Q.1 In a power plant water is pumped from 80 kPa to 3 MPa. Isentropic efficiency of pump is 0.80. Temperature is kept-constant. Find the specific work (kJ/kg) input for the pump.

(a) 0.34 (b) 2.48
(c) 2.92 (d) 3.43

Ans. (d)

Work input for compressor (theoretical)

$$= -V\Delta P$$

$$= -\frac{1}{\rho}(P_2 - P_1)$$

$$= -\frac{1}{1000}\left(3\times10^3 - 80\right)$$

$$= -2.92 \text{ kJ/kg}$$

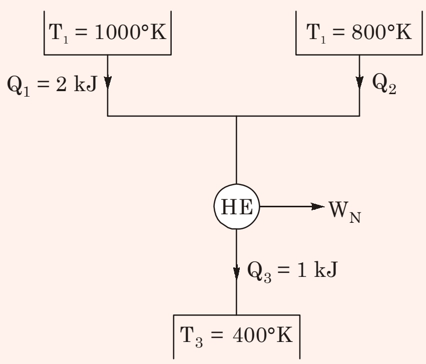
Actual work input $= \dfrac{2.92}{\eta_c} = \dfrac{2.92}{0.85}$

$$= \mathbf{3.43 \text{ kJ/kg}}$$

End of Solution

Q.2 A reversible heat engine receive 2 kJ of heat from reservoir at 1000°K and certain amount of heat from another reservoir at 800°K. It rejects 1 kJ of heat to reservoir at 400°K. Find net work output

Solution:



For reversible heat engine

$$(\Delta S)_{\text{Reversible cycle}} = 0$$

$$\Rightarrow \quad -\frac{Q_1}{T_1} - \frac{Q_2}{T_3} + \frac{Q_3}{T_3} = 3$$

$$\Rightarrow \quad -\frac{2}{1000} - \frac{Q_2}{800} - \frac{1}{400} = 0$$

$$\Rightarrow \quad Q_2 = 0.4 \text{ kJ}$$

From heat balance, $Q_1 + Q_2 = W_N + Q_3$

$$\Rightarrow \quad 2 + 0.4 = W_N + 1$$

$$\Rightarrow \quad W_N = \mathbf{1.4 \text{ kJ}}$$

End of Solution

Q.3 For a fully developed flow of water in a pipe of dia. = 10 cm, V = 0.1 m/sec. Kinematic viscosity = 10^{-5} m^2/sec. Find Darcy friction factor

Solution:

$$R_e = \frac{VD}{\nu} = \frac{0.1 \times 0.1}{10^{-5}} = 1000$$

Darcy friction factor,

$$f = \frac{64}{R_e} = \frac{64}{1000}$$

$$= \mathbf{0.064}$$

End of Solution

Q.4 For completely submerged body with centre of gravity G, Centre of buoyancy B. Submerged body will be stable if

(a) G above B
(b) G below B
(c) G coincident with B
(d) Independent of G and B

Ans. (b)

B should be above G.

End of Solution

Q.5 Water flow through pipe, whose inner dia. = 10 mm at the rate of 36 kg/hr at 25°C. Viscosity at 25°C = 0.001 kg/ms. Find Reynold's No.

Solution:

$$d = 10 \text{ mm} = 0.01 \text{ m}$$

$$m = 36 \text{ kg/hr} = \frac{36}{3600} = \frac{1}{100} \text{kg/sec}$$

$$= 10^{-2} \text{ kg/sec}$$

$$\mu = 0.001 \text{ kg/m-s}$$

$$R_e = ?$$

$$R_e = \frac{\rho V d}{\mu} = \frac{\rho d}{\mu} \times \frac{Q}{A} \qquad (Q = \text{flow rate } m^3/\text{sec})$$

$$= \frac{\rho Q d}{\mu \times \frac{\pi}{4} d^2} = \frac{4\rho Q}{\pi d \mu}$$

$$\Rightarrow \qquad R_e = \frac{4m}{\pi d \mu} = \frac{4 \times 10^{-2}}{\pi \times 0.01 \times 0.001}$$

$$= \mathbf{1273.2}$$

End of Solution

Q.6 1.5 kg of water in saturated liquid state at 2 bar (v_f = 0.00106, u_f = 504 kJ/kg, h_f = 505 kJ/kg). Heat added at constant pressure till temperature becomes 400°C (v = 1.5, u = 2967, h = 3277 kJ/kg). Find the heat added.

