Material Technology/ Electronic Control Technology

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NCEA Level 3
Scholarship 2012

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Axl:
Mechatronic Dog:
Stage Prop

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Axl: Mechatronic Dog

Introduction:

Year 13 Technology confronted me with a challenge of identifying and developing a brief. I considered a range of possible issues I had identified that could potentially be resolved, such as an exo-skeletal fore-arm brace to (in theory) reduce wrist and/or lower arm breakages in the occurrence of crashing while downhill mountain biking. After evaluating this project in particular, I was still not satisfied that I had an issue that would sustain, challenge and engage me with 'real' Technological practice (partly due to the lack of fore-arm breakages in the particular sport). I was looking for an issue that really needed solving, an issue that didn't have a known outcome, an issue that would challenge me to develop new knowledge and skills, and so, enable me to build on prior knowledge and skills in Technological practice. As well as this, I needed an issue that would engage me with a range of different stakeholders and experts.

When I was approached by Lewis, my main stakeholder/client, and director of the play "My Brilliant Divorce" to develop a dynamic stage prop for a real theatrical performance I knew I had found my project. Did the project have the scope for innovation, creativity, a chance to model and communicate ideas, learn new skills and knowledge, interact with professional technologists as well as a range of stakeholders, to work closely with a client, to plan, meet deadlines, to manufacture, to trial, test and evaluate, to explore Mechatronics?

Identify a need:

My uncle, Lewis Ablett-Kerr, has been directing and producing theatrical productions for almost twenty years at various theatres around Dunedin.

In August 2012 Lewis will be directing a one woman play “My Brilliant Divorce” by Geraldine Aron. The production will be performed at the Playhouse Theatre and will run from 24th of August to 1st September.

Solo acting requires strong and engaging props to add interest, and to act as a ‘distraction’. In this case a dog prop will be adding humour and an unexpected element to the play.

I was approached by Lewis and asked if I would consider manufacturing a prop for this production. I met with him and visited the theatre for that meeting. In doing so I was able to clarify his needs and draft my initial brief.

The 120 minute play is aimed at an adult audience with an element of humour in the dialog. It will be seen by approximately 50-100 people per evening.

Initial brief:

As a student of the year 13 Technology Hard Materials class, I am to design and construct a fully functional dog prop to be used in the play ‘My Brilliant Divorce’. The dog must be able to have a full range of movement as it is to interact with the actress on stage.

I am thoroughly looking forward to designing and manufacturing this project as it will involve several different areas of knowledge and skill in order to complete the tasks at hand.

(15 February 2012)

Conceptual statement:

Following my meeting with Lewis, I was able to confirm that I am to be designing and manufacturing a dog prop that is to be used in a play he is directing in August. The dog must be able to walk forwards, backwards, left, right, spin on the spot and hold a scroll in its mouth. This dog prop must be able to interact with the actress on stage throughout the play. Aesthetics of the dog such as shape, colour, size etc. have not yet been discussed, but will be defined later through research, conceptual sketches and development. The materials the dog will be made out of are also yet to be discussed once the main design and aesthetics have been confirmed. However, I do know that the materials I choose will have to be strong, durable and lightweight.

(15 February 2012)

Stakeholder and experts identified and prioritised:

Before I start this project, I have considered the people who will be likely to help out/influence what is wanted of the dog in both the design and manufacture of this project. The following people are all stakeholders who will directly influence various parts of my design.

Lewis Ablett Kerr/My main stakeholder- Will be the main influence of the design and aesthetics of this project, as it is him that is assigning me this task. There will have to be a fairly high level of consultation between my Lewis and I through out the design stage of this project if I am to make this dog to his specifications. Once all of the concepts have been developed and I understand exactly what he wants of the dog, I will be able to proceed with the manufacturing and construction of which consultation with Lewis will be less frequent.

John Maguire/My Technology Hard Materials teacher- Will contribute to this project in both the design and manufacture, as I will be able to go to him if I need advice on certain materials, construction techniques, and general input in the designing and manufacturing process. Because he is the teacher of my technology hard materials class, consultation with Mr Maguire will be convenient as I will be able to speak with him about the project during class.

Peter Cowan/An electrical engineer at the electrical division of Delta and Ambassador of Techlink - Will be able help out greatly with the electrical side of this project as it is what he specializes in. As well as this, Peter will be able to shed some light on my designs while also being able to give advice on certain electrical components needed in the manufacture of the dog. Consultation with Peter should be fairly convenient, as I am able to pop down to his work after school if I need to meet with him.

David Mulder/An electrical engineer and circuit designer at the electrical division of Delta - Will also be able to help out greatly with the electrical side that is required of this project, in particular the fabrication of the circuit board and the programming of the controller chips. Like Peter, David will also be able to shed light on aspects of my design, particularly in the circuit board making stage of this project. Consultation with David should also be fairly convenient, as David works directly across from peters desk at Delta, and so, when I need to go see peter, I can also see David at the same time.

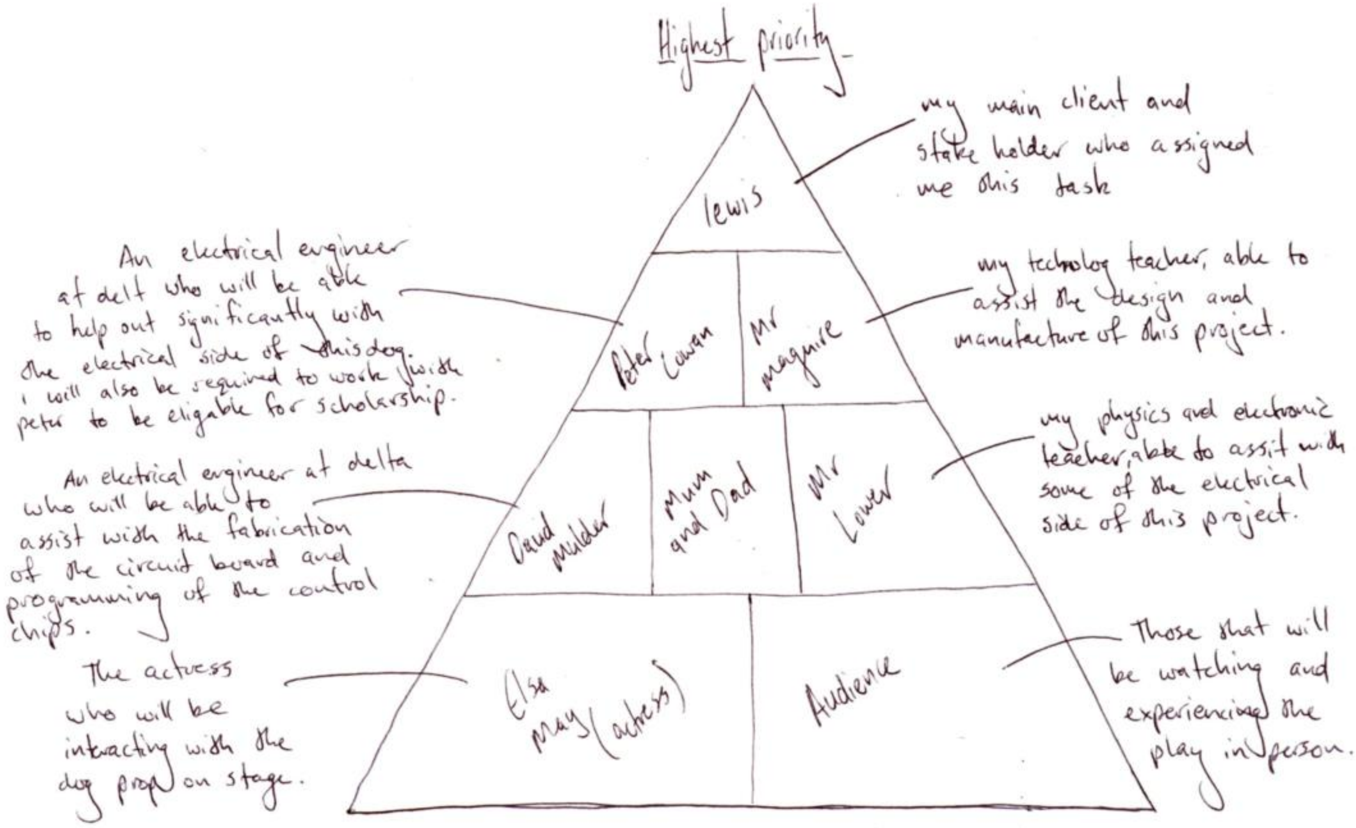
Jane Kerr and Ken Gorrie/My parents- Will also contribute to a fairly large part of both the design of the dog and design of the internal mechanisms that allow the dog to move. Consultation with my parents will be very convenient as I will be able to go to them whenever necessary to discuss my design ideas, and so, get their opinion on what they think about the project.

Philip Lower/My Electronics and Physics teacher- Should be able to help out with the circuitry and electrical componentry that will be required to run the dog. Like Mr Maguire, consultation with Mr Lower will also be convenient as I will be able to talk with him during school.

(16 February 2012)

Elsa May/The actress staring in the one woman play - Will also be a stakeholder for this project as she will be the one who interacts with the dog prop on stage. Although she wont have any direct influence on the design or manufacture of the prop, it will be her that will have to be able to work with and/or around the dog prop to effectively pull the play off.

The Audience/Those that will be watching the play - Will be similar stakeholders to Elsa (the actress), except rather than having to interact with the dog on stage, they will be he ones that come to see and experience the play. Because of this, these stakeholders are who the dog prop must appeal to the most.



Identify key factors:

Throughout this project there will be various factors that could affect the development and construction. These factors may consist of:

Time: Will be one of my most important key factors for this project as I will have to complete all my units of work and manufacture a working model before my deadline. To do this efficiently, I will have to manage my time carefully in order to stay within my deadline date. To do this I will have to make regularly revised time management charts to ensure I keep on track and achieve my milestone stages of my project.

Materials and Material Properties: Will also be a key component in the manufacture and final outcome of my project. I will have to research various different material properties to ensure I pick the very best materials for the job; In this case, materials that are strong, durable, light weight easily machined, affordable and readily available. Understanding material types and properties will enable me to make efficient choices regarding the best materials for the application.

Aesthetics: Will me a major key factor in the design of this project as it has to look and move in a believable manner that is both aesthetically pleasing to the audience and my main stakeholder. If the aesthetics are off, then the project wont be visually pleasing, and so, potentially look 'tacky'. Some examples of aesthetic key factors would be the dogs finishing. In order to get the finishing right on this project I will have to consult with Lewis and my other stakeholders to find out exactly what they want or suggest.

Ergonomics: Is important in this project because the dog has to be designed and manufactured to move like a real dog might (or at least close to it). I will have to research the movement of a dogs motion in order to make this dog prop convincing to the audience. In doing so I will also have to design a mechanism that will enable the dog to move as it would in real life.

Cost/Budget: Will have the potential to restrict my project as there will be several components that are likely to be expensive, such as the electrical componentry that will control the dog and allow it to move. I am unsure of the budget this project will have at this stage, and so, will need to talk to Lewis in order to find out how much he is willing to spend on it. Presently, I am estimating that the total cost of materials and electrical componentry required of this project will be in the low hundreds.

Manufacturing: Throughout the manufacturing process I will have to consider the best practice for the construction of my final design. I will have to be aware of the various different manufacturing processes that will be required in the construction of my final design, such as the assembly of the electrical componentry to the construction of the mechanical side of the dog.

Electrical componentry: The electrical componentry required in this project will be a major key factor particularly in the dog's movement. I will have to work closely with Peter Cowan (the electrical engineer) to make sure that each and every component I purchase and use is efficient and adequate for the job. Part of this key factor also relies on how strong the motors will have to be in order to move the dogs weight, and so, weight reduction will also be a fairly large key factor in the manufacturing of this project.

Ethics: Because this project is generating a piece of artwork effectively, I will need to consider who retains the rights of the dog once the run of the play is over, and whether the dog is presented as a product, or a service. As Lewis will be paying for the majority of the componentry needed to build the dog, I will have to discuss this matter with him.

Stake holders and stakeholder consultation: Will be a very large key factor in both the design and manufacture of this project, especially Lewis my main stakeholder who assigned me to this task. It will be his specifications that I will be working closely with in order to get the results that he wants for this project. I will not be able to design and manufacture this project without my stakeholders as it will be them that support me in both the designing and manufacturing processes.

Interactions with the Actress: Will be a very significant factor in that the final product of this dog prop will have to be able to interact fluently with the actress on stage during the performances. In doing so, the dog must interact with the actress both aesthetically and mechanically via being electronically controlled I.e. Not only must it be able to move around on stage and interact with the actress, It must look authentic and aesthetically pleasing while dong so.

Health and Safety (Codes of Practice): Are certain codes of practice and guide lines that I will have to make sure I work to when constructing this dog prop, in particular, when machining and in the use of power tools and machinery that will be required to carry out this project to ensure my working habits and practices are safe to both myself and those around me. As well as the codes of practice for general work and safety in the workshop, there are also certain codes of practice for theatre which I will have to familiarise myself with.

Movement: The movement that will be required of this dog prop will be a very significant key factor when it comes to actually controlling the dog on stage. To make this prop look authentic and not just like a dog on wheels, the movement has to be smooth and controlled in order to make it a believable on stage. Not only must it look good, but because the dog will have to interact with the actress, the mechatronics (mechanics and electronics) that physically move the dog have to be able to function without trouble, and so, allow it to be able to keep up with Elsa as she moves around.

Friction: With movement comes friction, and with friction comes lack of movement. Due to the mechanics and moving parts that will enable this dog to move, friction will play a very large part in both the design, manufacture and physical running of this prop, and so, I will have to be conscious of my methods when designing and manufacturing it as to reduce as much friction as possible in all areas that are likely to cause problem.

Weight and Weight Reduction: Will also be a potential problem in the design and manufacturing of this project, as with an increase of weight, comes an increase of friction, and as mentioned above, and increase in friction means a decrease in movement, thus, the heavier the prop becomes, the less efficiently/effectively it will be able to move around on stage. I will have to pay very close attention to certain weights being put on the dog in accordance to how much the motors that run it can withstand.

Function: The most import key factor. If the dog prop is unable to function properly, if at all, then I will have failed my project. Failure is not an option with this project. I have a ‘real’ issue, that has a ‘real’ deadline that must be met, otherwise my main stakeholder and client won’t have a functional dog prop.

Floor Surface: Will determine what materials the wheels of this dog prop will need to be made to ensure that it will run along the ground smoothly. This is a fairly significant key factor, as I will have to suit my designs to correspond with the texture of the floor, otherwise, the prop could potentially be immobile. I will have to take into account weather or not the prop will be moving over rough surfaces such as carpet, as this attribute of the stage could dramatically change how the dog will travel along the ground.

Prior Knowledge/Prior Personal Skills: Although I will be learning various new skills and gaining new knowledge, prior knowledge in both theoretical and physical/mechanical application will be useful both in the designing stages and in the manufacturing/fabrication stages of this project. Already having the knowledge in using various machinery and power tools will help move the project forward as I will have more time to work on the project rather than.

New Knowledge and Skills: Through out this project there will be various new skills that I will have to learn in order to complete certain aspects of my designs, for example, I will have to gain new knowledge in methods of remotely controlling the dog prop, and so, knowledge in electrical and remote control systems.

Sound: Because the playhouse theatre is moderately small, it is important that Axl doesn't have any distracting mechanical noises associated with his movement, as there are several poignant scenes that require silence.

Control: Axl's controls have to be intuitive enough so that whoever controlling him can learn his parts quickly, as I may not be available during the rehearsals or for the week of the play due exam commitments.

Integration of differing systems: Effectively, the project will be divided into three main processes: The design process, the mechanical process, and the electrical process. Integration of these three processes will be crucial In order for this project to be functional. If they are incompatible with each other, then the project will not be fit for performing.

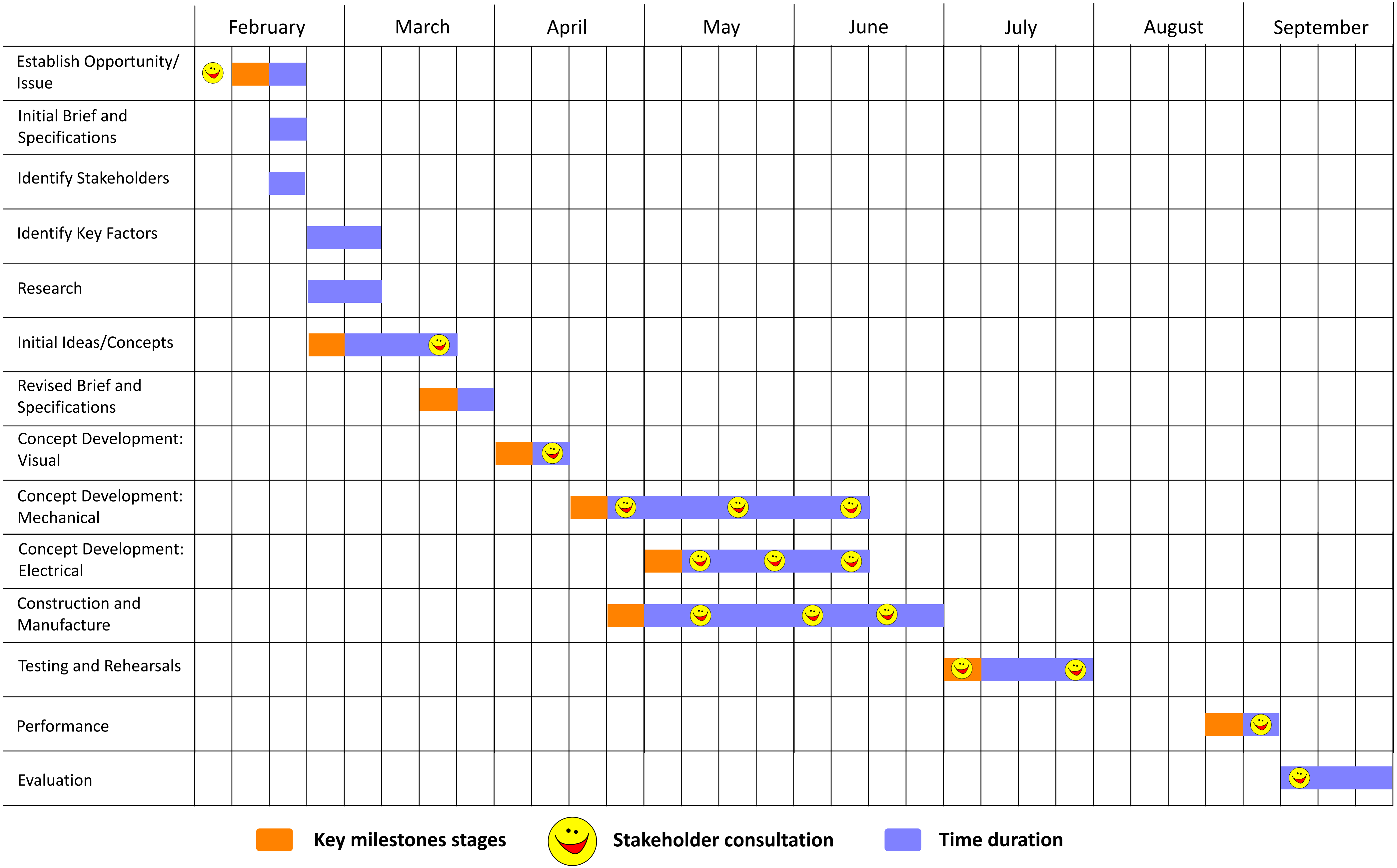
Failure is not an option for this project. As mentioned in the Key Factors under "Function", It is a priority that the prop is up and running strictly before its deadline. I have a 'real' issue that must meet a 'real' deadline no matter what.

Picture this: Opening night of the play. The audience are seated. Lights are dimmed. Stage lights illuminate. Audience are alert, focused, excited. Stage props are in place: A window, a table, a chair, a motionless Axl... The play begins with an exciting dialogue and movement. As Elsa engages with the audience, the audience respond with applause and laughter. She continues. 20 minutes into the play, her character is emotional. lonely. Her only prized possession in the room, her loving, faithful, trusting dog, Axl. She gets down on her knees as she calls to Axl, reaching out to pat his head as he responds to her call... Axl doesn't move... He does not approach Elsa as he should have... Axl remains motionless on the stage... Nightmare.

In a solo act performance this just simply could not happen. The actress depends on her stage presence and functional props. A single malfunction in the dog prop that hindered its movement so greatly it were unable to move could quite possibly ruin the performance. I was not going to have this on my shoulders. Axl HAS to function, respond, and interact on demand every time, every night for the week of the production to the best of its ability. I could not let lewis, my main stakeholder and director of the play down. The pressure was on me to make sure this project was going to function properly by its deadline.

Planning:

Gantt Chart - Preliminary time management:



Kavanagh College Technology Year Planner 2012

Year **Class** ***NCEA* Level** **Teacher**

Topic / Unit	Activities		Wk	Term one
	Introduce course + Course Outline		1	30th Jan – 3rd Feb
Project one -			2	7th – 10th
			3	13th – 17th
		School athletics 21st	4	20th – 24th
			5	27th – 2nd Mar
			6	5th Mar – 9th
	3-1	**1&2** Y12 retreat Week	7	12th – 16th
		3 Y12 retreat 22nd – 23rd	8	19th – 23rd
		Otago Aniv + Teach only	9	28th – 30th
			10	2nd April – 5th
				Term two
			1	23rd April – 27th
		Production no assessments	2	30th – 4th May
		1 Y 13 Retreat 7th – 8th 2 Y13 Retreat 10th – 11th	3	7th – 11th
		2 Y13 Retreat 17th – 18th	4	14th – 18th
			5	21st – 25th
			6	28th – 1st June
		4 day wk Queens Bday 4th **Y 11/13 Susp TT 3rd**	7	5th – 8th
	B. Project		8	11th – 15th
			9	18th – 22nd
			10	25th - 29th
				Term three
Project Two			1	16th – 20th July
			2	23rd – 27th
		Open Night 26th	3	30th – 3rd August
			4	6th – 10th
		Kavangh Day 15th	5	13th – 17th
		Teacher Only Day 24th	6	20th – 23rd
			7	27th – 31st
		SS Tournament Week	8	3rd Sept – 7th
	3.2	**Y11-13 Susp Exam Time**	9	10th – 14th
			10	17th – 21st
			11	24th – 28th
				Term four
			1	15th October –19th
		4day wk Labour Day 22nd ALL Assessments Due 26th	2	23rd – 26th
		Completion of external standards	3	29th – 2nd Nov
		Senior Prize 6th **7th Nov NZQA ext assess**	4	5th – 9th

Research: Investigation, Testing, Concepts and Development

Stakeholder Feedback and Discussion:

Before I start this project, I have compiled a couple of quick questions that I will email to my client in order to get a beter understanding of what is wanted of the dog both mechanically and aesthetically. The emails are as follows:

Hey Lewis

I've attached a questionnaire regarding the mechanical dog prop. It would be much appreciated if you could give as much detail as possible and email me back when you're finished, or if you've got any questions.

Thanks!

Adam

(27 February 2012)

....

Wow, Adam!

You are making me think now! I'll have a look at things tonight and email asap.

Regards

Lewis

(28 February 2012 2:00 PM)

....

Dear Adam

As previously discussed with you, I have been asked to direct a play for the Dunedin Repertory Society Inc for an eight-performance season from 24 August to 1 September 2012 at The Playhouse Theatre, Albany Street, Dunedin. The play, MY BRILLIANT DIVORCE by Geraldine Aron, a comedy with serious moments, is a one-woman (Angela) show about loss, loneliness, coping and recovering. The play has a minimal set and interactive sound effects.

Individual areas of the stage are spotlit and the stage directions say:

"… CR is Axl's area. Axl is a medium-sized dog on wheels, aged eleven. A white Cairn terrier is ideal. He wears a red neckerchief and has a rolled-up document in his mouth. On the crossbar of his pushing handle are three counting beads like an abacus."

Axl is Angela's daughter's dog but Vanessa is leaving to live with her punk boyfriend who "is more of a cat man" and so Axl is left with Angela. Axl appears to be re-positioned throughout the play, for example: "then he [Max] was gone… Axl and I left staring at the door"; "On December 25th, Axl and I exchanged gifts."

“She moves Axl across the stage.” “She picks up Axl and moves DR.””She returns Axl to his space UR” . There are two scenes where Axl could react by going into a spin. The notes on the Curtain call say: “if possible, Axl takes a bow and wags his tail”.

I think that it would add to both the comedy and the pathos of the piece if Axl could move independently and possibly have some moving part(s) as well (tail, legs, head?).

Therefore, I would like to commission you to create a mechanical dog that can be operated from off-stage to have a more active role in the play.

I have completed your Stakeholder questionnaire as much as I can at this time, but am more than happy to supply any additional information as the project develops. Please keep me informed regarding costings as well.

I look forward to hearing from you and please do not hesitate to contact me.

Kind Regards

Lewis ABLETT-KERR

A-K Productions

(6 March 2012 1:12 AM)

....

(Answered questionnaire on following page)

Stakeholder Questionnaire:

- Exactly what would you like the dog to do?

Ideally the dog should move forward and backward and possibly rotate in a circle (chasing his tail?). Additionally, if Axl had a moving body part (eg, head or tail or both) that would be effective. The rolled-up document must be able to be removed and unrolled. The beads on the abacus are moved to suggest the passing of time, but I do not think that it is an essential piece of business. There is a dream sequence where Axl rises into the air until he vanishes in the clouds. When Angels wakes, she does so "just in time to stop Axyl lifting his leg on the curtains". Again, activity from the dog is not essential, but some movement might be funny. Your views would be appreciated.

- What are key attributes of the dog? For example:

  - What kind of dog is it?

  - Exactly what must it look like?

  - Colour?

  - How big must the dog be? (Width, height and length)

Axl should be a middle-sized dog. The script suggests a Cairn terrier but I have an open mind as to breed other than it needs to be identifiable as a smallish pet dog. It would be fun if the dog had some punk feature (hairstyle, collar?) and his eyes possibly glowed in the dark. Axl should be a light colour so that when there are blackouts, Axl will remain visible. I am uncertain of his dimensions at this stage other than he must be clearly visible and identifiable from every seat in the auditorium. We should arrange a visit to the theatre in order to establish the appropriate dimensions.

- How long is the play? And so, how long must the dog be able to run for?

The duration of the play is approximately two hours with a 15-20 minute Interval.
Although the season of the play is 24 August – 1 September 2012, the prop would be required for rehearsal at least one week before the play opens.

- Do you want the dog to look fairly realistic? Or must it only be a representation of a dog (I.e. Stylized, toy like, almost like a silhouette)

I think I would like Axl to be stylized, possibly two-dimensional. I certainly do not want him to resemble a mechanical soft toy. A stylized dog would create some unreality which would help to emphasise Angela's solitariness. I would like to see design ideas from you to help establish the look of Axl.

- What would you prefer the dog to be made out of? (I.e. Wood, Balsa wood, metal, cardboard, polystyrene… etc.)

I would like your input on materials that would enable the dog to be seen, to be manoeuvrable and to be reliable.

(6 March 2012)

Concepts, Research and Development:

Aesthetic and Visual concepts and development.

Cairn Terrier Research:

After emailing Lewis my questionnaire regarding both the dog prop and the actual play itself, a particularly significant attribute I was able to attain from his reply was the specific breed the dog was going to be. The Cairn Terrier.

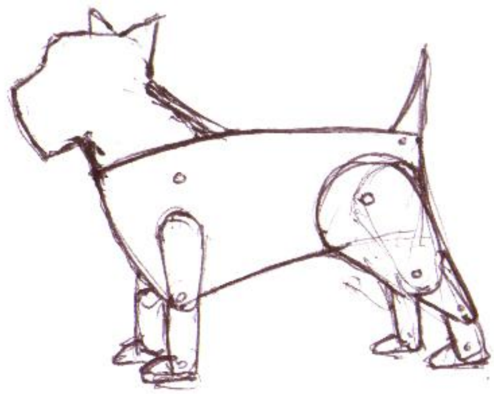
The Cairn Terrier is one of the oldest of the terrier breeds, originating in the Scottish Highlands and recognized as one of Scotland's earliest working dogs.

The Cairn Terrier descends from small terriers of Scotland that were also ancestors of similar breeds like the West Highland White Terrier, Scottish Terrier and Skye Terrier. Cairns were originally bred to hunt otters, foxes, badgers and rats. It's name comes from the the rock dens inhabited by badgers and foxes, called cairns, where would crawl into while hunting the animals.

This is the specific breed of dog that Lewis mentioned as Axl in the play, and so, this is the breed of dog that Lewis wants the final design of the dog prop to look like.

Cairn terrier

Initial concept sketch to show Lewis



Following the email to Lewis and the brief research I did regarding the specific breed of the dog prop, I sketched up a rough and simple outline using the pictures on the previous page as reference.

With this sketch I will be able to show lewis roughly how I think the dog prop will look, and so, whether or not this particular style of dog is what he wants the prop to look like. (8 March 2012)

The picture to the right is another rough sketch I did just as a small study of joints for my own benefit as to roughly see whereabouts the joints of the legs, head and tail could be placed. Once the exact design of the dogs shape is sorted out I will do this again on the final shape to determine where the joints will be on the real thing.

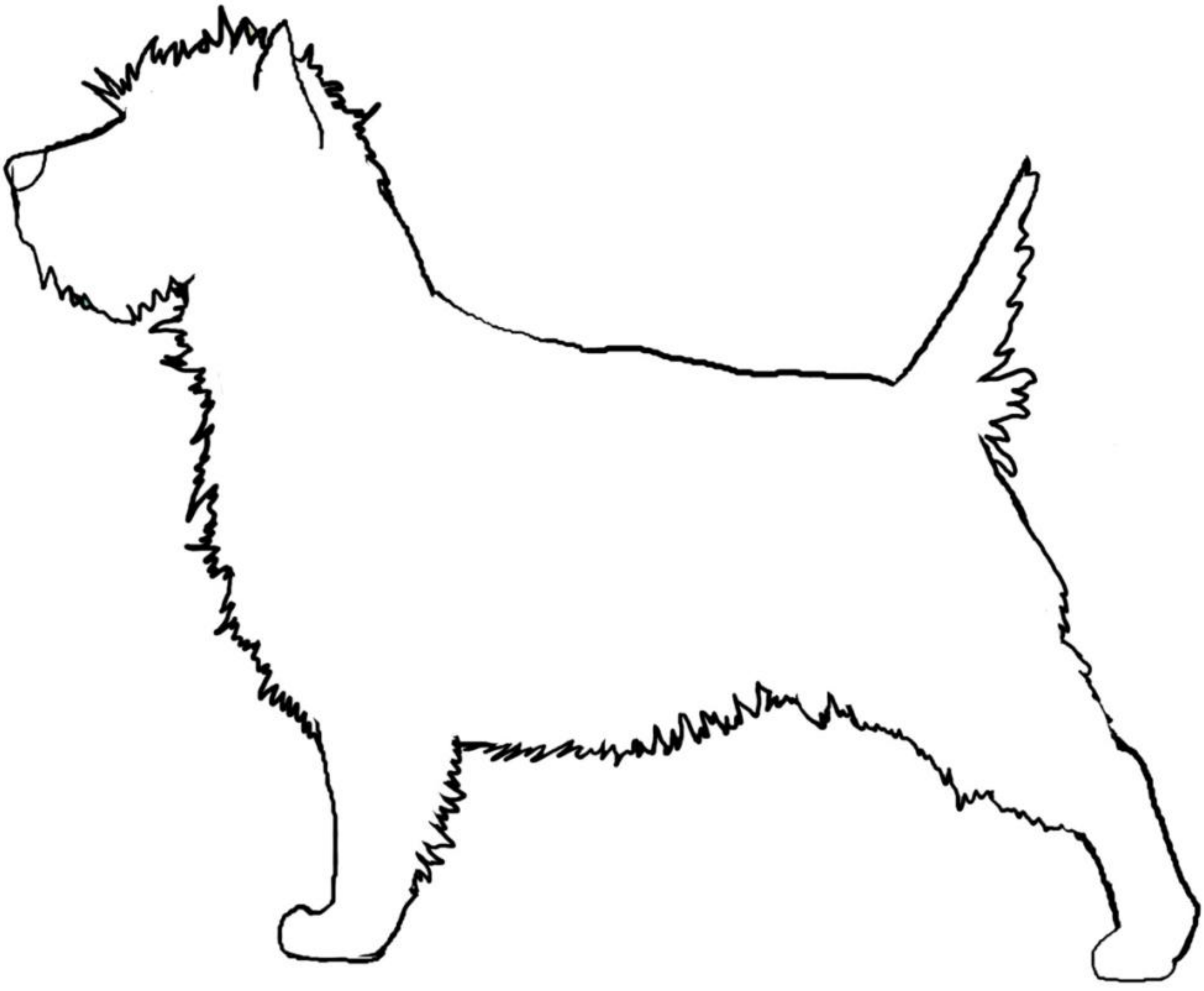
Stakeholder Consultation: Dog Breed and Shape Concepts:

I met up with Lewis to show him the rough sketch I had produced on the previous page to see what he thought of that particular style of dog on the following Saturday. (20 March 2012) He told me that that was exactly how he wanted the dog to look, but perhaps just a little less 'pudgy' round the neck region. Before I left I asked him if there was anything else at this stage that he wanted changed or added to this design before I further developed it into exactly how the dog will look, but he replied saying that everything seemed good to go as far as how it looked went.
With this positive feedback from Lewis I will now redraw the outline of the dog to exactly how it will look and then show him this developed drawing once again to make sure that everything still met his specifications.

(20 March 2012)

Concept Development: Final Design

After showing Lewis the sketch I had done and getting his feedback on what he thought of it, I did a finalised sketch of the outline of what it would look like directly side on as shown above, as it will be directly two dimensional from the side in the final product.
Once I had this feedback, I proceeded with drawing a good copy of the outline of the dog. To do this, I used Adobe Photoshop so I could use one of the dog pictures on the previous page as a template to draw around.

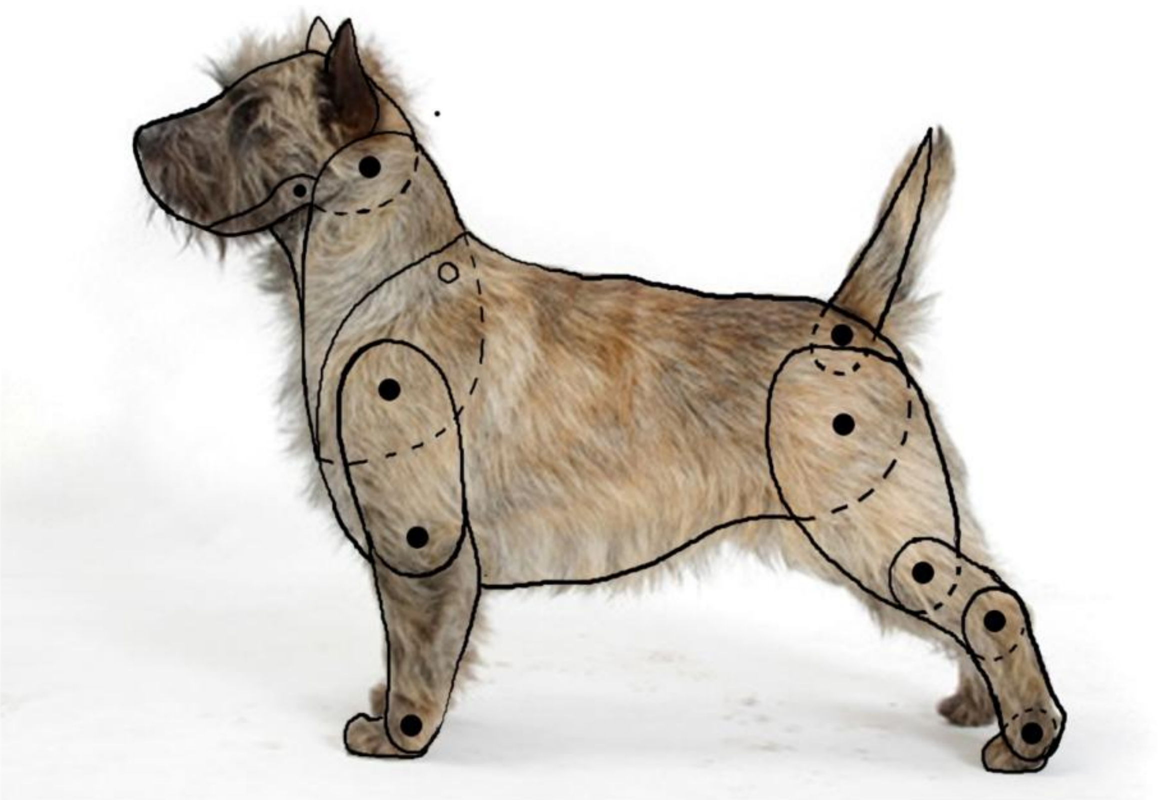


In using the dog picture as a template, I feel I have ended up with a fairly accurate representation of what the dog prop should look like.
I now need to meet up with Lewis again to check that this is exactly what he wants the dog to look like as the final product. As well as this, I will also have to determine where exactly the joints are going to be placed in relation to where they would be on a real dog.

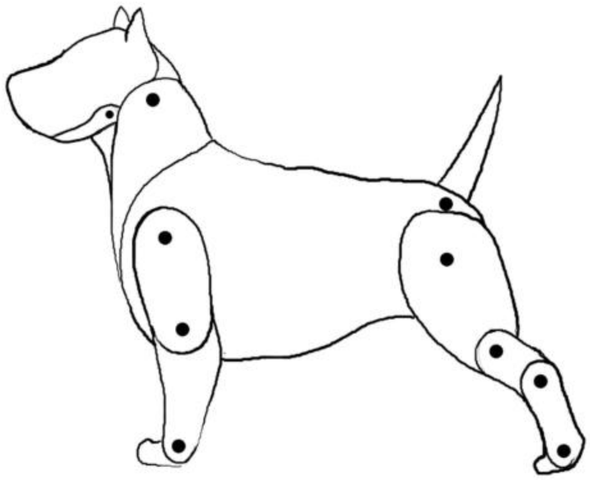
Concept Development: Joint Breakdown

When I met up with Lewis again to show him the final design for how the dog is going to look, he approved the design and said it was exactly how he wanted it to look.
With this approval of my design, I am now able to start with the joint layout so I will know exactly where the dog prop will be moving.
(22 March 2012)

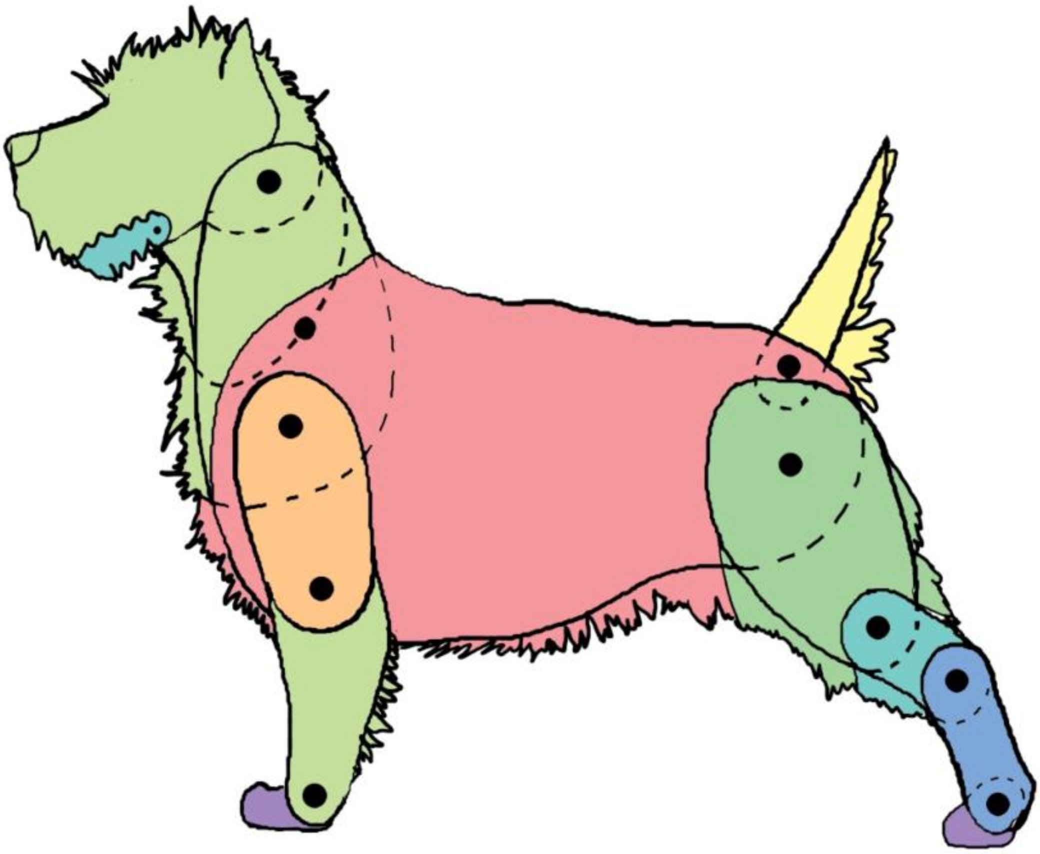
Using Adobe Photoshop again, I superimposed the final design that I had drawn, over the top of the picture of the cairn Terrier on the previous page as shown in the picture below. For this particular stage I redrew the dog without its hair, so that really, all that was showing was the shapes that would make up the dog. (as shown below)



From doing this, I am now able to mark out where I want the joints to be placed as shown by the black dots on the image above. You will also be able to see that each part of the dog has been segmented into it's own piece. This is to show that all these pieces will all be individual when it comes to assembling the dog on the final product.



Once this was sorted, and the initial idea for where the joints where going to be placed, I then added the fur outline back to this model so that it fit with each moving part comfortably.



As well as adding the fur, I also colour coated it so that it would be easier to distinguish between each separate part as shown.

Now that the rough idea for where the joints are going to be placed was finished, and that I know what the dog prop is going to look like, I need to arrange a time with Lewis to discuss and determine the size of the dog.

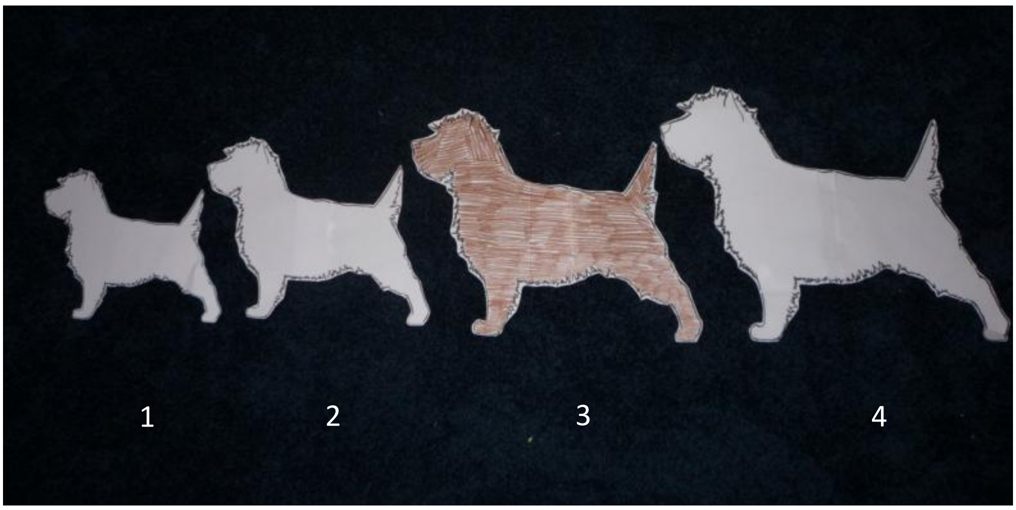
(24 March 2012)

Theatre Visit and Dog Scale Tests:

Before I get into the specific design of the mechanics and aesthetics that are involved in the dog prop, and now that i know what the dog is to look like, I have arranged to meet up with Lewis at the Play House theatre to discuss and test what size the dog will have to be in order to be seen clearly from all around the audience. After speaking with Lewis over the phone, we arranged to meet at the theatre on Saturday the 17th of March.

Here are a couple of photos I took of the stage itself, and also the audience seats.

To determine just how large the dog prop is going to have to be, I have printed out the dog design I did in Photoshop in four differing sizes as shown below. I also decided to colour one of the dogs brown in order to see how well the colour worked on the stage. (24 March 2012)



Here are the photos I took of the different sized dog cut-outs on the stage of the theatre. Unfortunately I am not the best photographer, so the photos didn't turn out all to clear as to define the different sizes of the dogs. However, I have labeled the photos accordingly to those on the previous page.

Stakeholder consultation: Dog sizing

After meeting up with Lewis and getting familiar with the stage the play is going to be held at, we were able to discuss the sizing of the dog using the several different sized dog cut-outs. From these various cut outs placed on the stage, we were able to walk around the audience seats and see if they were visible from various places, but mainly the very back seats where it will most likely be harder to see the dog from the back compared to the seats up front. After doing this we were also able to decide on the appropriate size for the dog so that it could be seen from every seat clearly.

