

AE - 2013

EE25BTECH11048 - Revanth Siva Kumar.D

- 1) The directional derivative of the function

$$f(x, y) = \frac{x^2 + xy^2}{\sqrt{5}}$$

in the direction

$$d = 2\hat{i} - 4\hat{j}$$

at $(x, y) = (1, 1)$ is _____.

(GATE AE 2013)

- a) $-\frac{1}{\sqrt{5}}$
b) $-\frac{2}{\sqrt{5}}$

- c) 0
d) $-\frac{1}{3}$

- 2) The value of

$$\int \frac{x+2}{x^2+4x-21} dx$$

is _____.

(GATE AE 2013)

- a) $\ln \sqrt{24/11}$
b) $\ln \sqrt{12/11}$

- c) $\ln \sqrt{2}$
d) $\ln(12/11)$

- 3) At $x = 0$, the function $y = |x|$ is _____.

(GATE AE 2013)

- a) continuous but not differentiable
b) continuous and differentiable
c) not continuous but differentiable
d) not continuous and not differentiable

- 4) One of the eigenvectors of the matrix

$$A = \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix}$$

is

$$v = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}.$$

The corresponding eigenvalue is _____.

(GATE AE 2013)

- 5) Which one of the following is the most stable configuration of an airplane in roll? (GATE AE 2013)

- a) Sweep back, anhedral and low wing
b) Sweep forward, dihedral and low wing
c) Sweep forward, anhedral and high wing
d) Sweep back, dihedral and high wing

- 6) Which one of the following flight instruments is used on an aircraft to determine its attitude in flight? _____

(GATE AE 2013)

- a) Vertical speed indicator
- b) Altimeter
- c) Artificial Horizon
- d) Turn-bank indicator

7) A supersonic airplane is expected to fly at both subsonic and supersonic speeds during its whole flight course. Which one of the following statements is TRUE? _____ (GATE AE 2013)

- a) Airplane will experience less stability in pitch at supersonic speeds than at subsonic speeds
- b) Airplane will feel no change in pitch stability
- c) Airplane will experience more stability in pitch at supersonic speeds than at subsonic speeds
- d) Pitch stability cannot be inferred from the information given

8) Which one of the following is favorable for an airplane operation? _____ (GATE AE 2013)

- a) Tail wind in cruise and head wind in landing
- b) Tail wind both in cruise and landing
- c) Head wind both in cruise and landing
- d) Head wind in cruise and tail wind in landing

9) Which one of the following is TRUE with respect to Phugoid mode of an aircraft? _____ (GATE AE 2013)

- a) Frequency is directly proportional to flight speed
- b) Frequency is inversely proportional to flight speed
- c) Frequency is directly proportional to the square root of flight speed
- d) Frequency is inversely proportional to the square root of flight speed

10) The x and y velocity components of a two dimensional flow field are

$$u = \frac{cy}{x^2 + y^2}, \quad v = \frac{-cx}{x^2 + y^2}$$

where c is a constant. The streamlines are a family of _____.

(GATE AE 2013)

- a) hyperbolas
- b) parabolas
- c) ellipses
- d) circles

11) Which one of the following statements is NOT TRUE for a supersonic flow? _____ (GATE AE 2013)

- a) Over a gradual expansion, entropy remains constant
- b) Over a sharp expansion corner, entropy can increase
- c) Over a gradual compression, entropy can remain constant
- d) Over a sharp compression corner, entropy increases

12) Consider a compressible flow where an elemental volume of the fluid is $\delta\Omega$, moving with velocity \mathbf{V} . Which one of the following expressions is TRUE? _____ (GATE AE 2013)

- a) $\nabla \cdot \mathbf{V} = \frac{1}{\delta\Omega} \frac{D\delta\Omega}{Dt}$
- b) $\nabla \cdot (\mathbf{V} \times \mathbf{r}) = \frac{1}{\delta\Omega} \frac{D\delta\Omega}{Dt}$
- c) $\frac{D\mathbf{V}}{Dt} = \frac{1}{\delta\Omega} \frac{D\delta\Omega}{Dt}$
- d) $\mathbf{V} \cdot (\nabla \times \mathbf{r}) = \frac{1}{\delta\Omega} \frac{D\delta\Omega}{Dt}$

