Problem

The apparent weight of an aircraft when on the ground at the equator is 100 t. Assuming it is flying straight and at a constant altitude over the equator at 1000 kmh^{-1}, what is its apparent weight (a) if it flies north, (b) if it flies west, and (c) if it flies east?

Solution

On the ground the aircraft is subject to gravity

$$\begin{aligned} g^* &= g - \omega^2 R_E \\ &= 9.807 - (7.292 \times 10^{-5})^2 (6.378 \times 10^6) \\ &= 9.807 - 0.034 = 9.773\, ms^{-2} \end{aligned}$$

(a) Flying north it's subject to an additional centrifugal force since it's following the Earth's curvature

$$\begin{aligned} g_N^* &= g^* - \frac{v^2}{R_E} \qquad \text{where} \quad v = \frac{10^6}{60 \times 60} = 277.8\, ms^{-1} \\ &= 9.773 - \frac{277.8^{\,2}}{6.378 \times 10^6} = 0.773 - 0.012 = 9.761\, ms^{-1} \\ \text{Apparent weight} &= \frac{g_N^*}{g^*} 100 \quad = \quad \frac{9.761}{9.773} \times 100 \\ &= 99.88\, t\, wt \end{aligned}$$

(b) Flying west it's subject to an additional *downwards* Corolis force

$$\begin{aligned} g_W^* &= g^* - \frac{v^2}{R_E} + 2\omega v \qquad \text{where} \quad \omega = 7.292 \times 10^{-5}\, ms^{-2} \\ &= 9.773 - 0.012 + 2(7.292 \times 10^{-5})(277.8) \\ &= 9.773 - 0.012 + 0.041 = 9.802\, ms^{-1} \\ \text{Apparent weight} &= \frac{g_W^*}{g^*} 100 \quad = \quad \frac{9.802}{9.773} \times 100 \\ &= 100.29\, t\, wt \end{aligned}$$

(c) Flying east the Coriolis is in the opposite direction

$$\begin{aligned} g_E^* &= g^* - \frac{v^2}{R_E} - 2\omega v \qquad \text{where} \quad \omega = 7.292 \times 10^{-5}\, ms^{-2} \\ &= 9.773 - 0.012 - 0.041 = 9.72\, ms^{-1} \\ \text{Apparent weight} &= \frac{g_E^*}{g^*} 100 \quad = \quad \frac{9.72}{9.773} \times 100 \\ &= 99.46\, t\, wt \end{aligned}$$
