GATE Aerospace Engineering

Sample Paper – 2

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 $\cdot$ 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 of density 1.225 kg/m^3 flows steadily through the streamtube shown at a mean speed of 20 m/s. At the station indicated the cross-sectional area is 0.50 m^2. The mass flow rate through the streamtube is: **[1 mark]**

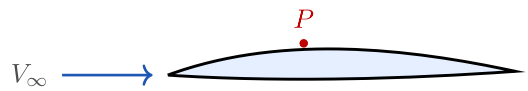
(A) 24.5 kg/s

(B) 6.13 kg/s

(C) 12.25 kg/s

(D) 10.0 kg/s

Q2. In the low-speed flow of air over the airfoil shown, the pressure coefficient at a point P on the upper surface is defined by $C_p = 1 - (V/V_\infty)^2$. At P the local speed is 1.5 times the freestream speed. The pressure coefficient at P is: **[1 mark]**



(A) -0.25

(B) $+1.00$

(C) -2.25

(D) -1.25

Q3. An aircraft flies at a true airspeed of 170 m/s at an altitude where the local speed of sound is 340 m/s. The freestream Mach number of the aircraft is: **[1 mark]**

(A) 2.0

(B) 0.85

(C) 1.0

(D) 0.5

Q4. An aircraft with a wing planform area of 25 m^2 flies at a speed of 40 m/s at sea level ($\rho = 1.225$ kg/m^3) with a lift coefficient of 0.50. The lift generated by the wing is: **[1 mark]**

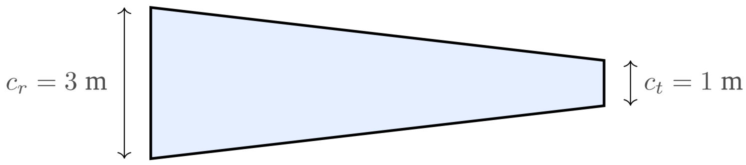
(A) 24500 N

(B) 12250 N

(C) 6125 N

(D) 9800 N

Q5. The tapered wing planform shown has a root chord of 3 m and a tip chord of 1 m. The taper ratio $(\lambda = c_t/c_r)$ of the wing is: **[1 mark]**



(A) 3.0

(B) 1.0

(C) 0.333

(D) 0.667

Q6. In a subsonic compressible flow the incompressible pressure coefficient at a point is $C_{p,0} = -0.40$. Using the Prandtl–Glauert compressibility correction $\left(C_p = C_{p,0}/\sqrt{1 - M_\infty^2}\right)$ at a freestream Mach number of 0.60, the corrected pressure coefficient is: **[1 mark]**

(A) -0.32

(B) -0.50

(C) -0.40

(D) -0.64

Q7. At the ISA tropopause the static air temperature is 216.65 K. Taking $\gamma = 1.4$ and $R = 287$ J/kg $\cdot$ K, the local speed of sound is nearest to: **[1 mark]**

(A) 316.9 m/s

(B) 340.3 m/s

(C) 288.0 m/s

(D) 295.0 m/s

Q8. A perfect gas ($\gamma = 1.4$) flows at a Mach number of 1.0. Using the isentropic relation $p_0/p = \left(1 + \frac{\gamma-1}{2}M^2\right)^{\gamma/(\gamma-1)}$, the ratio of stagnation pressure to static pressure is nearest to: **[1 mark]**

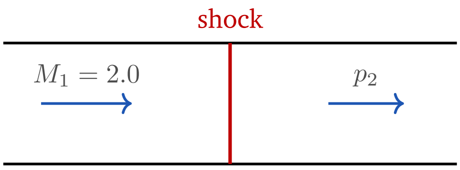
(A) 1.577

(B) 1.893

(C) 2.000

(D) 1.200

Q9. A normal shock stands in the duct shown, with an upstream Mach number of 2.0 in air ($\gamma = 1.4$). Using $p_2/p_1 = 1 + \frac{2\gamma}{\gamma+1}\left(M_1^2 - 1\right)$, the static-pressure ratio across the shock is nearest to: **[1 mark]**



(A) 1.5

(B) 3.5

(C) 5.0

(D) 4.5

Q10. A laminar boundary layer develops over a flat plate parallel to the flow. At a station where the Reynolds number based on plate length is $Re_L = 10^6$, the laminar skin-friction drag coefficient $\left(C_f = 1.328/\sqrt{Re_L}\right)$ is: **[1 mark]**

(A) 1.328×10^{-2}

(B) 5.00×10^{-3}

(C) 1.328×10^{-3}

(D) 6.64×10^{-4}

Q11. A wing section of chord 2 m moves through air at 50 m/s. The kinematic viscosity of the air is 1.5×10^{-5} m^2/s. The Reynolds number based on the chord is nearest to: **[1 mark]**

(A) 3.33×10^6

(B) 1.50×10^6

(C) 7.50×10^5

(D) 6.67×10^6

Q12. A thin symmetric airfoil follows the thin-airfoil result $c_\ell = 2\pi\alpha$ (with α in radians). The angle of attack required to produce a section lift coefficient of 0.50 is nearest to: **[1 mark]**

(A) $2.28°$

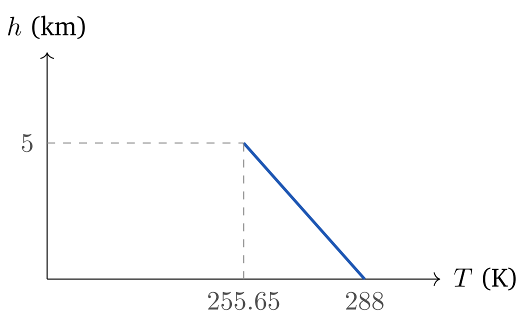
(B) $9.12°$

(C) $4.56°$

(D) $0.0796°$

Flight Mechanics & Space Dynamics

Q13. In the International Standard Atmosphere, the sea-level temperature is 288.15 K and the tropospheric lapse rate is 6.5 K per km. The ISA temperature at an altitude of 5 km, marked on the profile below, is: **[1 mark]**



