1. What is the adverb for the given word below?
Misogynous
A. Misogynousness B. Misogynity
C. Misogynously D. Misogynous
Ans. C.

2. Ram and Ramesh appeared in an interview for two vacancies in the same department. The probability of Ram's selection is 1/6 and that of Ramesh is 1/8. What is the probability that only one of them will be selected?

A. $\frac{47}{48}$ B. $\frac{1}{4}$
C. $\frac{13}{48}$ D. $\frac{35}{48}$

Ans. B.
P Ram = 1/6; p Ramesh = 1/8
P(only at) = p(Ram) × p(not Ramesh) + p(Ramesh) × $p(n_0 \times R_{am}) = \frac{1}{6}+\frac{7}{8}+\frac{1}{8}\times\frac{5}{6}$

$\Rightarrow \frac{12}{40}=\frac{1}{4}$

3. Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence:
Dhoni, as well as the other team members of Indian team, ______ present on the occasion.
A. were B. was
C. has D. have
Ans. B.

4. An electric bus has onboard instruments that report the total electricity consumed since the start of the trip as well as the total distance covered. During a single day of operation, the bus travels on stretches M, N, O and P, in that order. The cumulative distances travelled and the corresponding electricity consumption are shown in the table below

Stretch	Comulative distance(km)	Electricity used (kWh)
M	20	12
N	45	25
O	75	45
P	100	57

The stretch where the electricity consumption per km is minimum is
A. M B. N
C. O D. P
Ans. D.

Stretch	Comulative distance(km)	Electricity used (kWh)	Individual(km) Distance	Individual electricity(kWh)
M	20	12	20	12
N	45	25	25	13
O	75	45	30	20
P	100	57	25	12

For $M \Rightarrow {}^{12}\!/_{20} = 0.6$

$N \Rightarrow {}^{13}\!/_{25} = 0.555$

$O \Rightarrow {}^{20}\!/_{30} = 0.667$

$P \Rightarrow {}^{12}\!/_{25} = 0.48$

5. Choose the word most similar in meaning to the given word: Awkward
A. Inept B. Graceful
C. Suitable D. Dreadful
Ans. A.

6. In the following sentence certain parts are underlined and marked P, Q and R. One of the parts may contain certain error or may not be acceptable in standard written communication. Select the part containing an error. Choose D as your Answer: if there is no error
The student corrected
$\underset{P}{\underline{\text{all the errors}}}$ that $\underset{Q}{\underline{\text{the instructor marked}}}$ on the $\underset{R}{\underline{\text{answer book}}}$
A. P B. Q
C. R D. No Error
Ans. B.
The is not required in „Q"

7. Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.
Statement:
I. All film stars are playback singers.
II. All film directors are film stars.
Conclusions:
I. All film directors are playback singers.
II. Some film stars are film directors.
A. Only conclusion I follows
B. Only conclusion II follows
C. Neither conclusion I nor II follows
D. Both conclusions I and II follow
Ans. D.

8. Lamenting the gradual sidelining of the arts in school curricula, a group of prominent artists wrote to the Chief Minister last year, asking him to allocate more funds to support arts education in schools. However, no such increase has been announced in this year's Budget. The artists expressed their deep anguish at their request not being approved, but many of them remain optimistic about funding in the future.
Which of the statement(s) below is/are logically valid and can be inferred from the above statements?
i. The artists expected funding for the arts to increase this year.
ii. The Chief Minister was receptive to the idea of increasing funding for the arts.
iii. The Chief Minister is a prominent artist. iv. Schools are giving less importance to arts education nowadays.
A. iii and iv B. i and iv
C. i, ii and iv D. i and iii
Ans. B.

9. If $a^2 + b^2 + c^2 = 1$ then ab + bc + ac lies in the interval

A. $\left[1, \frac{2}{3}\right]$ B. $\left[\frac{-1}{2}, 1\right]$
C. $\left[-1, \frac{1}{2}\right]$ D. $[2, -4]$

Ans. B.

10. A tiger is 50 leaps of its own behind a deer. The tiger takes 5 leaps per minute to the deer's 4. If the tiger and the deer cover 8 metre and 5 metre per leap respectively, what distance in meters will the tiger have a run before it catches the deer?
A. 800 B. 600
C. 500 D. 450
Ans. A.

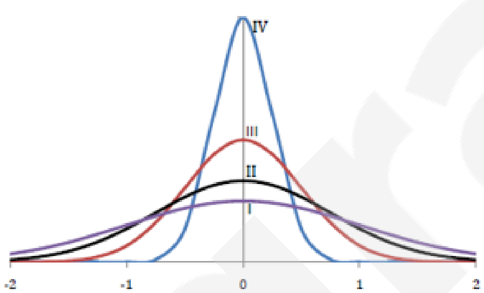
Tiger - 1leap ⇒ 8 meter
Speed = 5leap/hr = 40m/min
Deer → 1leap = 5meter
speed = 4hr = 20m/min
Let at time 't' the tiger catches the deer.
∴ Distance travelled by deer + initial distance between them
50 × 8 ⇒ 400m = distance covered by tiger.
⇒ 40 × t = 400 + 20t

$\Rightarrow t = \frac{400}{200}$ = 20 min

⇒ total distance ⇒ 400 + 20 × t = 800ms

Q. 11 to Q. 35 carry one mark each.

11 If any two columns of a determinant $P = \begin{vmatrix} 4 & 7 & 8 \\ 3 & 1 & 5 \\ 9 & 6 & 2 \end{vmatrix}$ are interchanged, which one of the following statements regarding the value of the determinant is CORRECT?
(A) Absolute value remains unchanged but sign will change.
(B) Both absolute value and sign will change.
(C) Absolute value will change but sign will not change
(D) Both absolute value and sign will remain unchanged
Ans. A.
Property of determinant: If any two row of column are interchanged, then magnitude of determinant remains same but sign changes.
12. Among the four normal distributions with probability density functions as shown below, which one has the lowest variance?



(A) I (B) II
(C) III (D) IV
Ans. D.
We have probability distribution function of Normal Distribution

$$f(x) = \frac{1}{\sigma\sqrt{\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad . . . (i)$$

Variance = σ^2 is lowest
σ also lowest
If σ decreases ⇒ f(x) increases (∵ from (i))
Curve will have highest peak.
So, IV has the lowest variance.
13. Simpson $s\frac{1}{3}$ rule is used to integrate the function $f(x) = \frac{3}{5}x^2 + \frac{9}{5}$ between x = 0 and x = 1 using the least number of equal sub-intervals. The value of the integral is __________

(A) 2 (B) 3
(C) 4 (D) 6
Ans. A.

