GATE Aerospace Engineering

Sample Paper – 7

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. An aircraft cruises at a true airspeed of 300 m/s at an altitude where the local speed of sound is 340 m/s. The flight Mach number is nearest to: **[1 mark]**

(A) 0.88

(B) 1.13

(C) 0.68

(D) 0.94

Q2. In a low-speed incompressible flow the freestream velocity is 100 m/s and, at a point on an airfoil, the local velocity is 120 m/s. The pressure coefficient $\left(C_p = 1 - (V/V_\infty)^2\right)$ at that point is: **[1 mark]**

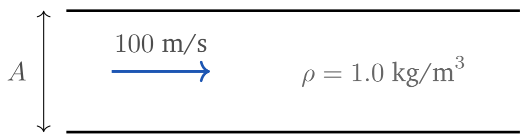
(A) -0.20

(B) $+0.44$

(C) -1.44

(D) -0.44

Q3. Air of density 1.0 kg/m^3 flows steadily through the duct shown at a mean velocity of 100 m/s across a cross-sectional area of 0.5 m^2. The mass flow rate through the duct is: **[1 mark]**



(A) 100 kg/s

(B) 25 kg/s

(C) 50 kg/s

(D) 150 kg/s

Q4. A two-dimensional airfoil section develops a circulation of 10 m^2/s in a stream of air ($\rho = 1.225$ kg/m^3) moving at 50 m/s. By the Kutta–Joukowski theorem $\left(L' = \rho V_\infty \Gamma\right)$, the lift per unit span is: **[1 mark]**

(A) 306.25 N/m

(B) 612.5 N/m

(C) 1225 N/m

(D) 500 N/m

Q5. A body with a reference area of $10\ \text{m}^2$ and a drag coefficient of 0.03 moves through air ($\rho = 1.225\ \text{kg/m}^3$) at $40\ \text{m/s}$. The drag force acting on the body is nearest to: **[1 mark]**

(A) 588 N

(B) 147 N

(C) 294 N

(D) 98 N

Q6. A thin airfoil has an incompressible (low-speed) lift coefficient of 0.50. Using the Prandtl–Glauert compressibility correction $\left(c_\ell = c_{\ell,0}/\sqrt{1 - M_\infty^2}\right)$ at a freestream Mach number of 0.60, the corrected lift coefficient is nearest to: **[1 mark]**

(A) 0.50

(B) 0.40

(C) 0.55

(D) 0.625

Q7. At sea level the static air temperature is 288 K. Taking $\gamma = 1.4$ and $R = 287$ J/kg · K, the local speed of sound is nearest to: **[1 mark]**

(A) 340.2 m/s

(B) 331.0 m/s

(C) 320.0 m/s

(D) 295.0 m/s

Q8. For the isentropic flow of air ($\gamma = 1.4$) at a Mach number of 2.0, the ratio of the local flow area to the sonic throat area $\left(A/A^*\right)$ is nearest to: **[1 mark]**

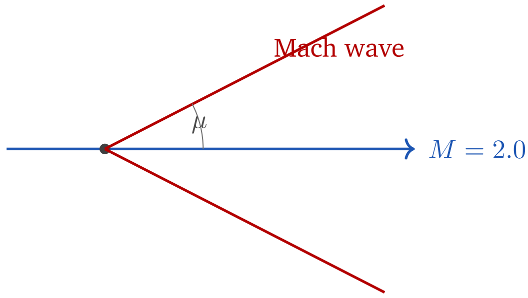
(A) 1.500

(B) 1.687

(C) 2.000

(D) 1.000

Q9. A slender body moves through still air at a Mach number of 2.0, generating the Mach wave shown. The Mach angle $\left(\mu = \sin^{-1}(1/M)\right)$ of the wave is: **[1 mark]**



(A) 45°

(B) 19.5°

(C) 30°

(D) 60°

Q10. A laminar boundary layer develops over a smooth flat plate held parallel to the flow. At a plate Reynolds number of 10^6, the average skin-friction coefficient given by the Blasius result $\left(C_f = 1.328/\sqrt{Re}\right)$ is nearest to: **[1 mark]**

(A) 0.00133

(B) 0.00066

(C) 0.00500

(D) 0.00266

Q11. Air flows at 45 m/s over a body of characteristic length 2 m. The kinematic viscosity of the air is 1.5×10^{-5} m^2/s. The Reynolds number based on the length is nearest to: **[1 mark]**

(A) 3.0×10^6

(B) 1.5×10^6

(C) 6.0×10^6

(D) 9.0×10^6

Q12. For a thin symmetric airfoil the section lift-curve slope is 2π per radian. Expressed per degree of angle of attack, the lift-curve slope is nearest to: **[1 mark]**

(A) 0.110 per degree

(B) 6.283 per degree

(C) 0.0175 per degree

(D) 0.550 per degree

Flight Mechanics & Space Dynamics

Q13. An aircraft of weight $20{,}000$ N flies at a speed where the power available from the engines is 1.0×10^6 W and the power required to overcome drag is 0.6×10^6 W. The steady rate of climb $\left(R/C = (P_a - P_r)/W\right)$ is: **[1 mark]**

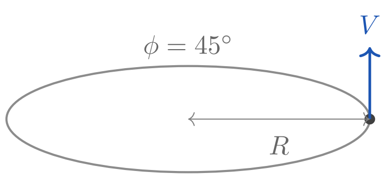
(A) 5 m/s

(B) 10 m/s

(C) 15 m/s

(D) 20 m/s

Q14. An aircraft performs a steady, level, co-ordinated turn at a true airspeed of 100 m/s with a bank angle of $45°$, as shown. The radius of the turn $\left(R = V^2/(g \tan\phi)\right)$ is nearest to: **[1 mark]**