(A) 255.65 K

(B) 216.65 K

(C) 223.15 K

(D) 248.15 K

Q14. An aircraft of weight 50,000 N flies in steady level flight at 100 m/s, where the total drag is 5000 N. The engine develops a thrust of 8000 N. The instantaneous rate of climb $\left(R/C = (T - D)V/W\right)$ available from this excess thrust is: **[1 mark]**

(A) 16 m/s

(B) 10 m/s

(C) 6 m/s

(D) 3 m/s

Q15. An aircraft of weight 40,000 N has a wing area of 20 m^2 and a maximum lift coefficient of 1.6. At sea level ($\rho = 1.225$ kg/m^3), the stalling speed in level flight is nearest to: **[1 mark]**

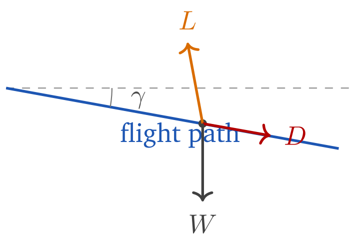
(A) 45.2 m/s

(B) 63.9 m/s

(C) 22.6 m/s

(D) 51.0 m/s

Q16. An aircraft descends in an unpowered, steady glide with a lift-to-drag ratio of 10, as shown by the free-body diagram. The glide (flight-path) angle below the horizontal, given by $\gamma = \tan^{-1}\left(1/(L/D)\right)$, is nearest to: **[1 mark]**



(A) 10.00°

(B) 8.53°

(C) 5.71°

(D) 2.86°

Q17. An aircraft with a best glide ratio (lift-to-drag ratio) of 20 loses power at a height of 3000 m above flat ground, in still air. The maximum horizontal distance it can glide is: **[1 mark]**

(A) 60 km

(B) 20 km

(C) 3 km

(D) 40 km

Q18. For an aircraft to possess longitudinal static stability, the centre of gravity must lie in a particular position relative to the neutral point. That required position of the centre of gravity is: **[1 mark]**

(A) behind (aft of) the neutral point

(B) exactly at the neutral point

(C) ahead of (forward of) the neutral point

(D) far behind the aerodynamic centre

Q19. An aircraft executes a steady, level (co-ordinated) turn at a constant bank angle of 30°. The load factor $\left(n = 1/\cos\phi\right)$ acting on the aircraft is nearest to: **[1 mark]**

(A) 1.000

(B) 1.155

(C) 1.414

(D) 2.000

Q20. For a certain aircraft the neutral point lies at $0.50\,\bar{c}$ and the centre of gravity lies at $0.28\,\bar{c}$ from the leading edge of the mean aerodynamic chord $\bar{c}$. The static margin of the aircraft is: **[1 mark]**

(A) 0.22

(B) 0.28

(C) 0.50

(D) 0.78

Q21. A satellite moves in a circular orbit of radius 7000 km about the Earth ($\mu = 3.986 \times 10^{14}$ m^3/s^2). Using $T = 2\pi\sqrt{r^3/\mu}$, the orbital period of the satellite is nearest to: **[2 marks]**

(A) 5829 s

(B) 2914 s

(C) 8640 s

(D) 3600 s

Q22. A satellite moves in a circular orbit of radius 10,000 km about the Earth. Taking $\mu = 3.986 \times 10^{14}$ m^3/s^2, the orbital speed of the satellite is nearest to: **[2 marks]**

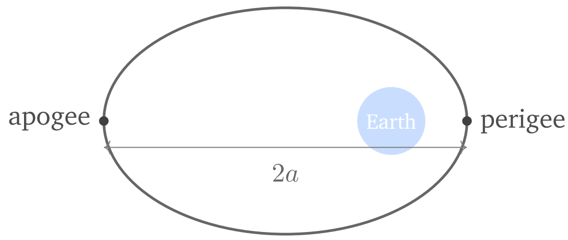
(A) 8.93 km/s

(B) 6.31 km/s

(C) 7.91 km/s

(D) 4.46 km/s

Q23. A satellite is in an elliptic orbit about the Earth (radius 6378 km) with a perigee altitude of 500 km and an apogee altitude of 2500 km, as shown. The eccentricity of the orbit $\left(e = (r_a - r_p)/(r_a + r_p)\right)$ is nearest to: **[2 marks]**



(A) 0.254

(B) 0.127

(C) 0.113

(D) 0.226

Aerospace Structures

Q24. A straight aluminium bar of length 2 m and cross-sectional area 500 mm^2 carries an axial tensile load of 40 kN. The material has Young's modulus 70 GPa. The axial elongation of the bar $\left(\delta = PL/AE\right)$ is nearest to: **[2 marks]**

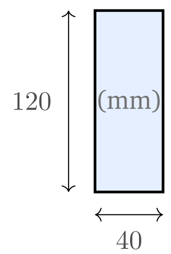
(A) 1.14 mm

(B) 4.57 mm

(C) 0.57 mm

(D) 2.29 mm

Q25. A beam has the solid rectangular cross-section shown (width 40 mm, depth 120 mm). At a section the bending moment is 8 kN·m. The maximum bending (flexural) stress at that section $\left(\sigma = 6M/(bd^2)\right)$ is: **[2 marks]**



(A) 83.3 MPa

(B) 41.7 MPa

(C) 125.0 MPa

(D) 166.7 MPa

Q26. A solid circular shaft of diameter 50 mm transmits a torque of 2 kN·m. The maximum torsional shear stress on the outer surface $\left(\tau = 16T/(\pi d^3)\right)$ is nearest to: **[2 marks]**

(A) 81.5 MPa

(B) 40.7 MPa

(C) 163.0 MPa

(D) 20.4 MPa

Q27. A thin-walled cylindrical pressure vessel of internal diameter 800 mm and wall thickness 6 mm carries an internal gauge pressure of 1.5 MPa. The longitudinal (axial) stress in the wall $\left(\sigma_L = pd/(4t)\right)$ is: **[2 marks]**

(A) 100 MPa

(B) 50 MPa

(C) 25 MPa

(D) 200 MPa

Q28. A fixed–free (cantilever) straight column of length 1 m has a second moment of area of 2×10^6 mm^4 about the buckling axis and is made of a material with Young's modulus 200 GPa. The Euler critical buckling load $\left(P_{cr} = \pi^2 EI/(4L^2)\right)$ is nearest to: **[2 marks]**

