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**HLK201 HELICOPTER DESIGN**  
**QUESTIONS SET 3**  
**ROTORCRAFT DESIGN AND OPTIMIZATION**

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**Q1.** (8 pts) Induced velocity in hover is:

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

If thrust increases by **21%** and rotor area is constant, induced velocity increases by approximately:

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

**Q2.** (12 pts) Induced power varies as:  $P_i \propto v_i^3$

If induced velocity increases by **20%**, induced power increases by approximately:

- a) 20%
  - b) 44%
  - c) 73%
  - d) 120%
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**Q3.** (8 pts) 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

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

- a) Reduce disk loading
  - b) Reduce induced velocity
  - c) Increase induced power
  - d) Improve hover efficiency
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**Q5.** (8 pts) Why is rotor tip Mach number typically limited to  $\approx 0.6$ ?

- a) To reduce induced power
  - b) To reduce disk loading
  - c) To avoid compressibility effects and noise
  - d) To increase thrust coefficient
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**Q6.** (16 pts) 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
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**Q7.** (8 pts) Excess power primarily determines:

- a) Rotor solidity
  - b) Lift coefficient
  - c) Climb rate, range, endurance
  - d) Tip Mach number
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**Q8.** (18 pts) 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
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**Q9.** (8 pts) 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
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**Q10.** (+20pts – 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
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**Q11.** (+20pts – Bonus Question 2)

Two design options must generate the same hover thrust  $T$  at the same  $\rho$ .

- 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  $P_i \propto \frac{1}{\sqrt{A}}$ .)

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