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GATE 2020 SOLUTIONS

AEROSPACE ENGINEERING

GA - General Aptitude

Q1 - Q5 carry one mark each.

Q.No. 1 The untimely loss of life is a cause of serious global concern as thousands of people get killed____accidents every year while many other die____diseases like cardio vascular disease, cancer, etc.

(A) in, of

(B) from, of

(C) during, from

(D) from, from

Ans. A

Q.No. 2 He was not only accused of theft_____of conspiracy.

(A) rather

(B) but also

(C) but even

(D) rather than

Ans. B

Q.No. 3 Select the word that fits the analogy:

Explicit: Implicit :: Express: ______

(A) Impress

(B) Repress

(C) Compress

(D) Suppress

Ans. B

Q.No. 4 The Canadian constitution requires that equal importance be given to English and French. Last year, Air Canada lost a lawsuit, and had to pay a six-figure fine to a French-speaking couple after they filed complaints about formal in-flight announcements in English lasting 15 seconds, as opposed to informal 5 second messages in French.

The French-speaking couple were upset at _____.

(A) the in-flight announcements being made in English.

(B) the English announcements being clearer than the French ones.

(C) the English announcements being longer than the French ones.

(D) equal importance being given to English and French.

Ans. C

Q.No. 5 A superadditive function $f(\cdot)$ satisfies the following property

$$f(x_1 + x_2) \geq f(x_1) + f(x_2)$$

Which of the following functions is a superadditive function for $x > 1$?

(A) e^x

(B) $\sqrt{x}$

(C) $1/x$

(D) e^{-x}

Ans. A

→f(x_1+x_2) ≥ f(x_1) + f(x_2)

By hit and trail (easy) -

Let x_1=2 and x_2=3

(A). $e^{2+3} \geq + e^3$ ....possible

(B). $\sqrt{(2+3)} \geq \sqrt{2} + \sqrt{3}$ ....not possible

(C). 1/ (2+3) ≥ 1/2 +1/3 ....not possible

(D). $e^{-2-3} \geq e^{-2} + e^{-3}$ ....not possible

Q6 - Q10 carry two marks each.

Q.No. 6 The global financial crisis in 2008 is considered to be the most serious world-wide financial crisis, which started with the sub-prime lending crisis in USA in 2007. The sub-prime lending crisis led to the banking crisis in 2008 with the collapse of Lehman Brothers in 2008. The sub-prime lending refers to the provision of loans to those borrowers who may have difficulties in repaying loans, and it arises because of excess liquidity following the East Asian crisis.

Which one of the following sequences shows the correct precedence as per the given passage?

(A) East Asian crisis→ subprime lending crisis →banking crisis→ global financial crisis.

(B) Subprime lending crisis→ global financial crisis→ banking crisis→ East Asian crisis.

(C) Banking crisis→ subprime lending crisis→ global financial crisis → East Asian crisis.

(D) Global financial crisis → East Asian crisis → banking crisis → subprime lending crisis.

Ans. A

Q.No. 7 It is quarter past three in your watch. The angle between the hour hand and the minute hand is ______.

(A) 0°

(B) 7.5°

(C) 15°

(D) 22.5°

Ans. B

Angle covered minute hand per minute = 6° (*Time reference is 12:00 hours*)

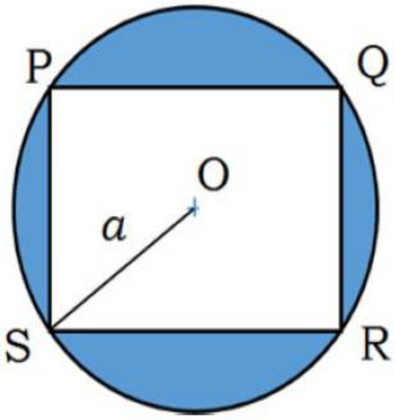
Angle covered by hour hand per minute = 0.5°

At 3:15 ⟹ Minute hand will travel 15 minutes and hence covering = 15x6 =90°

Hour hand could have travelled for 180+15=195 minutes and hence angle covered by hour hand = 0.5 x195 = 97.5°

Angle between 2 hands = 97.5 – 90 = 7.5°

Q.No. 8 A circle with centre O is shown in the figure. A rectangle PQRS of maximum possible area is inscribed in the circle. If the radius of the circle is a, then the area of the shaded portion is _____.



(A) $\pi a^2 - a^2$

(B) $\pi a^2 - \sqrt{2}a^2$

(C) $\pi a^2 - 2a^2$

(D) $\pi a^2 - 3a^2$

Ans. C

→ For maximum possible area in the circle,
Area = $\sqrt{2}a \times \sqrt{2}a = 2a^2$

Required area = $\Pi a^2 - 2a^2$

Q.No. 9 a, b, c are real numbers. The quadratic equation $ax^2 - bx + c = 0$ has equal roots, which is β, then

(A) $\beta = b/a$

(B) $\beta^2 = ac$

(C) $\beta^3 = bc/(2a^2)$

(D) $b^2 \neq 4ac$

Ans. C

ax^2-bx+c = 0

where a, b and c are constants and roots are real and equal.

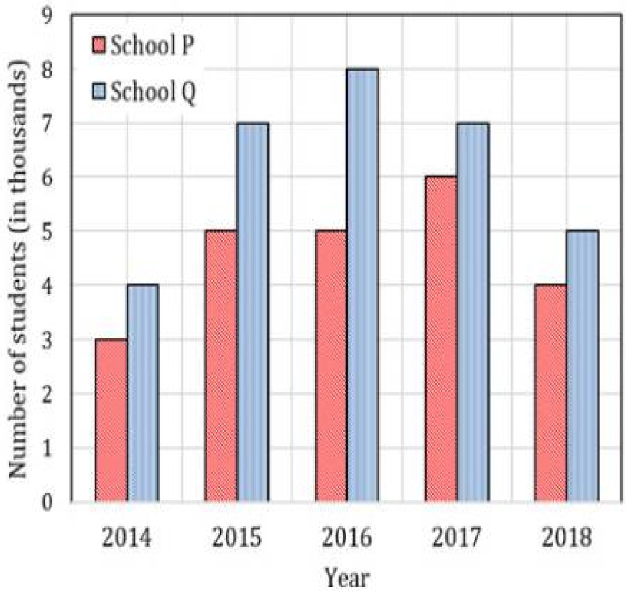
$\alpha+\beta= b/a$ 1

$\alpha\beta = c/a$ 2

And we know $\alpha = \beta$, so by above equation

$\beta^3 = bc/2a^2$

Q.No. 10 The following figure shows the data of students enrolled in 5 years (2014 to 2018) for two schools P and Q. During this period, the ratio of the average number of the students enrolled in school P to the average of the difference of the number of students enrolled in schools P and Q is_____.



(A) 8 : 23

(B) 23 : 8

(C) 23 : 31

(D) 31 : 23

Ans. B

The average no. of students evolved in school p , X = (3+5+5+6+4)/5= 23/5

The average of the difference of the no. of students enrolled in school p and q, Y = (1+2+3+1+1)/5 = 8/5

So, X/Y = 23/8

Q1 - Q25 carry one mark each.

Q.No. 1 For $f(x)=|x|$, with $\frac{df}{dx}$ denoting the derivative, the mean value theorem is not applicable because

(A) $f(x)$ is not continuous at $x=0$

(B) $f(x)=0$ at $x=0$

(C) $\frac{df}{dx}$ is not defined at $x=0$

(D) $\frac{df}{dx}=0$ at $x=0$

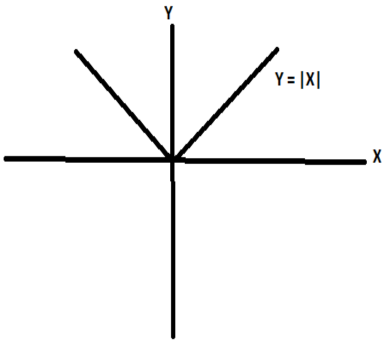
Ans. C

$f(x) = |x|$

$f(x)$ is continuous but $\frac{df(x)}{dx}$ is not defined at

$x = 0$.