(A) 509 m

(B) 2039 m

(C) 1019 m

(D) 1470 m

Q15. An aircraft performs a steady pull-up manoeuvre at a true airspeed of 100 m/s along a circular arc of radius 1000 m in the vertical plane. The load factor at the bottom of the pull-up $\left(n = 1 + V^2/(gR)\right)$ is nearest to: **[1 mark]**

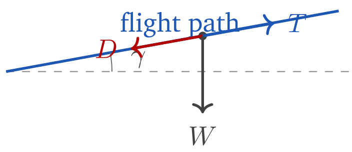
(A) 1.00

(B) 3.04

(C) 1.50

(D) 2.02

Q16. An aircraft of weight 20,000 N climbs steadily with an engine thrust of 6000 N against an aerodynamic drag of 4000 N, as shown in the free-body diagram. The climb angle $\left(\sin\gamma = (T - D)/W\right)$ is nearest to: **[1 mark]**



(A) 2.00°

(B) 8.53°

(C) 4.00°

(D) 5.74°

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 airplane to possess directional (weathercock) static stability about its centre of gravity, the yawing-moment coefficient C_n must vary with the sideslip angle β such that: **[1 mark]**

(A) $\dfrac{dC_n}{d\beta} < 0$

(B) $\dfrac{dC_n}{d\beta} > 0$

(C) $\dfrac{dC_n}{d\beta} = 0$

(D) $\dfrac{dC_\ell}{d\beta} > 0$

Q19. 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) 0.28

(B) 0.50

(C) 0.10

(D) 0.22

Q20. An aircraft of weight $30{,}000$ N has a wing planform area of 20 m^2. The wing loading (W/S) of the aircraft is: **[1 mark]**

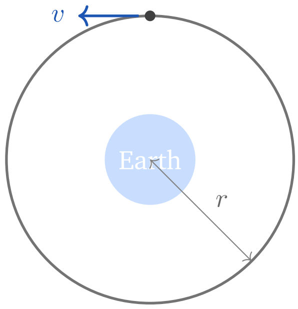
(A) 3000 N/m^2

(B) 1500 N/m^2

(C) 600 N/m^2

(D) 750 N/m^2

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



(A) 84.5 min

(B) 97.2 min

(C) 106 min

(D) 120 min

Q22. A satellite moves in a circular orbit of radius 8000 km about the Earth. Taking $\mu = 3.986 \times 10^{14}$ m^3/s^2, the orbital speed $\left(v = \sqrt{\mu/r}\right)$ is nearest to: **[2 marks]**

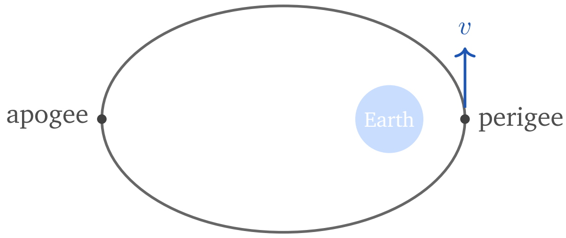
(A) 7.06 km/s

(B) 7.91 km/s

(C) 6.32 km/s

(D) 11.2 km/s

Q23. A satellite is in an elliptic orbit about the Earth with a perigee radius of 7000 km and a semi-major axis of 8000 km. Using the vis-viva equation $\left(v = \sqrt{\mu(2/r - 1/a)}\right)$ with $\mu = 3.986 \times 10^{14}$ m^3/s^2, the speed of the satellite at perigee is nearest to: **[2 marks]**



(A) 7.55 km/s

(B) 7.91 km/s

(C) 10.7 km/s

(D) 8.00 km/s

Aerospace Structures

Q24. A prismatic bar of length 2 m and cross-sectional area 500 mm^2 is made of a material with Young's modulus 200 GPa and carries an axial tensile load of 100 kN. The elongation of the bar $\left(\delta = PL/AE\right)$ is: **[2 marks]**

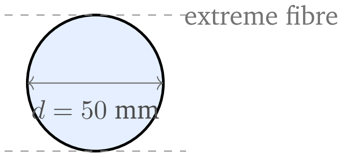
(A) 1 mm

(B) 4 mm

(C) 2 mm

(D) 0.5 mm

Q25. A beam has the solid circular cross-section shown, of diameter 50 mm. At a section the bending moment is 2 kN·m. The maximum bending stress $\left(\sigma = 32M/(\pi d^3)\right)$ at that section is nearest to: **[2 marks]**



(A) 82 MPa

(B) 163 MPa

(C) 326 MPa

(D) 120 MPa

Q26. A solid circular shaft of diameter 40 mm and length 1 m is made of a material with shear modulus 80 GPa and transmits a torque of 500 N·m. The angle of twist $\left(\theta = TL/(GJ),\ J = \pi d^4/32\right)$ over the length is nearest to: **[2 marks]**

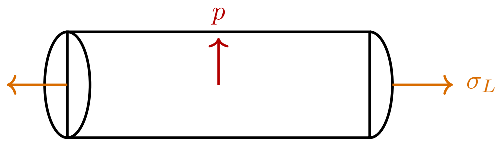
(A) $2.85°$

(B) $1.42°$

(C) $0.71°$

(D) $5.00°$

Q27. A thin-walled cylindrical pressure vessel of internal diameter 800 mm and wall thickness 8 mm carries an internal gauge pressure of 1.5 MPa, as shown. The longitudinal (axial) stress in the wall $\left(\sigma_L = pd/4t\right)$ is: **[2 marks]**



$d = 800$ mm, $t = 8$ mm

(A) 37.5 MPa

(B) 150 MPa

(C) 100 MPa

(D) 75 MPa

Q28. A fixed–free (cantilever) straight column of length 2 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]**

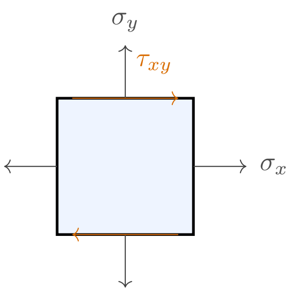
(A) 987 kN

(B) 494 kN

(C) 123 kN

(D) 247 kN

Q29. At a point in a loaded structural member the plane-stress components are $\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa and $\tau_{xy} = 20$ MPa, as shown on the stress element. The minor (minimum) principal stress at the point is nearest to: **[2 marks]**



