** The TTT diagram shows the times required for isothermal transition from

- austenite to pearlite.
- austenite to ferrite.
- ferrite to pearlite.
- martensite to pearlite.

Ans. A

Sol.

- TTT stands for time-temperature transformation (TTT) diagram, and it graphically describes the cooling rate required for the transformation of austenite to pearlite, bainite or martensite. Here, the most appropriate option is the time required for isothermal transition from austenite to pearlite.
- TTT diagram also gives the temperature at which such transformations take place.

- 76.** Water is flowing through a pipe of diameter 200 mm with a velocity of 3 m/s. What is the head loss due to friction for a length of 5 m if the coefficient of friction is given by $f = 0.02 + \frac{0.09}{Re^{0.3}}$, where Re Reynolds number? (Take the kinematic viscosity of water as 0.01 stokes, $g = 9.81 \text{ m/s}^2$ and $(6 \times 10^5)^{0.3} = 54.13$).

- 0.993 m of water
- 0.783 m of water
- 0.685 of water
- 0.552 m of water

Ans. A

Sol. Given,

Velocity of water (V) = 3 m/s

Diameter of pipe (d) = 200 mm = 0.2 m

Length of pipe (l) = 5 m

Kinematic viscosity (ν) = 0.01 stoke = $0.01 \times 10^{-4} \text{ m}^2/\text{s}$

$$Re = \frac{Vd}{\nu} = \frac{3 \times 0.2}{0.01 \times 10^{-4}} = 6 \times 10^5$$

Now,

$$\begin{aligned} \text{Coefficient of friction, } (f) &= 0.02 + \frac{0.09}{Re^{0.3}} \\ &= 0.02 + \frac{0.09}{(6 \times 10^5)^{0.3}} \end{aligned}$$

$$f = 0.02 + \frac{0.09}{54.13} = 0.0216$$

$$\therefore \text{head loss } (h_f) = \frac{4flV^2}{2dg}$$

$$= \frac{4 \times 0.0216 \times 5 \times 3^2}{2 \times 0.2 \times 9.81} = 0.991 \text{ m of water}$$

77. Water is flowing through a horizontal pipe of diameter 200 mm at a velocity of 3 m/s. A circular solid plate of diameter 150 mm is placed in the pipe to obstruct the flow. What is the loss of head due to obstruction in the pipe if $C_c = 0.62$? (Take $g = 9.81 \text{ m/s}^2$)

- A. 3.311 m B. 4.211 m
C. 5.211 m D. 6.211 m

Ans. A

Sol. Given:

Diameter of pipe, $D = 200 \text{ mm} = 0.20 \text{ m}$

Velocity, $V = 3.0 \text{ m/s}$

$$\text{Area of pipe, } A = \frac{\pi}{4} D^2 = \frac{\pi}{4} (0.2)^2 = 0.03141 \text{ m}^2$$

Diameter of obstruction, $d = 150 \text{ mm} = 0.15 \text{ m}$

\therefore Area of obstruction,

$$a = \frac{\pi}{4} (0.15)^2 = 0.01767 \text{ m}^2$$

$C_c = 0.62$

The head lost due to obstruction is given by

$$\begin{aligned} &= \frac{V^2}{2g} \left(\frac{A}{C_c(A-a)} - 1.0 \right)^2 \\ &= \frac{3 \times 3}{2 \times 9.81} \left[\frac{.03141}{0.62[.03141 - .01767]} - 1.0 \right]^2 \\ &= \frac{9}{2 \times 9.81} [3.687 - 1.0]^2 = 3.311 \text{ m.} \end{aligned}$$

78. Three pipes of length 800 m, 500 m and 400 m and of diameters 500 mm, 400 mm and 300 mm respectively are connected in series. These pipes are to be replaced by a single pipe of length 1700 m. What is the diameter of the single pipe?

A. $(0.007118)^{0.2} \text{ m}$ B. $(0.003609)^{0.3} \text{ m}$
C. $(0.003609)^{0.2} \text{ m}$ D. $(0.007118)^{0.3} \text{ m}$

Ans. A

Sol. Given:

Length of pipe 1, $L_1 = 800 \text{ m}$ and dia.,
 $d_1 = 500 \text{ mm} = 0.5 \text{ m}$

Length of pipe 2, $L_2 = 500 \text{ m}$ and dia.,
 $d_2 = 400 \text{ mm} = 0.4 \text{ m}$

Length of pipe 3, $L_3 = 400 \text{ m}$ and dia.,
 $d_3 = 300 \text{ mm} = 0.3 \text{ m}$

Length of single pipe, $L = 1700 \text{ m}$

Let the diameter of equivalent single pipe = d

$$\frac{L}{d^5} = \frac{L_1}{d_1^5} + \frac{L_2}{d_2^5} + \frac{L_3}{d_3^5}$$

$$\begin{aligned} \frac{1700}{d^5} &= \frac{800}{0.5^5} + \frac{500}{0.4^5} + \frac{400}{0.3^5} \\ &= 25600 + 48828.125 + 164609 = 239037 \end{aligned}$$

$$\therefore d^5 = \frac{1700}{239037} = 0.007118$$

$$\therefore d = (0.007118)^{0.2} = 0.3718 = 371.8 \text{ mm.}$$

- 79.** The head of water at the inlet of a pipe 2000 m long and 500 mm diameter is 60 m. A nozzle of diameter 100 mm at its outlet is fitted to the pipe. What is the velocity of water at the outlet of the nozzle if $f = 0.01$ for the pipe? (Take $g = 9.81 \text{ m/s}^2$)
- A. 30.61 m/s B. 34.81 m/s
C. 36.52 m/s D. 38.36 m/s

Ans. A

Sol. Length of pipe, $L = 2000 \text{ m}$
Dia. of pipe, $D = 500 \text{ mm} = 0.50 \text{ m}$
Dia. of nozzle at outlet, $d = 100 \text{ mm} = 0.1 \text{ m}$
Co-efficient of friction, $f = 0.01$
The velocity at outlet of nozzle is given by equation as

$$v = \sqrt{\frac{2gH}{\left(1 + \frac{4fL}{D} \times \frac{a^2}{A^2}\right)}} = \sqrt{\frac{2 \times 9.81 \times 60}{1 + \frac{4 \times .01 \times 2000}{0.5} \left(\frac{\pi d^2}{4 D^2}\right)^2}}$$

$$= \sqrt{\frac{2 \times 9.81 \times 60}{1 + \frac{4 \times .01 \times 2000}{0.5} \times \left(\frac{0.1 \times .1}{0.5 \times .5}\right)^2}} = 30.61 \text{ m/s.}$$

- 80.** Water is flowing with a velocity of 1.5 m/s in a pipe of length 2500 m and of diameter 500 mm. At the end of the pipe, a valve is provided. What is the rise in pressure if the valve is closed in 25 seconds ? (Take the value of C as 1460 m/s)
- A. 12 N/cm² B. 15 N/cm²
C. 16 N/cm² D. 18 N/cm²

Ans. B

Sol. Velocity of water, $V = 1.5 \text{ m/s}$
Length of pipe, $L = 2500 \text{ m}$
Diameter of pipe, $D = 500 \text{ mm} = 0.5 \text{ m}$
Time of close the valve, $T = 25 \text{ seconds}$
Value of C = 1460 m/s
Let the rise in pressure = p

The ratio, $\frac{2L}{C} = \frac{2 \times 2500}{1460} = 3.42$

From equation, we have if $T > \frac{2L}{C}$, the closure of valve is said to be gradual.