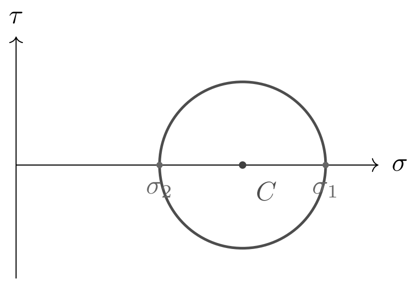
(A) 3948 kN

(B) 1974 kN

(C) 493 kN

(D) 987 kN

Q29. At a point in a loaded member the plane-stress components are $\sigma_x = 100$ MPa, $\sigma_y = 40$ MPa and $\tau_{xy} = 30$ MPa. Using the Mohr's-circle construction shown, the minor principal stress at the point is nearest to: **[2 marks]**



(A) 112.4 MPa

(B) 70.0 MPa

(C) 27.6 MPa

(D) 42.4 MPa

Q30. A prismatic bar of length 1 m and cross-sectional area 500 mm^2 is made of a material with Young's modulus 200 GPa and carries a static axial load of 50 kN. The strain energy stored in the bar $\left(U = P^2L/(2AE)\right)$ is: **[2 marks]**

(A) 50 J

(B) 25 J

(C) 6.25 J

(D) 12.5 J

Q31. A single-degree-of-freedom spring–mass system has a stiffness of 5000 N/m and a mass of 5 kg. The undamped natural frequency $\left(\omega_n = \sqrt{k/m}\right)$ of the system is nearest to: **[2 marks]**

(A) 100 rad/s

(B) 63.2 rad/s

(C) 31.6 rad/s

(D) 5.03 rad/s

Q32. A thin-walled closed tube encloses an area of 0.02 m^2 and carries a torque of 600 N·m. Using the Bredt–Batho theory, the shear flow in the wall $\left(q = T/(2A_m)\right)$ is: **[2 marks]**

(A) 15 kN/m

(B) 30 kN/m

(C) 7.5 kN/m

(D) 60 kN/m

Q33. A simply supported beam of span 2 m carries a concentrated load of 2 kN at mid-span. The beam has $E = 200$ GPa and $I = 1 \times 10^6$ mm^4. The mid-span deflection $\left(\delta = PL^3/(48EI)\right)$ 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 $\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa and $\tau_{xy} = 15$ MPa. The maximum in-plane shear stress at the point $\left(\tau_{\max} = \sqrt{((\sigma_x - \sigma_y)/2)^2 + \tau_{xy}^2}\right)$ is: **[2 marks]**

(A) 12.5 MPa

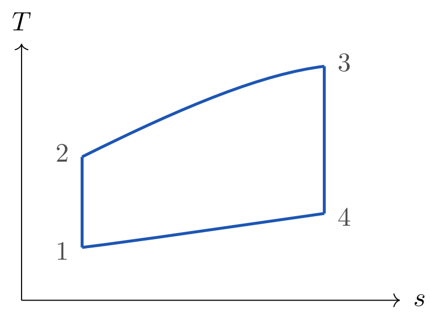
(B) 25.0 MPa

(C) 50.0 MPa

(D) 40.0 MPa

Propulsion

Q35. An ideal (air-standard) Brayton cycle operates with a compressor pressure ratio of 10 and $\gamma = 1.4$, as shown on the T–s diagram. The thermal efficiency of the cycle $\left(\eta = 1 - r_p^{-(\gamma-1)/\gamma}\right)$ is nearest to: **[2 marks]**



(A) 48.2%

(B) 37.5%

(C) 60.0%

(D) 51.8%

Q36. A turbojet ingests air at a mass flow rate of 40 kg/s. The flight (inlet) velocity is 250 m/s and the exhaust jet velocity is 550 m/s. Neglecting the fuel mass flow and pressure-thrust terms, the net thrust $\left(F = \dot{m}(V_e - V_0)\right)$ is: **[2 marks]**

(A) 22 kN

(B) 12 kN

(C) 10 kN

(D) 32 kN

Q37. A turbojet produces a net thrust of 12 kN while ingesting air at a mass flow rate of 40 kg/s. The specific thrust $\left(F_s = F/\dot{m}\right)$ of the engine is: **[2 marks]**

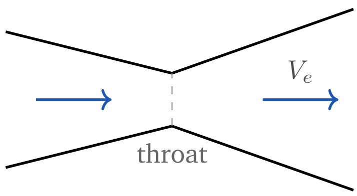
(A) 550 N · s/kg

(B) 250 N · s/kg

(C) 480 N · s/kg

(D) 300 N · s/kg

Q38. Air expands through the convergent–divergent nozzle shown. The static temperature drop from the chamber to the exit is 400 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 temperature at the throat to the stagnation temperature, $T^*/T_0 = 2/(\gamma + 1)$, is nearest to: **[2 marks]**

(A) 0.528

(B) 0.634

(C) 0.833

(D) 1.200

Q40. In an axial-flow compressor stage the mean blade speed is 210 m/s and the whirl (tangential) component of the absolute velocity increases by 200 m/s across the rotor. Using the Euler turbomachinery equation $\left(w = U\,\Delta C_w\right)$, the specific work input to the air is: **[2 marks]**

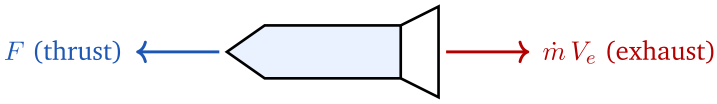
(A) 21 kJ/kg

(B) 42 kJ/kg

(C) 63 kJ/kg

(D) 84 kJ/kg

Q41. A rocket engine expels propellant at a mass flow rate of 200 kg/s with an effective exhaust velocity of 2800 m/s, as shown by the thrust free-body. For a perfectly expanded (pressure-matched) nozzle, the thrust produced $\left(F = \dot{m}V_e\right)$ is: **[2 marks]**