(A) 11.7 MPa

(B) 40.0 MPa

(C) 28.3 MPa

(D) 68.3 MPa

Q30. A structural material has a Young's modulus of 200 GPa. When it is loaded to a direct stress of 200 MPa within its elastic range, the strain energy stored per unit volume (modulus of resilience, $u = \sigma^2/2E$) is: **[2 marks]**

(A) 200 kJ/m^3

(B) 50 kJ/m^3

(C) 25 kJ/m^3

(D) 100 kJ/m^3

Q31. A single-degree-of-freedom spring–mass system has a stiffness of 2000 N/m and a mass of 5 kg. The undamped natural period of oscillation $\left(T = 2\pi\sqrt{m/k}\right)$ is nearest to: **[2 marks]**

(A) 0.10 s

(B) 3.18 s

(C) 0.628 s

(D) 0.314 s

Q32. A thin-walled closed tube encloses an area of 0.02 m^2 and carries a torque of 400 N·m. Using the Bredt–Batho theory, the shear flow $\left(q = T/(2A_m)\right)$ in the wall is: **[2 marks]**

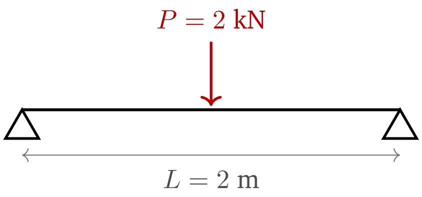
(A) 20 kN/m

(B) 10 kN/m

(C) 5 kN/m

(D) 40 kN/m

Q33. A simply-supported beam of span 2 m carries a concentrated load of 2 kN at mid-span, as shown. The beam has $E = 200$ GPa and $I = 2 \times 10^6$ mm^4. The mid-span deflection $\left(\delta = PL^3/48EI\right)$ is nearest to: **[2 marks]**



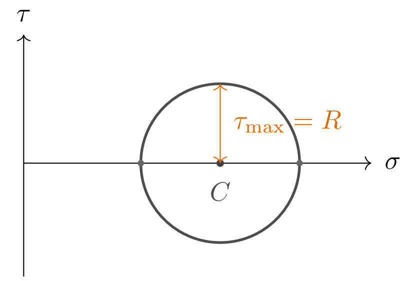
(A) 3.33 mm

(B) 1.67 mm

(C) 0.42 mm

(D) 0.833 mm

Q34. At a point in a thin skin the plane-stress components are $\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa and $\tau_{xy} = 30$ MPa. Using the Mohr's-circle construction shown, the maximum in-plane shear stress at the point is nearest to: **[2 marks]**



(A) 36.1 MPa

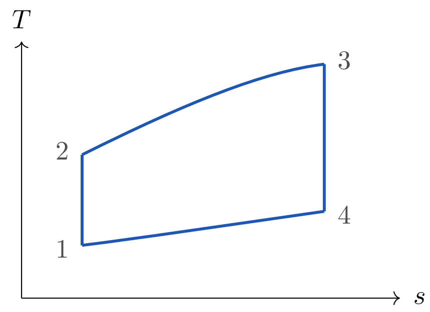
(B) 72.1 MPa

(C) 20.0 MPa

(D) 50.0 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 $\left(\eta = 1 - r_p^{-(\gamma-1)/\gamma}\right)$ of the cycle is nearest to: **[2 marks]**



(A) 60.0%

(B) 40.0%

(C) 48.2%

(D) 55.0%

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 650 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) 26 kN

(B) 16 kN

(C) 10 kN

(D) 32 kN

Q37. For the same turbojet, the net thrust is 16 kN while the air mass flow rate is 40 kg/s. The specific thrust $\left(F/\dot{m}\right)$ of the engine is: **[2 marks]**

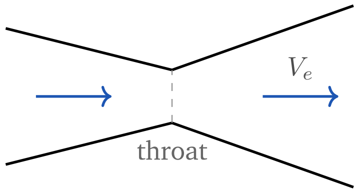
(A) 200 N · s/kg

(B) 400 N · s/kg

(C) 640 N · s/kg

(D) 800 N · s/kg

Q38. Air expands through the convergent–divergent nozzle shown, with a static temperature drop of 250 K from the chamber to the exit. 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) 709 m/s

(D) 317 m/s

Q39. Air ($\gamma = 1.4$) expands 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 $\left(T^*/T_0 = 2/(\gamma+1)\right)$ is nearest to: **[2 marks]**

(A) 0.833

(B) 0.528

(C) 0.634

(D) 0.500

Q40. In an axial-flow compressor stage the mean blade speed is 250 m/s and the whirl (tangential) component of the absolute velocity increases by 180 m/s across the rotor. Using the Euler turbomachinery equation, the specific work input $\left(w = U\,\Delta C_w\right)$ to the air is: **[2 marks]**

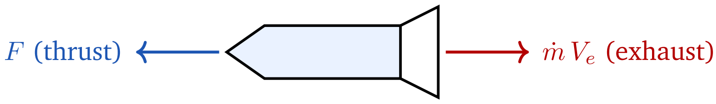
(A) 15 kJ/kg

(B) 30 kJ/kg

(C) 45 kJ/kg

(D) 60 kJ/kg

Q41. A rocket engine expels propellant at a mass flow rate of 80 kg/s with an effective exhaust velocity of 2500 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) 200 kN

(B) 300 kN

(C) 100 kN

(D) 400 kN

Q42. A rocket nozzle produces an effective exhaust velocity of 3432 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 nearest to: **[2 marks]**