$f'(x-h) \neq f'(x+h)$



Q.No. 2 For the function $f(x)=\frac{e^{-\lambda}}{\sigma\sqrt{2\pi}}$, where $\lambda=\frac{1}{2\sigma^2}(x-\mu)^2$, and σ and μ are constants, the maximum occurs at

(A) $x=\sigma$

(B) $x=\sigma\sqrt{2\pi}$

(C) $x=2\sigma^2$

(D) $x=\mu$

Ans. D

f(x) = $\frac{e^{-\lambda}}{\sigma\sqrt{2\pi}}$, λ = $\frac{1}{2\sigma^2}(x-\mu)^2$

→ For maximum, f'(x) = 0

So, x = μ

Q.No. 3 $y = Ae^{mx} + Be^{-mx}$, where A, B and m are constants, is a solution of

(A) $\frac{d^2y}{dx^2} - m^2y = 0$

(B) $A\frac{d^2y}{dx^2} + m^2y = 0$

(C) $B\frac{d^2y}{dx^2} + Ay = 0$

(D) $\frac{d^2y}{dx^2} + my = m^2$

Ans. A

y = Ae^{mx}+Be^{-mx}

∵ A, B and m are constants

Roots = -m, m

D^2-m^2 = 0

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

Q.No. 4 Which of the following statements is true about the effect of increase in temperature on dynamic viscosity of water and air, at room temperature?

(A) It increases for both water and air.

(B) It increases for water and decreases for air.

(C) It decreases for water and increases for air.

(D) It decreases for both water and air.

Ans. C

For water, $\mu = \mu_{\circ} . \frac{1}{1+\alpha T+\beta T^2}$

So, when T increases → Cohesion decreases → μ decreases.

For air, $\mu = \mu_{\circ} + \alpha T - \beta T^2$

So, when T increases → μ increases.

Q.No. 5 Given access to the complete geometry, surface pressure and shear stress distribution over a body placed in a uniform flow, one can estimate

(A) the moment coefficient, and the force on the body.

(B) the force coefficient, and the force on the body.

(C) the moment coefficient, and the moment on the body.

(D) the force and the moment on the body.

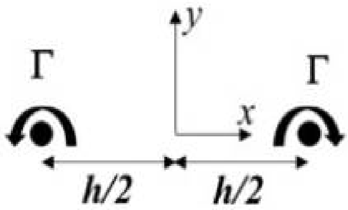
Ans. D

No matter how complex is the geometry of the body, the aerodynamic forces and moments acting on the surface of the body moving in the fluid are entirely due to pressure and shear. Hence the net effect of pressure and shear stress integrated over a complete body gives resultant aerodynamic force and moment acting on the body.

To calculate coefficients we need extra information regarding freestream velocity and density of the fluid. Hence **Options A, B and C** are omitted and only **Option D** is right.

Note: - Refer *Introduction to aerodynamics by John D Anderson chapter 1 section 5* for the derivation of these forces and moments due to pressure and shear acting on the body moving in the fluid.

Q.No. 6 A pair of infinitely long, counter-rotating line vortices of the same circulation strength Γ are situated a distance h apart in a fluid, as shown in the figure. The vortices will



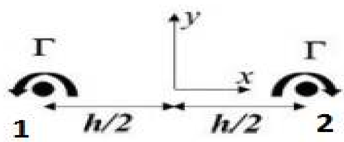
(A) rotate counter-clockwise about the midpoint with the tangential velocity at the line vortex equal to $\dfrac{\Gamma}{2\pi h}$

(B) rotate counter-clockwise about the midpoint with the tangential velocity at the line vortex equal to $\dfrac{\Gamma}{4\pi h}$

(C) translate along $+y$ direction with velocity at the line vortex equal to $\dfrac{\Gamma}{2\pi h}$

(D) translate along $+y$ direction with velocity at the line vortex equal to $\dfrac{\Gamma}{4\pi h}$

Ans. C

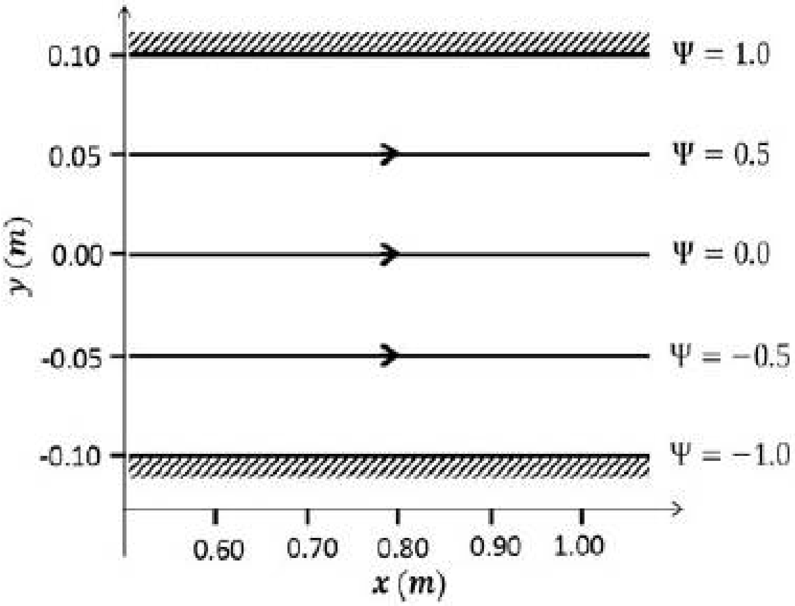


Velocity of (2) at (1), $V = \frac{\Gamma}{4\Pi h}$

Velocity of (1) at (2), $V = \frac{\Gamma}{4\Pi h}$

So finally vortex will be translate along +Y direction with velocity at the line vortex equal to $\frac{\Gamma}{2\Pi h}$.

Q.No. 7 The streamlines of a steady two dimensional flow through a channel of height 0.2 m are plotted in the figure, where Ψ is the stream function in m^2/s. The volumetric flow rate per unit depth is



(A) $1.0\ m^2/s$
(B) $2.0\ m^2/s$
(C) $0.5\ m^2/s$
(D) $0.1\ m^2/s$

Ans. B

The volumetric flow rate per unit depth

$Q = \psi_2 - \psi_1$

$= 1 - (-1) = 2\ m^2/s$

Q.No. 8 Which of the following options can result in an increase in the Mach number of a supersonic flow in a duct?

(A) Increasing the length of the duct

(B) Adding heat to the flow

(C) Removing heat from the flow

(D) Inserting a convergent-divergent section with the same cross-sectional area at its inlet and exit planes

Ans. C

Hint: Raleigh flow

Q.No. 9 Which one of the following conditions needs to be satisfied for $\phi = Ax^4 + By^4 + Cxy^3$ to be considered as an Airy's stress function?

(A) $A - B = 0$

(B) $A + B = 0$

(C) $A - C = 0$

(D) $A + C = 0$

Ans. B

Airy's stress function,

$\emptyset = Ax^4 + By^4 + Cxy^3$

$\sigma_x = \frac{\partial^2\emptyset}{\partial y^2}$, $\sigma_y = \frac{\partial^2\emptyset}{\partial x^2}$, $\tau_{xy} = -\frac{\partial^2\emptyset}{\partial x\partial y}$

$\because \nabla^2(\sigma_x + \sigma_y) = 0$

$\therefore \frac{\partial^4\emptyset}{\partial x^4} + 2\frac{\partial^4\emptyset}{\partial x^2\partial y^2} + \frac{\partial^4\emptyset}{\partial y^4} = 0$

So, A + B = 0

Q.No. 10 Consider the plane strain field given by $\varepsilon_{xx} = Ay^2 + x$, $\varepsilon_{yy} = Ax^2 + y$, $\gamma_{xy} = Bxy + y$. The relation between A and B needed for this strain field to satisfy the compatibility condition is

(A) $B = A$
(B) $B = 2A$
(C) $B = 3A$
(D) $B = 4A$

Ans. D

For Plan strain field,

ε_{xx} = Ay^2 + x

ε_{yy} = Ax^2 + y

γ_{xy} = Bxy + y

Compatibility condition

$$\frac{\partial^2 \gamma_{xy}}{\partial x \partial y} = \frac{\partial^2 \varepsilon_y}{\partial^2 x} + \frac{\partial^2 \varepsilon_x}{\partial^2 y}$$

So, B = 4A

Q.No. 11 For hyperbolic trajectory of a satellite of mass m having velocity V at a distance r from the center of earth (G: gravitational constant, M: mass of earth), which one of the following relations is true?

(A) $\frac{1}{2}mV^2 > \frac{GMm}{r}$

(B) $\frac{1}{2}mV^2 < \frac{GMm}{r}$

(C) $\frac{1}{2}mV^2 = \frac{GMm}{r}$

(D) $\frac{1}{2}mV^2 < \frac{2GMm}{r}$

Ans. A

For hyperbolic trajectory, $e > 1$

Orbital energy, β = T + Ø

$$\beta = \frac{1}{2}mv^2 - \frac{GMm}{r}$$

$$e = \sqrt{1 + \frac{2h^2\beta}{mr^2}}, \quad \text{Here } \beta \text{ is positive}$$

$$\frac{1}{2}mv^2 > \frac{GMm}{r}$$

Q.No. 12 For conventional airplanes, which one of the following is true regarding roll control derivative $\left(C_{l\delta_r} = \frac{\partial C_l}{\partial \delta_r}\right)$ and yaw control derivative $\left(C_{n\delta_r} = \frac{\partial C_n}{\partial \delta_r}\right)$, where δ_r is rudder deflection?

