



**ESE 2022**

**Preliminary  
Examination**

**Detailed  
Solution of**

**MECHANICAL  
ENGINEERING**

**Set-B**

Scroll down



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### Mechanical Engineering Paper Analysis of ESE 2022 Preliminary Examination

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## UPSC ESE Prelims 2022 Mechanical Engineering analysis by MADE EASY faculties

<https://www.youtube.com/watch?v=hVDugNdxRs>

1. Consider the following statements regarding microprocessors and microcontrollers:
1. A microcontroller is a single, very large-scale integrated chip that contains programmable electronic components.
  2. Address bus carries the signals relating to control actions.
  3. A microcomputer consists of a central processing unit, I/O interface and a memory block.
- Which of the above statements are correct?
- (a) 1 and 2 only    (b) 2 and 3 only  
(c) 1 and 3 only    (d) 1, 2 and 3

**Ans. (c)**

Address bus is used to transfer the address of either memory or I/O from the processor

**End of Solution**

2. Consider the following statements regarding microprocessor instructions :
1. Compare instruction reads the contents of a particular memory location and copied to a specific register in the processor.
  2. Jumps instruction changes the sequence in which the program is being carried out.
  3. Decrement instruction subtracts 1 from the contents of a specified location.
- Which of the above statements are correct?
- (a) 1 and 2 only    (b) 2 and 3 only  
(c) 1 and 3 only    (d) 1, 2 and 3

**Ans. (b)**

The compare instruction compares two operations. So, statements 1 is wrong.

**End of Solution**

3. Which one of the following statements is correct regarding characteristic parameters used in transducers?
- (a) Span is the deviation of the true value from the desired value.
  - (b) Precision is defined as the degree of exactness for which an instrument is designed or intended to perform.
  - (c) Sensitivity is the difference in the output for a given input when the value is approached from the opposite direction.
  - (d) Hysteresis of an instrument is defining as the ratio of the magnitude of the output signal to the magnitude of the input signal.

**Ans. (b)**

Out of the four options only 'B' can be considered least wrong. So, best choice will be option (b).

**End of Solution**

4. Consider the following statements regarding dynamic quantities in sensors and transducers:
1. The maximum amount by which the moving parts move beyond the steady state is known as over shoot.
  2. An output whose magnitude does not repeat with time is known as transient.
  3. An output whose magnitude has a definite repeating time cycle is called steady state periodic.
- Which of the above statements are correct?
- |                  |                  |
|------------------|------------------|
| (a) 1 and 2 only | (b) 2 and 3 only |
| (c) 1 and 3 only | (d) 1, 2 and 3   |

**Ans. (c)**

An output whose magnitude varies with time is known as transient output. So, statement 2 is wrong.

**End of Solution**

5. Consider the following statements regarding encoders:
1. An encoder is a device that provides digital output in response to a linear or angular displacement.
  2. A digital optical encoder is a device that converts motion into a sequence of digital pulses.
  3. An incremental encoder produces equally spaced pulses from one or more concentric tracks on the code disk.
- Which of the above statements are correct?
- |                  |                  |
|------------------|------------------|
| (a) 1 and 2 only | (b) 2 and 3 only |
| (c) 1 and 3 only | (d) 1, 2 and 3   |

**Ans. (d)**

Optical encoder is a digital sensor used to measure angular displacement and linear displacement.

Optical encoder converts input position information into output electrical pulses.

Incremental encoder consist of rotating disc on which equal length holes are drilled at equal distances.

So, all statements are correct.

**End of Solution**

6. Which one of the following statements is NOT correct regarding accelerometers?
- (a) In displacement seismic accelerometer, the displacement of seismic mass is measured by displacement transducer itself.
  - (b) In strain gauge accelerometer, the seismic mass is placed on a cantilever beam placed inside the housing.
  - (c) In potentiometric accelerometer, in a spring-mass-damper system, the mass is connected with the wiper arm of the potentiometer.
  - (d) The LVDT accelerometer consist of one primary and four secondary windings which are placed on either side of a central core.



Ans. (d)

LVDT accelerometer consists of one primary and two secondary windings which are placed on either side of a central core.

End of Solution

7. Which one of the following valves restricts or throttles the fluid in a particular direction to influence the volumetric flow of the fluid?

- (a) Check valve
- (b) Flow control valve
- (c) Quick exhaust valve
- (d) Sequence valve

Ans. (a)

Check valves restricts or throttles the fluid in a particular direction to influence the volumetric flow of the fluid. So, option (a) is correct.

End of Solution

8. Which one of the following instructions is conditional instruction which allow the user to change the order in which the processor scans the program?

- (a) Sequence instruction
- (b) Communications instruction
- (c) Control instruction
- (d) Arithmetic instruction

Ans. (c)

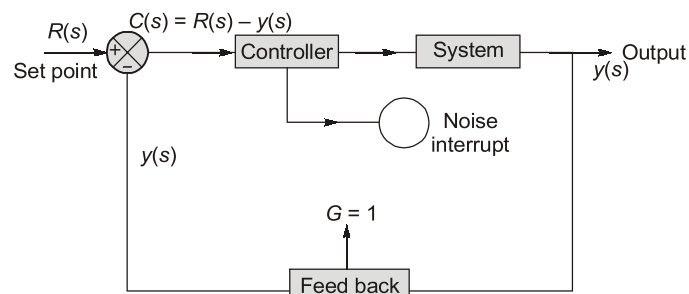
Control instruction allows the user to change the order in which processor scans the program.

End of Solution

9. Which one of the following signals are external commands signals provided to the controller?

- (a) Control signals
- (b) Controlled signals
- (c) Disturbance signals
- (d) Setpoint signals

Ans. (c)



So, noise interrupt/disturbance signal/noise signal is provided to the controller.

End of Solution

10. Which one of the following is the smallest increment of movement into which the robot can divide its work volume?
- (a) Spatial resolution of a robot                      (b) Accuracy of a robot  
(c) Repeatability of a robot                              (d) Compliance of a robot

Ans. (a)

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

End of Solution

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

Ans. (b)

In case of Tactile array sensor multiple arrays will be there where we can apply force which can be detected by the system.

End of Solution

12. Consider the following statements regarding robot end effectors:
1. Magnetic gripper can be a very feasible means of handling ferrous materials.
  2. Hooks can be used as end effectors to handle containers of parts and to load and unload parts hanging from overhead conveyors.
  3. Scoops and ladles can be used to handle certain materials in liquid or powder form.
- Which of the above statements are correct?
- (a) 1 and 2 only    (b) 2 and 3 only  
(c) 1 and 3 only    (d) 1, 2 and 3

Ans. (d)

All the given statements are correct regarding robot end effectors.

End of Solution

13. A flat plate of area  $1.5 \times 10^6 \text{ mm}^2$  is pulled with a speed of 0.4 m/s relative to another plate located at a distance of 0.15 mm from it. What is the power required to maintain this speed, if the fluid separating them is having viscosity as 1 poise?
- (a) 160 W    (b) 158 W  
(c) 145 W    (d) 130 W

Ans. (a)

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

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

$y = 0.15 \text{ mm} = 0.15 \times 10^{-3} \text{ m}$

$\mu = 1 \text{ poise} = 0.1 \text{ kg/m-s}$

$$P = F \times V = \frac{\mu AV}{y} \times V = \frac{\mu AV^2}{y}$$

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

End of Solution

14. A gas weighs 16 N/m<sup>3</sup> at 25°C and at an absolute pressure 0.25 N/mm<sup>2</sup>. What is the gas constant approximately? (Take acceleration due to gravity as 9.81 m/s<sup>2</sup>)
- (a) 514.68 Nmkg<sup>-1</sup>K<sup>-1</sup>                      (b) 542.55 Nmkg<sup>-1</sup>K<sup>-1</sup>  
(c) 562.68 Nmkg<sup>-1</sup>K<sup>-1</sup>                      (d) 592.55 Nmkg<sup>-1</sup>K<sup>-1</sup>

Ans. (a)

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

$$\frac{m}{V} \times 9.81 = 16$$

$$\frac{m}{V} = \frac{16}{9.81}$$

$$T_o = 25^\circ\text{C} = 298 \text{ K}$$

$$P_{\text{abs}} = 0.25 \text{ N/mm}^2 \\ = 0.25 \text{ N}/(10^{-3} \text{ m})^2$$

$$PV = mRT$$

$$P = \frac{m}{V}RT$$

$$0.25 \times 10^6 = \frac{16}{9.81} \times R \times 298$$

$$R = 514.36 \text{ Nm/kgK}$$

End of Solution

15. A pipe contains an oil of specific gravity 0.9. A differential manometer connected at the two points A and B shows a difference in mercury level as 15 cm. What is the difference of pressure at the two points? (Take acceleration due to gravity as 9.81 m/s<sup>2</sup>, specific gravity of mercury as 13.6 and density of water as 1000 kg/m<sup>3</sup>)
- (a) 18688 N/m<sup>2</sup>                      (b) 19688 N/m<sup>2</sup>  
(c) 15688 N/m<sup>2</sup>                      (d) 17866 N/m<sup>2</sup>

Ans. (a)

$$\Delta P = (\rho_{\text{manometric fluid}} - \rho_{\text{flowing fluid}}) \times g \times \text{differential head} \\ = (13600 - 900) \times 9.81 \times 0.15 \\ = 18688.081 \text{ N/m}^2$$

End of Solution

16. Which one of the following is used in case in which the clutch runs free when the machine is being driven in the intended direction?
- (a) Overrunning (b) Backstopping  
(c) Under running (d) Front stopping

Ans. (a)

End of Solution

17. In a band brake, the tension in the band decreases from the value  $P_1$  at the pivot side of the band to  $P_2$  at the lever side. If  $r$  is the radius of the drum, then the net torque on the drum is
- (a)  $\frac{(P_1 - P_2)}{r}$  (b)  $(P_1 - P_2)r$   
(c)  $\frac{(P_1 + P_2)}{r}$  (d)  $(P_1 + P_2)r$

Ans. (b)

End of Solution

18. Consider the following statements regarding transmission shafts:
1. Counter shaft is secondary shaft which is driven by the main shaft from which the power is supplied to a machine component.
  2. Jack shaft is an intermediate shaft between two shafts that is used in transmission of power.
  3. A line shaft consists of a number of shafts, which are connected in an axial direction by means of couplings.
- Which of the above statements is/ are correct?
- (a) 2 only (b) 1 and 3 only  
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (d)

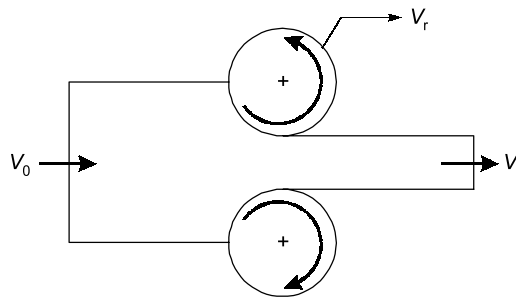
- A countershaft is a shaft which is connected to the main shaft with the help of a pair of gears, since it rotates opposite to the direction of rotation of main shaft, it is known as countershaft.
- Jack shaft is an intermediate shaft between two rotating shafts. Its sole purpose is to transfer power from one shaft to the another.
- A line shaft is a combination of shaft which are joined axially to one another with the help of couplings.

