Dynamics & Stability

Lecturer: Dr.ir. A.S.J. Suiker

Book: *Analytical Mechanics, by Josef S. Tőrők*
sold by VSV

Sample problems, answers, lecture slides, old exams etc.

Newton's first law

Every body maintains in its state
of being at rest or of moving uniformly
straight forward, except insofar as it is
compelled to change its state
by forces applied

Newton's second law

A change in motion is proportional to the motive force applied and takes place along the straight line in which that force is applied

Newton's second law

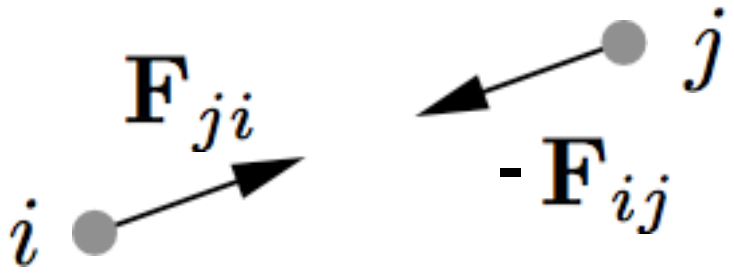
momentum

$$\sum \mathbf{F} = \frac{d\mathbf{p}}{dt}$$

Newton’s third law

To any action there is always an opposite and equal reaction; in other words, the actions of two bodies upon each other are always equal and always opposite in direction

Newton's third law

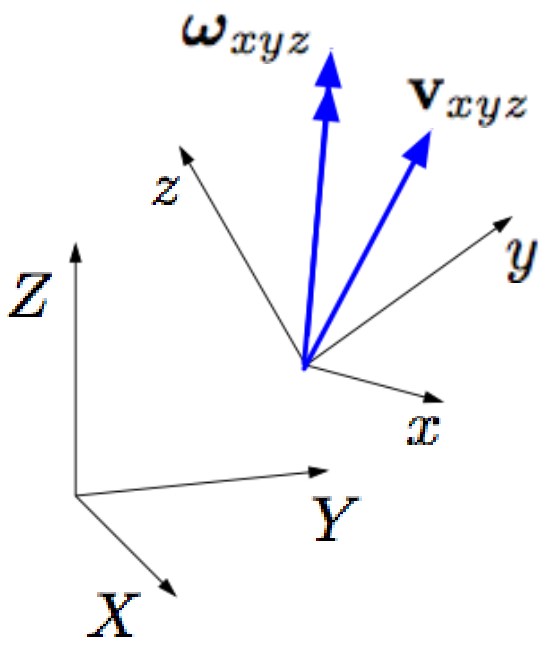


$$\mathbf{F}_{ij} = -\mathbf{F}_{ji}$$

Tacit assumption

Motion is measured with respect to an inertial frame of reference

Inertial frame of reference



$$\mathbf{v}_{xyz} = \text{constant}$$

$$\boldsymbol{\omega}_{xyz} = \mathbf{0}$$

$$\mathbf{u} = u\mathbf{e}$$

$$|\mathbf{e}| = 1$$

$$\begin{aligned}\dot{\mathbf{u}} &= \dot{u}\mathbf{e} + u\dot{\mathbf{e}} \\ &= \dot{u}\mathbf{e} + u(\boldsymbol{\omega} \times \mathbf{e}) \\ &= \dot{u}\mathbf{e} + \boldsymbol{\omega} \times \mathbf{u}\end{aligned}$$

$$\mathbf{v}_P = \mathbf{v}_{xyz} + \boldsymbol{\omega}_{xyz} \times \mathbf{r}_{rel} + \mathbf{v}_{rel}$$

$$\mathbf{a}_P?$$

$$\mathbf{v}_P = \mathbf{v}_{xyz} + \boldsymbol{\omega}_{xyz} \times \mathbf{r}_{rel} + \mathbf{v}_{rel}$$

$$\mathbf{a}_P = \mathbf{a}_{xyz} + \dot{\boldsymbol{\omega}}_{xyz} \times \mathbf{r}_{rel} + \underline{\boldsymbol{\omega}_{xyz} \times (\boldsymbol{\omega}_{xyz} \times \mathbf{r}_{rel})} + \underline{2(\boldsymbol{\omega}_{xyz} \times \mathbf{v}_{rel})} + \mathbf{a}_{rel}$$

Centripetal acceleration

Coriolis acceleration

Fictitious forces

$$
\begin{aligned}
\mathbf{a}_P \quad = \mathbf{a}_{xyz} \quad & +\dot{\boldsymbol{\omega}}_{xyz} \times \mathbf{r}_{rel} \\
& +\boldsymbol{\omega}_{xyz} \times (\boldsymbol{\omega}_{xyz} \times \mathbf{r}_{rel}) \\
& +2(\boldsymbol{\omega}_{xyz} \times \mathbf{v}_{rel}) \qquad\qquad +\mathbf{a}_{rel}
\end{aligned}
$$

Double-deck train

Focault's Pendulum

1st demonstration of earth's rotation (1851)