(A) $C_{l\delta_r} > 0$ and $C_{n\delta_r} < 0$

(B) $C_{l\delta_r} < 0$ and $C_{n\delta_r} > 0$

(C) $C_{l\delta_r} < 0$ and $C_{n\delta_r} < 0$

(D) $C_{l\delta_r} > 0$ and $C_{n\delta_r} > 0$

Ans. A

For positive δr, yawing moment will be negative.

$$Cn_{\delta r} < 0$$

For positive δr, rolling moment will be positive.

$$C_{l\delta r} > 0$$

Q.No. 13 The ratio of exit stagnation pressure to inlet stagnation pressure across the rotating impeller of a centrifugal compressor, operating with a closed exit, is

(A) 0

(B) 1

(C) > 1

(D) 0.5

Ans. C

→ Stagnation pressure is always increases across the impeller of a centrifugal compressor.

Q.No. 14 Which one of the following is a hypergolic propellant combination used in rocket engines?

(A) Liquid hydrogen – liquid oxygen
(B) Unsymmetrical dimethyl hydrazine – nitrogen tetroxide
(C) Rocket fuel RP-1 – liquid oxygen
(D) Liquid hydrogen – liquid fluorine

Ans. B

Q.No. 15 In aircraft engine thermodynamic cycle analysis, *perfectly expanded flow* in the nozzle means that the static pressure in the flow at the nozzle exit is equal to

(A) the stagnation pressure at the engine inlet.
(B) the stagnation pressure at the nozzle exit.
(C) the ambient pressure at the nozzle exit.
(D) the static pressure at the nozzle inlet.

Ans. C

We have total thrust equation from the thermodynamic cycle analysis of aircraft engine as given below

$$F = \dot{m}_a[(1+f)c_j - c_i] + (p_e - p_a)A_e$$

For the optimum expansion entire thrust is from the nozzle expansion and there will be no pressure thrust, hence only condition to obtain this thrust is omitting pressure thrust.

i.e.

$$(p_e - p_a)A_e = 0$$

This gives

$$p_e = p_a$$

Exit pressure of the nozzle is same as ambient pressure. **(Option C)**

Q. No. 16 Three long and slender aluminum bars of identical length are subjected to an axial tensile force. These bars have circular, triangular and rectangular cross sections, with same cross sectional area. If they yield at F_{circle}, $F_{triangle}$ and $F_{rectangle}$, respectively, which one of the following is true?

(A) $F_{circle} > F_{triangle} > F_{rectangle}$

(B) $F_{circle} < F_{triangle} < F_{rectangle}$

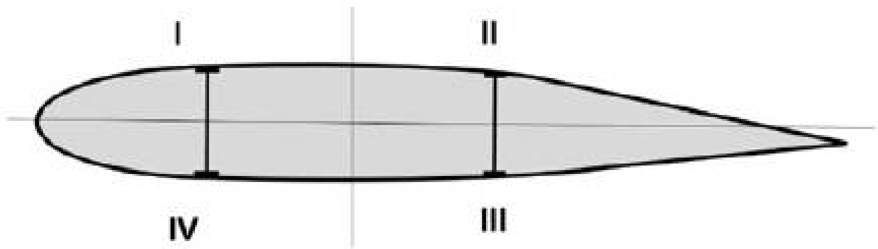
(C) $F_{triangle} > F_{circle} > F_{rectangle}$

(D) $F_{circle} = F_{triangle} = F_{rectangle}$

Ans. D

The yield stress does not depend on length or cross section.

Q.No. 17 The positive high angle-of-attack condition is obtained in a steady pull-out maneuver at the largest permissible angle-of-attack of the wing. Under this condition, at which of the following regions of the wing does the maximum tension occur?



(A) I

(B) II

(C) III

(D) IV

Ans. C

Aerodynamics loads passes through aerodynamic center which lies at ¼ of chord length for symmetrical aerofoil and for steady pullout at largest angle of attack, lift is upward.

At location III moments created by Lift will be highest and on bottom there will tension.

Q.No. 18 The natural frequency of the first mode of a rectangular cross section cantilever aluminum beam is ω rad/s. If the material and cross-section remain the same, but the length of the beam is doubled, the first mode frequency will become

(A) $\frac{\omega}{4}$ rad/s

(B) 4ω rad/s

(C) $\frac{\omega}{16}$ rad/s

(D) 16ω rad/s

Ans. A

Natural frequency, $\omega = \frac{\pi^2}{L^2}\sqrt{\frac{EI}{\rho A}}$

$$\rightarrow \omega \propto \frac{1}{L^2}$$

$\rightarrow So, \omega_{new}=\omega/4$

Q.No. 19 Given $A = \begin{pmatrix} \sin\theta & \tan\theta \\ 0 & \cos\theta \end{pmatrix}$, the sum of squares of eigenvalues of A is

(A) $\tan^2\theta$

(B) 1

(C) $\sin^2\theta$

(D) $\cos^2\theta$

Ans. B

A = $\begin{bmatrix} \sin\theta & \tan\theta \\ 0 & \cos\theta \end{bmatrix}$

$\lambda_1 + \lambda_2 = \sin\theta + \cos\theta$

$\lambda_1.\lambda_2 = \sin\theta \, . \cos\theta$

$\rightarrow {\lambda_1}^2 + {\lambda_2}^2 = (\lambda_1 + \lambda_2)^2 - 2\lambda_1.\lambda_2 = 1$

Q.No. 20 Burnout velocity of a space vehicle in a circular orbit at an angle 5 degrees above the local horizon around earth is 13.5 km/s. Tangential velocity of the space vehicle in the orbit is ______ km/s (*round off to two decimal places*).

Ans. 13.45 km/s

V_{Burnout} = 13.5 Km/s; theta = 5 degrees

$V_{\text{Tangential}} = V_{\text{Burnout}} \times \cos\theta = 13.5 \times \cos 5 = 13.45$ Km/s

Q.No. 21 Velocity of an airplane in the body fixed axes is given as [100 -10 20] m/s. The sideslip angle is ______ degrees (*round off to two decimal places*).

Ans. $-5.56°$

$$\rightarrow [u \quad v \quad w] \equiv [100 \quad -10 \quad 20]$$

$$V = \sqrt{(u^2 + v^2 + w^2)} = 102.46 \text{ m/s}$$

$v = V\sin\beta$

$\beta = -5.56°$

Q.No. 22 The similarity solution for the diffusion equation, $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$ is $u(x, t) = u(\eta)$, where similarity variable, $\eta = \frac{x}{\sqrt{\alpha t}}$. If $u(x, 0) = e^{-x^2}$, the ratio $\frac{u(0,1)}{u(0,4)}$ = ______ (*round off to one decimal place*).

Ans. 2

Reference for similarity solutions to diffusion equation can be found in

1) Incompressible flow by R.L Panton
2) Fluid mechanics by Pijush K Kundu and M.Cohen

Q.No. 23 Air enters the rotor of an axial compressor stage with no pre-whirl ($C_\theta = 0$) and exits the rotor with whirl velocity, $C_\theta = 150$ m/s. The velocity of rotor vanes, U is 200 m/s. Assuming $C_p = 1005$ J/(kg K), the stagnation temperature rise across the rotor is ______ K (*round off to one decimal place*).

Ans. 29.85 K

$Ct_1 = 0$, $Ct_2 = 150$ m/s, U = 200 m/s

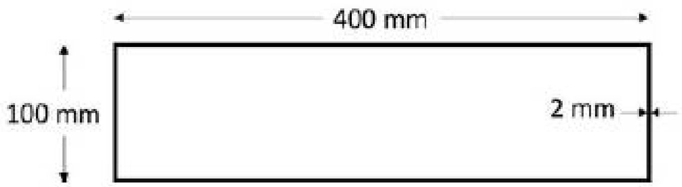
W = U. [Ct_2 - Ct_1] = 200*150 J/kg

$\because \Delta h = W$

Cp.ΔT = W = 200*150

$\Delta T = \frac{200*150}{1005}$ = 29.85 K

Q.No. 24 A thin walled beam of constant thickness shown in the figure is subjected to a torque of 3.2 kNm. If the shear modulus is 25 GPa, the angle of twist per unit length is ______ rad/m (*round off to three decimal places*).



