Question 1 to 5 carry One Mark each

1. Reaching a place of appointment on Friday. I found that I was two days earlier than the scheduled day. If I had reached on the following Wednesday then how many days late would I have been?

(a) one (b) Two (c) Three (d) Four

2. Choose the most appropriate phrase from the options given below to complete the following sentence.

The bus stopped to _____ more passengers.

(a) Take in (b) Take on (c) Take up (d) Take For

3. Choose the appropriate sentence from the following options.

(a) She has been discharged since (b) She has since been discharged

(c) She has been since discharged (d) She since has been discharged

4. Fill in the blank with an appropriate phrase.

The jet _____ into the air.

(a) Soared (b) Soured (c) Sourced (d) Sored

5. Choose the most appropriate word from the options given below to complete the following sentence.

If I had known that you were coming, I _____ you at the airport.

(a) Would meet (b) Would have met (c) Will have met (d) Had met

Question 6 to 10 carry Two Marks each

6. Which of the following can be logically inferred from the given statement.

"No other studied medicine except Helen"

(a) Helen only studied medicine (b) Only Helen studied medicine

(c) Helen studied only medicine (d) Helen studied medicine only

7. The average electricity bill of a household for January to June is Rs. 980, for July to September is Rs. 670, for October to December is Rs. 720. If the family goes on vacation for June and July and no electricity is used, what would be the average electricity bill for that year?

(a) Rs. 500 (b) Rs. 600 (c) Rs. 700 (d) Rs. 800

8. The following question has four statements of three segments each. Choose the alternative where the third segment in the statement can be deduced using both the preceding two but not just from one of them.

1. Sonia is an actress. Some actresses are pretty. Sonia is pretty.

2. All actors are pretty. Manoj is not an actor. Manoj is not pretty

3. Some men are cops. Some men are brave. Some brave people are cops.

4. All cops are brave. Some men are cops. Some men are brave.

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

9. A contractor, who got the contract for building the flyover, failed to construct the flyover in the specified time and was supposed to pay Rs. 50,000 for the first day of extra time. This amount increased by Rs. 4,000 each day. If he completes the flyover after one month of stipulated time, he suffers a loss of 10% in the business. What is the amount he received for making the flyover in crores of rupee? (One month = 30 days)

(a) 3.1 (b) 3.24 (c) 3.46 (d) 3.68

10. Examine the information given below. Who si to the imediate right of P among five person P,Q,R,S and T, facing north ?

Two statements, labeled I and II, are given below. You have to decide whether the date given in the statements are sufficient for answering the question. Using the data given in the statements, you have to choose the correct alternative.

Statements :

I. R is third to the left of Q and P is second to the right of R

II. Q is the immediate left of T who is second to the right of P.

(a) I alone is sufficient while II alone is not sufficient to answer the question
(b) II alone is sufficient while I alone is not sufficient to answer the question
(c) Either I (or) II is sufficient to answer the question
(d) Neither I Nor II is sufficient to answer the question

Question 11 to 35 carry One Mark each

11. The system AX = 0 in 'n' variables has non-trivial solution if

(a) $\rho(A) = n$ (b) $\rho(A) > n$ (c) $\rho(A) < n$ (d) $\rho(A) \geq n$

12. The minimum possible positive imaginary part of $\ell n\left(\sqrt{i}\right)$ in degrees is

13. $\lim_{n\to\infty}\left(1+\frac{\sin a}{n}\right)^n$ is equal to

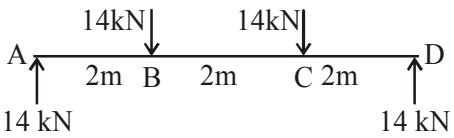
(a) $e^{a/2}$ (b) e^{a} (c) e (d) e^{2a}

14. Which of the following method cannot be applied for locating complex roots of an equation

(a) Bisection method (b) Regula Falsi (c) Secant method (d) Newton-Raphson

15. The positive value of x for which the function $f(x) = \int_0^x \left(1-t^2\right)e^{-t^2/2}dt$ has an extremum is

16. A wooden beam 200 mm × 200mm is simply supported on a span of 6m. When the beam is loaded with 14 kN load at each one-third span point, if failed. What is the modulus of rupture?



in N/mm^2

17. If in a process on the shop floor, the specifications are not met but the charts for variables show control, then which of the following action should be taken?

(a) changes the process

(b) change the method of measurement

(c) changes the worker or provide him training

(d) change the specification or upgrade the process

18. A velocity vector 'V' in 2-D flow is incline at an angle 'θ' to the x-axis. The resultant acceleration vector a

(a) will be always normal to V

(b) will be always parallel to V

(c) will have an inclination of (90-θ) to the y-axis

(d) will have an inclination θ to the x-axis which depends on the component of accleration

19. The axes of a three cylinder air compressor are at 120° to one another and their connecting rods are coupled to a single crank. The length of each connecting rod is 240 mm and the stroke is 160 mm. The reciprocating parts have a mass of 2.4 kg/cylinder. Determine the primary force if the engine runs at 2000 r.p.m.

20. The shear plane in case of bolts should

(a) be across threaded portion of shank (b) be parallel to axis of bolt

(c) be normal to threaded portion of shank (d) never be across the threaded portion

21. The ratio of internal conduction resistance to surface convection resistance is known as

(a) Grashoff number (b) Biot number (c) Stanton number (d) Prandtl number

22. 100 Ω strain gauge is bonded to a low carbon steel bar which has been subjected to tensile load. The bar has a uniform cross-sectional area of 0.5×10^{-4} m^2 and Young's modulus of low carbon steel is 200 GN/m^2. If a load of 50 kN produces a change of 1 Ω is gauge resistance then the gauge factor for the strain gauge is

23. Air enters into a gas turbine at pressure 40 bar and 1047°C with velocity 200 m/s. It flows adiabatically and leaves turbine at 1 bar with velocity 100 m/s. Determine the turbine output assume $\dot{m} = 1\ kg/s$, $C_p = 1.05$ kJ/kg-K, $\gamma = 1.4$

kW

24. What is hunting of thermostatic expansion valve?

(a) A variation of evaporator load with degree of superheat.

(b) A variation in pressure of the evaporator with variation of load.

