Collision Detection and Resolution

Collision Resolution: Examples

- Two billiard balls strike
  - Calculate ball positions at time of impact
  - Impart new velocities on balls
  - Play “clinking” sound effect
- Rocket slams into wall
  - Rocket disappears
  - Explosion spawned and explosion sound effect
  - Wall charred and area damage inflicted on nearby characters
- Character walks through wall
  - Magical sound effect triggered
  - No trajectories or velocities affected

Collision Resolution: Parts

- Resolution has three parts
  1. Prologue
  2. Collision
  3. Epilogue

Collision Resolution: Prologue

- Collision known to have occurred
- Check if collision should be ignored
- Other events might be triggered
  - Sound effects
  - Send collision notification messages

Collision Resolution: Collision

- Place objects at point of impact
- Assign new velocities
  - Using physics or
  - Using some other decision logic

Collision Resolution: Epilogue

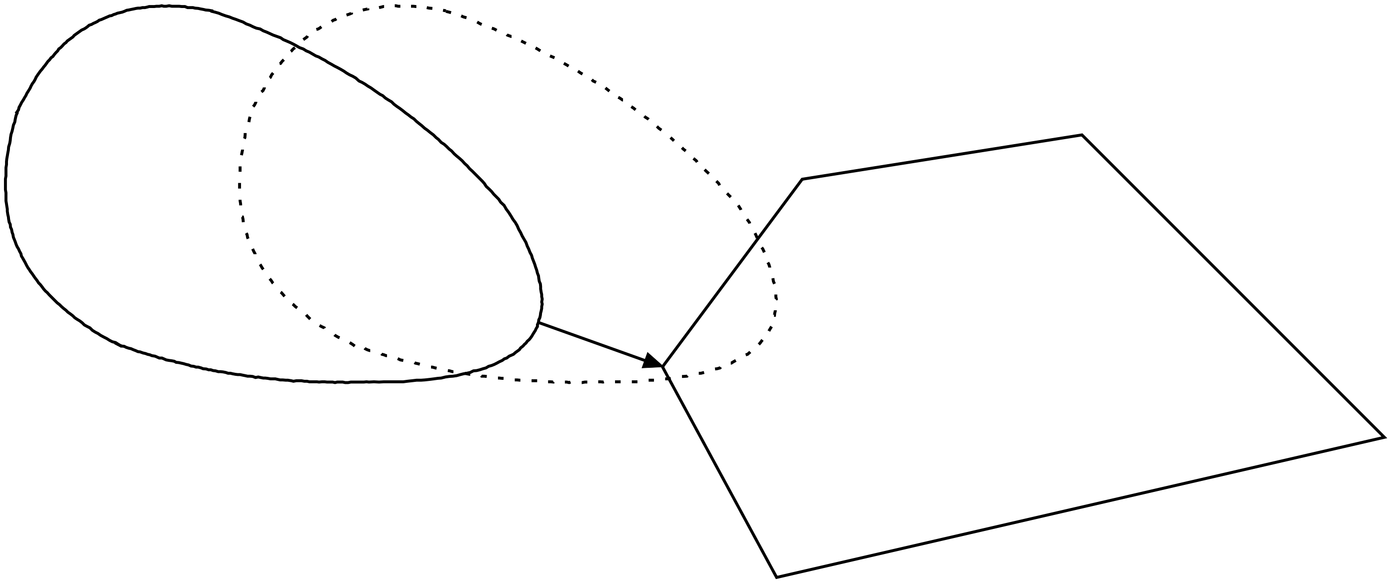
- Propagate post-collision effects
- Possible effects
  - Destroy one or both objects
  - Play sound effect
  - Inflict damage
- Many effects can be done either in the prologue or epilogue

