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Q.1 For a two-dimensional incompressible flow field given by $\vec{u} = A(x\hat{i} - y\hat{j})$, where $A > 0$, which one of the following statements is FALSE?

A. It satisfies continuity equation

B. It is unidirectional when $x \to 0$ and $y \to \infty$.

C. Its streamlines are given by $x = y$.

D. It is irrotational

(a) A (b) B

(c) C (d) D

Ans. (c)

C is the false statement

2D incompressible flow continuity equation.

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

$$\frac{\partial (Ax)}{\partial x} + \frac{\partial (-Ay)}{\partial y} = 0$$

A – A = 0 it satisfies continuity equation.

$\Rightarrow$ As $\vec{V} = Ax\,\hat{i} - Ay\hat{j}$

As $y \to \infty$ velocity vector field will not be defined along y axis.

So flow will be along x-axis i.e. 1-D flow.

$\Rightarrow$ Stream line equation for 2D

$$\frac{dx}{u} = \frac{dy}{v}$$

$$\frac{dx}{Ax} = \frac{dy}{-Ay}$$

$$\ln x = -\ln y + \ln c$$

$$\ln xy = \ln c$$

$xy = c \to$ streamline equation

Q.2 An ideal gas undergoes a process from state 1 (T_1 = 300 K, p_1 = 100 kPa) to state 2 (T_2 = 600 K, p_2 = 500 kPa). The specific heats of the ideal gaa are: c_p = 1 kJ/kg-K and C_v = 0.7 kJ/kg-K. The change in specific entropy of the ideal gas from state 1 to state 2 (in kJ/kg-K) is______(correct to two decimal places)

Ans. (0.21)

Ideal gas

State–1: $T_1 = 300$ K, $P_1 = 100$ kPa

State–2: $T_2 = 600$ K, $P_2 = 500$ kPa,

$c_p = 1$ kJ/kg-K, $c_p - c_v = R$, $c_v = 0.7$ kJ/kg-K

$$\Rightarrow \quad c_p - c_v = 1 - 0.7 = R$$

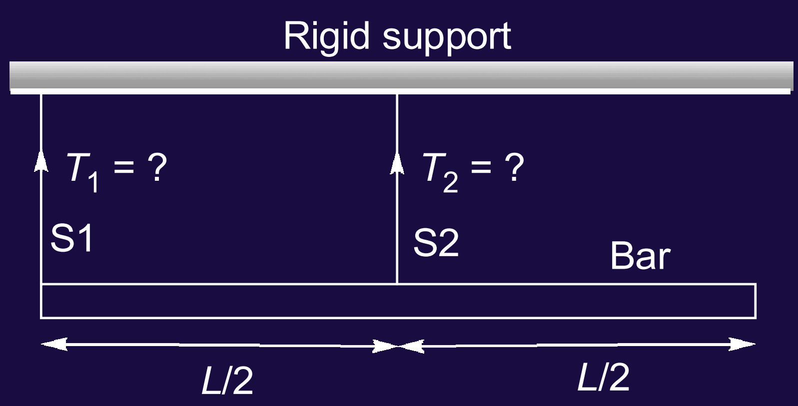
$$R = 0.3 \text{ kJ/kg-K}$$

Change in specific entropy

$$s_2 - s_1 = c_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1}$$

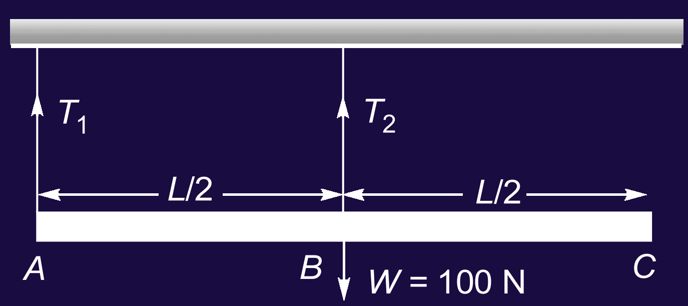
$$= 1 \times \ln\frac{600}{300} - 0.3\ln\frac{500}{100} = 0.21 \text{ kJ/kg-K}$$

Q.3 A bar of uniform cross section and weighing 100 N is held horizontally using two massless and inextensible strings S_1 and S_2 as shown in the figure.



(a) $T_1 = 100$ N and $T_2 = 0$ N
(b) $T_1 = 0$ N and $T_2 = 100$ N
(c) $T_1 = 75$ N and $T_2 = 25$ N
(d) $T_1 = 25$ N and $T_2 = 75$ N

Ans. (b)



$$T_1 + T_2 = 100 \text{ N} \quad \text{...(i)}$$

$$\Sigma M_A = 0$$

$$T_2 \cdot \frac{L}{2} = 100 \times \frac{L}{2}$$

$$\therefore \quad T_2 = 100 \text{ N}$$

$$T_1 = 0 \text{ N}$$

Q.4 For a Pelton wheel with a given water jet velocity, the maximum output power from the Pelton wheel is obtained when the ratio of the bucket speed to the water jet speed is ______(correct to two decimal places).

Ans. (0.50)

In Pelton wheel turbine for maximum efficiency,

$$\eta_{max} = \frac{u}{V_1} = \frac{1}{2} = 0.50$$

Q.5 A six-faced fair dice is rolled five times. The probability (in%) of obtaining "ONE" at least four times is

(a) 33.3 (b) 3.33
(c) 0.33 (d) 0.0033

Ans. (c)

A dice is rolled 5 times

$$n = 5$$

$$P = \text{(Probability of getting 1)} = \frac{1}{6}$$

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

Probability of getting 1 at least 4 times is

$$P(x \geq 4) = P(x = 4) + P(x = 5)$$

$$= {}^nC_4 p^4 q^{n-4} + {}^nC_5 p^5 q^{n-5}$$

$$= {}^5C_4 p^4 q^1 + {}^5C_5 p^5 q^0$$

$$= 5 \times \left(\frac{1}{6}\right)^4 \left(\frac{5}{6}\right)^1 + 1 \times \left(\frac{1}{6}\right)^5 \times \left(\frac{5}{6}\right)^0$$

$$= \frac{25}{(6)^5} + \frac{1}{(6)^5} = \frac{26}{(6)^5} = 0.0033$$

$$\% \text{ probability} = 0.33\%$$

Q.6 Using the Taylor's tool life equation with exponent n = 0.5, if the cutting speed is reduced by 50%, the ratio of new tool life to original tool life is

(a) 4 (b) 2
(c) 1 (d) 0.5

Ans. (a)

$$V_2 = \frac{V_1}{2}$$

$$V_1 T_1^{0.5} = V_2 T_2^{0.5}$$

$$V_1 T_1^{0.5} = \frac{V_1}{2} \cdot T_2^{0.5}$$

$$\left(\frac{T_2}{T_1}\right)^{0.5} = 2$$

$$\frac{T_2}{T_1} = 2^{\frac{1}{0.5}} = 4$$

Q.7 A grinding ratio of 200 implies that the

(a) grinding wheel wears 200 times the volume of the material removed.

(b) grinding wheel wears 0.005 times the volume of the material removed

(c) aspect ratio of abrasive particles used in the grinding wheel is 200

(d) ratio of volume of abrasive particle to that of grinding wheel is 200

Ans. (b)

Grinding ratio is defined as

$$= \frac{\text{Volume of work material removed } (V_m)}{\text{Volume of wheel wear } (V_w)}$$

$$200 = \frac{\text{Volume of work material removed } (V_m)}{\text{Volume of wheel wear } (V_w)}$$

Grinding wheel wears 0.005 times the volume of material removed.

Q.8 The number of atoms per unit cell and the number of slip systems, respectively, for a face-centered cubic (FCC) crystal are

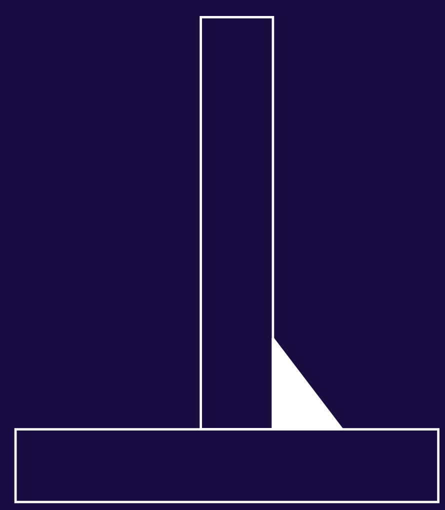
(a) 3, 3 (b) 3, 12

(c) 4, 12 (d) 4, 48

Ans. (c)

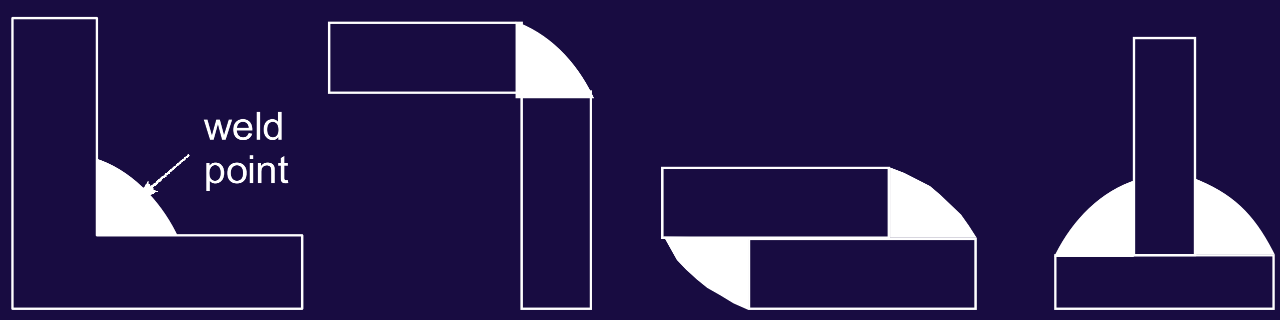
Unit cell	*N*	*CN*	*a / R*	*APF*
Simple cubic	1	6	2	0.52
Body centered cubic	2	8	$\frac{4}{\sqrt{3}}$	0.68
Face centered cubic	4	12	$\frac{4}{\sqrt{2}}$	0.74
Hexagonal close packed	6	12	a / R = 2 c/ a = 1.633	0.74

Q.9 The type of weld represented by the shaded region in the figure is



(a) groove (b) spot
(c) fillet (d) plug

Ans. (c)



Fillet weld on corner joint | Fillet weld on lap joint | Fillet weld on T-joint

Q.10 The height (in mm) for a 125 mm sine bar to measure a taper of 27′32′ on a flat work piece is______(correct to three decimal places).

Ans. (57.782)

$$\theta = 27°32'$$

$$= 27 + \left(\frac{32}{60}\right)^{\circ} = 27.533^{\circ}$$

In sine bar, $\sin\theta = \frac{H}{L}$

$$\therefore \quad \sin 27.533° = \frac{H}{125}$$

$$H = 57.782427$$

$$H \approx 57.782 \text{ mm}$$

Q.11 Interpolator in a CNC machine

(a) controls spindle speed
(b) coordinates axes movements
(c) operates tool changer
(d) commands canned cycle

Ans. (b)

As interpolator provides two functions:

1. It computes individual axis velocities to drive the tool along the programmed path at given feed rate.
2. It generates intermediate coordinate positions along the programmed path.

Q.12 If the wire diameter of a compressive helical spring is increased by 2%, the change in spring stiffness (in %) is _______(correct to two decimal places.)

