Aptitude Section

Question 1

Consider the following sentences :

(i) The number of candidates who appear for the GATE examination is staggering.

(ii) A number of candidates from my class are appearing for the GATE examination.

(iii)The number of candidates who appear for the GATE examination are staggering.

(iv)A number of candidates from my class is appearing for the GATE examination.

Which of the above sentences are grammatically CORRECT ?

(A) ii and iv (B) (i) and (ii) (C) (ii) and (iii) (D) (i) and (iii)

Ans. B

Question 2

Given below are two statements 1 and 2, and two conclusions I and II

Statement 1: All entrepreneurs are wealthy

Statement 2 : All wealthy are risk seekers

Conclusion 1 : All risk seekers are wealthy.

Conclusion 2 : Only some entrepreneurs are risk seekers.

Which is correct?

(A) Only conclusion I is correct.

(B) Only conclusion II is correct.

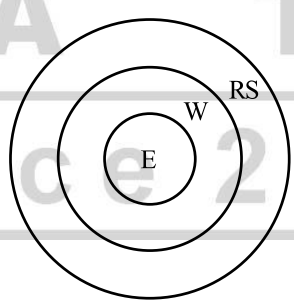
(C) Both conclusion I and II are correct .

(D) Neither Conclusion I nor II is correct .

Ans. D

Sol. (1) Can't say (Wrong)

(2) Definitely wrong



Hence, the correct option is (D).

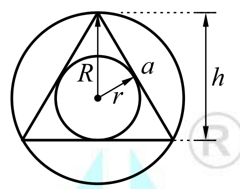
Question 3

The ratio of the area of the inscribed circle to the area of the circumscribed circle of an equilateral triangle is _______.

(A) 1/6 (B) 1/8 (C) 1/2 (D) 1/4

Ans. D

Sol.



$$h=\sqrt{3}a \qquad r=\frac{1}{3}h$$

$$R=\frac{2}{3}h \qquad \frac{r}{R}=\frac{1}{2}$$

$$\frac{(\text{Perimeter})_{small}}{(\text{Perimeter})_{big}}=\frac{2\pi r}{2\pi R}=\frac{r}{R}=\frac{1}{2}$$

$$\frac{(\text{Area})_{small}}{(\text{Area})_{big}}=\frac{\pi r^2}{\pi R^2}=\left(\frac{r}{R}\right)^2=\left(\frac{1}{2}\right)^2=\frac{1}{4}$$

Hence, the correct option is (D).

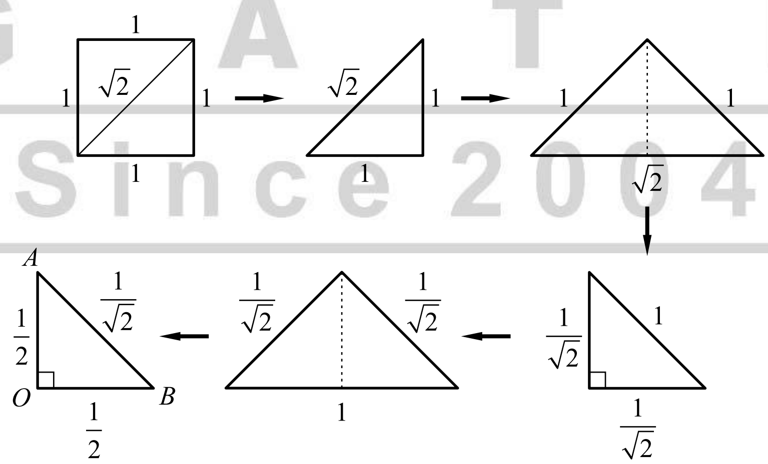
Question 4

Consider a square sheet of side 1 unit. The sheet is first folded along the main diagonal. This is followed by a fold along its line of symmetry. The resulting folded shape is again folded along its line of symmetry. The area of each face of the final folded shape, in square units, equal to _______

(A) 1/8 (B) 1/16 (C) 1/4 (D) 1/3

Ans. D

Sol.



$$AO=\sqrt{AB^2-OB^2}$$

$$AO=\sqrt{\frac{1}{2}-\frac{1}{4}}=\frac{1}{2}$$

Area of $\Delta AOB=\frac{1}{2}BO\times OA=\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}=\frac{1}{8}$ Square unit

Hence, the correct option is (D).

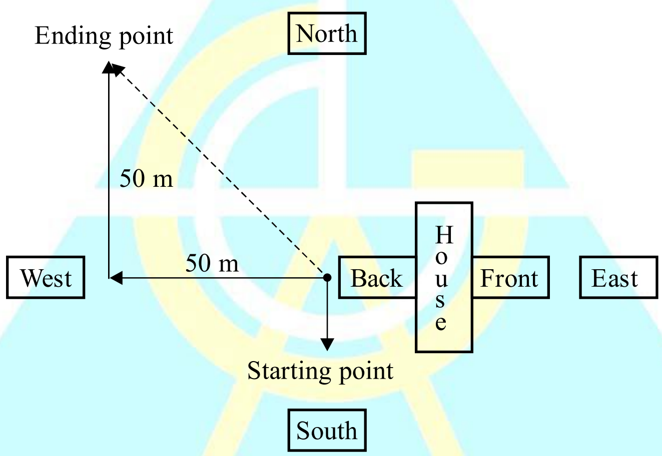
Question 5

The front door of Mr. X's house faces East. Mr. X leaves the house walking 50 m straight from the back door that is situated directly opposite to the front door. He then turns to his right walks for another 50 m and stops. The direction of the point Mr. X is now located at with respect to the starting point is __________

(A) North West (B) North East (C) South East (D) West

Ans. **A**

Sol.



At the end Mr. X is in North-West direction with respect to starting point.

Hence, the correct option is (A).

Question 6

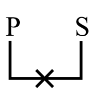
Five person P, Q, R, S and T are to be seated in a row, all facing the same direction, but not necessarily in the same order. P and T cannot be seated at either end of the row. P should not be seated adjacent to S. R is to be seated at the second position from the left end of the row. The number of distinct seating arrangements possible is :

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

Ans. **C**

Sol. **Step (1) :** Make proper drafting of given information,

1. P and T $\rightarrow$ end $\times$

2. 

3. Left end $\xrightarrow{2nd} R$

Step (2) : Make possibilities according to drafting,

$\underline{Q}$ $\underline{R}$ $\underline{P}$ $\underline{T}$ $\underline{S}$

$\underline{S}$ $\underline{R}$ $\underline{P}$ $\underline{T}$ $\underline{Q}$

$\underline{Q}$ $\underline{R}$ $\underline{T}$ $\underline{P}$ $\underline{S}$

Hence, the correct option is (C).

Question 7

The world is going through the worst pandemic in the past hundred years. The air travel industry is facing a crisis, as the resulting quarantine requirement for travelers led to weak demand.

In relation to the first sentence above, what does the second sentence do?

(A) The two statements are unrelated.

(B) States an effect of the first sentence.

(C) Restates an idea from the first sentence.

(D) Second sentence entirely contradicts the first sentence.

Ans. **(B)**

Sol.

Question 8

If $\oplus \div \odot = 2,\ \oplus \div \Delta = 3,\ \odot + \Delta = 5,\ \Delta \times \otimes = 10$ then the value of $(\otimes - \oplus)^2$ is

(A) 4 (B) 1 (C) 0 (D) 16

Ans. **B**

Sol. By given information we can conclude $\odot = \frac{\oplus}{2}$ and $\Delta = \frac{\oplus}{3}$

Put these values on $\odot + \Delta = 5$

We get, $\frac{\oplus}{2} + \frac{\oplus}{3} = 5$

$$\frac{3\oplus + 2\oplus}{6} = 5$$

$$5\oplus = 30$$

$$\oplus = 6$$

By equation,

$$\oplus \div \Delta = 3$$

$$\downarrow$$

$$6 \div 2 = 3$$

By equation,

$$\Delta \div \otimes = 10$$
$$\downarrow$$
$$2 \times 5 = 10$$

So, that

$$(\otimes - \oplus)^2$$
$$(5-6)^2 = 1$$

Hence, the correct option is (B).

Question 9

A digital watch X beeps every 30 secs while watch Y beeps 32 seconds. They beeped together at 10 AM. The immediate next time that they will beep together is _______.

(A) 10.42 AM (B) 11.00 AM (C) 10.00 AM (D) 10.08 AM

Ans. **D**

Sol. $x \rightarrow 30$ sec/beep

$y \rightarrow 32$ sec/beep

Take L.C.M. of limiting of x and y we get $\rightarrow 480$ sec

Convert this to minute $\rightarrow \dfrac{480}{60}\text{sec} = 8$ min

Earlier they beeped together at 10 am

Next they will beeped at 10 : 00 + 00 : 08 m

Hence, the correct option is (D).

Question 10

A box contains 15 blue balls and 45 black balls. If 2 balls are selected randomly, without replacement, the probability of an outcome in which the first selected is a blue ball and the second selected is a black ball, is ___________.

(A) 3/16 (B) 45/236 (C) 3/4 (D) 1/4

Ans. **B**

Sol. **Given :** Blue ball = 15, black ball = 45

Total ball = 60

Probability that the outcome in which the first selected is a blue ball and the second selected is a black ball

$$= \frac{15}{60} \times \frac{45}{59} = \frac{45}{236}$$

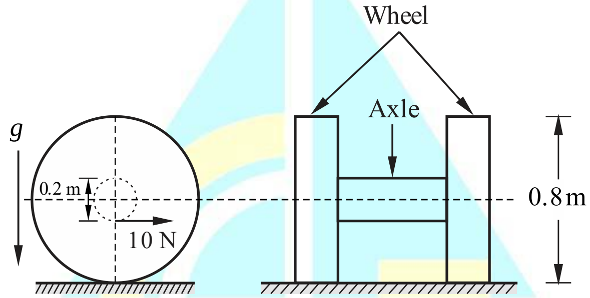
Hence, the correct option is (B).

Technical Section

Question 1

The wheels and axle system lying on a rough surface is shown in the figure. Each wheel has diameter 0.8 m and mass 1 kg. Assume that the mass of the wheel is concentrated at rim and neglect the mass of spokes. The diameter of axle is 0.2 m and its mass is 1.5 kg. Neglect the moment of Inertia of axle and assume $g = 9.81\ \text{m/s}^2$. An effort of 10 N is applied on the axle in the horizontal direction shown at mid span of the axle. Assume that the wheels move on a horizontal surface without slip. The acceleration of the wheel the axle system in horizontal direction is ________ m/s^2 (round off to one decimal place).