End of Solution

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

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

Ans. (c)



Here,

$V_r \rightarrow$  Roller velocity

$V_o \rightarrow$  Initial velocity of workpiece

$V_1 \rightarrow$  Final velocity of workpiece

$$\text{Forward slip} = \frac{V_1 - V_r}{V_r}$$

$$\text{Backward slip} = \frac{V_r - V_o}{V_r}$$

**End of Solution**

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

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

Ans. (d)

**End of Solution**

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

- (a) Optimistic time                                    (b) Pessimistic time  
(c) Likely time                                        (d) Unlikely time

Ans. (a)

**End of Solution**



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22. In which one of the following, the criticality of the item is most important than the cost factor of the item?
- (a) ABC analysis (b) VED analysis  
(c)  $p$  system (d)  $q$  system

Ans. (b)

VED analysis is a popular inventory management strategy that classifies materials according to their criticality for the business into three categories of vital, essential and desirable.

End of Solution

23. Which one of the following is the projections on a pattern that is used to make recesses in the mould to locate the core?
- (a) Sprue (b) Core print  
(c) Gate (d) Riser

Ans. (b)

Core print is the projection on the pattern and it is used to produce a recess in the mould to position the core properly.  
It is provided on the pattern but it will not be there on the casting.

End of Solution

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

Ans. (a)

**Permanent mould or gravity die casting**

**Advantages:**

1. High accuracy and surface finish.
2. Better mechanical properties due to fast rate.
3. Less labour is required.
4. Production rate is high.

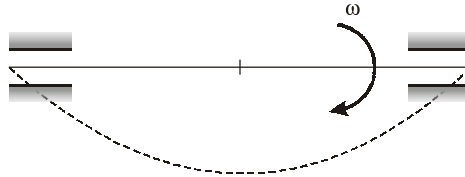
**Disadvantages:**

1. Due to chilling action hardness of surface is more.
2. It is not used for high melting point materials.
2. Not used for low production rate.
3. Gas defects can be present.

End of Solution

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

Ans. (c)



Critical speed = Resonance speed

$$\omega = \omega_n \text{ of transverse vibrations}$$

$$= \omega_n \text{ of lateral vibrations}$$

$$= \sqrt{\frac{s}{m}}$$

Where,  $s \rightarrow$  Bending stiffness,  $m \rightarrow$  Mass of system.

End of Solution

- Q.26 Which one of the following is formed due to large friction and stronger adhesion between chips and tool face?
- Continuous chip
  - Discontinuous chip
  - Continuous chip with built-up edge
  - Discontinuous chip with built-up edge

Ans. (c)

Due to high friction large heat is generated at chip tool interface, so continuous chip with built up edge is formed.

End of Solution

- Q.27 Total Quality Management (TQM) and Quality assurance are the responsibility of everyone involved in designing and manufacturing of the product. Who among the following pioneers has NOT been quality control heightened?
- Deming
  - Taguchi
  - Juran
  - B.F. Skinner

Ans. (d)

Deming, Taguchi and Juran are the names related to the quality control while B.F. Skinner is an American psychologist who developed the theory of operant conditioning, not related to quality control.

End of Solution



**Q.28** Which one of the following is the angle between the planes of end flank immediately below the end cutting edge and line perpendicular to the base and right angle to the axis?

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

**Ans. (c)**

**End of Solution**

**Q.29** Consider the following statements related to stepless drive of machine tools:

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

Which of the above statements are correct?

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

**Ans. (b)**

In stepless drives, we can obtain variable speeds, so statement 1 is wrong. This implies option (b) is correct.

**End of Solution**

**30.** Consider the following statements regarding machine vibration:

1. If the mechanical stresses are below the acceptable safe working stress levels of the materials involved, no direct protection methods are required.
2. If the stresses exceed the safe levels, corrective measures such as stiffening, reduction of inertia and bending moment effects, and incorporation of further support members, as well as possible uses of isolators, may be required.
3. Shock isolators differ from vibration isolators in that shock requires a stiffer spring and a higher natural frequency for the resilient element.

Which of the above statements are correct?

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

**Ans. (d)**

**End of Solution**

**Q.31** Which one of the following alloys is most suitable for applications in bearings, bushings, piston rings, steam fittings and gears?

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

Ans. (b)

Tin bronzes are used for piston pins, bushings, valve guides and bearings in machine tool industry. They are also used for stem fittings, impellers etc.

End of Solution

Q.32 In general, annealing is carried out to

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

Ans. (a)

Annealing process improves softness.

End of Solution

Q.33 Consider the following statements related to compute the equilibrium concentrations of the two phases:

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

Which of the above statements is/are correct?

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

Ans. (d)

All the three statements given indicate the steps in applications of lever rule.

End of Solution

Q.34 In which of the following microconstituents,  $\alpha$ -Ferrite +  $\text{Fe}_3\text{C}$  phases are present?

1. Spheroidite
2. Coarse pearlite
3. Fine pearlite

Select the correct answer using the code given below:

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

Ans. (d)

The three given phases contain  $\alpha$ -Ferrite and  $\text{Fe}_3\text{C}$  as microconstituent phases.

End of Solution

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

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

Ans. (a)

The ability of the material to absorb energy within elastic limit is resilience.

End of Solution

Q.36 What is the shape of indenter for Vicker's microhardness testing technique?

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

Ans. (c)

Diamond pyramid indenter is used in Vicker's hardness test.

End of Solution

37. Corrosion penetration rate is directly proportional to

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

Ans. (c)

$$\text{Corrosion penetration rate} = \frac{CW}{\rho AT}$$

∴ C = Constant

W = Weight loss

ρ = Density; A = Surface area of specimen

T = Exposure time

End of Solution

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

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

Ans. (d)

Galvanic cell corrosion can be prevented by breaking electrical connection by insulating the two metals from each other, and applying coatings to both materials.

End of Solution

39. Consider the following statements regarding corrosion :

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

Which of the above statements is/are correct?

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

Ans. (a)

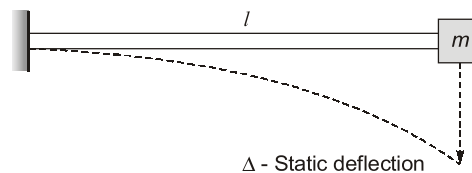
Only the statements 1 and 2 are correct for corrosion.

End of Solution

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

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

Ans. (a)



We know that in cantilever:

$$\Delta = \text{Static deflection}$$

$$\Delta = \frac{Wl^3}{3EI}$$

Natural frequency of transverse vibrations:

$$\omega_n = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{g}{\frac{Wl^3}{3EI}}}$$

$$= \sqrt{\frac{3EIg}{Wl^3}} = \sqrt{\frac{3EIg}{mgl^3}} \quad (W = mg)$$

$$= \sqrt{\frac{3EI}{ml^3}}$$

$E$  - Young's modulus,  $I$  - Area MI about bending axis

If new length  $l' = \frac{l}{2}$

$$\omega'_n = \sqrt{\frac{3EI}{m(l/2)^3}} = \sqrt{\frac{8(3EI)}{ml^3}} = \sqrt{8}\omega_n$$

End of Solution

41. Consider the following statements regarding kinematic pairs:
- When a pair has a point or line contact between the links, it is known as lower pair.
  - When the elements of a pair are held together mechanically, it is known as closed pair.
  - If two mating links have a turning as well as sliding motion between them, they form a screw pair.
  - When two links of a pair are in contact either due to force of gravity, they constitute an unclosed pair.

Which of the above statements are correct?

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

Ans. (d)

If pair elements are held together mechanically

- Permanent contact
- Closed pair (Self closed pair)

In screw pair

- Turning as well as linear propagation i.e. sliding occurs.

If pair elements are in contact due to force of gravity

- Forced closed pair
- Open air
- Unclosed pair

---

**End of Solution**

42. The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 rpm clockwise when looking from stern. If the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h, then the gyroscopic couple is
- |                |                |
|----------------|----------------|
| (a) 22.27 kN-m | (b) 21.27 kN-m |
| (c) 12.47 kN-m | (d) 11.47 kN-m |

Ans. (a)

Given:  $m = 3500$  kg,  $k = 0.45$  m,  $I = mk^2 = 3500 \times 0.45^2$ ,  $I = 708.75$  kg-m<sup>2</sup>,

$$N = 3000 \text{ rpm}, \omega = \frac{2\pi \times 3000}{60} = 314.1592 \text{ rad/s}$$

$$(\omega_p)_{\text{turning}} = \frac{V}{R} = \frac{(36 \times 5/18)}{100} = \frac{10}{100} = 0.1 \text{ rad/s}$$

$$\begin{aligned}
 C &= I \cdot \omega (\omega_p)_{\text{turning}} \\
 &= 708.75 \times 314.1592 \times 0.1 \\
 &= 22266.0379 \text{ N-m} \\
 &= 22.266 \text{ kN-m}
 \end{aligned}$$

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**End of Solution**

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

Which of the above statements are correct?

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

**Ans. (a)**

1, 2 and 4 statements are right but there is no such option. Best answer will be (a).

