Building a Human-Powered Vehicle

In this blog, you'll find the documentation of the development and the construction of a HPV - a human powered vehicle - which is our task in school as part of our p-seminar.

Friday, January 10, 2014

Project failed

Unfortunately, this week we had to admit that the construction of our HPV failed.
Since our seminar ends in just a few weeks, we now resumed why we could not finish building the vehicle:

- Even though we have a working brake installed on the rear wheel of the HPV, the two front wheels can not yet be used for slowing down the vehicle. The main problem was to connect two brake cables with one brake handle in order to brake both front wheels at the same time.
- We are completely missing a body for our vehicle, which is not necessary for a working HPV, but which we would have liked to add for better aerodynamics.
- The chain in generally working, but we would still need to exchange some screws and adjust the gearshift.
- We also have a fully functioning seat, although it would be good to construct some kind of guide that keeps it in the middle when there is a force pushing sideways.

Our main problem that kept us from finishing the construction was definitely a lack of time because we had to set other priorities in order to get along in school. That's why problems in time management evolved. These then leaded to organizational problems.

Overall, we can conclude that the aim of building a HPV was not reached, but that parts of it were accomplished.
Most of us were very interested in the project, brought in their ideas and worked with great commitment.
Communication between the different teams mostly worked fine, but sometimes it was not clear who was supposed to buy the needed material.
But for me, I can say that I did definitely learn something in this seminar, especially some engineering laws, such as the Ackermann steering geometry.
Additionally, I think we all found out that planning is extremely important for being able to successfully finish a project. In our project, we also had agreed on some dates for checking the progress we made and for comparing it with

the one we estimated. But unfortunately, we soon realized that our plans were to optimistic and that there was no chance of getting everything we planed done on time. Therefore, we now all know that a realistic planning is very important for the success of a project. It would probably be a good idea to assign one person to coordinate the timetable, to monitor the observance and to agree on countermeasures if milestones have been passed although the task has not been finished yet. This person should also be responsible for rescheduling the timetable if necessary.

Since I was the only one interested in taking home what we built so far and continue working on it in my free time, I will now take the vehicle home with me and hopefully finish the work on my own.

Posted by young-engineer at 18:44 No comments:

Saturday, December 14, 2013

Continuing the work

On Wednesday, at least one of each group came to work on the HPV.

Team body could finally take all measures they needed, since the construction of the seat was done. So, now they can review their design and start buying the material.

Team chain added a perforated tape to the two gears guiding the chain in order to make sure that the chain cannot jump off them anymore.

Team brake worked on the position of the brake mechanisms and fixed the brake cables they bought on the handles.

Finally, team seat started cushioning the seat and added a second inner tube for a better spring system.

Posted by young-engineer at 14:48 No comments:

Saturday, December 07, 2013

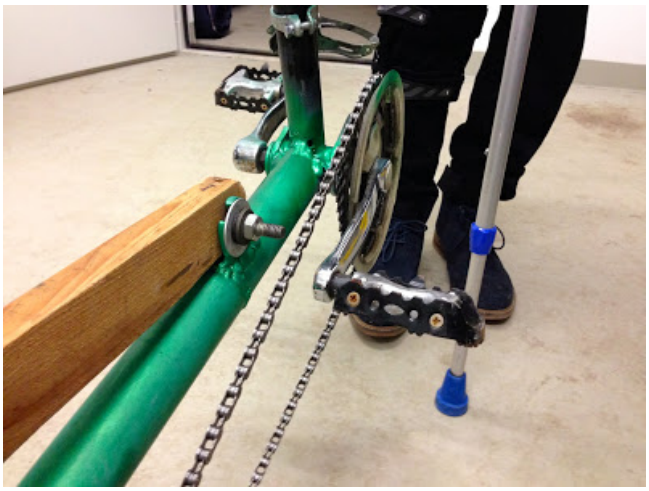
Constructing the seat and attaching the chain

On Wednesday, the seat team and the chain team met again to work on the frame.

First, team chain fixed the chain on the bike and moved the shifting cables in the right place. They had to remove the front shift because the angle was not right, so that the chain would have touched it all the time.
They also added two gears in the middle of the chain in order to shorten the

distance where the chain has no contact to a part of the shifting system. This allows us to guide the chain a little. But we still need some screws or other thin metal bars that are stable enough to carry those gears. Otherwise the power of the chain would simply bend them over until they are ineffective.
What we need as well is a hose clamp for fixing the shifting cable.

In the following pictures you can see the attached chain:



While team chain was working on the chain and the shifting system, team seat already started the construction of the seat. They had already bought the wood they needed and some metal pieces to connect everything. Among these, there were mainly hinges and angles. After the chain was secured into place and everything else was clear, team chain helped the other team build the seat. In the end, we were all happy about the look of our seat. Everything worked out good and the only thing we still have to do - concerning the seat - is to cushion it. But even with the wooden seat, sitting on the HPV was comfortable already. The seat can be moved back and forth, so that the seat position fits to your body size. The angle of the backrest can also be adjusted a little.