(A) 300 s

(B) 350 s

(C) 288 s

(D) 250 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) 1700 m/s

(C) 3399 m/s

(D) 4905 m/s

Q44. A gas-turbine engine has a propulsive efficiency of 0.60 and a thermal (cycle) efficiency of 0.50. The overall efficiency $\left(\eta_o = \eta_p\,\eta_{th}\right)$ of the engine is: **[2 marks]**

(A) 0.50

(B) 0.60

(C) 0.30

(D) 0.10

Q45. A jet engine produces a net thrust of 20 kN while flying at a true airspeed of 200 m/s. The propulsive (thrust) power $\left(P = FV_0\right)$ delivered by the engine is: **[2 marks]**

(A) 4 MW

(B) 8 MW

(C) 2 MW

(D) 10 MW

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 10 ($\gamma = 1.4$). The compressor-exit stagnation temperature $\left(T_{02} = T_{01}\, r_p^{(\gamma-1)/\gamma}\right)$ is nearest to: **[2 marks]**

(A) 290 K

(B) 560 K

(C) 480 K

(D) 600 K

Detailed Solutions

Q1.

Solution

Concept – Mach number: The Mach number is the ratio of the flow speed to the local speed of sound, $M = V/a$.

Step 1 – list the data: $V = 300$ m/s, $a = 340$ m/s.

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

Step 3 – substitute the numbers: $M = \dfrac{300}{340}$

Step 4 – evaluate: $M = 0.882$

Step 5 – round: $M \approx 0.88$

Final Answer: $M \approx 0.88 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept – pressure coefficient in incompressible flow: $C_p = 1 - \left(\dfrac{V}{V_\infty}\right)^2$.

Step 1 – list the data: $V_\infty = 100$ m/s, $V = 120$ m/s.

Step 2 – form the velocity ratio: $\dfrac{V}{V_\infty} = \dfrac{120}{100} = 1.20$

Step 3 – square the ratio: $\left(\dfrac{V}{V_\infty}\right)^2 = 1.20^2 = 1.44$

Step 4 – subtract from one: $C_p = 1 - 1.44$

Step 5 – evaluate: $C_p = -0.44$

Step 6 – interpret the sign: The negative value shows that the local flow is faster than the freestream, so the static pressure there is below freestream static pressure.

Final Answer: $C_p = -0.44 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept – mass flow rate: $\dot{m} = \rho A V$.

Step 1 – list the data: $\rho = 1.0$ kg/m^3, $A = 0.5$ m^2, $V = 100$ m/s.

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

Step 3 – multiply density by area: $\rho A = 1.0 \times 0.5 = 0.5$

Step 4 – multiply by the velocity: $\dot{m} = 0.5 \times 100$

Step 5 – evaluate: $\dot{m} = 50$ kg/s

Final Answer: $\dot{m} = 50$ kg/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – Kutta–Joukowski theorem: The lift per unit span is $L' = \rho V_\infty \Gamma$.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V_\infty = 50$ m/s, $\Gamma = 10$ m^2/s.

Step 2 – write the formula: $L' = \rho V_\infty \Gamma$

Step 3 – multiply density by velocity: $\rho V_\infty = 1.225 \times 50 = 61.25$

Step 4 – multiply by the circulation: $L' = 61.25 \times 10$

Step 5 – evaluate: $L' = 612.5$ N/m

Final Answer: $L' = 612.5$ N/m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept – drag force: $D = \frac{1}{2}\rho V^2 S\, C_D$.

Step 1 – list the data: $\rho = 1.225$ kg/m^3, $V = 40$ m/s, $S = 10$ m^2, $C_D = 0.03$.

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

Step 3 – compute the dynamic pressure: $q = \frac{1}{2}\rho V^2 = 0.5 \times 1.225 \times 1600$

$q = 0.6125 \times 1600 = 980$ Pa

Step 4 – multiply by area and drag coefficient: $D = 980 \times 10 \times 0.03$

Step 5 – evaluate step by step: $980 \times 10 = 9800$

$9800 \times 0.03 = 294$ N

Final Answer: $D = 294$ N $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

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

Step 1 – list the data: $c_{\ell,0} = 0.50$, $M_\infty = 0.60$.

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

Step 3 – form $1 - M_\infty^2$**:** $1 - 0.36 = 0.64$

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

Step 5 – divide: $c_\ell = \dfrac{0.50}{0.80}$

Step 6 – evaluate: $c_\ell = 0.625$

Final Answer: $c_\ell = 0.625 \Rightarrow \boxed{\text{D}}$

Answer: (D) 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, $T = 288$ K.

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

Step 3 – multiply by the temperature: $\gamma R T = 401.8 \times 288 = 115718.4$

Step 4 – take the square root: $a = \sqrt{115718.4}$

Step 5 – evaluate: $a = 340.2$ m/s

Final Answer: $a \approx 340.2$ m/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – isentropic area–Mach relation: $\frac{A}{A^*} = \frac{1}{M}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}M^2\right)\right]^{\frac{\gamma+1}{2(\gamma-1)}}$.

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

Step 2 – evaluate the exponent: $\dfrac{\gamma+1}{2(\gamma-1)} = \dfrac{2.4}{0.8} = 3$

Step 3 – evaluate $\dfrac{2}{\gamma+1}$**:** $\dfrac{2}{2.4} = 0.8333$

Step 4 – evaluate the bracket $1+\frac{\gamma-1}{2}M^2$**:** $1 + 0.2 \times 4 = 1 + 0.8 = 1.8$

Step 5 – multiply the two terms inside the brackets: $0.8333 \times 1.8 = 1.5$

Step 6 – raise to the power 3**:** $1.5^3 = 3.375$

Step 7 – divide by M**:** $\dfrac{A}{A^*} = \dfrac{3.375}{2} = 1.6875$

Final Answer: $A/A^* \approx 1.687 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept – Mach angle: A weak Mach wave makes an angle $\mu = \sin^{-1}(1/M)$ with the flow direction.

