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Q.1 The preferred option for holding an odd-shaped workpiece in a centre lathe is

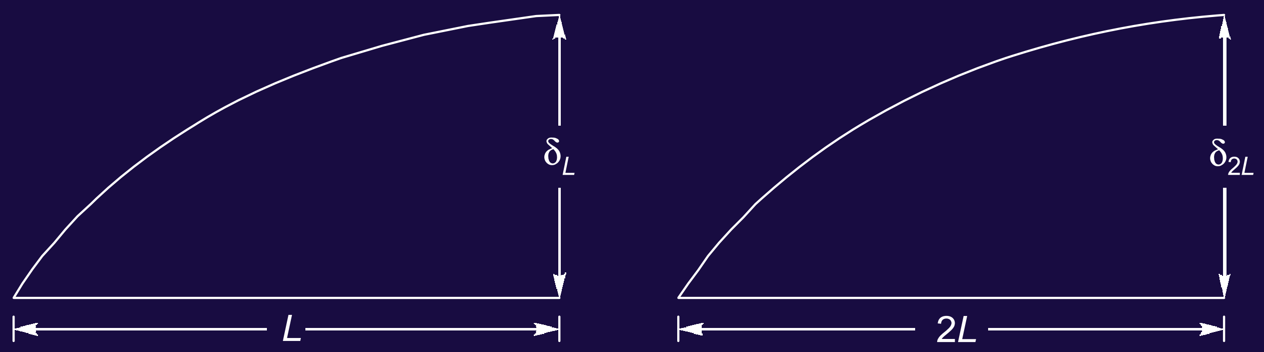
(a) live and dead centres (b) three jaw chuck
(c) lathe dog (d) four jaw chuck

Ans. (d)

- 4 jaw independently adjusted chuck are used to hold and support a wide variety of workpiece including odd shaped workpiece.
- Practically odd shaped job can be mounted on a face plate. **But this is not given as option.**
- Lathe dog may be used on round, square, rectangular and odd-shaped workpieces but most appropriate is option (d).

Q.2 The viscous laminar flow of air over a flat plate results in the formation of a boundary layer. The boundary layer thickness at the end of the plate of length L is δ_L. When the plate length is increased to twice its original length, the percentage change in laminar boundary layer thickness at the end of the plate (with respect to δ_L) is _______ (correct to two decimal places).

Ans. (41.42)



For laminar flow over flat plate,
As per Blasius equation,

$$\delta = \frac{5x}{\sqrt{\frac{\rho V_\infty x}{\mu}}}$$

$$\delta \;\alpha\; \sqrt{x}$$

$$\delta_L \;\alpha\; \sqrt{L}$$

$$\delta_{2L} \;\alpha\; \sqrt{2L}$$

$$\frac{\delta_{2L} - \delta_L}{\delta_L} \times 100 = \left[\frac{\sqrt{2L} - \sqrt{L}}{\sqrt{L}}\right] \times 100$$

$$= \left(\sqrt{2} - 1\right) \times 100 = 41.42\%$$

Q.3 Consider a function u which depends on position x and time t. The partial differential equation $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$ is known as the

(a) Wave equation
(b) Heat equation
(c) Laplace's equation
(d) Elasticity equation

Ans. (b)

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} \text{ is known as heat equation}$$

Q.4 Pre-tensioning of a bolted joint is used to

(a) strain harden the bolt head
(b) decrease stiffness of the bolted joint
(c) increase stiffness of the bolted joint
(d) prevent yielding of the thread root

Ans. (c)

Pretension increase stiffness of system.

Q.5 A hollow circular shaft of inner radius 10 mm outer radius 20 mm and length 1 m is to be used as a torsional spring. If the shear modulus of the material of the shaft is 150 GPa, the torsional stiffness of the shaft (in kN-m/rad) is ________ (correct to two decimal places).

Ans. (35.343)

$$\text{Torsional stiffness} = \frac{GI_P}{L}$$

$$= \frac{150 \times 10^9 \times \frac{\pi}{32}[0.04^4 - 0.02^4]}{1}$$

$$= 35343 \text{ Nm/rad} = 35.343 \text{ kNm/rad}$$

Q.6 The Fourier cosine series for an even function $f(x)$ is given by

$$f(x) = a_0 + \sum_{n=1}^{\infty} a_n \cos(nx)$$

The value of the coefficient a_2 for the function $f(x) = \cos^2(x)$ in $[0, \pi]$ is

(a) –0.5
(b) 0.0
(c) 0.5
(d) 1.0

Ans. (c)

$$\cos^2 x = \frac{1+\cos 2x}{2}$$

$$f(x) = \frac{1}{2} + \frac{\cos 2x}{2}$$

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cdot \cos nx$$

$$a_0 = 1$$

$$a_1 = 0,$$

$$a_2 = \frac{1}{2}$$

Q.7 The arrival of customers over fixed time intervals in a bank follow a Poisson distribution with an average of 30 customer/hour. The probability that the time between successive customer arrival is between 1 and 3 minutes is ________ (correct to two decimal places).

Ans. (0.383)

Given, arrival rate, $\lambda = 30/\text{hour}$

$$\lambda = \frac{1}{2} \text{ min.}$$

$$P = \text{prob.} = 1 - e^{-\lambda t}$$

$$P(1) = 1 - e^{-\frac{1}{2}\times 1} = 0.393$$

$$P(3) = 1 - e^{-\lambda t} = 1 - e^{-\frac{1}{2}\times 3}$$

$$= 1 - e^{-1.5} = 0.7768$$

$$P(1 \le T \le 3 \text{ min}) = 0.7768 - 0.393 = 0.383$$

Q.8 The minimum axial compressive load, P required to initiate buckling for a pinned-pinned slender column with bending stiffness EI and length L is

(a) $P = \dfrac{\pi^2 EI}{4L^2}$

(b) $P = \dfrac{\pi^2 EI}{L^2}$

(c) $P = \dfrac{3\pi^2 EI}{4L^2}$

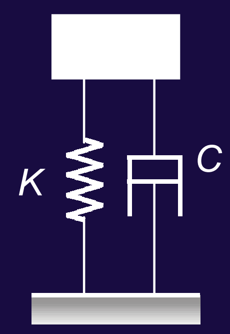
(d) $P = \dfrac{4\pi^2 EI}{L^2}$

Ans. (b)

For both ends hinged buckling load,

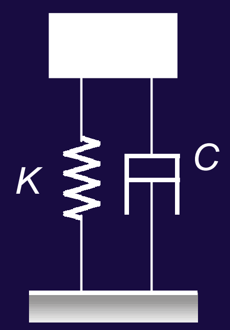
$$P = \frac{\pi^2 EI}{L^2}$$

Q.9 In a single degree of freedom underdamped spring-mass-damper system as shown in the figure, an additional damper, is added in parallel such that the system still remains underdamped. Which one of the following statements is ALWAYS true?



(a) Transmissibility will increase
(b) Tranmissibility will decrease
(c) Time period of free oscillations will increase
(d) Time period of free oscillations will decrease

Ans. (c)



Transmissibility,
$$\in = \frac{\sqrt{1+\left(\frac{2\xi\omega}{\omega_n}\right)^2}}{\sqrt{\left\{1-\left(\frac{\omega}{\omega_n}\right)^2\right\}^2+\left\{\frac{2\xi\omega}{\omega_n}\right\}^2}}$$

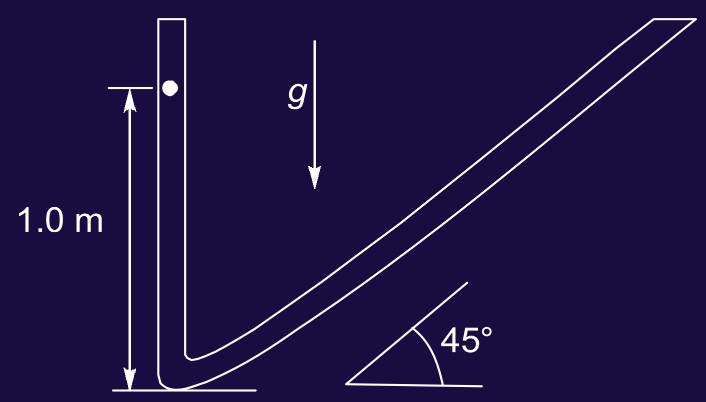
Additional damper is added into parallel.
Then damping will increase.
But it is still under damped.
But ξ will increase.
Here no unbalance force is there.

But $$\omega_d = \sqrt{1-\xi^2}\cdot\omega_n \qquad \left\{\omega_n = \sqrt{\frac{K}{M}}\right\}$$

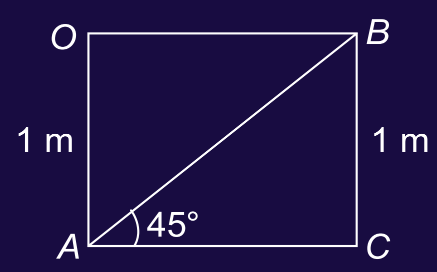
But as ξ increases
then ξ^2 will increase
Then ω_d will decrease

Then $T_d = \frac{2\pi}{\omega_d}$ will increase

Q.10 A ball is dropped from rest from a height of 1 m in a frictionless tube as shown in the figure. If the tube profile is approximated by two straight lines (ignoring the curved portion), the total distance travelled (in m) by the ball is ________ (correct to two decimal places).