You can see the seat as well as the mechanisms for changing the position in the following pictures:

Posted by young-engineer at 22:17 No comments:

Tuesday, November 19, 2013

Working on the frame

As we all needed to have a look at the frame before continuing to think about the details of our project, we used last week's class time to do so, take some measures and organize our material.
We also cut one handlebar into two pieces, of which we want to use one for the steering on each side. We will also place the brake handles and the gear levers on these pieces. This way they are always near to the hands.

Regarding the chain, everything looks good so far. One of the team members already put together all the small pieces they got from the local bicycle stores and managed to get a chain that is about 3.8 meters long. This should fit on

our bike perfectly.
During class they already placed two gear levers on the handlebar. The shift cables are both long enough, so they simply need to be adjusted a little.

The team responsible for the seat construction has pretty much decided to use wood and some kind of foamed material for the construction. They already went to a local craftsman's shop (OBI) in order to check the price for the needed material. They will now check with our classmate in charge of the finances, if they are allowed to buy everything.

The brake handles also got installed on the handlebar, so that now they will have to adjust the brakes and connect the brake cables to the shoe brakes in the front and the V-brake in the back. New cables might have to be bought.

For the body construction, the team needed to take a few measures while one of us was sitting on the bike and pretended to be pedaling. Using these measurements, they can design a final draft for the form of the body. After, we can buy the material and start with the construction.

The following two photos show the entire bike and the handlebar in detail:

Posted by young-engineer at 10:13 No comments:

Monday, November 11, 2013

Come-together of all the groups

Last Wednesday, we all came together again after one week of holiday. Each group explained what they had found out so far and what they thought would be the next step.

The group responsible for the construction of the seat introduced two different models to the rest of us:

Plan 1:
One could use four bike tubes and weave a net around them. Since they can stretch, this would be a spring system. But some of us had concerns about whether this would still be stable enough for pedaling, since the main force is leading towards the back of the seat.

Plan 2:
A seat could be constructed out of wood and placed on the construction that our teacher shows in the second video mentioned in the last post.

The chain team contacted a bicycle store in our area and asked them about old chains they have or chain parts they don't need. They showed interest in helping us with our school project and asked us to bring a part of the gearshift so that they could see what type of chain we needed. During class, this team got everything they needed from our teacher and they're going to show it to the owner of the bicycle store until our next meeting. Let's see what they find out.

The group in charge of the brakes found out what a break cable would cost and thought about different ideas for the placement of the brake handles. But for a final decision they first wanted to see the frame themselves and be able to measure some distances.

The team for designing and constructing the body found some information on the prices for the needed material and roughly calculated the amount needed.

So, on Wednesday, we will meet again and have a look at the frame. Then we should think about how to continue with the building process.

Posted by young-engineer at 16:30 No comments:

Sunday, November 10, 2013

Frame building completed

During the holidays, our teacher found some time to build the frame for the HPV.
For showing us how he worked on the bikes and how he put the whole frame together, he filmed all his actions and created two short films.

You can find them on youtube:

1st part: http://www.youtube.com/watch?v=QMzAlzhUVIo
2nd part: http://www.youtube.com/watch?v=fNnGJNX-snY

Unfortunately, it's all in German, but he simply describes what he is doing and what this is good for. I'm sure, one can also understand it by images only.

Posted by young-engineer at 13:33 No comments:

Thursday, October 17, 2013

Splitting up into groups

Last week on Wednesday, we met again in class and summed up what we had so far. Since the last post nothing changed about the collected material, but we think that we have now gathered enough so as to start building the HPV.

Our teacher, who has a collection of all the needed tools for building the frame such as an angle grinder and welding equipment and has therefore offered to build the frame himself. We were all happy about his offer and accepted it thankfully.

After we decided to split up into four groups, of which each of them is

responsible for one part of the HPV:

1. Seat construction including spring system:
   Marc, Maximilian, David
2. Chain, gearshift, chain guide, placement of shifters:
   Alex, Pierre
3. Brake, placement of brake handles:
   Hannes, Jakob, Leon, Helmut
4. Body construction:
   Leonie, Lea, Kristin

We are now working in these groups for about three weeks and we'll meet again after our fall holidays. By then, our teacher should be done with building the frame and we should have collected all the material we need. Having a look at the frame, we can then decide how to connect the parts that we're responsible for to the HPV.

Posted by young-engineer at 22:27 No comments:

Wednesday, October 02, 2013

Money and bike problems solved

On Tuesday, we got good news from our teacher: Their had been a little misunderstanding between him and our principal. The parents' association did not completely refuse our request for money, they simply did not agree to the amount of money. That's why they decided to sponsor our project with 300 € (instead of 450 €), which is still a good amount of money to work with. Thanks to the parents' association!