Here $T = 25 \text{ sec}$ and $\frac{2L}{C} = 3.42$

$\therefore T > \frac{2L}{C}$ and hence valve is closed gradually.

From gradually closure of valve, the rise in pressure is given by equation as

$$p = \frac{\rho VL}{T} = 1000 \times 2500 \times \frac{1.5}{25} = 150000 \text{ N/m}^2$$

$$= \frac{150000}{10^4} \frac{\text{N}}{\text{cm}^2} = 15.0 \frac{\text{N}}{\text{cm}^2}$$

- 81.** If a submerged body is in unstable equilibrium, then
- A. the centre of buoyancy is below the centre of gravity.
B. the centre of buoyancy is above the centre of gravity.
C. meta-centre is below the centre of buoyancy.
D. meta-centre is above the centre of buoyancy.

Ans. A

Sol. A submerged body is in unstable equilibrium, if the centre of buoyancy is below the centre of gravity.

- 82.** How much of concrete with $\gamma = 25 \text{ kN/m}^3$ must be attached to a beam having a volume of 0.1 m^3 and specific gravity 0.6 to cause both to sink in water ? (Take $g = 9.81 \text{ m/s}^2$)
- A. 0.825 kN
B. 0.745 kN
C. 0.525 kN
D. 0.645 kN

Ans. D

Sol. Given,

Specific weight of concrete (γ_c) = 25 kN/m³

volume of beam (V_b) = 0.1 m³

Specific gravity of beam (S_b) = 0.6

∴ Density of beam (ρ_b)

$$= 0.6 \times 1000 = 600 \text{ kg/m}^3$$

For both the completely sink under water,

weight = Buoyant Force

let V_c be volume of concrete block,

$$\therefore \gamma_c V_c + \rho_b V_b g = (V_c + V_b) \rho_{\text{water}} \times g$$

$$25000 \times V_c + 600 \times 0.1 \times 9.81 = (V_c + 0.1) \times 1000 \times 9.81$$

$$25000V_c + 588.6 = 9810V_c + 981$$

$$15190V_c = 392.4$$

$$V_c = 0.0258 \text{ m}^3$$

$$\therefore \text{weight} = 0.0258 \times 25 = 0.645 \text{ kN}$$

83. A liquid has a specific gravity of 1.9 and a kinematic viscosity of 6 stokes. What is the dynamic viscosity?

- A. 1.14 Ns/m² B. 2.44 Ns/m²
C. 3.40 Ns/m² D. 11.40 Ns/m²

Ans. A

Sol. Given,

Specific gravity (s) = 1.9

Density of liquid, $\rho = 1.9 \times 10^3 \frac{\text{kg}}{\text{m}^3}$

Kinematic viscosity (ν) = 6 stokes

$$= 6 \times 10^{-4} \frac{\text{m}^2}{\text{sec}}$$

$$\nu = \frac{\mu}{\rho}$$

Dynamic viscosity (μ) = $\nu \times \rho$

$$= 6 \times 10^{-4} \times 1.9 \times 10^3 = 1.14 \text{ Ns/m}^2$$

84. Oil of specific gravity 0.8 flows through a 0.2 m diameter pipe under a pressure of 100 kN/m². If the datum is 5 m below the centerline of the pipe and the total energy with respect to the datum is 35 Nm/N, the discharge is (Take $g = 9.81 \text{ m/s}^2$)

A. 0.58 m³/sec

B. 0.47 m³/sec

C. 0.31 m³/sec

D. 0.22 m³/sec

Ans. A

Sol. We know that,

$$\text{TEL} - \text{HGL} = \frac{v^2}{2g}$$

$$35 - \left[\frac{p}{\rho g} + z \right] = \frac{v^2}{2g}$$

$$35 - [12.74 + 5] = \frac{v^2}{2g}$$

$$v = 18.40 \text{ m/s}$$

$$Q = A \times v = 0.578 \text{ m}^3/\text{s}$$

85. Bernoulli's equation is obtained by

- A. integrating the Euler's equation of motion.
B. differentiating the Euler's equation of motion.
C. differentiating the Navier-Stokes equations.
D. integrating energy equation.

Ans. A

Sol. Bernoulli's equation is obtained by integrating the Euler's equation of motion.

86. Which one of the following is not the methodology of control separation of flow from boundary in the application of airfoils?

- A. Streamlining of blunt body shapes
B. Fluid ejection from the boundary layer
C. Suction of fluid from the boundary layer
D. Creating a motion of the boundary wall

Ans. B

Sol. To avoid Flow separation wake should be reduced by streamlining the body, pressure must decrease & velocity must increase which can be obtained by suction of fluid from boundary Layer and moving the boundary wall. So, incorrect method is fluid ejection from Boundary Layer.

87. What is the value of mass of the air in a room of size 4 m × 5 m × 6 m at 100 kPa and 25°C (Take R = 0.287 kPa. m³. Kg⁻¹.K⁻¹)?

- A. 150 kg B. 180 kg
C. 140 kg D. 130 kg

Ans. C

Sol. Given:

Volume of room, V = 4 × 5 × 6 = 120 m³

p = 100 kPa. T = 25°C = 298 K

$$\rho = \frac{p}{RT} = \frac{100}{0.287 \times 298}$$

$$\rho = 1.169 \text{ kg/m}^3$$

$$m = \rho \times V$$

$$= 1.169 \times 120$$

$$= 140 \text{ kg}$$

88. A body of weight 100 N is placed on a rough horizontal plane. What is the coefficient of friction if a horizontal force of 60 N just causes the body to slide over the horizontal plane?

- A. 0.4 B. 0.5
C. 0.6 D. 0.9

Ans. C

Sol. Weight of body, W = 100 N

Horizontal force, F = 60 N

We know that,

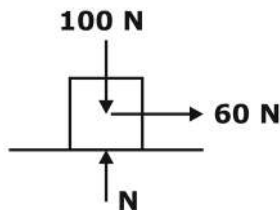
$$F = \mu N$$

From equilibrium condition, W = N

So, F = μW

$$\text{Or } 60 = \mu \times 100$$

$$\mu = 0.6$$



89. A body is moving with a velocity of 2 m/s. After 4 seconds, the velocity of the body becomes 5 m/s. The acceleration of the body is

- A. 0.55 m/s² B. 0.65 m/s²
C. 0.75 m/s² D. 0.45 m/s²

Ans. C

Sol. Initial velocity, u = 2 m/s

Final velocity, v = 5 m/s

From first law of motion

$$v = u + at$$

$$5 = 2 + a \times 4$$

$$a = \frac{3}{4} = 0.75 \text{ m/s}^2$$

90. The principal stresses at a point in an elastic material are 60 N/mm² tensile, 20 N/mm² tensile and 50 N/mm² compressive. What is the volumetric strain by considering Young's Modulus as 100 × 10³ N/mm² and μ = 0.3?

