ASSESSMENT and QUALIFICATIONS ALLIANCE

NEW SPECIFICATION
GCSE Design & Technology: Resistant Materials Technology

Exemplar Project Bike Stand

Autumn 2009

Identifying a need

Research & Specification

Generating Design Ideas

Developing the Product

Plan of Manufacture

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My Problem

As a keen cyclist and as a consequence of getting used regularly, my bike needs to be maintained regularly. Jobs such as lubricating and greasing the chain, bottom bracket and other components must be done on a weekly basis, or even more often when the bike has been used in the rain. Mending punctures must be done on a hopefully not to often basis as well, though in practice this happens more than I would like! Also, the bike is regularly washed, and every now and again, the gears and brakes need to be adjusted to keep them running smoothly.

All these jobs are either hard, or in the case of adjusting the gears and brakes, near impossible to do while the bike is on the floor as the cranks and wheels cannot be spun forward, and even from an ergonomic point of view having to bend over to do these things is far from ideal, and having to leave the bike leaning on either the forks or rear dropouts while a wheels is off is not good for the bike.

How often will the product be used?
The maintenance mentioned needs to be done on a weekly basis, or more often in winter when the bike will be frequently used on wet and salty roads.

What is the prospective market?
The product will be aimed at all cyclists, in particular those who do their own bike maintenance. This group includes both sexes and all ages, though based on height the product will be aimed at those of adult stature.

Design Brief

To design and manufacture a stand that will hold a bike so that regular maintenance may be carried out with ease.

Although I will only make one, the product must be able to be batch produced in the school workshop and will make use of jigs and templates wherever appropriate.

Research Plan

What?	Why?	How?
Cost	To ensure that the market can afford. and are willing to pay whatever the product costs, otherwise nobody will buy it.	1. Product Analysis – examine similar products and compare the prices. 2. Questionnaire – find out how much people are willing to spend by asking them first hand.
Bike dimensions and Weight	To make sure that the stand is capable of holding the weight of the bike, and that it is stable enough to hold the bikes of the desired sizes.	1. Product Analysis – look at the dimensions of different kinds of bikes 2. Media – use sources such as books and the internet to find out the typical sizes of bikes
What type of bike consumers own	To make sure that my product is suitable for the bikes that are commonly owned. and so that it does not have to be made suitable for types of bikes which it will never be used with	1. Questionnaire – ask people what kind of bike they own.
What characteristics features consumers look for in a workstand	To ensure that my product has all the features and characteristics that people want, otherwise if it were to be commercially produced no one would buy it.	1. Questionnaire – ask people first hand what features and characteristics they would want in a workstand.
Possible ways to hold the Bike	To make sure that my stand will be able to work with the widest range of bikes possible, by ensuring that it is able to hold all of them securely and in a position which allows bike maintenance to be performed easily.	1. Product Analysis – look at similar products and examine how they hold the bike 2. Questionnaire – ask people how they would prefer the stand to hold the bike 3. Media – find out commonly sized/shaped parts on bikes so that these can be held in the workstand
Aesthetics	To find out how much the market values aesthetics of a practical product like this and thus how much of an impact they have on the purchase of the product.	1. Questionnaire – ask people first hand how much they value the aesthetics of a workstand 2. Product Analysis – look at and compare the aesthetics of similar product which perform the same task.
Ergonomics	To ensure that my product is easy to use. This includes things such as the height the bike will be held at and the size and shape of the clamp.	1. Media – use books and the internet to find the relevant anthropometric data.
Materials	To ensure that I use the materials which are most suited to the specific part of the product that they will be used for.	1. Media – uses both print sources and the internet to find out the properties of materials, and thus which material is best suited to which task. 2. Questionnaire – ask people first hand to find out what their perceptions about materials are, so that I may use a material which the public perceive as suitable, making them more likely to buy the product. 3. Product analysis – examine similar product to find out which materials are used.
Workshop Resources	To ensure that we have the suitable tools in the school workshop for any materials or construction techniques that I wish to use.	1. Look at the tools that are in the workshop

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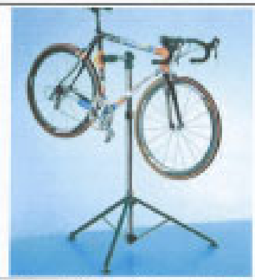
Product Analysis

Product				
Name	Topeak Prepstand Standard	Lifeline Spindoctor Deluxe	Park Tools PRS15 Professional Race	Tacx Cycle Spider Professional
Price	169.99	89.99	299.99	129.99
Material	Aluminium	Aluminium	Aluminium	Aluminium
Weight			11.6kg	
Foldable	Yes	Yes	Yes	Yes
Clamp Height	48" – 72'	Up to 60"	40 - 60	
Manufacturers description	Tough 6061 T6 aluminium tube 360° rotation clamp Easy to fold, store and open Clamp opening: 0.75" - 1.75"	Top quality stand for home and enthusiast use Long legs and wide base is stable and secure Rubber coated quick release jaws are easy to use and clamps on either the top tube or seat post.	Five-point leg system adjusts to create a super stable base Professional quality Clamp adjusts to fit tubes from 24mm to 76mm in width Adjustable clamping pressure prevents damage to thin walled tubes Clamp rotates 360	Tripod Legs provide solid support When folded takes up little space Bike clamps with soft rubber inlays protect paintwork from damage Suitable for nearly all frame tube diameters Clamp can be rotated 360 degrees
My Opinions	It looks stable, and the wide range of adjustability in both clamp height and rotation is a definite plus point, but it does not look like it is especially long lasting. I like it overall.	Again does not look particularly long lasting, but does look secure and stable. Rubber coated jaws are very good, as they will prevent scratching and rubbing of the paint. Simple looking clamp, though probably just as effective.	Looks very well built, with a stable base. Quite adjustable, and the clamp looks very well designed. It is also very easy to transport – light and foldable. Overall it is very good, though this is reflected in the price.	Again I like the rubber inlays on the clamps to prevent damage to paint, and the base looks very effective. Aesthetically I like this stand a lot – it has nice clean lines and a simple looking clamp.

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Possible ways to hold the Bike

In my product analysis, I found out that there were three main ways used to hold the bike:

- using a clamp which was able to rotate allowing the user the decide where he wanted to clamp the bike
- Using the Bottom bracket and down tube
- Using the Bottom bracket and front/rear forks.