Ans. (8.243)

Stiffness of helical spring

$$K = \frac{Gd^4}{64R^3 n}$$

d = spring wire diameter
R = mean coil radius
n = number of turns

$$\therefore \quad K \propto d^4$$

$$\frac{K'}{K} = \left(\frac{d'}{d}\right)^4$$

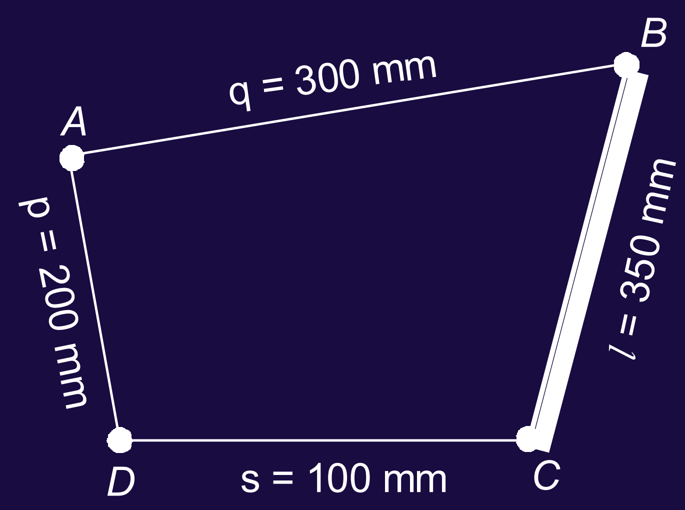
$$K' = \left(\frac{1.02d}{d}\right)^4 K$$

$$K' = 1.08243 \text{ K}$$

$$\% \text{ increase in stiffness} = \frac{K' - K}{K} \times 100\% = 8.243\%$$

Q.13 A four bar mechanism is made up of links of length 100, 200, 300 and 350 mm. If the 350 mm link is fixed, the number of links that can rotate fully is________.

Ans. (1)



$s = 100,\ p = 200,\ l = 350,\ q = 300$

$$(s + l) = 350 + 100 = 450 < (p + q)$$

$$450 < 200 + 300$$

$$450 < 500$$

Grashof law is satisfied.

350 mm link is fixed.

Then, shortest link = 100 mm s adjacent to fixed, will give crank only.

Q.14 Four red balls, four green balls and four blue balls are put in a box. Three balls are pulled our of the box at random one after another without replacement. The probability that all the three balls are red is

(a) 1/72 (b) 1/55

(c) 1/36 (d) 1/27

Ans. (b)

Probability that all the three balls are red is

$$= R{\cdot}R.R.$$

$$= \frac{4}{12}\times\frac{3}{11}\times\frac{2}{10} = \frac{24}{1320} = \frac{1}{55}$$

~~4R~~	4G	4B
~~3R~~		
2R		

Q.15 The rank of the matrix $\begin{bmatrix} -4 & 1 & -1 \\ -1 & -1 & -1 \\ 7 & -3 & 1 \end{bmatrix}$ is

(a) 1 (b) 2

(c) 3 (d) 4

Ans. (b)

Q.16 According to the Mean Value Theorem, for a continuous function $f(x)$ in the interval $[a, b]$, there exists a value ξ in this interval such that $\int_n^b f(x)dx =$

(a) $f(\xi)(b-a)$

(b) $f(b)(\xi - a)$

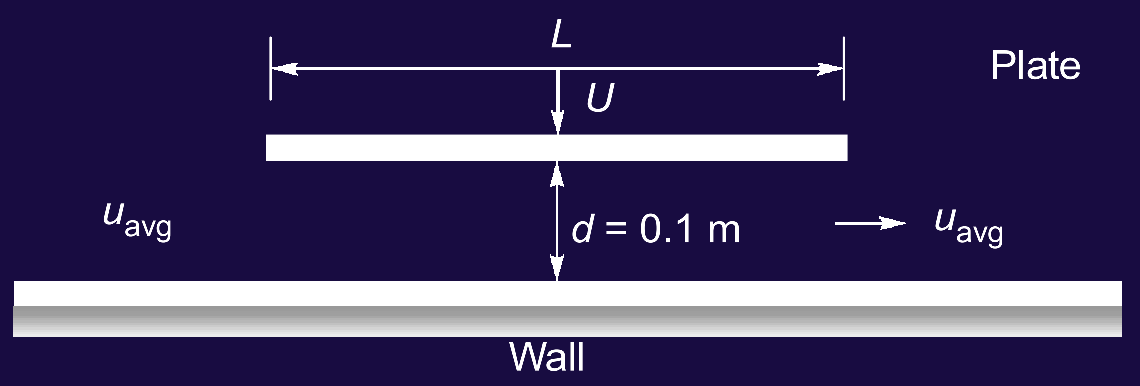
(c) $f(a)(b - \xi)$

(d) 0

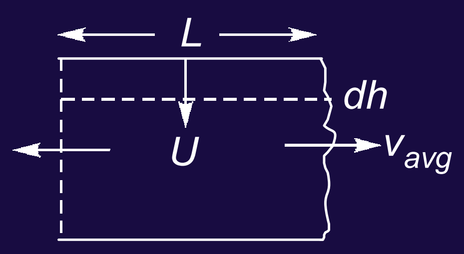
Ans. (a)

$$\int_a^b f(x)dx = f(x)(b-a)$$

Q.17 A flat plate of width L = 1 m is pushed down with a velocity U = 0.01 m/s towards a wall resulting in the drainage of the fluid between the plate and the wall as shown in the figure. Assume two-dimensional incompressible flow and that the plate remains parallel to the wall. The average velocity, u_{avg} of the fluid (in m/s) draining out at the instant shown in the figure is _______(correct to three decimal places).



Ans. (0.05)



Assuming length of plate as B

As per continuity

Let in infinitely small time 'dt' the plate displaced 'dh'

So, $$\frac{dh}{dt} = U$$

Rate of mass displaced through plate

= Rate of mass displaced between plates and wall

$$LBdh = 2 \times U_{avg} \times d \times Bdt$$

$$L\frac{dh}{dt} = 2\ U_{avg}\ d$$

$$U_{avg} = \frac{LU}{2d} = \frac{1 \times 0.01}{2 \times 0.1} = 0.05 \text{ m/s}$$

Q.18 $F(z)$ is a function of the complex variable $z = x + iy$ given by

$F(z) = iz + k\,Re(z) + i\,Im(z)$

For what value of k will F(z) satisfy the Cauchy-riemann equations?

(a) 0 (b) 1

(c) –1 (d) y

Ans. (b)

$$F(z) = iz + k\,Re(z) + i\,Im(z)$$
$$u + iv = i(x + iy) + kx + iy$$
$$u + iv = kx - y + i(x + y)$$
$$u = kx - y,\ v = x + y$$
$$u_x = k,\ u_y = -1$$
$$V = x + y$$
$$v_x = 1$$
$$v_y = 1$$
$$u_x = v_y$$
$$K = 1$$

Q.19 If σ_1 and σ_3 are the algebraically largest and smallest principal stresses respectively, the value of the maximum shear stress is

(a) $\frac{\sigma_1 + \sigma_3}{2}$ (b) $\frac{\sigma_1 - \sigma_3}{2}$

(c) $\sqrt{\frac{\sigma_1 + \sigma_3}{2}}$ (d) $\sqrt{\frac{\sigma_1 - \sigma_3}{2}}$

Ans. (b)

$$\text{Maximum shear stress} = \frac{\sigma_1 - \sigma_3}{2}$$

Q.20 The time series forecasting method that gives equal weightage to each of the m most recent observation is

(a) Moving average method (b) Exponential smoothing with linear trend

(c) Triple Exponential smoothing (d) Kalman Filter

Ans. (a)

It gives equal weightage to all data points.

Q.21 In a linearly hardening plastic material, the true stress beyond initial yielding

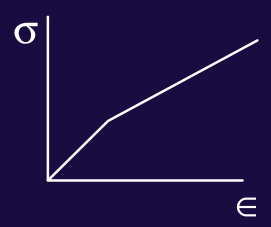
(a) increases linearly with the true strain

(b) decreases linearly with the true strain

(c) first increases linearly and then decreases linearly with the true strain

(d) remain constant

Ans. (a)



Q.22 A steel column of rectangular section (15 mm × 10 mm) and length 1.5 m is simply supported at both ends. Assuming modulus of elasticity, E = 200 GPa for steel, the critical axial load (in kN) is________(correct to two decimal places)

Ans. (1.097)

$$\text{Buckling load} = \frac{\pi^2 E I_{min}}{L^2} = \frac{\pi^2 \times 200 \times 10^3 \times \frac{15 \times 10^3}{12}}{1500^2} = 1096.62 \text{ N}$$

$$= 1.097 \text{ kN}$$

Q.23 Which one of the following statements is correct for a superheated vapour?

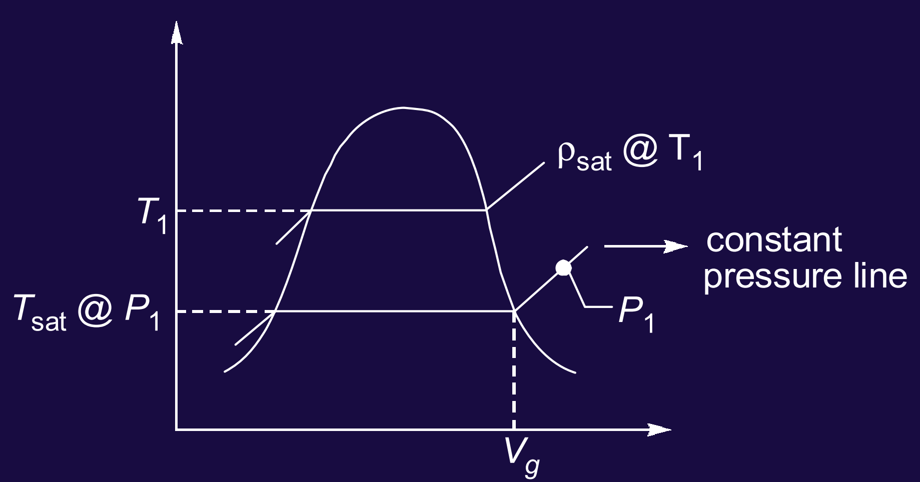
(a) Its pressure is less than the saturation pressure at a given temperature.

(b) Its temperature is less than the saturation temperature at a given pressure.

(c) Its volume is less than the volume of the saturated vapour at a given temperature.

(d) Its enthalpy is less than enthalpy of the saturated vapour at a given pressure.

Ans. (a)



P_{sat} @ T_1 → saturation pressure at T_1 temperature

P_1 → pressure of superheated vapour at state 1.

$$P_1 < P_{sat\,@\,T_1}$$

Q.24 The equation of motion for a spring-mass system excited by a harmonic force is

$$M\ddot{x} + Kx = F\cos(\omega t)$$

where M is the mass, K is the spring stiffness, F is the force amplitude and ω is the angular frequency of excitation. Resonance occurs when ω is equal to

(a) $\sqrt{\frac{M}{K}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{K}{M}}$

(c) $2\pi\sqrt{\frac{K}{M}}$ (d) $\sqrt{\frac{K}{M}}$

Ans. (d)

$$M\ddot{x} + Kx = f\cos(\omega t)$$

Resonance is when $\omega = \omega_n = \sqrt{\frac{K}{M}}$

Q.25 For an Oldham coupling used between two shafts, which among the following statements are correct?

I. Torsional load is transferred along shaft axis.
II. A velocity ratio of 1 : 2 between shaft is obtained without using gears.
III. Bending load is transferred transverse to shaft axis.
IV. Rotation is transferred along shaft axis.

