Whose Washing Machine?

Reflecting on an Intercultural Design-Build Project in the Kathmandu Valley

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Overview and context

In August 2008, the NGOs Prisoners Assistance Nepal and Wrench Nepal partnered to design and build a human-powered washing machine.

This document discusses several of the processes, technical and social, involved in the Wrench Nepal/Prisoners Assistance Nepal Washing Machine Design and Fabrication Project. We attempt to present our processes in this project and to provide analysis and critique where appropriate. Furthermore, the technical sections of this document should be read in context of the project's specific location and design, and in context of its social process.

We hope that both our mistakes and successes can inform future projects and the study of cross-cultural design-build projects.

About the Authors and Definitions

"We" are Mario Bruzzone and Aaron Wieler. At the time of this project, Mario was the Acting Director of Wrench Nepal, a now-suspended NGO that attempted to integrate models and processes from the bicycle co-op and Community Bike Shop movements into the context of international development. Before that, he worked with the Bike Kitchen in San Francisco in multiple capacities and has a long involvement with community organizing, cooperatives, and technical (and non-technical) writing.

Aaron is keenly interested in promoting ideas of community self-reliance through working with locally appropriate technologies. Information about Aaron's projects with bicycle ambulances for rural medical transport and DIY bicycle trailers can be found at the website bikecart.pedalpeople.com. He continues his work with Whirlwind Wheelchair, a non-profit organization that works with small and medium-sized production shops around the world to provide highly-usable and repairable wheelchairs in resource-limited environments.

We presented our workshop "Understanding bicycle-focused international development work: Case studies in Nepal and Namibia, and a facilitated discussion" at the Bike!Bike! annual conference of community bike organizations in San Francisco on September 27, 2008. That presentation touched on a number of the issues that we cover here, and a few that we do not. Mario also presented some of his experiences with this project at a talk at the Rice-cooker Infoshop in Kuala Lumpur, Malaysia on September 21, 2008.

We welcome feedback around both technical and social processes. Aaron's email is <aaron.wieler@gmail.com> and Mario's email is <mario.bruzzone@gmail.com>. This document can also be found online at http://bikecart.pedalpeople.com/washing.html

Definitions and Format

In this document:

- When we refer to the device, we mean the human-powered washing machine itself;
- When we say project, we mean the learning involved in creating the device, which includes but is not limited to fabrication and design;
- When we say process, we mean the ways in which we organize the project; and
- When we refer to the "wards," we refer to the children who live and are educated at the PA hostel. The school on-site serves the younger children; the older children attend school in town.

Finally, we include footnotes throughout this document especially to give commentary on processes and actions that we feel can be improved upon. We include starting points for both better technical production and better ways of knowing therein.

Participants and Sponsoring Organizations

The people primarily involved in the design and fabrication processes of this project were Agreni Pun Magar, Jivan Tamang, Jagat Dholi, Mario Bruzzone, and Aaron Wieler. We had additional aid from Krishna Bastakoti. The sponsoring organizations were Prisoners Assistance Nepal and Wrench Nepal. The people primarily involved in the project management processes were Mario Bruzzone, Aaron Wieler, and Indira Rana Magar.

Prisoners Assistance Nepal (hereafter PA Nepal, or just PA) is a Nepali Non-Governmental Organization (NGO) that feeds, shelters, and educates Nepali children[1] who would otherwise be incarcerated with a convicted parent. At the time of this project, PA Nepal served approximately 70 children, the vast majority at its hostel in the town of Sakhu (occasionally transliterated as Sankhu), approximately 20 km east-northeast of Kathmandu at the edge of the Kathmandu Valley. PA's founder—and director for the duration of the washing machine project—is Indira Rana Magar.

Indira is an Ashoka Fellow and one of Nepal's strongest and most persuasive advocates for prison reform. From a medium-low caste and from rural Nepal, she has run PA for more than a decade while taking care of her elderly mother and her now-teenaged daughter. In the context of Nepali society, Indira is a force of nature, and we consider ourselves incredibly fortunate to have been able to work with her. When we refer to the PA hostel, we refer to a 3 building hostel-school complex just north of the main town of Sakhu.

Wrench Nepal's stated mission during Mario's directorship in Kathmandu was as follows:

> Wrench Nepal is an organization that partners with local and locally-run NGOs to provide bicycle-based vocational trainings and projects for disadvantaged youth in the Kathmandu Valley.
>
> Our projects:
>
> • Provide opportunities for Nepalis to learn immediately marketable job skills
>
> • Teach general mechanical skills—e.g., which way a screw tightens, how bearing systems work—widely applicable to Nepali life and jobs in Nepal
>
> • Support and build English-language skills among our students, which is broadly applicable to job markets in Nepal and allows access to global bodies of knowledge
>
> • Empower youth through the mastery of skills and the completion of goals
>
> • Facilitate valuable cultural exchange with youth who would otherwise likely be denied the opportunity to learn from and reciprocally teach Western visitors in mutually rewarding ways
>
> • Support many of those whom mainstream Nepali society has left out or discarded, through inclusion in our projects
>
> • Support sustainable, environmentally-friendly solutions to the problems of transport
>
> • Create opportunities for a different—but no less qualified—type of person may participate and dialog in the challenges of development

Prior to the inception of this project, Mario taught a vocational-skills class at the PA hostel in Sakhu that focused on bicycles and other mechanically-similar transport (e.g., pushcarts, rickshaws, and trishaws); in teaching this class, Mario built personal relationships with a number of the older wards at the hostel, including some who did

1 There is semantic confusion on the term "Nepali." Nepalis are traditionally people from the Kathmandu Valley, where the traditional ethnic majority is Newar. Today "Nepali" more commonly refers to citizens of the nation-state of Nepal, but can still refer to people from the Kathmandu Valley. The children at the PA hostel are from a variety of ethnic groups, mostly from outside the Kathmandu Valley, so they are Nepalis in the second sense but not the first.

not contribute to the washing machine project. These relationships, however, did contribute towards the conception and operation of the project.

Documentation Goals

We are both committed to finding responsible ways to engage with the process of international development and cross-cultural projects. This document contains numerous sections that speak directly and indirectly to the social aspects of this project because we consider those aspects inseparable from the technical documentation. In a fundamental sense the pedal-powered washing machine project was designed to integrate Nepalis heretofore excluded into global bodies of knowledge, and we hope that this document can further understandings, both cultural and technical, of the difficulties of engaging in such projects.

Our goals for this document are threefold:

- to document the particular process of designing and building a particular product—here, a human-powered
- washing machine—in a specific locale—here, Nepal; to document that design
- and, more importantly, to document the social and technical facets of this process as inextricable from one another, and to describe the interchange between the two.

The Human-Powered Washing Machine Project

This document is a record of the process of designing and building a human-powered washing machine in the milieu of the PA hostel in Sakhu, Nepal.

It is our contention that the social and cultural milieu in which so-called "Appropriate Technology" devices are conceived, designed, and effected cannot be separated from the process of building the machine. We believe that the local contexts of design, fabrication, use, and repair of machines such as this should not be separated from the technological product. We attempt to communicate the whole of these contexts in this section.

Project Goals

The washing machine project was explicitly situated as an educational and capacity-building project among all participants. That is, to Mario; Aaron; Indira; and Jivan, Jagat, and Agreni, the project was about three general goals, without entering in to discussion of the specific form of the project or technology. These were:

- learning how to go about a design-build process
- learning specific fabrication processes
- fostering creative thinking and problem solving through design, explicitly including mechanical creativity

These were not the only goals of the project—as in any project, we sensed a multiplicity of unstated goals. In the conversation of a human-powered washing machine, further goals emerged. Below we include a partial list of these goals.

Specific goals for the washing machine project included:

- Vocational training and capacity building, effecting and modeling in practice mechanical creativity and creative thinking; fabrication skills; utilization of NGO resources; and ways to approach and resolve problems occurring in a design-build process
- Creating a functional product for PA Nepal—a machine that washes clothes in a more "effective" manner
- Creating a washing machine design that has replicability in Nepal
- Creating documentation that offers process-oriented as well as technical details
- Enacting responsible cultural engagement in a cross-cultural design project
- Creating washing machine design that offers informative case study to other design projects
- Learning collaboration skills

Narrative Process: Designing and Building the Washing Machine

We intend the narrative that follows to give a social context for the multitude of decisions, small and large, made during this project.We expect similar projects will encounter similar choices. Flows of technical decisions are co-created with flows of social and organizational decisions; neither organizational nor technical processes can be properly understood in full or semi-isolation from the other.

Readers should note that this narrative privileges person-hours spent by Mario and Aaron much more than those of the wards at the Sakhu hostel, who actually spent more time on the washing machine project than we did.

Early Aspects and Relationship-Building

Students in Wrench Nepal programs often ask for examples of the application of the skills they are learning. At PA these questions came up as the bicycle-repair class was near completion; Mario talked about both the applicability of bicycle repair skills to technologies similar to bicycles (such as motorbikes), and to some applications of pedal power to mechanical equipment, including grain threshing, ground-water pumps, and washing machines.[2]

Jagat in particular was excited by the idea of a pedal-powered washing machine. In the next few weeks he repeatedly brought up the idea. Agreni and Jivan were likewise enthusiastic about the opportunities such a project could provide.

Indira was more skeptical. There were, and continue to be, numerous challenges presented by the introduction of a pedal-powered washing technology. In terms of repair and maintenance infrastructure, she asked questions such as When the machine breaks, who fixes it? What does it mean to change the clothes-washing process? What does PA do about wastewater? What if the machine should be used a few times and then forgotten? Because of Wrench Nepal's short history, Indira correctly calculated that in all likelihood PA would end up maintaining the machine and its attendant complications.

But Indira's most pressing and important questions were those regarding the reintegration of the wards at the PA hostel into Nepali society. Most children at PA will return to home districts of traditional Nepali rural life distant both geographically and socially from Sakhu. Presenting a version of normalcy that involves too much non-traditional or atypical education, projects, or mores can jeopardize the ability of these children to rejoin the communities they have been removed from; this, in turn, may jeopardize both their contentedness and their agency over their own lives.

After an initial discussion, Mario was hopeful but thought it unlikely that Indira would agree to such a project. Because Indira brought up a number of concerns rather than flatly refusing, Mario also floated the idea to Aaron, who was then working in Ladakh, India. Aaron agreed to come if Indira approved the project.

