Gravity of the Earth

What is the magnitude of the acceleration due to the gravity of the earth on an object of mass $m$ near its surface?

$$m_e = 5.96 \times 10^{24} \text{ kg} \quad \quad G = 6.67 \times 10^{-11} \text{ N m}^2 / \text{ kg}^2$$

$$r_e = 6.37 \times 10^6 \text{ m} \quad \quad m = \text{mass of the object}$$

From Newton’s Law of Gravitation and Newton’s 2nd Law,

$$F_{\text{earth on } m} = -\frac{G m_e m}{r_e^2} = -ma$$

$$a = \frac{G m_e}{r_e^2} \quad \quad \text{acceleration of } m \text{ due to } m_e \text{ a distance } r_e \text{ away}$$

Notice this expression doesn’t contain the mass of the object at all!

* Is the magnitude of this observed acceleration different for different masses?  
  No, it is the same for any $m$ is since there is no $m$ term in the expression for $a$

$$a = \frac{(6.67 \times 10^{-11} \text{ N m}^2 / \text{ kg}^2)(5.96 \times 10^{24} \text{ kg})}{(6.37 \times 10^6 \text{ m})^2}$$

$$a \approx 9.8 \frac{m}{s^2} = g \quad \quad g \text{ is what we call the acceleration due to ‘the’ gravity of the earth.}$$

[In general, g can represent the acceleration due to gravity of any massive object]

Therefore, the earth exerts an attractive force on any object of mass $m$ near its surface causing it to accelerate at a rate of 9.8 m/s$^2$. 