- A. 1.20 × 10⁻⁴ B. 1.06 × 10⁻⁵
C. 1.30 × 10⁻³ D. 1.12 × 10⁻²

Ans. A

Sol. Given:

σ_x = 60 N/mm² (tensile)

σ_y = 20 N/mm² (tensile)

σ_z = 50 N/mm² (compressive)

Elastic Modulus (E) = 100 × 10³ N/mm²

Poisson ratio: μ = 0.3

Strain components are given as:

$$e_x = \frac{\sigma_x}{E} - \mu \frac{\sigma_y}{E} - \mu \frac{\sigma_z}{E}$$

$$e_y = \frac{\sigma_y}{E} - \mu \frac{\sigma_x}{E} - \mu \frac{\sigma_z}{E}$$

$$e_z = \frac{\sigma_z}{E} - \mu \frac{\sigma_x}{E} - \mu \frac{\sigma_y}{E}$$

Volumetric strain is given as:

$$e_v = e_x + e_y + e_z$$

$$= \frac{\sigma_x + \sigma_y + \sigma_z}{E} - 2\mu \left(\frac{\sigma_x + \sigma_y + \sigma_z}{E} \right)$$

$$e_v = \frac{\sigma_x + \sigma_y + \sigma_z}{E} (1 - 2\mu)$$

$$e_v = \frac{60 + 20 - 50}{100 \times 10^3} \{1 - 2 \times 0.3\}$$

$$e_v = 1.2 \times 10^{-4}$$

91. In an absorption type refrigeration system, heating in generator, refrigeration in evaporator and cooling by cooling water in condenser, take place at 95°C, -5°C and 30°C respectively. What is the maximum COP of the system?

- A. 1.17 B. 1.35
C. 1.52 D. 1.78

Ans. B

Sol. $(COP)_{VAR} = \frac{T_E}{T_C - T_E} \times \left(\frac{T_G - T_C}{T_G} \right)$

$$\Rightarrow \left(\frac{-5 + 273}{30 + 5} \right) \times \left(\frac{95 - 30}{95 + 273} \right)$$

$$\Rightarrow \frac{268}{35} \times \frac{65}{368}$$

$$= 1.35$$

92. Consider the following statements for sensible heat factor:

1. Sensible heat factor will be negative if sensible heat and latent heat are both negative.
2. Sensible heat factor will be negative if sensible heat is negative and latent heat is positive.
3. Sensible heat factor will be negative if sensible heat is positive and latent heat is negative.
4. Sensible heat factor will be negative if sensible heat and latent heat are both positive.

Which of the above statements are correct?

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

Ans. A

Sol. As we know that,

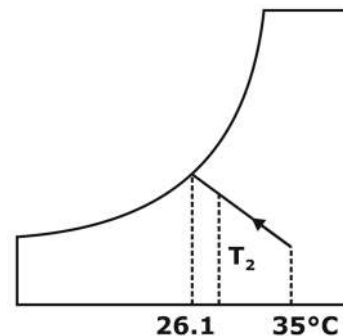
$$SHF = \frac{SH}{SH + LH}$$

1. Sensible heat factor will be positive if sensible heat and latent heat are both negative.
 2. Sensible heat factor will be negative if sensible heat is negative and latent heat is positive.
 3. Sensible heat factor will be negative if sensible heat is positive and latent heat is negative.
 4. Sensible heat factor will be positive if sensible heat and latent heat are both positive.
- 93.** If the air is initially at dry bulb temperature 35°C and wet bulb temperature 26.1 °C as it enters an air washer which has a humidifying efficiency of 85%, then what is the final dry bulb temperature of air washed with recirculated spray water?

- A. 26.81 °C B. 27.43 °C
C. 32.83 °C D. 30.49 °C

Ans. B

Sol. Humidifying efficiency



$$0.85 = \frac{(DBT)_1 - (DBT)_2}{35 - 26.1}$$

$$0.85 = \frac{35 - DBT_2}{35 - 26.1}$$

$$DBT_2 = 27.435 \text{ °C}$$

- 94.** Consider the following statements for Nucleate boiling:
1. For water, the critical heat flux does not exceed 1 MW/m^2 .
 2. Nucleate boiling is the most desirable boiling regime in practice because of high heat transfer rates.
 3. Heat flux increases at a higher rate with increase in temperature.
- Which of the above statements is/are correct?
- A. 1 only B. 2 only
C. 1 and 3 only D. 2 and 3 only

Ans. D

Sol. Maximum attainable heat flux for water in nucleate boiling is $q'' = 1 \text{ MW/m}^2$ at atmospheric pressure.

All the statements are correct but statements 2 and 3 seem to be the most appropriate.

- 95.** In drop-wise condensation, the heat transfer rate is
- A. 5 times less than that in film-wise condensation.
 - B. 15 times less than that in film-wise condensation.
 - C. 25 times more than that in film-wise condensation.
 - D. 10 times more than that in film-wise condensation.

Ans. D

Sol. Dropwise condensation is 10 times more than that in film wise condensation.

- 96.** 1 kg of water falls from an altitude of 1000 m above ground level. What is the change in the temperature of water at the foot of the fall, if there are no losses during the fall ? (Take specific heat of water as $1 \text{ kcal.kg}^{-1}.\text{K}^{-1}$ and $g = 9.81 \text{ m/s}^2$)

- A. 3.35°C B. 2.35°C
C. 3.32°C D. 4.12°C

Ans. B

Sol. Conservation of energy

$$mgH = m \times C \times \Delta T$$

$$9.81 \times 10^3 = 4.18 \times 10^3 \times \Delta T$$

$$\Delta T = 2.34^\circ\text{C}$$

- 97.** A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 0.105 MPa to a final state of 0.15 m^3 and 0.105 MPa , the pressure remaining constant during the process. There is a transfer of 40 kJ of heat from the gas during the process. How much does the internal energy of the gas change ?
- A. -24.25 kJ
 - B. -19.62 kJ
 - C. -15.91 kJ
 - D. -12.72 kJ

Ans. A

Sol. $V_1 = 0.3 \text{ m}^3$ $P_1 = 0.105 \text{ MPa}$.

$V_2 = 0.15 \text{ m}^3$ $P_2 = 0.105 \text{ MPa}$

$$dQ = -40 \text{ kJ}$$

$$dW = p (V_2 - V_1) = 0.105 \times 10^3 \times (0.15 - 0.3)$$

$$= -15.75 \text{ kJ}$$

$$dQ = dU + dW$$

$$-40 = dU - 15.75$$

$$dU = -24.25 \text{ kJ}$$

- 98.** The state of a simple compressible pure
- A. one independent property.
 - B. two independent properties.
 - C. three independent properties.
 - D. four independent properties.