Step 1 – list the data: $M = 2.0$.

Step 2 – form the sine of the angle: $\sin\mu = \dfrac{1}{M} = \dfrac{1}{2.0} = 0.5$

Step 3 – take the inverse sine: $\mu = \sin^{-1}(0.5)$

Step 4 – evaluate: $\mu = 30^\circ$

Final Answer: $\mu = 30^\circ \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept – Blasius average skin-friction coefficient: For a laminar flat-plate boundary layer, $C_f = \dfrac{1.328}{\sqrt{Re}}$.

Step 1 – list the data: $Re = 10^6$.

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

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

Step 4 – evaluate: $C_f = 0.001328$

Step 5 – round: $C_f \approx 0.00133$

Final Answer: $C_f \approx 0.00133 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

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

Step 1 – list the data: $V = 45$ m/s, $L = 2$ m, $\nu = 1.5 \times 10^{-5}$ m^2/s.

Step 2 – form the numerator VL: $VL = 45 \times 2 = 90$

Step 3 – divide by the kinematic viscosity: $Re = \dfrac{90}{1.5 \times 10^{-5}}$

Step 4 – evaluate: $Re = 6.0 \times 10^6$

Final Answer: $Re = 6.0 \times 10^6 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept – lift-curve slope per degree: The thin-airfoil slope is 2π per radian; to convert to per degree, multiply by $\pi/180$.

Step 1 – list the data: slope $= 2\pi$ per radian.

Step 2 – write the conversion: $a_0 = 2\pi \times \dfrac{\pi}{180}$ per degree

Step 3 – evaluate 2π: $2\pi = 6.2832$

Step 4 – evaluate $\dfrac{\pi}{180}$: $\dfrac{\pi}{180} = 0.017453$

Step 5 – multiply: $a_0 = 6.2832 \times 0.017453$

Step 6 – evaluate: $a_0 = 0.1097 \approx 0.110$ per degree

Final Answer: $a_0 \approx 0.110$ per degree $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – rate of climb from excess power: $R/C = \dfrac{P_a - P_r}{W}$, where P_a is power available and P_r is power required.

Step 1 – list the data: $P_a = 1.0 \times 10^6$ W, $P_r = 0.6 \times 10^6$ W, $W = 20000$ N.

Step 2 – compute the excess power: $P_a - P_r = 1.0 \times 10^6 - 0.6 \times 10^6$

$= 0.4 \times 10^6 = 400000$ W

Step 3 – divide by the weight: $R/C = \dfrac{400000}{20000}$

Step 4 – evaluate: $R/C = 20$ m/s

Final Answer: $R/C = 20$ m/s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept – radius of a level co-ordinated turn: $R = \dfrac{V^2}{g \tan\phi}$.

Step 1 – list the data: $V = 100$ m/s, $\phi = 45°$, $g = 9.81$ m/s^2.

Step 2 – evaluate $\tan\phi$**:** $\tan 45° = 1$

Step 3 – square the velocity: $V^2 = 100^2 = 10000$

Step 4 – form the denominator $g\tan\phi$**:** $9.81 \times 1 = 9.81$

Step 5 – divide: $R = \dfrac{10000}{9.81}$

Step 6 – evaluate: $R = 1019.4$ m ≈ 1019 m

Final Answer: $R \approx 1019$ m $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – load factor in a pull-up: At the bottom of a circular pull-up the lift must support the weight plus provide the centripetal force, so $n = 1 + \frac{V^2}{gR}$.

Step 1 – list the data: $V = 100$ m/s, $R = 1000$ m, $g = 9.81$ m/s^2.

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

Step 3 – form the denominator gR: $gR = 9.81 \times 1000 = 9810$

Step 4 – form the ratio: $\frac{V^2}{gR} = \frac{10000}{9810} = 1.0194$

Step 5 – add one: $n = 1 + 1.0194 = 2.0194$

Step 6 – round: $n \approx 2.02$

Final Answer: $n \approx 2.02 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – climb angle: For a steady climb, resolving along the flight path gives $T - D = W \sin\gamma$, so $\sin\gamma = \frac{T-D}{W}$.

Step 1 – list the data: $T = 6000$ N, $D = 4000$ N, $W = 20000$ N.

Step 2 – compute the excess thrust: $T - D = 6000 - 4000 = 2000$ N

Step 3 – form the ratio: $\sin\gamma = \frac{2000}{20000} = 0.1$

Step 4 – take the inverse sine: $\gamma = \sin^{-1}(0.1)$

Step 5 – evaluate: $\gamma = 5.74°$

Final Answer: $\gamma \approx 5.74° \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – maximum glide range: In a power-off glide the horizontal distance is $R = (L/D)_{\max} \times h$.

Step 1 – list the data: $(L/D)_{\max} = 20$, $h = 3000$ m.

Step 2 – write the formula: $R = (L/D)_{\max} \times h$

Step 3 – substitute the numbers: $R = 20 \times 3000$

Step 4 – evaluate: $R = 60000$ m

Step 5 – convert to kilometres: $R = 60$ km

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

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – directional (weathercock) static stability: Stability requires that a positive sideslip β produce a restoring (positive) yawing moment that turns the nose back into the wind, i.e. $\frac{dC_n}{d\beta} > 0$.

Step 1 – consider a disturbance: Suppose the aircraft develops a positive sideslip angle β (nose to one side of the relative wind).

Step 2 – state the restoring requirement: For stability the resulting yawing moment must act to reduce β, which means C_n must increase with β.

Step 3 – write the condition: $\frac{dC_n}{d\beta} > 0$

Step 4 – eliminate the wrong options: $dC_n/d\beta < 0$ is destabilising, $dC_n/d\beta = 0$ is neutral, and $dC_\ell/d\beta$ governs roll (dihedral effect), not directional stability.

Final Answer: $\frac{dC_n}{d\beta} > 0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – static margin: The static margin is the distance between the neutral point and the centre of gravity, in chord fractions, $SM = x_{NP} - x_{CG}$.