$f(x) = \frac{3}{5}x^2 + \frac{9}{5}$

x	0	0.5	1
f(x)	1.8	1.95	2.4

$$\Rightarrow \int_0^1 f(x) = \frac{h}{3}\left[y_0 + 4y_1 + y_2\right]$$

$$= \frac{0.5}{3}\left[1.8 + 4(1.95) + 2.4\right]$$

= 2

14. The value of $\lim_{x\to 0} \frac{1-\cos(x^2)}{2x^4}$ is
(A) 0 (B) $\frac{1}{2}$
(C) $\frac{1}{4}$ (D) undefined
Ans. C.
Solution ||

$$\lim_{x\to 0} \frac{1-\cos(x^2)}{2x^4} = \frac{0}{0}$$

Using L–Hospital Rule

$$\lim_{x\to 0} \frac{(\sin x^2)2x}{8x^3} = \frac{0}{0}$$

$$\lim_{x\to 0} \frac{(\cos x^2)2x.2x + (\sin x^2)2}{24x^2}$$

$$\lim_{x\to 0} \frac{\cos x^2}{6} + \lim_{x\to 0} \frac{\sin(x^2)}{12x^2}$$

$$= \frac{1}{6} + \frac{1}{12} = \frac{1}{4}$$

15. Given two complex numbers $Z_1 = 5 + (5\sqrt{3})i$ and $Z_2 = \frac{2}{\sqrt{3}} + 2i$, the argument of $\frac{Z_1}{Z_2}$ in degrees is
(A) 0 (B) 30
(C) 60 (D) 90

Ans. A.

$z_1 = 5 + (5\sqrt{3})i$

$z_2 = \frac{2}{\sqrt{3}} + 2i$

$\arg(z_1) = \theta_1 = \tan^{-1}\left(\frac{5\sqrt{3}}{5}\right)$

$\theta_1 = 60°$

$\arg(z_2) = \theta_2 = \tan^{-1}\left(\frac{2}{2\sqrt{3}}\right)$

$\theta_2 = 60°$

$\arg\left(\frac{z_1}{z_2}\right) = \arg(z_1) - \arg(z_2)$

= 60 – 60 = 0°

16. Consider fully developed flow in a circular pipe with negligible entrance length effects. Assuming the mass flow rate, density and friction factor to be constant, if the

length of the pipe is doubled and the diameter is halved, the head loss due to friction will increase by a factor of

(A) 4 (B) 16

(C) 32 (D) 64

Ans. D.

Solution ||

$$h_1 = \frac{fLQ^2}{12D^5}$$

$$h_2 = \frac{f \times 2L \times Q^2}{12(D/2)^5}$$

$$\Rightarrow \frac{h_2}{h_1} = 64$$

17. The Blasius equation related to boundary layer theory is a

(A) third-order linear partial differential equation

(B) third-order nonlinear partial differential equation

(C) second-order nonlinear ordinary differential equation

(D) third-order nonlinear ordinary differential equation

Ans. D.

$$2\frac{d^3f}{d\eta^2} = 0$$

third–order non–linear differential equation.

18. For flow of viscous fluid over a flat plate, if the fluid temperature is the same as the plate temperature, the thermal boundary layer is

(A) thinner than the velocity boundary layer

(B) thicker than the velocity boundary layer

(C) of the same thickness as the velocity boundary layer

(D) not formed at all

Ans. D.

For flow of viscous fluid over a flat plate, if the fluid temperature is the same as the plate temperature, the thermal boundary layer is not formed at all.

19. For an ideal gas with constant values of specific heats, for calculation of the specific enthalpy.

(A) it is sufficient to know only the temperature

(B) both temperature and pressure are required to be known

(C) both temperature and volume are required to be known

(D) both temperature and mass are required to be known

Ans. A.

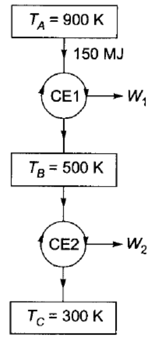
It is sufficient to know only the temperature.

20. A Carnot engine (CE-1) works between two temperature reservoirs A and B, where $T_A = 900K$ and $T_B = 500K$. A second Carnot engine (CE-2) works between temperature reservoirs B and C, where $T_C = 300K$ In each cycle of CE-1 and CE-2 all the heat rejected by CE-1to reservoir B is used b CE-2 For one cycle of operation, if the net Q absorbed by CE-1 from reservoir A is 150 MJ, the net heat rejected to reservoir C by CE-2 (in MJ) is ______________

(a) 10 MJ (b) 35 MJ

(c) 45 MJ (d) 50 MJ

Ans. D.



$$W_1 = \left(1 - \frac{500}{900}\right)150 = 66.66 \text{ MJ}$$

Heat rejected by CE_1

$$Q_{R_1} = (150 - 66.66) = 83.333 \text{ MJ}$$

T_B = 500 K

$$W_2 = \left(1 - \frac{300}{500}\right) \times \text{heat rejected by } CE_1$$

$$= \left(1 - \frac{300}{500}\right) \times 83.333 = 33.33 \text{ MJ}$$

Heat rejected by CE_2 = 83.333 – W_2 = 50 MJ.

21. Air enters a diesel engine with a density of 1.0 kg/m^3. The compression ratio is 21. At steady state, the air intake is 30×10^{-3}kg/s and the net work output is 15 kW. The mean effective pressure (in kPa) is_______

(a) 500 KPa (b) 250 KPa

(c) 350 KPa (d) 275 KPa

Ans. A.

Mean effective pressure (P_m)

$$= \frac{\text{Net work done / cycle}}{\text{Stroke volume}}$$

$$= \frac{\text{Work done/sec.}}{\text{volume displace/sec.}}$$

$$= \frac{\text{Work done/sec.}}{\frac{\text{mass of air intake / sec.}}{\text{density of air}}}$$

$$P_m = \frac{\text{Work done/sec.}}{\frac{30 \times 10^{-3}}{1}}$$

$$= \frac{15}{30 \times 10^{-3}} = 500\text{KPa}$$

22. A stream of moist air (mass flow rate = 10.1 kg/s) with humidity ratio of $0.01 \frac{kg}{kg\ dry\ air}$ mixes with a second stream of superheated water vapour flowing at 0.1 kg/s. Assuming proper and uniform mixing with no condensation, the humidity ratio of the final stream $(in \frac{kg}{kg\ dry\ air})$ is ____________

(a) 0.02 (b) 0.05

(c) 0.01 (d) 0.03

Ans. A.

Mass flow rate of moist air = 10.1 kg/s

$$\text{Humidity ratio } (\omega) = \frac{m_v}{m_a} = 0.01\text{kg/s}$$

$\Rightarrow$ Mass of moist air = Mass of dry air + Mass of water vapour

$\Rightarrow 10.1 = m_a + 0.01 \times m_a$

$\Rightarrow 10.1\ m_a = 10.1$

$\Rightarrow$ Mass of dry air (m_a) = $\frac{10.1}{1.01} = 10 kg/s$

$\Rightarrow$ Mass of water vapour $\left(m_{v_1}\right) = 10.1 - 10$

= 0.1 kg/s

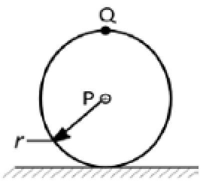
$\Rightarrow m_{v_2}$ = 0.1 kg / s

$\Rightarrow (m_v)_{total} = m_{v_1} + m_{v_2} = 0.2\ kg/s$

Humidity ratio (ω_{final}) = $\frac{m_v}{m_a} = \frac{0.2}{10}$

= 0.02 kg / ks of dy dry.

