In an increasing complex world, Dynamics and Control (D&C) works to enable the next technological breakthrough in application areas such as, e.g., smart mobility and health, by performing research to increase the efficiency, accuracy and reliability of mechatronic systems. This requires both model-based and data-based tools for the robust and agile design of smart systems, including detailed dynamic models for analysis, advanced numerical tools for simulation, automation strategies and experimental proofs-of-principle.

The challenge in our research
Our mission is to conduct high-level teaching and research in the area of Dynamics and Control, with emphasis on modeling, analysis and control of mechanical and mechatronic systems. Nonlinear dynamics and control, acoustics, vehicle dynamics and robotics are among the focal areas of the group. Fundamental research is combined with numerical tools and supported by dedicated laboratory experiments and/or direct implementation in industry (‘Industry as Laboratory’). We provide students with state-of-the-art knowledge of and skills in Dynamics and Control, certainly in the high-tech region that Eindhoven represents. This is a key scientific field which is relevant to many advanced application areas, such as, e.g., smart mobility, energy, manufacturing and health.

Subprograms of the Dynamic and Control Group
1. Nonlinear dynamics of mechanical systems
In this program, our key activities are the analytical, numerical, and experimental study of complex (nonlinear) mechanical systems. The strength of the research in this program is the combination of theoretical techniques and numerical tools for modeling and analysis with dedicated experimental studies, which jointly provides insight into how to tame or exploit nonlinearity in the design of mechanical systems. Furthermore, obtaining thorough understanding of the dynamic behavior of multiphysics macro- and micro-systems forms a part of this program.

2. (Vibro-)acoustics and noise control
This program deals with structural vibrations and the associated sound radiation. Our research addresses reduction of disturbances due to sound waves in high-precision systems, smart material designs for acoustic absorption and acoustic cameras (Near-field Acoustic Holography-NAH) and, more specifically, the use of sound waves to accurately measure vibration patterns.

3. Nonlinear control of motion systems, synchronisation and robotics
In the nonlinear control area, the emphasis is on problems related to (i) stability, stabilisation and performance of nonlinear/non-smooth control systems; (ii) synchronisation/coordination of mechanical systems; and (iii) embedded and networked control of mechanical systems. In the context of robotics, there is a special emphasis on 1) multiple-vehicles motion planning and coordination 2) control of robot-environment physical interaction for dynamic manipulation and locomotion, 3) teleoperation with communication delays.

4. Vehicle dynamics and control
The research focus is on modelling and analyzing the behavior of road vehicles and improving their performance using control.
A wide range of vehicles is considered, ranging from passenger and racing cars up to busses and multiple articulated commercial vehicles. Dedicated research is done specific vehicle components, e.g. tires and controllable shock absorbers, and the energy efficiency of battery electric vehicles.

Another subject is cooperative and autonomous driving to support improved traffic flows on highways and increased fuel efficiency. Moreover, we develop traffic automation strategies for urban scenarios, such as intersections, and autonomous operation of trucks in a warehouse environment.

5. Mechanical design (jointly with Control Systems Technology)
This program investigates statically determined mechanical design of machines and instruments. We focus on robotic surgery systems and systems related to the semiconductor industry research. Surrounding industries, academic hospitals and engineering companies provide additional training subjects in powertrains, automation, medical robotics development, and instruments for space and astronomy.

HyPerMotion
2015 IEEE Control Systems Technology Award ‘For the Development and Application of Variable-Gain Control techniques for High-Performance Motion Systems’.

Industrial positioning systems such as wafer steppers, pick-and-place machines, electron microscopes, printers and robots are developed by high-tech companies, many of which are located in the Eindhoven area. The designs of such systems are subject to increasingly high performance requirements in terms of positioning accuracy and speed. As an example, ASML’s wafer scanners need higher and higher positioning accuracy to support making smaller and more powerful computer chips to be used in the future’s laptops and mobile phones. The mechatronic designs of these devices are highly optimized but the design of the control systems is still largely based on traditional linear control theory. The aim of this project has been to realize a shift from linear to hybrid controllers in order to remove the performance limitations of classical linear control theory and to achieve superior positioning performance. To this end, design tools for hybrid controllers applicable to linear positioning systems have been developed. Industrial case studies:
- **ASML**: variable-gain and switching control for wafer stage positioning and vibration isolation;
- **Philips Innovation Services**: extremum seeking control for optimal positioning performance;
- **Assembléon (Kulicke&Soffa)**: Hybrid control for fast positioning of pick-and-place machines;
- **FEI Company (ThermoFischer)**: Bandwidth-on-demand control for motion stages in electron microscopes.

