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GATE 2017

Mechanical Engineering

(Afternoon Session : 04-02-2017)

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SESSION 2

Q.1 Two coins are tossed simultaneously. The probability (upto two decimal points accuracy) of getting at least one head is ______________.

Ans. (3/4)

End of Solution

Q.2 The emissive power of a blackbody is P. If its absolute temperature is doubled, the emissive power becomes

(a) 2P
(b) 4P
(c) 8P
(d) 16P

Ans. (d)

$E_b \propto T^4$ (Stefan Boltzmann Law of Radiation)

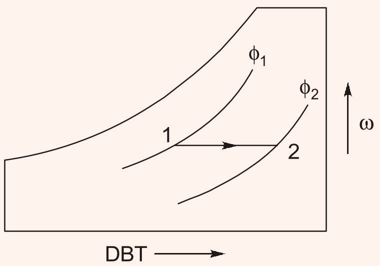
$$\frac{E_{b_2}}{E_{b_1}} = \left(\frac{2T}{T}\right)^4 \Rightarrow E_{b_2} = 16P$$

End of Solution

Q.3 If a mass of moist air contained in a closed metallic vessel is heated, then its

(a) relative humidity decreases
(b) relative humidity increases
(c) specific humidity increases
(d) specific humidity decreases

Ans. (a)



End of Solution

Q.4 A mass m of a perfect gas at pressure p_1 and volume V_1 undergoes an isothermal process. The final pressure is p_2 and volume is V_2. The work done on the system is considered positive. If R is the gas constant and T is the temperature, then the work done in the process is

(a) $p_1V_1 \ln\frac{V_2}{V_1}$
(b) $-p_1V_1 \ln\frac{p_1}{p_2}$
(c) $RT \ln\frac{V_2}{V_1}$
(d) $-mRT \ln\frac{p_2}{p_1}$

Ans. (b)

Work done on the system is considered as positive, so

$\delta W = -pdV$ (–ve sign is taken as dV is – ve during compression)

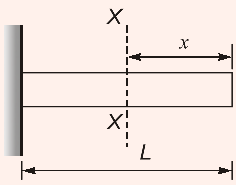
$$W = -\int_1^2 pdV = -\int_1^2 mRT\frac{dV}{V} = -mRT\int_1^2 \frac{dV}{V}$$

$$= -mRT\ln\frac{V_2}{V_1} = -mRT\ln\frac{p_1}{p_2} = -p_1V_1\ln\frac{p_1}{p_2}$$

End of Solution

Q.5 For a loaded cantilever beam of uniform cross-section, the bending moment (in Nmm) along the length is $M(x) = 5x^2 + 10x$, where x is the distance (in mm) measured from the free end of the beam. The magnitude of shear force (in N) in the cross-section at $x = 10$ mm is ___________.

Ans. (110 N)



$$(BM)_{X-X} = M_{X-X} = 5x^2 + 10x$$

$$(S.F)_{X-X} = F_{X-X} = ?$$

We know that at section $X - X$,

$$F_{X-X} = \frac{d}{dx}[5x^2 + 10x]$$

$$F_{X-X} = 10x + 10$$

$$(F_{X-X})_{x=10\text{ mm}} = 10(10) + 10 = 110\text{ N}$$

End of Solution

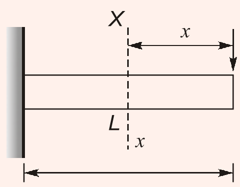
Q.6 A cantilever beam of length L and flexural modulus EI is subjected to a point load P at the free end. The elastic strain energy stored in the beam due to bending (neglecting transverse shear) is

(a) $\frac{P^2L^3}{6EI}$ (b) $\frac{P^2L^3}{3EI}$

(c) $\frac{PL^3}{3EI}$ (d) $\frac{PL^3}{6EI}$

Ans. (a)

Let U is the S.E. in the beam due to B.M. (M)



$$U = \int_0^L \frac{(M_{x-x})^2 dx}{2(EI)_{x-x}} = \int_0^L \frac{(Px)^2 dx}{2EI_{NA}}$$

$$U = \frac{P^2}{2EI_{N.A}}\int_0^L x^2(dx) = \frac{P^2}{2EI}\left(\frac{L^3}{3}\right)$$

$$U = \frac{P^2L^3}{6EI_{N.A.}}$$

End of Solution

Q.7 Which one of the following statements is TRUE for the ultrasonic machining (USM) process?
(a) In USM, the tool vibrates at subsonic frequency.
(b) USM does not employ magnetostrictive transducer.
(c) USM is an excellent process for machining ductile materials.
(d) USM often uses a slurry comprising abrasive-particles and water.

Ans. (d)
Ultrasonic Machining uses an abrasive slurry which transfers the impact load provided by the vibrating tool to the work piece.

End of Solution

Q.8 Consider a laminar flow at zero incidence over a flat plate. The shear stress at the wall is denoted by τ_w. The axial position x_1 and x_2 on the plate are measured from the leading edge in the direction of flow. If $x_2 > x_1$, then
(a) $\tau_w\big|_{x_1} = \tau_w\big|_{x_2} = 0$
(b) $\tau_w\big|_{x_1} = \tau_w\big|_{x_2} \neq 0$
(c) $\tau_w\big|_{x_1} > \tau_w\big|_{x_2}$
(d) $\tau_w\big|_{x_1} < \tau_w\big|_{x_2}$

Ans. (c)
Laminar flow over plate
As per Blasius

$$C_{fx} = \frac{0.664}{\sqrt{R_{ex}}}$$

and
$$C_{fx} = \frac{\tau_\omega}{\frac{1}{2}\rho u_\infty^2}$$

$$\frac{0.664}{\sqrt{\frac{u_\infty x}{\nu}}} = \frac{\tau_\omega}{\frac{1}{2}\rho u_\infty^2}$$

$$\tau_\omega \propto \frac{1}{\sqrt{x}}$$

as
$$x_2 > x_1$$
$$\tau_{\omega 2} < \tau_{\omega 1}$$

End of Solution

Q.9 For the stability of a floating body the
(a) centre of buoyancy must coincide with the centre of gravity
(b) centre of buoyancy must be above the centre of gravity
(c) centre of gravity must be above the centre of buoyancy
(d) metacentre must be above the centre of gravity

Ans. (d)

End of Solution

Q.10 The Laplace transform of te^t is

(a) $\frac{s}{(s+1)^2}$
(b) $\frac{1}{(s-1)^2}$
(c) $\frac{1}{(s+1)^2}$
(d) $\frac{s}{s-1}$

Ans. (b)

$$f(t) = te^t$$

$$L(t) = \frac{1}{s^2}$$

By first shifting rule

$$L(te^t) = \frac{1}{(s-1)^2}$$

End of Solution

Q.11 The heat loss from a fin is 6 W. The effectiveness and efficiency of the fin are 3 and 0.75 respectively. The heat loss (in W) from the fin, keeping the entire fin surface at base temperature is ___________.

Ans. (8)

q_{actual} from fin = 6 watt

$$\eta_{\text{fin}} = \frac{q_{\text{actual}}}{q_{\text{max. possible}}}$$ i.e. when entire fin at base temperature

$\therefore$ q from fin if entire fin at base temp

$$= \frac{q_{\text{act.}}}{0.75} = \frac{6}{0.75} = 8 \text{ watt}$$

End of Solution

Q.12 The standard deviation of linear dimensions P and Q are 3 μm and 4 μm, respectively. When assembled, the standard deviation (in μm) of the resulting linear dimension ($P + Q$) is ___________.

Ans. (5)

According to Root Sum Square or RSS model

$$\sigma_a = \sqrt{\sum_{i=1}^{n} \sigma_i^2}$$

where, σ_a = assembly tolerance standard deviation
σ_i = i^{th} component tolerance standard deviation

Here $\sigma_P = 3$ μm and $\sigma_Q = 4$ μm

$$\sigma_a = \sqrt{\sigma_P^2 + \sigma_Q^2} = \sqrt{3^2 + 4^2} = 5 \text{ μm}$$

End of Solution

Q.13 A steel bar is held by two fixed supports as show in the figure and is subjected to an increase of temperature ΔT = 100°C. If the coefficient of thermal expansion and Young's modulus of elasticity of steel are 11×10^{-6} /°C and 200 GPa, respectively, the magnitude of thermal stress (in MPa) induced in the bar is _______.