In my questionnaire I asked people where they would prefer the bike to be held. The vast majority (57%) said that they would prefer it to be held on the seat post. The next most popular choices were top tube and seat tube with 23% and 17% respectively. Only one person replied that they would like it held by the Front/Rear Forks and Bottom Bracket.

	Positive Points	Negative Points	Overall
Frame tubes	It is a convenient point to hold the bike, and allows the bike to be taken in and out with ease. It allows easy clamping of most steel and titanium frames, which tend to have a circular tube profile.	Modern bikes are commonly made out of aluminium and carbon. Aluminium bikes are often made using a technique called hydroforming, which results in non-cylindrical tube profiles. Carbon frames also make use of differently shaped tubes. While both of these allow the manufacturer to create a stiffer and/or more compliant bike, they would make clamping difficult. In the pursuit of lightweight frames, manufacturers also use tubes with very thin sidewalls which, whilst fine in normal use, are easily crushed by sideways forces, such as that of a clamp. This would result in irreparable damage to either a carbon or aluminium frame. A few frames also have extremely oversized tubes, meaning that clamping it would be either impossible or the user would only be able to clamp the bike in certain places, which would be inconvenient.	Not very good – even though it is easy to use it is only compatible with a small number of bikes, and could potentially break a frame.
Seat post	It is a convenient point to hold the bike, and allows the bike to be taken in and out with ease. Also almost all bikes have a cylindrical seat post, which makes clamping more effective. Seat post diameters also do not vary very much – diameters of posts range between 26.0mm and 31.6mm (though some BMX bikes make use of posts as small as 21.15). This would make clamping a wide variety of bikes easy.	Care would have to be taken by the user when clamping carbon fibre seat posts, to ensure that they are not damaged by over tightening, as the nature of the material means that it is likely to crack and then fall apart when it is put under load (such as being sat on) with possible safety implications if the bike is being ridden at the time. Many people however avoid this problem by having a cheap metal seat post to use when the bike is in the stand. In addition, some high-end bikes use Integrated seat posts or aero seat posts which do not have a circular cross section, making clamping difficult.	Good – it is easy to use and convenient, though it has compatibility issues with a small number of bikes. Many of the issues regarding carbon fibre seat posts and aero posts can be easily, and cheaply, solved.
Bottom bracket and front/rear forks	Allows all bikes to be clamped, regardless of frame material and tube profiles.	This design necessitates either the front or rear being taken off before the bike is placed in the stand, which seems slightly laborious. Care would also have to be taken to ensure that the stand does not knock the rear derailleur when the bike is held by the rear dropouts as this make cause it to become misadjusted.	Good –the fact that means a wheel has to be taken off before the bike can be put in the stand is made up for by its extremely wide range of compatibility.

Bike Dimensions

Bikes can vary a great deal in both size and shape. For example road bikes have lower handlebars to improve aerodynamics and skinny tires to enable them to go fast. Mountain bikes have higher, wider handlebars to improve ease of steering at low speeds, and thick, knobbly tires to improve off-road grip.

There are many other differences between the two types of bikes, with Hybrids somewhere in between the two types, attempting to provide the best of both worlds. For this reason the dimensions are not needed for my project, as any stand that can hold both road and mountain bikes will be able to hold one which is designed to be a mix of the two types.

The dimensions and weights of typical road and mountain bikes are shown below. The bike dimensions were all taken from the TRek Bikes website

Again to ensure that the stand is compatible with the widest range of bikes possible, I will take the smallest and largest sizes, and make sure that the stand is capable of holding bikes of these sizes.

Road Bike

	Frame Size	XS 50 cm	S 52 cm	S 54 cm	M 56 cm	M 58 cm	L 60 cm	XL 62 cm
A	Head Angle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	Seat Angle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	EFF Top Tube	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	Chain Stay	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	Bottom Bracket	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
F	Offset	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
G	Wheel Base	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Trail	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Stand Over	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Head Tube	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Frame Reach	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Frame Stack	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Seat Height Minimum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Seat Height Maximum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Mountain Bike

	Frame Size	S 15.5 in	M 17.5 in	M 18.5 in	L 19.5 in	XL 21.5 in
A	Head Angle	69.0°	69.0°	69.0°	69.0°	69.0°
B	Seat Angle	72.5°	72.5°	72.5°	72.5°	72.5°
C	EFF Top Tube	55.3	59.0	60.9	62.7	64.5
D	Chain Stay	43.0	43.0	43.0	43.0	43.0
E	Bottom Bracket	33.8	33.8	33.8	33.8	33.8
F	Offset	4.0	4.0	4.0	4.0	4.0
G	Wheel Base	108.4	110.3	111.3	114.0	116.0
	Actual Frame Size	39.4	41.9	44.5	47.0	50.8
	Trail	8.5	8.5	8.5	8.5	8.5
	Stand Over	72.7	74.1	75.8	77.3	80.0
	Head Tube	11.2	12.7	13.7	14.2	15.7

My Bike

A	Head Angle		73
B	Seat Angle		74
C	EFF Top Tube		53.5
D	Chain Stay		40.5
E	Bottom Bracket		26.5
F	Offset		4.5
G	Wheel Base		96.8
	Stand Over		78
	Head Tube		12.1

Summary of Research

From my Product Analysis I found out that:
- Workstands cost between £60 and £300.
- Most are made out of aluminium.
- Just over half the workstands I looked at were foldable.
- Most workstands are height adjustable.
- Most workstands have a clamp that can be rotated through 360°.
- One of the main advertising lines it stability – consumers must prize it highly.
- Many stands have plastic/rubber parts which prevent superficial damage to the bike.

From my Questionnaire I found that:
- Most people own road bikes, though mountain bike and hybrid owners still make up a large proportion of bike owners.
- Most people are willing to spend £51 - £100 on a workstand.
- The vast majority of people would not want the workstand to be wall mounted.
- There is a market for the product as most people maintain their bike themselves, and most people do this every 1-2 weeks.
- The majority of people would want the workstand to be transportable.
- The qualities that are prioritized most highly are holding the bike securely and stability.
- 2/3 of people would want a foldable workstand.
- The majority of people want their bike to be held in the workstand by the seat post, with the next most popular choices being the top tube and seat tube.
- Most people do not mind what material the workstand is made out of, but some people would prefer to be made out of metal.

From my research on Bike dimensions I found out that:
- The biggest stock size bike had a wheelbase of 116cm and the smallest a wheelbase of 972cm.

From my research on Bike weights I found out that:
- Though it would very rarely be required to, my bike stand should be able hold bikes of up to 30kg.