Ans. (2.414)



$$\frac{BC}{AB} = \sin 45°$$

$$AB = \frac{BC}{\sin 45°} = \frac{1}{\sin 45°} = 1.4142 \text{ m}$$

Total travel, $OA + AB = 1 + 1.4142$ m $= 2.414$ m

Q.11 Match the following products with the suitable manufacturing process

P	Toothpaste tube	1	Centrifugal casting
Q	Metallic pipes	2	Blow moulding
R	Plastic bottles	3	Rolling
S	Threaded bolts	4	Impact extrusion

(a) P-4, Q-3, R-1, S-2
(b) P-2, Q-1, R-3, S-4
(c) P-4, Q-1, R-2, S-3
(d) P-1, Q-3, R-4, S-2

Ans. (c)

Q.12 Select the correct statement for 50% reaction stage in a steam turbine.

(a) The rotor blade is symmetric
(b) The stator blade is symmetric
(c) The absolute inlet flow angle is equal to absolute exit flow angle
(d) The absolute exit flow angle is equal to inlet angle of rotor blade.

Ans. (d)

Q.13 The divergence of the vector field $\vec{u} = e^x\left(\cos y\hat{i} + \sin y\hat{j}\right)$ is

(a) 0
(b) e^x cosy + e^xsin y
(c) $2e^x$ cos y
(d) 2 e^x sin y

Ans. (c)

$$\vec{u} = e^x\cos y\hat{i} + e^x\cdot\sin y\hat{j}$$

$$\nabla\cdot\vec{u} = \frac{\partial}{\partial x}(u_1) + \frac{\partial}{\partial y}(u_2)$$

$$= \frac{\partial}{\partial x}\left(e^x\cdot\cos y\right) + \frac{\partial}{\partial y}\left(e^x\cdot\sin y\right)$$

$$= e^x\cos y + e^x\cos y$$

$$\nabla\cdot\vec{u} = 2e^x\cdot\cos y$$

Q.14 A local tyre distributor expects to sell approximately 9600 steel belted radial tyres next year. Annual carrying cost is Rs. 16 per tyre and ordering is Rs. 75. The economic order quantity of the tyres is

(a) 64
(b) 212
(c) 300
(d) 1200

Ans. (300)

$D = 9600$
C_h = Rs. 16/year
C_0 = Rs. 75/order

$$EOQ = \sqrt{\frac{2DC}{C_h}} = \sqrt{\frac{2\times 9600\times 75}{16}}$$

$$= \sqrt{1200\times 75} = 300$$

Q.15 For an ideal gas with constant properties undergoing a quasi-static process, which one of the following represents the change of entropy (Δs) from state 1 to 2?

(a) $\Delta s = C_p\ln\left(\frac{T_2}{T_1}\right) - R\ln\left(\frac{P_2}{P_1}\right)$
(b) $\Delta s = C_v\ln\left(\frac{T_2}{T_1}\right) - C_p\ln\left(\frac{V_2}{V_1}\right)$
(c) $\Delta s = C_p\ln\left(\frac{T_2}{T_1}\right) - C_v\ln\left(\frac{P_2}{P_1}\right)$
(d) $\Delta s = C_v\ln\left(\frac{T_2}{T_1}\right) + R\ln\left(\frac{V_1}{V_2}\right)$

Ans. (a)

Q.16 During solidification of a pure molten metal, the grains in the casting near the mould wall are

(a) coarse and randomly oriented
(b) fine and randomly oriented
(c) fine and ordered
(d) coarse and ordered

Ans. (b)

During solidifiction of pure metal at the surface of the mould due to fast rate of solidification randomly oriented fine grains are produced.

Q.17 Fatigue life of a material for a fully reversed loading condition is estimated from

$$\sigma_a = 1100\,N^{-0.15}$$

where σ_a is the stress amplitude in MPa and N is the failure life in cycles. The maximum allowable stress amplitude (in MPa) for a life of 1×10^5 cycles under the same loading condition is ________ (correction to two decimal places).

Ans. (195.61)

$$\frac{\sigma_{max} - \sigma_{min}}{2} = 1100\,N^{-0.15}$$

$$\frac{\sigma_{max} - (-\sigma_{max})}{2} = 1100\,N^{-0.15}$$

$$\frac{2\sigma_{max}}{2} = 1100\,N^{-0.15}$$

$$\sigma_{max} = 1100\,N^{-0.15} = 1100 \times (10^5)^{-0.15}$$

$$= 1100 \times (10)^{-0.75} = \frac{1100}{5.62}$$

$$\sigma_{max} = 195.61 \text{ MPa}$$

Q.18 Feed rate in slab milling operation is equal to

(a) rotation per minute (rpm)
(b) product of rpm and number of teeth in the cutter
(c) product of rpm, feed per tooth and number of teeth in the cutter
(d) product of rpm, feed per tooth and number of teeth in contact

Ans. (c)

Feed = FZN

F → Feed; Z → No. of teeth in the cutter; N → rpm

Feed rate in slab milling operation = f_m

$$f_m = f_t Z N$$

where, f_t = feed per tooth

Z = number of teeth in cutter

N = rpm

Q.19 Metal removal in electric discharge machining takes place through

(a) ion displacement
(b) melting and vaporization
(c) corrosive reaction
(d) plastic shear

Ans. (b)

In EDM, electric spark is the source due to which material undergoes fusion and vaporization.

Q.20 If y is the solution of the differential equation

$$y^3\frac{dy}{dx} + x^3 = 0,$$
$$y(0) = 1$$

the value of $y(-1)$ is

(a) –2
(b) –1
(c) 0
(d) 1

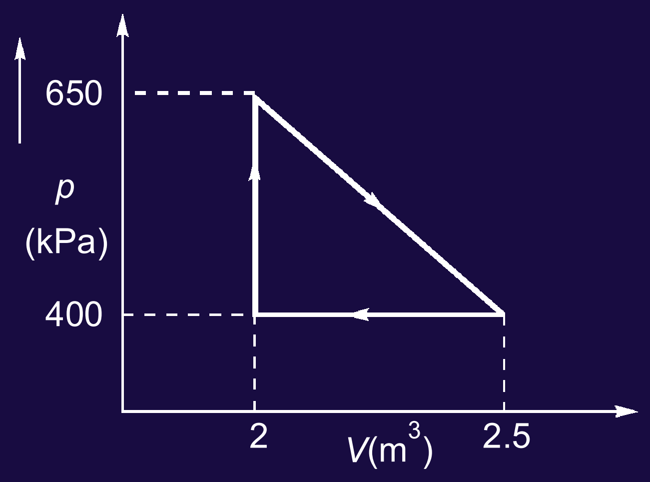
Ans. (c)

$$y^3\frac{dy}{dx} = -x^3$$
$$y^3 dy = -x^3\ dx$$
$$\int y^3 dy = -\int x^3 dx$$
$$\frac{y^4}{4} = \frac{-x^4}{4} + C$$
$$\frac{x^4 + y^4}{4} = C$$
$$y(0) = 1,$$
$$\frac{0+1}{4} = C$$
$$C = \frac{1}{4}$$
$$x^4 + y^4 = 1$$
$$y^4 = 1 - x^4$$
$$y = \sqrt[4]{1-x^4}$$

When, $x = -1$

$$y = 0$$

Q.21 An engine operates on the reversible cycles as shown in the figure. The work output from the engine (in kJ/cycle) is ________ (correct to two decimal places).



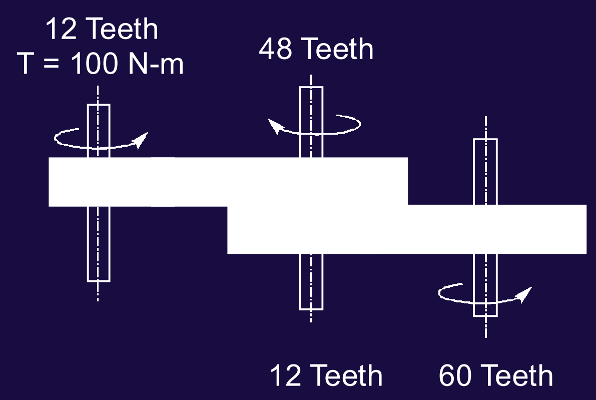
Ans. (62.5)

Work output = Area endosed on *pr* diagram

$$= \frac{1}{2}(2.5-2)\times(650-400)$$

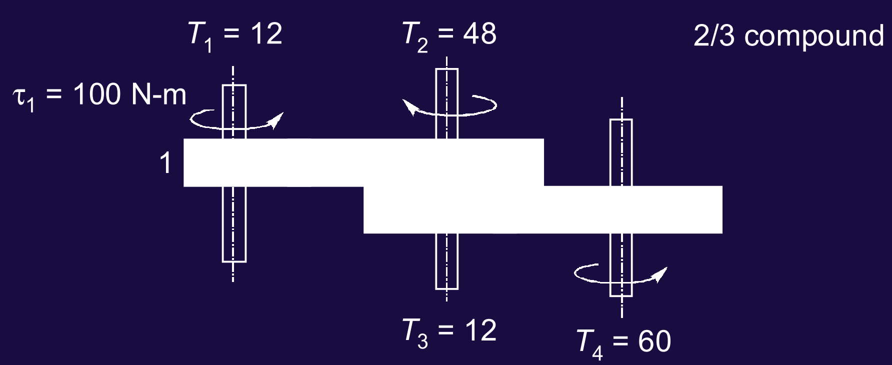
$$= 62.5 \text{ (kJ/cycle)}$$

Q.22 A frictionless gear train is shown in the figure. The leftmost 12-teeth gear is given a torque of 100 N-m. The output torque from the 60-teeth gear on the right in N-m is