Ans. (220)

We know that for completely restricted expansion, thermal stress developed in bar is given by

$$\sigma_{th} = \alpha(\Delta T)E = 11 \times 10^{-6} \times 100 \times 200 \times 10^{3}$$
$$= 220 \text{ MPa (comp. in native)}$$

End of Solution

Q.14 For a single server with Poisson arrival and exponential service time, the arrival rate is 12 per hour. Which one of the following service rates will provide a steady state finite queue length?

(a) 6 per hour
(b) 10 per hour
(c) 12 per hour
(d) 24 per hour

Ans. (d)

For steady state, $\mu > \lambda$

as λ = 12 cust/hr, we should go with option (d) 24/hr

End of Solution

Q.15 A sample of 15 data is as follows: 17, 18, 17 17, 13, 18, 5, 5, 6, 7, 8, 9, 20, 17, 3. The mode of the data is

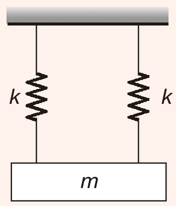
(a) 4
(b) 13
(c) 17
(d) 20

Ans. (c)

Mode means highest number of observations or occurrence of data most of the time as data 17, occurs four times, i.e., highest time. So mode is 17.

End of Solution

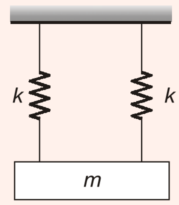
Q.16 A mass m is attached to two identical springs having constant k as shown in the figure. The natural frequency ω of this single degree of freedom system is



(a) $\sqrt{\dfrac{2k}{m}}$ (b) $\sqrt{\dfrac{k}{m}}$

(c) $\sqrt{\dfrac{k}{2m}}$ (d) $\sqrt{\dfrac{4k}{m}}$

Ans. (a)



Equivalent stiffness $k_{eq} = k + k = 2k$

Natural frequency is

$$\omega_n = \sqrt{\frac{k_{eq}}{m}} = \sqrt{\frac{2k}{m}}$$

End of Solution

Q.17 The state of stress at a point is $\sigma_x = \sigma_y = \sigma_z = \tau_{xz} = \tau_{zx} = \tau_{yz} = \tau_{zy} = 0$ and $\tau_{xy} = \tau_{yx} = 50$ MPa. The maximum normal stress (in MPa) at that point is ______.

Ans. (50)

Given state of stress condition indicates pure shear state of stress.

For pure shear state of stress,

Max. tensile stress = Max. comp. stress

= Max. Shear stress = τ_{XY} = 50 MPa

Hence, Max. normal stress = 50 MPa

End of Solution

Q.18 The divergence of the vector $-yi + xj$ is ___________.

Ans. (0)

$$\bar{F} = -y\bar{i} + x\bar{j}$$

$$\nabla \cdot \bar{F} = \frac{\partial}{\partial x}(-y) + \frac{\partial}{\partial y}(x)$$

$$= 0 + 0 = 0$$

End of Solution

Q.19 The determinant of a 2 × 2 matrix is 50. If one eigenvalue of the matrix is 10, the other eigen value is ___________.

Ans. (5)

The product of eigen value of always equal to the determinant value of the matrix.

$$\lambda_1 = 10 \quad \lambda_2 = \text{unknown} \quad |A| = 50$$

$$\lambda_1 \cdot \lambda_2 = 50$$

$$10\,(\lambda_2) = 50$$

$$\therefore \quad \lambda_2 = 5$$

End of Solution

Q.20 Given the atomic weight of Fe is 56 and that of C is 12, the weight percentage of carbon in cementite (Fe_3C) is ________.

Ans. (6.67)

$$\frac{12}{56 \times 3 + 12 \times 1} \times 100\% = 6.67\%$$

End of Solution

Q.21 It is desired to make a product having T-shaped cross-section from a rectangular aluminium block. Which one of the following processes is expected to provide the highest strength of the product?

(a) Welding
(b) Casting
(c) Metal forming
(d) Machining

Ans. (c)

In metal forming there will be increased mechanical properties due to change in grain size and work hardening.

End of Solution

Q.22 A machine component made of a ductile material is subjected to a variable loading with σ_{min} = – 50 MPa and σ_{max} = 50 MPa. If the corrected endurance limit and the yield strength for the material are σ_e' = 100 MPa and σ_y = 300 MPa, respectively, the factor of safety is __________.

Ans. (2)

Given variable loading is a completely reversed fatigue or variable loading because

$$\sigma_{max} = -\sigma_{min}$$

Hence, $\sigma_{mean} = \sigma_m = 0;\ \sigma_{variable} = \sigma_v = \sigma_{max}$

For completely reversed fatigue loading Soderberg, Goodman, Gerber and strength criterion will give same results.

As per strength criterion,

$$\sigma_{max} \le \sigma_{per} \quad \text{or} \quad \frac{\text{failure stress}}{\text{F.O.S.}}$$

$$\sigma_{max} = \frac{\text{Endurance limit}}{N}$$

$$N = \frac{\text{Endurance limit}}{\text{Max. stress}} = \frac{100}{50} = 2$$

End of Solution

Q.23 The crystal structure of aluminium is

(a) body-centred cubic
(b) face-centred cubic
(c) close-packed hexagonal
(d) body-centred tetragonal

Ans. (b)

Crystal Structure of materials

- FCC: Ni, Cu, Ag, Pt, Au, Pb, Al (soft)
- BCC: V, Mo, Ta, W (hard material)
- HCP: Mg, Zn
- Cobalt HCP < 420°C, FCC > 420°C
- Chromium HCP < 20°C , BCC >20°C
- Glass: Amorphous
- BCC: Ferrite or α-iron δ-ferrite or δ-iron
- FCC: Austenite or γ-iron

End of Solution

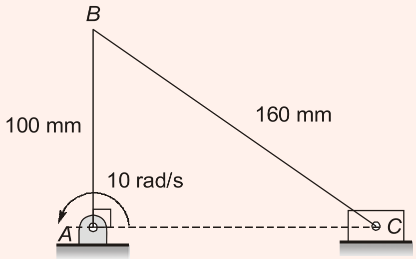
Q.24 Which one of the following statements is TRUE?

(a) Both Pelton and Francis turbines are impulse turbines.
(b) Francis turbine is a reaction turbine but Kaplan turbine is an impulse turbine.
(c) Francis turbine is an axial-flow reaction turbine.
(d) Kaplan turbine is an axial-flow reaction turbine.

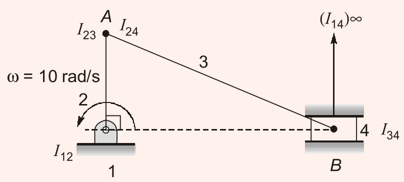
Ans. (d)

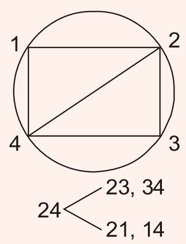
End of Solution

Q.25 In a slider-crank mechanism, the lengths of the crank and the connecting rod are 100 mm and 160 mm, respectively. The crank is rotating with an angular velocity of 10 radian/s counter clockwise. The magnitude of linear velocity (in m/s) of the piston at the instant corresponding to the configuration shown in the figure is _______.