The wards at the PA hostel, Jagat especially, lobbied Indira for some time without Mario's knowledge. Indira gave her tentative approval to the washing machine project less than two weeks before Aaron arrived in Kathmandu. Aaron's inclusion was a key point in favor of the project, as he brought an additional set of expertise with mechanical design, fabrication, and familiarity with re-appropriation of bicycle/pedal technology for mechanical processes.

The two week window of Aaron's time in Nepal provided the proximate cause for the washing machine project's accelerated time frame.

Approval Meeting with Indira Rana Magar

Location: Kathmandu

Before making the journey to Sakhu to begin the design process, we met with Indira in Kathmandu. Indira reiterated some of her concerns and needs for the project while reiterating her approval for the project. In addition to talking about existing clothes washing technologies and pedal power applications, we were able to confirm the goals of the project and come to agreement about how the project should be oriented and organized.

2 At the time, the website of the Guatemalan organization Mayapedal (supported in part by MIT in Cambridge, Massachusetts, and PEDAL in Vancouver, British Columbia) had a photo of a prototype pedal-powered washing machine; other ideas came from projects and prototypes by EcoSystems Nepal and the Specialized-sponsored Innovate or Die competition. Students from MIT's D-LAB had also published some information about their class project with pedal-powered washing machines, though it failed to contain much useful technical or social information for us.

We proposed a design process for the project, to ensure that the project stay focused on education and capacity building rather than product delivery. We proposed to facilitate a process in which our expertise and familiarity with fabrication would encourage the PA Nepal students to collaborate with us as equal voices in the project, instead of allowing our experience and power as foreigners and instructors to overpower the process and prescribe a technology. We also presented the ideas of iterative design, rapid prototyping, and collaboration with local fabrication shops.

From the outset we knew that this complete collaboration could not be realized.[3]We chose to focus on the skills of mechanical design, creative thinking, and project planning, over specific technical skills like machining.[4]

Design Meeting

Location: Sakhu

In Sakhu, Mario gave Aaron a tour of the facilities and introductions to many of the wards of the hostel. We sat down with Agreni, Jivan, and Jagat to begin a design process. We began with questions about washing clothes with machines.

- What does it mean to wash clothes with a machine?
- What does a washing machine do?

From there, we considered:

- Who will be using the washing machine?
- How old or young?
- How big or small are the users?
- How many clothes need to get washed at a time?
- What else will be washed besides clothes?
- How many people are using the machine?
- Are they using it around the same time?
- What do “washed” and “clean” mean?
- How will we know when clothes are fully washed?

How important are the following factors:

- Appearance/aesthetic
- Water use
- Amount of clothes washed
- Ease of use
- Length of washing cycle

3 Full collaboration was also compromised by some contradictions inherent in the praxis of non-institutional international development. We touch on a few of these contradictions in the the Lessons Learned and Reflections section.

4 For context, one example of this involves how we chose material for the drive shaft of the washing machine. We all talked about our choices and decided on steel tubing; at which point the purely technical question of pipe gauge (and the related question of bearing compatibility) was not put to Agreni, Jivan, or Jagat. Instead the project used Aaron’s working knowledge rather than teaching technical details of material specification. We encourage subsequent projects to consider how this choice reifies expertise and reinscribes agency-denying discourses of development. See the Lessons Learned and Reflections section for a partial discussion of this last point.

Finally, we considered:

- Is this project good idea? Why or why not?
- What are each of our goals with this project? (Learning, getting a machine built, etc)

We found the rationale for the washing machine, as laid out by the Agreni, Jagat, and Jivan, very convincing. In their view, the washing machine was appropriate for the PA hostel for a number of reasons: as a capacity-building process[5]; as a labor saving device; and as a way to keep the whole of the PA hostel significantly cleaner.

We started the technical design session with time to sketch on our own papers about washing machine technology. We suggested that because we had used washing machines all our lives, and because Jagat, Agreni and Jivan had only seen washing machines in movies, the students were in a better position to have ideas that weren't influenced by the familiar. We proposed that we each sketch any part of the technology, or the entire machine; to prepare, we discussed washing machine parameters, including the following:

- What is the flow of water through the machine? (How does it get in and out?)[6]
- What is the source of energy, and how does that energy run the machine?
- What does it look like?
- How do the clothes get in and out?
- How does the soap get in and out?

After about 15 minutes to sketch, we showed our ideas around the group and talked about them, then evaluated them together, to refine ideas into a basic model.[7]

At the end of the design session, we all agreed that:

- "Washing" includes de-scenting and delousing; and stain removal if possible
- The washing machine should wash clothes, bedsheets, and blankets; and if possible, carpets
- The washing machine should be able to wash 5 blankets at a time
- The machine should use no electricity, or else be solar-powered
- The machine's mechanical power (where appropriate) should be both pedals and a hand-crank
- The change from the bar soap previously used to wash clothes to powder or liquid soap was acceptable
- The issue of wastewater was significant
- The machine need not dry clothes; but that a way to mechanically dry clothes with the machine was desirable
- Steel construction was preferable

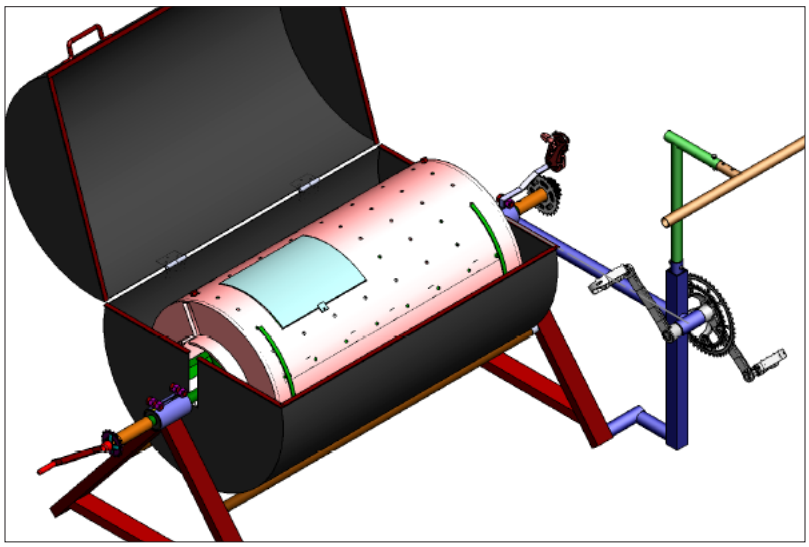
5 Agreni was most assertive on this point.

6 We note that the issue of water inputs and outputs was suggested by one of the wards, and was not something that Aaron and Mario had talked about together previously.

7 Future, similar projects may wish to consider giving each participant a dedicated notebook for design, to document the process and provide a place to make notes and experiment with ideas without having to show them to the whole group, a sometime-intimidating occurrence. We regret that we did not photograph the drawings from that design session, as they have since been lost.

Initial Part Selection

Location: Kathmandu



Left: A SolidWorks model of the completed washing machine. Right: The washing machine in progress. The tubing making the rectangle in the middle is the eggbeater. See Appendix for technical specifications and further descriptions of parts and components.

After the initial design charette at PA Nepal, we decided to build some of the basic design elements in Kathmandu, to have them available for further design brainstorming at the following design session in Sakhu. While we wanted to involve PA Nepal partners in as much of the fabrication as possible, practical time constraints necessitated that we do some fabrication ourselves. We decided to proceed with a horizontal axis drum-in-drum design, the basic design of four of the five sketches, as we suspected a higher feasibility of completing a working product within the short time frame.

We returned to Kathmandu to source and purchase parts, including steel tubing for the external frame and a compatible set of bearings, bearing-retaining barrels, and tubing for the axis of rotation. All these parts would be needed for any iteration out of the basic drum-in-drum design.

Our selection of parts gave primacy to:

- Durability of parts
- Parts availability for fabrication (to Aaron and Mario)
- Parts availability for repairability (to PA Nepal in Sakhu)
- Transparency of the washing machine technology for operation, maintenance, repairability, and replicability

We bought the majority of the steel tubing needed for this project in Teku, Kathmandu. New steel tube and angle ron came from the Rajesh Hardware steelyard. Another customer at Rajesh Hardware was interested in the washing machine project and offered to take us on his motorbike to a pair of KawaDiharu (scrapyards) nearby, where we bought used water pipe for bearing retaining barrels, and bearings.[8]

On our way back to Tripureshwor Marg, the main arterial of Teku, we found a bearing store, where we purchased used moped bearings for the drive shaft. Our process to design and source the bearing assembly was as follows:

- Determine minimum size appropriate for drive shaft. Our estimated span between bearing assemblies was 1.5 meters, and our estimated max vertical load was 45 kilograms. Without using calculations, we took a length of

8 This small action of taking us to a *KawaDi*—really, of communicating to us that there are KawaDiharu and that we might find what we need there—significantly decreased the cost and time needed for the washing machine project.

pipe, spanned 1.5 meters, and loaded it in the center with about 45 kilograms (as if a child sat on the drum), and then chose a tube size that was stiff enough to allow minimal deflection. Both 7/8" and 1" tubing outside diameters passed this test.[9]

• Determine bearing inside diameter (ID) compatible with drive shaft. Here, 7/8" or 1" or 1 1/8". Bearing availability in rural areas is driven largely the moped repair industry, so we looked for moped bearings. These are almost entirely Honda, and metric sizes. We found a 25mm ID x 52mm outside diameter (OD) x 15mm depth bearing fit this criterion

• Determine bearing OD that has a matching tube size available for a bearing retainer barrel. We tried to match this bearing size to a tube, and got close with water pipe that was slightly too large but within a tolerance that could be squeezed to the right diameter.

• Guess, check, evaluate iteratively, until an assembly was found to be compatible. We found a 1" tube could be reduced to 25mm, to fit a 25mm ID X 52mm OD bearing, and an approximately 55mm ID round tube, with a wall thickness about 2mm.

A lathe machinist in a shop near the scrap yard cut the outer bearing retaining tube into two equal length pieces, which saved the time of using hand tools.

Lastly, we purchased a 100 liter black plastic water container with a screw top lid. This was the largest dimension available that would fit inside a 55 gallon oil drum with enough room to spin freely. As the washing machine needed to be large enough to hold 5 blankets, our limiting factor was a compatible set of barrels that would allow laundry to rotating inside the inner barrel to come in contact with the water.