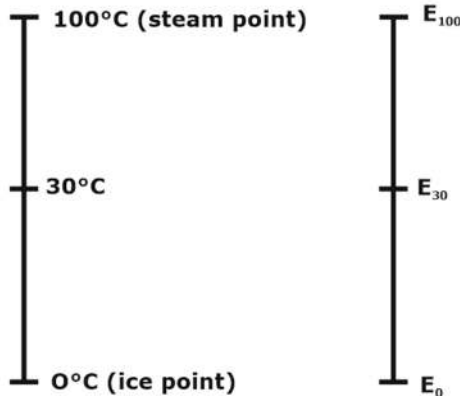
Ans. B

Sol. The state of a simple compressible system is completely specified by two independent, intensive properties.

- 99.** In a thermoelectric thermometer for $t^\circ\text{C}$ temperature, the emf is given as :
 $E = 0.003 t - 5 \times 10^{-7} t^2 + 0.5 \times 10^{-3}$ volts
 Thermometer is having reference junction at ice point and is calibrated at ice point and steam point. What is the temperature shown by the thermometer for a substance at 30°C ?
- A. 33.23°C
 B. 30.35°C
 C. 41.23°C
 D. 46.28°C

Ans. B

Sol.



- At ice point
 $E_0 = 0.5 \times 10^{-3}$ volts
- At steam point,
 $E_{100} = 0.003 \times 100 - 5 \times 10^{-7} \times (100)^2 + 0.5 \times 10^{-3} = 0.2955$ volts
- $E_{30} = 0.003 \times 30 - 5 \times 10^{-7} \times (30)^2 + 0.5 \times 10^{-3} = 0.09005$ volts

Temperature on thermometer,

$$\frac{T - 0}{100 - 0} = \frac{E_{30} - E_0}{E_{100} - E_0} = \frac{0.09005 - 0.0005}{0.2955 - 0.0005}$$

$$T = 30.35^\circ\text{C}$$

- 100.** Consider the following statements for comparison of heat and work:
- Both heat and work are transient phenomena.

- Both heat and work are boundary phenomena.
- Both heat and work are path functions and inexact differentials.

Which of the above statements are correct?

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

Ans. B

Sol. About heat and work transfer:

- Both heat and work are transient phenomena.
- Both heat and work are boundary phenomena.
- Both heat and work are path functions and inexact differentials.

- 101.** A tank containing a fluid is stirred by a paddle wheel. The work input to the paddle wheel is 5090 kJ. The heat transfer from the tank is 1500 kJ. What is the change in internal energy of this control mass? (Consider the tank and the fluid inside a control surface)

- A. - 3590 kJ B. + 3590 kJ
 C. + 4590 kJ D. - 4590 kJ

Ans. B

Sol. Given: $dW = -5090$ kJ

$$dQ = -1500 \text{ kJ}$$

As we know that,

$$dQ = dU + dW$$

$$-1500 = dU - 5090$$

$$\text{Or } dU = 3590 \text{ kJ}$$

- 102.** During the charging of a storage battery, the current is 20 A and the voltage is 12.8 V. The rate of heat transfer from the battery is 10 W. At what rate is the internal energy increasing?

- A. -256 J/s B. +246 J/s
 C. +256 J/s D. -246 J/s

Ans. B

Sol. Given:

$$I = 20$$

$$V = 12.8 \text{ V}$$

$$dQ = -10 \text{ W}$$

$$dW = 20 \times 12.8 = -256 \text{ W. } (\because \text{work done on the system})$$

We know that,

$$dQ = dU + dW$$

$$-10 = dU - 256$$

$$dU = 246 \text{ watt.}$$

103. A refrigerator operates on Reversed Carnot cycle. What is the power required to drive the refrigerator between temperatures of 42°C and 4°C , if heat at the rate of 2 kJ/s is extracted from the low temperature region?

- A. 0.174 kW B. 0.374 kW
C. 0.274 kW D. 0.474 kW

Ans. C

$$\text{Sol. COP} = \frac{T_2}{T_1 - T_2} = \frac{2}{P}$$

$$\Rightarrow \frac{4 + 273}{42 - 4} = \frac{2}{P}$$

$$\Rightarrow \frac{277}{38} = \frac{2}{P}$$

$$P = 0.274 \text{ kW}$$

104. Entropy generated (S_{gen}) can be taken as a criterion to indicate feasibility of process.

Which of the following conditions are correct?

- If $S_{\text{gen}} = 0$, then the process is a reversible process.
- If $S_{\text{gen}} > 0$, then the process is an irreversible process.
- If $S_{\text{gen}} < 0$, then the process is impossible.

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. About Entropy generation:

- If $S_{\text{gen}} = 0$, then the process is a reversible process.
- If $S_{\text{gen}} > 0$, then the process is an irreversible process.
- If $S_{\text{gen}} < 0$, then the process is impossible.

105. What is the critical radius of insulation for asbestos (thermal conductivity = $0.17 \text{ W.m}^{-1}.\text{C}^{-1}$) surrounding a circular pipe and exposed to room air at 20°C with heat transfer coefficient $3 \text{ W.m}^{-2}.\text{C}^{-1}$?

- A. 7.21 cm B. 6.37 cm
C. 5.67 cm D. 6.93 cm

Ans. C

Sol. Given,

Thermal conductivity of asbestos (k) = $0.17 \text{ W/m}^\circ\text{C}$

Heat transfer coefficient of air (h) = $3 \text{ W/m}^2\text{C}$

$$\text{Critical radius } (r_1) = \frac{k}{h} = \frac{0.17}{3} = 0.0567\text{m} \\ = 5.67 \text{ cm}$$

106. A turbine develops 8000 kW when running at 1000 rpm . The head on the turbine is 30 m . If the head is reduced to 18 m , what is the speed developed by the turbine?

- A. 67.46 rpm B. 95.24 rpm
C. 54.67 rpm D. 774.6 rpm

Ans. D

Sol. Power developed with head 30m (P_1) = 8000 kW

Initial head (H_1) = 30 m

Final head (H_2) = 18 m

Initial speed (N_1) = 1000 rpm

Speed at head of 18m (N_2) = ?

We know that,

$$\frac{N_1}{\sqrt{H_1}} = \frac{N_2}{\sqrt{H_2}}$$

$$\Rightarrow \frac{1000}{\sqrt{30}} = \frac{N_2}{\sqrt{18}} \text{ i.e. } N_2 = 774.596 \text{ rpm}$$

107. The steam turbine can be governed by the following methods except
 A. Reaction governing
 B. Throttle governing only
 C. Nozzle control governing only
 D. Combination of throttle and nozzle control governing,

Ans. A

Sol. The stream turbines are governed by all methods like nozzle governing, throttle governing and combination of nozzle & throttle governing. Reaction governing is not used as method of governing.

