The increase in wing lift ΔL due to the gust is given by

$$\Delta L = -\frac{1}{2}\rho V^2 S \frac{\partial C_L}{\partial \alpha} \Delta\alpha = -\frac{1}{2} \times 1.223 \times 250^2 \times 50 \times 4.8 \times 0.024$$

i.e.

$$\Delta L = -220\,140\,\text{N}$$

Hence

$$n = 1 - \frac{(220\,140 + 18\,162)}{145\,000} = -0.64$$

Finally the forward inertia force fW is given by

$$fW = D = \tfrac{1}{2}\rho V^2 S C_D = \tfrac{1}{2} \times 1.223 \times 250^2 \times 50 \times 0.0213$$

i.e.

$$fW = 40\,703\,\text{N}$$

Solutions to Chapter 15 Problems

S.15.1

Substituting the given values in Eq. (15.3)

$$S_a = 2 \times 230\left(1 - \frac{S_a}{2 \times 870}\right)$$

from which

$$S_a = 363\,\text{N/mm}^2$$

S.15.2

From Eq. (15.4)

$$S_a = 2 \times 230\left[1 - \left(\frac{S_a}{2 \times 870}\right)^2\right]$$

i.e.

$$S_a = 460 - 1.519 \times 10^{-4} S_a^2$$

or

$$S_a^2 + 6581.7 S_a - 3\,027\,600 = 0$$

Solving,

$$S_a = 432\,\text{N/mm}^2.$$

S.15.3

From Eq. (15.5) and supposing that the component fails after N sequences of the three stages

$$N\left(\frac{200}{10^4}+\frac{200}{10^5}+\frac{600}{2\times 10^5}\right)=1$$

which gives

$$N = 40$$

The total number of cycles/sequence is 1000 so that at 100 cycles/day the life of the component is

$$40\times\frac{1000}{100}=400\text{ days.}$$

S.15.4

From Eq. (15.30)

$$3320 = S(\pi\times 2.0)^{½}\times 1.0$$

which gives

$$S = 1324\,\text{N/mm}^2.$$

S.15.5

From Eq. (15.30)

$$K = S(\pi a_{\text{f}})^{½}\times 1.12$$

so that

$$a_{\text{f}} = \frac{1800^2}{\pi\times 180^2\times 1.12^2}$$

i.e.

$$a_{\text{f}} = 25.4\,\text{mm}$$

Now from Eq. (15.44)

$$N_{\text{f}} = \frac{1}{30\times 10^{-15}(180\times\pi^{½})^4}\left(\frac{1}{0.4}-\frac{1}{25.4}\right)$$

i.e.

$$N_{\text{f}} = 7916\text{ cycles.}$$

S.15.6

From Eq. (15.26)

$$D_g = F(V_e)^{5.26}$$

so that

$$D_g(200) = F(200)^{5.26} = 1.269F$$
$$D_g(220) = F(220)^{5.26} = 2.095F$$

Then

$$\frac{D_g(220)}{D_g(200)} = \frac{2.095F}{1.269F} = 1.65$$

i.e.

$$\text{Increase} = 65\%.$$

S.15.7

From Eq. (15.26)

$$D_g(240) = F(240)^{5.26} = 3.31 \times 10^{12}F$$
$$D_g(235) = F(235)^{5.26} = 2.96 \times 10^{12}F$$

Then, since

$$D_{gag} = 0.1D_{TOT}$$
$$D_{TOT}(240) = 0.1D_{TOT} + 3.31 \times 10^{12}F$$

and

$$D_{TOT}(235) = 0.1D_{TOT} + 2.96 \times 10^{12}F$$

Therefore

$$0.9D_{TOT}(240) = 3.31 \times 10^{12}F$$
$$D_{TOT}(240) = 3.68 \times 10^{12}F$$

Similarly

$$D_{TOT}(235) = 3.29 \times 10^{12}F$$

$$\text{Then, the increase in flights} = \frac{3.68 \times 10^{12}F}{3.29 \times 10^{12}F} = 1.12$$

i.e. a 12% increase.