AE - 2013

EE25BTECH11048 - Revanth Siva Kumar.D

1) For a flow through a Prandtl-Meyer expansion wave (GATE AE 2009)
   a) Mach number stays constant.
   b) Entropy stays constant.
   c) Temperature stays constant.
   d) Density stays constant.
2) For two-dimensional irrotational and incompressible flows (GATE AE 2009)
   a) Both potential and stream functions satisfy the Laplace equation.
   b) Potential function must satisfy the Laplace equation but the stream function need not.
   c) Stream function must satisfy the Laplace equation but the potential function need not.
   d) Neither the stream function nor the potential function need to satisfy the Laplace equation.
3) A trailing edge plain flap deflected downward increases the lift coefficient of an airfoil by (GATE AE 2009)
   a) Increasing the effective camber of the airfoil.
   b) Delaying the separation of the flow from the airfoil surface.
   c) Increasing the local airspeed near the trailing edge.
   d) Controlling the growth of the boundary layer thickness along the airfoil surface.
4) Thin airfoil theory predicts that the lift slope
$$\frac{dc_l}{d\alpha} = 2\pi$$
   for (GATE AE 2009)
   a) Symmetric airfoils only.
   b) Cambered airfoils only.
   c) Any airfoil shape.
   d) Joukowski airfoils only.
5) The ordinary differential equation
$$\frac{d^2y}{dx^2} + ky = 0$$
   where k is real and positive (GATE AE 2009)
   a) is non-linear
   b) has a characteristic equation with one real and one complex root
   c) has a characteristic equation with two real roots
   d) has a complementary function that is simple harmonic
6) A non-trivial solution to the $(n \times n)$ system of equations
$$[A]\{x\} = \{0\}$$
   where $\{0\}$ is the null vector (GATE AE 2009)
   a) can never be found
   b) may be found only if $[A]$ is not singular
   c) may be found only if $[A]$ is an orthogonal matrix
   d) may be found only if $[A]$ has at least one eigenvalue equal to zero
7) For a plane strain problem, the stresses satisfy the condition (GATE AE 2009)

a) $\tau_{xz} = \tau_{yz} = \sigma_z = 0$
b) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = \nu(\sigma_x + \sigma_y)$
c) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = \nu\tau_{xy}$
d) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = \nu(\sigma_x + \sigma_y) + (1-\nu)\tau_{xy}$

8) The propulsive efficiency of a turbo-jet engine moving at velocity U_∞ and having exhaust velocity U_e with respect to the engine is given by (GATE AE 2009)

a) $\dfrac{2}{\dfrac{U_\infty}{U_e} + 1}$
b) $1 - \dfrac{U_\infty}{U_e}$
c) $\dfrac{2U_\infty U_e}{U_e^2 + U_\infty^2}$
d) $\dfrac{2U_\infty}{U_e + U_\infty}$

9) An aircraft is flying at $M = 2$ where the ambient temperature around the aircraft is 250 K. If the specific heat ratio for air $\gamma = 1.4$, the stagnation temperature on the surface of the aircraft is (GATE AE 2009)

a) 200 K
b) 450 K
c) 350 K
d) 1450 K

10) The division of feed air to an aircraft gas-turbine combustor into primary and secondary streams serves which of the following purposes? P. a flammable mixture can be formed Q. cooling of combustor liner and flame tube can be accomplished R. specific fuel consumption can be reduced (GATE AE 2009)

a) P and R
b) Q and R
c) P and Q
d) P, Q and R

11) Classify the following propellants as: cryogenic (C), semi-cryogenic (SC), compressed gas (CG) and earth storable (ES)

- N_2O_4-UDMH: nitrogen tetra oxide and unsymmetrical di-methyl hydrazine
- LOX-RP1: liquid oxygen and kerosene
- LOX-LH_2: liquid oxygen and liquid hydrogen
- N_2: nitrogen gas

(GATE AE 2009)

a) N_2O_4-UDMH (ES), LOX-RP1 (C), LOX-LH_2 (C), N_2 (C)
b) N_2O_4-UDMH (SC), LOX-RP1 (SC), LOX-LH_2 (C), N_2 (C)
c) N_2O_4-UDMH (ES), LOX-RP1 (SC), LOX-LH_2 (C), N_2 (CG)
d) N_2O_4-UDMH (ES), LOX-RP1 (C), LOX-LH_2 (C), N_2 (CG)