Solution:

From the First law of thermodynamics

$$dq = du + Pdv$$
$$= (u_2 - u_1) + P(v_2 - v_1)$$
$$= (2967 - 504) + 2 \times 10^2(1.5 - 0.00106)$$
$$= 2762.78 \text{ kJ/kg}$$

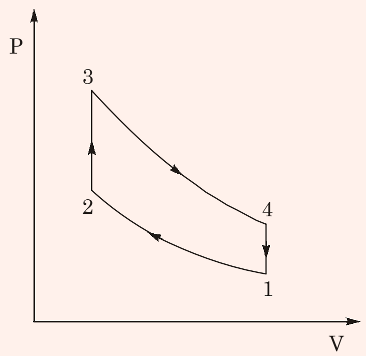
For 1.5 kg of water

$$Q = 2762.78 \times 1.5$$
$$= \mathbf{4144.182 \text{ kJ}}$$

End of Solution

Q.7 For an Otto cycle, given, pressure at inlet = 0.1 MPa, temperature at inlet = 308°K, γ = 1.4, R = 288.8 J/kgK. Compression ratio = 8. Maximum temperature = 2660°K. Find the heat supplied.

Solution:



Given:

$$P_1 = 0.1 \text{ MPa}$$
$$T_1 = 308°K$$
$$\gamma = 1.4$$
$$R = 288.8 \text{ J/kgK}$$
$$r = 8$$
$$T_3 = 2660°K$$
$$Q_S = mC_v(T_3 - T_2) \quad \text{...(i)}$$
$$C_v = \frac{R}{\gamma - 1} = \frac{288.8}{0.4}$$
$$= 722 \text{ J/kgK}$$
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = (8)^{0.4}$$

$\Rightarrow$

$$T_2 = 308 \times (8)^{0.4}$$
$$= 707.6°K$$
$$Q_S = 1 \times 722 \,(2660 - 707.6)$$
$$= \mathbf{1409.6 \text{ kJ/kg}}$$

End of Solution

Q.8 Given x is random variable, P(x) is probability density

x	1	2	3
P(x)	0.3	0.6	0.1

Find standard deviation.

(a) 0.18
(b) 0.36
(c) 0.54
(d) 0.6

Ans. (d)

Mean,

$$\bar{x} = \frac{\Sigma f_i x_i}{\Sigma f_i}$$
$$= \frac{1 \times 0.3 + 2 \times 0.6 + 3 \times 0.1}{0.3 + 0.6 + 0.1} = 1.8$$

Standard deviation

$$\sigma_x = \sqrt{\frac{\Sigma f_i x_i^2}{N} - \bar{x}^2}$$
$$= \sqrt{\frac{0.3 \times 1^2 + 0.6 \times 2^2 + 0.1 \times 3^2}{1} - 1.8^2}$$
$$= \mathbf{0.6}$$

End of Solution

Q.9 y = f(x) is the solution of $\frac{d^2y}{dx^2} = 0$. Boundary conditions are, y = 5, x = 10.

$\frac{dy}{dx} = 2$ at x = 10. Find f(15) = ?

Solution:

$$\frac{d^2y}{dx^2} = 0$$

$$\Rightarrow \quad \frac{dy}{dx} = C_1$$

At $x = 10, \frac{dy}{dx} = 2$

So, $C_1 = 2$

Hence, $\frac{dy}{dx} = 2$

$\Rightarrow \quad y = 2x + C_2$

At $x = 10, y = 5$

So $5 = 2 \times 10 + C_2$

$\Rightarrow \quad C_2 = -15$

Hence, $y = 2x - 15$

$$f(15) = y|_{x=15}$$

$$= 2 \times 15 - 15$$

$$= \mathbf{15}$$

End of Solution

Q.10 Value of $\lim_{x\to 0} \frac{x - \sin x}{1 - \cos x}$ is

(a) 0
(b) 1
(c) 3
(d) Not defined

Ans. (a)

$$\lim_{x\to 0} \frac{x - \sin x}{1 - \cos x} \quad \text{(0/0 form, applying 'L' Hospital rule)}$$

