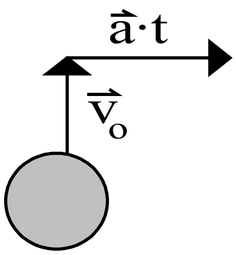
Chapter 3 Problem 83 [†]



Given
$\vec{v}_0 = 21\hat{j}\ km/s$
$\vec{a} = 0.035\hat{i}\ km/s^2$
$t = 4\ min = 240\ s$

Solution
Will firing the rocket 4 min result in a new velocity that is 22.6° from the original direction and displace it $5.36 \times 10^3\ km$?

First find the resultant velocity vector.

$$\vec{v} = \vec{v}_0 + \vec{a}t = \left\{21\hat{j} + 0.035\hat{i}(240\ s)\right\}\ km/s$$

$$\vec{v} = \left\{8.4\hat{i} + 21\hat{j}\right\}\ km/s$$

The direction of this vector is

$$\theta = tan^{-1}\left(\frac{8.4}{21}\right) = 21.8^\circ$$

The displacement is

$$\Delta\vec{r} = \vec{r} - \vec{r}_0 = \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$

$$\Delta\vec{r} = \left\{21\hat{j}\right\}\ km/s(240\ s) + \tfrac{1}{2}\left\{0.035\hat{i}\right\}\ km/s^2(240\ s)^2$$

$$\Delta\vec{r} = \left\{1008\hat{i} + 5040\hat{j}\right\}\ km$$

The position of the asteroid will be shifted to one side of its original trajectory by a distance of 1008 km.

If the rocket were fired a little bit longer, it would achieve the right angle. However, it still does not divert it enough to avoid a collision.

[†]Problem from Essential University Physics, Wolfson