(a) I and III (b) I and IV
(c) II and III (d) II and IV

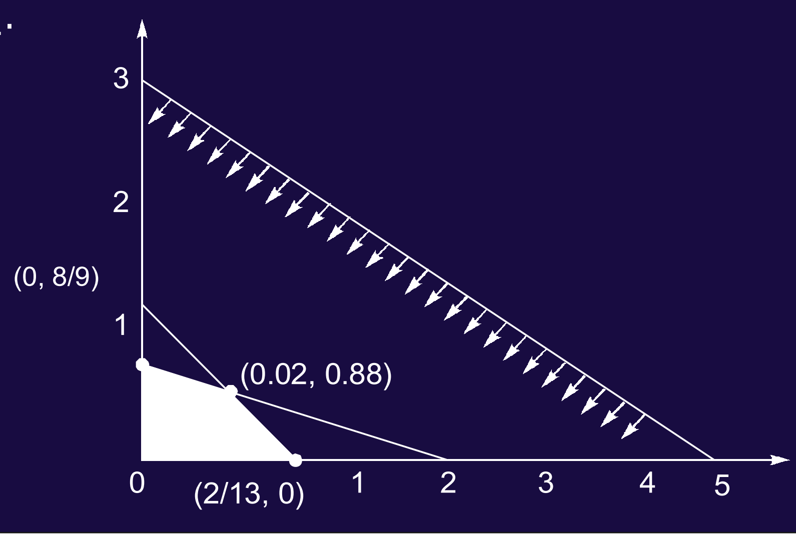
Ans. (b)

Q.26 The minimum value of $3x + 5y$ such that:

$3x + 5y \le 15$
$4x + 9y \le 8$
$13x + 2y \le 2$
$x \ge 0,\ y \ge 0$

is__________.

Ans. (0)



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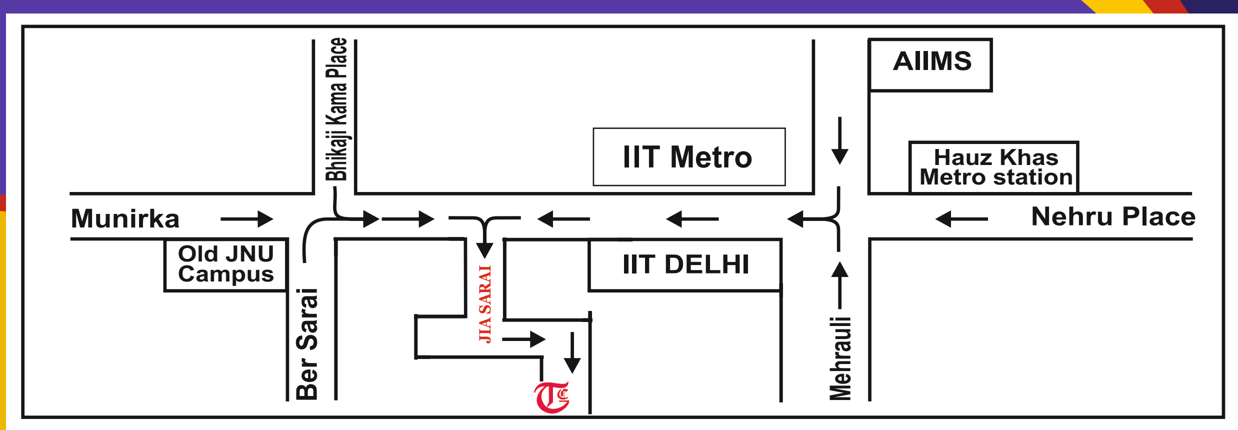


$$Z = 3x + 5y$$

Let us consider $3x + 5y \leq 15$ ...(i)

If $3x + 5y = 15$

$$x = 0 \quad y = 3$$

$$x = 5 \quad y = 0$$

Let us consider $4x + 9y \leq 8$ ...(ii)

If $4x + 9y = 8$

$$x = 0 \quad y = \frac{8}{9}$$

$$x = 2 \quad y = 0$$

Let us consider $13x + 2y \leq 2$ ...(iii)

If $3x + 2y = 2$

$$x = 0 \quad y = 1$$

$$x = \frac{2}{\sqrt{3}} \quad y = 0$$

Comparing (ii) and (iii)

$$4x + 9y = 8 \quad \text{...(ii)}$$

$$13x + 2y = 2 \quad \text{...(iii)}$$

From (ii) $x = \frac{8 - 9y}{4}$

Putting in (iii)

$$\frac{13(8 - 9y)}{4} + 2y = 2$$

$$104 - 117y + 8y = 8$$

$$109y = 96$$

$\therefore$ $y = 0.88$

Hence, $x = 0.02$

Checking at corner points:

$\therefore$ $Z\left(0, \frac{8}{9}\right) = 3(0) + 5\left(\frac{8}{9}\right) = 4.44$

$$Z(0.02, 0.88) = 3(0.02) + 5(0.88) = 4.46$$

$$Z\left(\frac{2}{13}, 0\right) = 3\left(\frac{2}{13}\right) + 5(0) = 0.46$$

At (0, 0) $Z = 0$ so minimum value will be 0.

Q.27 A bar is compressed to half of its original length. The magnitude of true strain produced in the deformed bar is _________(correct to two decimal places).

Ans. (0.693)

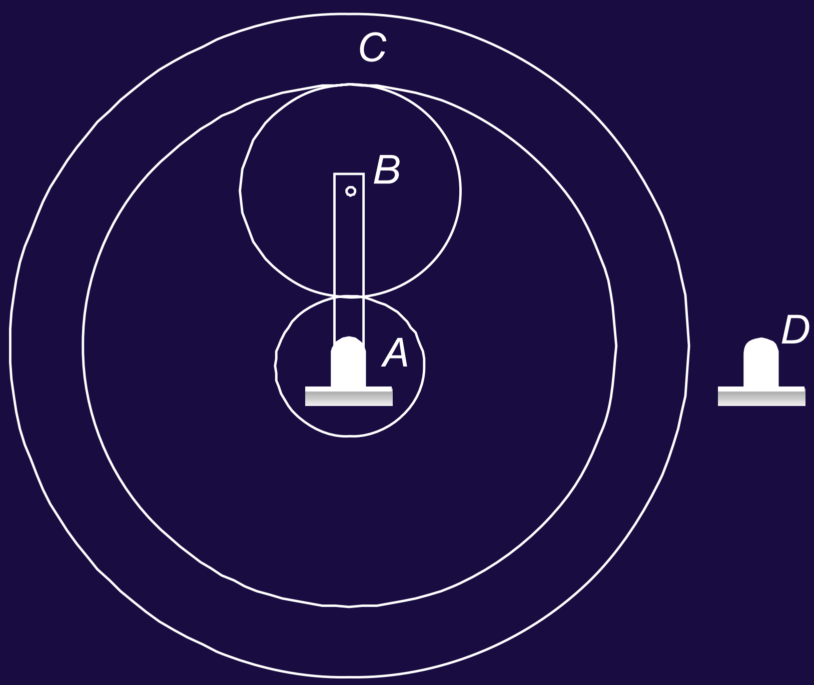
$L_0 \rightarrow$ Initial length

$$L = \frac{L_0}{2} \rightarrow \text{Final length}$$

$$\text{true strain} = \epsilon_T = \ln\frac{L}{L_0} = \ln\left[\frac{\left(\frac{L_0}{2}\right)}{L_0}\right] = \ln\frac{1}{2} = -0.693$$

As examiner mentioned "magnitude" only magnitude will be given 0.693.

Q.28 An epicyclic gear train is shown in the figure below. The number of teeth on the gears *A*, *B* and *D* are 20, 30 and 20, respectively. Gear *C* has 80 teeth on the inner surface and 100 teeth on the outer surface. If the carrier arm *AB* is fixed and the sun gear *A* rotates at 300 rpm in the clockwise direction, then the rpm of *D* in the clockwise direction is



(a) 240 (b) –240
(c) 375 (d) –375

Ans. (c)

$T_A = 20,\ T_B = 30,\ T_D = 20,\ T_C = 80$ (Inner), $T_C = 100$ (Outer)

Arm is fixed, no epicyclic nature. Taking clockwise direction as positive.

$$N_A = +300$$

(A, B) $$N_B = -\frac{300 \times 20}{30} = -200$$

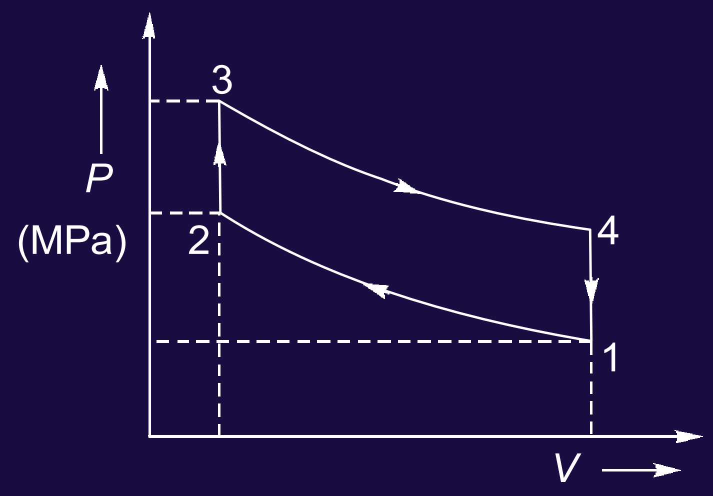
(B, C) $$N_C = -200 \times \frac{30}{80} = -75$$

(C, D) $$N_D = +75 \times \frac{100}{20} = +375$$

Q.29 An engine working on air standard Otto cycle is supplied with air at 0.1 MPa and 35°C. The compression ratio is 8. The heat supplied is 500 kJ/kg. Property data for air: c_p = 1.005 kJ/kgK, c_v = 0.718 kJ/kgK, R = 0.287 kJ/kgK. the maximum temperature (in K) of the cycle is_______(correct to one decimal place).