13) Consider a thin flat plate airfoil at a small angle α to an oncoming supersonic stream of air. Assuming the flow to be inviscid, $\frac{C_d}{C_l^2}$ is _____

(GATE AE 2013)

- a) zero
b) independent of α
c) proportional to α
d) proportional to α^2

14) The critical Mach number for a flat plate of zero thickness, at zero angle of attack, is _____

(GATE AE 2013)

15) A damped single degree-of-freedom system is vibrating under a harmonic excitation with an amplitude ratio of 2.5 at resonance. The damping ratio of the system is _____

(GATE AE 2013)

16) The cross-section of a long thin-walled member is as shown in the figure. When subjected to pure twist, point A _____
(GATE AE 2013)



Fig. 1

- a) does not move horizontally or axially, but moves vertically
b) does not move axially, but moves both vertically and horizontally
c) does not move horizontally, vertically or axially
d) does not move vertically or axially, but moves horizontally

17) The channel section of uniform thickness 2 mm shown in the figure is subjected to a torque of 10 Nm. If it is made of a material with shear modulus of 25 GPa, the twist per unit length in radians/m is _____
(GATE AE 2013)

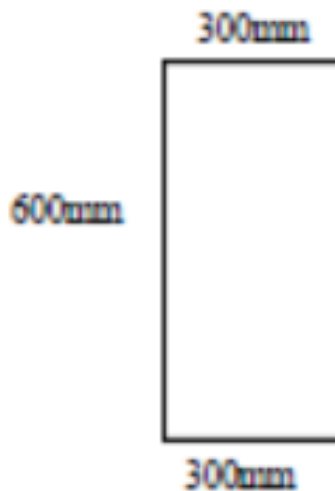


Fig. 2

18) The stiffened cross-section of a long slender uniform structural member is idealized as shown in the figure below. The lumped areas at A, B, C and D have equal cross-sectional area of 3 cm^2 . The

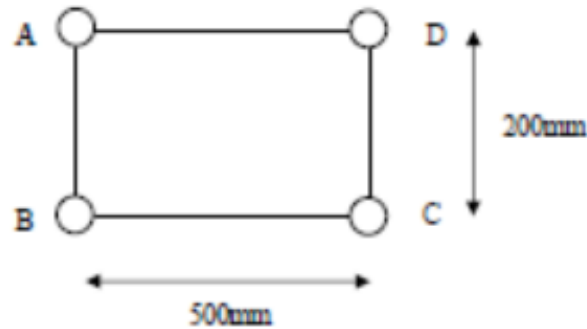


Fig. 3: Enter Caption

webs AB, BC, CD and DA are each 5 mm thick. The structural member is subjected to a twisting moment of 10 kNm. The magnitudes of the shear flow in the webs, q_{AB} , q_{BC} , q_{CD} and q_{DA} in kN/m are, respectively _____ (GATE AE 2013)

- | | |
|-------------------|-------------------|
| a) 20, 20, 20, 20 | c) 40, 40, 0, 0 |
| b) 0, 0, 50, 50 | d) 50, 50, 50, 50 |

19) Consider two engines P and Q. In P, the high pressure turbine blades are cooled with a bleed of 5% from the compressor after the compression process and in Q the turbine blades are not cooled. Comparing engine P with engine Q, which one of the following is NOT TRUE? (GATE AE 2013)

- Turbine inlet temperature is higher for engine P
- Specific thrust is higher for engine P
- Compressor work is the same for both P and Q
- Fuel flow rate is lower for engine P

20) The mass flow rate of air through an aircraft engine is 10 kg/s. The compressor outlet temperature is 400 K and the turbine inlet temperature is 1800 K. The heating value of the fuel is 42 MJ/kg and the specific heat at constant pressure is 1 kJ/kg-K. The mass flow rate of the fuel in kg/s is approximately _____ (GATE AE 2013)

21) For a given inlet condition, if the turbine inlet temperature is fixed, what value of compressor efficiency given below leads to the lowest amount of fuel added in the combustor of a gas turbine engine? (GATE AE 2013)

