1 Newton's laws of motion

1.1 Newton's first law of motion

A body continues in its state of rest, or of uniform motion in a straight line, unless compelled to change that state by forces impressed upon it.

$$\boxed{\vec{p} = m\vec{V}}$$

$$\begin{aligned}
\vec{p} &= \text{linear momentum vector (kg} \cdot \text{m/s)} \\
m &= \text{mass (kg)} \\
\vec{V} &= \text{velocity vector (m/s)}
\end{aligned}$$

$$\boxed{\vec{H} = I\vec{\Omega}}$$

$$\begin{aligned}
\vec{H} &= \text{angular momentum vector (kg} \cdot \text{m}^2\text{/s)} \\
I &= \text{moment of inertia (kg} \cdot \text{m}^2\text{)} \\
\vec{\Omega} &= \text{angular velocity vector (rad/s)}
\end{aligned}$$

$$\boxed{\vec{H} = \vec{R} \times m\vec{V}}$$

$$\begin{aligned}
\vec{H} &= \text{angular momentum vector (kg} \cdot \text{m}^2\text{/s)} \\
\vec{R} &= \text{position (m)} \\
m &= \text{mass (kg)} \\
\vec{V} &= \text{velocity vector (m/s)}
\end{aligned}$$

1.2 Newton's second law of motion

The time rate of change of an object's momenutm equals the applied force.

$$\boxed{\vec{F} = m\vec{a}}$$

$$\begin{aligned}
\vec{F} &= \text{force vector (kgm/s}^2 = \text{N)} \\
m &= \text{mass (kg)} \\
\vec{a} &= \text{acceleration (m/s}^2\text{)}
\end{aligned}$$

1.3 Newton's third law of motion

When body A exerts a force on body B, body B will exert an equal, but opposite, force on body A

2 Newton's laws of universal gravitation

$$\boxed{F_g = \frac{Gm_1m_2}{R^2}}$$

$$\begin{aligned}
F_g &= \text{force due to gravity (N)} \\
G &= \text{universal gravitational constant} \approx 6.674 \times 10^{-11}\,\text{N} \cdot \text{m}^2\text{/kg}^2 \\
m_1, m_2 &= \text{masses of two bodies (kg)} \\
R &= \text{distance between the two bodies (m)}
\end{aligned}$$

$$\boxed{a_g = \frac{\mu_{Earth}}{R^2}}$$

$$\begin{aligned}
a_g &= \text{acceleration due to gravity (m/s}^2\text{)} \\
\mu_{Earth} &\equiv G\,m_{Earth} \approx 3.986 \times 10^{14}\,\text{m}^3\text{/s}^2 \\
R &= \text{distance between the two bodies (m)}
\end{aligned}$$

3 Laws of conservation

3.1 Conservation of momentum

In the absence of outside forces, linear and angular momentum are conserved.

3.2 Energy

$$\boxed{E = KE + PE}$$

E = total mech. energy ($\mathrm{kg\,m^2/s^2}$)
KE = kinetic energy ($\mathrm{kg\,m^2/s^2}$)
PE = potential energy ($\mathrm{kg\,m^2/s^2}$)

$$\boxed{PE = m\,a_g h}$$

m = mass (kg)
a_g = acceleration due to gravity ($\mathrm{m/s^2}$)
h = height above ref. point (m)

$$\boxed{PE = -\frac{m\mu}{R}}$$

m = spacecraft's mass (kg)
μ = gravitational parameter ($\mathrm{km^3/s^2}$)
R = distance from Earth's center (km)

$$\boxed{KE = \frac{1}{2}mV^2}$$

KE = kinetic energy ($\mathrm{kg\,m^2/s^2}$)
m = mass (kg)
V = velocity (km/s)

$$\boxed{E = \frac{1}{2}mV^2 - \frac{m\mu}{R}}$$

E = total mech. energy ($\mathrm{kg\,m^2/s^2}$)
m = mass (kg)
V = velocity (km/s)
μ = gravitational parameter ($\mathrm{km^3/s^2}$)
R = position (km)

4 The restricted two-body problem

4.1 Coordinate systems

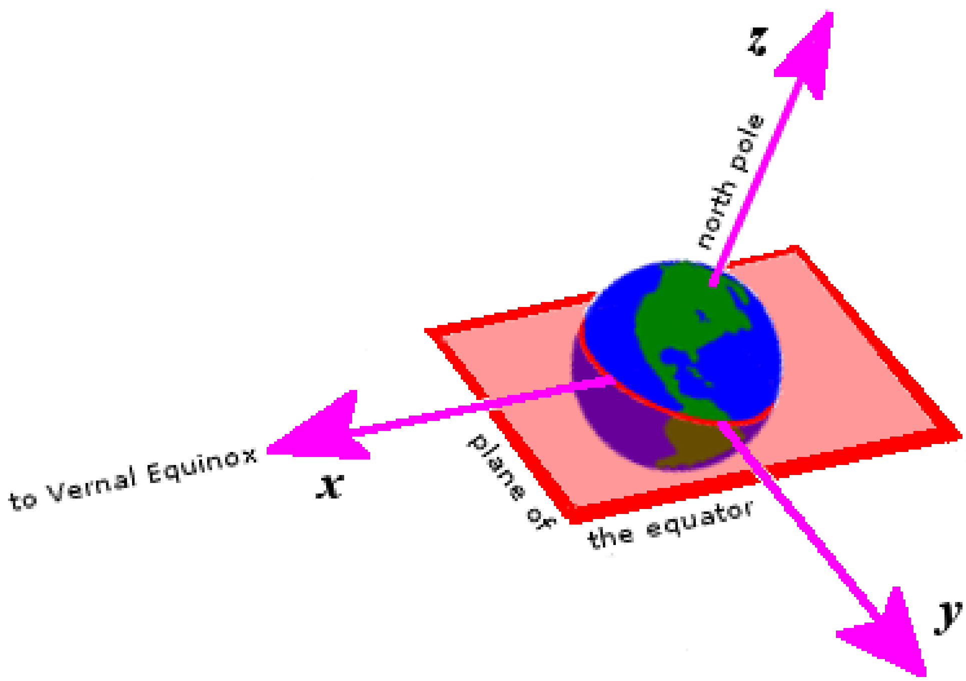

FIGURE 1 – Geocentric equatorial coordinates. The origin is the centre of the Earth. The fundamental plane is the plane of the Earth's equator. The primary direction (the x axis) is the vernal equinox. A right-handed convention specifies a y axis 90° to the east in the fundamental plane; the z axis is the north polar axis. The reference frame does not rotate with the Earth, rather, the Earth rotates around the z axis.