ACE *Pre*-GATE 2017 **Branch: Mechanical Engg.**

GENERAL APTITUDE

Q.1 – Q.5 Carry One Mark Each

01. 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

01. Ans: (B)

02. 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.

02. Ans: (B)

03. **Fill in the blank with an appropriate phrase.**
The jet _____ into the air.
(A) Soared. (B) Soured.
(C) Sourced. (D) Sored.

03. Ans: (A)

04. **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

04. Ans: (B)

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05. 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

05. Ans: (C)

Sol: Friday $\rightarrow$ 2 days earlier
Therefore, scheduled day = Friday + 2 = Sunday
Sunday + 3 = Wednesday
Therefore, I would have been late by 3 days

Q.6 – Q.10 Carry two marks each

06. A contractor, who got the contract for building the flyover, failed to construct the flyover in the specified time and was supposed to pay ₹ 50,000 for the first day of extra time. This amount increased by ₹ 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

06. Ans: (B)

Sol: The sum of money that the contractor was supposed to pay for the period of an month over the stipulated time is $= S_n = \frac{n}{2}[2a + (n-1)d]$

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

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

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

₹ 3240000 = ₹ 32.4 lakhs

Loss in the business = 10%

$\therefore$ Amount he received for making the flyover $= \frac{3240000}{0.1} = 32400{,}000$

= ₹ 3.24 crores

07. A person has to go from city A to city E. There is no direct way to reach city E from city A. However, there are intermediate cities B, C and D by which A can travel through. The information about the number of routes between any two cities is given in the table below.

A → B	7 routes
A → C	6 routes
A → D	8 routes
B → C	5 routes
B → E	4 routes
C → E	4 routes
D → E	6 routes

For instance, there are 5 ways in which the person can go from city B and city C. Also, the arrow between cities B and C indicates that the person can travel from city B to C but not from city C to B. In how many ways can that person travel from city A to city E?

(A) 140 (B) 240 (C) 100 (D) 72

07. Ans: (B)

Sol: The routes that can be used are ABE, ABCE, ACE and ADE.

For ABE, number of ways = 7 × 4 = 28

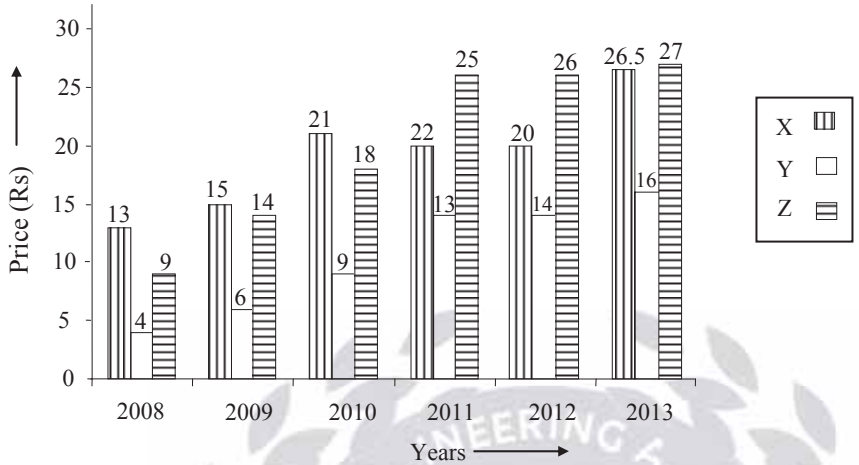
For ABCE, number of ways = 7 × 5 × 4 = 140

For ACE, number of ways = 6× 4 = 24

For ADE, number of ways = 8 × 6 = 48

$\therefore$ Total number of ways to travel from city A to city E = 28 +140 + 24 + 48 = 240.

08. The following bar graph shows the price per litre of different fuels X, Y and Z in the year 2008 to 2013. Study the graph carefully and answer the following question.



The percentage increase in the price of fuel X from 2008 to 2013 is ____% of the percentage increase in the price of fuel Z for the given period?

(A) 200% (B) 100% (C) 50% (D) 120%

08. Ans: (C)

Sol: Percentage increase in the price of fuel $X = \frac{26.5-13}{13} \times 100 = 100\%$

Percentage increase in the price of fuel $Z = \frac{27-9}{9} \times 100 = 200\%$

Percent of percentage increase of X to percentage increase of

$$Z = \frac{200-100}{200} \times 100 = \frac{100}{200} \times 100 = 50\%$$

09. Examine the information given below. Who is to the immediate right of P among five persons P, Q, R, S and T, facing north?

Two statements, labeled I and II, are given below. You have to decide whether the data 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

09. Ans: (C)

Sol: From statement I, we have the order: R – P, Q ……. (i)
From statement II, we have the order: P, Q, T ……. (ii)
It is clear from both the equations that Q is to the immediate right of P. So, either of the statements is sufficient to answer the question.

10. **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

10. Ans: (B)

MECHANICAL ENGINEERING

Q.11 – Q.35 Carry one mark each.

11. Helium changes its state from 9459.67 kPa and 28.3 litres to 586.06 kPa and 194 litres. Entropy change for 0.2 Kmol of helium in kJ/K is _____.

11. Ans: 1.065 kJ/K (Range 0.98 to 1.15)

Sol: $P_2 = 586.06$ kPa, $P_1 = 9459.67$ kPa,
$V_2 = 194$ litre, $V_1 = 28.3$ litre
Number of moles, n = 0.2

$$C_V = \overline{R} \times \frac{1}{\gamma - 1} = 8.314 \times \frac{1}{\frac{5}{3} - 1} = 12.471 \text{ kJ/kmol.K}$$

$$C_P = \gamma \overline{R} \times \frac{1}{\gamma - 1} = 8.314 \times \frac{5/3}{\frac{5}{3} - 1} = 20.785 \text{ kJ/kmol.K}$$

$$dS = C_P \, \ell n\left(\frac{V_2}{V_1}\right) + C_V \, \ell n\left(\frac{P_2}{P_1}\right)$$

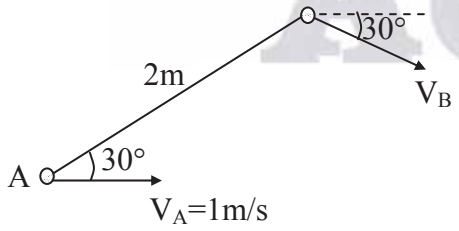
$$= 20.785 \, \ell n\left(\frac{194}{28.3}\right) + 12.471 \, \ell n\left(\frac{586.06}{9459.67}\right)$$

$$= 40.011 - 34.686$$

$$= 5.325 \text{ kJ/kmol.K}$$

Total entropy change = Number of moles × dS = 0.2 × 5.325 = 1.065 kJ/K

12. A rigid link AB is 2m long and oriented at 30° with horizontal as shown in figure. Magnitude of velocity of point B is _____ m/s.



12. Ans: 1.732 (Range 1.7 to 1.8)

Sol: For a rigid link, $\overline{AB}$ = constant

$\vec{V}_{AB} = 0$

$\therefore V_A \cos 30 = V_B \cos 60$

$\Rightarrow V_B = \dfrac{\cos 30}{\cos 60} = \sqrt{3} \text{ m/s} = 1.732 \text{ m/sec}$

13. A stepper motor of 300 steps per revolution is mounted on the lead screw of a drilling machine. The lead screw pitch 5 mm. Then BLU of the system is _____.