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

Step 2 – write the formula: $SM = x_{NP} - x_{CG}$

Step 3 – substitute the numbers: $SM = 0.50 - 0.28$

Step 4 – evaluate: $SM = 0.22$

Step 5 – interpret: A positive static margin (0.22, or 22% of the mean chord) confirms the aircraft is longitudinally statically stable.

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

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – wing loading: Wing loading is weight divided by wing planform area, W/S.

Step 1 – list the data: $W = 30000$ N, $S = 20$ m^2.

Step 2 – write the formula: $\frac{W}{S} = \frac{30000}{20}$

Step 3 – evaluate: $\frac{W}{S} = 1500$ N/m^2

Final Answer: $W/S = 1500$ N/m$^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept – orbital period of a circular orbit: $T = 2\pi\sqrt{\frac{a^3}{\mu}}$, with $a = r$ for a circular orbit.

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

Step 2 – cube the semi-major axis: $a^3 = (7 \times 10^6)^3 = 3.43 \times 10^{20}$ m^3

Step 3 – divide by μ: $\frac{a^3}{\mu} = \frac{3.43 \times 10^{20}}{3.986 \times 10^{14}} = 8.605 \times 10^5$ s^2

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

Step 5 – multiply by 2π: $T = 2\pi \times 927.6 = 5828.9$ s

Step 6 – convert to minutes: $T = \frac{5828.9}{60} = 97.1$ min ≈ 97.2 min

Final Answer: $T \approx 97.2$ min $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

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

Step 1 – list the data: $r = 8000$ km $= 8 \times 10^6$ m, $\mu = 3.986 \times 10^{14}$ m^3/s^2.

Step 2 – form the ratio μ/r**:** $\dfrac{\mu}{r} = \dfrac{3.986 \times 10^{14}}{8 \times 10^6}$

$= 4.9825 \times 10^7$ m^2/s^2

Step 3 – take the square root: $v = \sqrt{4.9825 \times 10^7}$

Step 4 – evaluate: $v = 7058.7$ m/s

Step 5 – convert to km/s: $v = 7.06$ km/s

Final Answer: $v \approx 7.06$ km/s $\Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q22

Q23.

Solution

Concept – vis-viva equation: $v = \sqrt{\mu\left(\dfrac{2}{r} - \dfrac{1}{a}\right)}$.

Step 1 – list the data: $r = 7000$ km $= 7 \times 10^6$ m, $a = 8000$ km $= 8 \times 10^6$ m, $\mu = 3.986 \times 10^{14}$ m^3/s^2.

Step 2 – evaluate $\dfrac{2}{r}$**:** $\dfrac{2}{7 \times 10^6} = 2.857 \times 10^{-7}$ m^{-1}

Step 3 – evaluate $\dfrac{1}{a}$**:** $\dfrac{1}{8 \times 10^6} = 1.250 \times 10^{-7}$ m^{-1}

Step 4 – take the difference: $2.857 \times 10^{-7} - 1.250 \times 10^{-7} = 1.607 \times 10^{-7}$ m^{-1}

Step 5 – multiply by μ**:** $3.986 \times 10^{14} \times 1.607 \times 10^{-7} = 6.406 \times 10^7$ m^2/s^2

Step 6 – take the square root: $v = \sqrt{6.406 \times 10^7} = 8004$ m/s

Step 7 – convert to km/s: $v \approx 8.00$ km/s

Final Answer: $v \approx 8.00$ km/s $\Rightarrow \boxed{\text{D}}$

$\boxed{\text{Answer: (D)}}$ Go Back to Q23

Q24.

Solution

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

Step 1 – list the data: $P = 100$ kN $= 1 \times 10^5$ N, $L = 2$ m, $A = 500$ mm^2 $= 5 \times 10^{-4}$ m^2, $E = 200$ GPa $= 2 \times 10^{11}$ Pa.

Step 2 – form the numerator PL**:** $PL = 1 \times 10^5 \times 2 = 2 \times 10^5$

Step 3 – form the denominator AE**:** $AE = 5 \times 10^{-4} \times 2 \times 10^{11} = 1 \times 10^8$

Step 4 – divide: $\delta = \dfrac{2 \times 10^5}{1 \times 10^8} = 2 \times 10^{-3}$ m

Step 5 – convert to millimetres: $\delta = 2$ mm

Final Answer: $\delta = 2$ mm $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – bending stress in a solid circular section: $\sigma = \dfrac{M}{Z}$ with the section modulus $Z = \dfrac{\pi d^3}{32}$, so $\sigma = \dfrac{32M}{\pi d^3}$.

Step 1 – list the data: $M = 2$ kN·m $= 2000$ N·m, $d = 50$ mm $= 0.05$ m.

Step 2 – cube the diameter: $d^3 = 0.05^3 = 1.25 \times 10^{-4}$ m^3

Step 3 – form the numerator $32M$**:** $32 \times 2000 = 64000$

Step 4 – form the denominator πd^3**:** $\pi \times 1.25 \times 10^{-4} = 3.927 \times 10^{-4}$

Step 5 – divide: $\sigma = \dfrac{64000}{3.927 \times 10^{-4}}$

Step 6 – evaluate: $\sigma = 1.630 \times 10^8$ Pa $= 163$ MPa

Final Answer: $\sigma \approx 163$ MPa $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – angle of twist of a circular shaft: $\theta = \dfrac{TL}{GJ}$, with $J = \dfrac{\pi d^4}{32}$.

Step 1 – list the data: $T = 500$ N·m, $L = 1$ m, $G = 80$ GPa $= 8 \times 10^{10}$ Pa, $d = 40$ mm $= 0.04$ m.