Ans. (1 m/s)





After plotting I-centres

Here, I_{23} and I_{24} will come at same point

Applying angular Velocity Theorem at I_{24}

$$\therefore \quad \omega_2(I_{24}I_{12}) = V_4 = V_B$$

$$V_B = \omega_2(I_{24}I_{12}) = 10 \times 0.1 \quad (I_{24}I_{12} = 100 \text{ mm} = 0.1 \text{ m} = AB)$$

$$V_B = 1 \text{ m/s}$$

End of Solution

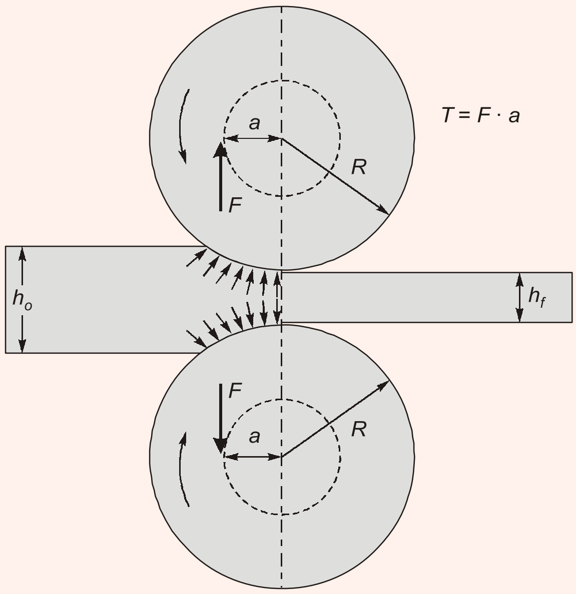
Q.26 A strip of 120 mm width and 8 mm thickness is rolled between two 300 mm diameter rolls to get a strip of 120 mm width and 7.2 mm thickness. The speed of the strip at the exit is 30 m/min. There is no front or back tension. Assuming uniform roll pressure of 200 MPa in the roll bite and 100% mechanical efficiency, the minimum total power (in kW) required to drive the two rolls is ________.

Ans. (*)

This question is wrong. For proper calculation we need velocity of neutral plane or velocity of roller. But in this question velocity of exit is given. From velocity of exit we may assume the velocity of neutral plane but can't calculate correctly.

After IITs' answer we will challenge and confirm the answer. I have given best answer for this question.

<u>Method</u>-I:



Projected length, $L_p = R\sin\alpha \approx \sqrt{R\Delta h} = \sqrt{150\times(8-7.2)} = 10.954$ mm

Projected Area, $A_p = L_p \times b = 10.954 \times 120 = 1314.48\ \text{mm}^2$

Roll Separating Force, $F = \sigma_o \times L_p \times b$ N $= 200 \times 1314.48$ N $= 262.9$ kN

[σ_o in N/mm^2 i.e. MPa]

Arm length (a in mm) $= 0.5\ L_p$ for hot rolling $= 0.5 \times 10.954$ mm $= 5.477$ mm

$= 0.45\ L_p$ for cold rolling

Torque per roller, $T = F \times \dfrac{a}{1000}$ Nm $= 262.9$ kN $\times 5.477$ mm $= 1439.9$ Nm

Total power for two roller,

$$P = 2T\omega \text{ in W} = 2T \times \frac{2\pi N}{60}$$

For the calculation of N we need velocity of neutral plane

Continuity equation

$$h_o\, b_o\, v_o = h_f\, b_f\, v_f$$

$$8 \times 120 \times v_o = 7.2 \times 120 \times 30$$

or $$v_o = 27 \text{ m/min}$$

Assuming velocity of neutral plane

average velocity, $$V = \frac{V_0 + V_f}{2} = \frac{27+30}{2} = 28.5 \text{ m/min}$$

Now, $$V = \pi DN$$

or $$28.5 = \pi \times 0.300 \times N$$

or $$N = 30.24 \text{ rpm}$$

∴ Total power for two roller,

$$P = 2T \times \frac{2\pi N}{60} = 2 \times 1439.9 \times \frac{2 \times \pi \times 30.24}{60} \text{ W}$$

$$= 9.1195 \text{ kW} \approx 9.12 \text{ kW}$$

Method-II :

Velocity at the neutral plane = ?

$$H_n\, V_n = H_2\, V_2 \quad \text{(Applying continuity)}$$

$$H_n = H_2 + 0.25\,\Delta H \quad \text{(Standard relation)}$$

$$= 7.2 + 0.25 \times 0.8 = 7.4 \text{ mm}$$

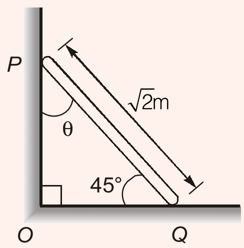
$$V_n = \frac{H_2 V_2}{H_n} = 29.19 \text{ m/min}$$

$$N = \frac{29.19 \times 1000}{\pi \times 300} = 30.98 \text{ rpm}$$

$$\text{total power} = 2T\omega = 2 \times 1439.9 \times 2\pi\frac{30.98}{60} = 9.34 \text{ kW}$$

End of Solution

Q.27 The rod PQ of length $L = \sqrt{2}$ m and uniformly distributed mass of M = 10 kg, is released from rest at the position shown in the figure. The ends slide along the frictionless faces OP and OQ. Assume acceleration due to gravity, g = 10 m/s^2. The mass moment of inertia of the rod about its centre of mass and an axis perpendicular to the plane of the figure is (ML^2/12). At this instant, the magnitude of angular acceleration (in radian/s^2) of the rod is ___________.



Ans. (7.5)

$$L = \sqrt{2}\ \text{m}$$
$$M = 10\ \text{kg}$$
$$g = 10\ \text{m/s}^2$$

Both the surfaces are smooth

$$\ddot{\theta} = \alpha = \frac{3g}{2L}\sin\theta$$

$$\alpha = \frac{3\times10}{2\times\sqrt{2}}\sin 45^\circ \qquad [\because\ \theta = 45^\circ]$$

$$a = \frac{3\times10}{2\times\sqrt{2}}\times\frac{1}{\sqrt{2}} = \frac{30}{4} = 7.5\ \text{rad/s}^2$$

End of Solution

Q.28 For the laminar flow of water over a sphere, the drag coefficient C_F is defined as $C_F = F/(\rho U^2 D^2)$, where F is the drag force, ρ is the fluid density, U is the fluid velocity and D is the diameter of the sphere. The density of water is 1000 kg/m^3. When the diameter of the sphere is 100 mm and the fluid velocity is 2 m/s, the drag coefficient is 0.5. If water now flows over another sphere of diameter 200 mm under dynamically similar conditions, the drag force (in N) on this sphere is ________.

Ans. (80)

For sphere-I, $\rho = 1000$ kg/m^3, $D_1 = 100$ mm $= 0.1$ m, $U_1 = 2$ m/s, $C_{F1} = 0.5$

For sphere-II, $D_2 = 200$ mm $= 0.2$ m

Since, Dynamically similar conditions,

$$C_{F1} = C_{F2} = 0.5; \qquad U_1 = U_2 = 2\ \text{m/s}$$

Drag force, $F_1 = C_{F1}\,(\rho U_1^2\ D_1^2) = 0.5 \times (1000 \times 2 \times 2 \times 0.1 \times 0.1) = 20$ N

$$\frac{F_1}{F_2} = \frac{C_{F1}(\rho U_1^2 D_1^2)}{C_{F2}(\rho U_2^2 D_2^2)}$$

$$\frac{20}{F_2} = \frac{D_1^2}{D_2^2} = \frac{0.01}{0.04}$$

$$F_2 = 80\ \text{N}$$

End of Solution

Q.29 A rod of length 20 mm is stretched to make a rod of length 40 mm. Subsequently, it is compressed to make a rod of final length 10 mm. Consider the longitudinal tensile strain as positive and compressive strain as negative. The total true longitudinal strain in the rod is

(a) – 0.5 (b) – 0.69
(c) – 0.75 (d) – 1.0

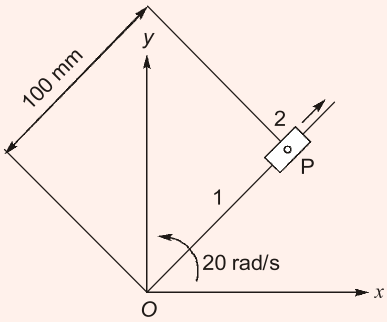
Ans. (b)

$$\varepsilon_E = \frac{L_f - L_0}{L_0} = \frac{10-20}{20} = -0.5$$

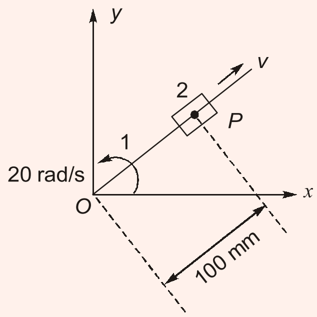
$$\varepsilon_T = \ln[1 + \varepsilon_E] = \ln[1 - 0.5] = -0.693$$

End of Solution

Q.30 Block 2 slides outward on link 1 at a uniform velocity of 6 m/s as shown in the figure. Link 1 is rotating at a constant angular velocity of 20 radian/s counterclockwise. The magnitude of the total acceleration (in m/s^2) of point P of the block with respect to fixed point O is ________.