We also found a bike on ebay for 15 € in driving distance. It now only needs to be picked up by one of us and then we should be ready for the construction of the frame of our HPV.

Posted by young-engineer at 22:27 No comments:

Saturday, September 28, 2013

Still in need of material

This Wednesday, we finally met again after our summer break. But although we all tried to find a suitable bike with a 16" front wheel during the holidays, none of us got lucky.

That's why we now decided to look for one on ebay. We are planning on spending a maximum of about 25 € for the bike.

Apart from that, it seems as if we have two bikes that we can use for the frame

and of which one wheel can be used for the rear wheel of the HPV. Furthermore we have one 16" bike of which the front wheel can be used for one of our two wheels in the front.

We also want to ask the parents' association for money again, since they denied our first request without any reasoning.

Our next meeting will be in two weeks, hopefully with a second wheel for the front and a satisfying answer from the parents' association.

Posted by young-engineer at 14:23 No comments:

Sunday, July 14, 2013

Still looking for the right material

On Tuesday, we discussed our progress regarding our HPV:

- The parents' association has unfortunately not guaranteed the financial help for our project so far. They'll have to decide in September when the new school year starts what to use their money for. So, we all hope the best so that we won't have to find other sponsors.
- One member of our group will be able to get his sister's bike (wheel size: 16 inch) of which we can use the front wheel for one ours. Since we also need the fork connected to the wheel, we have to find another bike of the same size for the second front wheel.
- Another classmate of mine will be able to get the rear wheel (size: 28 inch) that we need.

After having discussed all these topics, we went to the recycling center together in order to have a look at the containers containing scrap metal. We could not find a bike with wheels that are 16 inch big, so we agreed on going there every now and then on our own for the next two weeks. This way, we might be able to find a bike of the right size that we can work with.

We'll have our last meeting before summer break on Tuesday in one week. Hopefully, we get some more material until then, such as a small bike and some steel pipes for the frame. Then we could finally start construction after the holidays.

Posted by young-engineer at 22:23 No comments:

Monday, July 08, 2013

Calculation of costs for the construction of our HPV

Last Tuesday, we met again in class and discussed the size that each of us had calculated for the body of our HPV. We came to the conclusion that the body will most probably not be smaller than 10 and no bigger than 15 square meters.

So, we decided that we will need at least 15 square meters of glass fiber mats; if we want to improve the stability of the HPV we'll need twice this amount. In order to turn these glass fiber mats into glass fiber reinforced plastic, we additionally need 20 kg of polyester resin (includes the accelerator). Depending on the amount of glass fiber mats used, the amount of polyester resin might have to be reconsidered. The paint needs to be mixed with the polyester resin before soaking the glass fiber mats in this mixture. That's why 2 kg of special paint are needed.

For building the frame, we need some poles made out of steel. We hope to get these from old bikes from the recycling center for cheap.

Having estimated the amount of material we need, we calculated the amount of money that is needed for realizing this project.

Adding them all up, we counted a total of 250 to 300 euros. For additional material, we thought of another 150 euros.

Therefore, we wrote a letter to our school's parents' association asking them for a donation of 450 euros for our project.

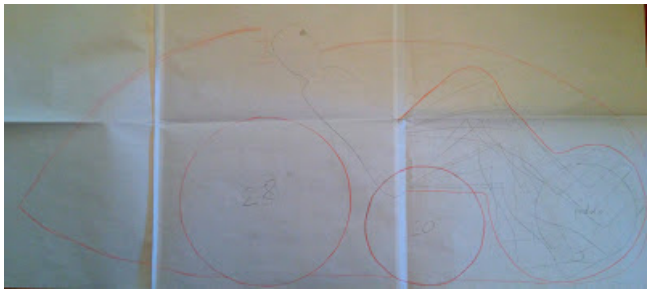
Let's hope they are willing to support us!

Posted by young-engineer at 19:06 No comments:

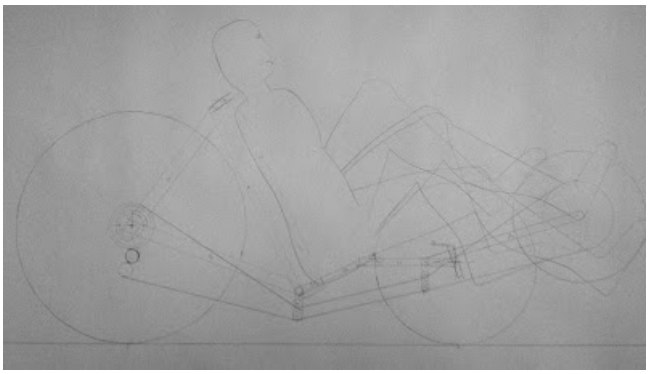
Sketches for the basic construction of our HPV

Until last Tuesday, our task was to finish our sketch true to scale, to improve it if needed and finally to calculate an approximate size for the body of the HPV.