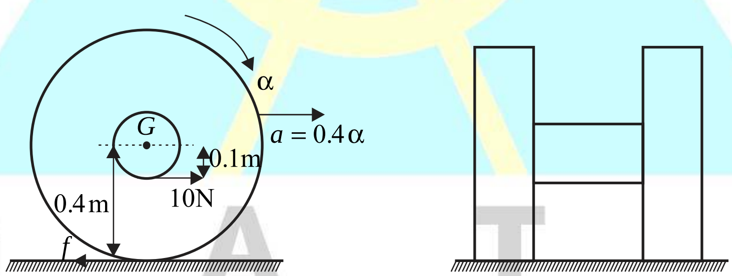
Engineering Mechanics (Dynamics)



Ans. 1.36

Sol.

Method-I



$M_W = 1\ \text{kg}$

$M_{\text{axle}} = 1.5\ \text{kg}$

Inertia of axle (to be neglect)

$M = (2\times1)+1.5 = 3.5\ \text{kg}$

$I_G = 2(1)\times0.4^2 = 0.32\ \text{kgm}^2$

$\Sigma F = ma$

$10 - f = 3.5a = 3.5\times0.4\alpha$

$f + 1.4\alpha = 10$ … (i)

$$\Sigma T_G = I_G \alpha$$

$$f \times 0.4 - 10 \times 0.1 = 0.32\alpha$$

$$0.4f - 0.32\alpha = 1 \qquad \ldots \text{(ii)}$$

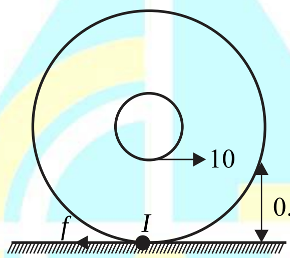
Solving (i) and (ii),

$$f = 5.227 \text{ N}$$

$$\alpha = 3.4091 \text{ rad/s}^2$$

$$a = \alpha \times 0.4 = 3.4091 \times 0.4 = 1.36 \text{ m/s}^2$$

Method-II



$$I_{I_w} = [I_{G_w} + (1 \times 0.4^2)] \times 2$$

$$= [(1 \times 0.4^2) + (1 \times 0.4^2)] \times 2$$

$$= 0.64$$

$$I_{axle_I} = I_{axle_G} + (1.5 \times 0.4^2)$$

$$= 0.24$$

$$I_I = 0.64 + 0.24 = 0.88$$

$$\Sigma T_I = I_I \alpha$$

$$10 \times 0.3 = 0.88\alpha$$

$$\alpha = 3.4091$$

$$a = 3.4091 \times 0.4 = 1.36 \text{ m/s}^2$$

Question 2

Consider the following differential equation $(1+y)\frac{dy}{dx} = y$. The solution of the equation that satisfies the condition $y(1) = 1$ is

Engineering Mathematics

(A) $ye^y = e^x$ (B) $y^2 e^y = e^x$ (C) $2ye^y = e^x + e$ (D) $(1+y)e^y = 2e^x$

Ans. **A**

Sol. $(1+y)\dfrac{dy}{dx} = y$

$$y(1) = 1$$

$$\int\left(\frac{1}{y}+1\right)dy = \int dx + c$$

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

$$0 + 1 = 1 + c \qquad [\because\ y(1) = 1]$$

$$c = 0$$

$$\ln y + y = x$$

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

$$\ln(ye^y) = \ln e^x$$

$$ye^y = e^x$$

Hence, the correct option is (A).

Question 3

A rigid tank of volume 50 m^3 contains a pure substance as a saturated liquid vapour mixture at 400 kPa. Of the total mass of the mixture, 20% mass is liquid and 80% mass is vapour. Properties at 400 kPa are : Saturation temperature, $T_{sat} = 143.61^0$C; Specific volume of Saturated liquid, $v_f = 0.001084\,\text{m}^3$/kg; Specific volume of saturated vapour, $v_g = 0.46242\,\text{m}^3$/kg. The total mass of liquid vapour mixture in the tank is _______ kg (round off to the nearest integer).

Engineering Thermodynamics (Pure Substance)

Ans. **135.08**

Sol. **Given :** $V = 50\,\text{m}^3$, $P = 400\,\text{kPa}$

Liquid $= 20\%$, Vapor $= 80\%$

$$x = \frac{0.8}{0.2+0.8} = 0.8$$

$$v_f = 0.001084\,\text{m}^3/\text{kg}$$

$$v_g = 0.46242\,\text{m}^3/\text{kg}$$

$$v = v_f + x(v_g - v_f)$$

$$v = 0.001084 + 0.8(0.46242 - 0.001084)$$

$$v = 0.37015 \text{ m}^3/\text{kg}$$

$$v = \frac{V}{m}$$

$$m = \frac{50}{0.37015} = 135.08 \text{ kg}$$

Question 4

A machine of mass 100 kg is subjected to an external harmonic force with a frequency of 40 rad/s. The designer decides to mount the machine on an isolator to reduce the force transmitted to the foundation. The isolator can be considered as a combination of stiffness (K) and damper (damping factor, ξ) in parallel. The designer has the following four isolators:

1. $K = 640\,\text{kN/m}, \xi = 0.70$
2. $K = 640\,\text{kN/m}, \xi = 0.07$
3. $K = 22.5\,\text{kN/m}, \xi = 0.70$
4. $K = 22.5\,\text{kN/m}, \xi = 0.07$

Arrange the isolators in the ascending order of the force transmitted to the foundation.

Theory of Machines (Vibration)

(A) $4-3-1-2$

(B) $3-1-2-4$

(C) $1-3-4-2$

(D) $1-3-2-4$

Ans. **(A)**

Sol. For $k = 640000$ N/m

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{640000}{100}} = 80 \text{ rad/s}$$

$$r = \frac{\omega}{\omega_n} = \frac{40}{80} = 0.5$$

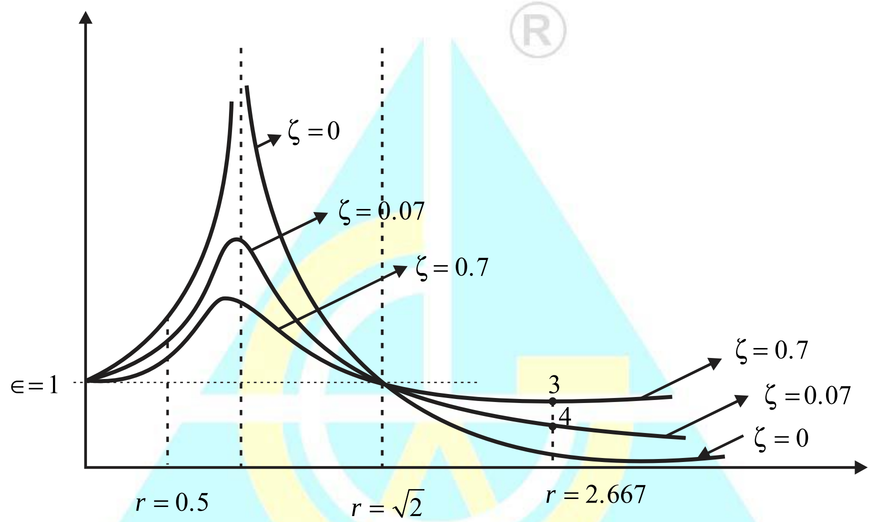
For $k = 22500$ N/m

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{22500}{100}} = 15 \text{ rad/s}$$

$$r = \frac{\omega}{\omega_n} = \frac{40}{15} = 2.667$$

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

Since $\in \propto F_t$. So, if $F_t \downarrow$ that means $\in \downarrow$.



For, $r < \sqrt{2}$ — $\in > 1$; $\zeta \uparrow, \in \downarrow$

For, $r > \sqrt{2}$ — $\in < 1$; $\zeta \uparrow, \in \uparrow$

From figure :

$$\in_4 < \in_3 < \in_1 < \in_2$$

$$4 < 3 < 1 < 2$$

Hence, the correct option is (A).

Question 5

In a pure orthogonal turning by a zero rake angle single point carbide cutting tool the shear force has been computed to be 400 N. If the cutting velocity $V_c = 100$ m/min, depth of cut $t = 2.0$ mm, feed $S_0 = 0.1$ mm/revolution and chip flow velocity $V_f = 20$ m/min, then the shear strength τ_s of the material will be _______ MPa.(round off to two decimal places).

Production Engineering (Machining)

Ans. **391.89**

Sol. **Given :** $\alpha = 0$

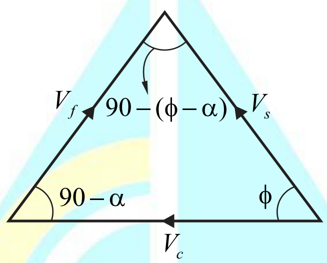
$$F_s = 400 \text{ N}$$

Cutting velocity $(V_c) = 100$ m/min

Depth of cut = 2 mm = width of cut (b)

Chip velocity $V_f = 20$ m/min

Feed $S_0 = 0.1$ mm/rev = uncut chip thickness



$$\frac{V_c}{\cos(\phi-\alpha)} = \frac{V_f}{\sin\phi}$$

$$\frac{\sin\phi}{\cos\phi} = \frac{V_f}{V_c}$$

$$\phi = \tan^{-1}\left(\frac{20}{100}\right)$$

$$\phi = 11.3^0$$

So, $$\tau_s = \frac{f_s}{bt}\sin\phi = \frac{400}{2\times 0.1}\sin(11.3)$$

$$\tau_s = 391.89 \text{ MPa}$$

Question 6

A shell and tube heat exchange is used as a steam condenser. Coolant water inters the tube at 300 K and at a rate of 100 kg/s. The overall heat transfer coefficient is 1500 $\text{W/m}^2\text{K}$ and total heat transfer area is 400 m^2. Steam condenses at a saturation temperature of 350 K. Assume that the specific heat of coolant water is 4000 J/kgK. The temperature of the coolant water coming out of the condenser is _______ K (round off to the nearest integer).

