HLK201 Helicopter Design Solution Sheet 1

Fundamentals of Helicopter Design

Q1 (7 pts)

Correct answer: c) Main rotor

The main rotor produces the majority of lift by generating aerodynamic force on the rotating blades. The tail rotor is primarily for anti-torque/yaw control.

Q2 (8 pts)

Correct answer: c) Pedals

Pedals command tail rotor (or anti-torque) thrust, which creates a yawing moment about the vertical axis.

Q3 (8 pts)

Correct answer: b) 200 N/m^2

Disk loading is thrust per rotor disk area.

Calculation / Steps:

- Use DL = T / A.
- Given T = 10,000 N and A = 50 m^2.
- DL = 10,000 / 50 = 200 N/m^2.

Common pitfall: Mixing up area units (m^2) or using rotor radius instead of rotor disk area.

Q4 (15 pts)

Correct answer: c) Symmetric

In ideal hover, there is no forward speed, so the inflow and velocity distribution across the rotor disk is (approximately) axisymmetric/symmetric.

Q5 (8 pts)

Correct answer: c) Hover

Hover is the flight condition where the helicopter maintains position (zero groundspeed) while producing lift equal to weight.

Q6 (8 pts)

Correct answer: b) Profile power

Profile power is the power required to overcome rotor blade profile drag. It exists whenever the rotor turns, even in hover.

Q7 (15 pts)

Correct answer: c) Hover requires maximum induced power

Induced power is associated with producing thrust (lifting the aircraft) and is highest in hover because there is no translational lift to reduce induced velocity.

Q8 (8 pts)

Correct answer: c) 1.225 kg/m^3

1.225 kg/m^3 is the standard sea-level air density used in many performance calculations (ISA standard).

Q9 (8 pts)

Correct answer: b) Tandem rotor

Tandem rotors counter-torque by using two main rotors rotating in opposite directions, eliminating the need for a tail rotor.

Q10 (15 pts)

Correct answer: b) Changes blade angle of attack equally

Collective changes pitch of all main-rotor blades by the same amount, increasing/decreasing total rotor thrust (and required power) without tilting the rotor disk.

Common pitfall: Confusing collective (total thrust control) with cyclic (disk-tilt/pitch-roll control).

Q11 (20 pts-Bonus Question)

Correct answer: b)

Using momentum theory in hover: $\vartheta_i = \sqrt{\frac{T}{2\rho A}}$ and $P_i = T\,\vartheta_i$, with $A = \pi R^2$.

Calculation / Steps:

- Compute disk area: $A = \pi R^2 = \pi \cdot 6^2 = 113.10\, m^2$.
- Compute induced velocity: $\vartheta_i = \sqrt{\frac{40{,}000}{2 \cdot 1.225 \cdot 113.10}} \approx \sqrt{144.35} \approx 12.0\, m/s$.
- Compute induced power: $P_i = T\,\vartheta_i = 40{,}000 \cdot 12.0 \approx 480\, kW$.

Common pitfall: The computed (ideal) result ($\sim 12.0\, m/s, \sim 480\, kW$) does not exactly match the listed options in the question. The closest option by $\vartheta_i$is (d). If you want a single correct MCQ option, adjust either R, A, or the answer choices.