Statics : Free body diagrams and Newton's 3rd law of motion

Stefan Bracher

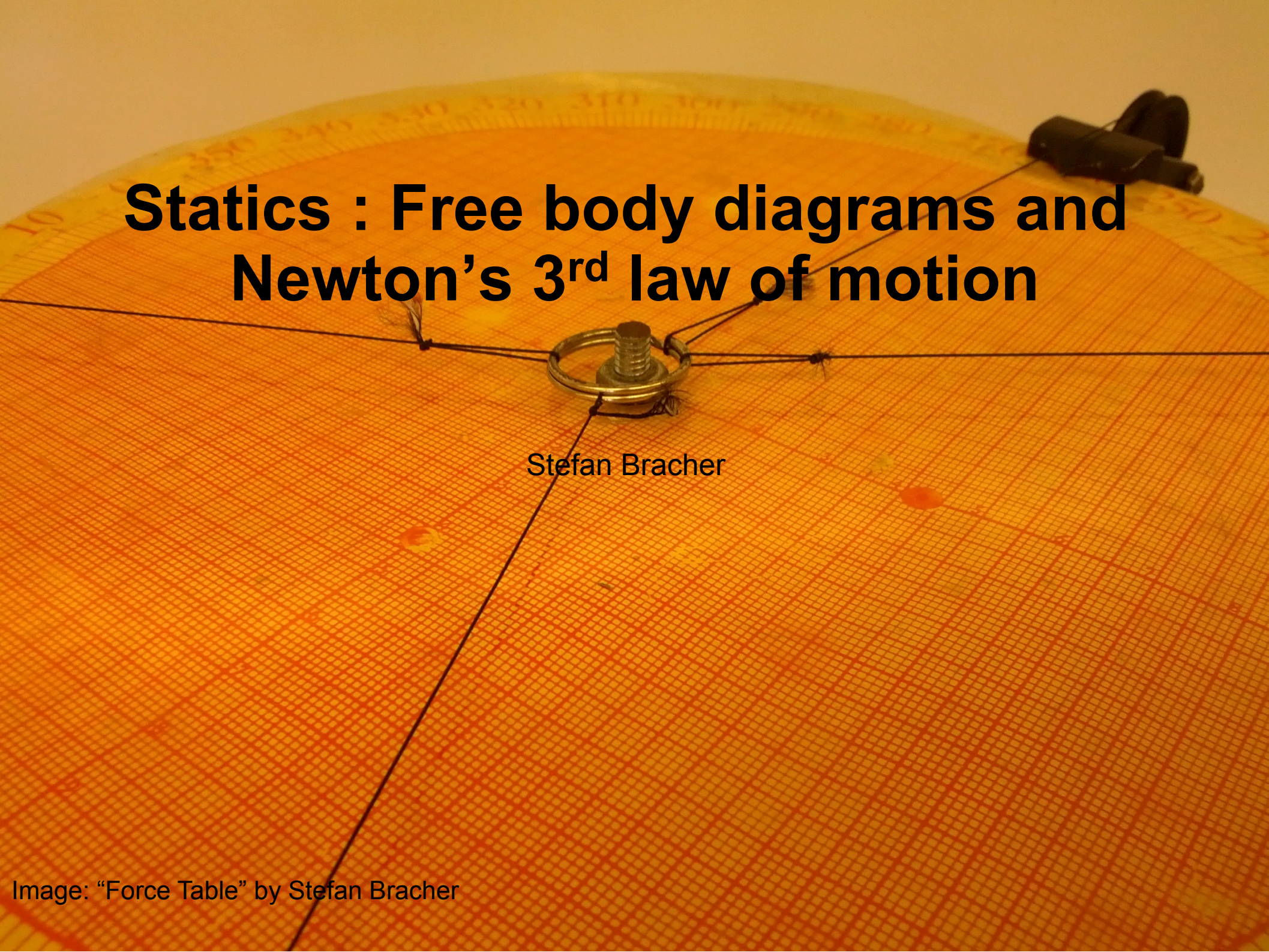

Image: "Force Table" by Stefan Bracher

Isaac Newton

- 25 December 1642 – 20 March 1727

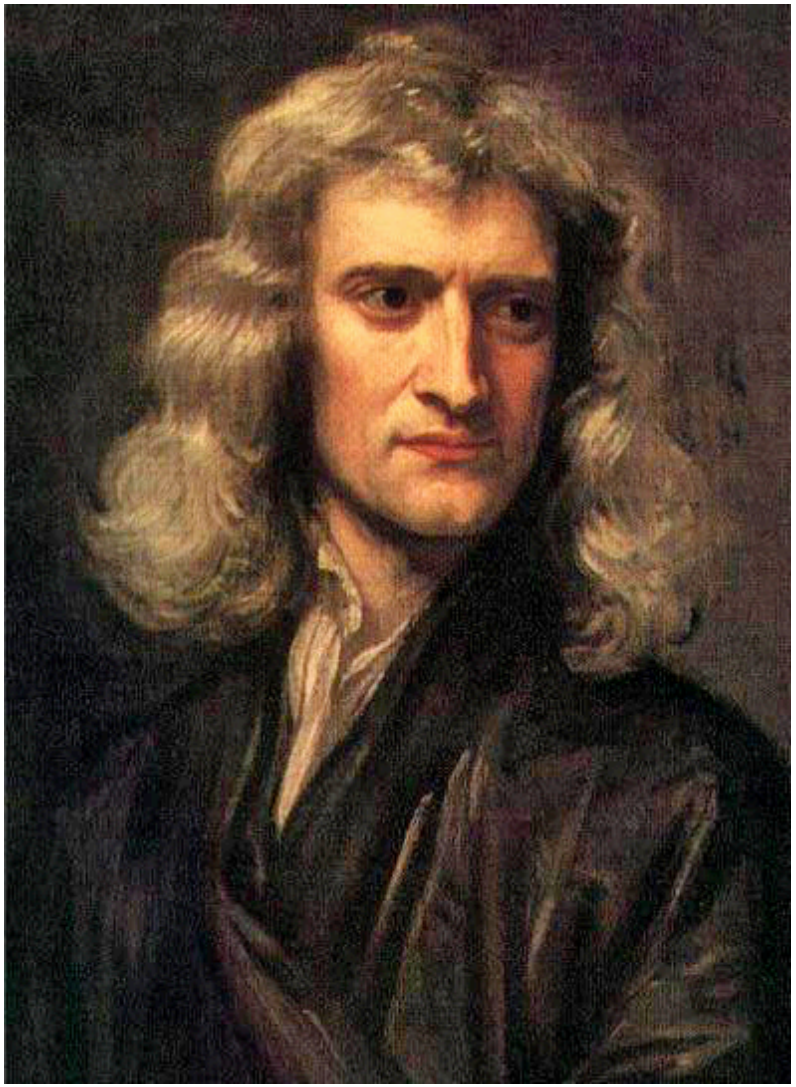

Image: Newton in 1689 by Godfrey Kneller
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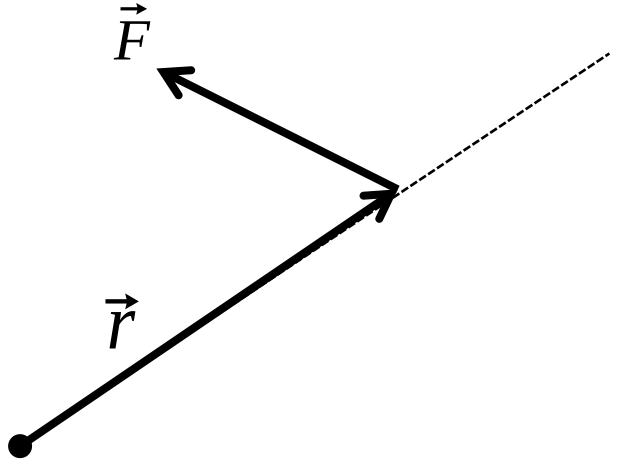
Newton’s Laws of Motion

	Linear	*Rotational*
Newton's 1st Law Newton's 2nd Law Newton's 3rd Law		