In the following picture, you can see a photo of my first sketch:



The second picture shows the improved sketch, which now also shows the frame that we'll need in order to connect all the pieces of our vehicle:



I came to the conclusion that the body will probably measure about 12 square meters.

Posted by young-engineer at 18:19 No comments:

Tuesday, June 11, 2013

Estimating the size of the HPV

Our task for today was to built a small figure according to the size of our body true to scale.

In the following picture you can see the small figure at a scale of 1 to 3.5. In all the spots with golden dots the body parts can be moved, so as to simulate pedaling and adjust the arms so that they can grab the handle bar.

So today, we started working with these figures. Each of us took a blank piece

of paper and sketched the body of the figure in the position that it will probably be lying in, in the HPV.
We measured the radius of regular bike pedals and estimated the size of the wheels.
For the two wheels in the front, we decided that - according to some literature we read in class - it was best to use wheels with a diameter of 20 to 22 inches. This way, they are more stable in curves.
For the wheel in the back, we agreed on a bike wheel that is as big as possible, which means that it should have a diameter of about 26 to 28 inches.

With this information, we could now put our figure in place and move its legs, so as to find out how much space we'll need to pedal and move our legs as part of the pedaling.
As soon as we were done with our sketches, we could now see how big the body of the HPV has to be at least. This way we can now approximately calculate the size of the body of our HPV, which is necessary in order to buy the right amount of material.

I hope to be able to upload a picture of my sketch as soon as possible.

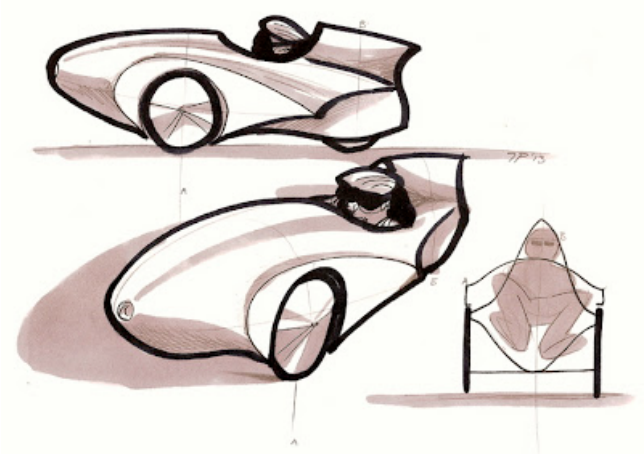
Posted by young-engineer at 18:39 No comments:

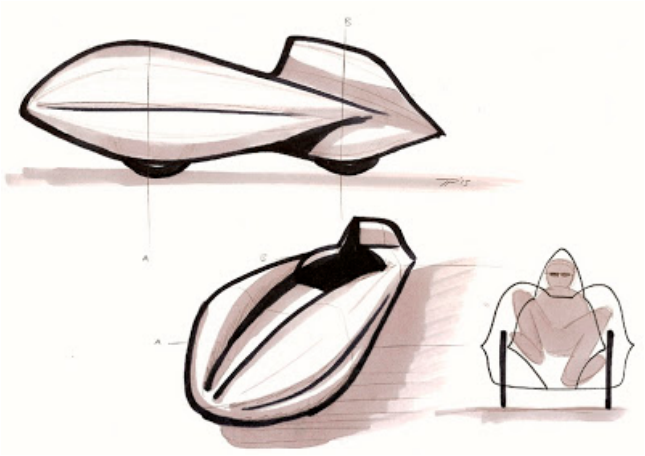
Tuesday, May 21, 2013

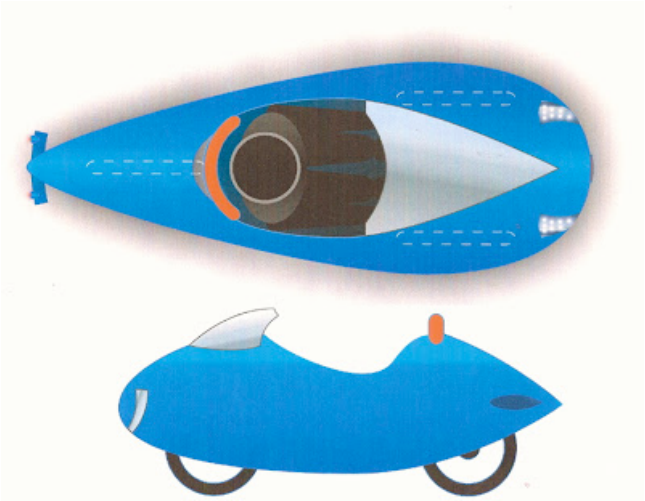
Next round of designing and technical thinking completed