Collision Resolution: Resolving Overlap Testing

1. Extract collision normal
2. Extract penetration depth
3. Move the two objects apart
4. Compute new velocities

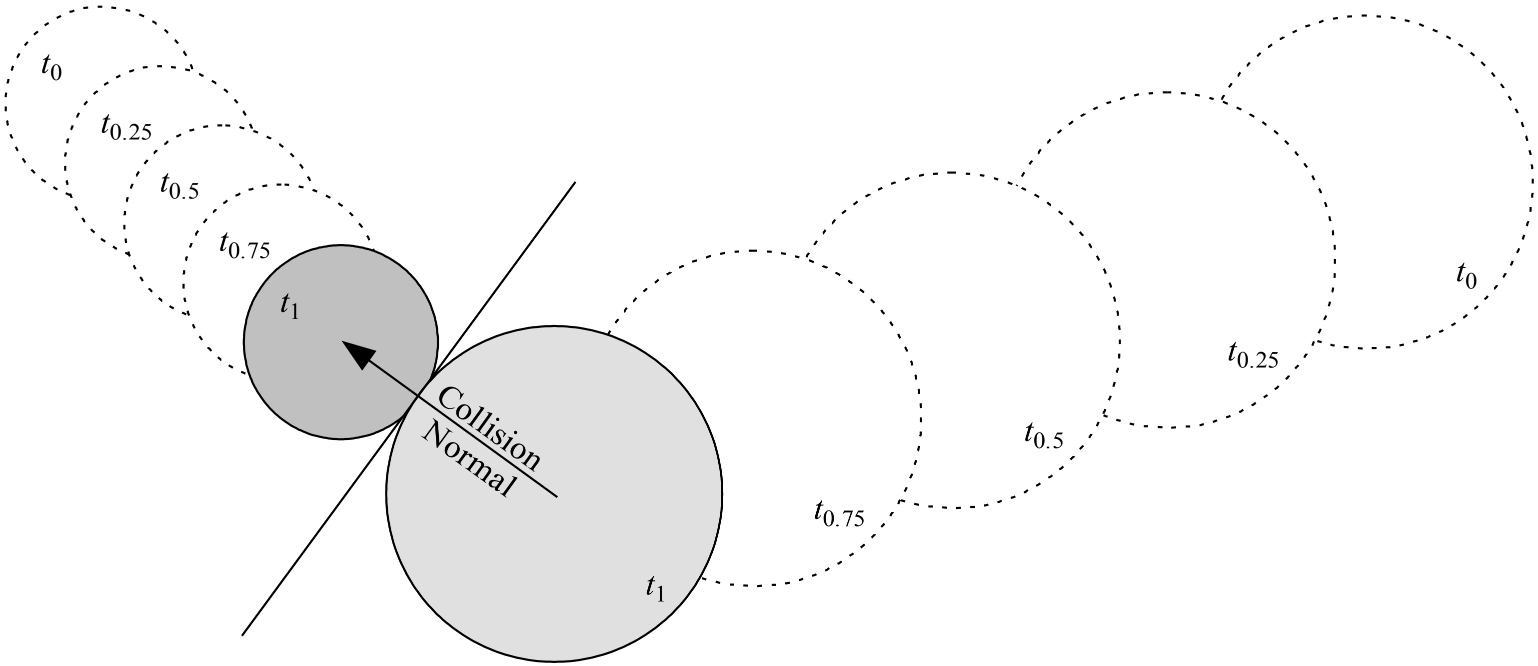
Collision Resolution: Extract Collision Normal

- Find position of objects before impact
- Use two closest points to construct the collision normal vector



Collision Resolution: Extract Collision Normal

- Sphere collision normal vector
  - Difference between centers at point of collision



Collision Resolution: Resolving Intersection Testing

- Simpler than resolving overlap testing
  - No need to find penetration depth or move objects apart
- Simply
  1. Extract collision normal
  2. Compute new velocities

Collision Response

- Newtonian Equation of Motion

$$F(t) = m \frac{d}{dt} V(t)$$

- Linear Impulse-momentum Equation

$$m_1 V_{1after} = m_1 V_{1before} + \lambda$$

- Newton's Third Law of Motion
  - "for every action there is an equal but opposite reaction"