At a moped repair shop near Bhat Bhateni, Mario's neighborhood in Kathmandu, Aaron welded half an "eggbeater" shape onto the central axle, to which the inner plastic barrel would be attached. He also reduced the ends of the 1" / 25.4mm tube to 25.0 to fit the bearing, one end on a bench grinder and the other end machined on a lathe by one of the men in the shop. He welded nuts onto the bearing retainer barrels to clamp around the bearings, to make the design replicable and repairable without access to a lathe since no tube size was available to press fit the bearings.[10]

We also welded legs onto the bearing assemblies, calculated with basic trigonometry to hold the bearing assembly at a height above the ground that would allow a 200 liter / 55 gallon steel drum to sit approximately 50mm off the ground.[11]

Fabrication with PA Nepal students

Location: Sakhu

We returned to Sakhu with the welded eggbeater/axle, bearing assemblies, inner plastic barrel, and lots of design problems to work on with the students. Another design meeting identified the next steps:

• Making holes in inner barrel to allow water to freely pass through barrel, but still keeping the clothes within

• Suspending the inner barrel from the eggbeater axle to hold it concentrically as it is rotated

• Designing the interaction between the inner and outer barrels

9 Available tubing used imperial nominal dimensions, such as 7/8" and 1". We worked primarily with metric units. There are 2.54 millimeters in an inch.

10 We drilled out one side of the nuts, and realized in retrospect that we should have used oversize nuts or tubing and a smaller bolt with a removable nut, in order to make the project more repairable and replicable.

11 Because the sizes of the inner barrel and outer barrel were so different, we needed to raise the outer barrel up so that its center (axis) was considerably above the axle. This kept the amount of water needed for each wash to a minimum by reducing the space between the barrels to about 15mm, the tolerance for bolts and deflection of the plastic.

• Designing a process for inputs and outputs such as clean and dirty clothes, clean water, soap, and dirty water

We talked about how to make holes in plastic barrel, and weighed the benefits of punching holes versus drilling them. We did not have access to a drill at PA Nepal hostel, though we could have gone into Sakhu to use one. We decided to try punching holes with hot metal, in order to quickly make many holes, and to reinforce the plastic around the holes (instead of weakening it, as drilling would have done). Agreni took charge of this process, and tried a combination of heating bolts and nails with the kitchen fire and candles, using pliers to hold the nails. Punching with a hot M10 bolt, held with pliers, worked better when there was a small nail hole in place first, and a bolt that was hot enough would punch about 6 holes before needing to be reheated. Approximately six children took turns making holes spaced about 8 cm apart. We also cut a hole in the bottom of the barrel for the axle, and a slot in the top end of the barrel to allow the egg beater to slide into the plastic barrel.

We assembled the bearing assemblies with the triangular legs, eggbeater drive shaft, and inner barrel. Once everything was assembled, we realized that we needed the other half of the eggbeater to support the plastic barrel when it was full of wet clothes, and perhaps additional ribs inside the barrel to lift the clothes, to allow them to be thrown back into the water.

We discussed the next steps for the barrel and pedal mechanism. The session led to a design of foot pedals on one side, and a hand crank on the other side of the axle. This would allow people of different sizes and strengths to operate the machine, and allow two kids to run the machine at the same time if they wanted.

Outer Barrel Fabrication

Location: Kathmandu

While in Kathmandu the following days, Mario and Aaron gathered a collection of bicycle components likely needed to finalize the design on the bicycle and hand crank drivetrains.We purchased a bottom bracket (BB), crankset, pedals, a single speed cassette for the hand crank side, a 6-speed freewheel for the bicycle side, a rear derailleur, and several BB cups to interface with the cassettes, as the threads are the same spacing.[12]

Next, we searched for a steel barrel to make the outer drum. We wanted to find a barrel that was close to a shop where we could cut it, and also close to Mario's house, to allow us to work continue work comfortably without moving it several times. At a KawaDi near Mario's house, we found a 55 gallon steel drum that had held cooking oil. Although the volume was approximately 4 times larger than that of the inner barrel, we were able to raise it to a height that reduced the volume of water needed to wash clothes.

The outer barrel's function is described here[13]:

• Positioned horizontally, holding water, containing but not contacting the rotating inner barrel

• Lid opens and closes to allow loading and unloading of clothes

• Contains water on wash and spin-dry speeds

We began by cutting the barrel lengthwise, along a chord approximately 5 cm away from a diameter. We then cut slots on each end for the spinning shaft to enter the barrel, keeping the sides as close as possible to the shaft to prevent splashing. With the addition of two hinges purchased from a hardware store, welded onto the top and bottom of the barrel, we positioned the barrel horizontally and simulated operation. We learned that we needed handles, a chain to limit how far the barrel could open, and a lip to cover the sharp edges. We cut and welded on 12mm x 3mm flat steel stock around all of the cut edges, with the exception of the hinged side of the barrel. We added two

12 At Aaron's prompting while shopping for bicycle parts at a shop in Tangal, Kathmandu, Mario asked where one could buy a bottom bracket shell—and the shopkeeper said to hold on a moment, because he had one. It was an extreme bit of good fortune to the project, as Mario found out later when trying to buy another.

13 See the Appendix for technical specifications.

handles on the front of the lid, and chains between the lid and base on both sides to stop the lid from opening past approximately 135 degrees.

Fabrication with PA Nepal Students Part 2

Location: Sakhu

In Sakhu, we prepared the separate components for welding and assembly. The students brought us into the town and introduced us to a welder who was making bed frames and window grates. Agreni negotiated permission for us to use his workshop space, though he wanted to do all the fabrication himself. Aaron strongly preferred workshop spaces where he could use tools himself, as the language barrier made it difficult to express information about tolerances, accuracy, and designing through prototyping. Lack of direct access to the tools and equipment also reduced the learning opportunities for everyone involved, primarily the students. On a positive note, however, this relationship gave information about designing for local fabrication in small shops—knowledge that helps designers to design for replicability and to understand repair options.[14]

At the welding shop in Sakhu, we assembled the washing machine frame, eggbeater axle, bearing assemblies, and inner and outer barrels. We cut the middle from the eggbeater axle to allow the clothes to fall through the center of the barrel as they are spun. We also welded on horizontal tubes that the outer barrel could rest on, by welding nested 7/8" and 1" tubes together, to allow for disassembly for transport.[15]

With a few observers from town and a pile of bike parts and steel tubes in front of the assembled washing machine base, we collaboratively designed the bicycle power mechanism. For the first time, we could see how all the parts would fit together, and having parts to manipulate and hold in place helped to transition the drive mechanism from a theoretical concept into a practical mechanism. Having physical parts to manipulate allowed the project participants to collaborate more equally on the design than had previously been possible.[16]

It was important to consider several design and usage constraints simultaneously, in the design of the drive train mechanism. Having the parts available was useful during this discussion. Our drivetrain design constraints included:

- A hand crank drive option
- A pedal drive option
- Multiple gear ratios to allow for slow washing or churning by smaller children, and fast spinning for spin dry cycle
- Easy disassembly to repair or replace any specific part
- Locally available bicycle components
- Bicycle drivetrain must be repairable without fabrication
- Durability, longevity, and resistance to monsoon

The following device emerged:

14 While not explicitly stated as a formal project goal, designing a product that is locally replicable without requiring specific training, tooling, or uncommon fabrication skills has the effect of allowing PA Nepal to expand the washing machine project more easily, if they ever chose to do so. It also implicitly teaches how to design for local production, in a way that Aaron and Mario could not. After working in the welding shop for a couple hours and cultivating a relationship, we were eventually permitted to use the tools ourselves.

15 In retrospect, this could be better designed to be smaller for transport, by welding short four short 7/8" tubes at every end of the two horizontal tubes, instead of only two short 7/8" tubes and two long 1" tubes welded directly to the triangular ends.

16 It became apparent here how much conceptual design favored our ways of thinking. Future projects may wish to consider and contemplate on how they might facilitate the use of physical models or approximating tools--even simply, with twigs, blocks, twine or paper clips, and other materials that are universally available--without those tools or models favoring their worldviews or ways of understanding technology.

• Crank drive on one side of the axle, with a single speed freewheel used as a ratchet to allow the handle to hang freely when pedals were used on the other side of the axle

• Pedal drive with 6 gear options on one side, this freewheel allowing the pedals to remain stationary when hand crank was used alone

• Freewheel threaded onto bottom bracket (non-fixed) cups, which were welded to a sleeve fitting over the axle of barrel rotation and attached with bolts and nuts

• Bottom bracket mounted to washing machine with welded tubes

• Separate chair required for pedaling, to reduce overall product size and complexity

• Adjustable handlebar position, to accommodate multiple rider sizes

• Shifter located on handle to change gears

• Rotating hand grip for hand crank, to allow user to grip handle while spinning

After drilling holes on the eggbeater axle and the sleeved attachment for the freewheel and cassette, we brought these two parts back to Kathmandu to complete. We also needed to make a steel structure for the hinged door on the inner barrel because the plastic proved to be too flexible to close securely with the hinges and clasp alone. Except for these items and the inner plastic barrel (which was at the PA Nepal hostel), the washing machine was otherwise assembled at this point at the welder's shop in Sakhu.

At the end of the day, we asked Agreni to ask how much we should pay the welder for using his tools, and for the welding work that he did. He requested 1000 Rs. This price was disproportionate to the amount of time he spent and the cost of the welder's consumables and expenses, especially compared to the other prices we had been asked for from other shops. At our request, Agreni negotiated the price down to 650 Rs.

When we were preparing to take the washing machine to PA Nepal, the welder asked if he could keep the washing machine for the rest of the day and the following morning. Mario was reluctant at first—the welding shop had been a difficult place to work, and the welder had been a frustrating partner, and we wanted to finish our interaction. Agreni then offered very valuable, and unsolicited, advice: she told us that it was proper for us to leave it for him. The next day we found out that he had asked for to keep the machine because a woman in town asked if he could copy it.[17]

We left the washing machine with the welder, with the understanding that Agreni organize a group to get the machine in the morning. Aaron and Mario returned to Kathmandu for the night, and to finish the final fabrication steps.

Crank end and door fabrication

Location: Kathmandu

Mario and Aaron completed final details of fabrication in Kathmandu, at the moped shop, where Aaron bored out the inside of a water pipe with a lathe, to slide over the 25mm diameter axle tube. This tube, cut into two lengths and capped with bottom bracket cups—the threads are identical to freewheel threads, 1.37" x 24 tpi—held the hand crank and pedal cassettes on either side of the washing machine. Mario created steel slats to reinforce the hinged plastic door on the inner barrel, and welded hinges to these slats. He also created a backing for the hinge plates on the barrel itself.[18]

17 We felt it best to defer to Agreni, Jagat, and Jivan's judgment. The event brought up questions about foreigners purchasing products and services, and finding the balance between paying for valuable services (and engaging in a local economy) and resisting attempts manipulate prices for foreigners, especially in ways that may in aggregate price locals out of a market.