(A) 560 kN

(B) 280 kN

(C) 5600 kN

(D) 200 kN

Q42. A rocket nozzle produces an effective exhaust velocity of 1962 m/s. Taking $g_0 = 9.81$ m/s^2, the specific impulse $\left(I_{sp} = V_e/g_0\right)$ of the rocket is: **[2 marks]**

(A) 300 s

(B) 350 s

(C) 250 s

(D) 200 s

Q43. A single-stage rocket has a specific impulse of 250 s (with $g_0 = 9.81$ m/s^2) and an initial-to-final mass ratio of 4. Using the Tsiolkovsky rocket equation, the ideal velocity increment Δv is nearest to: **[2 marks]**

(A) 2452 m/s

(B) 4905 m/s

(C) 7358 m/s

(D) 3400 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 12. The equivalence ratio of the mixture $\left(\phi = (A/F)_{\text{stoich}}/(A/F)_{\text{actual}}\right)$ is: **[2 marks]**

(A) 0.80

(B) 0.75

(C) 1.25

(D) 1.00

Q45. A jet engine flies at 180 m/s and produces an exhaust jet of velocity 420 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) 0.60

(B) 0.75

(C) 0.40

(D) 0.90

Q46. Air enters the compressor of a gas-turbine engine at a stagnation temperature of 290 K and is compressed isentropically through a pressure ratio of 4 ($\gamma = 1.4$). The compressor-exit stagnation temperature $\left(T_{02} = T_{01}\, r_p^{(\gamma-1)/\gamma}\right)$ is nearest to: **[2 marks]**

(A) 431 K

(B) 290 K

(C) 543 K

(D) 480 K

Detailed Solutions

Q1.

Solution

Concept – mass flow rate through a streamtube: The mass flow rate is $\dot{m} = \rho A V$, the product of density, area and mean velocity.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $A = 0.50$ m^2, $V = 20$ m/s.

Step 2 – write the formula: $\dot{m} = \rho A V$

Step 3 – multiply density by area: $\rho A = 1.225 \times 0.50 = 0.6125$

Step 4 – multiply by the velocity: $\dot{m} = 0.6125 \times 20$

Step 5 – evaluate: $\dot{m} = 12.25$ kg/s

Final Answer: $\dot{m} = 12.25$ kg/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – pressure coefficient in incompressible flow: $C_p = 1 - \left(\dfrac{V}{V_\infty}\right)^2$; where the flow speeds up, C_p becomes negative (suction).

Step 1 – list the data: $\dfrac{V}{V_\infty} = 1.5$.

Step 2 – square the velocity ratio: $\left(\dfrac{V}{V_\infty}\right)^2 = 1.5^2 = 2.25$

Step 3 – substitute into the formula: $C_p = 1 - 2.25$

Step 4 – evaluate: $C_p = -1.25$

Final Answer: $C_p = -1.25 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – Mach number: $M = \dfrac{V}{a}$, the ratio of flight speed to the local speed of sound.

Step 1 – list the data: $V = 170$ m/s, $a = 340$ m/s.

Step 2 – write the formula: $M = \dfrac{V}{a}$

Step 3 – substitute the numbers: $M = \dfrac{170}{340}$

Step 4 – evaluate: $M = 0.5$

Final Answer: $M = 0.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q3

Q4.

Solution

Concept – lift equation: $L = \frac{1}{2}\rho V^2 S\, C_L$.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V = 40$ m/s, $S = 25$ m^2, $C_L = 0.50$.

Step 2 – square the velocity: $V^2 = 40^2 = 1600$

Step 3 – compute the dynamic pressure: $q = \frac{1}{2}\rho V^2 = 0.6125 \times 1600 = 980$ Pa

Step 4 – multiply by the wing area: $qS = 980 \times 25 = 24500$ N

Step 5 – multiply by the lift coefficient: $L = 24500 \times 0.50 = 12250$ N

Final Answer: $L = 12250$ N $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept – taper ratio of a wing: $\lambda = \dfrac{c_t}{c_r}$, the ratio of tip chord to root chord.

Step 1 – list the data: $c_r = 3$ m, $c_t = 1$ m.

Step 2 – write the formula: $\lambda = \dfrac{c_t}{c_r}$

Step 3 – substitute the numbers: $\lambda = \dfrac{1}{3}$

Step 4 – evaluate: $\lambda = 0.333$

Final Answer: $\lambda = 0.333 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept – Prandtl–Glauert compressibility correction: $C_p = \dfrac{C_{p,0}}{\sqrt{1 - M_\infty^2}}$.

Step 1 – list the data: $C_{p,0} = -0.40$, $M_\infty = 0.60$.

Step 2 – square the Mach number: $M_\infty^2 = 0.60^2 = 0.36$

Step 3 – form the term under the root: $1 - M_\infty^2 = 1 - 0.36 = 0.64$

Step 4 – take the square root: $\sqrt{0.64} = 0.80$

Step 5 – divide: $C_p = \dfrac{-0.40}{0.80} = -0.50$

Final Answer: $C_p = -0.50 \Rightarrow \boxed{\text{B}}$

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, $T = 216.65$ K.

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

Step 3 – multiply by the temperature: $\gamma R T = 401.8 \times 216.65 = 87050$

Step 4 – take the square root: $a = \sqrt{87050}$

$a = 295.0$ m/s

Final Answer: $a \approx 295.0$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – isentropic stagnation pressure ratio: $\dfrac{p_0}{p} = \left(1 + \dfrac{\gamma - 1}{2} M^2\right)^{\gamma/(\gamma-1)}$.

Step 1 – list the data: $\gamma = 1.4$, $M = 1.0$.

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

Step 3 – square the Mach number: $M^2 = 1.0^2 = 1$

Step 4 – form the bracket: $1 + 0.2 \times 1 = 1.2$

Step 5 – evaluate the exponent $\frac{\gamma}{\gamma-1}$**:** $\frac{1.4}{0.4} = 3.5$

Step 6 – raise to the power: $\frac{p_0}{p} = 1.2^{3.5}$

$1.2^{3.5} = 1.893$

Final Answer: $\frac{p_0}{p} \approx 1.893 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – static-pressure ratio across a normal shock: $\frac{p_2}{p_1} = 1+\frac{2\gamma}{\gamma+1}\left(M_1^2-1\right)$.

