GATE Aerospace Engineering

Sample Paper – 1

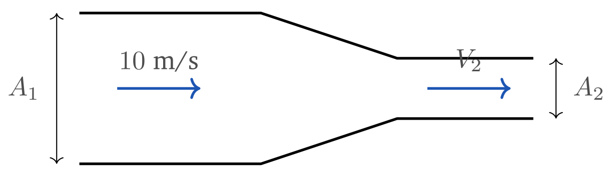
Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Aerospace Engineering** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise, take air as a perfect gas with $\gamma = 1.4$ and $R = 287$ J/kg · K, $g = g_0 = 9.81$ m/s^2, and standard Earth gravitational parameter $\mu = 3.986 \times 10^{14}$ m^3/s^2.

Aerodynamics

Q1. Air flows steadily and incompressibly through the converging duct shown. At the inlet the cross-sectional area is 0.20 m^2 and the mean velocity is 10 m/s. At the outlet the area is 0.05 m^2. By continuity, the mean velocity at the outlet is: **[1 mark]**



(A) 40 m/s

(B) 2.5 m/s

(C) 20 m/s

(D) 8 m/s

Q2. In the low-speed flow of air ($\rho = 1.225$ kg/m^3) over an airfoil, the freestream velocity is 50 m/s and, at a point on the upper surface, the local velocity is 70 m/s. Using Bernoulli's equation, the static pressure at that point, relative to the freestream static pressure, is: **[1 mark]**

(A) lower by 2940 Pa

(B) lower by 735 Pa

(C) lower by 1470 Pa

(D) higher by 1470 Pa

Q3. An aircraft flies at a true airspeed of 100 m/s at sea level, where the air density is 1.225 kg/m^3. The freestream dynamic pressure is: **[1 mark]**

(A) 12250 Pa

(B) 3062.5 Pa

(C) 6125 Pa

(D) 5000 Pa

Q4. An aircraft of weight 20,000 N with a wing planform area of 16 m^2 is in steady, level flight at a speed of 50 m/s at sea level ($\rho = 1.225$ kg/m^3). The lift coefficient required is nearest to: **[1 mark]**

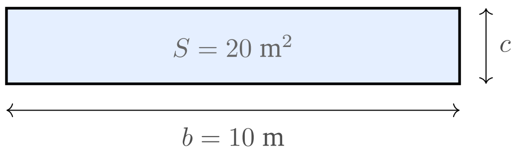
(A) 0.82

(B) 0.41

(C) 1.63

(D) 0.51

Q5. The rectangular wing planform shown has a span of 10 m and a planform area of 20 m^2. The aspect ratio of the wing is: **[1 mark]**



(A) 10

(B) 2

(C) 5

(D) 20

Q6. A finite wing has an aspect ratio of 8, an Oswald span efficiency factor of 0.90 and operates at a lift coefficient of 0.80. The induced-drag coefficient of the wing is nearest to: **[1 mark]**

(A) 0.0227

(B) 0.0283

(C) 0.0361

(D) 0.0180

Q7. At a certain altitude the static air temperature is 250 K. Taking $\gamma = 1.4$ and $R = 287$ J/kg $\cdot$ K, the local speed of sound is nearest to: **[1 mark]**

(A) 295.0 m/s

(B) 340.3 m/s

(C) 300.0 m/s

(D) 316.9 m/s

Q8. A perfect gas ($\gamma = 1.4$) flows at a Mach number of 2.0 with a static temperature of 250 K. The stagnation (total) temperature of the flow is: **[1 mark]**

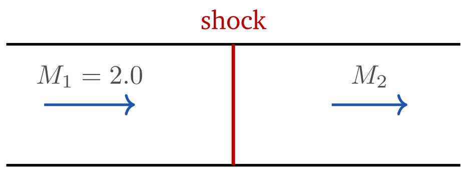
(A) 300 K

(B) 500 K

(C) 450 K

(D) 350 K

Q9. A normal shock stands in the duct shown, with an upstream Mach number of 2.0 in air ($\gamma = 1.4$). The Mach number of the flow just downstream of the shock is nearest to: **[1 mark]**



(A) 0.577

(B) 0.707

(C) 0.333

(D) 0.816

Q10. A laminar boundary layer develops over a flat plate held parallel to the flow. At a station where the local Reynolds number is 10^6 and the distance from the leading edge is $x = 1$ m, the Blasius boundary-layer thickness $\left(\delta = 5x/\sqrt{Re_x}\right)$ is: **[1 mark]**

(A) 10 mm

(B) 5 mm

(C) 2.5 mm

(D) 0.5 mm

Q11. A model of chord 0.5 m is tested in a wind tunnel at a speed of 30 m/s in air of density 1.225 kg/m^3 and dynamic viscosity 1.8×10^{-5} Pa $\cdot$ s. The Reynolds number based on the chord is nearest to: **[1 mark]**

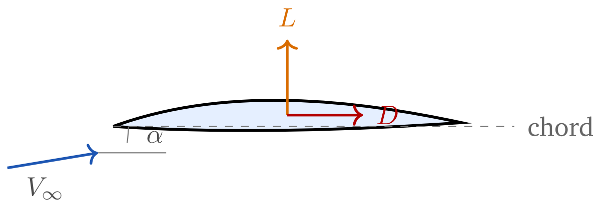
(A) 5.1×10^5

(B) 1.8×10^6

(C) 2.04×10^6

(D) 1.02×10^6

Q12. A thin symmetric airfoil is set at an angle of attack of 5° in a low-speed stream, as shown. Using the thin-airfoil result $c_\ell = 2\pi\alpha$ (with α in radians), the section lift coefficient is nearest to: **[1 mark]**



(A) 0.110

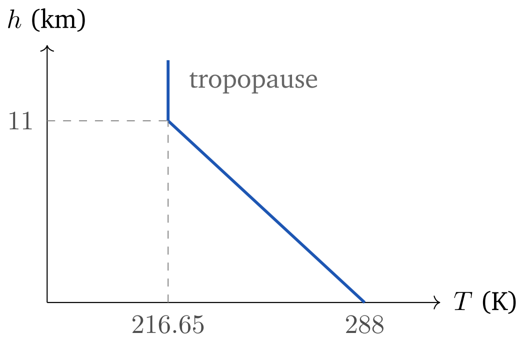
(B) 0.096

(C) 0.314

(D) 0.548

Flight Mechanics & Space Dynamics

Q13. In the International Standard Atmosphere (ISA), the sea-level temperature is 288.15 K and the tropospheric lapse rate is 6.5 K per km up to the tropopause at 11 km. The ISA temperature at 11 km, shown on the profile below, is: **[1 mark]**



(A) 223.15 K

(B) 216.65 K

(C) 255.65 K

(D) 288.15 K

Q14. An aircraft of weight $50{,}000$ N cruises in steady, level flight with a lift-to-drag ratio of 10. The thrust required from the engines is: **[1 mark]**

