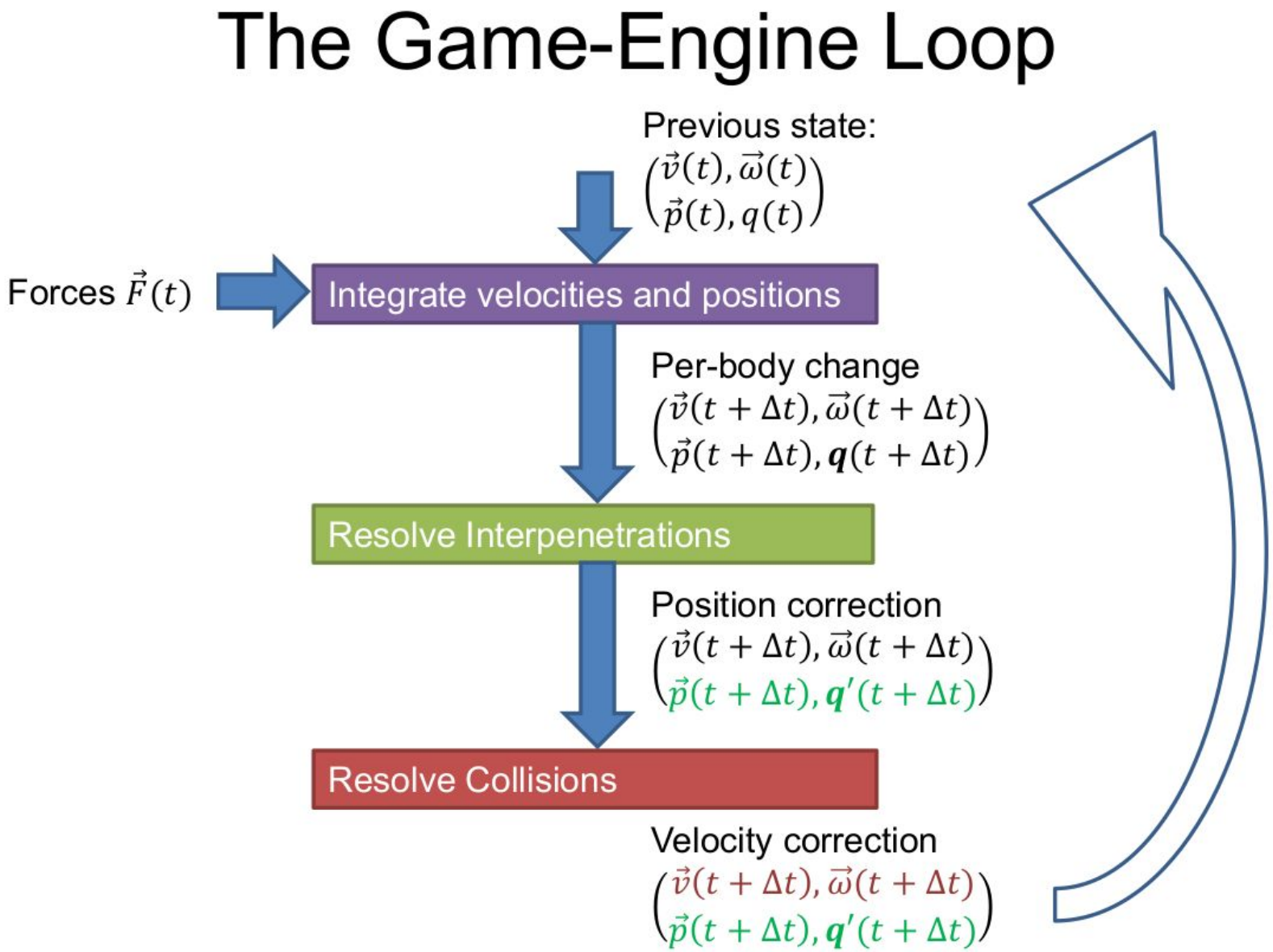
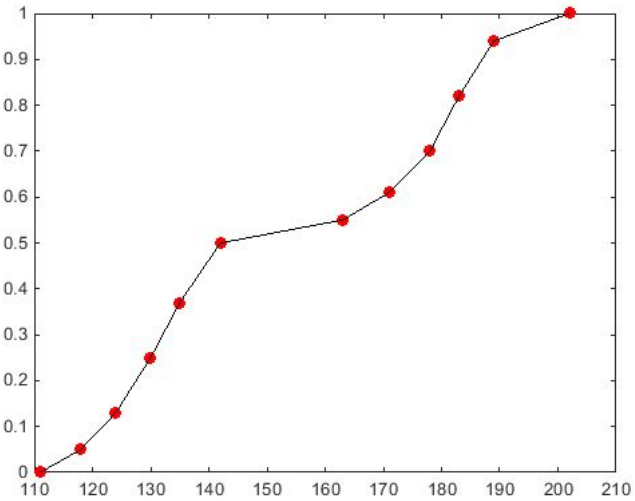
Time Integration (game engine loop)

