Equations

Stages of Flight:

1. Liftoff and Powered Flight
2. Coasting Flight
3. Descent
    a. With Parachute
    b. Other Recovery Methods

Key for all equations (unless otherwise mentioned):

$\overrightarrow{T}$: *Thrust Vector*
$\overrightarrow{F_D}$: *Drag Force Vector*
$\overrightarrow{a}$: *Acceleration Vector of the Rocket*
$\overrightarrow{g}$: *Acceleration Vector of the Earth's Gravity*
m : *Current Mass of the Rocket*
t : *Time Elapsed since Launch*
θ : *Angle of the Current Heading*

General Equations

Thrust Vector Function

$$\overrightarrow{T}(m,t) = \overrightarrow{v}(t)\frac{dm}{dt}$$

where,
$\overrightarrow{v}$: *Velocity Vector of the Exhaust, measured relative to the Rocket*
$\frac{dm}{dt}$: *The Mass Flow Rate of Exhaust*

Drag Force Vector Function

$$\overrightarrow{F_D}(t) = \frac{1}{2}\rho(\overrightarrow{v}(t)^2)C_D A$$

where,
ρ : *Density of Air at current Height*
$\overrightarrow{v}$: *Velocity Vector of the Rocket*
C_D : *Drag Coefficient of the Rocket*
A : *Area of the Orthographic Projection of the Rocket, projected from immediately in front of the rocket*

Acceleration Vector Function (during Liftoff and Powered Flight)

$$\overrightarrow{a_x}(m,t) = \frac{\overrightarrow{F_x}(m,t)}{m} = \frac{\left(\overrightarrow{T}(m,t) - \overrightarrow{F_D}(t)\right)\sin\theta - m\overrightarrow{g}}{m}$$

$$\overrightarrow{a_y}(m,t) = \frac{\overrightarrow{F_y}(m,t)}{m} = \frac{\left(\overrightarrow{T}(m,t) - \overrightarrow{F_D}(t)\right)\cos\theta}{m}$$

Acceleration Vector Function (during Coasting Flight)

$$\overrightarrow{a_x}(m,t) = \frac{-\overrightarrow{F_D}(t)\cos\theta}{m}$$
$$\overrightarrow{a_y}(m,t) = \frac{-\overrightarrow{F_D}(t)\sin\theta - m\overrightarrow{g}}{m}$$

Acceleration Vector Function (During Descent with a Parachute)*

$$\overrightarrow{a_x}(m) = \frac{\overrightarrow{F_W} - \overrightarrow{F_D}}{m}$$
$$\overrightarrow{a_y}(m,t) = \frac{m\overrightarrow{g} - \overrightarrow{F_D}}{m}$$

[$In\ this\ specific\ case, the\ drag\ is\ directed\ upwards\ due\ to\ the\ Parachute$]

$where,$
$\overrightarrow{F_W}$: $Force\ Vector\ on\ the\ Rocket\ due\ to\ Wind$

Equations for Descents using other Recovery Methods have to be derived based on the Recovery Method used

* May not be correct

References

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