(A) $50{,}000$ N

(B) $500{,}000$ N

(C) $25{,}000$ N

(D) $5{,}000$ N

Q15. An aircraft of weight $25{,}000$ N has a wing area of 16 m^2 and a maximum lift coefficient of 1.5. At sea level ($\rho = 1.225$ kg/m^3), the stalling speed in level flight is nearest to: **[1 mark]**

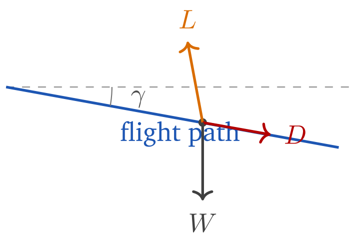
(A) 58.3 m/s

(B) 29.4 m/s

(C) 33.7 m/s

(D) 41.2 m/s

Q16. An aircraft descends in an unpowered, steady glide with a lift-to-drag ratio of 12, as shown by the free-body diagram. The glide (flight-path) angle below the horizontal is nearest to: **[1 mark]**



(A) $8.53°$

(B) $6.00°$

(C) $4.76°$

(D) $2.39°$

Q17. An aircraft with a best glide ratio (lift-to-drag ratio) of 15 loses power at a height of 2000 m above flat ground, in still air. The maximum horizontal distance it can glide is: **[1 mark]**

(A) 2 km

(B) 15 km

(C) 17 km

(D) 30 km

Q18. For an airplane to possess longitudinal static stability about its centre of gravity, the pitching-moment characteristics must satisfy: **[1 mark]**

(A) $\dfrac{dC_m}{d\alpha} < 0$ and $C_{m,0} > 0$

(B) $\dfrac{dC_m}{d\alpha} > 0$ and $C_{m,0} < 0$

(C) $\dfrac{dC_m}{d\alpha} > 0$ and $C_{m,0} > 0$

(D) $\dfrac{dC_m}{d\alpha} = 0$ and $C_{m,0} = 0$

Q19. An aircraft executes a steady, level (co-ordinated) turn at a constant bank angle of $60°$. The load factor $\left(n = 1/\cos\phi\right)$ acting on the aircraft is: **[1 mark]**

(A) 1.00

(B) 1.15

(C) 1.41

(D) 2.00

Q20. For a certain aircraft the neutral point lies at $0.40\,\bar{c}$ and the centre of gravity lies at $0.25\,\bar{c}$ from the leading edge of the mean aerodynamic chord $\bar{c}$. The static margin of the aircraft is: **[1 mark]**

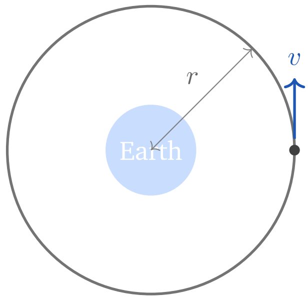
(A) 0.25

(B) 0.15

(C) 0.40

(D) 0.65

Q21. A satellite moves in a circular orbit of radius 7000 km about the Earth. Taking the Earth's gravitational parameter as $\mu = 3.986 \times 10^{14}$ m^3/s^2, the orbital speed of the satellite is nearest to: **[2 marks]**



(A) 7.55 km/s

(B) 7.91 km/s

(C) 11.2 km/s

(D) 10.7 km/s

Q22. Taking the Earth's radius as 6371 km and its gravitational parameter as $\mu = 3.986 \times 10^{14}$ m^3/s^2, the escape velocity from the surface of the Earth is nearest to: **[2 marks]**

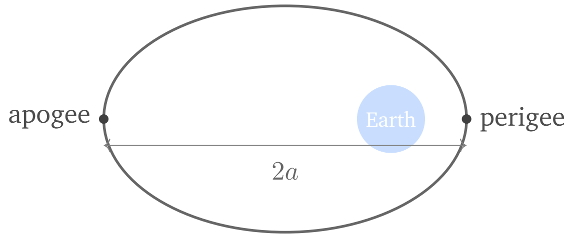
(A) 7.91 km/s

(B) 9.81 km/s

(C) 8.0 km/s

(D) 11.2 km/s

Q23. A satellite is in an elliptic orbit about the Earth (radius 6378 km) with a perigee altitude of 300 km and an apogee altitude of 3000 km, as shown. The semi-major axis of the orbit is: **[2 marks]**



(A) 16056 km

(B) 8028 km

(C) 6678 km

(D) 9378 km

Aerospace Structures

Q24. A straight bar of circular cross-section of diameter 25 mm carries an axial tensile load of 50 kN. The direct (normal) stress in the bar is nearest to: **[2 marks]**

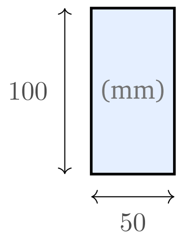
(A) 254.6 MPa

(B) 50.9 MPa

(C) 101.9 MPa

(D) 127.3 MPa

Q25. A beam has the solid rectangular cross-section shown (width 50 mm, depth 100 mm). At a section the bending moment is 5 kN·m. The maximum bending (flexural) stress at that section is: **[2 marks]**



(A) 30 MPa

(B) 120 MPa

(C) 60 MPa

(D) 90 MPa

Q26. A solid circular shaft of diameter 40 mm transmits a torque of 1 kN·m. The maximum torsional shear stress on the outer surface of the shaft is nearest to: **[2 marks]**

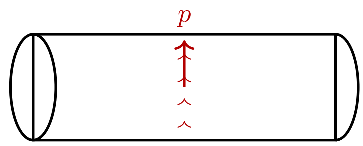
(A) 159.2 MPa

(B) 39.8 MPa

(C) 318.3 MPa

(D) 79.6 MPa

Q27. A thin-walled cylindrical pressure vessel of internal diameter 1 m and wall thickness 10 mm carries an internal gauge pressure of 2 MPa. The circumferential (hoop) stress in the wall is: **[2 marks]**



$d = 1$ m, $t = 10$ mm

(A) 100 MPa

(B) 50 MPa

(C) 200 MPa

(D) 25 MPa

Q28. A pin-ended (hinged–hinged) straight column of length 1 m has a second moment of area of 1×10^6 mm^4 about the buckling axis and is made of a material with Young's modulus 200 GPa. The Euler critical buckling load is nearest to: **[2 marks]**

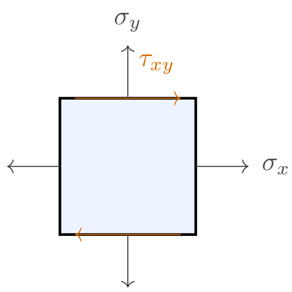
(A) 1974 kN

(B) 987 kN

(C) 493 kN

(D) 3948 kN

Q29. At a point in a loaded structural member the plane-stress components are $\sigma_x = 80$ MPa, $\sigma_y = 20$ MPa and $\tau_{xy} = 30$ MPa, as shown on the stress element. The major principal stress at the point is nearest to: **[2 marks]**