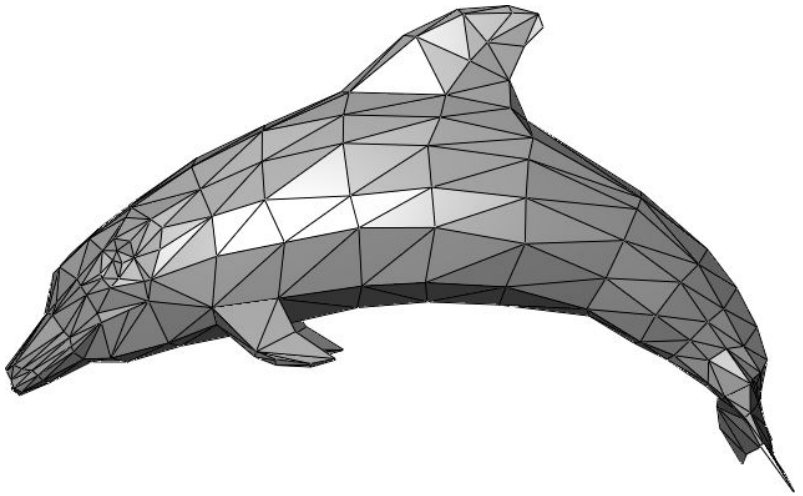


Time Integration (game engine loop)

Discrete time

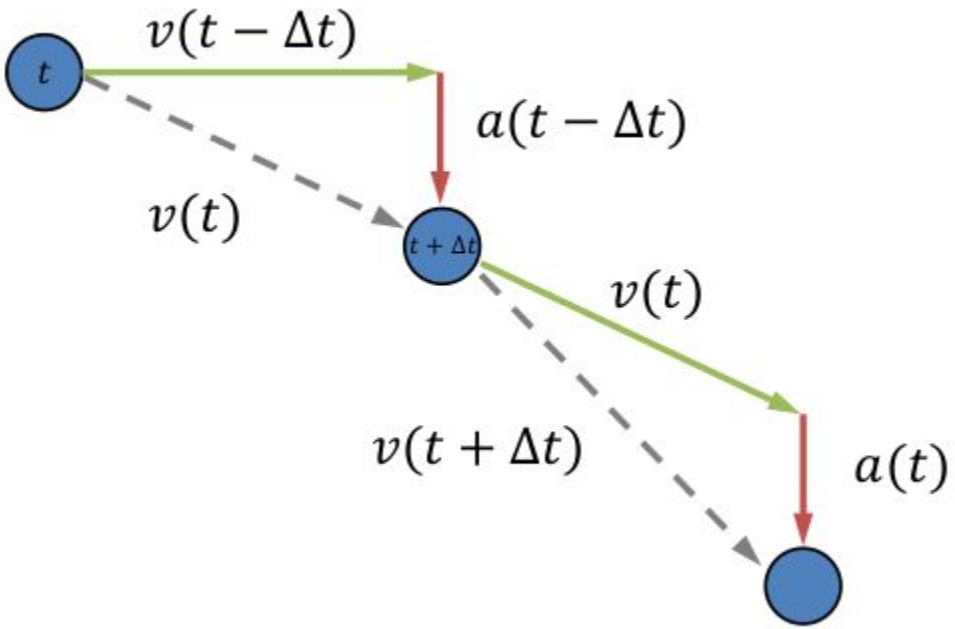
Discrete space





Stability and Convergence

Time Integration (game engine loop)