18 This design emerged from a failed iteration of the hinged door, which was too flexible without reinforcement; we feel that this example demonstrates the importance of including time for iterative prototyping, and allowing designs to emerge in response to other design ideas.

Assembly and Testing

Location: Sakhu

Aaron returned the following day to Sakhu to complete the last assembly steps and to prime the washing machine for painting. The list below describes the final steps, occurring largely concurrently over the course of one evening into the following day.

Fabrication steps for the final assembly:

- Added two ribs (90 degrees from the egg beaters) made from 1" x 2" rectangular tube, to help the spinning barrel lift the clothes to be thrown back into the water
- Bolted on the hinged door and made a clasp, for loading and unloading clothes into the inner plastic barrel (First design needed revision, second iteration worked)
- Filed bolt ends extending from the plastic barrel to make clearance for spinning inside steel drum without scraping[19]
- Sanded all surfaces for painting
- Primed all steel for painting with brush on red primer, including bearing surfaces (very lightly)
- Final paint (blue spray)[20]

Mario joined Aaron the following afternoon, after teaching bicycle repair classes with Wrench Nepal's other organizational partner. He arrived in time for the final assembly, and the first load of laundry. When we were ready to test, we discussed what we wanted to learn from the test, and looked around for some clothes to wash. Immediately most of the boys took off their shirts to put them into the machine.[21]

We filled the machine with some water and powder soap, added the clothes, and began pedaling and cranking. We learned that it was surprisingly easy to pedal or crank, especially with the small amount of clothes inside and enthusiastic kids. There was a tendency to spin too fast, so that the laundry would get stuck to the outside of the plastic barrel by centripetal acceleration and not have a chance to fall back into the water for agitation. We ran the test with the lid up, then when we let the water out to spin dry the clothes, we had to close the lid to prevent splashing. The machine seemed to perform well, but as it was dark we did not have time to wash and examine the clothes fully. More complete wash cycles occurred the following week.

19 We originally set this clearance too tight.

20 After Aaron left, tabs were welded to the bottom of the outer barrel, to prevent rotation around the triangular frame when the lid is open.

21 The lesson here is not to do this discussion right before testing will begin. We were all eager to use use the machine.

Project Process

A general outline of the washing machine project's process is as follows:

- Identify and accept challenge, in conjunction with partners and stakeholders
- Identify and agree on process to follow; identify challenges and strategize approach
- Identify project goals and indicators of success
- Develop design parameters and constraints
- Brainstorm solutions (expansion phase)
- Selection of solutions to try
- Implementation (iterative)
- Process check (technically functionality and socially acceptability)
- Evaluation (iterative)
- Presentation and Review
- Documentation and analysis
- Information sharing and replication
- Maintenance of Relationship and FeedbackProject Timeline

At the completion of the fabrication phase of the project:

- 9 month organizational relationship between Wrench Nepal and PA Nepal
- 12 working days over 2 weeks collaborative design/build process (Agreni, Jagat, Jivan, Mario, Aaron, PA Nepal students)
- 1 week follow up in Sakhu (Mario, Wrench Nepal staff, Indira, PA Nepal students)
- Occasional ongoing communication (Aaron, Mario, Indira)

Design Parameters Selection and Evaluation

The following section is a list of questions and discussions relevant to this project specifically but applicable to a variety of product-based technology design projects. We find it useful to ask *What is the underlying issue?* with questions that come up in the course of a design process. For example, with the question, Will women want to ride a bicycle attached to a washing machine?, some underling questions are:

- What are gender dynamics in Nepal, how are they enacted through washing clothes?
- What are the gender dynamics in Nepal around technology and machines?

A brainstorm on those questions leads to specific questions that can inform a design process, such as:

- Will women want to operate a bicycle to run a washing machine?
- If technology is traditionally controlled by men, and household chores such as washing clothes by women, how might this project bring up gender dynamics for families?
- In what ways is it our responsibility as foreigners to we find out what this effect will be?

Prompts in the Design Process and Design Constraints

Before traveling to Sakhu for our first site visit, we brainstormed a rough list of general questions that we thought important to ask the wards who would be creating the washing machine. In this document we move from questions of theory and praxis to questions of human-device interaction to technical questions. In practice however, we let theoretical prompts such as How might the machine work? lead to human-device interaction prompts such as Who will use the machine? Who does the majority of work—age, gender, size, etc.? and from there to technical prompts such as How do we provide power for the machine?

Theory and Praxis Prompts

- Why are we building a washing machine?
- What is the range of clothes we're washing?
- For the machine, how many people should be able to add energy at one time?
- Should that be done via feet, hands, both, or something else?
- How long are we willing to pedal or crank for?
- Is a machine for laundry is a good idea?
- What does a machine for laundry need to do?[22]
- What are the advantages to a machine?
- What could be fun about it?
- How might the machine work?

Human-Device Interaction Prompts

- Who will use the machine? Who does the majority of work—age, gender, size, etc.?
- Is it acceptable for women to use bicycle pedals?
- If not, what is more acceptable?[23]
- What happens in conditions of:
- Pedaling too fast?
- Too much laundry in the machine?
- How do we make this machine safe for operation by minors, including thoughts about:
- Kids climbing inside or being put inside the machine
- Pinch points, the placement of moving parts, and their danger to fingers, etc.
- What do we do when the machine breaks?

22 By this prompt, we mean to suggest washing, drying, sanitizing and so forth.

23 The answer to this, it turns out, is "it depends." Friends of Mario's living in the town of Buddhanilkantha found that for much of their community, bicycling was still risque for women, and that a pedal-powered machine would be less socially appropriate than (as one example) a washing machine that is treadle-powered. In Sakhu, however, there seemed less social constraint on women performing the pedalling motion, at least at the PA hostel.

Technical Prompts

- What are common laundry load sizes?
- How much water are we currently using for that amount of laundry?
- How much water are we willing to use?
- How long does it take to wash that amount of laundry
- How should we get water to it?
- Where should the waste water go?
- How should the clothes get in and out?
- How should the soap get in and out?
- How do we provide power for the machine?
- How do you know when the clothes are done?
- How many people should it take to move the machine?
- Should it be in a fixed location or mobile?[24]

Issues Addressed During the Initial Design Process (Ideation)

Agreni, Jivan, and Jagat participated in the initial design charrette. They were very excited and thorough in their follow-through of design problems. The issues in our list of prompts (above) were nearly all addressed in the flurry of drawings and discussions.

During our charrette, Agreni, Jivan, and Jagat determined that:

- The washing machine project would not be a failure if the washing machine failed to wash clothes adequately or at all
- The washing machine should wash clothes and bedsheets; and if possible, carpets
- The machine use no electricity, or else be solar-powered
- The machine's mechanical power (where appropriate) be both pedals and a hand-crank
- The change from the bar soap previously used to wash clothes to liquid soap was acceptable
- The issue of wastewater was significant
- The machine need not dry clothes; but that a way to mechanically dry clothes with the machine was desirable
- Steel construction was preferable over plastic.

Some questions that were brought up went unanswered at this point. These included:

- How does the gender dynamic of washing clothes differ between PA Nepal and Nepali customs in other areas or districts?
- What is clean?
- How do we know if the washing machine works?

24 We expected that the machine would stay outside all year round, including during the rains of the Monsoon from June to September.

Selection of Design Parameters

The following design parameters were selected by Aaron and Mario, from discussions with PA Nepal Management and the children.

The washing machine prototype:

- Must be built with parts and materials available in Kathmandu
- Must be built with fabrication processes available in small welding and auto repair shops in Kathmandu. In practice, this meant using the following tools: stick welder, vice, hacksaw, lathe, drill press, angle grinder/cutoff wheel, and manual die-cutting of solid stock
- Must be repairable in Sakhu with reduced materials and tool options (i.e., no lathe)
- Must utilize as simple fabrication and assembly processes as possible, and be as transparent as possible in construction
- Must only assemble in correct orientation, and it should be obvious if the parts are assembled incorrectly
- Must have hand and pedal operation functions
- Must be portable to be carried to PA Nepal hostel on paths
- Materials for the prototype should cost no more than $100 US
- Should have weather-proofing appropriate to stay outside all year

Feedback

The initial feedback for the washing machine was extremely positive. The washing machine was displayed at an art show to benefit PA Nepal at the Lazimpat Gallery Cafe on August 23. The wards at PA were very excited and proud of what they had made.[25]

In addition, during the building process in town at Sakhu feedback was also very positive. Agreni and Jagat pointed it out proudly to classmates and Sakhu residents, and even to us there was significant buzz about the machine—we repeatedly heard the phrases "wassing maseen" (meaning washing machine) and "wassingko lagi" (meaning "for washing") as the machine was being welded in town. In addition, the welder in Sakhu asked us to leave him with the washing machine for a few hours because we wanted to learn how it worked; we came to understand that a woman in town had asked if he could build one.

Further reinforcement of this positive immediate feedback came from the Agreni, Jivan, and Jagat, who asked Mario what "company" they should say built the machine, because people in Sakhu wanted to know. The kids fantasized about building such machines as a job, and proposed a name based on the first syllables of all our names. Finally, Agreni told Mario that they now wanted to try other models for the machine to see what might work even better.

25 They even painted "Paddle Washing Machine" on the sides.

Project Costs

The total cost of the washing machine prototype was 9145 Rs., approximately $135.48 USD at the time. This exceeded the $100 USD budget by $35.48. We are confident, however, that significant savings can be had. The going rate for steel drums at the time, for instance, was 700 Rs., about two-thirds of what Wrench Nepal paid. Likewise much of the new steel bought at Rajesh Hardware could have been purchased at KawaDi at significantly less cost.

The breakdown of the costs is as follows:

- Steel Drum: 1100 Rs.
- 100-liter plastic drum: 550 Rs.
- New steel, bought at Rajesh Hardware: 2475 Rs. This includes most tubing and angle iron used in the project
- Recycled steel: 640 Rs.
- Used steel and 2 old bearings used for sizing: 120 Rs.
- Hinges, nuts, and bolts, from Kankai Hardware: 342 Rs.
- Nuts and bolts: 110 Rs.
- Other small parts: 35 Rs.
- Bike Parts, including a bottom bracket shell, crankset, left crank arm & 2 freewheels: 1390 Rs.
- Small parts, bicycle: 185 Rs.
- 4 Bearings: 450 Rs.
- Welding charge at Sakhu: 650 Rs.
- Various other shop charges: 435 Rs.
- Others: 663 Rs.