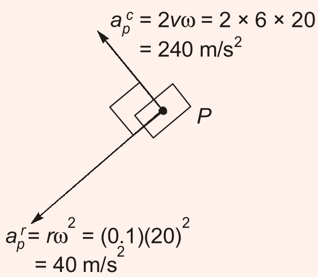
Ans. (243.310)



$V = 6$ m/s

$\omega = 20$ rad/s

Here the centripital and corialis acceleration will be there



Total Acceleration:

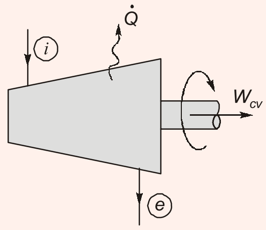
$$a_p = \sqrt{(40)^2 + (240)^2} = 243.310 \text{ m/s}^2$$

End of Solution

Q.31 A calorically perfect gas (specific heat at constant pressure 1000 J/kgK) enters and leaves a gas turbine with the same velocity. The temperature of the gas at turbine entry and exit are 1100 K and 400 K, respectively. The power produced is 4.6 MW and heat escapes at the rate of 300 kJ/s through the turbine casing. The mass flow rate of the gas (in kg/s) through the turbine is

(a) 6.14
(b) 7.00
(c) 7.50
(d) 8.00

Ans. (b)



$$c_p = 1 \text{ kJ/kg-K}$$
$$V_i = V_e \text{ (Inlet and exit velocity same)}$$
$$\dot{W}_{C.V} = 4.6 \text{ MW} = 4.6 \times 10^3 \text{ kW}$$
$$\dot{Q} = 300 \text{ kW}$$

Applying SFEE,

$$\dot{m}(h_i + \frac{1}{2}V_i^2 + gz_i) + \dot{Q} = \dot{m}(h_e + \frac{1}{2}V_e^2 + gz_e) + \dot{W}_{C.V.}$$

$$\dot{m}\left[c_p(T_i - T_e)\right] + \dot{Q} = \dot{W}_{C.V.} \quad \text{(Let } z_i = z_e\text{)}$$

$$\dot{m}\left[1 \times (1100 - 400)\right] + (-300) = 4.6 \times 10^3$$

$$\Rightarrow \quad \dot{m} = 7 \text{ kg/s}$$

End of Solution

Q.32 A helical compression spring made of a wire of circular cross-section is subjected to a compressive load. The maximum shear stress induced in the cross-section of the wire is 24 MPa. For the same compressive load, if both the wire diameter and the mean coil diameter are doubled, the maximum shear stress (in MPa) induced in the cross-section of the wire is __________.

Ans. (6)

Max. shear stress induced in spring wire of a helical compression spring is given by,

$$\tau_{max} = \frac{8WD}{\pi d^2}k_W \quad \text{or} \quad \frac{8WC}{\pi d^2}k_W$$

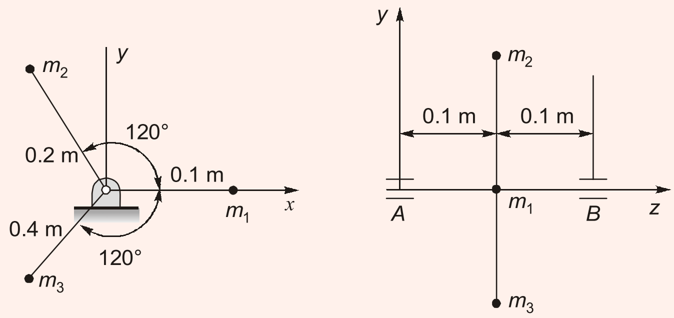
$$\tau_{max} \propto \frac{1}{d^2} \qquad [\because W_1 = W_2 = W;\ C_1 = C_2 \text{ (i.e., } C = \frac{D}{d}\text{)}$$
$$(k_W)_1 = (k_W)_2 = k_W]$$

$$\frac{\tau_2}{\tau_1} = \left(\frac{d_1}{d_2}\right)^2$$

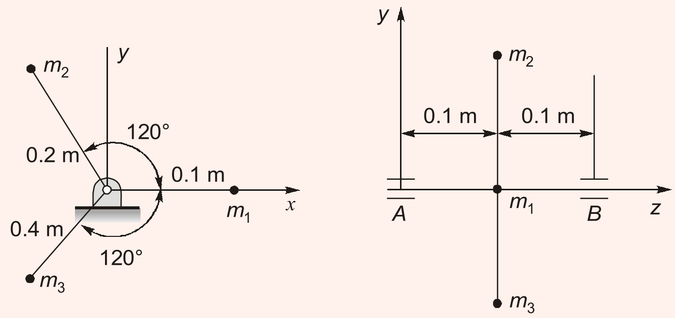
$$\frac{\tau_2}{24} = \left(\frac{d}{2d}\right)^2 \Rightarrow \tau_2 = 6 \text{ MPa}$$

End of Solution

Q.33 Three masses are connected to a rotating shaft supported on bearing A and B as shown in the figure. The system is in a space where the gravitational effect is absent. Neglect the mass of shaft and rods connecting the masses. For m_1 = 10 kg, m_2 = 5 kg and m_3 = 2.5 kg and for a shaft angular speed of 1000 radian/s, the magnitude of the bearing reaction (in N) at location B is ________.



Ans. (0)



It means all three masses are in same plane
let us calculates the net force

$$\Sigma F_x = \Sigma m r\omega^2\cos\theta = (10 \times 0.1 \times \omega^2) - (5 \times 0.2 \times \omega^2 \cos 60°) - (2.5 \times 0.4 \times \omega^2 \cos 60°)$$

$$= \left[1 - \left(5 \times 0.2 \times \frac{1}{2}\right) - \left(2.5 \times 0.4 \times \frac{1}{2}\right)\right]\omega^2 = 0$$

$$\Sigma F_y = \Sigma m r\omega^2 \sin\theta = (5 \times 0.2 \times \omega^2 \sin 60°) - (2.5 \times 0.4 \times \omega^2 \sin 60°)$$

$$= \left[\left(1 \times \frac{\sqrt{3}}{2}\right) - \left(1 \times \frac{\sqrt{3}}{2}\right)\right]\omega^2 = \left[\left(\frac{\sqrt{3}}{2} - \frac{\sqrt{3}}{2}\right)\right]\omega^2 = 0$$

Net force $$F = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = 0$$

Therefore reaction at B is zero.

$$R_B = 0$$

End of Solution

Q.34 In an orthogonal machining with a tool of 9° orthogonal rake angle, the uncut chip thickness is 0.2 mm. The chip thickness fluctuates between 0.25 mm and 0.4 mm. The ratio of the maximum shear angle to the minimum shear angle during machining is ____________.

Ans. **(1.494)**

Given
$$\alpha = 9^\circ$$
$$t = 0.2 \text{ mm}$$
$$t_{c\,max} = 0.4 \text{ mm}$$
$$t_{c\,min} = 0.25 \text{ mm}$$

$$\tan\phi_{max} = \frac{r_{max}\cos\alpha}{1 - r_{max}\sin\alpha} = \frac{\frac{0.2}{0.25}\cos 9^\circ}{1 - \frac{0.2}{0.25}\sin 9^\circ}$$

or $\phi_{max} = 42.09^\circ$

$$\tan\phi_{min} = \frac{r_{min}\cos\alpha}{1 - r_{min}\sin\alpha} = \frac{\frac{0.2}{0.4}\cos 9^\circ}{1 - \frac{0.2}{0.4}\sin 9^\circ}$$

or $\phi_{min} = 28.18^\circ$

$$\text{Ratio} = \frac{\phi_{max}}{\phi_{min}} = \frac{42.09}{28.18} = 1.494$$

End of Solution

Q.35 Consider the differential equation $3y''(x) + 27y(x) = 0$ with initial conditions $y(0) = 0$ and $y'(0) = 2000$. The value of y at $x = 1$ is ____________.