- | | |
|---------|---------|
| a) 1 | c) 0.85 |
| b) 0.95 | d) 0.8 |

22) A gas turbine engine is mounted on an aircraft which can attain a maximum altitude of 11 km from sea level. The combustor volume of this engine is decided based on conditions at _____ (GATE AE 2013)

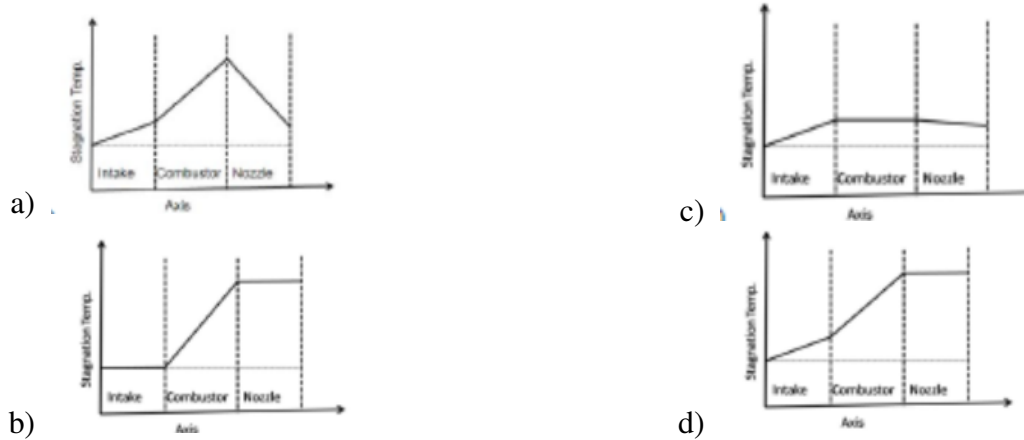
- | | |
|------------------|--------------------|
| a) sea level | c) 5.5 km altitude |
| b) 8 km altitude | d) 11 km altitude |

23) Consider the low earth orbit (LEO) and the geo synchronous orbit (GSO). Then (GATE AE 2013)

- ΔV requirement for launch to LEO is greater than that for GSO, and altitude of LEO is lower than that of GSO
- ΔV requirement for launch to LEO is lower than that for GSO, and altitude of LEO is lower than that of GSO

- c) ΔV requirement for launch to LEO is greater than that for GSO, and altitude of LEO is greater than that of GSO
 d) ΔV requirement for launch to LEO is lower than that for GSO, and altitude of LEO is greater than that of GSO

24) Which one of the following shows the CORRECT variation of stagnation temperature along the axis of an ideal ram jet engine? (GATE AE 2013)



25) A rocket motor has a chamber pressure of 100 bar and chamber temperature of 3000 K. The ambient pressure is 1 bar. Assume that the specific heat at constant pressure is 1 kJ/kg-K. Also assume that the flow in the nozzle is isentropic and optimally expanded. The exit static temperature in K is _____ (GATE AE 2013)

- a) 805
 b) 845
 c) 905
 d) 945

26) Let

$$I = \iint_S (y^2 \hat{i} + x^2 \hat{j} + x^2 y \hat{k})(x \hat{i} + y \hat{j} + z \hat{k}) dS,$$

where S denotes the surface of the sphere of unit radius centered at the origin. Here $\hat{i}, \hat{j}, \hat{k}$ denote three orthogonal unit vectors. The value of I is _____ (GATE AE 2013)

- a) 0
 b) $\frac{4\pi}{3}$
 c) $\frac{8\pi}{3}$
 d) 4π

27) Given that the Laplace transform,

$$\mathcal{L}(e^{at}) = \frac{1}{s-a},$$

then

$$\mathcal{L}(3e^{5t} \sinh 5t) =$$

(GATE AE 2013)

- a) $\frac{3s}{s^2 - 10s}$
 b) $\frac{3s}{s^2 - 10s}$
 c) $\frac{3s}{s^2 + 10s}$
 d) $\frac{3s}{s^2 + 10s}$