Reflections and Lessons Learned

The process and learning outcomes of the washing machine project feel successful to both of us. Even as we recognize the difficulty in evaluating a project separate from our personal experiences as participants and facilitators, we feel comfortable detailing some specific successes:

- Facilitating an educative process for all participants, including ourselves. Definitions of success and operation were decided on jointly, encouraging learning that felt practical rather than obligatory or abstractly beneficial. We stress that we were not only teachers, but students as well.
- Facilitating a working environment in which we had both organizational partners and students who were empowered to tell us no, or to say that we were wrong.
- Presenting an environment for the most-involved students to feel more confident through their involvement. We are especially encouraged by what we perceive as new skills to think creatively about technical problems and address those problems through design.
- Facilitating a design that is replicable in much of Nepal without us. The washing machine has a high level of transparency in its design, operation, and assembly, and we were encouraged that the welder in Sakhu wanted to

study the design to make a copy of it.

• Facilitating a fun project with people of much different social backgrounds from ourselves, even while we were able to complete the fabrication of the washing machine

• Documenting this process self-critically—we have attempted to communicate the experience and resultant understandings generated from this project, and we have attempted to do so in a way that emphasizes and prioritizes social processes for doing "Appropriate Technology."

All that said, we have strived to understand the ways in which this project and our own actions have reinscribed particular narratives about the process and value of development, narratives we find unsatisfactory. Three ways that we recognize that we have done so are:

• The washing machine project is implicated in the discourse of development in Nepal, and in crucial ways reinscribes it. Most specifically, the design and building of the washing machine is connected with the idea of ownership of or access to a washing machine—a device, in general, that is perceived as a signifier of being bikas, or "developed," since washing machines are most useful in locations where labor is expensive and capital is plentiful, very different from the conditions in much of Nepal.[26]

Because of the connection between washing machines and bikas, it is likely that some of the positive feedback that we received was due to a connection with bikas rather than any alleviated poverty, any health benefits, or any increased agency or empowerment that the washing machine might produce.

• Aaron's role as the outside specialist reinforces the enduring narrative of the white outsider "bringing development" to Nepalis heretofore too abikas ("un-bikas") to empower themselves. Though in our rhetoric with Indira, Agreni, Jagat, and Jivan we repeatedly articulated positions that foregrounded Nepali involvement, we remain unconvinced that we made inroads at challenging this narrative. Indeed, we likely entrenched it further.

• The lack of long-term follow-through normalizes short-term development projects as appropriate and acceptable. This is related to the above point. In some ways, this project has reinforced the habit of development organizations to act without an enduring commitment to the communities they serve, especially after their projects have materially occurred. This reinscribes the development framing in which we practioners act upon a community, in which we are the "agents" and our "beneficiaries" are passive recipients of our largess or magnanimity. Because this is structural, it occurs, we feel, despite our attempts to integrate the PA wards into all the processes of the project. For instance, while the project would not have happened without them, from their perspective it also would not have happened without us—and in the historical context of development in Nepal, as well as of development in general, that narrative of active-passive is inextricable from what we as individuals say or do.

One can easily synthesize from these a comparative social valuation of Western and local forms of knowledge in Nepal. As foreign development workers, as Westerners, and as Americans, we bring access to what might be termed symbolic capital—that is, certain broadly applicable skillsets, both easily teachable and communicable (e.g., English fluency) and those less teachable (e.g. understanding of a broadly Western cultural ethos and values). The second-order effects of these are wide-reaching: they include access to jobs and job security, access to food and food security, and numerous others. For this reason, any power dynamics at play, either subaltern or manifest, will favor us in myriad ways.

We recognize, then, that we are forced into a paradox: even as the access to Western forms of knowledge is a form of social capital, both instrumentally and symbolically, treating it as such delegitimizes other forms of knowledge.

26 The notion of *bikas* is pervasive in Nepal—Mario's landlord was in fact named Bikash aspirationally—and has been well explored by writers like Stacy Leigh Pigg and Laura Ahearn.

Readers who already possess a familiarity with the concept and its enactment may also wish to consult Mary Das Chene's "In the Name of Bikash," in *Studies in Nepali History and Society* Volume 1 No. 2 (1996).

In the context of Nepal, this treatment specifically delegitimizes Nepali knowledge. Our intuition is that there is nothing inherently "wrong" with engaging in a development project for knowledge exchange, nor with implementing a project with local people; but we acknowledge that our doing so has not been without cost.

We can also measure another indicator in this project: the utilization of the washing machine. We learned in the July 2009, almost a year after building the washing machine, that it is not in common use. It is used, at most, once per month. However, we are emphatic that to see the entire project as a failure is misguided: empowerment comes from participation and agency, not from technology. In relation to both the above power-knowledge relation, to see success and failure primarily as a function of technology is the imposition of a positivistic world view; it is to subscribe to a Western-centric discourse of measures and measurable outcomes.

Still, we will continue seeking to understand the factors that contributed to—and missing from—its adoption to common use. A longer feedback cycle for similar projects is crucial. Although our project was doubly constrained by Aaron's short window of availability and Mario's coming visa expiration, we still feel that we should have facilitated more of a process for us to measure project outcomes based on how the product was used; how Nepalis talked about and saw it; and how the participants felt about the project based upon further reflection.[27] A longer feedback cycle would have provided not only opportunities to learn about the product, but also to identify area of improvement for further iterations of the washing machine project. Although we are are still in that feedback cycle, we did not set up systems for evaluation and feedback while working in Nepal, so the feedback is minimal and limited in its scope.

Finding workshops in which we could work was a continual challenge. We found we established a good rapport in asking for fabrication opinions, in asking for help—particularly welding—and lastly in doing fabrication ourselves. We also noticed that as the washing machine began to look more and more like a usable product, the welding shops asked for more and more money. The machinist running the lathe near the scrap yard asked for 30 Rs. and we gave him 50 Rs., and the moped workshop asked for 50 Rs. for about 6 hours of work, and we gave them 200 Rs. The value of workshop space was quite high to us, but we did not want to negatively affect the local economy by overpaying. We paid the asking price plus a tip generally at the beginning of the project, and as the washing machine started having functionality and visually made sense as a product, the quoted price increased. The final workshop fee, from the welder in Sakhu, was 650 Rs. for just 3 hours of time.[28]

It is important to note that there is considerable difference between what is socially appropriate among the Nepalis boarded and housed at the PA hostel and Nepalis living in the vast rural regions of the country. Even though pedaling a bicycle is acceptable at the PA hostel, this is not necessarily the case elsewhere in Nepal, and is an important consideration before replicating this project.

27 Note that some of these processes were intended to continue, and failed to do so because of the suspension of Wrench Nepal under Mario's in-country successor.

28 We continue to be unsure about the most appropriate way to engage with the purchase of shop space and services, but we recommend asking questions and trusting your project partners to understand the interactions.

Transferability

Transferability is not only about the appropriateness of a specific device, or even of the appropriateness of a design process around a specific device, but also about the appropriateness of a knowledge model: that is, a model of interaction, of learning, of knowledge, and further, of discourses of all of these. Some of the most transferable components of this project, then, are the process of needs identification and appropriate process for working in another culture.

Process Transferability

We feel that this project incorporated specific processes that are themselves worth replicating. These include:

• This project was explicitly about education and capacity-building; that is, all stated evaluative criteria focused on the process of the project, rather than the operational success of the product. Situating the washing machine project as a process freed us to make sure that we were engaging with the process of technology in a way that we felt confident in; that is, it not only allowed us but indeed required us to integrate Jivan, Jagat, and Agreni in the design-build process.

We find two specific goods in this. First, the relationships between ourselves and the project and between ourselves and Jivan, Jagat, and Agreni allowed the project to move forward in a way that deemphasized Western-centric discursive regimes. Rather than approaching this project as a solution to a general problem—for example, that people in the Kathmandu Valley need a better way of washing clothes—seeing the process as educative meant that both the problems and solutions were understood dialogically.[29]

We note that the impetus for this project came from Jagat and Agreni most of all, and was enabled by Mario, rather than the other way round. Mario doubts that the project could have happened without their advocacy with Indira. Second, and related, the project occurred from a combination of knowledge Mario had of bicycle-machine projects and of what the wards perceived as a piece of good and useful technology to build. Jivan, Jagat, and Agreni perceived the educative qualities of the project to be applicable to their lives; that not only was the device potentially useful, but the process for going about creating the device was as well. We see this in turn as indicative of a potential for greater enhancement of agency than is possible from the imposition of any specific technology.

• The project was an extension of already-established relationships. Before the project, a formal relationship existed between Wrench Nepal and PA Nepal; in addition, there was a history of interactions and relationships in other ways—relationships between Mario and Jivan, Jagat, and Agreni, between Mario and Indira.

These relationships are crucial in myriad ways. For instance, they serve to partially deprivilege the "expertise" of the foreigner. Though Jivan, Jagat, and Agreni were generally more comfortable with Mario and empowered in their lives than the students and wards in Wrench Nepal's other partner organizations, Mario believes that these relationships benefited the project in ways too manifold and too discreet to quantify well. One example of this was that when the welder in Sakhu was acting disagreeably to the progress of the project, Agreni could tell Mario that his preferred method of interacting with the welder was not entirely socially appropriate, and suggest better ways of interacting to the benefit of everyone; we feel that it is difficult to overstate the importance of this sort of relationship.

• The process empowered partners to say no when necessary. Mario had been working to establish an organiza-

29 We choose "deemphasize" because it is difficult to envision a realistic development encounter where regimes of Western knowledge are not privileged, even as we have tried to move towards that. Further, we are aware that our ways of involving Jivan, Jagat, and Agreni in the design process were grounded in our own experiences and expectations of what that process could, should, and needed to entail. We encourage future projects to consider more equal ways of engaging in a design-build process.

tional relationship that was encouraging of criticism and suggestion about projects. The anecdote with Agreni and the welder is one example of this. Further, Mario and Indira checked in regularly during the course of the project. Indira's oversight occurred through suggestions as to what the purpose of the project ought to be; how the process with the wards ought to take place; what potential costs and externalities were or might be present; suggestions for how to best address the needs of specific children at the PA hostel; and thoughts on the social impact of a washing machine in the context of both Sakhu and the wards' later lives; and she was unafraid to say that certain ideas of actions were not good.

