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ESE 2021

Preliminary Examination

Detailed Solutions of

Mechanical Engineering

Set-C

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Expected Cutoff of ESE 2021 Prelims Exam (Out of 500 Marks)				
Branch	Gen	OBC	SC	ST
CE	260-270	250-260	220-230	220-230
ME	280-290	270-280	230-240	220-230
EE	250-260	240-250	210-220	200-210
E&T	270-280	260-270	220-230	210-220

Actual Cutoff of ESE 2020 Prelims Exam (Out of 500 Marks)				
Branch	Gen	OBC	SC	ST
CE	238	238	202	227
ME	262	250	214	202
EE	238	229	187	194
E&T	245	245	205	202

Mechanical Engineering Paper Analysis of ESE 2021 Preliminary Examination

Sl.	Subjects	Number of Questions
1.	Strength of Materials	12
2.	Machine Design	08
3.	Industrial Engineering	04
4.	Manufacturing Engineering	08
5.	Theory of Machines	13
6.	Material Science	12
7.	Thermodynamics	11
8.	Refrigeration & Air-conditioning	07
9.	Heat Transfer	05
10.	Power Plant Engineering	17
11.	IC Engines	04
12.	Fluid Mechanics	13
13.	Fluid Machinery	08
14.	Renewable Source of energy	11
15.	Mechatronics	11
16.	Robotics	01
17.	Engineeing Mechanics	05

UPSC ESE/IES Prelims 2021
Mechanical Engg. analysis and expected cutoff
by MADE EASY faculties

https://www.youtube.com/watch?v=tW0inciBEvw&t=5243s

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

1.   **(a)**

                                                                                    End of Solution

2.   Which one of the following materials has least piezoelectric charge sensitivity?
      (a) Quartz   (b) Barium Titanate
      (c) PZT   (d) PVDF

Ans. **(d)**
      Piezoelectric sensors are ceramics in nature. Like Quartz - $3SiO_2$ - (Ceramic in nature)
      Barium Titanate = $BaTiO_3$. (Ceramic nature).
      PVDF - Polymer - So its not ceramic.

                                                                                    End of Solution

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)**
$$T \propto V_D$$
$$T \propto P$$
      T = Torque
      V_D = Displacement volume
      P = Pressure

                                                                                    End of Solution

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)**
$$\text{Sensitivity} = \frac{\Delta \text{output}}{\Delta \text{ input}} = \frac{12}{3} = 4\,\text{mm/A}$$

                                                                                    End of Solution

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)**

$$F = PA$$
$$F \alpha A$$

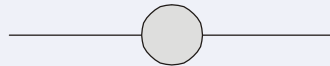$$\frac{F_1}{F_2} = \frac{A_1}{A_2} = \frac{(\pi/4)D_1^2}{(\pi/4)D_2^2}$$

$$= \left(\frac{D_1}{D_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^2$$

$$\frac{F_1}{6000} = \left(\frac{2}{6}\right)^2 = \frac{1}{9}$$

$$F_1 = \frac{6000}{a} = 666.66 = 667\,\text{N}$$

End of Solution

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)**

Normally open contacts symbol is —| |—

Normally closed contacts symbol is —|/|—

Instruction does not have symbol.
So answer is (c).

End of Solution

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)**

$$\text{Settling time } (T_s) = \frac{4}{\xi\omega_n}$$

$$T_s \propto \frac{1}{\omega_n}$$

End of Solution

8. A typical wrist mechanism with three rotational joints would be indicated by
(a) TRL
(b) TRT
(c) LLL
(d) TRR

Ans. **(d)**

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)**

Directions: Each of the next **six (6)** items consists of two statements, one labelled as '**Statement (I)**' and the other as '**Statement (II)**'. You are to examine these two statements carefully and select the answers to these items using the code given below:

Code:
(a) Both Statement (I) and Statement (II) are individually true, and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is not the correct explanation of Statement (I)
(c) Statement (I) is true, but Statement (II) is false
(d) Statement (I) is false, but Statement (II) is true

10. **Statement (I):** 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.

Ans. **(a)**

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.

Ans. **(a)**

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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.

Ans. **(d)**

End of Solution

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.

Ans. **(c)**

End of Solution

14. **Statement (I):** Wear is an issue whenever two components operate with relative motion between them or when liquid 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.

Ans. **(b)**

End of Solution

15. **Statement (I):** 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.

Ans. **(c)**

End of Solution

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)**
Hot extrusion of steel - Recrystallisation temperature of steel is 1000°C. So soap solution and vegetable oil will get vaporised easily, so option (b) and option (d) are ruled out. Copper sulphate boiling point is 650°C so molten glass will be used.

End of Solution

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)**

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

Ans. **(c)**
Low scrap is produced in indirect extrusion.

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

Ans. **(d)**
• Flakes are produced by presence of hydrogen during forging and it produces internal crack or rupture.
• Die shift is caused due to misalignment of upper and lower die.
• Fins and rags are loose projections present in forging.

20. Consider the following statements regarding desirable properties of cutting fluid:
1. It should get oxidised when left in air.
2. It should react with the materials or machine tool parts.
3. It should wet the surface of cutting tool and workpiece.
Which of the above statements is/are correct?
(a) 2 only
(b) 3 only
(c) 2 and 3 only
(d) 1, 2 and 3

Ans. **(b)**

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)

End of Solution

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 estimations of times.
(c) Network deals with uncertainties and hence three times estimations are considered.
(d) As there is no certainty of time, activity duration cannot be reduced.

Ans. (b)

End of Solution

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)

End of Solution

24. The major limitation with displacement or proximity probes is
(a) Size
(b) Time
(c) Accuracy
(d) Cost

Ans. (a)

End of Solution

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)

End of Solution

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)

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)
(a) The parts in Furnace brazing are first precleaned and then preloaded with brazing metal in appropriate contigelation, before being placed in a furnace.
(b) Heat source is oxyfuel gas with carburizing flame using in torch first joint is heated then depository in brazing rod in the joint.
(c) The source of heat in induction brazing is induction heating by high frequency AC current.
(d) In Dip brazing, the work piece is dipped in a molten bath of fillet material.

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)
To transmit a weak signal, the characteristic of a high frequency signal called as carrier are modified according to the instantaneous amplitude of base band/original signal.
• If amplitude of carrier is modified → Amplitude modulation.
• If frequency of carrier is modified → Frequency modulation.
• If phase of carrier is modified → phase modulation.

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 required 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)**
To open the value of full= 6V
Fully open state = $(11111111)^2 \rightarrow$ Binary value
= $(255)_{10} \rightarrow$ in decimal
So 6V is divided into range of 255 steps.