(c) Alternate over feeding and starving of refrigerant flow in the evaporator.

(d) This is not used in connection with expansion valve.

25. A cylindrical air receiver for a compressor is 2m in internal diameter and made of plates of 1.5mm thick. If the hoop stress is not to exceed 90 N/mm^2 and the axial stress is not to exceed 60 N/mm^2, what is the maximum safe pressure

[ ] N/mm^2

26. The probability law that determines the fractional defective is

(a) Poisson (b) Normal (c) Binomial (d) Exponential

27. Calculate the kinetic energy correction factor 'α' for the $\frac{u}{u_{max}} = \left[1 - \left(\frac{r}{r_0}\right)^2\right]$ in a circular pipe of radius 'r_0' [ ]

28. The distance between two parallel shafts is 18mm and they are connected by an Oldham's coupling. The driving shaft revolves at 160 r.p.m. What will be the maximum speed of sliding of the tongue of the intermediate piece along its groove?

(a) 0.45 m/s (b) 0.302 m/s (c) 0.8 m/s (d) 0.35 m/s

29. Compression formula is valid upto the slenderness ratio of

(a) 10 (b) 20 (c) 30 (d) 40

30. In spite of large heat transfer coefficient in boiling liquids, fins are used advantageously when the entire surface is exposed to

(a) Nucleate boiling (b) Film boiling (c) Transition boiling (d) All modes of boiling

31. The electrode feed rate required in electrochemical machining a metal of atomic weight 56, density 7.8 g/cm^3 and valency 2 with specific resistance 0.5 Ω/mm, tool gap 0.5 mm and maintained at 18 V and 500 A is

[ ] mm/s

32. During the adiabatic cooling of moist air

(a) DBT remains constant (b) Specific humidity remains constant

(c) Relative humidity remains constant (d) WBT remains constant

33. For a simply supported beam carries several concentrated loads. The shear force would be maximum?

(a) at mid span (b) under the smallest load

(c) under the largest load (d) at either of the supports

34. What is the value of the shape factor for two infinite parallel surface separated by a distance 'd'

(a) 0 (b) ∞ (c) 1 (d) d

35. When a sheet of width 300 mm and thickness 12 mm is reduced to 10 mm by using rolling operation with the rollers having the radius 250 mm, the average pressure acting between the rollers is 350 MPa. Determine the power required at 10 rpm and take the value of arm factor as 0.4

[ ] kW

Question 36 to 65 carry Two Marks each

36. The current required for 5 mm thick steel plates to be spot welded is 10,000 amperes. Then the current required for 1.5 mm thick aluminium plates to spot weld will be, if melting point of steel = 1400°C and melting point of Al = 660°C

[ ] Ampere

37. Which one of the following cycle working with in same temperature limits has the highest work ratio?

(a) Carnot cycle (b) Joule cycle (c) Otto cycle (d) Rankine cycle

38. A fluid indicate the following shear stress and deformation rates ;

(du/dy)	(units)	0	1	2	4
(τ)	(units)	10	15	20	30

This fluid is classified as

(a) Newtonian (b) Bingham plastic (c) Dilatant (d) Pscudo plastic

39. Determine the thickness of a 120 mm wide uniform plate for safe continuous operation if the plate is to be subjected to a tensile load that has a maximkum value of 250 kN and a minimum value of 100 kN. The endurance and yield point stress are 225 MPa and 300 MPa respectively. The factor of safety on yield points may be taken as 1.5

[ ] mm

40. The temperature of the air stream in a tube is measured with the help of the thermometer placed into a protective well filled with oil. The thermometer well is made of a steel tube (k = 55.8 W/mK), 120 mm long and 1.5 mm thick. The surface heat transfer coefficient from the air to the protective well is 23.3 W/m^2K and the temperature recorded by the thermometer is 84°C. Estimate the measurement error if the temperature at the base of the well is 40°C

[ ] °C

41. A slab milling operation is carried out on 250 mm long, 100 mm wide MS block at a feed rate of 0.25 mm/tooth and depth of cut 3 mm. Diameter of the cutter is 50 mm and has a 20 straight teeth and rotates at 100 rpm. The machining time for completing one cut will be

[ ] second

42. A gas turbine power plant has a specific output of 350 kJ/kg and an efficiency of 34%. A regenerator is installed and the efficiency increases to 51%. The specific output will be close to

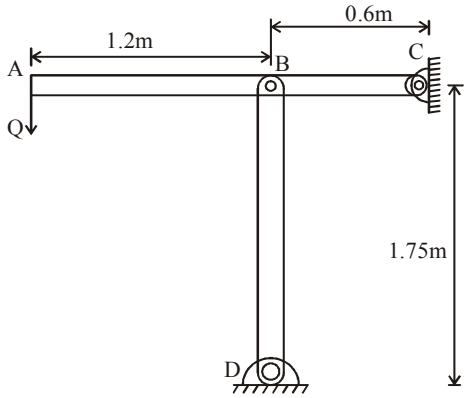
(a) 350 kJ/kg (b) 468 kJ/kg (c) 525 kJ/kg (d) 700 kJ/kg

43. Which thermometer is independent of the substance or material used in constructions

(a) mercury thermometer (b) alcohol thermometer

(c) ideal gas thermometer (d) resistance thermometer

44. A horizontal beam ABC 1.80 m long is pinned to a support at 'C' and supported by pin ended vertical steel section of side 50 mm. Based on the critical load of the column, what should be the safe load 'Q' for column applied at 'A' with a factor of safety of 2 ? Take E = 2×10^5 N/mm^2. If column is 1.75 m long as shown in figure the column is of square cross-sectional



45. The piezometric head of a flow is

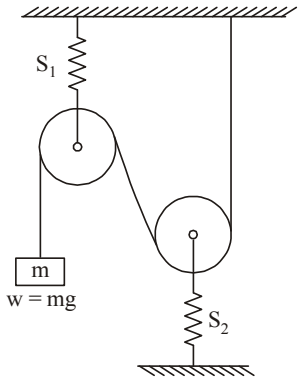
(a) The sum of the velocity head and datum head

(b) The sum of pressure head and datum head

(c) The sum of pressure head and velocity head

(d) The sum of pressure head, velocity head & datum head

46. Determine the frequency of vibration of the system as shown in figure. Neglect the mass of pulleys.



(a) $\sqrt{\frac{S_1 + S_2}{4S_1S_2m}}$ (b) $\sqrt{\frac{S_1S_2}{4(S_1 + S_2)m}}$ (c) $\sqrt{\frac{S_1S_2}{2(S_1 + S_2)m}}$ (d) $\sqrt{\frac{S_1 + S_2}{2S_1S_2\,m}}$

47. Two shafts are connected by means of a flange coupling to transmit torque of 25 N-m. The flanges of the coupling are fastened by four bolts of the same material at a radius of 30 mm. Find the size of the bolts if the allowable shear stress for the bolt material is 30 MPa

mm

48. A metal ingot, 5 cm × 8 cm × 12 cm, at a temperature of 50°C is losing heat by natural convection to air at 0°C. The vertical dimension is 12 cm. Find the coefficient of heat transfer.