23. A wheel of radius r rolls without slipping on a horizontal surface shown below. If the velocity of point P is 10 m/s in the horizontal direction, the magnitude of velocity of point Q (in m/s) is __________



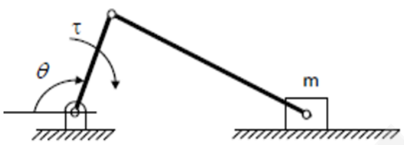
(A) 10 m/s (B) 15 m/s
(C) 20 m/s (d) 5 m/s

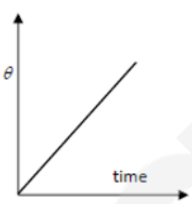
Ans. C.

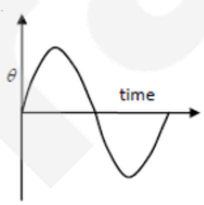
$V_P = r\omega = 10$ m/s

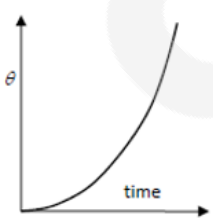
$V_Q = 2r\omega = 2 \times 10 = 20$ m/s

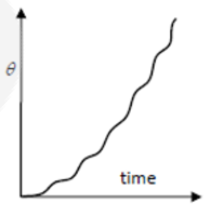
24. Consider a slider crank mechanism with nonzero masses and inertia. A constant torque τ s applied on the crank as shown in the figure. Which of the following plots best resembles variation of crank angle, θ versus time



(A)


(B)


(C)


(D)


Ans. D.

τ (torque) = $I\ddot{\theta}$

τ = constant

I = constant

$\tau = I\frac{d^2\theta}{dt^2}$

$\frac{d^2\theta}{dt^2} = \frac{\tau}{I}$

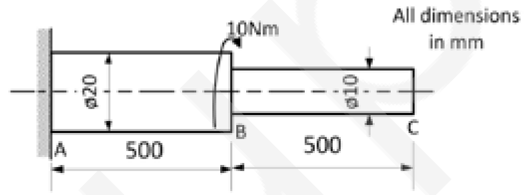
$\frac{d\theta}{dt} = \frac{\tau}{I}t + C_1$

$\theta = \frac{\tau}{I}\frac{t^2}{2} + C_1 t + C_2$

θ = f(t) = parabolic function

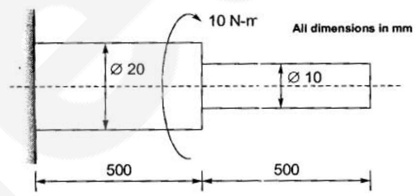
But practically graph will be fluctuating about ideal parabolic curve.

25. Consider a stepped shaft subjected to a twisting moment applied at B as shown in the figure. Assume shear modulus. G = 77 GPa. The angle of twist at C (in degrees) is _____________



(A) 0.2386 (B) 0.2368
(C) 0.6823 (D) 0.2638

Ans. B.



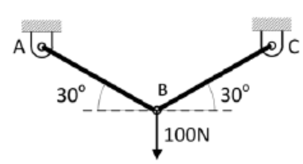
$\theta_C = \theta_B = \frac{TL}{GJ}$

$= \frac{10 \times 10^3 \times 500 \times 32}{\pi \times (20)^4 \times 77 \times 10^3}$

= 4.1338946×10^{-3} radian

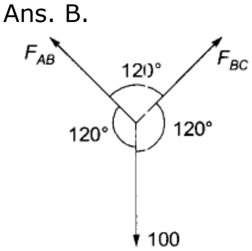
= 0.2368 degrees

26. Two identical trusses support a load of 100 N as shown in the figure. The length of each truss is 1.0 in: cross-sectional area is 200 mm^2; Young's modulus E = 200 GPa. The force in the truss AB (in N) is __________



(A) 50 (B) 100
(C) 75 (D) 150

Ans. B.



$\frac{F_{AB}}{\sin 120^\circ} = \frac{100}{\sin 120^\circ}$

F_{AB} = 100 N.

27. Consider a steel (Young's modulus E = 200 GPa) column hinged on both sides. Its height is 1.0 m and cross-section is 10 mm × 20 mm. The lowest Euler critical buckling load (in N) is___________

(a) 3456.869 N (b) 3529.367 N
(c) 3895.258 N (d) 3289.868 N

Ans. D.

$$F = \frac{\pi^2 EI}{L_e^2}$$

$$F = \frac{\pi^2 \times 200 \times 10^3 \times 20 \times 10^3}{12 \times (1000)^3}$$

= 3289.868 N

28. A swimmer can swim 10 km in 2 hours when swimming along the flow of a river, While swimming against the flow. She takes 5 hours for the same distance. Her speed in still water (in km h) is ________

(A) 4.5 km/h (B) 3.5 km/h
(C) 5.25 km/h (D) 4.75 km/h

Ans. B.

Let velocity of woman in still water = x
Velocity of river flow = y
(i) Swimming along the river flow
Resultant velocity of woman = x + y

$$\Rightarrow 2 = \frac{10}{x+y}$$

$\Rightarrow$ x + y = 5 . . . (i)
(ii) Swimming against the river flow
Resultant velocity of woman = x − y

$$\Rightarrow 5 = \frac{10}{x-y}$$

x − y = 2 . . . (ii)
Adding (i) and (ii)
2x = 7
x = 3.5 km/h.

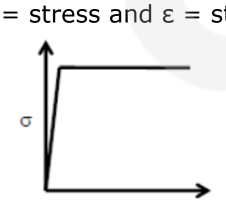
29. Which one of the following is the most conservative fatigue failure criterion?

(A) Soderberg (B) Modified Goodman
(C) ASME Elliptic (D) Gerber

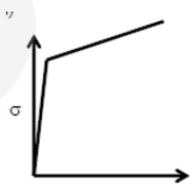
Ans. A.

Soderberg is the most conservative fatigue failure criterion.

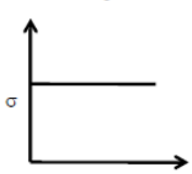
30. Which one of the following types of stress-strain relationship best describes the behaviour of brittle materials, such as ceramics and thermosetting plastics, (σ = stress and ε = strain)?



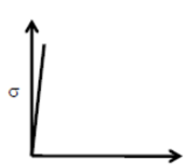
(A)



(B)



(C)



(D)

Ans. D.

A **stress-strain** curve is a graph derived from measuring load (stress - σ) versus extension (strain - ε) for a sample of a material. The nature of the curve varies from material to material.

31. Match the following products with preferred manufacturing processes:

	Product		**Process**
P	Rails	1	Blow molding
Q	Engine crankshaft	2	Extrusion
R	Aluminum channels	3	Forging
S	PET water bottles	4	Rolling

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

Ans. B.