Step 1 – list the data: $\gamma = 1.4$, $M_1 = 2.0$.

Step 2 – square the upstream Mach number: $M_1^2 = 2.0^2 = 4$

Step 3 – form $M_1^2 - 1$**:** $4 - 1 = 3$

Step 4 – evaluate the coefficient $\frac{2\gamma}{\gamma+1}$**:** $\frac{2 \times 1.4}{2.4} = \frac{2.8}{2.4} = 1.1667$

Step 5 – multiply by $(M_1^2 - 1)$**:** $1.1667 \times 3 = 3.5$

Step 6 – add 1: $\frac{p_2}{p_1} = 1 + 3.5 = 4.5$

Final Answer: $\frac{p_2}{p_1} = 4.5 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept – laminar flat-plate skin-friction (drag) coefficient: $C_f = \frac{1.328}{\sqrt{Re_L}}$ (Blasius result).

Step 1 – list the data: $Re_L = 10^6$.

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

Step 3 – substitute into the formula: $C_f = \frac{1.328}{1000}$

Step 4 – evaluate: $C_f = 1.328 \times 10^{-3}$

Final Answer: $C_f = 1.328 \times 10^{-3} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – Reynolds number using kinematic viscosity: $Re = \dfrac{VL}{\nu}$.

Step 1 – list the data: $V = 50$ m/s, $L = 2$ m, $\nu = 1.5 \times 10^{-5}$ m^2/s.

Step 2 – form the numerator VL**:** $VL = 50 \times 2 = 100$

Step 3 – divide by the kinematic viscosity: $Re = \dfrac{100}{1.5 \times 10^{-5}}$

Step 4 – evaluate: $Re = 6.667 \times 10^6$

$Re \approx 6.67 \times 10^6$

Final Answer: $Re \approx 6.67 \times 10^6 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept – thin-airfoil lift coefficient inverted for α**:** $c_\ell = 2\pi\alpha \Rightarrow \alpha = \dfrac{c_\ell}{2\pi}$, with α in radians.

Step 1 – list the data: $c_\ell = 0.50$.

Step 2 – form 2π**:** $2\pi = 6.2832$

Step 3 – divide to get α **in radians:** $\alpha = \dfrac{0.50}{6.2832} = 0.07958$ rad

Step 4 – convert radians to degrees: $\alpha = 0.07958 \times \dfrac{180}{\pi}$

$\alpha = 0.07958 \times 57.2958$

Step 5 – evaluate: $\alpha = 4.56°$

Final Answer: $\alpha \approx 4.56° \Rightarrow \boxed{\text{C}}$

Answer: (C) 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, $h = 5$ km.

Step 2 – compute the temperature drop: $Lh = 6.5 \times 5 = 32.5$ K

Step 3 – subtract from the sea-level value: $T = 288.15 - 32.5$

$T = 255.65$ K

Final Answer: $T = 255.65 \text{ K} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – rate of climb from excess thrust: $R/C = \dfrac{(T-D)V}{W}$, since the excess thrust power $(T-D)V$ raises the potential energy Wh.

Step 1 – list the data: $T = 8000$ N, $D = 5000$ N, $V = 100$ m/s, $W = 50000$ N.

Step 2 – form the excess thrust: $T - D = 8000 - 5000 = 3000$ N

Step 3 – multiply by the velocity (excess power): $(T-D)V = 3000 \times 100 = 300000$ W

Step 4 – divide by the weight: $R/C = \dfrac{300000}{50000}$

Step 5 – evaluate: $R/C = 6$ m/s

Final Answer: $R/C = 6 \text{ m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

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

Step 1 – list the data: $W = 40000$ N, $\rho = 1.225$ kg/m^3, $S = 20$ m^2, $C_{L,\max} = 1.6$.

Step 2 – form the numerator $2W$: $2W = 2 \times 40000 = 80000$

Step 3 – form the denominator $\rho S\, C_{L,\max}$: $1.225 \times 20 = 24.5$

$24.5 \times 1.6 = 39.2$

Step 4 – form the ratio: $\dfrac{80000}{39.2} = 2040.8$

Step 5 – take the square root: $V_s = \sqrt{2040.8}$

$V_s = 45.2$ m/s

Final Answer: $V_s \approx 45.2 \text{ m/s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

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

Step 1 – list the data: $L/D = 10$.

Step 2 – form the tangent of the angle: $\tan\gamma = \dfrac{1}{10} = 0.10$

Step 3 – take the inverse tangent: $\gamma = \tan^{-1}(0.10)$

Step 4 – evaluate: $\gamma = 5.71^\circ$

Final Answer: $\gamma \approx 5.71^\circ \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept – gliding range: The maximum horizontal glide distance is $R = (L/D) \times h$, since L/D equals horizontal distance per unit height lost.

Step 1 – list the data: $L/D = 20$, $h = 3000$ m.

Step 2 – multiply: $R = 20 \times 3000$

Step 3 – evaluate: $R = 60000$ m

Step 4 – convert to kilometres: $R = 60$ km

Final Answer: $R = 60$ km $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – longitudinal static stability and the neutral point: The neutral point is the CG position at which $dC_m/d\alpha = 0$. For a nose-down restoring moment ($dC_m/d\alpha < 0$), the CG must lie ahead of the neutral point.

Step 1 – recall the static-margin definition: Static margin $= x_{NP} - x_{CG}$ (in fractions of $\bar{c}$).

Step 2 – apply the stability requirement: A positive static margin requires $x_{CG} < x_{NP}$.

Step 3 – interpret: The centre of gravity must be forward of (ahead of) the neutral point.

Final Answer: CG ahead of the neutral point $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q18

Q19.

Solution

Concept – load factor in a level, banked turn: $n = \dfrac{1}{\cos\phi}$, where ϕ is the bank angle.

Step 1 – list the data: $\phi = 30°$.

Step 2 – evaluate the cosine: $\cos 30° = 0.8660$

Step 3 – take the reciprocal: $n = \dfrac{1}{0.8660}$

Step 4 – evaluate: $n = 1.155$

Final Answer: $n \approx 1.155 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – static margin: $\text{SM} = x_{NP} - x_{CG}$, both measured as fractions of the mean aerodynamic chord.