$$= \lim_{x\to 0} \frac{dx(x - \sin x)}{\frac{d}{dx}(1 - \cos x)}$$

$$= \lim_{x\to 0} \frac{1 - \cos x}{0 + \sin x} \quad \text{(0/0 form)}$$

$$= \lim_{x \to 0} \frac{\sin x}{\cos x}$$
$$= \mathbf{0}$$

End of Solution

Q.11 The argument of the complex no. $\frac{1+i}{1-i}$, where $i = \sqrt{-1}$ is

Solution:

$$\frac{1+i}{1-i} \times \frac{1+i}{1+i} = \frac{(1+i)^2}{1-i^2} = \frac{1+i^2+2i}{1+1}$$
$$= i = 0 + i$$

Argument $$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$
$$= \tan^{-1}\left(\frac{1}{0}\right)$$
$$= \tan^{-1}(\infty)$$
$$= \frac{\pi}{2}$$

End of Solution

Q.12 The state of stress of a point is given by σ_x = –6 MPa, σ_y = 4 MPa and τ_{xy} = –8 MPa. The maximum tensile stress (in MPa) at that point is

Solution:

$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$
$$= \frac{-6+4}{2} + \sqrt{\left(\frac{-6-4}{2}\right)^2 + (-8)^2}$$
$$= -1 + \sqrt{25+64}$$
$$= \mathbf{8.4339\ MPa}$$

End of Solution

Q.13 For a job in manufacturing process, arrival rate is 5 per shift of 8 hrs following Poisson's distribution. Service rate for the job is 40 min. Find the ideal time (in hr) of the job

(a) $\frac{1}{4}$ (b) $\frac{7}{5}$

(c) $\frac{14}{3}$ (d) $\frac{2}{3}$

Ans. (d)

Arrival rate, $\lambda = \frac{5}{8}$ jobs per hour

Service rate, $\mu = \frac{60}{40} = \frac{3}{2}$ jobs per hour

Fraction of time job is idle

$$= 1 - \frac{\lambda}{\mu} = 1 - \frac{5}{8} \times \frac{2}{3} = \frac{7}{12}$$

$\therefore$ Idle time = Expected waiting time in the system × Probability of idleness

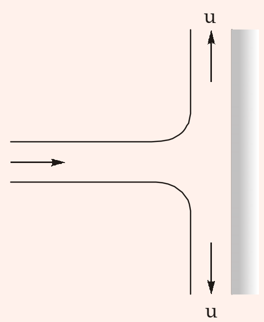
$$= \frac{1}{\mu - \lambda} \times \frac{7}{12} = \frac{1}{\frac{3}{2} - \frac{5}{8}} \times \frac{7}{12} = \frac{1}{\frac{12-5}{8} \times \frac{12}{7}}$$

$$= \frac{1}{\frac{7}{8} \times \frac{12}{7}} = \frac{8}{12} = \frac{2}{3}$$

End of Solution

Q.14 Water jet strikes a stationary vertical plate with a volume flow rate of 0.05 m^3/sec and exerts a force of 1000 N on the plate. Find out the dia. of jet

Solution:



Given, $Q = 0.05\ m^3/sec$

$F_N = 1000$ N

d = ?

$F_n = \rho A V^2$

$$= \rho A \times \left(\frac{Q}{A}\right)^2$$

$$= \frac{\rho Q^2}{A} = \frac{4\rho Q^2}{\pi d^2}$$

$$\Rightarrow \quad 1000 = \frac{4 \times 1000 \times 0.05^2}{\pi d^2}$$

$$\Rightarrow \qquad d = 0.0564 \text{ m}$$
$$= \mathbf{56.4\ mm}$$

End of Solution

Q.15 Which is a CFC refrigerant

(a) R744 (b) R290
(c) R502 (d) R718

Ans. (c)

R744 – CO_2
R290 – C_3H_8 (Propane)
R502 – $CHClF_3 + CClF_2CF_3$
R718 – Water

End of Solution

Q.16 Given $\begin{vmatrix} 1 & 3 & 0 \\ 2 & 6 & 4 \\ -1 & 0 & 2 \end{vmatrix} = -12$. Find determinant of $\begin{vmatrix} 2 & 6 & 0 \\ 4 & 12 & 8 \\ -2 & 0 & 4 \end{vmatrix} = ?$