Step 2 – compute the polar moment J: $d^4 = 0.04^4 = 2.56 \times 10^{-6}$

$J = \dfrac{\pi \times 2.56 \times 10^{-6}}{32} = 2.513 \times 10^{-7}\ \text{m}^4$

Step 3 – form the denominator GJ: $GJ = 8 \times 10^{10} \times 2.513 \times 10^{-7} = 20106$

Step 4 – form the numerator TL: $TL = 500 \times 1 = 500$

Step 5 – divide to get θ in radians: $\theta = \dfrac{500}{20106} = 0.02487$ rad

Step 6 – convert to degrees: $\theta = 0.02487 \times \dfrac{180}{\pi} = 1.425°$

Final Answer: $\theta \approx 1.42° \Rightarrow \boxed{\text{B}}$

Answer: (B) 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 $= 1.5 \times 10^6$ Pa, $d = 800$ mm $= 0.8$ m, $t = 8$ mm $= 0.008$ m.

Step 2 – form the numerator pd: $pd = 1.5 \times 10^6 \times 0.8 = 1.2 \times 10^6$

Step 3 – form the denominator $4t$: $4t = 4 \times 0.008 = 0.032$

Step 4 – divide: $\sigma_L = \dfrac{1.2 \times 10^6}{0.032}$

Step 5 – evaluate: $\sigma_L = 3.75 \times 10^7$ Pa $= 37.5$ MPa

Final Answer: $\sigma_L = 37.5$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

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

Step 1 – list the data: $E = 200$ GPa $= 2 \times 10^{11}$ Pa, $I = 2 \times 10^6$ mm^4 $= 2 \times 10^{-6}$ m^4, $L = 2$ m.

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

$\pi^2 EI = 9.8696 \times 2 \times 10^{11} \times 2 \times 10^{-6}$

$= 9.8696 \times 4 \times 10^5 = 3.948 \times 10^6$

Step 3 – form the denominator $4L^2$**:** $4L^2 = 4 \times 2^2 = 4 \times 4 = 16$

Step 4 – divide: $P_{cr} = \dfrac{3.948 \times 10^6}{16}$

Step 5 – evaluate: $P_{cr} = 246740 \text{ N} \approx 247 \text{ kN}$

Final Answer: $P_{cr} \approx 247 \text{ kN} \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q28**

Q29.

Solution

Concept – minor principal stress (plane stress): $\sigma_{1,2} = \dfrac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$; the minor value takes the minus sign.

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

Step 2 – compute the average stress: $\dfrac{\sigma_x + \sigma_y}{2} = \dfrac{60 + 20}{2} = 40$ MPa

Step 3 – compute the half-difference: $\dfrac{\sigma_x - \sigma_y}{2} = \dfrac{60 - 20}{2} = 20$ MPa

Step 4 – form the radius of Mohr's circle: $R = \sqrt{20^2 + 20^2} = \sqrt{400 + 400} = \sqrt{800}$

$R = 28.28$ MPa

Step 5 – subtract the radius from the average: $\sigma_2 = 40 - 28.28$

Step 6 – evaluate: $\sigma_2 = 11.7$ MPa

Final Answer: $\sigma_2 \approx 11.7 \text{ MPa} \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q29**

Q30.

Solution

Concept – modulus of resilience: The strain energy stored per unit volume at a direct stress σ is $u = \dfrac{\sigma^2}{2E}$.

Step 1 – list the data: $\sigma = 200 \text{ MPa} = 2 \times 10^8$ Pa, $E = 200 \text{ GPa} = 2 \times 10^{11}$ Pa.

Step 2 – square the stress: $\sigma^2 = (2 \times 10^8)^2 = 4 \times 10^{16}$

Step 3 – form the denominator $2E$**:** $2E = 2 \times 2 \times 10^{11} = 4 \times 10^{11}$

Step 4 – divide: $u = \dfrac{4 \times 10^{16}}{4 \times 10^{11}}$

Step 5 – evaluate: $u = 1 \times 10^5$ J/m^3 $= 100$ kJ/m^3

Final Answer: $u = 100$ kJ/m^3 $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – natural period of a spring–mass system: $T = 2\pi\sqrt{\dfrac{m}{k}}$.

Step 1 – list the data: $k = 2000$ N/m, $m = 5$ kg.

Step 2 – form the ratio m/k: $\dfrac{m}{k} = \dfrac{5}{2000} = 0.0025$ s^2

Step 3 – take the square root: $\sqrt{0.0025} = 0.05$ s

Step 4 – multiply by 2π: $T = 2\pi \times 0.05$

Step 5 – evaluate: $T = 0.3142$ s ≈ 0.314 s

Final Answer: $T \approx 0.314$ s $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q31

Q32.

Solution

Concept – shear flow in a thin-walled closed tube (Bredt–Batho): $q = \dfrac{T}{2A_m}$, where A_m is the enclosed (median) area.

Step 1 – list the data: $T = 400$ N·m, $A_m = 0.02$ m^2.

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

Step 3 – divide: $q = \dfrac{400}{0.04}$

Step 4 – evaluate: $q = 10000$ N/m $= 10$ kN/m

Final Answer: $q = 10$ kN/m $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – mid-span deflection of a simply-supported beam: For 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 $= 2 \times 10^{11}$ Pa, $I = 2 \times 10^6$ mm^4 $= 2 \times 10^{-6}$ m^4.

Step 2 – cube the span: $L^3 = 2^3 = 8$ m^3

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

Step 4 – form the denominator $48EI$: $EI = 2 \times 10^{11} \times 2 \times 10^{-6} = 4 \times 10^5$

$48EI = 48 \times 4 \times 10^5 = 1.92 \times 10^7$

Step 5 – divide: $\delta = \dfrac{16000}{1.92 \times 10^7}$

Step 6 – evaluate: $\delta = 8.33 \times 10^{-4}$ m $= 0.833$ mm

Final Answer: $\delta \approx 0.833$ mm $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q33

Q34.

Solution

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

Step 1 – list the data: $\sigma_x = 60$ MPa, $\sigma_y = 20$ MPa, $\tau_{xy} = 30$ MPa.

