1SC2110 – Rigid body dynamics

Instructors: Guillaume Puel
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 40
On-site hours (HPE): 22,50

Description

Many mechanical systems are designed to allow specific movements or to transmit forces in a controlled way; these mechanical linkages are generally composed of several solids in connection with each other, which can considered as perfectly rigid, since relative displacements are particularly significant in the joints. The study of these linkages then allows to quantify their performance as well as to design them in a relevant way. Besides, the modeling tools that are used can be adapted to describe systems from other fields: the course thus gives numerous examples coming from various fields of application, such as:

- vehicles dynamics (for terrestrial, aeronautical and space vehicles), which implies control and steering challenges;
- robotics, dealing with the design of mechanical linkages and of command laws;
- biomechanics, with the movement analysis of sporting technique;
- molecular dynamics, focusing on the movement analysis of molecules at very small scales.

Quarter number
ST2

Prerequisites (in terms of CS courses)
Elementary knowledge of point mechanics (notions of velocity, acceleration, force, moment).
1EL5000 - Continuum mechanics could be useful, but is not mandatory to follow the course.

Syllabus

- Kinematics of a perfectly rigid body : placement vector, velocity field, acceleration field. Forces and moments. Fundamental principles of dynamics for a rigid body
- Change of frame. Application to joints. Perfect joints : kinematics and forces
- Static determinacy/indeterminacy. Solution methods
- Intermediary examination (45 min) and summary session on solution methods
- Energetic methods: work-energy principle, principle of virtual work (application to a single rigid body)
- Real/virtual work for linkage forces. Application in the energetic methods. Lagrange's equations.
- Additional joint models (friction, backlash, elasticity, ...)
- Final examination (1.5h)

Class components (lecture, labs, etc.)

1h30 lectures followed by 1h30 tutorial classes, except for session 4
Total : 9h lectures, 12h tutorial classes, 1h30 final examination

Grading

Final examination: 1.5 hour with documents and non communicating calculators allowed
Overall grade = max(30% intermediary examination grade + 70% final examination grade , final examination grade)

Course support, bibliography

Lecture notes
``Self-service'' refresher practical work

Resources

Instructor name: Guillaume Puel
Maximum enrollment: 35 for each tutorial class

Learning outcomes covered on the course

Learning outcomes:

1. model in a relevant way a mechanical linkage made of several rigid bodies:
    a. justify the relevant choices of model and the associated parameterization (2D or 3D, perfect joints or not, ...)

b. determine the characteristics of each body, which are relevant for its dynamic study (location of the mass center, calculation of the inertia tensor)

2. determine the motion of the different rigid bodies with respect to time and the actions in play:
    - choose and apply a relevant solution strategy (isolations, projections, energetic approach or not) in order to obtain the motion equations of the different solids
    - solve these equations analytically or numerically in order to determine the relevant quantities allowing for making design choices