---

**End of Solution**

44. Which one of the following principles states that the inertia forces and couples, and external forces and torques on a body together give statical equilibrium?
- |                             |                             |
|-----------------------------|-----------------------------|
| (a) D' Alembert principle   | (b) Paul Ehrlich principle  |
| (c) David Hilbert principle | (d) Edward Jenner principle |

**Ans. (a)**

“The sum of all the external forces or couples along with inertia force or couple must be equal to zero”

$$\sum \vec{F}_{ext} + m\ddot{x} = 0$$

$$\sum \vec{\tau}_{ext} + I\ddot{\theta} = 0$$

This is D'Alembert's Principle.

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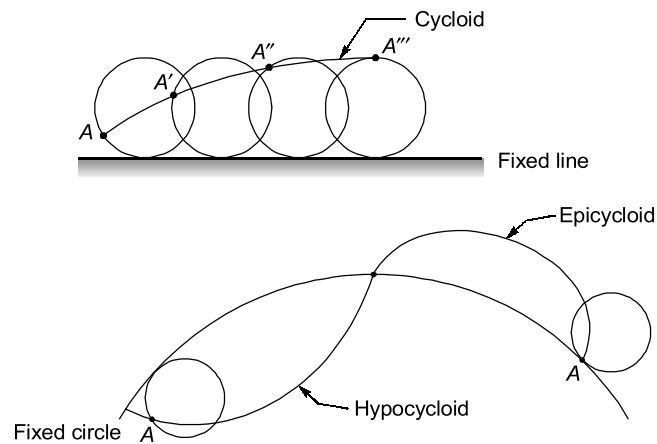
**End of Solution**

45. Consider the following statements regarding gears:
1. A cycloid is the locus of a point on the circumference of a circle that rolls without slipping on a fixed straight line.
  2. A hypocycloid is the locus of a point on the circumference of a circle that rolls without slipping on the circumference of another circle.
  3. An epicycloid is the locus of a point on the circumference of a circle that rolls without slipping inside the circumference of another circle.

Which of the above statements is/are correct?

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

Ans. (d)



Only (1) is correct.

End of Solution

46. Centroid of a body coincides with its centre of mass or its centre of gravity only if the material composing the body is
- (a) uniform or homogeneous                      (b) in equilibrium  
(c) in static equilibrium                          (d) translating with constant velocity

Ans. (a)

End of Solution

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

Ans. (c)

Thin cylinder:

$$\sigma_{\max} \leq \sigma_{\text{per}} \quad (\sigma_{\max} = \sigma_{\text{hoop}})$$

$$\sigma_h \leq \sigma_{\text{per}}$$

$$\frac{PD}{2t} \leq 20 \times 10^6$$

For,  $P = \rho gh = 1000 \times 9.81 \times 60 = 588.6 \times 10^3 \text{ Pa}$

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

$$\sigma_{\text{per}} = 20 \text{ MPa}$$

$$\Rightarrow \frac{588.6 \times 10^3 \times 750}{2 \times t} \leq 20 \times 10^6$$

$$\Rightarrow t \geq 11.03$$

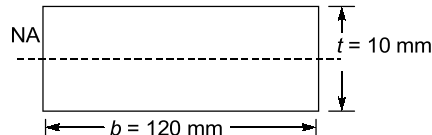
or  $t \approx 11 \text{ mm}$

End of Solution

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

Ans. (a)

By bending equation



$$(\sigma_b)_{\max} = \frac{E \cdot Y_{\max}}{R} = \frac{(200 \times 10^3) \times 5}{8000} = 125 \text{ MPa}$$

and

$$M = (\sigma_b)_{\max} \times Z_{NA}$$

$$= 125 \times \frac{120 \times 10^2}{6}$$

$$\left[ \because Z_{NA} = \frac{bt^2}{6} \right]$$

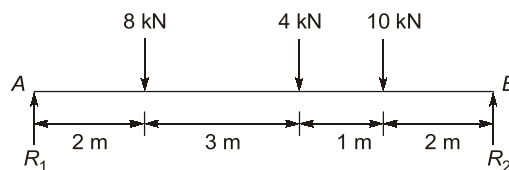
$$M = 250 \times 10^3 \text{ N-mm}$$

$$= 250 \text{ N-m}$$

End of Solution

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

Ans. (d)



$$\Sigma M_A = 0$$

$$\Rightarrow 8R_2 = 10 \times 6 + 4 \times 5 + 8 \times 2$$

$$R_2 = 12 \text{ kN}$$

$$\text{and } \Sigma F_y = 0$$

$$\Rightarrow R_1 + R_2 = 8 + 4 + 10$$

$$R_1 = 22 - 12 = 10 \text{ kN}$$

End of Solution



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

Ans. (d)

End of Solution

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

Ans. (b)

$$f_{\text{initial}} = 2.6 \text{ kN}$$

for ideal machine,

$$\eta = 1 = \frac{mA}{VR} = \frac{W}{P_i \times VR}$$

$$1 = \frac{1200}{P_i \times 18}$$

$$P_i = \frac{200}{3} \text{ kN}$$

$$f_{\text{increment}} = 1.4 \times 12 = 16.8 \text{ kN}$$

$$\text{Total friction} = 2.6 + 16.8 = 19.4 \text{ kN}$$

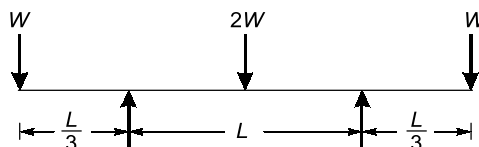
$$P_{\text{actual}} = \frac{200}{3} + 19.4 = 86.07 \text{ kN}$$

$$\eta = \frac{mA}{VR} = \frac{1200}{86.07 \times 18} = 0.7745 \text{ or } 77.45\%$$

End of Solution

52. The distance between the supports of a simply supported beam is  $L$ . The beam has two equal overhangs of length  $L/3$  over each support. The beam carries a point load  $2W$  at the centre and a point load  $W$  at each end. Deflection at the centre is  
 (a) 1.8 mm (b) 7.2 mm  
 (c) 0 mm (d) 3.6 mm

Ans. (c)



End of Solution

53. The maximum bending moment at the fixed end in a cantilever of length  $L$  carrying a uniformly distributed load  $W$  per unit length across the whole span is
- (a)  $WL^2/2$  (b)  $WL^2/4$   
(c)  $WL^3/4$  (d)  $WL^3/8$

Ans. (a)  
Cantilever beam carrying UDL  $W$  per unit length

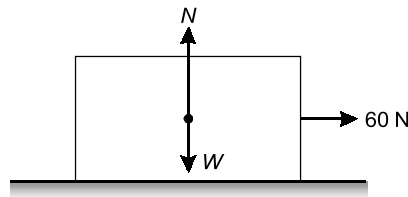


$$\text{Maximum bending moment} = M_{\max} = (W.L) \frac{L}{2} = \frac{WL^2}{2}$$

End of Solution

54. A body of weight 100 N is placed on a rough horizontal plane. If a horizontal force of 60 N just causes the body to slide over the horizontal plane, then the coefficient of friction between the body and the horizontal plane is
- (a) 0.6 (b) 0.3  
(c) 0.2 (d) 0.1

Ans. (a)



$$N = W = 100 \text{ N} \rightarrow NFL$$

$$60 = (f_s)_{\max} = \mu N$$

$$\mu = \frac{60}{100} = 0.6$$

End of Solution

55. A fire engine raises water at the rate of 6000 litres per minute through a height of 2 m and discharges it at 10 m/s. The H.P. of fire engine is nearly equal to (Take acceleration due to gravity as  $9.81 \text{ m/s}^2$ )
- (a) 6.5 (b) 7.2  
(c) 8.0 (d) 9.5

Ans. (\*)

End of Solution

56. A spherical vessel has 1 m diameter. It is subjected to internal pressure of 1.5 N/mm<sup>2</sup>. If maximum stress is not to exceed 200 N/mm<sup>2</sup> and joint efficiency is 80%, then the thickness of the plate required is
- (a) 3.20 mm (b) 4.21 mm  
(c) 5.22 mm (d) 2.34 mm

Ans. (d)

Thin spherical vessel

$$\text{Diameter, } D = 1 \text{ m}$$

$$\text{Pressure, } P = 1.5 \text{ N/mm}^2$$

$$\sigma_{\text{per}} = 200 \text{ N/mm}^2$$

$$\text{Point efficiency, } \eta = 80\%$$

$$\text{Thickness, } t = ?$$

$$\sigma_{\text{hoop}} \leq \sigma_{\text{per}}$$

$$\frac{PD}{4t\eta} \leq \sigma_{\text{per}}$$

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

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

End of Solution

57. A material has modulus of rigidity equal to  $0.4 \times 10^5$  N/mm<sup>2</sup> and bulk modulus equal to  $0.75 \times 10^5$  N/mm<sup>2</sup>. The Poisson's ratio is
- (a) 0.2736 (b) 0.1927  
(c) 0.3121 (d) 0.4376

Ans. (a)

$$\text{Given: Modulus of rigidity (T) } = 0.4 \times 10^5 \text{ N/mm}^2$$

$$\text{Bulk modulus, } k = 0.75 \times 10^5 \text{ N/mm}^2$$

$$E = 2G(1 + \mu) \quad \dots \text{ (i)}$$

$$E = 3k(1 - 2\mu) \quad \dots \text{ (ii)}$$

By (i) and (ii)

$$2G(1 + \mu) = 3k(1 - 2\mu)$$

$$\mu = 0.2736$$

End of Solution

58. For a 99.65 wt% Fe 0.35 wt% C alloy at a temperature just below the eutectoid, the fractions of the proeutectoid ferrite and pearlite are respectively
- (a) 0.44 and 0.56 (b) 0.56 and 0.44  
(c) 0.044 and 0.056 (d) 0.056 and 0.044



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• ME : 30<sup>th</sup> Jan, 2022 & 8<sup>th</sup> Mar, 2022  
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• CS : 8<sup>th</sup> Mar, 2022

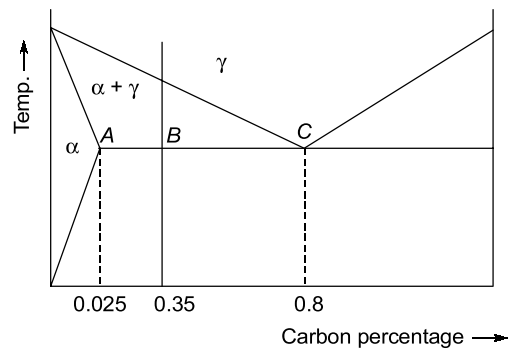
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Ans. (b)



$$\text{Fraction of proeutectoid ferrite} = \frac{BC}{AC} = \frac{0.8 - 0.35}{0.8 - 0.025} = 0.55$$

$$\text{Fraction of pearlite} = \frac{AB}{AC} = \frac{0.35 - 0.025}{0.8 - 0.025} = 0.42$$

End of Solution

59. Consider the following statements regarding the mechanical behaviour of iron-carbon alloys:

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

Which of the above statements is/are correct?