We decided that the dog is to be roughly 520mm long by 410mm high

(27 March 2012)

Revised Brief and Specifications:

From the email and questionnaire I sent to Lewis, I found out that my task is to design and manufacture a fully functional Cairn terrier-like dog prop that is to be used in the ‘one-man-play’ “My Brilliant Divorce” (by Geraldine Aron) directed by Lewis. I have been asked to design and construct a fairly stylized, almost two dimensional, medium/life sized dog that is able to be remotely controlled via someone in one of the stage wings. The dog must be table to move forwards, backwards, turn left and right, and spin on the spot. Additionally, Lewis thought it would be effective if the dog had a moving body part, for example, the head, tail or both, and potentially the ability to sit on demand if physically possible. The dog must also be able to carry a small rolled up scroll in its mouth that can be removed, unrolled, and placed back in its mouth. It mentions in the play that the dog (named Axl) has the beads of an abacus in the centre of its body; however, my client decided to flag this attribute as it was unnecessary. Aesthetically, the dog is wanted to have a certain sense of ‘punk’, for example, a particular hair style, collar etc. If possible, it would be beneficial if the dog was finished with a light colour so that when there are black outs, the dog will remain visible. The dog must be visible and identifiable from every seat in the auditorium. The duration of the play is approximately two hours with a 15-20 minute interval; this means that the battery source that is supplying the dog’s power must be able to run for this long. It would be beneficial for the materials used in the construction of this dog to be lightweight and durable as to take any unwanted pressure off the moving parts, yet sturdy enough to not break under its own weight. To meet these specifications, I will most likely be using Foam core board, Dense foam board, MDF, Pine and Thin plastic sheeting and tubes. To meet the deadline, this dog must be designed and manufactured by the 18th of August. Although the season of the play is the 24th of August - 1st of September, the dog will be required for rehearsal at least one week before the play opens.

Material Properties, Investigation, Testing and Choice Decisions:

Material Properties: Potential Material Options

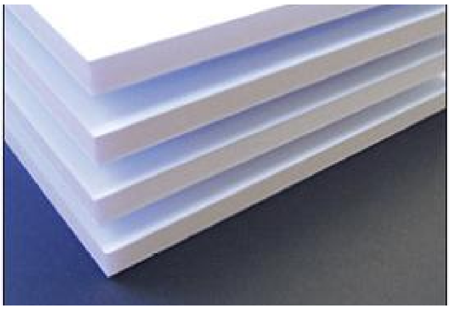
There are several various materials that this dog prop could be manufactured out of, however, some will be better for the job than others due to their certain properties such as weight, strength, cost etc. For this dog prop, it would be beneficial that it is as light as possible, yet strong and durable at the same time. While researching potential materials that could be used for this dog prop, I have decided to stick to the materials that I believe would most likely fit the specifications best.

MDF (Medium Density Fibreboard)

- MDF is an engineered wood product formed by breaking down hardwood or softwood residuals into wood fibres, often in a defibrator, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure. MDF is denser than plywood. It is made up of separated fibres, but can be used as a building material similar in application to plywood. It is stronger and much more dense than normal particle board. Thus also meaning that it can carry a certain amount of weight to it.

Polystyrene

-Polystyrene is an aromatic polymer made from the monomer styrene, a liquid hydrocarbon that is manufactured from petroleum by the chemical industry. Solid polystyrene is used for disposable cutlery, plastic models, CD and DVD cases, and smoke detector housings. Polystyrene is very light, and in some cases can be reasonably strong.



Foam Core Board

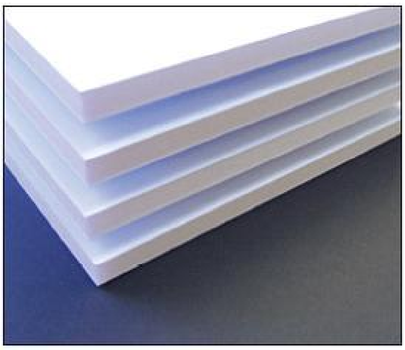
-Foam core board or Foam board is a very strong, lightweight and easily cut material used for the mounting of photographic prints, as backing in picture framing, in 3D design, and in painting. It is also in a material category referred to as "Paper-faced Foam Board". It consists of three layers, an inner layer of polystyrene clad with outer facing of either a white clay coated paper or brown kraft paper.

Cardboard

-Cardboard is a generic term for a light yet heavy-duty paper of various strengths, ranging from a simple arrangement of a single thick sheet of paper to complex configurations featuring multiple corrugated layers.

Dense foam board

-Like Foam core board, Dense foam board is very sturdy, light weight and easily machined. Unlike the Foam core board, it does not have paper faces, and so, is not so strong when in thin slices, however, is strong and durable in thicker proportions.



Codes of Practice

I have read and understood all of these codes; I have used them to help ensure I am working in a correct and safe way in all aspects off my manufacture.

Safety and Technology Education - A Guidance Manual for New Zealand Schools.

9.1 Information for All Teachers

The curriculum statement Technology in the New Zealand Curriculum defines structures and mechanisms as including

... a wide variety of technologies, from simple structures, such as a monument, or mechanical devices, such as a mousetrap, to large, complex structures such as a high-rise office block, or mechanical devices such as a motor car.

Technology in the New Zealand Curriculum, page 12

Teachers planning for safety in structures and mechanisms should have thorough knowledge and experience in this area. If this is not the case, teachers should seek advice from a specialist in this technological area. In the area of structures and mechanisms, the teacher's role in implementing safe practices and anticipating dangers is vital. Teachers should give careful instructions that are understood by all students and supported by clear, practical demonstrations. Students' behaviour with machines must be constantly monitored. In order to do this, teachers need to be fully aware of the dangers associated with each piece of machinery, know and use safe practices, and be able to plan ahead for the safety of students.

Full safety instructions must be given before any student uses any machine. This should include demonstrating any safety equipment to be either used or worn, and modelling safe working practices. Only one person at a time should use a machine, including starting and stopping it. The only exception to this is when another person is needed to help with heavy objects. Other students must stay a minimum of 1 metre (m) away from a machine when it is operating.

Students need to be taught how to prepare for work by:

- working out the correct order of operations before they begin;
- deciding on the correct machine to do the task;
- stacking or storing the required material in a convenient, safe place;
- checking materials for any potential handling hazards.

Using Machines Safely

The main rules for using machines safely are as follows.

- Never wear loose clothing, including loose sleeves, ties, or scarves, when working with machinery.
- Tie back and cover long hair.
- Wear solid footwear, not sandals, jandals, or open-toed shoes.
- Remove rings and other jewellery.

• Where processes have a particular hazard, use protective clothing, safety glasses, or noise protection as required.

•Plan and prepare correctly before operating a machine. This includes having a full knowledge of the machine, its hazards, and safe procedures for operating it. Never use any machine until you have been properly trained for using it.

•Use machinery only for the purpose that it was designed for.

• Check that all guards are in place.

• Check constantly for any defects. If you find any, isolate the machine and notify the person responsible for maintaining it.

• Obtain and use correct safety equipment.

Note: All metals, when drilled mechanically or turned, leave a waste called swarf. This is dangerous to handle because it has sharp edges. Clean up swarf with a brush and shovel.

Hand Tools

Always store tools in a safe position. When they are in use, place tools in the well of the bench or store them in racks with their sharp edges facing downwards so that the user will not cut themselves when handling them. Do not leave a tool on the floor or in a position where it can roll off a bench. Careful instruction must be given in the safe use of hand tools, and each tool should be used only for its correct purpose. Safety glasses must be worn when cutting or chipping some materials. Tools to be used in wood- or metal-based tasks are safer to use when they are sharp. Students should know how to recognise when a hand tool needs to be sharpened and understand the need to draw the teacher's attention to this. Before year 10, students are not expected to learn how to sharpen tools. However, students who are year 10 and over should be taught how to carry out minor maintenance and how to sharpen some tools. Metalworking tools are often subjected to hard, heavy use and need more frequent attention.

Electrical regulations require that all electrical appliances, including portable power tools isolating transformers, and RCDs used in school workshops, be:

•inspected and tested before use;

•inspected before being used again after repair;

•inspected at intervals not exceeding 12 months;

• tagged at inspection (each piece of equipment should be tagged, and all inspections should be carried out by a registered electrician or an approved power tool agent);

•recorded in a school register of all electrical equipment.

Outsourcing

In some areas of technology education, it is difficult to predict what outcomes student will want to develop. Students should not have to limit their choice of solutions to a particular technological problem because the school does not have the facilities to allow them to develop their solutions. For one-off projects, outsourcing of the final construction may be considered. The issues of cost versus choice of alternative solutions should always be considered as well as the availability of a reputable supplier. In some situations, the safety of the end-user of a product relies on the quality of the workmanship during its development. If teachers are not confident that students have all the skills needed to manufacture a product that is safe for the end-user, outsourcing of these skills should be encouraged. Examples of where outsourcing is encouraged are:

- in the repair or manufacture of petrol tanks and/or containers for flammable liquids;
- for any repair to bicycles, cars;
- for any other equipment where personal safety depends on the repaired part.

In this case, a reputable and qualified agent should be sought. This also applies to the modification of parts.

Machine Hazards

Examples of dangerous parts of machines are:

- revolving shafts, spindles, mandrels, bars, machine shafts, drilling-machine part drills, and chucks;
- revolving gears;
- belts and pulleys;
- chains and gears;
- connecting rods, links, and rotating wheels;
- reciprocating fixed parts;
- control handles and fixed parts;
- projections on revolving shafts, keys, set screws, and cottar pins;
- rotating parts and open pulleys;
- revolving cutting tools and saws;
- reciprocating knives and guillotines;
- abrasive wheels;
- endless cutting machines.

Using Machinery

Because all machines, whether wood based or metal based, can seriously injure the operator if used incorrectly, they must be correctly installed, safely guarded, and maintained. All permanently-wired machines should be anchored to the floor, and electrical machines on a wooden floor must be correctly earthed to prevent the build-up of static electricity.

Note: In years 7 to 10 in particular, teachers must check the set-up of all machines before students switch them on. Machines must be installed in locations where accidentally ejected material will not injure nearby students. Students should not be able to stand in line with work coming off a machine because of the danger of flying material. This applies, in particular, to circular saws, surface planers, and lathes. Students should also not look directly into the openings of a thicknesser in operation. Regular maintenance and overhauling of machines is an essential part of safety. Unsafe equipment must be identified, and the head of department or teacher in charge must be notified about it. Unsafe equipment must be taken out of service.

Band saw and scroll saw:

Carry out all adjustments with the machine turned off. Before students use a band or a scroll saw, the teacher must:

• fit and adjust the blades to the correct tension;

•adjust tool guides and guards to be just clear of work;

•warn students to keep their hands well clear of the cut line and to take care with sharp corners or curves so as not to jam the blade.

Drill (bench mounted and pedestal)

Before students use this machine, remind them to:

• always use safety glasses;

•choose the correct speed for the job;

• keep their hands clear of the revolving chuck or drill bit;

• ensure that only one person at a time is operating the drill;

• always remove the chuck key after tightening;

• carefully secure work. Large pieces of timber having small holes drilled in them may be safely held by hand. Hold small work in a vice or clamp it to the table.

Drilling machine

Wear safety glasses at all times. An additional concern when using drilling machines is the production of swarf. When metals are drilled, swarf comes off as a long curl. Break it by stopping the feed momentarily. Swarf is a waste from the drilling process, and it must never be handled without gloves. Clean it up with a small brush and shovel.

Lathe (metal)

In operating this machine, students should:

- wear safety glasses;
- tie back or net long hair;
- not wear loose clothing because it can get caught in the revolving work;
- remove the chuck key after tightening;
- when the workpiece protrudes excessively from the chuck, provide support by "steadies" and/or by the tail stock;
- set the correct speed and feed before starting the lathe and not change speeds while the machine is running;
- if the work is so long that it protrudes past the end of the machine, guard the protruding work.

Students should not:

- handle the swarf without gloves;
- touch revolving work;
- apply cloth or cotton waste to rotating work.

Lathe (wood)

Constant supervision of students is required, particularly when they begin a piece of work. Always wear safety glasses or a face shield. In operating this machine:

- keep other students 1 metre (m) away;
- use knot- and defect-free timber where possible, and ensure that any glued-up work is well fitted;
- reduce squared-off timber to an octagonal shape by planing or cutting the corners;
- select a safe cutting speed to suit the bulk of the wood to be turned and the nature of the selected timber;
- balance the wood to avoid vibration;

•make sure the work is secure by adjusting the tool rest and turning the work over by hand before starting to ensure that all adjustments are set correctly;

• if a brake is fitted, apply it steadily and cautiously;

• keep hands well away from the work;

• ensure that the handles of woodturning tools are firmly fitted;

• do not use tools made of old files;

•remove the tool rest when sanding.

Plastics

When working with plastics, read and follow the supplier’s instructions for all equipment and materials because these will differ between products. Ensure that any materials are safe to use for educational purposes and are the correct type for the operation being performed. Some materials can emit dangerous fumes or become flammable if incorrectly processed. Reputable suppliers will provide materials that are safe for educational use and training programmes for their products.

Using a hotplate system

As the working surface of a hotplate system can reach very high temperatures, the main hazard is burns. The hotplate must be positioned on a heat-resistant surface at an appropriate height for the age of the students so that they have safe and easy access to it. Ensure that the electrical supply lead cannot be snagged, causing the unit to move unexpectedly.

Injection moulding machine and thermoplastics thermoforming machine Ensure that the heaters in these machines are turned off when they are not in use, and never use these machines unless the heater guards are properly in place. Follow any other instructions supplied with the machines. Ensure that any materials are safe to use for educational purposes and that they are the correct type for the operation being performed. No teacher should use such a machine before receiving training in how to use it safely. Never use an oven when working with plastic materials.

Concepts, Research and Development:

Mechanical

Existing Solutions:

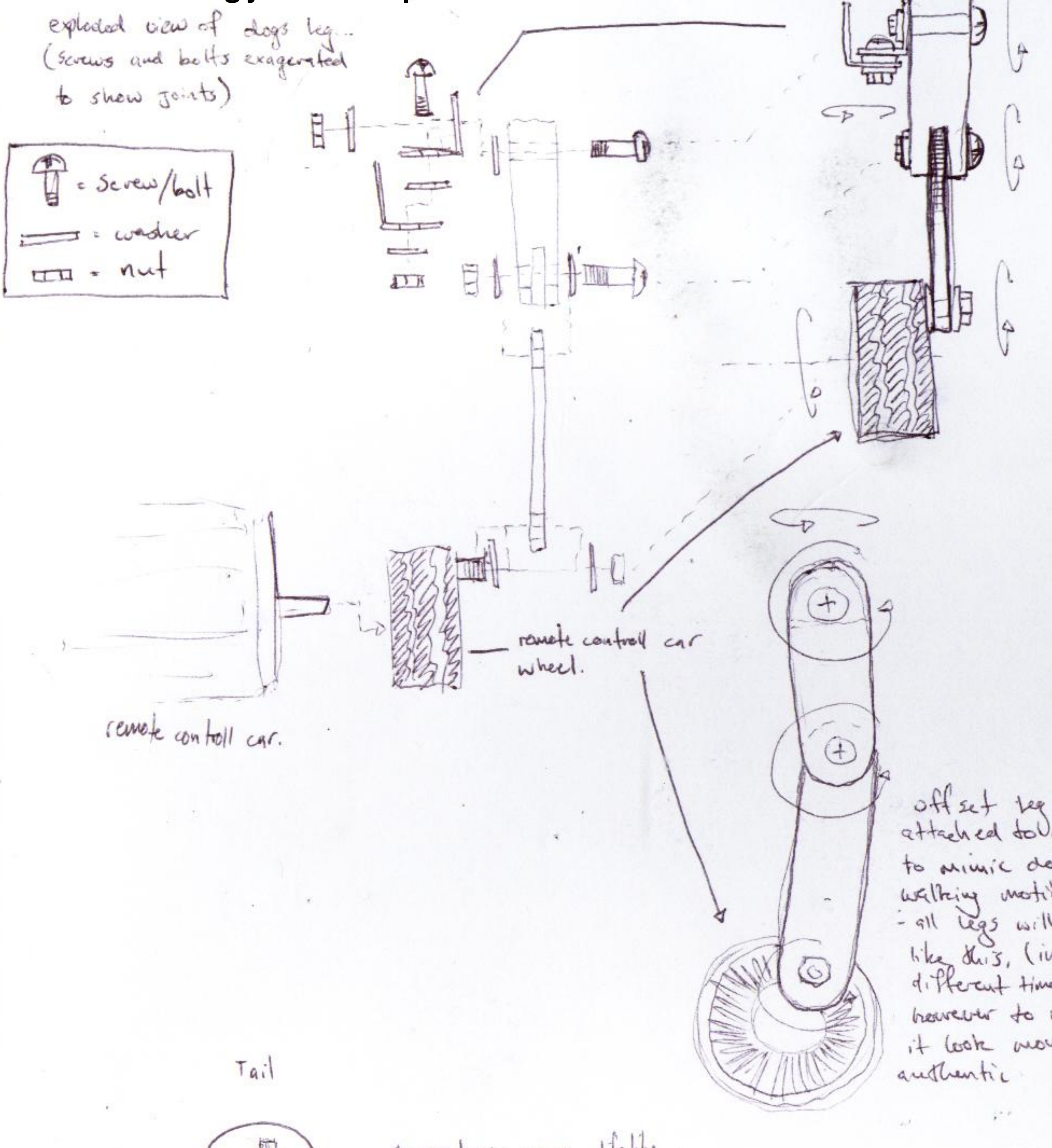
Although this is essentially all the dog has to be in terms of functionality, aesthetically it lacks the sense of 'realism' that Lewis is looking for in the dog prop.

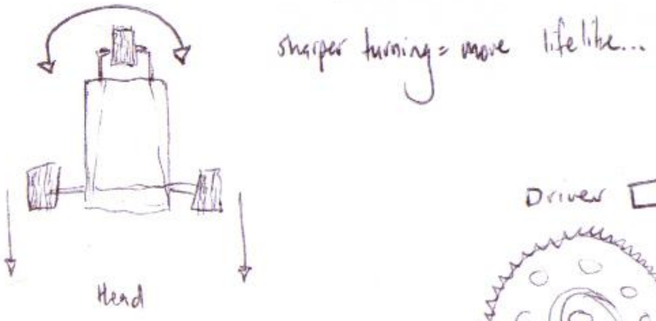
In this picture of a children's wooden toy dog, we can see that the legs have three separate pivot joints connecting them from the wheels to the body. These joints roughly resemble whereabouts a real dogs joints would be, and so give it the impression of walking when pulled along. This is due to the joint that connects the lower part of the leg to the wheel being offset as shown in the image above.

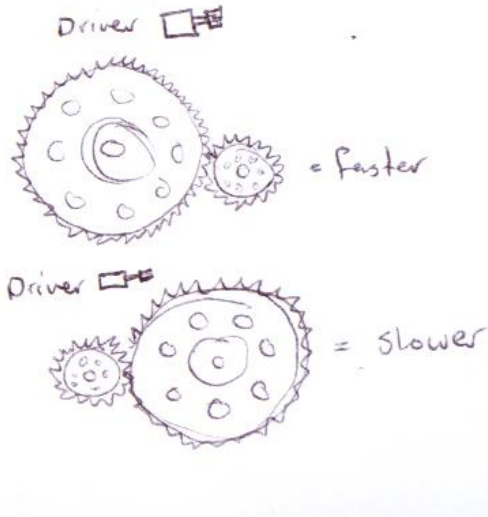
This type of linkage system is what I would like to use to create the walking motion as the dog moves on stage. In order for the dog to look as though it is actually walking, each leg should be offset by different amounts on each wheel.

(28 March 2012)

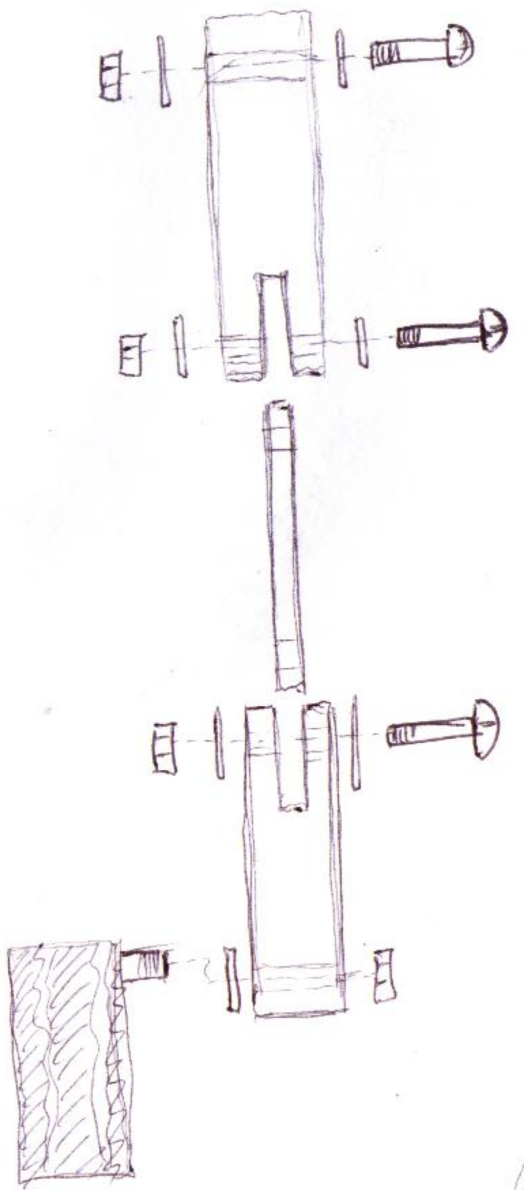
Front leg joint concept:

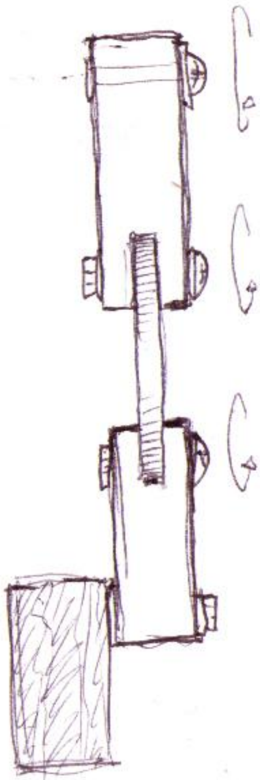




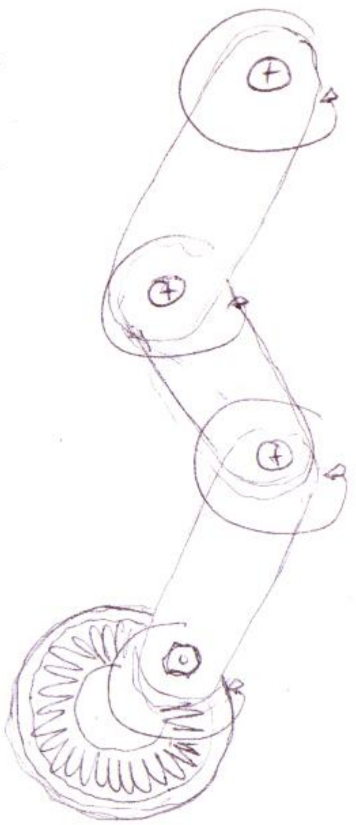


Rear leg joint concept:





Here are some of the concepts I have produced regarding joint methods in the dogs legs, in particular the rear legs. An exploded view as shown above shows how I intend on linking the separate parts of the leg together so that it still has the ability to move.



Front Leg Joint Prototype:

With the concept I had produced on the previous page, I made a mock-up leg joint out of Dense foam board and a wooden dowel to test both the foams material properties, and to see if having a flush joint would be more beneficial than having a layered joint like in the legs of the children's dog toy. While doing this I was also able to test how easy it is to work with Dense foam board on this sort of scale. Although the joint test was a very 'slap-dash' job, I was able to rule this material out of the manufacturing of limbs/moving parts as it didn't seem to hold its shape very well around the joint and seemed to almost erode away where there was too much movement due to its softness.
However, even though it doesn't hold up to well on moving parts, due to its density, the dense foam board would work well as a structural component. Because of this attribute of the foam board, I think I will consider using it as the inner body structure. (20 March 2012)

Something that I would also have to keep in mind when designing and manufacturing the legs, was the possibility that they might bend backwards if set up wrong in proportion to the height of the dogs body. I would have to test this, and find a solution to this problem once I found a suitable material and method to manufacture the legs.
I will now have to further investigate different materials that could potentially be suitable for the job of the dogs limbs.

(30 March 2012)

Material Decision:

I decided to further my study into what material the moving parts of the dog could be made out of after finding out that the Dense Foam board would not work well on the joints.
An initial idea I had was to make the joints and external parts of the dog (i.e. body, head etc.) out of thin sheets of MDF custom wood. Although this would have been a sturdy material to use, I had to remember that 'Weight Reduction' was one of my key factors, and so, for the amount that I would need to cover the dog (from the segmented dog outline I draw previously), I was able to see that the MDF would be too heavy a material for the job. However, like the Dense Foam Board, the MDF Custom wood might also come in handy for certain structural aspects of the dogs design. (20 March)

Foam Core Board
I had to find a material that would be strong and durable enough to withstand continuous movement, not disinterested when in motion, and be light enough not to make much of a difference to the dogs overall weight. (21 March 2012)

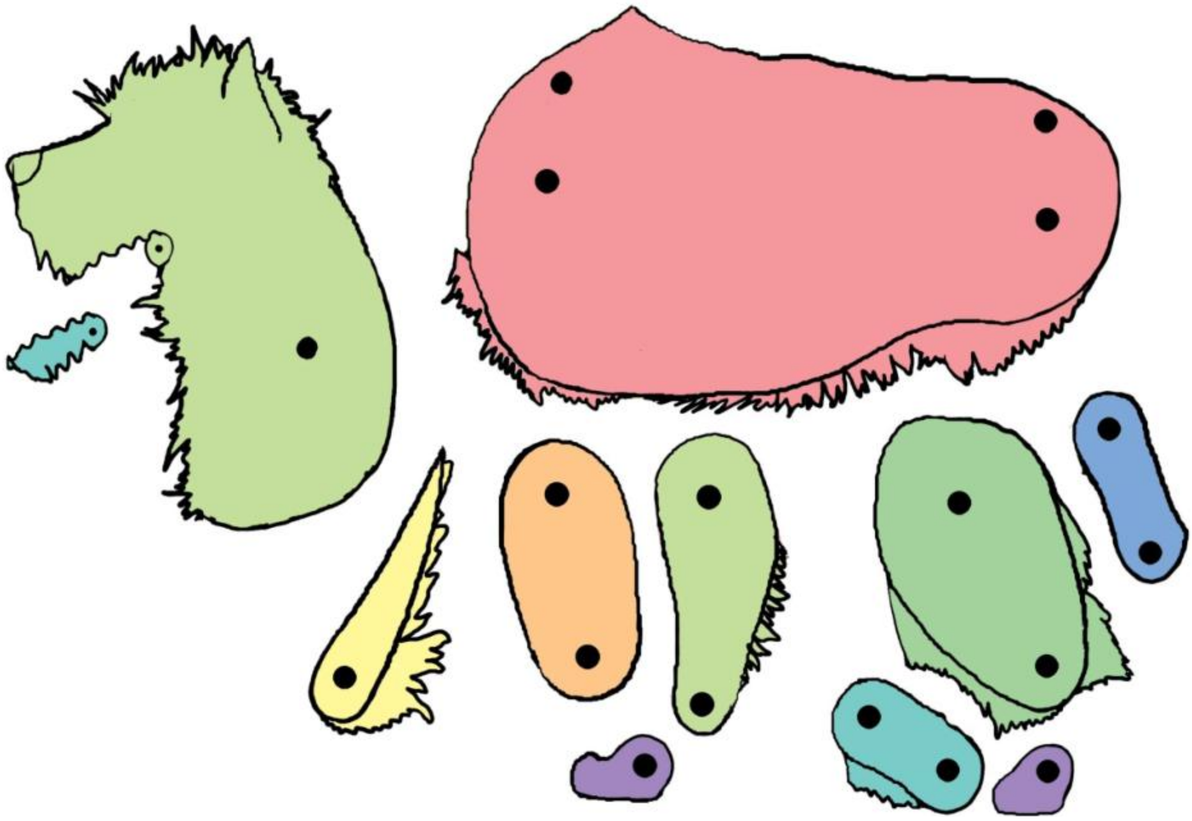
Fortunately, my dad mentioned a material known as Carpa Board, or, 'Foam Core Board' (as shown in the 'Material Properties' on the previous page).

This particular material was surprisingly light for how strong it was. Although similar to the Dense Foam Board, the Foam Core Board had a layer of paper on both sides. This seemed to be where most of it's strength lay.

Because of the strengthening paper that lines the sides, the Foam Core Board is capable of being much thinner than the Dense foam Board yet hold the same strength as a thicker piece of Dense Foam Board would. Effectively, the Foam Core Board could be seen as a light weight equivalent of the MDF Custom wood. Not only is it strong and light, but the Foam Core Board is also able to be machined fairly easily using either a craft knife or a band saw. Because of how dense the foam is in between the two layers of paper, when machined, the Foam Core Board isn't likely to crumble like polystyrene might.
Now that a suitable material has been chosen to use as the exterior parts of the dog, I can cut out the segmented shapes that make up each component. Once I have cut out the pieces I can start on designing ways of joining the limbs together.

(31 March 2012)

Visual Cutting Guide:

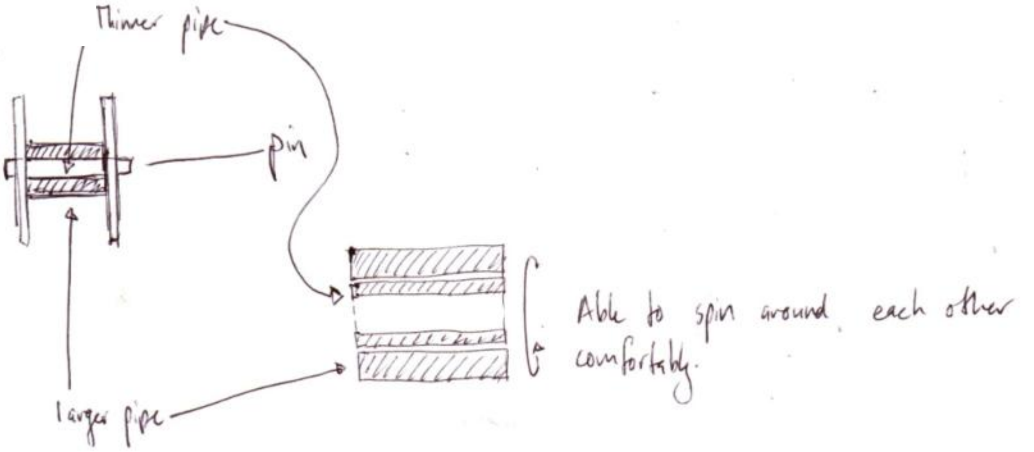


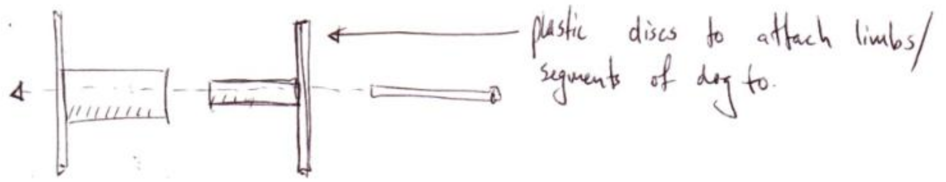
With the 'Dog outline' picture I had created on Adobe Photoshop, using Photoshop again, I cut each segment into their according piece as shown in the picture above. From there I printed each part out, traced them onto a sheet of Foam Core Board, and then cut them out using the band saw at school.

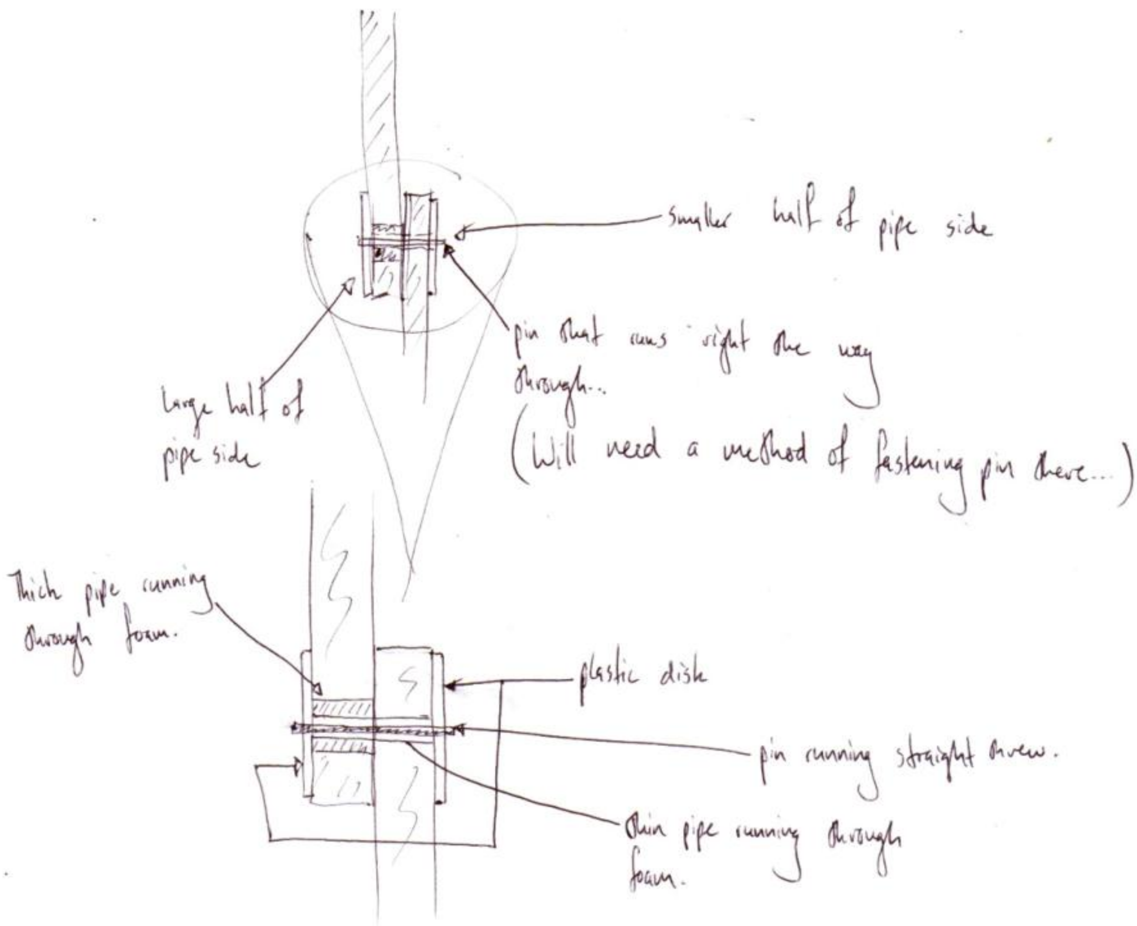
Now that all the pieces have been cut out of the Foam Core Board, I can now start designing the moveable joints that will attach these parts together.

(2 April 2012)

Joint Concepts:



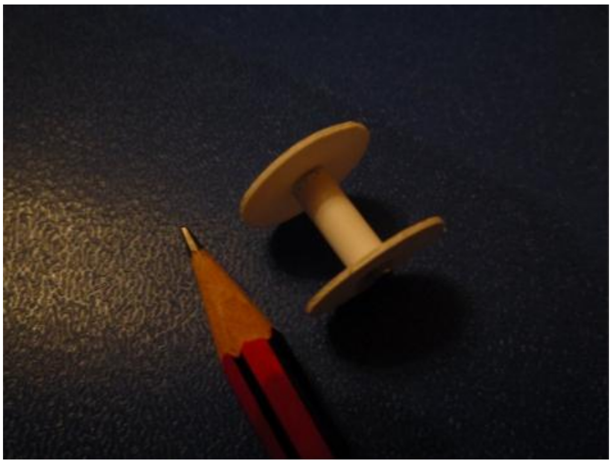


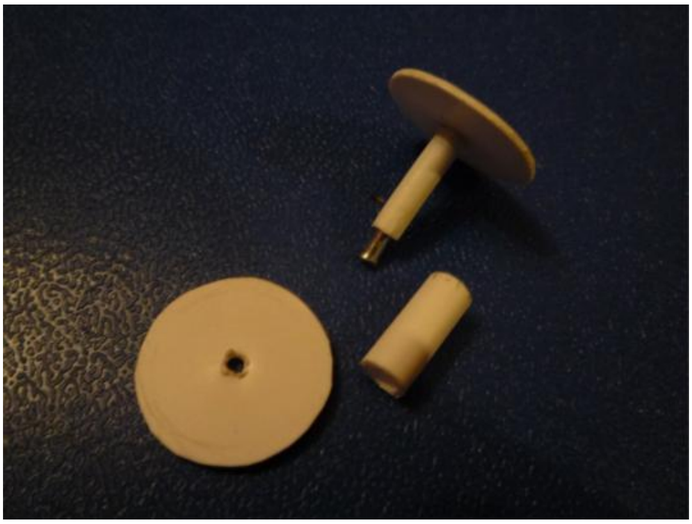


Concept Joint Prototype:

After having some trouble with the 'flush' joint method, I came up with another joint concept that uses small plastic discs (hand cut out of a larger plastic sheet) and two small different sized plastic tubes that fitt within each other comfortably. To allow this method to work, the separate parts of the limbs will have to be layered like in the picture of the dog on the previous page and in the concept I have drawn on the previous page to this one.

This is the prototype joint I made using the new concept. (Pencil to show scale)



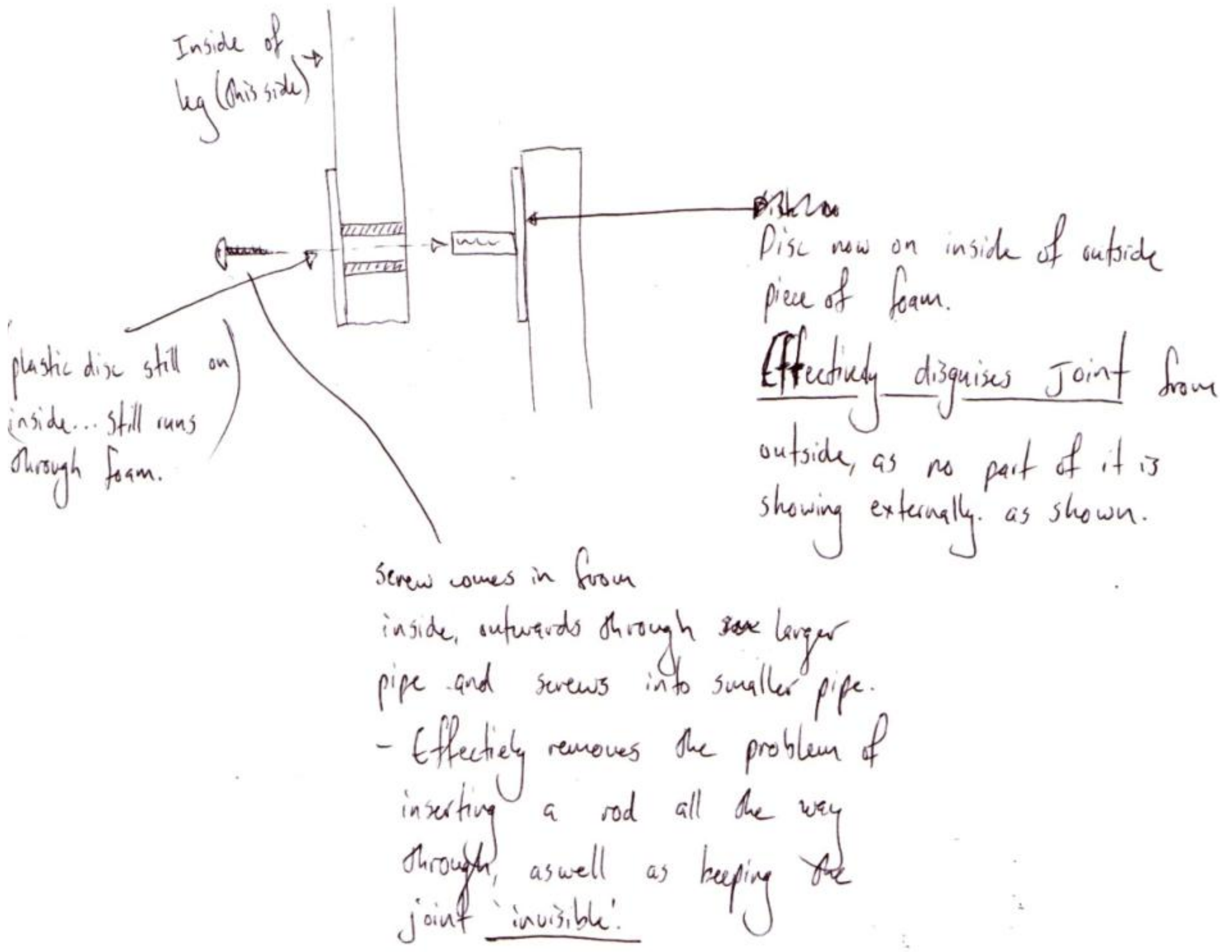


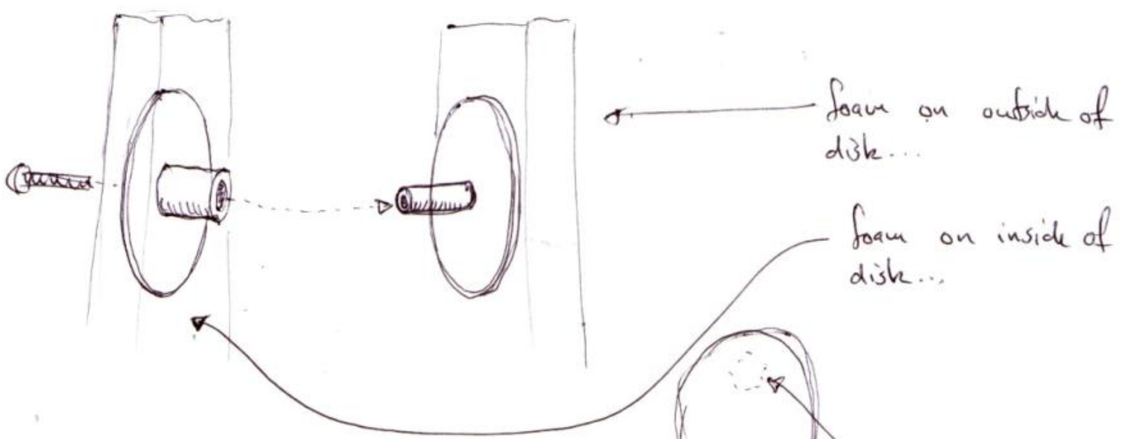
Looking at the joint disassembled, we can see that one side of the joint has a thin tube with a flat disc attached to the end. The other (although not assembled in this picture) has a thicker tube attached to another disc. The two tubes are able to fit into each other comfortably, therefore allowing the whole unit to move freely without very much friction at all. (which was one of my Key factors).

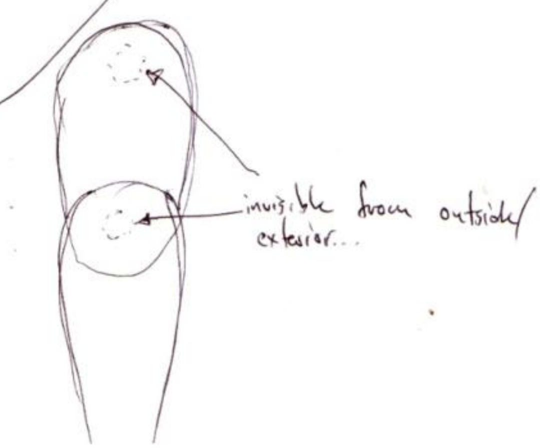
The disc with the small tube on it will be attached to the inside of the lower part of the leg. The disc with the larger tube will be attached to the inside of the upper part of the leg, however, the tube will be sticking through the foam core bored so that it can fit over the smaller tube.
However a downfall in this method is how the two halves of the joint are stuck together. A small pin (made from a cut nail) runs through the centre of both the discs, and in theory, hold the two sides of the joint together. Unfortunately, having this pin run through the centre doesn't hold the joint together very effectively, and so, tends to fall apart with too much movement.
I will have to further my study into how I can achieve this joint without having the pin running through the centre.