Heat Transfer (Heat Exchanger)

Ans. **338.8434**

Sol. **Given :** $T_{ci} = 300$ K, $\dot{m}_c = 100$ kg/sec, $U = 1500$ $\text{W/m}^2\text{-K}$

$A = 400 \text{ m}^2,\ T_{sat} = 350 \text{ K} = T_{hi} = T_{he}$

$C = 4000 \text{ J/kg-K},\ T_{ce} = ?$

$C_{ph} \to \infty = C_{max}$

$$C_{min} = 100 \times 4000 = 400,000$$

$$NTU = \frac{UA}{C_{min}} = \frac{1500 \times 400}{400,000} = 1.5$$

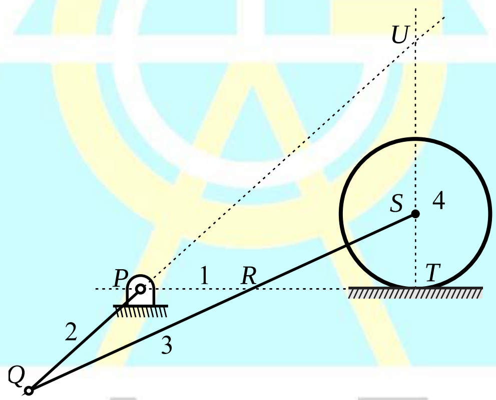
$$\varepsilon_{HE} = 1 - e^{-NTU} = \frac{T_{ce} - T_{ci}}{T_{hi} - T_{ci}}$$

$$1 - e^{-1.5} = \frac{T_{ce} - 300}{350 - 300}$$

$$T_{ce} = 50\left(1 - e^{-1.5}\right) + 300 = 338.8434 \text{ K}$$

Question 7

Consider the mechanism shown in the figure. There is a rolling contact without slip between the disc and ground.



Select the correct statement about instantaneous centers in the mechanism.

(A) Only points *P*, *Q*, *R*, *S* and *U* are instantaneous centres of mechanism

(B) Only points *P*, *Q*, *S* and *T* are Instantaneous centres of mechanism

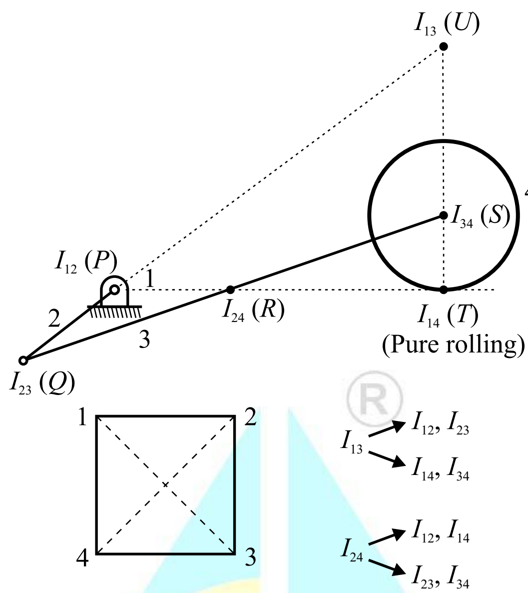
(C) Only points *P*, *Q* and *S* are Instantaneous centres of mechanism

(D) All points *P*, *Q*, *R*, *S*, *T* and *U* are Instantaneous centres of mechanism

Theory of Machines (Velocity Analysis)

Ans. **D**

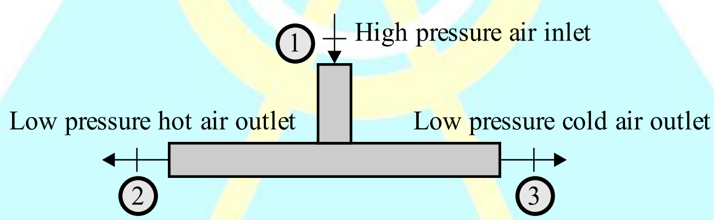
Sol.



Hence, the correct option is (D).

Question 8

An adiabatic vortex tube, shown in the figure given below is supplied with 5 kg/s of air (inlet 1) at 500 kPa and 300 K. Two separate streams of air are leaving the device from outlets 2 and 3. Hot air leaves the device at a rate of 3 kg/s from outlet 2 at 100 kPa and 340 K, while 2 kg/s of cold air stream is leaving the device from outlet 3 at 100 kPa and 240 K.

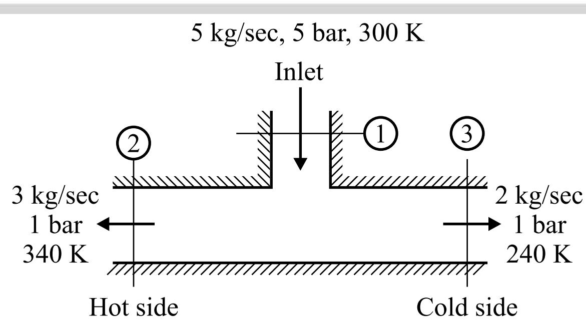


Consider constant specific heat of air is 1005J/kgK and gas constant is 287J/kgK. There is no work transfer across the boundary of this device. The rate of entropy generation is ______ kW/K (round off to one decimal place).

Engineering Thermodynamics (Entropy/Available Energy)

Ans. 2.238

Sol. Given :



For an open system,

$$\frac{\partial S_{cv}}{\partial t} = \sum m_i s_i - \sum m_e s_e + \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

$$\left(\frac{\partial S_{cv}}{\partial t}\right) = 0\,,\ \dot{Q} = 0$$ [∵ Flow is steady and duct is insulated]

$$\dot{S}_{gen} = \sum \dot{m}_e s_e - \sum m_i s_i$$

$$\dot{S}_{gen} = \left[(\dot{m}_2 s_2 + \dot{m}_3 s_3) - \dot{m}_1 s_i\right]$$

$$\dot{S}_{gen} = \left[(\dot{m}_2 s_2 + \dot{m}_3 s_3) - (\dot{m}_2 + \dot{m}_3) s_1\right]$$ [∵ $\dot{m}_1 = \dot{m}_2 + \dot{m}_3$ (conservation of mass)]

$$\dot{S}_{gen} = \dot{m}_2 (s_2 - s_1) + \dot{m}_3 (s_3 - s_1)$$

$$Tds = dh - vdp$$

$$ds = C_p \frac{dT}{T} - R\frac{dP}{P}$$

$$\Delta s = C_p \ln\left(\frac{T_f}{T_i}\right) - R\ln\left(\frac{P_f}{P_i}\right)$$

$$\dot{S}_{gen} = 3\left[1.005\ln\left(\frac{340}{300}\right) - 0.287\ln\left(\frac{1}{5}\right)\right] + 2\left[1.005\ln\left(\frac{240}{300}\right) - 0.287\ln\left(\frac{1}{5}\right)\right]$$

$$\dot{S}_{gen} = 1.763 + 0.475$$

$$\dot{S}_{gen} = 2.238\ \text{kW/K}$$

Question 9

A column with one end fixed and one end free has a critical buckling load of 100 N. For the same column if free end is replaced with a pinned end then critical buckling load will be _______ N (round off to the nearest integer).

Strength of Material (Theory of Column)

Ans. **800**

Sol. **Given :** $P_{cr_1} = 100\ \text{N}$

$$\frac{P_{cr_2}}{P_{cr_1}} = \frac{L_{e1}^2}{L_{e2}^2}$$

$$\frac{P_{cr_2}}{P_{cr_1}} = \frac{(2L)^2}{\left(\frac{L}{\sqrt{2}}\right)^2} = \frac{4L^2}{\frac{L^2}{2}} = 8$$

$$P_{cr_2} = 8P_{cr_1} = 800\ \text{N}$$

Question 10

Value of $\int_4^{5.2} \ln x\, dx$ using Simpson's one third rule with interval size 0.3 is

(A) 1.83 (B) 1.06 (C) 1.60 (D) 1.51

Engineering Mathematics

Ans. A

Sol.

$$\int_4^{5.2} \ln(x)dx$$

$$h = 0.3$$

$$n = \frac{b-a}{h} = \frac{5.2-4}{0.3} = 4$$

$$\int_a^b f(x)dx = \frac{h}{3}[(y_0 + y_n) + 4\times\text{Odd} + 2\times\text{Even}]$$

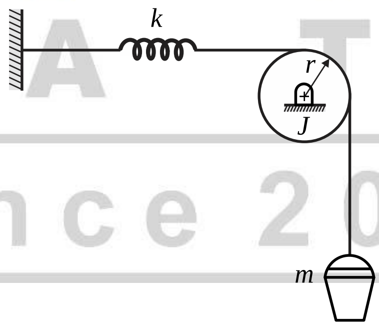
x	4	4.3	4.6	4.9	5.2
y	1.3862	1.4586	1.526	1.589	1.648
	y_0	y_1	y_2	y_3	y_4

$$\int_4^{5.2} \ln(x)dx = \frac{0.3}{3}[(1.3862+1.648)+(1.4586+1.589)+2\times1.526] = 1.8277$$

Hence, the correct option is (A).

Question 11

Consider the system shown in figure A rope goes over a pulley. A mass, m is hanging from rope. A spring of stiffness, k is attached at one end of rope. Assume rope is inextensible, massless and there is no slip between pulley and rope. The pulley radius is r and its mass moment of inertia is J. Assume that the mass is vibrating harmonically about its static equilibrium position. The natural frequency of the system is

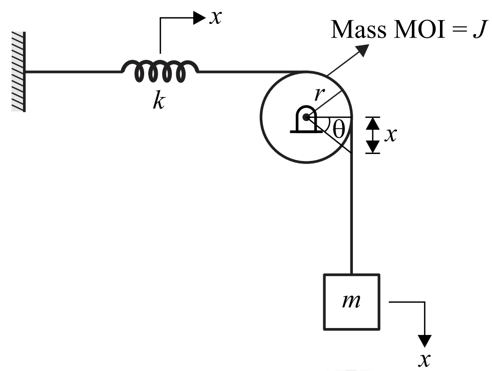


Mechanical Vibration

(A) $\sqrt{k/m}$ (B) $\sqrt{\frac{kr^2}{J}}$ (C) $\sqrt{\frac{kr^2}{J+mr^2}}$ (D) $\sqrt{\frac{kr^2}{J-mr^2}}$

Ans. C

Sol.



$$x = R\theta \Rightarrow \dot{x} = R\dot{\theta} \Rightarrow \dot{x} = R\dot{\theta}$$

$$K.E. = \frac{1}{2}m\dot{x}^2 + \frac{1}{2}J\dot{\theta}^2$$

$$K.E. = \frac{1}{2}m(R\dot{\theta})^2 + \frac{1}{2}J\dot{\theta}^2$$

$$K.E. = \frac{1}{2}(J + mR^2)\dot{\theta}^2$$

$$P.E. = \frac{1}{2}kx^2 = \frac{1}{2}k(R\theta)^2 = \frac{1}{2}kR^2\theta^2$$

$$\frac{d}{dt}[K.E + P.E] = 0$$

$$\frac{d}{dt}\left[\frac{1}{2}(J + mR^2)\dot{\theta}^2 + \frac{1}{2}kR^2\theta^2\right] = 0$$

$$\frac{1}{2}(J + mR^2)(2\dot{\theta}\dot{\theta}) + \frac{1}{2}(kR^2)(2\dot{\theta}\dot{\theta}) = 0$$

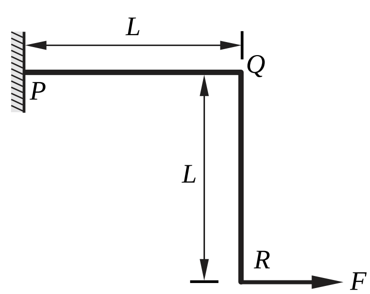
$$(J + mR^2)\dot{\theta} + kR^2\dot{\theta} = 0$$

$$\omega_n = \sqrt{\frac{kR^2}{J + mR^2}}$$

Hence, the correct option is (C).

