the lift coefficient is doubled and the induced drag *is four times as great*. If the flight load factor is changed from one to five, the induced drag is twenty-five times as great. If all other factors are held constant to single out this effect, it could be stated that "induced drag varies as the square of the lift"

$$\frac{D_{i_2}}{D_{i_1}}=\left(\frac{L_2}{L_1}\right)^2$$

where

D_{i_1} = induced drag corresponding to some original lift, L_1

D_{i_2} = induced drag corresponding to some new lift, L_2

(and q (or EAS), S, AR are constant)

This expression defines the effect of gross weight, maneuvers, and steep turns on the induced drag, e.g., 10 percent higher gross weight increases induced drag 21 percent, 4G maneuvers cause 16 times as much induced drag, a turn with 45° bank requires a load factor of 1.41 and this doubles the induced drag.

EFFECT OF ALTITUDE. The effect of altitude on induced drag can be appreciated by holding all other factors constant. The general effect of altitude is expressed by:

$$\frac{Di_2}{Di_1}=\left(\frac{\sigma_1}{\sigma_2}\right)$$

where

Di_1 = induced drag corresponding to some original altitude density ratio, σ_1

Di_2 = induced drag corresponding to some new altitude density ratio, σ_2

(and L, S, AR, V are constant)

This relationship implies that induced drag would increase with altitude, e.g., a given airplane flying in level flight at a given TAS at 40,000 ft. ($\sigma=0.25$) would have four times as much induced drag than when at sea level ($\sigma=1.00$). This effect results when the lower air density requires a *greater* deflection of the airstream to produce the same lift. However, if the airplane is flown at the same EAS, the dynamic pressure will be the same and induced drag will not vary. In this case, the TAS would be higher at altitude to provide the same EAS.

EFFECT OF SPEED. The general effect of speed on induced drag is unusual since low airspeeds are associated with high lift coefficients and high lift coefficients create high induced drag coefficients. The immediate implication is that *induced drag increases with decreasing airspeed*. If all other factors are held constant to single out the effect of airspeed, a rearrangement of the previous equations would predict that "induced drag varies inversely as the square of the airspeed."

$$\frac{Di_2}{Di_1}=\left(\frac{V_1}{V_2}\right)^2$$

where

Di_1 = induced drag corresponding to some original speed, V_1

Di_2 = induced drag corresponding to some new speed, V_2

(and L, S, AR, σ are constant)

Such an effect would imply that a given airplane in steady flight would incur one-fourth as great an induced drag at twice as great a speed or four times as great an induced drag at half the original speed. This variation may be illustrated by assuming that an airplane in steady level flight is slowed from 300 to 150 knots. The dynamic pressure at 150 knots is one-fourth the dynamic pressure at 300 knots and the wing must deflect the airstream four times as greatly to create the same lift. The same lift force is then slanted aft four times as greatly and the induced drag is four times as great.

The expressed variation of induced drag with speed points out that induced drag will be of