Given $\nu = 15.89 \times 10^{-6}$ m^2/s, k = 26.3×10^{-3} W/mK, Pr = 0.707, $\beta = \frac{1}{300}$ K^{-1} and Nu = $0.55(Ra)^{1/4}$

[ ] W/m^{2}K

49. A cup 5 cm in diameter and 7.5 cm in depth is to be drawn from 1.5 mm thick drawing steel with tensile yield strength of 315 MPa. The corner radius is negligible the blank diameter

[ ] cm

50. 20 kg/s of air at 30°C and a humidity ratio of 0.01 kg water vapour/kg air are mixed with 12 kg/s of air at 38°C and humidity ratio of 0.02 kg water vapour/kg air. If there is no external addition or removal of moisture and heat, determine humidity ratio of the resultant air stream in kg vapour/kg dry air

(a) 0.01 (b) 0.02 (c) 0.013 (d) 0.017

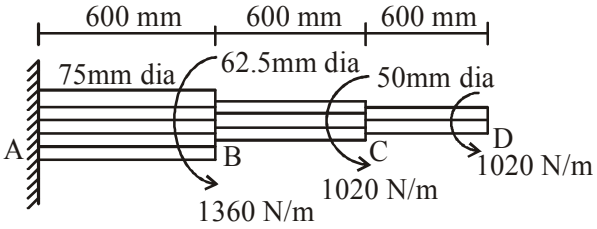
51. Steam at 300 kPa and 500°C (h = 3486.0 kJ/kg) enters a steam turbine and exists at atmospheric pressure and 350°C (h = 3175.8 kJ/kg). Heat losses in the turbine are 50 kW and the mass flow rate is 0.25 kg/s. Determine the power output of the turbine if kinetic energy losses are negligible

[ ] kW

52. An ideal air standard regenerative Brayton cycle is working between minimum and maximum temperature of 300 K and 1200 K respectively. Calculate the efficiency of the cycle when the operating pressure ration is 60% of the critical pressure ratio. Where the degree of regeneration becomes zero

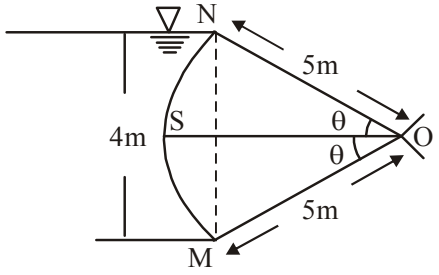
[ ] percentage

53. Figure shows a stepped shaft ABCD subjected to three torques 1360 Nm, 1020 Nm and 1020 Nm. Each segment of the shaft is 600 mm long. The diameter of the segments are 75 mm, 62.5 mm and 50 mm. What would be the maximum shear stress in the shaft



[ ] N/mm^2

54. A sector gate in the form of circular arc of radius 5 m retains water to a height of 4m as shown in the figure, calculate the magnitude of resultant force per unit length of the gate



(a) 10.99 kN (b) 77 kN (c) 79 kN (d) 13 kN

55. A particle starts from rest. What is the ratio of distances covered by it in the 3rd and 5th seconds of its motion?

(a) 3 : 8 (b) 4 : 9 (c) 5 : 11 (d) 5 : 9

56. If $\psi = 2xy$, the magnitude of the velocity vector at (2,-2) is

(a) $4\sqrt{2}$ (b) 4 (c) –8 (d) $\sqrt{2}$

57. Water enters a counter flow, double pipe heat exchanger 15°C, flowing at the rate of 1300 kg/h. It is heated by oil (C_p = 2000 J/kgK) flowing at the rate of 550 kg/h. From the inlet temperature of 94°C for an area 1 m^2 and overall heat transfer coefficient is 1075. Find NTU

(a) 3.52 (b) 2.78 (c) 3.18 (d) 3.78

58. An oil of density 917 kg/m^3 is being pumped in a pipe of diameter 15 cm. The discharge is measured as 850 L/min. The drop in pressure in a stream of 800 cm of pipeline, both ends of which are same elevation, is measured as 95 kPa. Find the viscosity of oil

[ ] Pa-s

59. For NH_3 – CH_4 mixture system existing in two phases in equilibrium. The number of independent properties required to fix the state of system are

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

60. The piston of an oil engine of area 0.0045 m^2 moves downward 75 mm, drawing in 0.00028 m^3 of fresh air from the atmosphere. The pressure in the cylinder is uniform during the process at 80 kPa, while the atmospheric pressure is 101.325 kPa. Find the displacement work done by the air finally in the cylinder.

[ ] Joule

61. A certain water heater operates under steady flow conditions receiving 4.2 kg/s water at 75°C temperature enthalpy 313.93 kJ/kg. The water is heated by mixing of steam which is supplied to the water at temperature 100.2°C and enthalpy 2676 kJ/kg. The mixture leaves the heater as liquid water at temperature 100°C and enthalpy 419 kJ/kg. How much steam must be supplied to heater per hours.