(A) 50.0 MPa

(B) 92.4 MPa

(C) 7.6 MPa

(D) 42.4 MPa

Q30. A prismatic bar of length 2 m and cross-sectional area 1000 mm^2 is made of a material with Young's modulus 200 GPa and carries a static axial load of 100 kN. The strain energy stored in the bar is: **[2 marks]**

(A) 100 J

(B) 50 J

(C) 25 J

(D) 75 J

Q31. A single-degree-of-freedom spring–mass system has a stiffness of 8000 N/m and a mass of 2 kg. The undamped natural frequency of the system is nearest to: **[2 marks]**

(A) 63.2 Hz

(B) 20.1 Hz

(C) 10.07 Hz

(D) 5.03 Hz

Q32. A thin-walled closed tube encloses an area of 0.01 m^2 and has a uniform wall thickness of 2 mm. It carries a torque of 500 N·m. Using the Bredt–Batho theory $\left(\tau = T/(2A_m t)\right)$, the shear stress in the wall is: **[2 marks]**

(A) 25.0 MPa

(B) 12.5 MPa

(C) 6.25 MPa

(D) 50.0 MPa

Q33. A cantilever beam of length 1 m carries a concentrated load of 1 kN at its free end. The beam has a flexural rigidity given by $E = 200$ GPa and $I = 1 \times 10^6$ mm^4. The vertical deflection at the free end $\left(\delta = PL^3/3EI\right)$ is nearest to: **[2 marks]**

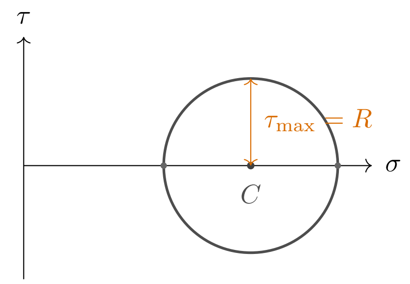
(A) 3.33 mm

(B) 1.67 mm

(C) 0.83 mm

(D) 5.00 mm

Q34. At a point in a thin skin the plane-stress components are $\sigma_x = 50$ MPa, $\sigma_y = 10$ MPa and $\tau_{xy} = 20$ MPa. Using the Mohr's-circle construction shown, the maximum in-plane shear stress at the point is nearest to: **[2 marks]**



(A) 28.3 MPa

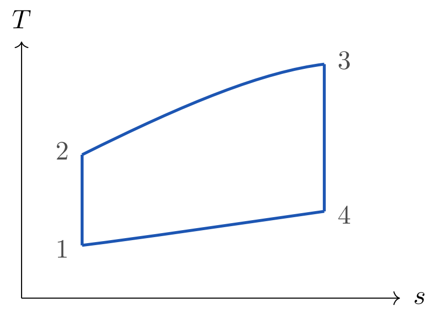
(B) 56.6 MPa

(C) 20.0 MPa

(D) 40.0 MPa

Propulsion

Q35. An ideal (air-standard) Brayton cycle operates with a compressor pressure ratio of 8 and $\gamma = 1.4$, as shown on the T–s diagram. The thermal efficiency of the cycle is nearest to: **[2 marks]**



(A) 50.0%

(B) 37.5%

(C) 44.8%

(D) 55.2%

Q36. A turbojet ingests air at a mass flow rate of 50 kg/s. The flight (inlet) velocity is 200 m/s and the exhaust jet velocity is 500 m/s. Neglecting the fuel mass flow and pressure-thrust terms, the net thrust is: **[2 marks]**

(A) 15 kN

(B) 25 kN

(C) 10 kN

(D) 35 kN

Q37. A jet engine produces a thrust of 10 kN while burning fuel at a rate of 0.5 kg/s. The thrust specific fuel consumption (TSFC) of the engine is: **[2 marks]**

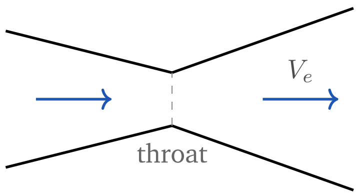
(A) 5×10^{-5} kg/(N · s)

(B) 2×10^{-4} kg/(N · s)

(C) 5×10^{-4} kg/(N · s)

(D) 2×10^{-5} kg/(N · s)

Q38. Air expands through the convergent–divergent nozzle shown. The stagnation temperature is such that the static temperature drop from the chamber to the exit is 200 K. Taking $c_p = 1005$ J/kg · K and negligible inlet velocity, the exit velocity $\left(V_e = \sqrt{2c_p\,\Delta T}\right)$ is nearest to: **[2 marks]**



(A) 449 m/s

(B) 897 m/s

(C) 634 m/s

(D) 317 m/s

Q39. Air ($\gamma = 1.4$) is expanded through a nozzle until the flow is just choked at the throat ($M = 1$). The ratio of the static pressure at the throat to the stagnation pressure, p^*/p_0, is nearest to: **[2 marks]**

(A) 0.634

(B) 0.528

(C) 0.833

(D) 0.487

Q40. In an axial-flow compressor stage the mean blade speed is 200 m/s and the whirl (tangential) component of the absolute velocity increases by 150 m/s across the rotor. Using the Euler turbomachinery equation, the specific work input to the air is: **[2 marks]**

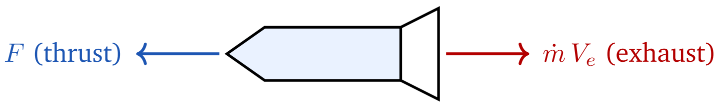
(A) 15 kJ/kg

(B) 30 kJ/kg

(C) 45 kJ/kg

(D) 60 kJ/kg

Q41. A rocket engine expels propellant at a mass flow rate of 100 kg/s with an effective exhaust velocity of 3000 m/s, as shown by the thrust free-body. For a perfectly expanded (pressure-matched) nozzle, the thrust produced is: **[2 marks]**



(A) 300 kN

(B) 200 kN

(C) 3000 kN

(D) 100 kN

Q42. A rocket nozzle produces an effective exhaust velocity of 2943 m/s. Taking $g_0 = 9.81$ m/s^2, the specific impulse of the rocket is: **[2 marks]**

(A) 288 s

(B) 350 s

(C) 300 s

(D) 250 s

Q43. A single-stage rocket has a specific impulse of 300 s (with $g_0 = 9.81$ m/s^2) and an initial-to-final mass ratio of 3. Using the Tsiolkovsky rocket equation, the ideal velocity increment Δv is nearest to: **[2 marks]**

(A) 2943 m/s

(B) 5886 m/s

(C) 8829 m/s

(D) 3233 m/s

Q44. A gas-turbine combustor burns a hydrocarbon fuel whose stoichiometric air–fuel ratio is 15. In operation the actual air–fuel ratio supplied is 20. The equivalence ratio of the mixture is: **[2 marks]**

(A) 1.33

(B) 0.75

(C) 1.00

(D) 0.50

Q45. A jet engine flies at 200 m/s and produces an exhaust jet of velocity 600 m/s. Using the ideal (Froude) propulsive efficiency $\left(\eta_p = 2V_0/(V_e + V_0)\right)$, the propulsive efficiency is: **[2 marks]**

(A) 0.50

(B) 0.75

(C) 0.25

(D) 1.00

Q46. Air enters the compressor of a gas-turbine engine at a stagnation temperature of 300 K and is compressed isentropically through a pressure ratio of 8 $(\gamma = 1.4)$. The compressor-exit stagnation temperature is nearest to: **[2 marks]**

(A) 300 K

(B) 480 K

(C) 600 K

(D) 543 K

Detailed Solutions

Q1.