Question 12

A plane frame *PQR* (fixed at *P* and free at *R*) is shown in the figure. Both member (*PQ* and *QR)* have length *L*, and flexural rigidity *EI*. Neglecting the effect of axial stress and transverse shear, the horizontal deflection at free end *R*, is

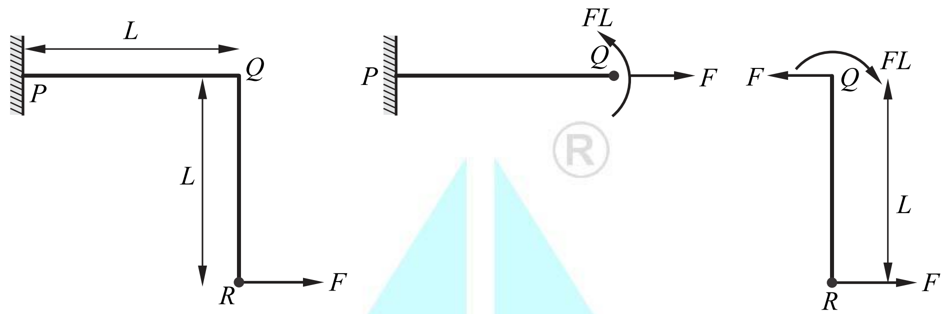


Strength of Material (Deflection of Beams)

(A) $\dfrac{2FL^3}{3EI}$ (B) $\dfrac{5FL^3}{3EI}$ (C) $\dfrac{4FL^3}{3EI}$ (D) $\dfrac{FL^3}{3EI}$

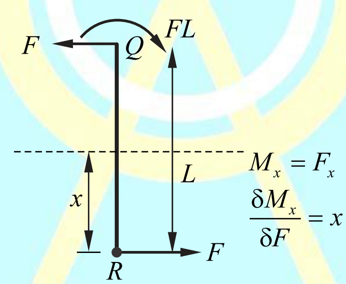
Ans. C

Sol.



$$x_R = (\delta_A)_{horizontal} = \frac{\partial U}{\partial F} = \int \frac{m_x \left(\frac{\partial M_x}{\partial F}\right)}{EI}$$

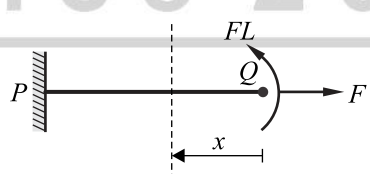
***RQ* portion :**



$$\left(\frac{\partial U}{dF}\right)_{RQ} = \int_0^L \frac{(F_x)(x)dx}{EI}$$

$$\left(\frac{\partial U}{dF}\right)_{RQ} = \frac{FL^3}{3EI}$$

***QP* portion :**



(Neglecting axial stress effect)

$$\left(\frac{\partial U}{dF}\right)_{QP} = \int_0^L \frac{(FL)(L)}{EI} dx = \frac{FL^3}{EI}$$

$$(\delta_A)_\mu = x_A = \frac{\delta U}{\partial F} = \frac{FL^3}{3EI} + \frac{FL^3}{EI} = \frac{4}{3}\frac{FL^3}{EI}$$

Hence, the correct option is (C).

Question 13

An object is moving with a mach number of 0.6 in an ideal gas environment, which is at a temperature of 350 K. The gas constant is 320 J/kgK and ratio of specific heats is 1.3. The speed of object is _______ m/s. (Round off to the nearest integer).

Engineering Thermodynamics(Compressible fluid flow)

Ans. 228.94

Sol. Given : $M = 0.6$, $T = 350\,\text{K}$, $R = 320\,\text{J/kg-K}$, $\gamma = 1.3$ and $V = ?$

$$M = \frac{V}{C}$$

$$C = \sqrt{\gamma RT} \qquad \text{For an ideal gas}$$

$$C = \sqrt{1.3 \times 320 \times 350}$$

$$M = 0.6 = \frac{V}{381.57}$$

$$V = 228.94\,\text{m/sec}$$

Question 14

Let the superscript T represents the transpose operation. Consider the function $f(x) = \frac{1}{2}x^T Qx - r^T x$, where $x \,\&\, r$ are $n \times 1$ vectors and Q is a symmetric $n \times n$ Metrix. The stationary point of $f(x)$ is

Engineering Mathematics

(A) $\frac{r}{r^T x}$ (B) $Q^T r$ (C) $Q^{-1} r$ (D) r

Ans. C

Sol. Given : $T \rightarrow$ Transpose

$$f(x) = \frac{1}{2}x^T Qx - r^T x$$

$$r, x \rightarrow n \times 1$$

$$Q \rightarrow n \times n$$

Consider, $n = 1$

$$f(x) = \frac{1}{2}Qx^2 - rx$$

$$f'(x) = 0$$

$$\frac{1}{2}Q\times 2x - r = 0$$

$$x = \frac{r}{Q}$$

$$x = rQ^{-1}$$

Hence, the correct option is (C).

Question 15

A PERT network has 9 activities on its critical path. The standard deviation of each activity on critical path is 3. The standard deviation of critical path is_________.

Industrial Engineering (CPM/PERT)

(A) 27 (B) 81 (C) 3 (D) 9

Ans. **D**

Sol. Activities along critical path $= 9$

Standard deviation of each activity is 3

SD along critical path $= \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 + \sigma_5^2 + \sigma_6^2 + \sigma_7^2 + \sigma_8^2 + \sigma_9^2}$

$$(SD)_{cp} = \sqrt{(3^2)\times 9}$$

$$(SD)_{cp} = 9$$

Hence, the correct option is (D).

Question 16

In forced convective heat transfer Stanton number (St), Nusselt number (Nu), Reynolds number (Re) and Prandtl number (Pr) are related as

Heat Transfer (Forced Convection)

(A) $\text{St} = \dfrac{\text{Nu}}{\text{Re Pr}}$ (B) $\text{St} = \dfrac{\text{Nu Re}}{\text{Pr}}$ (C) $\text{St} = \dfrac{\text{Nu Pr}}{\text{Re}}$ (D) $\text{St} = \text{Nu Pr Re}$

Ans. **A**

Sol. Stanton number is given by

$$St = \frac{Nu}{\text{Re}\,\text{Pr}}$$

Hence correct option is (A).

Question 17

The thickness, width and length of a metals slab are 50 mm., 250 mm. and 3600 mm. respectively. A rolling operation on this slab reduces the thickness by 10% and increases the width by 3%. The length of the rolled slab is ______ mm (round off to one decimal place).

Production Engineering (Rolling)

Ans. **3883.49**

Sol. **Given :** $h_0 = 50$ mm , $w_0 = 250$ mm

$L_0 = 3600$ mH , $h_f = 0.9h_0$ and $w_f = 1.03w_0$

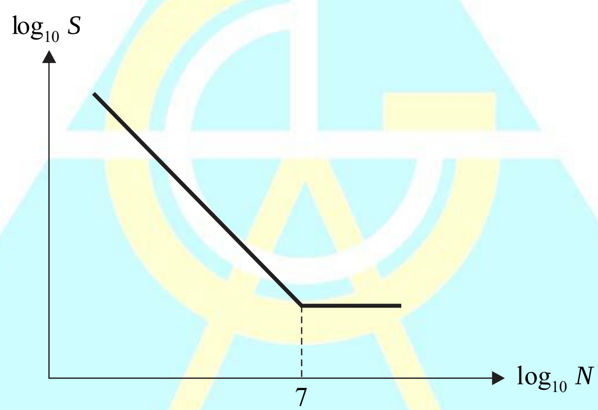
So, $$h_0 w_0 L_0 = h_f w_f L_f$$

$\Rightarrow$ $$h_0 w_0 L_0 = 0.9h_0 \times 1.03 w_0 \times L_f$$

$\Rightarrow$ $$L_f = \frac{3600}{0.9 \times 1.03} = 3883.49 \text{ mm}$$

Question 18

The figure shows the relationship between fatigue strength (S) and fatigue life (N) of a material. The fatigue strength of the material for a life of 1000 cycles is 450 MPa, while its fatigue strength for a life of 10^6 cycles is 150 MPa.

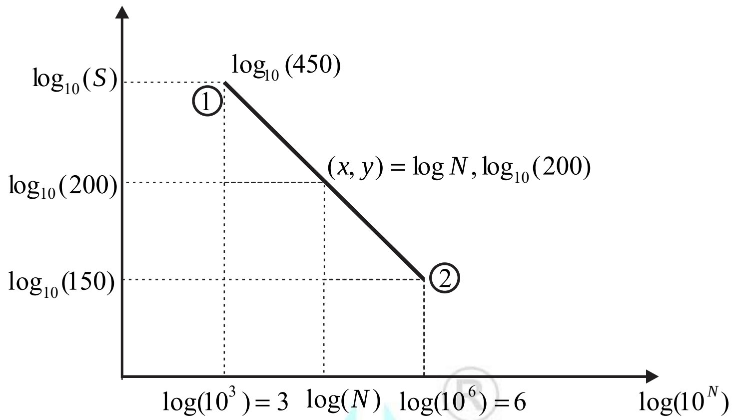


The life of a cylinder shaft made of this material subjected to an alternating stress of 200 MPa will then be _______ cycles (round off to the nearest integer).

Machine Design (Fluctuating Stress)

Ans. **163840**

Sol.



$$\frac{x-x_1}{x_2-x_1}=\frac{y-y_1}{y_2-y_1}$$

$$\frac{x-3}{6-3}=\frac{\log_{10}200-\log_{10}(450)}{\log_{10}(150)-\log(450)}$$

$$x = 5.214421$$

$$\log N = 5.214421$$

$$N = 163840.58 \text{ cycle}$$

$$N \approx 163840 \text{ cycles}$$

Question 19

The size distribution of powder particles used in Powder Metallurgy process can be determined by

(A) Laser absorption (B) Laser reflection

(C) Laser penetration (D) Laser scattering

Production Engineering (Powder Metallurgy)

Ans. **D**

Sol. The size distribution of powder particles used in powder metallurgy process can be determined by laser scattering.

Hence, the correct option is (D).

Question 20

Consider adiabatic flow of air through a duct. At a given point in the duct, velocity of air is 300 m/s, temperature is 330K and pressure is 180 kPa. Assume that the air behaves as a perfect gas with constant $C_p = 1.005$ kJ/kgK. The stagnation temperature at this point is ________ K (round off to two decimal places).