13. Ans: 0.0167 (Range 0.01 to 0.02)

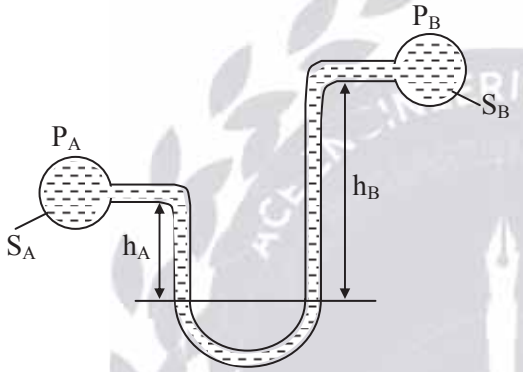
Sol: Given data

A stepper motor = 300 steps per revolution

Lead screw pitch = 5 mm

Then, $\text{BLU} = \frac{5}{300} = 0.0167$

14. Which of the following statements is / are true ?



(I) If $P_A = P_B$, S_A must be greater than S_B

(II) If $P_A = P_B$, S_A must be less than S_B

(III) If $S_A = S_B$, $P_A > P_B$

(IV) If $S_A = S_B$, $P_B > P_A$

(A) I & IV (B) I & III (C) II & III (D) II & IV

14. Ans: (B)

15. An inclined manometer uses mercury and has a least count of 3 mm. If the minimum pressure difference measured is 100 Pa, the approximate sensitivity of the manometer is

(A) 4 (B) 3 (C) 2 (D) 1.5

15. Ans: (A)

Sol: 3 mm of Hg = 3 × 133 Pa = 400 Pa (approx.)

(3 mm sinθ) of Hg = 100 Pa

$\Rightarrow \sin\theta = \frac{1}{4} \Rightarrow S = \frac{1}{\sin\theta} = 4$

$\therefore$ The sensitivity of the Manometer = 4

16. A block of metal is cooled in water bath, its unsteady temperature is considered uniform and is thus modelled using a lumped capacitance method. The product of blocks resistance to convection and its lumped thermal capacitance is
(A) Biot number (B) Nusselt number
(C) Thermal time constant (D) Fourier number

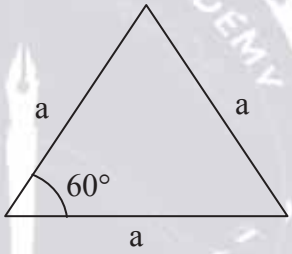
16. Ans: (A)

17. Liquid ammonia flows in a duct of section of equilateral triangle of 1 cm side. The average bulk temperature is 20°C and the duct wall is at uniform temperature of 50°C. The heat transfer per unit length (in W/m) is _____. [Take Nusselt number (N_u) = 2.47, k = 0.521 W/mK]
(A) 150 (B) 200 (C) 215 (D) 250

17. Ans: (B)

Sol: a = 1 cm (side) , T_{avg} = 20°C ,
T_s = 50°C , L = 1 m

Cross-sectional area,



$$A_C = \frac{\sqrt{3}}{4} \times a^2 = \frac{\sqrt{3}}{4} \times (0.01)^2$$

$$A_C = 4.33 \times 10^{-5}$$

Perimeter, P = 3a = 0.03

$$D_h = \frac{4 \times A_C}{P}$$

$$D_h = 5.7733 \times 10^{-3}$$

$$Nu = \frac{h D_h}{k}$$

$$2.47 = \frac{h \times 5.7733 \times 10^{-3}}{0.521}$$

$$\Rightarrow h = 222.898$$

$$Q = hPL (T_s - T_{avg})$$

$$\frac{Q}{L} = 222.898 \times 0.03 \times (50 - 20)$$

$$\frac{Q}{L} = 200.609 \text{ W/m}$$

18. In scheduling for minimizing mean tardiness and average in process inventory, the rules to be used respectively are
(A) EDD, SPT (B) SPT, EDD
(C) EDD, LPT (D) SPT, FCFS

18. Ans: (A)

Sol: For minimizing mean tardiness EDD rule is used for minimizing for average in process inventory SPT rule is used.

19. In a transportation problem after reaching optimality to find an alternative solution loop method of transferring units is adopted to the empty cells which are

(A) Positively evaluated (B) Negatively evaluated
(C) Zero evaluated (D) Infinity evaluated

19. Ans: (C)

Sol: Transferring units to zero evaluated cells after reaching optimality gives an alternative solution with the same transportation cost to the problem.

20. Match the following lists:

List – I

P. Hardening
Q. Normalising
R. Martempering
S. Austempering

List – II

1. Whole volume of martensite
2. Refined grains
3. Feathery shapes of cementite
4. Partial conversion of martensite incompinent
5. Improvement in ductility

Codes:

(A) P-4, Q-2, R-1, S-3 (B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3 (D) P-4, Q-3, R-2, S-1

20. Ans: (A)

21. A shaft of 200 mm diameter is supported on fluid film bearing of 200 mm length. The radial clearance is 0.1 mm. The value of $\left(\frac{ZN}{p}\right)$ based on rps is 20×10^{-6}. The Sommerfled number is _____ (Where, Z = viscosity)

(A) 20 (B) 80 (C) 200 (D) 800

21. Ans: (A)

Sol: $S = \frac{ZN}{p}\left(\frac{D}{C_d}\right)^2 = 20\times10^{-6}\left(\frac{200}{2\times0.1}\right)^2 = 20$

22. In an Ultrasonic machining operation, keeping all other parameters constant, the materials in the increasing order of their maximum wear ratio is
(A) Chromium steel < Ceramics < Tungsten < Glass
(B) Chromium steel < Tungsten < Ceramics < Glass
(C) Chromium steel < Tungsten < Glass < Ceramics
(D) Tungsten < Chromium steel < Glass < Ceramics

22. Ans: (B)

23. Match List – I with List – II and select the correct answer using the codes given below the list.

List–I (Special casting)	**List – II (Application)**
P. Slush casting	1. Wave guides of radar system
Q. Centrifugal casting	2. City water supply pipes
R. Gravity dies casting	3. Lamp shades
S. Investment casting	4. I.C Engine piston made by aluminium alloy
	5. Carburattor body made by aluminium alloy

(A) P-3, Q-2, R-5, S-1
(B) P-4, Q-1, R-5, S-3
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-3, R-2, S-4

23. Ans: (C)

NEW BATCHES FOR

ESE – 2017 Stage – II (Mains)

BATCH - 1	BATCH - 2
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	15th Feb 2017 (EE & CE)

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24. In the following type of arc welding, the electrons are leaving the electrode and traveling across the arc to the surface of the metal being welded. This is called as
(A) Direct Current straight polarity
(B) Direct Current Electrode Positive
(C) Alternate Current
(D) Reverse polarity

24. Ans: (A)

25. If a, b, c are all different from zero and $\begin{vmatrix} 1+a & 1 & 1 \\ 1 & 1+b & 1 \\ 1 & 1 & 1+c \end{vmatrix} = 0$ then the value of $(a^{-1} + b^{-1} + c^{-1}) = ?$

(A) abc (B) $a^{-1} b^{-1} c^{-1}$ (C) $-a - b - c$ (D) -1

25. Ans: (D)

Sol: $\begin{vmatrix} 1+a & 1 & 1 \\ 1 & 1+b & 1 \\ 1 & 1 & 1+c \end{vmatrix} = 0$

$(R_3 - R_2)$ & $(R_2 - R_1)$

$$\Rightarrow \begin{vmatrix} 1+a & 1 & 1 \\ -a & b & 0 \\ 0 & -b & c \end{vmatrix} = 0$$

$\Rightarrow (1 + a)(bc) + a(c + b) = 0$

$bc + abc + ac + ab = 0$

$\therefore (ab + bc + ac) = -abc$

$(c^{-1} + a^{-1} + b^{-1}) = -1$

26. If $x = e^{y+e^{y+e^{y+\cdots\cdots}}}$ then $\frac{dy}{dx} =$ _____.

(A) $(1 - x)$ (B) $\frac{(1-x)}{x}$ (C) $\frac{1}{x}$ (D) $\frac{x}{(1-x)}$

26. Ans: (B)

Sol: $x = e^{y+e^{y+e^{y+\cdots\cdots}}}$

$x = e^{y+x}$

$\log x = (y + x)$

$\therefore y = (\log x - x)$

$\Rightarrow \frac{dy}{dx} = \left(\frac{1}{x} - 1\right) = \left(\frac{1-x}{x}\right)$

27. The particular solution of $\left(\frac{d^2y}{dx^2} + y\right) = \cosh 3x$ is _____

(A) $\frac{1}{10}\sinh 3x$ (B) $\frac{1}{5}\sinh 3x$

(C) $\frac{1}{10}\cosh 3x$ (D) $\frac{1}{5}\cosh 3x$

27. Ans: (C)

Sol: $y_p = \frac{\cosh 3x}{(D^2+1)} = \frac{\left(e^{3x} + e^{-3x}\right)}{2(D^2+1)} = \frac{\left(e^{3x} + e^{-3x}\right)}{2(9+1)}$

