Gate AE-2023

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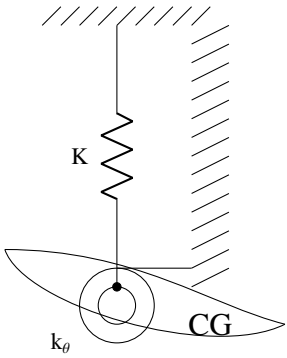
27) Which of the following statement (s) is/are true about the ribs of an airplane wing with semi-monocoque construction?
   a) For a rectangular planform wing, the dimensions of the ribs DO NOT depend on their spanwise position in the wing.
   b) Ribs increase the column buckling stress of longitudinal stiffeners connected to them.
   c) Ribs increase plate buckling stress of the skin panels.
   d) Ribs help in maintaining aerodynamic shape of the wing.

28) From the options given, select all that are true for turbofan engines with afterburners.
   a) Turning afterburner ON increases specific fuel consumption.
   b) Turbofan engines with afterburners have variable area nozzles.
   c) Turning afterburner ON decreases specific fuel consumption.
   d) Turning afterburner ON increases stagnation pressure across the engine.

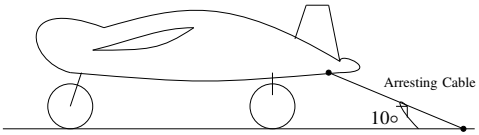
29) Which of the following statement (s) is/are true with respect to eigenvalues and eigenvectors of a matrix?
   a) The sum of the eigenvalues of a matrix equals the sum of the elements of the principal diagonal.
   b) If λ is an eigenvalue of a matrix A $\frac{1}{\lambda}$ is always an eigenvalue of its transpose $\left(A^T\right)$.
   c) If λ is an eigenvalue of an orthogonal matrix A $\frac{1}{\lambda}$ is always an eigenvalue of A.
   d) If a matrix has n distinct eigenvalues, it also has n independent eigenvectors.

30) For studying wing vibrations, a wing of mass M and finite dimensions has been idealized by assuming it to be supported using a linear spring of equivalent stiffness k and a torsional spring of equivalent stiffness k_θ as shown in the figure. The centre of gravity(CG) of the wing idealized as an airfoil is marked in the figure. The number of degree (s) of freedom for this idealized wing vibration model is _____. (Answer in integer)



31) The system of equations
$x - 2y + \alpha z = 0$
$2x + y - 4z = 0$
$x - y + z = 0$
has a non-trivial solution for $\alpha =$ _____. (Answer in integer)

32) An airplane weighing $40kN$ is landing on a horizontal runway during which it is retarded by an arresting cable mechanism. The tension in the arresting cable at a given instant, as shown in the figure, is $100kN$. Assuming that the thrust from the engine continues to balance airplane drag, the magnitude of horizontal load factor is _____. (round off to one decimal place)



33) The ratio of the speed of sound in $H_2\left(\text{ molecular weight } 2\frac{kg}{kmol}\right)$ to that in $N_{2\left(\text{ molecular weight } 28\frac{kg}{kmol}\right)}$ at temperature 300 K and pressure 2 bar is _____. (round off to two decimal place)

34) Airplane A and Airplane B are cruising at altitudes of $2km$ and $4km$,respectively. The free stream density and static pressure at altitude $2km$ are $1.01\frac{kg}{m^3}$ and $79.50kPa$ respectively, and at altitude $4km$ they are $0.82\frac{kg}{m^3}$ and $61.70kPa$, respectively. The differential pressure reading from the pitot-static tubes is $3kpa$ a for both the airplanes. Assuming incompressible flow, the ratio of cruise speeds of Airplane A to Airplane B is _____. (round off to two decimal place)

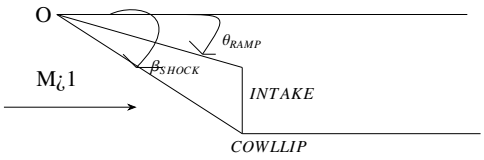
35) A supersonic vehicle powered by a ramjet engine is cruising at a speed of $1000\frac{m}{s}$ The ramjet engine burns hydrogen in a subsonic combustor to produce thrust. The

heat of combustion for hydrogen is $120\frac{MJ}{kg}$. The overall efficiency of the engine η_0, defined as the ratio of propulsive power to the total heat release in the combustor, is 40% Taking acceleration due to gravity $g_0 = 10\frac{m}{s^2}$, the specific impulse of the engine is _____. seconds (round off to two decimal place)

36) Given the function $y(x) = (x+3)(x-2)$, for $-4 < x < 4$. What is the value of x at which the function has a minimum?

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

37) A supersonic aircraft has an air intake ramp that can be rotated about the leading edge O such that the shock from the leading edge meets the cowl lip as shown in the figure. Select all the correct statement(s) as per oblique shock theory when the flight Mach number M is increased.



a) It is always possible to find a ramp setting θ_{RAMP} such that the shock still meets the cowl lip (β_{SHOCK} remains the same).
b) if θ_{RAMP} is held fixed, the shock angle β_{SHOCK} will increase
c) If M exceeds a critical value, it would NOT be possible to find a ramp setting θ_{RAMP} such that the shock still meets the cowl lip (β_{SHOCK} remains the same).
d) Shock angle $\beta_{SHOCK} < \sin^{-1}\left(\frac{1}{M}\right)$

38) Two missiles A and B powered by solid rocket motors have identical specific impulse, liftoff mass of 5600kg each, and burn durations of $t_A = 30s$ and $t_B = 70s$. The propellant mass flow rates $\dot{m}_A$ and $\dot{m}_B$, for missiles A and B, respectively, are given by
$\dot{m}_A = 120\frac{kg}{s}, 0 \le t \le 30$
$\dot{m}_B = 70\frac{kg}{s}, 0 \le t \le 70$
Neglecting gravity and aerodynamic forces, the relationship between the final velocities V_A and V_B of missiles A and B, respectively, is given by
a) $V_A = 4.1V_B$
b) $V_A = V_B$
c) $V_A = 0.5V_B$
d) $V_A = 0.7V_B$

39) A perfect gas stored in a large reservoir exhausts into the atmosphere through a convergent duct. The reservoir pressure is P_0 and temperature is T_0. The jet emerges

from the nozzle at choked conditions with average velocity u, Mach number M, pressure p, temperature T, and density ρ. If the reservoir pressure is increased, then

a) u, M, p, T, and ρ increase
b) u, p, T, and ρ increase, but M remains the same
c) u, M, and T remain the same, but p and ρ increase
d) u, M, T, and ρ remain the same, but p increase