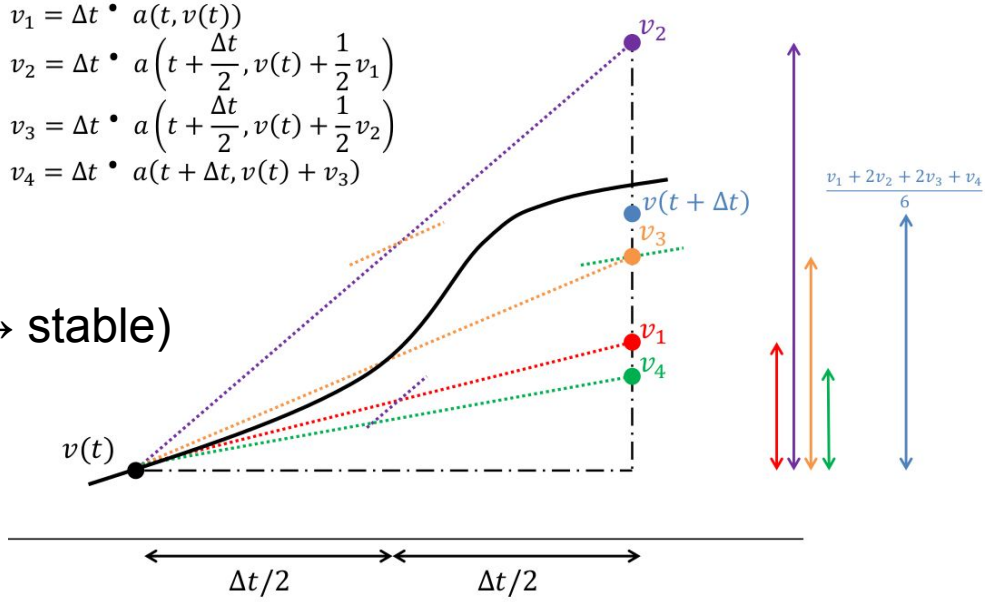


piecewise linear

v + dt(a(t)+a(t+dt))/2 Euler, 2 step

Runge Kutta

$$v_1 = \Delta t \bullet a(t, v(t))$$
$$v_2 = \Delta t \bullet a\left(t + \frac{\Delta t}{2}, v(t) + \frac{1}{2}v_1\right)$$
$$v_3 = \Delta t \bullet a\left(t + \frac{\Delta t}{2}, v(t) + \frac{1}{2}v_2\right)$$
$$v_4 = \Delta t \bullet a(t + \Delta t, v(t) + v_3)$$



semi implicit (simplectic = conserves energy → stable)

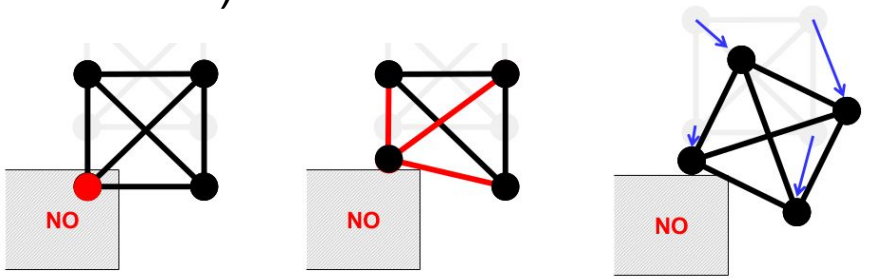
v+ = v + dt a

p+ = p + dt v+

Constraints

3 dof translation 3 dof rotation

Kinematic Pairs (reduced dof = degrees of freedom):
hinged joint
screw
cylinder
ball-socket joint
(on curve,surface)