Solution

Concept – steady incompressible continuity: For incompressible flow the volume flow rate is constant, so $A_1V_1 = A_2V_2$.

Step 1 – list the data: $A_1 = 0.20$ m^2, $V_1 = 10$ m/s, $A_2 = 0.05$ m^2.

Step 2 – write the continuity equation: $A_1V_1 = A_2V_2$

Step 3 – solve for V_2: $V_2 = \dfrac{A_1V_1}{A_2}$

Step 4 – substitute the numbers: $V_2 = \dfrac{0.20 \times 10}{0.05}$

Step 5 – evaluate the numerator: $0.20 \times 10 = 2.0$

Step 6 – divide: $V_2 = \dfrac{2.0}{0.05} = 40$ m/s

Final Answer: $V_2 = 40$ m/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept – Bernoulli's equation along a streamline: $p_\infty + \frac{1}{2}\rho V_\infty^2 = p + \frac{1}{2}\rho V^2$, so a faster local flow has a lower static pressure.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V_\infty = 50$ m/s, $V = 70$ m/s.

Step 2 – rearrange for the pressure change: $p - p_\infty = \frac{1}{2}\rho\left(V_\infty^2 - V^2\right)$

Step 3 – evaluate the squares: $V_\infty^2 = 50^2 = 2500$

$V^2 = 70^2 = 4900$

Step 4 – take the difference of squares: $V_\infty^2 - V^2 = 2500 - 4900 = -2400$

Step 5 – multiply by $\frac{1}{2}\rho$: $p - p_\infty = \frac{1}{2}(1.225)(-2400)$

$p - p_\infty = 0.6125 \times (-2400)$

$p - p_\infty = -1470$ Pa

Step 6 – interpret the sign: The pressure is 1470 Pa *lower* than the freestream pressure.

Final Answer: pressure lower by 1470 Pa $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept – dynamic pressure: $q = \frac{1}{2}\rho V^2$.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V = 100$ m/s.

Step 2 – square the velocity: $V^2 = 100^2 = 10000$

Step 3 – substitute into the formula: $q = \frac{1}{2}(1.225)(10000)$

Step 4 – multiply $\frac{1}{2}$ by the density: $\frac{1}{2} \times 1.225 = 0.6125$

Step 5 – complete the arithmetic: $q = 0.6125 \times 10000 = 6125$ Pa

Final Answer: $q = 6125$ Pa $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – lift equation in level flight: In steady level flight lift equals weight, $L = W = \frac{1}{2}\rho V^2 S\, C_L$, so $C_L = \dfrac{W}{\frac{1}{2}\rho V^2 S}$.

Step 1 – list the data: $W = 20000$ N, $\rho = 1.225$ kg/m^3, $V = 50$ m/s, $S = 16$ m^2.

Step 2 – compute the dynamic pressure: $q = \frac{1}{2}\rho V^2 = \frac{1}{2}(1.225)(50^2)$

$q = 0.6125 \times 2500$

$q = 1531.25$ Pa

Step 3 – multiply by the wing area: $q\,S = 1531.25 \times 16 = 24500$ N

Step 4 – divide the weight by qS: $C_L = \dfrac{20000}{24500}$

Step 5 – evaluate: $C_L = 0.816 \approx 0.82$

Final Answer: $C_L \approx 0.82 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – aspect ratio of a wing: $AR = \dfrac{b^2}{S}$, where b is the span and S the planform area.

Step 1 – list the data: $b = 10$ m, $S = 20$ m^2.

Step 2 – square the span: $b^2 = 10^2 = 100$ m^2

Step 3 – divide by the area: $AR = \dfrac{100}{20}$

Step 4 – evaluate: $AR = 5$

Final Answer: $AR = 5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept – induced-drag coefficient of a finite wing: $C_{D,i} = \dfrac{C_L^2}{\pi e\, AR}$.

Step 1 – list the data: $C_L = 0.80,\ e = 0.90,\ AR = 8.$

Step 2 – square the lift coefficient: $C_L^2 = 0.80^2 = 0.64$

Step 3 – form the denominator: $\pi e\, AR = \pi \times 0.90 \times 8$

$= 3.1416 \times 7.2$

$= 22.62$

Step 4 – divide: $C_{D,i} = \dfrac{0.64}{22.62}$

Step 5 – evaluate: $C_{D,i} = 0.0283$

Final Answer: $C_{D,i} \approx 0.0283 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept – speed of sound in a perfect gas: $a = \sqrt{\gamma R T}$.

Step 1 – list the data: $\gamma = 1.4,\ R = 287$ J/kg · K, $T = 250$ K.

Step 2 – form the product γR: $\gamma R = 1.4 \times 287 = 401.8$

Step 3 – multiply by the temperature: $\gamma R T = 401.8 \times 250 = 100450$

Step 4 – take the square root: $a = \sqrt{100450}$

$a = 316.9$ m/s

Final Answer: $a \approx 316.9$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – isentropic stagnation temperature: $\dfrac{T_0}{T} = 1 + \dfrac{\gamma - 1}{2}M^2$.

Step 1 – list the data: $\gamma = 1.4$, $M = 2.0$, $T = 250$ K.

Step 2 – evaluate $\dfrac{\gamma-1}{2}$**:** $\dfrac{1.4-1}{2} = \dfrac{0.4}{2} = 0.2$

Step 3 – square the Mach number: $M^2 = 2.0^2 = 4$

Step 4 – form the temperature ratio: $\dfrac{T_0}{T} = 1 + 0.2 \times 4 = 1 + 0.8 = 1.8$

Step 5 – multiply by the static temperature: $T_0 = 1.8 \times 250 = 450$ K

Final Answer: $T_0 = 450 \text{ K} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – downstream Mach number across a normal shock: $M_2^2 = \dfrac{1 + \frac{\gamma-1}{2}M_1^2}{\gamma M_1^2 - \frac{\gamma-1}{2}}$.

Step 1 – list the data: $\gamma = 1.4$, $M_1 = 2.0$, so $\frac{\gamma-1}{2} = 0.2$ and $M_1^2 = 4$.

Step 2 – evaluate the numerator: $1 + 0.2 \times 4 = 1 + 0.8 = 1.8$

Step 3 – evaluate the denominator: $\gamma M_1^2 = 1.4 \times 4 = 5.6$

$5.6 - 0.2 = 5.4$

Step 4 – form M_2^2**:** $M_2^2 = \dfrac{1.8}{5.4} = 0.3333$

Step 5 – take the square root: $M_2 = \sqrt{0.3333} = 0.577$

Final Answer: $M_2 \approx 0.577 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – Blasius laminar boundary-layer thickness: $\delta = \dfrac{5x}{\sqrt{Re_x}}$.