(3 April 2012)

Joint Development:

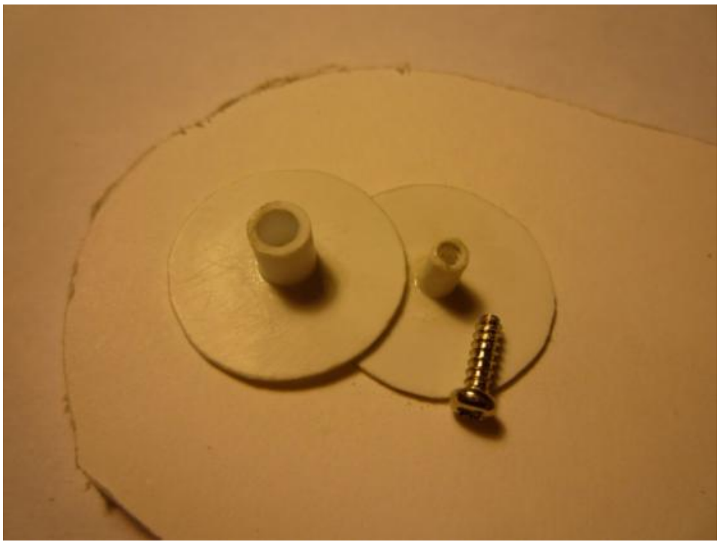


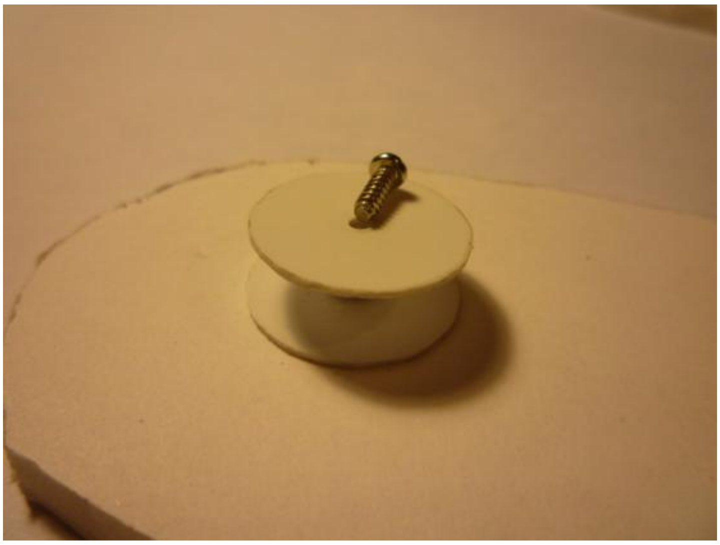




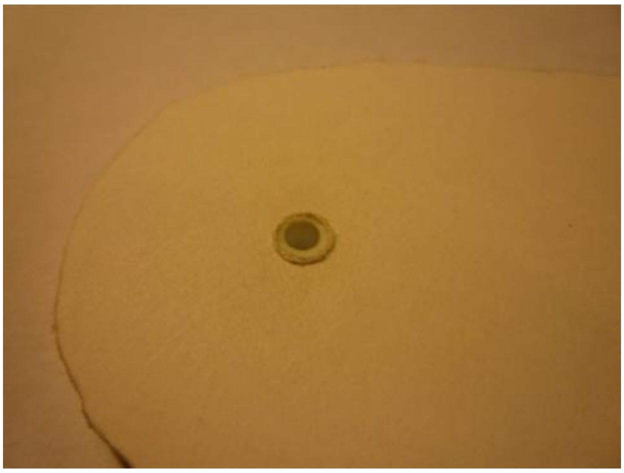
Because I didn't have a tap small enough to fit inside the smaller plastic pipe, I used a M2x5 self tapping screw that I found lying round the house. Fortunately, this screw happened to be the perfect size for the pipe.

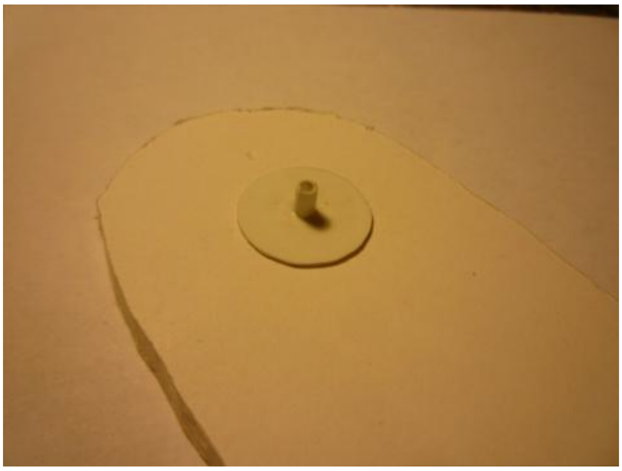
Final Joint Construction:



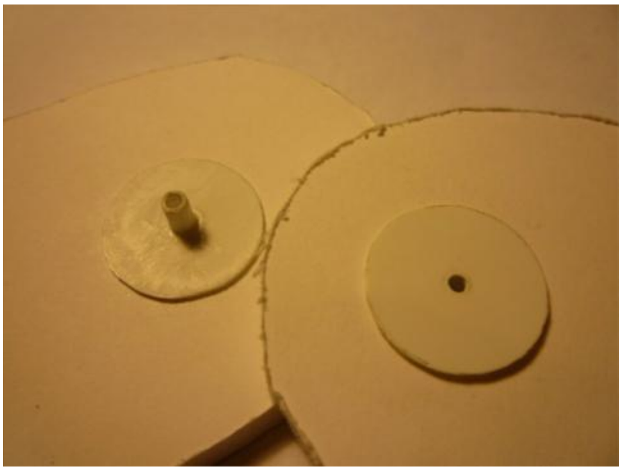


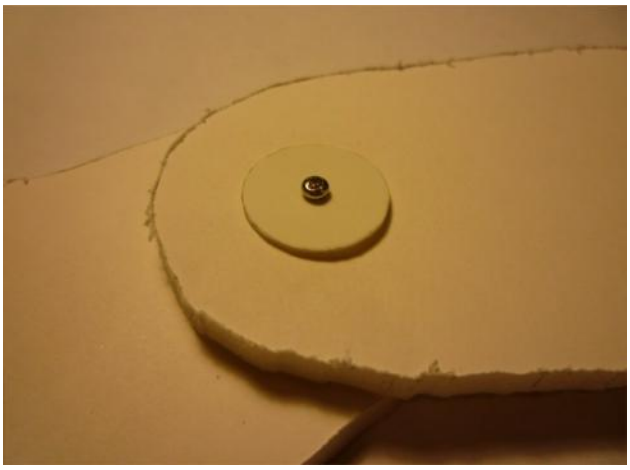
After further developing my prototype joint, I manufactured my developed concept and have ended up with an effective, fairly strong and easily movable joint that is effectively invisible from the outside.
After testing whether or not the plastic tubes could hold screw threads with the screw I found, and finding out that with the right sized screw they could, I was able to rule out the idea of the joint having a pin that runs right through it. Instead, a small M2 x 5 self tapping screw passes through the plastic disc with the large tube on it, and into the small tube on the other side. Because of this new method in holding the two sides of the joint together, the joint is able to be unscrewed and pulled apart with ease in the event of a malfunction or breakage.
Like the previous concept, the new joint will be attached to the separate limbs in the same way apart from the disc with the small tube on it, which will be attached as shown in the picture at the bottom (to the inside of the outer limb.. The half of the joint with the larger tube sticks through the foam core bored.

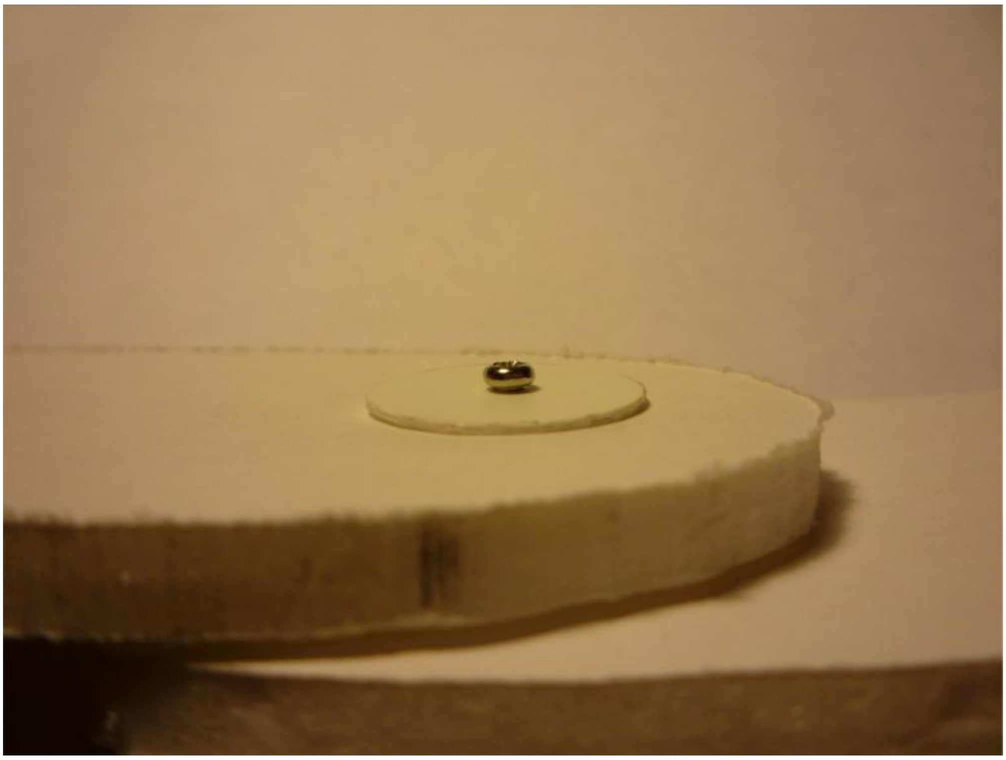




The other half of the joint (with the small tube) fits into the larger tube. The screw then comes through the back of the larger tube and into the smaller tube. (This is shown on the following page.
(5 April 2012)







When assembled and stuck to the body of the dog, the joints will be unseen as the screws sit on the inside of the legs.

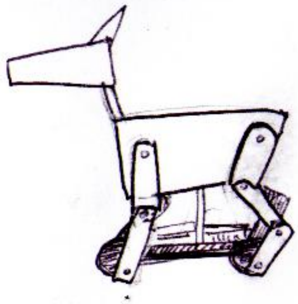
(5 April 2012)

‘Bobbling Head’

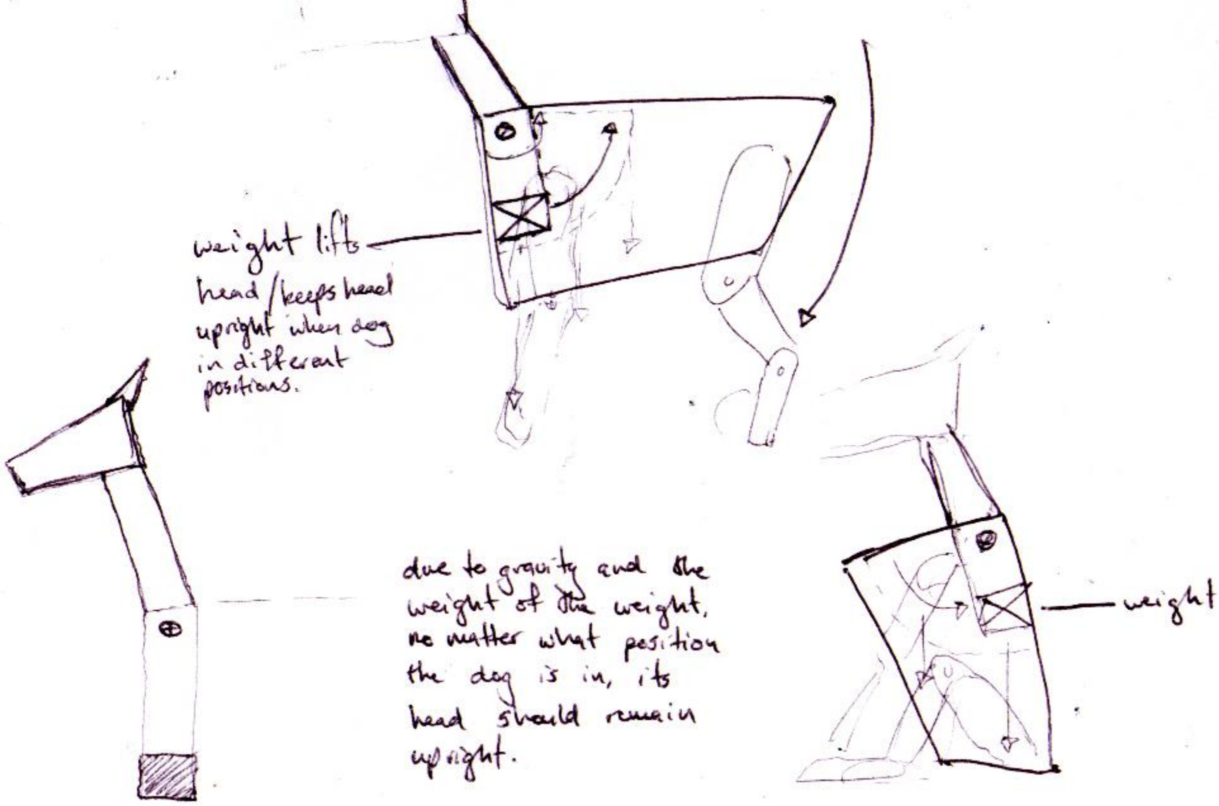
As mentioned in the brief and specifications, lewis said that he would prefer some sort of movement in the head and/or tail. In the pictures above there are various different ‘bobble head’ dogs. If the head and/or tail is wanted to move, I think using a simple mechanism like in the pictures above would be beneficial and relatively easy to manufacture. In theory this sort of mechanism would work effectively when the dog moved along the stage as it would reduce appearance of it looking like a static dog on wheels.

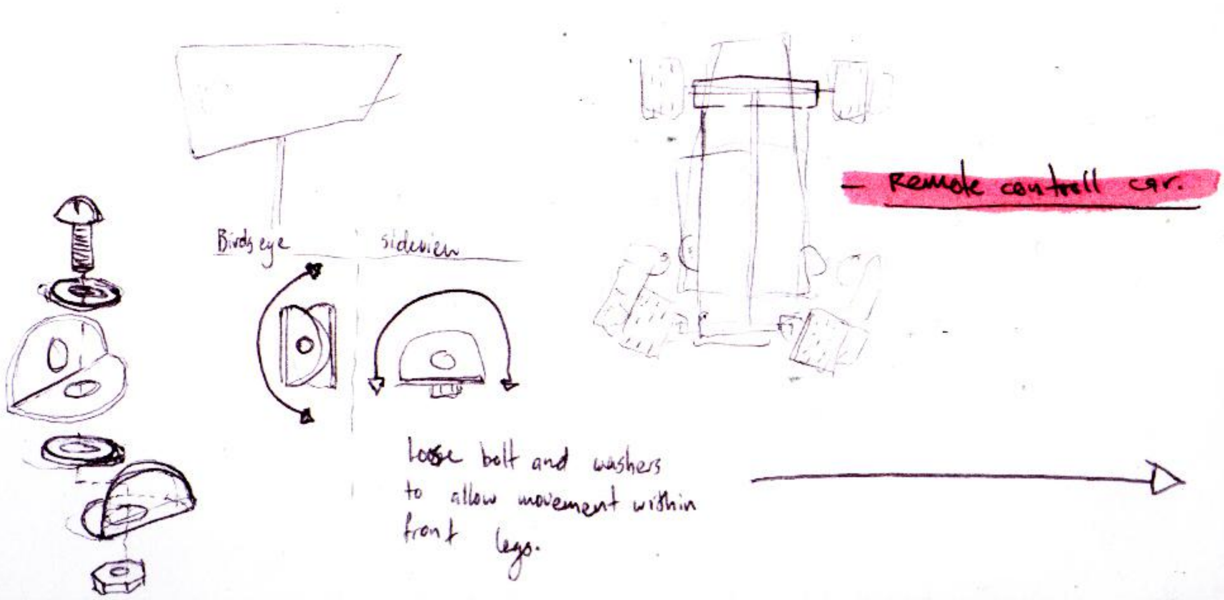
A counter weight would be attached to the base of the head in relation to the pivot point at the neck in order to give it a smooth sort of bobble as the dog moved along the stage.

Bobbling Head Concept:



My initial idea for the head to wobble back and forth, was to attach some sort of weight to the base of the neck that would extend into the body as shown in the rough sketch below. This not only would allow a small amount of movement in the head when the dog moved across the stage, but would also keep the head up right if the dog were able to sit down as shown in the sketch below.





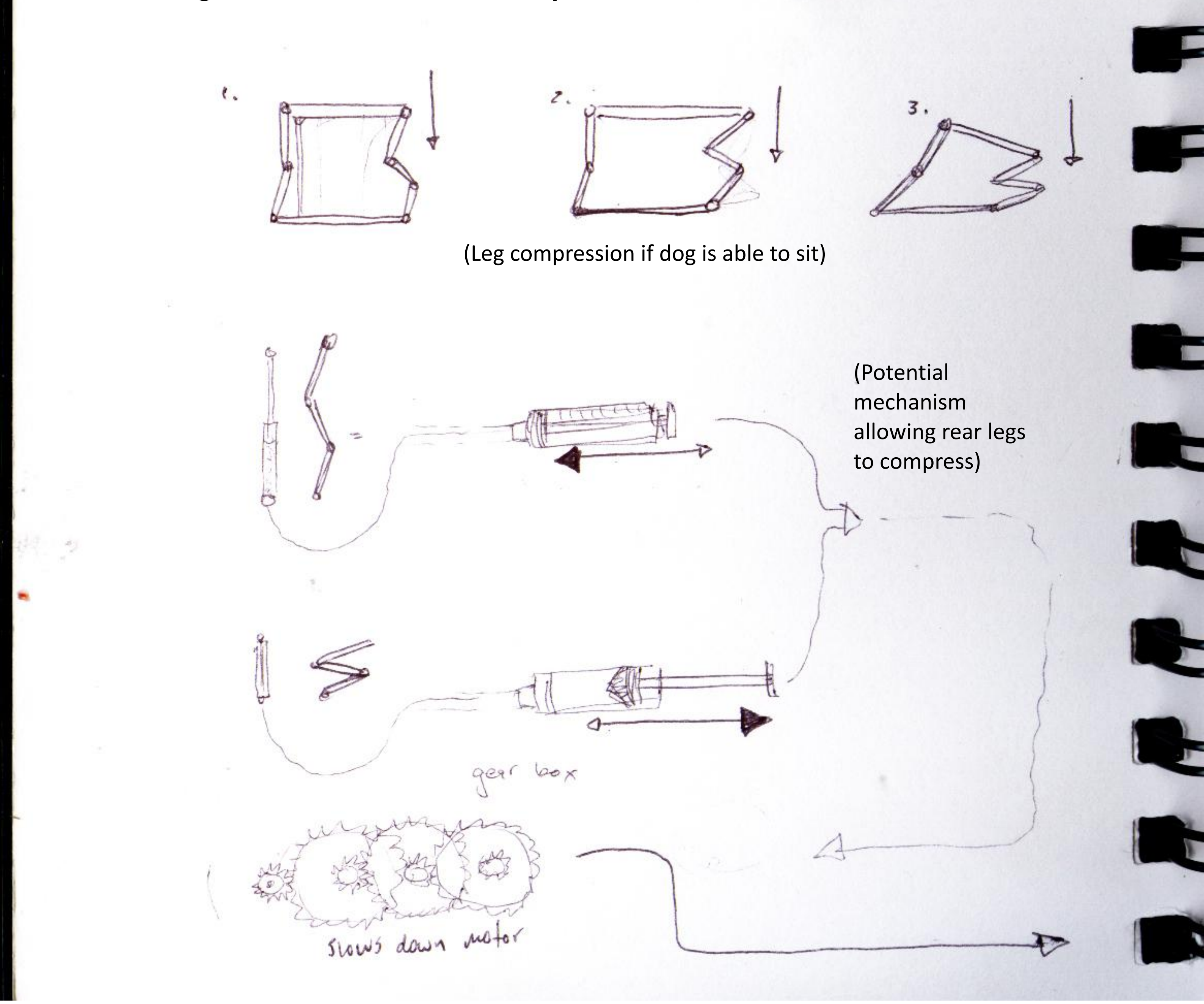
However, the design involving a counter-weight would mean adding potentially unnecessary weight to the whole dog, something of which I can’t afford if I am to make the dog prop as light as possible in the most efficient way possible.

With this problem that potentially interferes with one of my key factors, ‘Weight Reduction”, I will have to design a better, more efficient method of allowing the dogs head to ‘wobble’ as it moves across the stage.
(8 April 2012)

But before I did too much more development on the ‘wobbling’ head design, I figured it would be beneficial to try and come up with a design and mechanism that would allow the dog to sit down/stand up. This is because if the mechanism for this to happen cannot be achieved, then the whole mechanism for the head and neck will have to completely change in turn.

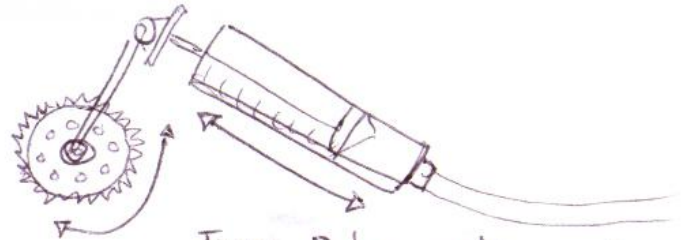
I did some quick brain storming sketches as a study that I could brig to Lewis so I could discuss weather or not having the dog being able to sit down/stand up would be beneficial.
(8 April 2012)

Sitting Down Mechanism Concept:

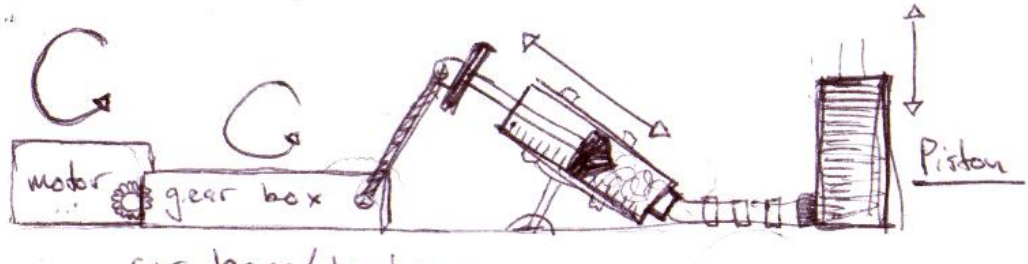


(Leg compression if dog is able to sit)

(Potential mechanism allowing rear legs to compress)

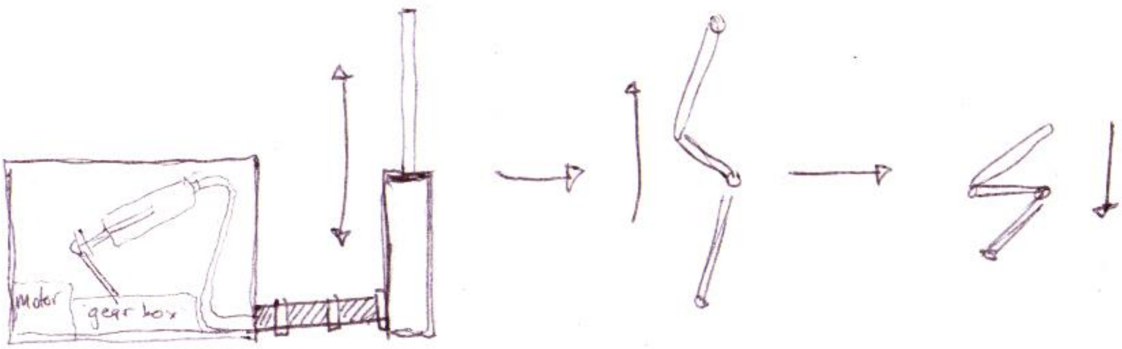


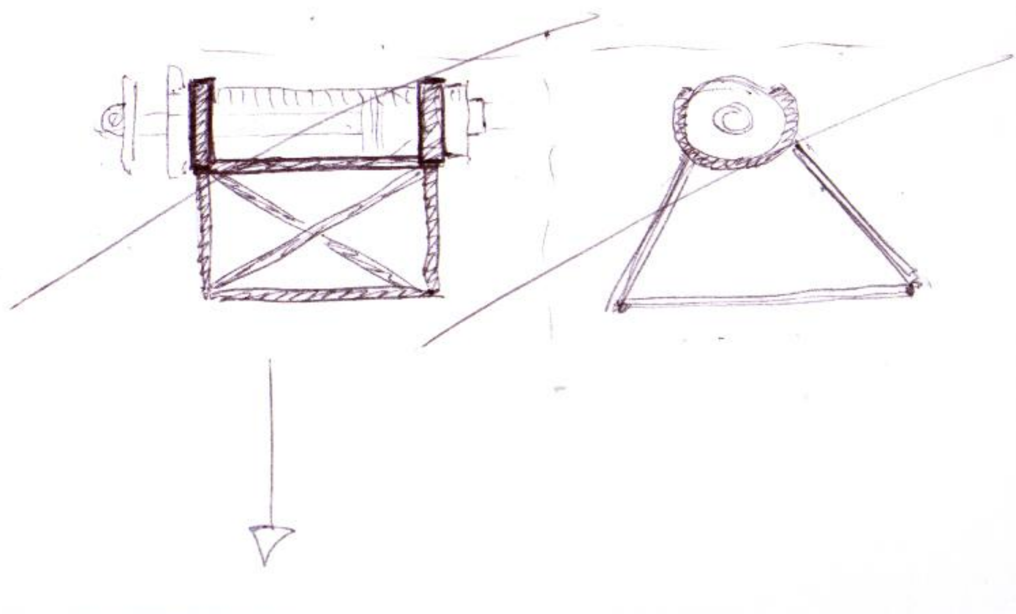
Turns Rotary motion into linear motion.
- motor would have to be slowed down using several cogs as a gear box... (shown on previous page.)

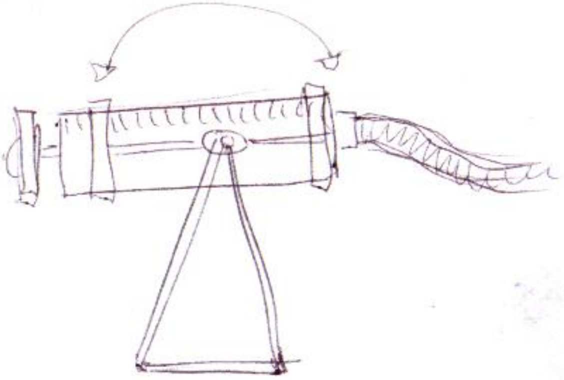


car base/dog base.

Rotory motion. ⟶ " ⟶ linear motion. ⟶ "





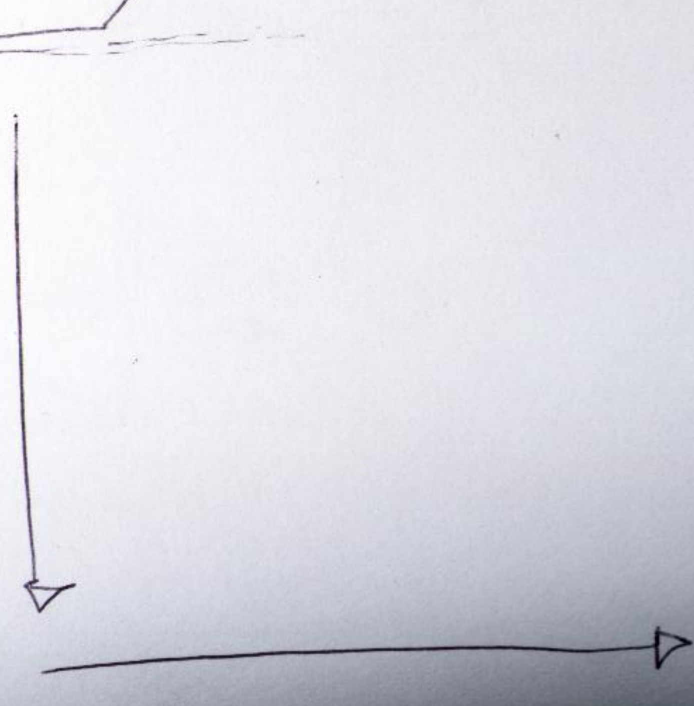


suringe has to be able to pivot otherwise motor will tear it off support...
(if suringe idea is used)

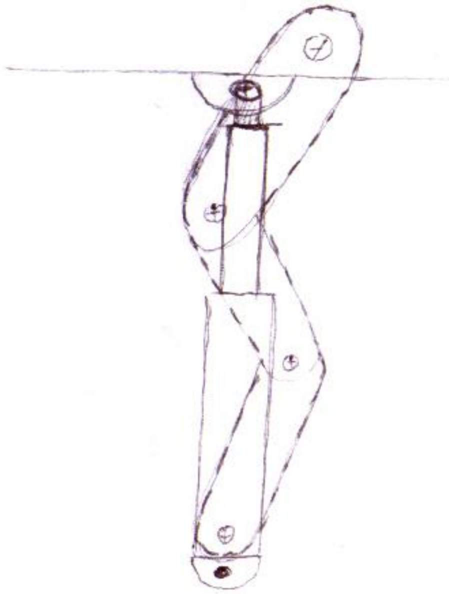
Suringe may or may not work; may put too much strain on motor (however gear box will help...).
Might be better to just go straight to actuator = less room for error ~~due~~ as suringe may leak air or alternatly not be strong enough to lift dog weight.
- only problem is that actuator will require batter sources.. Then again so will suringe...

- actuator => less room for error.

mounts will have to be attached to actuator (if not already attached) as to allow movement when dog sits down.



Conceptual Revision:



If actuator is directly behind leg, leg will conceal actuator to the eye... However, this means that the distance the leg compresses/bends will decrease, therefor not allowing a full 'sit down' position...

Materials: (potentially usable)

Bulsar wood - light, fairly strong (dependent on how bulsar wood is compiled).

wood - strong, heavier than bulsar wood, ∴ air piston may or may not be strong enough to lift the wood as it may be too heavy

After brainstorming a couple of ideas and sketching some rough concepts of a potential mechanism that would allow the dog to sit/stand on demand, I spoke to Lewis about whether it was necessary that the dog have this attribute, as manufacturing a mechanism that could lift a life size dog prop would prove to be rather difficult and potentially unreliable. Not only this, but having a mechanism strong enough to lift the whole rear of the dog at the scale the mechanism would have to be would also add a fair amount of both designing and unwanted weight.

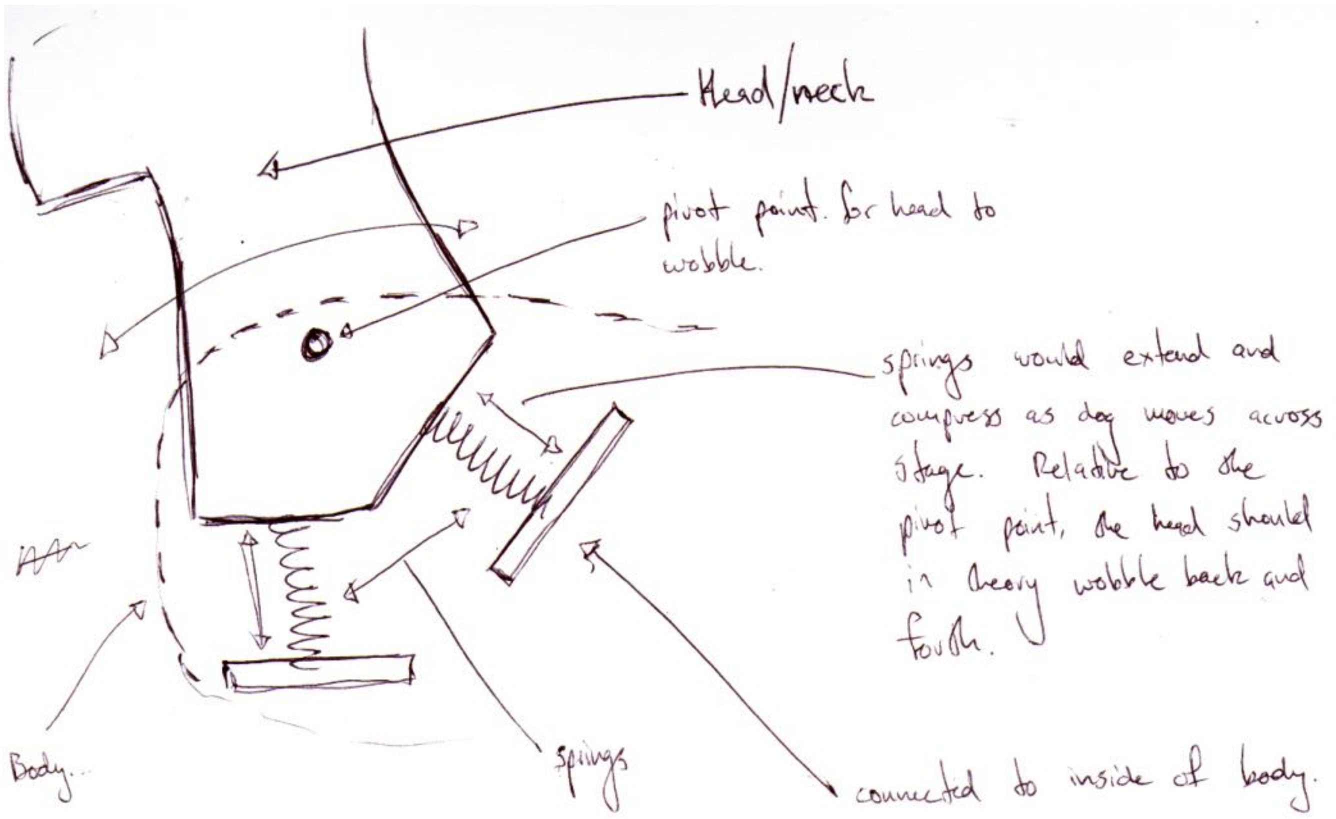
After speaking with Lewis about this matter, we decided that it might be better to leave this particular mechanism out of the design as it wasn't completely necessary, and would mean alot more designing and manufacturing especially at that scale.

With this decision, I can now continue with designing and developing the mechanism that will allow the head to 'wobble' back and forth.

(11 April 2012)

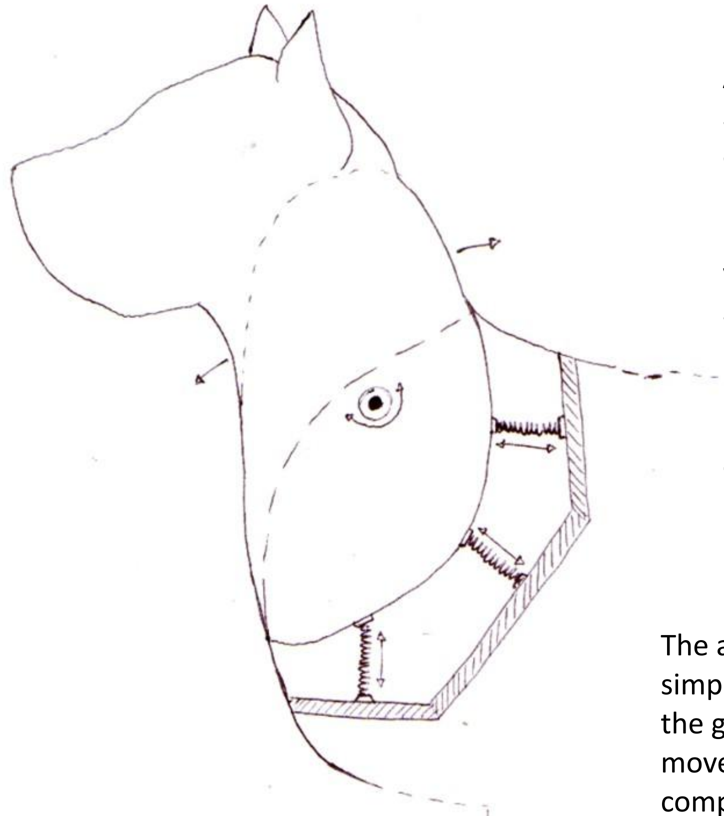
‘Wobbling Head’ Concept Continued...

Continuing with the ‘wobbling’ head mechanism design, I should now be able to change my initial concept to suit a dog that doesn’t need to sit/stand. With this in mind, I have come up with another concept that uses springs as a pose to a counter weight as shown below.



Although this concept still uses the same pivot point on the neck, there no longer has to be any weight to counter balance the weight of the head, but rather, springs that can be connected from the inside of the body to the base of the neck as shown above, in doing so, this should significantly reduce the weight that would be required in the previous concept. Depending on what springs would be used for this particular method, in theory, this will allow the head to ‘wobble’ back and forth.

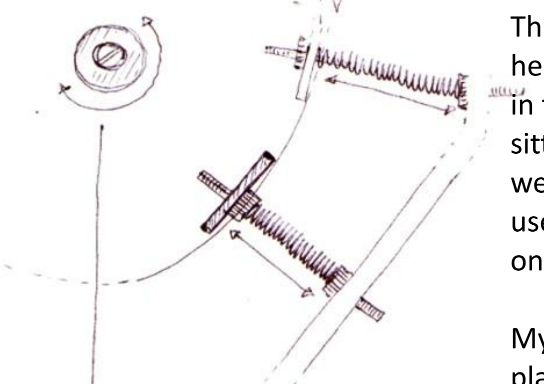
(12 April 2012)



After sketching the rough concept of another mechanism that would allow the dogs head to move (as shown on the previous page), I have developed on that particular idea a little further to see whether this mechanism would be achievable.

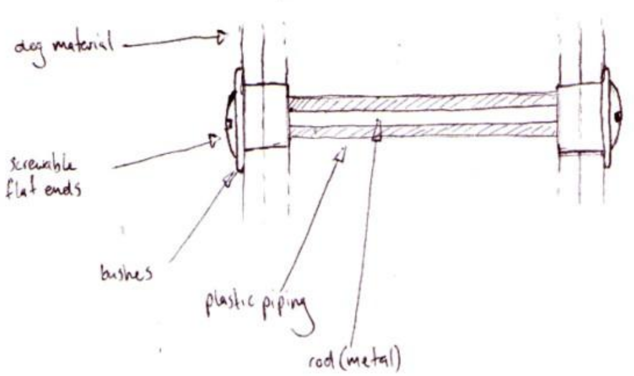
I have used the outline of the dog I produced earlier in “Aesthetic Visual Concpets” to work off when designing this mechanism.

The actual mechanism itself will work fairly simply, in that due to the weight in its head, and the general movement of the dog when it moves across the stage, will cause the springs to compress and expand relative to the pivot point at the top of the body and about half way down the neck.



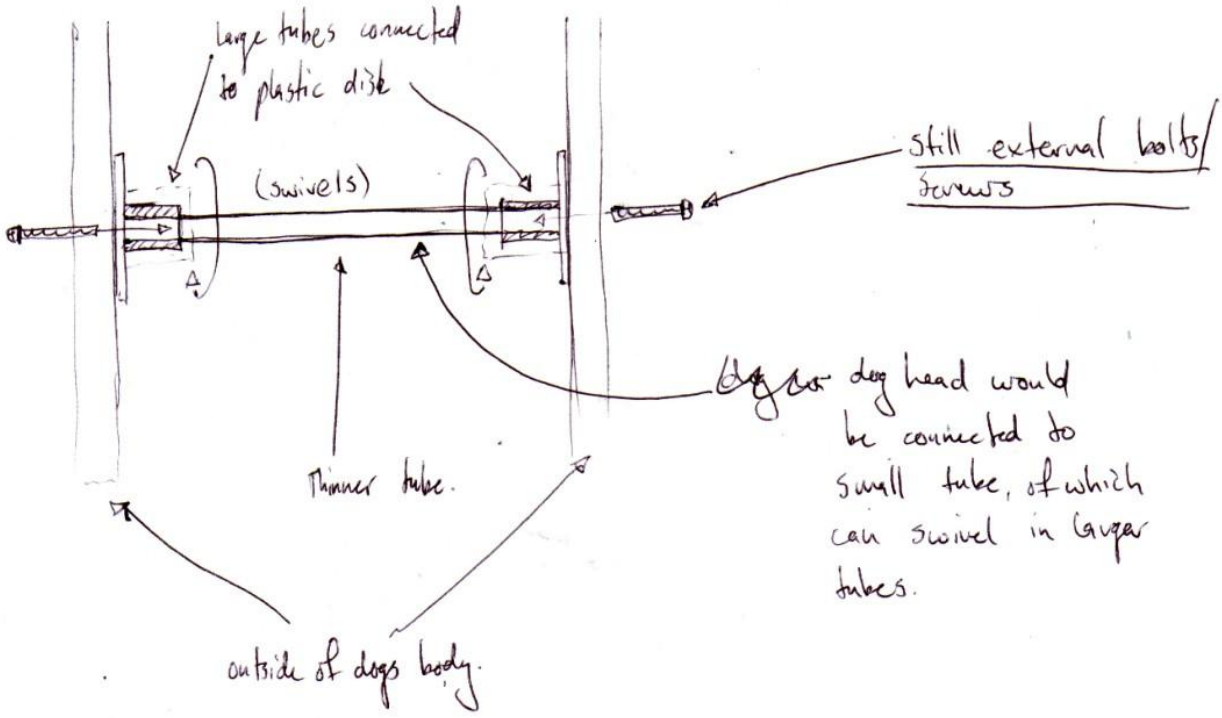
The mechanism that will physically hold the head to the body will be similar to that of those in the joints. Because having the smaller tube sitting/turning inside the larger tube worked so well with the joints on the legs, I decided to try use the same sort of concept for the pivot point on the neck.

My initial idea for this was to have the two plastic discs on the outside of the foam as shown in the picture to the left, which would be connected to the small plastic tube that ran through the middle of the body. The larger tube, with the head on it, would then slide over the smaller tube as to allow it to rock back and forth.



The only problem with this idea is that, unlike the invisible joints on the legs, the two plastic discs, and screws holding it together would be visible form the outside.
To match the joints on the legs, I will have to come up with another type of joint that will render it invisible from the outside, but also able to be taken apart.

Neck Joint Concept:



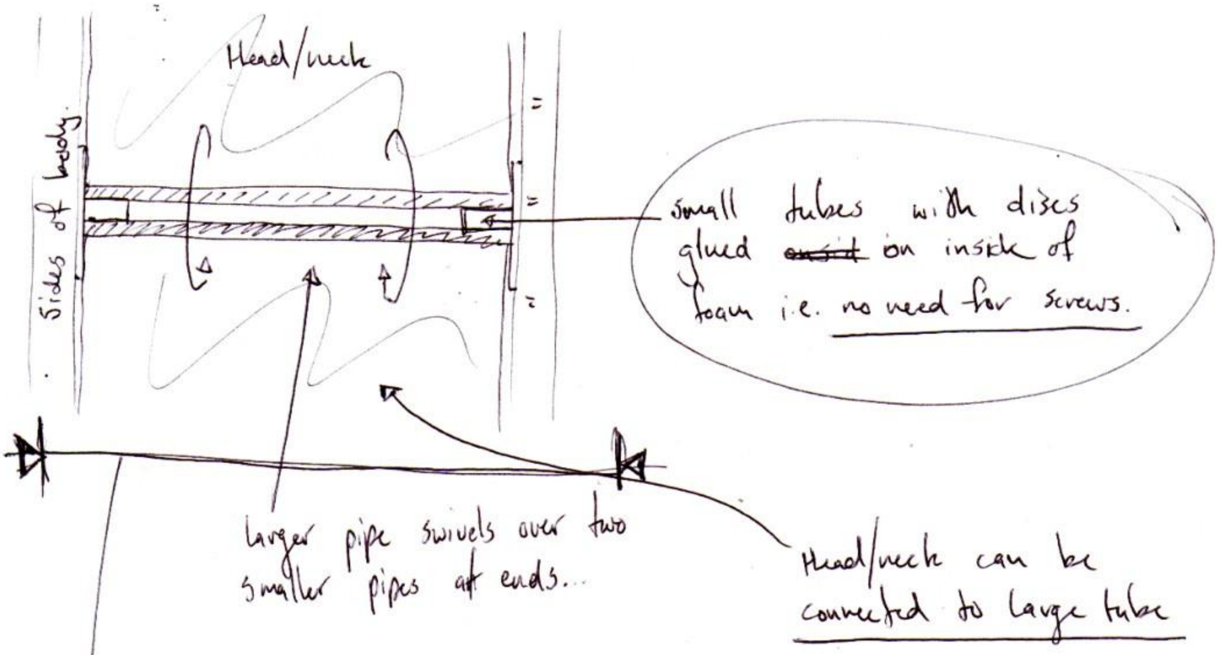
I tried developing my initial concept a little further so that the joint on the neck would be even less visible from the outside as shown in the sketch above, and so, more like 'invisible' joints on the legs. However, I was still left with having the screws showing at either end. Although this is better, it still wasn't 'invisible' from the outside.

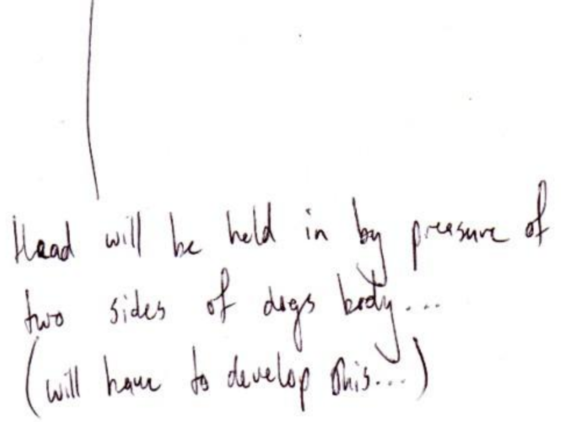
(13 April 2012)

Neck Joint Development: Final Design

After having the problem of the screws showing at the pivot point, I tried to further developed the previous concept even more to see if I was able to make it a completely unnoticeable joint. I used the design I had come up with for the leg joint as reference as to make them as similar as possible.