Ans. (1403.97)

$P_1 = 0.1$ MPa, $T_1 = 35°C = 308$ K



$$\frac{V_1}{V_2} = n = 8$$

$$Q_s = 500 \text{ kJ/kg}$$
$$c_p = 1.005 \text{ kJ/kgK}$$
$$c_v = 0.718 \text{ kJ/kgK}$$
$$R = 0.287 \text{ kJ/kgK}$$

$$\gamma = \frac{c_p}{c_v} = 1.399 \simeq 1.40$$

$$T_3 = T_{max} = ?$$

For process 1–2

$$P_1V_1^\gamma = P_2V_2^\gamma$$

$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^\gamma = 0.1 \times (8)^{1.4}$$

$$P_2 = 1.8379 \text{ MPa}$$

and $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow T_2 \frac{P_2V_2}{P_1V_1} T_1$$

$$T_2 = \frac{1.8379 \times 1}{0.1 \times 8} \times 308$$

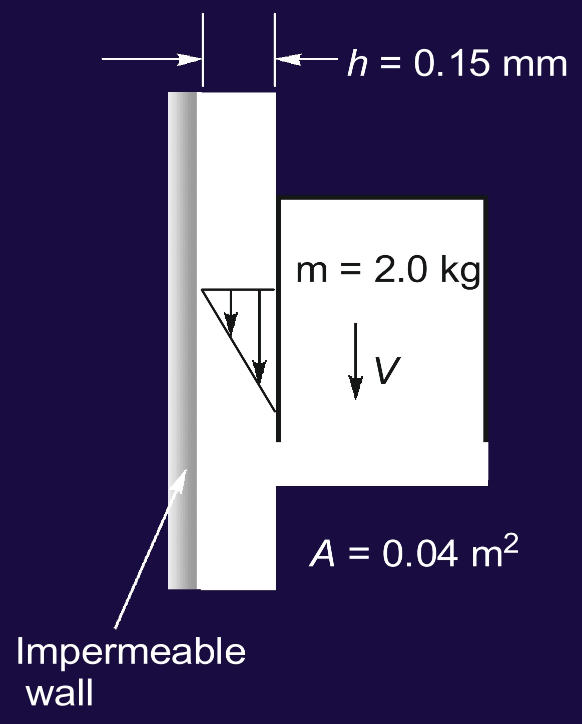
$$T_2 = 707.6 \text{ K}$$

For process 2 → 3

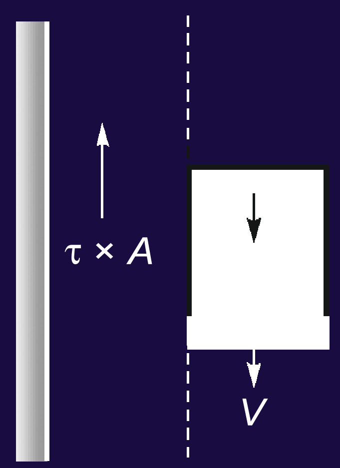
$$Q_s = C_V(T_3 - T_2) = 500 \text{ kJ/ kg}$$

$$0.718(T_3 - 707.6) = 500$$
$$T_3 = 1403.97 \text{ K}$$

Q.30 A solid block of 2.0 kg mass slides steadily at a velocity V along a vertical wall as shown in the figure below. A thin oil film of thickness h = 0.15 mm provides lubrication between the block and the wall. The surface area of the face of the block in contact with the oil film is 0.04 m^2. The velocity distribution within the oil film gap is linear as shown in the figure. Take dynamic viscosity of oil as 7×10^{-3} Pa-s and acceleration due to gravity as 10 m/s^2. Neglect weight of the oil. The terminal velocity V (in m/s) of the4 block is_____ (correct to one decimal place).



Ans. (10.714)



Terminal velocity is a constant velocity i.e. the net acceleration is zero.

So,
$$\Sigma F_{net} = ma$$
$$mg - \tau A = 0$$
$$\tau A = mg$$
$$\mu \frac{V}{h} A = mg$$
$$7 \times 10^{-3} \times \frac{V}{0.15 \times 10^{-3}} \times 0.04 = 2 \times 10$$
$$V = 10.714 \text{ m/s}$$

Q.31 A self-aligning ball bearing has a basic dynamic load rating (C_{10}, for 10^6 revolutions) of 35 kN. If the equivalent radial load on the bearing is 45 kN, the expected life (in 10^6 revolutions) is

(a) below 0.5 (b) 0.5 to 0.8

(c) 0.8 to 1.0 (d) above 1.0

Ans. (a)

$$C = 35 \text{ kN}$$

$$P_C = 45 \text{ kN}$$

$$L_{90} = \left(\frac{C}{P_C}\right)^3 = \left(\frac{35}{45}\right)^3 = 0.4705 \text{ MR}$$

Q.32 The maximum reduction in cross-sectional area per pass (R) of a cold wire drawing process is

$R = 1 - e^{-(n+1)}$

where n represents the strain hardening coefficient. For the case of a perfectly plastic material, R is

(a) 0.865 (b) 0.826

(c) 0.777 (d) 0.632

Ans. (d)

$$\sigma_d = \sigma_0 \ln\frac{A_0}{A_f}$$

For maximum reduction

$$\sigma_d = \sigma_0$$

$$\sigma_0 = \sigma_0 \ln\frac{A_0}{A_{f,\,min}}$$

$$\Rightarrow \quad 1 = \ln\left(\frac{A_0}{A_{f,\,min}}\right)$$

$$\Rightarrow \quad \frac{A_0}{A_{f,\,min}} = e = 2.71828$$

Maximum reduction in Area

$$R = \frac{A_0 - A_{f,\,min}}{A_0} = \left(1 - \frac{1}{e}\right) = \left(1 - \frac{1}{2.71828}\right) = 0.632$$

Q.33 The value of integral

$$\oiint_S \vec{r} \cdot \vec{n} ds$$

over the closed surface S bounding a volume, where $\vec{r} = x\hat{i} + y\hat{i} + z\hat{k}$ is the position vector and $\vec{n}$ is the normal to the surface S, is

(a) V
(b) $2V$
(c) $3V$
(d) $4V$

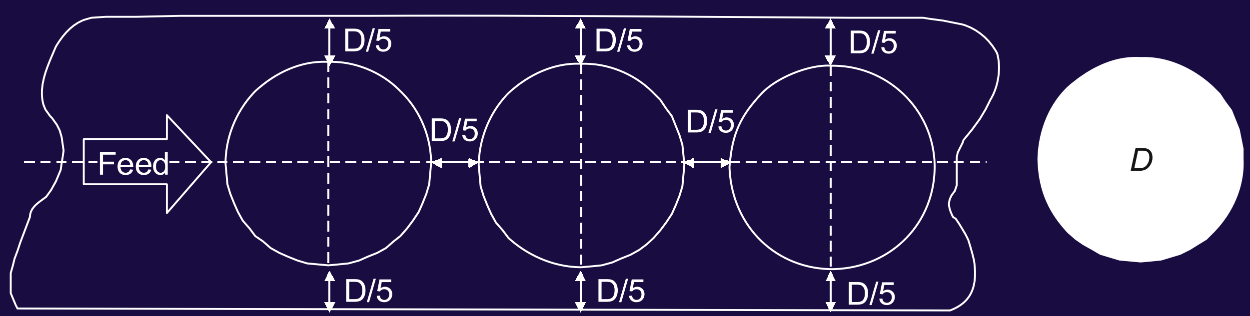
Ans. (c)

By Gauss Divergence Theorem

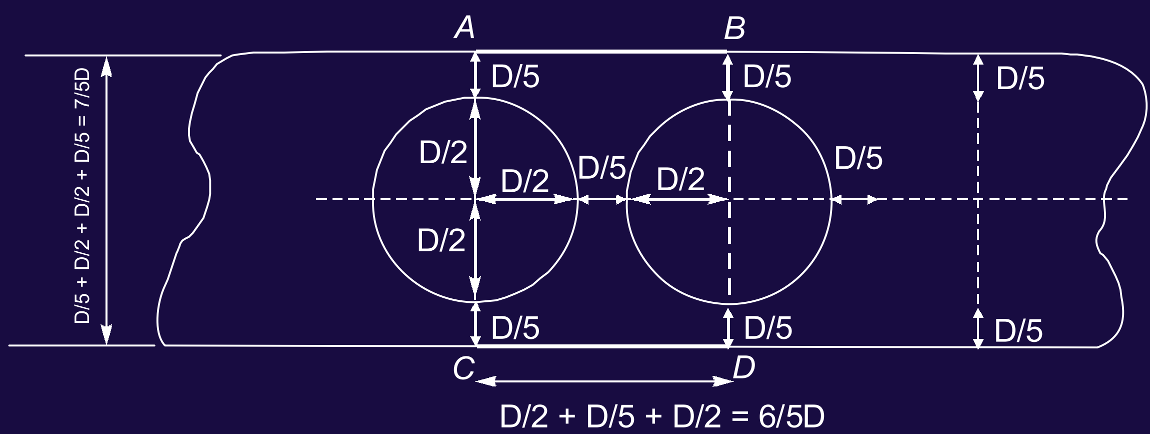
$$\iint_s \vec{r} \cdot \hat{n} ds = \iiint_v \bar{V} \cdot \vec{r} dV$$

$$= \iiint_v 3\, dV = 3V$$

Q.34 The percentage scrap in a sheet metal blanking operation of a continuous strip of sheet metal as shown in the figure _______(correct to two decimal places)



Ans. (53.25)



This rectangle ABCD will be repeated again and again.

$$A_t = \text{Total Area} = \frac{7}{5}D \times \frac{6}{5}D = \frac{42}{25}D^2$$

$$A_u = \text{Area of blanking Disc} = \frac{\pi D^2}{4}$$

$$\% \text{ of scrap} = \frac{A_t - A_u}{A_t} \times 100\%$$

$$= \left[1 - \frac{\left(\frac{\pi}{4}\right)}{\left(\frac{42}{25}\right)}\right] \times 100\% = 53.25\%$$

Q.35 An orthogonal cutting operations is being carried out in which uncut thickness is 0.010 mm, cutting speed is 130 m/min, rake angle is 15° and width of cut is 6 mm. It is observed that the chip thickness is 0.015 mm, the cutting force is 60 N and the thrust force is 25 N. The ratio of friction energy to total energy is __________(correct to two decimal places)

Ans. (0.4408)

$$t = 0.010 \text{ mm}$$
$$v = 130 \text{ m/min}$$
$$\alpha = 15°$$
$$b = 6 \text{ mm}$$
$$t_c = 0.015 \text{ mm}$$
$$F_c = 60 \text{ N}$$
$$F_t = 25 \text{ N}$$
$$F = F_c \sin\alpha + F_t \cos\alpha$$
$$= 60 \sin 15 + 25 \cos 15 = 39.6773 \text{ N}$$

Ratio of frictional energy to total energy

$$= \frac{F}{F_c} \cdot \frac{V_c}{V} = \frac{F}{F_c}\left(\frac{t}{t_c}\right) \qquad \left[\because \frac{t}{t_c} = \frac{V_c}{V} = r\right]$$

$$= \frac{39.6773}{60} \times \frac{0.010}{0.015} = 0.4408$$

Q.36 Let X_1, X_2 be two independent normal random variables with means μ_1, μ_2 and standard deviations σ_1, σ_2 respectively. Consider $Y = X_1 - X_2$; $\mu 1 = \mu 2 = 1$, $\sigma_1 = 1$, $\sigma_2 = 2$, Then,

(a) Y is normal distributed with mean 0 and variance 1

(b) Y is normally distributed with mean 0 and variance 5

(c) Y has mean 0 and variance 5, but is NOT normally distributed

(d) Y has mean 0 and variance 1, but is NOT normally distributed

Ans. (b)

$\mu_1 = 1, \mu_2 = 1, \sigma_1 = 1, \sigma_2 = 2$

x_1 and x_2 are two independent random variables

$$Y = X_1 - X_2$$

$$\mu(Y) = \mu(X_1 - X_2)$$

$$= \mu(X_1) - \mu(X_2) = \mu_1 - \mu_2 = 1 - 1 = 0$$

$$\text{Var}(Y) = \text{Var}(X_1 - X_2)$$

$$= \text{Var}(X_1) + \text{Var}(X_2) - \text{Cov}(X_1, X_2)$$

Since X_1 and X_2 are independent variables

$$\text{Var}(Y) = \text{Var}(X_1) + \text{Var}(X_2)$$

$$= \sigma_1^2 + \sigma_2^2 = 1 + 4$$

$$\text{Var}(Y) = 5$$

Q.37 An electrochemical machining (ECM) is to be used to cut a through hole into a 12 mm thick aluminium plate. The hole has a rectangular cross-section, 10 mm × 30 mm. The ECM operation will be accomplished in 2 minutes, with efficiency of 90%. Assuming specific removal rate for aluminium as 3.44×10^{-2} mm^3/(A s), the current (in A) required is _________(correct to two decimal places).