Step 1 – list the data: $x = 1$ m, $Re_x = 10^6$.

Step 2 – take the square root of the Reynolds number: $\sqrt{Re_x} = \sqrt{10^6} = 1000$

Step 3 – substitute into the formula: $\delta = \dfrac{5 \times 1}{1000}$

Step 4 – evaluate: $\delta = 0.005$ m

Step 5 – convert to millimetres: $\delta = 0.005 \times 1000 = 5$ mm

Final Answer: $\delta = 5$ mm $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q10**

Q11.

Solution

Concept – Reynolds number: $Re = \dfrac{\rho V L}{\mu}$.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V = 30$ m/s, $L = 0.5$ m, $\mu = 1.8 \times 10^{-5}$ Pa · s.

Step 2 – form the numerator $\rho V L$: $1.225 \times 30 = 36.75$

$36.75 \times 0.5 = 18.375$

Step 3 – divide by the viscosity: $Re = \dfrac{18.375}{1.8 \times 10^{-5}}$

Step 4 – evaluate: $Re = 1.0208 \times 10^6$

$Re \approx 1.02 \times 10^6$

Final Answer: $Re \approx 1.02 \times 10^6 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q11**

Q12.

Solution

Concept – thin-airfoil lift coefficient: $c_\ell = 2\pi\alpha$, with the angle of attack α expressed in *radians*.

Step 1 – list the data: $\alpha = 5^\circ$.

Step 2 – convert the angle to radians: $\alpha = 5 \times \dfrac{\pi}{180}$

$\alpha = 5 \times 0.017453$

$\alpha = 0.08727$ rad

Step 3 – multiply by 2π: $c_\ell = 2\pi \times 0.08727$

$c_\ell = 6.2832 \times 0.08727$

Step 4 – evaluate: $c_\ell = 0.548$

Step 5 – note the common trap: Using 5° directly in the formula (without converting to radians) gives the wrong answer; the angle must be in radians.

Final Answer: $c_\ell \approx 0.548 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept – ISA temperature in the troposphere: $T(h) = T_0 - Lh$, where $T_0 = 288.15$ K and $L = 6.5$ K/km.

Step 1 – list the data: $T_0 = 288.15$ K, $L = 6.5$ K/km, $h = 11$ km.

Step 2 – compute the total temperature drop: $Lh = 6.5 \times 11 = 71.5$ K

Step 3 – subtract from the sea-level value: $T = 288.15 - 71.5$

$T = 216.65$ K

Step 4 – interpret: This is the ISA tropopause temperature, held constant from 11 km up to 20 km.

Final Answer: $T = 216.65$ K $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – thrust in steady level flight: Level flight needs $L = W$ and $T = D$. Since L/D is given, $T = D = \dfrac{L}{L/D} = \dfrac{W}{L/D}$.

Step 1 – list the data: $W = 50000$ N, $L/D = 10$.

Step 2 – set lift equal to weight: $L = W = 50000$ N

Step 3 – divide by the lift-to-drag ratio: $T = \dfrac{50000}{10}$

Step 4 – evaluate: $T = 5000$ N

Final Answer: $T = 5000$ N $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q14

Q15.

Solution

Concept – stalling speed: At the stall the lift coefficient is at its maximum, so $W = \frac{1}{2}\rho V_s^2 S\, C_{L,\max}$, giving $V_s = \sqrt{\dfrac{2W}{\rho S\, C_{L,\max}}}$.

Step 1 – list the data: $W = 25000$ N, $\rho = 1.225$ kg/m^3, $S = 16$ m^2, $C_{L,\max} = 1.5$.

Step 2 – form the numerator $2W$: $2W = 2 \times 25000 = 50000$

Step 3 – form the denominator $\rho S\, C_{L,\max}$: $1.225 \times 16 = 19.6$

$19.6 \times 1.5 = 29.4$

Step 4 – divide: $\dfrac{50000}{29.4} = 1700.7$

Step 5 – take the square root: $V_s = \sqrt{1700.7} = 41.24$ m/s

Final Answer: $V_s \approx 41.2$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – glide angle in an unpowered descent: For a steady glide the flight-path angle satisfies $\tan\gamma = \dfrac{1}{L/D}$.

Step 1 – list the data: $L/D = 12$.

Step 2 – form the tangent of the glide angle: $\tan\gamma = \dfrac{1}{12} = 0.08333$

Step 3 – take the inverse tangent: $\gamma = \tan^{-1}(0.08333)$

Step 4 – evaluate: $\gamma = 4.76°$

Step 5 – interpret: A higher L/D gives a shallower (smaller) glide angle, so a glide ratio of 12 gives a shallow $4.76°$ descent.

Final Answer: $\gamma \approx 4.76° \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – glide range: In still air the horizontal distance covered in a glide is $R = h \times (L/D)$.

Step 1 – list the data: $h = 2000$ m, $L/D = 15$.

Step 2 – multiply the height by the glide ratio: $R = 2000 \times 15$

Step 3 – evaluate: $R = 30000$ m

Step 4 – convert to kilometres: $R = 30$ km

Final Answer: $R = 30 \text{ km} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept – longitudinal static stability: Static stability requires a restoring moment when the airplane is disturbed in pitch, and the ability to trim at a positive lift angle.

Step 1 – restoring-moment condition: If a small increase in α produces a nose-down (negative) pitching moment that opposes the disturbance, the aircraft is stable. This needs $\dfrac{dC_m}{d\alpha} < 0$.

Step 2 – trim condition: To trim ($C_m = 0$) at a useful positive angle of attack, the pitching-moment coefficient at zero lift must be positive, $C_{m,0} > 0$.

Step 3 – combine the two conditions: A statically stable airplane must have $\dfrac{dC_m}{d\alpha} < 0$ together with $C_{m,0} > 0$.

Why the other options are wrong:

- B and C, $dC_m/d\alpha > 0$: a positive slope gives a diverging (destabilising) moment, so the aircraft is statically **unstable**.
- D, both zero: gives neutral stability with no positive trim angle, not a stable airplane.

Final Answer: $\dfrac{dC_m}{d\alpha} < 0$ and $C_{m,0} > 0 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – load factor in a level turn: In a steady, co-ordinated level turn the vertical component of lift balances weight, $L\cos\phi = W$, so the load factor is $n = \dfrac{L}{W} = \dfrac{1}{\cos\phi}$.

Step 1 – list the data: $\phi = 60°$.

Step 2 – evaluate the cosine: $\cos 60° = 0.5$

Step 3 – take the reciprocal: $n = \dfrac{1}{0.5}$

Step 4 – evaluate: $n = 2.0$

Final Answer: $n = 2.0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – static margin: SM $= \dfrac{x_{NP} - x_{cg}}{\bar{c}}$, the distance from the c.g. to the neutral point, in chord units. A positive value indicates static stability.