∴ Resolution/change of 1 bit = $\dfrac{6V}{255}$ = 0.023V

End of Solution

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. **(c)**
Hall effect sensor involves
• Magnetic flux intensity
• EMF induced
• Current

End of Solution

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?
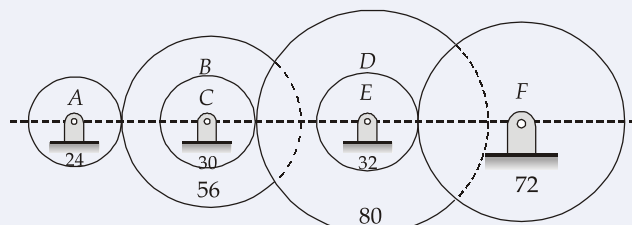
(a) 57.14 rpm (b) 32.51 rpm
(c) 74.63 rpm (d) 69.72 rpm

Ans. (a)

$$\omega_B = \omega_C, \ \omega_D = \omega_E$$
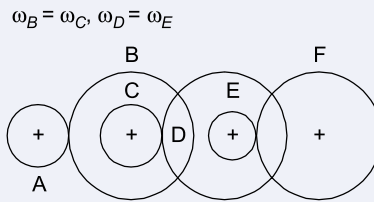
DVR: (A, C, E)
DVN: (B, D, F)

$$T_A = 24, \ T_B = 56, \ T_C = 30$$
$$T_D = 80, \ T_E = 32, \ T_F = 72$$

$$\text{S.R} = \frac{\omega_A}{\omega_F} = \frac{T_B \times T_D \times T_F}{T_A \times T_C \times T_E} = \frac{56 \times 80 \times 72}{24 \times 30 \times 32} = \frac{N_A}{N_F}$$

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

$$\Rightarrow \qquad\qquad N_F = 57.14 \text{ r.p.m}$$

End of Solution

---

32. A quick-return mechanism is to be designed, where the outward stroke must consume 1.2s and the return stroke 0.8s. 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)

Crank always rotates with uniform speed.

It means

1 rev → 2 sec

2π rad → 2 sec

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

(r.p.m.) $$N = \frac{\omega \times 60}{2\pi} = \frac{\pi \times 60}{2\pi} = 30 \text{ r.p.m.}$$

$$N = 30 \text{ r.p.m.} = 30 \text{ rev/min}$$

End of Solution

---

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)

$$m_{reci} = 40 \text{ kg}$$
$$m_{rot} = 30 \text{ kg}$$
$$N = 150 \text{ rpm}$$
$$\text{Stroke} = 350 \text{ mm}$$

$$r = \frac{350}{2} = 175 \text{ mm} = 0.175 \text{ m}$$

Mass to be balanced,

$$m_{rot} + 0.60 \, m_{reci} = 30 + (0.60) \times 40$$
$$= 54 \text{ kg} \qquad\qquad (b = 320 \text{ mm} = 0.320 \text{ m})$$
$$(m \, r \omega^2) = B \, b \, \omega^2$$
$$mr = Bb$$
$$54 \times 0.175 = B \times 0.320$$

$$B = \frac{54 \times 0.175}{0.320} = 29.53 \text{ kg}$$

End of Solution

---

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)

Total no. of plates (n) = 7
Width, (b) = 60 mm
Thickness, t = 6 mm
Central load, 2P = 3 kN
Permissible bending stress,

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

$$\sigma_b = \frac{6PL}{nbt^2}$$

$$150 = \frac{6 \times 1500 \times L}{7 \times 60 \times 6^2}$$

$$L = 252 \text{ mm} = \text{Half the length of leaf spring}$$
$$2L = \text{Length of leaf spring} = 504 \text{ mm}$$

End of Solution

---

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.
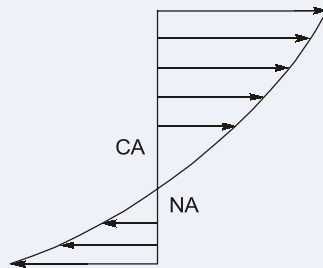
Ans. **(a)**

As per MSST $S_{ys} = \dfrac{S_{yt}}{2}$

End of Solution

36. In curved beams, normally the nature of stress distribution is
  (a) linear   (b) circular
  (c) parabolic   (d) hyperbolic

Ans. **(d)**
Curved beams bending stress distribution is non-linear and hyperbolic and as shown in figure.

End of Solution

37. Consider the following statements regarding crack:
  1. Crack is more likely to occur in the regions of discontinuity such as oil holes.
  2. Crack is more likely to occur in the regions of irregularities in machining operations such as stamp mark.
  3. 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?
  (a) 1 and 2 only   (b) 2 and 3 only
  (c) 1 and 3 only   (d) 1, 2 and 3

Ans. **(d)**
Fatigue cracks are likely to be initiated in the following regions:
  1. Discontinuities or stress concentration regions
  2. Surface irregularities
  3. Defects region

End of Solution

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?
(a) 750 MPa
(b) 120 MPa
(c) 27.38 MPa
(d) 10.95 MPa

Ans. **(b)**
As per MPST

$$\sigma_1 = \frac{S_{yt}}{N} = \frac{300}{2.5} = 120 \, MPa$$

39. Which one of the following theories gives satisfactory results for brittle materials?
(a) Maximum principal stress theory
(b) Maximum shear stress theory
(c) Distortion energy theory
(d) Shear stress energy theory

Ans. **(a)**
MPST is the best TOF for brittle materials.

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)**
For rect. cross-section equivalent dia (d_e)

$$d_e = 0.808\sqrt{bh} = 139.35 \, mm \simeq 140 \, mm$$

'd_e' is used to determine size factor for non-rotating cylindrical component.

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. **(d)**

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)**

Lubricant functions:
1. to reduce friction and wear.
2. To carry away the extra heat generated.
3. To act as coolant.
4. To protect surfaces from corrosion.

End of Solution

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)**

Single plate clutch (SPC) is also known as dry clutch due to the absence of coolant. Multiplate clutch (MPC) is also known as wet clutch because of coolant oil

Hence, $(\mu)_{SPC} > (\mu)_{MPC}$

       $(T_f)_{SPC} > (T_f)_{MPC}$

End of Solution

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)**

End of Solution

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. (b)

Welded joints are used in pressure vessels because of 100% tight of leak proof joint.
- Strength of single V, Butt joint is more than square Butt joint.
- Residual stresses are developed during the welding operation because it is performed at higher temp.

End of Solution

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)

$$r = 0.124 \text{ nm}$$

For bcc strictire.
$$a = \frac{4r}{\sqrt{3}} = \frac{4 \times 0.124}{\sqrt{3}} = 0.2864$$

End of Solution

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)

Cu os FCC
$$a = 0.361$$

$$d_{(220)} = \frac{a}{\sqrt{2^2 + 2^2 + 0^2}} = \frac{0.361}{\sqrt{8}} = 0.1276 \text{ nm}$$

End of Solution

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)**

The statement given in choice (c) belongs to tie line rule, but not to lever rule.