$= \frac{1}{10}\cosh 3x$

28. $L^{-1}\left\{\frac{e^{-1/s}}{s^{1/2}}\right\} = \frac{\cos 2\sqrt{t}}{\sqrt{t}}$ then $L^{-1}\left\{\frac{e^{-a/s}}{s^{1/2}}\right\} = ?$

(A) $\frac{\cos 2\sqrt{at}}{\sqrt{at}}$ (B) $\frac{\cos 2\sqrt{t}}{\sqrt{at}}$

(C) $\frac{\cos 2\sqrt{at}}{\sqrt{t}}$ (D) $\frac{\cos \sqrt{at}}{\sqrt{t}}$

28. Ans: (C)

Sol: By using change of scale properly

$L^{-1}\left\{f\left(\frac{s}{a}\right)\right\} = a\,F(at)$

$L^{-1}\left\{\frac{e^{\frac{-1}{(s/a)}}}{\left(\frac{s}{a}\right)^{\frac{1}{2}}}\right\} = \frac{a\cos 2\sqrt{at}}{\sqrt{at}}$

$\Rightarrow L^{-1}\left\{\frac{e^{-a/s}}{s^{1/2}}\right\} = \frac{\cos 2\sqrt{at}}{\sqrt{t}}$

29. A biased die such that any even number is twice likely to occur for any odd number is rolled once. What is the probability of getting a number greater than '3' occurring in a single roll of the die?

(A) $\frac{4}{9}$ (B) $\frac{5}{9}$ (C) $\frac{3}{9}$ (D) $\frac{1}{9}$

29. Ans: (B)

Sol:

X	1	2	3	4	5	6
P(X)	P	2P	P	2P	P	2P

But P + 2P + P + 2P + P + 2P = 9P = 1

$$= P = \frac{1}{9}$$

$\therefore$ Required probability = 2P + P + 2P = 5P = $\frac{5}{9}$

30. When member subjected to combined loading is bending moment M = 1600 N-m and twisting moment, T = 10 kN-m, find the principal stress (major), when the diameter of member is 80 mm.

(A) 11.99 MPa (B) 4.49 MPa (C) 2.9 MPa (D) 60 MPa

30. Ans: (B)

Sol: $\sigma_{1,2} = \frac{\pi}{16d^3}\left(M \pm \sqrt{M^2 + T^2}\right)$

$$= \frac{\pi}{16\times 80^3}\left(1600\times 10^3 \pm \sqrt{\left(1600\times 10^3\right)^2 + \left(10\times 10^6\right)^2}\right)$$

$$\sigma_{1,2} = \frac{\pi}{16\times 80^3}\left(1600\times 10^3 \pm \sqrt{1.0256\times 10^{14}}\right)$$

$\therefore \sigma_1 = 4.49$ MPa

31. Consider the following statements.

P. Poisson's ratio for incompressible material is 0.5

Q. In pure bending the beam bends in the form of circular arc.

R. Middle third rule, for no tension is applicable for solid circular cross sections

Which of the following statements are correct.

(A) P and Q (B) P and R

(C) Q and R (D) P, Q and R

31. Ans: (A)

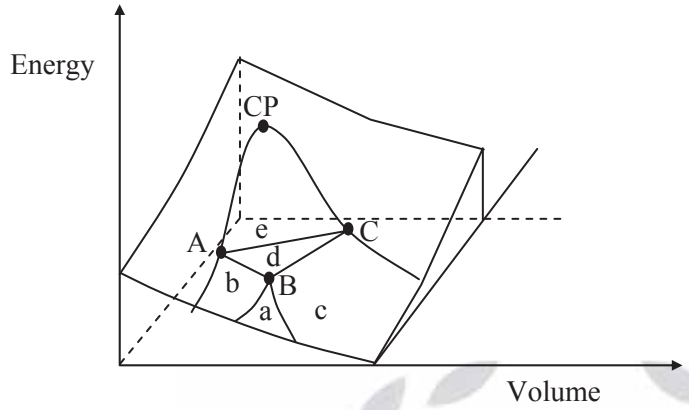
Sol:

(i) For incompressible material poisson's ratio is zero.

(ii) Incase of pure bending the beam bends in the form of arc of a circle with (R = constant). This is one of the assumptions in bending theory

(iii) Middle third rule is applicable for a rectangular (or) square sections. For solid circular section middle fourth rule is applicable.

32. The energy volume diagram for water is given below:

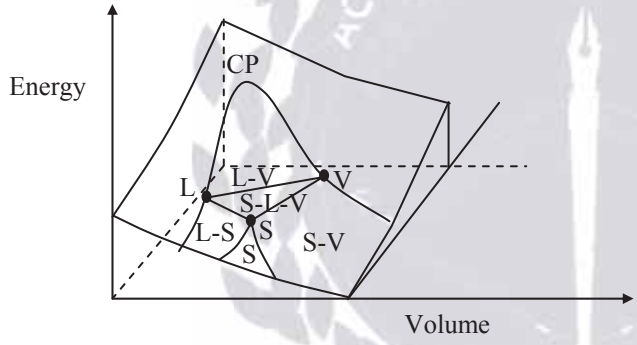


The triple point is given by the region

(A) a (B) b (C) c (D) d

32. Ans: (D)

Sol:



The triple point is represented like a plane in energy volume diagram, solid liquid vapour region in the form of a triangle represents the triple point.

33. If 6 litres of a gas at a pressure of 100 kPa are compressed according to $Pv^2 = C$ until the volume becomes 2litre. Find the work done on the system?

(A) –900 J (B) 1200 J (C) –1500 J (D) 800 J

33. Ans: (B)

Sol: $P_1V_1^2 = P_2V_2^2$

$100\times6^2 = P_2 \times V_2^2$

$$P_2 = 100 \times \frac{6^2}{2^2} = 900\,\text{kPa}$$

$$_1W_2 = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{100\times6 - 900\times2}{2-1} = -1200\ \text{J}$$

34. The rotor of a ship rotates in clockwise direction when viewed from stern and the ship takes a left turn. The effect of gyroscopic couple acting on it will be
(A) to lower the bow and stern
(B) to raise the bow and stern
(C) to raise the stern and lower the bow
(D) to raise the bow and lower the stern

34. Ans: (D)

35. Two identical involute spur gears are in mesh. The module is 4 mm and each gear has 22 teeth. If the operating pressure angle is 20°. The minimum value of addendum needed to ensure continuous transmission of motion is
(A) 7.5 mm (B) 5.5 mm (C) 2.35 mm (D) 1.35 mm

35. Ans: (C)

Sol: To ensure continuous transmission of motion at least one pair of teeth should be in contact.
i.e., contact ratio should be ≥ 1

Path of contact, $\dfrac{\text{Path of contact}}{\text{Circular pitch} \times \cos\phi} \geq 1$

$$\frac{2\left(\sqrt{R_a^2 - (R\cos\phi)^2} - R\sin\phi\right)}{\frac{2\pi R}{T} \times \cos\phi} \geq 1$$

Given, m = 4 mm, T = 22 , $\phi = 20°$,

$$R = \frac{mT}{2} = 44$$

$\therefore\ R_a \geq 46.35$

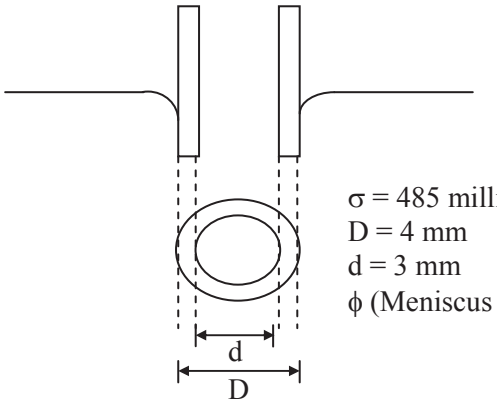
R + addendum $\geq$ 46.35 mm

Addendum $\geq$ 2.35mm

Minimum addendum = 2.35 mm

Q.36 – Q.65 carry two marks each.