Ans. **(94.08)**

The direction is $3y''(x) + 27y(x) = 0$

The auxillary equation is
$$3m^2 + 27 = 0$$
$$m^2 + 9 = 0$$
$$m = \pm 3i$$

Solution is $y = c_1 \cos 3x + c_2 \sin 3x$

given that $y(0) = 0$

$\therefore$ $0 = c_1$
$$y' = -3c_1 \sin 3x + 3c_2 \cos 3x$$
$$y'(0) = 2000$$
$$2000 = 0 + 3c_2$$
$$c_2 = \frac{2000}{3}$$

$\therefore$ Solution is $y = \frac{2000}{3}\sin 3x$

when $x = 1$ $\quad y = \frac{2000}{3}\sin 3 = 94.08$

End of Solution

Q.36 The volume and temperature of air (assumed to be an ideal gas) in a closed vessel is 2.87 m^3 and 300 K, respectively. The gauge pressure indicated by a manometer fitted to the wall of the vessel is 0.5 bar. If the gas constant of air is R = 287 J/kgK and the atmospheric pressure is 1 bar, the mass of air (in kg) in the vessel is

(a) 1.67
(b) 3.33
(c) 5.00
(d) 6.66

Ans. (c)

$$P_g = 5 \text{ bar} = 50 \text{ kPa; R} = 287 \text{ J/kgK} = 0.287 \text{ kJ/kgK}$$

Ideas gas equation:

$$PV = mRT$$

Here P is absolute pressure:

$$P = P_{abs} = P_{gauge} + P_{\text{atm}} = 50 + 101.325$$
$$= 151.325 \text{ kPa}$$

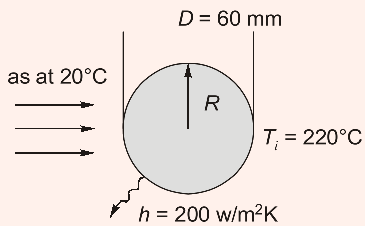
$$m = \frac{PV}{RT} = \frac{151.325 \times 2.87}{0.287 \times 300} = 5.04 \text{ kg}$$

End of Solution

Q.37 A metal ball of diameter 60 mm is initially at 220°C. The ball is suddenly cooled by an air jet of 20°C. The heat transfer coefficient is 200 W/m^2K. The specific heat, thermal conductivity and density of the metal ball are 400 J/kgK, 400 W/mK and 9000 kg/m^3, respectively. The ball temperature (in °C) after 90 seconds will be approximately

(a) 141
(b) 163
(c) 189
(d) 210

Ans. (a)



$$c_p = 400 \text{ J/kgK}$$
$$k = 400 \text{ W/mK}$$
$$\rho = 9000 \text{ kg/m}^3$$
$$\text{Time } (\tau) = 90 \text{ sec}$$

Since K being high and size of ball being small, lumped heat analysis is valid.

$$\Rightarrow \quad e^{\left(\frac{hA}{\rho v c_p}\right)\tau} = \frac{T_i - T_\infty}{T - T_\infty} \quad \Rightarrow \quad \left(\frac{h_A}{\rho v c_p}\right)\tau = \ln\left(\frac{T_i - T_\infty}{T - T\infty}\right)$$

Put

$$\frac{A}{V} = \frac{3}{R} = \frac{3}{\left(\frac{30}{1000}\right)}$$

$$\left(\frac{hA}{\rho v c_p}\right)\tau = \left(200 \times \frac{3}{0.03} \times \frac{1}{9000} \times \frac{1}{400}\right) \times 90 = 0.5$$

$$\frac{220 - 20}{T - 20} = e^{0.5} = 1.6487$$

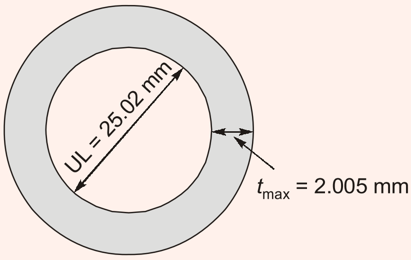
$$T = 141.3°\text{C}$$

End of Solution

Q.38 A cylindrical pin of $25^{+0.020}_{+0.010}$ mm diameter is electroplated, plating thickness is $2.0^{\pm 0.005}$ mm. Neglecting the gauge tolerance, the diameter (in mm, up to 3 decimal points accuracy) of the GO ring gauge to inspect the plated pin is ________.

Ans. (29.030)

GO ring gauge will inspect maximum metal conditions i.e. UL of shaft i.e. Largest size after platting.



$$\text{UL after platting} = 25.02 + 2.005 + 2.005 \text{ mm} = 29.030 \text{ mm}$$

End of Solution

Q.39 In a counter-flow heat exchanger, water is heated at the rate of 1.5 kg/s from 40°C to 80°C by an oil entering at 120°C and leaving at 60°C. The specific heats of water and oil are 4.2 kJ/kgK and 2 kJ/kgK, respectively. The overall heat transfer coefficient is 400 W/m^{2}K. The required heat transfer surface area (in m^2) is

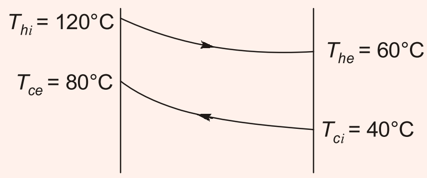
(a) 0.104
(b) 0.022
(c) 10.4
(d) 21.84

Ans. (d)

H_E = Counterflow type

$\Delta T_i = 120 - 80 = 40°C$

$\Delta T_e = 60 - 40 = 20°C$



$$(LMTD)\text{ Counterflow} = \frac{\Delta T_i - \Delta T_e}{\ln \frac{\Delta T_i}{\Delta T_e}} = \frac{40-20}{\ln \frac{40}{20}}$$

$$= 28.86°C$$

$$Q = \dot{m}_C c_{p_C} (T_{ce} - T_{ci})$$

$$= 1.5 \times 4.2 \times 10^3 (80 - 40) \text{ watt}$$

$$Q = 252000 \text{ Watt}$$

also $$Q = UA\Delta T_m$$

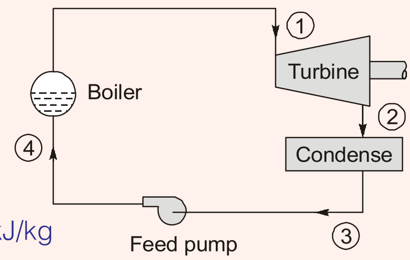
$$A = \frac{Q}{U\Delta T_m} = \frac{1.5 \times 4.2 \times 10^3 \times 40}{400 \times 28.86} = 21.83 \text{ m}^2$$

End of Solution

Q.40 In the Rankine cycle for a steam power plant the turbine entry and exit enthalpies are 2803 kJ/kg and 1800 kJ/kg, respectively. The enthalpies of water at pump entry and exit are 121 kJ/kg and 124 kJ/kg respectively. The specific steam consumption (in kg/kWh) of the cycle is ____________.