12) A conventional altimeter is a (GATE AE 2009)

a) Pressure transducer
b) Temperature transducer
c) Density transducer
d) Velocity transducer

13) The relation between an airplane's true airspeed V_{TAS} and equivalent airspeed V_{EAS} in terms of the density ratio $\sigma = \dfrac{\rho}{\rho_0}$, where ρ_0 is the air density at sea-level and ρ is the air density at the altitude at which the airplane is flying, is given by the formula: (GATE AE 2009)

a) $\frac{V_{EAS}}{V_{TAS}} = \sigma$
b) $\frac{V_{EAS}}{V_{TAS}} = \sigma^2$
c) $\frac{V_{EAS}}{V_{TAS}} = \sqrt{\sigma}$
d) $\frac{V_{EAS}}{V_{TAS}} = \frac{1}{\sqrt{\sigma}}$

14) An unswept fixed-winged aircraft has a large roll stability if the wing is placed (GATE AE 2009)

a) low on the fuselage and has negative dihedral angle
b) low on the fuselage and has positive dihedral angle
c) high on the fuselage and has negative dihedral angle
d) high on the fuselage and has positive dihedral angle

15) Thrust available from a turbojet engine (GATE AE 2009)

a) increases as altitude increases
b) increases up to the tropopause and then decreases
c) remains constant at all altitudes
d) decreases as altitude increases

16) If $C_{m_{CG}}$ is the pitching moment coefficient about the center of gravity of an aircraft, and α is the angle of attack, then

$$\frac{dC_{m_{CG}}}{d\alpha}$$

is (GATE AE 2009)

a) a stability derivative which represents stiffness in pitch
b) a stability derivative which represents damping in pitch
c) a control derivative in pitch
d) positive for an aircraft that is stable in pitch

17) The life of a geo-stationary communications satellite is limited by (GATE AE 2009)

a) the working life of the on-board electronic circuitry
b) the time it takes for its orbit to decay due to atmospheric drag
c) the quantity of on-board fuel available for station-keeping
d) the number of meteorite impacts that the satellite structure can withstand before breaking up

18) For a critically damped single degree of freedom spring-mass-damper system with a damping constant c of 4 Ns/m and spring constant k of 16 N/m, the system mass m is (GATE AE 2009)

a) 0.5 kg
b) 0.25 kg
c) 2 kg
d) 4 kg

19) In a thin walled rectangular tube subjected to equal and opposite forces P as shown in the figure, the shear stress along leg AB is

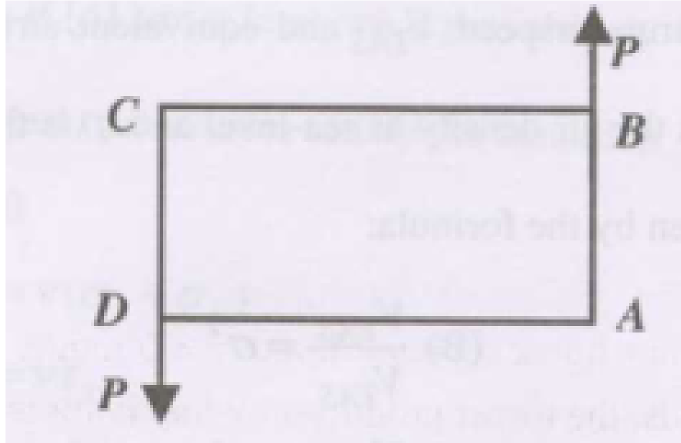


Fig. 1

(GATE AE 2009)

a) zero
b) constant non-zero
c) varies linearly
d) varies parabolically

20) For the thin walled beam cross section as shown in the figure, the shear centre lies at

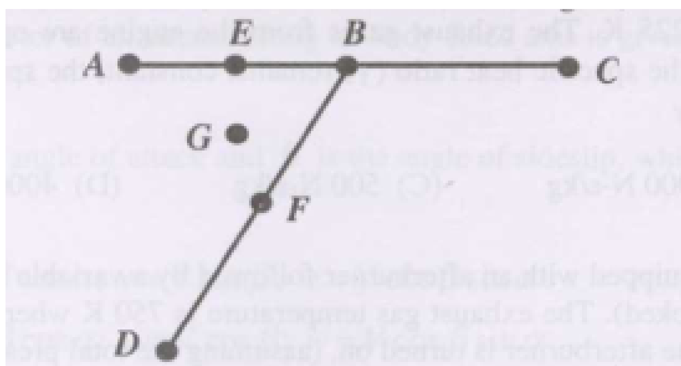


Fig. 2

(GATE AE 2009)

a) Mid point of AB, i.e. at point E
b) Mid point of BD, i.e. at point F
c) Junction point B
d) at a point G lying within the area ABC