(a) 630 kg/h (b) 705 kg/h (c) 772 kg/h (d) 790 kg/h

62. If $A = \begin{bmatrix} 1 & 0 & 0 \\ i & \frac{-1}{2}+\frac{i\sqrt{3}}{2} & 0 \\ 0 & 1+2i & \frac{-1-i\sqrt{3}}{2} \end{bmatrix}$

then trace of A^{102} is

[ ]

63. The value of $\iint_S \vec{A}\cdot\vec{ds}$, where $\vec{A} = x^3\hat{i} + y^3\hat{j} + z^3\hat{k}$ and S is the surface of the sphere $x^2 + y^2 + z^2 = a^2$ is

(a) $\frac{7\pi}{5}a^3$ (b) $\frac{32\pi}{5}a^5$ (c) $\frac{9\pi}{5}a^3$ (d) $\frac{12\pi}{5}a^5$

64. If $u-v = (x-y)(x^2+4xy+y^2)$ and $f(z) = u + iv$ is an analytic function of $z = x + iy$, f(z) in terms of z is

(a) $-iz^3 + c'$ (b) $z^3 + c'$ (c) $iz^3 + c'$ (d) $-z^3 + c'$

65. A random variable X has probability density function f(x) as given as

$$f(x) = \begin{cases} a + bx + cx^2 & 0 < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

If the expected value E(X) = $\frac{1}{2}$ and $E(X^2) = \frac{2}{3}$ Pr(X < .5) is

ANSWER & EXPLANATION

1. *Ans. (c)*

Friday → 2 days earlier

Therefore, scheduled day = Friday + 2 = Sunday

Sunday + 3 = Wednesday

Therefore, I would have been late by 3 days

2. *Ans. (b)*

3. *Ans. (b)*

4. *Ans. (a)*

5. *Ans. (b)*

6. *Ans. (b)*

7. *Ans. (c)*

Average electricity bill from January to June

= Rs. 980

∴ Total electricity bill from January to May

= 980 × 5 = Rs. 4900

(As no electricity is used in June)

Similarly, total electricity bill from August to September (as no electricity is used in July)

= 670 × 2 = Rs. 1340

And total electricity bill from October to December = 720 × 3 = Rs. 2160

Therefore, total electricity bill from January to December = 4900 + 1340 + 2160 = Rs.8400

Thus, average electricity bill for the whole year

$$= \frac{8400}{12} = \text{Rs. } 700$$

8. *Ans. (c)*

9. *Ans. (b)*

The sum of money that the contractor was supposed to pay for the period of an month over the stipulated time is

$$= S_n = \frac{n}{2}[2a + (n-1)d]$$

$$a = 50{,}000 \; ; \; n = 30 \; ; \; d = 4000$$

$$S_{30} = \frac{30}{2}[2 \times 50{,}000 + (30-1) \times 4000]$$

$$= 15\,[100{,}000 + 29 \times 4000]$$

Rs. 3240000 = Rs.32.4 lakh

Loss in the business = 10%

∴ Amount he received for making the flyover

$$= \frac{3240000}{0.1} = 32400{,}000$$

= Rs. 3.24 crores

10. *Ans. (c)*

11. *Ans.* (c)

Non-Trivial solution means infinite solutions

i.e., $|A| = 0$ and $\rho(A) < n$

where, 'n' is the no. of variables.

12. *Ans.* (45)

$$\ell n\left(\sqrt{i}\right) \Rightarrow \ell n i^{1/2}$$

$$\Rightarrow \quad \frac{1}{2}\ell n i \Rightarrow \frac{1}{2}\ell n e^{i\pi/2}$$

$$\Rightarrow \quad \frac{1}{2}\left(\frac{i\pi}{2}\right) \Rightarrow i\left(\frac{\pi}{4}\right)$$

$\frac{\pi}{4}$ in degrees is 45°.

13. *Ans.* (b)

$$\lim_{n\to\infty}\left(1+\frac{\sin a}{n}\right)^n = 1^\infty$$

∴ Using formulae

$$\lim_{n\to\infty} f(x)^{g(x)} = e^{\lim_{x\to a}\left(g(x)(f(x)-1)\right)}$$

$$\lim_{n\to\infty}\left(1+\sin\left(\frac{a}{n}\right)\right)^n = e^{\lim\limits_{n\to\infty}(n)\left(1+\sin\left(\frac{a}{n}\right)-1\right)}$$

$$\Rightarrow \quad e^{\lim\limits_{n\to\infty} n\cdot\sin\left(\frac{a}{n}\right)} = e^{\lim\limits_{n\to\infty}\frac{\sin a/n}{a/n}\cdot a}$$

$$\Rightarrow \quad e^{a\left[\lim\limits_{x\to 0}\frac{\sin x}{x}=1\right]}$$

14. ***Ans.*** **(a)**

15. ***Ans.*** **(1)**

$$f(x) = \int_0^x \left(1-t^2\right)e^{-t^2/2}dt$$

$$f'(x) = \left(1-x^2\right)e^{-x^2/2}$$

For extremum,

$$f'(x) = 0$$

$$\left(1-x^2\right)e^{-x^2/2} = 0$$

Positive value of x = 1.

16. ***Ans. (21) N/mm²***

Section modulus of the beam section

$$Z = \frac{200^3}{6}mm^3$$

Maximum bending moment

$$M = 14 \times 2$$

$$= 28 \text{ KN-m}$$

Modulus of rupture

$$\sigma_m = \frac{M}{Z} = \frac{28\times10^6}{\frac{(200)^3}{6}}$$

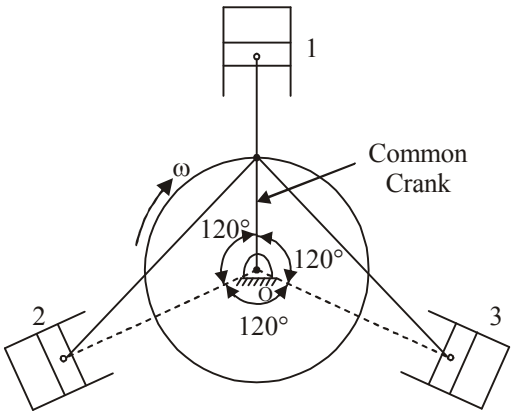
$$= 21 \text{ N/mm}^2$$

17. ***Ans.(b)***

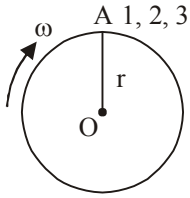
18. ***Ans (d)***

19. ***Ans. (12 to 13) N***

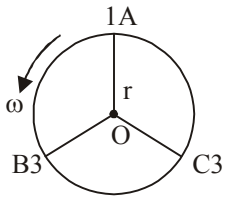
The position of 3 cylinders as shown in figure