Product	**Process**
Rails	Rolling
Engine crankshaft	Forging
Aluminum channels	Extrusion
PET water bottles	Blow molding

32. Holes of diameter $25.0^{+0.040}_{+0.020}\ mm$ are assembled interchangeably with the pins of diameter $25.0^{+0.005}_{+0.008}\ mm$. The minimum clearance in the assembly will be

(A) 0.048 mm (B) 0.015 mm
(C) 0.005 mm (D) 0.008 mm

Ans. B.

Minimum clearance = minimum hole - maximum shaft
= 25 + 0.020 – 25 + 0.005
= 0.015 mm

33. Under certain cutting conditions, doubling the cutting speed reduces the tool life to $(\frac{1}{16})^{th}$ of tile original. Taylor's tool life index (n) for this tool-work piece combination will be ___________

(A) 0.56 (B) 0.35
(C) 0.25 (D) 0.65

Ans. C.

$VT^n = C$

$$V_1 T_1^n = 2V_1 \times \left(\frac{T_1}{16}\right)^2$$

Solving this equation
We get n = 0.25.

34. In a linear arc welding process, the heat input per unit length is inversely proportional to

(A) welding current
(B) welding voltage
(C) welding speed
(D) duty cycle of tile power source

Ans. C.

In a linear arc welding process, the heat input per unit length is inversely proportional to welding speed.

35. The function of interpolator in a CNC machine controller is to
(A) control spindle speed
(B) coordinate feed rates of axes
(C) control tool rapid approach speed
(D) perform Miscellaneous (M) functions (tool change. coolant control etc.)

Ans. B.

The function of interpolator in a CNC machine controller is to coordinate feed rates of axes.

Q. 36 - Q. 65 carry two marks each.

36. Consider a spatial curve in three-dimensional space given in parametric form by $x(t) = \cos t, y(t) = \sin t, z(t) = \frac{2}{\pi} t, 0 \le t \le \frac{\pi}{2}$.
The length of the curve is _________
(A) 1.98 (B) 1.86
(C) 1.96 (D) 2.65

Ans. B.

$$S = \int \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2}\, dt$$

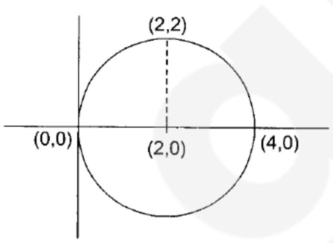
$$S = \int_0^{\pi/2} \sqrt{(-\sin t)^2 + (\cot t)^2 + \left(\frac{2}{\pi}\right)^2}\, dt$$

$$= \int_0^{\pi/2} \sqrt{1 + \left(\frac{4}{\pi^2}\right)} dt \ \sqrt{1 + \left(\frac{4}{\pi^2}\right)} [t]_0^{\pi/2}$$

37. Consider an ant crawling along the curve $(x-2)^2 + y^2 = 4$, where x and y are in meters. The ant starts at the point (4, 0) and moves counter-clockwise with a speed of 1.57 meters per second. The time taken by the ant to reach the point (2, 2) is (in seconds) _________
(A) 2 sec. (B) 5 sec.
(C) 4 sec. (D) 6 sec.

Ans. A.

$(x - 2)^2 + (y^2) = (2^2)$, is a circle of radius 2 m and centre at (2, 0)



Time to reach from (4, 0) to (2, 2) is

$$\text{time} = \frac{\text{Distance}}{\text{Speed}}$$

$$\frac{\left(\frac{2\pi r}{4}\right)}{1.57} = \frac{\left(\frac{2\pi 2}{4}\right)}{1.57} = \frac{\pi}{1.57} = 2\,\text{sec}.$$

38. Find the solution of $\frac{d^2y}{dx^2} = y$ which passess through the origin and the point (In2,$\frac{3}{4}$).
(A) $y = \frac{1}{2}e^x - e^{-x}$ (B) $y = \frac{1}{2}(e^x + e^{-x})$
(C) $y = \frac{1}{2}(e^x - e^{-x})$ (D) $y = \frac{1}{2}e^x + e^{-x}$

Ans. C.

$$\frac{d^2y}{dx^2} = y$$

$\Rightarrow D^2y = y \ (\therefore d/dx = D)$

$(D^2 - 1)\, y = 0$

$D^2 - 1 = 0$

$D = \pm 1$

$y = C_1 e^x + C_2 e^{-x}$

Given point passes through origin

$\Rightarrow 0 = C_1 + C_2$

$C_1 = - C_2$ . . . (i)

Also, point passes thorough (In 2, 3/4)

$$\Rightarrow \frac{3}{4} = C_1 e^{\ln 2} + C_2 e^{-\ln 2}$$

$$\frac{3}{4} = 2C_1 + \frac{C_2}{2}$$

$\Rightarrow C_2 + 4C_1 = 1.5$ . . . (ii)

From (i), $C_1 = - C_2$, putting in (ii), we get

$\Rightarrow - 3C_2 = 1.5$

$C_2 = - 0.5$

$\therefore C_1 = 0.5$

$\Rightarrow y = 0.5\, (e^x - e^{-x})$

$$y = \frac{e^x - e^{-x}}{2}$$

39. The probability of obtaining at least two “SIX” in throwing a fair dice 4 times is
(A) 425/432 (B) 19/144
(C) 13/144 (D) 125/432

Ans. B.

$n = 4;\ p = \frac{1}{6}$

$q = 1 - \frac{1}{5} = \frac{5}{6}$

$p(x \ge 2) = 1 - p(x < 2)$

$= 1 - [p(x = 0) + p(x = 1)]$

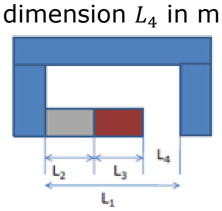
$$= 1 - \left[4C_0 \left(\frac{1}{6}\right)^0 \left(\frac{5}{6}\right)^4 + 4C_1 \left(\frac{1}{6}\right)^1 \left(\frac{5}{6}\right)^3\right]$$

40. In the assembly shown below, the part dimensions are:

$L_1 = 22.0^{\pm 0.01}\ mm$

$L_2 = L_3 = 10.0^{\pm 0.005}\ mm$

Assuming the normal distribution of part dimensions, the dimension L_4 in mm for assembly condition would be:



(A) $2.0^{\pm 0.008}$ (B) $2.0^{\pm 0.012}$

(C) $2.0^{\pm 0.016}$ (D) $2.0^{\pm 0.020}$

Ans. D.

$L_{1max} = L_{2max} + L_{3max} + L_{1max}$
$L_{4max} = L_{1max} - (L_{2max} + L_{3max})$
$= 22.01 - (505 + 10.005)$
$= 2mm$
$L_{4min} = L_{1min} - (L_{4min} + L_{3min})$
$= 2mm$
$L_4 = 2 \pm 0.00$ mm.