End of Solution

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)**

The statement number 1 belongs to thermoplastic materials. But, it is given as thermosetting polymers. Hence, it is not considered among correct statements. The statements 2 and 3 are correct, for polymers.

End of Solution

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)**

Spheroidised structures are softest, even compared to annealed structures. Bainite, tempered martensite, are relatively more harder than spheroidite.

End of Solution

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)**

End of Solution

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 12000 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)**

$$k = 0.5 \text{ m}$$
$$N = 250 \text{ rpm}$$
$$\omega = \left(\frac{2\pi \times 250}{60}\right) \text{rad/s}$$

800 holes/hr
800 holes/3600 sec
1 hole/4.5 sec

$$\text{Cycle time} = 4.5 \text{ sec}$$
$$\text{Exact punching time} = 1.5 \text{ sec}$$
$$E_{hole} = 12000 \text{ N-m}$$
$$P_{motor} = E_{hole} \times \text{Number of hole/sec}$$
$$= 12000 \times \frac{800}{3600} = \frac{12000}{4.5} = 2666.6666 \text{ Watt}$$

Energy derived by motor during punching
$$\text{Punching time} = 1.5 \text{ sec}$$
$$\Rightarrow \quad 1.5 \times \frac{12000}{4.5} = \frac{12000}{3} = 4000 \text{ N–m}$$

End of Solution

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)**

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

N - No. of links

L - No. of loops

$$DOF = 11 - (2 \times 4 - 1)$$
$$= 11 - (8 + 1)$$
$$= 2$$

End of Solution

---

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)**

End of Solution

---

55. Consider the following statements regarding cams:

1. A cam in which the follower moves radially from the centre 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)**

End of Solution

---

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)**

Point 1 → correct

Point 2 → correct

Point 3 → correct
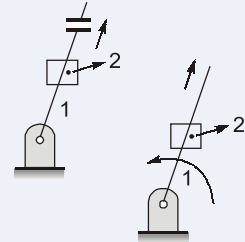
End of Solution

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)**

$$T_n = \frac{2\pi}{\omega_n} = \frac{2\pi}{\sqrt{\frac{s}{m}}} = 2\pi\sqrt{\frac{m}{s}}$$

$$\frac{2 = 2\pi\sqrt{\frac{m}{s}}}{3 = 2\pi\sqrt{\frac{m+2}{s}}}$$

$$\frac{4}{9} = \frac{m}{m+2}$$

$$\Rightarrow \qquad 4m + 8 = 9\,m$$

$$5m = 7$$

$$m = \frac{8}{5} = 1.6 \text{ kg}$$

End of Solution

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)**

$$f_n = 2.85 \text{ Hz}$$

$$\omega_n = 2\pi f_n = (2\pi \times 2.85) \text{ rad/s}$$

$$N_{\text{critical}} = \frac{\omega_n \times 60}{2\pi} = 2\pi \times \frac{2.85 \times 60}{2\pi} = 171 \text{ rpm}$$

End of Solution

59. Consider the following statements regarding gears:
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 dedendum circle.
3. The circle passing through the roots of teeth is called addendum circle.
4. 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)**

End of Solution

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)**

$$T = 30$$
$$N_G = 200 \text{ rpm}$$
$$m = \frac{D}{T} = \frac{D}{30} = 2 \text{ mm}$$
$$D = 60 \text{ mm}$$
$$R = 30 \text{ mm}$$
$$V_{\text{pitch line}} = V_{\text{rolling}} = R\omega_G$$
$$= 30 \times \frac{2\pi \times 200}{60} = 628.31 \text{ mm/s}$$

End of Solution

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
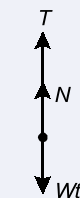(a) 120 N
(b) 135 N
(c) 150 N
(d) 175 N

Ans. (c)
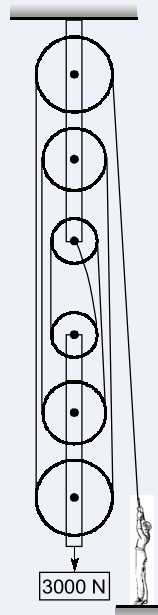
FBD of lower bar,
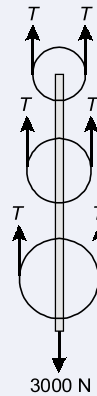
$$6T = 3000$$
$$T = 500 \text{ N}$$

FBD of man,

$$N + T = 650 \rightarrow \text{NFL}$$
$$N = 650 - 500$$
$$N = 150 \text{ N}$$

62. A particle starts with an initial velocity of 200 cm/s and moves with a uniform retardation of 10 cm/s^2. If it describes 1500 cm in time t, 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)**

u = 200 cm/s, a = –10 cm/s^2, S = 1500 cm

$$S = ut + \frac{1}{2}at^2$$

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

$$1500 = 200t - 5t^2$$

$$5t^2 - 200t + 1500 = 0$$

$$t_1 = 30s, \ t_2 = 10s$$

End of Solution

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)**

End of Solution

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 to 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 only

Ans. **(d)**

End of Solution

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)**

Only first statement is correct because dilatation means volumetric strain.

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. **(*)**
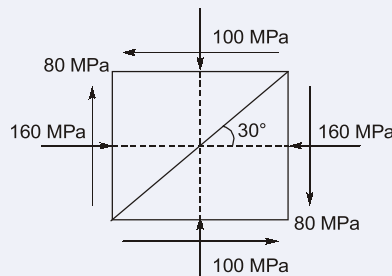
$$\sigma_x = -160 \text{ MPa}$$
$$\sigma_y = -100 \text{ MPa}$$
$$\tau_{xy} = 80 \text{ MPa}$$
$$\theta = 60°$$

$$(\sigma_n)_{\theta=60°} = \frac{1}{2}\left[-160-100\right] + \frac{1}{2}\left[-160+100\right]\cos120° + 80\sin60°$$
$$= -45.72 \text{ MPa}$$

None of the given options are correct.

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)**

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)**

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 statement is/are correct?
(a) 1 only
(b) 2 only
(c) 1 and 2 only
(d) 2 and 3 only

Ans. **(c)**

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)**

Volume of FCC unit cell = $a^3 = \left(\dfrac{4R}{\sqrt{2}}\right)^3 = 16R^3\sqrt{2}$

End of Solution

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, d)**

All the elements given in the choices, increase hardenability. However, except Ni, other elements are carbide forming elements. Among those elements other than Ni, molybdenum carbide possess high hardness. Hence, molybdenum is chosen. However, Mn also contributes to hardnes, wear resistance, by lattice distortion.