Step 1 – list the data: $x_{NP} = 0.40\,\bar{c}$, $x_{cg} = 0.25\,\bar{c}$.

Step 2 – take the difference: $x_{NP} - x_{cg} = 0.40\,\bar{c} - 0.25\,\bar{c} = 0.15\,\bar{c}$

Step 3 – divide by the chord: SM $= \dfrac{0.15\,\bar{c}}{\bar{c}} = 0.15$

Step 4 – interpret: The neutral point is aft of the c.g., so the margin is positive (15%) and the aircraft is statically stable.

Final Answer: SM $= 0.15 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept – circular orbital speed: For a circular orbit the gravitational force provides the centripetal force, giving $v = \sqrt{\dfrac{\mu}{r}}$.

Step 1 – list the data: $\mu = 3.986 \times 10^{14}$ m^3/s^2, $r = 7000$ km $= 7.0 \times 10^6$ m.

Step 2 – form the ratio μ/r: $\dfrac{\mu}{r} = \dfrac{3.986 \times 10^{14}}{7.0 \times 10^6}$

$= 5.694 \times 10^7$ m^2/s^2

Step 3 – take the square root: $v = \sqrt{5.694 \times 10^7}$

$v = 7546$ m/s

Step 4 – convert to km/s: $v = 7.55$ km/s

Final Answer: $v \approx 7.55$ km/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – escape velocity: $v_{esc} = \sqrt{\dfrac{2\mu}{r}}$, which is $\sqrt{2}$ times the circular-orbit speed at the same radius.

Step 1 – list the data: $\mu = 3.986 \times 10^{14}$ m^3/s^2, $r = 6371$ km $= 6.371 \times 10^6$ m.

Step 2 – form $\dfrac{2\mu}{r}$: $2\mu = 2 \times 3.986 \times 10^{14} = 7.972 \times 10^{14}$

$\dfrac{2\mu}{r} = \dfrac{7.972 \times 10^{14}}{6.371 \times 10^6}$

$= 1.2513 \times 10^8$ m^2/s^2

Step 3 – take the square root: $v_{esc} = \sqrt{1.2513 \times 10^8}$

$v_{esc} = 11186$ m/s

Step 4 – convert to km/s: $v_{esc} = 11.2$ km/s

Final Answer: $v_{esc} \approx 11.2$ km/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – semi-major axis of an ellipse: The perigee and apogee radii are measured from the Earth's centre, and $a = \dfrac{r_p + r_a}{2}$.

Step 1 – form the perigee radius: $r_p = R_E + h_p = 6378 + 300 = 6678$ km

Step 2 – form the apogee radius: $r_a = R_E + h_a = 6378 + 3000 = 9378$ km

Step 3 – add the two radii: $r_p + r_a = 6678 + 9378 = 16056$ km

Step 4 – halve the sum: $a = \dfrac{16056}{2}$

$a = 8028$ km

Final Answer: $a = 8028$ km $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – axial (direct) stress: $\sigma = \dfrac{P}{A}$, with A the area of the circular section.

Step 1 – compute the cross-sectional area: $A = \dfrac{\pi}{4}d^2 = \dfrac{\pi}{4}(25)^2$

$= \dfrac{\pi}{4} \times 625$

$= 490.87 \text{ mm}^2$

Step 2 – convert the load to newtons: $P = 50 \text{ kN} = 50000 \text{ N}$

Step 3 – divide load by area: $\sigma = \dfrac{50000}{490.87}$

Step 4 – evaluate: $\sigma = 101.86 \text{ N/mm}^2$

$\sigma \approx 101.9 \text{ MPa}$

Final Answer: $\sigma \approx 101.9 \text{ MPa} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – flexural stress: $\sigma = \dfrac{M}{Z}$, with the rectangular section modulus $Z = \dfrac{b\,d^2}{6}$.

Step 1 – compute the section modulus: $Z = \dfrac{b\,d^2}{6} = \dfrac{50 \times 100^2}{6}$

Step 2 – evaluate d^2: $100^2 = 10000$

Step 3 – finish the section modulus: $Z = \dfrac{50 \times 10000}{6} = \dfrac{500000}{6}$

$Z = 83333 \text{ mm}^3$

Step 4 – convert the moment to N·mm: $M = 5 \text{ kN} \cdot \text{m} = 5 \times 10^6 \text{ N} \cdot \text{mm}$

Step 5 – divide moment by section modulus: $\sigma = \dfrac{5 \times 10^6}{83333}$

$\sigma = 60 \text{ MPa}$

Final Answer: $\sigma = 60 \text{ MPa} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – torsion of a solid circular shaft: $\tau_{\max} = \dfrac{16T}{\pi D^3}$.

Step 1 – list the data: $T = 1\ \text{kN} \cdot \text{m} = 1 \times 10^6\ \text{N} \cdot \text{mm}$, $D = 40$ mm.

Step 2 – cube the diameter: $D^3 = 40^3 = 64000\ \text{mm}^3$

Step 3 – form the denominator πD^3: $\pi D^3 = 3.1416 \times 64000 = 201062$

Step 4 – form the numerator $16T$: $16T = 16 \times 1 \times 10^6 = 1.6 \times 10^7$

Step 5 – divide: $\tau_{\max} = \dfrac{1.6 \times 10^7}{201062}$

$\tau_{\max} = 79.6$ MPa

Final Answer: $\tau_{\max} \approx 79.6\ \text{MPa} \Rightarrow \boxed{\text{D}}$

$\boxed{\text{Answer: (D)}}$ Go Back to Q26

Q27.

Solution

Concept – hoop stress in a thin cylinder: $\sigma_h = \dfrac{p\,d}{2t}$, where d is the internal diameter and t the wall thickness.

Step 1 – list the data: $p = 2$ MPa, $d = 1$ m $= 1000$ mm, $t = 10$ mm.

Step 2 – form the numerator $p\,d$: $p\,d = 2 \times 1000 = 2000$

Step 3 – form the denominator $2t$: $2t = 2 \times 10 = 20$

Step 4 – divide: $\sigma_h = \dfrac{2000}{20}$

$\sigma_h = 100$ MPa

Step 5 – note the longitudinal stress: The longitudinal stress $\sigma_l = pd/4t = 50$ MPa is half the hoop stress, which is why the vessel tends to split along its length first.

Final Answer: $\sigma_h = 100\ \text{MPa} \Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q27

Q28.

Solution

Concept – Euler buckling load (pinned–pinned): $P_{cr} = \dfrac{\pi^2 EI}{L_e^2}$, with the effective length $L_e = L$ for hinged–hinged ends.

Step 1 – list the data (consistent units): $E = 200$ GPa $= 200000$ N/mm^2, $I = 1 \times 10^6$ mm^4, $L = 1$ m $= 1000$ mm.