Solution:

$$\begin{vmatrix} 2 & 6 & 0 \\ 4 & 12 & 8 \\ -2 & 0 & 4 \end{vmatrix} = 2^n \times -12$$

$$= 2^3 \times -12$$
$$= \mathbf{-96}$$

End of Solution

Q.17 Why it is difficult to weld Aluminium

(a) low MP of Al
(b) High thermal conductivity
(c) Softness
(d) Specific heat capacity is low

Ans. (a)

End of Solution

Q.18 A pair of spur gear with module 5 mm and a centre distance of 450 mm is used for a speed reduction of 5 : 1. No. of teeth on pinion is

Solution:

Given, $m = 5$

Centre distance $(n) = 450$ mm

Speed reduction = 5 : 1

i.e., $$\frac{Z_G}{Z_P} = \frac{5}{1}$$

$$\Rightarrow \quad Z_G = 5Z_P \qquad \text{...(i)}$$

$$x = r_1 + r_2$$

$$= \frac{d_1 + d_2}{2}$$

$$= \frac{mZ_g + mZ_P}{2}$$

$$\Rightarrow \quad 450 = \frac{5 \times Z_G + 5 \times Z_P}{2}$$

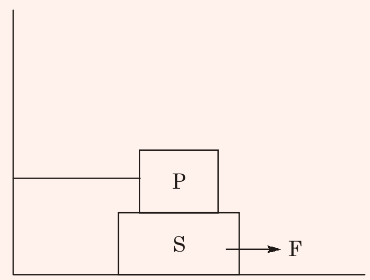
$$\Rightarrow \quad Z_G + Z_P = 180$$

$$\Rightarrow \quad 5Z_P + Z_P = 180 \text{ (from eq. (i))}$$

$$\Rightarrow \quad Z_P = \mathbf{30}$$

End of Solution

Q.19 Mass P is attached with an inextensible string as shown in figure. Mass of P = 100 kg. mass of S = 150 kg. μ for all surfaces = 0.4. Find F (in kN) required for movement of S.



(a) 0.69
(b) 0.88
(c) 0.98
(d) 1.37

Ans. (d)

$$F = \mu R_1 + \mu R_2$$

$$F = \mu(W_S + W_P) + \mu W_P$$

$$= [0.4(150 + 100) + 0.4 \times 100] \times 9.81$$

$$= 1373.4 \text{ N}$$

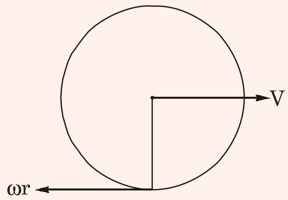
$$= \mathbf{1.37 \text{ kN}}$$

End of Solution

Q.20 A wheel is rolling without slipping on a plane surface with the centre velocity of V. What will be velocity of the point of contact

(a) Velocity V ⊥ to the surface
(b) V in the direction of motion
(c) V in the opposite direction of motion
(d) Zero

Ans. **(d)**



Velocity of point of contact = 0.

End of Solution

Q.21 A rod of length 250 mm in fixed in between two immovable plates. It is heated upto 250°C. Given coefficient of thermal expansion, $\alpha = 1 \times 10^{-5}/°C$, and E = 200 GPa. Stress developed (in MPa) in the beam is

Solution:

Given,

$$l = 250 \text{ mm}$$
$$\Delta t = 250°C$$
$$\alpha = 1 \times 10^{-5}/°C$$
$$E = 200 \text{ GPa}$$
$$\sigma = ?$$
$$\sigma = E.\alpha.\Delta t$$
$$= 200 \times 10^3 \times 1 \times 10^{-5} \times 250$$
$$= 500 \text{ MPa}$$

End of Solution

Q.22 If Taylor's tool life exponent 'n' is 0.2 and the tool change time is 1.5 minute. Then the tool life (in minute) for maximum production rate

Solution:

Given, $n = 0.2$

Tool change time, $T_C = 1.5$ minute

Tool life = ? (For max. production rate)

$$\text{Tool life} = T_{MP} = \left\{\left(\frac{1}{n-1}\right)T_C\right\}$$

$$= \left(\frac{1}{0.2} - 1\right) \times 1.5$$

$$= \mathbf{6\ minute}$$

End of Solution

Q.23 Given initial length 'L_0' subjected to drawing process.
$L(t) = L_0(1 + t^2)$, (t is in minute)
Find true strain (ε_T) in min^{-1} = ?, at the end of '1' minute.