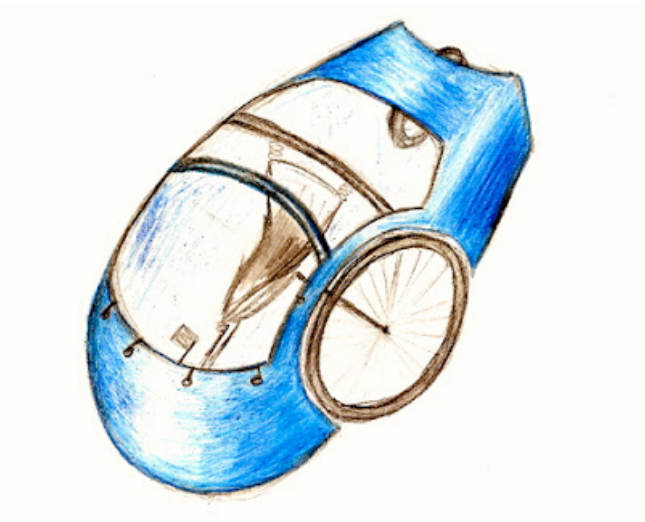
One week ago, we met again and presented our new invented designs, the way of steering with two wheels in the front and a way of cushioning the seat of the vehicle.

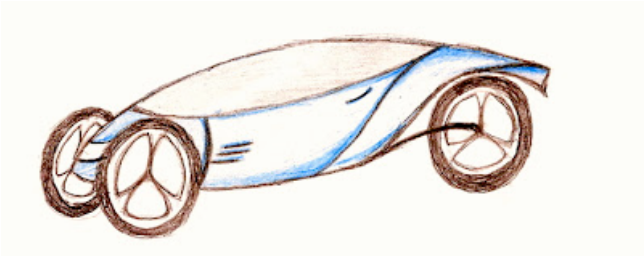
All designs now have two wheels in the front and one wheel in the back - our teacher also thought about some possible designs:

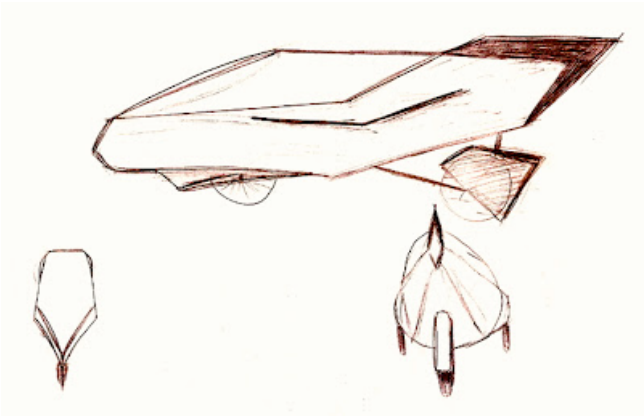












Our teacher explained that it was absolutely essential to cushion the seat, since the spine is not in an upright position like on a bike and is therefore not in a good position to absorb hits itself. Hence, we agree on cushioning the seat itself and not the whole vehicle because this type of spring is easier and cheaper to get and the effect it has is the same or even better. By softening the seat, we can also lower the risk of injuries.

For finding out a way of steering two wheels, we did some research on recumbent bikes and came to the conclusion that a lot of them use the Ackermann steering geometry. It is shown in the following video that I generated from my CAD program (first from the front right corner of the vehicle, after from the top):

Safari Power Saver
Click to Start Flash Plug

The two bars leading to the back of the vehicle have to be orientated towards the center of the turning circle. For additional information, please have a look at the according Wikipedia page:

http://en.wikipedia.org/wiki/Ackermann_steering_geometry

Finally, our teacher came back to talking about aerodynamics. He showed us some formulas so that we could see, which factors are important for us to minimize:

$$F = F_d \times m \times g$$

where

$$F_d = 0{,}5 \times \rho \times c_d \times A \times v^2$$

F – force needed for compensating the drag
F_d – drag force
c_d – drag coefficient
A – reference area
ρ – mass density
v – speed of the vehicle relative to the air

Therefore, we concluded that we will have to minimize the area A looking from the front of the HPV and the weight m of the vehicle in order to have a force that is as small as possible. The other values are constant and cannot be influenced.

Our task is now to measure the size of our body and come up with a calculation for the size of our vehicle.

Posted by young-engineer at 11:31 No comments:

Tuesday, May 07, 2013

Selection of material

After a one week break that we used for researching different sorts of materials, we discussed them in group today.

So after we all presented what we found out, we had three different options for the body of our HPV:

A construction ...
1. ... out of wood
2. ... out of aluminum poles and tarpaulin
3. ... out of glass fiber reinforced plastics

So we considered three aspects for each material: how easy the material can be shaped, how much it will weigh and how much it will cost.

