MECHANICS IN SPORTS
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TRACKS AND THIS COURSE
Tracks and this course is about expanding the students' experience and competence in cross-disciplinary collaboration. In this course (TRA100/TRA105 – bachelor/master) within the theme Health and sports technology we welcome students from all programmes with relevant prerequisites.

COURSE CONTENTS
Basic concepts in mechanics and physics

Solid mechanics and structural dynamics

Biomechanics

COURSE PREREQUISITES
• Basic courses in mechanics, dynamics and solid mechanics
• Courses in the finite element method, structural dynamics composite mechanics are meriting but not a requirement.

LEARNING OUTCOMES
• Be able to explain how basic concepts in mechanics and physics such power, friction, balance of forces total energy can be used to study athletic performance.
• Understand basic mechanical concepts of composite mechanics and how composite material characteristics can be beneficial in sports engineering
• Understand basic mechanical concepts of loading rate-dependent (viscoelastic) materials and how they can be used for energy absorption in sports (impact, damping etc.)
• Discuss sources of common sports injuries, and how these can be mitigated or avoided
• Be able to synthesize and apply knowledge, as specified in points above, to tackle or master problems with open solution spaces

COURSE ENROLLMENT
Apply to the course no later than 15 May by sending an e-mail including a motivation letter to: martin.fagerstrom@chalmers.se. Please attach your CV and course transcripts.

We aim at 20 students (minimum 5) in balanced project groups with a mix of competences and backgrounds (master and bachelor). If the interest is high, there will be a selection of students based on their competence, interests and motivation. Interviews may be called upon.
Course aim
The aim of this course is to educate the students to mechanical aspects important in sports. Having a wide perspective, ‘sports’ in this context involves elite sports, recreational sports, parasport and movement-enabling technologies such as orthotics and prosthetics. The material covered falls within three themes: Basic concepts in mechanics and physics, solid mechanics and structural dynamics and biomechanics.

In the first theme, basic concepts in mechanics and dynamics will be revisited in the context of sports challenges. Although it will be expected that students already have taken basic courses in mechanics and dynamics, concepts such as power, friction, balance of forces and conservation of linear and angular momentum and total energy will be used to study athletic performance. In relation to this, we will also study the basics of human metabolism in order to explain the relation between useful energy and total energy consumed. This section will serve as a basic introduction in the course at the same time as it will reinforce concepts already presented in other courses the students have taken. It is also expected to give the student a better understanding of how basic mechanical concepts can be used to device more efficient race strategies or training schemes for athletes on all levels. Examples will be taken from e.g. skiing and cycling.

In the second theme Solid mechanics and structural dynamics, three-dimensional stress-strain relations will be repeated and then extended to orthotropic and viscous (composite) materials (very common in modern lightweight sports products). We will discuss the basic solid mechanics of a polymer and a composite lamina, as well as basic laminate theory to establish the material stiffness of thin parts. Also, basic knowledge in composite strength will be explained such that basic composite design can be conducted. In particular, this part will be focused on understanding ways to design sports products and to understand the (sometimes) competing demands from stiffness, strength and vibration characteristics. A final part of this theme will involve basics in structural dynamics and how this is important in sports.

In the third theme Biomechanics, we will introduce fundamental human kinematics, anatomy, physiology and typical sports related overload and traumatic injuries. We will also explain how these
can be predicted, avoided and how these risks change with age. Finally, we will present human muscle activation systems and how these can be modelled. Here we will also work for having a guest lecture by Kristian Samuelsson (or Jón Karlsson), sports medicine orthopedic surgeon at Sahlgrenska Academy.

**Learning objectives**

After completed course all students are expected to have fulfilled the general learning objectives of TRA100 or TRA105, depending on whether they follow the advanced track or the basic track. Specifically, all students are expected to

1. be able to explain how basic mechanical concepts such power, friction, balance of forces and conservation of linear and angular momentum and total energy can be used to study athletic performance.
2. understand basic mechanical concepts of composite mechanics and how composite material characteristics can be beneficial in sports engineering
3. understand basic mechanical concepts of loading rate-dependent (viscoelastic) materials and how they can be used for energy absorption in sports (impact, damping etc.)
4. discuss sources of common sports injuries, and how these can be mitigated or avoided.
5. be able to explain fluid mechanics concepts such as drag, lift and the Magnus effect, and how aerodynamic (or hydrodynamic) resistance affects in sports.
6. be able to synthesize and apply knowledge, as specified in points 1-5 above, to tackle or master problems with open solution spaces

**Organisation**

The course (7.5 hp or more) is scheduled to be running during one semester in autumn 2020. Initially the students are given introductory lectures by the teachers to get oriented within each of the three main themes as listed above. Then the student selects a project which covers at least one (but preferably more) of these fields (projects to be defined by the teachers).

The projects are preferably a mix between theoretical and experimental parts. Theoretical parts will involve conducting mechanical analyses (analytical and numerical) to analyse sports performance, to design experiments and/or to design specific sports components (or a generic idealisation thereof) driven by a list of requirements to be identified by the group (from more generic demands coming from the sports sector). Here, it is expected that the students dig deeper in the theme(s) required in their project (assisted by the teachers). To handle this, additional teaching will be provided in a ‘flipped’ fashion, driven by needs identified by the project groups. Examples of this can be to dig deeper in FEA of composites, mechanical behaviour of polymer foams, experimental biomechanics etc.

During the final part of the course, the students of each group will prepare a lecture within their project field and present it to their fellow students in the other groups. This should involve a presentation of the project, but also relevant theory gained during its course.

**Literature**

Lecture slides, excerpts from (e-)books and recommended scientific papers, beside what is identified by the students during the course of the project work.

**Examination**

The course will be mainly examined based on the project outcome, summarized in a written and an oral report. As part of this examination, the quality of relevant demonstrator material in terms of hardware prototypes or software developed will be important input. The other elements examined
are the learnings from lectures, examined in quizzes held at several occasions to guarantee the general understanding from all three themes.

**Prerequisites**

The course is open to Bachelor students and Master students from all programs at Chalmers with basic courses in mechanics, dynamics and solid mechanics. In the application, students are expected to declare within which of the four main themes they are interested in conducting their project. When selecting a theme, it will also be expected that the student will take responsible for that particular theme in the cross-disciplinary project teams. Depending on program and the background of the student, some fields may be more suitable.

**Miscellaneous**

1. The course may handle 3 projects with 5-6 participants in each. In the selection of students, the course responsible teachers will consider the students course background and declared interest to balance competence and engagement.
2. It may be possible to work on challenges presented by external stakeholders, e.g., commercial actors, professional athletes or sport federations, or the public health care sector

**Course duration:** September – December 2020.

**Enrollment:**

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**Examiner:** Martin Fagerström

**Lecturers:** Martin Fagerström (mechanics and solid mechanics), Thomas Abrahamsson (structural dynamics), Johan Davidsson (biomechanics)