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

Step 3 – square the half-difference: $20^2 = 400$

Step 4 – square the shear stress: $\tau_{xy}^2 = 30^2 = 900$

Step 5 – add and take the square root: $R = \sqrt{400 + 900} = \sqrt{1300}$

Step 6 – evaluate: $\tau_{\max} = 36.06$ MPa ≈ 36.1 MPa

Final Answer: $\tau_{\max} \approx 36.1$ MPa $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q34

Q35.

Solution

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

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: $10^{0.2857} = 1.9307$

Step 4 – take the reciprocal: $r_p^{-(\gamma-1)/\gamma} = \dfrac{1}{1.9307} = 0.5179$

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

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

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

Answer: (C) Go Back to Q35

Q36.

Solution

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

Step 1 – list the data: $\dot{m} = 40$ kg/s, $V_0 = 250$ m/s, $V_e = 650$ m/s.

Step 2 – compute the velocity increment: $V_e - V_0 = 650 - 250 = 400$ m/s

Step 3 – multiply by the mass flow: $F = 40 \times 400$

Step 4 – evaluate: $F = 16000$ N $= 16$ kN

Final Answer: $F = 16$ kN $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – specific thrust: The specific thrust is the thrust per unit air mass flow, $F/\dot{m}$.

Step 1 – list the data: $F = 16$ kN $= 16000$ N, $\dot{m} = 40$ kg/s.

Step 2 – write the ratio: $\dfrac{F}{\dot{m}} = \dfrac{16000}{40}$

Step 3 – evaluate: $\dfrac{F}{\dot{m}} = 400$ N · s/kg

Step 4 – note the units: 1 N · s/kg = 1 m/s, so the specific thrust is 400 m/s of equivalent velocity increment.

Final Answer: $F/\dot{m} = 400\ \text{N} \cdot \text{s/kg} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – nozzle exit velocity from energy conservation: With negligible inlet velocity, $V_e = \sqrt{2c_p\,\Delta T}$.

Step 1 – list the data: $c_p = 1005\ \text{J/kg} \cdot \text{K}$, $\Delta T = 250\ \text{K}$.

Step 2 – form the product $2c_p\Delta T$: $2 \times 1005 \times 250$

Step 3 – evaluate the product step by step: $2 \times 1005 = 2010$

$2010 \times 250 = 502500$

Step 4 – take the square root: $V_e = \sqrt{502500}$

Step 5 – evaluate: $V_e = 708.9\ \text{m/s} \approx 709\ \text{m/s}$

Final Answer: $V_e \approx 709\ \text{m/s} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – critical (sonic) 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 – form the ratio: $\dfrac{T^*}{T_0} = \dfrac{2}{2.4}$

Step 4 – evaluate: $\dfrac{T^*}{T_0} = 0.8333 \approx 0.833$

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

Answer: (A) Go Back to Q39

Q40.

Solution

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

Step 1 – list the data: $U = 250$ m/s, $\Delta C_w = 180$ m/s.

Step 2 – write the formula: $w = U\,\Delta C_w$

Step 3 – multiply: $w = 250 \times 180$

Step 4 – evaluate: $w = 45000$ J/kg

Step 5 – convert to kJ/kg: $w = 45$ kJ/kg

Final Answer: $w = 45$ kJ/kg $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q40

Q41.

Solution

Concept – ideal rocket thrust: For a perfectly expanded nozzle, $F = \dot{m}V_e$.

Step 1 – list the data: $\dot{m} = 80$ kg/s, $V_e = 2500$ m/s.

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

Step 3 – multiply: $F = 80 \times 2500$

Step 4 – evaluate: $F = 200000$ N

Step 5 – convert to kN: $F = 200$ kN

Final Answer: $F = 200$ 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: $V_e = 3432$ m/s, $g_0 = 9.81$ m/s^2.

Step 2 – write the formula: $I_{sp} = \dfrac{V_e}{g_0} = \dfrac{3432}{9.81}$

Step 3 – evaluate: $I_{sp} = 349.8$ s

Step 4 – round: $I_{sp} \approx 350$ s

Final Answer: $I_{sp} \approx 350$ s $\Rightarrow \boxed{\text{B}}$

Answer: (B) 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 ≈ 3399 m/s

Final Answer: $\Delta v \approx 3399$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q43

Q44.

Solution

Concept – overall efficiency of an air-breathing engine: $\eta_o = \eta_p\, \eta_{th}$, the product of propulsive and thermal efficiencies.

Step 1 – list the data: $\eta_p = 0.60$, $\eta_{th} = 0.50$.

Step 2 – write the formula: $\eta_o = \eta_p \times \eta_{th}$

Step 3 – multiply: $\eta_o = 0.60 \times 0.50$

Step 4 – evaluate: $\eta_o = 0.30$

Final Answer: $\eta_o = 0.30 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – propulsive (thrust) power: The useful thrust power is $P = FV_0$.

Step 1 – list the data: $F = 20$ kN $= 20000$ N, $V_0 = 200$ m/s.

Step 2 – write the formula: $P = FV_0$

Step 3 – multiply: $P = 20000 \times 200$

Step 4 – evaluate: $P = 4 \times 10^6$ W

Step 5 – convert to megawatts: $P = 4$ MW

Final Answer: $P = 4$ MW $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q45

Q46.

Solution

Concept – isentropic compressor exit temperature: $T_{02} = T_{01}\, r_p^{(\gamma-1)/\gamma}$.

Step 1 – list the data: $T_{01} = 290$ K, $r_p = 10$, $\gamma = 1.4$.

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: $10^{0.2857} = 1.9307$

Step 4 – multiply by the inlet temperature: $T_{02} = 290 \times 1.9307$

Step 5 – evaluate: $T_{02} = 559.9$ K ≈ 560 K

Final Answer: $T_{02} \approx 560$ K $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q46

Answer Key

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