Determining the horizontal and vertical location of the center of gravity of a taildragger

By measuring the weights on the main wheels and tail wheel with the airplane at two different attitudes, one can determine both the horizontal and vertical location of the center of gravity (CG). Referring to figure 1, the top figure shows the airframe in the standard configuration for measuring the location of the CG. This configuration is often defined with the main longeron level. All measurements are made relative to the axle of the main gear. The location of the CG is (x, y) where x and y are the horizontal and vertical distances of the CG from the main axle, respectively.

To determine x, the quantities you will measure are: the total weight on the main wheels W_{mains}, the weight on the tail wheel W_{tail}, and the horizontal distance between the main gear axle to the point below the axle of the tail wheel X. The horizontal location of the CG relative to the main gear axle is given by

$$x = \frac{W_{\text{tail}}}{W_{\text{total}}} X, \tag{1}$$

where $W_{\text{total}} = W_{\text{mains}} + W_{\text{tail}}$.

Now, set the tail wheel on the ground as in the bottom figure in figure 1, and measure the new horizontal location of the CG relative to the main axle x'.

$$x' = \frac{W'_{\text{tail}}}{W_{\text{total}}} X', \tag{2}$$

Now, the value of y can be determined using trigonometry by measuring the angle change θ; see figure 2. The CG location relative to the main gear axle moves to (x', y') where

$$x' = x\cos(\theta) + y\sin(\theta). \tag{3}$$

Therefore, the vertical position of the CG in the the standard configuration is given by

$$y = \frac{x' - x\cos(\theta)}{\sin(\theta)}. \tag{4}$$

One can repeat this process for additional heights of the tail wheel to check that the results for y are the same within measurement error. If the tail is lifted relative to the standard configuration, use negative values for θ.

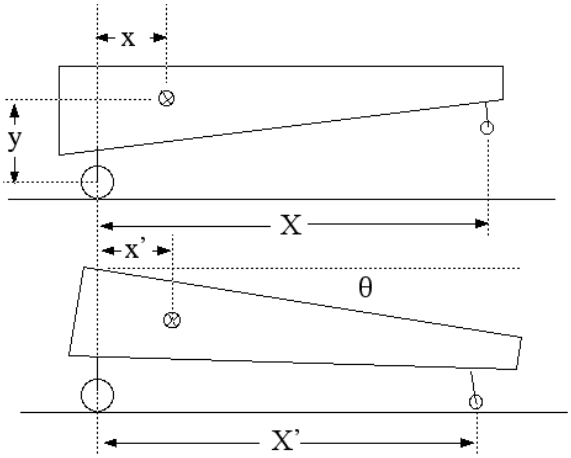

Figure 1: Configuration of the aircraft in flight configuration (top) and three-point configuration (bottom). The angle θ can be measured using an angle measuring tool or by using $\theta = \arctan(H/X) + \arctan(R/X)$, where H is the height of the bottom of the tailwheel above the main axle in the top figure, and R is the height of the main axle above the ground.

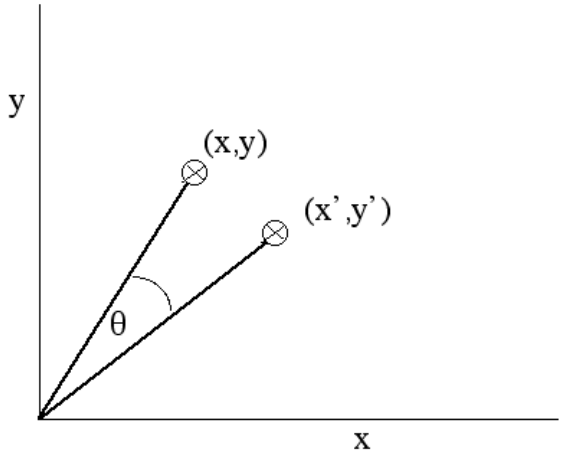

Figure 2: Movement of the location of the CG as the fuselage is rotated downward by angle θ. The horizontal position of the CG moves to $x' = x\cos(\theta) + y\sin(\theta)$.