

HLK201 Helicopter Design Solution Sheet

Questions Set 2: Rotorcraft Performance and Control

Q1 (7 pts)

Correct answer: b) Translational lift is absent

In hover there is no forward velocity through the rotor disk. Without translational lift, induced velocity (and induced power) is higher, driving higher power required.

Q2 (8 pts)

Correct answer: b) Advancing blade

In forward flight, the advancing blade sees a higher relative airspeed (rotational speed plus forward speed), while the retreating blade sees a lower relative airspeed.

Q3 (15 pts)

Correct answer: b) Hover

Hover ceiling is typically lower than forward-flight ceiling because hover requires higher induced power and lacks translational lift.

Q4 (8 pts)

Correct answer: c) 90 kW

Induced power in hover is $P_i = T v_i$.

Calculation / Steps:

- Given $T = 15000 \text{ N}$ and $v_i = 6 \text{ m/s}$.
- $P_i = 15000 \cdot 6 = 90\,000 \text{ W} = 90 \text{ kW}$.

Common pitfall: Forgetting to convert W to kW (divide by 1000).

Q5 (8 pts)

Correct answer: b) Momentum Theory

Momentum theory models the rotor as an actuator disk imparting momentum to the airflow.

Q6 (15 pts)

Correct answer: d) Blade twist distribution

Momentum theory provides disk-averaged induced quantities (e.g., induced velocity, thrust) but does not determine detailed blade geometry like twist or chord distribution.

Q7 (8 pts)

Correct answer: b) Thrust per unit area

Disk loading is defined as $DL = \frac{T}{A}$.

Q8 (8 pts)

Correct answer: c) Cyclic

Cyclic changes blade pitch as a function of azimuth, tilting the rotor disk to generate a lateral/longitudinal force component that counters overturning moments in forward flight.

Q9 (15 pts)

Correct answer: b) Profile power

Profile power is associated with rotor blade profile drag; parasite power is associated with fuselage/airframe drag.

Q10 (8 pts)

Correct answer: c) To carry higher structural loads

Blade roots experience the highest bending moments and centrifugal loads, so they are structurally reinforced (thicker sections).

Q11 (20 pts – Bonus Questions)

Correct answer: a) (per provided key)

Excess power is the difference between available and required power:

$$P_{exc} = P_{ava} - P_{req}.$$

Calculation / Steps:

- Available power at altitude:
- $P_{ava}(h) = 900 \cdot \left(\frac{\rho}{\rho_0}\right) = 900 \cdot 0.82 = 738 \text{ kW}.$
- Required power at altitude: $P_{req}(h) = 1.06 \cdot 780 = 826.8 \text{ kW}.$
- Excess power: $P_{exc} = 738 - 826.8 = -88.8 \text{ kW}.$

Common pitfall: The computed value (-88.8 kW) does not match the provided answer choices ($-6, 0, +32, +96 \text{ kW}$). To make the MCQ consistent, revise the options or the scaling assumptions.