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

Ans. (c)

When coarseness of pearlite increases, the layers resist slipping very less, relative to each other. Hence, steel becomes more ductile.

End of Solution

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

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

Ans. (a)

Maximum concentration of alloying elements is only 2% in high strength- low alloy steels.

End of Solution

61. Which one of the following is the angle through which the cam turns during the time the follower rises?
- (a) Angle of ascent (b) Angle of dwell  
(c) Angle of descent (d) Angle of action

Ans. (a)

The cam rotation in which follower rises.

⇒ Angle of ascent ( $\theta_0$ )

⇒ Also known as outstroke angle.

End of Solution

62. Consider the following statements regarding cams:
1. Base circle is the smallest circle tangent to the cam profile (contour) drawn from the centre of rotation of a radial cam.
  2. Pitch curve is the curve drawn by the trace point assuming that the cam is fixed, and the trace point of the follower rotates around the cam.
  3. Pitch circle is the circle passing through the pitch point and concentric with the base circle.
  4. The smallest circle drawn tangent to the pitch curve is known as the prime circle.
- Which of the above statements are correct?
- (a) 1 and 3 only (b) 2 and 4 only  
(c) 2 and 3 only (d) 1, 2, 3 and 4

Ans. (d)

End of Solution

63. Consider the following statements regarding acceleration analysis:
1. A graphical method to find the location of the centre of curvature of the locus of a point on a moving body, is known as Bobillier construction.
  2. A graphical method by which inflection circle can be drawn without requiring the curvatures of the centrodes, is known as Hartmann construction.
  3. Bobillier theorem states that the angle subtended by one of the rays with the centrode tangent is equal to negative of the angle subtended by the other ray with the collineation axis.
- Which of the above statements is/are correct?
- (a) 1 and 3 only (b) 3 only  
(c) 2 only (d) 1, 2 and 3

Ans. (a)

End of Solution

64. Consider the following parameters:  
 $s$  = length of the shortest link,  
 $l$  = length of the longest link,  
 $p$  = length of one of the intermediate length links,  
 $q$  = length of the other intermediate length links;  
 According to the Grashof's criteria, if  $s + l > p + q$ , then the category of four bar mechanism is
- (a) Double crank  
 (b) Crank rocker  
 (c) Change point  
 (d) Triple rocker

Ans. (d)  
 If  $(s + l) > (p + q)$   
 Then Grashof's law will not be satisfied.  
 In that case :  
 Any link fixed  $\Rightarrow$   
 Input  $\rightarrow$  Rocker  
 Output  $\rightarrow$  Rocker  
 Coupler  $\rightarrow$  Rocker  
 $\Rightarrow$  Triple rocker mechanism

End of Solution

65. A uniform disc of 150 mm diameter has mass of 5 kg. It is mounted centrally in bearings which maintain its axle in a horizontal plane. The disc spins about its axle with a constant speed of 1000 rpm, while the axle precesses uniformly about the vertical at 60 rpm. The gyroscopic couple acting on the disc is approximately?
- (a) 6.5 Nm  
 (b) 7.2 Nm  
 (c) 8.5 Nm  
 (d) 9.2 Nm

Ans. (d)  
 Disc :  $m = 5$  kg,  $d = 150$  mm  
 $\Rightarrow r = 75$  mm = 0.075 m  

$$I = \frac{mr^2}{2} = \frac{5 \times (0.075)^2}{2}$$

$$= 0.0140625 \text{ kg-m}^2$$
 $N = 1000$  rpm  

$$\omega = \frac{2\pi \times 1000}{60} = 104.719 \text{ rad/s}$$
 $N_p = 60$  rpm  

$$\omega_p = \frac{2\pi \times 60}{60} = 6.2831 \text{ rad/s}$$

$$C = I\omega\omega_p$$

$$= 0.0140625 \times 104.719 \times 6.2831$$

$$C = 9.2525 \text{ N-m}$$

End of Solution

66. A system of rotating masses is in dynamic balance when
- there does not exist any resultant centrifugal force only.
  - there does not exist any resultant couple only.
  - there does not exist any resultant centrifugal force as well as resultant couple.
  - there exists both resultant centrifugal force and resultant couple.

Ans. (c)

End of Solution

67. Wear rating of a long shoe drum brake is
- directly proportional to friction power
  - directly proportional to brake shoe area
  - inversely proportional to friction torque on drum
  - inversely proportional to friction power

Ans. (a)

Wear  $\propto$  work done by friction force as power  $\propto$  torque  $\propto$  force  
 $\therefore$  Wear is directly proportional to frictional power.

End of Solution

68. What is the required basic dynamic load rating,  $C$  for a ball bearing to carry a radial load of 550 kg from a shaft rotating at 500 rpm that is part of an assembly conveyor in a manufacturing plant? (Take the design life as  $1 \times 10^9$  rev)
- 5000 kg
  - 5500 kg
  - 4000 kg
  - 4500 kg

Ans. (b)

For ball bearing,  $L_{90} = \left(\frac{C}{Pe}\right)^3$  Million revolution

$$\Rightarrow 1000 = \left(\frac{C}{550}\right)^3$$

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

End of Solution

69. A catalog lists the basic dynamic load rating for a ball bearing to be 8000 kg for a rated life of  $1 \times 10^6$  rev. What is expected  $L_{10}$  life of the bearing if it is subjected to a load of 4000 kg? (Take  $k = 3$  for ball bearing)
- $8 \times 10^6$  rev
  - $6 \times 10^6$  rev
  - $4 \times 10^6$  rev
  - $2 \times 10^6$  rev



Ans. (a)

$$\left(\frac{L_2}{L_1}\right) = \left(\frac{P_1}{P_2}\right)^3 C = \text{Constant}$$

$$P_2 = \frac{P_1}{2} \Rightarrow L_2 = 8L_1$$

End of Solution

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

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

Ans. (a)

Maximum shear stress theory and distortion energy theory are used for ductile materials.

End of Solution

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

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

Ans. (d)

End of Solution

72. Wear performance of the brakes can be improved to

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

Ans. (b)

Wear performance of the brakes can be improved by

- Keep pressure between the friction material and the material of the disc or drum as uniform as practical.
- Friction material that have low bond strength between constituent particles.
- Friction materials that not have relatively high adhesion when in contact with the disc or drum material because if adhesion is high than wear will be high.

End of Solution

73. Consider the following statements regarding the parameters involved in the rating of clutches and brakes:
1. Torque required to accelerate or decelerate the system
  2. Time required to accomplish the speed change.
  3. The cycling rate is required.
- Which of the above statements is/are correct?
- (a) 2 only (b) 1 and 2 only  
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (b)

The cycling rate or how frequently one apply brake is not parameters in rating of clutches and breaks.

End of Solution

74. In the design of spur gear, the load distribution factor can be minimized by specifying which of the following?
1. Accurate teeth
  2. Narrow face widths
  3. Long shaft spans between bearings
- Select the correct answer using the code given below:
- (a) 1 and 2 only (b) 1 and 3 only  
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Long shaft spans between bearings leads to larger deflection and that is difficult for bearing but load distribution factor not specify by shaft spam.

End of Solution

75. Which one of the following fatigue failure criteria is used in graphical method equation?
- (a) Soderberg fatigue failure criteria  
(b) Goodman fatigue failure criteria  
(c) Smith diagram fatigue failure criteria  
(d) Gerber fatigue failure criteria

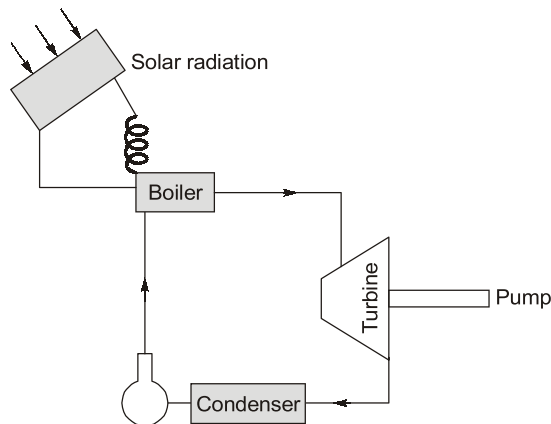
Ans. (c)

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

End of Solution

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

Ans. (a)



End of Solution

77. The concentration ratio of as high a value as 3000 can be obtained by
- modified flat plate collector
  - compound parabolic concentrator
  - cylindrical parabolic concentrator
  - central tower receiver

Ans. (d)

$$\frac{\text{Area of aperture}}{\text{Area of receiver}} = \text{CR}$$

Central tower receiver obtain very high concentration ratio by using reflecting mirrors and is approximately equal to 3000.

End of Solution

78. The angle between the sun's ray and its projection on a horizontal surface is known as
- Inclination angle
  - Zenith angle
  - Solar azimuth angle
  - Hour angle

Ans. (a)

End of Solution

79. The total solar radiation received at any point on the earth's surface is the sum of the direct and diffuse radiation and is referred as
- Total diffuse radiation
  - Insolation
  - Total radiation
  - Total specular radiation

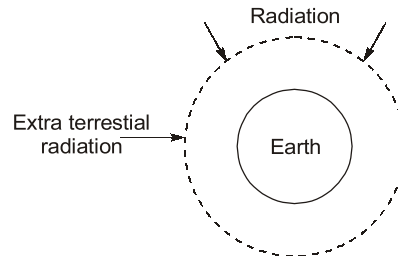
Ans. (c)

$$I_t = I_d + I_b$$

End of Solution

80. The rate at which solar energy arrives at the top of the atmosphere is called
- (a) Total energy (b) Radiation  
(c) Solar constant (d) Radiation constant

Ans. (c)



End of Solution

81. Consider the following statements regarding solar ponds:
1. It is possible to produce electricity from a solar pond by using a special 'High temperature' heat engine coupled to an electric generator.
  2. In a large solar pond, the thermal capacitance and resistance can be made large enough to retain the heat in the bottom layer from summer to winter and the pond can therefore be used for heating buildings in the winter.
  3. A solar pond is an ingenious collector, which uses water as its top cover.
- Which of the above statements are correct?
- (a) 1 and 2 only (b) 2 and 3 only  
(c) 1 and 3 only (d) 1, 2 and 3

Ans. (b)

Solar ponds are used for low temperature applications, so statement 1 is wrong which implies option (b) is correct.