(a) 5
(b) 20
(c) 500
(d) 2000

Ans. (d)



$$\tau_1 = 100 \text{ Nm}$$

Let speed of 1 is N_1

(1, 2): $N_2 = N_1 \times \frac{T_1}{T_2} = N_1 \times \frac{12}{48} = \frac{N_1}{4}$

$$N_3 = N_2 = \frac{N_1}{4}$$

(3, 4):

$$N_4 = N_3 \times \frac{T_3}{T_4} = \frac{N_1}{4} \times \frac{12}{60}$$

$$N_4 = \frac{N_1}{20}$$

By Power conservation

(Assume η (efficiency) = 1)

$$\tau_1 \times N_1 = \tau_4 \times N_4$$

$$100 \times N_1 = \tau_4 \times \frac{N_1}{20}$$

$$\tau_4 = 2000 \text{ N-m}$$

Q.23 The peak wavelength of radiation emitted by a black body at a temperature of 2000 K is 1.45 μm. If the peak wavelength of emitted radiation changes to 2.90 μm, then the temperature (in K) of the black body is

(a) 500 (b) 1000

(c) 4000 (d) 8000

Ans. (b)

From Wein's displacement law

For black body,

$$\lambda_M T = \text{constant}$$

$$\lambda_{M1} T_1 = \lambda_{M2} T_2$$

$$1.45 \times 2000 = \lambda_{M2} T_2 = 2.90 \times T_2$$

$$\therefore \quad T_2 = \left(\frac{1.45}{2.90} \times 2000\right) = 1000 \text{ K}$$

Q.24 If $A = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 4 & 5 \\ 0 & 0 & 1 \end{bmatrix}$ then $\det(A^{-1})$ is ________ (correct to two decimal places).

Ans. (0.25)

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 4 & 5 \\ 0 & 0 & 1 \end{bmatrix}$$

$$|A| = 4$$

$$|A^{-1}| = \frac{1}{|A|} = \frac{1}{4}$$

Q.25 Denoting L as liquid and M as solid in a phase-diagram with the subscripts representing different phases, a *eutectoid* reaction is described by

(a) $M_1 \to M_2 + M_3$
(b) $L_1 \to M_1 + M_2$
(c) $L_1 \to M_1 + M_2$
(d) $M_1 + M_2 \to M_3$

Ans. (a)

$$\underset{\gamma\text{ - iron}}{M_1} \to \underset{\alpha\text{ - ferrite}}{M_2} + \underset{\text{cementite }(Fe_3C)}{M_3}$$

Q.26 A circular hole of 25 mm diameter and depth of 20 mm is machined by EDM process. The material removal rate (in mm^3/min) is expressed as $4 \times 10^4\, IT^{-1.23}$ where I = 300 A and the melting point of the material, T = 1600° C. The time (in minutes) for machining this hole is _______ (correct to two decimal places).

Ans. (7.1431)

$$\text{MRR} = 4 \times 10^4\ \text{I}T^{-1.23}\ \text{mm}^3/\text{min}$$

Volume required to remove

$$= \frac{\pi}{4}D^2L = \frac{\pi}{4}\times 25^2 \times 20$$
$$= 9817.477\ \text{mm}^3$$

Now,
$$\text{MRR} = 4 \times 10^4 \times I \times T^{-1.23}$$
$$= 4 \times 10^4 \times 300 \times (1600)^{-1.23}$$
$$= 3 \times 4 \times 10^6 \times (1600)^{-1.23}$$
$$= 1374.40\ \text{mm}^3/\text{min}$$

$$\text{Time required} = \frac{9817.477}{1374.4}$$
$$= 7.1431\ \text{min.}$$

Q.27 Taylor's tool life equation is used to estimate the life of a batch of identical HSS twist drills by drilling through holes at constant feed in 20 mm thick mild steel plates. In test 1, a drill lasted 300 holes at 150 rpm while in test 2, another drill lasted 200 holes at 300 rpm. The maximum number of holes that can be made by another drill from the above batch at 200 rpm is _______ (correct to two decimal places).

Ans. (253.53)

Time required for drilling a hole

$$t = \frac{L}{fN}$$

Here 'L' const. 'f' const, N is variable.

$$V_1 = \pi D \times 150\ \text{m/min}$$

$$T_1 = 300 \times \frac{L}{f \times 150}\text{min}$$

$$V_2 = \pi D \times 300 \text{ min}$$

$$T_2 = 200 \times \frac{L}{f \times 300} \text{min}$$

$$V_3 = \pi D \times 200 \text{ min}$$

$$T_3 = x \times \frac{L}{f \times 200} \text{min} \qquad \text{[No. of hole is '}x\text{']}$$

$$V_1 T_1^n = V_2 T_2^n$$

$$\pi D \times 150 \times \left(300 \times \frac{L}{f \times 150}\right)^n = \pi D \times 300 \times \left(200 \times \frac{L}{f \times 300}\right)^n$$

or,
$$2^n = 2\left(\frac{2}{3}\right)^n$$

or,
$$3^n = 2$$

$$n = 0.63093$$

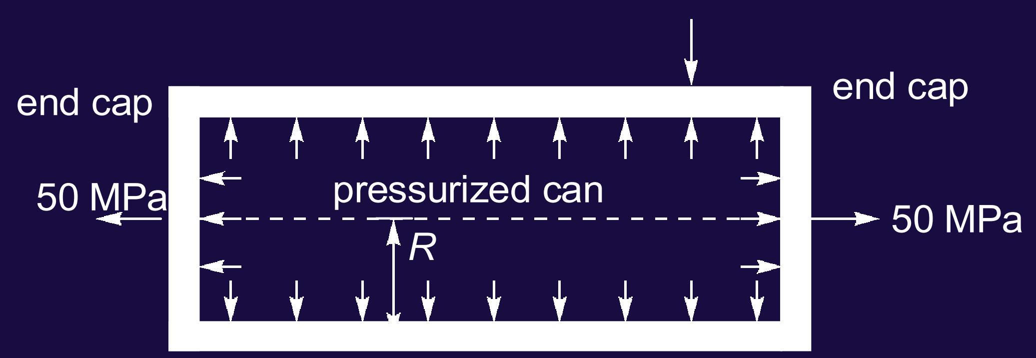
$$V_1 T_1^n = V_3 T_3^n$$

$$\pi D \times 150 \times \left(300 \times \frac{L}{f \times 150}\right)^{0.63093} = \pi D \times 200 \times \left(x \times \frac{L}{f \times 200}\right)^{0.63093}$$

$$3 \times 2^{0.63093} = 4 \times \left(\frac{x}{200}\right)^{0.63093}$$

$\Rightarrow$
$$x = 253.53$$

Q.28 A thin-walled cylindrical can with rigid end caps has a mean radius R = 100 mm and a wall thickness of t = 5 mm. The can is pressurized and an additional tensile stress of 50 MPa is imposed along the axial direction as shown in the figure. Assume that the state of stress in the wall is uniform along its length. If the magnitudes of axial and circumferential components of stress in the can are equal, the pressure (in MPa) inside the can is __________ (correct to two decimal places).



Ans. (5)

$$\text{Circumferential stress, } \sigma_n = \frac{PR}{t}$$

$$\text{Axial stress, } \sigma_L = \frac{PR}{2t} + 50 \text{ MPa}$$

Now,
$$\sigma_n = \sigma_L$$

$$\frac{PR}{t} = \frac{PR}{2t} + 50 \text{ MPa}$$

$$\therefore \quad \frac{PR}{2t} = 50 \text{ MPa}$$

$$P = \frac{50 \times 2 \times 5}{100} = 5 \text{ MPa}$$

Q.29 Let X_1 and X_2 be two independent exponentially distributed random variables with means 0.5 and 0.25 respectively. Then $Y = \min(X_1, X_2)$ is

(a) exponentially distributed with mean $\frac{1}{6}$

(b) exponentially distributed with mean 2

(c) normally distributed with mean $\frac{3}{4}$

(d) normally distributed with mean $\frac{1}{6}$

Ans. (a)

$$\text{Mean } (x_1) = 0.5$$

$$\frac{1}{\lambda_1} = 0.5$$

$$\lambda_1 = \frac{1}{0.5} = 2$$

$$\text{Mean } (x_2) = 0.25$$

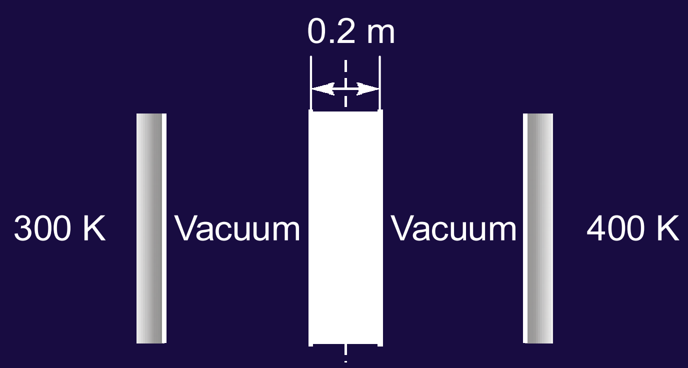
$$\frac{1}{\lambda_2} = 0.25$$

$$\lambda_2 = \frac{1}{0.25} = 4$$

$$y = \text{mean } (x_1, x_2)$$

$$\text{Mean } (y) = \frac{1}{\lambda_1 + \lambda_2} = \frac{1}{2+4} = \frac{1}{6}$$

Q.30 A 0.2 m thick infinite black plate having a thermal conductivity of 3.96 W/m-K is exposed to two infinite black surfaces at 300 K and 400 K as shown in the figure. At steady state the surface temperature of the plate facing the cold side is 350 K. The value of Stefan-Boltzmann constant σ is 5.67×10^{-8} W/m^2 K^4. Assuming 1-D heat conduction, the magnitude of heat flux through the plate (in W/m^2) is ________ (correct to two decimal places).