End of Solution

72. Which one of the following related to the most stable arrangement of atoms in a crystal is **not** correct?

(a) Preserves electrical neutrality

(b) Maximizes strong ion-ion repulsion

(c) Satisfies discreteness of all covalent bonds

(d) Packs the atoms are closely as possible

Ans. **(b)**

Maximum repulsion between ions cannot promote strong bond.

End of Solution

73. The dielectric constant of rubber varies between

(a) 0.5 and 1.0

(b) 1.0 and 1.5

(c) 1.5 and 2.0

(d) 2.5 and 5.0

Ans. **(d)**

Dielectric constant of rubber is approximately 4.

End of Solution

74. Consider the following statements for ductile fracture:
1. The material undergoes substantial plastic deformation with high energy absorption before fracture.
2. Presence of cracks on the surface of material initiates this type of failure.
3. Fracture occurs due to necking.

Which of the above statements is(are) correct?
(a) 1 only
(b) 1 and 2 only
(c) 2 and 3 only
(d) 1 and 3 only

Ans. **(d)**
Surface cracks initiate brittle fracture, but not ductile fracture.

End of Solution

75. The TTT diagram shows the times required for isothermal transition from
(a) austenite to pearlite.
(b) austenite to ferrite.
(c) ferrite to pearlite.
(d) martensite to pearlite.

Ans. **(a)**
TTT diagram shows the times required for transformation of austenite to pearlite.

End of Solution

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 $f = 0.02 + \dfrac{0.09}{Re^{0.3}}$, where Re is Reynolds number? [Take the kinematic viscosity of water as 0.01 stoke, g = 9.81 m/s² and $(6 \times 10^5)^{0.3}$ = 54.13]
(a) 0.993 m of water
(b) 0.783 m of water
(c) 0.685 m of water
(d) 0.552 m of water

Ans. **(a)**

$$D = 200 \text{ mm}; \quad \nu = 0.1 \text{ stokes}$$
$$V = 3 \text{ m/s}; \quad g = 9.81$$
$$L = 5 \text{ m} \quad (6 \times 10^5)^{0.3} = 54.13$$

Friction coefficient, $f = 0.02 + \dfrac{0.09}{(Re)^{0.3}} = 0.02166$

$$Re = \frac{\rho VD}{\mu} = \frac{10^3 \times 3 \times 0.2}{0.1 \times 10^{-4} \times 10^3} = 6 \times 10^5$$

$$h_L = \frac{4fLV^2}{2gD} = \frac{4 \times 0.02166 \times 5 \times (3)^2}{2 \times 9.81 \times 0.2}$$
$$= 0.993 \text{ m of water}$$

End of Solution

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 $C_c = 0.62$?
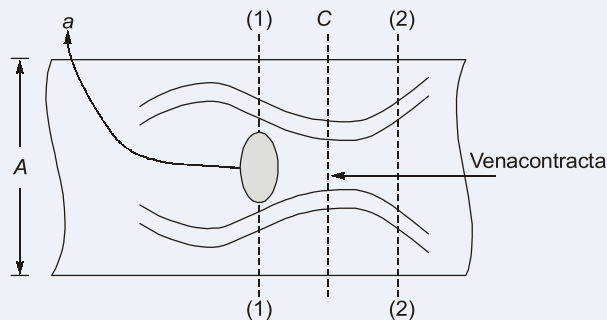[Take $g = 9.81$ m/s^2]

(a) 3.311 m   (b) 4.211 m

(c) 5.211 m   (d) 6.211 m

Ans. **(a)**

Given: $D = 200$ mm, $V = 3$ m/s, $d = 150$ mm, $C_C = 0.62$, $g = 9.81$

$A \rightarrow$ Area of pipe

$a \rightarrow$ Area of obstruction

$$A_1 = (A - a)$$

Main losses are after expansion

$$h_{obs} = \frac{(V_C - V_2)^2}{2g} \quad \ldots (i)$$

$$C_C = \frac{A_C}{A_1}$$

$$C_C = \frac{A_C}{(A - a)}$$

$$A_C = C_C(A - a)$$

$$A_C V_C = A_2 V_2$$

$$V_C = \frac{A_2 V_2}{A_C} = \frac{A_2 V_2}{C_C(A - a)} \quad \ldots (ii)$$

$$(h_L)_{obstruction} = \frac{1}{2g}\left[\frac{A_2 V_2}{C_C(A - a)} - V_2\right]^2$$

$$(h_L)_{obstruction} = \frac{V^2}{2g}\left[\frac{A}{C_C(A - a)} - 1\right]^2$$

$$= \frac{(3)^2}{2 \times 9.81}\left[\frac{\frac{\pi}{4} \times (0.2)^2}{0.62 \times \frac{\pi}{4}[(0.2)^2 - (0.15)^2]} - 1\right]^2 = 3.311\,\text{m}$$

$$= 3.311 \text{ m}$$

End of Solution

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) $(0.007118)^{0.2}$ m (b) $(0.003609)^{0.3}$ m

(c) $(0.003609)^{0.2}$ m (d) $(0.007118)^{0.3}$ m

Ans. **(a)**

$$\frac{l_{eq}}{d_{eq}^5} = \frac{l_1}{d_1^5} + \frac{l_2}{d_2^5} + \frac{l_3}{d_3^5}$$

$$\frac{1700}{d_{eq}^5} = \frac{800}{0.5^5} + \frac{500}{0.4^5} + \frac{400}{0.3^5}$$

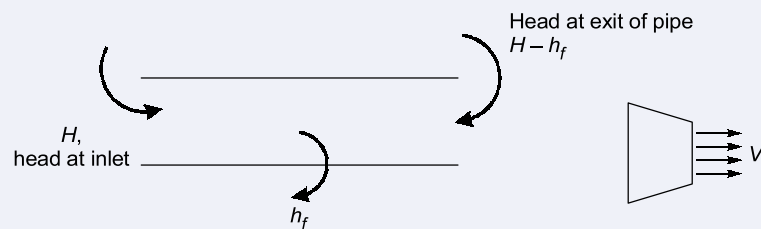$$\frac{1700}{d_{eq}^5} = (25600 + 48828.12 + 164609.05)$$

$$\frac{1700}{d_{eq}^5} = 239037.17$$

$$d_{eq} = (0.007118)^{0.2} \text{ m}$$

End of Solution

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 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)**

