

## Reference List 15-464 / 15-664 Mar 15, 2021

Today we spoke about contact and collision detection. Witkin and Baraff's SIGGRAPH course notes are a great place to start for a basic introduction (and for how to derive that impulse calculation).

Andrew Witkin and David Baraff, Physically Based Modeling: Principles and Practice, Online SIGGRAPH 1997 Course Notes, 1997 <https://www.cs.cmu.edu/~baraff/sigcourse/>

The course textbook, if you already have it, also has a wealth of information that is useful for getting started:

Rick Parent. Computer Animation: Algorithms and Techniques, 3rd Edition. Chapter 7.4, September 2012

The go-to reference for fully understanding basic impulse based techniques is still Brian Mirtich's 1996 dissertation:

Brian Vincent Mirtich. Impulse-based Dynamic Simulation of Rigid Body Systems. UC Berkeley PhD thesis, Fall 1996  
<https://people.eecs.berkeley.edu/~jfc/mirtich/thesis/mirtichThesis.pdf>

Penalty-based methods compute the contact forces based on the penetration depth and normal velocity of a pair of objects using linear or nonlinear spring-damper model. A classic implementation can be found here:

Yamane, Katsu, and Yoshihiko Nakamura. "Stable penalty-based model of frictional contacts." In Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006. ICRA 2006., pp. 1904-1909. IEEE, 2006.  
<https://ieeexplore.ieee.org/document/1641984>

We talked about how to do the penalty method "right." Note that there is code available for this technique on the linked web page.

Hongyi Xu, Yili Zhao, and Jernej Barbič. Implicit multibody penalty-based distributed contact. IEEE transactions on visualization and computer graphics 20.9 (2014): 1266-1279.  
<http://barbic.usc.edu/implicitContact/>

Constraint-based methods compute constraint forces that are designed to exactly cancel any external accelerations that would result in interpenetration. These references can get you started with setting up, solving, and generally understanding constraint based systems:

<https://www.toptal.com/game/video-game-physics-part-iii-constrained-rigid-body-simulation>

Michael Bradley Cline, Rigid Body Simulation with Contact and Constraints. UBC Master thesis. 2002

<https://open.library.ubc.ca/cIRcle/collections/ubctheses/831/items/1.0051676>

David Baraff. Non-penetrating Rigid Body Simulation. Eurographics 1993 State of the Art Reports. <https://www.cs.cmu.edu/~baraff/papers/eg93.pdf>

Finally, we took a quick look at this paper on using staggered projections to solve a system with many simultaneous contacts:

Kaufman, Danny M., Shinjiro Sueda, Doug L. James, and Dinesh K. Pai. "Staggered projections for frictional contact in multibody systems." In *ACM SIGGRAPH Asia 2008 papers*, pp. 1-11. 2008.

[http://www.cs.ubc.ca/labs/sensorimotor/projects/sp\\_sigasia08/](http://www.cs.ubc.ca/labs/sensorimotor/projects/sp_sigasia08/)