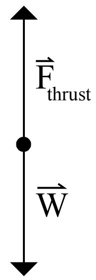
Chapter 4 Problem 56 [†]



Given
$m_{F-14} = 1.6 \times 10^4\ kg$
$F_{F-14} = 2.7 \times 10^5\ N$
$m_{747} = 3.6 \times 10^5\ kg$
$F_{747} = 7.7 \times 10^5\ N$

Solution
Can either the F-14 or the 747 jumbo jet do a vertical climb. The free-body diagram for each plane is given above. In order for the plane to make a vertical climb the acceleration must be positive. From Newton's second law we get

$$\Sigma\vec{F} = m\vec{a}$$

$$\vec{F}_{thrust} + \vec{W} = m\vec{a} > 0$$

Therefore,

$$\vec{F}_{thrust} > -\vec{W}$$

$$F_{thrust}\hat{j} > -(-mg\hat{j})$$

$$F_{thrust} > mg$$

For the F-14

$$F_{F-14} > (1.6 \times 10^4\ kg)(9.8\ m/s^2) = 1.6 \times 10^5\ N$$

Since the thrust of the F-14 is greater than $1.6 \times 10^5\ N$, the F-14 can fly vertically.

The acceleration can be found by using the free body diagram and Newton's 2nd law.

$$\vec{F}_{thrust} + \vec{W} = m\vec{a}$$

The thrust is in the positive y direction and the weight is in the negative y direction resulting in the equation

$$F_{thrust}\hat{j} - mg\hat{j} = m\vec{a}$$

Solving for acceleration gives

$$\vec{a} = \frac{F_{thrust}\hat{j} - mg\hat{j}}{m} = \frac{F_{thrust} - mg}{m}\hat{j}$$

[†] Problem from Essential University Physics, Wolfson

$$\vec{a} = \frac{2.7 \times 10^5\ N - (1.6 \times 10^4\ kg)(9.8\ m/s^2)}{1.6 \times 10^4\ kg}\hat{j}$$

$$\vec{a} = 7.1\hat{\ }m/s^2$$

For the 747 jumbo jet

$$F_{747} > (3.7 \times 10^5\ kg)(9.8\ m/s^2) = 3.6 \times 10^6\ N$$

Since the thrust of the 747 is less than $3.6 \times 10^6\ N$, the 747 can not fly vertically.