From my research on where the bike should be held I found out that:
- Overall the best ways of holding the bike is either by the seat post or by the bottom bracket and front/rear forks.
- Holding a bike by the front/rear forks is the most compatible, but requires the wheels to be taken off.
- Holding a bike by the seat post is the most practical, though there are issues with damage to carbon fibre seat posts, and compatibility issues with integrated seat posts.

I will use my research on both materials and ergonomics to refer to while developing ideas, as no conclusions can be made without quoting large amounts of data and I need to know more about the design of my product before I can state a specific material.

Design Brief:

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Although I will only make one, the product must be able to be batch produced in the school workshop and will make use of jigs and templates wherever appropriate

Specifications

My Product must have, or be capable of the following specifications:

Budget:
1. Cost between £51 - £100.

Function:
2. Be suitable for use with road, mountain and hybrid bikes
3. Be able to hold a bike of up to 30kg.
4. Be able to hold bikes with a wheelbase of between 95 cm and 120cm.
5. Be stable when holding a bike
6. Be able to hold the bike securely
7. Hold the bike either by the seat post or the bottom bracket and front rear forks.
8. Be easily foldable
9. Be able to fold compactly for transportation
10. Be freestanding

Materials:
11. Be made largely out of metal.
12. Have plastic/rubber parts which prevent superficial damage to the bike.

Ergonomics;
13. Be height adjustable.
14. All parts that interface with the user (such as knobs etc) must be ergonomic.

Workshop Resources;
15. Be able to be made in our school workshop

Safety:
16. Comply with all relevant safety legislation.

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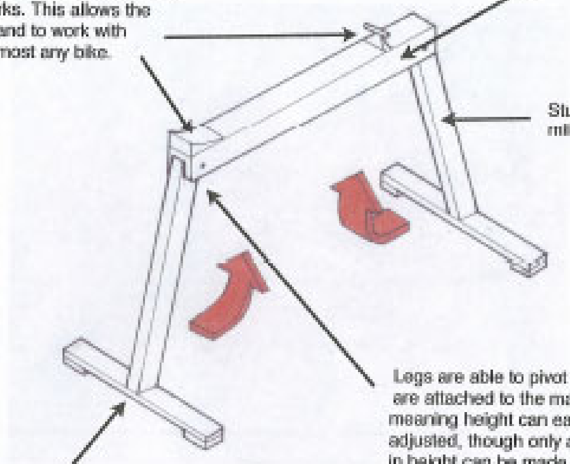
1

Made using a box girder or aluminium channel.

Bike held securely by the bottom bracket and front forks. This allows the stand to work with almost any bike.

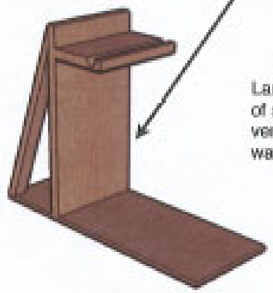


Sturdy frame made from mild steel?

Legs are able to pivot where there are attached to the main cross piece, meaning height can easily be adjusted, though only a small change in height can be made. It also allows the stand to be folded and stored or transported with ease.

Wide feet provide a stable base while rubber attachments on the bottom ensure it does not slip. These would be cheap, keeping costs down, yet still effective.

Large, fixed position upright is very stable but means that the stand could be neither folded for storage nor transported.

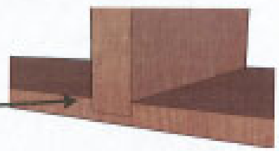


Large, wide base provides lots of stability, yet because it is not very tall would not get in the way.

Stand could be made fro
m wood, which would be better suited to this design than any other material - it is cheap, easy to shape and strong. Because the stand may be kept in sheds or garages where it would be exposed to damp it would have to be varnished or painted to make sure the would does not rot. Alternatively treated wood could be used, though this tends to have a rougher finish which would be less aesthetically desirable. A manmade board such as plywood would be most suitable because it is available in wide widths and is cheap and durable.

Supports for upright ensure that the stand is strong and durable.

A cutout in the base which the upright rests in will provide extra strength to the joint.

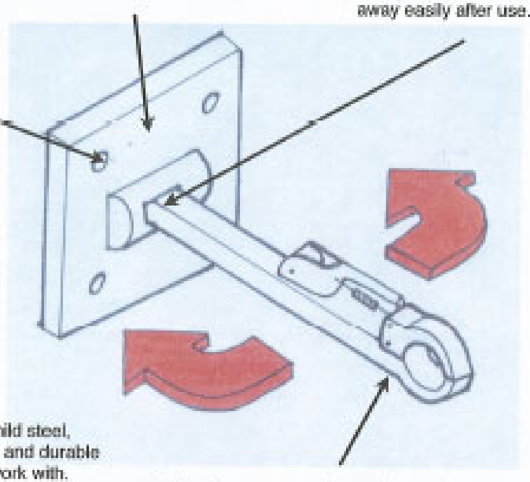


2

This stand is wall mounted. This is very good in that it allows to set the stand at any height they want, though once the height is set there is no adjustability, so it cannot be used ergonomically be=y more than one person nor can it be used both standing up and sitting down.

Because the stand is wall mounted it needs the user to have wall space available to put it on. It also would obviously not be transportable, though as the arm can pivot it folds away easily after use.

Four screws securely attach the stand to the wall.

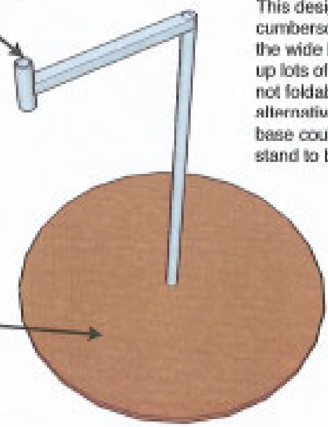


Could be made from mild steel, which would be strong and durable yet relatively easy to work with.

The clamp uses a spring and pivots to allow it to open and close easily and quickly. This means that the bike needs to be held for only a small amount of time before the stand is supporting it, making taking the bike in and out very easy.

The upright would probably be made out of mild steel, and could be made to be adjustable so that the product is suitable for users of many different heights.

This clamp is simple to make, yet still will hold the bike effectively. A catch would be used to secure it, and a high friction material would be used on the inside to ensure that both the bike does not slip and that no superficial damage occurs while the bike is clamped.