End of Solution

82. Which one of the following is a vertical axis wind mill?
- (a) Darrieus type wind mill (b) Propeller type wind mill  
(c) Sail type wind mill (d) Multi blade type wind mill

Ans. (a)

End of Solution

83. Consider the following statements regarding solar radiation measurement:
1. Pyranometer collimates the radiation to determine the beam intensity as a function of incident angle.
  2. Pyranometer measures the total hemi-spherical solar radiation.
  3. Pyrhemliometer collimates the radiation to determine the beam intensity as a function of incident angle.
- Which of the above statements is/are correct?
- (a) 1 only (b) 2 and 3 only  
(c) 1 and 2 only (d) 3 only

Ans. (b)

Pyranometer are used to measure the total hemispherical solar radiation whereas pyrliometer measures beam radiations reaching earth surface.

End of Solution

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

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

Ans. (c)

End of Solution

85. **Statement I** : Centre of pressure is calculated by using the "Principle of Moments".  
**Statement II** : The moment of the resultant force about an axis is equal to the sum of moments of the components about the same axis.

Ans. (a)

Both statements are correct but statement II does not support statement I.

End of Solution

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

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

Ans. (b)

End of Solution

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

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

Ans. (b)

End of Solution

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

**Statement II** : Frictions is dependent on extent of area but independent on normal reaction.

Ans. (c)

Statement I is partially right because friction increases with speed but statement II is absolutely wrong, so best answer will be (c).

End of Solution

89. **Statement I** : The percent elongation is assumed to be based on a gage length of 2.00in unless some other gage length is specifically indicated.  
**Statement II** : Theoretically, a material is considered ductile if its percent elongation is greater than 5% (lower values indicated brittleness).

**Ans. (b)**

Both statements are correct independently. However, statement II can't be correct reason for statement I, because for a given shape of specimen and its area of cross-section, gauge length standardization is one based on BARBA's law. It states that for geometrically similar specimens, the percentage elongation, will be the same.

End of Solution

90. **Statement I** : Mechanization means something is done or operated by machinery as well as by hand.  
**Statement II** : Mechanization of the manufacturing means milestone oriented trend towards minimizing the human efforts to the extent of its possibility, by adopting mechanical and electrical means or methods for automating the different manufacturing processes.

**Ans. (d)**

Mechanization means something is done or operated by machinery only without using hand operations.  
So, statement I is wrong.

End of Solution

91. Which one of the following statements is NOT correct regarding Rankine cycle?  
(a) For the steam boiler, the ideal process would be a reversible constant pressure heating process of water to form steam.  
(b) For the turbine, the ideal process would be a reversible adiabatic expansion of steam.  
(c) For the condenser, it would be a reversible constant pressure heat rejection as the steam condenses till it becomes saturated liquid.  
(d) For the pump, the ideal process would be the reversible adiabatic expansion of the liquid ending at the final pressure.

**Ans. (d)**

For pump ideal process would be reversible adiabatic compression. So option (d) is not correct.

End of Solution

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

Ans. (b)

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

End of Solution

93. Which one of the following statements is correct?

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

Ans. (c)

End of Solution

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

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

Ans. (b)

End of Solution

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

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

Ans. (d)

Babcock and Wilcox boiler is a water tube boiler.

End of Solution

96. Which one of the following statements is correct?
- In water tube boiler, water surrounds the tubes and hot gases are inside the tubes.
  - The boilers which produce steam at pressures of 10 bar and below are called high pressure boiler.
  - Lancashire boilers are externally fired boiler.
  - Stirling boilers are externally fired boiler.

Ans. (d)

In water tube boiler water flows inside the tubes and hot gases surrounds the tubes. Low pressure boiler produces steam at pressure below 10 bar. Lancashire boiler is a fire tube boiler which is internally fired.

End of Solution

97. In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and overall plant are 0.97, 0.95, 0.92, 0.42 and 0.33 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries?
- 9.29%
  - 8.50%
  - 7.32%
  - 6.76%

Ans. (c)

$$\begin{aligned}\eta_{\text{overall}} &= \eta_{\text{gen}} \times \eta_{\text{turb}} \times \eta_{\text{boiler}} \times \eta_{\text{cycle}} \times (1 - \eta_{\text{auxi}}) \\ 0.33 &= 0.97 \times 0.95 \times 0.92 \times 0.42 \times (1 - \eta_{\text{auxi}}) \\ \eta_{\text{auxi}} &= 7.32\%\end{aligned}$$

End of Solution

98. An ideal cycle is impracticable because:
- there is an ideal fluid available which is considered as working fluid.
  - it is not possible to transfer heat of expanding steam to the fluid in the turbine itself.
  - it is always possible to transfer heat of expanding steam to the fluid in the turbine itself.
  - there is no possibility of excessive humidity in low pressure stages of the turbine.

Ans. (b)

It is impossible to design heat exchanger inside turbine for transferring heat of expanding steam to feed water.

End of Solution

99. Match the following:

List-I (Boiler type)

List-II (Pressure in kg/cm<sup>2</sup>)

- |                    |        |
|--------------------|--------|
| A. La Mont boiler  | 1. 84  |
| B. Loeffler boiler | 2. 170 |
| C. Benson boiler   | 3. 135 |
| D. Velox boiler    | 4. 230 |

Select the correct matching using the codes given below:



Codes:

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

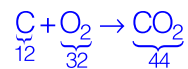
Ans. (c)

End of Solution

100. What is the amount of air required to burn one kg of fuel and product of combustion for a fuel the percentage composition of which is given as C = 70%, H<sub>2</sub> = 30%?
- (a) 16.54 kg (b) 17.54 kg  
(c) 18.54 kg (d) 19.54 kg

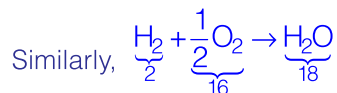
Ans. (c)

For complete combustion, oxygen required



For burning 1 kg of carbon =  $\frac{32}{12} = 2.666$  kg of O<sub>2</sub> is required

For 70% carbon, O<sub>2</sub> required =  $\frac{32}{12} \times 0.7 = 1.866$  kg



For burning 2 kg of H<sub>2</sub> = 16 kg of O<sub>2</sub> is required

O<sub>2</sub> required for 30% H<sub>2</sub> =  $\frac{16}{2} \times 0.3 = 2.4$  kg

Total O<sub>2</sub> required = 2.4 + 1.866 = 4.266

∴ Nitrogen required =  $\frac{77}{23} \times 4.266 = 14.28$  kg

∴ Air mass required = M<sub>O<sub>2</sub></sub> + M<sub>N<sub>2</sub></sub>  
= 14.28 + 4.266 = 18.54 kg

End of Solution



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

Ans. (b)

End of Solution

102. Match the following:

**List-I**

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

**List-II**

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

Select the correct matching using the code given below:

**Codes:**

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

Ans. (d)

End of Solution

103. Which one of the following fuel cells has lowest operating temperature?
- (a) PEMFC
  - (b) MCFC
  - (c) PAFC
  - (d) SOFC

Ans. (a)

Order of operating temperature for fuel cells.  
SOFC > MCFC > PAFC > PEMFC  
So, PEMFC has lowest operating temperature.

End of Solution

104. Adjusting the nacelle about the vertical axis to bring the rotor facing wind is known as  
 (a) Pitch control (b) Hub control  
 (c) Rotor control (d) Yaw control

Ans. (d)

End of Solution

105. In a distributed collector solar thermal electric power plant, the heat collected in collectors is used to dissociate ammonia into nitrogen and hydrogen at approximately  
 (a) 300 atm pressure (b) 150 atm pressure  
 (c) 100 atm pressure (d) 40 atm pressure

Ans. (a)

End of Solution

106. Lumped system analysis assumes a uniform temperature distribution throughout the body, which will be the case only when the thermal resistance of the body to heat conduction is  
 (a) 3 (b) 2  
 (c) 1 (d) 0

Ans. (d)

Biot number ( $Bi$ ) is given by

$$Bi = \frac{R_{cond}}{R_{conv}}$$

For uniform temperature distribution throughout the body,  $R_{cond} = 0$ .

$$\Rightarrow Bi = 0$$

End of Solution

107. Which one of the following is NOT a fluid property for convection heat transfer coefficient?  
 (a) Dynamic viscosity (b) Thermal conductivity  
 (c) Density (d) Rate of convection

Ans. (d)

$$h = f(v, D, \rho, \mu, C_p, k)$$

End of Solution

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

- (a)  $\delta = \frac{5x}{Re_x^{0.5}}; C_f = \frac{0.664}{Re_x^{0.5}}$  (b)  $\delta = \frac{0.382x}{Re_x^{0.5}}; C_f = \frac{0.0592}{Re_x^{0.5}}$   
 (c)  $\delta = \frac{0.382x}{Re_x^{1/5}}; C_f = \frac{0.0592}{Re_x^{1/5}}$  (d)  $\delta = \frac{5x}{Re_x^{1/5}}; C_f = \frac{0.664}{Re_x^{1/5}}$

Ans. (c)

The value of boundary layer thickness and local friction coefficient for turbulent flow is given by

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

End of Solution

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

- (a) Hydrodynamic entry length                      (b) Thermal entrance region  
(c) Hydrodynamic entrance region                (d) Thermal entry length

Ans. (c)

End of Solution

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

- (a)  $Nu_d = 0.023(Re_d^{0.8})(Pr)^n$   
(b)  $Nu_d = 0.023(Re_d^{0.4})(Pr)^{2n}$   
(c)  $Nu_d = 0.023(Re_d^{0.8})(Pr)^{2n}$   
(d)  $Nu_d = 0.023(Re_d^{0.4})(Pr)^n$

Ans. (a)

The Dittus-Boelter equation (for turbulent flow) is an explicit function for calculating the Nusselt number and is given by

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

End of Solution

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

- (a) Sea water    (b) Refrigerating liquid  
(c) Fuel oil    (d) Industrial air

Ans. (c)

Value of fouling factor is the highest for fuel oil and is around 0.0009 (m<sup>2</sup> k/W).