108. In a gas turbine plant, heat supplied is 667.2 kJ/kg, and heat rejected is 391.43 kJ/kg. What is the thermal efficiency of the plant?

- A. 57.29% B. 72.51%
 C. 41.33% D. 32.83%

Ans. C

Sol. Given,

Heat supplied, $Q_s = 667.2$ kJ/kg

Heat rejected, $Q_R = 391.43$ kJ/kg

$$\eta = 1 - \frac{\text{heat rejected}}{\text{heat supplied}}$$

$$\eta = 1 - \frac{Q_R}{Q_s} = 1 - \frac{391.43}{667.2} = 41.33\%$$

109. The constant pressure gas turbine works on

- A. Stirling Cycle B. Atkinson Cycle
 C. Rankine Cycle D. Brayton Cycle

Ans. D

Sol. Gas Turbine works on Brayton cycle.

110. In hydraulic turbines, if the energy available at inlet is only kinetic energy, then that type of turbine is

- A. Reaction turbine B. Impulse turbine

- C. Francis turbine D. Kaplan turbine

Ans. B

Sol. Impulse hydraulic turbine: -

An impulse hydraulic turbine is a turbine that is driven by high velocity jets of water directed on to vanes or buckets attached on wheel. In these turbines, all potential energy available at inlet gets converted into kinetic energy by nozzle. So, energy available at inlet is only kinetic energy.

111. A centrifugal pump has an impeller of 30 cm outer diameter. The vane tips are radial at the outlet. For a rotative speed of 1450 rpm, what is the manometric head developed ? (Assume a manometric efficiency of 82% and take $g = 9.81 \text{ m/s}^2$)

- A. 37.24 m B. 43.38 m
 C. 29.46 m D. 32.88 m

Ans. B

Sol. Given,

Outer diameter of impeller = 30 cm

Rotational speed of pump = 1450 rpm

Manometric efficiency of pump = 82%

Acceleration due to gravity = 9.81 m/s^2

Manometric eff. =

$$\frac{\text{manometric head}}{\text{head imparted by impeller to water}}$$

$$\eta_{\text{mano.}} = \frac{gH_m}{V_{w2}u_2} = \frac{gH_m}{u_2^2}$$

$$0.82 = \frac{9.81 \times H_m}{u_2^2}$$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.30 \times 1450}{60} = 22.77 \text{ m/s}$$

$$0.82 = \frac{9.81 \times H_m}{(22.77)^2}$$

$$H_m = 43.38 \text{ m}$$

112. Lenoir cycle is used for

- A. Gas turbines B. Pulse jet engines
C. S.I. engines D. C.I. engines

Ans. B

Sol. The Lenoir cycle is an idealized thermodynamic cycle often used to model a pulse-jet engine.

It comprises of 3 cycles:

- (i) Heat added at constant volume.
- (ii) Adiabatic Expansion.
- (iii) Exhaust of the hot gasses at a constant pressure.

113. A diesel engine has a compression ratio of 20 and cut-off takes place at 5% of the stroke. What is the cut-off ratio?

- A. 1.21 B. 1.47
C. 1.73 D. 1.95

Ans. D

Sol. Given,

$$\text{Compression ratio } (r) = 20 = \frac{V_1}{V_2}$$

$$\text{Cut-off } (V_3 - V_2) = 0.05 V_s = 0.05 (V_1 - V_2)$$

$$\text{Or } V_3 - V_2 = 0.05 (V_1 - V_2)$$

$$\text{Or } \frac{V_3}{V_2} - 1 = 0.05 \left(\frac{V_1}{V_2} - 1 \right)$$

$$\text{Or } \frac{V_3}{V_2} - 1 + 0.05(20 - 1) = 1.95$$

114. The cubic capacity of a four-stroke over-square spark-ignition engine is 275cc. The clearance volume is 25 cc. What is the compression ratio of the engine?

- A. 8 B. 10
C. 12 D. 14

Ans. C

Sol. Given,

$$\text{Cubic capacity of SI engine } (V_s) = 275 \text{ cc}$$

$$\text{Clearance volume } (V_c) = 25 \text{ cc}$$

As we know that,

Compression ratio, $r =$

$$\frac{V_s + V_c}{V_c} = \frac{275 + 25}{25} = 12$$

115. The mechanical efficiency of a single-cylinder four-stroke engine is 60%. The frictional power is estimated to be 30 kW. What is the indicated power?

- A. 120 kW B. 75 kW
C. 150 kW D. 130 kW

Ans. B

Sol. Given,

$$\text{Mechanical efficiency } (\eta_m) = 60\%$$

$$\text{Frictional power } (F_p) = 30 \text{ kW}$$

As we know that

$$\text{Indicated power } (IP) = \text{Brake power } (BP) +$$

$$\text{Frictional power } (FP)$$

$$IP = BP + 30$$

$$\text{Or } BP = IP - 30$$

$$\& \eta_m = \frac{BP}{IP}$$

$$\text{Or } 0.6 = \frac{IP - 30}{IP}$$

$$\text{Or } 0.6 IP = IP - 30$$

$$\text{Or } 0.4 IP = 30$$

$$\text{Or } IP = 75 \text{ kW}$$

116. A four-stroke petrol engine at full load delivers 100 kW. It requires 10 kW to rotate it Without load at same speed. What is the mechanical efficiency at half load?

- A. 67.82% B. 70.24%
C. 77.32% D. 83.33%

Ans. D

Sol. Given,

$$\text{BP at full load} = 100 \text{ kW}$$

$$\text{Frictional power} = 10 \text{ kW}$$

As we know that,

Mechanical efficiency,

$$\eta_m = \frac{BP}{IP}$$

At half load, BP = 50 kW

And Frictional power (FP) = 10 kW

So, IP = 50 + 10 = 60 kW

$$\therefore \eta_m = \frac{BP}{IP} = \frac{50}{60} = 0.833 \text{ or } 83.33\%$$

117. Freon-12 is used in a simple saturation cycle, with suction saturation temperature of -10°C and condensing saturation temperature of 30°C . If the clearance volume is 6% of the stroke volume, what is the volumetric efficiency? (Consider specific volume at suction and discharge to be $0.07815 \text{ m}^3/\text{kg}$ and $0.025 \text{ m}^3/\text{kg}$ respectively)

- A. 87.24% B. 71.31%
C. 64.85% D. 55.43%

Ans. A

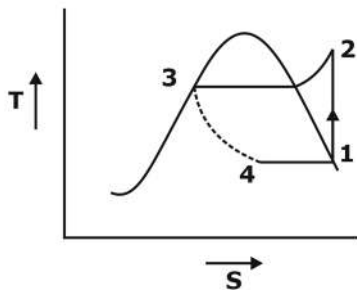
Sol. Given,

Specific volume at suction = $0.07815 \text{ m}^3/\text{kg}$,

Specific volume at discharge = $0.025 \text{ m}^3/\text{kg}$

$V_c = 6\%V_s$

$$C = \frac{V_c}{V_s} = 6\% = 0.06$$



$$P_1 V_1^n = P_2 V_2^n$$

$$\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} = \frac{V_1}{V_2}$$

$$\eta_v = 1 + C - C \left(\frac{P_2}{P_1}\right)^{1/n}$$

$$= 1 + 0.06 - 0.06 \left(\frac{0.7815}{0.025}\right) = 87.24\%$$

118. Relative ozone destruction efficiency of R-12 is

- A. 0.29 B. 0.86
C. 0.05 D. 0.57

Ans. B

Sol.