This design would be cumbersome to transport as the wide base would take up lots of space. It is also not foldable, though alternative designs of the base could allow for the stand to be made foldable.

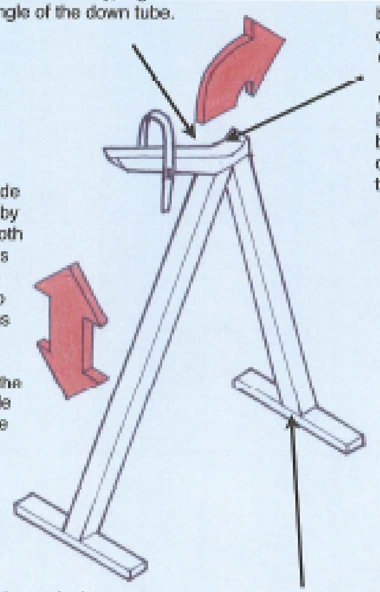
Wide base would provide the stand with stability. It would be relatively small in height so as to ensure that it is not a tripping hazard. Plywood would be the most suitable for this as it is available in large sizes and durable, yet is still cheap.

3

Allowing the place where the bike rests to pivot allows the bike to be held at a wide variety of angles. This also means that all bikes can be held horizontally, regardless of the angle of the down tube.

This stand holds the bike by the bottom bracket, with the bottom of the down tube also being supported. To ensure the bike does not fall off, a strap goes around the down tube which can be fasten by a buckle. Either a simple belt like strap and buckle could be used or a more complicated ratchet buckle, such as that often found on ski boots.

This stand could be made to be height adjustable by allowing the length of both legs to be changed. This would make this design more time consuming to make than other designs which only require one support to be made adjustable, and thus is the product were to be made commercially it would be more expensive.

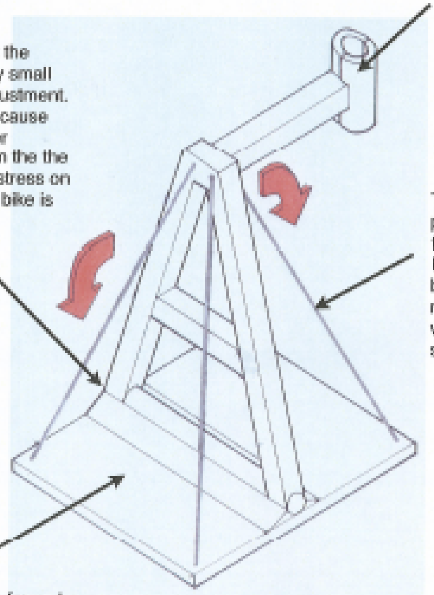


I very much like the clean, sleek aesthetic of this design, and think that it has potential to be able to fold very compactly as well.

Wide feet provide a stable base, ensuring that the stand does not fall over. As with other designs, a variety of different feet could be used depending on whether cost or effectiveness is valued most highly.

This design of clamp is cheap and simple to make, which would keep costs down. A simple catch would secure the clamp, with a compressible, high friction material used on the inside to ensure that a wide range of tube sizes can be held. This however may not be very durable as it relies on the materials elasticity, so may have to be periodically replaced. Care would have to be taken to ensure the material chosen to use is both suitable for this purpose and cheap, especially since the user will have to replace it at their own cost, and a high cost dissuade potential buyers from considering the product.

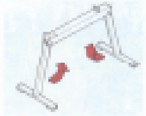
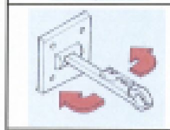
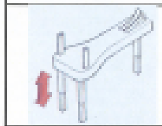
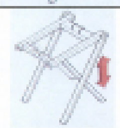
The upright pivots at the base, allowing a very small amount of height adjustment. This however would cause the bike to lean either towards or away from the the user, placing undue stress on the seat post if the bike is held by it.



The upright is held securely in place by cables. Tensioners on these could allow the cables to be pulled tight. THese could be bought rather than made, but may mean that the stand is very expensive, especially since four are needed.

The base would be made from cheap man made board, such as plywood, which would be wide to ensure the stand is as stable as possible.

4

Design	My comments	Does it meet my specifications?	My chosen design to develop
	I like that fact that this design is easily foldable, though the small range of adjustability is a problem, however it could be solved during the development stages with relative ease. I dislike the fact that the front wheel must be taken off to put the bike in the stand.	It meets all the specifications, though the design only has a small range of height adjustability.	
	I strongly dislike the lack of both height adjustability and being able to fold. This design would be heavy and not transportable at all, and aesthetically I think it looks cumbersome. THe bike is only held by a cutout which the top tube rests in - this is not secure and does not hold the bike completely still, which could be a problem.	This design fails to meet specifications 7, 8, 9, 11 and 13. This is a large number, indicating that the design has several major areas of weakness.	
	I really like this design, and I think that it also has a lot of potential for development to solve some of its minor flaws. The method of holding the bike is secure, and the bike can be taken in and out with ease.	This design meets all the specifications apart from 8, though I think that this method of holding the bike is very good, and is perhaps a way I did not look at during my research on 'Possible ways to hold the bike'.	✓
	I dislike the lack of height adjustably - this is a fundamental design law, and could not be easily solved during development. This design is however very stable, but can be folded which is a plus point. Tensioning cables seem a bit of an unnecessary faff. The design of clamp is okay, but could be made much better during development.	This design fails to meet specification 13, which is central to the ease of use of my product and thus is very important.	
	I like the design of this stand, though in my case lack of wall space could be a problem. It can be set to any height the user wants, though once set the height cannot be changed, limiting it to one user. The clamp design is very good, and holds the bike securely. It is not transportable, and not freestanding either.	The design does not meet specification 10 or 13, but apart from these all specifications are met. In addition in my Questionnaire the vast majority of people said that they would not like a wall mounted stand.	
	I like this stand a lot. It is very stable and the clamp design holds the bike securely, though it could be changed to something easier to use during development. It is easily height adjustable, and could again easily be developed to be foldable.	This meets all the specifications, though it could be developed to be able to fold more compactly, and have a better clamp design.	
	I do not like the design of this stand. It take up a lot of space while in use. Adjusting the height would take a long time as each leg needs to be change individually, and even if the stand was to be made foldable, it would need a relatively large amount of space to store it.	This design does not meet specification 8, and though it meets specification 9, it does not fold very compactly and thus fails to meet 9.	
	This stand needs the bike to be turned over to be put in it, which I do not like. The bike would not be held as securely as in some of the other designs, and there might be compatibility issues with some shapes of handlebars. I does however fold easily and compactly to be stored when not in use.	This deign does not meet specification 7, but does however meet all other specifications.	

