Due Date: 22 October 2007

Propeller Design Project

Design a fixed-pitch propeller for the following aircraft and conditions driven by the engine provided:

Aircraft and Flight Conditions:

Weight: 3550 lb
Planform Area: 210 ft^2
Drag polar: $C_D = 0.024 + 0.048\ C_L^2$
Cruising Altitude: 10,000 ft
Cruising Speed: 170 mph or better
Engine: AVCO Lycoming IO-540-J rated at 250 BHP running at 2300 RPM
Note: During the take-off run, the hub centerline is 6.5 feet above the ground

Propeller:

Airfoil: $C_{L\alpha} = 0.097$/deg and assume zero lift angle to be zero degrees; the following tabular values of section c_l and c_d are provide:

c_l	c_d
0	0.0093
0.2	0.0095
0.4	0.01
0.6	0.011
0.8	0.0125
1.0	0.015
1.2	0.02
1.4	0.0275

Notes: You may use an alternate blade design if you can find all the relevant data and demonstrate its use for propellers. You may use nonlinear twist and chord variation if you can rationalize your selection/design. Try the following initial linear variation of twist and chord length:

$\beta_{hub} = 40°$, $\beta_{tip} = 10°$
$c_{hub} = 7.5$ in, $c_{tip} = 4.5$ in
You may assume the hub to be located at $0.15 \le r/R \le 0.3$

Design Activity:

1. Your problem is to determine a suitable propeller (D, B, twist, chord etc.) with a good enough efficiency to produce the required cruise power and thrust as well as take-off performance. First optimize the pitch at 0.75R for take-off and cruise separately and then find a compromise pitch for a fixed pitch propeller.
2. The project will require you to find differential thrust and torque coefficient as a function of x = r/R. You must integrate these quantities to calculate C_T, and C_Q. From this effort, power coefficient (C_P) and propeller efficiency (η) can be determined.
3. You should then check to make sure the engine could actually drive the propeller at these flight conditions. If not, what can you do?
4. Once an acceptable design is determined, map the propeller parameters (C_T, C_Q, C_P and η) as a function of advance ratio for the take-off and cruise $\beta_{0.75R}$ angles. Also calculate Activity Factor for your design.