Ans. 0.01 rad/m

T = 3.2 kN-m, G = 25GPa

$\because \frac{T}{J} = \frac{G\theta}{l} = \frac{\tau}{R}$

$\because$ J = $\frac{4A_m^2}{\int \frac{ds}{t}}$ (for a closed section)

J = 0.0128X10^{-3}

$\frac{\theta}{l} = \frac{T}{JG}$ = 0.01 rad/m

Q.No. 25 An airplane of mass 5000 kg is flying at a constant speed of 360 km/h at the bottom of a vertical circle with a radius of 400 m, as shown in the figure. Assuming that the acceleration due to gravity is 9.8 m/s^2, the load factor experienced at the center of gravity of the airplane is _________ (*round off to two decimal places*).

Ans. 3.55

m = 5000 kg, v = 360 km/h = 100m/s

R = 400 m

$\because$ R = $\frac{V^2}{g(n-1)}$

So, n = 3.55

Q26 - Q55 carry two marks each.

Q.No. 26 The equation $x\frac{dx}{dy} + y = c$, where c is a constant, represents a family of

(A) exponential curves

(B) parabolas

(C) circles

(D) hyperbolas

Ans. C

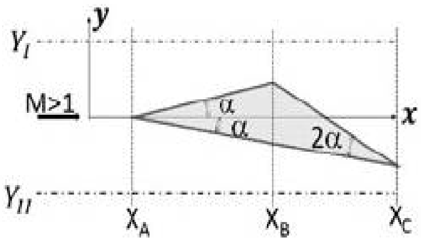
$x\frac{dx}{dy}$ + y = c

xdx +(y-c)dy = 0

$\frac{x^2}{2} + \frac{(y-c)^2}{2} = k$

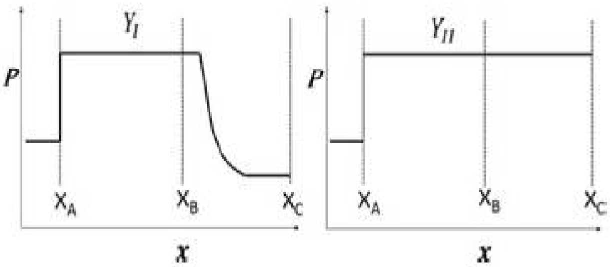
$x^2 + (y - c)^2 = k \quad \rightarrow$ Circle

Q.No. 27 A wedge shaped airfoil is placed in a supersonic flow as shown in the figure (not to scale). The corners of the wedge are at $x = x_A$, $x = x_B$, $x = x_C$, respectively.

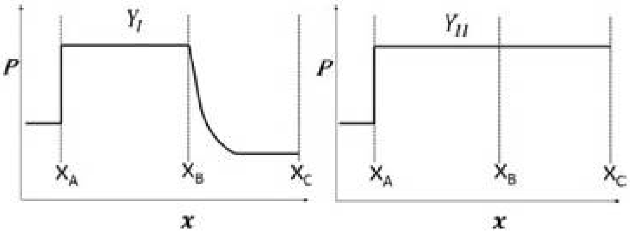


Which one of the following represents the correct static pressure profiles along $y = Y_I$ and $y = Y_{II}$?

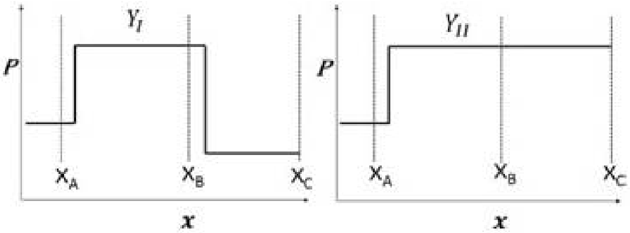
(A)



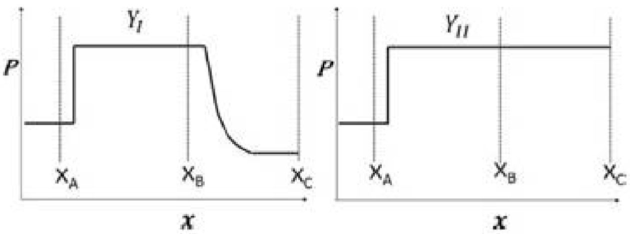
(B)



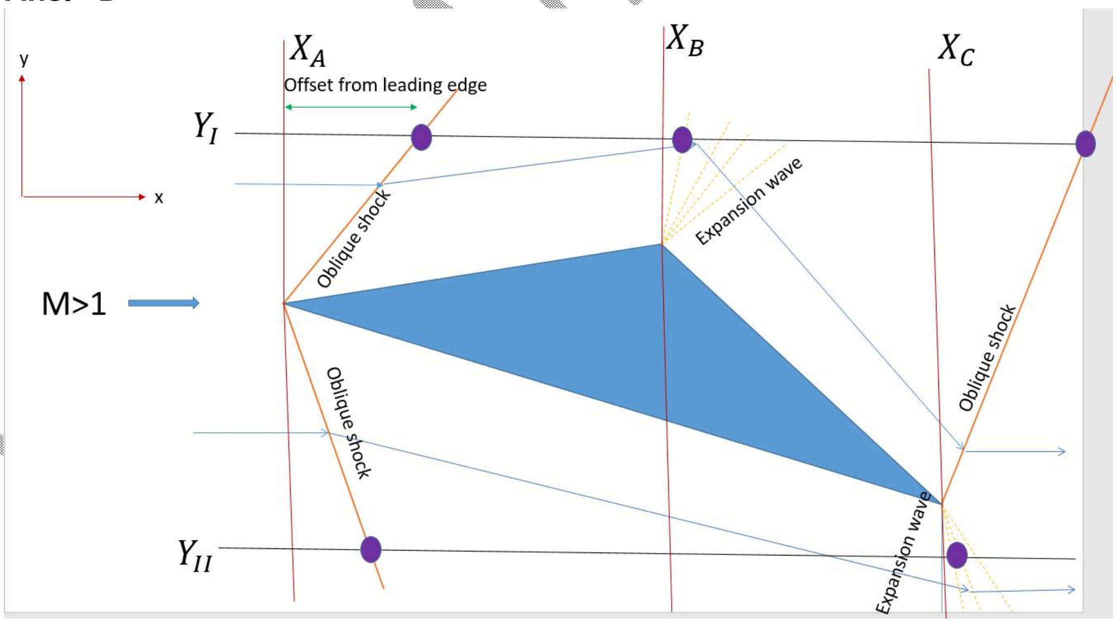
(C)



(D)



Ans. D



From the detailed figure given above, it is clear that intersection points for Y_I and Y_{II} lines are little offset from points X_A , X_B &X_C, also flow direction changes only after encountering the shock wave, then remains parallel to the wall. Hence **option A** and

option B are straight away omitted. We know that across oblique shock wave static pressure increases and stagnation pressure decreases. Whereas in expansion waves stagnation properties unchanged but static pressure decreases in gradual manner (Note: - this is not sharp change in Prandtl Mayer expansion fan).

Now **option C** also omitted because it doesn't satisfy gradual change across expansion wave. So only option satisfies both physics as well as geometry of the flow is **Option D**.

Q.No. 28 The value of Poisson's ratio at which the shear modulus of an isotropic material is equal to the bulk modulus is

(A) $\frac{1}{2}$

(B) $\frac{1}{4}$

(C) $\frac{1}{6}$

(D) $\frac{1}{8}$

Ans. D

$K = E/3(1-2\mu)$, $G = E/2(1+\mu)$

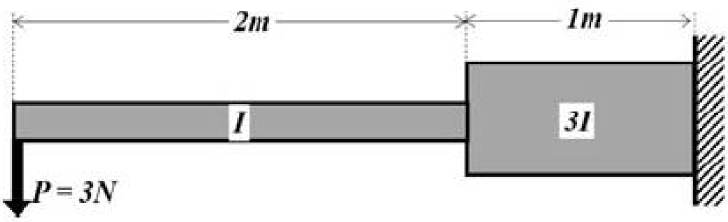
$\rightarrow K = G$ (Given)

$3(1-2\mu) = 2(1+\mu)$

$3 - 6.\mu = 2 + 2.\mu$

$\mu = 1/8$

Q.No. 29 A load P is applied to the free end of a stepped cantilever beam as shown in the figure. The Young's modulus of the material is E, and the moments of inertia of the two sections of length 2 m and 1 m are I and $3I$, respectively. Ignoring transverse shear and stress concentration effects, the deflection at the point where the load is applied at the free end of the cantilever is



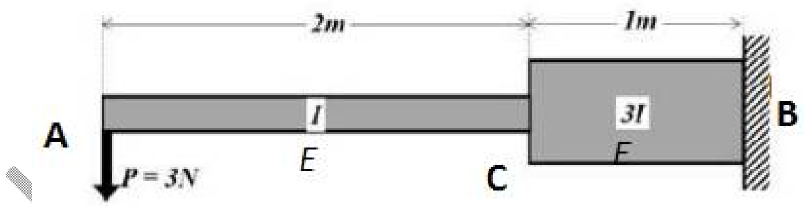
(A) $\frac{23}{243EI}$

(B) $\frac{1}{3EI}$

(C) $\frac{43}{3EI}$

(D) $\frac{23}{3EI}$

Ans. C



→ Part AC, here BC is rigid

$$\delta_1 = \frac{WL^3}{3EI} = \frac{3 .2^3}{3EI} = \frac{24}{3EI}$$

→ Part BC, Here at point C is load of N and moment of 3×2 N-m due to AC bar.