36. The value of upward thrust (in milli N) imparted by the fluid on the glass tube is_____



σ = 485 milli N/m
D = 4 mm
d = 3 mm
ϕ (Meniscus Angle) = 130^o

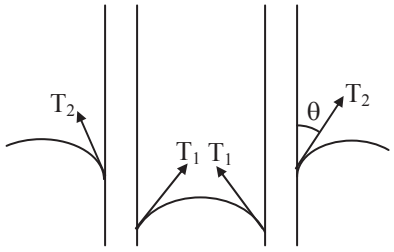
36. Ans: 6.85 Range: (6 to 7)

Sol: $\theta = 180 - \phi = 50^o$

$F = \sigma.L$

$\Rightarrow T_1 = \sigma\pi d$

$= (0.485) \times \pi \times 3 \times 10^{-3}$



Similarly $T_2 = \sigma\pi D$

$= (0.485) \times \pi \times 4 \times 10^{-3}$

Upward thrust $= (T_1 + T_2) \cos 50^o$

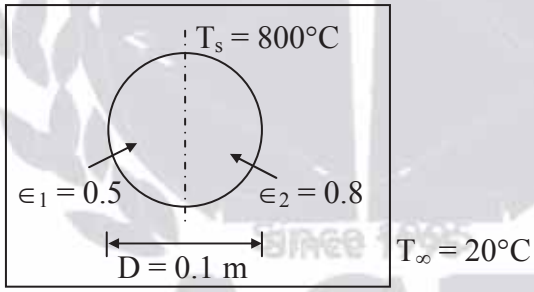
$= 6.85 \times 10^{-3}$ N

= 6.85 milli N

37. A sphere having diameter of 10 cm has one hemisphere with an emissivity of 0.5 and other hemisphere with an emissivity of 0.8 the entire sphere is heated to a uniform temp of 800°C and enclosed by a large room maintained at 20°C. Calculate the total heat lost by the sphere (in Watt) is _____(Take $\sigma = 5.67 \times 10^{-8}$ W/m^{2}k^4)

37. Ans: 1526 (range 1524 to 1528)

Sol:



$T_s = 800 + 273 = 1073$ K

$T_\infty = 20 + 273 = 293$ K

$A_2 = A_1 = 2\pi r^2 = 0.01570$

$Q_1 = \in_1 A_1\sigma\left(T_s^4 - T_\infty^4\right) = 587$ W

$Q_2 = \in_2 A_2\sigma\left(T_s^4 - T_\infty^4\right) = 939$ W

$Q_{total} = Q_1 + Q_2$

= 587 + 939 = 1526 Watt

38. The two-bin approach is used to control inventory for a particular low cost component. Each bin holds 1000 units. The annual usage of the component is 40,000 units. Cost to order the component is around 50. If the actual annual holding cost per unit is only Rs. 4/-. The total variable cost for the two-bin approach is _____ (Rs.)

38. Ans: 4000/-, Range: (4000 to 4000)

Sol: Q = 1000 units,

$$\text{Total variable cost} = \frac{A}{Q}\times S + \frac{Q}{2}\times CI$$

$$= \frac{40{,}000}{1000}\times 50 + \frac{1000}{2}\times 4$$

$$= 2000 + 2000 = 4000$$

When items in one bin are completely exhausted an order is placed. By the time the order materializes items in second bin are used and the process is repeated.

39. To drill a 20 mm diameter hole in cast Iron work piece at 450 rpm and 0.2 mm feed. The specific power is 0.03 kW-min/cm^3 and motor efficiency is 90%. Then the power of electric motor (kW) for a drilling machine is _____

39. Ans: 0.942 (range 0.8 to 1.0)

Sol: Hole diameter (D) = 20 mm = 2.0 cm
Speed (N) = 450 rpm
Feed (f) = 0.2 mm/rev = 0.02 cm/rev
Specific power (S) = 0.03 kW-min/cm^3
Efficiency (η) of motor = 90% = 0.90
Power (P) = ?
Volume of metal removed during drilling operation (V)

$$= \frac{\pi}{4}\times D^2 \times f \times N$$

$$= \frac{\pi}{4}(2.0)^2 \times 0.02 \times 450$$

$$= 28.274 \text{ cm}^3/\text{min}$$

Power required at the drill = V × S = 28.274 × 0.03
= 0.848 kW

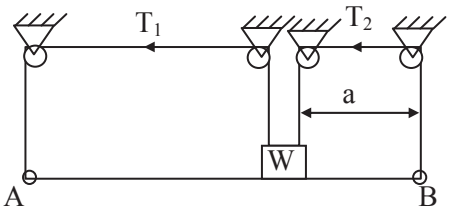
$$\text{Power of electric motor} = \frac{0.848}{\eta} = \frac{0.848}{0.9} = 0.942 \text{ kW}$$

40. Air enters the compressor of an ideal gas-refrigeration cycle at 10°C and 80 kPa. If the maximum and minimum temperatures are 250°C and –50°C, the compressor work (in kJ/kg) is _____.

40. Ans: 240, Range: (238 to 242)

Sol: Maximum temperature = compressor exit temperature = T_2 = 250°C
Compressor inlet temperature = T_1 = 10°C
Specific heat of air = 1 kJ/kg
Compressor work = $C_P(T_2 - T_1)$
= 1(250 – 10) = 240 kJ/kg

41. AB is a massless rod of length L. Find T_1 and T_2 for equilibrium to be established.



(A) $T_1 = \frac{W}{2}\left(\frac{a}{L}\right)$; $T_2 = \frac{W}{2}\left(\frac{L+a}{L}\right)$

(B) $T_1 = \frac{W}{2}\left(\frac{a}{L}\right)$; $T_2 = \frac{W}{2}\left(\frac{L-a}{L}\right)$

(C) $T_1 = \frac{W}{2}\left(\frac{L-a}{L}\right)$; $T_2 = \frac{W}{2}\left(\frac{a}{L}\right)$

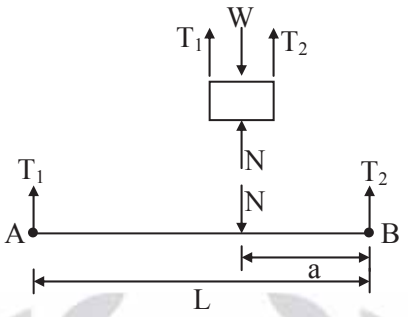
(D) $T_1 = \frac{W}{2}\left(\frac{2a}{L}\right)$; $T_2 = \frac{W}{2}\left(\frac{L-2a}{L}\right)$

41. Ans: (B)

Sol:

For Block:

$$W = N + T_1 + T_2$$



For Rod:

$N = T_1 + T_2$

$\Rightarrow W = 2(T_1 + T_2)$

$\sum M_B = 0$

$T_1 L = (T_1 + T_2)a$

$$T_2 = \frac{T_1(L-a)}{a}$$

$$\Rightarrow \frac{W}{2} = T_1 + T_1\left(\frac{L-a}{a}\right)$$

$$\Rightarrow T_1 = \frac{Wa}{2L} \quad \text{.....(1)}$$

$$\frac{W}{2} = T_1 + T_2$$

$$\Rightarrow T_2 = \frac{W}{2} - \frac{Wa}{2L} = \frac{W}{2}\left(\frac{L-a}{L}\right) \quad \text{.....(2)}$$

42. A rope of mass "M" and length "L" is tied at A and whirled at an angular veloicty of "ω". The tension in the rope at a radius 'r' from A is

(A) $\frac{M.\omega^2}{2L}.r^2$ (B) $\frac{M.\omega^2}{2L}(L^2 - r^2)$

(C) $\frac{M.\omega^2}{2L}(L^2 + r^2)$ (D) $\frac{M.\omega^2}{L}(L^2 + r^2)$

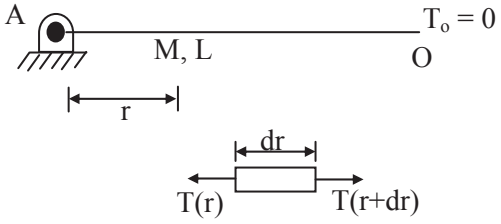
42. Ans: (B)