Ans. (391.61)

Under steady state condition, all rate of heat transfer i.e. from surface at 400 K to black plate (via radiation), inside black plate (via conduction) and from black plate to surface at 300 K (via radiation) are equal.

So, heat flux through wall = flux from wall to surface at 300 K

$$= \frac{\sigma(350^4 - 300^4)}{\frac{1}{1} + \frac{1}{1} - 1} = 391.612 \text{ watt/m}^2$$

Q.31 For a position vector $r = x\hat{i} + y\hat{j} + z\hat{k}$ the norm of the vector can be defined as $|\vec{r}| = \sqrt{x^2 + y^2 + z^2}$. Given a function $\phi = \ln|\vec{r}|$, its gradient $\nabla\phi$ is

(a) $\vec{r}$

(b) $\dfrac{\vec{r}}{|\vec{r}|}$

(c) $\dfrac{\vec{r}}{\vec{r} \cdot \vec{r}}$

(d) $\dfrac{\vec{r}}{|\vec{r}|^3}$

Ans. (c)

$$\phi = \ln r$$

$$\nabla\phi = \nabla(\ln r)$$

$$f(r) = \ln(r)$$

$$f'(r) = \frac{1}{r}$$

$$\nabla f(r) = \frac{f'(r)}{r} \cdot \vec{r} = \left(\frac{1}{r}\right) \times \left(\frac{1}{r}\right) \cdot \vec{r}$$

$$\nabla f(r) = \frac{\vec{r}}{r^2}$$

Q.32 Following data correspond to an orthogonal Turning of a 100 mm diameter rod on a lathe. Rake angle: +15°; Uncut chip thickness 0.5 mm, nominal chip thickness after the cut 1.25 mm. The shear angle (in degrees) for this process is _______ (correct to two decimal places).

Ans. (23.32)

$$\alpha = 15^\circ$$
$$t = 0.5 \text{ mm}$$
$$t_c = 1.25 \text{ mm}$$
$$r = \frac{t}{t_c} = \frac{0.5}{1.25} = 0.4$$
$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.4\cos 15}{1 - 0.4\sin 15}$$
$$\phi = 23.3155^\circ \approx 23.32^\circ$$

Q.33 A test is conducted on a one-fifth scale model of a Francis turbine under a head of 2 m and volumetric flow rate of 1 m^3/s at 450 rpm. Take the water density and the acceleration due to gravity as 10^3 kg/m^3 and 10 m/s^2, respectively. Assume no losses both in model and prototype turbines. The power (in MW) of a full sized turbine while working under a head of 30 m is ________ (correct to two decimal places).

Ans. (29.05)

$$\frac{D_m}{D_p} = \frac{1}{5}$$

Model	Prototype
$H = 2$ m	$H = 30$ m
$Q = 1$ m^3/s	$P = ?$
$N = 450$ rpm	
$\rho = 1000$ kg/m^3	
$g = 10$ m/s^2	

For model

$$\rho_m = \rho_g QH$$
$$= 1000 \times 10 \times 1 \times 2 = 20 \text{ kW}$$

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

$$N_P = \sqrt{\frac{H_P}{H_M}} \times \frac{D_M}{D_P} \times N_M$$

$$= \sqrt{\frac{30}{2}} \times \frac{1}{5} \times 450 = 348.56 \text{ rpm}$$

$$\left.\frac{P}{D^5N^3}\right|_P = \left.\frac{P}{D^5N^3}\right|_M$$

$$P_P = P_M \times \frac{D_P^5}{D_M^5} \times \frac{N_P^3}{N_M^3}$$

$$P_P = 20 \times 5^5 \times \frac{348.56^3}{450^3}$$

$$P_P = 29.05 \text{ MW}$$

Q.34 A steel wire is drawn from an initial diameter (d_1) of 10 mm to a final diameter (d_f) of7.5 mm. The half cone angle (α) of the die is 5° and the coefficient of friction (μ) between the die and the wire is 0.1. The average of the initial and final yield stress $[(\sigma_Y)_{avg}]$ is 350 MPa. The equation for drawing stress σ_f. (in MPa) is given as:

$$\sigma_f = (\sigma_Y)_{avg}\left\{1+\frac{1}{\mu\cot\alpha}\right\}\left[1-\left(\frac{d_f}{d_i}\right)^{2\mu\cot\alpha}\right]$$

The drawing stress (in MPa) required to carry out this operation is _______ (correct to two decimal places).

Ans. (316.25)

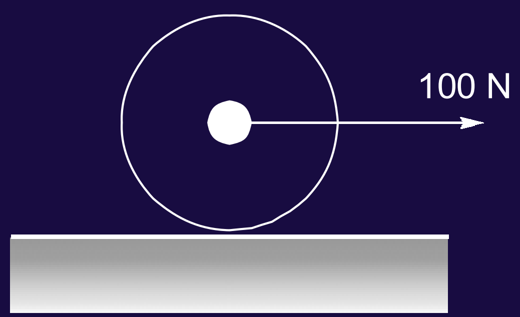
$$d_i = 10 \text{ mm}$$
$$d_f = 7.5 \text{ mm}$$
$$\alpha = 5^\circ$$
$$\mu = 0.1$$
$$(\sigma y)_{avg} = 350 \text{ MPa}$$

$$\sigma_f = (\sigma_y)_{avg} \times \left\{1+\frac{1}{\mu\cot\alpha}\right\}\left[1-\left(\frac{d_f}{d_i}\right)^{2\mu\cot\alpha}\right]$$

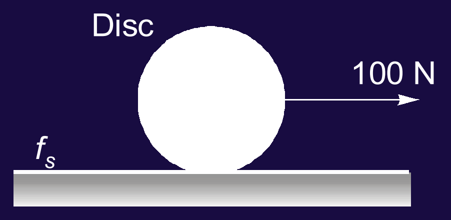
$$= 350 \times \left[1+\frac{1}{0.1\cot 5}\right]\left[1-\left(\frac{7.5}{10}\right)^{2\times 0.1\times\cot 5}\right]$$

$$= 316.2472 \text{ MPa} \approx 316.25 \text{ MPa}$$

Q.35 A force of 100 N is applied to the centre of a circular disc, of mass 10 kg and radius 1 m, resting an a floor as shown in the figure. If the disc rolls without slipping on the floor, the linear acceleration (in m/s^2) of the centre of the disc is _______ (correct to two decimal places).



Ans. (6.666)



$$m = 10 \text{ kg}, \; R = 1 \text{ m}$$

$$I = \frac{mR^2}{2} = \frac{m \times 1^2}{2} = \frac{m}{2}$$

$$100 - f_s = m_a$$

$$100 - f_s = 10\,a \qquad \text{...(i)}$$

$$f_s \times R = I\alpha$$

$$f_s \times 1 = \frac{m}{2} \times \alpha$$

$$f_s = \frac{m}{2} \times a \qquad \begin{bmatrix} a = R\alpha = 1 \times \alpha \\ a = \alpha \end{bmatrix}$$

$$f_s = \frac{ma}{2} \qquad \text{...(ii)}$$

By (i) and (ii): $100 - \frac{ma}{2} = 10a$

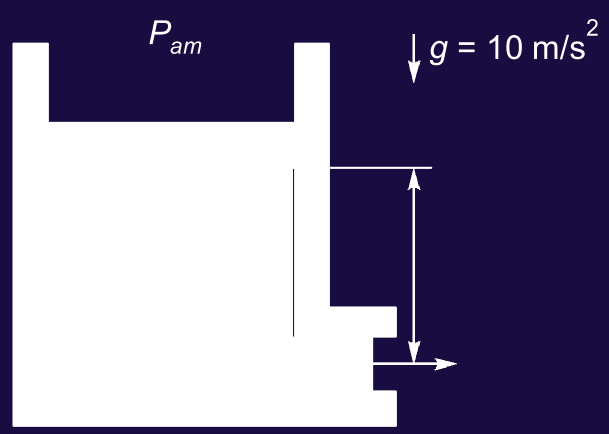
$$100 - \frac{10 \times a}{2} = 10a$$

$$100 - 5a = 10a$$

$$15a = 100$$

$$a = \frac{100}{15} = 6.666 \text{ m/s}^2$$

Q.36 A frictionless circular piston of area 10^{-2} m^2 and mass 100 kg sinks into a cylindrical container of the same area filled with water of density 1000 kg/m^3 as shown in the figure. The container has a hole of area 10^{-3} m^2 at the bottom that is open to the atmosphere. Assuming there is no leakage from the edges of the piston and considering water to be incompressible, the magnitude of the piston velocity (in m/s) at the instant shown is _______ (correct to three decimal places).