• The project had multiple levels of oversight. Indira provided a level of oversight, as described above. Further oversight of a kind was provided by local residents in Sakhu, local fabricators whose shops we patronized, and other foreign development practioners. Of these, we feel that the crowds of local residents that gathered around the welding done in town served most helpfully. Our project in the town of Sakhu was attended by not only by the foreigners and Nepalis involved in fabrication, but watched, gossiped about, and cheered or egged on by local residents from a wide variety of professions, especially as it came close to completion. It was clear to us that in front of the local residents, the project was a source of great pride for the Nepali students from PA Nepal who were sanding parts, reaming holes to larger diameters, and fitting pieces together. This pride is one (potential) indication that the greater community in Sakhu did not find the washing machine inherently inappropriate, silly, or socially problematic.

Yet another indicator of the project's appropriateness to the community was desire for imitation of the washing machine. A local resident who had seen our process and progress asked the welder in town if he could make her a washing machine of her own; the welder asked us to leave the machine with him so he could study it. This suggests that the desire for the technological output of the project—that is, a machine to make clothes washing easier—was present in Sakhu outside of the immediate community whom the project was designed with, for, and by.

• The project was flexible and responsive to the social and physical environment, especially the lack of dependable infrastructure. Our experience with the project was influenced by the familiar social interactions and conventions of North America, and it was a necessary step to devalue our cultural expectations. In addition to logistical and infrastructural differences from our culture—for example, access to electricity throughout Nepal is not dependable, even in electrified areas; transport often takes a comparatively long time and several modes of transit for "short" distances—it was important to remember that our emotional responses to project difficulties were influenced by our personalities and that which is familiar and comfortable.

Because so much of the process of the washing machine project is about forms of organizing and interaction, we feel that this project's success suggests strongly that an extremely wide variety of experiences and knowledges can be successful at (accomplishing the rhetoric of) development, much wider than is suggested by typical job qualifications of development work. There is no reason, for instance, that an organizer of low-income housing in minority neighborhoods of the U.S. would not be equally if not more qualified and, later, successful at accomplishing (the rhetoric of) development than typical development professionals.

We were fortunate that the difficulties we faced were primarily logistical or infrastructural rather than interpersonal communication among the project partners. We asked the students and Indira many, many questions to understand how to best address problems. Several factors contributed to the relationship that led to good communication and a minimum of frustration among people in the project (as far as we know). We tried to remind one other about cultural differences that lead to misunderstandings, and to keep perspective in unfamiliar circumstances. Perhaps most importantly, everyone in PA Nepal was very tolerant and supportive of our own struggle to understand Nepali culture and cultural practices.

Device Transferability

This specific design is not meant to be transferred outside of Nepal, or perhaps even Sakhu, or perhaps even replicated in Sakhu. While we hope that our anecdotes, lessons learned, and documentation can implicate a larger organizational and social dialogue of inter-cultural project participation, there are several aspects of the technology that are indeed transferable. The milieu of the Kathmandu Valley is likely similar to many other locales in terms of infrastructure for manufacture, repair, services, and so forth.

Bearing choice may be an example of this: 1" tubing size is available in most of the world, as are the bearing that we used, from mopeds. Likewise, the ends are triangular bases of rectangular steel tube, because of availability, strength, cost, and manufacturability, and triangles because of basic geometric conditions.

We believe the following design components of the washing machine may be transferable:

- bearing assembly design and component choice
- inner and outer barrel materials and fabrication processes
- general form of horizontal axis drum-in-drum design
- hand crank and pedal hybrid design
- hinge design on outer barrel
- tool choice for manufacture and repair(lathe and mill not required)
- ability to disassemble all components for repair, replacement, and transportation

We encourage other projects to reevaluate the following design elements of this project:

- water flow in and out
- weather proofing of bearings and bicycle drivetrain
- removing pinch points from drivetrain
- preventing water leakage around hinge in barrel
- smallest disassembled size for transportation
- rust-proofing, especially the outer barrel
- ergonomics and physiology of pedaling and hand-cranking

On a final note: it is exciting to build things that spin by bicycle power. Bicycles are commonly available around the world; parts are inexpensive, generally interchangeable, and replaceable. But while reappropriating bicycles and pedal technology is sexy, and appeals to some first world sense of "appropriateness" for less-industrialized contexts, the excitement and this "logic" of cutting apart bicycle parts to make things spin and move should not be the driving factor in component and design selection when designing products that may become household technology. Indeed, we would advocate using principles of universal design whenever possible. If a device is designed to fit a right hand perfectly, but not fit a left hand, a user group will be excluded. Similarly with this project, the utilization of both hand and foot cranks in the final design added not just the possibility for operation by someone with limited leg mobility, but the inclusion of many different people, strengths, and preferences to use the technology. Where inclusion and universal access may be built into a design, we should go out of our way to make sure it happens.

Conclusions

We feel that the washing machine project was "successful" for all participants. Together, we all completed designed and built a functional prototype of a human-powered washing machine; the process of this project incorporated several aspects worthy of wide application, which are detailed in the "Transferability" section.

Our feelings of "success" do not preclude great improvements by future projects, nor do they mean that we made no significant errors in judgment or in practice. We believe that we provided a worthwhile and empowering educational experience; that we engaged with Indira and the greater community in a process that incorporated their needs and values; and that we were able to collaboratively build a working prototype. We hope that the project will "last"—that is, that the process of building and, most important, the aspects of empowerment, will stay with Jivan, Jagat, and Agreni, just as we hope the physical washing machine will. Indeed, projects such as the washing machine must be understood as the results of medium- and long-term interactions with affected or potentially-affected communities. The washing machine project itself was the result of a five-month collaboration between Wrench Nepal and PA Nepal, not the two and a half weeks during which the project was designed and built. Still, a longer collaboration, especially after the prototype washing machine was operational, would have been preferable.[30]

We likewise caution in the "Device Transferability" subsection that while bicycle technology was appropriate in this context, this is not universally so. One cannot simply create a bicycle-based device out of local parts and expect it to be useful. We advocate using user-based design processes and incorporating universal design in any project, rather than using an existing technology (such as bicycles) as the driving factor in component and design selection. The example prompts described in the "Prompts in the Design Process and Design Constraints" subsection are meant to elicit this sort of inclusion.

It is similarly important that the praxis of this project was driven by the beneficiaries of the project—the wards at the PA hostel in Sakhu—and not by us. We hoped at the outset that, by undertaking a project significantly driven by the desires of its beneficiaries, we could enable a project that empowers its beneficiaries and enhances their agency over their own lives without simultaneously subordinating their culture and cultural and social practices. Arturo Escobar writes that "Appropriate Technology" projects too often problematize "social life as a technical problem, as a matter of rational decision and management to be entrusted to that group of people—the development professionals—whose specialized knowledge allegedly qualified them for the task,"[31] and we have tried to heed that admonition.

We feel that this project and this document are worthwhile for future practitioners to learn from.

Furthermore, as we wrote in the "Process Transferability" section above, we feel that this project's outcome suggests strongly that an extremely wide variety of experiences and knowledges can be successful at (accomplishing the rhetoric of) development, much wider than is suggested by typical job qualifications and requirements of development work. We likewise suggest that a broader group of development practioner-participants would often be more effective at empowerment, capacity-building, and agency-building for all the reasons that social and intellectual diversity is beneficial for societies and social groups at large.

We especially encourage readers to consider the ways the washing machine is implicated in the discourse of development in Nepal. We have endeavored to understand the ways in which this project and our own actions have reinscribed particular narratives about the process and value of development. These include the way that Aaron's role as an outside specialist reinforces the enduring narrative of the white outsider bringing development and the ways that the lack of long-term follow-through normalizes short-term projects as appropriate and acceptable. We

30 Note that our intent was to gain longer-term feedback via Wrench Nepal's continued involvement with PA; but that Mario's replacement at WN resigned a month after Mario left and WN went on hiatus not long after that.

31 Escobar, *Encountering Development,* p. 52

are acutely aware that our premises—such as "poverty is bad" or, even more problematically, "we can help these people"—for doing development are normative claims; even as we have attempted to enact defensible processes of cultural interaction and engagement, we are certain that there are ways we have in fact enacted practices that other, future practitioners will wish to avoid.

It is our hope that the other benefits of this project outweigh these drawbacks.

Reading list

The following is a list of books and articles that resonated in some way with our experience as practioners of development. We include theory and practice here, fiction and non-, as all have proved important (often in non-overlapping ways) to our conceptions and understandings of the physical and social locations that this project exists within.

Suggested Reading about Development

Maria Eriksson Baaz. *The Paternalism of Partnership: A Postcolonial Reading of Identity in Development Aid.* London: Zed Books, 2005.

Arturo Escobar. *Encountering Development: The Making and Unmaking of the Third World.* Princeton, New Jersey: Princeton University Press, 1995.

James Ferguson with Larry Lohmann. "The Anti-Politics Machine: 'Development' and Bureaucratic Power in Lesotho," *The Ecologist,* Vol. 24 No. 5 (1994), pp. 176–181.

Paulo Freire. *Pedagogy of the Oppressed.* London: Continuum, 2000.

Phil Woodhouse and Admos Chimhowu. "Development Studies, Nature and Natural Resources: Changing Narratives and Discursive Practices," in *A Radical History of Development Studies: Individuals, Institutions, and Ideologies,* ed. Uma Kothari, pp. 180–199. London: Zed Books, 2006.

Suggested Reading about Cross-cultural Technology Projects

McRobie, George. *Small is Possible.* New York: Harper & Row, 1981.

Papanek, Victor J. *Design for the Real World.* Chicago: Academy Chicago, 1985.

Schumacher, E.F. *Small is Beautiful.* New York: Harper & Row, 1973.

Smillie, Ian. *Mastering the Machine Revisited: Poverty, Aid, and Technology.* London: ITDG Publishing, 2000.

Willoughby, Kelvin W. *Technology Choice.* London: Westview Press, 1990.

Suggested Reading about Development in South Asia

Arjun Appadurai. "Deep Democracy: Urban Governmentality and the Horizon of Politics," *Environment & Urbanization,* Vol. 13, No. 2 (October 2001).

Helena Norberg-Hodge. *Ancient Futures: Learning from Ladakh.* San Francisco: Sierra Club Books, 1991.

Stacy Leigh Pigg. "Inventing Social Categories through Place: Social Representations and Development in Nepal." *Comparative Studies in Society and History,* Vol. 34 No. 3, pp. 491–513 (1992).