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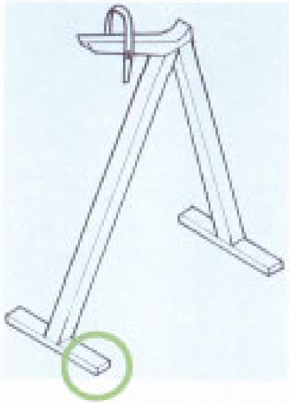
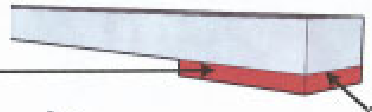
Evaluation & Testing

Photographic Evidence

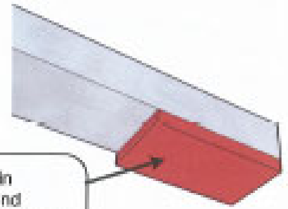
Feet





Regular shape and profile means they can be easily cut from a sheet of material of the correct thickness, keeping costs down.

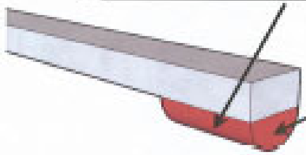
Large contact area with feet means they can be fixed on securely, through glue, bolts, or a combination of the two.



Large surface area in contact with the ground means that they will be very grippy, so reducing the chance of the stand slipping.

The shape means that they will have to be specially made for my project, and will thus be costly, unless semi circular rubber of the correct diameter is available.

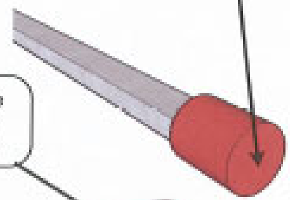
Semi circular design allows the feet to be stable when they are at any angle.



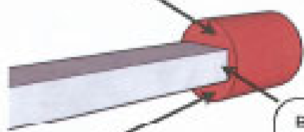
Large contact area with feet means they can be fixed on securely, through glue, bolts, or a combination of the two.

This shape also means that they will have a very small contact area, resulting in increased chance of the stand slipping.

Circular shape means they will work at many different angles.



As they protrude above the foot of the stand, they may become a tripping hazard.



Small contact patch means that they will be less grippy than other designs.

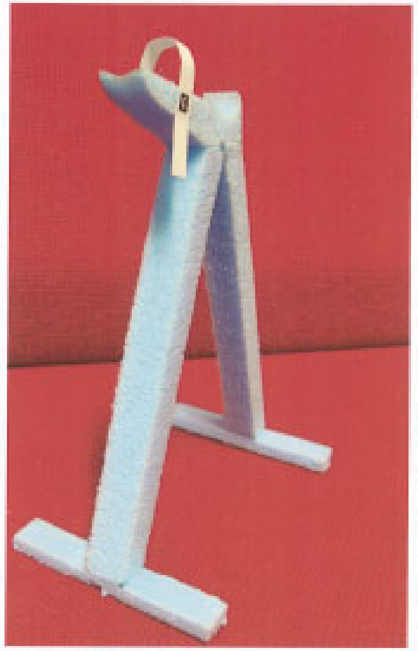
Because they feet over the foot of the stand, they would have to be made specially for my project, meaning their cost will be high.

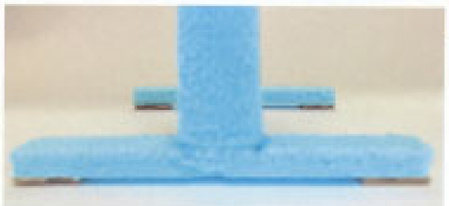
Modeling

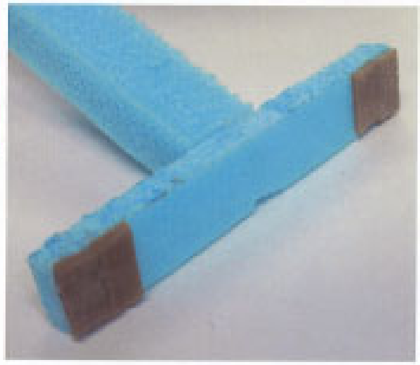
Visually I think my model is quite sleek and compact, and it is also quite stable, though fact that the blue foam flexes a little under pressure means that the top part which would hold the bike tends to lower slightly when weight is applied. This however would not be a problem with my real product, as I would choose a material which is stiff enough for the forces that will be applied to it.

I need to work on how the joint at the top, which would allow the bike to be held at different angles would work, and also how I will make it will be height adjustable. In addition I need to decide how I will make the strap which secures the bike adjustable.

As well as this I experienced problems with the model sliding on smooth surfaces; again this is probably due to the nature of the blue foam that I used, though the addition of pieces of rubber on the bottom to simulate the presence of rubber feet helped greatly. These were however included on my original design, but this reinforced the fact that they improve the ease of use of the product.







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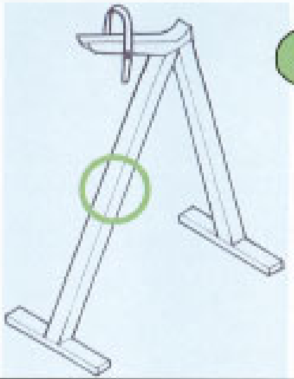
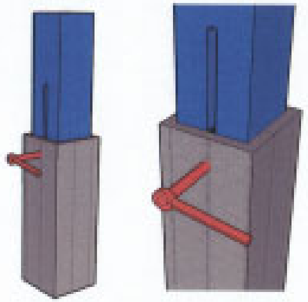
Height Adjustability



1

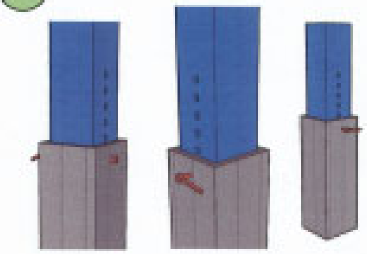


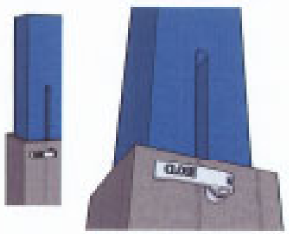
This design is good as in allows the height to be set to any value at all within the upper and lower limits, meaning that the user can set the height to the exact height which is ergonomically optimum for them. The pin that holds it together is threaded, and when tightened it hold the inner section of tubing t the correct height though friction, and so may be prone to slipping, and be able to hold less weight than other designs. This also necessitates close tolerances between inner and outer sections of tubing, as if there is too big a size difference, it will not be able to clamp the inner section effectively. It would however be quick and easy to adjust, and could easily be taken apart to allow the stand to fold compactly.