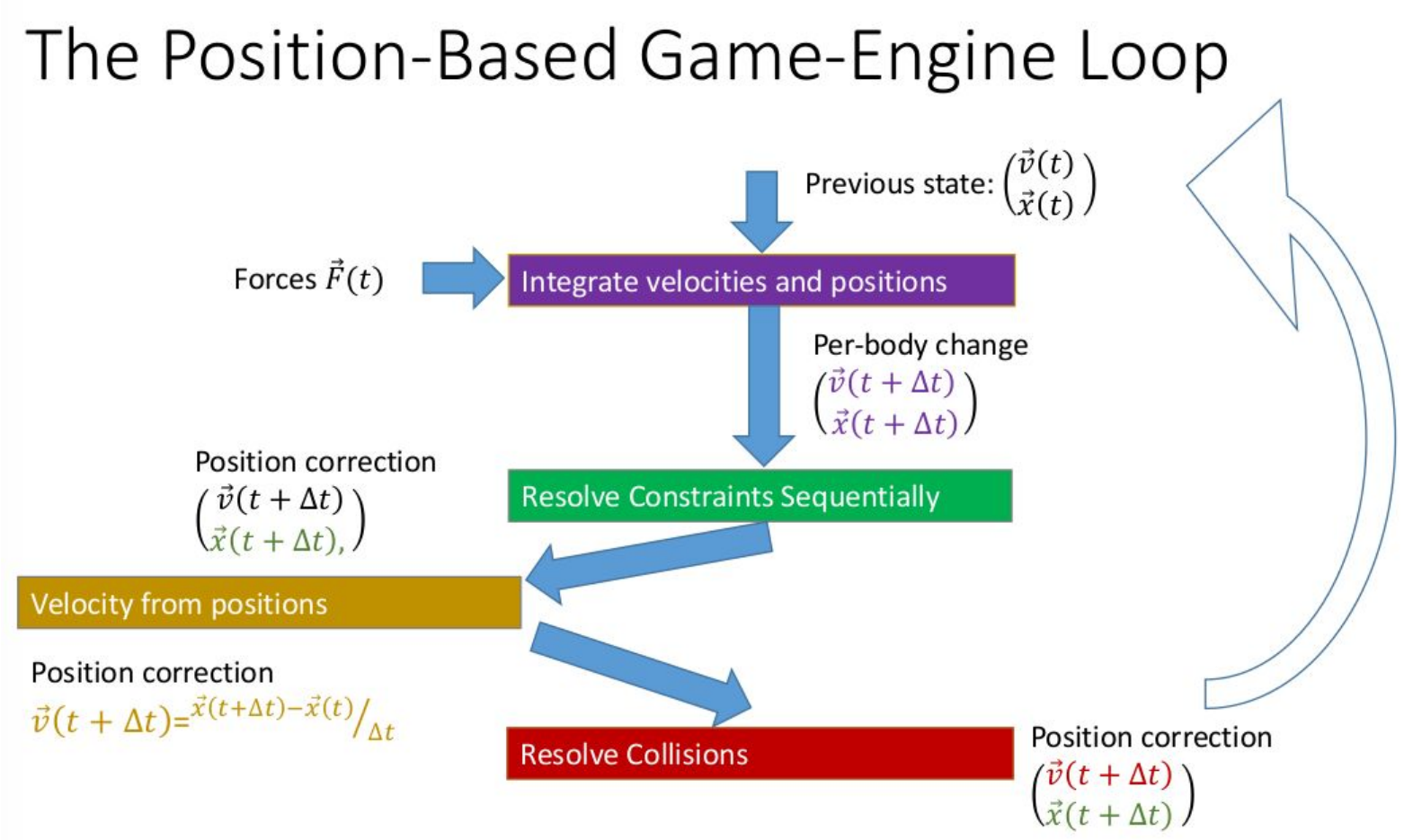


Enforce one constraint at a time (collision ordering)
Linearize C(p+dp) = C(p)+dC.dp
connect: p1-p2=0 bend: acos(n1.n2) < eps

Motion Control: switch between kinematic control and dynamic interaction

torque: https://www.youtube.com/watch?v=wuJwwHdAD9Q
proportional derviative controller: torque = k_a(ang_0-ang) + k_w(w_0-w)
adjust according to difference in target and current joint angles/ angular velocity

Time Integration (game engine loop)



https://www.youtube.com/watch?v=j5igW5-h4ZM