Escape Velocity

We start with Newton's law of gravitation and derive the escape velocity of a planet.

A simplified version of Newton's Law is as follows. The force of gravity on an object of mass m that is distance r from the center of the earth is given by

$$F(r) = \frac{km}{r^2}$$

where k is a constant that is a characteristic of the earth. In the metric system, the units of k are $\frac{m^3}{s^2}$.

Question 1 *Use the following two facts to find the value of k in $\frac{m^3}{s^2}$ to three significant digits.*

- *A 100-kg object weighs 980 N at the surface of the Earth.*
- *The Earth's radius is 6400 km.*

Solution

(a) $\mathrm{k} = 4.01 \cdot 10^8 \frac{m^3}{s^2}$

(b) $\mathrm{k} = 4.01 \cdot 10^{14} \frac{m^3}{s^2}$ ✓

(c) $\mathrm{k} = 418 \frac{m^3}{s^2}$

(d) $\mathrm{k} = 4.18 \cdot 10^8 \frac{m^3}{s^2}$

Hint: *The two facts from this question can be plugged into the law of gravity.*

Hint: *There is a problem with the units of the Earth's radius. Make sure you convert it to meters!*

Plugging in the values gives $980N = \frac{k(100kg)}{(6400000m)^2}$, and so $k = 4.01 \cdot 10^{14} \frac{m^3}{s^2}$.

Learning outcomes: Use an improper integral in an application problem. Integrate a force function to compute work. Correctly handle units during calculus operations.