Lecture overview

1. CAD/CAE technology. History and state-of-the-art
2. Representation of curves and surfaces
   CAD applications: Mold design, Finite element and sheet metal.
3. Model exchange and Multibody Simulation.
4. **Man/machine interfaces and anthropometry**
5. Ergonomics and biomechanics

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Program for today

1. Introduction
2. Human factors and anthropometry
3. Digital manikins
4. CATIA Human Builder

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Some terminology

- **Ergonomics and Human Factors**: Scientific field dealing with the working human body and its parameters and limitations.
- **Anthropometry**: The study and measurement of human physical dimensions
- **Biomechanics**: The science of the mechanics of living organisms.

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Why is this important to mechanical engineers?

- A very large part of the products we design have a human interface.
- The immediate human perception of a product in many cases determines its success in the marketplace.
- Products with a bad user interface can be
  - Difficult or impossible to operate
  - Dangerous
  - Uncomfortable
- Bad user interfaces have consequences for product liability.

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Example: Automotive package design

- As a minimum the seat must be adjustable forward and backward. Otherwise:
  - Impossible
  - Unsafe
- Adjustment of seat back angle and seat height enhances comfort.
- Adjustment of the steering wheel is necessary to avoid fatigue.
- All this is costly. How can these adjustments be optimized to people of different sizes?

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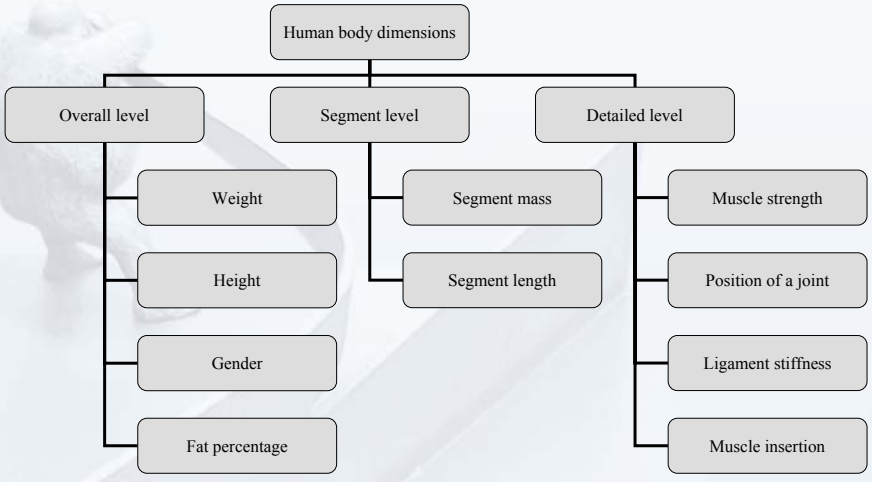
The human body as a parametric model



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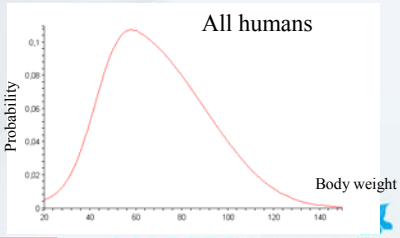
Anthropometry and Statistics

- Mass products are not designed for one particular individual but for a cross section of the population.
- Percentiles are based on statistical distributions.
- The idea is that any dimension in the human body has some statistical distribution, for instance the normal distribution.
- The deviation reduces when we narrow to a particular gender or population.



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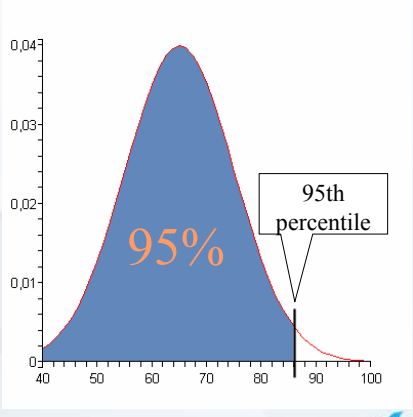
Percentiles

- A percentile designates a certain dimension.
- Only 5% of the population has a larger dimension than the 95th percentile number.
- Many products are designed for people between 5th percentile females and 95th percentile males.
- Notice that the actual dimension depends strongly on the population.
- The Chinese population is much smaller than the Dutch population.



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Basic assumptions

- We assume that the individual dimensions of the human body are not independent:
  - Tall people tend to have large feet
  - People with high weight tend to be stronger than light people
  - Men tend to be stronger than women
  - Americans tend to be larger than Chinese people
- This allows us to scale bodies approximately based on just a few simple parameters such as height, weight, gender, and population.

