EM III.1 – Worksheet 2: Remarks on Relative Mechanics (I)

Background Idea

A mechanical relation is formulated with respect to a system A (e.g. Newton’s 2nd law refers to an inertial system) \[ \iff \] The physical variables appearing in the formula are only

* known
* measurable
* analytically describable

* ...

in a system B moving relatively to A or * the description in B is very favourable / much more easier than in A.

Furthermore: Motion of B rel. to A has to be known!

Thought Experiment

In General: mathematical/physical formulas often are very abstract - try to give them a meaning, e.g. try to find verbal paraphrases of the formulas’ components!

Try the following: take a piece of paper and draw an orthogonal \((\xi, \eta)\)-system (with origin \(O'\)) on it – this is your relativ system, so add a "B" to your drawing. Now put the paper on your desk and place a small item (e.g. a coin) on your paper – in the following we are talking about this item’s motion. The item is abstracted as a particle, i.e. only the position but not the orientation of the object is examined. Your desk will represent the "absolut" \((x, y)\)-system A. Since in most cases the edges of a desk are orthogonal, they are a good choice to define the \(a_{1/2}\) vectors (choose an arbitrary corner as origin \(O\)) – the \(b_{1/2}\) are already drawn on your paper. Now all preparatory work is done: we have two frames defined by unit-vectors (with origins) and we have an object to study.

Ask yourself, what the variable \(r_{rel}\) is describing in this set-up!

Move the piece of paper on a circular path while always keeping the edges of your paper parallel to the edges of the desk. Don’t touch the item while moving the paper.

Describe \(v_{rel}\). During the motion, the unit vectors of both systems stay parallel (i.e. don’t change orientation one to the other) - knowing this, quantify \(A_{\omega} \equiv B\). Obviously, the item is moving with respect to the table, while it doesn’t change position with respect to the paper – how is the nonzero component of the total velocity called?

Now rotate your paper without translating the origin \(O'\).

Is there a component \(v_{trans,R}\)? Is there an angular velocity \(A_{\omega} \equiv B\)? Try to find out why the formula of the translational velocity \(v_{trans,R}\) does contain a relative vector!

Step by Step

Relative Motion: freeze motion of the relative frame B and only consider what is happening within the relative system!

Transport Motion: now freeze motion within B - we are only considering the velocities/accelerations due to the motion of the relative system. Be careful: though motion is "frozen" the particle still has a position \(r_{rel}\), which appears e.g. in the rotational part of the transport velocity!