This design is very similar to the one above, though it utilizes a prefabricated quick-release to clamp inner and outer sections of tubing together. This would make adjusting the height even easier and quicker, and would also appeal to my prospective market (bike owners) who already both use and trust quick releases on their bikes. Again it requires close tolerances between inner and outer sections of tubing, and it may be hard to acquire tubing with this property.

The height in this design is adjusted by removing a pin, and placing it in one of several holes drilled at different heights. Though this makes adjusting the height slightly harder, it entirely eliminates the possibility of slippage when the stand is in use, and it is still reasonably easy to change the height. The pin could either be threaded and have a nut on the end as shown here, or more likely be a cotter pin which would allow for even quicker removal, and be just as secure when in use. A cotter pin is shown below.

3

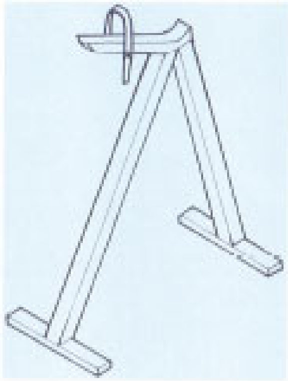




2

My chosen design is design 1, as I think that the property of being able to be adjusted to any height if very good, yet it still should be secure enough not to slip when in use. As it uses no prefabricated parts, it helps to keep costs down, and yet has as good a function as if a quick release were used. This choice does however depend on the availability of telescopic tubing, and depending on whether or not I can get some this choice may have to change.

Materials and Construction



Materials

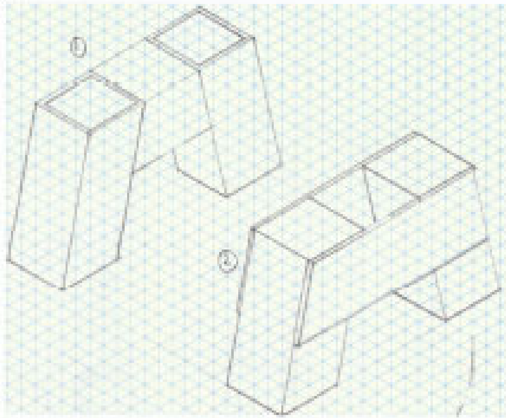
As the shape of the design of bike holder that I have chosen necessitates it to be cast, aluminium will be used for this as it is easier to use due to its lower melting point and often produces a better finish. It is also plenty strong and hard enough for the intended use where the brittleness of cast iron would be a disadvantage. Once the bike holder has been cast, the softer aluminium will also be much easier to work with than the high carbon content steel used.

For the rest of the project I will use mild steel. This is available in a wide range of sizes and shapes of tubing, so I will likely to be able to achieve a close enough tolerance between the inner and outer sections to allow me to use the method of adjusting the height that I prefer the most. Mild steel also can be joined much more easily than alternatives such as aluminium, as is can be both welded and brazed to produce secure joints, whereas I would have great difficulty joining aluminium securely in the school workshop. It is hard enough to avoid being damaged when the project is in use as it does not dent as easily as aluminium, and the legs are the places where the stand is most likely to receive knocks, so it is most important to use a hard material here. Though it is hard, it is still relatively easy to work with compared to higher carbon content steels such as stainless steel, and so can be shaped easily. As it will rust, it will need to have a protective finish applied to it, which would be one of the main advantages of aluminium.

Joining Tubing

There are three main joints between tubing in my project – one between the legs and the feet (one on each leg), one between the outer sections at the top of each leg and one between the inner section and outer section at the top of one leg only. The first joint is suited to welding – it is a T-joint, and so has a relatively low surface area in contact. As it is between a long, load bearing leg and a foot it needs to be strong and welding will provide a joint with these properties, yet it will still look clean and sleek once the welds have been ground. The material that will be used (mild steel) also welds well without any distortion or cracking due to its low carbon content. MIG welding will be used as this is the equipment available to me in the school workshop.

The second joint could be done in one of two ways. Firstly, it could be welded to with another piece of box section tubing (1). This would produce a smooth join, and is in keeping with the sleek look throughout by project. Once the welds were ground the joint would be near invisible, and it would be very strong and resistant to flex. The join could also be done by brazing a piece of sheet metal of a suitable thickness to either side, as in (2). This looks somewhat bulky



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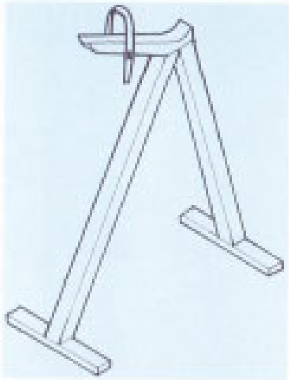
Finish



Powder Coating

This allows a choice of colour, and is easily done using the equipment available in the school workshop. Though it can produce a thin coating, it would be difficult to achieve this over the large areas that my product involves, and a thin coating is especially important where my tubing is telescopic. It would also be near impossible to achieve a uniform, even coating, detracting from the aesthetics of my project. It would also be more time consuming than other finishes, as heat must be applied to harden the finish. It is however very environmentally friendly, as overspill can be reused and no VOCs or harmful greenhouse gasses are emitted.

Black Oxide

This finish provides a very high level and attractive finish, which is also slightly corrosion resistant. It limits the colour choice to black which is a definite negative, and it is also quite labour intensive as the parts must be cleaned, black oxided, and then waxed or oiled with intervening rinses. It requires the use of toxic chemicals, is hazardous and very dangerous, so if this were to be used it would need to be done professionally by someone with the correct knowledge and equipment.

Paint

Paint (applied from a spray can) is quick and esy to apply, and provides quite a high level of finish. It gives a thin, even coating which will prevent rusting, particularly important for my product as it is likely to be kept in garages/ sheds where it is often moist. It also allows me to choose from a wide range of colours, meaning that my product would be able to be very aesthetically pleasing.

My chosen finish is paint, as it is the easiest and cheapest to apply, yet still gives a good looking uniform finish in a range of colours that is suitable for the intended use of my product. It also provides good corrosion resistance, which would otherwise be a problem for a product made from mild steel.