Ans. (968.992)

Volume of metal to be removed

$$= (10 \times 30) \times 12 \text{ mm}^3 = 3600 \text{ mm}^3$$

$$\text{Ideal energy required} = \frac{3600 \text{ mm}^3}{3.44 \times 10^{-2} \dfrac{\text{mm}^3}{(\text{A}\,s)}} = 104651.163 \text{ As}$$

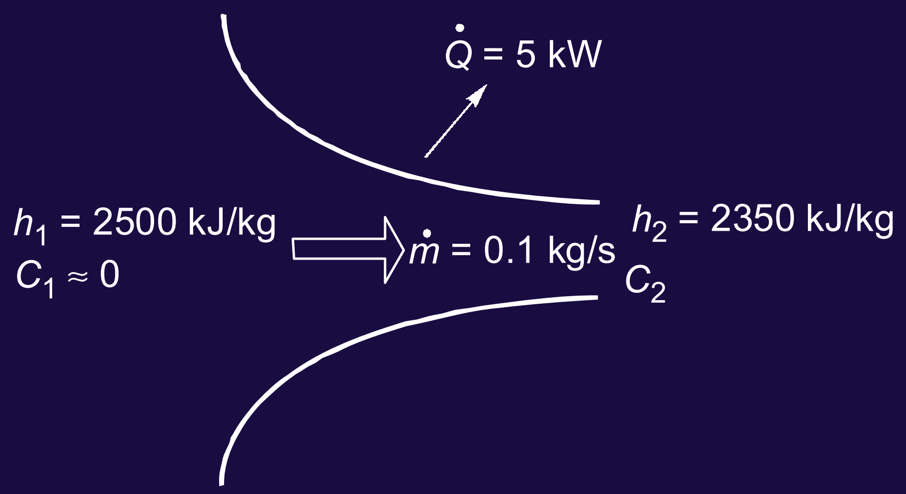
$$\text{Actual energy required} = \frac{104651.163}{0.9} As$$

$$= 116279.07 \text{ As}$$

$$\text{Time is 2 min} = 120 \text{ s}$$

$$\therefore \quad \text{Current} = \frac{116279.07}{120} A = 968.992 A$$

Q.38 Steam flows through a nozzle at mass flow rate of $\dot{m}$ = 0.1 kg/s with a heat loss of 5 kW. The enthalpies at inlet and exit are 2500 kJ/kg and 2350 kJ/kg, respectively. Assuming negligible velocity at inlet ($C_1 \approx 0$), the velocity (C_2) of steam (in m/s) at the nozzle exit is _______(correct to two decimal places)



Ans. (447.213)

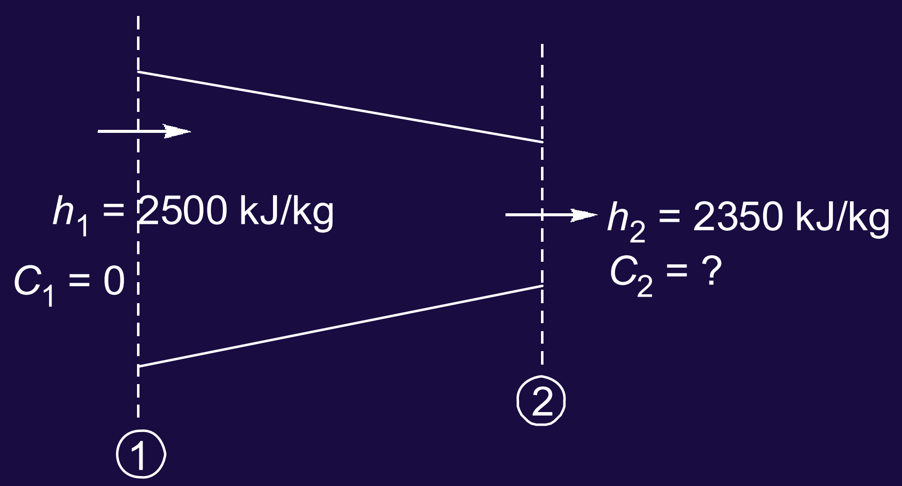
$\dot{m}$ = 0.1 kg/s, $\dot{Q}$ = 5 kW (heat loss)

Applying SFEE

$$\dot{m}\left(h_1 + \frac{1}{2}c_1^2 + gz_1\right) + \dot{Q} = \dot{m}\left(h_2 + \frac{1}{2}c_2^2 + gz_2\right) + \dot{w}_{cv}$$

$c_1 = 0$ and $\dot{w}_{cv} = 0$

$$z_1 = z_2 \text{ (assume)}$$



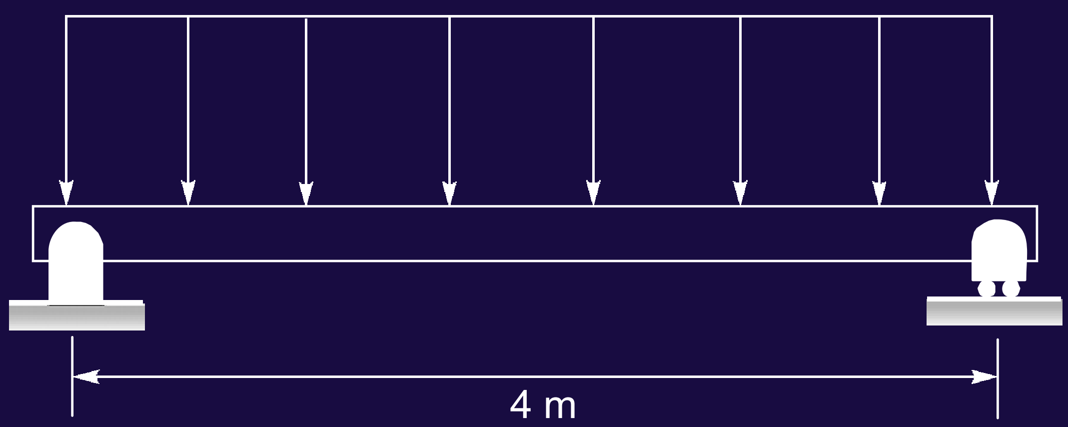
$$\dot{m}h_1 + \dot{Q} = \dot{m}h_2 + \dot{m}\frac{1}{2}c_2^2$$

$$\Rightarrow \quad \dot{m} \times \frac{1}{2}c_2^2 = \dot{m}(h_1 - h_2) + \dot{Q}$$

$$\Rightarrow \quad 0.1 \times \frac{1}{2}c_2^2 \times 10^{-3} = 0.1(2500 - 2350) - 5$$

$$c_2 = 447.213 \text{ m/s}$$

Q.39 A simply supported beam of width 100 mm, height 200 mm and length 4 m is carrying a uniformly distributed load of intensity 10 kN/m. The maximum bending stress (in MPa) in the beam is ______(correct to one decimal place)



Ans. (30)

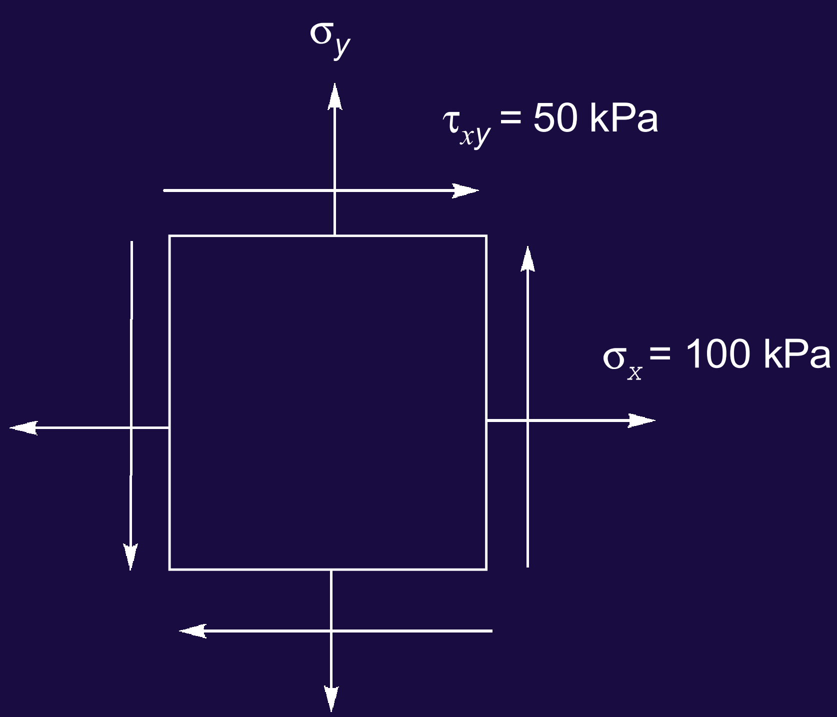
$$\text{Maximum B.M.. } M = \frac{wL^2}{8} = \frac{10\times16}{8} = 20 \text{ kNm} \qquad (L = 4)$$

Maximum Bending Stress

$$\sigma_{max} = \frac{M}{I} y_{max} = \frac{20\times10^3}{\left(\frac{0.1\times0.2^3}{12}\right)} \times 0.1$$

$$= 30 \times 10^6 \text{ N/m}^2 = 30 \text{ MPa}$$

Q.40 The state of stress at a point, for a body in place stress, is shown in the figure below. If the minimum principal stress is 10 kPa, then the normal stress σ_s (in kPa) is



(a) 9.45 (b) 18.88
(c) 37.78 (d) 75.50

Ans. (c)

$$\sigma_x = 100 \text{ kPa}, \ \tau_{xy} = 50 \text{ kPa}$$

Minimum principal stress= $\dfrac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$

$$10 = \frac{100 + \sigma_y}{2} - \sqrt{\left(\frac{100 - \sigma_y}{2}\right)^2 + 50^2}$$

$$\therefore \quad \sqrt{\left(50 - \frac{\sigma_y}{2}\right)^2 + 50^2} = 50 + \frac{\sigma_y}{2} - 10 = 40 + \frac{\sigma_y}{2}$$

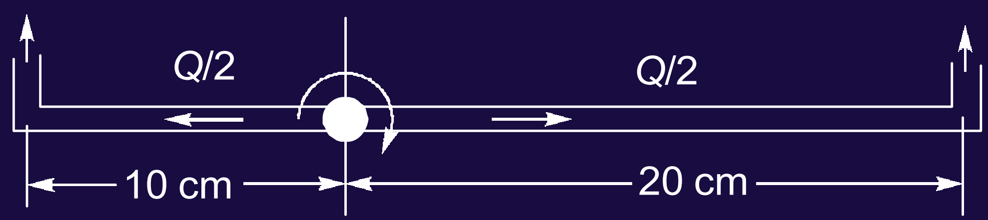
By squaring

$$2500 + \frac{\sigma_y^2}{4} - 50\sigma_y + 2500 = 1600 + \frac{\sigma_y^2}{4} + 40\sigma_y$$

$$\therefore \quad 90\,\sigma_y = 3400$$

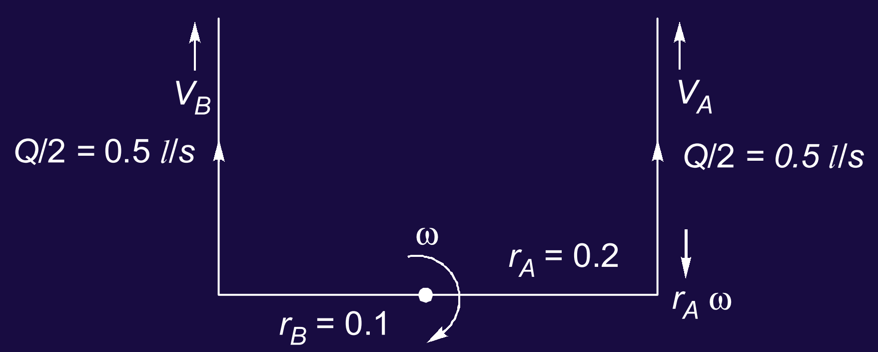
$$\sigma_y = 37.78 \text{ MPa}$$

Q.41 A sprinkler shown in the figure rotates about its hinge point in a horizontal plane due to water flow discharged through its two exit nozzles.