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Ans. (1.456)

$$A_1V_1 = A_2V_2$$

$$V_2 = \left(\frac{A_1}{A_2}\right)V_1$$

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1 = \frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2$$

$$\left[\frac{P_{atm}+\frac{100\times 10}{10^{-2}}}{\rho\times g}\right]\times\frac{V_1^2}{2g}+0.5 = \frac{P_{atm}}{\rho g}+\frac{A_1^2}{A_2^2}\times\frac{V_1^2}{2g}$$

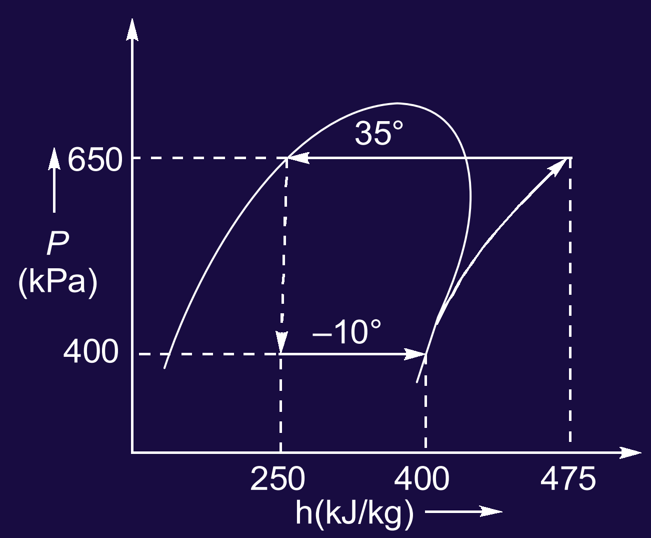
$$\frac{1000}{10^{-2}\times 100\times 10}+0.5 = \left(\frac{A_1^2}{A_2^2}-1\right)\frac{V_1^2}{2g}$$

$$10 + 0.5 = (10^2-1)\frac{V_1^2}{2g}$$

$$V_1^2 = \frac{10.5\times 2\times 10}{99} = 2.12$$

$$V_1 = 1.456 \text{ m/s}$$

Q.37 A standard vapor compression refrigeration cycle operating with a condensing temperature of 35° C and an evaporating temperature of –10° C develops 15 kW of cooling. The p-h diagram shows the enthalpies at various states. If the isentropic efficiency of the compressor is 0.75, the magnitude of compressor power (in kW) is _______ (correct to two decimal places).



Ans. (10)

$$RC = 15 \text{ kW}$$

$$RC = \dot{m}\times(h_1-h_4)$$

$$15 = \dot{m}\times(400-250)$$

$$\dot{m} = 0.1 \text{ kg/sec}$$

$$\omega_{isentropic} = (h_2-h_1) = (475-400) = 75 \text{ kJ/kg}$$

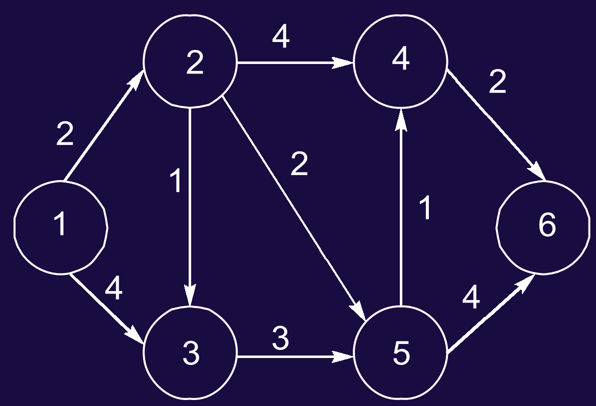
$$\eta_C = \frac{\omega_{isentropic}}{\omega_{actual}}$$

$$\omega_{actual} = \frac{75}{0.75} = 100 \text{ kJ/kg}$$

$$\omega_{actual} = \dot{m} \times \omega_{actual} = 0.1 \times 100$$

$$P_{\dot{m}} = 10 \text{ kW}$$

Q.38 The arc lengths of a directed graph of a project are as shown in the figure. The shortest path length from node 1 to node 6 is ________ .



Ans. (7)

Shortest path is

$$1 \xrightarrow{2} 2 \xrightarrow{2} 5 \xrightarrow{1} 4 \xrightarrow{2} 6$$

Shortest length = 7

It is the problem of shortest path which will be 7.

In this question do not confuse with critical path. Examinar ask shortest path. Critical path is the longest path which is not asked in this question.

Q.39 For sand-casting a steel rectangular plate with dimensions 80 mm × 120 mm × 20 mm, a cylindrical riser has to be designed. The height of the riser is equal to its diameter. The total solidification time for the casting is 2 minutes. In Chvorinov's law for the estimation of the total solidification time, exponent is to be taken as 2. For a solidification time of 3 minutes in the riser, the diameter (in mm) of the riser is ________ (correct to two decimal places).

Ans. (51.84)

casting size = 80 × 120 × 20 mm

$(t_s)_{casting} = 2$ min

$(t_s)_{riser} = 3$ min

Riser, $h = d$, $\quad (t_s)_{casting} = k\left(\frac{V}{A}\right)^2$

$$2 = k\left(\frac{80 \times 120 \times 20}{2(80 \times 120 + 120 \times 20 + 20 \times 80)}\right)^2$$

$$k = 0.040138 \text{ min/mm}^2$$

Riser : $$(t_s)_{riser} = k\left(\frac{V}{A}\right)^2$$

$$3 = 0.040138\left(\frac{V}{A}\right)^2$$

$$\left(\frac{V}{A}\right) = 8.64$$

$$\frac{d}{6} = 8.64$$

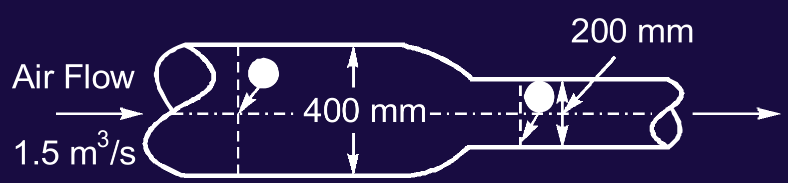
Riser if $h = d$ then $\frac{V}{A} = \frac{d}{6}$

$$\frac{V}{A} = \frac{\frac{\pi}{4}d^2h}{2\frac{\pi}{4}d^2 + \pi dh}$$

If $h = d$, then $\left(\frac{V}{A}\right) = \frac{d}{6}$

$$h = d = 51.84 \text{ mm}$$

Q.40 Air flows at the rate of 1.5 m^3/s through a horizontal pipe with a gradually reducing cross-section as shown in the figure. The two cross-sections of the pipe have diameters of 400 mm and 200 mm. Take the air density as 1.2 kg/m^3 arid assume inviscid incompressible flow. The change in pressure $(p_2 - p_1)$ (in kPa) between sections 1 and 2 is



(a) –1.28 (b) 2.56
(c) –2.13 (d) 1.28

Ans. (a)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 \qquad \{Z = \text{constant}\}$$

$$A_1 = \frac{\pi}{4} \times 0.4^2$$

$$A_1 = 0.1256 \text{ m}^2$$

$$A_2 = \frac{\pi}{4} \times 0.2^2$$

$$A2 = 0.0314 \text{ m}^2$$

$$\frac{P_2 - P_1}{\rho g} = \frac{V_1^2 - V_2^2}{2g}$$

$$\frac{P_2 - P_1}{1.2} = \frac{1}{2}\left[\frac{Q^2}{A_1^2} - \frac{Q^2}{A_2^2}\right]$$

$$P_2 - P_1 = 0.6 \times (1.5)^2 \left[\frac{1}{A_1^2} - \frac{1}{A_2^2}\right]$$

$$P_2 - P_1 = 1.35\left[\frac{1}{0.01577} - \frac{1}{0.00985}\right]$$

$$= 1.35[63.41 - 1015.22]$$

$$= -1284.94 = -1.28 \text{ kPa}$$

Q.41 A vehicle powered by a spark ignition engine follows air standard Otto cycle ($\gamma = 1.4$). The engine generates 70 kW while consuming 10.3 kg/hr of fuel. The calorific value of fuel is 44.000 kJ/kg. The compression ratio is _______ (correct to two decimal places).

Ans. (7.61)

$$\gamma = 1.4$$

$$B.P. = 70 \text{ kN}$$

$$\dot{m}_f = 10.3 \text{ kg/hr}$$

$$CV = 44000 \text{ kJ/kg}$$

$$\eta = \frac{B.P.}{\dot{m}_f \times CV} = \frac{70}{\frac{10.3}{3600} \times 44000} \times 100\%$$

$$\eta = 0.556$$

$$\eta_{otto} = 1 - \frac{1}{(n)^{\gamma - 1}} = 0.556$$

$$\Rightarrow \quad 1 - \frac{1}{(n)^{1.4-1}} = 0.556$$

$$\frac{1}{(n)^{0.4}} = 0.4439$$

$$n = 7.61$$

Q.42 Ambient air is at a pressure of 100 kPa, dry bulb temperature of 30° C and 60% relative humidity, The saturation pressure of water at 30° C is 4.24 kPa. The specific humidity of air (in g/kg of dry air) is ________ (correct to two decimal places).

