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# Math dictionary

|  |  |  |
| --- | --- | --- |
|  | Full Name | Description |
|  | Old Position | The position before integration |
|  | New Position | The position after integration |
|  | Old Velocity | The velocity before integration |
|  | New Velocity | The velocity after integration |
|  | Delta Time | Reciprocal timestep |
|  | Force | 3D force vector |
|  | Mass | Mass |
|  | Acceleration | Second derivative of motion |
|  | Coeff of Friction | Square root of the combined coefficients |
|  | Coeff of Static Friction | Resting friction between two surfaces |
|  | Coeff of Kinematic Friction |  |
|  | Friction | 3D friction force vector |
|  | Normal force | 3D force that keeps objects from intersecting |
|  | Coeff of Restitution |  |

# Integration methods

|  |  |  |  |
| --- | --- | --- | --- |
|  | Order | Pros | Cons |
| Explicit Euler | 1st | Simple | Inaccurate with variable acceleration  Unstable in edge cases |
| Semi-implicit Euler | 1st | Simple  Accurate with small timesteps | Slightly less accurate then explicit |
| Implicit Euler | 1st | Solves most edge cases | Expensive |
| Verlet | 2nd | Accurate  Lower memory usage | No explicit velocity |
| Runge-Kutta 4 | 4th | Very accurate  Better at big timesteps | Complicated  Needs custom acceleration functions  Can lose energy |

## Examples

Explicit Euler:

Semi-implicit Euler:

Verlet:

## Requirements

* Objects should not gain energy without a force being applied.
* Timestep is fixed, but it should handle big timesteps to keep performance.
* Should be easily integrated into a SIMD vectorized system.
* Should not need additions if other systems get upgraded.

# Friction models

|  |  |  |
| --- | --- | --- |
|  | Pros | Cons |
| Constant Force | Very cheap | Not physically based |
| Coulomb |  |  |

## Requirements

* Dry friction should not violate Coulomb’s law .
* Should be able to handle traction.
* Surface roughness should affect the friction   
  (more roughness = more friction).
* Friction should generate heat.
* Velocity should be independent.

## Examples

Constant force:

# Impulses

|  |  |
| --- | --- |
| Symbols | Meaning |
|  | Position relative to the contact point |
|  | Contact point / Collision point |
|  | Object position |
|  | Relative velocity |
|  | Object velocity |
|  | Object angular velocity |
|  | Object coefficient of restitution |
|  | Contact normal / Collision normal |
|  | Object inverse mass |
|  | Object inverse moment of inertia tensor |
|  | Impulse magnitude |

# References

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