The total flow rate Q through the sprinkler is 1 litre/sec and the cross-sectional area of each exit nozzle is 1 cm^2. Assuming equal flow rate through both arms and a frictionless hinge, the steady state angular speed of rotation (rad/s) of the sprinkler is ______(correct to two decimal places).

Ans. (10)



Relative velocities of water with sprinkler

$$V_A = \frac{Q/2}{A} = \frac{1 \times 10^{-3}}{2 \times 10^{-4}} = 5 \text{ m/s}$$

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

Absolute velocity from B side

$$V'_{Abs} - (+r_B\omega) = V_B$$

$$V'_{Abs} = V_B + r_B\omega$$

$$= 5 + 0.1\ \omega$$

Absolute velocity from A side

$$V_{Abs} - (-r_A\omega) = V_A$$

$$V_{Abs} = V_A - r_A\omega$$

$$V_{Abs} = 5 - 0.2\ \omega$$

The external torque to the sprinkler is zero.

So, $\Sigma T = 0$

$$\dot{m}_A V_{Abs} r_A - \dot{m}_B V'_{Abs} r_B = 0$$

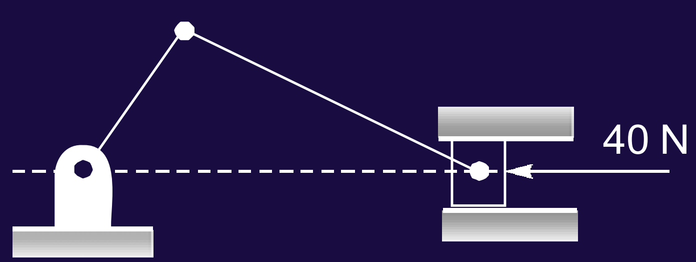
$$\rho\left(\frac{Q}{2}\right)\{5 - 0.2\ \omega\}0.2 - \rho\frac{Q}{2}\{5 + 0.1\ \omega\}0.1 = 0$$

$$1 - 0.04\ \omega - 0.5 - 0.01\ \omega = 0$$

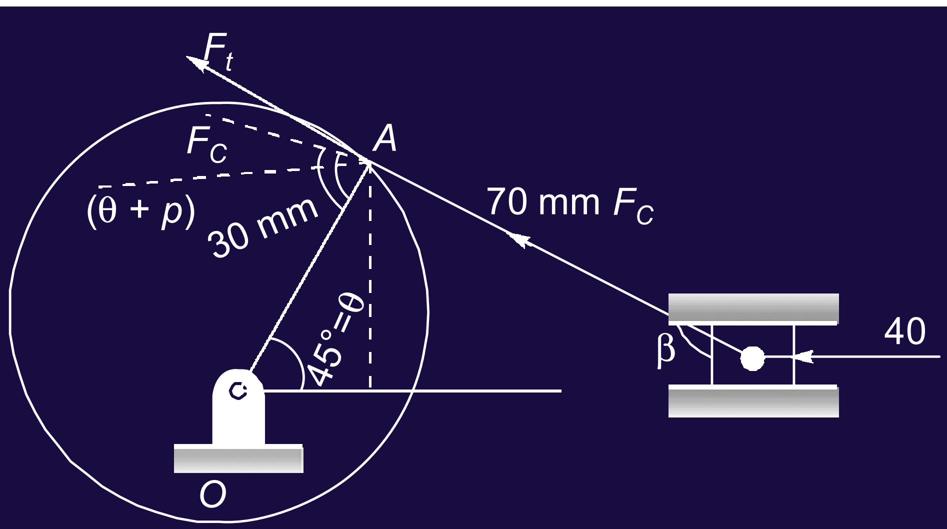
$$0.05\ \omega = 0.5$$

$$\omega = 10 \text{ rad/s}$$

Q.42 A slider crank mechanism is shown in the figure. At some instant, the crank angle is 45° and a force of 40 N is acting towards the left on the slider. The length of the crank is 30 mm and the connecting rod is 70 mm. Ignoring the effect of gravity, friction and inertial forces, the magnitude of th crankshaft torque (in Nm) needed to keep the mechanism in equilibrium is__________(correct to two decimal places).



Ans. (1.12)



$$30\sin 45° = 70\sin\beta$$

$$\sin\beta = \frac{30\sin 45}{70} = 0.303045$$

$$\beta = 17.6406°$$

$$F_C\cos\beta = 40$$

$$F_C = \frac{40}{\cos\beta} = 41.9737 \text{ N}$$

$$F_t = F_C\sin(\theta + \beta)$$

$$= 41.9737 \times \sin(17.6406° + 45°)$$

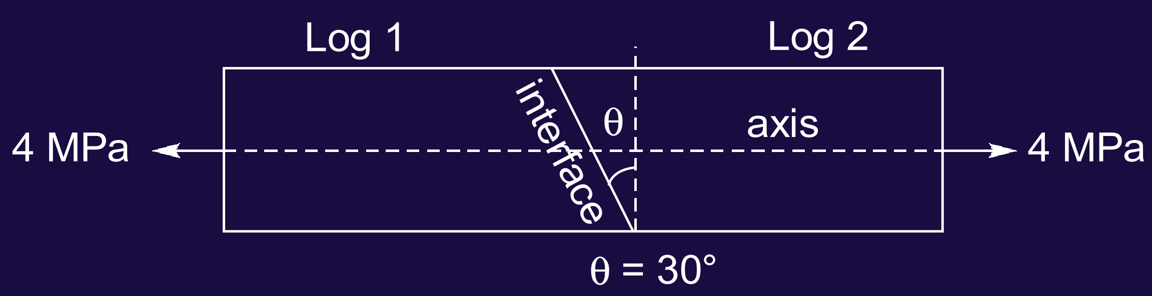
$$F_t = 37.2785 \text{ N}$$

$$T = F_t \times r = 47.2785 \times 0.030$$

$$= 1.1183 \text{ N-m} = 1.118 \text{ N-m}$$

$$= 1.12 \text{ N-m}$$

Q.43 A carpenter glues a pair of cylindrical wooden logs by bonding their end faces at an angle of $\theta = 30°$ as shown in the figure.



The glue used at the interface fails if

Criterion 1 : the maximum normal stress exceeds 2.5 MPa

Criterion 2 : the maximum shear stress exceeds 1.5 MPa

Assume that the interface fails before the logs fail. When a uniform tensile stress of 4 MPa is applied, the interface

(a) fails only because of criterion 1
(b) fails only because of criterion 2
(c) fails because of both criteria 1 and 2
(d) does not fail.

Ans. (c)

Normal stress on inclined plane

$$T' = \sigma_x \cos^2\theta$$

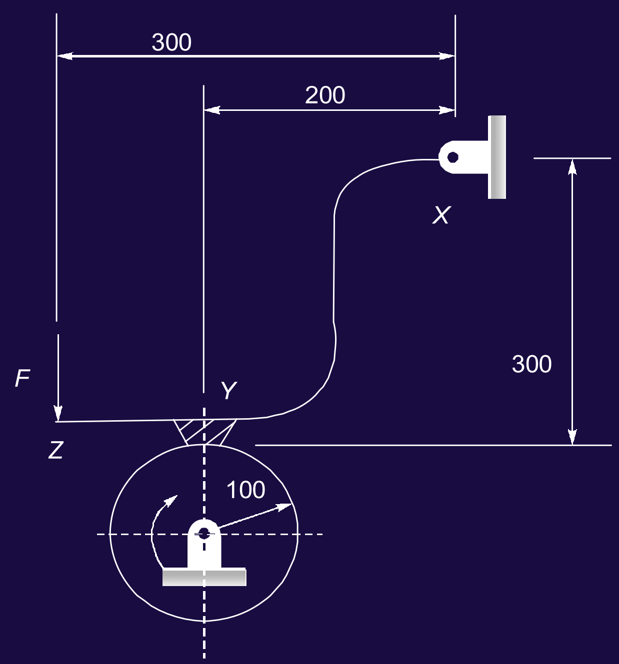
$$= 4 \times \cos^2 30 = 3 \text{ MPa}$$

Shear stress on inclined plane $\tau' = \frac{\sigma_x}{2}\sin 2\theta$

$$= 2 \times \sin 60° = 1.73 \text{ MPa}$$

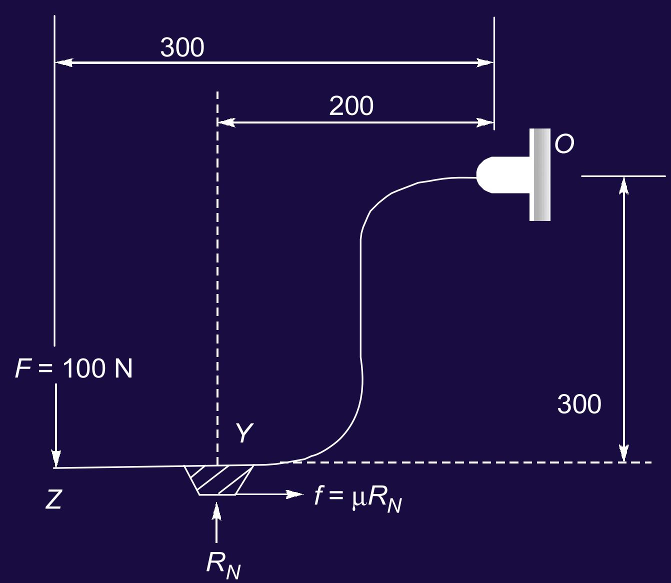
Since both the stress exceeds the given limits, answer is option (c).

Q.44 The schematic of an external drum rotating clockwise engaging with a short shoe is shown in the figure. the shoe is mounted at point Y on a rigid lever XYZ hinged at point X. A force F = 100 N is applied at the free end of the lever as shown. Given that the coefficient of friction between the shoe and the drum is 0.3, the braking torque (in Nm) applied on the drum is __________(correct to two decimal places).



(All dimensions are in mm)

Ans. (8.18)



$\Sigma M_0 = 0$

$F \times 300 \circlearrowleft + f \times 300 \circlearrowleft = RN \times 200 \circlearrowright$

$$100 \times 300 + \mu R_N \times 300 = R_N \times 200$$

$$100 \times 300 + 0.3 \times R_N \times 300 = R_N \times 200$$

$$300 = 1.1\ R_N$$

$$R_N = 272.72 \text{ N}$$

Braking Torque $= \mu R_N \times R = 0.3 \times 272.72 \times 0.100 = 8.18$ Nm

Q.45 Processing times (including step times) and due dates for six jobs waiting to be processed at a work centre are given in the table. The average tardiness (in days) using shortest processing time rule is _______(correct to two decimal places).