21) Let M_0 be the total mass of a single stage rocket, M_p be the total mass of propellant, M_L be the mass of payload carried by the rocket and M_S be the mass of inert structural components. If I_{sp} is the specific impulse of the propulsion system (in seconds) and g is the acceleration due to gravity, then the maximum velocity that can be attained by the rocket vehicle in the absence of gravity and atmospheric drag is given by

$$gI_{sp} \ln\left(\frac{M_0}{M_p}\right)$$

(GATE AE 2009)

a) $gI_{sp}\ln\left(\frac{M_0}{M_p}\right)$
b) $gI_{sp}\ln\left(\frac{M_0}{M_L+M_S}-1\right)$
c) $gI_{sp}\ln\left(\frac{M_0}{M_S}\right)$
d) $gI_{sp}\ln\left(\frac{M_0}{M_0-M_P}\right)$

22) An ideal axial compressor is driven by an ideal turbine across which the total temperature ratio is 0.667. If the total temperature at turbine inlet is $T_0 = 1500\ K$ and specific heat of gas $c_p = 1\ kJ/kg/K$, the power drawn by the compressor per unit mass flow rate of air is approximately (GATE AE 2009)

a) 300 kW/kg/s
b) 1000 kW/kg/s
c) 600 kW/kg/s
d) 500 kW/kg/s

23) The performance of a solid rocket motor is improved by replacing the old propellant with a new one. The new propellant gives a combustion temperature 40% higher than the previous propellant without appreciable change in molecular weight of combustion products and other operating parameters. By approximately what percentage is the specific impulse of the new motor higher than the old one?
(GATE AE 2009)

a) 18%
b) 96%
c) 42%
d) 112%

24) A solid rocket motor has an end burning grain of cross-sectional area $A_{CS} = 0.4\ m^2$. The density of propellant is $\rho_p = 1500\ kg/m^3$ and has linear regression rate $\dot{r} = 5\ mm/s$. If the specific impulse of the propulsion system is $I_{sp} = 200$ seconds, the thrust produced by the motor is approximately (GATE AE 2009)

a) 3 kN
b) 6 kN
c) 1.5 kN
d) 12 kN

25) An ideal ramjet is flying at an altitude of 10 km with a velocity of 1 km/s. The ambient pressure is 0.25 bar and temperature is 225 K. The exhaust gases from the engine are optimally expanded and leave the nozzle at 900 K. If the specific heat ratio (γ) remains constant, the specific thrust developed by the engine is approximately (GATE AE 2009)

a) 1000 N-s/kg
b) 2000 N-s/kg
c) 500 N-s/kg
d) 4000 N-s/kg

26) A combat aircraft engine is equipped with an afterburner followed by a variable area convergent nozzle (operating with the nozzle choked). The exhaust gas temperature is 750 K when afterburner is off and 3000 K when it is on. When the afterburner is turned on, (assuming the total pressure remains the same, the mass of fuel added in the afterburner is negligible i.e., the mass flow rate remains the same, and the specific heat ratio (γ) remains constant), approximately by what factor must the nozzle area be changed? (GATE AE 2009)

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

27) An airplane flying at 100 m/s is pitching at the rate of 0.2 deg/s. Due to this pitching, the horizontal tail surface located 4 m behind the centre-of-mass of the airplane will experience a change in angle of attack, which is (GATE AE 2009)

a) 0.01 deg
b) 0.008 deg
c) 0.04 deg
d) 0.004 deg

28) The contribution of the horizontal tail to the pitching moment coefficient about the center of gravity ($C_{m_{CG}}$) of an aircraft is given by

$$C_{m_{\text{tail}}} = 0.2 - 0.0215\alpha$$

where α is the angle of attack of the aircraft. The contribution of the tail to the aircraft longitudinal stability (GATE AE 2009)
a) is stabilizing
b) is destabilizing
c) is nil
d) cannot be determined from the given information