Ans. (3.6)

Given data



$$h_1 = 2803 \text{ kJ/kg}$$
$$h_2 = 1800 \text{ kJ/kg}$$
$$h_3 = 121 \text{ kJ/kg}$$
$$h_4 = 124 \text{ kJ/kg}$$
$$w_T = h_1 - h_2 = 2803 - 1800 = 1003 \text{ kJ/kg}$$
$$w_P = h_4 - h_3 = 124 - 121 = 3 \text{ kJ/kg}$$
$$w_{net} = w_T - w_P = 1003 - 3 = 1000 \text{ kJ/kg}$$
$$ssc = \frac{3600}{w_{net}} = \frac{3600}{1000} = 3.6 \text{ kg/kWh}$$

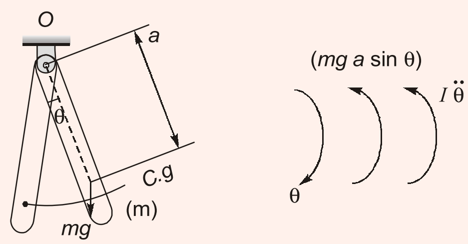
End of Solution

Q.41 The radius of gyration of a compound pendulum about the point of suspension is 100 mm. The distance between the point of suspension and the centre of mass is 250 mm. Considering the acceleration due to gravity is 9.81 m/s^2, the natural frequency (in radian/s) of the compound pendulum is ________.

Ans. (15.660)

If we displace this by an angle θ clockwise:

Compound pendulum



$$I\ddot{\theta} + mg.a \sin\theta = 0$$

Taking θ very small:

$$\sin\theta \approx \theta \qquad (k = 100 \text{ mm} = 0.1 \text{ m})$$

$$I\ddot{\theta} + mg.a.\theta = 0$$

$$\ddot{\theta} + \left(\frac{mg}{I}a\right)\theta = 0$$

Here $I = mk^2 = m(0.1)^2$ (I is the MI about the point of Hinge)

$$I = m(0.01) \text{ kg-m}^2$$
$$a = 250 \text{ mm} = 0.250 \text{ m}$$
$$g = 9.81 \text{ m/s}^2$$
$$\ddot{\theta} + \left(\frac{m \times 9.81 \times 0.250}{(0.01)m}\right)\theta = 0$$
$$\ddot{\theta} + (245.25)\theta = 0$$
$$\omega_n = \sqrt{245.25} = 15.660 \text{ rad/s}$$

End of Solution

Q.42 If $f(z) = (x^2 + ay^2) + ibxy$ is a complex analytic function of $z = x + iy$, where $i = \sqrt{-1}$, then

(a) $a = -1, b = -1$
(b) $a = -1, b = 2$
(c) $a = 1, b = 2$
(d) $a = 2, b = 2$

Ans. (b)

Given that the analytic function

$$f(2) = (x^2 + ay^2) + i\ bxy$$
$$u + i\ v = (x^2 + ay^2) + i\ (bxy)$$
$$u = x^2 + ay^2; \qquad v = bxy$$
$$u_x = 2x; \quad u_y = 2ay; \quad v_x = by; \quad v_y = bx$$
$$u_x = v_y; \quad u_y = -v_x$$
$$2x = bx; \quad 2ay = -by$$
$$b = 2; \quad 2a = -b \qquad \text{since } b = 2$$
$$2a = -2$$
$$a = -1$$

End of Solution

Q.43 Consider the matrix $A = \begin{bmatrix} 50 & 70 \\ 70 & 80 \end{bmatrix}$ whose eigenvectors corresponding to eigenvalues λ_1 and λ_2 are $x_1 = \begin{bmatrix} 70 \\ \lambda_1 - 50 \end{bmatrix}$ and $x_2 = \begin{bmatrix} \lambda_1 - 80 \\ 70 \end{bmatrix}$, respectively. The value of $x_1^T x_2$ is ___________.

Ans. (0)

$$A = \begin{bmatrix} 50 & 70 \\ 70 & 80 \end{bmatrix}$$

Eigen values of A are λ_1, λ_2

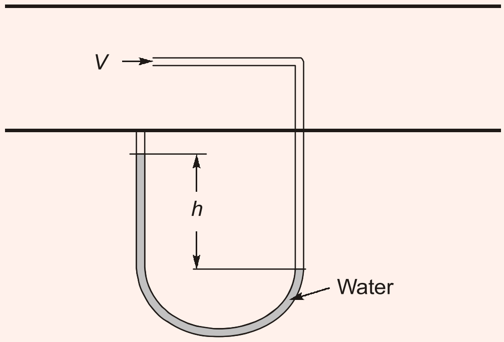
$$\lambda_1 + \lambda_2 = 130$$
$$\lambda_1\lambda_2 = -900$$

Given that $\quad X_1 = \begin{bmatrix} 70 \\ \lambda_1 - 50 \end{bmatrix} \quad X_2 = \begin{bmatrix} \lambda_2 - 80 \\ 70 \end{bmatrix}$

$$X_1^T X_2 = [70 \quad \lambda_1 - 50]\begin{bmatrix}\lambda_2 - 80 \\ 70\end{bmatrix}$$
$$= 70\,\lambda_2 - 5600 + 70\,\lambda_1 - 3500$$
$$= 70\,(\lambda_1 + \lambda_2) - 9100 = 70\,(130) - 9100$$
$$= 9100 - 9100 = 0$$

End of Solution

Q.44 The arrangement shown in the figure measures the velocity V of a gas of density 1 kg/m^3 flowing through a pipe. The acceleration due to gravity is 9.81 m/s^2. If the manometric fluid is water (density 1000 kg/m^3) and the velocity V is 20 m/s, the differential head h(in mm) between the two arms of the manometer is ________.



Ans. (20.38)

Method : (i)

Given data: $\rho_{gas} = 1$ kg/m^3; $g = 9.81$ m/s^2, $\rho_m = 1000$ kg/m^3, $V = 20$ m/s

Dynamic pressure of gas = $(\rho g h)_{water}$

$$\frac{1}{2}\rho_{gas}V^2 = \rho_m \times 9.81 \times h$$

$$\frac{1}{2}\times 1 \times (20)^2 = 1000 \times 9.81 \times h$$

or $h = 0.02038$ m of water

$= 20.38$ mm of water

Method : (ii)

$\rho_m = 1000$ kg/m^3, $\rho_w = 1$ kg/m^3

$V = 20$ m/s

$$V = \sqrt{2gh\left(\frac{\rho_m}{\rho_w} - 1\right)}$$

$$20 = \sqrt{2 \times 9.81 \times h\left(\frac{1000}{1} - 1\right)}$$

$h = 20.40$ mm of water

End of Solution

Q.45 The surface integral $\iint_S F \cdot n dS$ over the surface S of the sphere $x^2 + y^2 + z^2 = 9$, where $F = (x + y)i + (x + z)j + (y + z)k$ and n is the unit outward surface normal, yields ____________.

Ans. (226.08)

$$F = (x + y)i + (x + z)j + (y + z)k$$

$$\nabla \cdot F = \frac{\partial}{\partial x}(x+y) + \frac{\partial}{\partial y}(x+z) + \frac{\partial}{\partial z}(y+z)$$

$$= 1 + 0 + 1 = 2$$

By Gauss divergence theorem

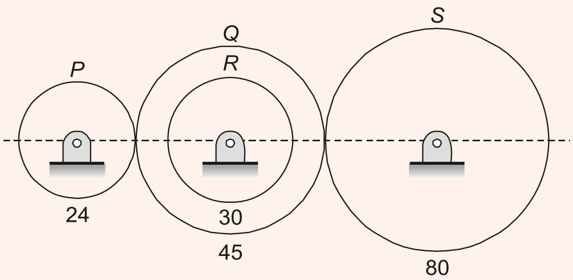
$$\iint_S F \cdot \hat{n} dS = \iint_V \nabla \cdot \bar{F} dV = \iint_V 2 dV$$

$$= 2V \text{ where } V \text{ is volume of } x^2 + y^2 + z^2$$

$$= 2\left(\frac{4}{3}\pi(3)^3\right) = 226.08$$

End of Solution

Q.46 A gear train shown in the figure consists of gears P, Q, R and S. Gear Q and gear R are mounted on the same shaft. All the gears are mounted on parallel shafts and the number of teeth of P, Q, R and S are 24, 45, 30 and 80, respectively. Gear P is rotating at 400 rpm. The speed (in rpm) of the gear S is ________.