$$m_2 V_{2after} = m_2 V_{2before} - \lambda$$

Frictionless Collision Response

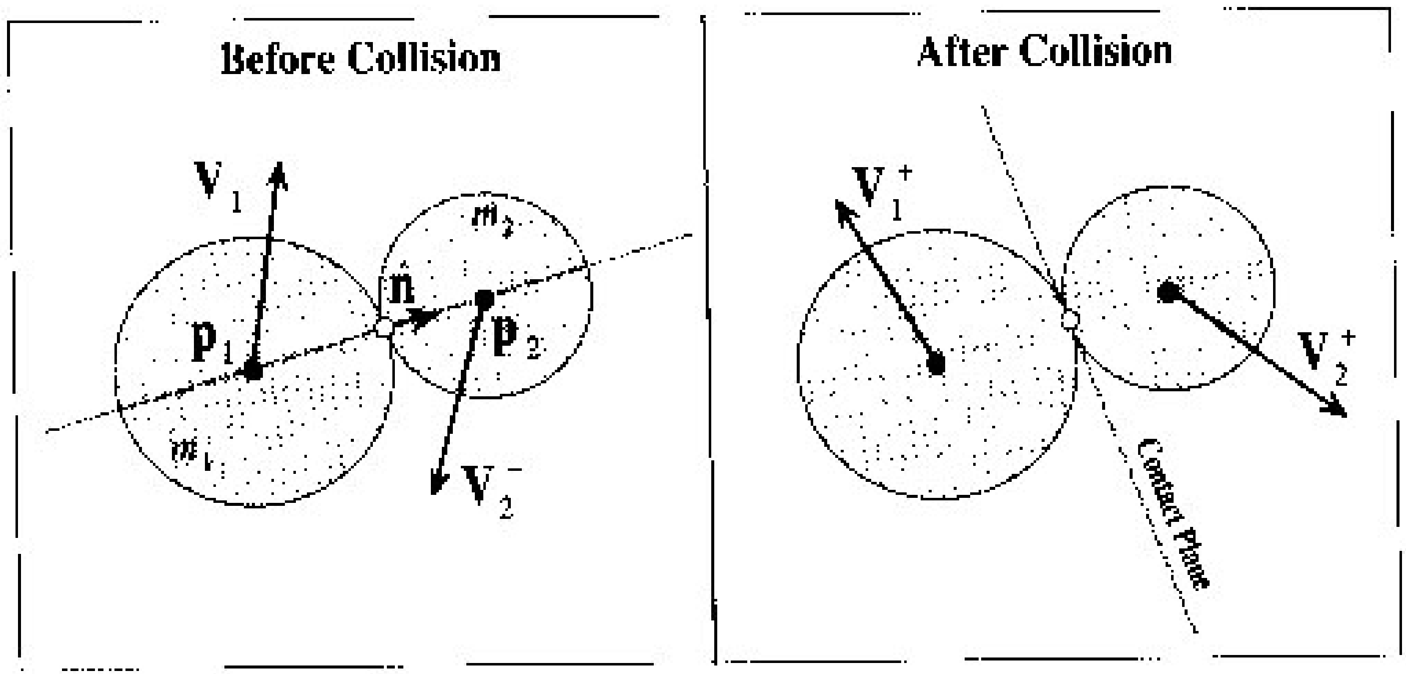
- No friction $\qquad \vec{\lambda} = \lambda \vec{n}$
- Coefficient of restitution: c

$$\left(V_{1after} - V_{2after}\right).\vec{n} = -c\left(V_{1before} - V_{2before}\right).\vec{n}$$

- Linear impulse resolution:

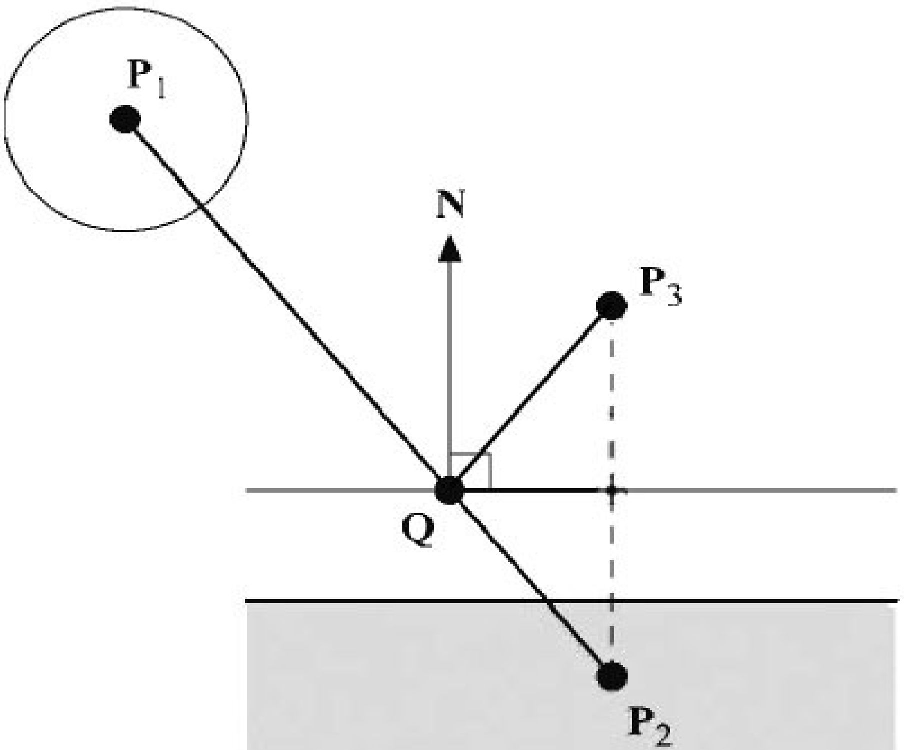
$$\lambda = \frac{\left[m_1 m_2 (1+c)\left(V_{1before} - V_{2before}\right).\vec{n}\right]}{\left(m_1 + m_2\right)} \vec{n}$$