Fortunately I have come up with a new method of attaching the head/neck that doesn't require screws at either end as shown in the sketch below.
This idea works almost in the same way that the leg joints work, in that the two plastic discs with the small tube attached to them gets glued to the inside of the the body. The thicker tube then gets inserted into the material that pads out the neck, which is then slid over the smaller tubes to allow it to rock.



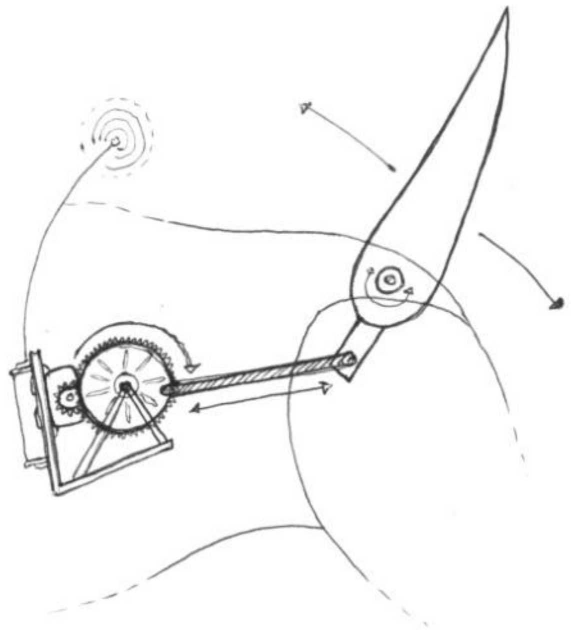


The only minor problem that this causes, is that to be able to be disassembled, the whole side of the body will have to be removable. As well as this, the only thing that will hold on the head are the two smaller plastic tubes and the pressure of the two sides of the body holding it there.

However, I should be able to design a mechanism that will fasten the removable side of the body to the main shape, and in turn, a mechanism that will keep that head on securely.

(5 April 2012)

Tail Mechanism Concept and Development:



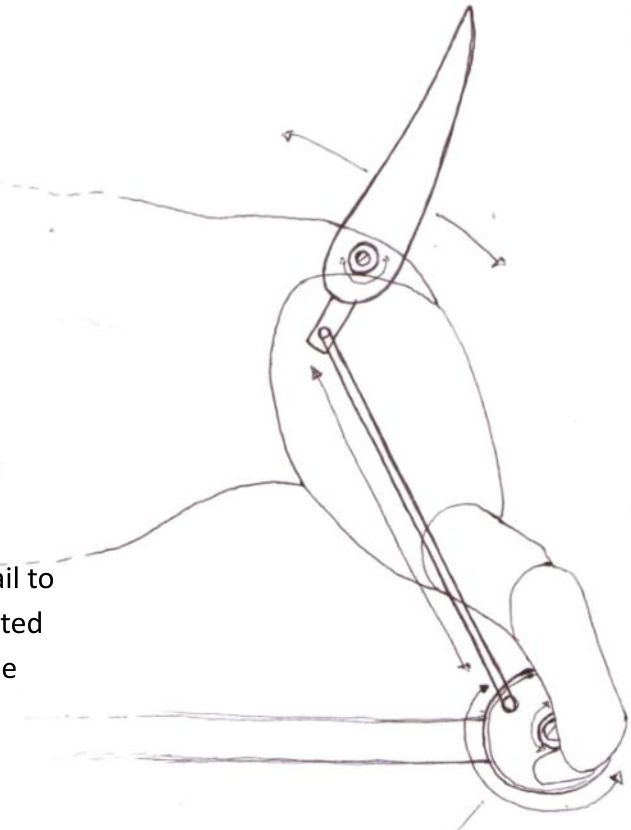
Instead of connecting the tail to the wheel in the previous concept, the second concept would be to attach the end of the tail to a small seperate motor mechanism, of which would be remotely operated.
The advantage of having a seperate moter and remote controll system would be that the dog would then be able to move its tail indipendantly of the dog moving.

However, the disadvantage is that it would require its own remote controll system and battery source.

My initial concept for allowing the dogs tail to wag back and forth, was to connect it up to the same remote control device that would run the motors. However I decide to flag this method and try come up with a more efficient way of doing this, as this seemed like a bit if a waste of useful space inside the body.

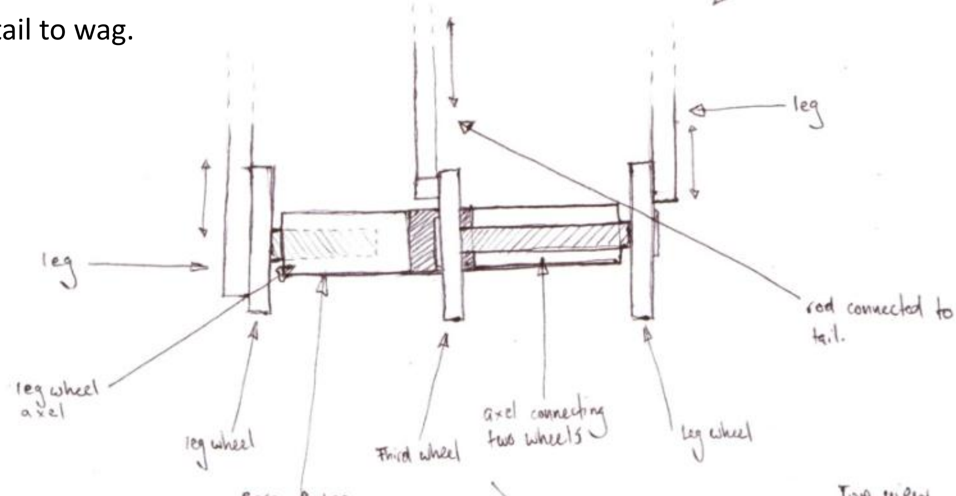
Developed Tail Mechanism Concept:

In order to have the tail moving, a long rod attached to the bottom of the tail could be attached to an offset point on the wheel that is also connected to one of the dogs legs. However, because the tail is in the middle of the body widthways, a seperate third wheel might have to have the tail connected to it instead of the leg.

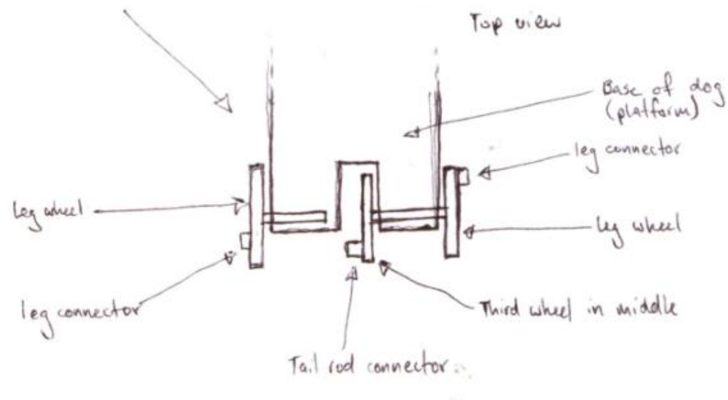


After thinking of another way to allow the tail to move, I came up with a method that connected the base of the tail to a wheel inside the base that then connected to the main wheels. Effectively, this would allow the tail to wag whenever the dog moved.

As shown in the sketch below, a shaft coming off the base of the tail attaches to a crank in the base. Having the shaft offset like this allows the shaft to move back and fourth, which in turn, allows the tail to wag.



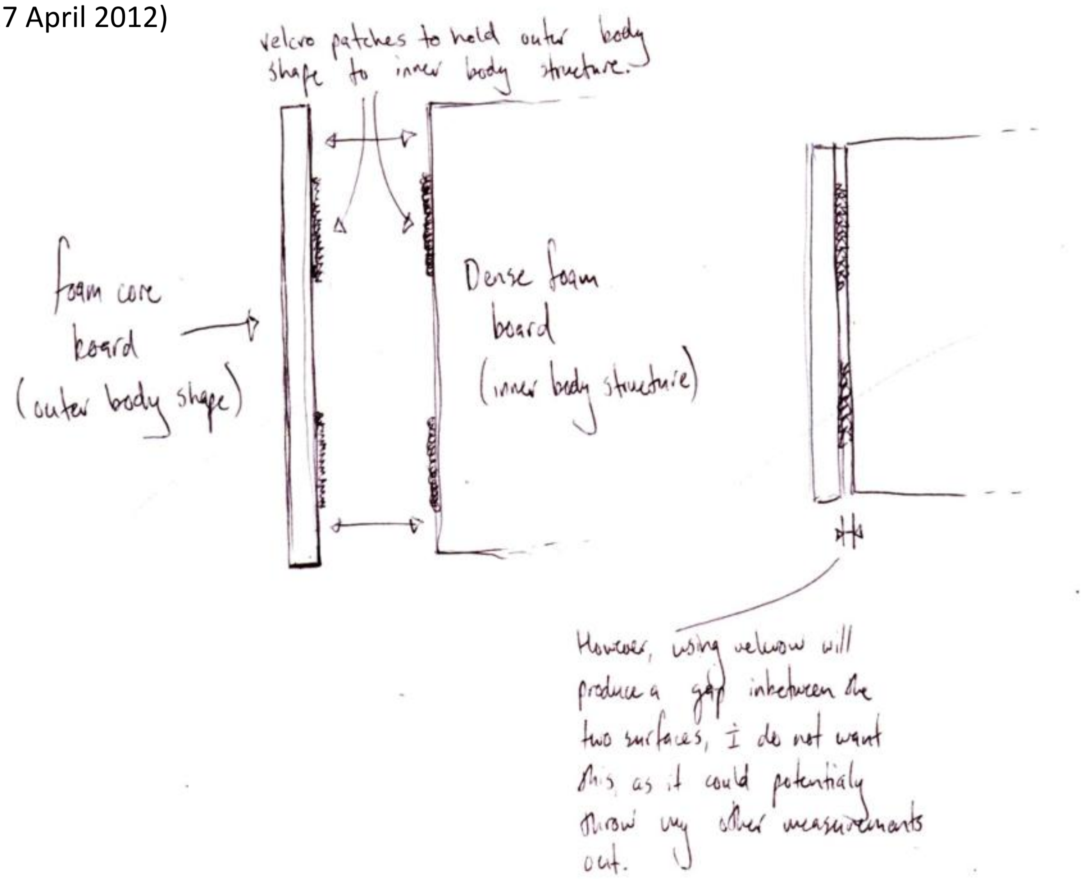
The third wheel will be attached to one of the leg wheel axles so that when the wheels move, the tail moves. The third wheel that the tail is connected onto would be possitioned in the middle of the base of the dog, and so will only be connected by one side so that the rod connected to the tail can move around it.

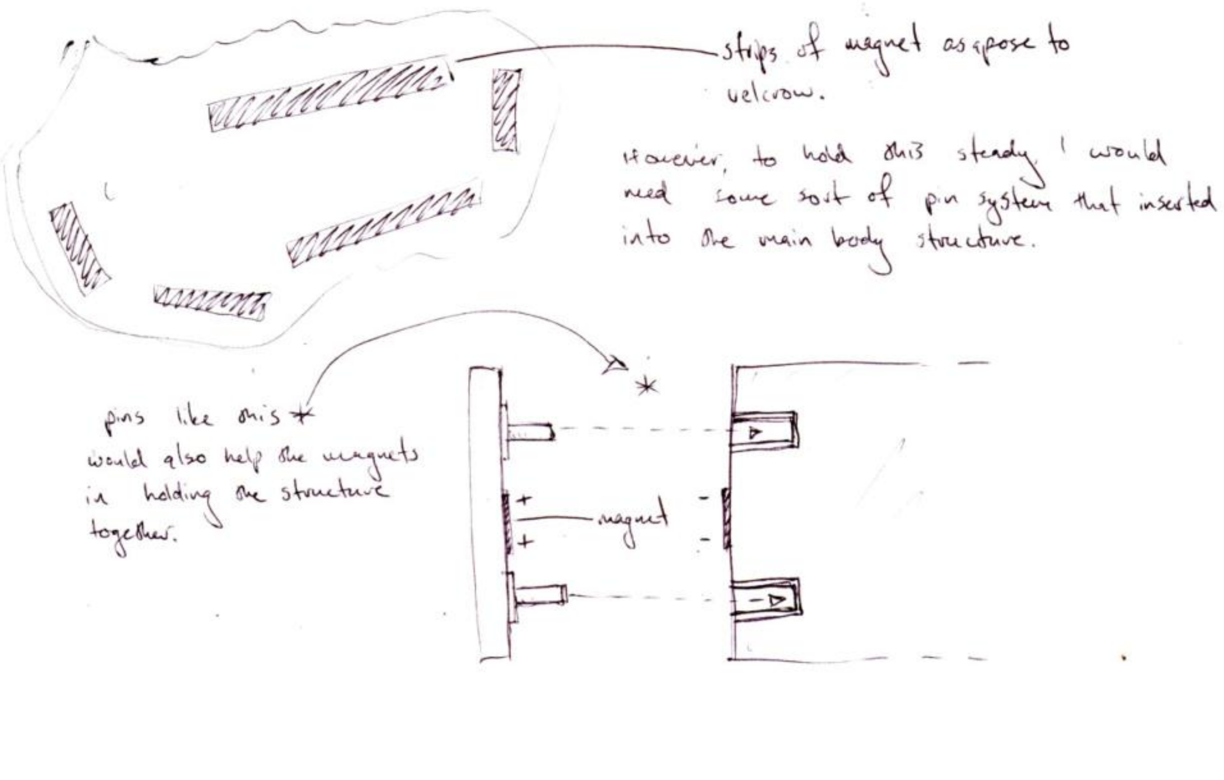


Removable Side:

Now that the concept for the neck pivot is finalised, I have been left with another problem. Somehow I need to think of a way to allow the side of the dogs body to be removed easily, combined with a design that will securely fix the head to it's pivot.

(17 April 2012)

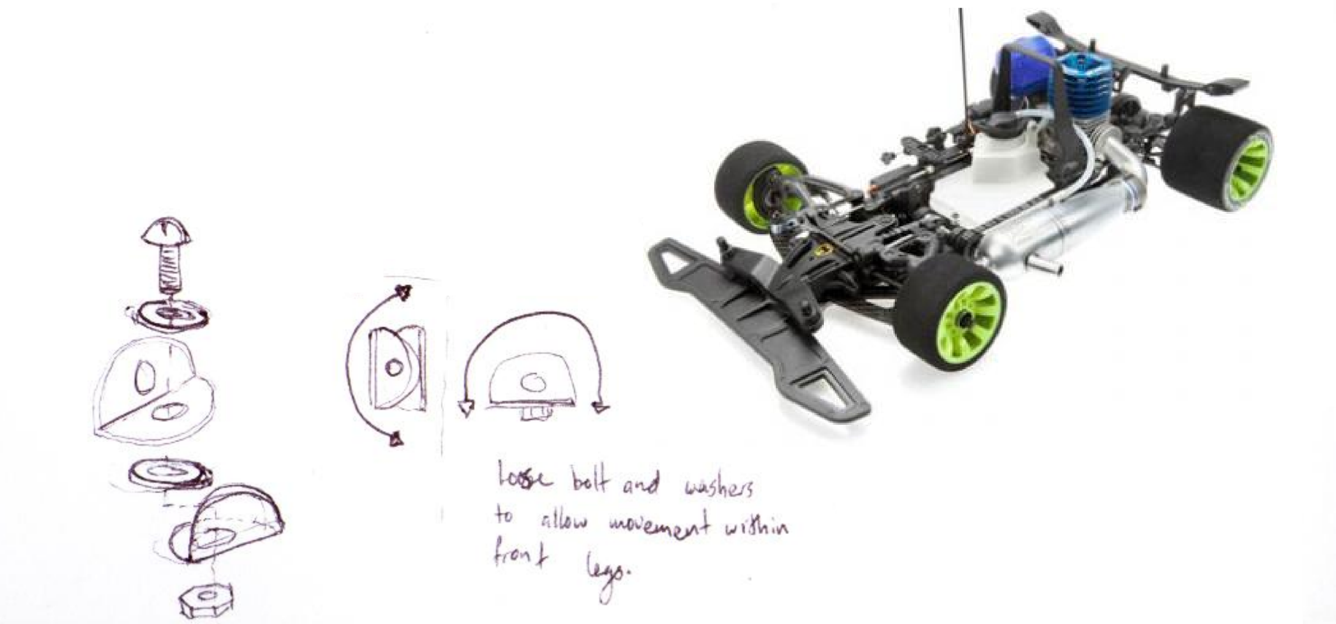




Base Design:

One of the most crucial aspects of this project is the design and manufacture of the 'base'. Effectively, the 'base' will be a remotely controlled structure which the dog will be mounted on top of. Structurally, the base will have to support the whole dog and all of the electrical and mechanical systems. It has to be an unobtrusive part of the dog's design, all while being confined to an area no bigger than the maximum dimensions of the dog.
It is the base that will have the potential to either make or break this project. If I am unable to successfully accomplish the designing stage, or more importantly, the manufacturing stage, then I will not have a functional dog prop to present to Lewis when it comes to the week of the play. Almost each and every part of the overall design of this dog prop revolves around how the base will be designed and manufactured (with the exception of a couple of aspects that are vice-versa, such as the dimensions of the dog, which in turn, will directly influence the dimensions of the base)

To begin, I have brain stormed various methods and solutions that could potentially be used for achieving the base.



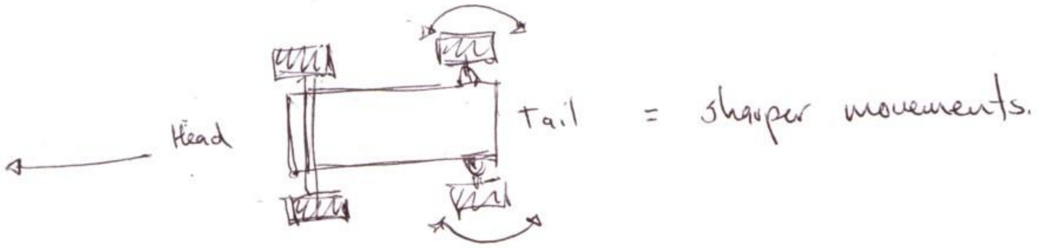
Because the base was going to be such a complex part of my design, I had an initial idea of using a pre-fabricated remote control device such as a remote control car with basic forward, backward, left and right controls. In doing so, I wouldn't have to design, develop and manufacture my own base along with all the electrical componentry required to run it.
Although in theory using a pre-made remote control device that the dog would sit on top of would appear to be easier in some regards, it may prove to be harder than I had initially thought. Because I wanted to stick with the idea of having the legs of the dog connected to an offset point on the wheels of the base, it would mean that (if a pre-fabricated base was used) the two front legs would not only have to be able to move back and forth, but pivot at the shoulder also. This is due to the front wheel steering a pre-made remote control device would have.
(20 April 2012)

I continued to sketch up a couple of concepts that might help reduce this problem.

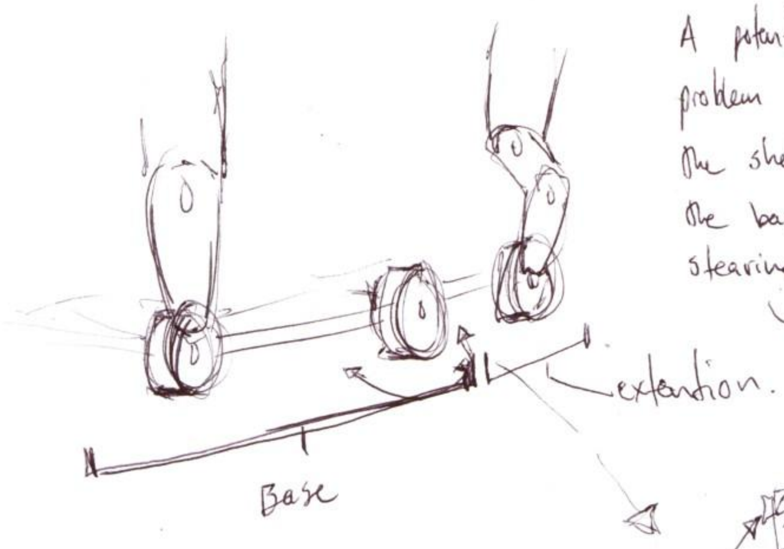
Steering Mechanism Concept:

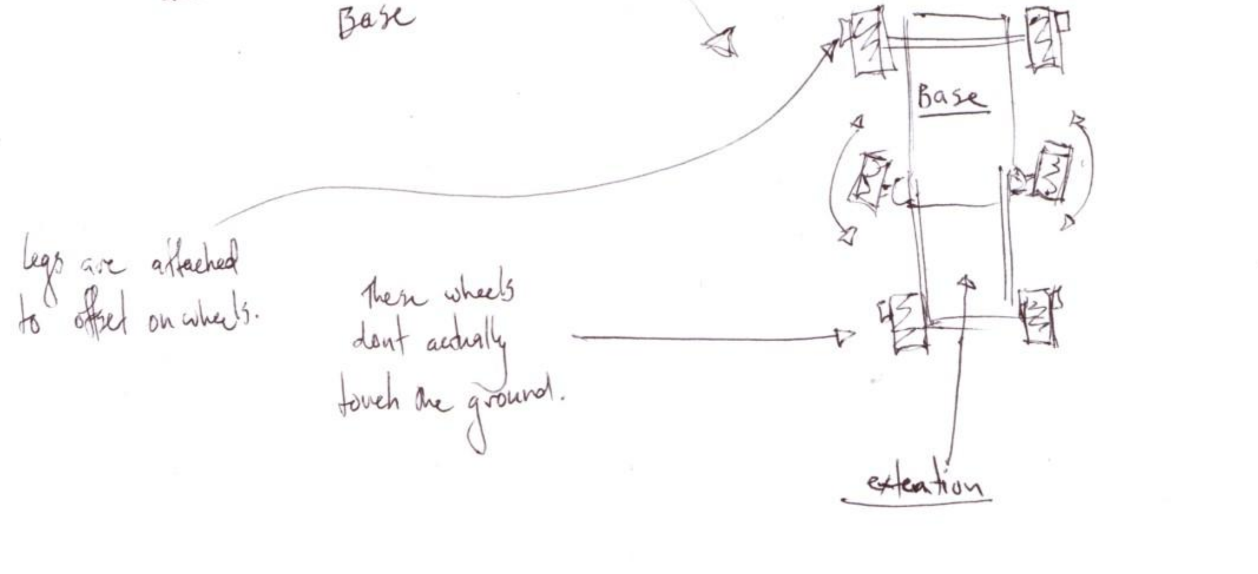
I had the idea of flipping the base so that the steering wheels were at the back like you would see in a forklift. Because of this reverse steering system, forklifts are able to make much tighter turns as a pose to a vehicle with front wheel steering. And so, I thought this might be a beneficial attribute of the dogs movement in being able to turn tightly.

thought this might be beneficial for my own design. Would make it more like how a dog would move.



A potential solution to the problem of having a pivot at the sholder could be to extend the base backward with the stearing wheel in the middle.





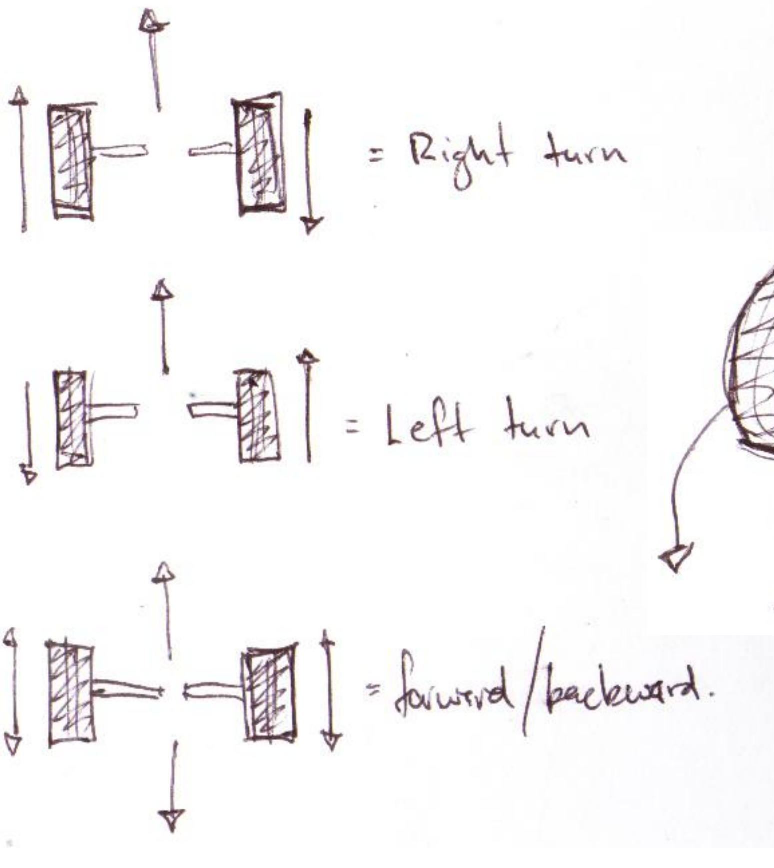
However, even though this would potentially improve the dog's movement, I decided that creating the dog on top of a pre-fabricated base would be too restricting to my initial designs. As well as this, having to create certain 'rigs' and 'set-ups' to specifically fit around the pre-fabricated base would require more time designing and testing.

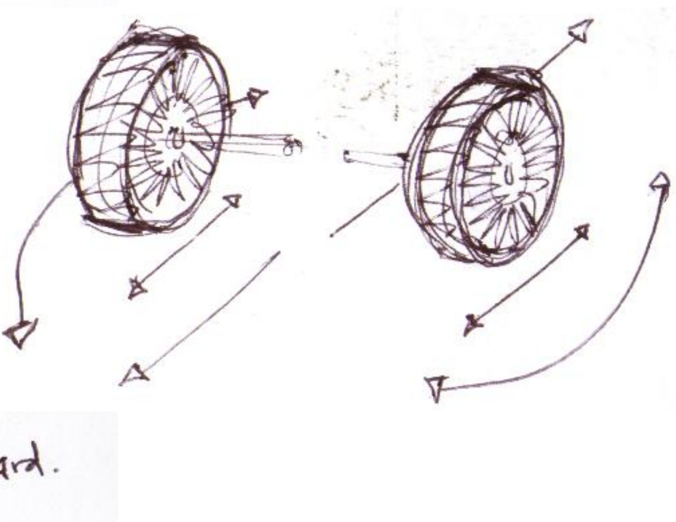
Even though it would seem that creating a remote control base entirely out of scratch would require a lot more work and more time spent designing each and every part, I think that in fact it would be a lot easier. If I were to create my own base, I would be able to work within my own limitations and not of the limitations of a pre-fabricated base. This in turn would allow me to create a dog in relation to a specific size and shape that I specify, as a pose to creating a dog to the shape and size of a pre-made base. (23 April 2012)

Fortunately, Mr Lower (my physics and electronics teacher) lent me a small infra-red remote control tank kit-set he happened to have so I could test and investigate different remote control methods. (20 April 2012)

(See "Concepts, Research and Development: Electrical" for testing, investigation and research in the remote control systems that will be required to run the dog)

Because this kit set was of a tank design, it used a different kind of 'Base' compared to a standard remote control car. Instead of having one motor that drives the rear wheels while the front two steer, the tank was mounted with two separate motors on either side of the base. To steer, the two motors would drive in opposite directions, thus allowing it to spin on the spot.

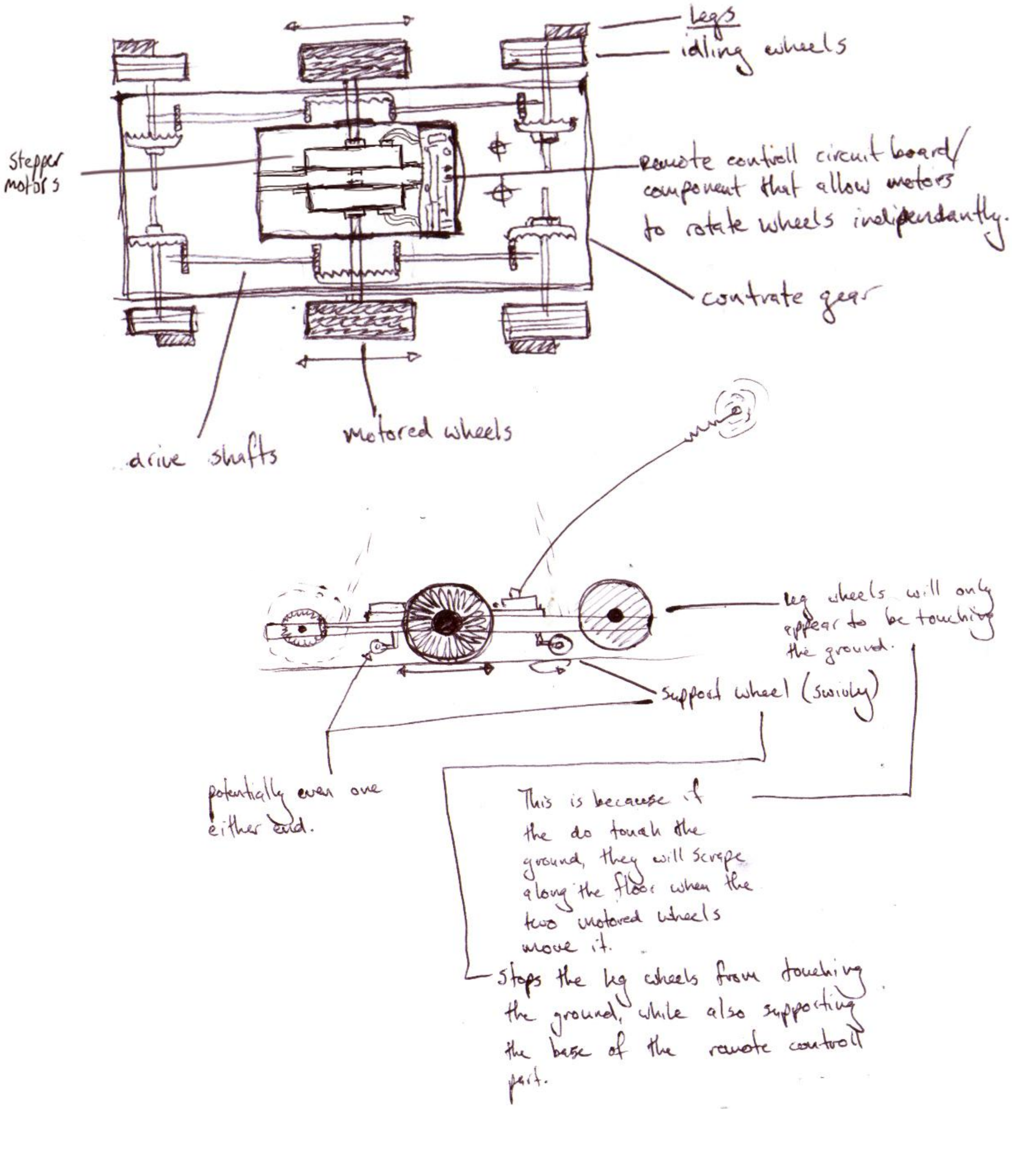




Drive Mechanism:

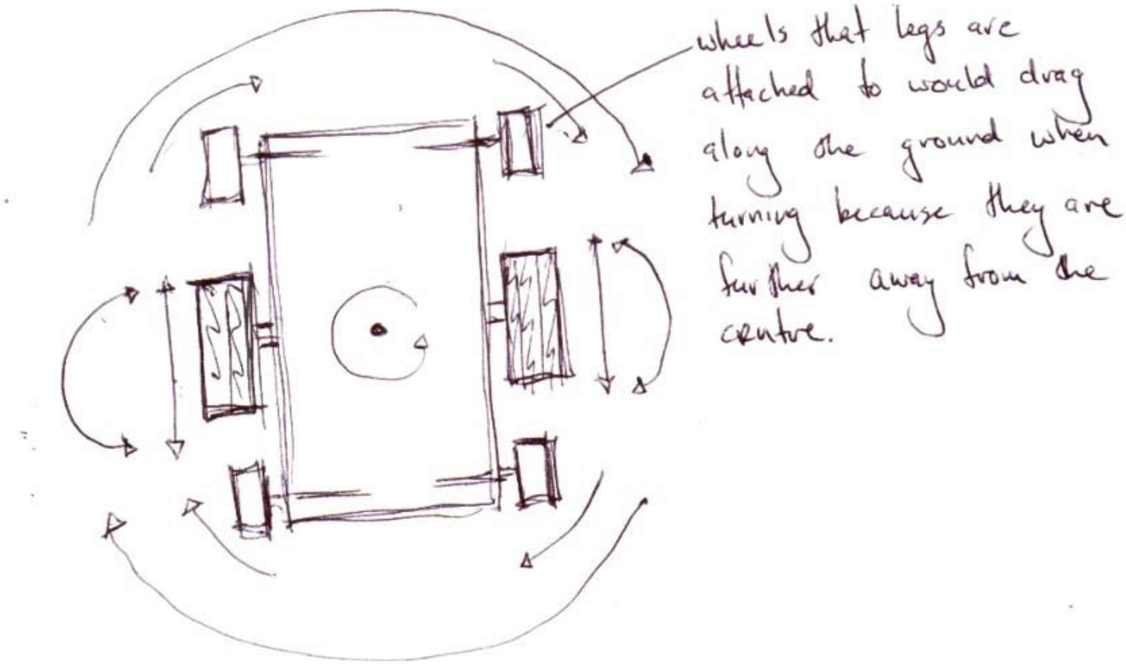
Not only would this type of drive mechanism be beneficial in making it easier to design and manufacture my own base from scratch, but it also provides the ability to spin on the spot (a key attribute that Lewis wanted so that it would look like it was chasing its tail) and turn sharply, and so, better resemble a dogs typical movements. (24 April 2012)

I sketched up a couple ideas that could allow the dog to be manufactured over a base design like this, while also keeping in mind that the legs need to move to resemble a walking motion.

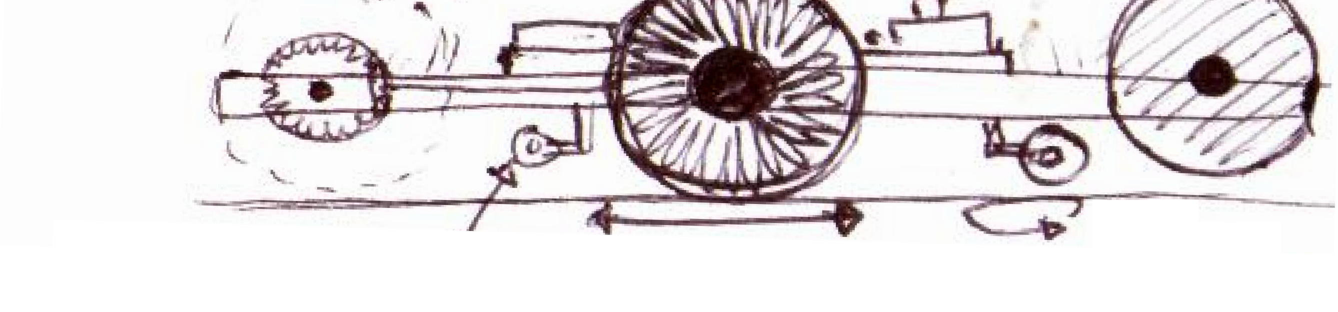


Using the remote control tank that Mr Lower gave me as reference, I have produced an initial idea for how the base could be made as shown on the previous page. The main structure really only needs to be a platform with a section cut out of the middle big enough to fit the two motors and the circuit board that controls it. At this stage I am unsure what type of motors I will use, but because Mr Lower happened to have two spare stepper motors in his back room at school I decided to include these in my design as they seemed like they would be able to do the job.

Because the middle wheels are what will physically drive the base, and so, allow the base a three hundred and sixty degree rage of movement on the spot due to the tank design, I have had to design it so that the wheels that the legs will attach to do not touch the ground. This is because if these wheels *were* able to touch the ground, then they would drag when the dog turned, and so, increase the friction.



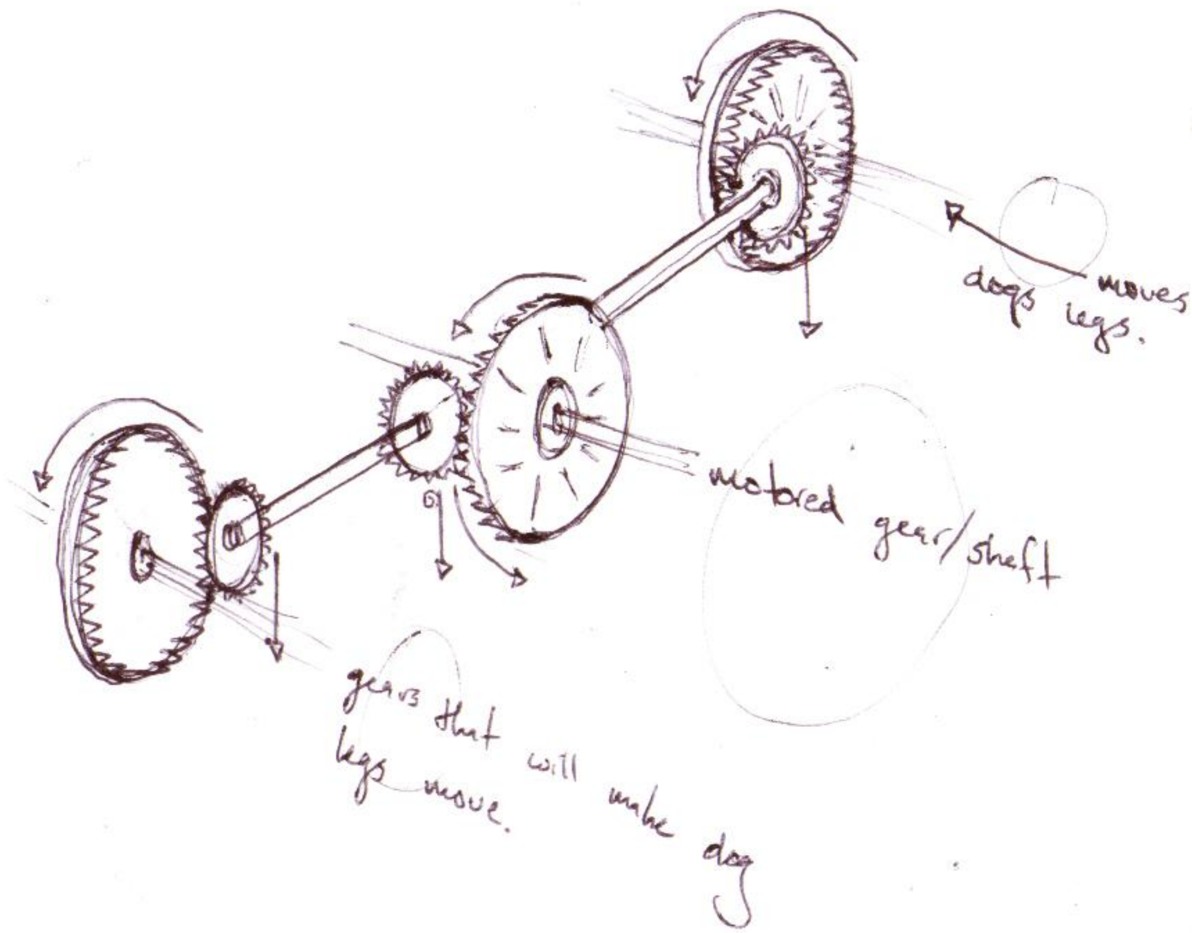
This is also due to the wheels that the legs will be attached to having a larger radius than the wheels that move the dog at the centre. To fix this problem, the wheels connected to the motors at the centre will have to be larger than the wheels the dogs legs are attached to. However, this causes another problem, due to the centre wheels being larger, the base will tip/rock back and forth. To reduce this problem, small swivelling wheels can be attached to the bottom of the base to keep it horizontal with the ground as shown below.



Drive Shaft Mechanism Concept:

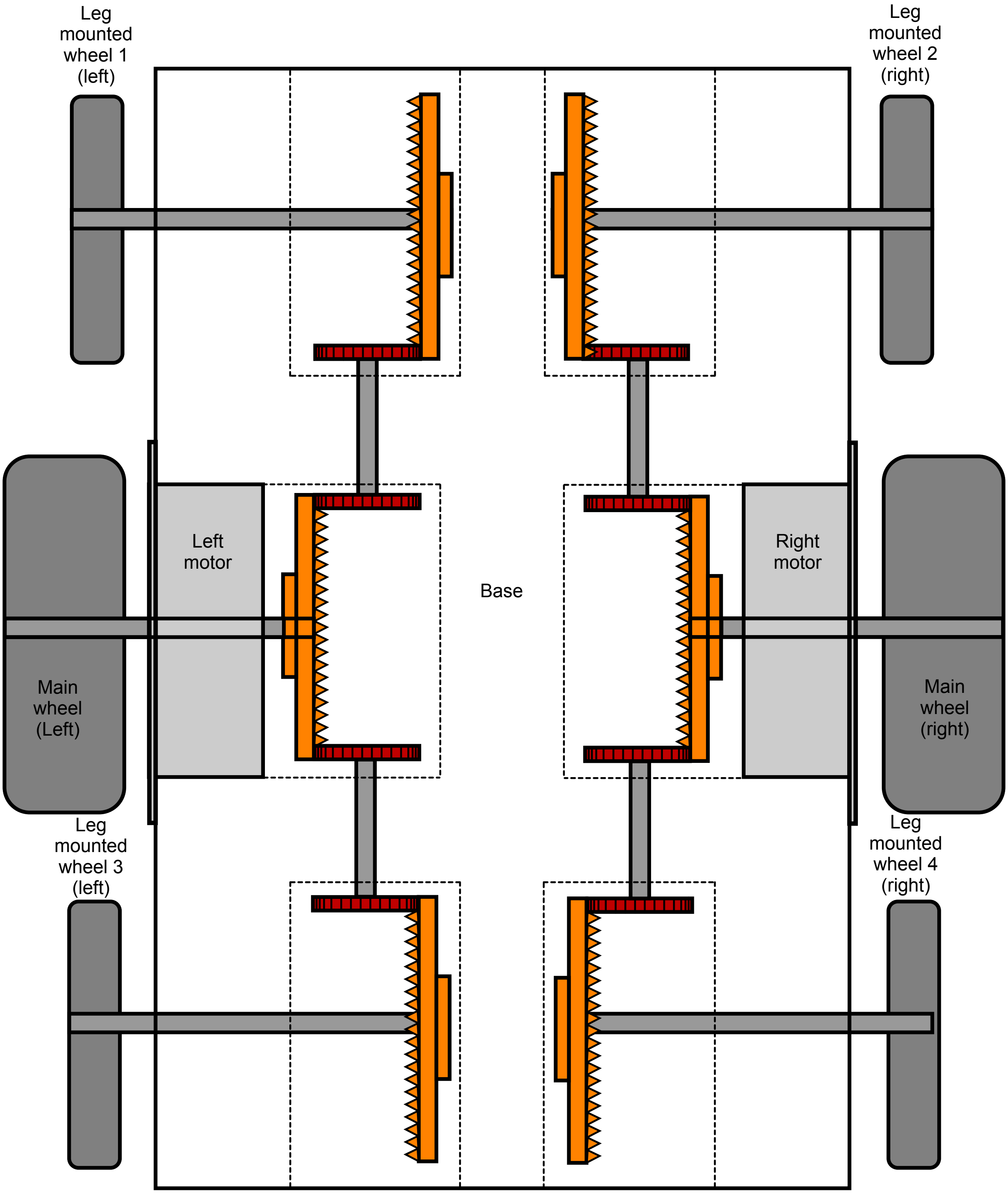
Because the new base concept only requires two wheels to be on the ground to move, and because the wheels that the legs will be attached to can't touch the ground due to the rotating motion, I have come up with a design that uses a series of gears and axles to allow the legs to move as shown below.

To allow the legs to 'walk' in time with how fast the dog/base is moving, I will have to calculate and find the right gear ratios in order to do this.



However, for the time being, this is my initial concept to allow the legs to move in time with the movement of the 'tank-like' base. The centre contrate cog will be directly attached to the main wheels that touch the ground, from here, two axles with cogs at either end will extend either side of the centre. At the end of these axles will sit another two contrate axles which will be directly connected to the wheels that the dogs legs attach to.
This in theory should allow the legs to move directly in time with the speed the dog will be walking at once the gear ratios have been calculated. (24 April 2012)

Base schematic: Refined Gear Concept



Although this is not to scale and the measurements are wrong, I have produced a refined concept on ‘Xara Photo and Graphic Designer 7’ to show exactly how I intend on setting up the gears inside the base including the two stepper motors.

