Tutorial problems for Propellers

1. An small aircraft is propelled by a 3.05 m diameter propeller, which produces 4.45 kN of thrust. The aircraft is flying at 160 km/hr at an altitude where the atmospheric conditions are such that the density of air is 1.003 kg/m^3. Using momentum theory compute : (i) the induced velocity through the disk, (ii) the final velocity of the flow in the far wake.

[(i) 5 m/s; (ii) 54.75 m/s)]

2. Compute the diameter of the flow field in the far wake of a propeller of diameter 3.05 m, which produces a propulsive thrust of 8.9 kN of thrust while flying at a speed of 322 km/hr.

[2.95 m]

3. A 907.2 kg helicopter is powered by a 9.144 m diameter rotor. When the helicopter is landing it descends at an uniform rate under sea level conditions, and the induced velocity is ⅓ the rate of descent of the helicopter. Compute the velocity at which the helicopter is descending.

[Hint : assuming $v_1 = 2v$; Rotor upward thrust = $\frac{m.dV}{dt}$ =2.A.ρ(V - v).v = Helicopter weight]

[15.82 m/s]

4. i) An aircraft cruises at 644 km/hr speed at sea level is powered by a propeller with gear box ratio of 1;2 powered by an engine with rpm 2600 and supply power 1491.5 kW. Compute the propeller diameter and the efficiency of the propeller at this operating condition. If the propeller is a variable pitch propeller what would be its efficiency at 161 km/hr. [Hint : use the speed-power characteristics plot given for solution].

ii) Solve the same problem if the propulsive unit is rated at 1342 kW, while the engine rotates at 2400 rpm.

[i) η_{prop} = 86% at J= 2.25; D = 3.667m; at low speed, η_{prop} = 50% ; ii) D=3.572m, η_{prop} = 85% at J=2.5]

5.An aircraft while cruising at 724 km/hr is expected to encounter 5927 N of drag. The propeller flying this aircraft is of diameter 3.657 m and is designed with NACA 5868-9 3-bladed propeller blades. The engine delivers 1491.4 kW while the propeller runs at 1300 rpm. Check if the aircraft propeller matching for cruise flight is achieved. Compute any extra power or power shortfall that may be found.

[Cruise flight is possible; 82 kW extra power available.]

6.An aircraft propeller is dsigned after NACA 5868-9 propeller of diameter 4.572 m, and is equipped with constant speed mechanism to hold the speed at 1200 rpm. The engine supplies 1789.7 kW. (BHP) at this propeller rpm. Plot a graph of THP (Thrust horse power available) versus speed, using flight speeds of 161, 322, 483, 644 and 805 km/hr. Also show the efficiency variation and blade angle variation with flight speed on the graph.

[Hint : @ V_{flight}= 483 km/hr, η_{prop}= 89%, $\beta=32^0$, THP =1593 kW]

7. Compute the induced angle at a station 70% of the blade span from the root of a propeller where the following specifications apply: Number of blades = 4, forward speed 482.8 km/hr, diameter = 6.1 m, Solidity = 0.1, Blade angle, $\beta = 20^0$, airfoil lift slope, a_0 = 0.1 per degree, rotational speed = 2100 rpm.

[1.05^0]

8.Compute the induced angle when the following specifications apply: number of blades = 4, diameter = 3.05 m, reference station under analysis = 1.22 m, blade width = 15.25 cm, forward speed of the aircraft = 325 km/hr, blade setting angle, $\beta = 25^0$, airfoil lift slope, a_0 = 0.1 per degree, rotational speed = 2000 rpm.

[1.5^0]

9.An aircraft flying at 592 km/hr is powered by a propeller rotating at 1800 rpm. The propeller is of 3.05 m diameter and uses NACA 0015 airfoil section, which has a minimum drag coefficient, C_D = 0.01, within the lift, C_L range from 0 to 0.45. At the reference blade section at 0.9144 m from the root, where the blade angle is 47.7^0 compute the following :

(i) local flow angle at the station, (ii) induced angle, (iii) Ψ_T, Ψ_Q (iv) dC_T/dx, dC_Q/dx.

[43.7^0 ; 0.51^0 ; 0.435, 0.451 ; 0.0549, 0.017]