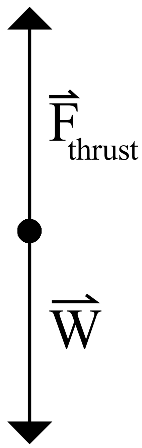
Chapter 4 Problem 61 †



Given

$m_{F-35A} = 18\ Mg = 18 \times 10^6\ g = 1.8 \times 10^4\ kg$
$F_{F-35A} = 191\ kN = 1.91 \times 10^5\ N$
$m_{A-380} = 560\ Mg = 560 \times 10^6\ g = 5.6 \times 10^5\ kg$
$F_{A-380} = 1.5\ MN = 1.5 \times 10^6\ N$

Solution

Can either the F-35A or the Airbus A-380 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-35A

$$F_{F-35A} = (1.8 \times 10^4\ kg)(9.80\ m/s^2) = 1.76 \times 10^5\ N$$

Since the thrust of the F-35A is greater than $1.91 \times 10^5\ N$, the F-35A 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

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

†Problem from Essential University Physics, Wolfson

Solving for acceleration gives

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

$$\vec{a} = \frac{1.91 \times 10^5\ N - (1.8 \times 10^4\ kg)(9.8\ m/s^2)}{1.8 \times 10^4\ kg}\hat{j}$$

$$\vec{a} = 0.81\hat{j}\ m/s^2$$

For the Airbus A-380

$$F_{A-380} > (5.6 \times 10^5\ kg)(9.8\ m/s^2) = 5.49 \times 10^6\ N$$

Since the thrust of the A-380 is less than $5.49 \times 10^6\ N$, the 747 can not fly vertically.