29) The linearized dynamics of an aircraft (which has no large rotating components) in straight and level flight is governed by the equations

$$\frac{d(x)}{dt} = \begin{pmatrix} [A] & [B] \\ [C] & [D] \end{pmatrix} (x)$$

where $(x) = \begin{pmatrix} u & w & q & \theta & v & p & r & \phi \end{pmatrix}^T$. $[A], [B], [C]$ and $[D]$ are 4×4 matrices and $[0]$ is the 4×4 null matrix. Which of the following is true? (GATE AE 2009)
a) $[A] \neq [0]$; $[B] \neq [0]$; $[C] = [0]$; $[D] \neq [0]$
b) $[A] = [0]$; $[B] \neq [0]$; $[C] \neq [0]$; $[D] = [0]$
c) $[A] \neq [0]$; $[B] = [0]$; $[C] = [0]$; $[D] \neq [0]$
d) $[A] \neq [0]$; $[B] = [0]$; $[C] \neq [0]$; $[D] = [0]$

30) The velocity vector of an aircraft along its body-fixed axis is given by $\mathbf{V} = \begin{pmatrix} u \\ v \\ w \end{pmatrix}$. If V is the magnitude of $\mathbf{V}$, α is the angle of attack and β is the angle of sideslip, which of the following set of relations is correct? (GATE AE 2009)

a) $u = V \sin\beta \cos\alpha$; $v = V \sin\beta$; $w = V \cos\beta \sin\alpha$
b) $u = V \cos\beta \cos\alpha$; $v = V \cos\beta$; $w = V \cos\beta \sin\alpha$
c) $u = V \cos\beta \cos\alpha$; $v = V \sin\beta$; $w = V \sin\beta \sin\alpha$
d) $u = V \cos\beta \cos\alpha$; $v = V \sin\beta$; $w = V \cos\beta \sin\alpha$

31) An aircraft of mass 2500 kg in straight and level flight at a constant speed of 100 m/s has available excess power of 1.0×10^6 W. The steady rate of climb it can attain at that speed is (GATE AE 2009)
a) 100 m/s
b) 60 m/s
c) 40 m/s
d) 20 m/s

32) The acceleration due to gravity on the surface of Mars is 0.385 times that on earth, and the diameter of Mars is 0.532 times that of earth. The ratio of the escape velocity from the surface of Mars to the escape velocity from the surface of earth is approximately (GATE AE 2009)
a) 0.453
b) 0.205
c) 0.851
d) 0.724

33) Which of the following statements are true for flow across a stationary normal shock? P. Stagnation temperature stays constant. Q. Stagnation pressure decreases. R. Entropy increases. S. Stagnation pressure increases. T. Stagnation temperature increases. (GATE AE 2009)
   a) P, Q, R
   b) Q, R, S
   c) R, S, T
   d) S, T, P
34) A model airfoil in a wind tunnel that is operating at 50 m/s develops a minimum pressure coefficient of -6.29 at some point on its upper surface. The local airspeed at that point is (GATE AE 2009)
   a) 50 m/s
   b) 125 m/s
   c) 135 m/s
   d) 150 m/s
35) A symmetrical airfoil section produces a lift coefficient of 0.53 at an angle of attack of 5 degrees measured from its chord line. An untwisted wing of elliptical planform and aspect ratio 6 is made of this airfoil. At an angle of attack of 5 degrees relative to its chordal plane, this wing would produce a lift coefficient of (GATE AE 2009)
   a) 0.53
   b) 0.48
   c) 0.40
   d) 0.36
36) Consider an ideal flow of density ρ through a variable area duct as shown in the figure below:

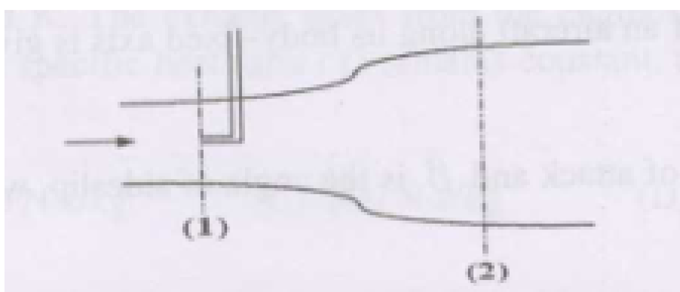


Fig. 3

(GATE AE 2009)

   a) $-\frac{1}{2}\rho\left(1-\frac{A_1^2}{A_2^2}\right)V_1^2$
   b) $\frac{1}{2}\rho\left(1-\frac{A_1^2}{A_2^2}\right)V_1^2$
   c) $\frac{1}{2}\rho\left(1+\frac{A_1^2}{A_2^2}\right)V_1^2$
   d) $-\frac{1}{2}\rho\left(1+\frac{A_1^2}{A_2^2}\right)V_1^2$
37) Two vortices of the same strength and sign are placed a distance d apart as shown below. Assume that the vortices are free to move and the fluid is ideal.
   Which of the following statements is true?