Wood is easy to shape, but can only be used to create two-dimensional

shapes. It is not very expensive, but weighs a lot.

The tarpaulin construction can be shaped by forming the aluminum poles and span the tarpaulin above them. Therefore the form is not very precise and might change because of aerodynamic resistance. It is light and does not cost much.

Glass fiber reinforced plastics have the big advantage that they can be shaped three-dimensional, which means that almost any form is possible. Apart from that it is comparatively light, but is also the most expensive one of the three materials.

After all, we decided to use glass fiber reinforced plastics because this means that we can invent our own design and won't have any problems constructing it.

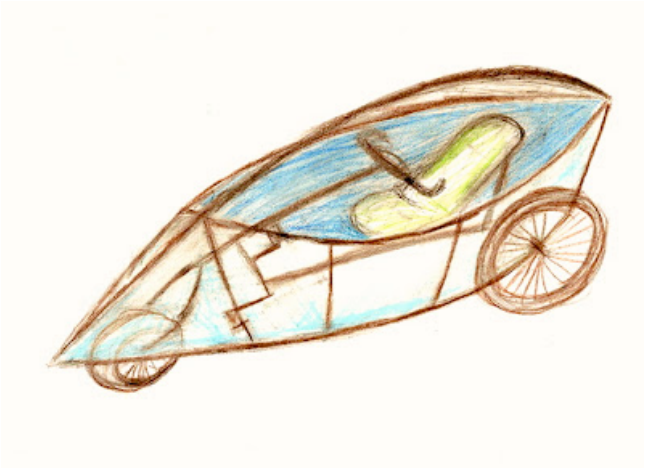
Apart from the material aspect we reconsidered the placing of the three wheels. In order to be able to design a vehicle that is shaped aerodynamically, we now decided to think about a model that has two wheels in the front and one wheel in the back.
Next week, we will talk about our ideas in class.

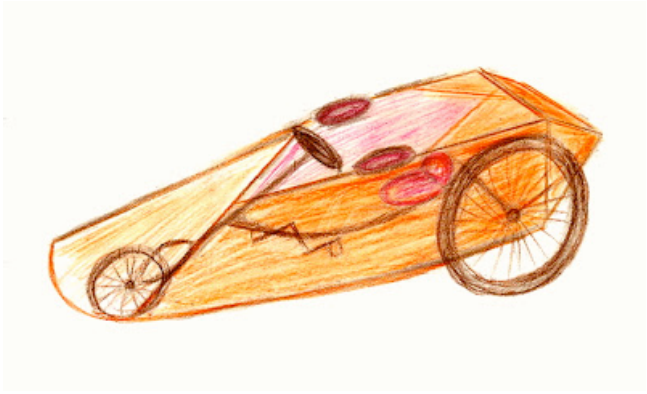
Posted by young-engineer at 22:47 2 comments:

