569.

Problem 41.44 (RHK)

A small spaceship whose mass, with occupant, is 1500 kg *is drifting in outer space, where the gravitational field is negligible*. If *the astronaut turns on a* 10.0-kW *laser beam, we have to find the speed that the spaceship would attain in one day because of the reaction force associated with the momentum carried away by the beam.*

Solution:

From the principle of conservation of momentum, we note that there will be a force F on the space ship equal in magnitude to the momentum acquired per second by the spaceship because of emission of the 10.0-kW laser beam. The magnitude of F will be

$$F = \frac{P}{c} = \frac{10\times10^{3}}{3\times10^{8}}\ \text{N} = 33.33\times10^{-6}\ \text{N}.$$

As the mass of the spaceship is 1500 kg, the acceleration of the spaceship because of the laser beam emission will be

$$a = \frac{F}{M} = \frac{33.33 \times 10^{-6}}{1500} \text{ m s}^{-2} = 2.22 \times 10^{-8} \text{ m s}^{-2}.$$

We note that

$$1 \text{ day} = 8.640 \times 10^{4} \text{ s}.$$

The speed gained by the spaceship because a 10.0-kW laser is kept on for one day will therefore be

$$v = at = 2.222 \times 10^{-8} \times 8.640 \times 10^{4} \text{ m s}^{-1}$$
$$= 0.192 \times 10^{-2} \text{ m s}^{-1} = 1.92 \text{ mm s}^{-1}.$$