565.

Problem 41.37 (RHK)

Radiation from the Sun striking the Earth has an intensity of $1.38\ \text{kW m}^{-2}$. (a) *Assuming that the Earth behaves like a flat disk at right angles to the Sun's rays and that all the incident energy is absorbed, we have to calculate the force on the Earth due to the radiation pressure*; *we will compare it with the force due to sun's gravitational attraction by calculating* F_{rad}/F_{grav}.

Solution:

We will use the following astronomical data in answering this problem:

Mass of the Sun, $M_{sun} = 1.99\times10^{30}$ kg ’

Mass of the Earth, $M_{earth} = 5.98\times10^{24}$ kg,

Mean orbital radius of the Earth, $R_{orb} = 1.50\times10^{8}$ km,

and

Mean radius of the Earth, $R_{earth} = 6.37\times10^{6}$ m.

Force on the Earth due to the radiation pressure will be equal to the momentum transferred per unit time to the

Earth because of the absorption of the solar radiation. Therefore, the force on the Earth due to the absorption of the solar radiation assuming that the Earth behaves like a flat disk at right angles to the Sun's rays will be

$$F_{rad} = \frac{\left(\pi R_{earth}^2\right) \times I}{c} = \frac{\pi \times \left(6.37 \times 10^6\right)^2 \times 1.38 \times 10^3}{3 \times 10^8} \text{ N}$$

$$= 586 \times 10^6 \text{ N}.$$

And by the Newton's law of universal gravitation, the gravitational force on the Earth due to the Sun will be

$$F_{grav} = \frac{GM_{sun}M_{earth}}{R_{orb}^2}$$

$$= \frac{6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 5.98 \times 10^{24}}{\left(1.50 \times 10^{11}\right)^2} \text{ N}$$

$$= 3.53 \times 10^{22} \text{ N}.$$

Therefore,

$$\frac{F_{rad}}{F_{grav}} = \frac{586 \times 10^6}{3.53 \times 10^{22}} = 1.66 \times 10^{-14}.$$