28) Values of a, b, c which render the matrix

$$Q = \begin{pmatrix} \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{2}} & a \\ \frac{1}{\sqrt{3}} & 0 & b \\ \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{2}} & c \end{pmatrix}$$

orthonormal are, respectively

(GATE AE 2013)

a) $\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0$

c) $\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$

b) $\frac{1}{\sqrt{6}}, -\frac{2}{\sqrt{6}}, \frac{1}{\sqrt{6}}$

d) $-\frac{1}{\sqrt{6}}, \frac{2}{\sqrt{6}}, -\frac{1}{\sqrt{6}}$

29) A function $y(t)$ satisfies the differential equation

$$\frac{d^2y}{dt^2} - 2\frac{dy}{dt} + y = 0$$

and is subject to the initial conditions $y(t = 0) = 0$ and $\frac{dy}{dt}(t = 0) = 1$. The value of $y(t = 1)$ is

(GATE AE 2013)

a) e

c) 1

b) 0

d) -1

30) A glider is launched from a 500 m high hilltop. Following data is available for the glider. Zero lift drag coefficient $C_{D0} = 0.02$, aspect ratio $AR = 10$ and Oswald efficiency factor $e = 0.95$. The maximum range of the glider in km is _____ (GATE AE 2013)

31) Which one of the following criteria leads to maximum turn rate and minimum radius in a level turn flight? (GATE AE 2013)

a) Highest possible load factor and highest possible velocity

b) Lowest possible load factor and lowest possible velocity

c) Highest possible load factor and lowest possible velocity

d) Lowest possible load factor and highest possible velocity

32) Consider an airplane with rectangular straight wing at dihedral angle $\Gamma = 10^\circ$. Lift curve slope of wing airfoil section (constant over the whole span of the wing) is $c_{\ell\alpha} = 5.4/\text{rad}$. The roll stability derivative, $C_{\ell\beta}$ in per radian is _____ (GATE AE 2013)

33) Consider one-dimensional isentropic flow at a Mach number of 0.5. If the area of cross-section of a streamtube increases by 3% somewhere along the flow, the corresponding percentage change in density is _____ (GATE AE 2013)

34) The potential flow model for a storm is represented by the superposition of a sink and a vortex. The stream function in the (r, θ) system is

$$\psi = -\frac{\Delta}{2\pi} r + \frac{\Gamma}{2\pi} \ln r,$$

where $\Delta = -\Gamma = 100 \text{ m}^2/\text{s}$. Assume a constant air density of 1.2 kg/m^3 . The gauge pressure at a distance of 100 m from the storm eye is (GATE AE 2013)

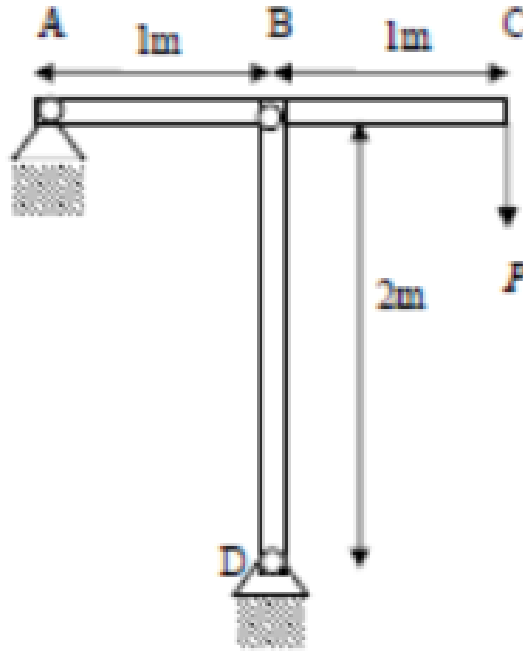


Fig. 7

(GATE AE 2013)

- 42) The thin rectangular plate has dimensions $L \times b \times t$. It develops a stress field corresponding to an applied bending moment M as shown in the figure. A valid Airy's stress function is

(GATE AE 2013)

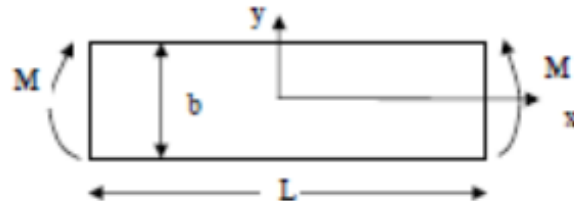


Fig. 8

- | | |
|-------------------------|---------------------------------|
| a) $\frac{2M}{tb^3}x^3$ | c) $\frac{2M}{tb^3}(x^3 + y^3)$ |
| b) $\frac{2M}{tb^3}y^3$ | d) $\frac{2M}{tb^3}y^4$ |

