AE 234/711 Aircraft Propulsion
Tutorial 4 - Propellers

1. Express the propeller efficiency in terms of J.
2. Verify that the power coefficient (C_P and advance ratio (J) are dimensionless.
3. Show that the optimum condition for propeller blade performance is

$$\left.\frac{V_a}{\omega r}\right|_{opt} = -\frac{C_{_D}}{C_{_L}} + \sqrt{\left(\frac{C_{_D}}{C_{_L}}\right)^2 + 1}$$

   where the propeller efficiency takes the value

$$\eta_{prop}|_{opt} = \left(\left.\frac{V_a}{\omega r}\right|_{opt}\right)^2$$

4. A light utility aircraft employs a $180hp$ normally-aspirated piston engine, with a $6ft$ diameter propeller. Assuming the ideal actuator disk power is 75% of the above, ascertain the static thrust at SSL conditions, and also at flight speeds of 60 and 120 ft/s.
5. Consider a twin-engine airplane that is powered by propeller engines. Let the flight speed be 120 ft/s. The propeller has a tip radius of $R = 6$ ft. Consider the propeller blade airfoil to have the following characteristics:

$$c_l = a_o\alpha, \text{ where } a_o = 5.7\text{rad}^{-1}, \text{ and } c_{l_{max}} = 1.2$$
$$c_d = 0.01 + 0.02\,(c_l - 0.15)^2 \text{ , where we maintain } c_l \geq 0.15$$

   Let the hub radius by $r_h = 0.2R$. If the propeller is rotating at an rpm of 2500, what should be the pitch angle variation along the propeller?