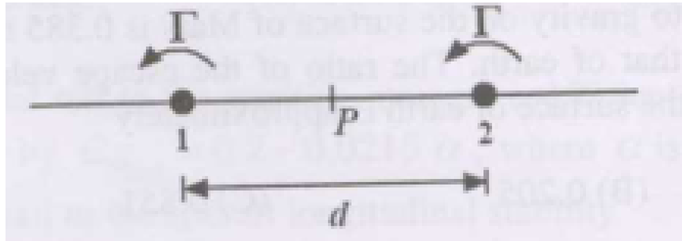


Fig. 4

(GATE AE 2009)

a) Vortices 1 and 2 spiral inwards with an initial angular speed $\frac{\Gamma}{2\pi d^2}$ to finally merge and form one vortex of twice the strength.
b) Vortices 1 and 2 spiral inwards with an initial angular speed $\frac{\Gamma}{\pi d^2}$ to finally merge and form one vortex of twice the strength.
c) Vortices 1 and 2 perpetually revolve about the midpoint P with radius of revolution $\frac{d}{2}$ and angular speed $\frac{\Gamma}{2\pi d^2}$.
d) Vortices 1 and 2 perpetually revolve about the midpoint P with radius of revolution $\frac{d}{2}$ and angular speed $\frac{\Gamma}{\pi d^2}$.

38) The laminar boundary layer over a large flat plate held parallel to the flow is 7.2 mm thick at a point 0.33 m downstream of the leading edge. If the free stream speed is increased by 50%, then the new boundary layer thickness at this location will be approximately (GATE AE 2009)

a) 10.8 mm b) 8.8 mm c) 5.9 mm d) 4.8 mm

39) Consider a simply supported beam of length $2L$ with an overhang of length L, loaded by an end moment M, as shown below.

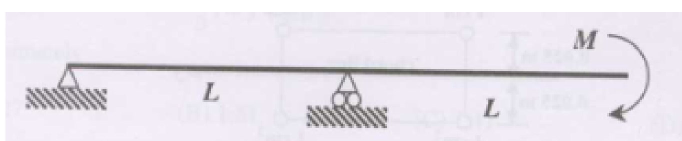
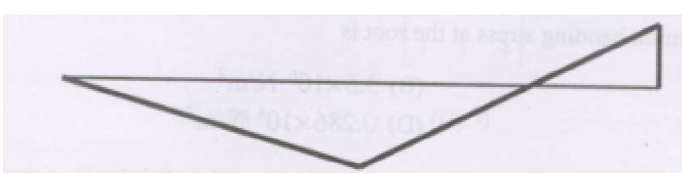
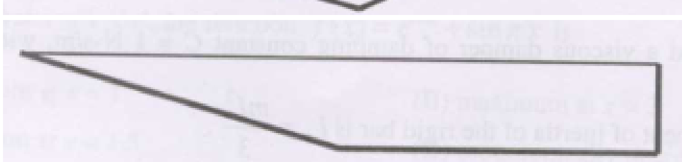


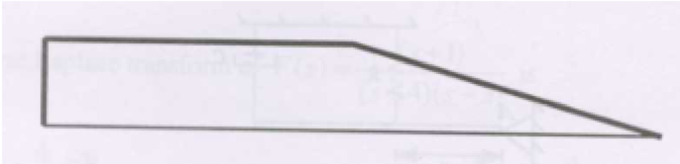
Fig. 5

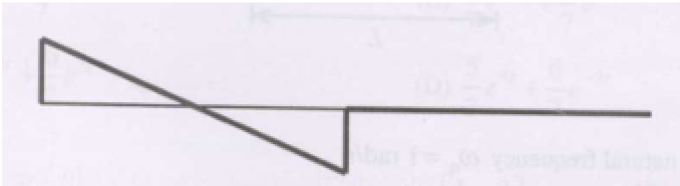
The bending moment distribution for this beam is

(GATE AE 2009)

a) 

b) 

c) 

d) 

40) For the spring-mass system shown below, the natural frequencies are

(GATE AE 2009)

