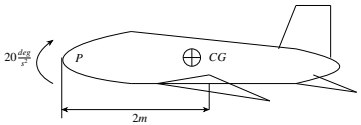
2019-AE-40-52

EE24BTECH11006 - Arnav Mahishi

1) The airplane shown in figure starts executing a symmetric pull-up maneuver from steady level attitude with a constant nose-up pitch acceleration of $20\frac{deg}{s^2}$. The vertical load factor measured at this instant at the centre of gravity (CG) is 2. Given that the acceleration due to gravity is $9.81\frac{m}{s^2}$, the vertical load factor measured at point P on the nose of the airplane, which is 2 m ahead of the CG, is _____ (round off to 2 decimal places).



2) Consider an airplane with a weight of 8000 N, wing area of $16m^2$, wing zero-lift drag coefficient of 0.02, Oswald's efficiency factor of 0.8, and wing aspect ratio of 6, in steady level flight with wing lift coefficient of 0.375. Considering the same flight speed and ambient density, the ratio of the induced drag coefficient during steady level flight to that during a 30° climb is _____(round off to 2 decimal places).

3) The product of earth's mass (M) and the universal gravitational constant (G) is $GM = 3.986 \times 10^{14}\frac{m^3}{s^2}$. The radius of earth is $6371km$. The minimum increment n the velocity to be imparted to a spacecraft flying in a circular orbit around the earth at an altitude of $4000km$ to make it exit earth's gravitational field is _____$\frac{km}{s}$ (round off to 2 decimal places).

4) A propeller driven airplane has a gross take-off weight of 4905 N with a wing area of $6.84m^2$. Assume that the wings are operating at the maximum $\frac{C_L^{\frac{3}{2}}}{C_D}$, of 13, the propeller efficiency is 0.9 and the specific fuel consumption of the engine is $0.76\frac{kg}{kW-hr}$. Given that the density of air at sea level is $1.225\frac{kg}{m^3}$ and the acceleration due to gravity is $9.81\frac{m}{s^2}$, the weight of the fuel required for an endurance of 18 hours at sea level is _____(round off to the nearest integer).

5) The design of an airplane is modified to increase the vertical tail area by 20% and decrease the moment arm from the aerodynamic centre of the vertical tail to the airplane centre of gravity by 20%. Assuming all other factors remain unchanged, the ratio of the modified to the original directional static stability $\left(C_{N_\beta}, \text{ due to tail fin}\right)$ is _____ (round of to two decimal places)

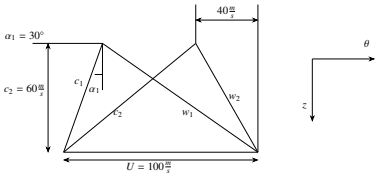
6) For a rocket engine, the velocity ratio r is $\frac{V_a}{V_e}$, where V_a is the vehicle velocity and V_e is the exit velocity of the exhaust gases. Assume the flow to be optimally

expanded through the nozzle. For $r = 2$, if F is the thrust produced and m is the mass flow rate of exhaust gases, then, $\frac{F}{mV_e}$ is _____

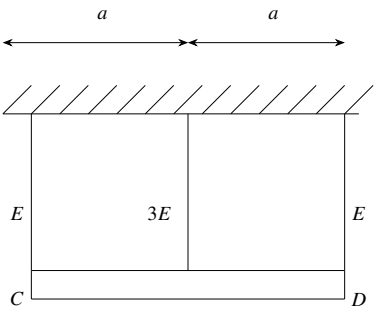
7) The specific impulse of a rocket engine is $3000\frac{Ns}{kg}$.The mass of the rocket at burnout is 1000kg. The propellant consumed in the process is 720 kg. Assume all factors contributing to velocity loss to be negligible.The change in vehicle velocity δu is _____ $\frac{km}{s}$ (round off to 2 decimal places).

8) The combustion products of a gas turbine engine can be assumed to be a calorically perfect gas with $\gamma = 1.2$. The pressure ratio across the turbine stage is 0.14. The measured turbine inlet and exit stagnation temperatures are 1200 K and 900 K, respectively. The total-to-total turbine efficiency is _____% (round off to the nearest integer).

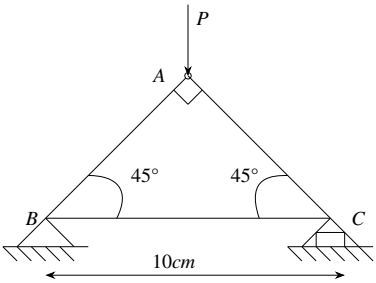
9) The figure shows the velocity triangles for an axial compressor stage. The specific work input to the compressor stage is _____$\frac{kJ}{kg}$ (round of to 2 decimal places).



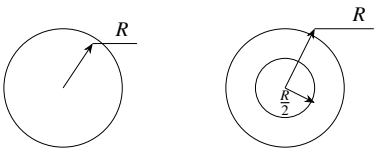
10) As shown in the figure, a rigid slab CD of weight W (distributed uniformly along its length) is hung from a ceiling using three cables of identical length and cross-sectional area. The central cable is made of steel (Young's modulus = 3E) and the other two cables are made of aluminium (Young's modulus=E). The percentage of the total weight taken by the central cable is _____% (round off to the nearest integer)



11) All the bars in the given truss are elastic with Young's modulus 200GPa, and have identical cross-sections with moment of inertia 0.1cm. The lowest value of the load P at which the truss fails due to buckling is _____KN (round off to the nearest integer).



12) A solid circular shaft is designed to transmit a torque T with a factor of safety of 2. It is proposed to replace the solid shaft by a hollow shaft of the same material and identical outer radius. If the inner radius is half the outer radius, the factor of safety for the hollow shaft is _____(round off to 1 decimal place).



13) In the structure shown in the figure, bars AB and BC are made of identical material and have circular cross-sections of 10mm radii. The yield stress of the material under uniaxial tension is 280MPa. Using the von Mises yield criterion, the maximum load along the z-direction (perpendicular to the plane of paper) that can be applied at C, such that AB does not yield is N (round off to the nearest integer).