Refrigerant	Chemical Formula	Relative ozone destruction efficiency
R-11	CCl_3F	1
R-12	CCl_2F_2	0.82
R-113	$\text{CCl}_2\text{FCClF}_2$	0.85
R-114	$\text{CClF}_2\text{CClF}_2$	0.58

119. An air cooled condenser has 6 m^2 of surface with a removal of $50 \text{ kJ}\cdot\text{hr}^{-1}\cdot\text{m}^{-2}\cdot^\circ\text{C}^{-1}$. What is the refrigerant temperature to dissipate 5235 kJ/hr , if the room temperature is 25°C ?

- A. 24.31°C B. 35.82°C
C. 42.45°C D. 56.94°C

Ans. C

Sol. Given,

Condenser surface area = 6 m^2

Heat capacity = $50 \text{ kJ}\cdot\text{hr}^{-1}\cdot\text{m}^{-2}\cdot^\circ\text{C}^{-1}$

Heat dissipate = 5235 kJ/hr ,

$$50 \times 6 \times \Delta T = 5235$$

$$\Delta T = \frac{5235}{6 \times 50} \Rightarrow 17.45$$

$$T_R - T_{\text{air}} = 17.45$$

$$T_R = 17.45 + 25 \Rightarrow 42.45^\circ\text{C}$$

120. The actual and theoretical COP of rolling piston compressor are 3.6 and 4.7 respectively. What is the relative COP ?

- A. 8.3 B. 16.92
C. 1.3 D. 0.76

Ans. D

Sol. Given,

$$\text{Actual COP} = 3.6$$

$$\text{theoretical COP} = 4.7$$

As we know that,

$$\text{Relative COP} = \frac{\text{Actual COP}}{\text{Theoretical COP}} = \frac{3.6}{4.7} = 0.76$$

121. A fuel consists of 92% carbon, 7% hydrogen and remaining residual matter by mass. Working from first principles, the higher calorific value of the fuel is

- A. 40176 kJ/kg B. 41176 kJ/kg
C. 40876 kJ/kg D. 41678 kJ/kg

Ans. A

Sol. 1 mole of carbon = 393.5 kJ/mol

$$1 \text{ mole of H}_2 = 286 \text{ kJ/mol}$$

take = 1000 grams

So, 920 grams of carbon

$$\text{Moles of carbon} = \frac{920}{12}$$

$$\text{Moles of H}_2 = \frac{70}{2}$$

Total energy released,

$$= \frac{920}{12} \times 393.5 + \frac{70}{2} \times (286)$$

$$= 40175 \text{ kJ/kg.}$$

122. In order to burn a fuel completely, Which of the following basic conditions must be fulfilled?

1. Supply enough air for complete combustion of fuel.
2. Secure low turbulence for thorough mixing of fuel and air.
3. Maintain a furnace temperature high enough to ignite the incoming fuel air mixture.
4. Provide a furnace volume large enough to allow time for combustion to be completed.

Select the correct answer using the code given below:

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

Ans. C

Sol. Complete combustion requires that the following conditions be satisfied:

- (i) An adequate air (oxygen) supply.
- (ii) Adequate fuel/air mixture.
- (iii) Appropriate furnace temperature for fuel ignition.
- (iv) Adequate combustor residence time for complete combustion, thus furnace volume should be sufficient large.
- (v) Turbulence cause by swirl assists in the rapid and complete combustion of highly diluted mixtures.

123. The efficiency of any cycle increases with

- A. the decrease of maximum pressure and the constant of exhaust pressure.
- B. the decrease of maximum pressure and the decrease of exhaust pressure.
- C. the increase of maximum pressure and the decrease of exhaust pressure.
- D. the increase of maximum pressure and the constant of exhaust pressure.

Ans. C

Sol. Efficiency of any cycle increases with increase of maximum pressure & decrease of exhaust pressure.

124. In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and the overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33, respectively. What is the efficiency of auxiliaries?

- A. 98.14%
- B. 92.68%
- C. 83.41%
- D. 75.14%

Ans. B

Sol. Given,

Generator efficiency = 0.97,
turbine (mechanical) efficiency = 0.95,
boiler efficiency = 0.92,

cycle efficiency = 0.42,

Overall plant efficiency = 0.33

$$\eta_{\text{Overall}} = \eta_{\text{boiler}} \times \eta_{\text{generator}}$$

$$\times \eta_{\text{turbine}} \times \eta_{\text{cycle}} \times \eta_{\text{auxillary}}$$

$$\eta_{\text{aux.}} = \frac{0.33}{0.97 \times 0.95 \times 0.92 \times 0.42} = 0.926$$

$$\eta_{\text{aux.}} = 92.68\%$$

125. Consider the following statements for analysis of steam cycles :

1. A steam power plant continuously converts the energy stored in fossil fuels or fissile fuels into shaft work.
2. Steam power plants work on Brayton cycle.
3. In supercritical steam cycle, steam is generated in a 'once-through' boiler at a pressure above the critical point of 27.5 bar.
4. Deaerator is used for the purpose of deaerating the feedwater.

Which of the above statements are correct?

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

Ans. C

Sol.

1. A steam power plant continuously converts the energy stored in fossil fuels or fissile fuels into shaft work.
2. Steam power plants work on Rankine cycle.
3. In supercritical steam cycle, steam is generated in a 'once-through' boiler at a pressure above the critical point of 221.2 bar.
4. Deaerator is used for the purpose of deaerating the feedwater.

126. Consider the following statements for solid fuels :

1. Peat is the first stage in the formation of coal from wood.

2. The average calorific value of bituminous coal is 1524 kJ/kg.

3. Anthracite is very hard coal and has a shining black lustre.

4. Wood charcoal is obtained by destructive distillation of wood.

Which of the above statements are correct ?

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

Ans. B

Sol. 1. Peat is the first stage in the formation of coal from wood.

2. The average calorific value of bituminous coal is around 33000 kJ/kg.

3. Anthracite is very hard coal and has a shining black lustre.

4. Wood charcoal is obtained by destructive distillation of wood.

127. Consider the following statements for fluidized bed boilers:

1. Fluidized bed boilers produce steam from fossil and waste fuels by using a technique called fluidized bed combustion.

2. Cyclone separators are gas cleaning devices that utilize the centrifugal force created by a spinning gas stream to separate particles from a gas.

3. In a pressurized fluidized bed boiler, the combustion process takes place in a pressurized environment resulting in a compact furnace and improved combustion efficiency.

