HW 2

1. $C = 6$; $k = 1.8$

a. $C = \bar{U}\left[0.568 + \frac{0.433}{k}\right]^{-1/k}$

$$\bar{U} = \frac{C}{\left[0.568 + \frac{0.433}{k}\right]^{-1/k}} = \frac{6}{\left[0.568 + \frac{0.433}{1.8}\right]^{-1/1.8}}$$

$\bar{U} = 5.33$ Ft/s

b. $P(6.5 \le U \le 7.5) = e^{-\alpha_1} - e^{-\alpha_2}$

$\alpha_1 = \left(\frac{U_1}{C}\right)^k = \left(\frac{6.5}{6}\right)^{1.8}$ $\alpha_2 = \left(\frac{U_2}{C}\right)^k = \left(\frac{7.5}{6}\right)^{1.8}$

$\alpha_1 = 1.155$ $\alpha_2 = 1.494$

$P(6.5 \le U \le 7.5) = e^{-1.155} - e^{-1.494} = 0.091$

$0.091 \cdot 365 \frac{\text{day}}{\text{yr}} \cdot 24 \text{ hrs} = \boxed{793 \text{ hrs./yr.}}$

c. $P(U \ge 16) = e^{-\alpha_0}$ $\alpha_0 = \left(\frac{U_0}{C}\right)^{1.8} = \left(\frac{16}{6}\right)^{1.8} \doteq 5.844$

$P(U \ge 16) = e^{-5.844} \doteq 0.0029$

$0.0029 \cdot 365 \cdot 24 = \boxed{25.4 \text{ hrs/year}}$

2. a. $P(14 \le U \le 25) = e^{-\beta_1} - e^{-\beta_2}$

$\beta_1 = \frac{\pi}{4}\left(\frac{U_1}{\bar{U}}\right)^2 \qquad \beta_2 = \frac{\pi}{4}\left(\frac{U_2}{\bar{U}}\right)^2$

$= \frac{\pi}{4}\left(\frac{14}{10}\right)^2 = 1.539 \qquad = \frac{\pi}{4}\left(\frac{25}{10}\right)^2 = 4.909$

$P(14 \le U \le 25) = e^{-1.539} - e^{-4.909} = 0.207$

$0.207 \cdot 365 \cdot 24 =$ **1815.2 hrs/yr.**

Annual Energy prod. $= 1815\ (1000)^{kW} =$ **1.82 GW**

b. Cut out speed = 25

$P(25 \ge U) = e^{-\beta_0} \qquad \beta_1 = \frac{\pi}{4}\left(\frac{25}{10}\right)^2 = 4.909$

$P(25 \ge U) = e^{-4.909} =$ **64.65 hrs./yr.**

3. a. $\Gamma = SU = (\pi D)(\Omega R) = (\pi D)\left(2\pi \frac{N}{60}\right)\left(\frac{D}{2}\right)$

$= \pi^2 D^2 \frac{N}{60}$ ✓

b. $\frac{L_0}{h} = \Delta U \Gamma =$ **$\Delta U\ \pi^2 D^2 \frac{N}{60}$**

4. $D = 0.75$ m $\quad N = 60$ rpm $\quad \rho_a = 1.225\ kg/m^3 \quad h = 7.5$

$U = 10$ m/s

$L_0 = (7.5\ m)\left(1.225\ \frac{kg}{m^3}\right)(10\ m/s)(\pi^2)(0.75^2)\left(\frac{60}{60}\right)$

$L_0 = 510\ N$

4. $\nu = 1.33 \cdot 10^{-5}\ m^2/s$

a. $Re = \frac{UC}{\nu}$ $\quad U = 16.14 \quad C = 1.41$

$$Re = \frac{(16.14)(1.41)}{1.33 \cdot 10^{-5}} = \boxed{1.711 \cdot 10^6}$$

b. $U = 75.08 \quad C = 0.35$

$$Re = \frac{(75.08)(0.35)}{1.33 \cdot 10^{-5}} = \boxed{1.976 \cdot 10^6}$$