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Digital Manikins

- A digital manikin is a geometric model of a human body usually with these features:
- It has joints and can be put into the positions a normal human body can assume.
- It can be scaled between genders, populations, and sizes based on statistical databases.
- The CAD system CATIA has a built-in digital manikin called Human Builder
- Other popular products within this field are Jack/Jill from UGS and Ramsis from Human Solutions.
- Some manikins are stand-alone, and some can be integrated with CAD

Jack

Ramsis

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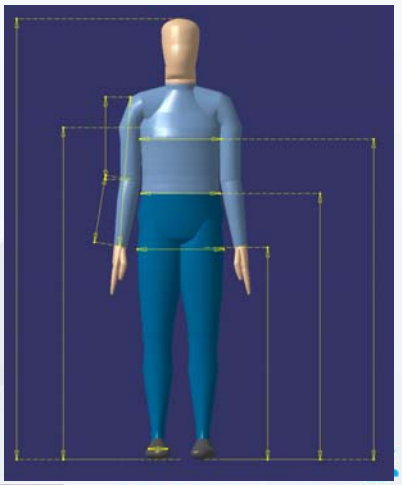
ANYBODY RESEARCH PROJECT

CATIA Human Builder

CATIA's digital manikin is called Human Builder.

It also goes under the name Delmia.

It was originally developed by a company called Safework, which is now a part of Dassault.



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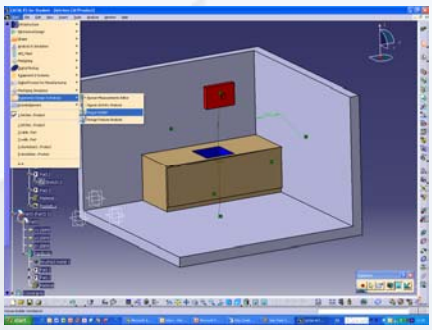
Starting Human Builder

- A digital manikin in CATIA becomes a part of the product much like any other model part.
- First create the product you want to investigate.
- Make sure the product is the active item in the model.
- Click Start -> Ergonomics Design and Analysis -> Human Builder.



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Definition of a manikin

- The vertical menu on the right-hand side of the screen changes.
- Click the “Create a manikin” icon
  - This initiates a dialogue to define a manikin

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Percentiles

Ergonomics and “Human factors” operate statistically with the concept of percentiles for bodily dimensions. The 50th percentile is average. This means that 50% of the population is smaller than the 50th percentile.

As a celebration ☺ of traditional gender roles we place the average 50th percentile woman in our kitchen.

Under ”Optional” we can choose the population that the sizes are based on. Danes are larger than Frenchmen and probably fit the American population better.

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Reference point

The reference point is the point where we presume the body is attached to the environment.

The automotive industry uses the H-point to place drivers in seats. It is a point located in the pelvis.

Here it is more relevant to keep the lowest foot on the floor.

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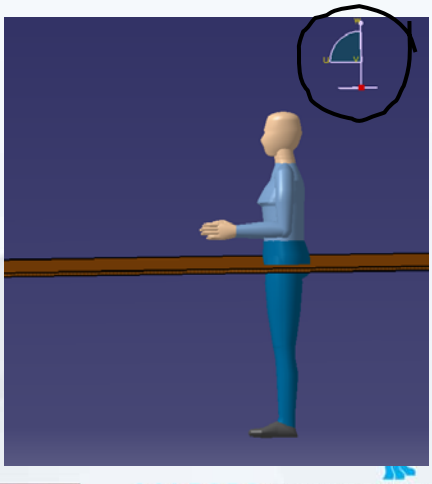
Placement

You now have a manikin, which is probably half way under the floor and must be moved into place in front of the kitchen table.

The manikin is a part of the ”product” and as such it can be moved around with the compass. The compass is an ingenious little device that is known also from 3DS Max.

Before you can move the manikin you must make sure that the Product and not the manikin is the currently active object. This is done by double-clicking ”Product1” in the feature tree.



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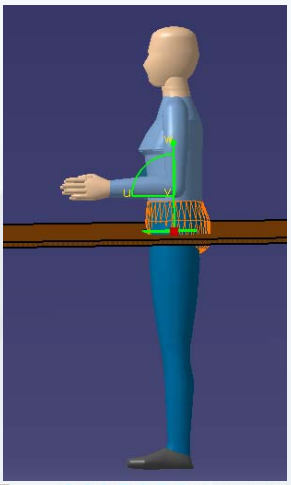
Moving with the compass

Click once on the manikin in the feature tree to select it. Subsequently grab the compass at its red origin and drop it on the manikin. When the compass has grabbed the manikin it turns green.

