헬리콥터 고급이론 과제물 3번

제출기한: 5월 25일 (금)

1.

(a) Consider Eq. (11) of your notes (p. 48) and show that the Newton-Raphson iterative procedure applied to the inflow equation, represented by

$$\lambda_{n+1} = \lambda_n - (f / f')$$

results in expression (12) of your notes (p.48)

$$\lambda_{n+1} = \frac{\left[\mu \tan\alpha + \frac{C_T}{2}\frac{\left(\mu^2 + 2\lambda_n^2\right)}{\left(\mu^2 + \lambda_n^2\right)^{3/2}}\right]}{\left[1 + \frac{C_T}{2}\frac{\left(\lambda_n\right)}{\left(\mu^2 + \lambda_n^2\right)^{3/2}}\right]}$$

The error in this expression is

$$\varepsilon = \left|\frac{\lambda_{n+1} - \lambda_n}{\lambda_{n+1}}\right|$$

When using this equation it is convenient to start the iteration with

$$\lambda_H = \sqrt{\frac{C_T}{2}}$$

(b) Using this expression to evaluate the inflow for the following cases:

- $\mu = 0.1$, $\alpha = 5°$ $C_T = 0.005$
- $\mu = 0.2$; $\alpha = 6°$; $C_T = 0.005$
- $\mu = 0.3$ $\alpha = 7°$ $C_T = 0.005$

2.

Explain and discuss the potential benefits to be gained from using blade twist, planform taper, low solidity, large radius, and low rotational speed for the main rotor of a heavy lift helicopter that is designed to operate primarily in hover. Discuss any disadvantages associated with these design factors.

3.

(a) A rigid rotor blade with a uniform mass distribution has its flapping hinge located at a distance e from the axis of rotation. Furthermore, a concentrated mass M is located at the tip of the blade. Assume that the uniform mass distribution can be represented by a mass m/per unit length. If the rotor is rotating with constant angular speed Ω, calculate the natural frequency of the blade about the flapping hinge. Assume $\frac{e}{R} << 1$ where R is the blade radius.

(b) Assume that the rotor is hovering. Calculate the mean coning angle β_0, when the collective pitch setting on the blades is $\theta_0 = 10$ degrees.

4.

A rotor in a given flight condition has the following flapping motion with respect to the control axis (control plane): $\beta(\psi) = 6^\circ - 4^\circ \cos\psi - 4^\circ \sin\psi$. (a) Sketch a side view and rear view of the rotor. (b) How much is the TPP inclined in the fore and aft direction? Forward or backward? (c) How much is the TPP inclined laterally? Is the advancing or retreating blade high? (d) What angle does the blade make with the control plane at $\psi = 0, 90, 180, 270$ degrees. (e) At what azimuth angle is the flapping angle greatest? What is the flapping angle at this point?