Step 1 – list the data: $x_{NP} = 0.50\,\bar{c}$, $x_{CG} = 0.28\,\bar{c}$.

Step 2 – subtract: $\text{SM} = 0.50 - 0.28$

Step 3 – evaluate: $\text{SM} = 0.22$

Final Answer: $\text{SM} = 0.22 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – period of a circular orbit: $T = 2\pi\sqrt{\dfrac{r^3}{\mu}}$.

Step 1 – list the data: $r = 7000\text{ km} = 7 \times 10^6\text{ m}$, $\mu = 3.986 \times 10^{14}\text{ m}^3/\text{s}^2$.

Step 2 – cube the radius: $r^3 = (7 \times 10^6)^3 = 3.43 \times 10^{20}\text{ m}^3$

Step 3 – divide by μ: $\dfrac{r^3}{\mu} = \dfrac{3.43 \times 10^{20}}{3.986 \times 10^{14}} = 8.605 \times 10^5$

Step 4 – take the square root: $\sqrt{8.605 \times 10^5} = 927.6$

Step 5 – multiply by 2π: $T = 2\pi \times 927.6 = 6.2832 \times 927.6$

Step 6 – evaluate: $T = 5829 \text{ s} \approx 97 \text{ min}$

Final Answer: $T \approx 5829 \text{ s} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – circular orbital speed: $v = \sqrt{\dfrac{\mu}{r}}$.

Step 1 – list the data: $r = 10000 \text{ km} = 1 \times 10^7 \text{ m}$, $\mu = 3.986 \times 10^{14} \text{ m}^3/\text{s}^2$.

Step 2 – divide μ by r: $\dfrac{\mu}{r} = \dfrac{3.986 \times 10^{14}}{1 \times 10^7} = 3.986 \times 10^7$

Step 3 – take the square root: $v = \sqrt{3.986 \times 10^7}$

$v = 6313 \text{ m/s}$

Step 4 – convert to km/s: $v = 6.31 \text{ km/s}$

Final Answer: $v \approx 6.31 \text{ km/s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept – eccentricity of an elliptic orbit: $e = \dfrac{r_a - r_p}{r_a + r_p}$, where r_p and r_a are the perigee and apogee radii measured from the Earth's centre.

Step 1 – list the data: Earth radius $R_E = 6378$ km, perigee altitude $= 500$ km, apogee altitude $= 2500$ km.

Step 2 – form the perigee radius: $r_p = 6378 + 500 = 6878$ km

Step 3 – form the apogee radius: $r_a = 6378 + 2500 = 8878$ km

Step 4 – form the numerator $r_a - r_p$: $8878 - 6878 = 2000$ km

Step 5 – form the denominator $r_a + r_p$: $8878 + 6878 = 15756$ km

Step 6 – divide: $e = \dfrac{2000}{15756} = 0.127$

Final Answer: $e \approx 0.127 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – axial elongation of a bar: $\delta = \dfrac{PL}{AE}$.

Step 1 – list the data: $P = 40$ kN $= 40000$ N, $L = 2$ m, $A = 500$ mm^2 $= 500 \times 10^{-6}$ m^2, $E = 70$ GPa $= 70 \times 10^9$ Pa.

Step 2 – form the numerator PL**:** $PL = 40000 \times 2 = 80000$

Step 3 – form the denominator AE**:** $AE = 500 \times 10^{-6} \times 70 \times 10^9$

$AE = 3.5 \times 10^7$

Step 4 – divide: $\delta = \dfrac{80000}{3.5 \times 10^7}$

Step 5 – evaluate: $\delta = 2.286 \times 10^{-3}$ m

Step 6 – convert to millimetres: $\delta = 2.29$ mm

Final Answer: $\delta \approx 2.29$ mm $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – maximum bending stress in a rectangular section: $\sigma = \dfrac{M}{Z}$ with $Z = \dfrac{bd^2}{6}$, so $\sigma = \dfrac{6M}{bd^2}$.

Step 1 – list the data: $M = 8$ kN $\cdot$ m $= 8 \times 10^6$ N $\cdot$ mm, $b = 40$ mm, $d = 120$ mm.

Step 2 – square the depth: $d^2 = 120^2 = 14400$ mm^2

Step 3 – form the denominator bd^2**:** $bd^2 = 40 \times 14400 = 576000$ mm^3

Step 4 – form the numerator $6M$**:** $6M = 6 \times 8 \times 10^6 = 48 \times 10^6$ N $\cdot$ mm

Step 5 – divide: $\sigma = \dfrac{48 \times 10^6}{576000}$

Step 6 – evaluate: $\sigma = 83.3$ N/mm^2 $= 83.3$ MPa

Final Answer: $\sigma \approx 83.3$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – torsional shear stress in a solid circular shaft: $\tau = \dfrac{16T}{\pi d^3}$.

Step 1 – list the data: $T = 2$ kN $\cdot$ m $= 2 \times 10^6$ N $\cdot$ mm, $d = 50$ mm.

Step 2 – cube the diameter: $d^3 = 50^3 = 125000$ mm^3

Step 3 – form the denominator πd^3**:** $\pi d^3 = 3.1416 \times 125000 = 392699$ mm^3

Step 4 – form the numerator $16T$**:** $16T = 16 \times 2 \times 10^6 = 32 \times 10^6$ N $\cdot$ mm

Step 5 – divide: $\tau = \dfrac{32 \times 10^6}{392699}$

Step 6 – evaluate: $\tau = 81.5$ MPa

Final Answer: $\tau \approx 81.5$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q26

Q27.

Solution

Concept – longitudinal stress in a thin cylinder: $\sigma_L = \dfrac{pd}{4t}$ (half the hoop stress).

Step 1 – list the data: $p = 1.5$ MPa, $d = 800$ mm, $t = 6$ mm.

Step 2 – form the numerator pd**:** $pd = 1.5 \times 800 = 1200$

Step 3 – form the denominator $4t$**:** $4t = 4 \times 6 = 24$

Step 4 – divide: $\sigma_L = \dfrac{1200}{24}$

Step 5 – evaluate: $\sigma_L = 50$ MPa

Final Answer: $\sigma_L = 50$ MPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept – Euler buckling of a fixed–free column: For a fixed–free (cantilever) column the effective length is $2L$, so $P_{cr} = \dfrac{\pi^2 EI}{(2L)^2} = \dfrac{\pi^2 EI}{4L^2}$.