End of Solution

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

Cooling water flow rate : 4 L/s

Water temperature : Inlet 30°C and outlet 40°C

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

What is the actual refrigerating capacity of the unit?

[Take  $C_w = 4.1868$ ]

(a) 34.7 TR

(b) 45.6 TR

(c) 52.6 TR

(d) 48.6 TR

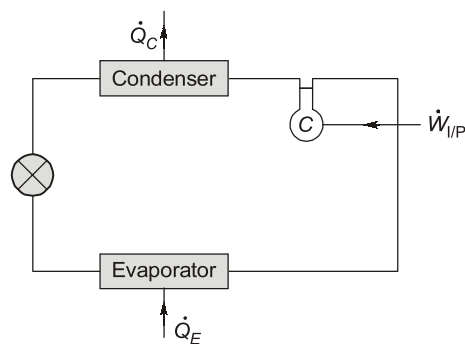
Ans. (a)

$$RC = 140.7 \text{ kW}$$

$$\rho_w = 1 \text{ kg/L} = 1000 \text{ kg/m}^3$$

$$\dot{Q}_C = \dot{Q}_{\text{water}} = \dot{m}_w C_w (40 - 30)$$

$$= 4 \times 4.18 \times 10 = 167.472 \text{ kJ/s}$$



$$\dot{W} = 48 \times 0.95 = 45.6 \text{ kW}$$

$$\dot{Q}_E + \dot{W} = \dot{Q}_C$$

$$\dot{Q}_E = 121.872 \text{ kW} = 34.655 \text{ TR}$$

End of Solution

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

(a) Pressure

(b) Enthalpy

(c) Internal energy

(d) Entropy

Ans. (a)

End of Solution

114. 100 kg of ice at  $-5^{\circ}\text{C}$  is placed in a bunker to cool some vegetables. 24 hours later, the ice has melted into water at  $10^{\circ}\text{C}$ . What is the average rate of cooling in kJ/h provided by the ice? (Take specific heat of ice is  $1.94 \text{ kJ/kgK}$ ; Specific heat of water is  $4.1868 \text{ kJ/kgK}$ ; latent heat of fusion of ice at  $0^{\circ}\text{C}$  is  $335 \text{ kJ/kg}$ )
- (a) 1611 kJ/h (b) 1811 kJ/h  
 (c) 1711 kJ/h (d) 1911 kJ/h

Ans. (a)

Given:  $m = 100 \text{ kg}$ ,  $C_{ice} = 1.94 \text{ kJ/kgK}$ , Latent heat of water =  $335 \text{ kJ/kg}$ ,  $C_{water} = 4.1868 \text{ kJ/kgK}$

$$-5^{\circ}\text{C} \xrightarrow{\text{ice}} 0^{\circ}\text{C} \longrightarrow 0^{\circ}\text{C} \xrightarrow{\text{water}} 10^{\circ}\text{C}$$

$$Q = m(C_{ice} \times \Delta T_{ice} + LH + C_w \times \Delta T_{water})$$

$$\therefore Q = 378656.8 \text{ kJ}$$

$$\dot{Q} = 1610.7 \text{ kJ/h}$$

End of Solution

115. Which of the following principles and processes involved in the production of low temperatures are correct?
1. Adiabatic demagnetization
  2. Thermoelectric cooling
  3. Reversible adiabatic expansion of a gas
  4. Irreversible adiabatic expansion of a real gas
- Select the correct answer using the code given below:
- (a) 1 and 3 only (b) 1, 3 and 4 only  
 (c) 1, 2 and 3 only (d) 1, 2, 3 and 4

Ans. (d)

End of Solution

116. Which one of the following is used in aircraft refrigeration?
- (a) Vapour compression cycle refrigeration  
 (b) Gas cycle refrigeration  
 (c) Vapor absorption cycle refrigeration  
 (d) Steam ejector cycle refrigeration

Ans. (b)

End of Solution

117. An ammonia ice plant operates between a condenser temperature of  $35^{\circ}\text{C}$  and a evaporator temperature of  $-15^{\circ}\text{C}$ . It produces 10 tons of ice per day from water at  $30^{\circ}\text{C}$  to ice at  $-5^{\circ}\text{C}$ . Assume simple saturation cycle, what is the capacity of the refrigeration plant? (Take specific heat of ice is  $1.94 \text{ kJ/kgK}$ . Specific heat of water is  $4.1868 \text{ kJ/kgK}$ ; latent heat of fusion of ice at  $0^{\circ}\text{C}$  is  $335 \text{ kJ/kg}$ )
- (a) 54.43 kW (b) 64.32 kW  
 (c) 74.52 kW (d) 84.23 kW

**Ans. (a)**

Given:  $m = 10$  tons ice,  $C_{ice} = 1.94$  kJ/kgK, Latent heat of water = 335 kJ/kg,  
 $C_{water} = 4.1868$  kJ/kgK,  $t = 24$  hours

$$30^{\circ}\text{C} \xrightarrow{\text{water}} 0^{\circ}\text{C} \longrightarrow 0^{\circ}\text{C} \xrightarrow{\text{ice}} -10^{\circ}\text{C}$$

$$Q = 10 \times 10^3 (4.1868 \times 30 + 335 + 1.94 \times 10)$$

$$= 4800.039 \text{ MJ}$$

$$RC = \frac{Q}{t} = 55.55 \text{ kW}$$

**End of Solution**

**118.** Consider the following statements in a vapor compression refrigeration system:  
 It is observed that an increase in condenser pressure, similarly results in

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

Which of the above statements are correct?

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

**Ans. (c)**

**End of Solution**

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

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

**Ans. (a)**



$$R - (m - 1) (n + 1) (p)$$

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

R114

Note: Tetra = 4

**End of Solution**

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

1. Methane
2. Butane
3. R134a

Select the correct answer using the code given below:

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



Ans. (b)

Methane and butane are hydrocarbons which are explosive in nature whereas R-134a is used in domestic applications and is not explosive in nature.

End of Solution

121. A body of dimensions 1.5 m × 1.0 m × 2 m, weighs 1962 N in water. What is the weight of the body in air? (Take acceleration due to gravity as 9.81 m/s<sup>2</sup>)

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

Ans. (a)

$$\begin{aligned}
 W_{\text{apparent weight}} &= W_{\text{real weight}} - F_{\text{buoyant force}} \\
 W_{\text{real weight}} &= W_{\text{app}} + F_B \\
 &= W_{\text{app}} + \rho_f g V_{fd} \\
 &= 1962 + 1000 \times 9.81 \times 1.5 \times 1 \times 2 \\
 &= 31392 \text{ N}
 \end{aligned}$$

End of Solution

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

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

Ans. (a)

$$\begin{aligned}
 \nabla V &= 0 \text{ for continuity equation} \\
 \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} &= 0 \\
 \frac{\partial u}{\partial x} + \frac{\partial}{\partial y} \{2y^2\} + \frac{\partial}{\partial z} \{2xyz\} &= 0 \\
 \frac{\partial u}{\partial x} + 4y + 2x &= 0 \\
 \frac{\partial u}{\partial x} &= -2xy - 4y
 \end{aligned}$$

On integrating,

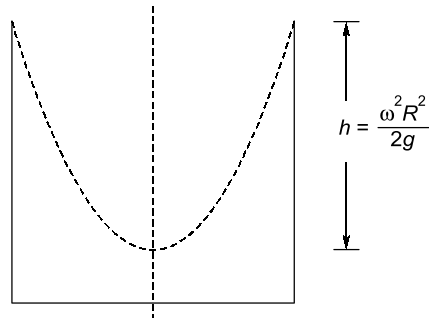
$$u = -x^2y - 4xy + f(y, z)$$

End of Solution

123. An open circular tank of 20 cm diameter and 100 cm long contains water upto a height of 60 cm. The tank is rotated about its vertical axis at 300 rpm. What is the depth of parabola formed at the free surface of water? (Take acceleration due to gravity as 9.81 m/s<sup>2</sup>)

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

Ans. (a)



$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 300}{60} = 10\pi$$

$$h = \frac{(10\pi)^2 \times 0.1^2}{2 \times 9.81}$$

$$= 0.503$$

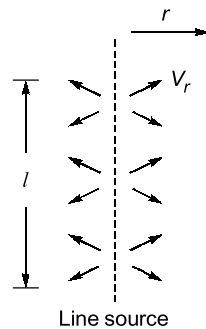
$$= 50.3 \text{ cm}$$

End of Solution

124. What is the velocity of flow at radius of 0.8 m, if the water is flowing radially outward in a horizontal plane from a source at a strength of 12 m<sup>2</sup>/s?