Plan of Manufacture

Task	Description	Tools/ Machines	Health and Safety Precautions	Alternative used in Industry
Modelling and testing	Make a model from Styrofoam to test the aesthetics and use of rubber feet on my project.	Scroll saw, Sandpaper, Hot glue gun	Apron, (this will be used for all other tasks as well), Safety goggles.	Rapid Prototype
Make pattern of 'bike holder' from styrofoam	Using CAD/CAM manufacture the bike holder to the correct dimensions. Due to unforeseen constraints of the size of the pattern imposed by the router in the school workshop, the size of the pattern had to be changed so that it would fit on the router bed.	CNC Milling Machine	Ensure safety guard is closed.	
	Shape the other faces of the pattern by hand, as the router cannot shape multiple faces to the correct shapes.	Scroll saw, PVC glue, G-cramp, Sandpaper and sanding block, steel rule.	Safety Goggles, ensure emergency stop is in quick and easy reach.	
Cast the pattern from Aluminium	Due to the nature of the shape of the pattern, 'lost mould' casting must be used. Pack the drag, fit pins for sprue and riser, pack cope, Creating pouring basin and remove Pins.	Casting Flask (consisting cope and drag) Moulding sand, pins, strake, wooden wedge for ramming sand.		Machined from a solid block using a CNC milling machine
	Pour the molten aluminium onto the mould.	Crucible, Furnace,	Gloves, Safety goggles.	
	Cut off sprue and file flush.	Junior Hacksaw, Hand Files.		
Mill the pattern	Mill the pattern at the two planes needed.	Vertical milling machine	Safety goggles.	

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Fill the 'bike holder'	As lost pattern casting must be used and the pattern will be made from Styrofoam, a slag will form on the 'top' of the casting, which will need to be removed and then filled using 'Chemical Metal' for aesthetic reasons. File and sand flush.	Chemical Metal, Hand Files, iron brush, Chemical metal, Emery paper.	Dust Mask, Safety Googles.	
Drill the 'bike holder'	Two holes need to be drilled in the bike holder so that it can be attached to the legs.	Pillar Drill	Pillar drill guard and emergency stop pedal, ensure chuck key has been removed, Safety goggles.	
	Drill and then tap (7mm hole, M8 Tap) the holes that attach the strap.	Pillar Drill, M8 taps (taper, plug and bottoming)	Pillar drill guard and emergency stop pedal, ensure chuck key has been removed, Safety goggles.	
Legs	Measure out and cut both the inner and outer sections of tubing at the correct dimensions/angles, including the outer sections of tubing for the top of each leg.	Steel Rule, Scriber, tri-square, Heavy duty cut off saw.	Ensure emergency stop button of cut off saw is in easy reach, Safety goggles.	Automated Guillotine and CNC Router
	Mark out and drill holes in both inner and outer sections of tubing to allow the height to be adjusted.	Steel rule, scriber, odd leg callipers. tri-square, centre-punch, Pillar drill.	Pillar drill guard and emergency stop pedal, ensure chuck key has been removed, Safety goggles.	
	Check fit of cotter pin, and if necessary file holes for a better fit. File holes smooth.	Hand Files.		
	Cut 4 pieces of sheet steel to the correct size to ensure a slid fit for the outer section at the top of one leg, and then braze. File smooth.	Steel Rule, Scriber, guillotine, Brazing hearth, brazing flux, plain brass brazing rod, oxy-acetylene torch, Hand files.	Gloves, Safety goggles, air extraction.	
	Drill two holes in the brazed section at the top of the legs by	Pillar Drill, Centre punch, Steel Rule	Pillar drill guard and emergency stop pedal, ensure chuck key has	

Changes made during Manufacture

Telescopic Tubing

As I speculated before, telescopic tubing has been hard to get hold of, so instead we are using 32mm square section tubing with 26 mm tubing inside it. This work well, though the 1mm gap on each side between the inner and outer sections of tubing will force me to make several changes to my plans. First of all, the method of adjusting the height will have to be changed, as the size difference means that the inner section will not be able to be held by the friction resulting from squeezing the walls of the tubing together with a pin. I will instead use design 3, which uses a removable pin and holes at different heights to change the height. This however increases the strength of my design as there is no possibility of the legs slipping. Testing has revealed that a cotter pin is significantly easier and quicker to use than a nut and a bolt, so I will use cotter pins for this application.

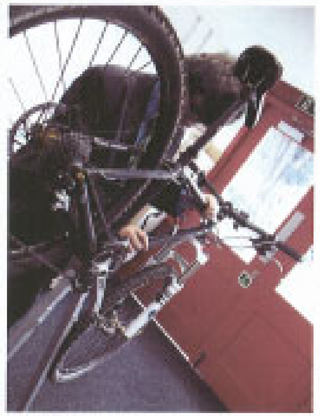
Shape of the bike holder

As detailed in my plan of manufacture, the maximum size block of Styrofoam that would fit on the computer controlled milling machine was limited by its table size, and so I have had to modify my design so that it can still be CNC'ed, as the accuracy of it would not be replicable by hand. I have had to reduce both the height and the length of it. The height has been extended to the original dimensions by gluing appropriately sized blocks or Styrofoam on, and this should be hard to notice once it has been cast. The length however will have to remain shortened, though this should not impair the function or my product.

Attaching the Bike holder to the legs

I originally intended to use cotter pins for this purpose, but we were unable to get some of the correct length and diameter (the diameter of the pin is limited by the dimensions of the tubing, as there must be two holes drilled to allow for the angle of the bike holder to be adjusted.) Instead of cotter pins, I was going to use bolts, which I removed the thread from on the lathe (the shank was just long enough to go though the bike holder, some extra length was however needed for the hole in which the snap pin would go). The only bolts we had available were however made of toughened steel, so I found I was unable to drill the hole for the snap pin. Instead I used I shortened the length of the bolts on the lathe (so a clean end could be achieved) and left the thread on, onto which a nut is placed. Though this has proved to be slower than using a cotter pin in testing, it is however still acceptable, and I think even adds slightly to the aesthetic of my project.