Ans. (16.24)

$$P_{atm} = 100 \text{ kPa}$$

$$DBT = t = 30°C \rightarrow P_{vs} = 4.24 \text{ kPa}$$

$$\phi = 60\%$$

$$\phi = \frac{P_v}{P_{vs}} \Rightarrow 0.6 = \frac{P_v}{4.24}$$

$$P_V = 2.544 \text{ kPa}$$

$$W = 0.622 \times \frac{P_v}{P_{atm} - P_v}$$

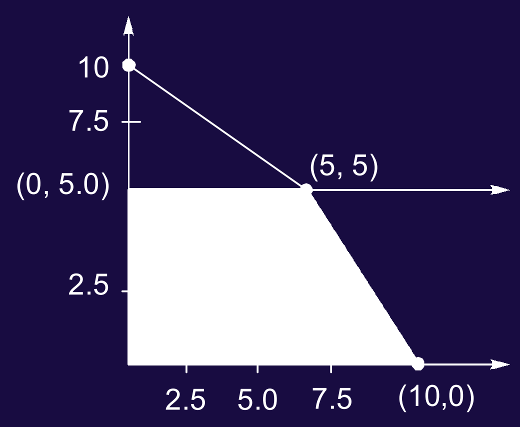
$$W = 0.622 \times \frac{2.544}{100 - 2.544}$$

$W = 16.24$ gram/kg of dry Air

Q.43 The problem of maximizing $z = x_1 - x_2$ subject to constrains $x_1 + x_2 \le 10$, $x_1 \ge 0$, $x_2 \ge 0$ and $x_2 \le 5$ has

(a) no solution
(b) one solution
(c) two solutions
(d) more than two solutions

Ans. **(b)**



Max., $Z = x_1 - x_2$

Constratins : $x_1 + x_2 \le 10$;

$x_1 \ge 0$; $x_2 \ge 0$ and $x_2 \le 5$

$Z(0, 5) = 0 - 5 = -5$

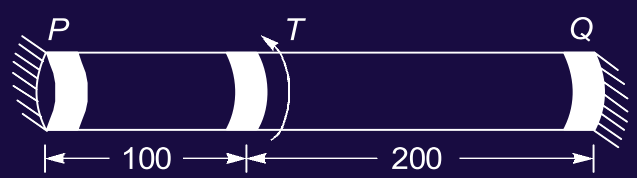
$Z(5, 5) = 5 - 5 = 0$

$Z(10, 0) = 10 - 0 = 10$

$Z_{max} = 10$ at $(10, 0)$

$\therefore$ The problem has one solution

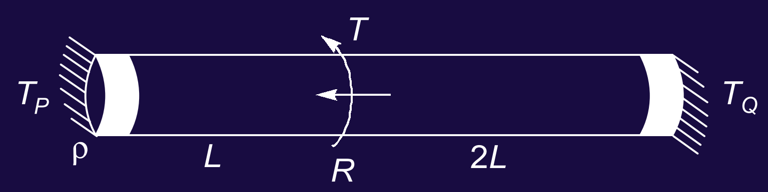
Q.44 A bar of circular cross section is clamped at ends P and Q as shown in the figure. A torsional moment $T = 150$ Nm is applied at a distance of 100 mm from end P. The torsional reactions (Tp, Tq) in Nm at the ends P and Q respectively are



(All dimensions are in mm)

(a) (50, 100)
(b) (75, 75)
(c) (100, 50)
(d) (120, 30)

Ans. (c)



$$T_P + T_Q = T \qquad \ldots(i)$$

$$\theta_{PR} + \theta_{RQ} = 0$$

$$\frac{T_P \cdot L}{GI_P} + \frac{(T_P - T)2L}{GI_P} = 0$$

$$T_P + 2T_P = 2T$$

$$T_P = \frac{2T}{3} = 100 \text{ Nm}$$

From equation (i),

$$T_Q = \frac{T}{3} = 50 \text{ N-m}$$

Q.45 A welding operation is being performed with voltage = 30 V and current = 100 A. The cross-sectional area of the weld bead is 20 mm^2. The work-piece and filler are of titanium for which of the specific energy of melting is 14 J/mm^3. Assuming a thermal efficiency of the welding process 70%, the welding speed (in mm/s) is ________ (correct to two decimal places).

Ans. (7.5)

Welding speed (mm/s) = ?

$$\text{Effective power} = \eta_{th} \times (VI)$$

$$= 0.7 \times 30 \times 100 = 2100 \text{ J/S}$$

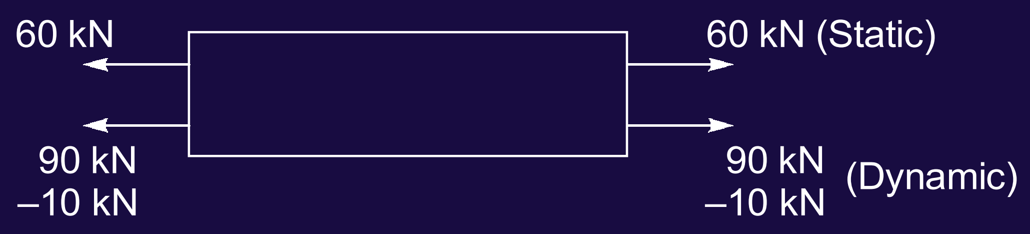
$$\text{Sp.engery} = \frac{\text{Power}}{A \times V}$$

$$V = \frac{\text{Power}}{\text{sp.energy} \times A}$$

$$= \frac{2100}{14 \times 20} = 7.5 \text{ mm/s}$$

Q.46 A bar is subjected to a combination of a steady load of 60 kN and a load fluctuating between –10 kN and 90 kN. The corrected endurance limit of the bar is 150 MPa. the yield strength of the material is 480 MPa and the ultimate strength of the material is 600 MPa. The bar cross-section is square with side *a*. If the factor of safety is 2, the value of a (in mm), according to the modified Goodman's criterion, is _______ (correct to two decimal places).

Ans. (31.62)



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

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

$$P_m = 100 \text{ kN}$$

$$Pa = 50 \text{ kN}$$

$$\sigma_m = \frac{100 \times 10^3}{a^2} \text{MPa}$$

$$\sigma_a = \frac{50 \times 10^3}{a^2} \text{MPa}$$

Solution by Goodman Equation,

$$\frac{\sigma_m}{S_{ut}} + \frac{\sigma_a}{\sigma_e} = \frac{1}{N}$$

$$100\left[\frac{100}{a^2 \times 600} + \frac{50}{150a^2}\right] = \frac{1}{2}$$

$$a^2 = 1000$$

$$a = 31.62 \text{ mm}$$

Solution by Langar equation,

$$\frac{\sigma_m}{S_{yt}} + \frac{\sigma_a}{S_{yt}} = \frac{1}{N}$$

$$100\left[\frac{100}{480a^2} + \frac{50}{480a^2}\right] = \frac{1}{2}$$

$$a^2 = 625$$

$$a = 25 \text{ mm}$$

Hence final answer by modified Goodman's Griterion is 31.62 mm.

Q.47 Given the ordinary differential equation

$$\frac{d^2y}{dx^2} + \frac{dy}{dx} - 6y = 0$$

with $y(0) = 0$ and $\frac{dy}{dx}(0) = 1$, the value of $y(1)$ is ________ (correct to two decimal places).

Ans. (1.4678)

$$(D^2 + D - 6)y = 0$$
$$y(0) = 0,$$
$$y'(0) = 1$$
$$(D + 3)(D - 2)y = 0$$
$$D = 2, -3$$
$$\text{C.F.} = C_1e^{2x} + C_2e^{-3x}$$
$$y = C_1e^{2x} + C_2e^{-3x}$$
$$y(0) = 0$$

So, $$0 = C_1 + C_2 \quad \text{...(i)}$$

$$\frac{dy}{dx} = 2C_1e^{2x} - 3C_2e^{-3x}$$
$$y'(0) = 1,$$
$$1 = 2C_1 - 3C_2 \quad \text{...(ii)}$$

From equation (i) and (ii),

$$C_1 = \frac{1}{5},$$
$$C_2 = \frac{-1}{5}$$
$$y = \frac{1}{5}e^{2x} - \frac{1}{5}e^{-3x}$$

When, $$x = 1$$

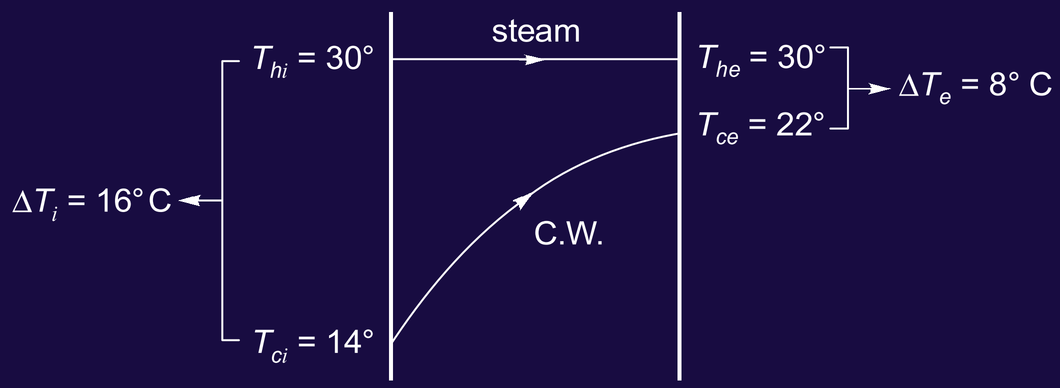
$$y(1) = \frac{e^2 - e^{-3}}{5} = 1.4678$$

Q.48 Steam in the condenser of a thermal power plant is to be condensed at a temperature of 30° C with cooling water which enters the tubes of the condenser at 14° C and exits at 22° C. The total surface area of the tubes is 50 m^2. and the overall heat transfer coefficient is 2000 W/m^2. The heat transfer (in MW) to the condenser is ________ (correct to two decimal places).

Ans. (1.154)

Since steam is condensing, the temperature of hot fluid remains constant.

∴ Temperature profiles of hot and cold fluids are



∴ $$\text{(LMTD) of } HE = \frac{\Delta T_i - \Delta T_e}{\ln\frac{\Delta T_i}{\Delta T_e}} = \frac{16-8}{\ln\left(\frac{16}{8}\right)} = 11.54°\text{ C}$$

Total heat transfer rate between steam

$$\text{C.W.} = Q = U\,A\,\text{LMTD W}$$
$$= 2000 \times 50 \times 11.54$$
$$= 11.54 \times 10^5 \text{ W}$$
$$= 1.154 \text{ MW}$$

Q.49 The true stress (in MPa) versus true strain relationship for a metal is given by

$$\sigma = 1020\,\varepsilon^{0.4}$$

The cross-sectional area at the start of a test (when the stress and strain values are equal to zero) is 100 mm^2. The cross-sectional area at the time of necking (in mm^2) is ________ (correct to two decimal places).