Job	Processing time (days)	Due date (days)
A	3	8
B	7	16
C	4	4
D	9	18
E	5	17
F	13	19

Ans. (6.33)

By SPT Rule

Job	P.T.	D.D.	Job Flow Time	Tardiness
A	3	8	0 + 3 = 3	0
C	4	4	3 + 4 = 7	3
E	5	17	7 + 5 = 12	0
B	7	16	12 + 7 = 19	3
D	9	18	19 + 9 = 28	10
F	13	19	28 + 13 = 41	22
				38

Total tardiness = 38

$$\text{Average tardiness per job} = \frac{\text{Total tardiness}}{\text{No. of Jobs}} = \frac{38}{6} = 6.33 \text{ days}$$

Q.46 An explicit forward Euler method is used to numerically integrate the differential equation

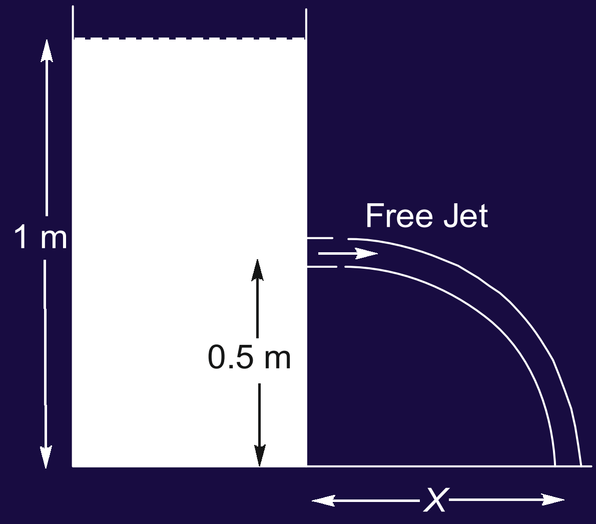
$$\frac{dy}{dt} = y$$

using a time step of 0.1. With the initial condition $y(0) = 1$,t he value of y(1) computed by this method is _______(correct to two decimal places).

Ans. (2.5937)

$$y_1 = y_0 + hf(t_0, y_0)$$
$$= y_0 + hy_0$$
$$= 1 + 0.1\ (1)$$
$$y_1 = 1.1$$
$$y_2 = y_1 + hf(t_1, y_1)$$
$$= y_1 + h.y_1$$
$$= 1.1 + 0.1(1.1)$$
$$y_2 = 1.21$$
$$y_3 = y_2 + hf(t_2, y_2)$$
$$= y_2 + h.y_2$$
$$= 1.21 + 0.1 \times 1.21$$
$$y_3 = 1.331$$
$$y_4 = y_3 + h.f(t_3, y_3)$$
$$= y_3 + h.y_3$$
$$= 1.331 + 0.1 \times 1.331$$
$$y_4 = 1.4641$$
$$y_5 = y_4 + h.f(t_4, y_4)$$
$$= y_4 + h.y_4$$
$$= 1.4641 + 0.1 \times (1.4641)$$
$$= 1.61051$$
$$y_6 = y_5 + h.f(t_5, y_5)$$
$$= y_5 + h.y_5$$
$$= 1.61051 + 0.1 \times 1.61051$$
$$y_6 = 1.771561$$
$$y_7 = y_6 + h.f(t_6, y_6)$$
$$= y_6 + h \times y_6$$
$$= 1.771561 + 0.1 \times 1.771561 = 1.9487$$
$$y_8 = y_7 + h.f(t_7, y_7)$$
$$= y_7 + h.y_7$$
$$= 1.9487 + 0.1 \times (1.9487)$$
$$y_8 = 2.14357$$
$$y_9 = y_8 + h.f(t_8, y_8)$$
$$= y_8 + h.y_8 = 2.14357 + 0.1 \times 2.14357$$
$$y_9 = 2.3579$$
$$y_{10} = y_9 + h.f(t_9, y_9) = y_9 + h.y_9$$
$$= 2.3579 + 0.1 \times (2.3579)$$
$$y_{10} = 2.5937$$

Q.47 A tank open at the top with a water level of 1 m, as shown in the figure, has a hole at a height of 0.5 m. A free jet leaves horizontally from the smooth hole. The distance X (in m) where the jet strikes the floor is



(a) 0.5 (b) 1.0
(c) 2.0 (d) 4.0

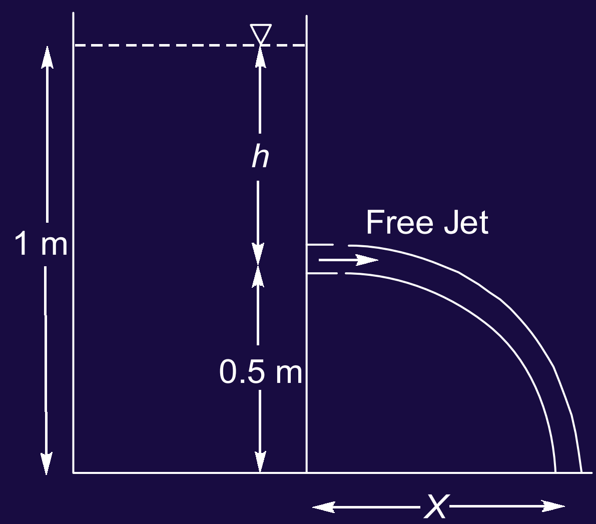
Ans. (b)

Let free jet velocity is x displacement

$$t = \frac{x}{V}$$

As per Torricelli's formula, $V = \sqrt{2gh}$

$$t = \frac{x}{\sqrt{2gh}} \quad ...(i)$$



By second law of motion equation

$$s = ut + \frac{1}{2}gt^2$$

For free fall $u = 0,\ s = \frac{1}{2}gt^2$

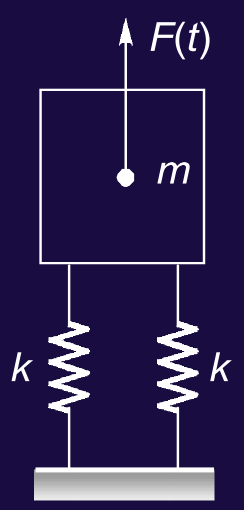
$$t = \sqrt{\frac{2s}{g}}$$ ...(ii) is the time of free fall of object

By equation (i) and (ii)

$$\frac{x}{\sqrt{2gh}} = \sqrt{\frac{2s}{g}}$$

$$x = \sqrt{4hs} = \sqrt{4 \times 0.5 \times 0.5} = 1\,\text{m}$$

Q.48 A machine of mass m = 200 kg is supported on two mounts, each of stiffness k = 10 kN/m. The machine is subjected to an external force (in N) F(t) = 50 cos 5t. Assuming only vertical translatory motion, the magnitude of the dynamic force (in N) transmitted from each mount to the ground is ________(correct to two decimal places).



Ans. (33.333)

$m = 200$ kg, $k = 10$ kN/m $= 10000$ N/m

$$K_{eq} = K + K = 10000 + 10000 = 20000 \text{ N/m}$$

$$F_t = 50 \cos 5\,t$$

$$F_0 = 50 \text{ N}$$

$$\omega = 5 \text{ rad/s}$$

$$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{20000}{200}} = \sqrt{100} = 10 \text{ rad / s}$$

$$\frac{\omega}{\omega_n} = \frac{5}{10} = \frac{1}{2}$$

No damping $\Rightarrow c = 0 \Rightarrow \xi = 0$

Transmissibility $$\epsilon = \frac{\sqrt{1 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left\{\frac{2\xi\omega}{\omega_n}\right\}^2}} \qquad (\xi = 0)$$

$$= \frac{1}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2}} = \frac{1}{\sqrt{\left\{1 - \left(\frac{1}{2}\right)^2\right\}^2}} = \frac{1}{1 - \frac{1}{4}} = \frac{1}{\frac{3}{4}} = \left(\frac{4}{3}\right)$$

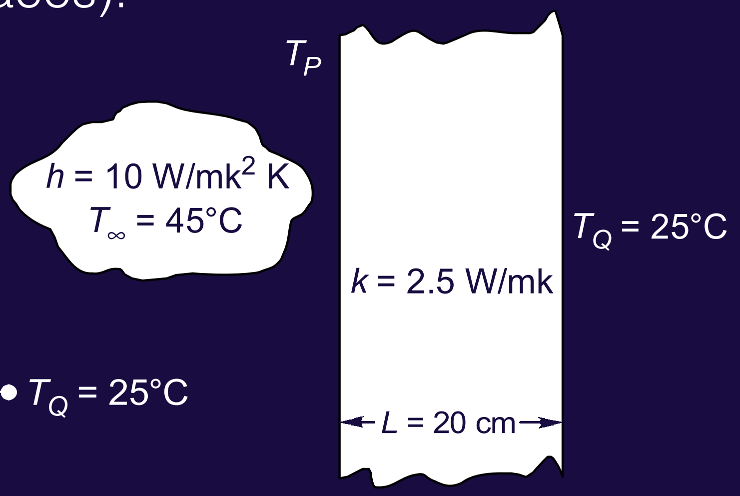
$$\epsilon = \frac{F_t}{F_0}$$

$$\frac{4}{3} = \frac{F_t}{50}$$

$$F_t = \frac{200}{3} = 66.666 \text{ N}$$

$$\text{Force from each mount} = \frac{F_t}{2} = \frac{66.666}{2} = 33.333 \text{ N}$$

Q.49 A plane slab of thickness L and thermal conductivity *k* is heated with a fluid on one side (*P*), and the other side (*Q*) is maintained at a constant temperature, *TQ* of 25°C, as shown in the figure. The fluid is at 45°C and the surface heat transfer coefficient, *h*, is 10 W/m^2K. The steady state temperature. TP (in °C) of the side which is exposed to the fluid is ________(correct to two decimal places).



Ans. (33.889)

Assuming steady state conditions

Thermal circuit

$$q = \text{Rate of heat transfer} = \frac{45 - T_P}{1/hA} = \frac{T_p - 25}{L/kA}$$

$$\Rightarrow \quad \frac{45 - T_P}{\left(\frac{1}{10}\right)} = \frac{T_P - 25}{\frac{0.2}{2.5}}$$

$$T_p = 33.889°\text{C}$$

Q.50 $F(s)$ is the Laplace transform of the function

$f(t) = 2t^2 e^{-t}$

F(1) is__________(correct to two decimal places).

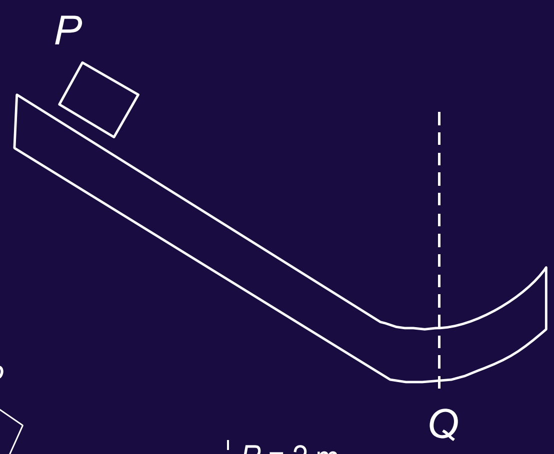
Ans. (0.5)

$$L(t^2) = \frac{L^2}{S^3} \qquad L(2t^2) = \frac{4}{S^3}$$

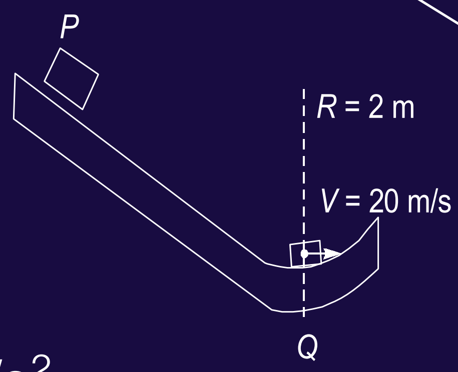
$$F(s) = L[e^{-t} \cdot 2t^2] = \frac{4}{(S+1)}$$

$$F(1) = \frac{4}{(1+1)^3} = \frac{4}{8} = 0.5$$

Q.51 Block P of mass 2 kg slides down the surface and has a speed 20 m/s at the lowest point, Q where the local radius of curvature is 2 m as shown in the figure. Assuming g = 10 m/s^2, the normal force (in N) at Q is _________(correct to two decimal places).