For nozzle (it converts total heat to dynamic head)

$$H - h_f = \frac{V_x^2}{2g}$$

$$\text{Area of nozzle} = \frac{\pi}{4}d_x^2$$

$$A_x = 0.00785$$

$$H - \frac{fLQ^2}{12.1d^5} = \frac{V_x^2}{2g}$$

$$60 - \frac{4 \times 0.01 \times 2000}{12.1 \times (0.5)^5} \times Q^2 = \frac{V_x^2}{2g}$$

$$2 \times g[60 - 211.57 \ Q^2] = V_x^2$$

$$1177.2 - 4151 \ Q^2 = V_x^2$$

$$1177.2 - 4151 \ A_x^2 V_x^2 = V_x^2$$

$$1177.2 - 0.256 V_x^2 = V_x^2$$

$$0.256 V_x^2 = 1177.2$$

$$V_x^2 = 937.26$$

$$V_x = 30.61 \ \text{m/s}$$

End of Solution

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/cm^2 　　　　　　　　　　(b) 15 N/cm^2

(c) 16 N/cm^2 　　　　　　　　　　(d) 18 N/cm^2

Ans. **(b)**

Given : V = 1.5 m/s, L = 2500 m, D = 500 mm, C = 1460 m/s

$$t' = 25s$$

Reference time, $T = \dfrac{2L}{C} = \dfrac{2 \times 2500}{1460} = 3.42$

$t' \rightarrow$ Time of closure of valve = 25s

$T \rightarrow$ Reference time = $\dfrac{2L}{C} = \dfrac{2 \times 2500}{1460} = 3.425$

As $t' > T$

$\therefore$ Gradual closure

For gradual closure

$$p = \frac{\rho V L}{t'} = \frac{10^3 \times 1.5 \times 2500}{25}$$

$$= 15 \times 10^4 \ \text{N/m}^2$$

$$= 15 \ \text{N/cm}^2$$

End of Solution

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)

82. How much of concrete with $\gamma = 25$ 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 m/s^2]
    (a) 0.825 kN   (b) 0.745 kN
    (c) 0.525 kN   (d) 0.645 kN

Ans. (d)

$$r_{concrete} = 25 \text{ kN/m}^3$$
$$s_{beam} = 0.6$$
$$V_{beam} = 0.1 \text{ m}^3$$
Let V = Volume of concrete
$$(\text{Wt})_{concrete} + (\text{Wt})_{beam} = F_B$$
$$[25000 \times V] + [600 \times 9.81 \times 0.1] = 10^3 \times 9.81 [V + 0.1]$$
$$V = 0.0258327 \text{ m}^3$$
Wt of concrete added = $25 \times 10^3 \times 0.0258327$
$$= 0.645 \text{ kN}$$

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/m^2 (b) 2.44 Ns/m^2
    (c) 3.40 Ns/m^2 (d) 11.40 Ns/m^2

Ans. (a)

$$S = 1.9, \rho = 1900 \text{ kg/m}^3,$$
$$\nu = 6 \times 10^{-4} \text{ m}^2/\text{s},$$
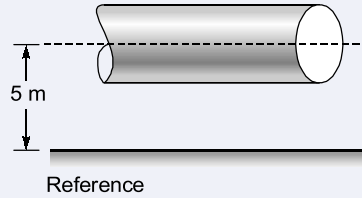$$\mu = \nu \times \rho = 1.14 \text{ Ns/m}^2$$

84. Oil of specific gravity 0.8 flows through a 0.2 m diameter pipe under a pressure of 100 kN/m^2. 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 m/s^2]
    (a) 0.58 m^3/sec   (b) 0.47 m^3/sec
    (c) 0.31 m^3/sec   (d) 0.22 m^3/sec

Ans. (a)

$\rho = 800 \text{ kg/m}^3$

$D = 0.2 \text{ m}$

$p = 100 \text{ kN/m}^2$

5 m

Reference

Total head $= \dfrac{P}{w} + Z + \dfrac{V^2}{2g}$

$35 = \left[\dfrac{100 \times 10^3}{800 \times 9.81}\right] + 5 + \dfrac{V^2}{2g}$

$V = 18.4011 \text{ m/s}$

$Q = 0.5780 \text{ m}^3/\text{s}$

End of Solution

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)

End of Solution

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

End of Solution

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 $R = 0.287 \text{ kPa·m}^3 \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$]
   (a) 150 kg   (b) 180 kg
   (c) 140 kg   (d) 130 kg

Ans.   **(c)**

$$V = 4\ m \times 5\ m \times 6\ m = 120\ m^3$$
$$P = 100\ kPa$$
$$T = 298\ K$$
$$m = \frac{PV}{RT} = 140.3\ kg$$

End of Solution

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
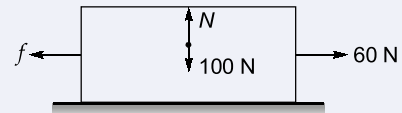(c) 0.6   (d) 0.9

Ans.   **(c)**

$$W = 100\ N$$
$$N = 100\ N \rightarrow NFL$$
At verge of motion $\Rightarrow 60 = (f_s)_{max}$
$$60 = \mu \times 100$$
$$\mu = 0.6$$

End of Solution

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/s^2 (b) 0.65 m/s^2
(c) 0.75 m/s^2 (d) 0.45 m/s^2

Ans.   **(c)**

$$u = 2\ m/s,\ V = 5\ m/s,\ t = 4s$$
$$V = u + at$$
$$5 = 2 + 4a$$
$$\frac{3}{4} = a$$
$$\Rightarrow \qquad a = 0.75\ m/s^2$$

End of Solution

90.   The principal stresses at a point in an elastic material are 60 N/mm^2 tensile, 20 N/mm^2 tensile and 50 N/mm^2 compressive. What is the volumetric strain by considering Young's Modulus as 100×10^3 N/mm^2 and $\mu = 0.3$?
(a) 1.20×10^{-4} (b) 1.06×10^{-5}
(c) 1.30×10^{-3} (d) 1.12×10^{-2}

Ans. **(a)**

$$\varepsilon_v = \left(\frac{1-2\mu}{E}\right)\left(\sigma_1 + \sigma_2 + \sigma_3\right)$$

$$= \left(\frac{1-2\times0.3}{100\times10^3}\right)\left(60 - 50 + 20\right)$$

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

End of Solution

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)**

$$T_G = 95 + 273 = 368\text{ K}$$
$$T_E = 268\text{ K}$$
$$T_O = 303\text{ K}$$

$$(\text{COP})_{max} = \frac{T_E\left(T_G - T_O\right)}{T_G\left(T_O - T_E\right)} = \frac{268\left(368 - 303\right)}{368\left(303 - 268\right)} = 1.352$$

End of Solution

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)

