Physics 11
Applying Newton’s Laws

Gravity
Friction

Gravitational Force
⇒ Every object (with mass) in the universe exerts an attractive force on every other object (with mass) in the universe.
⇒ The gravitational force between two objects with mass is given by:

\[ F = \frac{G m_1 m_2}{r^2} \]

- \( m_1 \) & \( m_2 \) → masses of each object
- \( r \) → distance between objects
- \( G = 6.673 \times 10^{-11} \) Nm\(^2\)/kg\(^2\)

Gravitational Force

weight ⇒ the gravitational force that the earth exerts on an object

\[ F = \frac{G m_1 m_2}{r^2} \rightarrow w = \frac{G M_{\text{earth}} m}{R_{\text{earth}}^2} \]

- \( G = 6.673 \times 10^{-11} \) Nm\(^2\)/kg\(^2\)
- \( M_{\text{earth}} = 5.98 \times 10^{24} \) kg
- \( R_{\text{earth}} = 6.38 \times 10^6 \) m

\[ w = (9.8 \text{ m/s}^2) m \]

\[ w = mg \]

Friction

⇒ There are two types of friction forces:
- static friction (\( f_s \))
- kinetic friction (\( f_k \))

⇒ Frictional forces arise because of the bonded contact of the surface atoms of two surfaces in contact.
⇒ The two surfaces will literally fuse at the contact points.
**Friction**

⇒ For reference, the “hills” are ~100 atomic diameters high.

⇒ The adhesive forces become negligible at distances of about 4 – 5 atomic diameters.

**Cool Fact:** If two highly polished and carefully cleaned metal surfaces were brought together in a very good vacuum, the surfaces would cold-weld together instantly and form a single piece of metal.

⇒ If \( F < f_{s,\text{max}} \), then \( f_s = F \).

\[
f_{s,\text{max}} = \mu_s N
\]

\[
f_k = \mu_k N
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