- 43) A cantilever beam of negligible mass is 0.6 m long. It has a rectangular cross-section of width 8 mm and thickness 6 mm and carries a tip mass of 1.4 kg. If the natural frequency of this system is 10 rad/s, Young's modulus of the material of the beam in GPa is _____. (GATE AE 2013)
- 44) A simply supported beam with overhang is loaded by uniformly distributed load of intensity q as shown in the figure. The bending moment at the mid-point of AB is (GATE AE 2013)

- | | |
|------------------------------|-------------------------------|
| a) $\frac{qL^2}{16}$ sagging | c) $\frac{3qL^2}{16}$ hogging |
| b) $\frac{qL^2}{16}$ hogging | d) $\frac{3qL^2}{16}$ sagging |

- 45) Thrust of liquid oxygen-liquid hydrogen rocket engine is 300 kN. The O/F ratio used is 5. If the fuel mass flow rate is 12.5 kg/s, the specific impulse of the rocket motor in Ns/kg is
(GATE AE 2013)
- a) 3800 c) 4200
b) 4000 d) 4400
- 46) In a 50% reaction axial compressor stage, the local blade velocity is 300 m/s and the axial component of velocity is 100 m/s. If the absolute inlet flow angle $\alpha_1 = 45^\circ$, the work per unit mass done on the fluid by the stage in kJ/kg is
(GATE AE 2013)
- a) 30 c) 50
b) 40 d) 60
- 47) Consider two rockets P and Q fired vertically up with identical specific impulse and a payload of 2 kg. Rocket P has 2 identical stages, and each stage has 200 kg of propellant and 20 kg of structural weight. Rocket Q has a single stage with 400 kg of propellant and 40 kg of structural weight. Neglecting drag and gravity effects, the ratio of the change in velocity of P to that attained by Q is
(GATE AE 2013)
- a) 1.13 c) 1.33
b) 1.23 d) 1.43

Common Data for Questions 48 and 49:

Data for an airplane are given as follows: weight $W = 30$ kN, thrust available at sea-level $T_a = 4000$ N, wing planform area $S = 30$ m², maximum lift coefficient $C_{L_{max}} = 1.4$, and drag coefficient $C_D = 0.015 + 0.024C_L^2$. Assume air density at sea-level $\rho_\infty = 1.22$ kg/m³.

- 48) Stall speed of the airplane in m/s is _____ (GATE AE 2013)
- a) 17.36 c) 45.52
b) 34.22 d) 119.46
- 49) Minimum and maximum speeds of the airplane in level flight condition at sea-level in m/s are respectively _____ (GATE AE 2013)
- a) 17.36 and 180 c) 34.22 and 119.46
b) 17.36 and 34.22 d) 17.36 and 119.46

Common Data for Questions 50 and 51:

An aircraft is flying at Mach number $M = 1.5$, where the ambient temperature is 250 K . The stagnation temperature of gases at the entry to the nozzle is 800 K . The nozzle is choked and always under expanded. Assume the molecular weight of the exhaust gases to be 29, the ratio of specific heats to be 1.4 and the universal gas constant is $8314\text{ J/kmol} \cdot \text{K}$.

- 50) For which one of the nozzle exit Mach numbers given below is the propulsive efficiency highest?
(GATE AE 2013)
- a) 1 c) 2
b) 1.5 d) 2.5
- 51) For which one of the nozzle exit Mach numbers given below is the thrust highest?
(GATE AE 2013)

- a) USA and Japan
- b) USA and Australia
- c) England and France
- d) Japan and Australia

64) If $|-2X + 9| = 3$ then the possible value of $|-X| - X^2$ would be:

(GATE AE 2013)

- a) 30
- b) -30
- c) -42
- d) 42

65) All professors are researchers.

Some scientists are professors.

Which of the given conclusions is logically valid and is inferred from the above arguments:

(GATE AE 2013)

- a) All scientists are researchers
- b) All professors are scientists
- c) Some researchers are scientists
- d) No conclusion follows

END OF THE QUESTION PAPER