41. A DC welding power source has a linear voltage-current *(V-I)* characteristic with open circuit voltage of 80 V and a short circuit current of 300 A. For maximum arc power, the current (in Amperes) should be set as_______

(A) 150 A (B) 175 A
(C) 180 A (d) 100 A

Ans. A.

$$V = V_{OC} - \left(\frac{V_{OC}}{I_{SC}}\right)I$$

$$\Rightarrow V = 80 - \left(\frac{80}{300}\right)I$$

$\Rightarrow P = VI = (80 - 0.26666\ I)I$
$= 80\ I - 0.2666\ I^2$
for power to be maximum

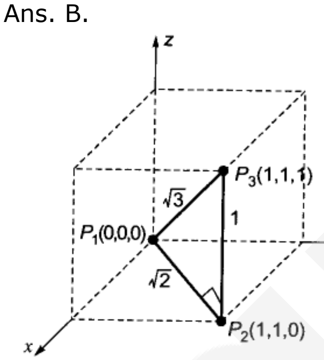
$$\left(\frac{dP}{dI}\right) = 0$$

$\Rightarrow 80 - 2 \times 0.2666I = 0$
$\Rightarrow I = 150$ A

42. A triangular facet in a CAD model has vertices: P1 (0,0,0); P2(1,1,0) and P3(1,1,1). The area of the facet is

(A) 0.500 (B) 0.707
(C) 1.414 (D) 1.732

Ans. B.



$$\text{Area} = \frac{1}{2} \times \sqrt{2} \times 1$$

$$\frac{\sqrt{2}}{2} = 0.707.$$

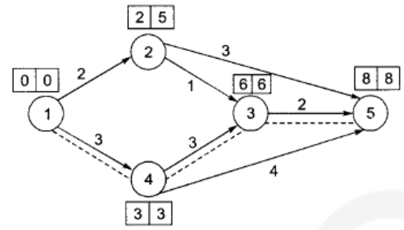
43. Following data refers to the activities of a project, where, node 1 refers to the start and node 5 refers to the end of the project.

Activity	Duration (days)
1-2	2
2-3	1
4-3	3
1-4	3
2-5	3
3-5	2
4-5	4

The critical path (CP) in the network is

(A) 1-2-3-5 (B) 1-4-3-5
(C) 1-2-3-4-5 (D) 1-4-5

Ans. B.



Critical path = 1 – 4 – 3 – 5.

44. For a canteen, the actual demand for disposable cups was 500 units in January and 600 units in February. The forecast for the month of January was 400 units. The forecast for the month of March considering smoothing coefficient as 0.75 is __________

(A) 569 (B) 345
(C) 659 (D) 468

Ans. A.

$(F)_{Feb} = (F)_{Jan} + \alpha[D_{Jan} - F_{Jan}]$
$= 400 + 0.75\ [500 - 400]$
$= 475$
$(F)_{March} = (F)_{Feb} + \alpha[D_{Feb} - F_{Feb}]$
$= 475 + 0.75\ [600 - 475]$
$= 568.75 \approx 569.$

45. An orthogonal turning operation is carried out under the following conditions: rake angle = 5°; spindle rotational speed = 400 rpm: axial feed = 0.4 m/min and radial depth of cut = 5 mm. The chip thickness, t_c, is found to be 3 mm. The shear angle (in degrees) in this turning process is________

(A) 32.24 (B) 30.35
(C) 30.56 (D) 32.45

Ans. A.

$$\text{Chip thickness ratio (r)} = \frac{3}{5} = 0.6$$

To find shear angle (ϕ)

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.6\cos 5}{1 - 0.6\sin 5} = 0.6306$$

$\phi = \tan^{-1}(0.6306) = 32.24°$

46. The solidification time of a casting is proportional to$(\frac{V}{A})^2$, where V is the volume of the casting and A is the total casting surface area losing heat. Two cubes of same material and size are cast using sand casting process. The top face of one of the cubes is completely insulated. The ratio of the solidification time for the cube with top face insulated to that of the other cube is

(A) $\frac{25}{36}$ (B) $\frac{36}{25}$
(C) 1 (D) $\frac{6}{5}$

Ans. B.

$$T_{solidification} = k\left(\frac{V}{A}\right)^2$$

$$\Rightarrow \frac{T_1}{T_2} = \frac{k\left(\frac{V_1}{A_1}\right)^2}{k\left(\frac{V_2}{A_2}\right)^2}$$

$V_1 = V_2$

$$\Rightarrow \frac{T_1}{T_2} = \frac{A_2^2}{A_1^2} = \frac{(6a^2)^2}{(5a^2)^2} = \frac{36}{25}$$

47. In a slab rolling operation, the maximum thickness reduction (∇h_{max}) is given by $\nabla h_{max} = \mu^2 R$, where R is the radius of the roll and μ is the coefficient of friction between the roll and the sheet. If $\mu = 0.1$, the maximum angle subtended by the deformation zone at the centre of the roll (bite angle in degrees) is______

(A) 5.71 (B) 5.25

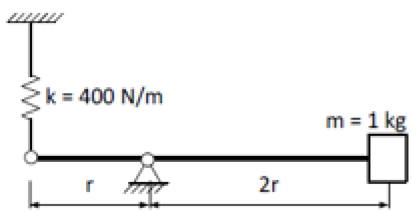
(C) 4.75 (D) 6.71

Ans. A.

$$\theta = \tan^{-1}\sqrt{\frac{\Delta h}{R}} = \tan^{-1}\mu$$

= 5.7106°

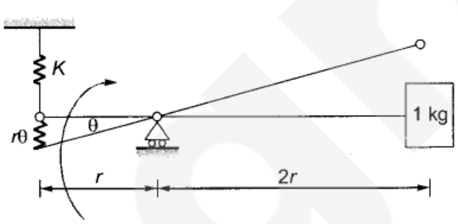
48. Considering massless rigid rod and small oscillations, the natural frequency (in rad/s) of vibration of the system shown in the figure is



(A) $\sqrt{\frac{400}{1}}$ (B) $\sqrt{\frac{400}{2}}$

(C) $\sqrt{\frac{400}{3}}$ (D) $\sqrt{\frac{400}{4}}$

Ans. D.



Q Change in angular positions of rod in anticlockwise direction.

Restoring torque = (Krθ)r will act in clockwise direction

So, $\tau = -Kr^2\theta$

$I\alpha = -Kr^2\theta$

$$\alpha = -\frac{Kr^2}{I}\theta$$

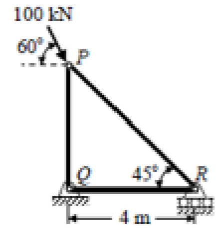
$$\omega_n = \sqrt{\frac{Kr^2}{I}}$$

$I = m(2r^2) = 1(4r^2)$

$$I = \sqrt{\frac{400 \times r^2}{1 \times 4r^2}} = \sqrt{\frac{400}{4}}$$

ω_n = 10 rad/s.

49. For the truss shown in figure, the magnitude of the force in member PR and the support reaction at R are respectively



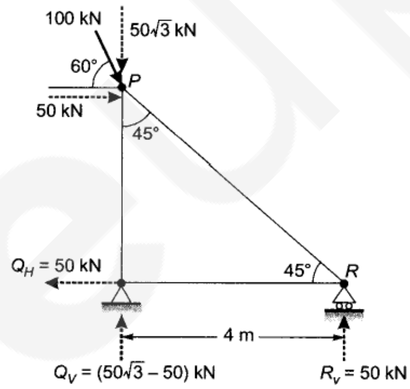
(A) 122.47 kN and 50 kN

(B) 70.71 kN and 100 kN

(C) 70.71 kN and 50 kN

(D) 81.65 kN and 100 kN

Ans. C.