Solution:

$$L(t) = L_0(1 + t^2)$$

$$\varepsilon_T = \int d\varepsilon = \int \frac{dL}{L}$$

$$L = L_0(1 + t^2)$$

$\Rightarrow$ $$dL = L_0 \times 2t\ dt$$

$$\varepsilon_T = \int_0^1 \frac{2tL_0 dt}{L_0(1+t^2)} = \int_0^1 \frac{2tdt}{(1+t^2)}$$

Now, Let $(1 + t^2) = z$

$\Rightarrow$ $2t\ dt = dz$

at $t = 0,\ z = 1$

at $t = 1,\ z = 2$

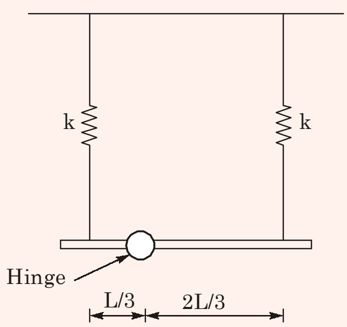
$\therefore$ $$\varepsilon_T = \int_1^2 \frac{dz}{z} = \log_e(z)\Big|_1^2$$

$$= \log_e 2 - \log_e 1$$

$$= \mathbf{0.693\ min.^{-1}}$$

End of Solution

Q.24

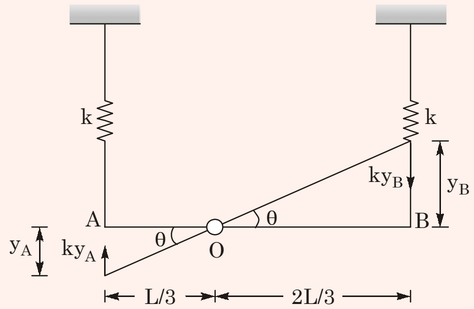


Mass of the beam is 'm' and spring stiffness is 'k'. A hinge is attached with the beam as shown above. What will be the natural frequency of the system.

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

(c) $\sqrt{\frac{2k}{m}}$ (d) $\sqrt{\frac{5k}{m}}$

Ans. (d)



$$\theta = \frac{y_A}{(L/3)} = \frac{y_B}{(2L/3)}$$

$$I_0 = I_c + m\left(\frac{2L}{3} - \frac{L}{2}\right)^2$$

$$I_0 = \frac{mL^2}{12} + \frac{mL^2}{36}$$

$$I_0 = \frac{mL^2}{9}$$

Taking $\Sigma M_0 = 0$

$$\Rightarrow \quad \left(ky_A \times \frac{L}{3}\right) + \left(ky_B \times \frac{2L}{3}\right) + I_0\ddot{\theta} = 0$$

$$\Rightarrow \quad k\theta\left(\frac{L}{3}\right)^2 + k\theta\left(\frac{2L}{3}\right)^2 + \frac{mL^2}{9}\ddot{\theta} = 0$$

$$\Rightarrow \quad \left(\frac{mL^2}{9}\right)\ddot{\theta} + \left(\frac{5kL^2}{9}\right)\theta = 0$$

$$\Rightarrow \quad \ddot{\theta} + \frac{5k}{m}\theta = 0$$

$$\Rightarrow \quad \ddot{\theta} + \omega_n^2\theta = 0$$

$$\therefore \quad \omega_n = \sqrt{\frac{5k}{m}}$$

End of Solution

Q.25 Which one of the following is odd one out

(a) WEKO
(b) IQWA
(c) FNTX
(d) NVBD

Ans. (d)

End of Solution

Q.26 Consider the following:

I. Mating gear is a higher pair
II. Revolute pair is lower pair

(a) Both are correct
(b) I is correct, II is incorrect
(c) I is incorrect, II is correct
(d) Both are incorrect

Ans. (a)

End of Solution

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