Newton's Laws of Motion

	Linear	*Rotational*
Newton's 1st Law	$\vec{F}_{net} = 0 \Leftrightarrow \vec{a} = 0$	$\vec{\tau}_{net} = 0 \Leftrightarrow \vec{\alpha} = 0$
Newton's 2nd Law	$\vec{F}_{net} = m\vec{a}$	$\vec{\tau}_{net} = I\vec{\alpha}$
Newton's 3rd Law	$\vec{F}_{AB} = -\vec{F}_{BA}$	$\vec{\tau}_{AB} = -\vec{\tau}_{BA}$



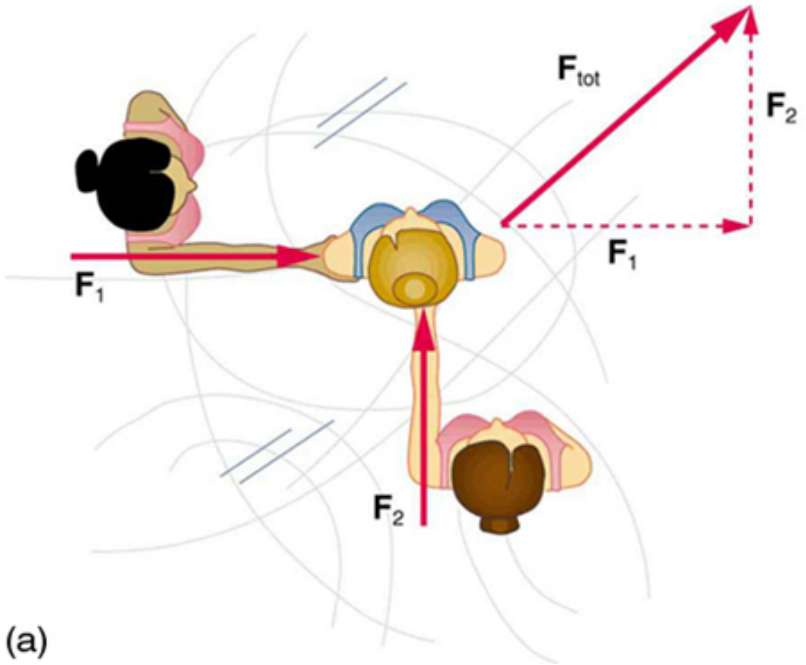
$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\tau = r F \sin(\alpha)$$