The compass supplies three axes, three planes, and three rotations by which you can move the manikin with the mouse.

Make the manikin stand in front of the kitchen table.



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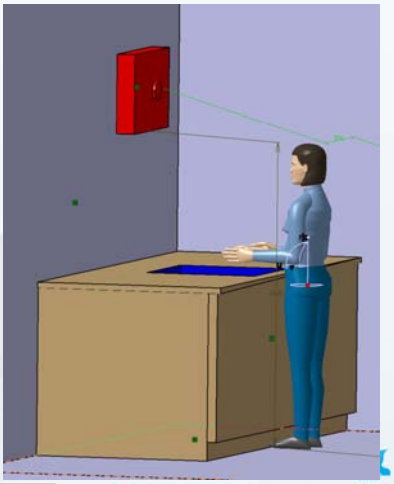
Evaluating proportions

Just looking at the body in relation to the environment gives a lot of information about the ergonomics. It looks like the kitchen table is perhaps a bit high for the 50 percentile woman, but it can be used.

On the other hand, the woman has no chance of reaching the loudspeaker on the wall.



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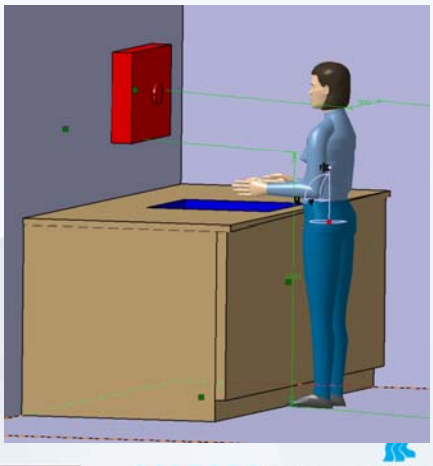
Can the subject reach the button?

After a change of dimensions of the table and loudspeaker placement, the proportions look more reasonable.

But can the subject reach the loudspeaker button? A reach analysis can provide the answer.



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Reach analysis

Reach analysis has three functions:

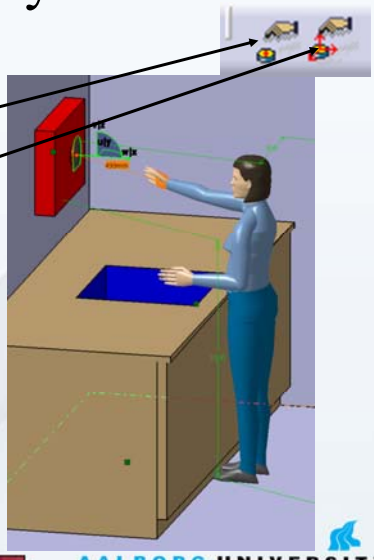
1. Moving a body part as close to a given point as possible.
2. Same as 1 but with given orientation.
3. Computation of a reach envelope.

Place the compass on the speaker button.

Pick the ”Reach (position only)” function.

Then click on the right hand to indicate that this is the part that will grab the button on the speaker.

The arm will reach out and try to grab the button. In this case it turns out that it cannot reach the button.



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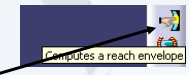
Reach Envelope

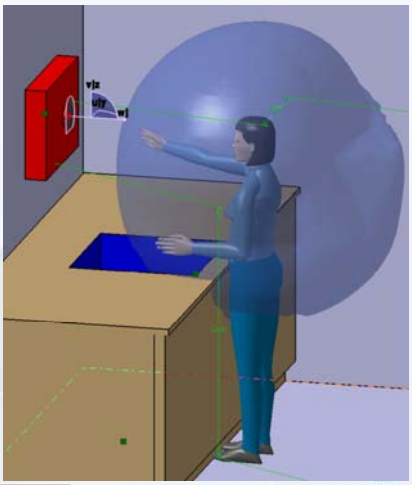
It can be difficult to guess if some other placement of the speaker on the wall will allow reach. Rather than moving it around in all possible positions we can make the system compute a reach envelope.



Just click the ”Reach Envelope” button and wait a little while.

It appears that no position of the speaker will allow convenient reach.

Perhaps a remote control is the best solution?



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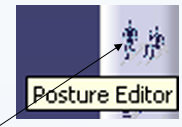
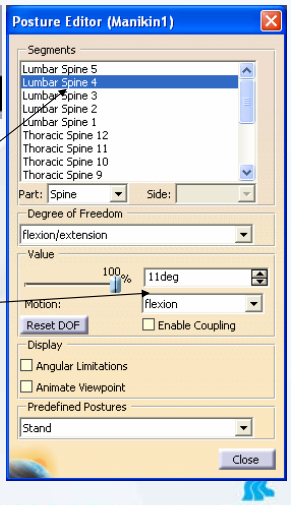
Setting of Posture

Human Builder gives you several options for setting the posture. The most direct way is “Posture Editor”.