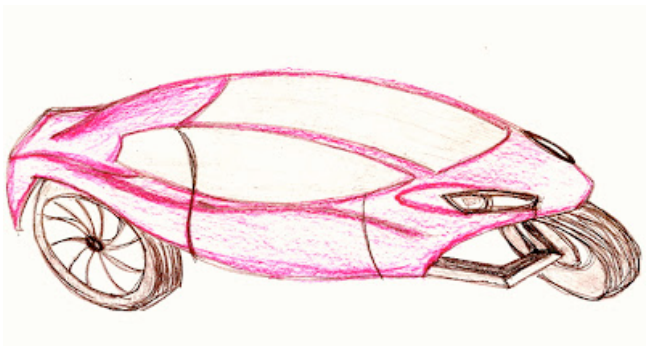
Sunday, April 28, 2013

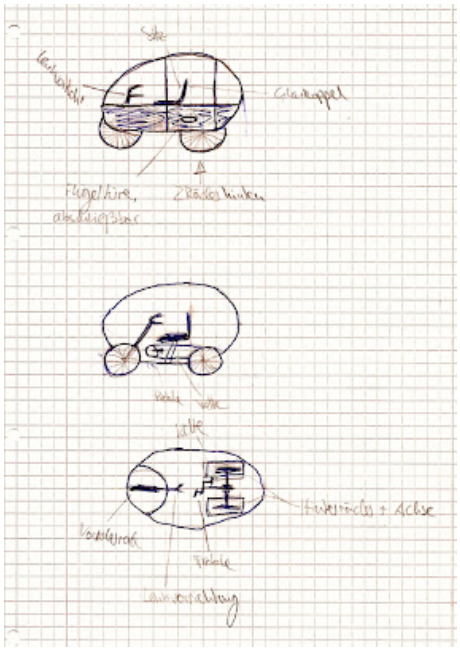
Several design sketches

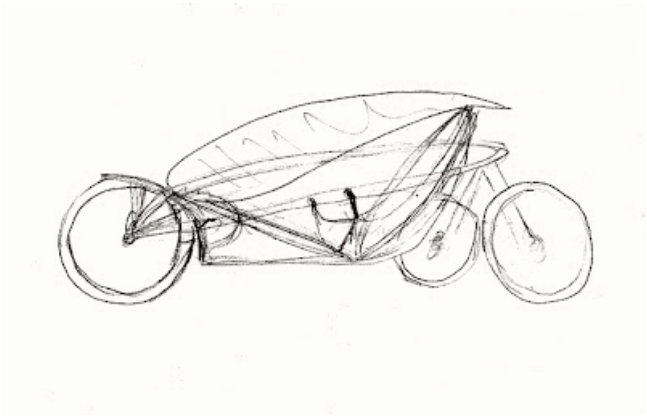
As promised about a week ago, I will now upload the pictures of the designs made by some of my classmates. Thanks again to our teacher for scanning them in.

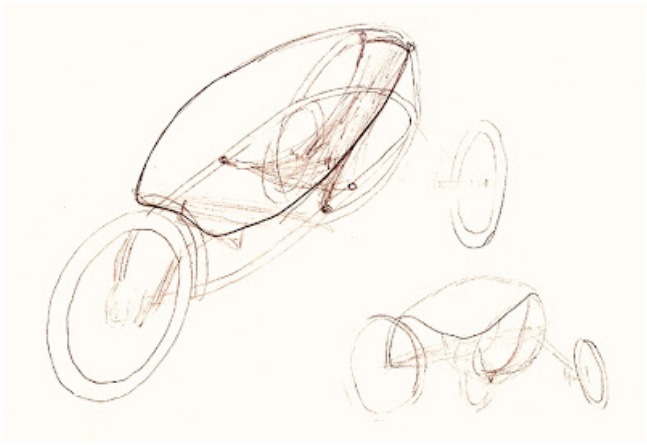


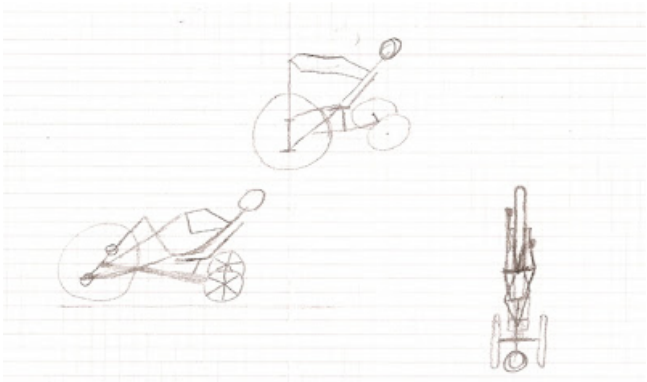












Posted by young-engineer at 14:39 No comments:

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Sunday, April 28, 2013

Back in class

On Tuesday, we all met again in class and discussed our further steps in the course of the project. After all, we came to the conclusion that we will need a milestone just before our next holidays, which means on May 14th. We decided to agree on one concept until that point and to make sure we know, which materials we want to use for construction.

Apart from the discussion about our next milestone, we also thought about the importance of reducing wind resistance for our HPV. Since some people among us had different opinions of whether it is necessary to consider this factor or not, our teacher suggested that our management group should ask a university student to give us a speech about aerodynamics. Our teacher already had contact with him about a year ago in the course of another school project.

Finally, the technics group presented their new way of steering the HPV. We all agreed on the main parts of it, but left some space to think about the details.

Posted by young-engineer at 14:30 No comments:

Wednesday, April 17, 2013

Presentations in class

Yesterday, we were back in class and each of the three groups presented their progress on the their field of action. These will be listed in the following paragraphs.

Management:
The group planned the dates for milestones, so as to speed up our work a little. But since some of us disagreed with the suggested dates - some of them were quite early, we did not come up with a final timeline so far.

Design:
Each of the group members created their individual idea of the design for our HPV. We were all allowed to have a look at them and discuss their advantages

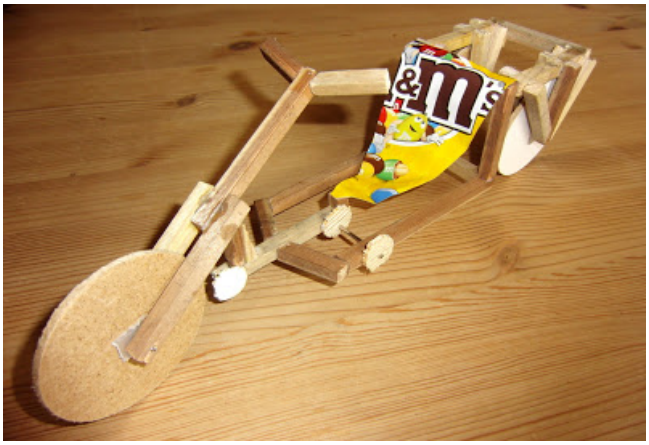
and disadvantages. This way, we'll hopefully be able to agree on one design - probably a mix of different ideas - that we all like and that can be manufactured in a way that works for us.
I will upload some pictures of the designs as soon as our teacher has scanned them in.