Sol: By force balancing

$$T(r) - T(r + dr) = dm.r.\omega^2$$

$$dm = \frac{M}{L}.dr$$

$$-dT = \frac{M}{L}.\omega^2.r.dr$$



$$T = \frac{-M}{L}.\omega^2.\frac{r^2}{2} + C \quad \text{------- (1)}$$

At $r = L$; $T = T_o = 0$

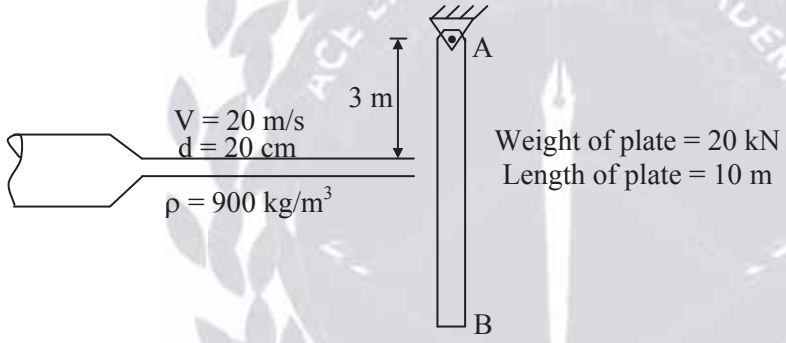
$$0 = \frac{-M}{L}\omega^2.\frac{L^2}{2} + C$$

$$C = \frac{M}{L}.\frac{\omega^2}{2}.L^2$$

Substitute C in Equation (1)

$$T = -\frac{M}{L}\omega^2\frac{r^2}{2} + \frac{M}{L}\omega^2L^2 \Rightarrow \ T = \frac{M\omega^2}{2L}(L^2 - r^2)$$

43. The angle of inclination of the flat plate with respect to the vertical axis, in the given below system is _____ degree



(A) 15.5 (B) 19.8 (C) 21.8 (D) 25.5

43. Ans: (B)

Sol: $F_N = \rho AV^2\cos\theta$

For equation

$\sum M_A = 0$

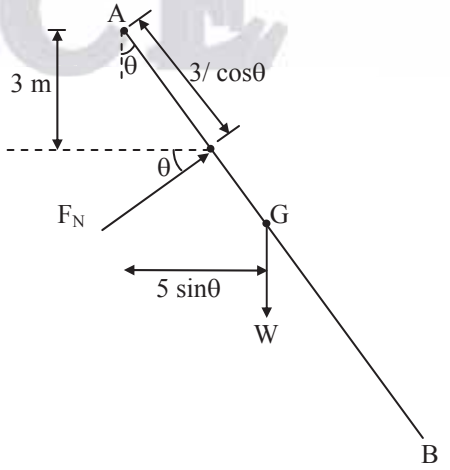
$$\Rightarrow M_A^{F_N} = M_A^W$$

$$\Rightarrow F_N\left(\frac{3}{\cos\theta}\right) = W(5\sin\theta)$$

$$3(\rho AV^2) = 5W\sin\theta$$

$$\Rightarrow \sin\theta = \frac{3\times 900\times\pi\times(0.2)^2\times 20^2}{5\times 4\times 20{,}000}$$

$$\Rightarrow \theta = 19.83^o$$



44. Pelton turbine working under a head of 20m with a deflection angle of 120°. Assuming optimum condition, the hydraulic efficiency of a turbine will be ____ (Take, g = 10 m/s^2)
(A) 25% (B) 50 % (C) 75 % (D) 100 %

44. Ans: (C)

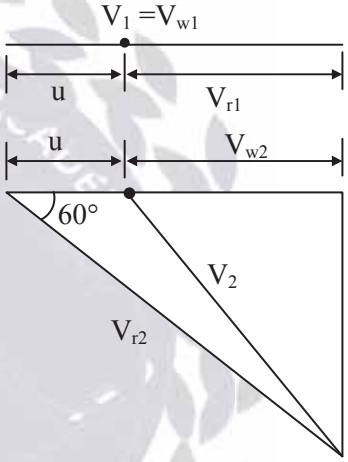
Sol: $\eta_{hyd} = \dfrac{(V_{w1} + V_{w2})u}{gH}$

$V_1 = c_v\sqrt{2gH}$

$c_v = 1,\ \ g = 10\ m/s^2$

$V_1 = \sqrt{2\times10\times20} = 20\ m/s$

$u = \dfrac{V_1}{2} = \dfrac{20}{2} = 10\,m/s$ (For optimum condition)



$V_1 = V_{w1} = 20\ m/s$,

$V_{r1} = V_1 - u = 20 - 10 = 10\ m/s$

$V_{r2} = C_v\ V_{r1} = 10\ m/s$

$V_{w2} = V_{r2}\cos\phi - u$

$= 10\cos60 - 10 = -5\ m/s$

$\eta_{hyd} = \dfrac{(V_{w1} + V_{w2})\,u}{gH}$

$= \dfrac{(20 + (-5))\times10}{10\times20} = \dfrac{15}{20} = 75\%$

45. A 4 mm diameter and 10 cm long aluminium fin (k = 237 W/m°C) is attached. If the heat transfer coefficient is 12 W/m^2°C, determine the percent error in the rate of heat transfer from the fin when the infinitely long fin assumption is used instead of the adiabatic fin tip assumption.
(A) 36.4 % (B) 63.5 % (C) 3.6 % (D) 6.3 %

45. Ans: (B)

Sol: Given data,

$D = 4\times10^{-3}$ m,

L = 0.1 m,

k = 237 W/m°C ,

h = 12 W/m^2°C

$P = \pi D = 0.01256$

$A_c = \dfrac{\pi}{4}D^2 = 1.2566\times10^{-5}$

$m = \sqrt{\dfrac{4h}{kD}} = \sqrt{\dfrac{hP}{kA_c}}$

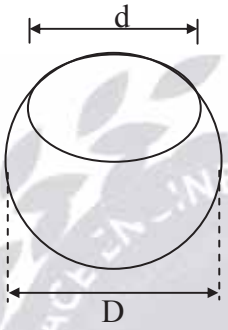
m = 7.114, mL = 0.7114

tanh(mL) = 0.61155

$$\%\,\text{error} = \frac{Q_{\text{long fin}} - Q_{\text{ins tip}}}{Q_{\text{ins tip}}} = \frac{kA_c m\theta_0 - kA_c m\theta_0 \tanh mL}{kA_c m\theta_0 \tanh mL}$$

$$= \frac{1 - \tan h\, mL}{\tan hmL} = \frac{1}{\tanh mL} - 1 = \frac{1}{0.61155} - 1 = 63.5\ \%$$

46. Consider the cavity formed by sphere having opening size (d) as shown figure. Find the view factor between the inner surace of cavity and the opening of the cavity



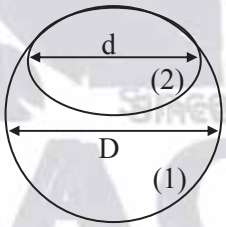
(A) $\frac{D^2}{4d - D^2}$ (B) $\frac{4d^2}{D^2 - d^2}$ (C) $\frac{d^2}{4 - D^2}$ (D) $\frac{d^2}{4D^2 - d^2}$

46. Ans: (D)

Sol: $F_{22} = 0$

$F_{21} + F_{22} = 1$

$F_{21} = 1$



$$A_2 = \frac{\pi}{4}d^2$$

$$A_1 = \pi D^2 - \frac{\pi}{4}d^2$$

$A_1F_{12} = A_2F_{21}$

$$F_{12} = \frac{A_2}{A_1}(1)$$

$$F_{12} = \frac{\frac{\pi}{4}d^2}{\pi D^2 - \frac{\pi}{4}d^2} = \frac{\frac{\pi}{4}d^2}{\pi\left(D^2 - \frac{d^2}{4}\right)} = \frac{\frac{\pi}{4}d^2}{\pi\left(\frac{4D^2 - d^2}{4}\right)}$$

$$F_{12} = \frac{\pi d^2}{4} \times \frac{4}{\pi\left(4D^2 - d^2\right)}$$

$$F_{12} = \frac{d^2}{4D^2 - d^2}$$

47. Maximize $Z = 4x_1 + 6x_2 + x_3$
s.t $2x_1 - x_2 + 3x_3 \le 5;$
$x_1, x_2, x_3 \ge 0$
The solution to the problem is
(A) Unbounded (B) Unique (C) No solution (D) Finitely many