(25 April 2012)

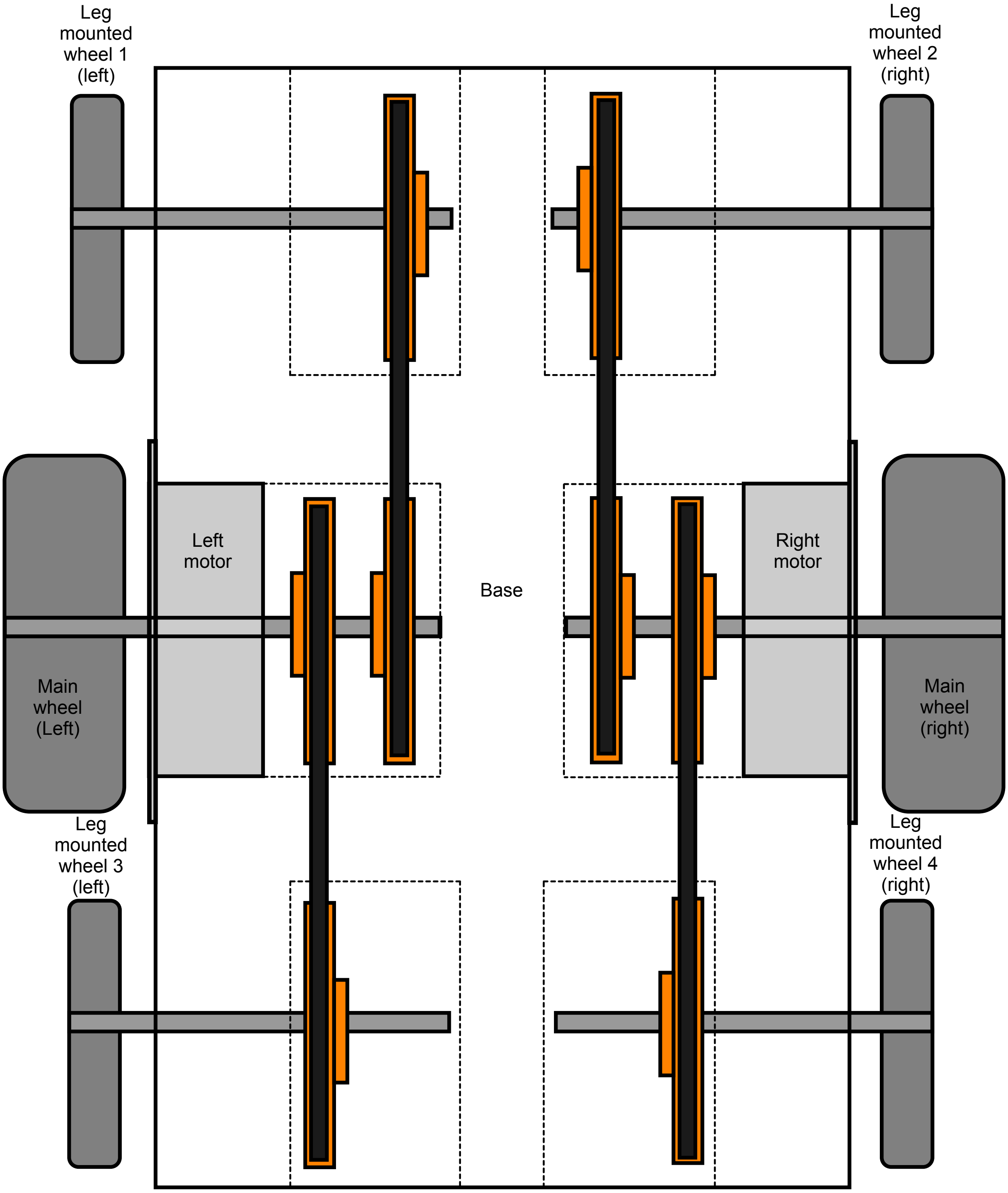
Peter Cowan

At this point in my project, I had been introduced to Peter Cowan, the IPENZ professional engineer I am required to work with to make my project eligible for scholarship.
Peter Cowan is an assistant engineer at the electrical division of 'Delta' and Ambassador of Techlink who will be able to assist me with various aspects of my project, in particular, the design and manufacturing of the circuitry that will be required to allow the dog to be remotely controlled.

On the 18th of April 2012, I met up with Peter for the first time at school to explain and discuss my project with him, and so, see if he could critique any areas of my designs so far. Fortunately, after showing him the base design concepts I had done on the previous pages, he suggested a much more efficient method of moving the legs via the mechanism inside the base. Instead of using a gearing mechanism to link each leg to the main motored wheels, he suggested using some sort of pulley system to reduce the amount of gearing that would be needed. In doing this, the amount of precise mechanics I would have had to design and manufacture would be greatly reduced.
As well as this, we also discussed various alternatives to using stepper motors as the main motoring system. Peter suggested using permanent magnet DC motors instead of stepper motors, as setting up a stepper motors can require a lot of work and prior knowledge (both of which we weren't very confident with as peter nor I had very much experience in using).

From this meeting with Peter, I can now re-design the gear system with pulleys and permanent magnet DC motors.
(28 April 2012)

Refined Base schematic: Pulley concept



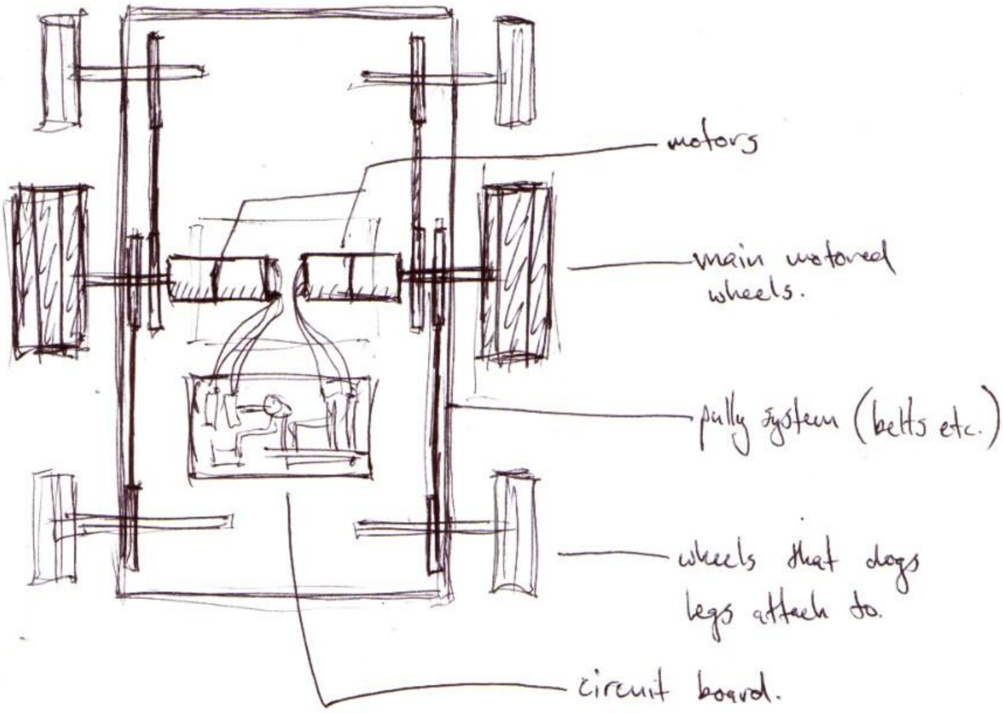
After meeting up with Peter and discussing an alternative method in allowing the legs to move in time with the motors, I have edited the base concept I produced earlier to have a pulley system as a pose to a gear system as shown above. However, I still need to design and develop the base to allow for permanent magnet DC motors instead of the stepper motors shown in the picture above.

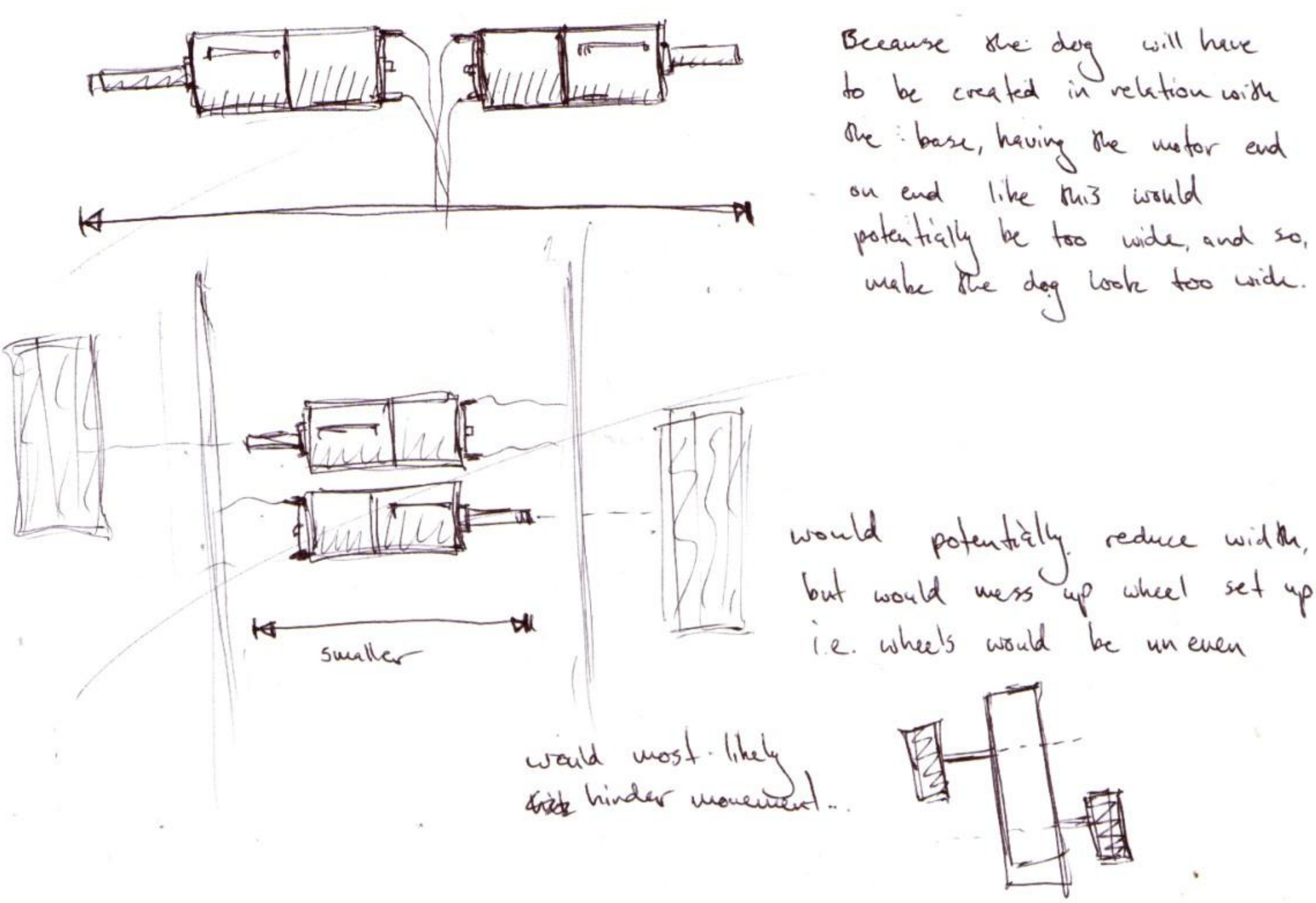
(30 April 2012)

Refined Base Concept: DC Motors

I went into the Dunedin branch of 'Jaycar Electrical' to see if I could find a DC motor suitable for the base as Peter had recommended. Fortunately, I was able to find a 12 volt, geared down 70RPM, permanent magnet DC motor. I text Peter to ask him if he agreed with the motor choice and he seemed to think that that would be able to do the job. However, because it spins at 70RPM, I would have to calculate the wheel diameter to ensure the dog moves along the stage at the right speed.

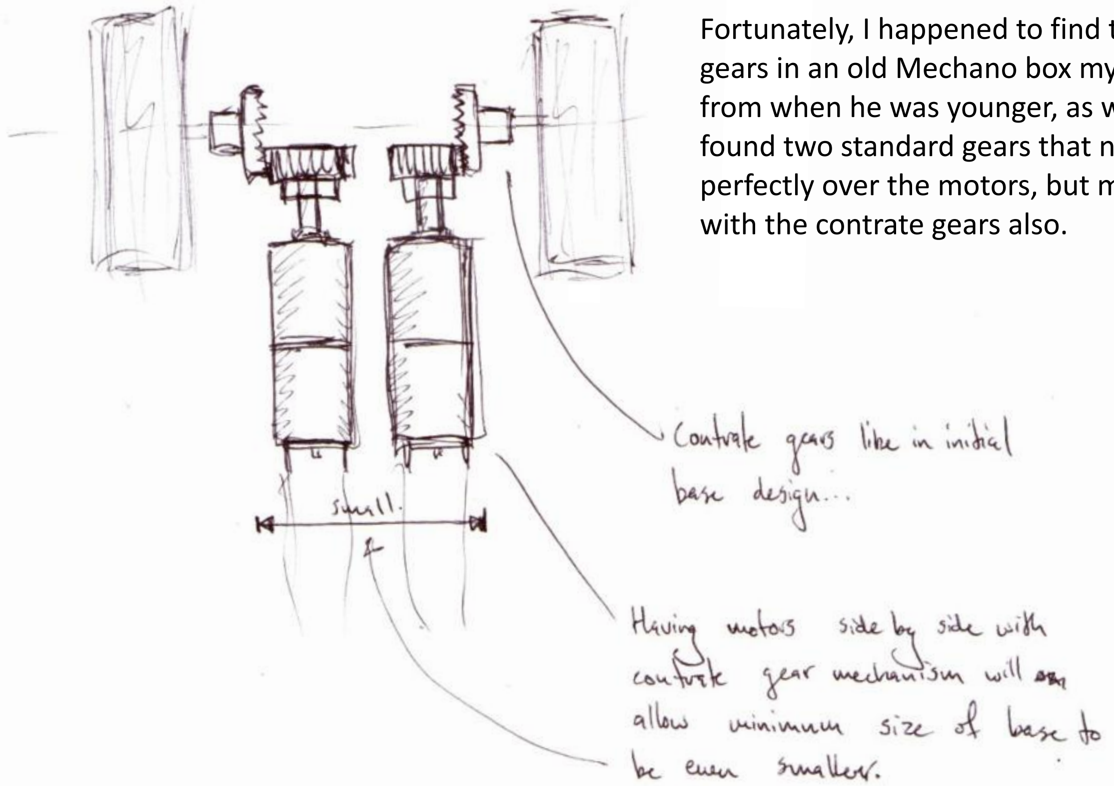
(1 May 2012)



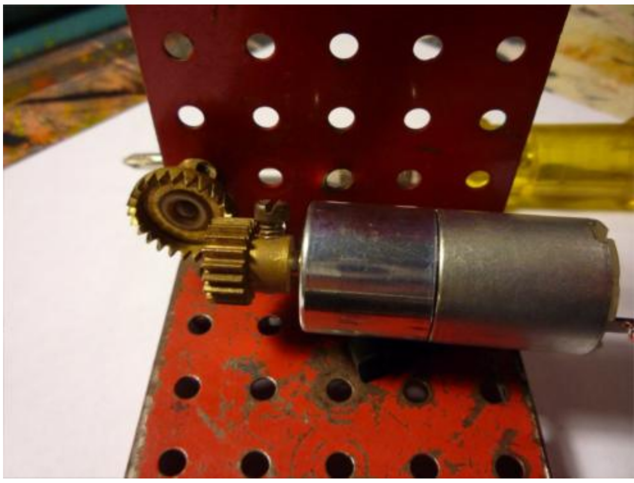


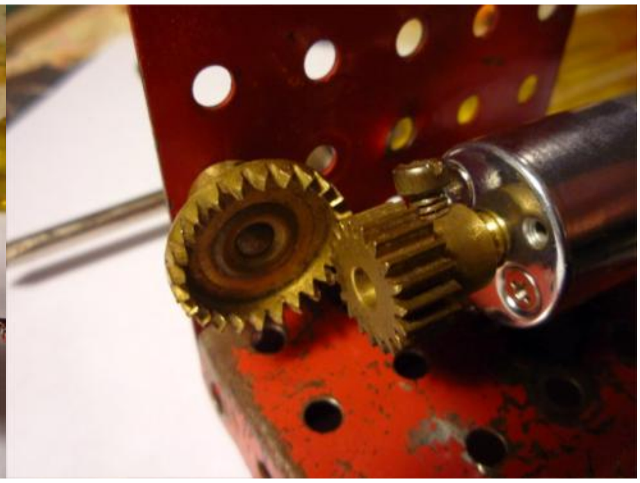
Motor Rig Concept and Prototype:

After thinking of different ways of arranging the two motors as to reduce the width of the dog as shown on the previous page, I managed to come up with a system that would allow the motors to both face the same direction and sit side by side in the base. Like the original design for the mechanism that would allow the legs to move on the base, this rig will use the same sort of mechanism, in particular, the contrate gears.



Fortunately, I happened to find two contrate gears in an old Mechano box my dad had kept from when he was younger, as well as this I found two standard gears that not only fitted perfectly over the motors, but meshed perfectly with the contrate gears also.





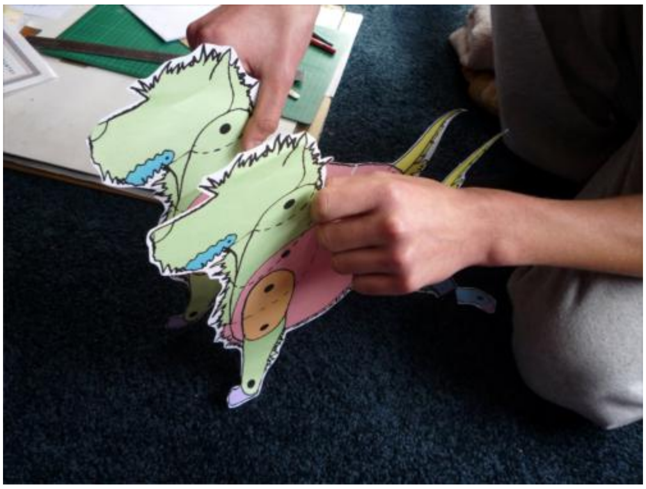
Although it will require a little more work to make this rig functional, it is far better than having the motors end on end or side my side facing opposite directions (as shown in the concepts on the previous page). As well as this, the minimum width of the base will now be able to decrease significantly due to the motors being side by side.
I will now have to design a rig that can hold the motors parallel to each other like in the drawing above, as well as keeping in mind how wide the dog must be and how the base is going to be constructed.

(2 May 2012)

Width Determination:

Before I start developing the base, a crucial specification of the dog I need to find out is exactly how wide it is going to be. Once this measurement is found, I can then use it to design and develop the base in relation to the width of the dog.

In order to find the width of the dog, I have used two cut outs of the dogs outline I had produced earlier and held them side by side as shown in the pictures below.



From here, I increased and decreased the space between the two cut outs in small increments while asking my mum what width she thought looked proportional to the rest of the dog.
Once we had come to an agreement on what we thought looked good, I got my mum to measure the distance between the two cut outs.

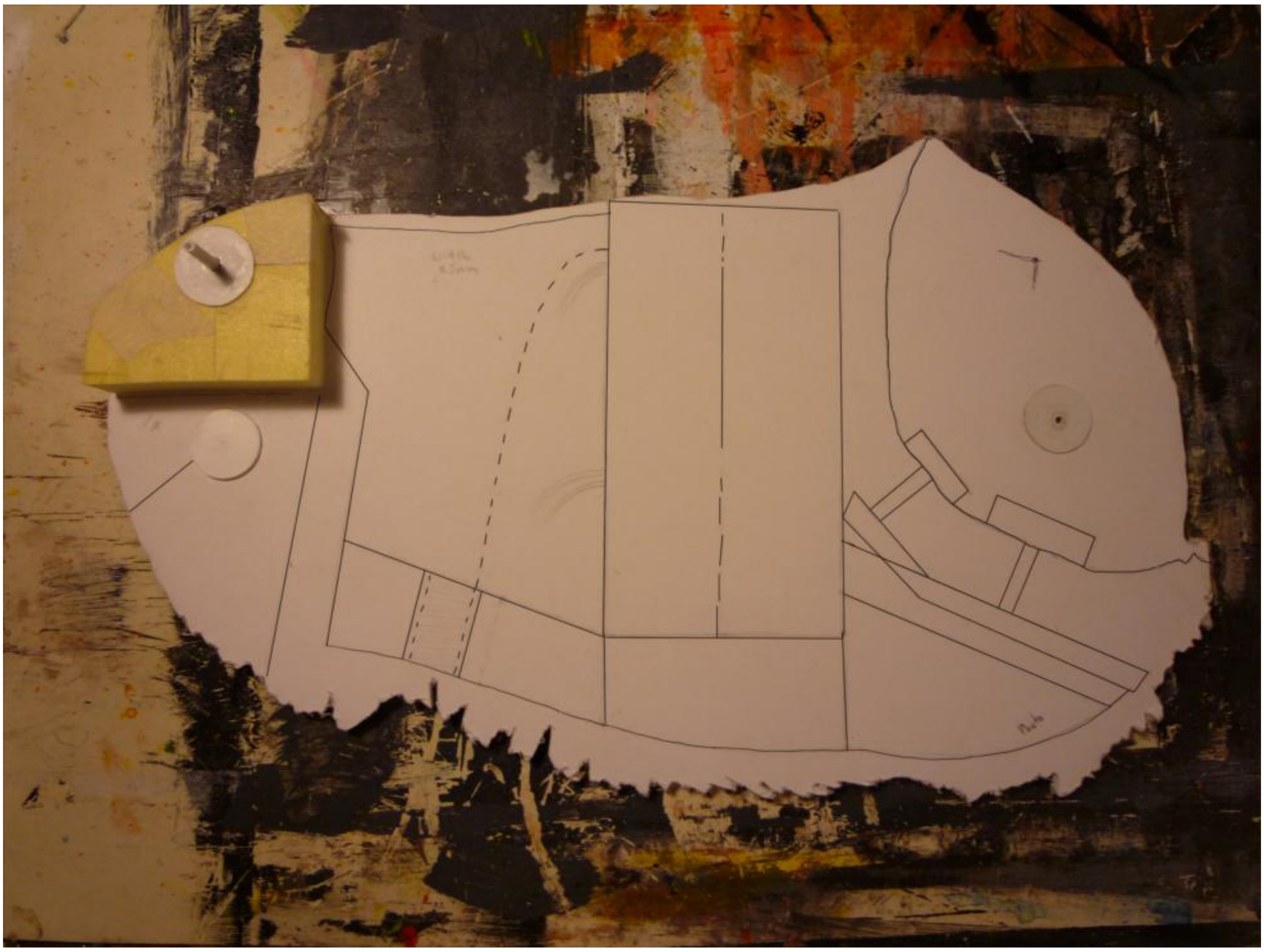
We both agreed that the width of the dog looked best at 85mm. I can now use this measurement to design and develop the base in proportion to the dog. As well as this, I can now make the actual dog out of the Dense Foam board and Foam Core board.

(4 May 2012)

Revised Brief and Developed Specifications:

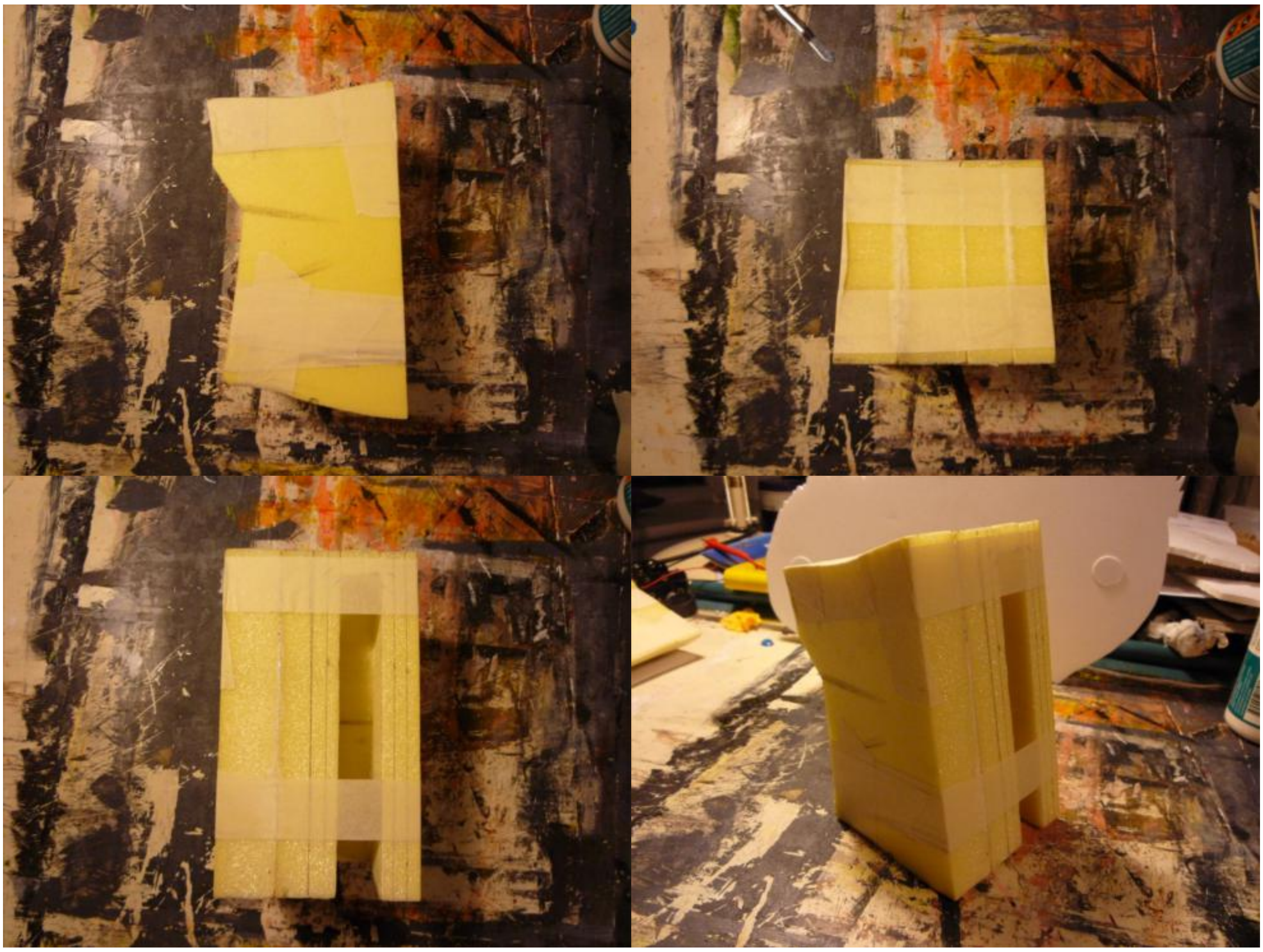
My task is to design and manufacture a fully functional Cairn terrier-like dog prop that is to be used in the 'one-man-play' "My Brilliant Divorce" (by Geraldine Aron) directed by Lewis, my main stakeholder. I have been asked to design develop and construct a stylized, two dimensional-like, life sized dog that is able to be remotely controlled via someone in one of the stage wings. The dog, who's name in the play is Axl, must be table to move forwards, backwards, turn left, right, and spin on the spot as though chasing its tail. Additionally, Axl must having a movable head with an openable and closable mouth as to hold the scroll of divorce documents in. As well as this, the tail must be able to wag back and forth when he moves. Axl must be finished in a light brown colour (to be specified later) so that when the lights are dimmed, he will remain visible. Axl must be visible and identifiable from every seat in the auditorium. The duration of the play is approximately two hours, this means that the battery source that is supplying the dog's power and the battery source that is supplying the remote control handset must be able to run for this long. It would be beneficial for the materials used in the construction of this dog to be lightweight and durable as to take any unwanted pressure off the moving parts, yet sturdy enough to not break under its own weight. To meet this these material specifications, I will be manufacturing Axl out of Foam Core Board, Dense Foam Board, MDF Custom Wood, Plastic and Pine. To meet the deadline, this dog must be designed and manufactured by the 18th of August. Although the season of the play is the 24th of August - 1st of September, the dog will be required for rehearsal at least one week before the play opens.

Interior Body Structure

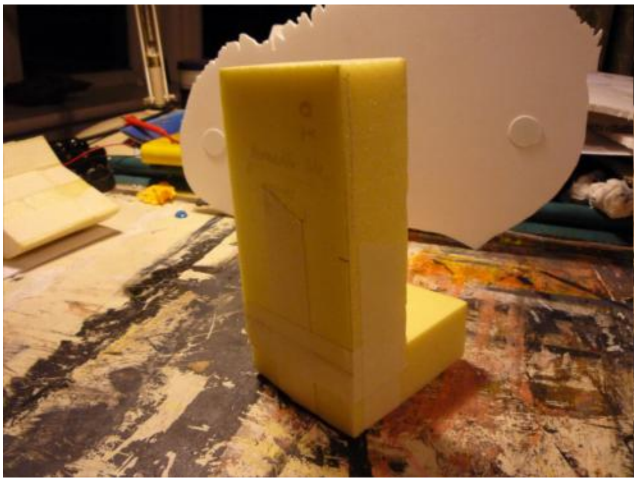


Using one of the cut out sides of the dogs body, I have drawn on various shapes to represent where the dense foam board will be inside the body. From this, I can easily transfer these shapes onto the dense foam board, make sure the width is 85mm, then cut it out using the band saw.

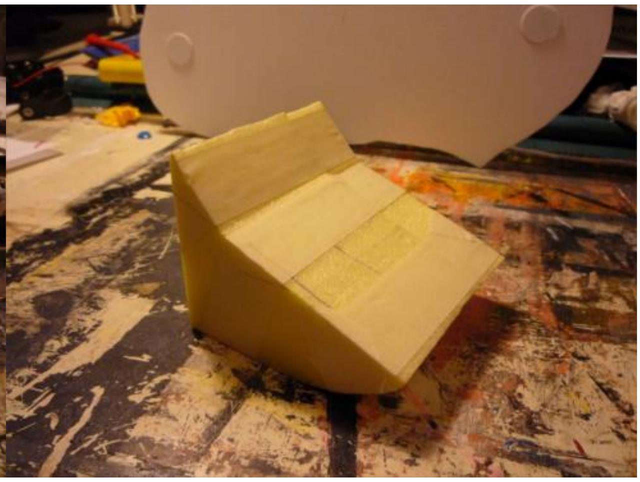
Rear foam section:



Centre foam section:

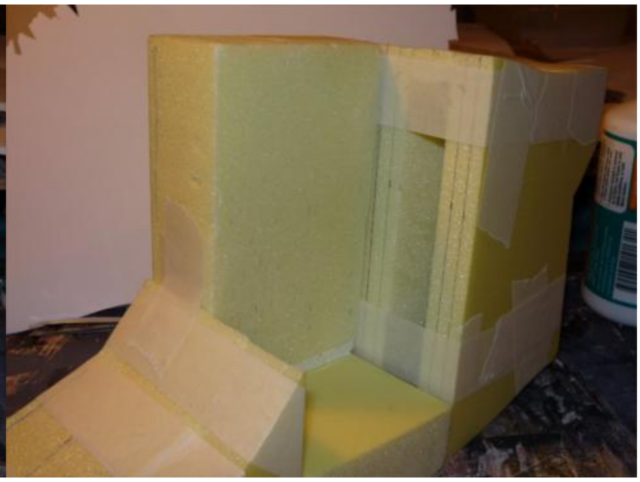


Front foam section:

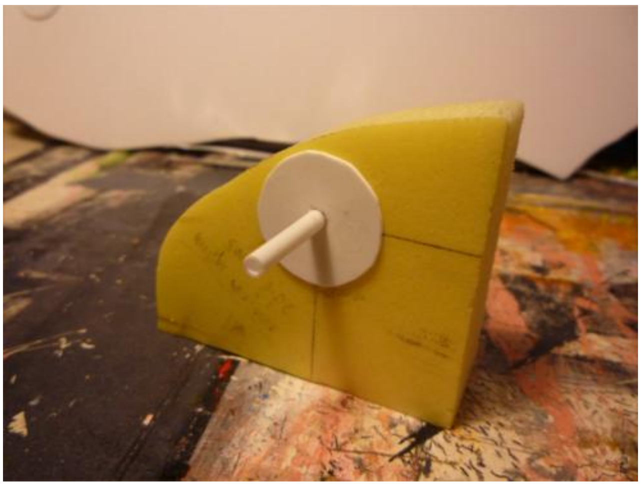


In the ‘Rear foam section’ there is a small gap between the layers of foam as shown above. I have designed it like this so that the wires connected to the motors and the battery are able to travel up through the body and into the circuit board that will sit in the gap in the ‘Centre foam section’.


Each section of foam is glued together using standard PVA glue so that it makes one whole unit as shown in the first two pictures.

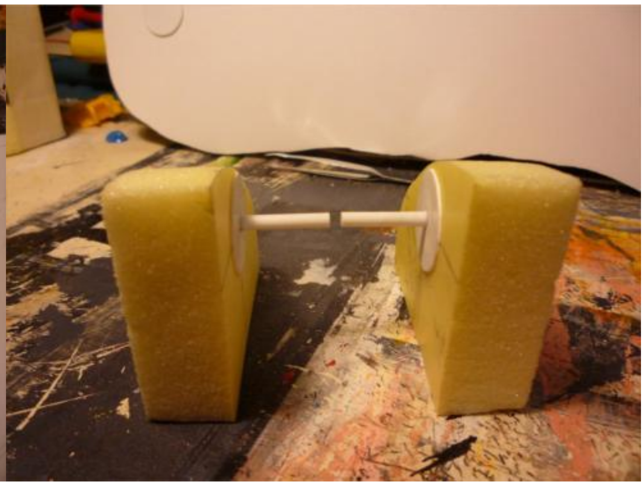



As mentioned on the previous page, the large section missing from the middle of the foam structure will hold the circuit board. The wires that come off the circuit board will then travel down the gap through the rear section of foam to where they will attach to the motors and battery.

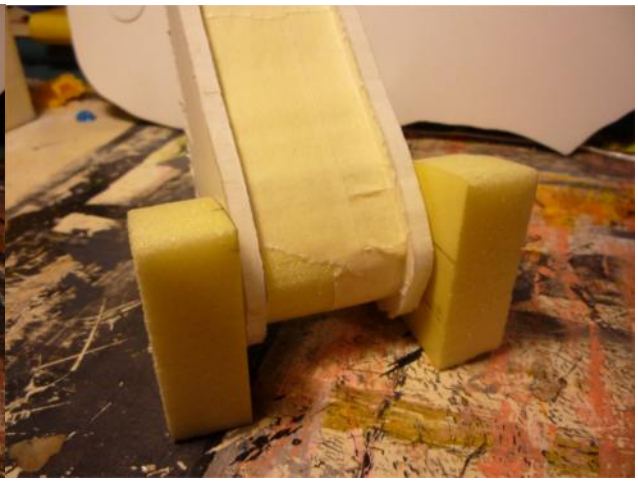


Sitting directly behind the interior foam section will be the mount for the tail. This mechanism uses the same structure and joint method as in the head/neck. However, Instead of being attached to springs (like the head) the bottom of the tail will be connected to a crank that attaches to a pulley on the base. This pulley will be linked directly to the main wheels, so when the dog is moving, the tail will wag back and forth.

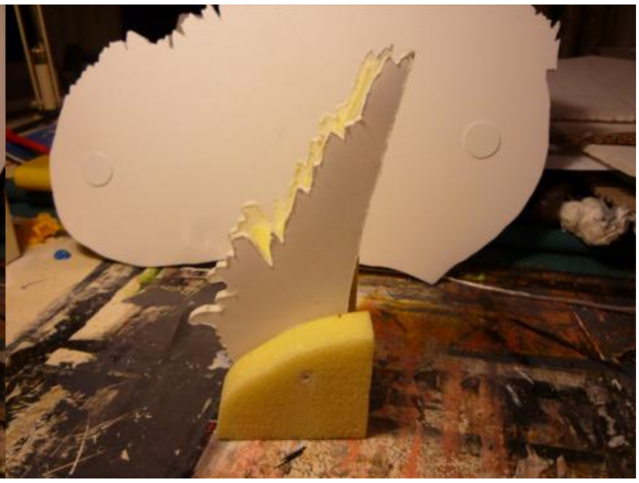
Tail Mount Construction:

The picture on the left shows where the tail joint will be positioned on both sides of the dogs body. The picture to the right shows roughly how the two halves of this joint will sit when the dogs body is assembled. Due to the dog having a removable side, the two halves of the joint will be separate, one half being attached to one side of the body, and the other being attached to the other side.

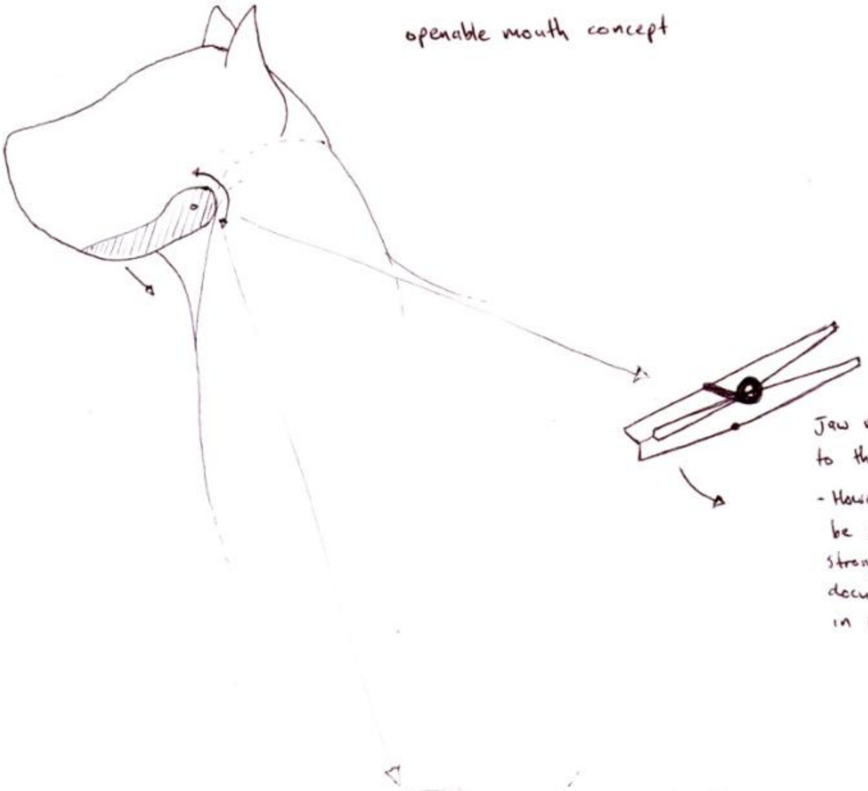



The tail will slide over the two tubes and fit into place like so.

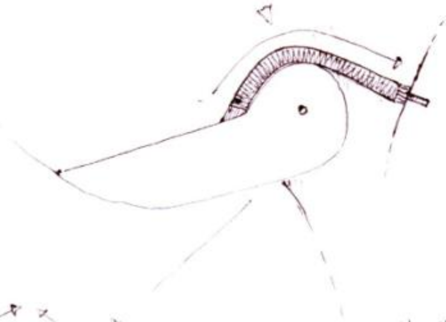



Thus allowing movement to the tail as shown above.

Jaw Mechanism Concept and Development:

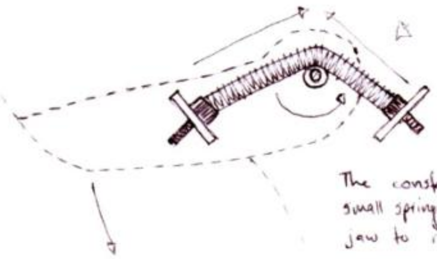


Jaw mechanism will be similar to that of a standard peg.
- However, peg spring may or may not be suitable as it may be too strong, and so crush the paper documents that must be placed in its mouth.

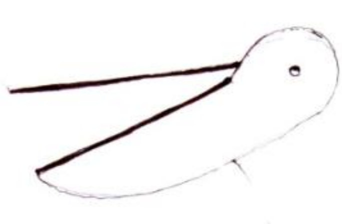


alternative to the peg mechanism, the jaw could be held shut with either one or more small springs. each spring would be attached from the top of the bottom jaw, and would stretch back over the hinge where it will be connected to a mount somewhere positioned inside the neck.

unlike the peg design, this should be able to hold the documents sufficiently without crushing them.

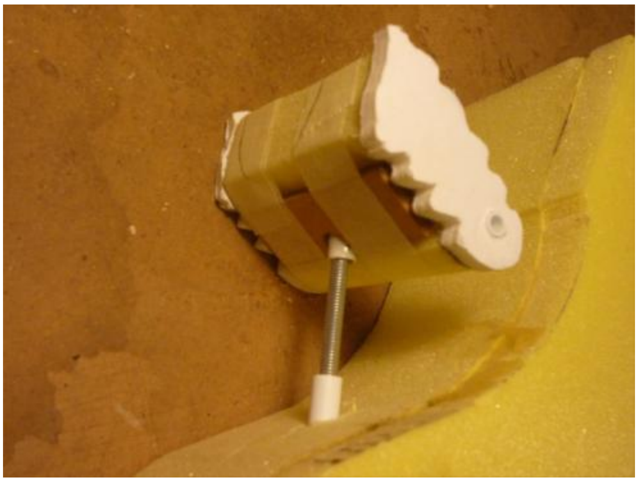


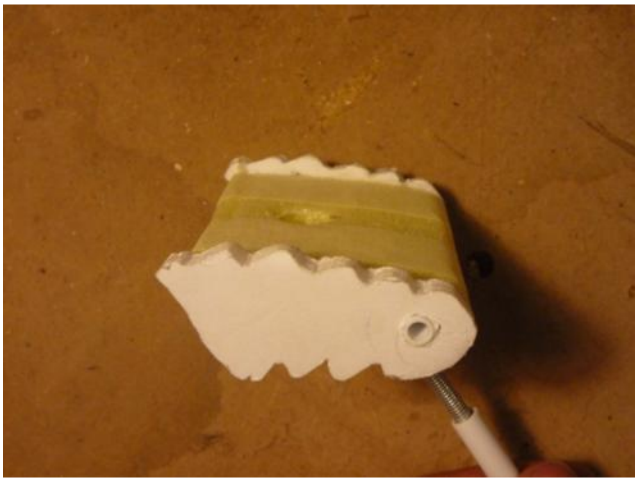
The constant tension of the small springs will enable the jaw to remain closed. However, due to the constant tension the spring will be under, the materials for this part of the construction will have to be chosen carefully as they will be under constant tension all the time weather the jaw is opened or closed.



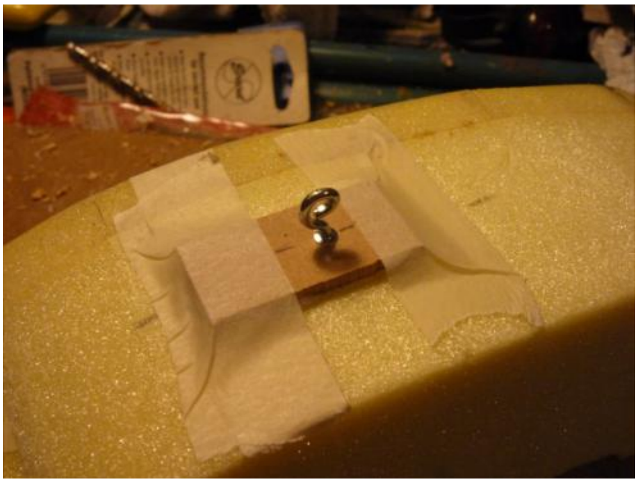
depending on how sufficient the spring system will be, it couldnt hurt to line the bottom and top jaw with thin rubber just to increase the friction between the paper document and the jaw so that its less likely to fall out.

