

## Helicopter Engineering H.W. No. 2

Due: 05/08/2020 (Fri) 6:00 PM

1.

Suppose a hypothetical helicopter, somewhat similar to the Bell Jet Ranger, with the following data:

weight	$W = 3000 \text{ lb}$	$(1.333 \times 10^4 \text{ N})$
rotor radius	$R = 16 \text{ ft}$	$(4.88 \text{ m})$
rotor disk area	$A = \pi R^2 = 804 \text{ ft}^2$	$(74.7 \text{ m}^2)$
rotor tip speed	$V_t = 700 \text{ ft/sec}$	$(213 \text{ m/sec})$
rotor blade chord	$c = 1 \text{ ft (=constant)}$	$(0.3048 \text{ m})$
number of blades	$N = 2$	
blade profile drag coefficient	$c_{d_0} = 0.01$	
lift-curve slope	$a = 6$	

Take atmospheric density and pressure at sea level, respectively, as

$$\rho = 0.00238 \text{ slug/ft}^3 \quad (1.226 \text{ kg/m}^3), \quad p_\infty = 2116 \text{ lb/ft}^2 \quad (1.013 \times 10^5 \text{ N/m}^2)$$

Assume that the inflow is uniform  $\lambda_H = \frac{V_H}{\Omega R}$

- Find the non-dimensional pressure change  $\Delta p/p_\infty$  across the rotor disk.
- Find the value  $w$  of the induced velocity far below the rotor, according to the momentum theory.
- Find the thrust coefficient  $C_T$ .
- Find the (local) lift coefficient  $c_l$  at  $r = \frac{1}{2}R$ .
- Find the (local) blade pitch angle  $\theta$  at  $r = \frac{1}{2}R$ , in degrees.
- Find the ratio  $C_{P_p} / C_{P_i}$  of the profile-power coefficient to the induced-power coefficient.

$3000 = 1.333 \times 10^4 =$   
 $\gamma =$

2.

For a hovering helicopter with coaxial rotors, estimate the hovering horsepower required and the pitch settings for the rotor blades if

$$\begin{aligned}c &= 25'' \\R &= 185'' \\b &= 2 \text{ blades per rotor} \\T &= 6500 \text{ lb (total); RPM} = 300 \\ \theta &= \theta_1 / (r/R) \text{ (ideal twist)} \\ \rho &= 0.00238 \text{ slugs/ft}^3 \\ C_{d0} &= 0.012 \text{ (independent of } \alpha) \\ a &= 5.73 \text{ (per radian)}\end{aligned}$$

Neglect slipstream contractions in calculating rotor interference effects, but discuss qualitatively its influence on required  $\theta$ . You can also assume that each rotor produces 3250 lbs of thrust.