Primary Cranks



(a) Primary Direct Crank



(b) Primary Reverse Crank

Figure (b) indicates that the primary reverse cranks form a balanced system and therefore unbalanced primary force is due to direct cranks only & is given by

Maximum primary force = $3\frac{m}{2}r\omega^2$

$$= 3\times\frac{2.4}{2}\times0.08\times\left(\frac{2\pi\times2000}{60}\right)^2$$

$= 3 \times 1.2 \times 0.08 \times 43865$

= 12633 N or 12.633 kN

20. ***Ans.(d)***

21. ***Ans.(b)***

22. ***Ans. (2)***

$$E = \frac{\sigma}{\frac{dl}{l}}$$

$$\frac{dl}{l} = \frac{\sigma}{E} = \frac{50\times10^3}{0.5\times10^{-4}\times200\times10^9}$$

$$= 0.005$$

$$\text{Gauge factor} = \frac{\frac{dR}{R}}{\frac{dl}{l}} = \frac{\frac{1}{100}}{0.005} = 2$$

23. ***Ans. (900 to 930) kW***

$$\dot{m}\left(h_1 + \frac{C_1^2}{2} + gZ_1\right) + \dot{Q}$$

$$= \dot{m}\left(h_2 + \frac{C_2^2}{2} + gZ_2\right) + \dot{W}$$

$\dot{Q} = 0$ (adiabatic process) and ΔP.E. = 0

$$h_1 + \frac{C_1^2}{2} = h_2 + \frac{C_2^2}{2} + \dot{W}$$

$$\dot{W} = C_p(T_1 - T_2) + \frac{C_1^2 - C_2^2}{2}$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 1320\left(\frac{1}{40}\right)^{0.285}$$

$$T_2 = 461.3 \text{ K}$$

So,

$$\dot{W} = 1.05(1320 - 461.3) + \frac{200^2 - 100^2}{2}$$

$$= 916.63 \text{ kW}$$

24. ***Ans. (c)***

Alternat overfeeding and starving of refrigerant flow in the evaporator a causes hunting in thermostatic expansion valve.

25. ***Ans. (1.3 to 1.4) N/mm²***

Limiting the hoop stress

$$\sigma_1 = \frac{Pd}{2t} = 90 \text{N/mm}^2$$

$$P = \frac{2\times1.5\times90}{2000} = 1.35 \text{ N/mm}^2$$

Limiting the axial stress

$$\sigma_2 = \frac{Pd}{4t} = 60 \text{N/mm}^2$$

$$P = \frac{4\times1.5\times60}{2000} = 1.8 \text{N/mm}^2$$

Maximum safe air pressure is = 1.35 N/mm²

26. ***Ans.(c)***

27. ***Ans. (2)***

28. ***Ans. (b)***

$$\omega = \frac{2\pi\times160}{60} = 16.75 \text{ rad/s}$$

max velocity of sliding = Angular velocity of shaft × distance between shafts

$$= \omega \times d$$
$$= 16.75 \times 0.018$$
$$= 0.302 \text{ m/s}$$

29. ***Ans.(d)***

30. ***Ans.(b)***

31. ***Ans. (2.6 to 2.8) mm/s***

$$e = \frac{56}{2} = 28 \qquad \left[\frac{\Delta V}{I} = \rho_s \cdot \frac{l}{A}\right]$$

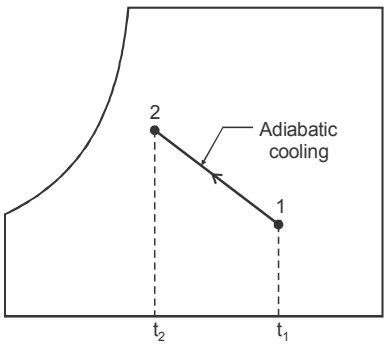
$$MRR = \frac{e}{F}\times\frac{I}{p}$$

$$= \frac{28\times500\times1000}{96500\times7.8} = 18.6\ \text{mm}^3/\text{s}$$

$$\text{Feed rate} = \frac{\text{MRR}}{\text{A}} = \frac{\text{MRR}\times\Delta\text{V}}{\rho_s \times l \times \text{I}}$$

$$= \frac{18.6\times18}{0.5\times0.5\times500} = 2.68\ \text{mm/sec}$$

32. ***Ans. (d)***



During adiabatic cooling of moist air enthalpy of mosit air remains constant. Since constant enthalpy lines and constant wet bulb temperature lines are almost same hence wet bulb temperature also remains constant during adiabatic cooling.

33. ***Ans. (d)***

34. ***Ans.(c)***

35. ***Ans. (43 to 45) kN***

$P_{avg} = 350$ MPa

$F_{avg} = P_{avg} \times bL$

$L = \sqrt{R\Delta h} = \sqrt{250\times2} = 22.36$ mm

$F_{avg} = 350 \times 300 \times 22.36$

$= 2347800\ \text{N} = 2347.8\ \text{kN}$

Torque

$T = F_{avg} \times \lambda L$

$= 2347.8 \times 0.4 \times 22.36 \times 10^{-3}$

$= 21\ \text{kNm}$

$P = 2T\omega$

$= 2\times 1.046 \times 21 = 43.96\ \text{kW}$

36. ***Ans. (1340 to 1400) Ampere***

$t_1 = 5$ mm, $t_2 = 1.5$ mm

$I_1 = 10{,}000$ Amps, $I_2 = ?$

$MP_1 = 1400 + 273 = 1673$ K

$MP_2 = 660 + 273 = 933$ K

$t \propto Q \propto M \cdot P \propto I^2$

$$\frac{I_2}{I_1} = \sqrt{\frac{M\cdot P_2 \times t_1}{M\cdot P_1 \times t_2}} = 10000\sqrt{\frac{933\times5}{1673\times1.5}}$$

$= 1363.28\ \text{A}$

37. ***Ans. (d)***

Rankine cycle has highest work ratio.