47. Ans: (A)

Sol: $Z_{max} = 4x_1 + 6x_2 + x_3$
s.t.
$2x_1 - x_2 + 3x_3 \le 5$
$x_1, x_2, x_3 \ge 0$
on conversion
$Z_{max} = 4x_1 + 6x_2 + x_3 + 0S_1$
$2x_1 - x_2 + 3x_3 + S_1 = 5$

C_j / SV	4 x_1	6 x_2	1 x_3	0 S_1	B_0	Minimum Ratio
0 S_1	2	(–1) PE	3	0	5	5/–1 = –5 → No leaving vector
Z_j	0 4	0 (6)	0 1	0 0	0	

Entering vector

Entering vector is there which indicates improvement to the solution is possible. But minimum ratio column is having only negative values. Hence there is no leaving vector. *Hence we say that it is a case of unbounded solution to the problem.*

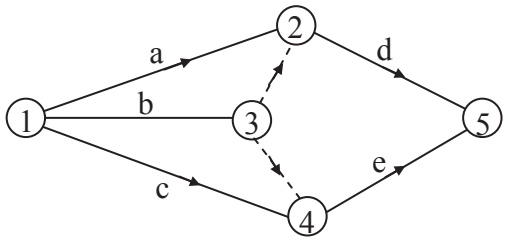
48. For a project, the following gives the list of activities and the precedence relationships:

Activity	Immediate Predecessor
a	-
b	-
c	-
d	a, b
e	b, c

The number of dummy activities in the network are
(A) Zero (B) One
(C) Two (D) Three

48. Ans: (C)

Sol:



In network diagram dummy activities are Two.

49. Life of a component under heavy load alone is 100 Hrs and Normal load is 1000 Hrs. How many hours it can be operated at normal load, if its is found to be operated for 10 Hrs at heavy load?
(A) 600 Hrs (B) 700 Hrs (C) 800 Hrs (D) 900 Hrs

49. Ans: (D)

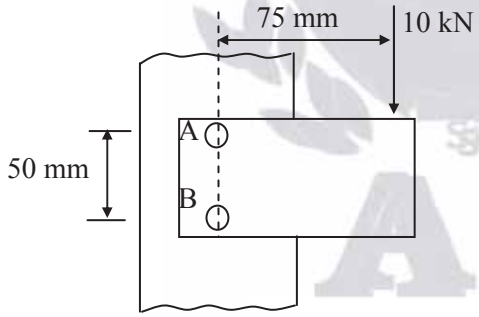
Sol: As per Miner's rule

$$\frac{n_1}{N_1}+\frac{n_2}{N_2}=1$$

$$\frac{10}{100}+\frac{n_2}{1000}=1$$

$\therefore n_2 = 900$ Hrs

50. Rivetted joint A and B shown in figure, the resulting shear load on heavily loaded rivet is



(A) 5 kN (B) 15 kN (C) 15.81 kN (D) 20 kN

50. Ans: (C)

Sol: P = 10 kN, e = 75 mm ,

Direct shear load, $P_D = \frac{10}{2} = 5\,kN$

Secondary shear load, $P_S = C \times L_{max} = \frac{Pe}{\sum L^2} \times L_{max} = \frac{10 \times 75}{2(25)^2} \times 25 = 15$ kN

As both loads are perpendicular to each other,

The resultant shear load $= \sqrt{5^2 + 15^2} = 15.811$ kN

51. During deep drawing a steel shell of inside diameter of 85.2 mm and is made from 2.4 mm thickness sheet having 2300 kg/cm^2 yield strength. If blank diameter is 136 mm, then Die opening size (mm) and drawing force (tonnes) are respectively _____. [Assume, constant to cover bending and friction (K) = 0.6 for ductile material]

(A) 92.4, 19.67 (B) 87.6, 14.2

(C) 90, 19.67 (D) 90, 14.2

51. Ans: (D)

Sol: Given data:

Die opening size

Punch size (d) = 85.2 mm = 8.52 cm

Yield strength (σ_y) = 2300 kg/cm^2

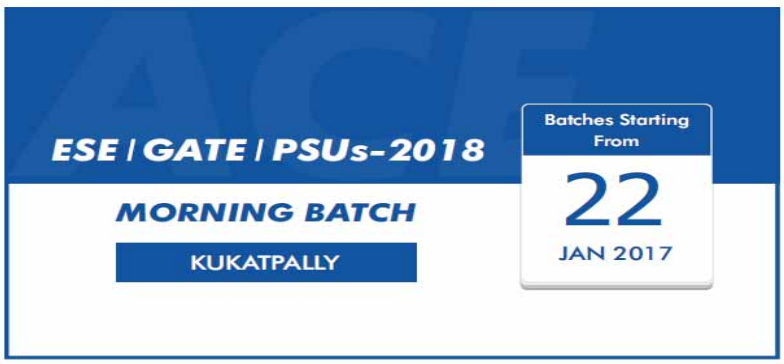
Thickness of sheet metal (t) = 2.4 mm

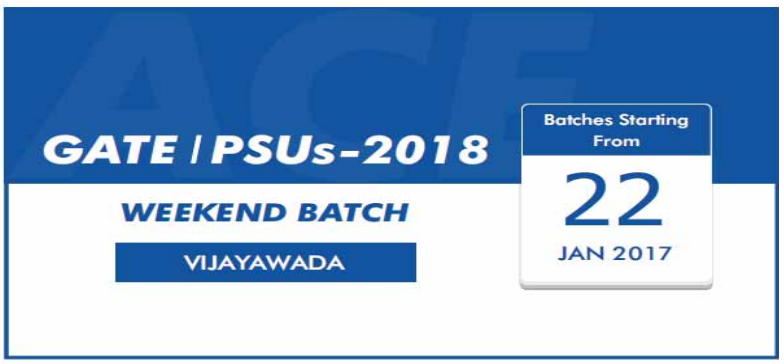
Blank diameter (D) = 136 mm

Die opening size = Punch size + 2 (thickness of sheet metal) = 85.2 mm + 2(2.4) = 90 mm

Drawing force (F) $= \pi \times d \times t \times \sigma_y \left[\frac{D}{d} - K\right] = \pi \times 9 \times 0.24 \times 2300 \times \left[\frac{136}{90} - 0.6\right]$

= 14.2 Tonnes





52. In a surface grinding operation the following data is obtained
Wheel speed = 22 m/s
Table speed = 0.18 m/s
Tangential force = 88 N
Depth cut = 0.018 mm
Width of cut = 14 mm
Then the power required per mm^3 of metal removed per second (J/mm^3) is _____
(A) 42.68 (B) 45.36 (C) 48.72 (D) 49.23

52. Ans: (A)
Sol: Given data,
Tangential force (F) = 88 N
Wheel speed (V) = 22 m/s
Power required (P) = F × V = 88 × 22 = 1936 watts
Depth of cut (d) = 0.018 mm
Width of cut (b) = 14mm
Work speed (f_m) = 0.18 m/s = 180 mm/sec
Volume of metal removed per sec (W) = d × b × f_m = 0.018 × 14 × 180 = 45.36 mm^3
Power required per mm^3 = $\frac{P}{W} = \frac{1936}{45.36}$ = 42.68 J/mm^3

53. If $\begin{vmatrix} a+1 & a+2 & a+p \\ a+2 & a+3 & a+q \\ a+3 & a+4 & a+r \end{vmatrix} = 0$ then p, q, r are in
(A) A. P (B) G. P (C) H. P (D) None of these

53. Ans: (A)
Sol: $\begin{vmatrix} a+1 & a+2 & a+p \\ a+2 & a+3 & a+q \\ a+3 & a+4 & a+r \end{vmatrix} = 0$

$(R_3 - R_2)$ $(R_2 - R_1)$

$$\Rightarrow \begin{vmatrix} a+1 & a+2 & a+p \\ 1 & 1 & q-p \\ 1 & 1 & r-q \end{vmatrix} = 0$$

