The Boeing 777 has a wing planform area of 4,605 square feet (ft^2). (a) Assuming a takeoff weight of 506,000 lb and a takeoff velocity of 160 mil/h, calculate the lift coefficient at forcruise at mach number 0.83 at 30,000 ft, assuming the same weight.

Solution:

(a) for steady level fight, weight is equal to lift.

$$C_L = \frac{L}{q_\infty S} \qquad L = W$$

$$= \frac{W}{q_\infty S}$$

The Velocity must be expressed in consistent unit, since

60 mil/hr = 88 ft/s

$$\therefore V_\infty = 160 \text{ mil/hr} = 160 \times \frac{88}{60} \text{ ft/s} = 234.7 \text{ ft/s}$$

from the chart, @ Standard Sea level

$$\rho_\infty = 0.002377 \text{ slug per cubic foot (slugs/ft}^3\text{)}$$

$$\therefore q_\infty = \frac{1}{2}\rho_\infty V_\infty^2 = \frac{1}{2}(0.002377)(234.7)^2 = 65.45 \text{ lb/ft}^2$$

$$\therefore C_L = \frac{W}{q_\infty S} = \frac{506,000}{(65.45)(4,605)} = 1.68.$$

$$\boxed{C_L = 1.68}$$

(b) @ 30,000 ft from chart $\rho_\infty = 8.907 \times 10^{-4}$ slug/ft^3

$T_\infty = 411.86^\circ R$, $R = 1716$

$$\therefore a_\infty = \sqrt{\gamma R T}$$

$$= \sqrt{1.4 \times 1,716 \times 411.86}$$

$$= 994.7 \text{ ft/s}$$

$$V_\infty = a_\infty M_\infty = (994.7)(0.53)$$

$$= 825.6 \text{ ft/s}$$

$$\therefore q_\infty = \tfrac{1}{2} \rho_\infty V_\infty^2 = \tfrac{1}{2} (8.907 \times 10^{-4})(825.6)^2$$

$$= 303.56 \text{ lb/ft}^2$$

$$\therefore C_L = \frac{W}{q_\infty S} = \frac{506,000}{(30256)(4,605)} = 0.362$$

$$\boxed{C_L = 0.362}$$