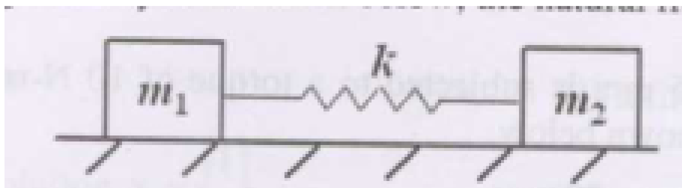


Fig. 6

a) 0 and $\sqrt{\dfrac{k(m_1 + m_2)}{m_1 m_2}}$

b) 0 and $\sqrt{\dfrac{k(m_1 + m_2)}{2m_1 m_2}}$

c) 0 and $\sqrt{\dfrac{k}{m_1 + m_2}}$

d) 0 and $\sqrt{\dfrac{k}{2(m_1 + m_2)}}$

41) The buckling load for a simply supported column of rectangular cross section of dimensions $1\,\text{cm} \times 1.5\,\text{cm}$ and length $0.5\,\text{m}$ made of steel ($E = 210 \times 10^9$ N/m^2) is approximately

(GATE AE 2009)

a) 10 kN b) 4 kN c) 23 kN d) 46 kN

42) A wing root cross section is idealized using lumped areas (booms) as shown below.

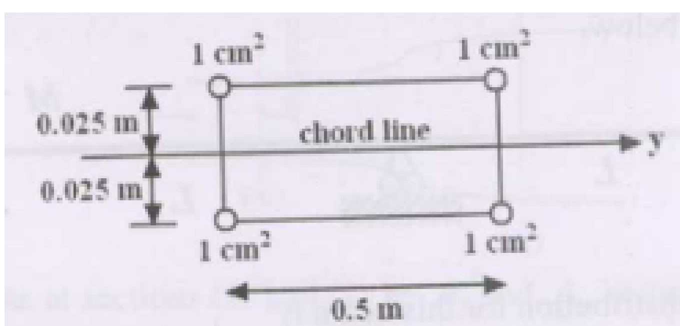


Fig. 7

The wing root bending moment in steady level flight is $M_y = 10$ N-m. If the airplane flies at a load factor $n = 3.5$, the maximum bending stress at the root is

(GATE AE 2009)

a) 1×10^6 N/m^2
b) 3.5×10^6 N/m^2
c) 7×10^6 N/m^2
d) 0.286×10^6 N/m^2

43) A uniform rigid bar of mass $m = 1$ kg and length $L = 1$ m is pivoted at A. It is supported by a spring of stiffness $k = 1$ N/m and a viscous damper of damping constant $C = 1$ N-s/m, with $a = \sqrt{\frac{1}{3}}$ m as shown below. The moment of inertia of the rigid bar is $I_A = \frac{mL^2}{3}$.

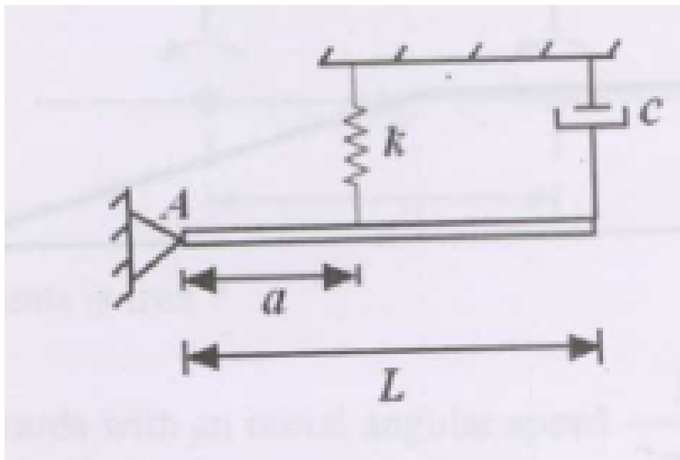


Fig. 8

The system is

(GATE AE 2009)

a) overdamped
b) underdamped with natural frequency $\omega_n = 1$ rad/s
c) critically damped
d) underdamped with natural frequency $\omega_n = 2$ rad/s

44) A 2-celled tube with wall thickness 0.5 mm is subjected to a torque of 10 N-m. The resulting shear flows in the two cells are q_1 and q_2 as shown below.