Ans. (67.032)

Given, $\sigma = 1020\,\varepsilon^{0.4}$

at UTS, $\varepsilon_T = n = 0.4$

at UTS, neak formation starts,

$$\varepsilon_T = 0.4 = \ln\left(\frac{A_0}{A_f}\right)$$

$$0.4 = \ln\left(\frac{100}{A_f}\right)$$

$$\frac{A_0}{A_f} = e^{0.4}$$

$$A_f = \frac{100}{e^{0.4}}$$

Cross-section area at the time of necking,

$$A_f = 67.032 \text{ mm}^2$$

Q.50 Let z be a complex variable. For a counterclockwise integration around a unit circle C, centered at origin.

$$\oint_c \frac{1}{5z-4}dz = A\pi i$$

the value of A is

(a) $\frac{2}{5}$ (b) $\frac{1}{2}$

(c) 2 (d) $\frac{4}{5}$

Ans. (a)

$$5z - 4 = 0$$

$$z = \frac{4}{5} \text{ lies inside circle,}$$

$$|z| = 1$$

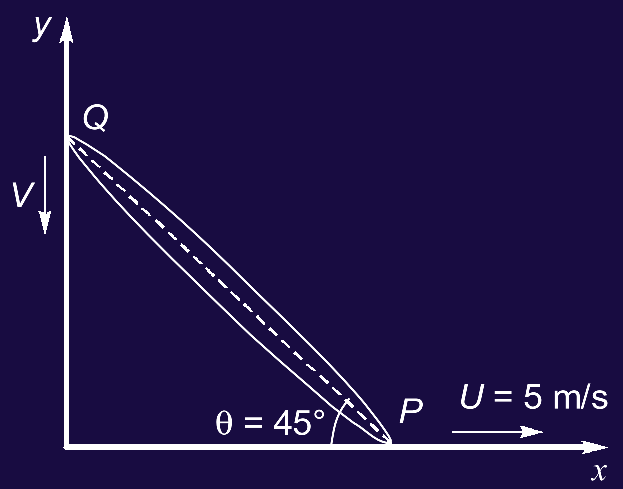
$$\int \frac{1}{(5z-4)}dz = A\pi i$$

$$\frac{1}{5}\int \frac{1}{\left(Z-\frac{4}{5}\right)}dz = A\pi i$$

$$\int \frac{\left(\frac{1}{5}\right)}{\left(Z-\frac{4}{5}\right)}dz = 2\pi i \cdot f\left(\frac{4}{5}\right) = 2\pi i \times \left(\frac{1}{5}\right) = \frac{2}{5}\pi i$$

$$A = \frac{2}{5} = 0.4$$

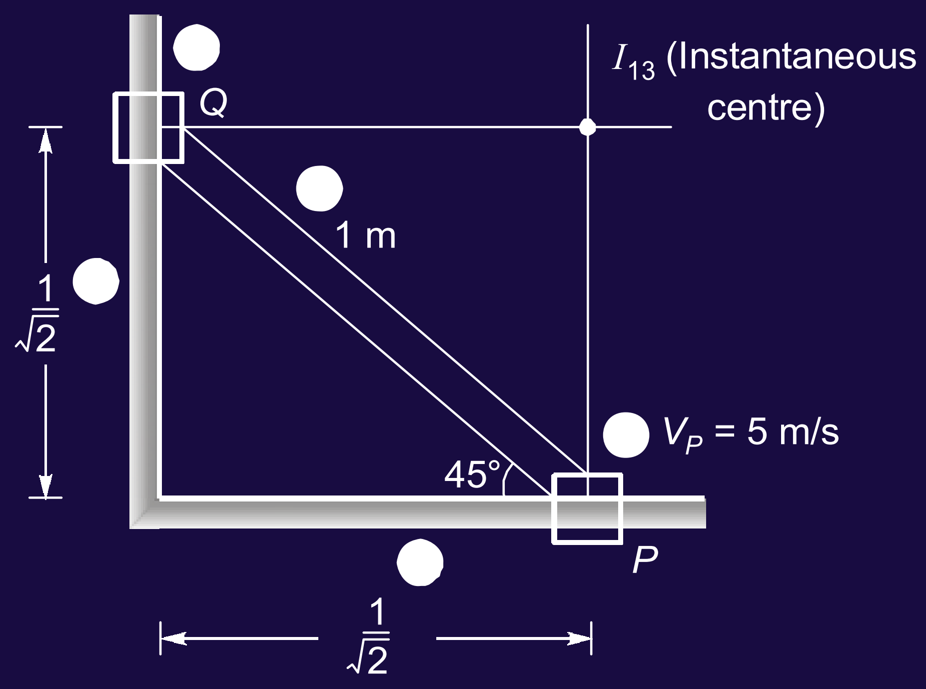
Q.51 A rigid rod of length 1 m is resting at an angle $\theta = 45°$ as shown in the figure. The end P is dragged with a velocity of $U = 5$ m/s to the right. At the instant shown, the magnitude of the velocity V (in m/s) of point Q as it moves along the wall without losing contact is



(a) 5 (b) 6

(c) 8 (d) 10

Ans. (a)



Treating like the elliptical trammeds.

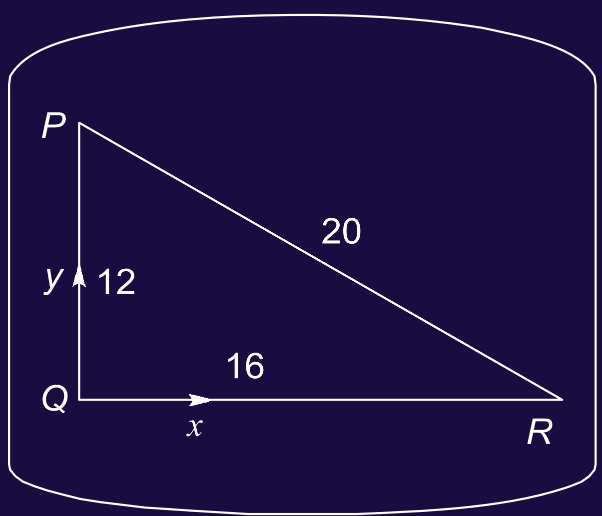
Rod motion (P, Q) (By sitting on I_{13})

$$\frac{V_P}{I_{13}P} = \frac{V_Q}{I_{13}Q}$$

$$\frac{5}{\left(\frac{1}{\sqrt{2}}\right)} = \frac{V_Q}{\left(\frac{1}{\sqrt{2}}\right)}$$

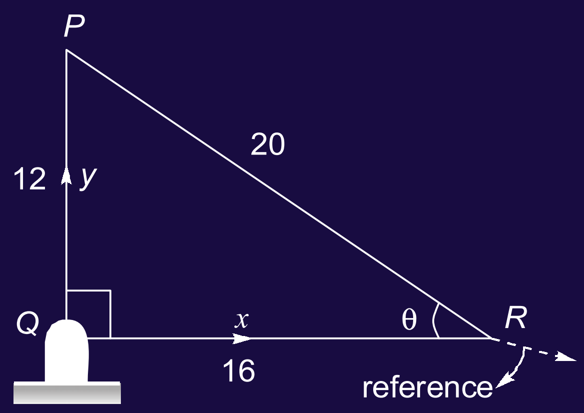
$$V_Q = 5 \text{ m/s}$$

Q.52 In a rigid body in plane motion, the point R is accelerating with respect to point P at $10\angle 180°$ m/s^2. If the instantaneous acceleration of point Q is zero, the acceleration (in m/s^2) of point R is



(a) $8\angle 233°$
(b) $10\angle 225°$
(c) $10\angle 217°$
(d) $8\angle 217°$

Ans. (d)



As acceleration of point Q is zero, so this rigion body PQR is hinged at Q.

$$\vec{a}_{RP} = \vec{a}_R - \vec{a}_P$$

is given 10 m/s^2 an angle of 180°, that means only radial acceleration is hence at that instant and reference is PR

$$a_{RP} = (RP)\omega^2 = 10$$

$\Rightarrow$ $$20\omega^2 = 10$$

$\Rightarrow$ $$\omega = \frac{1}{\sqrt{2}}$$

as α of whole body remains same so point R has only radial acceleration at that instant

$$a_R = QR(\omega^2)$$

$$= 16 \times \frac{1}{2} = 8 \text{ m/s}^2$$

and will be in the horizontal backward design, but our reference is only PR. So the angle of it from reference is $(180 + \theta)$

from ΔPQR $$\tan\theta = \frac{12}{16}$$

$\Rightarrow$ $$\theta = 36.8698°$$

So, $180 + 36.8698 = 216.8698 ; 217°$

So answer is $8\angle 217°$

Q.53 In a cam-follower, the follower rises by h as the cam rotates by δ (radians) at constant angular velocity ω (radians/s). The follower is uniformly accelerating during the first half of the rise period and it is uniformly decelerating in the latter half of the rise period. Assuming that the magnitudes of the acceleration and deceleration are same, the maximum velocity of the follower is