38. ***Ans (b)***

$$\tau = A.\left(\frac{\partial u}{\partial y}\right)^n + B$$

at $\frac{\partial u}{\partial y} = 0$,

$\tau = 10$

$B = 10$

39. ***Ans (11 to 12)mm***

Area of the plate

$A = bt = 120\ t\ \text{mm}^2$

The average load

$$P_m = \frac{P_{max} + P_{min}}{2} = \frac{250+100}{2}$$

$P_m = 175$ kN

Average stress

$$\sigma_m = \frac{175\times10^3}{120t}\ \text{N/mm}^2$$

Variable load amplitude

$$P_a = \frac{P_{max} - P_{min}}{2} = \frac{250-100}{2}$$

$P_a = 75$ kN

Variable stress amplitude

$$\sigma_a = \frac{75}{120t}\ \text{N/mm}^2$$

Soderberg eqn.

$$\frac{\sigma_m}{\sigma_y}+\frac{\sigma_a}{\sigma_e}=\frac{1}{FOS}$$

$$\frac{175\times10^3}{120t\times300}+\frac{175\times10^3}{120t\times225}=\frac{1}{1.5}$$

$$\frac{7.64}{t}=\frac{1}{1.5}\Rightarrow \quad t=11.5\text{ mm}$$

40. ***Ans. (15 to 17)°C***

$$\frac{T_L-T_\infty}{T_o-T_\infty}=\frac{1}{\cosh(ml)}$$

$$m=\sqrt{\frac{hP}{kA}}=\sqrt{\frac{23.3\times\pi D}{55.8(\pi D^2)}}$$

$$=\sqrt{\frac{23.3}{55.8(0.0015)}}=16.7$$

$$mL=(16.7)(0.12)=2$$

$$\frac{T_L-T_\infty}{T_o-T_\infty}=\frac{1}{\cosh(2)}=\frac{1}{3.76}=0.266$$

$$T_\infty=\frac{T_L-0.266T_o}{1-0.266}=\frac{84-0.266(40)}{0.734}$$

$$=100°C$$

The measurement error

$$=T_\infty-T_L$$

$$=100-84=16°C$$

41. ***Ans. (30 to 33)second***

Length of approach in slab milling is

$$L_A=\sqrt{d(D-d)}=\sqrt{3(50-3)}$$

$$=18.87$$

Time for one cut

$$=\frac{L+L_A}{f}=\frac{250+11.87}{0.25\times20\times\frac{100}{60}}$$

$$=31.5\text{ sec}$$

42. ***Ans. (a)***

In case of gas turbine, regeneration decreases the heat supplied. It has no effect an power output.

43. ***Ans. (c)***

44. ***Ans. (55 to 56) kN***

Given

$$l=1.75\text{ m}=1750\text{ mm}$$

$$b=d=50\text{ mm}$$

$$I=\frac{(50)^4}{12}$$

Critical load

$$P=\frac{\pi^2EI}{\ell^2}$$

$$P=\frac{\pi^2\times2\times10^5}{(1750)^2}\times\frac{(50)^4}{12}$$

$$=335.70\text{ kN}$$

Safe load for column $=\frac{P}{FOS}$

$$=\frac{335.70}{2}$$

$$=167.85\text{ kN}$$

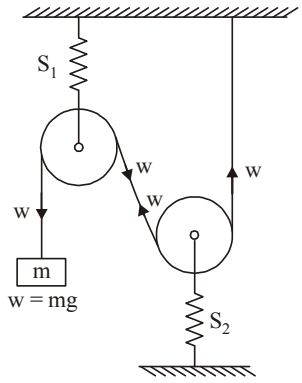
For the equilibrium of the beam, ABC, taking moment about C,

$$Q\times1.8=167.85\times10^3\times0.6$$

$$Q=55.95\text{ kN}$$

45. ***Ans (b)***

46. ***Ans. (b)***



Force in each spring = 2w

Deflection on mass m,

Δ = 2 (deflection of spring 1 + deflection of spring 2)

$$= 2\left(\frac{2w}{S_1}+\frac{2w}{S_2}\right)$$

$$= 4mg\left[\frac{S_1+S_2}{S_1S_2}\right]$$

$$\omega_n = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{g(S_1S_2)}{4mg(S_1+S_2)}}$$

$$= \sqrt{\frac{S_1S_2}{4(S_1+S_2)m}}$$

47. ***Ans (2.70 to 3.20)mm***

Shearing load carried by flange coupling

$$P_s = \frac{T}{R_P} = \frac{25\times10^3}{30}$$

P_s = 833.3 N

d_c = Core diameter of the bolt

Resisting load on the bolts

$$P = \frac{\pi}{4}(d_c)^2(\tau)n$$

$$P = \frac{\pi}{4}(d_c)^2(30)(4)$$

$$P = 94.26\ (d_c)^2$$

$$(d_c)^2 = \frac{833.3}{94.26} = 8.84$$

d_c = 2.97 mm

48. ***Ans. (8 to 9) W/m²K***

$$L_c = \frac{L_HL_V}{L_H+L_V} = \frac{8\times12}{8+12} = 4.8 \text{ cm}$$

$$R_a = G_r\times P_r = \frac{g\beta L^3(T_s-T_\infty)}{\nu^2}\times P_r$$

$$= \frac{(9.81)\left(\frac{1}{300}\right)(0.048)^3(50-0)}{(15.89\times10^{-6})^2}\times0.707$$

