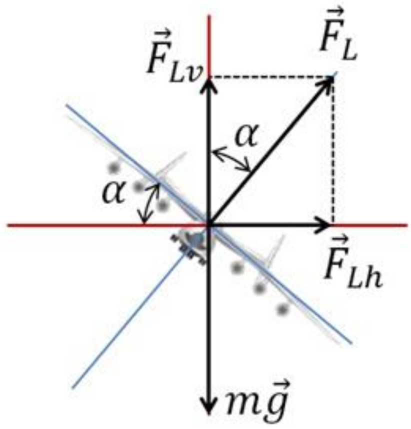
Answer on Question #70576, Physics / Mechanics | Relativity

Question. An airplane of mass 16800 kg is flying in a straight line at a constant altitude and with a speed of 620.0 km/h. The force that keeps the airplane in the air is provided entirely by the aerodynamic lift generated by the wings. The direction of this force is perpendicular to the wing surface. Calculate the magnitude of the lift generated by the wings of this airplane.

To change the direction of the plane, its wings are banked. If the wings of the plane are banked 37.5° to the horizontal, what is the radius of the circle in which the plane will be flying? Assume that the speed remains 620.0 km/h during the turn and that the magnitude of the lift provided by the wings is unchanged. What is the magnitude of the vertical acceleration that the airplane experiences as a result of the turn?

Given.

$m = 16800\ kg; v = 620.0\ \frac{km}{h} = 172.2\ \frac{m}{s}; \alpha = 37.5°.$



Find.

$F_L - ?; R - ?; a_v - ?.$

Solution.

The magnitude of the lift during regular flight

$$\boldsymbol{F_L = mg} = 16800 \cdot 9.81 \approx \mathbf{1.65 \cdot 10^5}\ \boldsymbol{N}.$$

With the wings banked (see figure), the horizontal component of the lift is

$$F_{Lh} = F_L \cdot \sin\alpha = mg \cdot \sin\alpha.$$

Then

$$\sum F_h = ma_c \quad \rightarrow \quad F_{Lh} = ma_c \quad \rightarrow \quad mg \cdot \sin\alpha = m \cdot \frac{v^2}{R} \quad \rightarrow \quad \boldsymbol{R} = \frac{\boldsymbol{v^2}}{\boldsymbol{g \cdot \sin\alpha}} = \frac{172.2^2}{9.81 \cdot \sin 37.5°} = \mathbf{4965}\ \boldsymbol{m}.$$

The magnitude of the vertical acceleration

$$\sum F_v = ma_v \quad \rightarrow \quad mg - F_{Lv} = ma_v \quad \rightarrow \quad mg - F_L \cdot \cos\alpha = ma_v$$

$$mg - mg \cdot \cos\alpha = ma_v \rightarrow \boldsymbol{a_v = g(1 - \cos\alpha)} = 9.81(1 - \cos 37.5°) = \mathbf{2.03}\ \boldsymbol{\frac{m}{s^2}}.$$

Answer: $F_L = 1.65 \cdot 10^5\ N, R = 4965\ m, a_v = 2.03\ \frac{m}{s^2}.$