$(R_3 - R_2)$

$$\Rightarrow \begin{vmatrix} a+1 & a+2 & a+p \\ 1 & 1 & q-p \\ 0 & 0 & r-2q+p \end{vmatrix} = 0$$

$\therefore (r - 2q + p)(a + 1 - a - 2) = 0$
$\therefore (p + r) = 2q$
i.e., 'q' is the AM of p and q

54. The solution of $\frac{d^2y}{dx^2} = y$ which passes through the origin and $\left(\ell n2, \frac{3}{4}\right)$ is _____

(A) $y = \frac{e^x}{2} - e^{-x}$ (B) $\frac{3}{8}\left(e^x + e^{-x}\right)$ (C) $y = \frac{1}{2}\left(e^x - e^{-x}\right)$ (D) $\frac{e^x}{2} + e^{-x}$

54. Ans: (C)

Sol: The given equation is $(D^2 - 1)\, y = 0$
i.e., $D = \pm 1$ are the roots of A. E
$\therefore y = (C_1e^x + C_2e^{-x})$
If it passes through the origin i.e. $x = 0, y = 0$
then $C_1 + C_2 = 0$ ..... (1)
Similarly if passes through $\left(\ell n2, \frac{3}{4}\right)$

then $\frac{3}{4} = \left(2C_1 + 0.5C_2\right)$ ..... (2)

By solving (1) & (2) for C_1 ; C_2
We get $C_1 = 0.5$ & $C_2 = -0.5$
$\therefore y = \frac{1\left(e^x - e^{-x}\right)}{2}$ is the required solution.

55. $\int_C \frac{z\cos z}{\left(z - \frac{\pi}{2}\right)^2} dz =$? where 'C' is $|Z - 1| = 1$

(A) $i\pi$ (B) $-i\pi$ (C) $i\pi^2$ (D) $-i\pi^2$

55. Ans: (D)

Sol: $z = \frac{\pi}{2} = \frac{3.14}{2} = 1.57$ is a pole of order '2' lies inside 'C'

$\therefore \int_C \frac{z\cos z}{\left(z - \frac{\pi}{z}\right)^2} dz = 2\pi i\, f^1\left(\frac{\pi}{2}\right)$ (where $f(z) = z\cos z$)

$= 2\pi i\left(\frac{-\pi}{2}\right) = -\pi^2 i$

56. $f(x, y) = (x^2 + y^2 + 6x\ 12)$ has
(A) maximum value at (–3, 0) (B) minimum value at (–3, 0)
(C) maximum value at (0, –3) (D) minimum value at (0, –3)

56. Ans: (B)

Sol: $\frac{\partial f}{\partial x} = (2x + 6) = 0$ ……. (1)

$\frac{\partial f}{dy} = 2y = 0$ ……. (2)

By solving (1) & (2) for (x, y) = (–3, 0) is the stationary point

$r = \frac{\partial^2 f}{\partial x^2} = 2$, $s = \frac{\partial^2 f}{\partial x \partial y} = 0$, $t = \frac{\partial^2 f}{\partial y^2} = 2$

$\therefore$ At (–3, 0); $(rt - s^2) = 4$ & $r = 2$

$\therefore$ we get minimum value of f(x ,y)

57. In Gas Metal arc welding the power source characteristics is $V_p = 36 - \frac{I}{60}$ and the arc characteristic is $V_a = 2l_a + 27$. The change in power of the arc if the arc length is changed from 3 mm to 4 mm. Where 'V_p' and 'V_a' are voltage, 'I' is current and l_a is arc length in mm.
(A) 2100 VA (B) 3840 VA (C) 5940 VA (D) 7200 VA

57. Ans: (B)

Sol: Power source characteristic is

$$V_p = 36 - \frac{I}{60} \text{ …..… (1)}$$

Arc characteristic $(V_a) = 2l_a + 27$ …… (2)

Equating these equations (1) & (2)

$36 - \frac{I}{60} = 2\ell_a + 27$

$I = 60 \times (9 - 2l_a)$

Power $(P_2) = (2l_a + 27) \times 60 \times (9 - 2\ l_a)$

When $l_a = 3$mm

$P_3 = (2\times3 + 27) \times 60 \times (9 - 2 \times 3)$

$= 33 \times 60 \times 3 = 5940$ VA

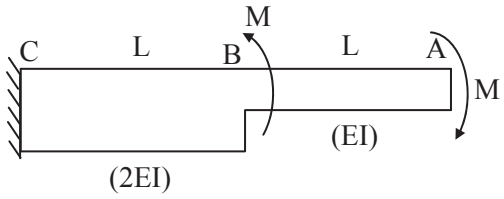
When $l_a = 4$ mm

$P_4 = (2\times 4 + 27) \times 60 \times (9 - 2 \times 4)$

$= 35 \times 60 = 2100$ VA

$\therefore$ Change in power of Arc = 5940 – 2100 = 3840 VA

58. A cantilever beam shown in figure is subjected to the loading. The free end deflection of the beam is



(A) $\frac{ML^2}{2EI}$ (B) $\frac{ML^2}{3EI}$ (C) $\frac{2ML^2}{3EI}$ (D) $\frac{ML^2}{EI}$

58. Ans: (A)

Sol: Using conjugate beam method

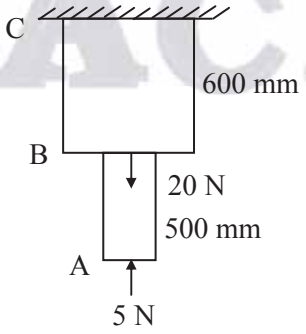
Conjugate beam

Deflection at free end of contilever beam is = BM at the free end of conjugate beam

$y_A = (BM)_A$ of conjugate beam

$$= \frac{M}{EI}(L)\left(\frac{L}{2}\right) = \frac{ML^2}{2EI}$$

59. A stepped bar is hung from the ceiling as shown in figure. The cross-section of AB = 500 mm^2 and BC = 200 mm^2. Assuming density of both the rods are 75,000 N/m^3. The axial force just above B is



(A) 32.5 N (B) 22.5 N (C) 90 N (D) 100 N

59. Ans: (B)

Sol: The forces acting below point-B

$= + 20 - 5 +$ weight of AB

$= + 20 - 5 + \gamma$ (volume of AB)

$= + 20 - 5 + (75000\ N/m^3)\ (0.5\ m \times 200 \times 10^{-6}\ m^2) = + 20 - 5 + 7.5 = 22.5\ N$

60. An air-water vapour mixture is contained in a rigid, closed vessel with a volume of $35m^3$ at 1.5 bar, 120°C and ϕ = 10%. The specific volume of water vapour in air (m^3/kg) is _____ (at 120°C saturation pressure = 1.985 bar)

(A) 8.239 (B) 4.195 (C) 9.145 (D) 5.914

60. Ans: (C)

Sol: $P_v = \phi \times P_{sat} = 0.1 \times 1.985 = 0.1985$ bar = 19.85 kPa

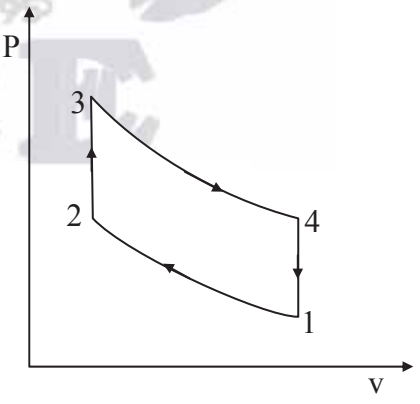
$$v = \frac{R}{M_v} \times \frac{T}{P_v} = \left(\frac{8.314}{18}\right)\left(\frac{393}{19.85}\right) = 9.145\ m^3/kg$$

61. The compression ratio of a cold air-standard Otto cycle is 9. At the end of the expansion process the pressure is 655 kPa and the temperature is 550 K. The heat rejection from the cycle is 200 kJ/kg of air. Assuming k = 1.4. Determine the mean effective pressure in kPa ?