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$\delta_C = \frac{3\,.1^3}{3E.3I} + \frac{3.2.1^2}{2E.3I} = \frac{4}{3EI}$

$\theta_C = \frac{3\,.1^2}{2E.3I} + \frac{3\,.2.1}{E.3I} = \frac{5}{2EI}$

$\rightarrow \delta_2 = \delta_C + \theta_C.2$

$= \frac{4}{3EI} + \frac{5}{2EI} = \frac{19}{3EI}$

$\rightarrow \delta_A = \delta_1 + \delta_2$

$= \frac{24}{3EI} + \frac{19}{3EI} = \frac{43}{3EI}$

Q.No. 30 The three dimensional strain-stress relation for an isotropic material, written in a general matrix form, is

$$\begin{Bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \varepsilon_{zz} \\ \gamma_{yz} \\ \gamma_{xz} \\ \gamma_{xy} \end{Bmatrix} = \begin{bmatrix} A & C & C & 0 & 0 & 0 \\ C & A & C & 0 & 0 & 0 \\ C & C & A & 0 & 0 & 0 \\ 0 & 0 & 0 & B & 0 & 0 \\ 0 & 0 & 0 & 0 & B & 0 \\ 0 & 0 & 0 & 0 & 0 & B \end{bmatrix} \begin{Bmatrix} \sigma_{xx} \\ \sigma_{yy} \\ \sigma_{zz} \\ \tau_{yz} \\ \tau_{xz} \\ \tau_{xy} \end{Bmatrix}$$

A, B and C are compliances which depend on the elastic properties of the material. Which one of the following is correct?

(A) $C = \frac{A}{2} - B$

(B) $C = \frac{A}{2} + B$

(C) $C = A + \frac{B}{2}$

(D) $C = A - \frac{B}{2}$

Ans. D

ISOTROPIC LINEAR ELASTIC MATERIALS

$$\begin{bmatrix} \epsilon_{11} \\ \epsilon_{22} \\ \epsilon_{33} \\ 2\epsilon_{23} \\ 2\epsilon_{13} \\ 2\epsilon_{12} \end{bmatrix} = \frac{1}{E} \begin{bmatrix} 1 & -\nu & -\nu & 0 & 0 & 0 \\ & 1 & -\nu & 0 & 0 & 0 \\ & & 1 & 0 & 0 & 0 \\ & & & 2(1+\nu) & 0 & 0 \\ & symm & & & 2(1+\nu) & 0 \\ & & & & & 2(1+\nu) \end{bmatrix} \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \sigma_{23} \\ \sigma_{13} \\ \sigma_{12} \end{bmatrix}$$

$\rightarrow \gamma_{ij} = 2\epsilon_{ij}$

So, A = 1

B = 2(1+υ)

C = -υ

$\Rightarrow$ C = A - $\frac{B}{2}$

Q.No. 31 For three different airplanes A, B and C, the yawing moment coefficient (C_n) was measured in a wind-tunnel for three settings of sideslip angle β and tabulated as

	Airplane A	Airplane B	Airplane C
$\beta = -5$ deg	-0.030	-0.025	0.040
$\beta = 0$ deg	0	0	0
$\beta = 5$ deg	0.030	0.025	-0.040

Which one of the following statements is true regarding directional static stability of the airplanes A, B and C?

(A) All three airplanes A, B, and C are stable.

(B) Only airplane C is stable, while both A and B are unstable.

(C) Airplane C is unstable, A and B are stable with A being more stable than B.

(D) Airplane C is unstable, A and B are both stable with A less stable than B.

Ans. C

For directional static stability, $\frac{dC_n}{d\beta} > 0$

a/p	A	B	C
Yawing moment	$\frac{dC_n}{d\beta} > 0$ (stable)	$\frac{dC_n}{d\beta} > 0$ (stable)	$\frac{dC_n}{d\beta} < 0$ (unstable)

Aero plane **A** is more stable than aero plane **B.**

Q.No. 32 A closed curve is expressed in parametric form as $x = a\cos\theta$ and $y = b\sin\theta$, where $a = 7$ m and $b = 5$ m. Approximating $\pi = \frac{22}{7}$, which of the following is the area enclosed by the curve?

(A) 110 m^2
(B) 74 m^2
(C) 35 m^2
(D) 144 m^2

Ans. A

x= a cos θ , y = b sin θ

a = 7m, b = 5m, π = 22/7

$\rightarrow \sin\theta^2 + \cos\theta^2 = \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \rightarrow$ ellipse

Area = $\pi ab = \frac{22}{7} \times 7 \times 5 = 110$ m^2

Q.No. 33 An axial compressor is designed to operate at a rotor speed of 15000 rpm and an inlet stagnation temperature of 300 K. During compressor testing, the inlet stagnation temperature of the compressor measured was 280 K. What should be the rotor speed for the compressor to develop the same performance characteristics during this test as in the design condition?

(A) 14000 rpm

(B) 14491 rpm

(C) 15526 rpm

(D) 16071 rpm

Ans. B

$$\frac{N}{\sqrt{T_{01}/T_{ref}}} = \text{Const.}$$

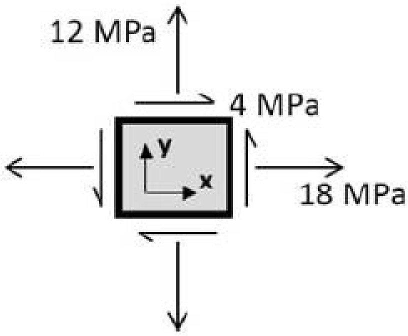
$\rightarrow$ V $\propto$ N

$$\rightarrow N \propto \sqrt{T_{01}/T_{ref}}$$

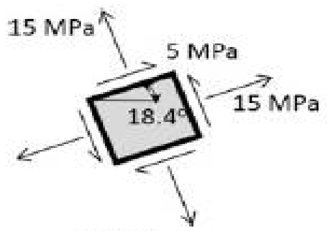
$$\rightarrow \frac{N_2}{N_1} = \frac{\sqrt{T_{02}/T_{ref}}}{\sqrt{T_{01}/T_{ref}}} = \sqrt{\frac{T_{02}}{T_{01}}}$$

So, N_2 = 14491 rpm

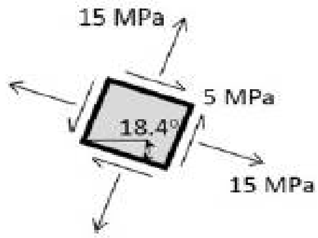
Q.No. 34 For the state of stress shown in the figure, which one of the following represents the correct free body diagram showing the maximum shear stress and the associated normal stresses?