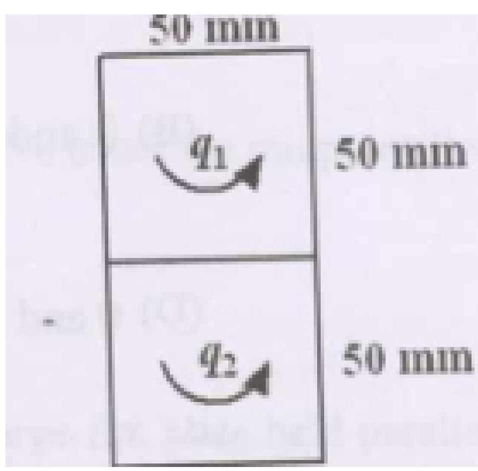


Fig. 9

The torque balance equation (Bredt-Batho formula) for this section leads to

(GATE AE 2009)

a) $q_1 - q_2 = 2000$ N/m
b) $q_1 + 2q_2 = 2000$ N/m
c) $q_1 + q_2 = 2000$ N/m
d) $2q_1 + q_2 = 2000$ N/m

45) The value of the integral

$$\int_0^{\pi} \frac{dx}{1 + x + \sin x}$$

evaluated using the trapezoidal rule with two equal intervals is approximately

(GATE AE 2009)

a) 1.27
b) 1.81
c) 1.41
d) 0.71

46) The product of the eigenvalues of the matrix

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 1 \\ 1 & 1 & 4 \end{pmatrix}$$

is

(GATE AE 2009)

a) 20
b) 24
c) 9
d) 17

47) In the interval $1 \leq x \leq 2$, the function $f(x) = e^x + \sin \pi x$ is

(GATE AE 2009)

a) maximum at $x = 1$
b) maximum at $x = 2$
c) maximum at $x = 1.5$
d) monotonically decreasing

48) The inverse Laplace transform of

$$F(s) = \frac{s + 1}{(s + 4)(s - 3)}$$

is

(GATE AE 2009)

a) $\frac{3}{7}e^{4t} + \frac{4}{7}e^{3t}$
b) $\frac{3}{7}e^{-4t} + \frac{4}{7}e^{3t}$
c) $\frac{5}{7}e^{-4t} + \frac{6}{7}e^{3t}$
d) $\frac{5}{7}e^{4t} + \frac{6}{7}e^{-3t}$

49) The linear system of equations $\left(A\right)\mathbf{x} = \mathbf{b}$ where

$$\left(A\right) = \begin{pmatrix} 1 & 2 \\ 2 & 4 \end{pmatrix}, \quad \mathbf{b} = \begin{pmatrix} 3 \\ 3 \end{pmatrix}$$

has

(GATE AE 2009)

a) no solution

b) infinitely many solutions

c) a unique solution $\mathbf{x} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$

d) a unique solution $\mathbf{x} = \begin{pmatrix} 0.5 \\ 0.5 \end{pmatrix}$

50) The correct iterative scheme for finding the square root of a positive real number R using the Newton-Raphson method is

(GATE AE 2009)

a) $x_{n+1} = \sqrt{R}$

b) $x_{n+1} = \frac{1}{2}\left(x_n + \frac{R}{x_n}\right)$

c) $x_{n+1} = \frac{1}{2}\left(\sqrt{x_n} + \sqrt{\frac{R}{x_{n-1}}}\right)$

d) $x_{n+1} = \frac{1}{2}\left(\sqrt{R} + x_n\right)$

Common Data for Questions 51 and 52:

The roots of the characteristic equation for the longitudinal dynamics of a certain aircraft are

$$\lambda_1 = -0.02 + 0.2i, \quad \lambda_2 = -0.02 - 0.2i, \quad \lambda_3 = -2.5 + 2.6i, \quad \lambda_4 = -2.5 - 2.6i,$$

where $i = \sqrt{-1}$.

51) The pair of eigenvalues that represent the phugoid mode is

(GATE AE 2009)

a) λ_1 and λ_3 b) λ_2 and λ_4 c) λ_3 and λ_4 d) λ_1 and λ_2

52) The short period damped frequency is

(GATE AE 2009)

a) 2.6 rad/s b) 0.2 rad/s c) 2.5 rad/s d) 0.02 rad/s

Common Data for Questions 53 and 54:

Consider the vector field $\left(A\right) \equiv (y^3 + z^3)\left(i\right) + (x^3 + z^3)\left(j\right) + (x^3 + y^3)\left(k\right)$ defined over the unit sphere

$$x^2 + y^2 + z^2 = 1.$$

53) The surface integral (taken over the unit sphere) of the component of $\left(A\right)$ normal to the surface is

