1.17 A communications satellite weighs 4400 N on Earth where $g = 9.81$ m/s^2. What is the weight of the satellite, in N, as it orbits Earth where the acceleration of gravity is 0.224 m/s^2? Express each weight in lbf.

KNOWN: Weight of communications satellite on Earth.

FIND: Determine weight of the satellite, in N, as it orbits Earth where the acceleration of gravity is 0.224 m/s^2. Express the satellite weight, in lbf, on Earth and in orbit.

SCHEMATIC AND GIVEN DATA:

$W_{\text{Sat(Earth)}} = 4400$ N
$g_{\text{Earth}} = 9.81$ m/s^2
$g_{\text{orbit}} = 0.224$ m/s^2

ENGINEERING MODEL:
1. Gravitational acceleration on Earth is constant at 9.81 m/s^2.
2. Gravitational acceleration at orbital altitude is constant at 0.224 m/s^2.

ANALYSIS: Weight of the satellite is the force of gravity and varies with altitude. Mass of the satellite remains constant. Applying Newton's second law to solve for the mass of the satellite yields

$$W = mg \rightarrow m = W/g$$

On Earth,

$$m = W_{\text{Sat(Earth)}}/g_{\text{Earth}}$$

$$m = \frac{(4400\ \text{N})}{\left(9.81 \dfrac{\text{m}}{\text{s}^2}\right)}\left|\frac{1\ \text{kg}\cdot\text{m/s}^2}{1\ \text{N}}\right| = 448.5\ \text{kg}$$

Solving for the satellite weight in orbit,

$$W_{\text{Sat(orbit)}} = mg_{\text{orbit}}$$

$$W_{\text{Sat(orbit)}} = (448.5\ \text{kg})\left(0.224 \frac{\text{m}}{\text{s}^2}\right)\left|\frac{1\ \text{N}}{1\ \text{kg}\cdot\text{m/s}^2}\right| = \underline{\mathbf{100.5\ N}}$$

Although the mass of the communications satellite is constant, the weight of the satellite is less at orbital altitude than on Earth since the acceleration due to gravity is less at orbital altitude than on Earth.

To determine the corresponding weights in lbf, apply the conversion factor, 1 lbf = 4.4482 N.

$$W_{\text{Sat(Earth)}} = (4400\text{ N})\left|\frac{1\text{ lbf}}{4.4482\text{ N}}\right| = \mathbf{989.2\text{ lbf}}$$

$$W_{\text{Sat(orbit)}} = (100.5\text{ N})\left|\frac{1\text{ lbf}}{4.4482\text{ N}}\right| = \mathbf{22.6\text{ lbf}}$$