Ans. (120)

$$T_P = 24$$
$$T_Q = 45 \qquad N_P = 400 \text{ rpm}$$
$$T_R = 30 \qquad N_S = ?$$
$$T_S = 80$$

Here gear R is not mashing at all.

$$\frac{N_P}{N_Q} = \frac{T_Q}{T_P} = \frac{45}{24} \quad ...(1)$$

$$\frac{N_Q}{N_S} = \frac{T_S}{T_Q} = \frac{80}{45} \quad ...(2)$$

By (1) × (2)

$$\frac{N_P}{N_S} = \frac{45}{24} \times \frac{80}{45}$$

$$N_S = N_P \times \frac{24}{80} = \frac{400 \times 24}{80}$$

$$N_S = 120 \text{ r.p.m}$$

End of Solution

Q.47 Maximize $Z = 5x_1 + 3x_2$,
subject to
$x_1 + 2x_2 \leq 10$
$x_1 - x_2 \leq 8$
$x_2 , x_2 \geq 0$
In the starting simplex tableau, x_1 and x_2 are non-basic variables and the value of Z is zero. The value of Z in the next simplex tableau is ________.

Ans. (40)

$$\text{Max. } Z = 5x_1 + 3x_2 + 0 \times S_1 + 0 \times S_2$$
$$x_1 + 2x_1 + S_1 = 10$$
$$x_1 - x_2 + S_2 = 8$$

	x_1	x_2	S_1	S_2	b_i	$\theta_i = b_i / a_{ij}$
e_i 0 S_1	1	2	1	0	10	10
0 S_2	(1)*	–1	0	1	8	8
C_j	5	3	0	0		
Z_j	0	0	0	0		
Δ_j	5	3	0	0		

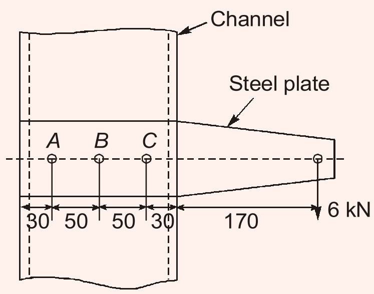
Key Row

Key column

Objective function will increase by ₹ 5 per unit of x_1 and bring 8 units.
So, total increase (18 × 5 = ₹ 40)

End of Solution

Q.48 A steel plate, connected to a fixed channel using three identical bolts A, B and C, carries a load of 6 kN as shown in the figure. Considering the effect of direct load and moment, the magnitude of resultant shear force (in kN) on bolt C is



All dimensions are in mm

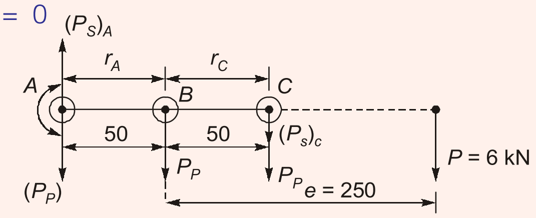
(a) 13
(b) 15
(c) 17
(d) 30

Ans. (c)

$$P_P = \frac{P}{n} = \frac{P}{3} = 2\text{ kN}$$

$$r_A = r_C = 50;\ (P_S)_A = (P_S)_C$$

$$r_B = 0 \Rightarrow (P_S)_B = 0$$



$$\frac{(P_S)_C}{r_C}\left[r_C^2 + r_B^2 + r_A^2\right] = P \times e$$

$$(P_S)_C \times 2 \times r_C = P \times e$$

$$(P_S)_C = \frac{6 \times 250}{2 \times 50} = 15\text{ kN}$$

$$\theta_A = 180°;\ \theta_C = 0°$$

Resultant shear force $(R_C) = P_P + (P_S)_C$ $\quad [\because\ \theta_C = 0°]$

$$R_C = 2 + 15 = 17\text{ kN}$$

$$R_A = (P_S)A - P_P = 13\text{ kN}$$

$$R_B = P_P = 2\text{ kN}$$

End of Solution

Q.49 During the turning of a 20 mm diameter steel bar at a spindle speed of 400 rpm, a tool life of 20 minute is obtained. When the same bar is turned at 200 rpm, the tool life becomes 60 minute. Assume that Taylor's tool life equation is valid. When the bar is turned at 300 rpm, the tool life (in minute) is approximately

(a) 25 (b) 32
(c) 40 (d) 50

Ans. (b)

$$V_1 = \pi D \times 400\text{ m/min};\quad T_1 = 20\text{ min}$$

$$V_2 = \pi D \times 200\text{ m/min};\quad T_2 = 60\text{ min}$$

Now using Taylor's equation

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

or $\pi D \times 400 \times (20)^n = \pi D \times 200 \times 60^n$

or $n = 0.6309$

and $V_3 = \pi D \times 300\text{ m/min};\quad T_3 = ?$

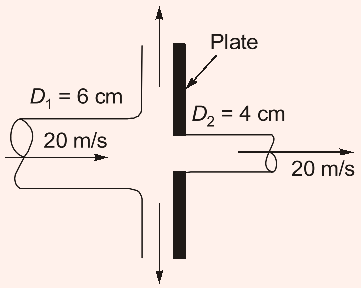
$$V_1 T_1^n = V_2 T_2^n = V_3 T_3^n$$

$$\pi D \times 400 \times (20)^{0.6309} = \pi D \times 300 \times T_3^{0.6309}$$

$\therefore$ $T_3 = 31.55\text{ min} \approx 32\text{ min}$

End of Solution

Q.50 A 60 mm diameter water jet strikes a plate containing a hole of 40 mm diameter as shown in the figure. Part of the jet passes through the hole horizontally, and the remaining is deflected vertically. The density of water is 1000 kg/m^3. If velocities are as indicated in the figure, the magnitude of horizontal force (in N) required to hold the plate is ________.



Ans. (628.32)

$$\rho = 1000 \text{ kg/m}^3$$

$$\text{Force, } F = \text{momentum}_{inlet} - \text{momentum}_{outlet}$$

$$F = (\dot{m}v)_{in} - (\dot{m}v)_{out}$$

$$F = \rho\left[\frac{\pi}{4}(D_1^2 - D_2^2)\right] \times V^2 = 1000\frac{\pi}{4} \times [0.06^2 - 0.04^2] \times 20^2$$

$$= 628.32 \text{ N}$$

End of Solution

Q.51 The principal stresses at a point in a critical section of a machine component are σ_1 = 60 MPa, σ_2 = 5 MPa and σ_3 = – 40 MPa. For the material of the component, the tensile yield strength is σ_y = 200 MPa. According to the maximum shear stress theory, the factor of safety is

(a) 1.67 (b) 2.00
(c) 3.60 (d) 4.00

Ans. (b)

As per max. shear stress theory,
safe condition for design,

$$\text{Absolute } \tau_{max} = \frac{S_{YS}}{N} \text{ or } \frac{S_{Yt}}{2N}$$

$$\text{Absolute } \tau_{max} = \text{larger of } \left[\left|\frac{\sigma_1 - \sigma_2}{2}\right|, \left|\frac{\sigma_2 - \sigma_3}{2}\right|, \left|\frac{\sigma_3 - \sigma_1}{2}\right|\right]$$

$$= \left|\frac{\sigma_3 - \sigma_1}{2}\right| \quad [\because \sigma_1 \text{ and } \sigma_3 \text{ are unlike in nature}]$$

$$= \left|\frac{-40 - 60}{2}\right| = 50 \text{ MPa}$$

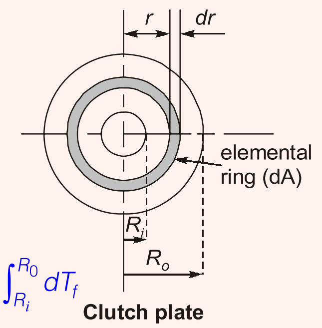
Hence,
$$50 = \frac{200}{2(N)}$$

$$N = 2$$

End of Solution

Q.52 A single-plate clutch has a friction disc with inner and outer radii of 20 mm and 40 mm, respectively. The friction lining in the disc is made in such a way that the coefficient of friction μ varies radially as $\mu = 0.01r$, where r is in mm. The clutch needs to transmit a friction torque of 18.85 kN mm. As per uniform pressure theory, the pressure (in MPa) on the disc is ________.