Product Testing



When I used my project, I found out several things about it. First of all, when putting the bike in the stand I was surprised by how easy it was to put the bike in the stand. This is a definite plus point, as it can often be somewhat of a struggle to get bikes in maintenance stands. The bike was held by the stand, though the hold was definitely not as secure as I would want. This problem was caused by two things – the short length of the 'bike holder' and the low angle which it was held at. The short length was due to constraints imposed by the machinery we have in the school workshop as detailed before, and so was out of my control. I would definitely find a way to get round this in the future, if I was to make my project again. The low angle was caused by where I drilled the holes in the bike holder, and I mistakenly drilled them in a straight line, so as to give it a symmetrical aesthetic, not realising the importance of a steep angle. This was definitely an oversight in my development, but was impossible to test during manufacture as I could not test it with a bike until the holes were drilled, by which time it was too late to change anything.

My product was however very aesthetically pleasing - the sleek small design was cited as a nice change from other stands, which are all much bulkier and less compact. The finish was also overall a success, though it does scratch quite easily – even from a short period of testing there are a few scratches on the legs.

I was also very pleased with the ease with which the height of the stand could be changes, and also the angle of the bike holder. As a whole it is easy to assemble disassemble the stand so that it can be stored and transported easily, though the bolt at the top of the removable leg can be a bit troublesome to get in, as you must line up three separate pieces of metal (six holes in all) before you put the bolt through. However this got easier after I had done it a few times, and I do not cite this as much of a problem overall.

Some comments and opinions I received on my project:

'I like the finish, and the design gives easy access to work on the whole bike – good overall.'

'It was good, though there was not enough stability in the hold of the bike and the bike lacked protection.'

'I really liked the aesthetic, though the bike could have been held more securely.'

'It was disappointing that the bike was not held that securely – but overall I think it is a very good product – it just wouldn't be quite up to more rigorous maintenance that requires large amounts of force.'

'I like the fact that it has a small footprint compared to a lot of stands, and also that it can fold away very well. It is compact also, though the bike can wobble a little when it is in the stand.'

Evaluation

Fitness for its intended purpose (A comparison with my specifications)

My Product must have, or be capable of the following specifications:

Budget:
1. Cost between £51 - £100.

Function:
2. Be suitable for use with road, mountain and hybrid bikes
3. Be able to hold a bike of up to 30kg.
4. Be able to hold bikes with a wheelbase of between 95 cm and 120cm.
5. Be stable when holding a bike
6. Be able to hold the bike securely
7. Hold the bike either by the seat post or the bottom bracket and front rear forks.
8. Be easily foldable
9. Be able to fold compactly for transportation
10. Be freestanding

Materials:
11. Be made largely out of metal.
12. Have plastic/rubber parts which prevent superficial damage to the bike.

Ergonomics;
13. Be height adjustable.
14. All parts that interface with the user (such as knobs etc) must be ergonomic.

Workshop Resources;
15. Be able to be made in our school workshop

Safety:
16. Comply with all relevant safety legislation.

My product meets specifications 2,5, 8 9, 10, 11, 12, 13, 14, 15, and 16. I have not calculated the exact cost, though I am extremely confident that my product would come in at under this – most of the cost would be taken up by the steel tubing and the aluminium that I used to cast with (in our workshop scrap aluminium was used for this so this cost nothing in my case) neither of which is expensive. It would be able to retail for £51-£100 and leave a very significant product margin. I have unable to test it with a bike of 30kg as bikes this heavy are very rare, though it has been able to hold a weight of just over 50kg, so I cannot see a problem with this specification being

The same is true for the limits of the bikes wheelbase it is able to hold – bikes of this size are rare so I have been unable to get hold of one to test my project with. My stand does hold the bike well enough, though I would not call it 100% secure – this will be detailed later in product testing. My project half meets specification 7 – as detailed in my design choice page, it holds it by the bottom bracket – a method overlooked in my research on 'Ways to hold the Bike'.

Reflective opinions or my achievements

I think that overall my project was a success. Everything went according to plan, though as expected some changes had to be made during manufacture. The only notable one, which is admittedly quite major, is in the change of the part of the stand that holds the bike. This had to be reduced in size due to constraints from the machinery in the work shop, and then extra time had to be taken to glue on additional bits of Styrofoam, which worsened the initial finish of the casting. Due to the reduction in width, the diameter of the cut which holds the bike tubing also had to be reduced, so my stand cannot hold some larger diameter tubes so well.

I think that my product does look good, though the surfaces of the bike holder do have some imperfections on them. After being initially unsure about the silver and black combination I now like it, however I have found that the paint scratches very easily – especially on the inner sections of telescopic tubing. An improvement that I would make to my product in the future would be to use a more durable finish.

I think that I managed my time reasonably well throughout the project. Some processes, such as making the pattern, did however take much longer than I thought, though the actual casting itself was much quicker than I thought it would be. My use of equipment was in my opinion good, and my persistence to double check measuring out several times before I did anything paid off, as I realised mistakes before they had an affect, and everything was cut and drilled accurately.

Suggested modifications

There are several improvements that I would like to make to my project. The first thing I would do is to address the problem of the front wheel turning whilst the bike is held in the stand. I have found this to hinder some maintenance tasks, such as those which involve the front brake and wheel. When the bike is in the stand, the bars turn to one side, and are prone to slamming in to the top tube, possibly causing damage to the bike, meaning this problem needs to be addressed. There are two ways in which this could be done. As this is also a problem on many other bike stands, a separate part could be supplied which hold the handlebars straight by connecting them to the top tube, down tube or seat tube. This could be quick and easy to shape though it does not look very good, and would be somewhat of a mismatch compared to the aesthetics of the rest of my product. An example aftermarket product is shown below. Other similar products are also somewhat unsightly, and all would be something of a pain to put on/take off the bike whenever it was taken in or out of the stand. My preferred solution would be to attach two 'legs' to the bike stand which would be able to fold down so they were either side of the wheel, which would stop it from turning. These would be easily folded down once the bike was in the stand and so would cause little extra hassle yet would be just as effective.

The second modification I would make is to lengthen the part of the stand which is in contact with the bike, as this would mean the bike would be held securely, and though it seems to work well in testing, I have to admit that I am somewhat insecure about expensive, high end bikes being held in such a way, even though this fear is merely based on aesthetics. Lengthening this would make the consumer believe the bike was being held securely, and thus make them more likely to buy my product.

Lastly and most importantly, I would modify my design so that the angle the bike is held at is steeper. I would achieve this by drilling the holes in the bike holder in a slightly different place, though I would be slightly hesitant to do this as it spoils the symmetrical looks of my product. There is however no other easy solution tot his problem, and it would not really impact on the overall aesthetic.

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