(GATE AE 2009)

a) π b) 1 c) 0 d) 4π

54) The magnitude of the component of $\left(A\right)$ normal to the spherical surface at the point

$$\left(r\right) = \left(\tfrac{1}{\sqrt{3}}i + \tfrac{1}{\sqrt{3}}j + \tfrac{1}{\sqrt{3}}k\right)$$

is

(GATE AE 2009)

a) $\frac{1}{3}$ b) $\frac{2}{3}$ c) $\frac{3}{3}$ d) $\frac{4}{3}$

Common Data for Questions 55 and 56:

The partial differential equation for the torsional vibration of a shaft of length L, torsional rigidity GJ, and mass polar moment of inertia per unit length I, is

$$\frac{\partial^2\theta}{\partial t^2} = GJ\frac{\partial^2\theta}{\partial x^2},$$

where θ is the twist.

55) If the shaft is fixed at both ends, the boundary conditions are:

(GATE AE 2009)

a) $\left.\frac{\partial\theta}{\partial x}\right|_{x=0} = 0$ and $\left.\frac{\partial\theta}{\partial x}\right|_{x=L} = 0$
b) $\theta(0) = 0$ and $\theta(L) = 0$
c) $\left.\frac{\partial\theta}{\partial x}\right|_{x=0} = 0$ and $\theta(L) = 0$
d) $\theta(0) = 0$ and $\left.\frac{\partial\theta}{\partial x}\right|_{x=L} = 0$

56) If the n^{th} mode shape of torsional vibration of the above shaft is $\sin\left(\frac{n\pi x}{L}\right)$, then the n^{th} natural frequency of vibration, i.e., ω_n, is given by

(GATE AE 2009)

a) $\omega_n = \frac{n\pi}{L}\sqrt{\frac{GJ}{I}}$
b) $\omega_n = \frac{(2n+1)\pi}{2L}\sqrt{\frac{GJ}{I}}$
c) $\omega_n = \frac{n\pi}{2L}\sqrt{\frac{GJ}{I}}$
d) $\omega_n = \frac{(2n+1)\pi}{L}\sqrt{\frac{GJ}{I}}$

Statement for Linked Answer Questions 57 and 58:

Air enters the combustor of a gas-turbine engine at a total temperature T_0 of 500 K. The air stream is split into two parts: primary and secondary streams. The primary stream reacts with fuel supplied at a fuel-air ratio of 0.05. The resulting combustion products are then mixed with the secondary air stream to obtain gas with total temperature of 1550 K at the turbine inlet. The fuel has a heating value of 42 MJ/kg. The specific heats of air and combustion products are taken as $c_p = 1$ kJ/kg/K.

57) If the sensible enthalpy of fuel is neglected, the temperature of combustion products from the reaction of primary air stream with fuel is approximately

(GATE AE 2009)

a) 2100 K
b) 3200 K
c) 2600 K
d) 1800 K

58) The approximate ratio of mass flow rates of the primary air stream to the secondary air stream required to achieve the turbine inlet total temperature of 1550 K is

(GATE AE 2009)

a) 2:1
b) 1:2
c) 1:1.5
d) 1:1

Statement for Linked Answer Questions 59 and 60:

A piston compresses 1 kg of air inside a cylinder as shown

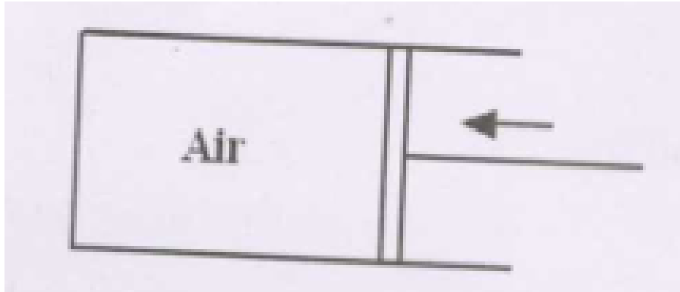


Fig. 10

The rate at which the piston does work on the air is 3000 W. At the same time, heat is being lost through the walls of the cylinder at a rate of 847.5 W.

59) After 10 seconds, the change in specific internal energy of the air is

(GATE AE 2009)

a) 21,525 J/kg
b) -21,525 J/kg
c) 30,000 J/kg
d) -8,475 J/kg

60) Given that the specific heats of air at constant pressure and volume are c_p = 1004.5 J/kg·K and c_v = 717.5 J/kg·K respectively, the corresponding change in the temperature of the air is

(GATE AE 2009)

a) 21.4 K
b) -21.4 K
c) 30 K
d) -30 K

END OF THE QUESTION PAPER