Engineering Thermodynamics(Compressible fluid flow)

Ans. **374.77**

Sol. **Given :** $V = 300\,\text{m/sec}$, $P = 180\,\text{kPa}$, $T_1 = 330\,K$

$C_P = 1.005\,\text{kJ/kgk}$ and $C_P = 1.005\,\text{kJ/kgk}$

Applying SFEE,

$$h_{0_1} + \frac{V_d}{2} = h_1 + \frac{V_1^2}{2}$$

$$C_P T_{0_1} + 0 = C_P T_1 + \frac{V_1^2}{2}$$

$$T_{0_1} = T_1 + \frac{V_1^2}{2C_P}$$

$$T_{0_1} = T_1\left[1 + \frac{V_1^2}{2C_P T_1}\right]$$

$$T_{0_1} = 330\left[1 + \frac{(300)^2}{2\times1005\times330}\right]$$

$$T_{0_1} = 374.77\,\text{K}$$

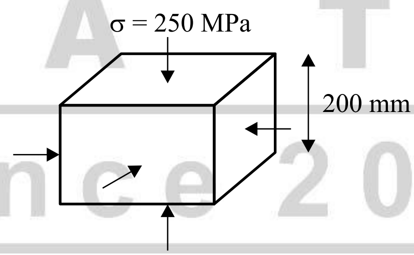
Question 21

A steel cubic block of side 200 mm is subjected to hydrostatic pressure of 250 N/mm^2. The elastic modulus is 2×10^5 N/mm^2 and Poisson's ratio is 0.3 for steel. The side of the block is reduced by ________ mm. (round off to two decimal places).

Strength of Material (Volumetric Strain)

Ans. **0.1**

Sol. **Given :** $E = 2\times10^5$ N/mm^2



$$E = 3K(1-2\mu)$$

$$k = \frac{2\times10^5}{3(1-2\times0.3)} = 1.67\times10^5\ \text{N/mm}^2$$

We can take as

$$k = \frac{\sigma_b}{\varepsilon_v} = \varepsilon_v = \frac{250}{1.67\times10^5} = 1.497\times10^{-3}$$

$$\varepsilon_v = \frac{\delta V}{V}$$

$$V_f = V - V \cdot \varepsilon_v$$

$$(L^3) = 200^3 - 200^3 \times 1.497 \times 10^{-3}$$

$$L' = 199.9\,\text{mm}$$

$$\delta L = L - L' = 200 - 199.9 = 0.1\,\text{mm}$$

Question 22

The torque provided by a engine is given by $T(\theta) = 12000 + 2500\,\text{Sin}(2\theta)$ Nm, where θ is the angle turned by the crank from inner dead center. The mean speed of engine is 200 rpm and it drives a machine that provides a constant resisting torque. If variation of the speed from the mean speed is not to exceed $\pm 0.5\%$, the minimum mass moment of inertia of the flywheel should be ______ kg-m^2 (round off to the nearest integer).

Theory of Machines (Turning Moment Diagram)

Ans. **569.98**

Sol. **Given :** $T = 12000 + 2500\sin 2\theta$

$$N = 200\,\text{rpm} = \omega = \frac{\partial \pi N}{60} = 20.944\,\text{rad/s}$$

$$T_{resting} = T_r = \cos t = T_{av}$$

$$K_s = \pm 0.5\% = 1\% = 0.01$$

From turning moment equation,

Cycle angle $(\theta) = \frac{2\pi}{2} = \pi$

$$T_{av} = \frac{\text{Work done per cycle}}{\theta}$$

$$T_{av} = \int_0^{\pi} \frac{(12000 + 2500\sin 2\theta)d\theta}{\pi} = 12000\,\text{Nm}$$

Crank angle at which $T = T_{av}$

$$12000 + 2500\sin 2\theta = 12000$$

$$2500\sin 2\theta = 0$$

$$2\theta = 0, \pi, 2\pi$$

$$\theta = \underset{\theta_a}{\underset{\downarrow}{0}}, \underset{\theta_b}{\underset{\downarrow}{\pi/2}}, \underset{\theta_c}{\underset{\downarrow}{\pi}}$$

$$E_a = E' \text{ minimum}$$

$$E_b = E' + \int_{\theta_a}^{\theta_b} (T_1 - T_2) d\theta = E' + \int_{0}^{\pi/2} (2500 \sin 2\theta)\, d\theta$$

$$E_b = E' + 2500 \text{ maximum}$$

$$E_c = E_b + \int_{\theta_b}^{\theta_c} (T_1 - T_2) d\theta = E' + 2500 + \int_{\pi/2}^{\pi} (2500 \sin 2\theta)\, d\theta$$

$$E_c = E'$$

$$E_f = E_{max} - E_{min}$$

$$E_f = E' + 2500 - E'$$

$$E_f = 2500 \text{ Nm}$$

$$I\omega^2 k_s = 2500$$

$$I(20.944)^2 \times 0.01 = 2500$$

$$I = 569.98 \text{ kgm}^2$$

Question 23

A vertical shaft Francis turbine rotates at 300 rpm. The available head at the inlet to the turbine is 200 m. The tip speed of the rotor is 40 m/s. Water leaves the runner of the turbine without whirl. Velocity at the exit of the draft tube is 3.5 m/s. The head losses in different components of the turbine are : (i) stator and guide vanes: 5.0 m, (ii) Rotor: 10 m, and (iii) Draft tube: 2 m. Flow rate through the turbine is 20 m^3/s. Take $g = 9.8$ m/s^2. The hydraulic efficiency of the turbine is ________ % (round off to one decimal place).

Hydraulic Machinery (Turbine)

Ans. **93.43**

Sol. **Given :** $N = 300 \text{ rpm}$, $H = 200 \text{ m}$,

$u_1 = 40 \text{ m/s}$, $V_{w_2} = 0$ and $V = 3.5 \text{ m/sec}$

Losses :

Stator and Guide vanes $= 0.5$ m

Rotor = 10 m

Draft tube = 2 m

Apply energy balance :

$$200 = \left(\frac{V_{w_1} u_1}{g}\right) + (10 + 2 + 0.5) + \frac{3.5^2}{2 \times g}$$

$$\frac{V_{w_1} u_1}{g} = 186.875 \text{ m} / 182.375 \text{ m}$$

$$\eta_{ny} = \frac{(V_{\omega_1} u_1)/g}{H}$$

$$\eta_{ny} = \frac{186.075}{200} \times 100 = 93.43\% / 91.18$$

Question 24

The allowance provided in between a hole and a shaft is calculated from the difference between

Mechanical Measurement and Meterology (Limit ,fit Tolerance)

(A) lower limit of the shaft and upper limit of the hole

(B)upper limit of the shaft and upper limit of the hole

(C) upper limit of the shaft and lower limit of the hole

D)lower limit of the shaft and lower limit of the hole

Ans. **C**

Sol. The allowance provided between a hole and shaft is calculated from the different between upper limit of shaft and upper limit of hole.

Allowance = UL of shaft and LL of hole.

Hence, the correct option is (C).

Question 25

The Cast Iron which possesses all the carbon in combined form as cementite is known as

Material Science (Structure of Material)

(A) Malleable Cast Iron (B)White Cast Iron (C) Grey Cast Iron (D) Spheroidal Cast Iron

Ans. **B**

Sol. The cast iron which possesses all the carbon in combine form as cementite is known as white C.I.

Hence, the correct option is (B).

Question 26

For a two-dimensional, incompressible flow having velocity components u and v in x and y directions, respectively, the expression

$\frac{\partial(u^2)}{\partial x} + \frac{\partial(uv)}{\partial y}$ can be simplified to

Fluid Mechanics (Fluid Kinematics)

(A) $2u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$ (B) $u\frac{\partial u}{\partial x} + u\frac{\partial v}{\partial y}$ (C) $2u\frac{\partial u}{\partial x} + u\frac{\partial v}{\partial y}$ (D) $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$

Ans. **D**

Sol. $\frac{\partial u^2}{\partial x}+\frac{\partial (uv)}{\partial y}$

Differentiating,

$$2u\frac{\partial u}{\partial x}+u\frac{\partial v}{\partial y}+v\frac{\partial u}{\partial y}$$

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

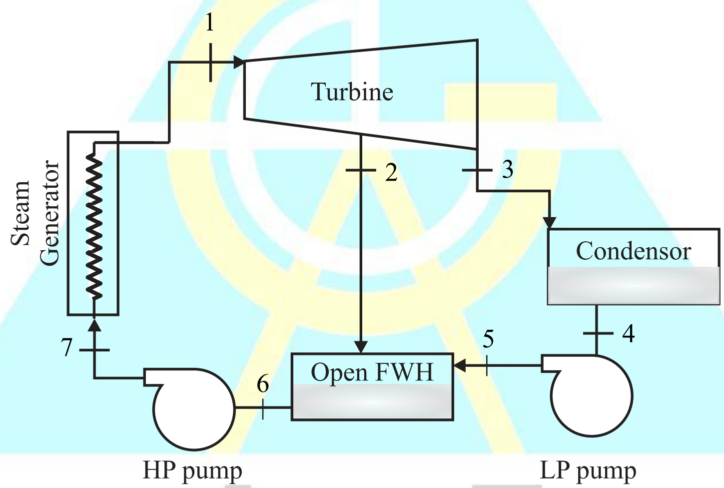
$$u\frac{\partial u}{\partial x}+u\left[\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right]+v\frac{\partial u}{\partial y}$$ ($\because$ for $2D$ incompressible flow $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$)

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

Hence, the correct option is (D).

Question 27

Consider the open feed water heater (FWH) shown in the figure given below:



Specific enthalpy of steam at location 2 is 2624 kJ/kg. Specific enthalpy of water at location 5 is 226.7 kJ/kg and specific enthalpy of saturated water at location 6 is 708.6 kJ/kg. If the mass rate of water entering the open feed water heater (at location 5) is 100 kg/s then the mass flow rate of steam at location 2 will be ______ kg/s (round off to one decimal place).

Applied Thermodynamics (Regenerative Cycle)

Ans.

Sol.

Question 28

The value of $\int_0^{\frac{\pi}{2}}\int_0^{\cos\theta} r\sin\theta\, dr\, d\theta$ is

Engineering Mathematics

(A) 0 (B) π (C) $\frac{1}{6}$ (D) $\frac{4}{3}$

Ans. **C**

Sol. $I = \int_0^{\pi/2}\int_0^{\cos\theta} r\sin\theta\, dr\, d\theta$

$$I = \int_0^{\pi/2}\left[\int_{r=0}^{\cos\theta} r\,dr\right]\sin\theta d\theta$$

$$I = \int_{\theta=0}^{\pi/2}\left(\frac{r^2}{2}\right)_0^{\cos\theta}\sin\theta d\theta$$

$$I = \frac{1}{2}\int_{\theta=0}^{\pi/2}\sin\theta\cos^2\theta d\theta$$

Now, using Gamma function with $m = 1,\ n = 2$.