Jaw Mechanism Construction:





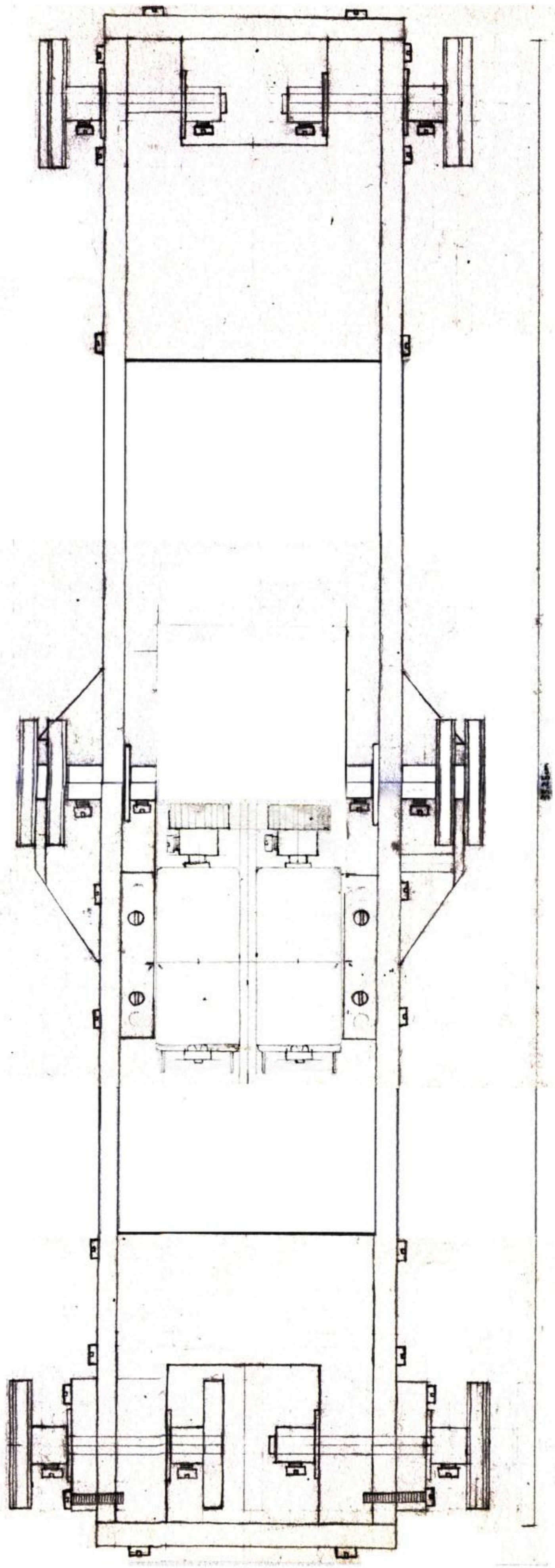
Like the rest of the dogs body, the jaw was designed and constructed using the same method, a Dense Foam board centre with Foam Core board on the outside that makes up the jaw outline as shown above. The jointing mechanism used in the jaw is fairly similar to that in the tail and in the neck, however, instead of the smaller tube having a break in it (like in the head in tail, allowing them to disassemble) it will run right the way through. This is because the head won't have to be disassembled like the rest of the dog, therefore can be permanently set like this.
As shown in the pictures at the top, the plastic tube that slides over the top of the spring gets glued into a hole at the front of the dogs neck. When the head is fully assembled,

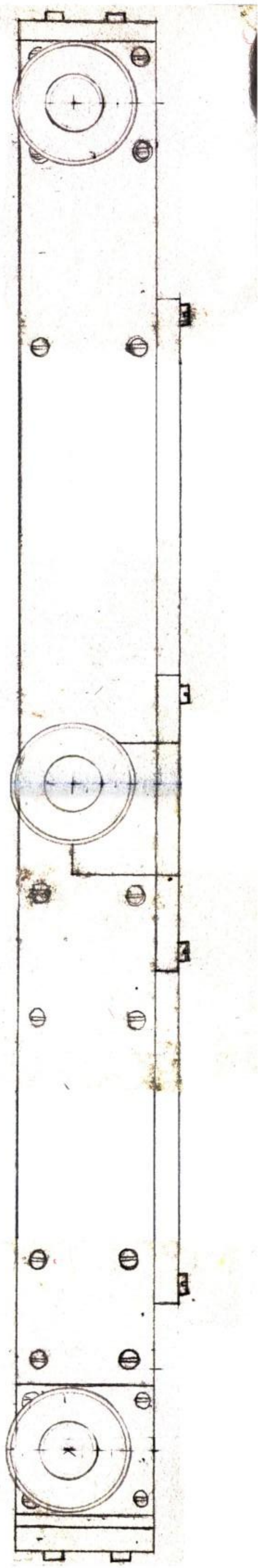


Directly behind the jaw on the back of the neck and at the very bottom of the head structure as shown in the two bottom pictures, are the mounts where the springs that allow the head to 'wobble' attach to.

Base Plan Drawing:

(6 May 2012)



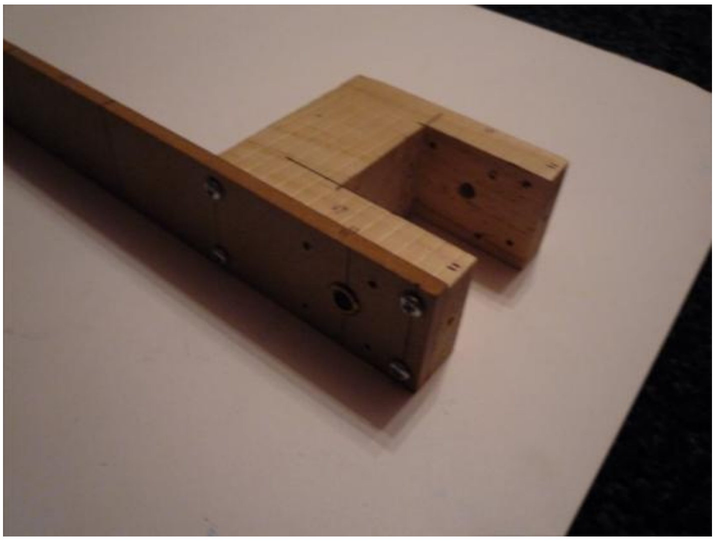


On the previous page I have scanned in the pencil drawing I produced showing exactly how I intend on creating the base keeping in mind the measurement I had found previously. The original drawing was produced on an A3 sized piece of paper at a scale of 1:1. To mark out exactly where the pulleys are to be positioned, I used the Cairn terrier cut out I had produced earlier and measured between the two feet. This measurement showed me where I would have to position the pulleys at either end to ensure the legs will be in the right place when it comes to constructing it. All the different width measurements on the original drawing are in precise relation to the dogs limbs to ensure they attach to the pulleys properly.
At this stage, the majority of the base is to be made out of pine and MDF custom wood, including the rigs that hold the motors and pulleys in place.

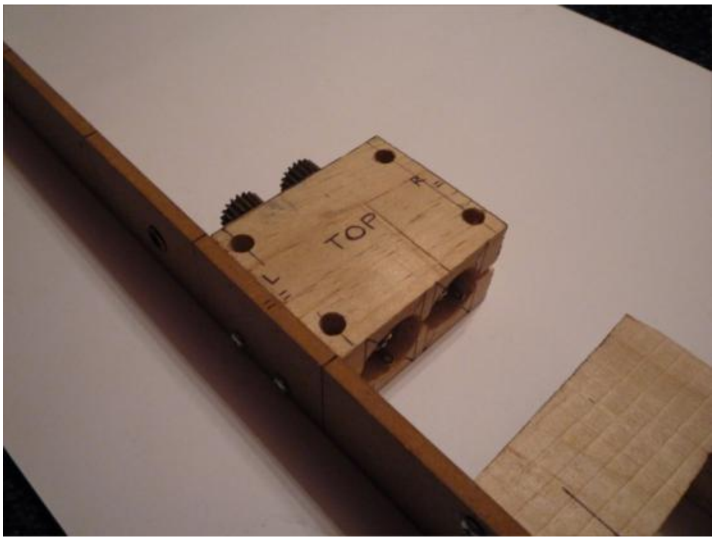
From the original 1:1 scale drawing, I am now able to begin constructing the base as a semi-prototype/final design. I say this because there are certain things that may have to be changed in this design as they cannot be calculated in concepts, but rather, have to be in a physical form to test, and so, I will construct this base design keeping in mind that certain might need to be changed or developed further.

(8 May 2012)

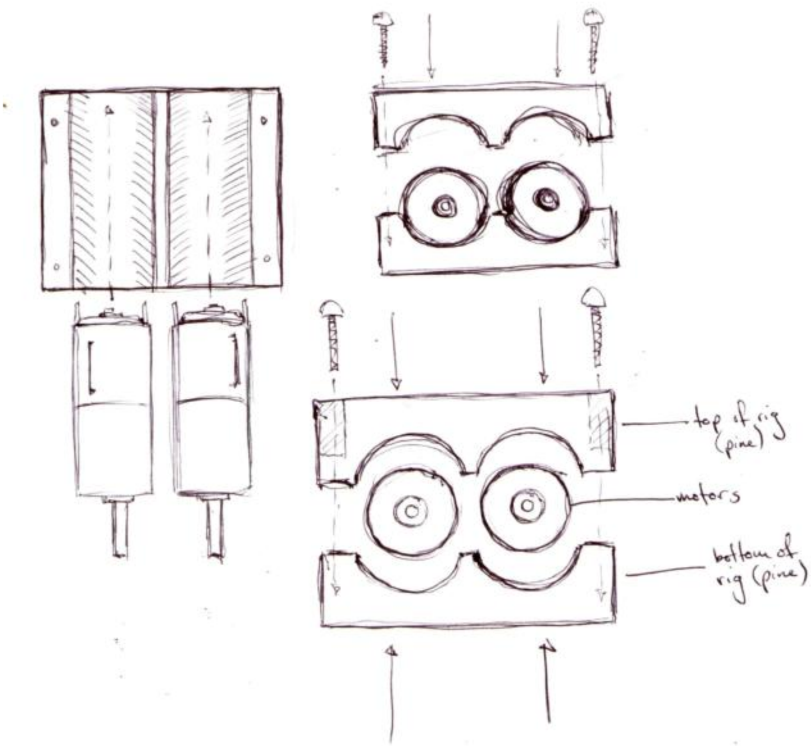
Base Construction:

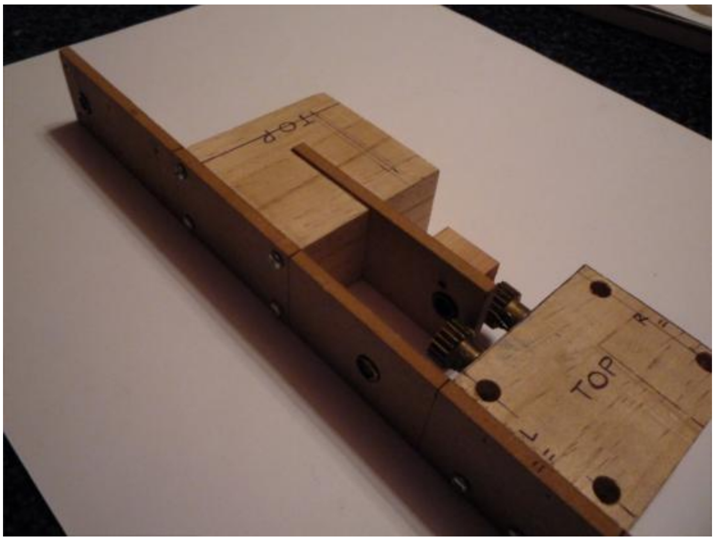


The rear section of the base is slightly larger than the front section of the base, as not only will it hold both the exterior pulleys that the rear legs attach to, but one on the inside to allow the tail crank mechanism to attach to as well (as shown in the base design plan view)

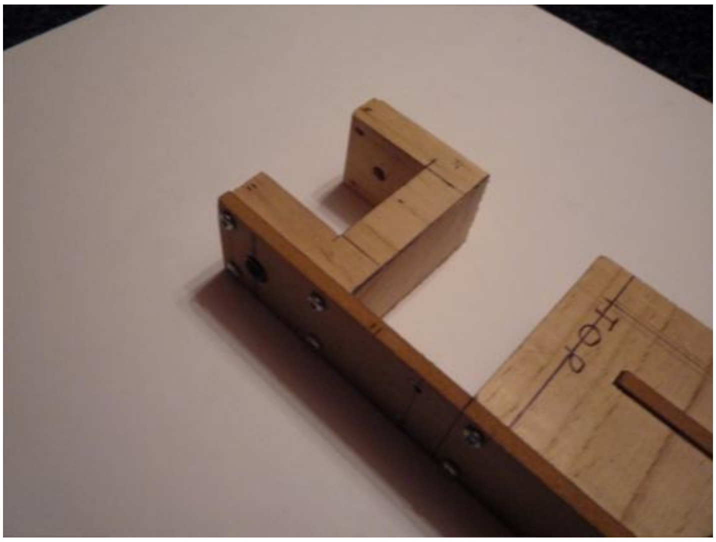


The initial design for the double motor rig (also made of pine) is effectively two pieces of pine with two 21mm holes drilled in them that comfortably clamp down on both of the motors via four screws (as shown in the drawing bellow)

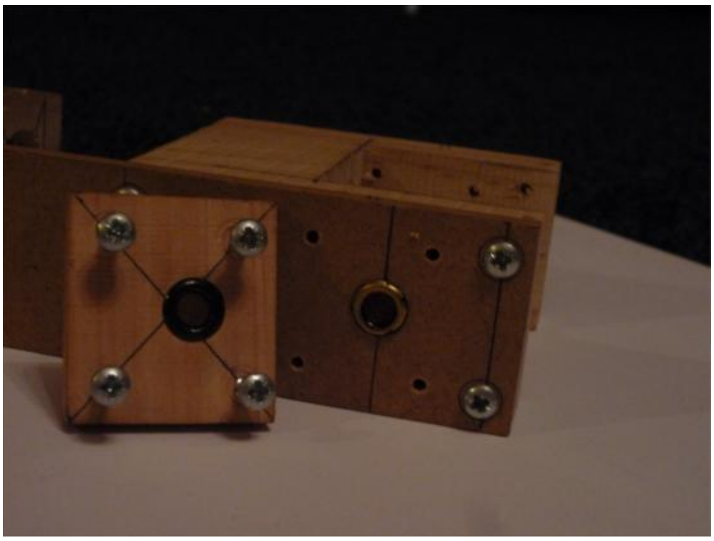




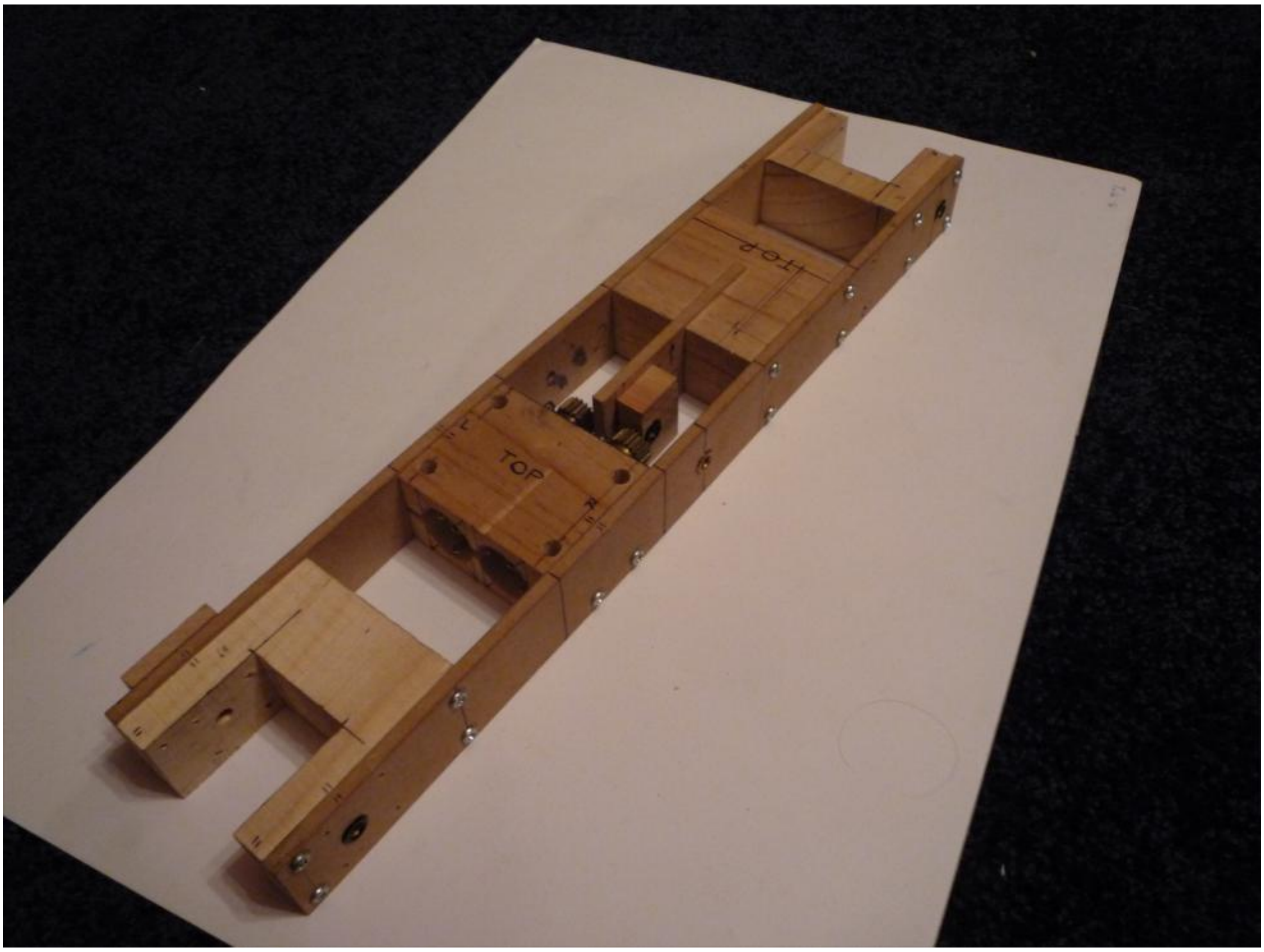
The new mechanism to support the main wheels axle’s (made from pine and MDF custom wood)



The front section of the base will hold both of the exterior pulleys that the front legs attach to.



Small blocks of pine are screwed on the outside of the rear section of the base to act as spacers. This sis because the rear legs have one more joint than the front legs, therefore they extend outward from the body/base further. Two small brass bushes have been inserted into the wood (as well as all the other holes that hold axles) to reduce any unwanted friction.



Running along the sides of the base are two strips of 5mm MDF Custom wood to hold all of the interior pieces together. Each hole that the axles fit through have small brass bushes to help reduce any friction that might be caused if the axles were to rub directly against the wood. Once the base has been completed, I will lubricate these bushes to further reduce friction between the points of contact. The spacer on the right rear section is missing as I forgot to screw it on before I took the picture, however, as shown on the previous page, the two spacers at the back also have brass bushes in them.

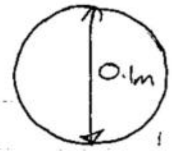
From here I can now start making the main wheels as well as the pulleys that will link the dogs legs to the main wheels. I will also have to design and construct the mechanism that will attach the dogs body to the base. Effectively, this just has to be two legs that extend out from the base and up into the dogs body. As well as this, I will have to meet up with Peter to discuss battery sources that will be able to power the dog for 2 hours each night. (Find Battery research in 'Concepts, Research and Development: Electrical' under the heading **'Batteries'**)

(14 May 2012)

Main Wheel Diameter Calculations:

YG2732 12V DC 70RPM

Wheel size 10cm



Circumference = $\pi \times 0.1m = 0.314m$

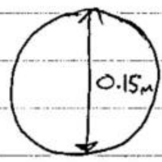
$\frac{70RPM}{60 \text{ seconds}} = 1.16$ revolutions per second

Therefore velocity = $0.314m \times 1.16$ rev/s

= 0.364 m/s ~ 3 seconds/meter

Which is equivalent to 1.31 km/hr

Wheel size 15cm



Circumference = $\pi \times 0.15m = 0.471m$

$\frac{70RPM}{60 \text{ seconds}} = 1.16$ revolutions/sec

∴ Velocity = $0.471m \times 1.16$ rev/s

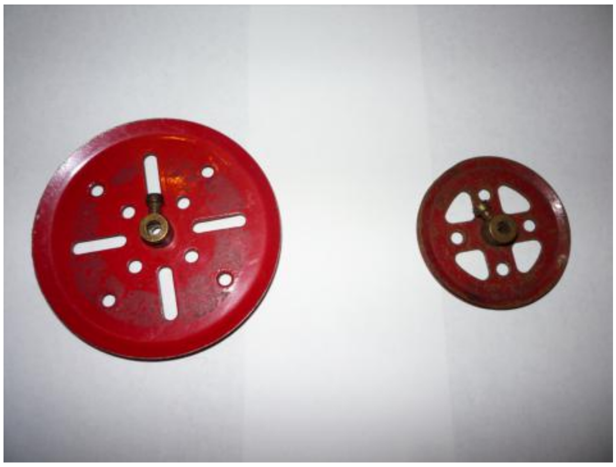
= 0.547 m/s or ~ 1.8 seconds/meter

From these calculations, I have decided to make the main wheels 120mm. This should be large enough to allow an adequate speed in the dogs movement, yet small enough not to lift the base off the ground too much.

(15 May 2012)

Pulleys and Pulley Sizing:

To determine the size of the pulleys that will be required to allow the dogs legs to move, I was able to do some tests with some of the Mechano pulleys that were in my Dads Mechano box that I had found earlier.

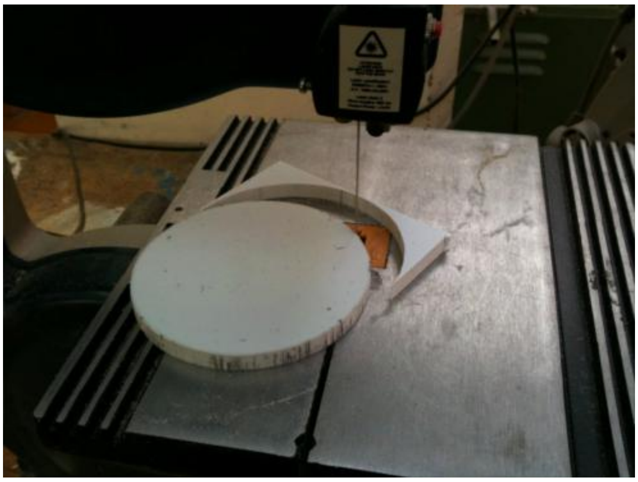


Fortunately, due to the small holes in the pulleys shown above, I was able to see the speed relationship between different diameters. From prior knowledge, I knew that at a large pulley turning a small pulley would make the smaller pulley rotate faster, and that two pulleys of the same size would rotate at the same speed. Using this knowledge, I knew that if the legs were connected to the main wheels, and the pulley system linking the two were of equal size, then the legs would rotate at the same speed as the main wheels. However, I figured that I might be better to have the legs moving slightly faster than the main wheels, simply because the main wheels rotate slightly slower (as seen when I attached the Mechano pulleys to the base).

Because of this, I decided to make the pulleys that connect to the main wheels the size of the outer hole on the red pulley, and the pulleys that the feet will attach to the size of the inner hole on the red pulley. If this doesn’t work as intended on the final product, I will always be able to add slightly larger or smaller discs to where the feet connect to the pulleys.

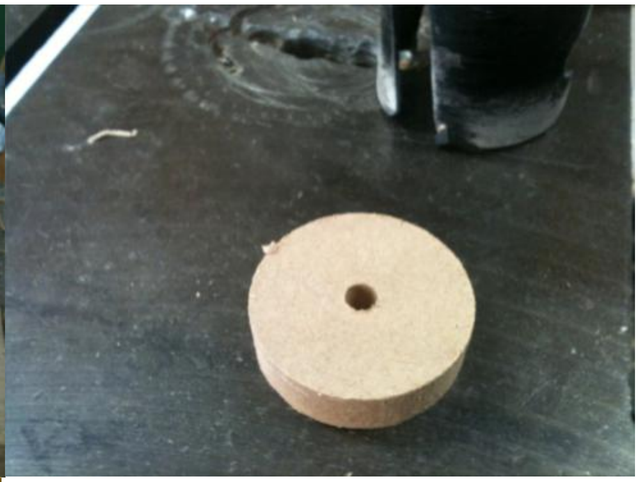
(16 May 2012)

Main Wheel Construction:

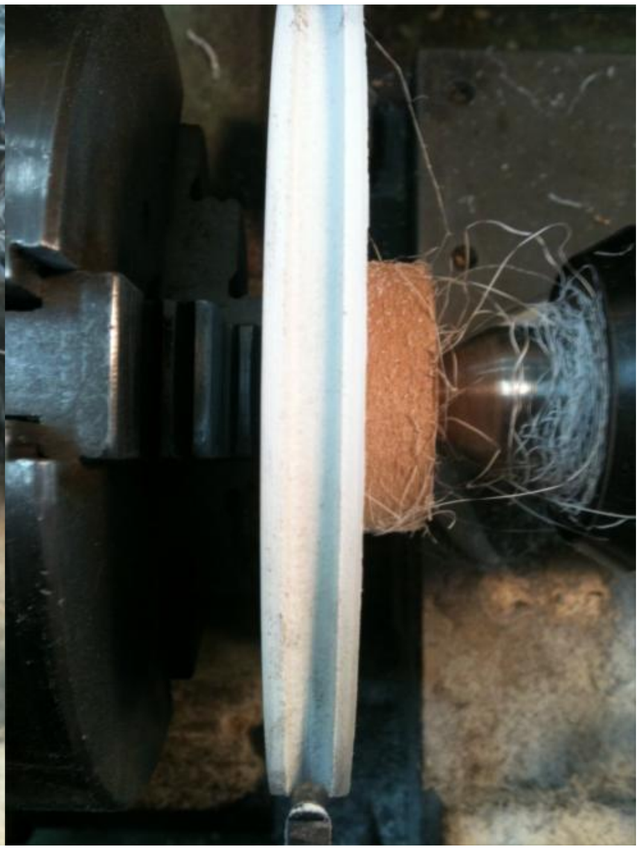


I met up with Mr Maguire on a Saturday morning (18th May) to get some assistance with the machining of the wheels and pulleys. To cutting the wheel shape out of the plastic, I used the band saw and roughly cut around the edges I had marked. I cut it roughly because I knew I would have to shave it down on the lathe later.

To drill the holes in the centre of the wheels I used the three jaw chuck and the drill attachment on the lathe.



To be able to shave down the outside of the wheel, I had to make a small wooden disk that would fit in between the wheel and the live centre on the lathe as shown in the picture to the left. I had to do this so that the wheel wasn't just held in by the axle running through its centre, but rather, was supported at both ends while I shaved it down and cut the groove in it.

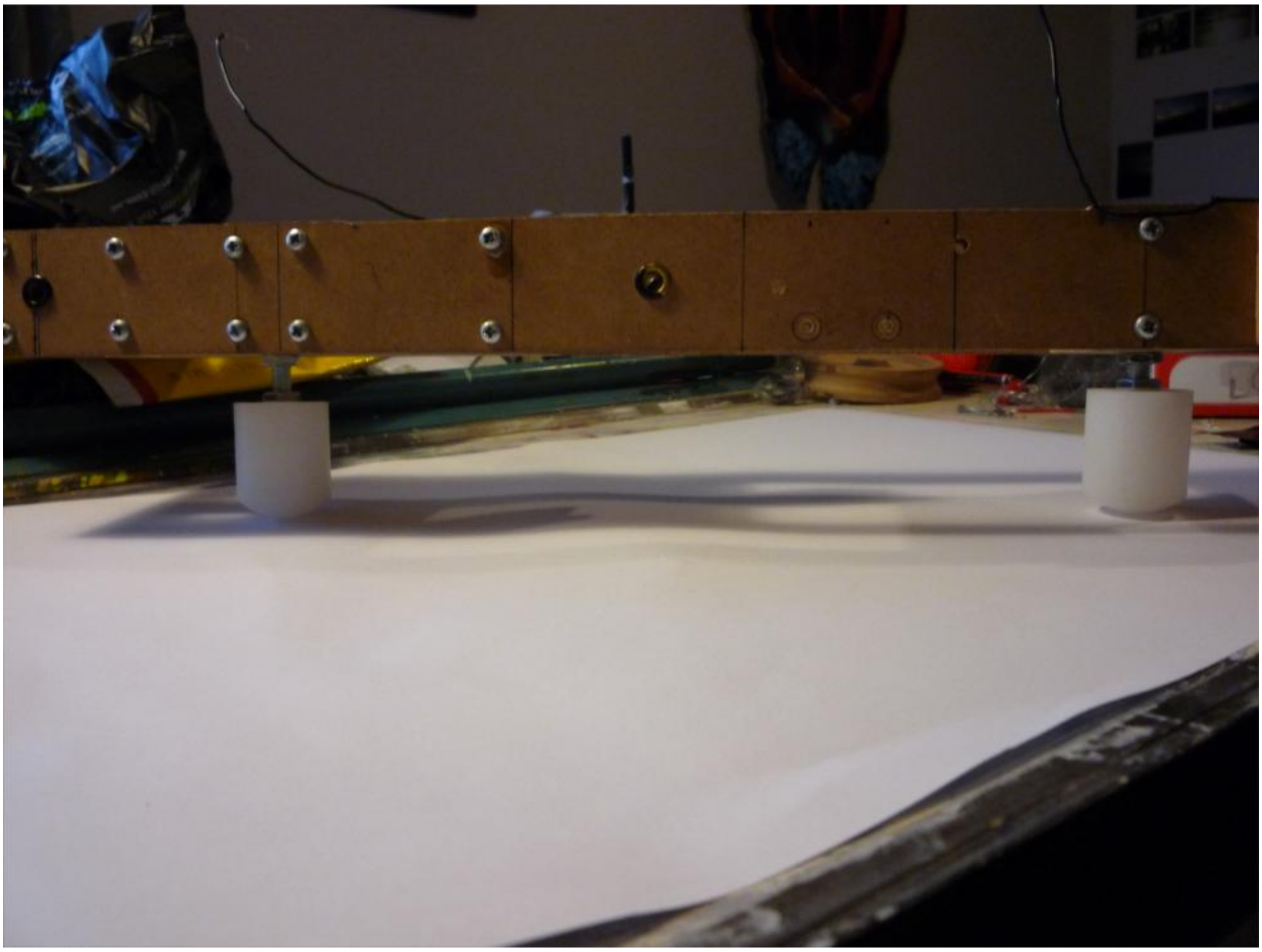



To cut the groove in the wheel, I got Mr Maguire to grind the a cutting tool (specific to the lathe) into a particular shape that would allow the O-ring to fit around the circumference comfortably as shown above.
This was the exact same process for the machining of each of the pulleys also.

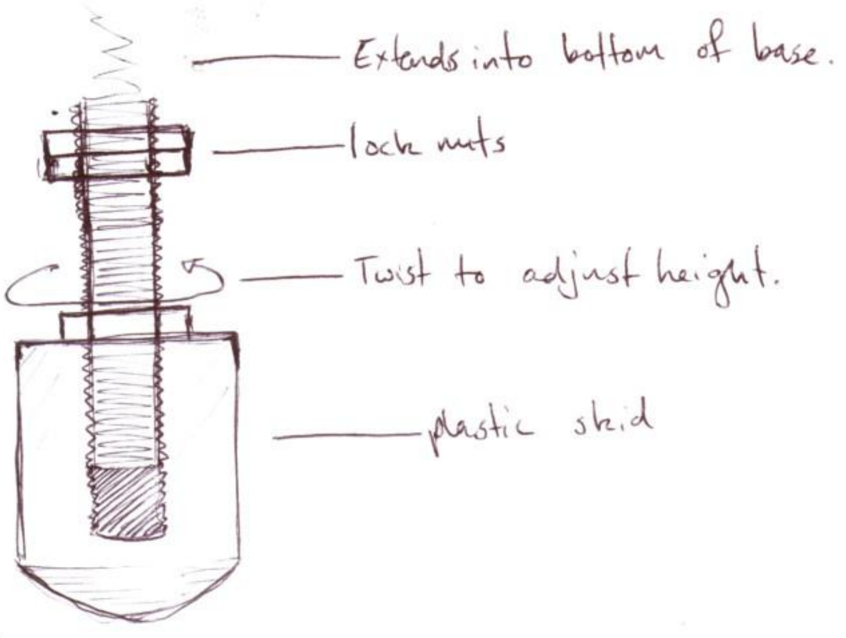
(18 May 2012)

Skids for Base:

While we were making both the wheels and the pulleys, we were also able to come up with a prototype of the skids that would slide across the ground, and so, stabilise the dog due to the two main wheels being the only points of contact with the ground.



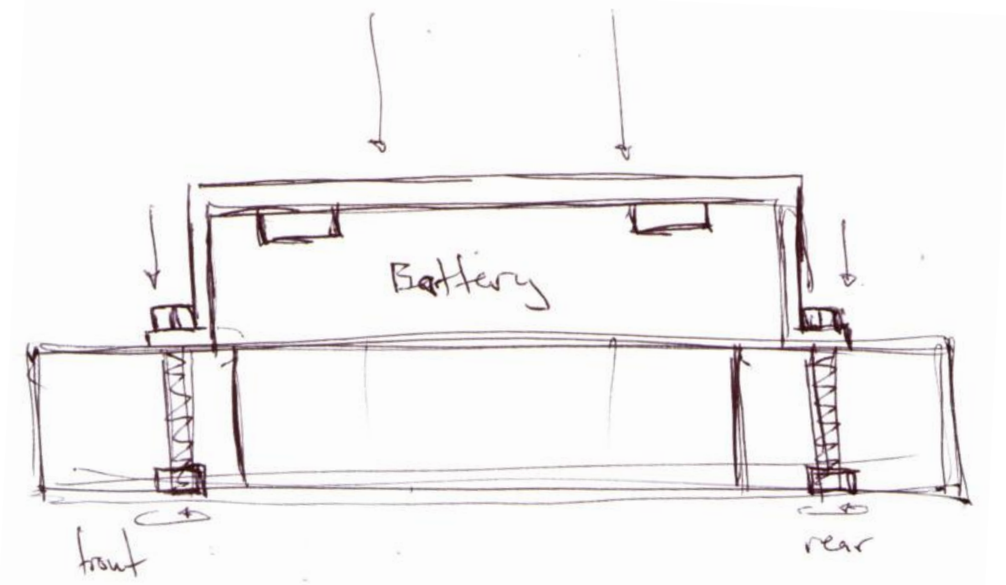
While I was working on the wheels, Mr Maguire volunteered to lathe these for me out of the same plastic as the pulleys to save some time. Effectively, they are just cylinders with rounded ends, attached to the bottom of the base via shaved down bolts as shown in the picture below.



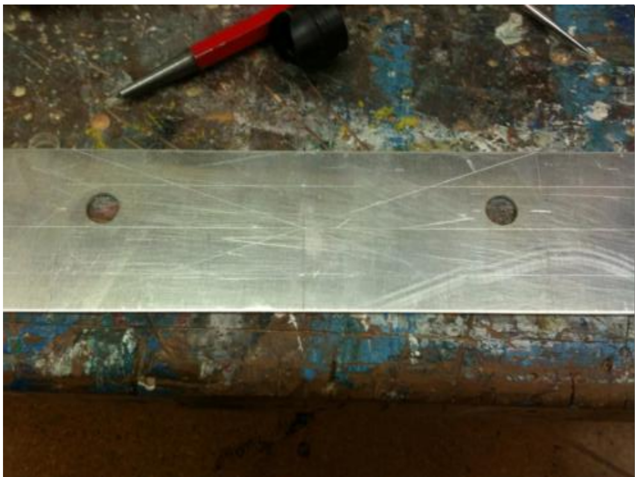
Battery Clamp Design and Construction:

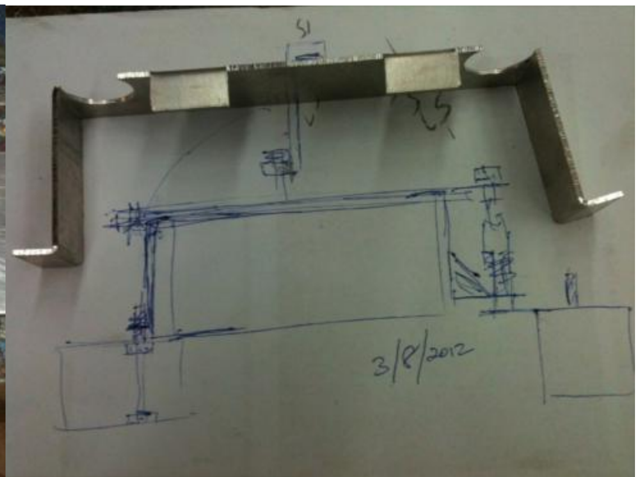
Now that the main wheels and pulley linkage system is finished and functional, I have to design a mechanism that can hold the lead acid battery rigidly in place on top of the base. (30 April 2012)

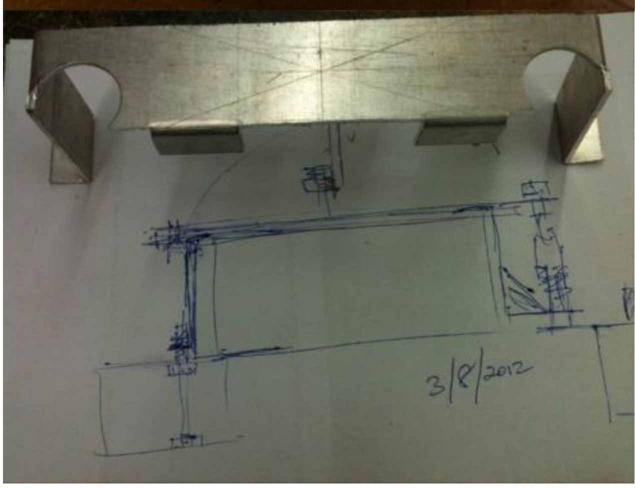
All the mechanism really needs to be is some sort of plate that can fit over the top of the battery, clamp down, and fasten into the base (as shown in the sketch below)



I met up Mr Maguire again on the following Monday after school to see if we could make this idea work. As well as this, we looked into a system that would fasten the dog on top of the base.
(20 May 2012)







Mr Maguire suggesting using sheeted aluminium as it is strong, light weight and easily machinable (as long as nothing needed to be welded as we don't have the proper equipment at school to weld aluminium)

Body Support Mechanism:

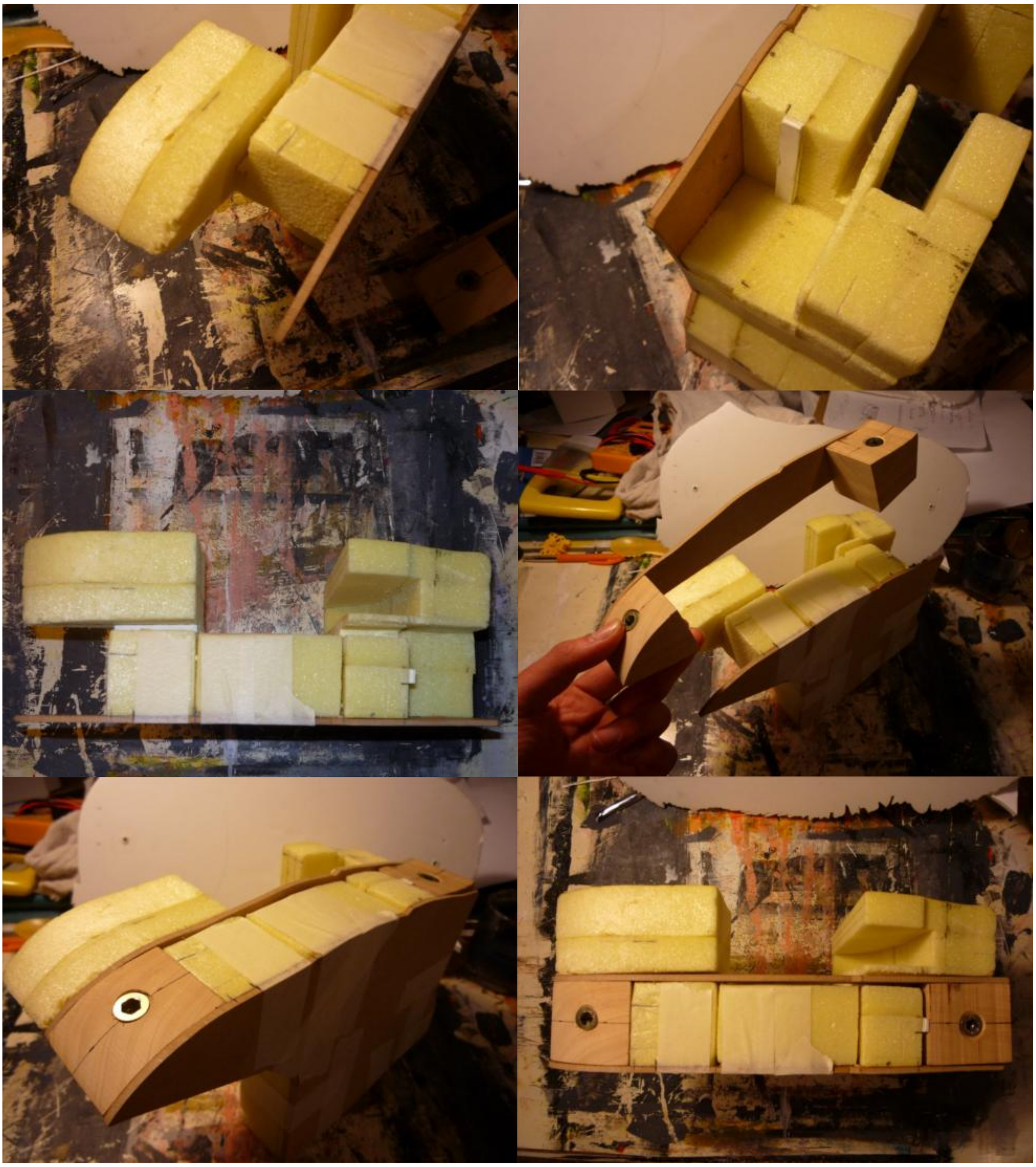

The mechanism we designed is effectively a thin piece of MDF Custom wood with two pieces of macrocarpa at either end. Macrocarpa was chosen for this mechanism because it is denser than pine, and so, more likely to hold a thread. To allow this mechanism to be supported above the base we decide to try using two 6mm aluminium rods. However, to allow these rods to sit firmly into the wood, we used .... as shown in the pictures below. We removed the thread inside the two that are in the base so that the aluminium rods would just slide in. We kept the two in the mechanism threaded so that the threaded aluminium rods would screw in.

Front:

Rear:


Inside Structure Modification:

Before we could attach this mechanism to the base, a couple of modifications had to be done to the inner body structure as shown below.

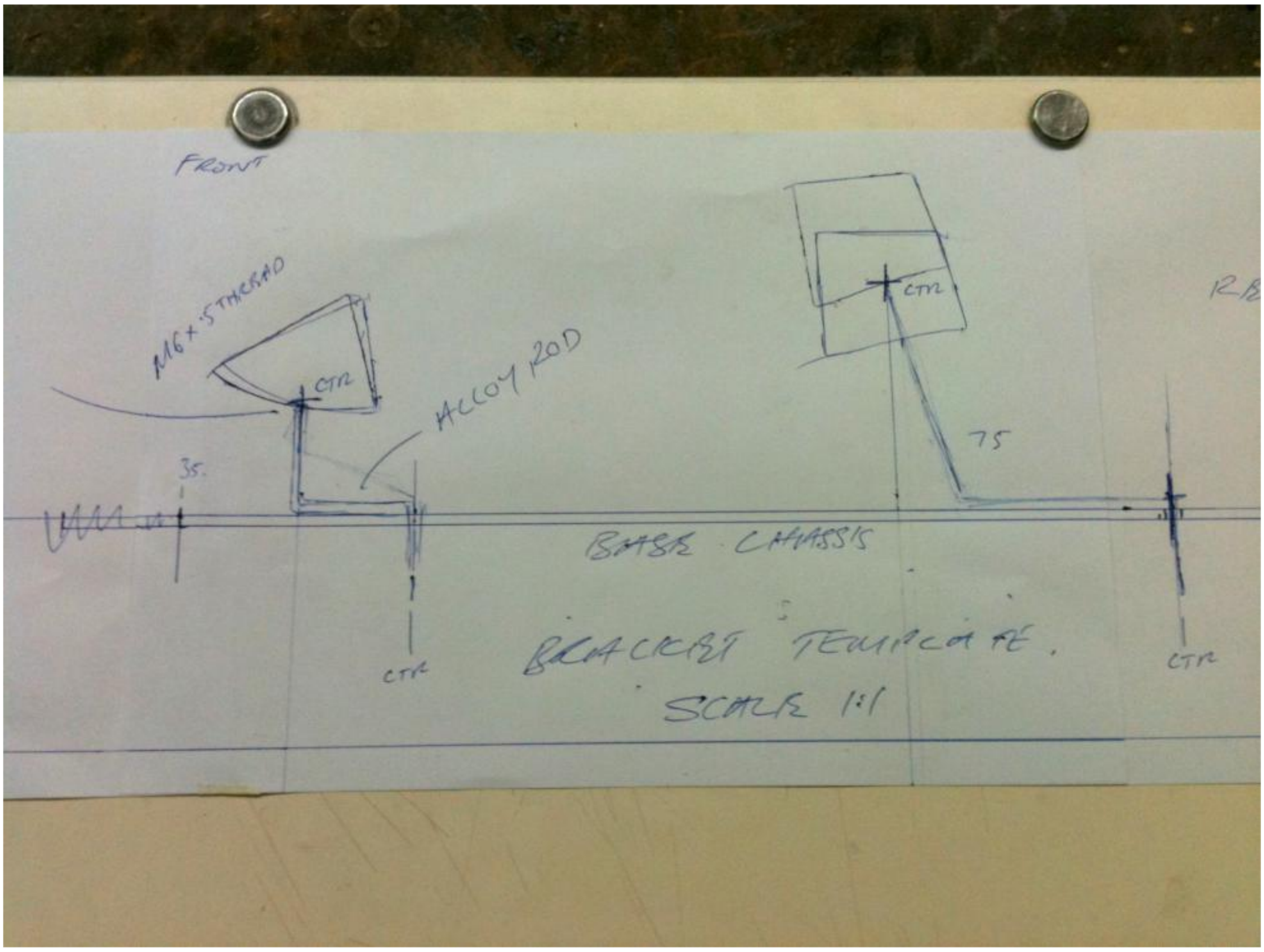


Having cut out these parts on the dogs inner structure, the mechanism that will support the dog over the base now fits into place as shown above. As well as this, I have added a MDF custom wood panel to the right side of the body to help support the mechanism and keep it in place. As well as this, I will also act as the base for the removable side as mentioned in the concepts earlier. From here, I can now finish the aluminium rods that will attach the two elements of this mechanism together.