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. (i) Fluidized bed boilers produce steam from fossil and waste fuels by using a technique called fluidized bed combustion. FBC boilers can be operated efficiently with a variety of fuels.

(ii) Cyclone separators are gas cleaning devices that utilize the centrifugal force created by a spinning gas stream to separate particles from a gas.

(iii) In a pressurized fluidized bed boiler, the combustion process takes place in a pressurized environment resulting in a compact furnace and improved combustion efficiency.

128. Consider the following statements for steam turbines:

1. The ratio of actual enthalpy drop to isentropic enthalpy drop is known as mechanical efficiency.

2. The ratio of enthalpy drop in moving blades to enthalpy drop in the stage is known as degree of reaction.

3. Rateau turbine is the example of reaction turbine.

4. Curtis turbine is the example of impulse turbine.

Which of the above statements are correct?

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

Ans. A

Sol. (i). The ratio of actual enthalpy drop to isentropic enthalpy drop is known as nozzle efficiency.

(ii). The ratio of enthalpy drop in moving blades to enthalpy drop in the stage is known as degree of reaction.

(iii). Rateau turbine is pressure compounded impulse turbine.

(iv). Curtis turbine is velocity compounded impulse turbine.

129. Consider the following statements for cooling towers:

1. Cooling tower is an artificial device used to cool the hot cooling water coming out of condenser more effectively.

2. The amount of water usually lost with induced draft cooling tower ranges from 5% to 6% by evaporation.

3. The amount of water usually lost with induced draft cooling tower ranges from 7% to 8% by drift losses.

4. The rate of evaporation of water and its cooling float on the remaining water depends upon the relative humidity of air passing through the tower.

Which of the above statements are correct ?

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

Ans. A

Sol. About Cooling towers:

1. Cooling tower is an artificial device used to cool the hot cooling water coming out of condenser more effectively.

2. The amount of water usually lost with induced draft cooling tower ranges from 3% to 4% by evaporation.

3. The amount of water usually lost with induced draft cooling tower ranges from 0.02% to 0.03% by drift losses.

4. The rate of evaporation of water and its cooling float on the remaining water depends upon the relative humidity of air passing through the tower.

130. A single-acting reciprocating pump, running at 50 rpm delivers $0.0073 \text{ m}^3/\text{s}$ of water. The diameter of the piston is 200 mm and stroke length is 300 mm. What is the percentage slip of the pump?

- A. 5.29% B. 6.29%
C. 7.29% D. 8.29%

Ans. B

Sol. Given,

Single acting reciprocating pump

$$\text{Theoretical discharge } (Q_{th.}) = \frac{ALN}{60}$$

$$Q_{\text{actual}} = 0.00736 \text{ m}^3/\text{sec}$$

$$\% \text{ slip} = \frac{(Q_{th.} - Q_{act.})}{Q_{th.}}$$

$$Q_{th} = \frac{ALN}{60} = (0.2)^2 \times 0.3 \times \frac{50}{60}$$

$$= 7.854 \times 10^{-3} \text{ m}^3 / \text{sec}$$

$$\% \text{ slip} = 6.29\%$$

131. A pump discharges a liquid into a tank at the rate of $0.032 \text{ m}^3/\text{s}$. The tank, 1.5 m in diameter and 4.20 m in height, can hold 3500 kg of liquid. The density of the liquid and mass flow rate of the liquid handled by the pump are respectively,

- A. 471.57 kg/m^3 and 16 kg/s
B. 471.57 kg/m^3 and 15 kg/s
C. 481.57 kg/m^3 and 16 kg/s
D. 481.57 kg/m^3 and 15 kg/s

Ans. B

Sol. Given,

$$\text{Flow rate } Q = 0.032 \text{ m}^3/\text{s}$$

$$\text{Vol. of cylinder} = \frac{\pi}{4} \times D^2 \times h = 7.422 \text{ m}^3$$

$$\text{time} = \frac{7.422}{0.032}$$

$$t = 232 \text{ sec.}$$

$$\text{mass flow rate} = \frac{3500}{232} = 15.08 \text{ kg/s}$$

$$\rho = \frac{m}{v} = \frac{3500}{7.422} = 471.57 \text{ kg / m}^3$$

132. In Francis turbine, as the water discharge is radial at the outlet, the velocity whirl at the outlet becomes

- A. 1
B. 0
C. ∞
D. 0.5

Ans. B

Sol. The Francis turbine, as the water discharge is radial at the outlet, the velocity whirl at the outlet becomes zero. ($V_{w2} = 0$)

(As flow is radial)

$$V_{w2} = 0, V_2 = V_{f2} \Rightarrow \beta = 90^\circ$$

$$\eta_H = \frac{V_{w1} u_1}{gH}$$

133. A pump impeller is 375 mm in diameter and it discharges water with velocity components of 2 m/s and 12 m/s in the radial and tangential directions respectively. The impeller is surrounded by a concentric cylindrical chamber with parallel sides, the outer diameter being 450 mm. If the flow in the chamber is a free spiral vortex, what are the tangential velocity and radial velocity at the outlet of the chamber respectively?

- A. 12 m/s and 1.67 m/s
B. 10 m/s and 1.67 m/s
C. 12 m/s and 1.76 m/s
D. 10 m/s and 1.76 m/s

Ans. B

Sol. Given,

inner diameter of impeller $D_1 = 375$ mm
 outer diameter of impeller $D_2 = 450$ mm

$$V_{f1} = 2 \text{ m/s}$$

For Free vortex
 $(V = \omega r) = \text{const}$

$$V_{w1} = 12 \text{ m/s}$$

$$V_{w1}R_1 = V_{w2}R_2$$

$$\Rightarrow V_{w2} = V_{w1} \frac{R_1}{R_2} = 12 \times \frac{375}{450} = 10 \text{ m/s}$$

$$\boxed{V_{w2} = 10 \text{ m/s}}$$

Also,

$$V_{f1}R_1 = V_{f2}R_2$$

$$\Rightarrow V_{f2} = V_{f1} \times \frac{R_1}{R_2} = 2 \times \frac{375}{450}$$

$$\Rightarrow \boxed{V_{f2} = 1.667 \text{ m/s}}$$

134. Which one of the following types of impellers is used to handle highly solid-laden liquids like concrete and slurry?

- A. Fully Open Impeller
- B. Semi-Enclosed Impeller
- C. Fully-Enclosed Impeller
- D. Quarter Open Impeller

Ans. A

Sol. Fully open impeller is used to handle highly solid-laden liquids like concrete and slurry.

Open impellers are generally faster and easier to clean and repair.