Step 1 – list the data: $E = 200$ GPa $= 200 \times 10^9$ Pa, $I = 2 \times 10^6$ mm^4 $= 2 \times 10^{-6}$ m^4, $L = 1$ m.

Step 2 – form the product EI**:** $EI = 200 \times 10^9 \times 2 \times 10^{-6} = 4 \times 10^5$

Step 3 – multiply by π^2: $\pi^2 EI = 9.8696 \times 4 \times 10^5 = 3.9478 \times 10^6$

Step 4 – form the denominator $4L^2$: $4L^2 = 4 \times 1^2 = 4$

Step 5 – divide: $P_{cr} = \dfrac{3.9478 \times 10^6}{4}$

Step 6 – evaluate: $P_{cr} = 986960 \text{ N} \approx 987 \text{ kN}$

Final Answer: $P_{cr} \approx 987 \text{ kN} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept – minor principal stress (plane stress): $\sigma_2 = \dfrac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$.

Step 1 – list the data: $\sigma_x = 100$ MPa, $\sigma_y = 40$ MPa, $\tau_{xy} = 30$ MPa.

Step 2 – form the centre of Mohr's circle: $\dfrac{\sigma_x + \sigma_y}{2} = \dfrac{100 + 40}{2} = 70$ MPa

Step 3 – form the half-difference: $\dfrac{\sigma_x - \sigma_y}{2} = \dfrac{100 - 40}{2} = 30$ MPa

Step 4 – compute the radius: $R = \sqrt{30^2 + 30^2} = \sqrt{900 + 900} = \sqrt{1800}$

$R = 42.43$ MPa

Step 5 – subtract the radius from the centre: $\sigma_2 = 70 - 42.43$

Step 6 – evaluate: $\sigma_2 = 27.6$ MPa

Final Answer: $\sigma_2 \approx 27.6 \text{ MPa} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q29

Q30.

Solution

Concept – strain energy in an axially loaded bar: $U = \dfrac{P^2 L}{2AE}$.

Step 1 – list the data: $P = 50 \text{ kN} = 50000 \text{ N}$, $L = 1$ m, $A = 500 \text{ mm}^2 = 500 \times 10^{-6} \text{ m}^2$, $E = 200 \text{ GPa} = 200 \times 10^9$ Pa.

Step 2 – square the load: $P^2 = (50000)^2 = 2.5 \times 10^9$

Step 3 – multiply by the length: $P^2 L = 2.5 \times 10^9 \times 1 = 2.5 \times 10^9$

Step 4 – form the denominator $2AE$: $AE = 500 \times 10^{-6} \times 200 \times 10^9 = 1 \times 10^8$

$2AE = 2 \times 10^8$

Step 5 – divide: $U = \dfrac{2.5 \times 10^9}{2 \times 10^8}$

Step 6 – evaluate: $U = 12.5$ J

Final Answer: $U = 12.5 \text{ J} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – undamped natural frequency of a spring–mass system: $\omega_n = \sqrt{\dfrac{k}{m}}$ (in rad/s).

Step 1 – list the data: $k = 5000$ N/m, $m = 5$ kg.

Step 2 – form the ratio k/m: $\dfrac{k}{m} = \dfrac{5000}{5} = 1000$

Step 3 – take the square root: $\omega_n = \sqrt{1000}$

Step 4 – evaluate: $\omega_n = 31.6$ rad/s

Final Answer: $\omega_n \approx 31.6 \text{ rad/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – shear flow in a thin closed section (Bredt–Batho): $q = \dfrac{T}{2A_m}$, where A_m is the area enclosed by the wall mid-line.

Step 1 – list the data: $T = 600 \text{ N} \cdot \text{m}$, $A_m = 0.02 \text{ m}^2$.

Step 2 – form the denominator $2A_m$: $2A_m = 2 \times 0.02 = 0.04 \text{ m}^2$

Step 3 – divide: $q = \dfrac{600}{0.04}$

Step 4 – evaluate: $q = 15000$ N/m

Step 5 – express in kN/m: $q = 15$ kN/m

Final Answer: $q = 15 \text{ kN/m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – mid-span deflection of a simply supported beam with a central point load: $\delta = \dfrac{PL^3}{48EI}$.

Step 1 – list the data: $P = 2$ kN $= 2000$ N, $L = 2$ m, $E = 200$ GPa $= 200 \times 10^9$ Pa, $I = 1 \times 10^6\ \text{mm}^4 = 1 \times 10^{-6}\ \text{m}^4$.

Step 2 – cube the span: $L^3 = 2^3 = 8\ \text{m}^3$

Step 3 – form the numerator PL^3: $PL^3 = 2000 \times 8 = 16000$

Step 4 – form the product EI: $EI = 200 \times 10^9 \times 1 \times 10^{-6} = 2 \times 10^5$

Step 5 – form the denominator $48EI$: $48EI = 48 \times 2 \times 10^5 = 9.6 \times 10^6$

Step 6 – divide: $\delta = \dfrac{16000}{9.6 \times 10^6} = 1.667 \times 10^{-3}$ m

Step 7 – convert to millimetres: $\delta = 1.67$ mm

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

Answer: (B) Go Back to Q33

Q34.

Solution

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

Step 1 – list the data: $\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa, $\tau_{xy} = 15$ MPa.

Step 2 – form the half-difference: $\dfrac{\sigma_x - \sigma_y}{2} = \dfrac{60 - 20}{2} = 20$ MPa

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

$15^2 = 225$

Step 4 – add: $400 + 225 = 625$

Step 5 – take the square root: $\tau_{\max} = \sqrt{625}$

Step 6 – evaluate: $\tau_{\max} = 25.0$ MPa

Final Answer: $\tau_{\max} = 25.0\ \text{MPa} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q34

Q35.

Solution

Concept – thermal efficiency of an ideal Brayton cycle: $\eta = 1 - \dfrac{1}{r_p^{(\gamma-1)/\gamma}}$.