Frictionless Collision Response for sphere-sphere collision



Rebound

- In case of collision with environment (camera, hero, etc.) with rebound



$$P_3 = P_2 - 2 * (\overrightarrow{QP_2} \cdot \vec{N}) * \vec{N}$$

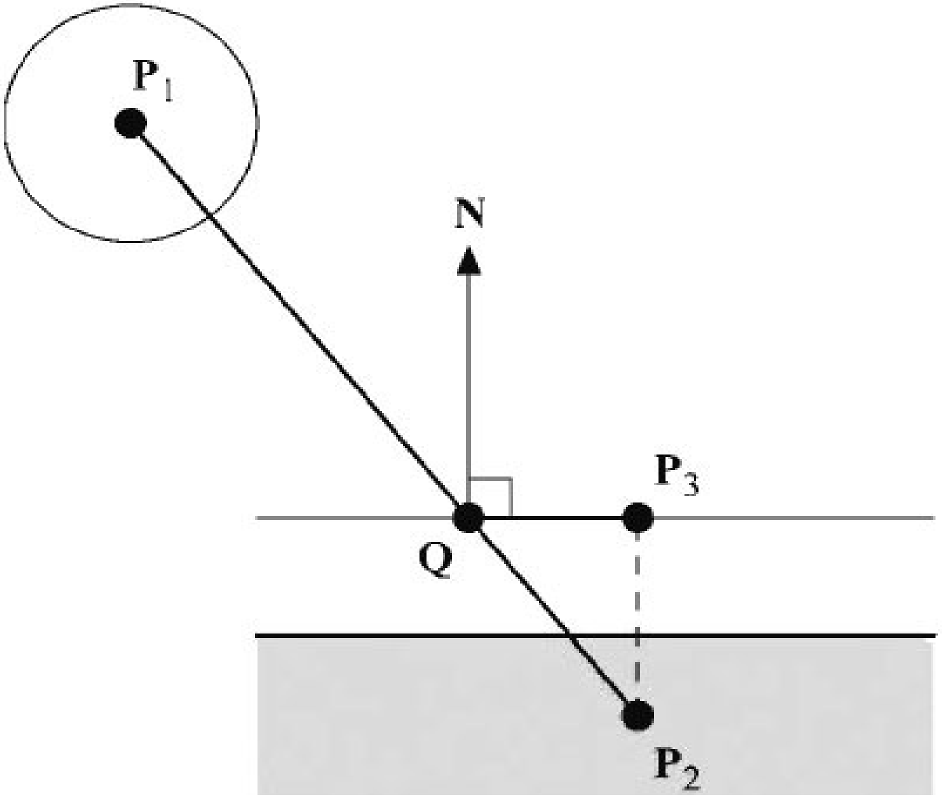
$$P_{init} = P_3$$

- $\vec{V}_{init} = c * |V_q| * norm(\overrightarrow{QP_3})$

$c : rebound\ coef.$

Sliding

- In case of collision with environment (camera, hero, etc.) without rebound



$$P_3 = P_2 - (\overrightarrow{QP_2} \cdot \vec{N}) * \vec{N}$$

$$P_{init} = P_3$$

$$\vec{V}_{init} = c * |V_q| * norm(\overrightarrow{QP_3})$$