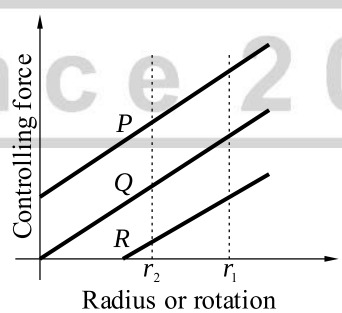
$$= \frac{1}{2}\times\frac{\Gamma\left(\frac{1+1}{2}\right)\Gamma\left(\frac{2+1}{2}\right)}{2\Gamma\left(\frac{1+2+2}{2}\right)} = \frac{1}{4}\times\frac{\Gamma 1\,\Gamma\frac{3}{2}}{\Gamma\frac{5}{2}}$$

$$= \frac{1}{4}\times\frac{1\times\Gamma\frac{3}{2}}{\frac{3}{2}\Gamma\frac{3}{2}} = \frac{1}{6}$$

Hence, the correct option is (C).

Question 29

The controlling force curves P, Q and R for a spring controlled governor are shown in the figure, where r_1 and r_2 are any two radii of rotation.



Theory of Machines (Governer)

(A) P-Unstable; Q-Stable; R-Isochronous
(B) P-Stable; Q-Unstable; R-Isochronous
(C) P-Stable; Q-Isochronous; R-Unstable
(D) P-Unstable; Q-Isochronous; R-Stable

Ans. **D**

Sol. $P \rightarrow$ Unstable

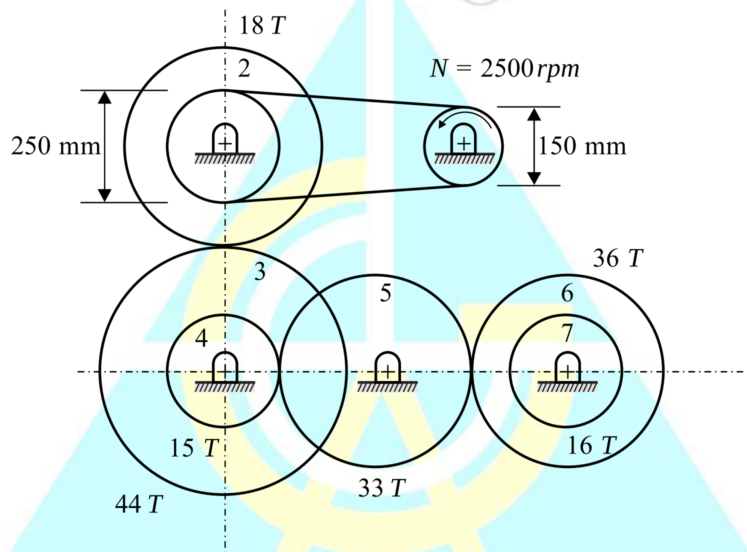
$Q \rightarrow$ Isochronous

$R \rightarrow$ Stable

Hence, the correct option is (D).

Question 30

A power transmission mechanism consists of a belt drive and a gear train as shown in the figure.



Diameters of pulleys of belt drive and number of teeth (T) on the gears 2 to 7 are indicated in thefigure. Thespeed and direction of rotation of gear 7, respectively, are

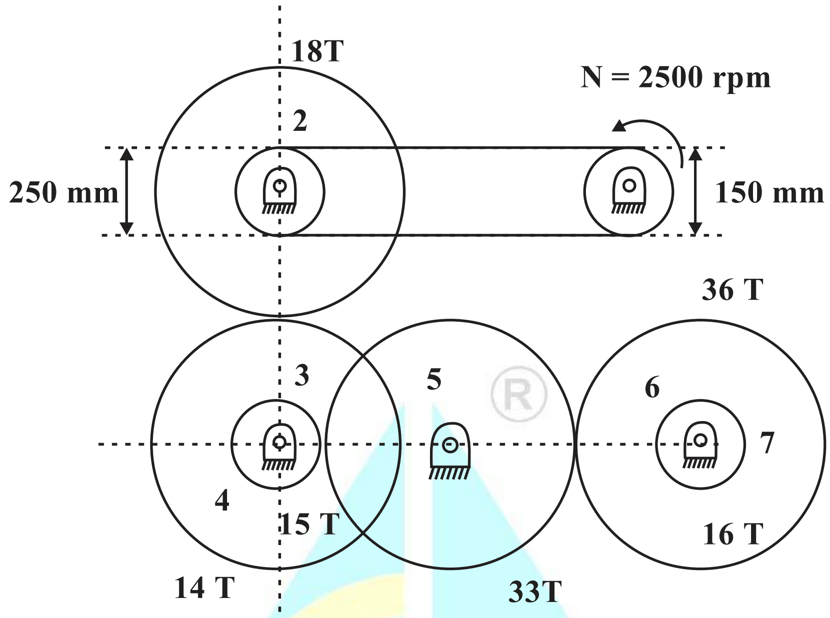
Theory of Machines (Gear and Gear Trains)

(A) 255.68 rpm; anticlockwise (B) 255.68 rpm; clockwise

(C) 575.28 rpm; anticlockwise (D) 575.28 rpm; clockwise

Ans. **B**

Sol. **Given :** $T_2 = 18, T_3 = 44, T_4 = 15, T_6 = 36$



$$N_1 = N_0 \times \frac{150}{250}$$

$$N_1 = 2500 \times \frac{150}{250} = 1500 \text{ rpm}$$

$$N_2 = N_1$$

$$N_3 = \frac{N_2 \times T_2}{T_3}$$

$$N_3 = \frac{1500 \times 18}{44} = 613.63 \text{ rpm}$$

$$N_4 = N_3$$

$$N_6 = \frac{N_4 \times T_4}{T_3}$$

$$N_6 = \frac{613.63 \times 15}{36} = 255.68 \text{ rpm}$$

$$N_7 = N_6$$

$\because$ $N_7 = 255.68$ rpm clockwise.

Hence, the correct option is (B).

Question 31

Which of the following is responsible for eddy viscosity (or turbulent viscosity) in a turbulent boundary layer on a flat plate ?

Fluid Mechanics (Air Turbulent flow)

(A) Reynolds stresses (B) Nikuradse stresses
(C) Prandtl stresses (D) Boussinesq equation stresses

Ans. **A**

Sol. Reynold stresses is responsible for eddy viscosity (turbulent viscosity) in a turbulent layer on a flat plate.
Hence, the correct option is (A).

Question 32

Daily production capacity of a bearing manufacturer company is 30000 bearings. The daily demand of the bearing is 15000. The holding cost per year of keeping a bearing in the inventory is Rs. 20. The setup cost for the production of a batch is Rs. 1800. Assuming 300 working days in a year, the economic batch quantity in number of bearings is_____. (in integer)

Industrial Engineering (Inventory Control)

Ans. **40250**

Sol. **Given :**

Production rate $= 30000$ bearings /day

Demand rate $= 15000$ bearings /day

$$C_h = 20/\text{unit/year}$$

$$C_0 = 1800/\text{order}$$

Working days $= 300$

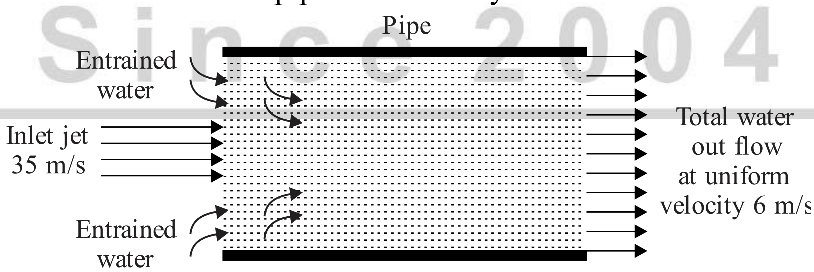
Annual demand $= 300 \times 15000 = 4500000$

$$E \text{ batch quantity} = \sqrt{\frac{2DC_0}{C_h}\left(\frac{P}{p-d}\right)} = \sqrt{\frac{2\times 4500000\times 1800}{20}\times\left(\frac{30000}{30000-15000}\right)}$$

E.B.Q. $= 40249.2$ bearings $= 40250$ bearings

Question 33

A high velocity water jet of cross section area = 0.01 m^2 and velocity = 35 m/s enters a pipe filled with stagnant water. The diameter of pipe is 0.32 m. This high velocity water jet entrains additional water from the pipe and the total water leaves the pipe with velocity of 6 m/s as shown in the figure.

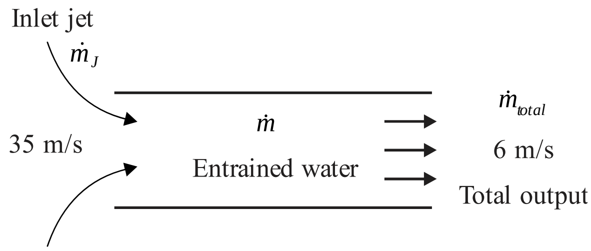


The flow rate of entrained water is _______ litres/s (round off to two decimal places).

Fluid Mechanics (Pipe Flow)

Ans. **132.548**

Sol. **Given :** $a_J = 0.01\text{ m}^2$, $v_J = 35\text{ m/sec}$, $d = 0.32\text{ m/sec}$



$$\dot{m}_J + \dot{m} = \dot{m}_{total}$$

$$\delta Q_J + \delta Q = \delta Q_{total}$$

$$Q = Q_{total} - Q_J$$

$$Q = \frac{\pi}{4}(0.32)^2 \times 6 - 0.01 \times 35$$

$$Q = 0.13254\text{ m}^3/\text{sec}$$

$$Q = (0.13254 \times 1000)\text{ lit/sec}$$

$$Q = 132.548\text{ lit/sec}$$

Question 34

Ambient pressure, temperature and relative humidity at a location are 101 kPa, 300 K and 60% respectively. The saturation pressure of water at 300 K is 3.6 kPa. The specific humidity of ambient air is ______ g/kg of dry air

Refrigeration and Air Conditioning (Psychrometry)

(A) 21.9 (B) 21.4 (C) 13.6 (D) 35.1

Ans. **C**

Sol. **Given :** $P = 101\text{ kPa}$; $T = 300\text{ K}$ and $\phi = 0.6$

$P_{vs} = 3.6\text{ kPa}$ at 300 K

$$\omega = ?$$

$$\phi = \frac{p_v}{p_{vs}} \Rightarrow p_v = 0.6 \times 3.6$$

$$p_v = 2.16\text{ kPa}$$

$$\omega = 0.622\frac{p_v}{p - p_v} = \omega = 0.622 \times \frac{2.16}{(101 - 2.16)}$$

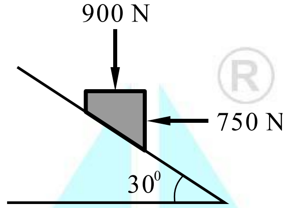
$$\omega = 0.013593\frac{\text{kg water vapour}}{\text{kg of dry air}}$$

$$\omega = 13.6 \frac{\text{gm water vapour}}{\text{kg of dry air}}$$

Hence, the correct option is (C).

