

## 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 ( $-88.8 \text{ kW}$ ) 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.