Suggested Non-fiction about Nepal

Laura M. Ahearn. *Invitations to Love: Literacy, Love Letters, and Social Change in Nepal.* Ann Arbor: University of Michigan Press, 2001.

Manjushree Thapa. *Forget Kathmandu: An Elegy for Democracy.* New Delhi: Penguin, 2005.

Suggested Fiction about South Asia

Mohsin Hamid. *The Reluctant Fundamentalist.* Orlando, Florida: Harvest Books, 2008.

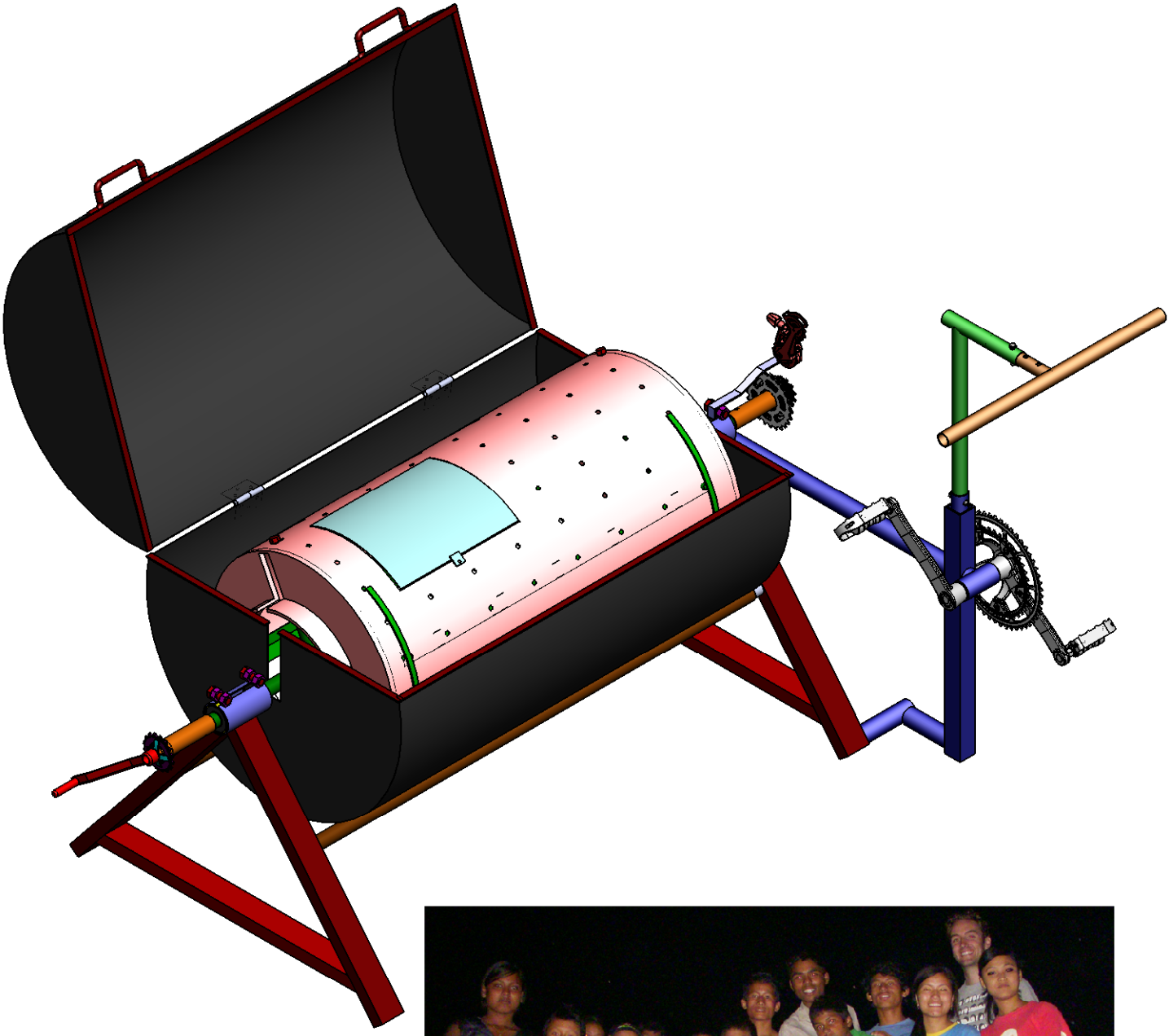
Salman Rushdie. *The Moor's Last Sigh.* New York: Vintage, 1997

Samrat Upadhyay. *Arresting God in Kathmandu.* New York: Mariner, 2001.

Appendix

The following appendix includes models of the human-powered washing machine.

Technical Drawings
PA Nepal/ Wrench Nepal Washing Machine, 2008



PA Nepal and Wrench Nepal Washing Machine project group

Iso-Overview

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A. Wieler July-8-09

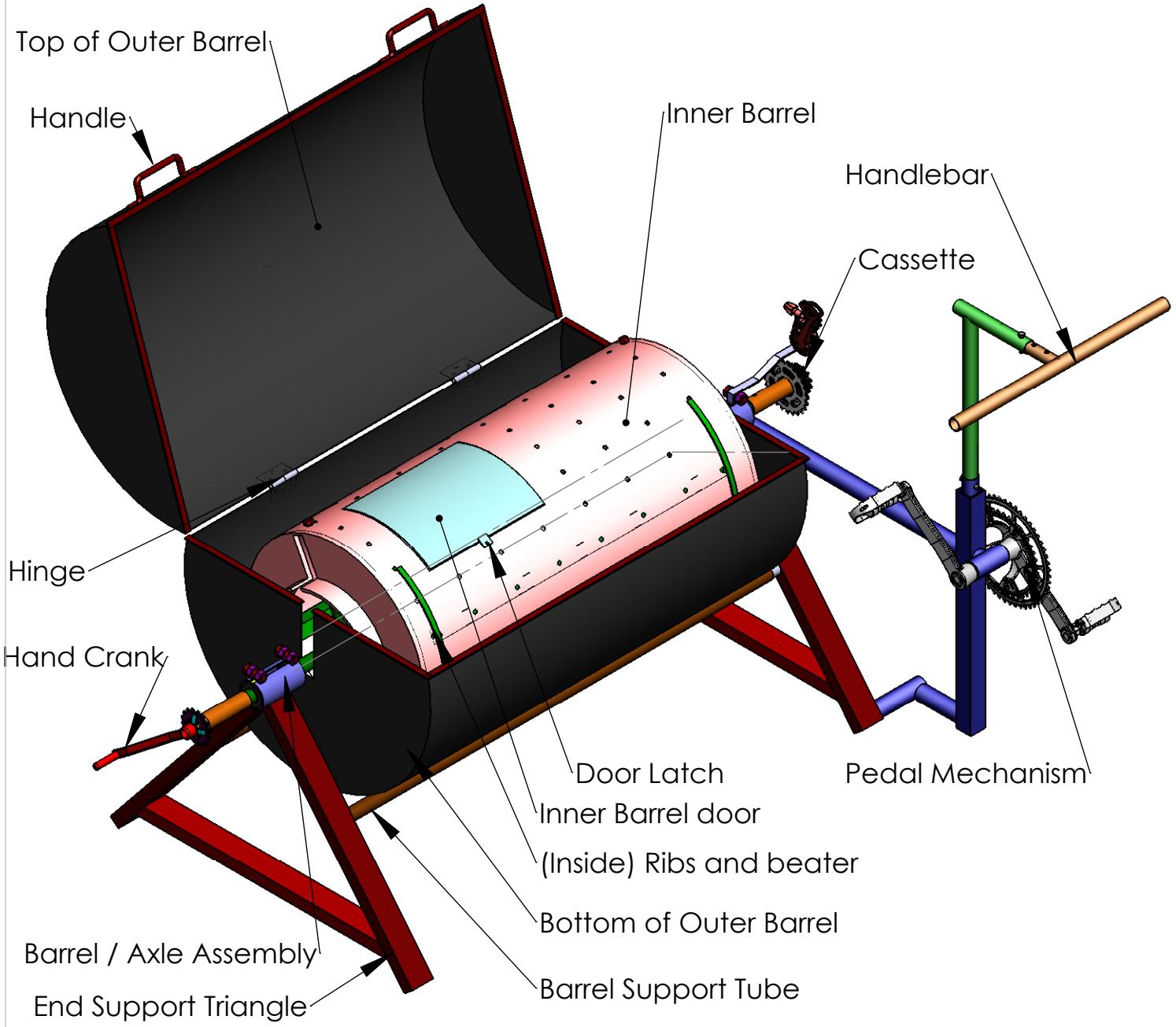
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES: ± 1 MM UNLESS OTHERWISE NOTED.

Prisoners Assistance Nepal / Wrench Nepal

COMMENTS:

SIZE A | DWG. NO. washing machine drawing set | REV.