$R_a = 7.16\times10^5$

$Nu = 0.55\ Ra^{1/4} = 0.55(7.16\times10^5)^{1/4}$

$= 15.99$

$$h = \frac{15.99\times(26.3\times10^{-2})}{0.048}$$

$= 8.77\ W/m^2K$

49. ***Ans. (13 to 14) cm***

Cup diameter = 5 cm,

Depth = 7.5 cm,

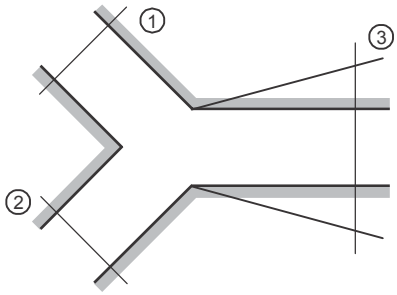
Thickness = 1.5 mm, σ_y = 315 MPa

Blank diameter = $\sqrt{d^2+4dh}$

$$= \sqrt{5^2+4\times5\times7.5}$$

= 13.23 cm

50. ***Ans. (c)***



Section-I

m_1 = 20 kg/sec

$$\omega_1 = 0.01\left(\frac{\text{kg vapour}}{\text{kg dry air}}\right)$$

T_1 = 30°C

Water balance

$m_1\omega_1 + m_2\omega_2 = m_3\omega_3$

$20\times0.01 + 12\times0.02 = 32\ \omega_3$

Section-II

m_2 = 12 kg/sec

$$\omega_2 = 0.02\left(\frac{\text{kg vapour}}{\text{kg dry air}}\right)$$

$$T_2 = 38°C$$

$$m_1 + m_2 = m_3$$

$$20 + 12 = m_3$$

$$m_3 = 32 \text{ kg/sec}$$

$$\omega_3 = \frac{0.2 + 0.24}{32} = 0.01375 \frac{\text{kg vapour}}{\text{kg dry air}}$$

51. ***Ans. (27 to 28) kW***

$m_1h_1 - Q = m_2h_2 + W$

$0.25 \times 3486 - Q = 0.25 \times 3175.8 + W$

$W = 0.25(3486 - 3175.8) - 50$

$= 27.55$ kW

52. ***Ans. (55 to 58) percentage***

$$(r_p)_{critical} = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}} = \left(\frac{1200}{300}\right)^{\frac{1.5}{2\times.4}}$$

$$= (4)^{1.75} = 11.313$$

$r_p = 0.6\, r_{pc} = 0.6 \times 11.313 = 6.78$

$(\eta_{Brayton})_{ideal\ regenerative}$

$$= 1 - \frac{T_{min}}{T_{max}}(r_p)^{\frac{\gamma-1}{\gamma}} = 1 - \frac{300}{1200}(6.78)^{\frac{0.4}{1.4}}$$

$$= 0.25(6.78)^{0.2857} = 0.568$$

$$= 56.8\%$$

53. ***Ans. (42 to 43) N/mm²***

Torque on the segment AB

= 1020+1020+1360 = 3400 Nm

Torque on the segment BC

= 1020+1020 = 2040 N.m

Torque on the segment CD

= 1020 Nm

Maximum shear stress in AB

$$= \frac{16 \times 3400 \times 10^3}{\pi(75)^3} = 41.05 \text{ N/mm}^2$$

Maximum shear stress in BC

$$= \frac{16 \times 2040 \times 10^3}{\pi(62.5)^3} = 42.56 \text{ N/mm}^2$$

Maximum shear stress in CD

$$= \frac{16 \times 1040 \times 10^3}{\pi(50)^3} = 41.56 \text{ N/mm}^2$$

So we have maximum shear stress in the shaft = 42.56 N/mm²

That is in BC portion

54. ***Ans*** **(c)**

$$\sin\theta = \frac{4/2}{5} \quad ;$$

$$\phi = 23.578°$$

$$F_H = \rho g (A)_{projected} \times \bar{h}$$

$$= 9.81 \times 10^3 \times (4 \times 1) \times \frac{4}{2}$$

$$= 78.480 \text{ kN}$$

F_V = Weight of water displaced by gate

= ρg[Area of OMSN–Triangle area of OMN]

$$F_V = 10.99 \text{ kN}$$

$$F_R = \sqrt{F_H^2 + F_v^2} = 79.08 \text{ kN}.$$

55. ***Ans. (d)***

We know

$$S_n = u + \frac{a}{2}(2n-1)$$

$$S_3 = 0 + \frac{a}{2}\left[(2\times 3) - 1\right]$$

Similarly $S_3 = \frac{5a}{2}$

$$S_5 = 0 + \frac{a}{2}\left[(2\times 5) - 1\right]$$

$$S_5 = \frac{9a}{2}$$

Ratio is $\frac{5a}{2} : \frac{9a}{2} \Rightarrow 5 : 9$

56. ***Ans (a)***

$$\psi = 2xy$$

$$u = -\frac{\partial\psi}{\partial y} = -2x = -4$$

$$v = \frac{\partial\psi}{\partial x} = 2y = -4$$

$$v = \sqrt{u^2 + v^2} = 4\sqrt{2}$$

57. ***Ans. (a)***

$$C_c = \dot{m}_c C_c = \frac{1300(4186)}{3600}$$

$$C_h = \dot{m}_h C_h = \frac{(500)(2000)}{3600}$$

$$C_{min} = C_h = 305.55 \text{ W/K}$$

$$R = \frac{C_{min}}{C_{max}} = \frac{305}{1511.61}$$

$$NTU = \frac{UA}{C_{min}} = \frac{1075 \times 1}{305.55} = 3.52$$

58. ***Ans. (0.10 to 0.12) Pa-s***

$$\bar{u} = \frac{Q}{A} = \frac{0.850}{\frac{\pi}{4} \times 0.15^2}$$

$$\bar{u} = 0.8017$$

$$h_f = \frac{\Delta P}{\rho g} = \frac{95 \times 10^3}{917 \times 9.81} = 10.56 \text{ m.}$$

$$h_f = \frac{32\mu\bar{u}L}{\rho g D^2}$$

$$\mu = 0.104 \text{ Pa-s}$$

59. ***Ans. (b)***

We know that

$$P + F = C + 2$$

$$2 + F = 2 + 2$$

$$F = 2$$

So, 2 properties required.

60. ***Ans. (27) Joule***

Here we have to find out the work done on the air in the cylinder.

Work = Change in volume due to piston displacement × Pressure inside the piston

$$= 0.0045 \times 0.075 \times 80 \times 10^3$$

$$= 27 \text{ Joule}$$

61. ***Ans. (b)***

$$4.2 \times 313.93 + m\,(2676)$$

$$= 419\,(4.2 + m)$$

$$m = 705.6 \text{ kg/h}$$

62. ***Ans.* (3)**

A is a lower triangular matrix. For any triangular matrix A if diagonal elements are (a, b, c) than the diagonal elements of A^n are (a^n, b^n, c^n).