Project in collaboration with the Control Systems Technology group. Output: 14 journal papers, 12 international conferences and 5 master theses.
PhD-student Frans Duijnhouwer

'I am the odd one out in the Dynamics and Control research group. Unlike most PhD students, I come from the world of business. I have been working for some time for a company that makes micro gas turbines. The company wants to manufacture a micro gas turbine that does not use oil films for lubrication, but air. That is quite a challenge, at rates of 240,000 rpm.

I started my research by looking for a solution for the micro bearings. A good bearing design is needed to keep the rotor stable at high speed. I ultimately found that an entirely new design was needed for the turbine.

Between now and a few months' time I hope to be able to start testing my first prototype. Over the past few months I have developed the turbine based on computer models that predict the rotor dynamic behavior. Now we will see whether practice matches the theory. It will be a real exciting time.

I combine my PhD research with my job. And that is not easy. On average, I spend about three days a week at the faculty and two days at work. Fortunately, my boss gives me plenty of room to continue working on my doctoral research. In spite of the pressure, I have never looked back. I am still one hundred percent behind my choice, especially because I have been paired with professor Henk Nijmeijer and associate professor Rob Fey. Wonderful people and real experts in their fields. They challenge me, give me input and fresh ideas. I would advise anyone who can do a PhD to jump at the chance. Not just for the qualification, but also to really delve into a subject.

Associate professor Igo Besselink

'The Dynamics and Control research group works on modeling, analyzing and controlling mechanical and mechatronic systems. Non-linear dynamics and control engineering applied to robotics, acoustics and vehicle dynamics are focus areas of our group. In many cases our research is math-based.

But our students have to have skills that go beyond making theoretical models and mathematical calculations. We expect that they can work pragmatically and show creativity. Although it is attractive to remain at your computer, we force students to step away from pure theory and do experiments in our lab. It is important not to lose your connection with practice. In this respect it is very helpful that we have strong ties to business. In the Dynamics and Control research group we are very careful with our students and post-docs. We have regular meetings in which we extensively discuss progress in research studies. Supervision quality is paramount for us. As a teacher I expect my students to take me seriously, and they can expect the same from me.

Because we are a broad research group, our students end up in very different walks of life. Some choose to go on and do a PhD, others will start up their own company. Multinationals, research institutes and various automotive companies are also popular.'

Master’s student Anika Brandsma

‘For me, my choice for the Dynamics and Control research group was completely logical. I’ve been building robots out of Lego with my father from when I was a little girl. It started playfully, but soon got a lot more serious. I am especially interested in dynamics. We are now traveling across the world to show our constructions and pass on our passion for technology.

I started my graduation research two months ago. My research focuses on the behavior of cooperative cars that drive in a circle. What happens when one of these cars brakes? Does the disturbance slowly dampen and die out or is it amplified? In the latter case we have to look for a solution. I have just finished my literature search and I am now working on making a computer model. Later on, I will also make an experimental setup. If all goes well, I hope to graduate in December.

It’s true that there are not many women in the Mechanical Engineering faculty. But you get used to it. I think it is great that I can increase my knowledge of dynamics within the faculty and specifically in this research group.

I look back with satisfaction on my internship in Australia. I worked for three months in the drones lab of RMIT University in Melbourne. Together with a few colleagues I researched a sensor that can determine the orientation of a drone. It was not only very instructive, but also a lot of fun. I would recommend to anyone to do an internship abroad. It is fascinating to see more of the world, and you will get to know a country in a whole different way.

I don’t know whether I’ll be going abroad again after graduating. But it’s a foregone conclusion that I’ll be working on robotics.'