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

Ans. (c)



$$Q = V_r \times 2\pi r l$$

$$V_r = \frac{(Q/l)}{2\pi r}$$

$$V_r = \frac{q}{2\pi r} \quad (q = \text{source strength})$$

$$V_r = \frac{12}{2 \times \pi \times 0.8} = 2.387 \text{ m/s}$$

End of Solution

125. A pitot-static tube is used to measure the velocity of water in a pipe. The stagnation pressure head is 6 m and static pressure head is 5 m. What is the velocity of flow assuming the coefficient of tube equal to 0.98? (Take acceleration due to gravity as  $9.81 \text{ m/s}^2$ )
- (a) 1.24 m/s (b) 2.68 m/s  
(c) 3.56 m/s (d) 4.34 m/s

Ans. (d)

$$\begin{aligned} \text{Velocity of flow, } V &= C_v \sqrt{2g(h_{\text{stag}} - h_{\text{static}})} \\ &= 0.98 \sqrt{2g \times (6 - 5)} = 4.34 \text{ m/s} \end{aligned}$$

End of Solution

126. A fluid of viscosity  $0.7 \text{ Ns/m}^2$  and specific gravity 1.3 is flowing through a circular pipe of diameter 100 mm. The maximum shear stress at the pipe wall is given as  $196.2 \text{ N/m}^2$ . What is the pressure gradient of the flow?
- (a)  $7848 \text{ N/m}^2$  per m (b)  $-7848 \text{ N/m}^2$  per m  
(c)  $-9848 \text{ N/m}^2$  per m (d)  $9848 \text{ N/m}^2$  per m

Ans. (b)

Given:  $\mu = 0.7 \text{ Ns/m}^2$ ,  $s = 1.2$ ,  $d = 100 \text{ mm}$ ,  $\tau_o = 196.2 \text{ N/m}^2$ ,  $\frac{\partial P}{\partial x} = ?$

$$\tau = -\frac{\partial P}{\partial x} \times \frac{r}{2}$$

$$\tau_o = -\left(\frac{\partial P}{\partial x}\right) \times \frac{R}{2}$$

$$-\left(\frac{196.2 \times 2}{50 \times 10^{-3}}\right) = \frac{\partial P}{\partial x}$$

$$\frac{\partial P}{\partial x} = -7848 \text{ N/m}^2$$

End of Solution

127. A oil of viscosity 10 poise flows between two parallel fixed plates which are kept at distance of 50 mm apart. What is the rate of flow of oil between the plates if the drop of pressure in a length of 1.2 m be  $0.3 \text{ N/cm}^2$  and the width of the plate is 200 mm?
- (a) 6.2 litre/s (b) 3.2 litre/s  
(c) 8.2 litre/s (d) 5.2 litre/s

Ans. (d)

Given:  $\mu = 10 \text{ poise} = 1 \text{ Ns/m}^2$ ,  $y = 50 \text{ mm} = 0.050 \text{ m}$ ,  $Q = ?$

$$-\frac{\partial P}{\partial x} = \frac{0.3}{10^{-4} \times 1.2} = 2500$$

$$\text{Width} = 200 \text{ mm} = 200 \times 10^{-3} \text{ m}$$

$$\begin{aligned} Q &= -\frac{1}{12\mu} \left( \frac{\partial P}{\partial x} \right) \times t^3 \times b \\ &= \frac{1}{12 \times 1} \times 2500 \times (50 \times 10^{-3})^3 \times 200 \times 10^{-3} \\ &= 5.20 \text{ l/s} \end{aligned}$$

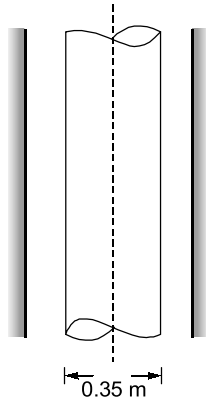
**End of Solution**

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

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

Ans. (a)

Given:  $d = 0.35 \text{ m}$ ,  $N = 200 \text{ rpm}$ ,  $L = 100 \text{ mm}$ ,  $y = 2 \text{ mm}$ ,  $\mu = 0.8 \text{ Ns/m}^2$



$$\omega = \frac{2\pi \times 200}{60}$$

$$T = F \times R = \frac{\mu AV \times R}{y} = \frac{\mu 2\pi R L R \omega}{y} \times R$$

$$\begin{aligned} &= \frac{2\pi\omega L R^3}{y} = \frac{2\pi(0.8)(20.44) \times 0.1 \times 5.359375 \times 10^{-3}}{2 \times 10^{-3}} \\ &= 28.20 \end{aligned}$$

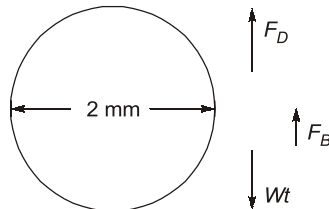
$$P = T \times \omega = 0.59 \text{ kW}$$

**End of Solution**



129. A sphere of diameter 2 mm falls 150 mm in 20 seconds in a viscous liquid. The density of the sphere is  $7500 \text{ kg/m}^3$  and of liquid is  $900 \text{ kg/m}^3$ . What is the coefficient of viscosity of the liquid? (Take acceleration due to gravity as  $9.81 \text{ m/s}^2$ )
- (a) 22.31 poise (b) 25.62 poise  
(c) 19.17 poise (d) 32.21 poise

Ans. (c)



$$U_{\infty} = \frac{150 \times 10^{-3}}{20} = 7.5 \times 10^{-3}$$

$$R_o = \frac{\rho U_{\infty} D}{\mu}$$

Given:  $d = 2 \text{ mm}$ ,  $t = 20 \text{ s}$ ,  $\rho_s = 7500 \text{ kg/m}^3$ ,  $\rho_f = 900 \text{ kg/m}^3$

$$F_D + F_B = Wt$$

$$\text{Terminal velocity, } U_{\infty} = \frac{d^2 g (\rho_s - \rho_f)}{18\mu}$$

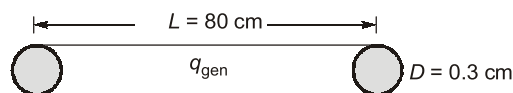
Coefficient of viscosity,

$$\begin{aligned} \mu &= \frac{d^2 g (\rho_s - \rho_f)}{18U_{\infty}} = \frac{(0.002)^2 \times 9.81 \times [7500 - 900]}{18 \times 7.5 \times 10^{-3}} \\ &= 19.18 \text{ poise} \end{aligned}$$

End of Solution

130. The resistance wire of a 1200 W hair dryer is 80 cm long and has a diameter of 0.3 cm. What is the rate of heat generation in the wire per unit volume?
- (a) 212  $\text{W/cm}^3$  (b) 312  $\text{W/cm}^3$   
(c) 512  $\text{W/cm}^3$  (d) 412  $\text{W/cm}^3$

Ans. (a)



$\dot{q}$  = Heat generation per unit volume

$$\dot{q} = \frac{\text{Power}}{\pi R^2 L} = \frac{1200}{\frac{\pi}{4} (0.3)^2 \times 80} \text{ W/cm}^3$$

$$\dot{q} = 212.3 \text{ W/cm}^3$$

End of Solution



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

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

Ans. (a)

$$\frac{\partial^2 T}{\partial r^2} + \frac{1}{r} \frac{\partial T}{\partial r} + \frac{1}{r^2} \frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2} + \frac{\dot{q}}{k} = \frac{1}{\alpha} \left( \frac{\partial T}{\partial t} \right)$$

Here,  $\dot{q} = g \text{ W/m}^3$

$$r \frac{\partial^2 T}{\partial r^2} + \frac{\partial T}{\partial r} + \frac{\dot{q}r}{k} = 0$$

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

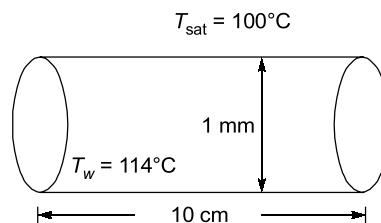
$$\frac{1}{r} \frac{\partial}{\partial r} \left( r \frac{\partial T}{\partial r} \right) + \frac{\dot{q}}{k} = 0$$

End of Solution

132. An electric current is passed through a wire  $1 \text{ mm}$  in diameter and  $10 \text{ cm}$  long. The wire is submerged in liquid water at atmospheric pressure and the current is increased until the water boils. For this situation,  $h$  is  $5000 \text{ W/m}^2^\circ\text{C}$  and the water temperature will be  $100^\circ\text{C}$ . How much electric power must be supplied to the wire to maintain the wire surface at  $114^\circ\text{C}$ ?

- (a)  $21.99 \text{ W}$                       (b)  $32.39 \text{ W}$   
 (c)  $42.39 \text{ W}$                       (d)  $52.36 \text{ W}$

Ans. (a)



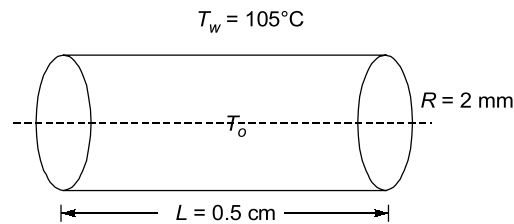
$$q_{\text{convection}} = h \times \pi DL \times (T_w - T_{\text{sat}})$$

$$\begin{aligned} \text{Power} &= 5000 \times \pi \times \frac{1}{1000} \times \frac{10}{100} \times (114 - 100) \\ &= 21.99 \text{ W} \end{aligned}$$

End of Solution

133. A 2 kW resistance heater wire whose thermal conductivity is  $15 \text{ W/m}^\circ\text{C}$  has a diameter of 4 mm and a length of 0.5 m, is used to boil the water. If the outer surface temperature of resistance wire is  $105^\circ\text{C}$ , what is the temperature at the centre of the wire?
- (a)  $136^\circ\text{C}$  (b)  $126^\circ\text{C}$   
(c)  $146^\circ\text{C}$  (d)  $156^\circ\text{C}$

Ans. (b)



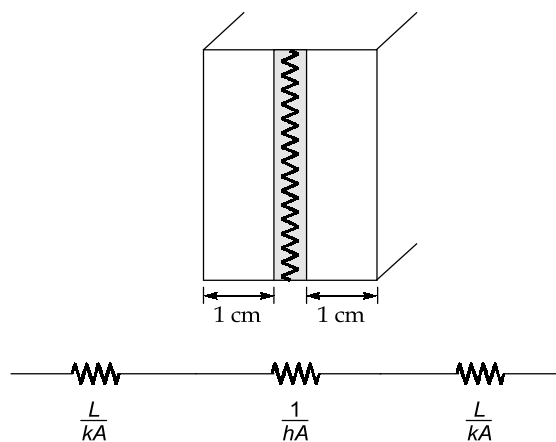
$$T_o - T_w = \frac{\dot{q}R^2}{4k}$$

$$\begin{aligned} T_o - 105 &= \frac{2000}{4 \times 15} \times \left(\frac{2}{1000}\right)^2 \times \frac{1}{\pi R^2 \times L} \\ &= \frac{2000}{4 \times 15} \times \frac{1}{\pi \times 0.5} \\ T_o &= 126^\circ\text{C} \end{aligned}$$