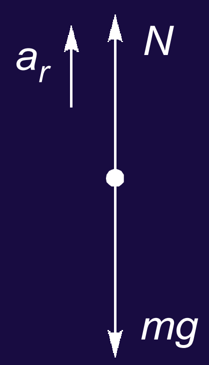


Ans. (420)



$m = 2$ kg, $g = 10$ m/s^2

FBD of mass *P* at point *Q*



$N - mg = ma_r$ at no slip condition.

$$N = mg + \frac{mv^2}{R} = 2 \times 10 + \frac{2 \times 20 \times 20}{2} = 420 \text{ N}$$

Q.52 In a Lagrangian system, the position of a fluid particle in a flow is described as $x = x_0 e^{-kt}$ and $y = y_0 e^{kt}$ where t is the time while x_0, y_0, and k are constants. The flow is

(a) unsteady and one-dimensional
(b) steady and two-dimensional
(c) steady and one-dimensional
(d) unsteady and two-dimensional

Ans. (d)

x direction scalar of velocity field,

$$u = \frac{dx}{dt}$$

$$u = -kx.e^{-kt}$$

y direction scalar of velocity field

$$v = \frac{dy}{dt}$$

$$v = ky_0e^{kt}$$

$$\vec{V} = u\hat{i} + v\hat{j}$$

$$\vec{v} = -kx_0e^{-kt}\hat{i} + ky_0e^{kt}\hat{j}$$

u & v are non zero scalar $t \geq 0$ so it is 2D flow.

2D possible flow field

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

$$\frac{\partial}{\partial x}\left(-kx_oe^{-kt}\right) + \frac{\partial}{\partial y}\left(ky_0e^{kt}\right) = 0$$

0 + 0 = 0 continuity satisfied.

$$\frac{\partial u}{\partial t} = +k^2x_0e^{-kt}$$

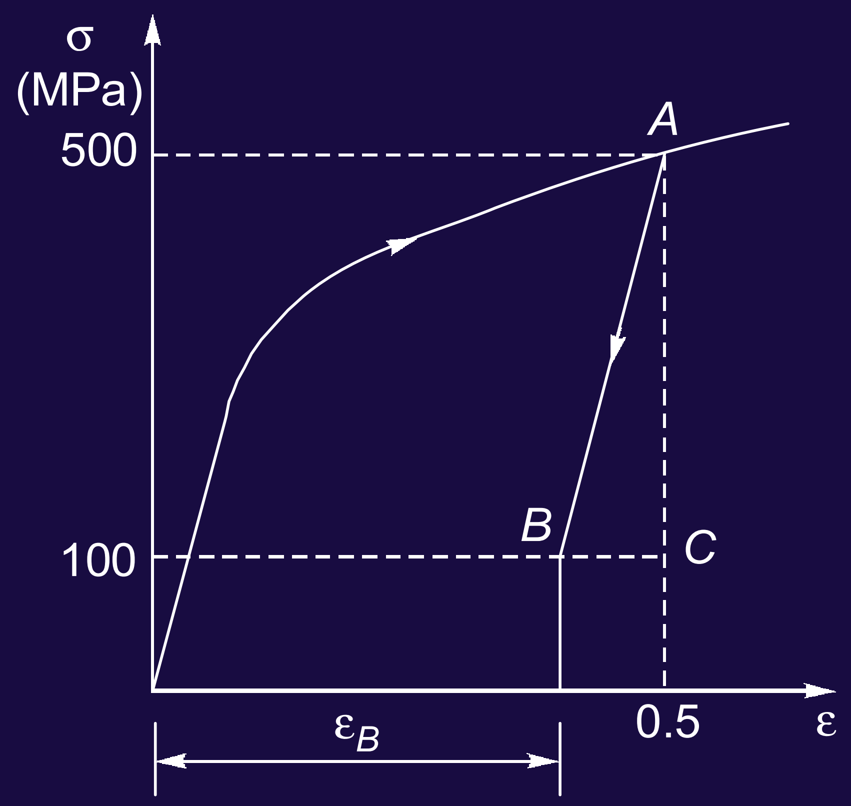
$$\frac{\partial v}{\partial t} = k^2y_0e^{kt}$$

$$\frac{\partial u}{\partial t} \neq 0$$

$$\frac{\partial v}{\partial t} \neq 0$$

So, flow is unsteady.

Q.53 The true stress (σ), true strain (ε) diagram of a strain hardening material is shown in figure. First, there is loading up to point A, i.e. up to stress of 500 MPa and strain of 0.5. then from point A, there is unloading up to point B, i.e. to stress of 100 MPa, Given that the Young's modulus E = 200 GPa, the natural straint at point B (ε_B)________(correct to two decimal places).



Ans. (0.498)

We know that

Slope of AB line is E

$$E = \frac{AC}{BC}$$

$$200 \times 10^3 \text{ MPa} = \frac{(500-100)\text{MPa}}{BC}$$

$$BC = \frac{400}{200 \times 10^3} = 0.002$$

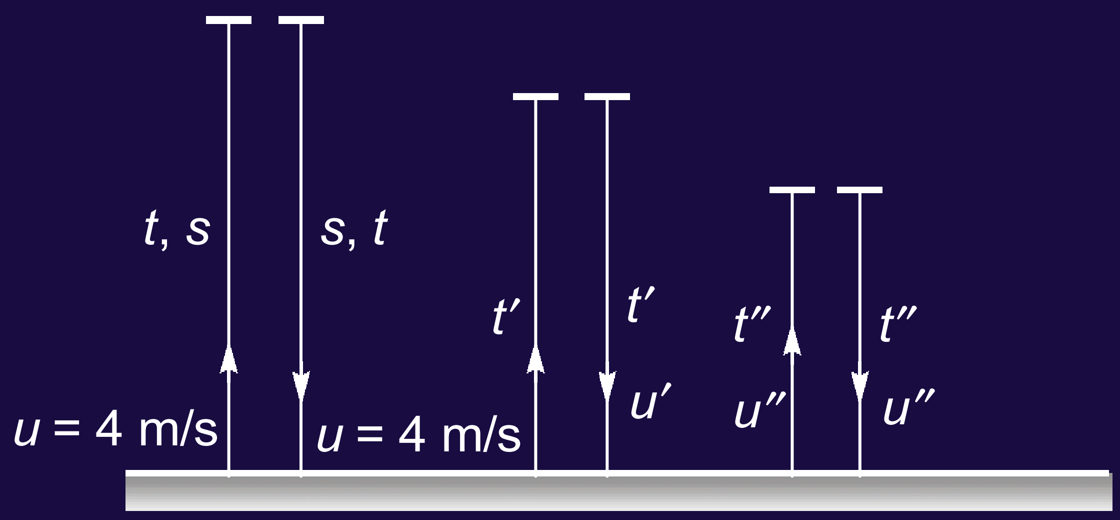
$\therefore$ $$\epsilon_E = 0.5 - 0.002 = 0.498$$

Q.54 A point mass is shot vertically up from ground level with a velocity of 4 m/s at time, $t = 0$. It loses 20% of its impact velocity after each collision with the ground. Assuming that the acceleration due to gravity is 10 m/s^2 and that air resistance is negligible, the mass stops bouncing and comes to complete rest on the ground after a total time (in seconds) of

(a) 1 (b) 2

(c) 4 (d) ∞

Ans. (c)



(1) → $t = ?$

$$v = u + at$$
$$0 = 4 - 10t$$
$$t = \frac{4}{10} = 0.4s$$

(2) → $t' = ?$

$$u' = 0.8 \times u$$
$$= 0.8 \times 4 = 3.2 \text{ m/s}$$
$$v' = u' + at'$$
$$0 = 3.2 - 10t'$$
$$t' = \frac{3.2}{10} = 0.32s$$

(3) → $t'' = ?$

$$u'' = 0.8\ u'$$
$$= 0.8 \times 3.2 = 2.56 \text{ m/s}$$
$$v'' = u'' + at''$$
$$0 = 2.56 - 10t''$$
$$t'' = 0.256s$$

So, t, t', t'' are forming a GP series

So, total time $= 2(t + t' + t'' + \ldots.. 0)$

$$= 2[0.4 + 0.32 + 0.256 + \ldots. 0]$$
$$= 2 \times \frac{0.4}{1-0.8} = 2 \times 2 = 4s$$

Q.55 A tank of volume 0.05 m^3 contains a mixture of saturated water and saturated steam at 200°C. The mass of the liquid present is 8 kg. The entropy (in kJ/kgK) of the mixture is_______________(correct of two decimal places)

Property data for saturated steam and water are:

At 200°C, Psat = 1.5538 MPa

$v_f = 0.001157 \text{ m}^3/\text{kg}$, $v_t = 0.12736 \text{ m}^3/\text{kg}$

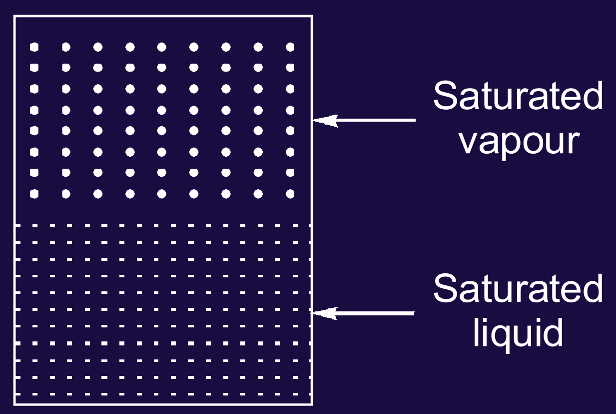
$s_{fg} = 4.1014 \text{ kJ/kgK}$, $s_f = 2.3309 \text{ kJ/kgK}$

Ans. (2.49)

Total volume of tank (V) = 0.05 m^3

Means of liquid (m_2) = 8 kg

$$x = \frac{m_V}{m_V + m_L} \text{ (dryness fraction)}$$



$$V = V_L + V_V$$

$$V_V = m_V v_V$$

$$v_V = v_g @ 200° \text{ C}$$

$$= 0.12736 \text{ m}^3/\text{kg}$$

$$V_V = m_L v_L$$

$$v_L = v_f @ 200° \text{ C}$$

$$= 0.001157 \text{ m}^3/\text{kg}$$

$\left[\begin{array}{l} V_L - v \text{ of liquid in tank} \\ V_V - v \text{ of vapour in tank} \end{array}\right]$

$$V_L = 8 \times 0.001157 = 9.256 \times 10^{-3} \text{ m}^3$$

$$0.05 = 9.256 \times 10^{-3} + V_V$$

$$V_V = 0.0474 \text{ m}^3$$

So, $$0.04074 = m_V \times 0.12736$$

$$m_V = 0.3198 \text{ kg}$$

$$x = \frac{0.3198}{0.3198 + 8}$$

$\Rightarrow$ $$x = 0.0384$$

Specific entropy of mixture(s)

$$s = s_f + x s_{fg}$$

$$s = 2.3309 + 0.0384 \times 4.1014$$

$$s = 2.4884 \text{ kJ/kg-K}$$

....THE END...