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

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)

$$DBT = 35°C$$
$$WBT = 26.1°C$$

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

$$t = 27.43°C$$
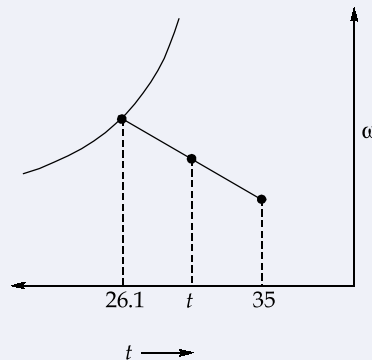
94. Consider the following statements for Nucleate boiling:
1. For water, the critical heat flux does not exceed 1 MW/m^2.
2. Nucleate boiling is the most desirable boiling regime in practice because of high heat transfer rates.
3. Heat flux increases at a higher rate with increase in temperature.
Which of the above statements is(are) correct?
(a) 1 only   (b) 2 only
(c) 1 and 3 only   (d) 2 and 3 only

Ans. (b)

Critical heat flux $\geq$ 1 MW/m²

Point of inflection

Heat flux W/m²

Water at 1 atm pressure
T_{sat} = 100°C

4°C   30°C

$\Delta T = (T_\omega - T_{sat})$
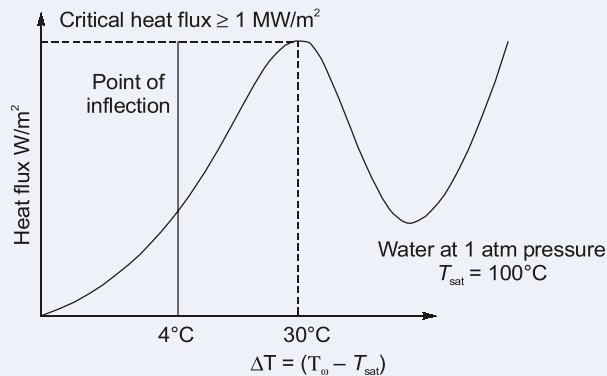
In the Nucleate boiling, beyond point of inflection, 'h' value decreases due to interference of bubbles formed on the surface of wire which will prevent the contact of liquid with wire. As such the rate of increase of heat flux with ΔT decrease, in this region there are vapour bubbles rise as jets (OR) columns ($\Delta T \simeq 10°$ to 30°C) and subsequently merge into slugs of vapour.
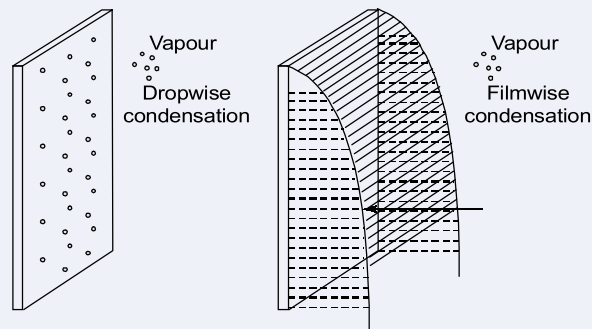
End of Solution

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 in film-wise condensation.
       (d) 10 times more than that in film-wise condensation.

Ans. (d)

Vapour

Dropwise condensation

Vapour

Filmwise condensation

In filmwise condensation, the sliding film will act as barrier to the H.T. offering Thermal resistance between vapour and wall thereby reducing the HT rate as compared to that in dropwise condensation.

End of Solution

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 kcal.kg⁻¹.K⁻¹ and g = 9.81 m/s²]
       (a) 3.35°C   (b) 2.35°C
       (c) 3.32°C   (d) 4.12°C

Ans. (b)

$$m = 1 \text{ kg}, \ Z = 1000 \text{ m}$$
$$mgz = mc \ dt$$
$$9.81 \times 1000 \times 10^{-3} \text{ kJ} = 1 \times 4.186 \times dt$$
$$dt = 2.343°C$$
$$\approx 2.35°C$$

End of Solution

97. A stationary mass of gas is compressed without friction from an initial state of 0.3 m³ and 0.105 MPa to a final state of 0.15 m³ 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)

$V_1 = 0.3 \text{ m}^3$, $P_1 = 0.105 \text{ MPa} = 105 \text{ kPa}$, $V_2 = 0.15 \text{ m}^3$, $P_2 = 105 \text{ kPa}$

```
 1 |----↓--•----|
   |            |
 2 |------•-----|
   |            |
   |----------↘-|
              Q = 40 kJ
```
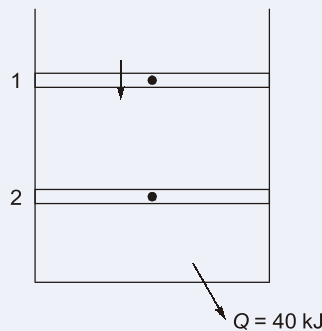
$$Q = \Delta U + W$$
$$-40 = \Delta U + [+105 (0.15 - 0.3)]$$
$$\Delta U = -24.25 \text{ kJ}$$

End of Solution

98. The state of a simple compressible pure substance can be fixed by specifying
(a) one independent property   (b) two independent properties
(c) three independent properties   (d) four independent properties

Ans. (b)

End of Solution

99. In a thermoelectric thermometer for t°C temperature, the emf is given as: $E = 0.003t - 5 \times 10^{-7} \ t^2 + 0.5 \times 10^{-3}$ 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) 36.28°C
(c) 41.23°C   (d) 46.28°C

Ans. **(*)**
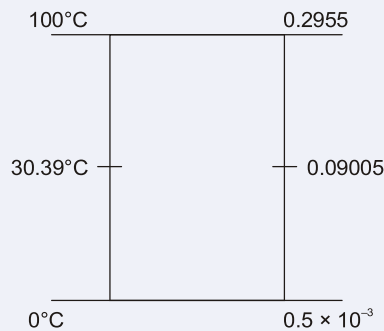
$$E = 0.003t - 5 \times 10^{-7}\ t^2 + 0.5 \times 10^{-3}$$
$$E_0 = 0.5 \times 10^{-3}$$
$$E_{100} = 0.2955$$
$$E_{30} = 0.09005$$

$$\frac{t - 0}{100 - 0} = \frac{0.09 - 0.5 \times 10^{-3}}{0.2955 - 0.5 \times 10^{-3}}$$

$$t = 30.393°C$$

End of Solution

100. Consider the following statements for comparison of heat and work:
1. Both heat and work are transient phenomena.
2. Both heat and work are boundary phenomena.
3. 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)**

End of Solution

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)

$$Q = \Delta U + W$$
$$-1500 = \Delta U + (-5090)$$
$$\Delta U = +3590 \text{ kJ}$$