(a) $\frac{4h\omega}{\delta}$ (b) $h\omega$

(c) $\frac{2h\omega}{\delta}$ (d) $2\,h\omega$

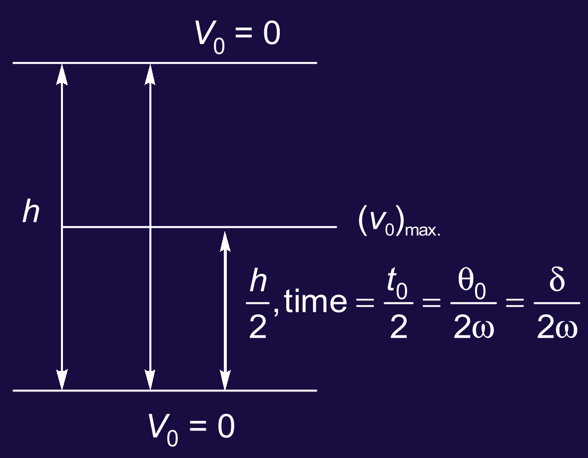
Ans. (c)

Here, outstroke angle

$$\theta_0 = \delta$$

and stroke length = h

angular velocity = ω



$$V = u + at$$

$$(V_0)_{max} = 0 + a \times \frac{t_0}{2} = a \times \frac{\delta}{2\omega} \qquad \text{. . . (i)}$$

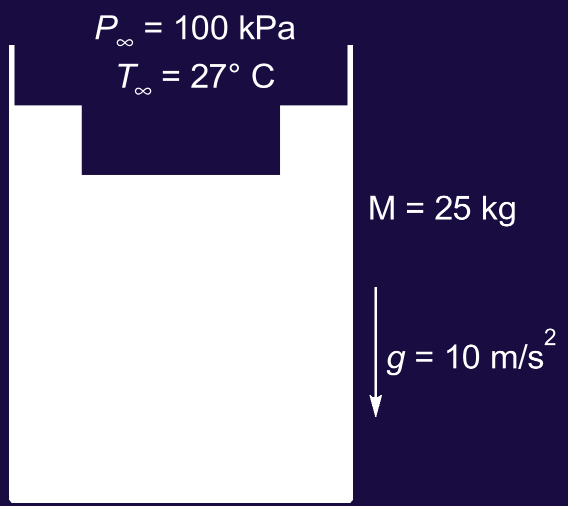
$$\frac{h}{2} = 0 + \frac{1}{2}a\left(\frac{t_0}{2}\right)^2$$

$$h = \frac{at_0^2}{4} = \frac{a\delta^2}{4\omega_2}$$

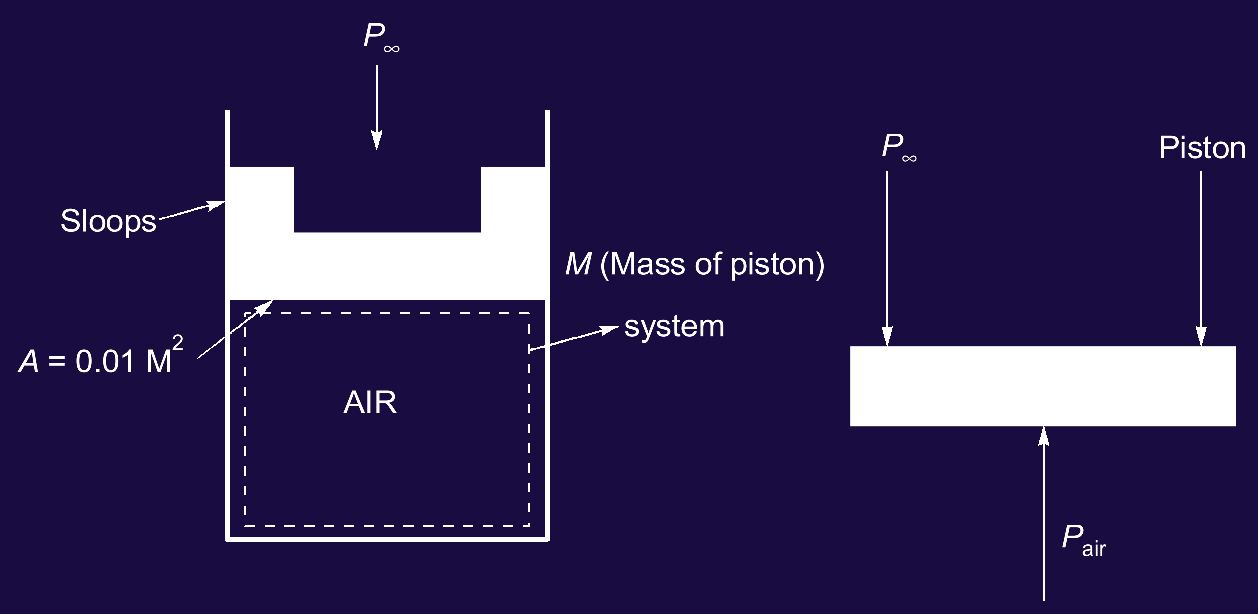
$$a = \frac{4\omega^2 . h}{\delta^2} \qquad \text{. . . (ii)}$$

By(i) and (ii), $(V_0)_{max} = \frac{a\delta}{2\omega} = \frac{4\omega^2 . h}{\delta^2} \times \frac{\delta}{2\omega} = \frac{2\omega . h}{\delta}$

Q.54 Air is held inside a non-insulated cylinder using a piston (mass M = 25 kg and area A = 100 cm^2) and stoppers (of negligible area), as shown in the figure. The initial pressure P_1 and temperature T_1 of air inside the cylinder are 200 kPa and 400° C, respectively. The ambient pressure P_∞ and temperature T_∞ are 100 kPa and 27° C respectively. The temperature of the air inside the cylinder (°C) at which the piston will begin to move is ________ (correct to two decimal places).



Ans. (146.026)



$$P_\infty = 100 \text{ kPa}$$

$$P_{piston} = \frac{Mg}{A} = \frac{25\times 9.81\times 10^{-3}\text{kN}}{0.01\text{m}^2}$$

$$P_{piston} = 24.525 \text{ kPa}$$

Total external pressure = $P_\infty + P_{piston}$ = 124.525 kPa.

Initial pressure of air, P_i = 200 kPa.

Piston will be about to come down if system pressure is equal to total pressure i.e. 124.525 kPa.

⇒ Final pressure of air at which is about to move is p_f = 124.525 kPa

Applying mass conservation at two states $i \xi f$

$$M_i = M_f$$

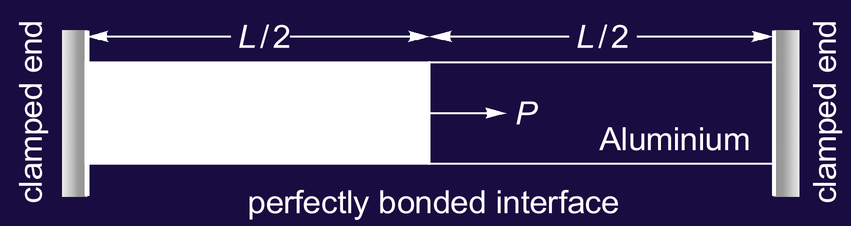
$$\frac{P_i V_i}{RT_i} = \frac{P_f V_f}{RT_f} = V_i = V_f$$

$$\frac{200\text{ kPa}}{673\text{ K}} = \frac{124.525\text{ kPa}}{T_f}$$

$$T_f = 419.026 \text{ K}$$

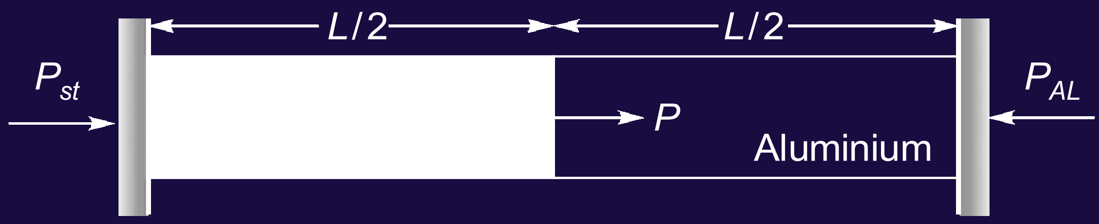
$$T_f = 146.026° \text{ C}$$

Q.55 A bimetallic cylindrical bar of cross sectional area 1 m^2 is made by bonding Steel (Young's modulus = 210 GPa) and Aluminium (Young's modulus = 70 GPa) as shown in the figure. To maintain tensile axial strain of magnitude 10^{-6} Steel bar and compressive axial strain of magnitude 10^{-6} Aluminum bar, the magnitude of the required force P (in kN) along the indicated direction is



(a) 70
(b) 140
(c) 210
(d) 280

Ans. (d)



$$P_{st} + P_{Al} = P \quad \ldots (i)$$

$$\Delta_{st} + \Delta_{Al} = 0$$

$$\frac{P_{st}\cdot\frac{L}{2}}{AE_{st}} + \frac{(P_{st}-P)\frac{L}{2}}{A.E_{AL}} = 0$$

$$\frac{P_{st}}{210} + \frac{P_{st}-P}{70} = 0$$

$\therefore$
$$P_{st} = \frac{3P}{4}$$

Now,
$$\Delta_{st} = \frac{P_{st}\cdot\frac{L}{2}}{A.E_{st}}$$

$$\in_{st} = \frac{P_{st}}{A.E_{st}} = \frac{3P}{4AE_{st}}$$

$\therefore$
$$P = \frac{E_{st}\times 4A\in_{st}}{3}$$

$$= \frac{10^{-6}\times 4\times 1\times 2.10\times 10^{9}}{3}$$

$$= 280 \text{ kN}$$