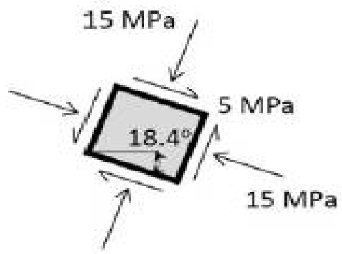
(A)



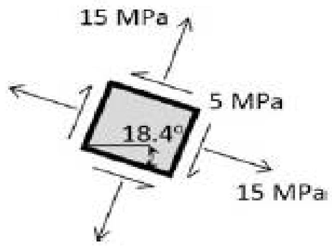
(B)



(C)



(D)



Ans. B

σ_x = 18 MPa, σ_y = 12MPa, τ = 4 MPa

$\rightarrow \sigma_{n1} = \frac{\sigma_x+\sigma_y}{2} + \frac{\sigma_x-\sigma_y}{2}.\cos 2\theta + \tau \sin 2\theta$ .... (1)

$\rightarrow \sigma_t = -\frac{\sigma_x-\sigma_y}{2}.\sin 2\theta + \tau \cos 2\theta$ .... (2)

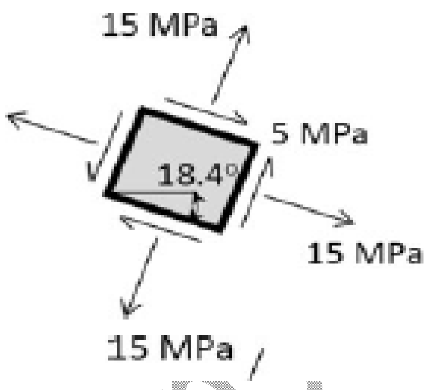
$\rightarrow \sigma_x + \sigma_y = \sigma_{n1} + \sigma_{n2}$ .... (3)

For Maximum shear stress, by eq. (2)

$\tan 2\theta_s = -\frac{\sigma_x-\sigma_y}{2\tau} = -\frac{18-12}{2*4}$

θ_s = - 18.43°

So σ_{n1}= 15 MPa, σ_{n2}= 15 MPa and σ_t= 5 MPa



Q.No. 35

In the equation $AX = B$, $A = \begin{bmatrix} \frac{1}{\sqrt{2}} & 0 & \frac{1}{\sqrt{2}} \\ 0 & 1 & 0 \\ \frac{1}{\sqrt{2}} & 0 & \frac{-1}{\sqrt{2}} \end{bmatrix}$, $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \\ -\sqrt{2} \end{bmatrix}$, where A is an orthogonal matrix, the sum of the unknowns, $x+y+z =$_____ (*round off to one decimal place*).

Ans. 1

AX = B

$$\begin{bmatrix} 1/\sqrt{2} & 0 & 1/\sqrt{2} \\ 0 & 1 & 0 \\ 1/\sqrt{2} & 0 & -1/\sqrt{2} \end{bmatrix} . \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ -\sqrt{2} \end{bmatrix}$$

So,

x = -z .... (1)

y = 1 .... (2)

x – z = -2 .... (3)

By above three equations,

x = 1, y = and z = -1

→ x + y + z = 1

Q.No. 36 If $\int_0^1 (x^2 - 2x + 1)\,dx$ is evaluated numerically using trapezoidal rule with four intervals, the difference between the numerically evaluated value and the analytical value of the integral is equal to ______ (*round off to three decimal places*).

Ans. 0.0104

→ Analytical method,

$\int_0^1 (x^2 - 2x + 1)\,dx = \left(\frac{x^3}{3} - 2.\frac{x^2}{2} + x\right)_0^1 = \frac{1}{3} = 0.33$

→ Numerically trapezoidal method,

f(x) = $x^2 - 2x + 1$

h = $\frac{1-0}{4}$ = 0.25

	y_0	y_1	y_2	y_3	y_4

x	0	0.25	0.5	0.75	1
f(x)	1	0.5625	0.25	0.065	0

$\int_0^1 (x^2 - 2x + 1)\, dx = \frac{h}{2}[(y_0 + y_4) + 2.(y_1 + y_2 + y_3)] = 0.3437$

→ Numerical – Analytical = 0.0104

Q.No. 37 The table shows the lift characteristics of an airfoil at low speeds. The maximum lift coefficient occurs at 16 degrees.

Angle of attack α (in degrees)	Lift coefficient C_l
0	0.10
4	0.53

Using Prandtl-Glauert rule, the lift coefficient for the airfoil at the angle of attack of 6 degrees and free stream Mach number of 0.6 is _____ (*round off to two decimal places*).

Ans. 0.93125

$\rightarrow C_L = (\frac{\partial C_L}{\partial \alpha}).\alpha. + C_{L0}$

$\because \frac{\partial C_L}{\partial \alpha} = 0.01075$

$C_L = 0.01075 \times \alpha + 0.1$

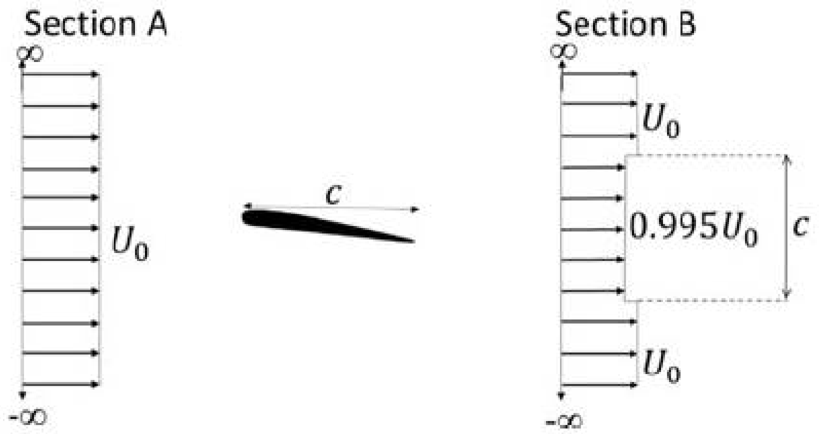
At $\alpha = 6^\circ$

$C_L = 0.01075 \times 6 + 0.1 = 0.745$

C_L at compressible flow(M = 0.6),

$C_{Lm} = \frac{C_{L,incompressibe}}{\sqrt{1-M^2}} = \frac{0.745}{\sqrt{1-0.6^2}} = 0.93125$

Q.No. 38 A low speed uniform flow U_o is incident on an airfoil of chord c. In the figure, the velocity profile some distance downstream of the airfoil is idealized as shown for section B. The static pressure at sections A and B is the same. The drag coefficient of the airfoil is _________ (*round off to three decimal places*).



Ans. 0.00997

The static pressure is same at section A and B. $(0.995U_0)^2$

So, Δp = 0

→ Drag = $momentum$|inlet - $momentum$|outlet

D = $\rho A U_0^2 - [\rho(A - C)U_\infty^2 + \rho C(0.995U_0)^2]$

= $0.0099\rho c U_0^2$

$C_D = \frac{D}{\frac{1}{2}\rho U_0^2 C} = 0.00997$

Q.No. 39 An oblique shock is inclined at an angle of 35 degrees to the upstream flow of velocity 517.56 m/s. The deflection of the flow due to this shock is 5.75 degrees and the temperature downstream is 182.46 K. Assume the gas constant $R = 287$ J/(kg K), specific heat ratio $\gamma = 1.4$, and specific heat at constant pressure $C_p = 1005$ J/(kg K). Using conservation relations, the Mach number of the upstream flow can be obtained as ______ (*round off to one decimal place*).

Ans. 2

$\theta = 5.75°$

$\emptyset = 35°$

$\rightarrow \tan\theta = 2\cot\beta\left(\frac{M_1^2 .\sin\beta^2 - 1}{M_1^2(\gamma + \cos 2\beta) + 2}\right)$

$0.1 = 2 \times 1.428\left(\frac{M_1^2 \times 0.33 - 1}{M_1^2(0.342 + 2) + 2}\right)$

$M_1 = 2$

Q.No. 40 The thickness of a laminar boundary layer (δ) over a flat plate is, $\frac{\delta}{x} = \frac{5.2}{\sqrt{Re_x}}$, where x is measured from the leading edge along the length of the plate. The velocity profile within the boundary layer is idealized as varying linearly with y. For freestream velocity of 3 m/s and kinematic viscosity of 1.5×10^{-5} m^2/s, the displacement thickness at 0.5 m from the leading edge is ____________ mm (*round off to two decimal places*).

Ans. 4.11 mm

$\rightarrow \frac{u}{u_\infty} = \frac{y}{\delta}$ (linear velocity profile)

$\delta^* = \int_0^\delta (1 - \frac{u}{u_\infty}).dy$

$= \left[y - \frac{y^2}{2.\delta}\right]_0^\delta$

$= \delta - \frac{\delta}{2} = \frac{\delta}{2}$

$\rightarrow \delta^* = \frac{5.2\,x}{2\sqrt{Re_x}}$

$\delta^*|$ At x=0.5 = $\frac{2.6\times0.5}{\sqrt{\frac{3\times0.5}{1.5\times10^{-5}}}}$ = 4.11

Q.No. 41 A wing of 15 m span with elliptic lift distribution is generating a lift of 80 kN at a speed of 90 m/s. The density of surrounding air is 1.2 kg/m^3. The induced angle of attack at this condition is ________ degrees (*round off to two decimal places*).