Technics:
We presented the physical model out of wood as well as the CAD model (see pictures in the last post). But we all agreed on the fact that we still have to develop a different way of steering for the HPV, since we are not able to make any sharp curves so far. So our task for next week is to come up with another idea of steering our HPV in order to decrease the turning radius.

Posted by young-engineer at 21:10 No comments:

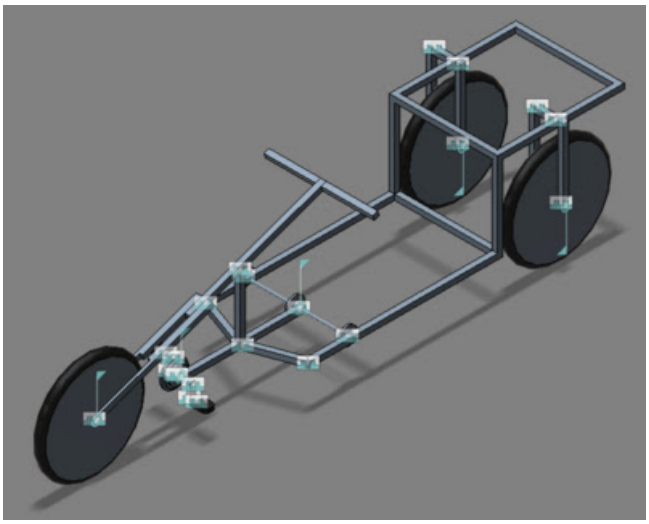
First "prototype" and a CAD model

On the weekend, I got up with the idea of creating a first small "prototype" of a possible HPV out of wood and spokes. So I measured my sketch and recalculated the dimensions needed for different parts of the skeletal structure. After a few hours of sawing and gluing, I had accomplished to build a first model, which look as shown on the following picture.



But after I was done building the physical model, I came to the conclusion that it would use up too much time if we were going to build a model for each change we worked out.

Therefore, I decided to inform myself a bit about CAD (computer-aided design) programs and about how to use them. This way, we could build 3D models on the computer without having to construct them with any physical material - but they would still look real. Another positive aspect is the fact that this type of model is more precise than one that is manufactured manually. After having found a program that was not too hard to deal with, I got to work and generated our first CAD model:



Comparing these two pictures, you will probably notice that we already had some new ideas on the weekend. As we wanted to power both wheels, we were still looking for a way to do so without having problems in curves, since one wheel automatically turns faster than the other one and therefore they cannot simply be connected by an axis. Discussing this problem, we came to the conclusion that we could use two freewheels in the back. This way, we could power both wheels with one chain each. But since one driver would have a problems pedaling two chains, we decided to use a second axis. This means that the HPV would have one axis that is powered by pedaling and another one - connected to the first one by a chain - that splits up the power in a 1:1 transmission to each side. This can also be seen in the picture shown above.

Posted by young-engineer at 11:19 No comments:

Tuesday, April 09, 2013

First draft of the engineering part of the HPV

Today, the group that is responsible for the technic parts of the HPV and that I am part of, got together in school and worked on a first draft connecting all our ideas.

We decided that every one of our group should draw a sketch of the construction we agreed on today, so that we can choose the best one for presenting it to the design and the management group next week.

Posted by young-engineer at 17:47 2 comments:

Permission to get scrap metal

Today after school, I dropped by the recycling center once again and fortunately the boss was there. After having explained our project, he allowed

our group to come and get some of their scrap metal (mostly bikes) whenever we need it.

Since this means that we can get the material for this part of the HPV for free, the project will probably be a lot easier to finance.

Posted by young-engineer at 15:40 No comments:

Monday, April 08, 2013

Back to the recycling center

As I contacted the service for the waste at the recycling center today, they told me to talk to the boss of the recycling center.

So actually, as they are not open today, I will have to check out what their boss thinks about our idea of getting some of their old scrap metal tomorrow.

Posted by young-engineer at 16:28 No comments:

Saturday, April 06, 2013

Been at the recycling center

I went to the recycling center today, so as to find out, whether we can get some of their scrap metal (e.g. old bikes) for the construction of our HPV.

In fact, we'll need to contact the service that is responsible for the waste located at the recycling center. According to the information I received, it should not be a problem to get a permission from them.

Posted by young-engineer at 18:38 No comments:

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