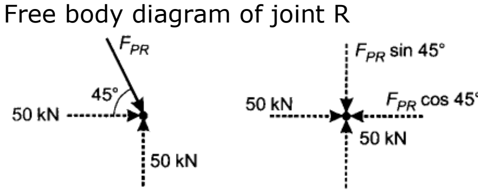
$\Sigma M_Q = 0$

$R_V \times 4 - 50 \times 4 = 0$

R_V = 59 kN

Force in member QR = 50 kN (Tensile)

Free body diagram of joint R



$F_{PR}\cos 45° = 50$

$$F_{PR} = \frac{50}{\cos 45°}$$

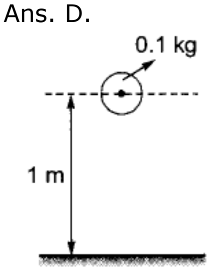
F_{PR} = 70.7106 kN

50. A ball of mass 0.1 kg, initially at rest, is dropped from height of 1m. Ball hits the ground and bounces off the ground. Upon impact with the ground, the velocity reduces by 20%. The height (in m) to which the ball will rise is ____________

(A) 0.56 m (b) 0.76 m

(C) 0.84 m (d) 0.64 m

Ans. D.



Velocity with which ball hits the ground

$V_1 = \sqrt{2gh}$
$= \sqrt{2 \times 9.81 \times 1}$
= 4.4294 m/s
V_2 = 0.8 × 4.4294 = 3.5436

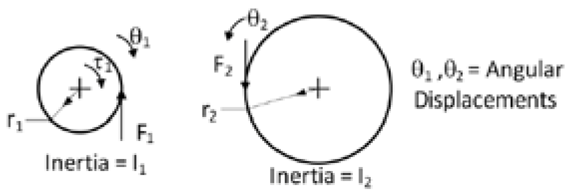
$\Rightarrow$ Now $\frac{1}{2}mV_2^2$ is kinetic energy of ball which will be decreasing as it goes upwards (because work is done against gravity) and gravitational potential energy increase

$$\Rightarrow \frac{1}{2}mV_2^2 = mgh'$$

$$h' = \frac{V_2^2}{2g}$$

$h' = 0.64$ m.

51. A pinion with radius r_1, and inertia I_1 is driving a gear with radius r_2 and inertia I_2. Torque τ_1 is applied on pinion. The following are free body diagrams of pinion and gear showing important forces (F_1 and F_2) of interaction. Which of the following relations hold true?



(A) $F_1 \neq F_2;\ \tau_1 = I_1\theta_1; F_2 = I_2\frac{r_1}{r_2{}^2}\theta_1$

(B) $F_1 = F_2; \tau_1 = \left[I_1 + I_2\left(\frac{r_1}{r_2}\right)^2\right]\theta_1; F_2 = \frac{r_1}{r_2{}^2}\theta_1$

(C) $F_1 = F_2;\ \tau_1 = I_1\theta_1; F_2 = I_2\frac{1}{r_2}\theta_2$

(D) $F_1 \neq F_2;\ \tau_1 = \left[I_1 + I_2\left(\frac{r_1}{r_2}\right)^2\right]\theta_1; F_2 = I_2\frac{1}{r_2}\theta_2$

Ans. B.

$\tau_1 - F_1r_1 = I_1\ddot{\theta}_1$ . . . (i)
$F_1 = F_2$ . . . (ii)
[Action and reaction are equal by Newton's 3rd law]

$F_2r_2 = \tau_2 = I_2\ddot{\theta}_2$ . . . (iii)
From (ii) and (iii)

$$F_2 = F_1 = \frac{I_2\ddot{\theta}_2}{r_2} \quad . . . (iv)$$

From (i) and (iv)

$$\tau_1 - \left(\frac{I_2\ddot{\theta}_2}{r_2}\right)r_1 = I_1\ddot{\theta}_1 \quad . . . (v)$$

We know, $r_1\omega_1 = r_2\omega_2$

$r_1\ddot{\theta}_1 = r_2\ddot{\theta}_2$

$$\ddot{\theta}_2 = \frac{r_1}{r_2}\ddot{\theta}_1$$

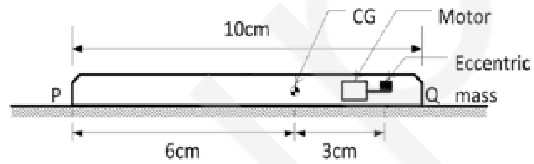
$$\tau_1 = I_1\ddot{\theta}_1 + \frac{I_2}{r_2}\left[\frac{r_1}{r_2}\ddot{\theta}_1\right]r_1$$

$$\tau_1 = \left[I_1 + I_2\left[\frac{r_1}{r_2}\right]^2\right]\ddot{\theta}_1$$

$$\tau_2 = I_2\ddot{\theta}_2 = F_2r_2$$

$$F_2 = \frac{I_2}{r_2}\ddot{\theta}_2 = \frac{I_2}{r_2}\left[\frac{r_1}{r_2}\ddot{\theta}_1\right]$$

52. A mobile Phone has a small motor with an eccentric mass used for vibrator mode. The location of the eccentric mass on motor with respect to center of gravity (CG) of the mobile and the rest of the dimensions of the mobile phone are shown. The mobile is kept on a flat horizontal surface.



Given in addition that the eccentric mass = 2 grams, eccentricity = 2.19 mm. mass of the mobile = 90 grams. g = 9.81 m/s^2. Uniform speech of the motor in RPM for which the mobile will get just lifted off the ground at the end Q is approximately

(A) 3000
(B) 3500
(C) 4000
(D) 4500

Ans. B.

$\Sigma M_P = 0$ [moment about P = 0]
mg × 6 = m_e (2.19 × 10^{-3})(ω^2) × [9]
90 × 9.81 × 6 = 2(2.19 × 10^{-3})ω^2 × 9

$$366.5836 = \omega = \frac{2\pi N}{60}$$

N = 3500.6158 rpm

53. A machine element is subjected to the following bi-axial state of stress: $\sigma_x = 80$ MPa; $\sigma_y = 20$MPa; $\tau_{xy} = 40$MPa. If the shear strength of the material is 100 MPa, the factor of safety as per Tresca's maximum shear stress theory is

(A) 1.0
(B) 2.0
(C) 2.5
(D) 3.3

Ans. B.

$$\sigma_1 = \frac{80+20}{2} + \sqrt{\left(\frac{80-20}{2}\right)^2 + 40^2}$$

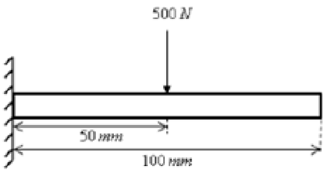
$= 50 + \sqrt{50^2} = 100$

$\sigma_2 = 0$

$$\tau = \frac{\sigma_1 - \sigma_2}{7} = 50$$

$$FOS = \frac{100}{50} = 2$$

54. A cantilever beam with flexural rigidity of 200 N.m^2 is loaded as shown in the figure. The deflection (in mm) at (lie tip of the beam is ___________



(a) 0.5624 (b) 0.2604
(c) 0.6526 (d) 0.3402
Ans. B.