**End of Solution**

134. The thermal contact conductance at the interface of two 1 cm thick aluminium plates is measured to be  $11000 \text{ W/m}^2\text{C}$ . What is the thickness of the aluminium plate whose thermal resistance is equal to the thermal resistance of the interface between the plates? (Take the thermal conductivity of aluminium at room temperature as  $237 \text{ Wm}^\circ\text{C}$ )
- (a) 3.15 cm (b) 5.13 cm  
(c) 1.28 cm (d) 2.15 cm

Ans. (d)



Contact resistance = Plate resistance



$$\frac{1}{hA} = \frac{L}{kA}$$

$$L = \frac{k}{h} = \frac{237}{11000} = 2.15 \text{ cm}$$

**End of Solution**

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

- (a)  $\frac{h\delta}{k} < 0.2$  (b)  $\frac{hk}{\delta} < 0.2$   
(c)  $\frac{h\delta}{k} < 2$  (d)  $\frac{hk}{\delta} < 2$

Ans. (a)

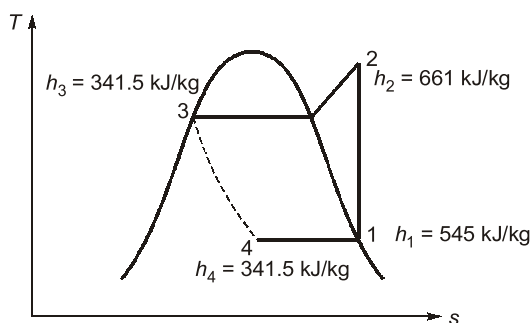
**End of Solution**

136. A hydrocarbon refrigerator operating on equal proportions of propane and isobutane by mass works on simple saturation cycle. The condenser and evaporator pressure are 14 bar and 1.4 bar. What is the approximate theoretical COP of the system?

[Take properties:  $h_1 = 545 \text{ kJ/kg}$ ;  $h_3 = 341.15 \text{ kJ/kg} = h_4$ ;  $S_1 = 2.47 \text{ kJ/kgK} = S_2$ ;  $h_2 = 661 \text{ kJ/kg}$  and  $T_2 = 63^\circ\text{C}$ ]

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

Ans. (a)



$$\text{COP} = \frac{RE}{W_{i/p}} = \frac{h_1 - h_3}{h_2 - h_1} = \frac{545 - 341.15}{661 - 545} = 1.757$$

**End of Solution**

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

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

Select the correct answer using the code given below:

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

Ans. (b)

End of Solution

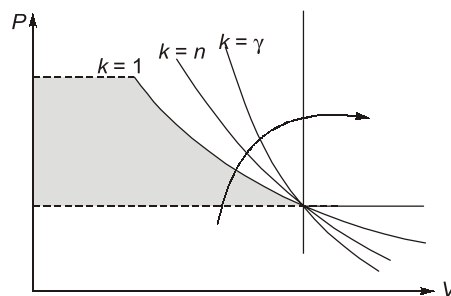
138. A capillary tube in a one-ton R22 air conditioner has a bore of 2.3 mm. Saturated liquid from the condenser enters at a temperature of 48°C and flows adiabatically through the tube until its temperature is 5°C. The friction factor is given as  $f = 0.32/Re^{0.25}$ . What is the length of the capillary tube? (Take intermediate sections at 40°C, 30°C, 20°C and 10°C and the mass flow rate of the refrigerant as 0.02417 kg/s)
- (a) 13.41 kg.s<sup>-1</sup>.m<sup>-1</sup>  
(b) 16.42 kg.s<sup>-1</sup>.m<sup>-1</sup>  
(c) 19.42 kg.s<sup>-1</sup>.m<sup>-1</sup>  
(d) 22.46 kg.s<sup>-1</sup>.m<sup>-1</sup>

Ans. (\*)

End of Solution

139. The work required for compressing one kg of air is minimum if the compression is carried out
- (a) adiabatically  
(b) isothermally  
(c) isentropically  
(d) isochorically

Ans. (b)



The work required for compression is minimum for compression carried isothermally.

As, 
$$W = \int -VdP$$

End of Solution

140. Consider the following statements regarding torque converter:
1. A torque converter is a modified form of fluid coupling.
  2. A reciprocating pump is used in a torque converter.
- Which of the above statements is/are correct?
- (a) 1 only  
(b) 2 only  
(c) Both 1 and 2  
(d) Neither 1 nor 2

Ans. (a)

End of Solution

141. A one fourth scale model of a pump was tested in a laboratory at 1000 rpm. The head developed and power input at the best efficiency point were found to be 7 m and 25 kW respectively. What is the speed of the prototype if the prototype pump has to operate against a head of 36 m?
- (a) 467 rpm (b) 567 rpm  
(c) 667 rpm (d) 767 rpm

Ans. (b)

$$\frac{D_m}{D_p} = \frac{1}{4}$$

Model	Prototype
$N = 1000$ rpm	$N = ?$
$H = 7$ m	$H = 36$
$P = 24$ kW	

$$\left. \frac{H}{D^2 N^2} \right|_M = \left. \frac{H}{D^2 N^2} \right|_P$$

$$N_p^2 = \frac{H_p}{H_m} \times \left( \frac{D_m}{D_p} \right)^2 \times N_m^2 = \frac{36}{7} \times \left( \frac{1}{4} \right)^2 \times 1000^2$$

$$N_p = \frac{6}{\sqrt{7}} \times \frac{1}{4} \times 1000 = \frac{1500}{\sqrt{7}} = \frac{1500}{2.64}$$

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

End of Solution

142. Consider the following statements regarding Euler turbine equation:
1. The axial component produces a bending of the shaft which is taken by the journal bearings.
  2. The axial force only can cause the rotation of the runner and produce work.
  3. The tangential force only can cause the rotation of the runner and produce work.
  4. The radial component produces a bending of the shaft which is taken by the journal bearings.

Which of the above statements are correct?

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

Ans. (c)

End of Solution

143. Which one of the following turbines is the most popularly used one in the medium head range of 60 m–300 m?
- (a) Kaplan turbine (b) Francis turbine  
(c) Pelton turbine (d) Deriaz turbine

Ans. (b)

End of Solution

144. Match the following:

**List-I (Turbine types)**

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

**List-II (Flow directions)**

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

Select the correct matching using the code given below:

**Codes:**

**A B C D**

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

**Ans. (a)**

**End of Solution**

145. A Kaplan turbine plant develops 2000 kW under a head of 8 m while running at 100 rpm. The discharge is 250 m<sup>3</sup>/s. The tip diameter of the runner is 6.5 m and the hub to tip ratio is 0.43. What is the flow ratio based on tip speed? (Take acceleration due to gravity as 9.81 m/s<sup>2</sup>)

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

**Ans. (d)**

Given :  $P = 2000$  kW;  $H = 8$  m,  $N = 1000$  rpm,  $Q = 250$  m<sup>3</sup>/sec,  $D_0 = 6.5$  m,  $D_b = 0.43 \times D_0 = 2.8$  m

$$K_{f2} = ? = \frac{V_{f1}}{\sqrt{2gH}}$$

$$Q = \frac{\pi}{4}(D_0^2 - D_b^2) \times V_{f1}$$

$$V_{f1} = 9.25 \text{ m/s}$$

$$K_f = \frac{V_{f1}}{\sqrt{2gH}} = \frac{9.25}{\sqrt{2 \times 9.81 \times 8}} = 0.73$$

**End of Solution**

146. The water in a jet-propelled boat is drawn amid-ship and discharged at the back with an absolute velocity of 15 m/s. The boat speed is 30 km/hr. The cross-sectional area of the jet at the back is 0.03 m<sup>2</sup>. What is the efficiency of the jet propulsion?

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

Ans. (b)

Absolute velocity of jet,  $V = 15$  m/s

Cross-sectional area of jet,  $A = 0.03$  m<sup>2</sup>

Boat velocity,  $U = 30$  km/hr = 8.33 m/s

$$\begin{aligned}\text{Efficiency, } \eta &= \frac{2U}{V+2U} \\ &= \frac{2 \times 8.33}{15 + 2 \times 8.33} = 52.62\%\end{aligned}$$

End of Solution

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

Ans. (b)

End of Solution

148. Consider the following statements regarding stalling in axial compressor:
- The flow separation occurring on the suction side of the blade is called negative stalling.
  - The flow separation occurring on the pressure side of the blade is called positive stalling.
  - The rotating stall decreases the effectiveness of the compressor.
  - The delivery pressure significantly drops with large stalling leading to flow reversal.
- Which of the above statements are correct?
- |                  |                  |
|------------------|------------------|
| (a) 1 and 2 only | (b) 2 and 3 only |
| (c) 3 and 4 only | (d) 1 and 4 only |

Ans. (\*)

End of Solution

149. In a double acting pump, the work saved by fitting air vessels is about
- |           |           |
|-----------|-----------|
| (a) 19.2% | (b) 29.2% |
| (c) 39.2% | (d) 50.2% |

Ans. (c)

Work saved by air vessel in single acting pump is 84.8%

For double acting work saved is 39.2%.

End of Solution

150. A single acting reciprocating pump has a bore of 200 mm and a stroke of 350 mm and runs at 45 rpm. The suction head is 8 m and the delivery head is 20 m. What is the theoretical discharge of water if the slip is 12%? (Take acceleration due to gravity as  $9.81 \text{ m/s}^2$ )
- (a) 7.260 l/s (b) 6.956 l/s  
(c) 3.456 l/s (d) 4.586 l/s

Ans. (\*)

Single acting reciprocating pump,

$$D = 0.2 \text{ m}; L = 0.35 \text{ m}; N = 45 \text{ rpm}$$

$$\begin{aligned} \text{Theoretical, } Q &= \frac{ALN}{60} = \frac{\left(\frac{\pi}{4} D^2\right) LN}{60} \\ &= \frac{\frac{\pi}{4} (0.2^2) \times 0.35 \times 45}{60} \end{aligned}$$

$$\text{Theoretical, } Q = 8.24 \text{ l/s}$$

If we calculate actual discharge which is

$$Q_{\text{act}} = 0.88 \times Q_{\text{th}}$$

$$Q_{\text{act}} = 7.26 \text{ l/s}$$

End of Solution