$$I = \int x^2 \, dm$$

Free Body Diagrams

- Used to analyze statics and dynamics problems
- All interactions of the object with the environment are replaced by forces



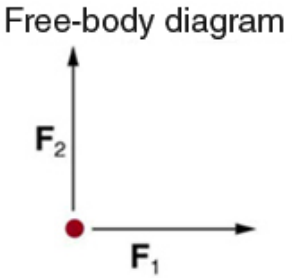


Image: "Free Body Diagram of a group of Ice-Skaters". *(Creative Commons CC-BY-4.0 https://creativecommons.org/licenses/by/4.0/)* OpenStax, College Physics. OpenStax CNX. Apr 4, 2017 http://cnx.org/contents/031da8d3-b525-429c-80cf-6c8ed997733a@9.74

More Examples

- Newton's Apple
- Box on a surface
- Skydiver in free-fall
- Airplane (in flight)
- Satellite (in geostationary orbit)

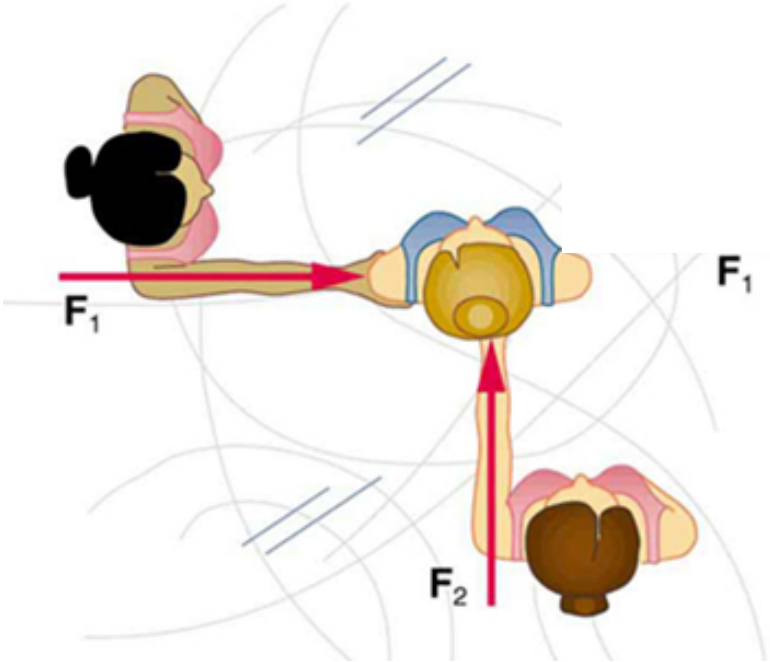
Newton's 3rd Law of motion

If object A exerts a force on object B, then object B exerts a force on object A equal in magnitude and opposite in direction

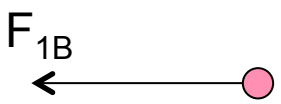
$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Newton's 3rd Law of motion

Example: If the skater on the left applies a force on the blue skater in the middle (F_{B1}) then the blue skater applies an equal force in opposite direction on the skater on the left.



FBD left skater (1)



FBD blue skater (B)

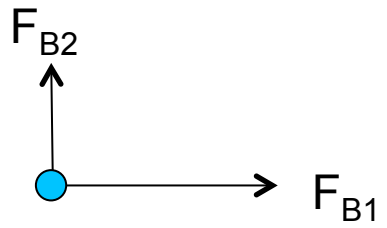


Image: "Group of Ice-Skaters". *(Creative Commons CC-BY-4.0 https://creativecommons.org/licenses/by/4.0/)* OpenStax, College Physics. OpenStax CNX. Apr 4, 2017 http://cnx.org/contents/031da8d3-b525-429c-80cf-6c8ed997733a@9.74

Further reading

OpenStax, College Physics “Force and Newton’s Laws of motion”

http://cnx.org/contents/Ax2o07Ul@9.74:AvUqAiSE@5/Introduction-to-Dynamics-Newto