Ans. (0.5)



$$d_A = 2\pi r(dr)$$

Normal load on elemental ring $(dW) = p2\pi r dr$

Frictional force on elemental ring $(dF_f) = \mu dW$

Frictional torque transmitted by elemental ring,

$$dT_f = (dF_f)r$$

Hence, $dT_f = \mu p 2\pi r^2 dr$

Total frictional torque transmitted by clutch plate $(T_f) = \int_{R_i}^{R_0} dT_f$

$$T_f = \int_{R_i}^{R_0} \mu p 2\pi r^2 dr$$

As per U.P.T. $T_f = 2\pi p \int_{R_i}^{R_0} \mu r^2 dr$

$$T_f = 2\pi p \int_{R_i}^{R_0} (0.01r) r^2 dr$$

$$(T_f)_{U.P.T.} = (2\pi p)(0.01)\left[\frac{R_0^4 - R_i^4}{4}\right]$$

$$18.85 \times 10^3 = 2\pi p(0.01)\left[\frac{40^4 - 20^4}{4}\right]$$

$$p = 0.5 \text{ MPa}$$

End of Solution

Q.53 A product made in two factories, P and Q, is transported to two destinations, R and S. The per unit costs of transportation (in Rupees) from factories to destinations are as per the following matrix:

Factory \ Destination	R	S
P	10	7
Q	3	4

Factory P produces 7 units and factory Q produces 9 units of the product. Each destination requires 8 units. If the north-west corner method provides the total transportation cost X (in Rupees) and the optimized (the minimum) total transportation cost is Y (in Rupees), then $(X - Y)$, in Rupees, is

(a) 0
(b) 15
(c) 35
(d) 105

Ans. (*)

$X = 105$

Using penalty corner method and following modi method we get

	R	S	Penalty		
P	10 (4)	7 / 7	7	3	0
Q	5 / 3	4 / 1	9	1	– 3
	8	8			
Penalty	7	3			
v_j	6	7			

– 4 water value indicates that its optimum table, so

$$Y = 7 \times 7 + 3 \times 8 + 4 = 49 + 24 + 4 = 78$$
$$X - Y = 105 - 77 = 28$$

End of Solution

Q.54 One kg of an ideal gas (gas constant R = 287 J/kgK) undergoes an irreversible process from state-1 (1 bar, 300 K) to state-2 (2 bar, 300 K). The change in specific entropy ($s_2 - s_1$) of the gas (in J/kgK) in the process is ________.

Ans. (–198.93)

Change in specific entropy of ideal gas

$$s_f - s_i = c_p \ln\frac{T_f}{T_i} - R\ln\frac{P_f}{P_i}$$
$$= 1005\ln\frac{300}{300} - 287\ln\frac{2}{1}$$
$$= 0 - 287\ \ln 2 = -198.93\ \text{J/kg-K}$$

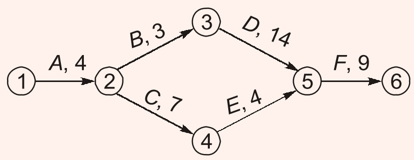
End of Solution

Q.55 A project starts with activity A and ends with activity F. The precedence relation and durations of the activities are as per the following table:

Activity	Immediate predecessor	Duration (days)
A	–	4
B	A	3
C	A	7
D	B	14
E	C	4
F	D, E	9

The minimum project completion time (in days) is ________.

Ans. (30)



There are two path,

$A - B - D - F = 30$ days

$A - C - E - F = 24$ days

Critical path *A-B-D-F* and of 30 days and it is also minimum time required to complete a project.

GENERAL APTITUDE

End of Solution

Q.1 If a and b are integers and $a - b$ is even, which of the following must always be even?

(a) ab
(b) $a^2 + b^2 + 1$
(c) $a^2 + b + 1$
(d) $ab - b$

Ans. (d)

End of Solution

Q.2 The ways in which this game can be played ________ potentially infinite.

(a) is
(b) is being
(c) are
(d) are being

Ans. (a)

End of Solution

Q.3 If you choose plan *P*, you will have to ______ plan Q, as these two are mutually _____.

(a) forgo, exclusive
(b) forget, inclusive
(c) accept, exhaustive
(d) adopt, intrusive

Ans. (a)

End of Solution

Q.4 P looks at Q while Q looks at R, P is married, R is not. The number of pairs of people in which a married person is looking at an unmarried person is

(a) 0
(b) 1
(c) 2
(d) cannot be determined

Ans. (d)

End of Solution

Q.5 A couple has 2 children. The probability that both children are boys if the older one is a boy is
(a) 1/4
(b) 1/3
(c) 1/2
(d) 1

Ans. (c)

End of Solution

Q.6 All people in a certain island are either 'Knights' or 'Knaves' and each person knows every other person's identity. Knights NEVER lie, and knaves ALWAYS lie.
P says 'Both of us are knight'. Q says 'None of us are knaves'
Which one of the following can be logically inferred from the above?
(a) Both P and Q are knights
(b) P is a knight; Q is a knave
(c) Both P and Q are knaves
(d) The identities of P, Q cannot be determined

Ans. (d)

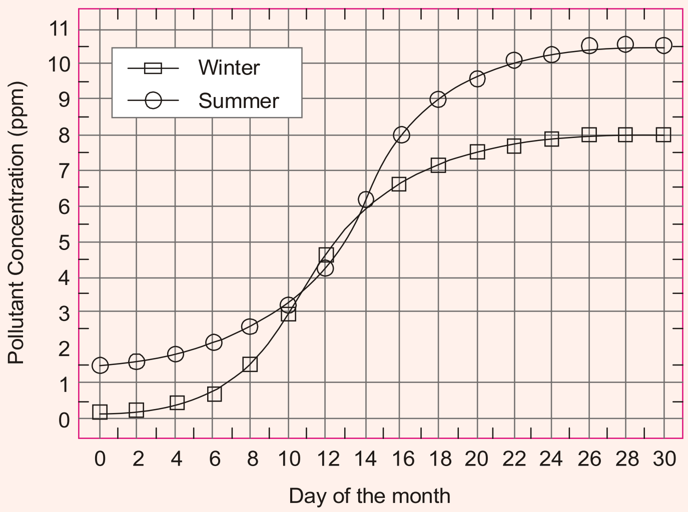
End of Solution

Q.7 There are 4 women P, Q, R, S and 5 men V, W, X, Y, Z in a group. We are required to form pairs each consisting of one woman and one man. P is not to be paired with Z, and Y must necessarily be paired with someone. In how many ways can 4 such pairs be formed?
(a) 74
(b) 76
(c) 78
(d) 80

Ans. (c)

End of Solution

Q.8 In the graph below, the concentration of a particular pollutant in a lake is plotted over (alternate) days of a month in winter (average temperature 10°C) and a month in summer (average temperature 30°C)



Consider the following statements based on the data shown above:

i. Over the given month, the difference between the maximum and the minimum pollutant concentrations is the same in both winter and summer.

ii. There are at least four days in the summer month such that the pollutant concentrations on those days are within 1 ppm of the pollutant concentrations on the corresponding days in the winter month.

Which one of the following options is correct?

(a) only i
(b) only ii
(c) both i and ii
(d) Neither i nor ii

Ans. (b)

End of Solution

Q.9 X bullocks and Y tractors take 8 days to plough a field. If we halve the number of bullocks and double the number of tractors, it takes 5 days to plough the same field. How many days will it take X bullocks alone to plough the field?

(a) 30
(b) 35
(c) 40
(d) 45

Ans. (a)

End of Solution

Q.10 If you are looking for a history of India, or for an account of the rise and fall of the British Raj, or for the reason of the cleaving of the subcontinent into two mutually antagonistic parts and the effects this mutilation will have in the respective sections, and ultimately on Asia, you will not find it in these pages; for though I have spent a lifetime in the country, I lived too near the seat of events, and was too intimately associated with the actors, to get the perspective needed for the impartial recording of these matters."

Which of the following is closest in meaning to 'cleaving'?

(a) deteriorating
(b) arguing
(c) departing
(d) splitting

Ans. (d)

End of Solution

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