Step 2 – form the numerator $\pi^2 EI$: $\pi^2 = 9.8696$

$\pi^2 EI = 9.8696 \times 200000 \times 1 \times 10^6$

$= 9.8696 \times 2 \times 10^{11}$

$= 1.9739 \times 10^{12}$

Step 3 – form the denominator L_e^2: $L_e^2 = 1000^2 = 1 \times 10^6$ mm^2

Step 4 – divide: $P_{cr} = \dfrac{1.9739 \times 10^{12}}{1 \times 10^6}$

$P_{cr} = 1.9739 \times 10^6$ N

Step 5 – convert to kN: $P_{cr} = 1974$ kN

Final Answer: $P_{cr} \approx 1974$ kN $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – principal stresses in plane stress: $\sigma_{1,2} = \dfrac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$.

Step 1 – list the data: $\sigma_x = 80$ MPa, $\sigma_y = 20$ MPa, $\tau_{xy} = 30$ MPa.

Step 2 – compute the mean (centre of Mohr's circle): $\dfrac{\sigma_x + \sigma_y}{2} = \dfrac{80 + 20}{2} = 50$ MPa

Step 3 – compute the half-difference: $\dfrac{\sigma_x - \sigma_y}{2} = \dfrac{80 - 20}{2} = 30$ MPa

Step 4 – compute the radius: $R = \sqrt{30^2 + 30^2} = \sqrt{900 + 900}$

$R = \sqrt{1800} = 42.43$ MPa

Step 5 – add to the mean for the major principal stress: $\sigma_1 = 50 + 42.43 = 92.43$ MPa

Final Answer: $\sigma_1 \approx 92.4$ MPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – strain energy in axial loading: $U = \dfrac{P^2 L}{2AE}$.

Step 1 – list the data (consistent units): P = 100 kN = 100000 N, L = 2 m = 2000 mm, A = 1000 mm^2, E = 200000 N/mm^2.

Step 2 – square the load: $P^2 = (100000)^2 = 1 \times 10^{10}$

Step 3 – form the numerator P^2L: $P^2L = 1 \times 10^{10} \times 2000 = 2 \times 10^{13}$

Step 4 – form the denominator $2AE$: $2AE = 2 \times 1000 \times 200000 = 4 \times 10^8$

Step 5 – divide: $U = \dfrac{2 \times 10^{13}}{4 \times 10^8} = 5 \times 10^4\ \text{N} \cdot \text{mm}$

Step 6 – convert to joules: $U = 50000\ \text{N} \cdot \text{mm} = 50\ \text{J}$

Final Answer: $U = 50\ \text{J} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – natural frequency of a spring–mass system: $\omega_n = \sqrt{\dfrac{k}{m}}$ and the natural frequency in hertz is $f_n = \dfrac{\omega_n}{2\pi}$.

Step 1 – list the data: $k = 8000$ N/m, $m = 2$ kg.

Step 2 – form the ratio k/m: $\dfrac{k}{m} = \dfrac{8000}{2} = 4000$

Step 3 – take the square root for ω_n: $\omega_n = \sqrt{4000} = 63.25$ rad/s

Step 4 – divide by 2π to get f_n: $f_n = \dfrac{63.25}{2\pi} = \dfrac{63.25}{6.2832}$

Step 5 – evaluate: $f_n = 10.07$ Hz

Step 6 – avoid the trap: Option A (63.2) is the angular frequency ω_n in rad/s, not the frequency in Hz.

Final Answer: $f_n \approx 10.07\ \text{Hz} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – Bredt–Batho shear stress in a thin closed tube: $\tau = \dfrac{T}{2\,A_m\,t}$, where A_m is the area enclosed by the mean wall line.

Step 1 – list the data (SI units): $T = 500\ \text{N}\cdot\text{m}$, $A_m = 0.01\ \text{m}^2$, $t = 2\ \text{mm} = 0.002$ m.

Step 2 – form the denominator $2A_mt$**:** $2A_mt = 2 \times 0.01 \times 0.002$

$= 4 \times 10^{-5}\ \text{m}^3$

Step 3 – divide the torque by the denominator: $\tau = \dfrac{500}{4 \times 10^{-5}}$

Step 4 – evaluate: $\tau = 1.25 \times 10^7$ Pa

Step 5 – convert to MPa: $\tau = 12.5$ MPa

Final Answer: $\tau = 12.5$ MPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – cantilever tip deflection under an end load: $\delta = \dfrac{PL^3}{3EI}$.

Step 1 – list the data (consistent units): $P = 1\ \text{kN} = 1000\ \text{N}$, $L = 1\ \text{m} = 1000$ mm, $E = 200000\ \text{N/mm}^2$, $I = 1 \times 10^6\ \text{mm}^4$.

Step 2 – cube the length: $L^3 = 1000^3 = 1 \times 10^9\ \text{mm}^3$

Step 3 – form the numerator PL^3**:** $PL^3 = 1000 \times 1 \times 10^9 = 1 \times 10^{12}$

Step 4 – form the denominator $3EI$**:** $3EI = 3 \times 200000 \times 1 \times 10^6 = 6 \times 10^{11}$

Step 5 – divide: $\delta = \dfrac{1 \times 10^{12}}{6 \times 10^{11}}$

Step 6 – evaluate: $\delta = 1.667$ mm

Final Answer: $\delta \approx 1.67$ mm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q33

Q34.

Solution

Concept – maximum in-plane shear stress: $\tau_{\max} = R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$, the radius of Mohr's circle.

Step 1 – list the data: $\sigma_x = 50$ MPa, $\sigma_y = 10$ MPa, $\tau_{xy} = 20$ MPa.

Step 2 – compute the half-difference: $\frac{\sigma_x - \sigma_y}{2} = \frac{50 - 10}{2} = 20$ MPa

Step 3 – square the two terms: $20^2 = 400$

$\tau_{xy}^2 = 20^2 = 400$

Step 4 – add and take the square root: $\tau_{\max} = \sqrt{400 + 400} = \sqrt{800}$

$\tau_{\max} = 28.28$ MPa

Final Answer: $\tau_{\max} \approx 28.3$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – ideal Brayton-cycle thermal efficiency: $\eta = 1 - \frac{1}{r_p^{(\gamma-1)/\gamma}}$, a function of pressure ratio only.

Step 1 – list the data: $r_p = 8$, $\gamma = 1.4$.

Step 2 – evaluate the exponent: $\frac{\gamma - 1}{\gamma} = \frac{0.4}{1.4} = 0.2857$

Step 3 – raise the pressure ratio to that power: $8^{0.2857} = 1.8114$

Step 4 – take the reciprocal: $\frac{1}{1.8114} = 0.5521$

Step 5 – subtract from one: $\eta = 1 - 0.5521 = 0.4479$

Step 6 – express as a percentage: $\eta = 44.8\%$

Final Answer: $\eta \approx 44.8\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – net thrust of a turbojet: Neglecting the fuel flow and pressure terms, $F = \dot{m}\,(V_e - V_0)$.

Step 1 – list the data: $\dot{m} = 50$ kg/s, $V_0 = 200$ m/s, $V_e = 500$ m/s.