End of Solution

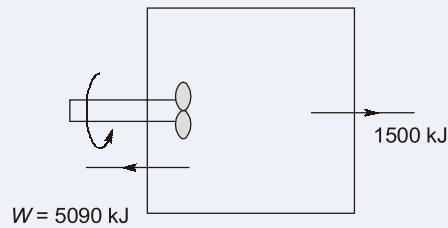**102.** During the charging of a storage battery, the current is 20 A and the voltage is 12.8 V. The rate of heat transfer from the battery is 10W. At what rate is the internal energy increasing?
(a) −256 J/s
(b) +246 J/s
(c) +256 J/s
(d) −246 J/s

Ans. (b)
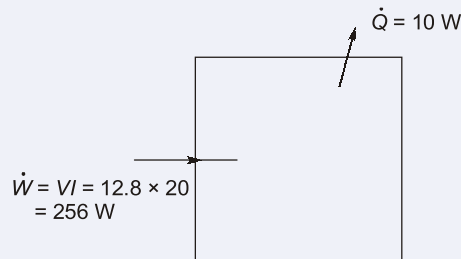
$$W = VI = 12.8 \times 20 = 256 \text{ W}$$
$$Q = \Delta U + W$$
$$-10 = \Delta U + (-256)$$
$$\Delta U = +246 \text{ kJ}$$

End of Solution

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)

$$(COP)_{ideal} = \frac{277}{315 - 277}$$

$$\frac{2}{\dot{W}} = \frac{277}{315 - 277}$$

$$\dot{W} = 0.274 \text{ kW}$$

End of Solution

104. Entropy generated (S_{gen}) can be taken as a criterion to indicate feasibility of process. Which of the following conditions are correct?

1. If $S_{gen} = 0$, then the process is a reversible process.
2. If $S_{gen} > 0$, then the process is an irreversible process.
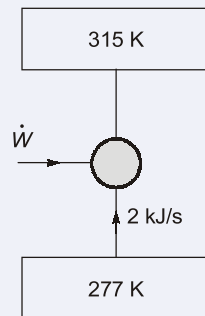3. If $S_{gen} < 0$, then the process is impossible.

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)

End of Solution

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

(a) 7.21 cm   (b) 6.37 cm

(c) 5.67 cm   (d) 6.93 cm

Ans. (c)

$$r_{critical} = \frac{k_{ins}}{h} = \left(\frac{0.17}{3}\right) m = 5.67 \text{ cm}$$

End of Solution

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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) 77.46 rpm

Ans. **(*)**

$$P_1 = 8000 \text{ kW}$$
$$N_1 = 1000 \text{ rpm}$$
$$H_1 = 30 \text{ m}, \ H_2 = 18 \text{ m}$$
$$N_2 = ?$$

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

$$\frac{1000}{\sqrt{30}} = \frac{N_2}{\sqrt{18}}$$

$$N_2 = 774.6 \text{ rpm}$$

End of Solution

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)**

End of Solution

108. In a gas turbine plant, heat supplied is 667.2 kg/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)**

$$\eta = 1 - \frac{Q_R}{Q_S} = 1 - \frac{391.43}{667.2} = 1 - 0.5866$$

$$= 0.4134 = 41.34\%$$

End of Solution

109. The constant pressure gas turbine works on

(a) Stirling Cycle
(b) Atkinson Cycle
(c) Rankine Cycle
(d) Brayton Cycle

Ans. **(d)**

End of Solution

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)**

End of Solution

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 m/s²)
(a) 37.24 m
(b) 43.38 m
(c) 29.46 m
(d) 32.88 m

Ans. **(b)**

$$d_2 = 30 \text{ cm} = 0.3 \text{ m}$$
$$\phi = 90° \Rightarrow V_{w2} = u_2$$
$$N = 1450 \text{ rpm}$$
$$\eta_{mano} = 82\%$$
$$\eta_{mano} = \frac{gH_m}{V_{w2}u_2}$$
$$u_2 = \frac{\pi d_2 N}{60} = \frac{\pi \times 0.3 \times 1450}{60} = 22.77 \text{ m/s}$$
$$\eta_{mano} = 0.82 = \frac{9.81 \times H_m}{22.77^2}$$
$$H_m = 43.36 \text{ m}$$

End of Solution

112. Lenoir cycle is used for
(a) Gas turbines
(b) Pulse jet engines
(c) S.I. engines
(d) C.I. engines

Ans. **(b)**

End of Solution

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)

$$r = 20$$
$$c = 0.05$$
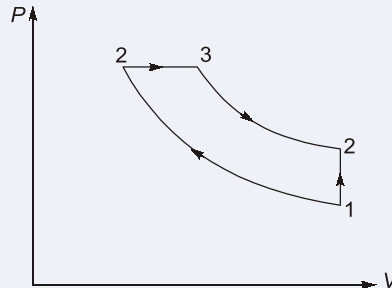
$$\frac{V_1}{V_2} = 20$$

$$0.05 = \frac{V_3 - V_2}{V_1 - V_2} = \frac{\dfrac{V_3}{V_2} - 1}{\dfrac{V_1}{V_2} - 1} = \frac{\dfrac{V_3}{V_2} - 1}{20 - 1}$$

$$\frac{V_3}{V_2} = 1.95$$

End of Solution

---

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

(a) 8　　　　　　　　　　　　　　　(b) 10
(c) 12　　　　　　　　　　　　　　(d) 14

Ans. (c)

$$V_S = 275 \text{ cm}^3$$
$$V_C = 25 \text{ cm}^3$$

$$r = \frac{V_1}{V_2} = \frac{V_C + V_S}{V_C} = \frac{25 + 275}{25} = 12$$

End of Solution

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)

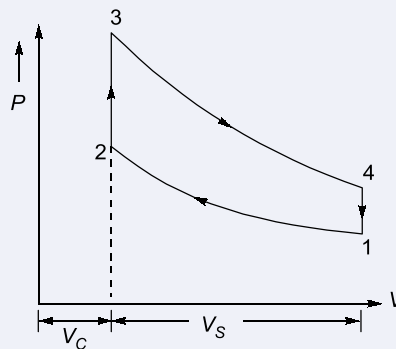$$\eta_m = \frac{BP}{BP + FP} = \frac{IP - FP}{IP}$$

$$0.6 = 1 - \frac{FP}{IP}$$

$$\frac{FP}{IP} = 0.4$$

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

End of Solution

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)

$$BP = 100 \text{ kW}$$
$$FP = 10 \text{ kW}$$

$$\eta_m = \frac{BP/2}{BP/2 + FP} = \frac{50}{50 + 10} \times 100 = 83.33\%$$

End of Solution

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 m^3/kg and 0.025 m^3/kg respectively)
     (a) 87.24%   (b) 71.31%
     (c) 64.85%   (d) 55.43%

Ans. (a)

$$T_E = -10°C = +263 \text{ K}$$
$$T_C = +30°C = 303 \text{ K}$$
$$V_C = 0.06 \ V_S$$
$$P_1 V_1^n = P_2 V_2^n$$
$$\left(\frac{P_2}{P_1}\right)^{1/n} = \frac{V_1}{V_2}$$
$$\eta_V = 1 + 0.06 - 0.06\left(\frac{V_1}{V_2}\right) = 1 + 0.06 - 0.06\left(\frac{0.07815}{0.025}\right)$$
$$\eta_V = 0.87244 = 87.24\%$$

End of Solution

---

118. Relative ozone destruction efficiency of R-12 is
   (a) 0.29   (b) 0.86
   (c) 0.05   (d) 0.57

Ans. (b)
   Relative ozone destruction efficiency is calculated with reference to R11 being taken as 100% or 1.