It provides a menu in which you can control the joint positions if you know the anatomical terminology

Try bending the upper body a bit forward.





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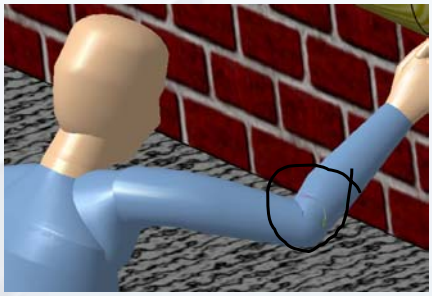
Forward kinematics
- a more intuitive way to set the posture

With forward kinematics you can pick a joint and manipulate it directly.

This can be an advantage when you do not know the anatomical terminology for joints and angles.

Small arrows indicating the joint rotations pop up when you move the mouse pointer over the model.

It takes a bit of practice to control it.



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Inverse kinematics manipulation

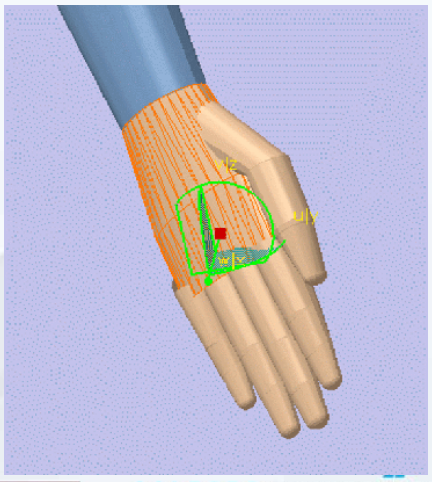
This function allows the user to grab a segment, for instance a hand, and pull it in some direction. The other joints follow along as well as they can.

Double-click the manikin in the feature tree to make sure it is active.

Pick the ”Inverse kinematics worker frame mode” button.

Click once on a surface, for instance the hand. The compass snaps to it.

Now move the compass around and see the hand following it.



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Field of vision

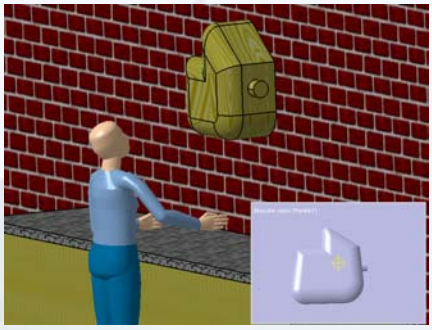
"Modify vision"

It is often useful to simulate the manikin's field of vision.

In Human Builder you can see the model through the manikin's eyes.

Click the eye icon and then the manikin. You will see a small window visualizing the manikins field of vision.

The field of vision window gets updated as you move the manikin's head position.



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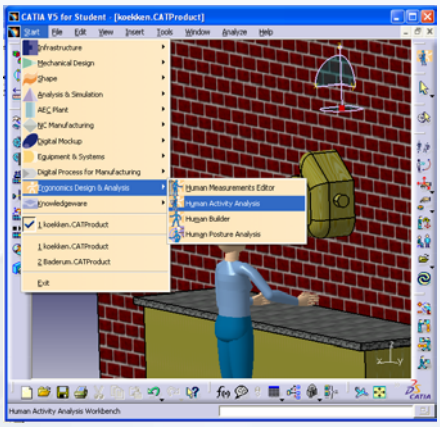
Human activity analysis

CATIA's manikins can compute allowable push, pull, and lift according to an American ergonomics standard. It is in principle just a question of looking the numbers up in a database and is very different from a real biomechanical simulation.

Pick Start -> Ergonomics design & analysis -> Human activity analysis.

Then click Carry Analysis and the manikin. The maximum acceptable weight the current manikin can safely lift is computed.



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CATIA and Human Builder Demo

Modeling a kitchen

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Assignments and homework

1. Start CATIA and build your own kitchen including a radio and a sink.
2. Insert a 50 percentile female manikin into the kitchen you have made.
3. Adjust the dimensions of the kitchen to fit so that she can switch on the radio as well as do the dishes.
4. Check the reach envelope for some relevant working situation.
5. Insert a new manikin – a 95 percentile male – and check how he fits into the kitchen you have made.
6. Investigate his necessary posture to reach into the sink.
7. Before next lecture: Go to www.anybodytech.com and download and install the AnyBody Modeling System.

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