SS14 throwing system improvements

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Friction is calculated in the `ReduceLinearVelocity` function in `TileFrictionController.cs` using the following change in velocity:

$$
\begin{aligned}
& & v' &= v + dv && (1)\\
& & &= v \cdot (1 - F \cdot dt) && (2)\\
&\Leftrightarrow & dv &= -F \cdot v \cdot dt && (3)\\
&\Leftrightarrow & \dot{v}(t) &= \frac{dv}{dt} = -F \cdot v(t) && (4)
\end{aligned}
$$

where F is the friction given by the product of the `TileFrictionModifier` cvar, the tile friction given in `TileFrictionController.cs` and the body modifier set via `TileFrictionEvent`.

This differential equation is solved by an exponential decay

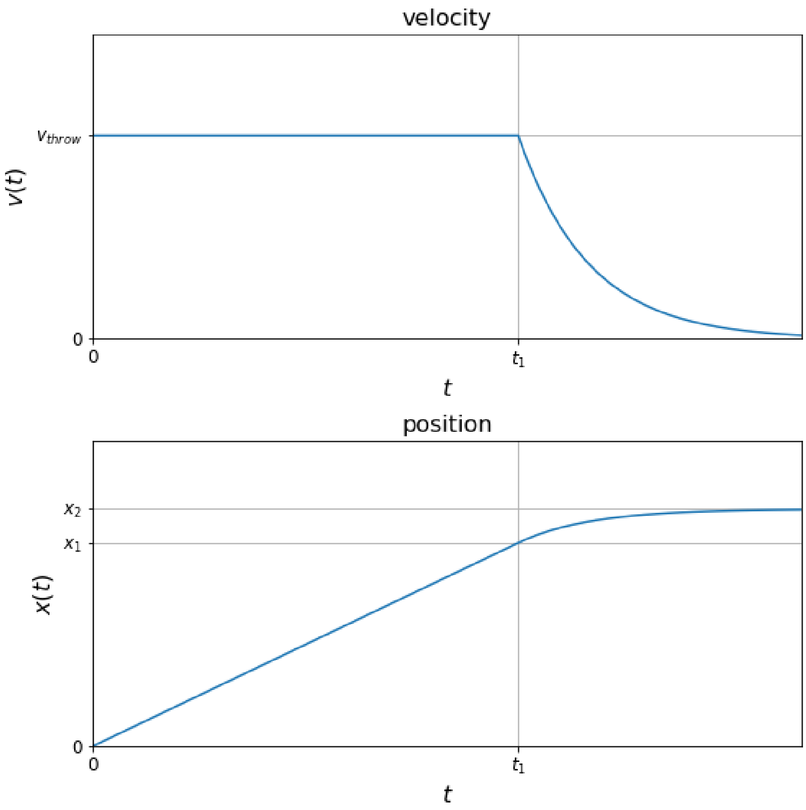
$$v(t) = v_{throw} \cdot \exp(-F \cdot (t - t_1)) \tag{5}$$

where v_{throw} is the initial velocity and t_1 the starting time of the decay. When thrown, items are first set to be in the air for the time t_1, during which they receive no friction and therefore stay at constant velocity. When landing, a `LandEvent` is raised. Note that the slowdown is independent of the object's mass.

The velocity and position over time are plotted below. We calculate the distance from the starting position when landing via

$$d_1 = v_{throw} \cdot t_1 \tag{6}$$

After landing the item will slide on the ground until it stops moving at position d_2. While from a mathematical point of view the item will never completely stop and never reaches d_2 exactly, numerically its velocity is set



to zero below a certain threshold. By integrating the velocity we calculate

$$
\begin{aligned}
d_2 &= d_1 + \int_{t_1}^{\infty} v_{throw} \cdot \exp(-F \cdot (t - t_1))dt && (7)\\
&= d_1 + \left[-\frac{v_{throw}}{F} \cdot \exp(-F \cdot (t - t_1) \right]_{t_1}^{\infty} && (8)\\
&= d_1 - \frac{v_{throw}}{F} \cdot \exp(-\infty) + \frac{v_{throw}}{F} \exp(0) && (9)\\
&= d_1 + \frac{v_{throw}}{F} && (10)
\end{aligned}
$$

We rearrange this to

$$
\begin{aligned}
d_2 &= v_{throw} \cdot t_1 + \frac{v_{throw}}{F} && (11)\\
&= v_{throw} \cdot \left(t_1 + \frac{1}{F} \right) && (12)\\
\Leftrightarrow \quad v_{throw} &= \frac{d_2}{(t_1 + \frac{1}{F})} && (13)
\end{aligned}
$$

With this formula we are able to calculate the required throwing speed v_{throw} for a desired throwing distance d_2 (given by the player's cursor position).The time t_1 is a free parameter. If it is too low, the item will slide on the floor for most of the distance. If it is too high, the item will be thrown very slowly in a high arc. As a reasonable choice we set

$$t_1 = p_{flyTime} \cdot \frac{d_2}{v_{base}} \tag{14}$$

where $p_{flyTime}$ is the percentage of time the item would be in the air if it would not slow down after landing, and $v_{base} = 10$ is the corresponding base throwing speed given by the `HandsComponent`. We choose $p_{flyTime} = 0.8$ so that the item is in the air for approximately 80% of the time of the throw.

For throwing weapons like spears or hypodarts we want slightly different throwing mechanics. Using the above throwing parameters, the spear would slowly land at the opponents feet if the player's cursor is directly above the opponent. Therefore we use

$$\begin{aligned} t_1 &= \frac{d_2}{v_{base}} \\ v_{throw} &= v_{base} \end{aligned}$$

instead. This makes the item land at the cursor position and slide a little further along the ground from there. To select which items should follow this behavior we add a new `LandAtCursorComponent`. This should be added to all throwing weapons that pierce the opponent or are supposed to land (but not stop) exactly at his position.