End of Solution

---

119. An air cooled condenser has 6 m^2 of surface with a removal of 50 $kJ.hr^{-1}.m^{-2}.°C^{-1}$. 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)
$$Q = hA\Delta T$$
$$= hA \ (T_{ref} - T_{room})$$
$$5235 = 50 \times 6 \times (T_{ref} - 25) \text{ kJ/hr}$$
$$T_{ref} = 42.45°C$$

End of Solution

---

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

End of Solution

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)**

1 mole of carbon = 393.5 kJ/mol

1 mole of hydrogen = 286 kJ/mol

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

$$\text{Moles of } H_2 = \frac{70}{2}$$

$$\text{Energy released} = \frac{920}{12} \times 393.5 + \left(\frac{70}{2}\right) \times 286 = 40175 \text{ kJ/kg}$$

End of Solution

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)**

End of Solution

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)**

End of Solution

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)
$$0.33 = 0.97 \times 0.95 \times 0.92 \times 0.42 \times \eta$$
$$\eta = 92.69\%$$

End of Solution

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)

End of Solution

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)

End of Solution

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)**

End of Solution

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)**

End of Solution

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 towers 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 effect 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)**

End of Solution

130. A single-acting reciprocating pump, running at 50 rpm delivers 0.00736 m^3/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)**

$$N = 50 \text{ rpm}$$

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

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

`

$$L = 0.3 \text{ m}$$

$$\% \text{ slip} = ? = \frac{Q_{th} - Q_{act}}{Q_{th}}$$

$$Q_{th} = \frac{ALN}{60} = \frac{\left(\frac{\pi}{4}D^2\right) \times L \times N}{60}$$

$$= \frac{\left(\frac{\pi}{4} \times 0.2^2\right) \times 0.3 \times 50}{60} = 0.00785 \text{ m}^3/\text{sec}$$

$$\% \text{ slip} = \frac{0.00785 - 0.00736}{0.00785} = 6.29\%$$

End of Solution

**131.** A pump discharges a liquid into a tank at the rate of 0.032 m^3/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)**

$$Q = 0.032 \text{ m}^3/\text{sec}$$
$$m = 3500 \text{ kg}$$

$$\text{Density} = \frac{\text{Mass}}{\text{Vol. of tank}} = \frac{3500}{\text{Area} \times \text{Height of tank}}$$

$$= \frac{350}{\left(\dfrac{\pi}{4} \times 1.5^2\right) \times 4.2} = 471.57 \text{ kg/m}^3$$
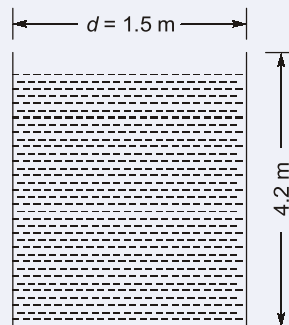
Mass flow rate = Density × Q = 471.57 × 0.032
Mass flor rate = 15 kg/sec

End of Solution

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)**
For Francis turbine, $V_{w2} = 0$

End of Solution

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 concentrical 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)**

$$d_2 = 375 \text{ mm}, \quad d_3 = 450 \text{ mm}$$
$$V_{f2} = 2 \text{ m/s}$$
$$V_{w2} = 12 \text{ m/s}$$

For free vortex, $\quad Vr = \text{Constant}$

$$V_{w2}r_2 = V_{w3}r_3$$

$$12 \times \frac{375}{2} = V_{w2} \times \frac{450}{2}$$

$$V_{w3} = 10 \text{ m/s}$$
$$V_{f2}r_2 = V_{f3}r_3$$

$$2 \times \frac{375}{2} = V_{f3} \times \frac{450}{2}$$

$$V_{f3} = 1.67 \text{ m/s}$$

End of Solution

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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)**
 Fully Open Impeller

End of Solution

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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)**
 Friction head for delivery pipe,

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

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

$$h_{fdm} = \frac{fL_d}{2gd_s}\left(\frac{A}{A_d}r\omega\right)^2$$

$$h_{fda} = \text{Average } h_{fd} = (2/3)h_{fdm}$$

End of Solution

136. In various solar energy storage systems, 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)

End of Solution

137. What is the standard value of solar constant adopted by World Radiation Centre?
(a) 1192 W/m^2
(b) 1084 W/m^2
(c) 1927 W/m^2
(d) 1367 W/m^2

Ans. (d)
Solar constant is the total radiation energy received from SUN per unit time per unit area on a theoretical surface perpendicular to the SUN's rays and at Earth's mean distance from the Sun.

End of Solution

138. What is the tip speed ratio of savonius wind turbine rotor?
(a) 1
(b) 3
(c) 5
(d) 7

Ans. (a)

End of Solution

139. What is the solidity of American multiblade wind turbine rotor?
(a) 0.4
(b) 0.7
(c) 0.9
(d) 1

Ans. (c)

End of Solution

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)

End of Solution

141. The percentage of hydrogen in producer gas is
(a) 34%
(b) 27%
(c) 18%
(d) 8%

Ans. (c)

End of Solution

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)

End of Solution

143.   The operating temperature of alkaline fuel cell is
        (a) 39°C   (b) 90°C
        (c) 127°C   (d) 192°C

Ans.   (b)
        The operating temperature of alkaline fuel cell is in the range of 70°C to 100°C.

End of Solution

144.   The ideal emf produced by polymer electrolyte membrane fuel cell at 25°C is
        (a) 3.57V   (b) 2.94V
        (c) 1.23V   (d) 0.73V

Ans.   (c)

End of Solution

145.   Which one of the following fuel cells has highest efficiency?
        (a) PAFC   (b) MCFC
        (c) PEMFC   (d) AFC

Ans.   (d)

End of Solution

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)

End of Solution

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)

End of Solution

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)

End of Solution

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, 2 and 4 only   (d) 2, 3 and 4 only

Ans. (b)

End of Solution

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   (d) 2, 3 and 4 only

Ans. (c)

End of Solution

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