EI = 200 Nm^2

$$\delta_{\text{at tip}} = \frac{500 \times 0.05^3}{3 \times 200} + \frac{500 \times 0.05^2}{2 \times 200}[0.05]$$

= 0.2604 mm.

55. A precision instrument package (m = 1 kg) needs to be mounted on a surface vibrating at 60 Hz. It is desired that only 5% of the base surface vibration amplitude be transmitted to the instrument. Assume that the isolation is designed with its natural frequency sig lesser than 60 Hz, so that the effect of damping may be ignored. The stiffness (in N/m) of the required mounting pad is
(a) 6767.72 N/m (b) 6567.83 N/m
(c) 6734.76 N/m (d) 7634.82 N/m
Ans. A.
Given, $\omega = 2\pi f$
$\omega = 2\pi \times 60$
$\omega = 120\ \pi$
m = 1 kg

$$\frac{F_{TR}}{F_0} = \frac{\sqrt{1+(2\xi r)^2}}{\sqrt{(1-r^2)^2+(2\xi r)^2}}$$

No damping,
$\therefore \xi = 0$

$$\frac{F_{TR}}{F_0} = 0.05$$

$$0.05 = \frac{1}{r^2-1}$$

$r^2 - 1 = 2C$

$r = \sqrt{21}$

$$\frac{\omega}{\omega_n} = \sqrt{21}$$

$$\frac{120\pi}{\omega_n} = \sqrt{21}$$

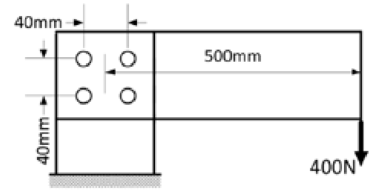
$\omega_n = 82.266$

$$\sqrt{\frac{K}{m}} = 82.266$$

$$\sqrt{\frac{K}{1}} = 6767.728$$

K = 6767.72 N/m.

56. A horizontal plate has been joined to a vertical post using four rivets arranged as shown in the figure. The magnitude of the load on the worst loaded rivet (in N) is



(a) 1767.77 N (b) 1839.83 N
(c) 1856.98 N (d) 1789.87 N
Ans. B.
Primary force (P_1) = 100 N

$$P_1'' = P_2'' = P_3'' = P_4'' = \frac{P_e \times r}{4r^2}$$

$$= \frac{400 \times 500 \times \left(40\sqrt{2}/2\right)}{4 \times \left(\frac{40\sqrt{2}}{2}\right)^2}$$

$$P_1'' = \frac{400 \times 500 \times 20\sqrt{2}}{4 \times \left(20\sqrt{2}\right)^2}$$

$$= \frac{400 \times 500}{4 \times \left(20\sqrt{2}\right)^2}$$

$P_1'' = 1767.766N$
(1 and 4) are worst loaded

$$\therefore P_{net}^2 = P_1 + P_1''^2 + 2P_1P_1'' \cos 45°$$

P_{net} = 1839.83N.

57. For flow through a pipe of radius R, the velocity and temperature distribution are as follows: $u(r,x) = C_{1,}\ and\ T(r,x) = C_2\,[1-(\frac{r}{R})^3]$, where $C_1\ and\ C_2$ are constants. The bulk mean temperature is given by $T_m = \frac{2}{U_m R^2}\int_0^R u\ (r,x)T(r,x)rdr$, with U_m being the mean velocity of flow. Tile value of T_m is

(A) $\frac{0.5C_2}{U_m}$ (B) $0.5C_2$

(C) $0.6C_2$ (D) $\frac{0.6C_2}{U_m}$

Ans. D.

$$T_m = \frac{2}{U_m R^2}\int_0^R u(r,\ x)T(r,\ x)r\,dr = 0.6C_2$$

58. Match the following pairs:

	Equation		Physical Interpretation
P	$\nabla \times \vec{V} = 0$	I	Incompressible continuity equation
Q	$\nabla \cdot \vec{V} = 0$	II	Steady flow
R	$\frac{D\vec{V}}{Dt} = 0$	III	Irrotational flow
S	$\frac{\partial \vec{V}}{\partial t} = 0$	IV	Zero acceleration of fluid particle

(A) P-IV, Q-I, R-II, S-III (B) P-IV, Q-III, R-I, S-II
(C) P-III, Q-I, R-IV, S-II (D) P-III, Q-I, R-II, S-IV
Ans. C.

Incompressible continuity equation = $\nabla \cdot \vec{v} = 0$

Steady flow = $\dfrac{\partial \vec{v}}{\partial t} = 0$

Irrotational flow = $\nabla \times \vec{v} = 0$

Zero acceleration of fluid particle = $\dfrac{D\vec{v}}{Dt} = 0$

Hence (C) is the correct answer.

59. The velocity field of an incompressible flow is given by
$\boldsymbol{V} = (a_1 x + a_2 y + a_3 z)\boldsymbol{i} + (b_1 x + b_2 y + b_3 z)\boldsymbol{j} + (c_1 x + c_2 y + c_3 z)\boldsymbol{k}$ where $a_1 = a_2$ *and* $c_3 = -4$. The value of b_2 is _________

(a) 4 (b) 2
(c) 1 (d) 6

Ans. B.

From continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$a_1 + b_2 + c_2 = 0$

$\Rightarrow 2 + b_2 - 4 = 0$

$\Rightarrow b_2 = 4 - 2 = 2.$

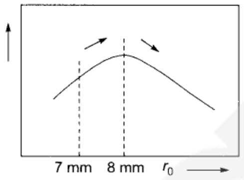
60. A 10 mm diameter electrical conductor is covered by an insulation of 2 mm thickness. The conductivity of the insulation surface is 0.08 W/m-K and the convection coefficient at the insulation surface is 10 W/m^2-K. Addition of further insulation of the same material will

(A) increase heat loss continuously
(B) decrease heat loss continuously
(C) increase heat loss to a maximum and then decrease heat loss
(D) decrease heat loss to a minimum and then increase heat loss

Ans. C.

$$r_{critical} = \frac{k}{h} = \left(\frac{0.08}{10}\right) m$$

= 0.008 m = 8 mm

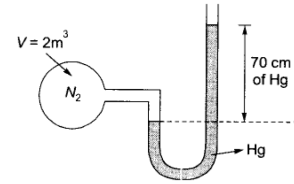


Heat transfer rate first increases, reaches maximum then decreases.

61. Temperature of nitrogen in a vessel of volume 2 m^3 is 288 K. A U-tube manometer connected to the vessel shows a reading of 70 cm of mercury (level higher in the end open to atmosphere). The universal gas constant is 8314 J/kmol-K, atmospheric pressure is 1.01325 bar, acceleration due to gravity is 9.81 m/s^2 and density of mercury is 13600 kg/m^3. The mass of nitrogen (in kg) in the vessel is ___________

(a) 4.56 kg (b) 5.46 kg
(c) 4.34 kg (d) 6.45 kg

Ans. A.