Ans. 1.33°

b = 15m, e = 1, L = 80 KN, V_∞ = 90 m/s, ρ = 1.2 Kg/m^3

$\rightarrow L_e = \rho_\infty.V_\infty.\Gamma_0.\frac{b}{4}.\pi$

80x1000 = 1.2x90xΓ_0x$\frac{15}{4}$.xπ

Γ_0 = 62.87 m^2/s

$\alpha_{ie} = \frac{\Gamma_0}{2bV_\infty} = \frac{62.87}{2x15x90}$ = 0.02328 rad = 0.02328*57.3 = 1.33°

Q.No. 42 A solid circular shaft, made of ductile material with yield stress σ_Y = 280 MPa, is subjected to a torque of 10 kNm. Using the Tresca failure theory, the smallest radius of the shaft to avoid failure is ______ cm (*round off to two decimal places*).

Ans. 3.56 cm

σ_y = 280 MPa, T = 10 KN-m

$\tau_{max1} = \frac{\sigma_y - 0}{2}$ = 140 MPa

$\tau_{max} = \frac{16.T}{\pi d^3} = \tau_{max1}$ (Tresca –failure theory)

d = $\left(\frac{16.T}{\pi \tau_{max1}{}^3}\right)^{\frac{1}{3}}$ = 71.38 mm

r = d/2 = 35.67 mm = 3.56 cm

Q.No. 43 The ratio of tangential velocities of a planet at the perihelion and the aphelion from the sun is 1.0339. Assuming that the planet's orbit around the sun is planar and elliptic, the value of eccentricity of the orbit is ____________ (*round off to three decimal places*).

Ans. 0.017

$V_p = \sqrt{\frac{\mu(1+e)}{a(1-e)}}$, $V_a = \sqrt{\frac{\mu(1-e)}{a(1+e)}}$

$\rightarrow \frac{V_p}{V_a} = \frac{1+e}{1-e}$ = 1.0339

$\rightarrow$ e = 0.01

Q.No. 44 The eigenvalues for phugoid mode of a general aviation airplane at a stable cruise flight condition at low angle of attack are $\lambda_{1,2} = -0.02 \pm i\,0.25$. If the acceleration due to gravity is 9.8 m/s^2, the equilibrium speed of the airplane is ________ m/s (*round off to two decimal places*).

Ans. 55.33 m/s

Phugoid mode,

$\lambda_{1,2}$ = -0.02 ± I 0.25

$\rightarrow \omega_p = \sqrt{2}\,.\frac{g}{V_0}$

$s^2 - (\lambda_1 + \lambda_2).S + \lambda_1.\lambda_2 = 0$

$s^2 + 0.04\,S + (0.02^2 + 0.25^2) = 0$

$s^2 + 0.04S + 0.0629 = 0$

$\omega_p = \sqrt{0.0629} = 0.2507$

$V_0 = \sqrt{2}.\,.\frac{g}{\omega_p} = 55.33$ m/s

Q.No. 45 For a general aviation airplane with tail efficiency $\eta = 0.95$, horizontal tail volume ratio $V_H = 0.453$, downwash angle slope $\frac{d\varepsilon}{d\alpha} = 0.35$, wing lift curve slope $C^w_{L\alpha} = 4.8$ rad^{-1}, horizontal tail lift curve slope $C^t_{L\alpha} = 4.4$ rad^{-1}, shift in neutral point location as a percentage of mean aerodynamic chord is _____ (*round off to two decimal places*).

Ans. 25.64 %

η = 0.95, V_H= 0.453, $\frac{d\varepsilon}{d\alpha}$ = 0.35,

$C_{L\alpha_w}$ = 4.8 rad^{-1} =a_w , $C_{L\alpha_t}$ = 4.4 rad^{-1} = a_t

$\rightarrow \frac{X_{NP}}{C_w} = \frac{X_{ac}}{C_w} + \frac{a_t}{a_w} . (1 - \frac{d\varepsilon}{d\alpha}).\eta. V_H$

$= 0 + \frac{4.4}{4.8}. (1-0.35)\times 0.95\times 0.453$

= 0.2564

= 25.64 % of the chord

Q.No. 46 A single engine, propeller driven, general aviation airplane is flying in cruise at sea-level condition (density of air at sea-level is 1.225 kg/m^3) with speed to cover maximum range. For drag coefficient C_D = 0.025 + 0.049 C_L^2 and wing loading W/S = 9844 N/m^2, the speed of the airplane is _____ m/s (*round off to one decimal place*).

Ans. 150 m/s

A single engine propeller driven a/c –

At SL, ρ_∞= 1.225 kg/m^3

→ C_D= 0.025 + 0.049$C_L{}^2$, w/s = 9844 N/m^2

→ $R = \frac{\eta_p}{SFC}.\frac{C_L}{C_D}.ln\frac{W_0}{W_1}$

→ For maximum range, $(\frac{C_L}{C_D})$ should be maximum

∴ $C_{Di} = C_{D0}$ = K$C_L{}^2$

$C_L = \sqrt{\frac{C_D}{K}}$ = 0.714

C_D = 2C_{D0} = 0.05

$\rightarrow$ V = $\sqrt{\frac{2W}{\rho S C_L}}$ = $\sqrt{\frac{2*9844}{1.225*0.714}}$ = 150 m/s

Q.No. 47 The design flight Mach number of an ideal ramjet engine is 2.8. The stagnation temperature of air at the exit of the combustor is 2400 K. Assuming the specific heat ratio of 1.4 and gas constant of 287 J/(kg K), the velocity of air at the exit of the engine is ______ m/s (*round off to one decimal place*).

Ans. 1717 m/s

Ideal Ramjet engine,

$\rightarrow M_a = M_e$ = 2.8, T_{0e}= 2400K, γ = 1.4, R = 287 J/Kg.K

$\frac{T_{0e}}{T_e} = 1 + \frac{\gamma-1}{2}.M_e^2$ = 2.56

T_e = 937.5 K, $\because T_a$ = 288.16 K

$\rightarrow V_a = M_e.\sqrt{\gamma R T_a}$ = 2.8.$\sqrt{1.4*287*288.16}$ = 952.75 m/s

$\rightarrow V_e = \sqrt{\frac{T_e}{T_a}} \times V_a = \sqrt{\frac{937.5}{288.16}} \times$ 952.75 = 1717 m/s

Q.No. 48 The operating conditions of an aircraft engine combustor are as follows.

The rate of total enthalpy of air entering the combustor = 28.94 MJ/s.

The rate of total enthalpy of air leaving the combustor = 115.42 MJ/s.

Mass flow rate of air = 32 kg/s.

Air to fuel mass ratio = 15.6.

Lower heating value of the fuel = 46 MJ/kg.

The efficiency of the combustor is ______ % (*round off to two decimal places*).

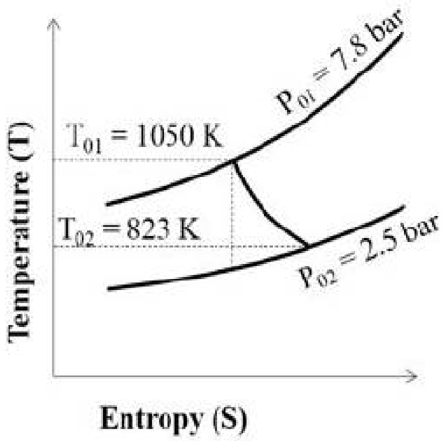
Ans. 91.65 %

$\rightarrow h_{02} = h_{01} + \eta_b . \frac{m_f}{m_a}$.LHV.$m_a$

115.42 = 28.94 +$\eta_b . \frac{46}{15.6}$.32

η_b = 0.9165 = 91.65 %

Q.No. 49 The figure shows the T-S diagram for an axial turbine stage.



Assuming specific heat ratio of 1.33 for the hot gas, the isentropic efficiency of the turbine stage is ________ %(*round off to two decimal places*).

Ans. 88.21 %

γ = 1.33

$\rightarrow \eta_{iT} = \frac{T_{01}-T_{02}}{T_{01}-T_{02}'} = \frac{1-\frac{T_{02}}{T_{01}}}{1-\frac{T_{02}'}{T_{01}}}$

$\rightarrow \frac{T_{02}'}{T_{01}} = \left(\frac{P_{02}}{P_{01}}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{2.5}{7.8}\right)^{\frac{\gamma-1}{\gamma}}$ = 0.754

$\rightarrow \frac{T_{02}}{T_{01}}$ = 0.783

$\rightarrow \eta_{iT} = \frac{1-0.783}{1-0.754}$ = 0.8821 = 88.21 %

Q.No. 50 A rocket engine has a sea level specific impulse of 210 s and a nozzle throat area of 0.005 m^2. While testing at sea level conditions, the characteristic velocity and pressure for the thrust chamber are 1900 m/s and 50 bar, respectively. Assume the acceleration due to gravity to be 9.8 m/s^2. The thrust produced by the rocket engine is ________ kN (*round off to one decimal place*).