Question 35

A block of negligible mass rests on a surface that is inclined at 30° to horizontal plane as shown in figure.When a vertical force of 900 N and a horizontal force of 750 N are applied, the block is just about to slide.

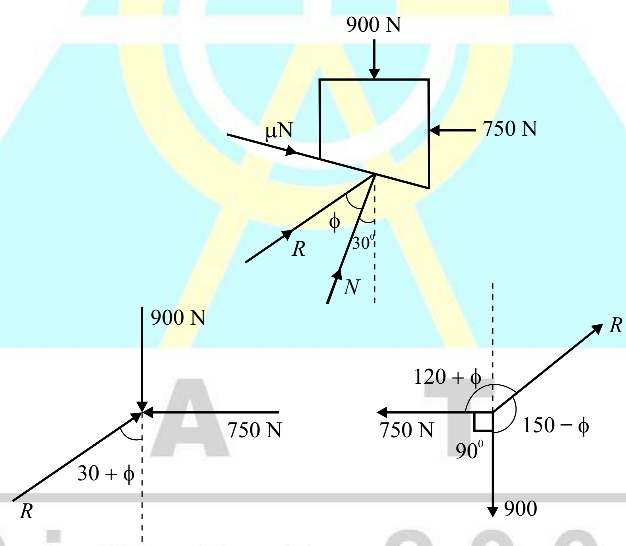


The coefficient of static friction between the block and the surface is____ (round of to two decimal places).

Engineering Mechanics (Friction)

Ans. **0.173**

Sol.



From Lamis theorem,

$$\frac{R}{\sin 90} = \frac{750}{\sin(150-\phi)} = \frac{900}{\sin(120+\phi)}$$

On solving, $\phi = 9.805^0$

Coefficient of friction, $\mu = \tan\phi = \tan(9.805) = 0.173$

Question 36

Value of $(1+i)^8$, where $i = \sqrt{-1}$ is equal to

Engineering Mathematics

(A) 16 (B) 4 (C) 4*i* (D) 16*i*

Ans. **A**

Sol. $(1+i)^8 = (1-1+2i)^4 = (2i)^4 = 16$

Hence, the correct option is (A).

Question 37

A cantilever beam with a uniform flexural rigidity $(EI = 200\times10^6\ \text{Nm}^2)$ is loaded with a concentrated force at its free end. The area of the bending moment diagram corresponding to the full length of the beam is 10000 Nm^2. The magnitude of the slope of the beam at its free end is _____ micro radian (round off to the nearest integer).

Strength of Material (Deflection of Beam)

Ans. **50**

Sol. **Given :** $EI = 200\times10^6\ \text{Nm}^2$

Area of BMD between A and B $= 10000\ \text{Nm}^2$

$$\theta_A - \theta_B = \frac{\text{Area of BMD between } A \text{ and } B}{EI}$$

$$\theta_A = \frac{200\times10^6}{10000}$$

$$\theta_A = 50\times10^{-6}\ \text{rad}$$

$$\theta_A = 50\ \text{rad}$$

Question 38

The machining process that involves ablation is

Production Engineering (Non Conventional Machining Method)

(A) Abrasive Jet Machining (B) Chemical Machining

(C) Laser Beam Machining (D) Electrochemical Machining

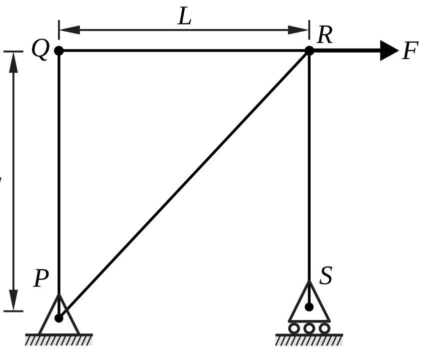
Ans. **C**

Sol. Ablation involves in laser beam machining.

Hence, the correct option is (C).

Question 39

A plane truss PQRS (PQ = RS, and <PQR = 90) is shown in the figure.



The forces in the members PR and RS, respectively, are _____

Engineering Mechanics (Truss)

(A) $F(compressible)$ and $\sqrt{2}\ F(compressible)$

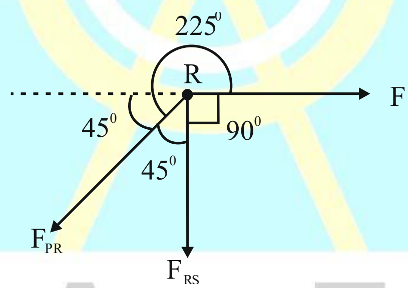
(B) $\sqrt{2}F(tensile)$ and $F(compressible)$

(C) $\sqrt{2}F(tensile)$ and $F(tensile)$

(D) $F(tensile)$ and $\sqrt{2}F(tensile)$

Ans. **B**

Sol. At joint Q, no load is acting. So, force in member PQ & QR will be zero.



$$\frac{F_{PR}}{\sin 90^0} = \frac{F_{RS}}{\sin 225^0} = \frac{F}{\sin 45^0}$$

$$F_{PR} = \frac{F}{\sin 45^0} \times \sin 90^0 = \frac{F}{\frac{1}{\sqrt{2}}} \times 1$$

$$F_{PR} = \sqrt{2}F\,(T)$$

$$F_{RS} = \frac{F}{\sin 45^0} \times \sin 225^0 = \frac{F}{\frac{1}{\sqrt{2}}} \times \left(-\frac{1}{\sqrt{2}}\right)$$

$$F_{RS} = F\,(C)$$

Question 40

A surface grinding operation has been performed on a Cast Iron plate having dimensions 300 mm (*length*) $\times$ 10 mm (*width*) $\times$ 50 mm (*height*). The grinding was performed using an alumina wheel having a wheel diameter of 150 mm and wheel width of 12 mm. The grinding velocity used is 40 m/s, table speed is 5 m/min, depth of cut per pass is $50 \mu m$ and the number of grinding passes is 20. The average tangential and average normal forces for each pass are found to be 40 N and 60 N respectively. The value of the specific grinding energy under the aforesaid grinding condition is __________ J/mm^3 (round off to one decimal place).

Production Engineering (Grinding)

Ans.

Sol.

Question 41

In a CNC machine tool, the function of an interpolator is to generate

Production Engineering (CNC Machine Toool)

(A) error signal for tool radius compensation during machining
(B) reference signal prescribing the shape of the part to be machined
(C) NC code from the part drawing during post processing
(D) signal for lubrication pump during machining

Ans. **B**

Sol. In CNC machine tool function of half interpolator is to generate reference signal prescribing the shape of the part to be machined.

Hence, the correct option is (B).

Question 42

A cast product of a particular material has dimensions, 75 mm$\times$ 125 mm $\times$ 20 mm. The total solidification time for the cast product is found to be 2.0 minutes as calculated using Chvorinov's rule having the index $n = 2$. If under the identical casting conditions, the cast product shape is changed to a cylinder having diameter = 50 mm and height = 50 mm, the total solidification time will be ______minutes(round off to the two decimal places).

Production Engineering (Casting)

Ans. **2.82**

Sol. **Given :** Slab $= 75 \times 125 \times 20 \text{ mm}^3$

$$(t_s)_{slab} = 2 \text{ min}$$

Cylinder $\Rightarrow d = h = 50$ mm

$$\frac{(t_s)_{cylinder}}{(t_s)_{slab}} = \frac{\left(\dfrac{d}{6}\right)^2}{\left(\dfrac{V}{SA}\right)^2}$$

$$\frac{(t_s)_{cylinder}}{(t_s)_{slab}} = \frac{\left(\frac{50}{6}\right)^2}{\left(\frac{75\times125\times20}{2(75\times125+20\times125+20\times75)}\right)^2}$$

$$(t_s)_{cylinder} = 2.82 \text{ min}$$

Question 43

The Von-Mises stress at a point in a body subjected to forces is proportional to the square root of the

Machine Design (Theory of Failure)

(A) plastic strain energy per unit voume
(B) distortional strain energy per unit voume
(C) total strain energy per unit voume
(D) dilatational strain energy per unit voume

Ans. **B**

Sol. Von-Mises stress is proportional to square root of distortion strain energy.

Hence, the correct option is (B).

Question 44

A factory produces $m(i=1,2,......,m)$ products, each of which requires processing on n $(j=1,2,....,n)$ workstations. Let a_{ij} be the amount of processing time that one unit of the i^{th} product requires on the j^{th} workstation. Let the revenue from selling one unit of the i^{th} product be r_i and h_i be the holding cost per unit per time period for the i^{th} product. The planning horizon consists of T $(t=1,2,.....,T)$ time periods. The minimum demand that must be satisfied in time period t is d_{it} and the capacity of the j^{th} workstation in time period t is c_{jt}. Consider the aggregate planning formulation below, with decision variables S_{it} (amount of product i sold in time period t), X_{it} (amount of product i manufactured in time period t) and I_{it} (amount of product i held in inventory at the end of time period t)

$$\max \sum_{t=1}^{T}\sum_{i=1}^{m}(r_i S_{it} - h_i I_{it})$$

Subject to

$$S_{it} \geq d_{it} \forall i,t$$

<Capacity constraint>

<Inventory balance constraint>

$$X_{it}, S_{it}, I_{it} \geq 0; I_{io} = 0$$

The capacity constraints and inventory balance constraints for this formulation respectively are

Industrial Engineering (Aggregate Planning)

(A) $\sum_{i}^{m} a_{ij} X_{it} \le c_{jt} \forall i,t$ and $I_{it} = I_{it-1} + X_{it} - d_{it} \forall i,t$

(B) $\sum_{i}^{m} a_{ij} X_{it} \le d_{it} \forall i,t$ and $I_{it} = I_{i,t-1} + S_{it} - X_{it} \forall i,t$

(C) $\sum_{i}^{m} a_{ij} X_{it} \le d_{it} \forall i,t$ and $I_{it} = I_{i,t-1} + X_{it} - S_{it} \forall i,t$

(D) $\sum_{i}^{m} a_{ij} X_{it} \le c_{it} \forall j,t$ and $I_{it} = I_{i,t-1} + X_{it} - S_{it} \forall i,t$

Ans.