135. In a single reciprocating pump without air vessel, the ratio of the average frictional head to the maximum frictional head in the delivery pipe is

- A. 1/2
- B. 1/3
- C. 2/3
- D. 3/4

Ans. C

Sol. For delivery pipe

$$\text{Frictional head } (h_{fd}) = \frac{fLV_d^2}{2gd_d}$$

$$V_d = \frac{A}{A_d} r\omega \sin \theta \text{ (delivery velocity)}$$

put in above

$$h_{fd} = \frac{fL_d}{2gd_d} \left(\frac{A}{A_d} r\omega \sin \theta \right)^2$$

Maximum h_{fd} is at $\left(\theta = \frac{\pi}{2} \right)$ and hence

$$(h_{fd})_{\text{max.}} = \frac{fL_d}{2gd_d} \left(\frac{A}{A_d} r\omega \right)^2$$

$$(h_{fd})_{\text{avg.}} = \text{Avg. } h_{fd} = \frac{2}{3} (h_{fd})_{\text{max.}}$$

136. In various solar energy storage System, pumped hydro-electric storage system falls under which one of the following categories?

- A. Thermal energy storage
- B. Electrical energy storage
- C. Mechanical energy storage
- D. Electromagnetic energy storage

Ans. C

Sol. Mechanical Energy storage system considers hydroelectric storage system.

137. What is the standard value of solar constant adopted by World Radiation Centre ?

- A. 1192 W/m²
- B. 1084 W/m²
- C. 1927 W/m²
- D. 1367 W/m²

Ans. D

Sol. Standard value of solar constant adopted by world Radiation centre is 1367 W/m².

138. What is the tip speed ratio of savonius wind turbine rotor ?

- A. 1
- B. 3
- C. 5
- D. 7

Ans. A

Sol. Tip speed ratio of the wind turbine is given by,

$$\text{TSR} = \frac{\text{speed of tip of the rotor blade}}{\text{speed of oncoming air}} = \frac{r\omega}{u_0}$$

Where,

r = Radius of the tip of the wind turbine

ω = Angular velocity of the turbine hub

u_0 = Speed of the oncoming air to turbine blades

tip speed ratio of savonius wind turbine rotor is 1.

139. What is the solidity of American multiblade wind turbine rotor ?

- A. 0.4 B. 0.7
C. 0.9 D. 1

Ans. B

Sol. Solidity is defined as the ratio of blade area to swept are:

$$\text{Solidity, } \sigma = \frac{Nb}{2\pi R}$$

Where,

N = No. of blades, b = blades width, R = Blade radius

$$\sigma = \frac{\text{Ratio of blade area}}{\text{Circumference of rotor}}$$

the solidity of American multiblade wind turbine rotor is 0.70.

140. The energy density of Bio-ethanol is

- A. 8.3 MJ/kg B. 14.6 MJ/kg
C. 26.9 MJ/kg D. 34.7 MJ/kg

Ans. C

Sol. Energy density of bioethanol is 26.9 MJ/kg.

141. The percentage of hydrogen in producer gas is

- A. 34% B. 27%
C. 18% D. 8%

Ans. C

Sol. Percentage of hydrogen in producer gas is 18%.

142. In single basin, double effect scheme, power is generated

- A. during filling.
B. during emptying.
C. on ebb only.
D. on both flood and ebb.

Ans. D

Sol. In single basin, double effect scheme, power is generated on both flood and ebb. Two-way (reversible) hydraulic turbines are used.

143. The operating temperature of alkaline fuel cells is

- A. 39°C B. 90°C
C. 127°C D. 192°C

Ans. B

Sol. Operating temperature of alkaline fuel cell is 90°C.

144. The ideal emf produced by polymer electrolyte membrane fuel cell at 25°C is

- A. 3.57 V B. 2.94 V
C. 1.23 V D. 0.73 V

Ans. C

Sol. Ideal emf produced by polymer electrolyte membrane fuel cell is 1.23 V.

145. Which one of the following fuel cells has highest efficiency ?

- A. PAFC B. MCFC
C. PEMFC D. AFC

Ans. D

Sol. Among all the given options Alkaline fuel cell has efficiency of 64%

PEMFC → 48-58%

AFC → 64%

PAFC → 42%

MCFC → 50%

SOFC → 60-65%

146. How many kilograms of steam per day is produced by 15 m diameter community solar cooker developed by Centre for Scientific Research, Auroville (Puducherry) ?

- A. 100 kg B. 300 kg

- C. 600 kg
- D. 1000 kg

Ans. C

Sol.

- A 15-m diameter community solar cooker has been developed at the Centre for Scientific Research, Auroville (Puducherry).
- Around 600kg of steam per day could be generated from this bowl.

147. In a solar passive space heating system, the south-facing thick wall is called

- A. Vent wall
- B. Trombe wall
- C. Damper wall
- D. Ventilation wall

Ans. B

Sol. In solar passive system of heating the space involved heat absorption using thermal storage in form of a south facing thick wall called Trombe wall.

148. All power plants use superheated steam due to which of the following advantages?

1. Superheating is mostly done from waste heat of boiler without additional cost of fuel.
2. The plant efficiency increases due to higher temperature of steam.
3. There is less corrosion and erosion of equipment due to absence of moisture in the steam.

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. B

Sol. Effects of regenerative feedwater heating for the same turbine output:

1. It significantly increases the cycle efficiency and reduces the heat rate.
2. It increases the steam flow rate (Requiring bigger boiler).

3. It decreases the steam flow to the condenser (Requiring smaller condenser).
4. If there is no change of boiler output, the turbine output drops.

149. What are the effects of regenerative feedwater heating for the same turbine output?

1. It significantly increases the cycle efficiency and reduces the heat rate.
2. It increases the steam flow rate.
3. It increases the steam flow to the condenser.
4. If there is no change of boiler output, the turbine output drops.

Select the correct answer using the code given below :

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

Ans. B

Sol. The effects of regenerative feedwater heating for the same turbine output may be summarized as follows:

1. It significantly increases the cycle efficiency and reduces the heat rate (reducing operating cost).
2. It increases the steam flow rate (requiring bigger boiler).
3. It reduces the steam flow to the condenser (needing smaller condenser).
4. If there is no change of boiler output, the turbine output drops.

150. Which of the following are the advantages of pulverized coal firing ?

1. Higher boiler efficiency.
2. Fast response for no load changes.
3. Ability to use low preheated air reducing internal losses.

4. Ability to release large amounts of heat enabling it to generate about 2000 t/h of steam in one boiler.

Select the correct answer using the code given below :

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

Ans. C

Sol. Advantages of Pulverized Coal Firing

- 1. Low excess air requirement
- 2. Less fan power
- 3. Ability to use highly preheated air reducing exhaust losses
- 4. Higher boiler efficiency

5. Ability to burn a wide variety of coals

6. Fast response to load changes

7. Ease of burning alternately with, or in combination with gas and oil

8. Ability to release large amounts of heat enabling it to generate about 2000 t/h of steam or more in one boiler

9. Ability to use fly ash for making bricks etc.

10. Less pressure losses and draught need.

Disadvantages

1. Added investment in coal preparation unit

2. Added power needed for pulverizing coal

3. Investment needed to remove fly ash before ID fan

4. Large volume of furnaces needed to permit desired heat release and to withstand high gas temperature.

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