$(P_{absolute})$ of N_2 = [101.3 kPa + wh] KPa

$$= 101.3 + \left(13.6 \times 9.81 \times \frac{70}{100}\right) KPa$$

= 194.6 KPa

As N_2 being ideal gas,

pv = mRT

$$m = \left(\frac{pV}{RT}\right) kg$$

$$R_{N_2} = \frac{8.314}{28} = 0.296 \text{ kJ/kg K}$$

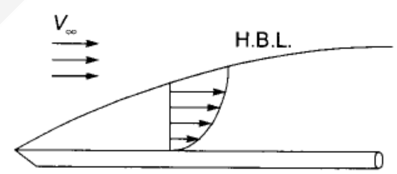
$$m = \frac{194.6 \times 2}{0.296 \times 288}$$

= 4.56 kg.

62. Air (ρ= 1.2 kg/$m^3$and kinematic viscosity. $v = 2 \times 10^{-5}\, m^2$/s) with a velocity of 2 m/s flows over the top surface of a flat plate of length 2.5 m. If the average value of friction coefficient is $C_f = \frac{1.328}{\sqrt{Re_x}}$,the total drag force (in N) per unit width of the plate is________

(a) 0.0125 Newton (b) 0.0213 Newton
(c) 0.0159 Newton (d) 0.0169 Newton

Ans. C.



Drag force = average shear stress × area

$\bar{\tau}$ = average shear stress

$$= \overline{C_f} \times \frac{\rho V_\infty^2}{2}$$

$$= \frac{1.328}{\sqrt{Re_L}} \times \frac{\rho V_\infty^2}{2}$$

Re_L = Local Reynold number at trailing edge = $\dfrac{V_\infty L \rho}{\mu}$

$$= \frac{2 \times 2.5 \times 1.2}{1.2 \times 2 \times 10^{-5}} = 2.5 \times 10^5 \text{ (laminar flow)}$$

Drag force =

$$\bar{\tau} \times A = \frac{1.328}{\sqrt{2.5 \times 10^5}} \times \frac{1.2 \times 2^2}{2} \times (2.5 \times 1)$$

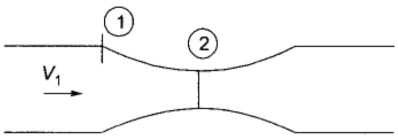
= 0.0159 Newton.

63. Water (ρ = 1000 kg/m^3) flows through a venturimeter with inlet diameter 80 mm and throat diameter 40 mm. The inlet and throat gauge pressures are measured to be 400 kPa and 130 kPa respectively. Assuming the venturimeter to be horizontal and neglecting friction, the inlet velocity (in m/s) is

(a) 4 m/sec (b) 2 m/sec

(c) 6 m/sec (d) 1 m/sec

Ans. C.



$$\frac{P_1}{w}+\frac{V_1^2}{2g}+z_1=\frac{P_2}{w}+\frac{V_2^2}{2g}+z_2$$

$$\frac{P_1}{w}-\frac{P_2}{w}=\frac{V_2^2-V_1^2}{2g} \quad . . . (i)$$

$Q = a_1V_1 = a_2V_2$

$$\Rightarrow \frac{\pi}{4}(80)^2\times V_1=\frac{\pi}{4}(40)^2\times V_2$$

$$V_1 = \left(\frac{1}{2}\right)^2\times V_2=\left(\frac{V_2}{4}\right)$$

Putting in (i), we get

$$\frac{400-130}{9.81}=\frac{1}{2\times 9.81}\left[(4V_1)^2-V_1^2\right]$$

$$V_1^2=\left(\frac{400-130}{9.81}\right)\times 2\times 9.81\times\frac{1}{15}$$

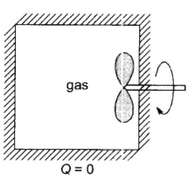
$\Rightarrow V_1 = 6$ m/sec.

64. A well insulated rigid container of volume $1\ m^3$ contains 1.0 kg of an ideal gas $[C_p = 1000\ J/(kg.K)$ and $C_v = 800\ J/(kg.K)]$ at a pressure of 10^5 Pa. A stirrer is rotated at constant rpm in the container for 1000 rotations and the applied torque is 100 N-m. The final temperature of the gas (in K) is

(A) 500.04 (B) 1773.26

(C) 785.45 (D) 1285.39

Ans. D.



Work done = Torque × angular displacement

= 100 × 2π × 1000

= – 628.318 kJ

$p_1v_1 = mRT_1$

$$T_1=\frac{p_1v_1}{mR}=\frac{10^2\times 1}{0.2\times 1}=500K$$

$\therefore R = C_p - C_v = 0.2$ kJ/kg–K

According to 1st law of thermodynamic

$Q - W = \Delta U$

$-(-628.318)$ kJ $= mC_v(T_2 - T_1)$

$$\Rightarrow T_2 = 500+\frac{628.318}{1\times 0.8}=1285.39\ K$$

65 Steam enters a well insulated turbine and expands is entropically throughout. At an intermediate pressure, 20 percent of the mass is extracted for process heating and the remaining steam expands is entropically to 9 kPa.

Inlet to turbine: $P = 14\ MPa, T = 560°C, h = 3486\frac{kJ}{kg}, s = 6.6\ kJ/(kg.K)$

Intermediate stage: h = 2776 kJ/kg

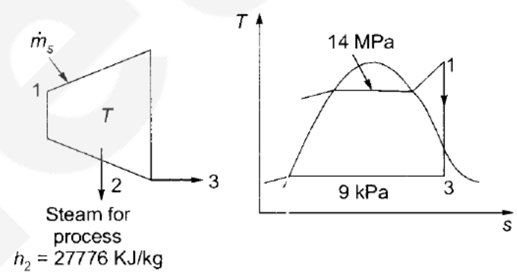
Exit of turbine: $P = 9\ kPa, h_f = 174\ kJ/kg, h_g = 2574\ kJ/kg, s_f\ 0.6\ kJ/(kg.K), s_g = 8.1\ kJ/(kg.K)$

If the flow rate of steam entering the turbine is 100 kg/s, then the work output (in MW) is___________

(a) 125.56 (b) 135.65

(c) 145.65 (d) 165.56

Ans. A.



$S_1 = S_3$

$S_1 = (S_t + x_3 + S_{fg})$

$6.6 = 0.6 + x_3\ (8.1 - 0.6)$

Dryness fraction at exit

$$x_3=\frac{6.6-0.6}{(8.1-0.6)}=0.8$$

$h_3 = (h_f + x_3\ h_{fg})$ at 9kPa

$= 174 + 0.8\ (2574 - 174)$

= 2094 kJ/kg

Work output

$= m_{steam}\ [(h_1 - h_2) + 0.8\ (h_2 - h_3)]$

= 100[(3486 – 2776)+ 0.8(2776 – 2094)]

= 125560 kW

= 125.56 Mw.

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