$\therefore$ Diagonal elements of A^{102} are

$$1^{102}, \left(\frac{-1}{2} + \frac{i\sqrt{3}}{2}\right)^{102}, \left(\frac{-1-i\sqrt{3}}{2}\right)^{102}$$

$$\left(\frac{-1}{2} + \frac{i\sqrt{3}}{2}\right)^{102} \Rightarrow \left(e^{i2\pi/3}\right)^{102} \text{ Þ } e^{i68\pi}$$

$$\Rightarrow \cos 68\pi + i\sin 68\pi = 1$$

$$\left(\frac{-1}{2} - \frac{i\sqrt{3}}{2}\right)^{102} \Rightarrow \left(e^{-i2\pi/3}\right)^{102} \Rightarrow e^{-68\pi i}$$

$$= \cos(-68\pi) - i\sin 68\pi$$

$$= 1$$

$$1^{102} = 1$$

$\therefore$ the diagonal elements of $(A)^{102}$ are 1, 1 and 1.

$\therefore$ trace (A) = 1 + 1 + 1 = 3

63. ***Ans.* (d)**

S is a surface of the sphere, enclosing a volume therefore Gauss divergence theorem is applicable.

$$\iint_S \vec{A} \cdot \vec{ds} = \iiint_V \left(\text{div}\vec{A}\right) dV$$

$$\Rightarrow \iiint_V \left(\frac{\hat{i}\partial}{\partial x}+\frac{\hat{j}\partial}{\partial y}+\frac{\hat{k}\partial}{\partial z}\right)\left(x^3\hat{i}+y^3\hat{j}+z^3\hat{k}\right)dV$$

$$\Rightarrow \iiint_V \left(3x^3+3y^2+3z^2\right)dV$$

$$\Rightarrow 3\iiint \left(x^2+y^2+z^2\right)dV$$

In spherical system

$$x = r\sin\theta\cos\phi;\ y = r\sin\theta\sin\phi$$

$$z = r\cos\theta$$

$$dV = r^2\sin\theta\,dr\,d\theta\,d\phi$$

$3\iiint_V r^2\left(r^2\sin\theta\,dr\,d\theta\,d\phi\right)$ [Breaking the whole volume into 8 octant]

$$\Rightarrow 3\times 8\int_0^{\pi/2} d\phi\cdot\int_0^{\pi/2}\sin\theta\,d\theta\int_0^a r^4\cdot dr$$

$$\Rightarrow 24\times\frac{\pi}{2}\cdot(\cos\theta)\Big|_0^{\pi/2}\cdot\frac{r^5}{5}\Big|_0^a = \frac{12\pi}{5}a^5$$

64. ***Ans.*** **(a)**

$$u-v = (x-y)\left(x^2+4xy+y^2\right)$$

$$f(z) = u + iv$$

$$if(z) = iu - v$$

$$F(z) = f(z)\cdot(i+1) = \underbrace{(u-v)}_{u} + \underbrace{i(u+v)}_{v}$$

$$= u + iv.$$

$$u = (x-y)\left(x^2+4xy+y^2\right)$$

$$\frac{\partial u}{\partial x} = 3x^2+6xy-3y^2$$

$$\phi_1 = \left.\frac{\partial u}{\partial x}\right|_{(z,0)} = 3z^2$$

$$\frac{\partial u}{\partial y} = 3x^2-6xy-3y^2$$

$$\phi_2 = \left.\frac{\partial u}{\partial y}\right|_{(z,0)} = 3z^2$$

$$F(z) = \int\phi_1 dz - i\int\phi_1 dz$$

$$\Rightarrow \int 3z^2dz - i\int 3z^2dz + c$$

$$f(z)(1+i) = z^3 - iz^3 + c$$

$$= z^3(1-i)+c$$

$$f(z) = \frac{z^3}{(1+i)}+\frac{c}{(1+i)}$$

$$\Rightarrow \frac{z^3(1-i)(1-i)}{(1+i)(1-i)}+\frac{c(1-i)}{(1+i)(1-i)}$$

$$\Rightarrow \frac{z^3(1-1-2i)}{1+1}+\frac{c(1-i)}{2}$$

$$\Rightarrow -iz^3+c'$$

65. ***Ans.*** **(0.5)**

$$\int_0^1 f(x)\cdot dx = 1 \quad (\text{Total probability} = 1)$$

$$\Rightarrow \int_0^1\left(a+bx+cx^2\right)dx = 1$$

$$ax+\frac{bx^2}{2}+\frac{cx^3}{3}\Big|_0^1 = 1$$

$$\Rightarrow a+\frac{b}{2}+\frac{c}{3} = 1$$

$$\Rightarrow 6a+3b+2c = 6 \qquad ...(1)$$

$$E(X) = \frac{1}{2}$$

$$\int_0^1 xf(x)dx = \frac{1}{2}$$

$$\Rightarrow \int_0^1 x\left(a+bx+bx^2\right)dx = \frac{1}{2}$$

$$\Rightarrow \left.\frac{ax^2}{2}+\frac{bx^3}{3}+\frac{cx^4}{4}\right|_0^1 = \frac{1}{2}$$

$$\Rightarrow \frac{a}{2}+\frac{b}{3}+\frac{c}{4}=\frac{1}{2}$$

$$\Rightarrow 6a+4b+3c = 6 \quad ...(2)$$

$$E\left(X^2\right) = \frac{2}{3}$$

$$\int_0^1 x^2\cdot\left(a+bx+cx^2\right)dx = \frac{2}{3}$$

$$\Rightarrow \frac{a}{3}+\frac{b}{4}+\frac{c}{5} = \frac{2}{3}$$

$$\Rightarrow 20a+15b+12c = 40 \quad ...(3)$$

Solving (1), (2) and (3)

$$a = 11;\ b = -60,\ c = 60$$

P (X < .5)

$$\Rightarrow \int_0^{.5} f(x)\cdot dx = \int_0^{.5}\left(11-60x+60x^2\right)dx$$

$$11x\Big|_0^{.5} - \frac{60}{2}x^2\Big|_0^{.5} + \frac{60}{3}x^3\Big|_0^{.5}$$

$$\Rightarrow \frac{11}{2}-30\times\frac{1}{4}+20\times\frac{1}{8}$$

$$\Rightarrow \frac{11}{2}-\frac{15}{2}+\frac{5}{2} = \frac{11}{2}-\frac{10}{2} = \frac{1}{2}$$

$$= 0.5$$