(A) 1316.63 (B) 916.16 (C) 1136.36 (D) 1631.63

61. Ans: (A)

Sol: $$\eta = 1 - \frac{1}{(r_k)^{\gamma-1}} = 1 - \frac{1}{(9)^{0.4}} = 0.585$$



$$Q_S = \frac{Q_R}{1-\eta} = \frac{200}{1-0.585} = 481.93\ kJ/kg$$

$$w_{net} = Q_S - Q_R = 481.93 - 200 = 281.93$$

$$v_1 = v_4 = \frac{0.287 \times 550}{655} = 0.2409\ m^3/kg$$

$$v_2 = \frac{v_1}{9} = \frac{0.2409}{9} = 0.02677\ m^3/kg$$

$$MEP = \frac{Q_S - Q_R}{v_1 - v_2} = \frac{W_{net}}{v_1 - v_2}\ \frac{kJ/kg}{m^3/kg}$$

$$= \frac{281.93}{0.2409 - 0.02677} = \frac{281.93}{0.21413} = 1316.63\ kPa$$

62. A compressor receives 4 kg/s of air at 20°C from the atmosphere and delivers it at a pressure of 18 MPa. If the compression process can be approximated by a polytropic process with n = 1.3, calculate the rate of heat loss from the system in kW?
(A) –661 (B) 661 (C) 6087 (D) –6087

62. Ans: (B)

Sol: $\dot{m} = 4 kg/sec$, $P_1 = 100$ kPa, $P_2 = 18000$ kPa,
$n = 1.3$, $R = 0.287$ kJ/kg.K

$$\dot{W}_{comp} = \dot{m}\frac{nR}{n-1}T_1\left[\left(\frac{P_2}{P_1}\right)^{(n-1)/n} - 1\right] = \left(4\frac{(1.3)(0.287)}{1.3-1}(293)\right)\left[\left(\frac{18000}{100}\right)^{0.3/1.3} - 1\right]$$

$$= 3374 \text{ kW}$$

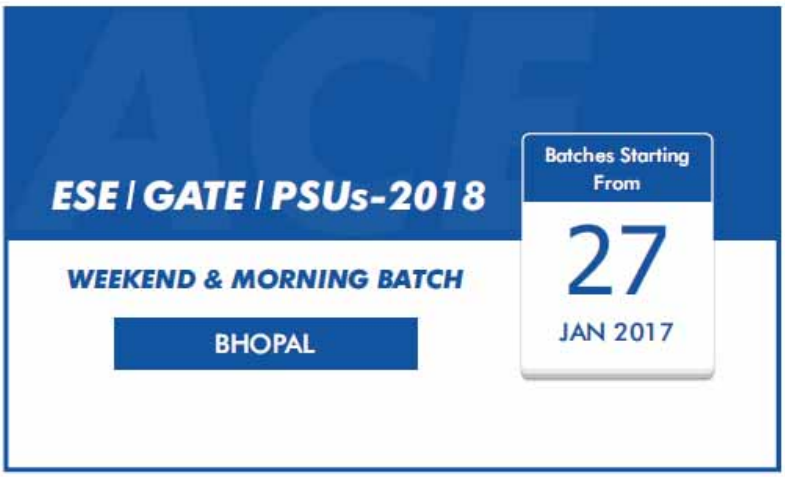
$$\dot{Q} = \dot{m}\Delta h + \dot{W}_{comp}$$

$$= \dot{m}C_p(T_2 - T_1) + \dot{W}_{comp}$$

$$= \dot{m}C_pT_1\left[\left(\frac{P_2}{P_1}\right)^{(n-1)/n} - 1\right] + \dot{W}_{comp} = (4)(1.00)(293)\left[\left(\frac{18000}{100}\right)^{0.3/1.3} - 1\right] - 3374$$

$$= -661 \text{ kW}$$

(Compressor power input is given in negative sign as it is work done on the system)

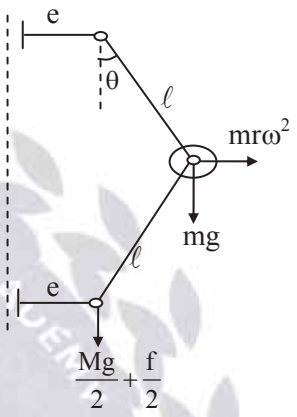


63. The arms of a Porter governor are 17.8 cm long and are hinged at a distance of 3.8 cm from the axis of the governor. Mass of each ball is 1.15 kg and mass of sleeve is 20 kg. The governor sleeve begins to rise at 280 rpm when the links are at an angle of 30° to the vertical. Determine the friction force on the governor sleeve
(A) 10 N (B) 21 N (C) 206 N (D) 15 N

63. Ans: (A)

Sol: Given

e = 3.8 cm, ℓ = 17.8 cm
m = 1.15 kg, θ = 30°
M = 20 kg, N = 280 rpm



$$\omega = \frac{2\pi}{60} \times 280 = 29.321 \text{ rad/s}$$

$mr\omega^2 = (Mg+mg+f)\tan\theta$

$r = e + \ell \sin\theta = 12.7$ cm

$$Mg+mg+f = \frac{mr\omega^2}{\tan\theta}$$

$$= \frac{1.15 \times 0.127 \times 29.321^2}{\tan 30} = 217.5 \text{ N}$$

$\therefore f = 217.5 - (20+1.15) \times 9.81 = 10$ N

64. Torque exerted on crank shaft of a two-stroke engine is given by

$T = (15000 + 2000 \sin 2\theta - 1800 \cos 2\theta)$ Nm

Where crank angle measured from inner dead center is θ. Load torque is constant. Find the angular acceleration (in deg/s^2) of the flywheel at $\theta = 30^o$ is _____ [Take the mass moment of inertia of flywheel is 1090 kgm^2]
(A) 0.763 (B) 43.7 (C) 48.7 (D) 52.7

64. Ans: (B)

Sol: Given $T = (15000 + 2000 \sin 2\theta - 1800 \cos 2\theta)$ Nm

$\because$ sin2θ and cos2θ are symmetric functions with respect to x –axis

i.e., θ - axis

$T_{mean} = 15000$ Nm

At $\theta = 30^o$,

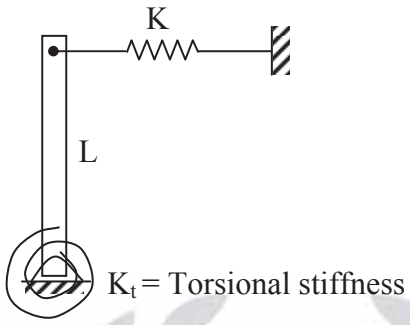
$T = 15832.05$ Nm

$\Delta T = T - T_{mean} = 832.05$ Nm

$\Delta T = I\alpha$

$$\Rightarrow \alpha = \frac{\Delta T}{I} = \frac{832.05}{1090} = 0.763 \text{ rad/s}^2 = 43.737 \text{ deg/s}^2$$

65. A uniform bar of mass 'm' is connected as shown in figure. The natural frequency (in rad/s) of resulting free vibrations is



(A) $\sqrt{\frac{3K}{m}+\frac{3K_t}{mL^2}}$ (B) $\sqrt{\frac{3K}{m}+\frac{3K_t}{mL^2}-\frac{3g}{2L}}$

(C) $\sqrt{\frac{3K}{m}+\frac{3K_t}{mL^2}+\frac{3g}{2L}}$ (D) $\sqrt{\frac{3K}{m}+\frac{K_t}{mL^2}+\frac{3g}{L}}$

65. Ans: (B)

Sol: Equation of motion of vertical lever based problem is

$$I_0\ddot{\theta}+K_t\theta+KL^2\theta-mg\times\frac{L}{2}\theta$$

For a rod I_0 about one end is $\frac{mL^2}{3}$

$$\frac{mL^2}{3}\ddot{\theta}+\left(KL^2+K_t-\frac{mgL}{2}\right)\theta=0\ ,$$

$$\omega_n=\sqrt{\frac{K_{eq}}{m}}$$

$$\omega_n=\sqrt{\frac{KL^2+K_t-\frac{mgL}{2}}{\frac{mL^2}{3}}}=\sqrt{\frac{3K}{m}+\frac{3K_t}{mL^2}-\frac{3g}{2L}}$$