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HLK201 HELICOPTER DESIGN

QUESTIONS SET 3

ROTORCRAFT DESIGN AND OPTIMIZATION

Q1. (8 p) Induced velocity in hover is:

$$\vartheta_i = \sqrt{\frac{T}{2\rho A}}$$

If thrust increases by $\mathbf{21}\%$ and rotor area is constant, induced velocity increases by approximately:

a) 5%
b) 10%
c) 21%
d) 33%

Q2. (12 p) Induced power varies as: $P_i \propto {\vartheta_i}^3$

If induced velocity increases by $\mathbf{20}\%$, induced power increases by approximately:

a) 20%
b) 44%
c) 73%
d) 120%

Q3. (8 p) Two helicopters generate equal thrust.
Helicopter B has **twice the rotor area** of Helicopter A.
The induced power of B relative to A is approximately:

a) 0.25
b) 0.50
c) 0.71
d) 1.00

Q4. (14 p) Reducing rotor radius while keeping thrust constant will:

a) Reduce disk loading
b) Reduce induced velocity
c) Increase induced power
d) Improve hover efficiency

Q5. (8 p) Why is rotor tip Mach number typically limited to **≈ 0.6**?

a) To reduce induced power
b) To reduce disk loading
c) To avoid compressibility effects and noise
d) To increase thrust coefficient

Q6. (16 p) Which statement is **correct**?

a) Profile power dominates in hover
b) Parasite power dominates at zero forward speed
c) Induced power dominates in hover
d) Tail rotor power is negligible

Q7. (8 p) Excess power primarily determines:

a) Rotor solidity
b) Lift coefficient
c) Climb rate, range, endurance
d) Tip Mach number

Q8. (18 p) Which statement is **false**?

a) Momentum Theory predicts induced velocity
b) Blade Element Theory provides geometry effects
c) Momentum Theory alone is sufficient for blade design
d) BEMT combines both theories

Q9. (8 p) Increasing rotor disk area while keeping thrust constant will:

a) Increase disk loading
b) Increase induced velocity
c) Reduce induced power
d) Increase profile power

Q10. (+20p – Bonus Question 1) Which change most improves **hover efficiency**?

a) Higher disk loading
b) Shorter rotor blades
c) Larger rotor disk area
d) Higher tip Mach number

Q11. (+20p – Bonus Question 2)

Two design options must generate the same hover thrust T at the same ρ.

- Design A: rotor radius R
- Design B: rotor radius $1.30\ R$

Assuming ideal momentum theory, what is the ratio of induced power:

$$\frac{P_{i,B}}{P_{i,A}} = ?$$

a) 0.59

b) 0.77

c) 0.88

d) 1.3

(Hint logic: $A \propto R^2$, and for fixed thrust $P_i \propto \frac{1}{\sqrt{A}}$.)