Step 1 – list the data: $r_p = 10$, $\gamma = 1.4$.

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: $10^{0.2857} = 1.931$

Step 4 – take the reciprocal: $\dfrac{1}{1.931} = 0.5179$

Step 5 – subtract from 1: $\eta = 1 - 0.5179 = 0.4821$

Step 6 – express as a percentage: $\eta = 48.2\%$

Final Answer: $\eta \approx 48.2\% \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q35

Q36.

Solution

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

Step 1 – list the data: $\dot{m} = 40$ kg/s, $V_0 = 250$ m/s, $V_e = 550$ m/s.

Step 2 – form the velocity difference: $V_e - V_0 = 550 - 250 = 300$ m/s

Step 3 – multiply by the mass flow rate: $F = 40 \times 300$

Step 4 – evaluate: $F = 12000$ N

Step 5 – express in kN: $F = 12$ kN

Final Answer: $F = 12 \text{ kN} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – specific thrust: $F_s = \dfrac{F}{\dot{m}}$, the thrust delivered per unit mass flow of air.

Step 1 – list the data: $F = 12 \text{ kN} = 12000$ N, $\dot{m} = 40$ kg/s.

Step 2 – write the formula: $F_s = \dfrac{F}{\dot{m}}$

Step 3 – substitute the numbers: $F_s = \dfrac{12000}{40}$

Step 4 – evaluate: $F_s = 300\ \text{N} \cdot \text{s/kg}$

Final Answer: $F_s = 300\ \text{N} \cdot \text{s/kg} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – exit velocity from an energy balance: 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: $c_p = 1005\ \text{J/kg} \cdot \text{K}$, $\Delta T = 400\ \text{K}$.

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

$2010 \times 400 = 804000$

Step 3 – take the square root: $V_e = \sqrt{804000}$

Step 4 – evaluate: $V_e = 896.7\ \text{m/s} \approx 897\ \text{m/s}$

Final Answer: $V_e \approx 897\ \text{m/s} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q38

Q39.

Solution

Concept – critical (choked) temperature ratio: At $M = 1$, $\dfrac{T^*}{T_0} = \dfrac{2}{\gamma + 1}$.

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

Step 2 – form the denominator $\gamma + 1$: $\gamma + 1 = 1.4 + 1 = 2.4$

Step 3 – divide: $\dfrac{T^*}{T_0} = \dfrac{2}{2.4}$

Step 4 – evaluate: $\dfrac{T^*}{T_0} = 0.833$

Final Answer: $\dfrac{T^*}{T_0} \approx 0.833 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q39

Q40.

Solution

Concept – Euler work of a compressor stage: $w = U\,\Delta C_w$, the product of blade speed and the change in whirl velocity.

Step 1 – list the data: $U = 210$ m/s, $\Delta C_w = 200$ m/s.

Step 2 – multiply: $w = 210 \times 200$

Step 3 – evaluate: $w = 42000$ J/kg

Step 4 – express in kJ/kg: $w = 42$ kJ/kg

Final Answer: $w = 42$ kJ/kg $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q40**

Q41.

Solution

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

Step 1 – list the data: $\dot{m} = 200$ kg/s, $V_e = 2800$ m/s.

Step 2 – multiply: $F = 200 \times 2800$

Step 3 – evaluate: $F = 560000$ N

Step 4 – express in kN: $F = 560$ kN

Final Answer: $F = 560$ kN $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q41**

Q42.

Solution

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

Step 1 – list the data: $V_e = 1962$ m/s, $g_0 = 9.81$ m/s^2.

Step 2 – write the formula: $I_{sp} = \dfrac{V_e}{g_0}$

Step 3 – substitute the numbers: $I_{sp} = \dfrac{1962}{9.81}$

Step 4 – evaluate: $I_{sp} = 200$ s

Final Answer: $I_{sp} = 200$ s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q42

Q43.

Solution

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

Step 1 – list the data: $I_{sp} = 250$ s, $g_0 = 9.81$ m/s^2, $\frac{m_0}{m_f} = 4$.

Step 2 – form the effective exhaust velocity $I_{sp}\, g_0$**:** $I_{sp}\, g_0 = 250 \times 9.81 = 2452.5$ m/s

Step 3 – take the natural log of the mass ratio: $\ln 4 = 1.3863$

Step 4 – multiply: $\Delta v = 2452.5 \times 1.3863$

Step 5 – evaluate: $\Delta v = 3400$ m/s

Final Answer: $\Delta v \approx 3400$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q43

Q44.

Solution

Concept – equivalence ratio: $\phi = \frac{(A/F)_{\text{stoich}}}{(A/F)_{\text{actual}}}$; $\phi > 1$ is a rich (fuel-excess) mixture.

Step 1 – list the data: $(A/F)_{\text{stoich}} = 15$, $(A/F)_{\text{actual}} = 12$.

Step 2 – form the ratio: $\phi = \frac{15}{12}$

Step 3 – evaluate: $\phi = 1.25$

Step 4 – interpret: Since $\phi > 1$, less air is supplied than needed for complete combustion, so the mixture is rich.

Final Answer: $\phi = 1.25 \Rightarrow \boxed{\text{C}}$

Answer: (C) 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: $V_0 = 180$ m/s, $V_e = 420$ m/s.

Step 2 – form the numerator $2V_0$**:** $2V_0 = 2 \times 180 = 360$

Step 3 – form the denominator $V_e + V_0$**:** $V_e + V_0 = 420 + 180 = 600$

Step 4 – divide: $\eta_p = \dfrac{360}{600}$

Step 5 – evaluate: $\eta_p = 0.60$

Final Answer: $\eta_p = 0.60 \Rightarrow \boxed{\text{A}}$

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: $T_{01} = 290$ K, $r_p = 4$, $\gamma = 1.4$.

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: $4^{0.2857} = 1.486$

Step 4 – multiply by the inlet temperature: $T_{02} = 290 \times 1.486$

Step 5 – evaluate: $T_{02} = 431.0$ K

$T_{02} \approx 431$ K

Final Answer: $T_{02} \approx 431$ K $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q46

Answer Key

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