

8. The centers of mass (with centimeters understood) for each of the five sides are as follows:

$$\begin{aligned}(x_1, y_1, z_1) &= (0, 20, 20) && \text{for the side in the } yz \text{ plane} \\(x_2, y_2, z_2) &= (20, 0, 20) && \text{for the side in the } xz \text{ plane} \\(x_3, y_3, z_3) &= (20, 20, 0) && \text{for the side in the } xy \text{ plane} \\(x_4, y_4, z_4) &= (40, 20, 20) && \text{for the remaining side parallel to side 1} \\(x_5, y_5, z_5) &= (20, 40, 20) && \text{for the remaining side parallel to side 2}\end{aligned}$$

Recognizing that all sides have the same mass m , we plug these into Eq. 9-5 to obtain the results (the first two being expected based on the symmetry of the problem).

(a)

$$x_{\text{com}} = \frac{mx_1 + mx_2 + mx_3 + mx_4 + mx_5}{5m} = \frac{0 + 20 + 20 + 40 + 20}{5} = 20 \text{ cm}$$

(b)

$$y_{\text{com}} = \frac{my_1 + my_2 + my_3 + my_4 + my_5}{5m} = \frac{20 + 0 + 20 + 20 + 40}{5} = 20 \text{ cm}$$

(c)

$$z_{\text{com}} = \frac{mz_1 + mz_2 + mz_3 + mz_4 + mz_5}{5m} = \frac{20 + 20 + 0 + 20 + 20}{5} = 16 \text{ cm}$$

21. Using Eq. 9-22, the necessary speed v is

$$v = \frac{p}{m} = \frac{(1600 \text{ kg})(1.2 \text{ km/h})}{80 \text{ kg}} = 24 \text{ km/h} .$$

31. Our notation is as follows: the mass of the motor is M ; the mass of the module is m ; the initial speed of the system is v_0 ; the relative speed between the motor and the module is v_r ; and, the speed of the module relative to the Earth is v after the separation. Conservation of linear momentum requires $(M + m)v_0 = mv + M(v - v_r)$. Therefore,

$$v = v_0 + \frac{Mv_r}{M + m} = 4300 \text{ km/h} + \frac{(4m)(82 \text{ km/h})}{4m + m} = 4.4 \times 10^3 \text{ km/h} .$$

42. (a) We use Eq. 9-42. The thrust is

$$\begin{aligned} R v_{\text{rel}} &= Ma \\ &= (4.0 \times 10^4 \text{ kg}) (2.0 \text{ m/s}^2) \\ &= 8.0 \times 10^4 \text{ N} . \end{aligned}$$

(b) Since $v_{\text{rel}} = 3000 \text{ m/s}$, we see from part (a) that $R \approx 27 \text{ kg/s}$.