Step 2 – take the velocity difference: $V_e - V_0 = 500 - 200 = 300$ m/s

Step 3 – multiply by the mass flow rate: $F = 50 \times 300$

Step 4 – evaluate: $F = 15000$ N

Step 5 – convert to kN: $F = 15$ kN

Final Answer: $F = 15$ kN $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q36

Q37.

Solution

Concept – thrust specific fuel consumption: TSFC $= \dfrac{\dot{m}_f}{F}$, the fuel mass burnt per unit thrust per unit time.

Step 1 – list the data: $\dot{m}_f = 0.5$ kg/s, $F = 10$ kN $= 10000$ N.

Step 2 – form the ratio: TSFC $= \dfrac{0.5}{10000}$

Step 3 – evaluate: TSFC $= 5 \times 10^{-5}$ kg/(N · s)

Final Answer: TSFC $= 5 \times 10^{-5}$ kg/(N · s) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q37

Q38.

Solution

Concept – nozzle exit velocity from the energy equation: With negligible inlet velocity, $\frac{1}{2}V_e^2 = c_p\,\Delta T$, so $V_e = \sqrt{2c_p\,\Delta T}$.

Step 1 – list the data: $c_p = 1005$ J/kg · K, $\Delta T = 200$ K.

Step 2 – form the product $2c_p\,\Delta T$: $2 \times 1005 = 2010$

$2010 \times 200 = 402000$

Step 3 – take the square root: $V_e = \sqrt{402000}$

Step 4 – evaluate: $V_e = 634$ m/s

Final Answer: $V_e \approx 634$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – critical pressure ratio at a choked throat: At $M = 1$, $\dfrac{p^*}{p_0} = \left(\dfrac{2}{\gamma+1}\right)^{\gamma/(\gamma-1)}$.

Step 1 – list the data: $\gamma = 1.4$.

Step 2 – evaluate the base $\dfrac{2}{\gamma+1}$**:** $\dfrac{2}{1.4+1} = \dfrac{2}{2.4} = 0.8333$

Step 3 – evaluate the exponent $\dfrac{\gamma}{\gamma-1}$**:** $\dfrac{1.4}{0.4} = 3.5$

Step 4 – raise the base to the exponent: $0.8333^{3.5} = 0.5283$

Step 5 – state the result: $\dfrac{p^*}{p_0} = 0.528$

Final Answer: $p^*/p_0 \approx 0.528 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – Euler turbomachinery work: For an axial stage the specific work is $w = U\,\Delta C_w$, the blade speed times the change in whirl velocity.

Step 1 – list the data: $U = 200$ m/s, $\Delta C_w = 150$ m/s.

Step 2 – multiply the two quantities: $w = 200 \times 150$

Step 3 – evaluate: $w = 30000$ J/kg

Step 4 – convert to kJ/kg: $w = 30$ kJ/kg

Final Answer: $w = 30$ kJ/kg $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q40

Q41.

Solution

Concept – rocket thrust (matched nozzle): For a perfectly expanded nozzle the pressure term vanishes and $F = \dot{m}\, V_e$.

Step 1 – list the data: $\dot{m} = 100$ kg/s, $V_e = 3000$ m/s.

Step 2 – multiply mass flow by exhaust velocity: $F = 100 \times 3000$

Step 3 – evaluate: $F = 300000$ N

Step 4 – convert to kN: $F = 300$ kN

Final Answer: $F = 300$ kN $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q41

Q42.

Solution

Concept – specific impulse: $I_{sp} = \dfrac{V_e}{g_0}$, expressed in seconds.

Step 1 – list the data: $V_e = 2943$ m/s, $g_0 = 9.81$ m/s^2.

Step 2 – divide the exhaust velocity by g_0: $I_{sp} = \dfrac{2943}{9.81}$

Step 3 – evaluate: $I_{sp} = 300$ s

Final Answer: $I_{sp} = 300$ s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q42

Q43.

Solution

Concept – Tsiolkovsky rocket equation: $\Delta v = I_{sp}\, g_0 \ln\left(\dfrac{m_0}{m_f}\right)$.

Step 1 – list the data: $I_{sp} = 300$ s, $g_0 = 9.81$ m/s^2, $\dfrac{m_0}{m_f} = 3$.

Step 2 – form the effective exhaust velocity $I_{sp}\, g_0$: $I_{sp}\, g_0 = 300 \times 9.81 = 2943$ m/s

Step 3 – take the natural log of the mass ratio: $\ln 3 = 1.0986$

Step 4 – multiply: $\Delta v = 2943 \times 1.0986$

Step 5 – evaluate: $\Delta v = 3233$ m/s

Final Answer: $\Delta v \approx 3233$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q43

Q44.

Solution

Concept – equivalence ratio: $\phi = \dfrac{(A/F)_{\text{stoich}}}{(A/F)_{\text{actual}}}$; $\phi < 1$ is a lean (excess-air) mixture.

Step 1 – list the data: $(A/F)_{\text{stoich}} = 15$, $(A/F)_{\text{actual}} = 20$.

Step 2 – form the ratio: $\phi = \dfrac{15}{20}$

Step 3 – evaluate: $\phi = 0.75$

Step 4 – interpret: Since $\phi < 1$, more air is supplied than needed for complete combustion, so the mixture is lean.

Final Answer: $\phi = 0.75 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q44

Q45.

Solution

Concept – ideal (Froude) propulsive efficiency: $\eta_p = \dfrac{2V_0}{V_e + V_0}$.

Step 1 – list the data: $V_0 = 200$ m/s, $V_e = 600$ m/s.

Step 2 – form the numerator $2V_0$: $2V_0 = 2 \times 200 = 400$

Step 3 – form the denominator $V_e + V_0$: $V_e + V_0 = 600 + 200 = 800$

Step 4 – divide: $\eta_p = \dfrac{400}{800}$

Step 5 – evaluate: $\eta_p = 0.50$

Final Answer: $\eta_p = 0.50 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – isentropic compression temperature ratio: $\dfrac{T_{02}}{T_{01}} = r_p^{(\gamma-1)/\gamma}$.

Step 1 – list the data: $T_{01} = 300$ K, $r_p = 8$, $\gamma = 1.4$.

Step 2 – evaluate the exponent: $\dfrac{\gamma - 1}{\gamma} = \dfrac{0.4}{1.4} = 0.2857$

Step 3 – raise the pressure ratio to that power: $8^{0.2857} = 1.8114$

Step 4 – multiply by the inlet temperature: $T_{02} = 300 \times 1.8114$

Step 5 – evaluate: $T_{02} = 543.4$ K

$T_{02} \approx 543$ K

Final Answer: $T_{02} \approx 543 \text{ K} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q46**

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	C	4	A	5	C
6	B	7	D	8	C	9	A	10	B
11	D	12	D	13	B	14	D	15	D
16	C	17	D	18	A	19	D	20	B
21	A	22	D	23	B	24	C	25	C
26	D	27	A	28	A	29	B	30	B
31	C	32	B	33	B	34	A	35	C
36	A	37	A	38	C	39	B	40	B
41	A	42	C	43	D	44	B	45	A
46	D								