(22 May 2012)

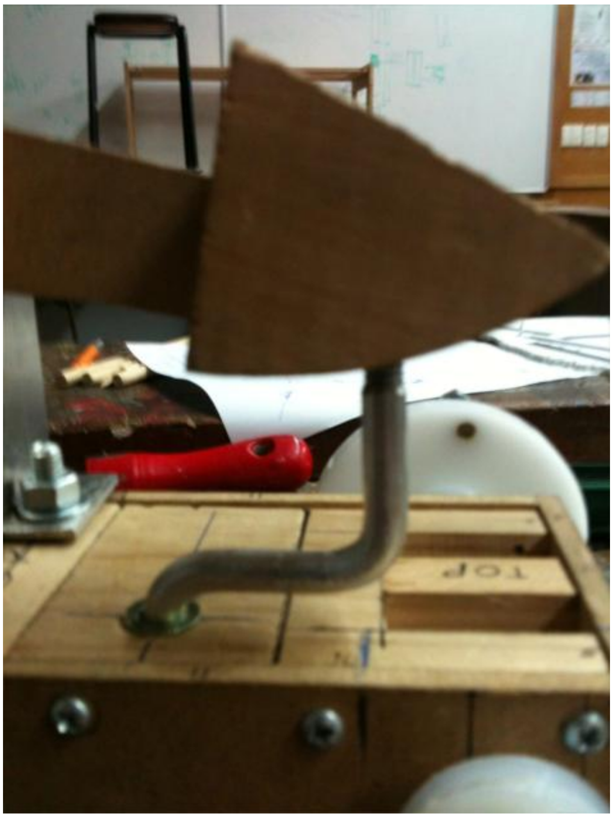
Body Support Attachment System:

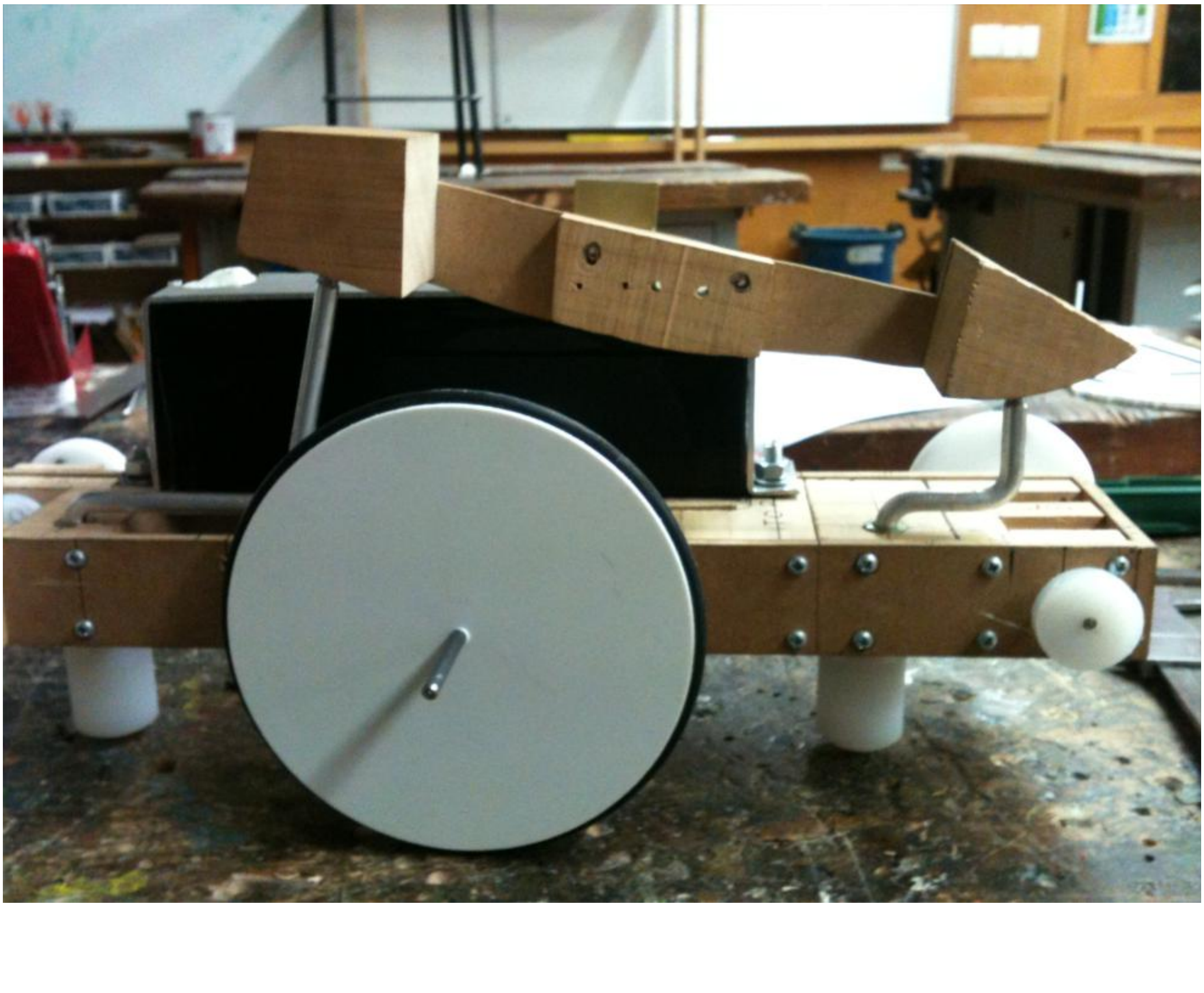
I met up with Mr Maguire again after school on the following Friday (4 May 2012) to get some assistance with bending the aluminium so that it would sit comfortably on the base. Together we drew a 1:1 scale drawing of how the aluminium rods would have to be bent. Prior to this, to find exactly where this mechanism would be positioned, I held the dog above the base in the position it would be when completed while Mr Maguire took measurements in relation to the base and the mechanism that will be holding up the dogs body.



Once the scale drawing had been produced, we threaded one end of the rods, then put it in the vice and manually bent it as close to the drawing as possible.

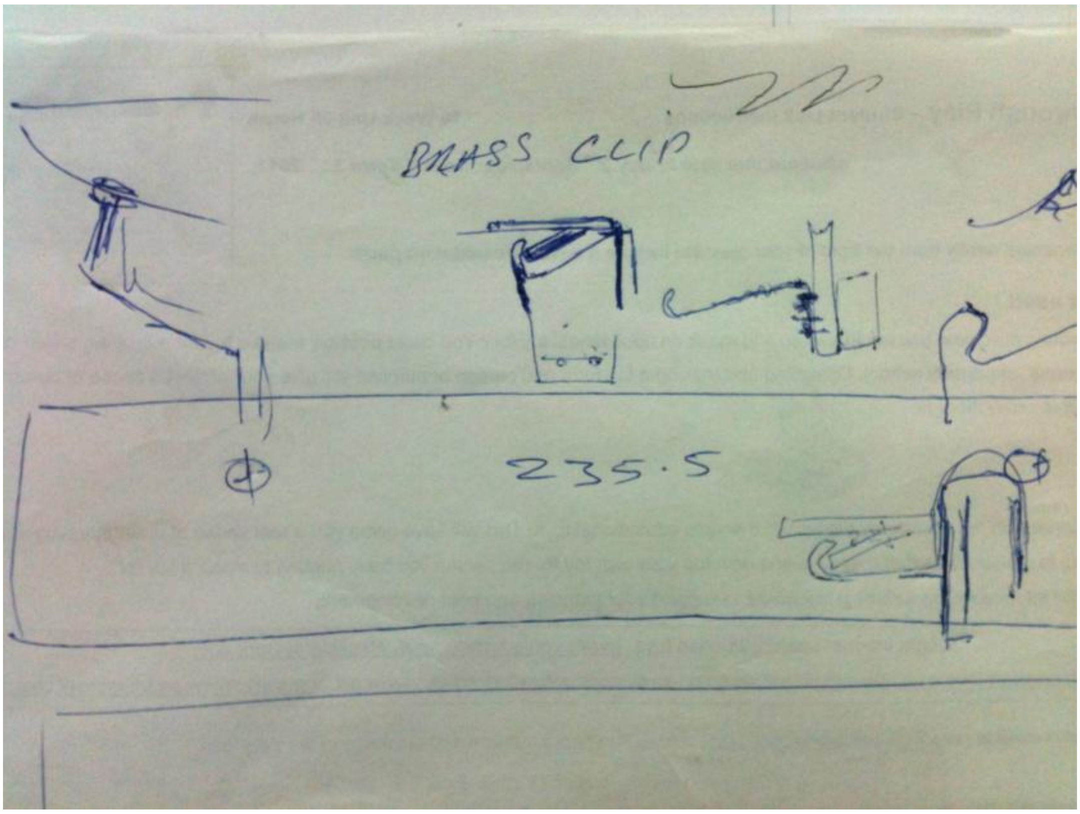
(23 May 2012)





Body Support Clipping Mechanism:

However, once the mechanism was in position, we noticed that it wasn't as sturdy as we'd hoped, but instead, had a fair amount of movement when the dogs body sat on top of it. To fix this problem, we would have to design and construct a clipping mechanism that would hold the support firmly to the base.



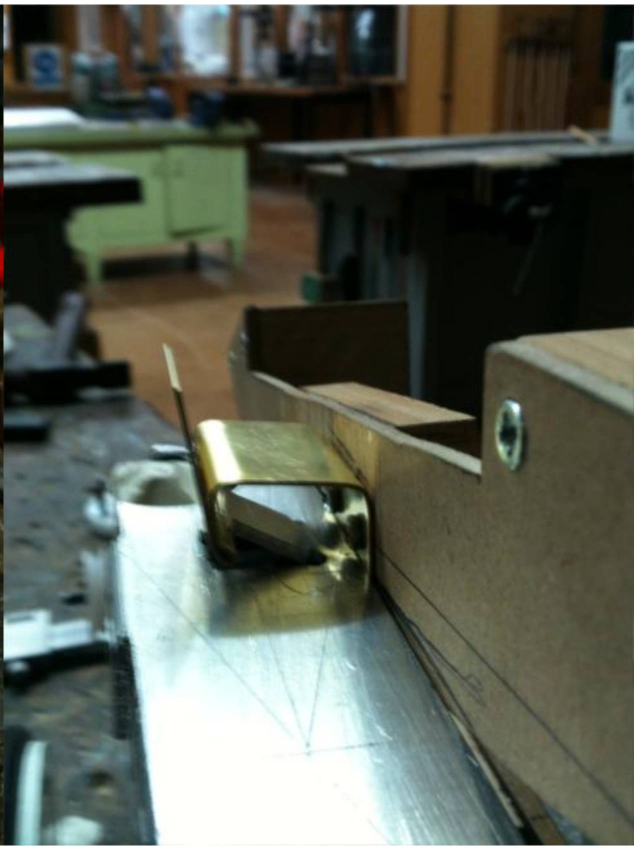
We designed the clipping mechanism so that it would latch on to the aluminium sheet that clamped down the battery, as the battery nor the clamp were likely to move due to the bolts keeping it in place.

Although a little fuzzy, the picture to the left shows the flap that had to be cut into the aluminium sheet. The clip that will be attached to the mechanism that sits up inside the dogs body will clip over this flap, and so, increase the stability of the dog when attached to the base.

The clip was made out of a thin, yet sturdy sheet of brass I had purchased from a hobby shop. After bending the piece of brass into the shape we had designed, all that needed to be done was to attach it to the mechanism that sits in the dogs body as shown to the left.

Once the clip had been fastened on, we were able to fit the structure into place on the base as shown below. Fortunately, the clip fitted over the flap perfectly without any adjustments having to be made.

A feature of this system is that it can be both easily clipped in, and easily clipped off thanks to the natural 'springiness' of the brass, and the 'trigger' that, when pressed, unclips from the flap in the aluminium.



Motor Rig Re-design:

Unfortunately, due to the motor rig being made out of pine, it started to deteriorate and loose its grip on the motors just from pushing it along the ground by hand. Because pine is a very soft wood, it doesn't hold threads very well, and so, can't withstand being assembled and disassembled repeatedly. Because of this problem, I will have to come up with a rig that uses a better method of attaching the motors to the base.

(23 May 2012)

I met up with Mr Maguire at school again to speak to him about this problem and to see if he had any useful input on how we could go about re-designing the motor rig. Fortunately, we were able to come up with a design that would effectively hold the motors in place. Because it was a bit of a 'spur of the moment' design, most of the construction and fabrication of this rig were done without much prior design, and instead, designed and constructed as we went along.

To start, we went down to 'Absolutely Plastics' to find a suitable block we could make the rig out of. From here, we used the same measurements off the old motor rig, and tried drilling two 21mm holes in the block of plastic we had purchased as shown below using a vertical drill press. we used an 8mm drill bit as a pilot hole before moving onto the 21mm drill bit. Unfortunately, when we started to drill with the 21mm drill bit, the pilot hole we previously drilled was not large enough, and so, this caused the 21mm drill bit to grab onto the block of plastic, tearing it out of the clamps. Luckily, the block of plastic was undamaged.

(25 May 2012)

Because using the vertical drill press didn't work, I suggested using the four jaw chuck on the lathe, using the live centre to make sure the drill piece would drill directly into the pilot holes as shown in the picture to the left.

Instead of moving straight to the 21mm drill bit, we decided it would be best to increase the size of the pilot hole by gradual increments each time. In doing so, this would reduce the chance of the 21mm drill bit grabbing hold of the plastic again and pulling it out to the chuck.

After successfully drilling the pilot holes, we were able to move onto the 21mm drill bit. Slowly and cautiously we drilled through the plastic block.

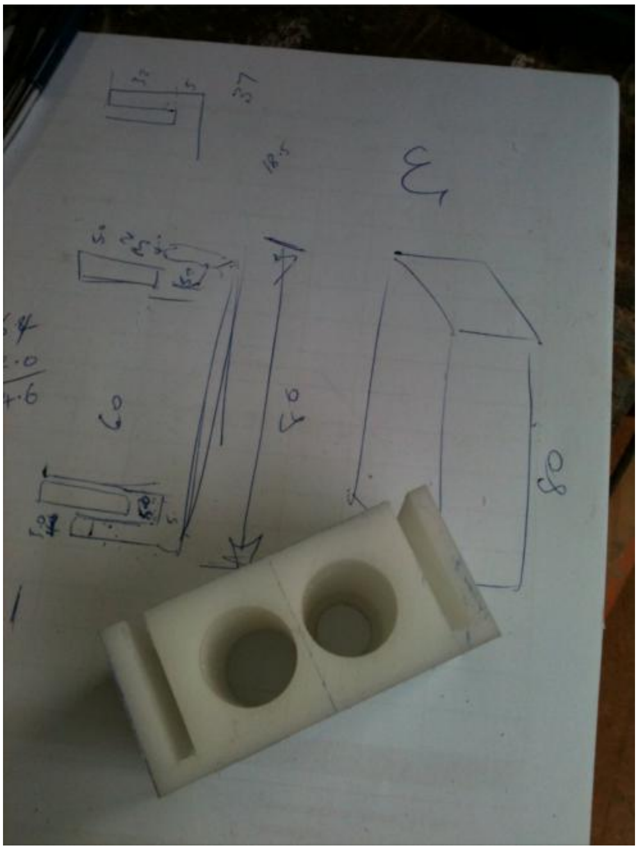
Fortunately, the drill bit didn't catch, and so the two holes the motors will fit into were completed.

(25 May 2012)

Now that the holes have been drilled and the motors fit in perfectly, we will now have to cut the block down to the right size and shape in order for it to fit inside the base comfortably.

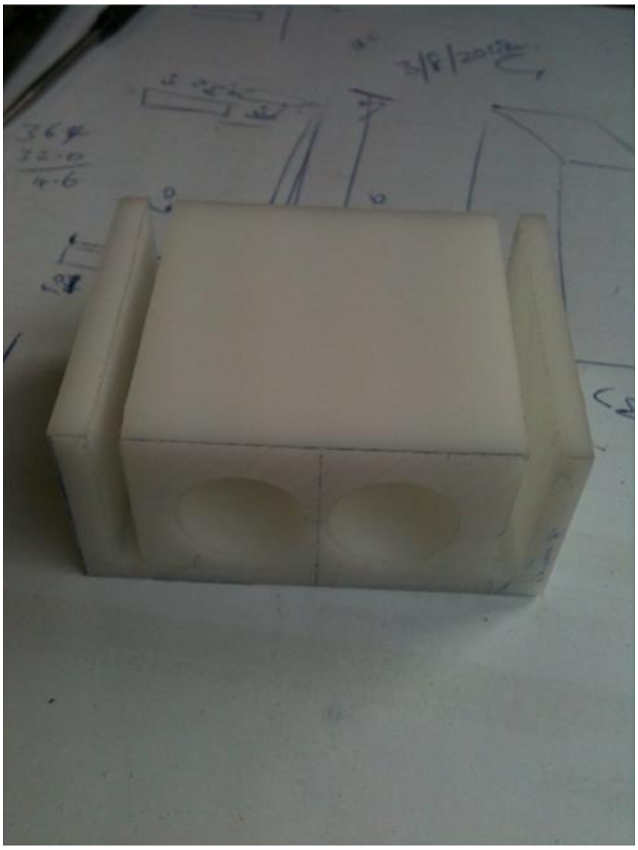
To do this, we were able to use the four jaw chuck in the lathe to shave the surfaces down. Once this had been done and the block was the right shape, Mr Maguire suggested a method of attaching it to the base so that I wouldn’t be likely to move at all.

(25 May 2012)



The idea was to slice slits down the sides of the block so that they would slide over the MDF panels that made up the sides of the base. Once in place, I would have to drill through the sides to fasten it to the MDF.

Because I am unable to use the bench saw (due to school workshop rules) I got Mr Maguire to do it for me.



Now that the motor rig structure is complete, I will have to come up with a method of fastening the motors so they cannot spin inside it.

(25 May 2012)

I was able to come up with a system that would effectively hold both of the motors rigid.

To do this, I used an off cut from the brass clip I had made earlier to hold the support structure to the battery. With this, I drilled several holes in it in relation to the ones on the motors as shown to the left. Fortunately, the motors had small threaded holes at the ends which the brass plate was able to fasten to. Because of this, the two motors and the brass plate were now effectively one unit that would be able to be fastened to the block.

To attach the brass plate to the plastic block, four holes had to be drilled around where the motors sit as shown in the middle left picture. Long thin screws like the one in the top left picture travel through the brass plate and into the block. These long screws are then held in by small nuts that have been placed in holes on both the bottom and the top of the rig as shown in the picture above, and the picture to the left.

Final Motor Rig (Re-designed):

The picture above shows how the re-designed motor rig sits into the base. As mentioned previously, it will be fastened in place by screws that run through the MDF panels.

Dog Assembly:

Concepts, Research and Development :

Electrical

Infra-Red Remote Control Tanks:

After meeting with Lewis at the theatre and discussing what size the dog is going to be, I also have to determine how the dog prop is going to be able to move. Fortunately my Physics/Electronics teacher had a set of Infra-red remote controlled tanks that he lent me so I can test the motors and the movement of the dog on stage. In order to test the infra-red remote control system and the motors in the tanks on the actual stage I will have to arrange another meeting with Lewis at the theatre. (20 April 2012 6:30 PM)

Remote control Tank: On Stage Testing

These are the pictures I took of the remote control tank on the stage while testing the movement and infra red signals.

The picture to the left here is of the 'worker light' that seemed to disrupt the infra red signals of the tank, and so cause it to not move.

After finding out that the tank was unable to run due to the bright light of the 'worker light', I placed my hand directly over the infra red receiver as to block out the light that stopped it from moving previously. I found that in doing this, the tank was able to run again.

Because of this problem, I would have to look into some sort of method that would reduce light coming in contact with the receiver, or look into another method of remotely controlling the dog altogether..

Stakeholder consultation

After meeting with Lewis at the theatre again with the small infra-red, remote control tank to test the movement and remote control capability of the dog, I found out that the infra-red signals get disrupted by strong light. I am unsure whether the actual stage lights will affect the signals, but seeing as the 'worker' light that was on at the time was causing this problem, then I am assuming that the stage lights will also cause this problem (as they are much brighter and more intense.) Due to this problem, I will either have to do tests on what sort of light will interfere with the signals, design something that can cover the receiver to block out the light, or re-think the remote control system, and if necessary, change the remote control to radio frequency rather than infra-red.

(24 April 2012)

Because I was unsure whether or not the Infra Red remote control method was going to work at this stage due to the stage lights, I decided it would probably be beneficial to research another means of remotely controlling the dog along side testing the Infra Red method.

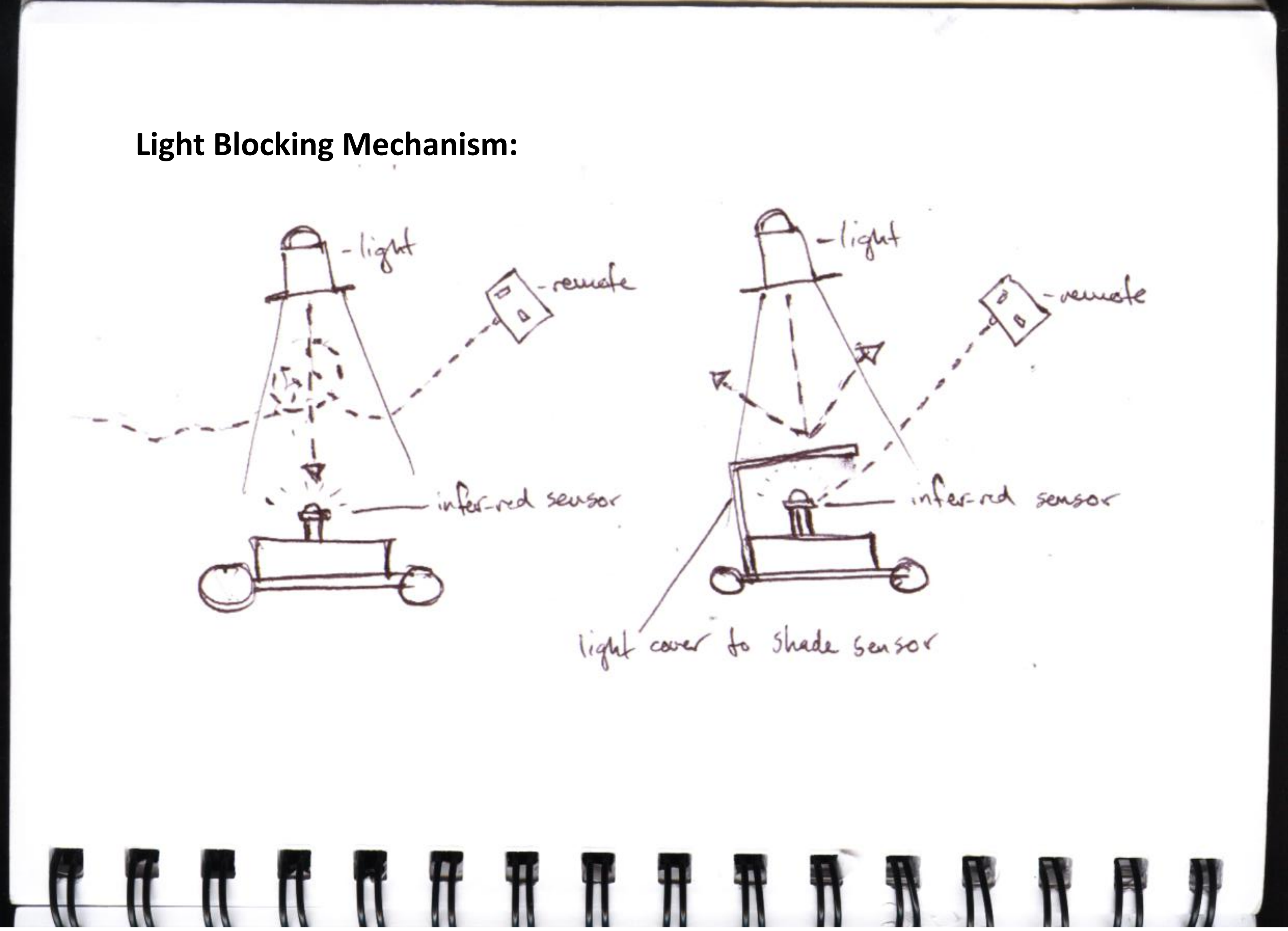
Radio Frequency Remote Control.

From prior knowledge, I knew that unlike the Infra Red remote control, light wouldn't be as likely to effect radio frequency. This is because instead of a direct beam traveling towards the receiver (like Infra Red), multiple waves of a certain frequency do, and so, are less likely to be effected (if at all) by light.

"Radio frequency (RF) is a rate of oscillation in the range of about 3 kHz to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals. RF usually refers to electrical rather than mechanical oscillations. In order to receive radio signals an antenna must be used. However, since the antenna will pick up thousands of radio signals at a time, a radio tuner is necessary to tune in to a particular frequency or frequency range. This is typically done via a resonator (In its simplest form, a circuit with a capacitor and an inductor forming a tuned circuit) The resonator amplifies oscillations within a particular frequency band, while reducing oscillations at other frequencies outside the band.

(Wikipedia: http://en.wikipedia.org/wiki/Radio_frequency)

Light Blocking Mechanism:

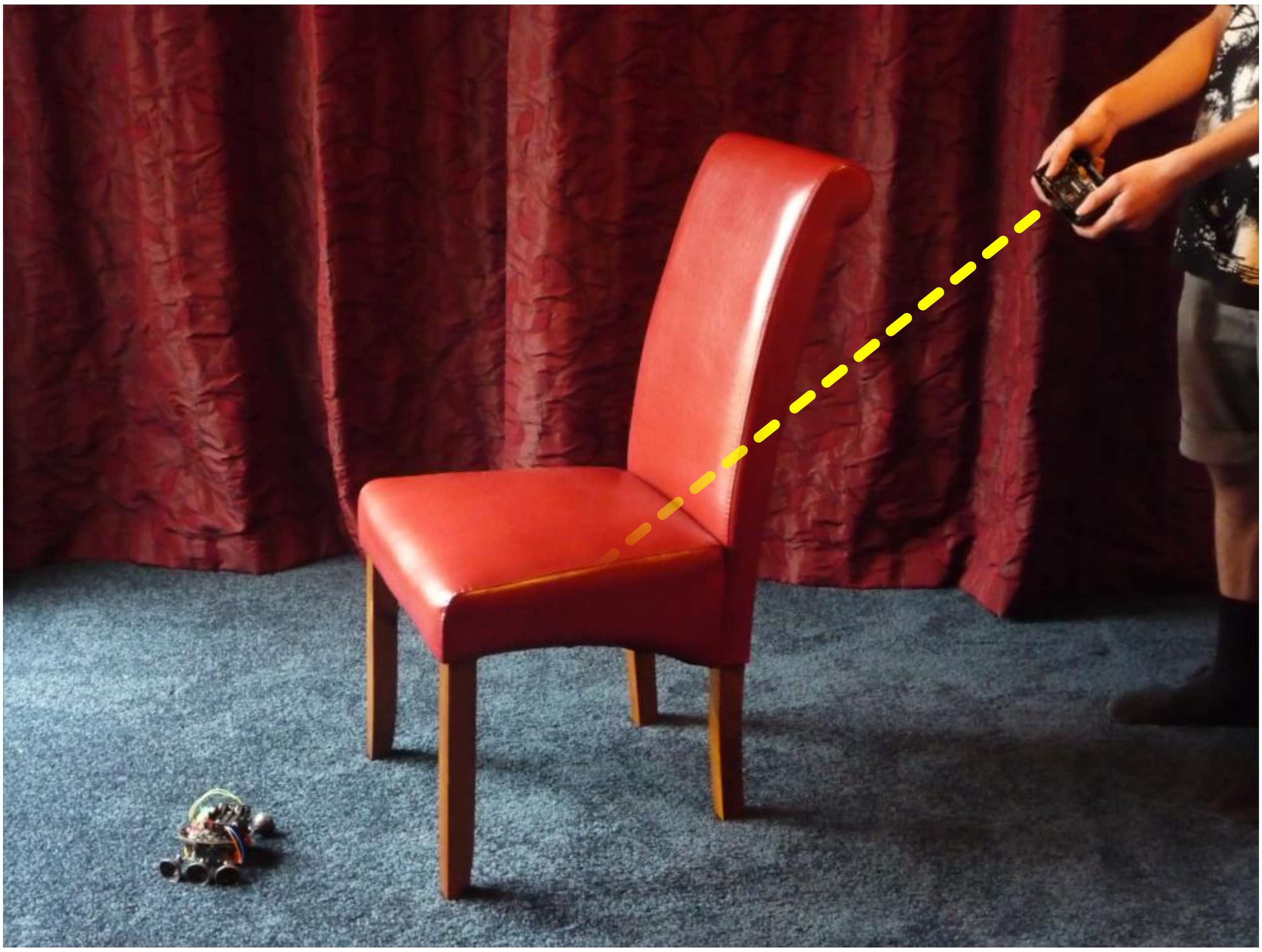


I came up with a very simple mechanism that would act as a cover for the Infra red receiver as shown in the rough sketch above (the funny looking block with wheels being the dog). Because I still had other tests to do regarding the Infra red remote control system, and because I wasn't 100% confident that this method would be reliable, as well as having done a simple test ny placing an object over the receiver, I chose to leave it as just a drawn concept at this stage as a pose making a mock up, simply because more research regarding this method of remote control was required in order to make sure it would be a reliable method.

(25 April 2012)

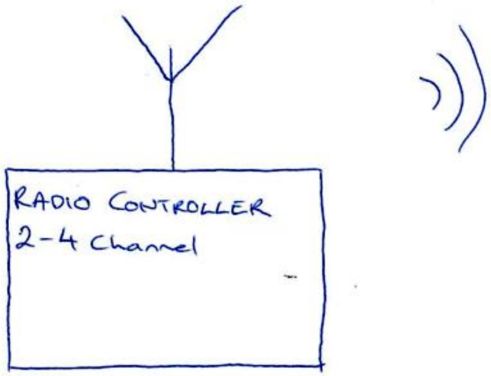
Infra-Red Remote Control Signal Testing:

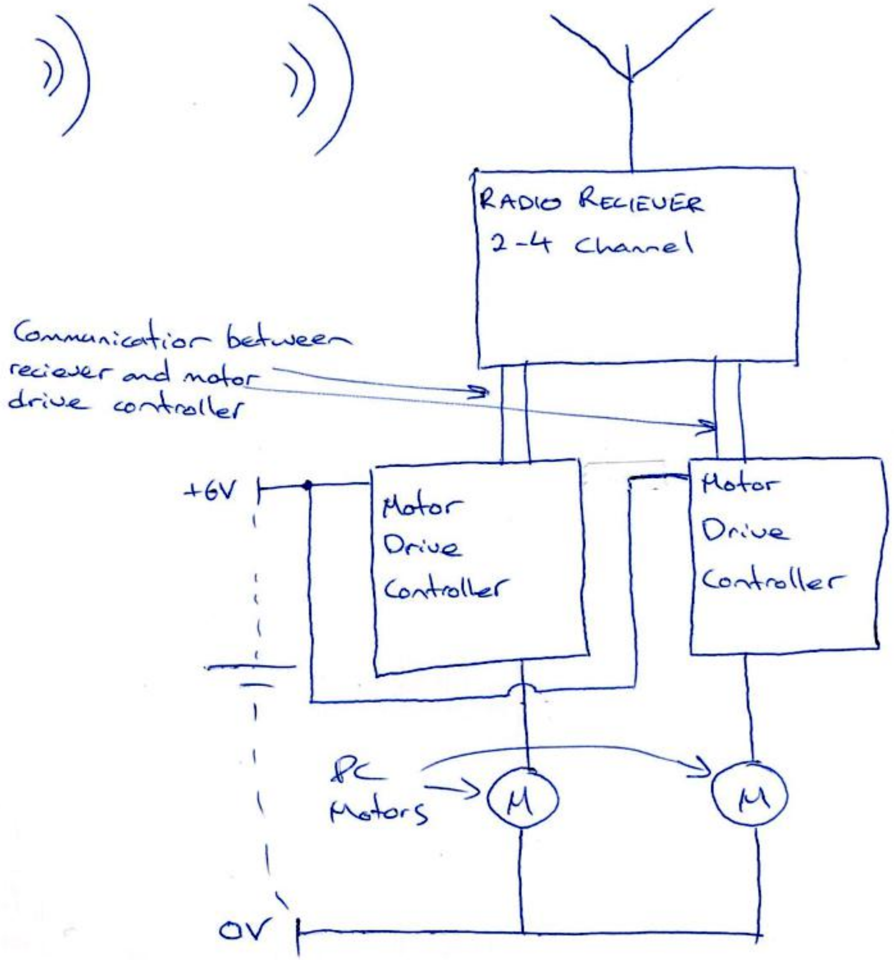
Along side coming up with concepts to block out light to the receiver, I decide to further my study into the infra red remote control system to see just how reliable it would prove to be in this project. In doing so, I set up various furniture with the tank on one side, and the controller on the other as shown in the picture below. I did this because there will be furniture on the stage that the dog will have to move around to interact with the actress, and also to test any other flaws of the Infra red controlling system. The results clearly showed that objects interfering with a direct line of sight from the controller to the tank causes the tank to lose its signal, and so, is unable to function properly. This is a prime example that can refer back to one of my key factors, 'Function'. Although the tank still functions to a certain degree, some of its movements are delayed and 'sketchy'. Thus I have ruled the infra red controling system out of my design as it would be too risky having a method of moving the dog that potentially wouldn't work, and instead, have decided to use a radio frequency control system.



(27 April 2012)

OVERVIEW OF CIRCUITS TO CONTROL DC MOTORS

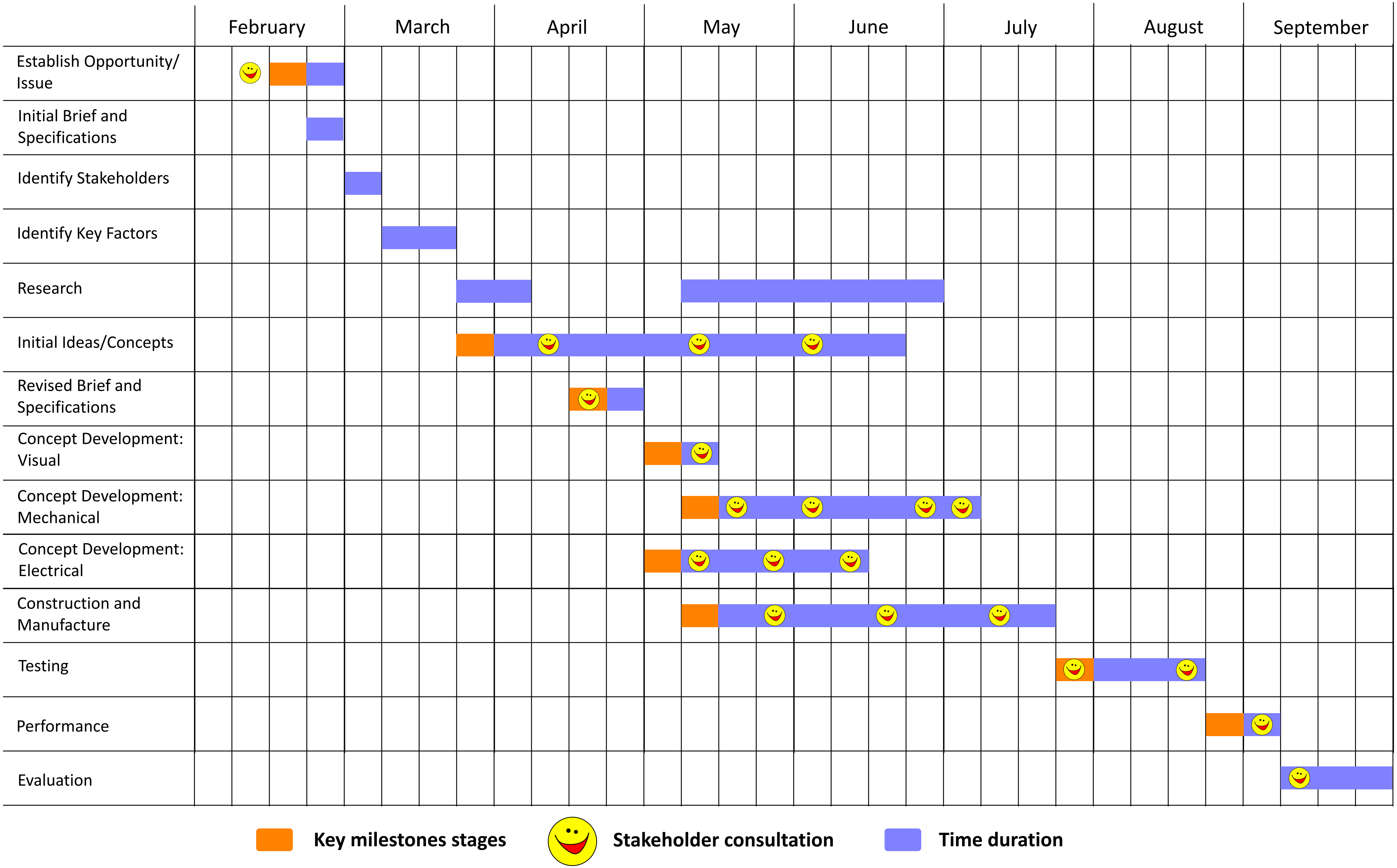




Here is a simplified sketch of the radio frequency controller/transmitter and receiver and how it relates to the motoring systems in the base of the dog prop that Peter drew to show me the rough lay out of how the componentry will have to be set up.

It should be fairly straight forward to wire up the dog if all of the components are pre-built.

Gantt Chart - Revised time management:



Batteries

Before I scheduled a time to meet up with peter, I went into Jaycar Electronics to look at various AA batteries as a potential power source for running the dog. Because the motors I had purchased require 12 volts, I would have to buy eight AA batteries. But because the dog would be required to be active for two hours every night for eight nights, I didn't need a calculator to tell me that I would need more than eight batteries. A standard pack of 4, non-rechargeable batteries, cost around $9.00, but because I needed eight just for the dog, I would have to buy two packs, making the total $18.00. Because I didn't know how many times I would have to change the batteries, I made an estimate that they would have to be changed at least every performance. This would mean that I would have to buy 16 four packs of AA batteries, coming to a total of around $144.00.
With the rechargeable batteries, a standard four pack would cost around $14.00, so for eight batteries I would be looking at around $28 dollars, plus the cost of a charger, which was around $40.00-$50.00. Already this was starting to get too pricey for my budget, so I decided to make a time to meet up with Peter to discuss an alternative power source.

(5 April 2012)

I met up with Peter at Delta this time (where Peter works) on the 6th April, so we could discuss potential power sources to run the dog. I told him that id been into Jaycar Electronics to look at various AA battery options, but after calculating a rough price, decided that they would be too expensive.
After some brain storming, Peter suggested a type of battery that's commonly used in cars and motor bikes called a 'Rechargeable Sealed Lead Acid Battery'. When peter first mentioned that this type of battery was commonly used in motor vehicles, my initial thought was "Woah, that's going to be a tad big don't you think?", however, he then mentioned that it was possible to purchase these 'lead acid batteries' in a much smaller scale. He went onto the Jaycar Electronics website to see if we could find one that would fit the specifications of the dog. Fortunately, we were able to find a 12 volt, sealed lead acid battery with the dimensions "177.5 x 61.5 x 35mm". This was perfect with respect to how large the base was, as well as how many volts the two motors needed. However, one attribute of the battery that was a rather large downfall, was its weight. Due to it being a 'Lead' acid battery, this meant that it would be heavy.
We looked up the specifications (on following page) of this particular battery to see exactly how heavy it was, and also, if it would be able to last on stage for two hours every night.

Battery Amperage/Hour Calculation:

BATTERY CAPACITY

0.1A

0.2A — Standby.

$0.2A + (0.375 \times 2)A = 0.95A$ – Driving.

50% of 2hours

$0.2A \times 1 = 0.2Ah$

$0.95 \times 1 = 0.95Ah$

1.15Ah   1.5 safety Factor

1.725Ah

After doing the calculations to determine the amperage/hours of the battery, we were able to confirm that it would be able to last the two hours on stage. Being fairly generous with the numbers, we calculated that the amperage used to run the dog would be around 1.75 Ah (amperage/hours), which was under the 2.2 amperage/hours specified on the battery.

Now that I am able to confirm what type of battery is going to be used for powering the dog, I am now able to integrate the physical properties of the battery (size, shape etc.) with my base design.

(29 April 2012)

Radio Frequency Remote control:

With the ruling out of the the infra-red remote control system, Peter suggested using the:

'Futaba Attack 2ER 2 channel radio control system'

In his opinion this was a suitable solution to the remote control problem. I purchased this from:

Foam works
RC Bandit
62 Lunn Ave
Mt Wellington
Ph: 09 580 1200

One small problem with this remote control device however, was that the levers on the handset were the standard forward, reverse, left and right controls, as a pose to the controls on the remote control tanks that Mr Lower lent to me where both levers were forward and reverse. We had considered modifying the radio frequency hand set so that both of the levers were facing forward, until later reading in the manual "Do not modify or disassemble the handset...". Fortunately, Peter suggested that he might be able to programme the circuit inside the dog to suit this attribute of the remote handset.

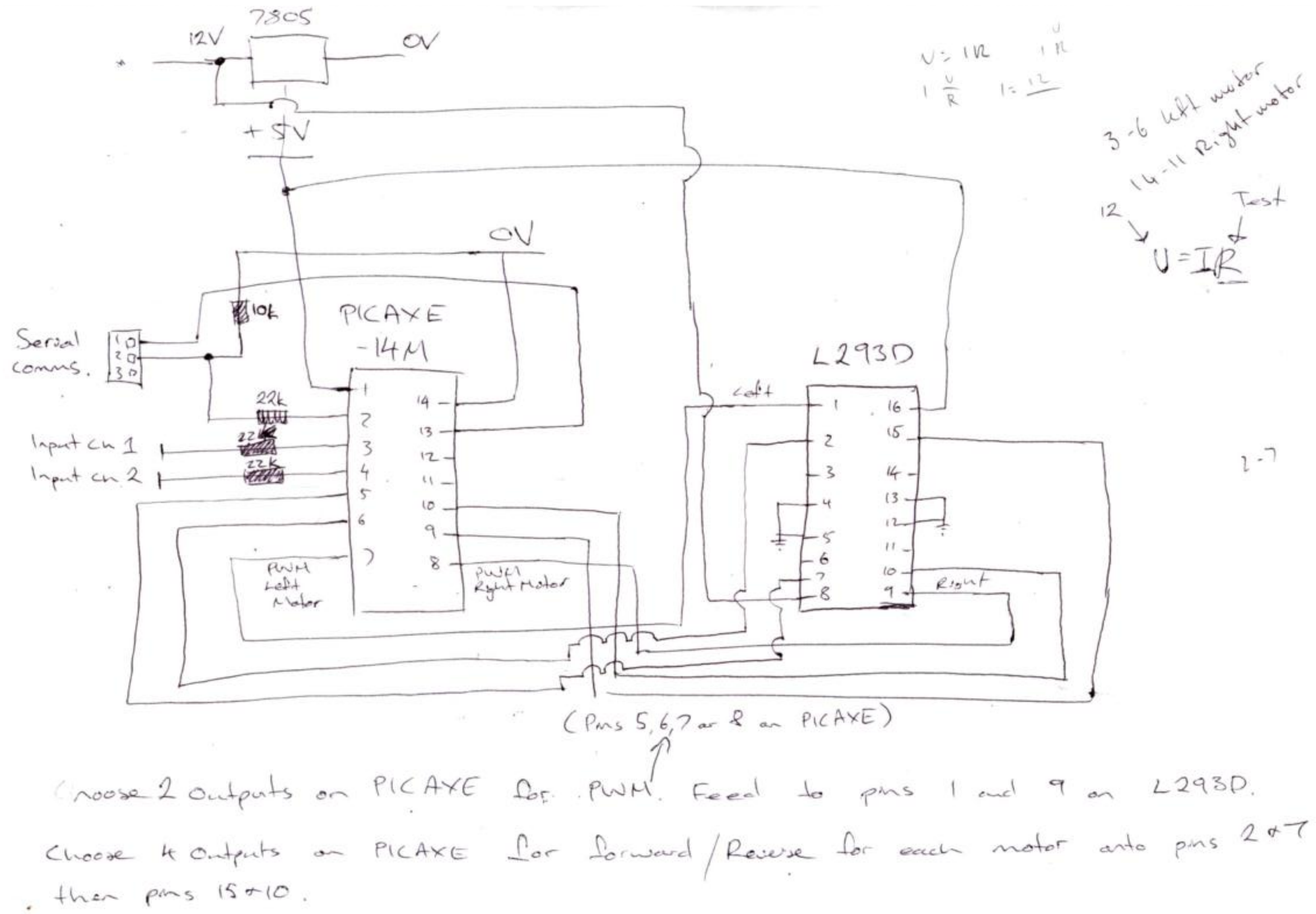
(1 May 2012)

Circuit Board

To allow this dog to move, not only would it need the two motors and the battery, but a circuit board and the necessary electrical componentry to communicate with the remote control. The research, testing and investigation process for these systems required a lot of work as well as learning new skills.