Sol.

Question 45

Ambient air flows over a heated slab having flat, top surface at $y = 0$. The local temperature (in Kelvin) profile within the thermal boundary layer is given by $T(y) = 300 + 200\exp(-5y)$ where y is the distance measured from the slab surface in meters. If the thermal conductivity of air is 1.0 W/mK and that of the slab is 100 W/mK, then the magnitude of temperature gradient $\left|\frac{dT}{dy}\right|$ within the slab at $y = 0$ is _______ K/m (round off to the nearest integer).

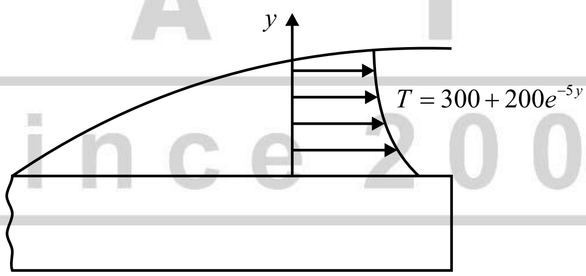
Heat Transfer (Convection)

Ans. **10**

Sol. **Given :**

$k_{air} = 1\,\text{W/mK}$

$k_{slab} = 100\,\text{W/mK}$



$k_{slab} = 100$ W/mK

$\because$ $$\{(Q_{cond})_{slab}\}_{y=0} = \{(Q_{cond})_{air}\}_{y=0}$$

$$-k_{slab} \times \left|\frac{dT}{dy}\right|_{y=0} = -k_{air} \times \left|\frac{d}{dy}(300 + 200e^{-5y})\right|_{y=1}$$

$$\left|\frac{dT}{dy}\right|_{y=0} = \frac{1}{100}\left|-1000e^{-\delta y}\right|_{y=0} = \frac{-1000}{100} = -10\text{ K/m}$$

Magnitude of temperature gradient $= 10\text{ K/m}$.

Question 46

A spot welding operation performed on two pieces of steel yielded a nugget with a diameter of 5 mm and a thickness of 1 mm. The welding time was 0.1 s. The melting energy for the steel is 20 J/mm^3. Assuming the heat conversion efficiency as 10%, the power required for performing the spot welding is _______ kW (round off to two decimal places).

Production Engineering (Welding)

Ans. 26.179

Sol. **Given :** $d_n = 5\text{ mm}$, $h_n = 1\text{ mm}$, $t = 0.15\text{sec}$

Melting energy $= 20\text{ J/mm}^3$

$$\eta = 0.1 = \frac{\dfrac{\dfrac{\pi}{4}\times 5^2 \times 1 \times 20}{0.15}}{\text{Power}}$$

Power = 26179.93 Watts

Power = 26.179 kW

Question 47

Consider an n×n matrix A and a non-zero n×1 vector p. Their product Ap = α^2p, where $\alpha \in \Re$ and $\alpha \notin \{-1,0,1\}$. Based on the given information, the Eigen value of A^2 is :

Engineering Mathematics

(A) α (B) α^2 (C) $\sqrt{\alpha}$ (D) α^4

Ans. D

Sol. **Given :** $AP = \alpha^2 P$

On comparison with $AX = \lambda X$

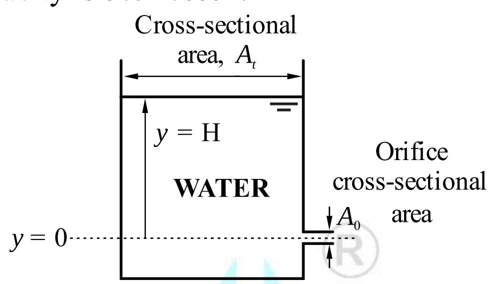
i.e. Eigen value of A is α^2

So, Eigen value of A^2 is $(\alpha^2)^2 = \alpha^4$

Hence, the correct option is (D).

Question 48

Water flows out from a large tank of cross sectional area $A_t = 1\ \text{m}^2$ through a small, rounded orifice of cross sectional area $A_0 = 1\ \text{cm}^2$, located at $y = 0$. Initially the water level (H), measured from y = 0, is 1 m. The acceleration due to gravity is $9.8\ \text{m/sec}^2$.



Neglecting any losses, the time taken by water in the tank to reach a level of $y = \dfrac{H}{4}$ is ______ seconds (round off to one decimal place).

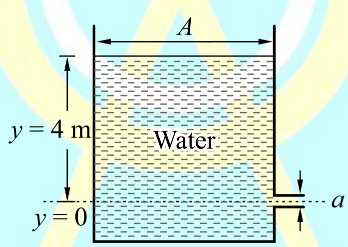
Fluid Mechanics (Fluid Dynamics)

Ans. **4517.54**

Sol. **Given :** $A = 1\text{m}^2$; $a = 1\text{cm}^2 = 10^{-4}\ \text{m}^2$

and $g = 9.8\ \text{m/sec}^2$

No losses, $C_d = 1$



When H_2 becomes $\dfrac{H}{4} = 1\text{m}$

$$T = \frac{2A(\sqrt{H_1} - \sqrt{H_2})}{C_d . a\sqrt{2g}}$$

$$T = \frac{2\times1\times(\sqrt{4} - \sqrt{1})}{1\times10^{-4}\times\sqrt{2\times9.8}} = 4517.54\,\text{sec}$$

Question 49

The Mean and variance, respectively, of a binomial distribution for n independent trials with the probability of success as p, are

Engineering Mathematics

(A) $\sqrt{\text{np}}, \text{np}(1\text{-}2\text{p})$ (B) np, np (C) np, np(1- p) (D) $\sqrt{\text{np}}, \sqrt{\text{np}(1\text{-}\ \text{p})}$

Ans. **C**

Sol. Binomial distribution,

Mean = np

Variance = npq = np (1 – p)

Hence, the correct option is (C).

Question 50

The demand and forecast of an item for 5 months are given in the table.

Month	Demand	Forecast
April	225	200
May	220	240
June	285	300
July	290	270
August	250	230

The Mean Absolute Percent Error (MAPE) in the forecast is _____ %.

Industrial Engineering (Forecasting)

Ans. 8.068

Sol.

Month	D_i Demand	F_i	Error $D_i - F_i$	$\left\lvert\frac{D_i - F_i}{D_i}\right\rvert \times 100$
April	225	200	25	11.1
May	220	240	–20	9.09
June	285	300	–15	5.26
July	290	270	20	6.89
August	250	230	20	8.00
				40.34

Mean absolute percentage error (MAPE)

$$\text{MAPE} = \sum_{i=1}^{n} \frac{\left\lvert\frac{D_i - F_i}{D_i}\right\rvert \times 100}{n} = \frac{40.34}{5}$$

$$\text{MAPE} = 8.068$$

Question 51

A two dimensional flow has velocities in x and y directions given by $u = 2xyt$ and $v = -y^2 t$, where t denotes time. The equation for streamline passing through $x = 1,\ y = 1$ is

Fluid Mechanics (Fluid Kinamatics)

(A) $x^2 y = 1$ (B) $x^2 y^2 = 1$ (C) $xy^2 = 1$ (D) $\frac{x}{y^2} = 1$

Ans. **C**

Sol. **Given :** $u = 2xyt$ and $v = -y^2 t$

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

$$\frac{dx}{2xyt} = \frac{dy}{-y^2 t}$$

$$\frac{dx}{2x} = \frac{dy}{-y}$$

On integrating

$$\frac{1}{2}\ln(x) = -\ln(y) + c$$

At $x = 1$, $y = 1$

$$\frac{1}{2}\ln(1) = -\ln(1) + c$$

$$c = 0$$

$$\frac{\ln x}{2} + \ln y = 0$$

$$\frac{\ln x + 2\ln y}{2} = 0$$

$$\ln xy^2 = \ln 1$$

$$xy^2 = 1$$

Hence, the correct option is (C).

Question 52

Find the positive real root of $x^3 - x - 3 = 0$ using Newton-Raphson method. If the starting guess (x_0) is 2, the numerical value of the root after two iterations (x_2) is _______. (round off to the nearest integer).

Engineering Mathematics

Ans. **1.6736**

Sol. $f(x) = x^3 - x - 3 = 0,$

$$f'(x) = 3x^2 - 1$$

$x_0 = 2,$

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

$$x_1 = 2 - \frac{3}{11} = \frac{19}{11} = 1.7272$$

$$x_2 = x_1 - \frac{f(x_1)}{f'(x_1)}$$

$$x_2 = \frac{19}{11} - \frac{0.42606}{7.94965} = 1.6736$$

Question 53

Consider an ideal vapour compression refrigeration cycle working on R-134a refrigerant. The COP of the cycle is 10 and the refrigeration capacity is 150 kJ/kg. The heat rejected by the refrigerant in the condenser is ______kJ/kg (round off to the nearest integer).

Refrigeration and Air Conditioning (VCRS)

Ans. **165**

Sol. **Given :** $COP = 10,\ RC = 150\ \text{kJ/kg}$

$(Q_R)_{\text{condenser}} = ?$

$$COP = 10 = \frac{RC}{P_{in}}$$

$$10 = \frac{150}{P_{in}}$$

$$P_{in} = 15\ \text{kJ/kg}$$

$$(Q_R)_{\text{condenser}} = RC + P_{in}$$

$$= (150 + 15) = 165\ \text{kJ/kg}$$

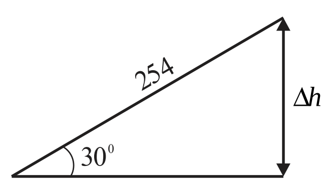
Question 54

A 76.2 mm gauge block is used under one end of a 254 mm sine bar with roll diameter of 25.4 mm. The height of gauge blocks at the other end of the sine bar to measure an angle of 30^0 is ______ mm. (round off to the nearest integer).

Mechanical Measurement and Meterology (Sine Bar)

Ans. **203.2**

Sol.



$$\Delta h = 127\ \text{mm}$$

So block height $= 127 + 76.2 = 203.2\ \text{mm}$

Question 55

If the Laplace transform of a function $f(t)$ is given by $\frac{s+3}{(s+1)(s+2)}$, then $f(0)$ is

Engineering Mathematics

(A) 1 (B) $\frac{3}{2}$ (C) $\frac{1}{2}$ (D) 0

Ans. **A**

Sol. $f(t) = L^{-1}\left[\frac{s+3}{(s+1)(s+2)}\right]$

$$f(t) = L^{-1}\left[\frac{2}{(s+1)} - \frac{1}{(s+2)}\right]$$

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

$$f(0) = 2 - 1 = 1$$

Hence, the correct option is (A).

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