Ans. 27.07 KN

At SL, I_{sp} = 210 s, A_{th} = 0.005m^2, C* = 1900 m/s, P_c = 50 bar

$P_c.A_{th} = \dot{m}_p$.c* .... (1)

$I_{sp} = \frac{F}{\dot{m_p}.g} = \frac{c}{g}$ .... (2)

By equation (1),

$\dot{m}_p = \frac{50\times10^5\times0.005}{1900}$ = 13.157 Kg/s

By equation (2),

C = 2058 m/s

→ F = $\dot{m}_p.C$ = 27.07 KN

Q.No. 51 A critically damped single degree of freedom spring-mass-damper system used in a door closing mechanism becomes overdamped due to softening of the spring with extended use. If the new damping ratio (ξ_{new}) for overdamped condition is 1.2, the ratio of the original spring stiffness to the new spring stiffness (k_{org} / k_{new}), assuming that the other parameters remain unchanged, is ________ (*round off to two decimal places*).

Ans. 1.44

$\because \xi = \frac{C}{C_c} = \frac{C}{2\sqrt{mk}}$

→ For critical damping, $\because \xi = 1 = \frac{C}{2\sqrt{mk}} = 1$

C = $2\sqrt{mk_1}$ ……….. (1)

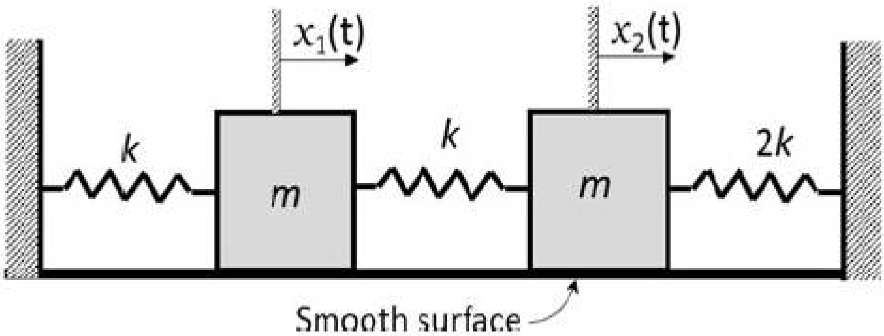
→ For over damped, $\xi = 1.2 = \frac{C}{2\sqrt{mk}}$

C = $1.2 * 2\sqrt{mk_2}$ ……….. (2)

→ $\frac{(1)^2}{(2)^2}$, $\frac{1}{1} = \frac{1}{1.44} \cdot \frac{k_1}{k_2}$

$\frac{k_1}{k_2} = 1.44$

Q.No. 52 The two masses of the two degree of freedom system shown in the figure are given initial displacements of 2 cm (x_1) and 1.24 cm (x_2). The system starts to vibrate in the first mode. The first mode shape of this system is $\phi_1 = [1 \ \ a]^T$, where $a =$ ______ (*round off to two decimal places*).



Ans. 0.62

→ For mass M_1,

$X_1' + X_1'' = 2$ cm

→ For mass M_2,

$X_2' + X_2'' = 1.24$ cm

→ $x_1 = X_1' \cos(\omega_{n1} t) + X_1'' \cos(\omega_{n2} t)$

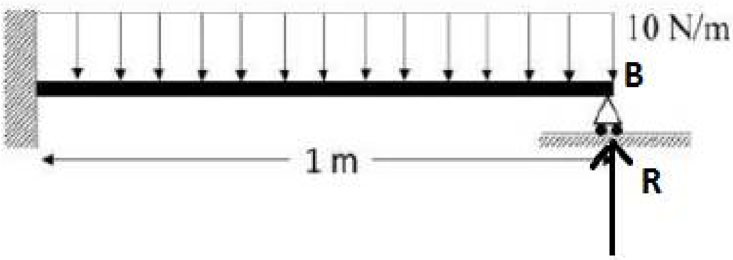
→ $x_2 = X_2' \cos(\omega_{n1} t) + X_2'' \cos(\omega_{n2} t)$

∵ Here X_1'' and X_2'' are negligible.

So, $X_1' = 2$ cm and $X_2' = 1.24$ cm

$\emptyset = \frac{X_1'}{X_2'} = \frac{2}{1.24} = \frac{1}{0.62}$

Q.No. 53 As shown in the figure, a beam of length 1 m is rigidly supported at one end and simply supported at the other. Under the action of a uniformly distributed load of 10 N/m, the magnitude of the normal reaction force at the simply supported end is ________N (*round off to two decimal places*).



Ans. 3.75 N

→ Due to UDL, $Y_{b1} = \frac{wL^4}{8EI}$

→ Due to point load, $Y_{b2} = \frac{WL^3}{3EI} = \frac{RL^3}{3EI}$

So, $Y_{b1} - Y_{b2} = \frac{wL^4}{8EI} - \frac{RL^3}{3EI} = 0$

$R = \frac{wL.3}{8} = \frac{10.1.3}{8} = 3.75$ N

Q.No. 54 An airplane of mass 4000 kg and wing reference area 25 m^2 flying at sea level has a maximum lift coefficient of 1.65. Assume density of air as 1.225 kg/m^3 and acceleration due to gravity as 9.8 m/s^2. Using a factor of safety of 1.25 to account for additional unsteady lift during a sudden pull-up, the speed at which the airplane reaches a load factor of 3.2 is ______ m/s (*round off to two decimal places*).

Ans. 63.02 m/s

Given,

m = 4000kg, S = 25m^2 , $C_{L,max}$ at SL = 1.65, ρ = 1.225 kg/m^3 ,

g = 9.8 m/m^2

→ FOS = 1.25, n = 3.2

→ L = nW .... (1)

→ $\frac{1}{2}\rho V_{unsteady}^2 S C_L = n_{unsteady} W$.............. (2)

→ FOS = $\frac{n_{steady}}{n_{usteady}}$ .... (3)

By equations (2) and (3),

$$V_{unsteady} = \sqrt{\frac{2nW}{\rho S C_{L} FOS}}$$

$$= \sqrt{\frac{2\times3.2\times4000\times9.8}{1.225\times25\times1.65\times1.25}}$$

= 63.02 m/s

Q.No. 55 A Pitot tube mounted on the wing tip of an airplane flying at an altitude of 3 km measures a pressure of 0.72 bar, and the outside air temperature is 268.66 K. Take the sea level conditions as, pressure = 1.01 bar, temperature = 288.16 K, and density = 1.225 kg/m^3. The acceleration due to gravity is 9.8 m/s^2 and the gas constant is 287 J/(kg K). Assuming standard atmosphere, the equivalent airspeed for this airplane is ______ m/s (*round off to two decimal place*).

Ans. 59.93 m/s

Aero plane at SL,

P_∞ = 1.01bar, T_∞ = 288.16 K, ρ_∞ = 1.225Kg/m^3, g = 9.8 m/s^2

R = 287 J/kg.K

Aero plane at 3 Km measures pressure P_0= 0.72 bar and outside temperature T=268.6 K

dT/dh = a; a=lapse rate= -6.5 k/km

$(T-T_{sea\text{-}level})/(h-0) = -6.5$ k/km ⇒ $(T-288.16)/(3-0) = -6.5$ ⇒ T= 268.66 k

$P/P_{sea\text{-}level} = (T/T_{sea\text{-}level})^{-(g/a*R)}$ ⇒ $P/1.01 = (268.66/288.16)^{5.2586}$ ⇒ P =0.698 bar

$$\rightarrow \frac{1}{2}\rho V^2 = \frac{1}{2}\rho_\infty V_\infty^{\ 2}$$

$$\rightarrow V_\infty = \sqrt{\frac{2(P_0-p)}{\rho_\infty}} = \sqrt{\frac{2(0.72-0.698)}{1.225} * 10^5} = 59.93 \text{ m/s}$$

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Result-

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EEE- AIR-1382, 1973 and more
ME- GATE Score- 555, 504 and more

GATE 2019 -**AIR- 2, 4, 42, 53, 58, 69, 98, 98, 114, 123, 142, 168, 168, 190, 205, 219, 236, 260, 286, 313, 333, 333, 342, 369, 375, 421, 489, 506, 517, 1510, 1920, 2359, 2625, 3413, 3896, 5100, 6362, 6508 and more**

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