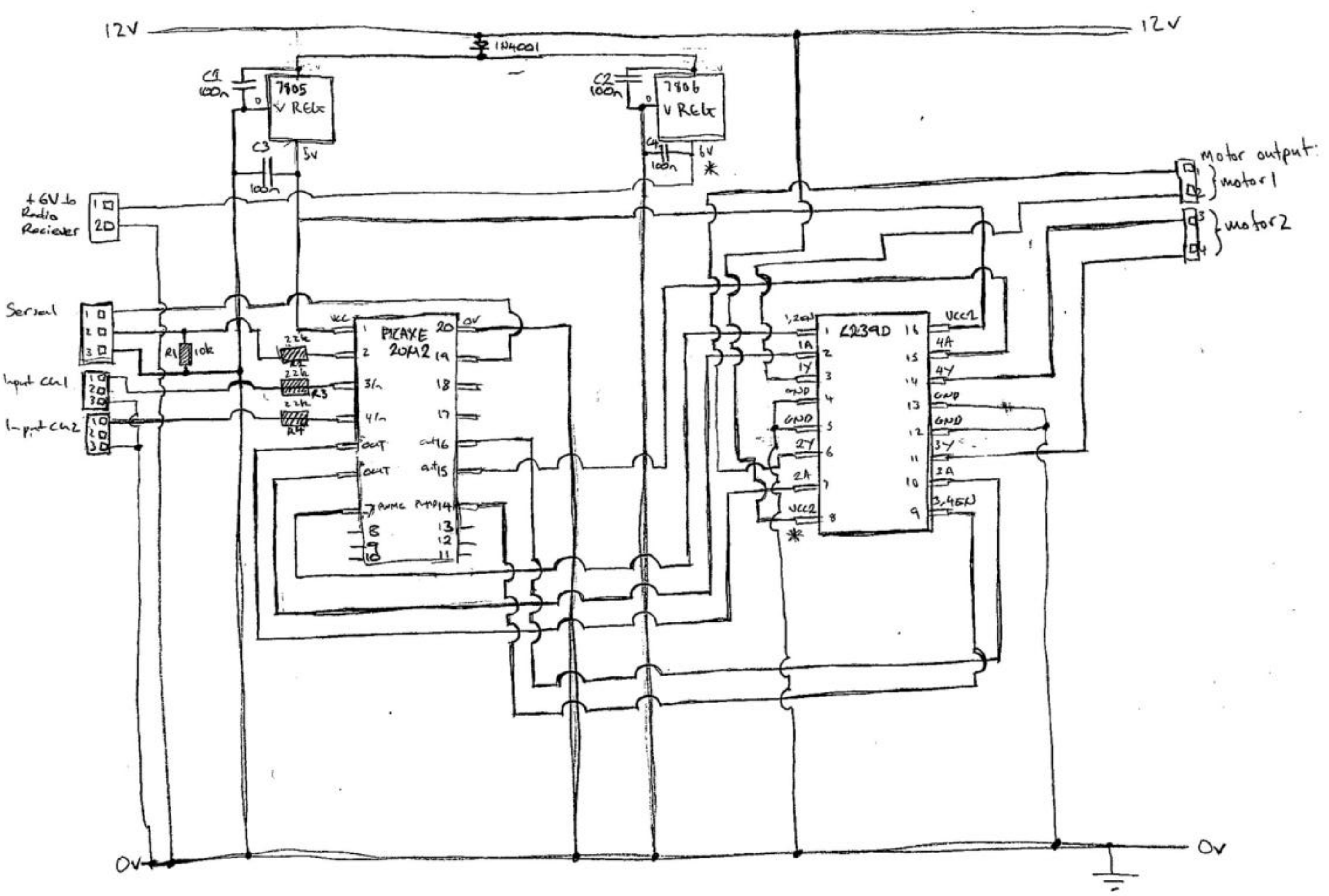
Prior to the majority of my designs, concepts, development and manufacturing, I had briefly discussed options of controling the dogs movement with Mr Lower (my physics and electronics teacher) who suggested using a PICAXE control chip. (3 March 2012)

I later made a time to meet up with Peter at Delta to talk about the PICAXE control chip Mr Lower had suggested, and so, to get his opinion on whether or not I should use this chip to control the dogs movement. Not only did peter agree with using this type of control chip, he was able to specify the necessary components I would need to make this circuit functional. With this, we were also able to come up with a draft schematic of how the circuit board would be laid out.



After Peter and I had drawn up this schematic, I was required to add in a couple more components and tracks (wires) that Peter had left out so that I could do it myself. He told me that I would need to add in a 6v Voltage regulator to the motor control chip, the four motor outputs, the radio receiver input, four capacitors to connect to the voltage regulators, and a diode connecting to the positive voltage rail. (10 May 2012)

Revised Circuit Schematic:

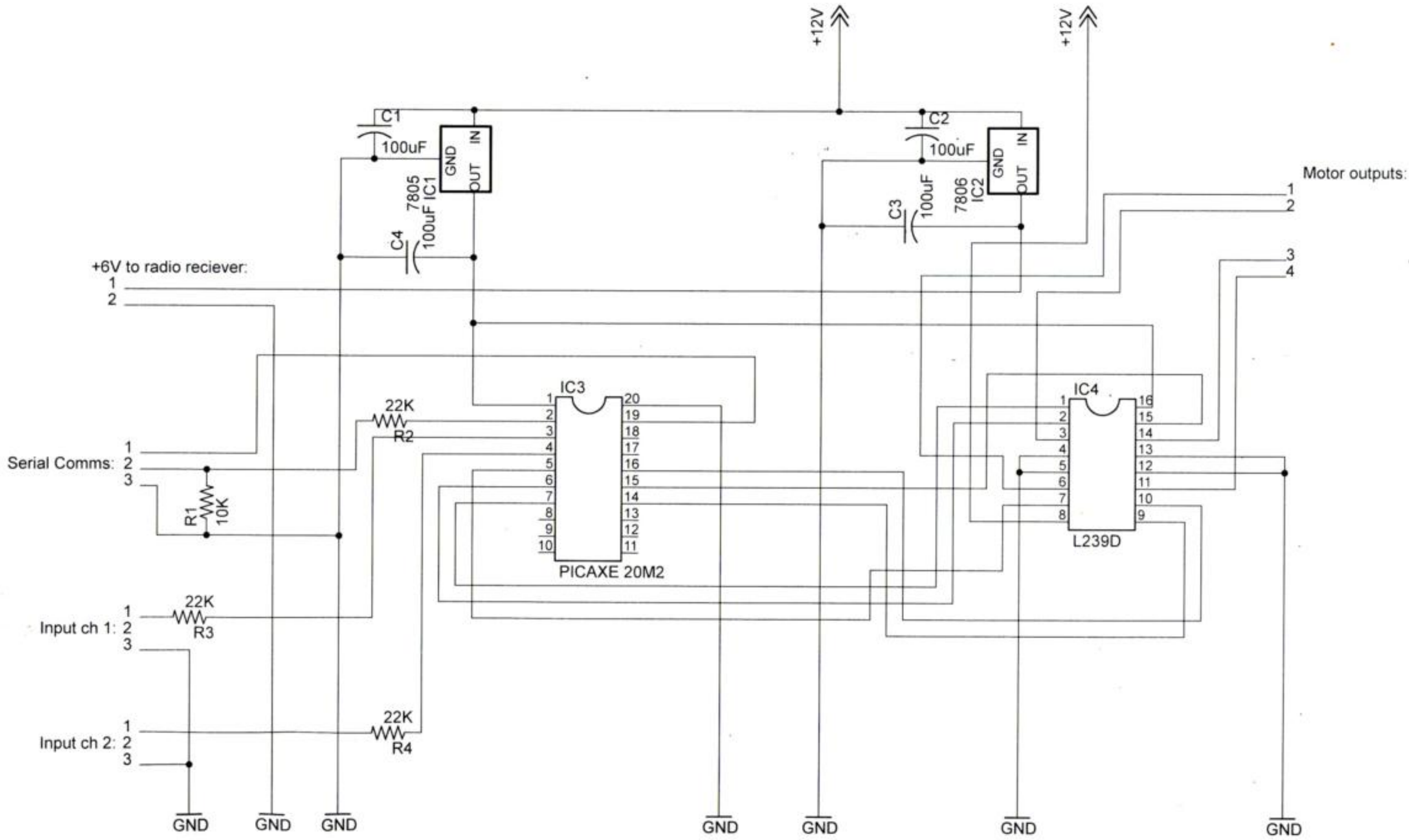


I re-drew the circuit schematic with the components that needed to be added as shown above. Once I had done this, I emailed it to Peter to get him to check it. Fortunately, everything appeared to be fine with the drawing I had produced. From here, I will now need to transfer this schematic into a circuit schematic design program called EAGLE. Once it has been drawn in EAGLE, I will then be able to print it out on a special type of board that will allow me to create my physical circuit board to control the dogs movement. However, before I could proceed with this, I will have to learn how to use 'EAGLE' as we hadn't yet learnt to use it in my electronics class. (14 May 2012)

Fortunately, I was able to learn the basic but necessary skills of how to use this program in an afternoon via a couple of online tutorials my Dad was able to find. With this new skill learnt, I can now reproduce my drawn schematic onto EAGLE.

(16 May 2012)

Revised Circuit Schematic on EAGLE Programme:



Once I had completed the circuit schematic on EAGLE, I emailed it to Peter to get him to check it again and make sure everything was in its according place. Once everything was checked and good to go, Peter introduced me to David Mulder, another electrical engineer that works across from him. Because Peter didn't have much experience in circuit board printing and programming, he asked if David (who happened to design and fabricate circuit boards in his spare time) would like to assist me with this part of the circuit board process. Fortunately, David said he would be more than happy to help me out with the fabrication of my circuit board.

I will now have to email David to sort out a time in the weekend for me to meet at his house and make the circuit board (as his workshop and circuit fabricating gear was at his house).
I will also have to purchased the components Peter had specified earlier so that once the circuit board is ready, I will be able to solder on the components straight away.

(18 May 2012)

I was able to purchase all the components I required to make the circuit functional from various places both here in Dunedin, and around the country after a little bit of searching. As well as this, I had emailed David asking what time would suit him to make the circuit board. We agreed to meet at his house on the coming Sunday at 3:00pm.

Fabrication of Circuit Board Process: (New knowledge and skills learnt)

As arranged, I met up with David on Sunday the 20th May 2012 at his house to design and photo-etch the circuit board.

I loaded up the schematic I had produced earlier on EAGLE onto David's computer. From here (since David had a beter understanding of EAGLE than I did) he 'optimised the schematic. This involved rearranging the tracks (wires) so that there were the least amount of 'jumpers' possible. A 'jumper' is the term for a track that has to cross another track in order to get to its destination. To do so, a wire has to come out of the circuit board and cross over a track like a bridge.
Once the circuit schematic had been optimised, scaled to the right size, and checked over by David to make sure that everything was as efficient as possible, we could then begin the printing process.
-To begin, we simply printed the circuit schematic off EAGLE onto a special type of photographic paper that was coated in a thin layer of clay.

-From here, we went out to David's workshop to cut the copper plated board (PCB board) that would later become the circuit into the right shape.

-After this, we cut out the circuit schematic we had printed off earlier and ironed it face down to the copper plated board. The thin layer of clay on the surface of the photographic paper allowed it to adhere to the board once it had been ironed.

-Once Ironed to the board, we let it soak in a bowl of warm water for about five minutes before carefully peeling it off. Due to the ink on the printed schematic being denser than the paper, the paper peeled off effortlessly, leaving the ink tracks printed on the board.

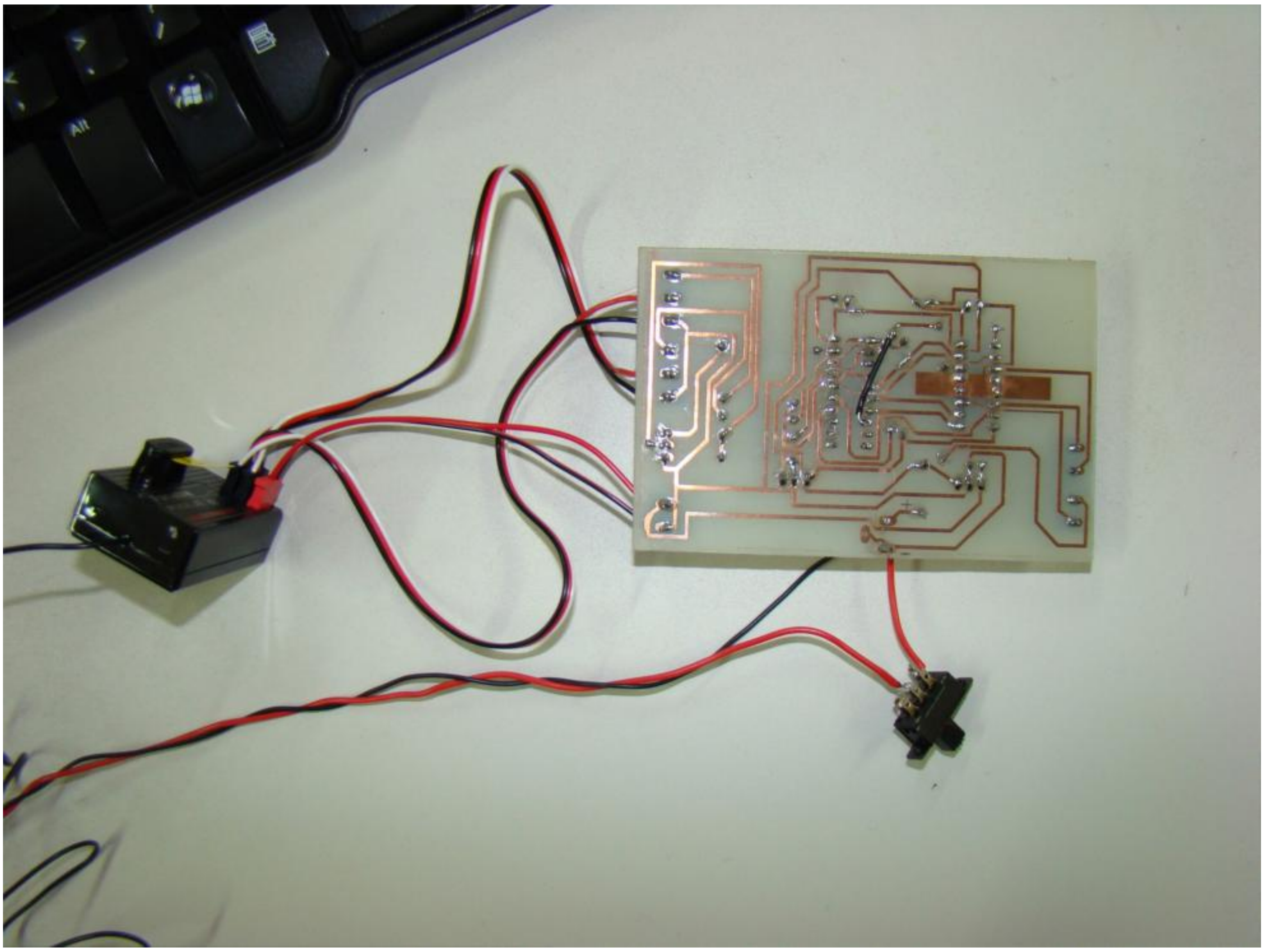
-After all of the paper had been removed, we then submerged the PCB Board in a particular alkaline solution that would eat away at the copper, but leave the ink tracks of the schematic.

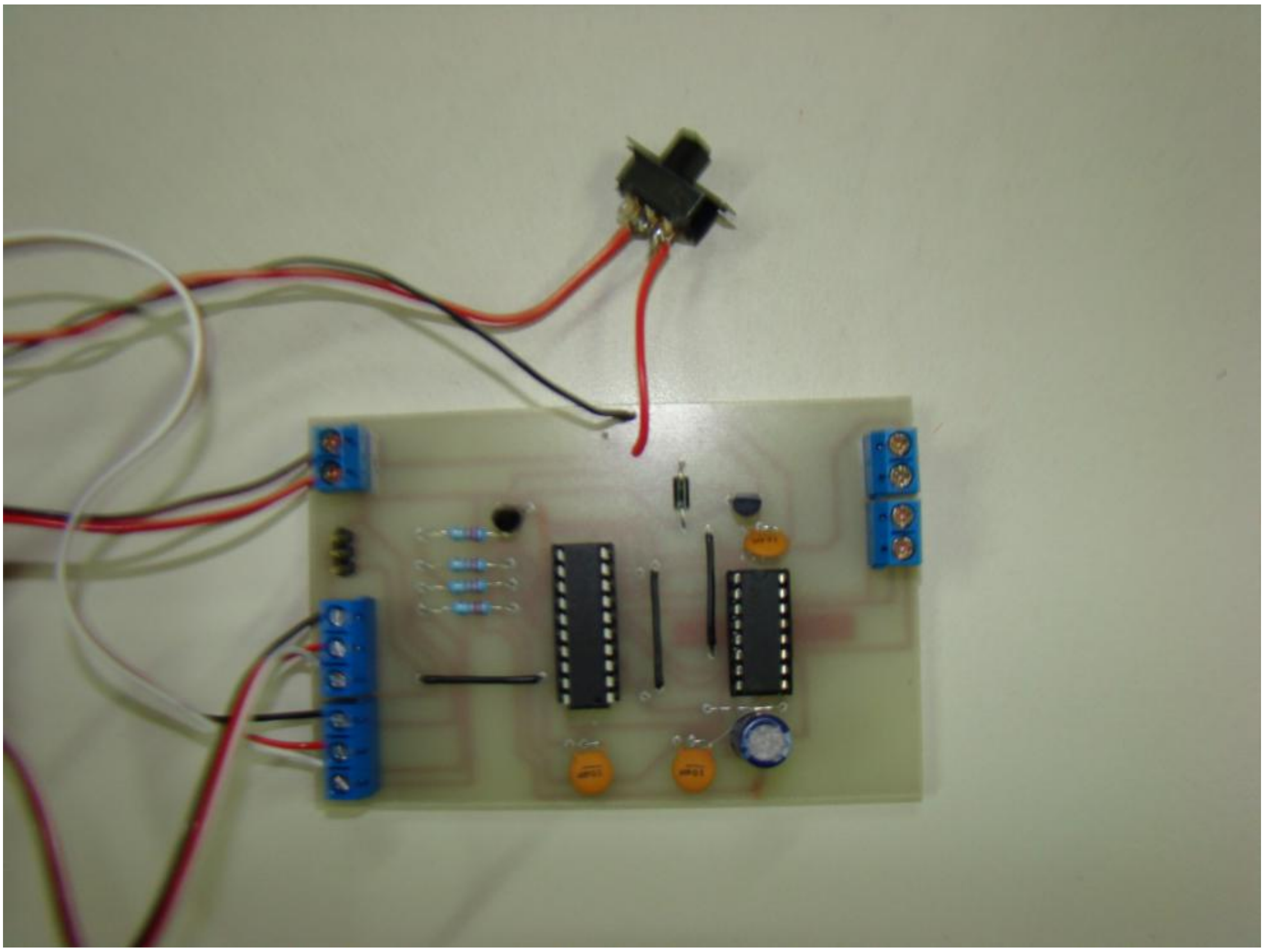
-Once all of the uncovered copper had been dissolved in the solution, using wire wool, I polished away the thin layer of ink, leaving the perfectly formed tracks of copper that make up the circuit.

Now that the base of the circuit is completed, I can start soldering on the components that will allow it to function.

(20 May 2012)

Finished Circuit Board:





PICAXE Programming and Chip Malfunction

Now that all the components have been soldered on and the circuit is completed, I will need to make another time to meet up with Peter and David at Delta to discuss the programming of the PICAXE chip.

(21 May 2012)

On the 24th of May 2012 I stopped by Delta to give Peter and David the completed circuit board and the radio frequency remote control handset. Because I had no idea how to programme the PICAXE chip (as we had not covered the topic in electronics yet) Peter said that he and David would see what they could do as far as programming it went, and get back to me later in the week.

(24 May 2012)

On the following Saturday, Peter called me on my cellphone to come to Delta with the two motors and test if the programming had worked. Fortunately, when they had the circuit board hooked up with the oscilloscope, the programming was successful and the circuit board worked. However, we then tried hooking it up with the two motors. This was not so successful. At this stage, none of us were sure why, but the motors weren't responding to the remote control handset like it had just moments before with the oscilloscope. Instead, they were 'twitching' and moving at random intervals even when the remote wasn't in use. As this continued, I started to smell a distinct burning smell, and realised that one of the components was getting fried. After pointing this out to Peter and David we switched the circuit off immediately and tested the components with a multi-meter to see what was making the smell.
Unfortunately, the motor control chip had fried and was no longer usable.
Peter believed that this could have something to do with either the voltage spiking, or an excess of back voltage coming back through the chip, but because nothing else could be done at this stage, Peter suggested leaving the circuit board with him and David so they could take a look at it during the week, and so, determine what exactly went wrong.

After this problem, I will now have to purchase another motor control chip and await Peters diagnosis of what might have happened.

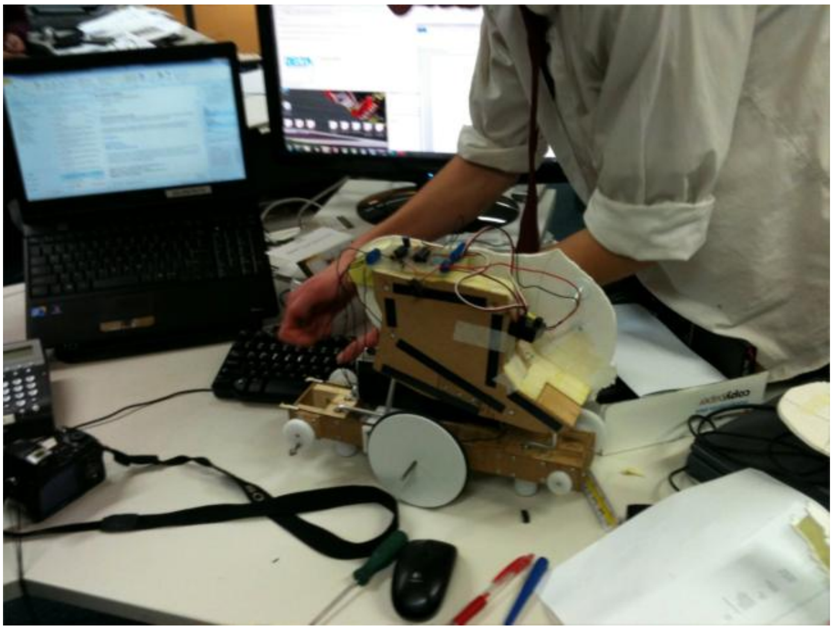
(26 May 2012)

Once Peter had fixed the problem, we arranged to meet up again at Delta on the following Tuesday (fortunately by this time the extra motor control chip had arrived). It turned out another capacitor had to be added onto the circuit to stop the voltage spiking and destroying the chip. After having a successful test with the oscilloscope, we tried the motors again. Success! The motors were now working perfectly with the remote control handset.
From this we organised for myself and Mr Maguire to meet up with Peter on the coming Friday at Delta to test the motors and electrical componentry inside the dog itself.

(29 May 2012)

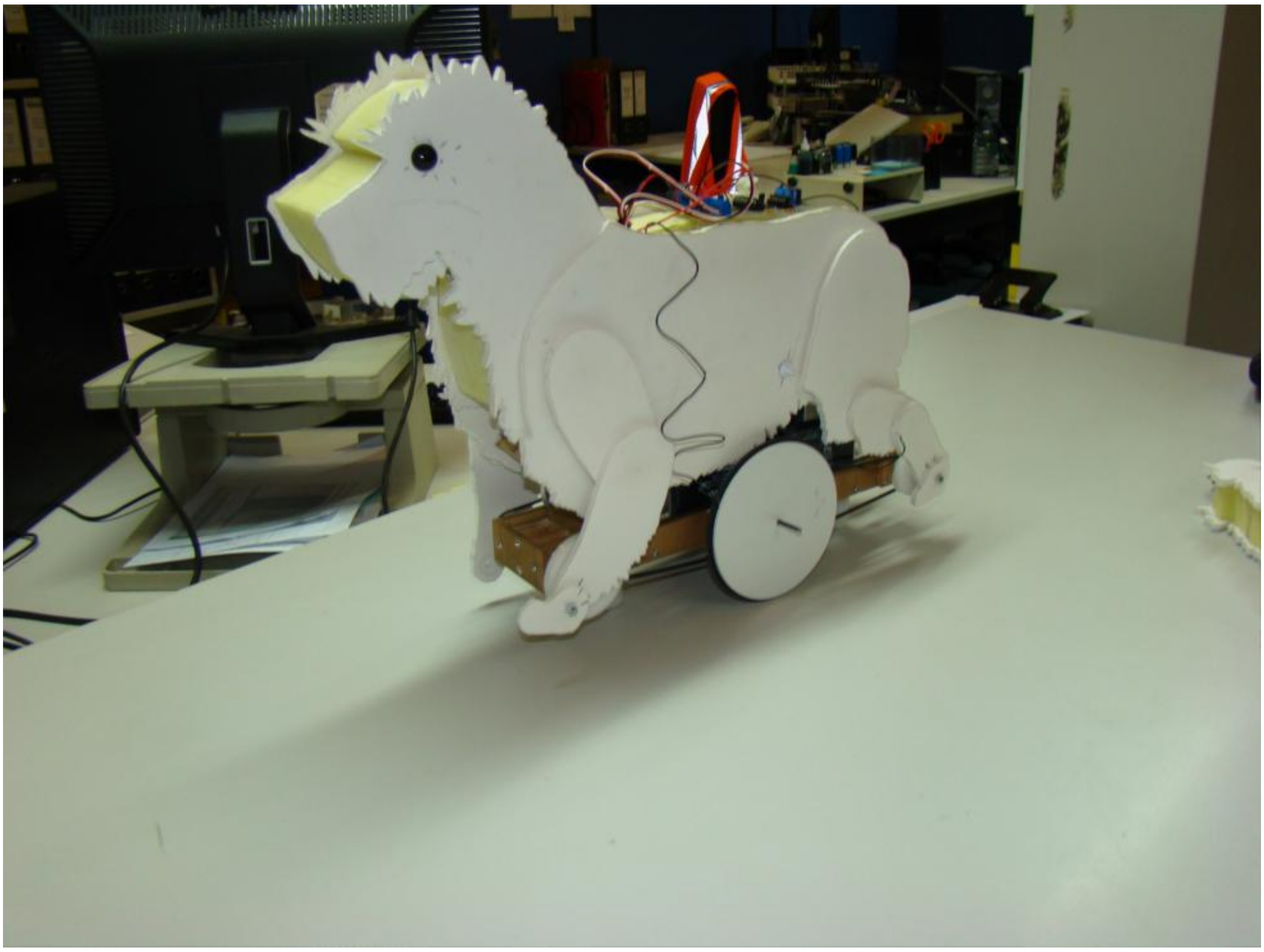
Dog Setup Before Full Test with Peter:

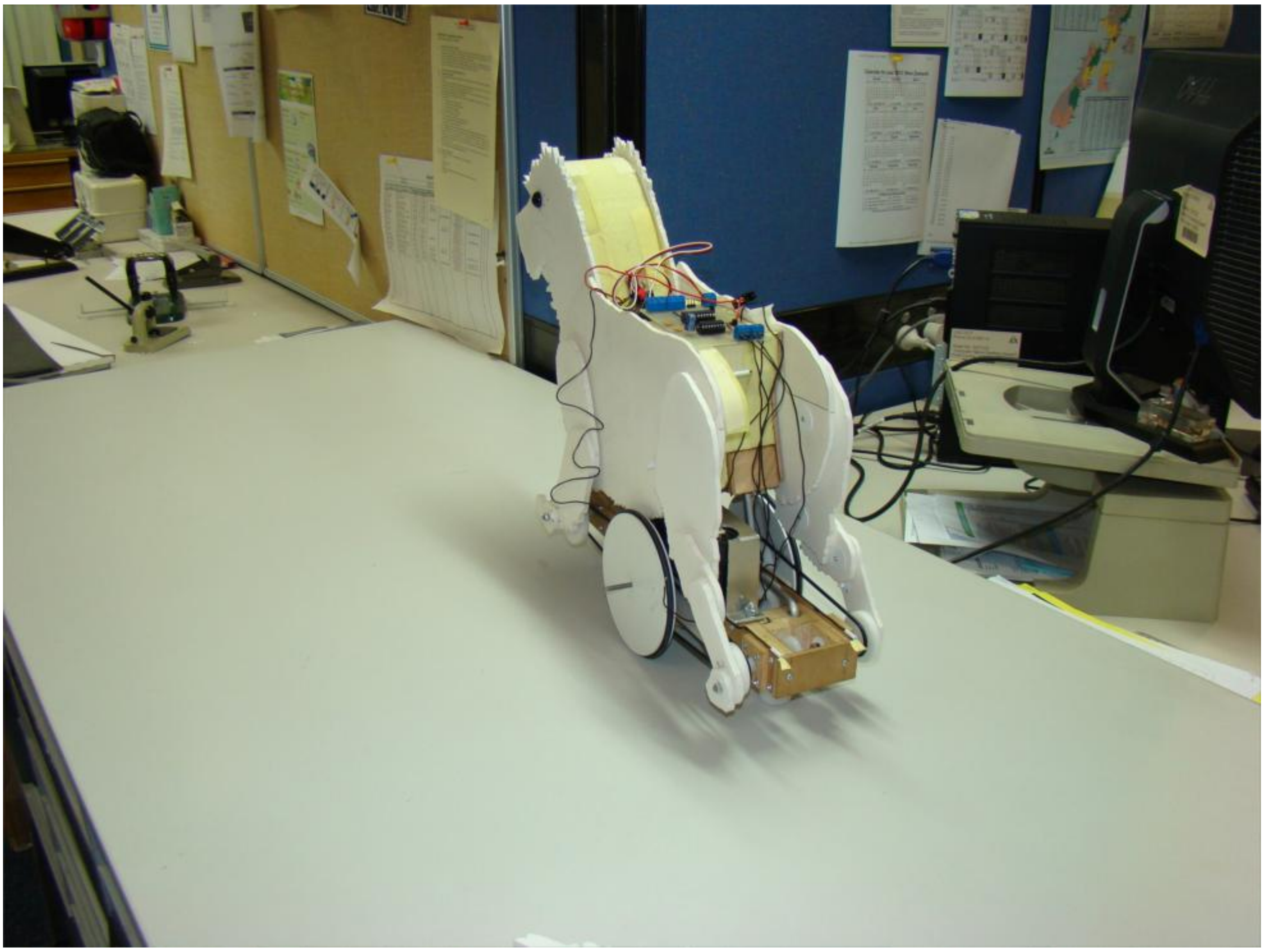
Peter assisted me with the setup of the dog before the full test. This involved connecting all of the wires to their according places.



We decided to keep the circuit board out of the hole inside the body structure, instead we just sat it on top. This was so we would be able to access it easily if something went wrong.

Full Electrical and Mechanical Test of Dog with Peter, David and Mr Maguire:





Success! The dog worked as intended. (1 June 2012)

However, there were a couple of things that needed to be tweaked in order to get it running as smoothly as possible. For example, we diagnosed that the friction between the bushes and the axles was causing the dog to 'judder' a little when moving. This could simply be reduced by oiling all the points of contact.
Apart from this, the dog worked and functioned well for what it was required to do. As mentioned previously, we had the problem of the remote control handset levers being different to the levers on the tanks that Mr Lower had lent me. However, thanks to Peter and David's programming, the controls were very easy to pick up, as they had made it so that shifting the left/right lever would make the dog spin left/right on the spot. This now made it very easy to control, as no longer would I have to think about controlling the dog like a tank, but instead, like a standard forward/reverse and left/right remote control device.

(1 June 2012)

Later that night I continued to test the movement of the fully assembled dog on the cork tiles in my dinning room. Unaware that either the rubber from the wheels on cork was building up static, or my general static charge I was carrying, I accidentally touched the exposed tracks on the back of the circuit when I was testing weather or not the chips were heating up. This caused a rather large and unexpected spark. Unfortunately, I had shorted out the circuit board again.

"**#@%$#!%*!**"

I will now have to make another meeting with Peter so he can asses the damages.

(1 June 2012)

I met up with Peter on the following Monday (4 May 2012) to sow him the circuit board and to see whether any damage was done. After testing the circuit with his multi-meter, to my relief, none of the components were damaged in any way, but instead, me accidentally touching the back of the circuit had blown part of one of the tracks off. Luckily, this was an easy fix, and all that needed to be done was to solder a wire between the two broken tracks (which we were able to do then and there).

I resolved to be more careful with the circuit board next time... and so, stuck a piece of balsa wood to the back, covering the exposed tracks and components.

(4 May 2012)

Testing Dog at Theatre with Lewis:

Now that the circuit has been fixed, and the dog and all of its mechanisms are finished, I can make a time to meet up with Lewis to show him the final product in motion. As well as this, we will also be able to discuss what colours the dog should be.
We organised to meet at the theatre on the coming Saturday, the 9th May 2012.

(6 May 2012)

Here we see Lewis directing me to where he wants Axl to move across the stage.

Stakeholder Consultation and Feedback:

After meeting up with Lewis at the Playhouse theatre and testing the dogs movement on stage, Lewis was delighted with Axl's movement and agility, especially the spinning on the spot motion. As well as this, Lewis was more than happy with how Axl had turned out aesthetically. He joked that it was rather unnerving having something that wasn't real walk up to him as though it were real.
While we were at the theatre, we were also able to discuss what colour the dog should be, as well as what colour the base should be. I brought along a manilla paper cut out of the dog to see what Lewis thought of that particular colour as shown in the photo below.

Lewis decided that this colour was the one to go with, as it both looked good as a typical dog colour, and that it was able to be seen from all around the audience, even with the lights dimmed.
As far as painting the base went, we decided that I would probably be beneficial to colour it the same as the floor. In doing so, it would partially hide the fact that Axl is standing on a base. Fortunately, there was a spare tub of this colour that we were able to use in the back room, as the floor had only been painted a couple days prior.

From this stakeholder feedback I now know that Lewis is very happy with what I have produce. As well as this, I can now purchase the brown paint similar to that of the manilla paper cut out for the dog, and also start painting the base the purple/blue of the floor.

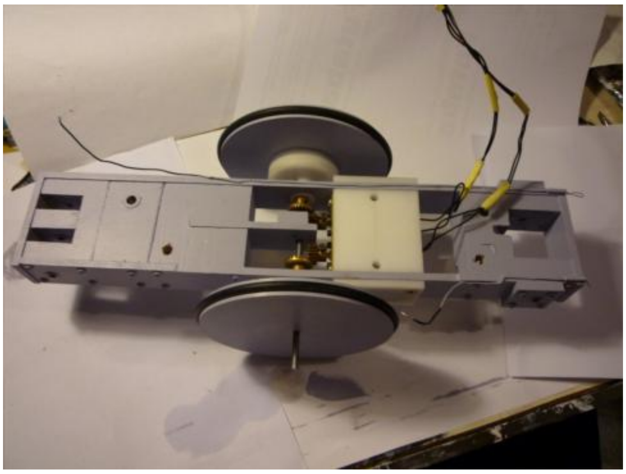
(6 May 2012)

Finishing:

To acquire the brown paint needed to cover the dog, my mum bought in a sample of the brown manilla pater to 'Mitre 10' in order to get it colour matched. Once they had found the right match, my Mum purchased a 500ml pottle of the matched paint. I then used this paint to cover the dog, and the purple paint I acquired from the theatre to paint the base as shown below.

(10 May 2012)





The Performance:

From the 24th of August to the 1st of September, Axl performed on stage with actress Elsa May for two hours each night in the play ‘My Brilliant Divorce’. He operated with out a hitch, and was well received by the audience.

Final Evaluation:

Product Testing and Evaluation

"Axl: Mechatronic Dog"

Conceptual statement: To design and manufacture a remote control, life sized Cairn terrier stage prop to perform for two hours every night for eight nights in the play "My Brilliant Divorce".

I have developed what my stakeholders consider to be a creative and innovative solution to address the needs identified within my brief.
I have used research, investigation, trialling, testing of materials, exploration of my design concepts, modelling of my ideas, and consultation with experts and stakeholders to achieve this result.

My product resolves the problem of having a real, and unpredictable animal perform on stage without having to use a stuffed toy or inanimate stage prop, all while working within the confines of the theatre .

Developing 'Axl' the mechatronic dog prop, has been a journey full of challenges in Technology Materials this year. Not only was I able to build off prior technological skills and knowledge from previous years at school, but I have also developed many new skills in Materials Technology, Electronics Control Technology, Mechatronics, design and manufacturing. It was a privilege being able to work alongside IPENZ professional engineers as well as my stakeholders in order to come up with my design concepts, and ultimately my final product.

I believe that 'Axl' has effectively met all the specifications and attributes that Lewis, my main stakeholder, made for this dog prop. As Lewis had requested, the final product is a life sized, remotely controlled dog. A Cairn terrier with a three hundred and sixty degree range of movement. Because of its size, Axl is able to be seen effectively from every seat in the Playhouse theatre. Both Axl's head and tail are articulated to allow movement when walking due to certain mechanisms hidden in the body. It has the ability to holding light objects in its mouth, in this case, the divorce documents, as stated by the script.

Overall, Axl was able to function efficiently and reliably for two hours a night for all of the eight days the play ran. On stage, the prop was both aesthetically pleasing and reliably functional. It was able to move and interact with the actress, and perform as the centre of attention for a number of scenes.

Although the brief for this project is a very simple idea, what physically allows the dog to move is extremely complex. The design, development and manufacturing of this project has been a very large undertaking.

I believe that Axl met the requirements of being a theatre performer, as he was able to quickly and efficiently respond to the directors requests during the rehearsals. At no stage through out the performances did Axl give away to the audience that he was remotely controlled, but instead, gave the appearance of being a self motivated actor in the play. His mechanisms and motors were quiet and unobtrusive. One advantage of Peter's implementation of the remote control system was that his controls were intuitive and easy to pick up by who ever had to control Axl. Another advantage of the remote control system was that it gave proportional control over his movements. This meant Axl could accelerate or Decelerate smoothly, and so, made his movements more life-like. Due to my Exam time table, Axl had to be operated by two people through out the rehearsals and the run of the play, my self and my father. *"The dog was surprisingly easy to operate and reliable" Ken Gorrie (Dad).*

My initial tests using the Infra-red remote control system were unsuccessful and unreliable due to the receiver needing a clear line of sight with the transmitter to function. Because there were a number of objects on stage that were part of the set design, I had to look for another solution for controlling the dog.
Using a radio frequency remote control meant the controls were able to function over a much greater distance than required on stage, and so, around objects. However, using this radio frequency remote system meant that he was occasionally vulnerable to radio interference if the handset was switched off while the receiver was still on. This interference could cause Axl to move randomly on stage, however, we were aware of this and made sure that the remote was always on when he was performing.

The batteries chosen for powering the dog were more than equal to the task. Not once was there a problem with losing power on stage, and even after several weeks of being stored, he was still able to function. On the other hand, the batteries required to power the remote hand set did have to be replaced, once during the performance, which meant the remote had to be switched off briefly. This resulted in a little bit of random motion in the dog, and ended with the dog facing the back wall. It was a matter of trial and error as to how long we could rely on the batteries. In hind sight, a sensible thing to do would have been to log how many hours the batteries had been in use for, and so, change them as needed.

Aesthetically, I believe Axl was well suited to the design of the play. His simple and stylised design was able to fit in well with the simple abstract stage set, and the non realistic mis-en-scene of this production. The testing of colour and size allowed me to produce a dog that was well suited to the brief and specifications.

Weight was a one of the most important key factor in the manufacture of this project. I believe I chose fairly suitable materials for the job at hand. They were light enough not to cause too much load on the motors on the completed project, and strong enough to allow it to last for over 16 hours of performing. However, modifications had to be made to the pine motor rig due to wear from being under the strain of supporting the motors. Because of this the pine started to deteriorate, and so, lose its grip on the motors. Another problem with the initial pine rig design, was that screwing and unscrewing the clamping screws repeatedly wore down the treads holding the screws in, which in turn, also lead to losing grip on the motors. To solve this problem, me and my technology teacher, Mr Maguire, re-designed the rig to be made out of a plastic block that we machined on the lathe. This provided plenty of strength and only a little more weight.

I believe the Foam core board was a suitable choice for the exterior of Axl, as it was light, easy to machine, fairly sturdy and was able to be painted over. An advantage of Axl's 2 dimensional design was that the foam core board could be used on almost every part of him. Parts that the foam core board couldn't be used on were able to be constructed out of Dense foam board, which was also light, durable and easy to work with. I was able to find a successful and innovative solution into the problem of mechanically articulating the Foam core board that was durable enough to last over 16 hours of use. However, a loose screw did cause a joint to fail in one leg at the very end of a performance. Fortunately, this wasn't visible to the audience as the lights were dimming for the end of the play.

The physical construction of Axl had to be split into three separate areas, all of which required a lot of work both designing and manufacturing. These three areas were mechanical, electrical and design. In order for the dog to function, these three areas had to be carefully integrated. In the end I believe I successfully achieved this. The mechanical aspect of this project involved a lot of development both prior to and during construction. The aluminium supports that held up the dog's body required precise and complex bending to accommodate all the restrictions of the surrounding components that made up the base. This process was easier to accomplish by trial and error than calculation due to the number of unknown variables. Apart from having to redesign the motor rig as mentioned previously, the rest of the construction went fairly smoothly.

Because the electronics side of the dog was mostly out of my range of knowledge, I had to seek help from two of my stakeholders, Peter Cowan, an IPENZ electrical engineer from the electrical division of Delta, also an ambassador of 'Futerintech', and David Mulder, aslo an IPENZ engineer from the electrical division of Delta. Peter was able to help out significantly and provide important input into the majority of the electrical process. David was also able to provide helpful input, in particular, with the design and fabrication of the circuit board. A process that I would not have been able to complete without their assistance.

If I were to re-visit this project, I think I would do some things differently. The present dog is a good, functional prototype, but I can think of some ways that I could refine my designs or material choices. For example, the base is currently made form pine and MDF with various plastic components (such as the motor rig). I think this could be better engineered by fabricating it either on a 3D plastics printer, or commissioning a specialist to manufacture it for me out of one piece of plastic. In doing this, I would have more time to develop the design and wouldn't have to worry about the limitations of the materials. Another area that could be further developed would be exploiting the possibilities of the radio frequency remote control, In that I could use more channels to animate different parts of the dog.

I am extremely proud of what I have achieved this year. This has been a huge learning curve for me. I have developed many new skills and knowledge, and built on my prior knowledge in technology. I was able to use various skills from my other subjects to help me develop my project such as maths, physics, electronics and art. I have developed a good relationship with my stakeholders and experts while doing this project. It has also given me a good insight into the realities of the design process and the engineering industry. I plan to begin to study product design next year where I hope to further my skills and knowledge. I would like to thank all my stakeholders, experts and people who have dedicated their time, energy and expertise to this project.

IPENZ Engineer Report: Peter Cowan

Engineer's Comment:

I was invited to be the Neighbourhood Engineer for Adam Gorrie's Yr 13 technology project which involved a design brief from the local drama society to make a mechatronic dog.

The "Axl" Mechatronic Dog project was a particularly technical project. In my opinion the level of skill required was typical of a second professional year at University!

I helped Adam develop and specify the electronic componentry required to build Axl the mechatronic dog. We then worked together to develop a circuit schematic for the required electronics. Finally, we integrated all the electronic components together to bring Axl to life!

To ensure the best outcome for Adam, I requested the assistance of a senior engineer, David Mulder, also from Delta. David tutored Adam in hardware and software design and implementation.

The student Adam worked diligently and consistently throughout the project to ensure a successful outcome for his stakeholder the director of "My Brilliant Divorce". I am sure this is partly due to John Maguire [Teacher] tutoring Adam throughout the project ensuring his project milestones were met.

Having performed technology at school about nine years ago, I was impressed when I was how Adam's technology course was preparing him for a career in engineering.

Finally, Adam invited David and I to attend the opening night of the play. It was thoroughly enjoyable and was great to see and hear the reaction of the crowd when Axl, the mechatronic dog, started chasing his tail!

I felt a great deal of responsibility while mentoring Adam as I knew his project had many complexities and I wanted to ensure a positive result. Subsequently I had a great deal of satisfaction seeing the result of Axl in action during the play. I also gained positive recognition from my Delta upper management for assisting Adam, Kavanagh College and Futureintech with this project.

Peter Cowan, Delta Utility Services.

Appendix:

Materials Costing:

Components	Cost:
Remote Control Handset and Receiver	$111.50
PICAXE 14Pin Control Chip	$11.80
14Pin and 16Pin IC Sockets	$5.96
5v Voltage regulator	$0.79
6v Voltage regulator	$12.05
L293Dx: 4 Channel Motor driver Chip	$7.40
3 Way PCB Mount Screw Terminal (x3)	$5.70
2 Way PCB Mount Screw Terminal (x2)	$3.00
Dm12-2.2 12v 2.2Ah Sealed Lead Acid Battery	$28.00
Permanent Magnet DC Motors (x2)	$24.00
Panasonic Alkaline AA Batteries 8 Pack (x3)	$15.00
Foam Core Board	$23.00
Brown Paint	$12.00
Stainless Steel Axles (x2)	$10.00
Glue	$4.00
M2x5 Screws	$3.00

Total: $277.20