GATE - AE - 2009 - 37 - 48

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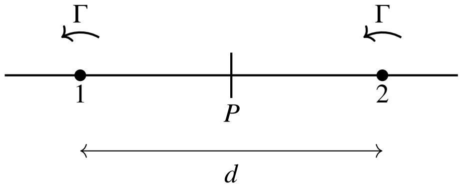
1) Two vortices of the same strength and sign are placed a distance d apart as shown below. Assume that the vortices are free to move and the fluid is ideal.



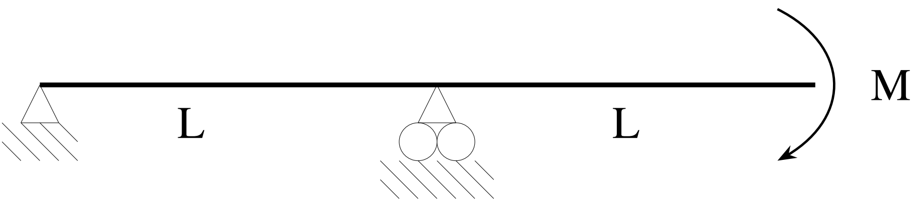
Which of the following statements is true? (GATE AE 2009)

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 $\frac{\Gamma}{\pi d^2}$.

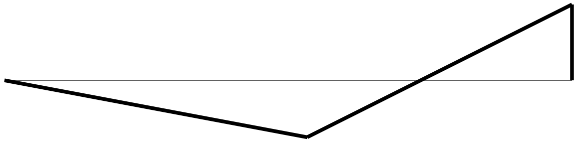
2) The laminar boundary layer over a large flat plate held parallel to the flow is 7.2 mm thick at a point 0.33 m downstream of the leading edge. If the free stream speed is increased by 50%, then the new boundary layer thickness at this location will be approximately (GATE AE 2009)

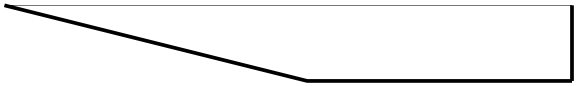
a) 10.8 mm b) 8.8 mm c) 5.9 mm d) 4.8 mm

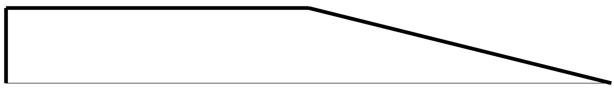
3) Consider a simply supported beam of length $2L$ with an overhang of length L, loaded by an end moment M, as shown below.

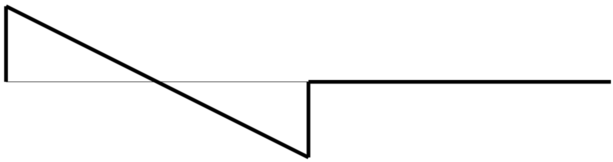


The bending moment distribution for this beam is (GATE AE 2009)

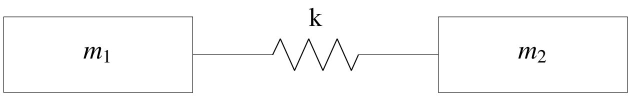
a) 

b) 

c) 

d) 

4) For the spring-mass system shown below, the natural frequencies are (GATE AE 2009)



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

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

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

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

5) The buckling load for a simply supported column of rectangular cross section of dimensions 1 cm × 1.5 cm and length 0.5 m made of steel ($E = 210 \times 10^9$ N/m^2) is approximately (GATE AE 2009)

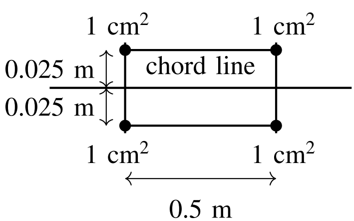
a) 10 kN

b) 4 kN

c) 23 kN

d) 46 kN

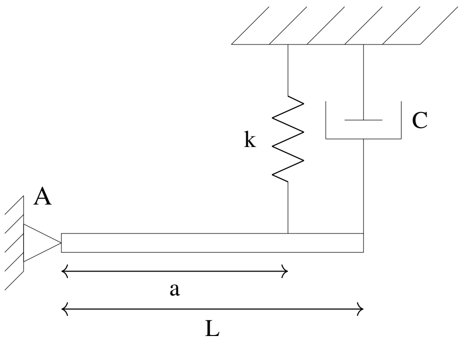
6) A wing root cross section is idealized using lumped areas (booms) as shown below.



The wing root bending moment in steady level flight is $M_y = 10\,\text{N-m}$. If the airplane flies at a load factor $n = 3.5$, the maximum bending stress at the root is: (GATE AE 2009)

a) $1 \times 10^6\,\text{N/m}^2$ b) $3.5 \times 10^6\,\text{N/m}^2$ c) $7 \times 10^6\,\text{N/m}^2$ d) $0.286 \times 10^6\,\text{N/m}^2$

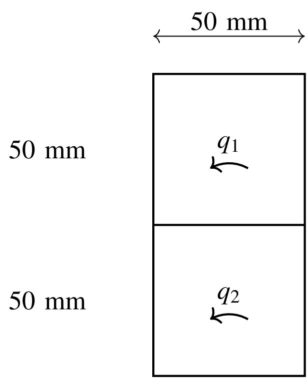
7) A uniform rigid bar of mass $m = 1\,\text{kg}$ and length $L = 1\,\text{m}$ is pivoted at A. It is supported by a spring of stiffness $k = 1\,\text{N/m}$ and a viscous damper of damping constant $C = 1\,\text{N-s/m}$, with $a = \frac{1}{\sqrt{3}}\,\text{m}$ as shown below. The moment of inertia of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



The system is: (GATE AE 2009)

a) Overdamped
b) Underdamped with natural frequency $\omega_n = 1\,\text{rad/s}$
c) Critically damped
d) Underdamped with natural frequency $\omega_n = 2\,\text{rad/s}$

8) 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.



The torque balance equation (Bredt-Batho formula) for this section leads to: (GATE AE 2009)

a) $q_1 - q_2 = 2000\,\text{N/m}$
b) $q_1 + 2q_2 = 2000\,\text{N/m}$
c) $q_1 + q_2 = 2000\,\text{N/m}$
d) $2q_1 + q_2 = 2000\,\text{N/m}$

9) 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

10) 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

11) In the interval $1 \leq x \leq 2$, the function $f(x) = e^{\pi x} + \sin \pi x$ is (GATE AE 2009)

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

12) 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) $\frac{5}{7}e^{4t} + \frac{6}{7}e^{-3t}$