SCALE:1:50 | WEIGHT: | SHEET 1 OF 10



Exploded Diagram: Parts Names

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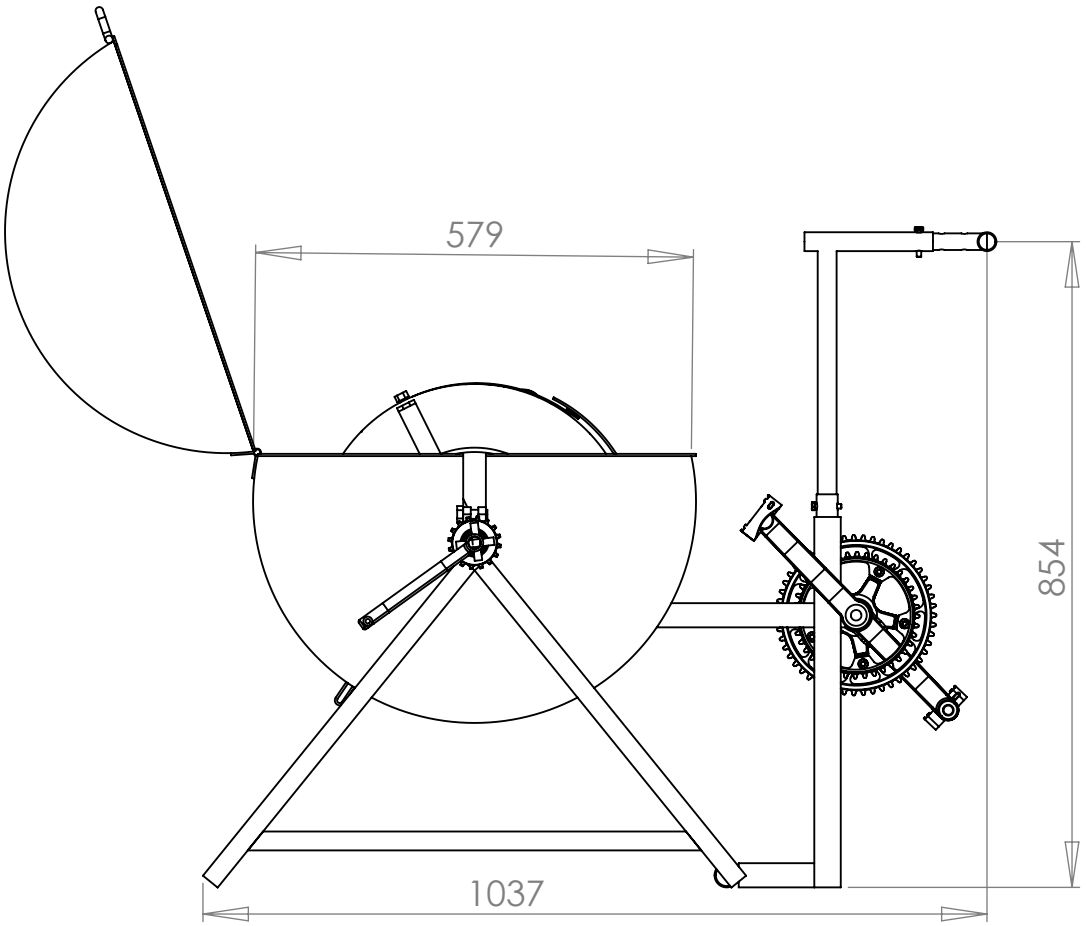
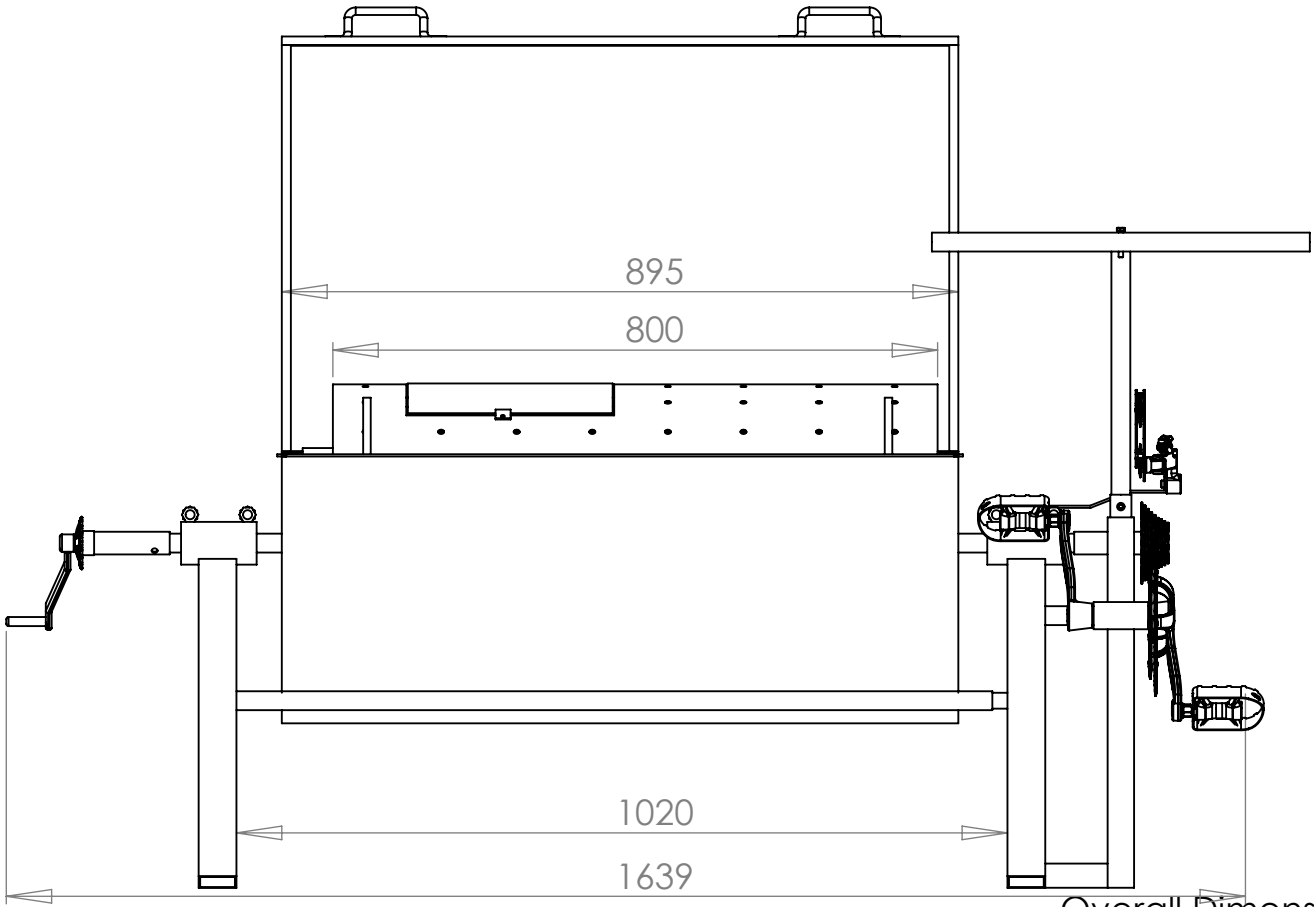
SIZE A | DWG. NO. washing machine drawing set | REV.

SCALE:1:50

SHEET 2 OF 10





Overall Dimensions

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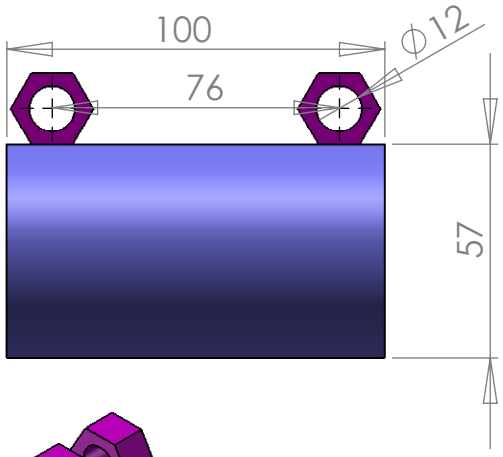
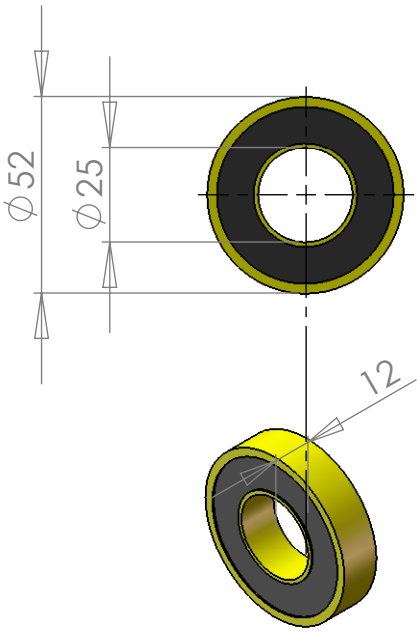
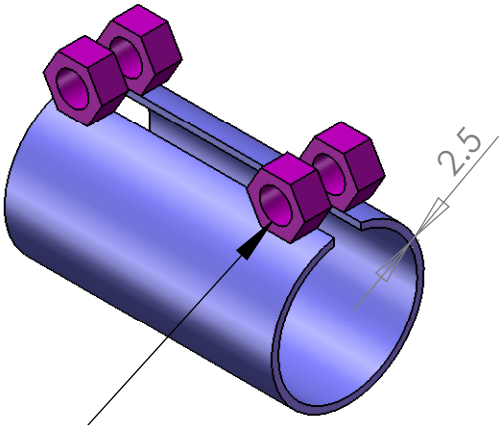
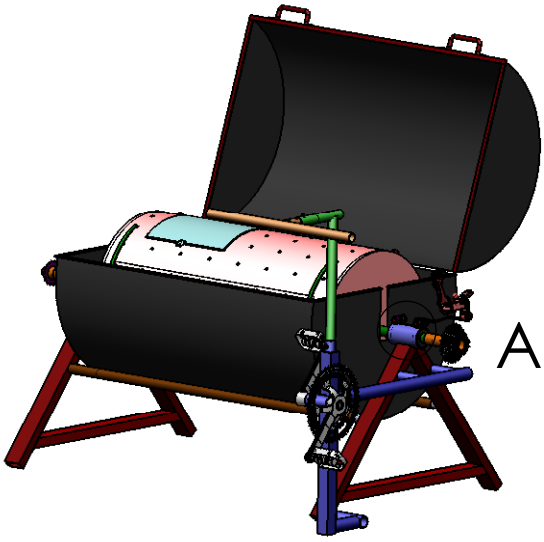
SIZE	DWG. NO.	REV.
A	washing machine drawing set	
SCALE:1:50		SHEET 3 OF 10



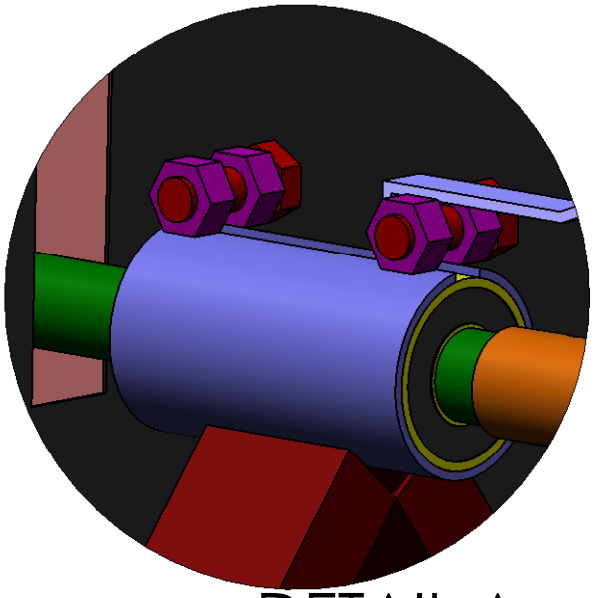




Drill out the inside of these M12 nuts to 12mmto allow a bolt to spin freely, and tighten against another nut



A



DETAIL A
SCALE 1 : 2

Barrel / Axle Assembly

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COMMENTS:

SIZE A | DWG. NO. washing machine drawing set | REV.

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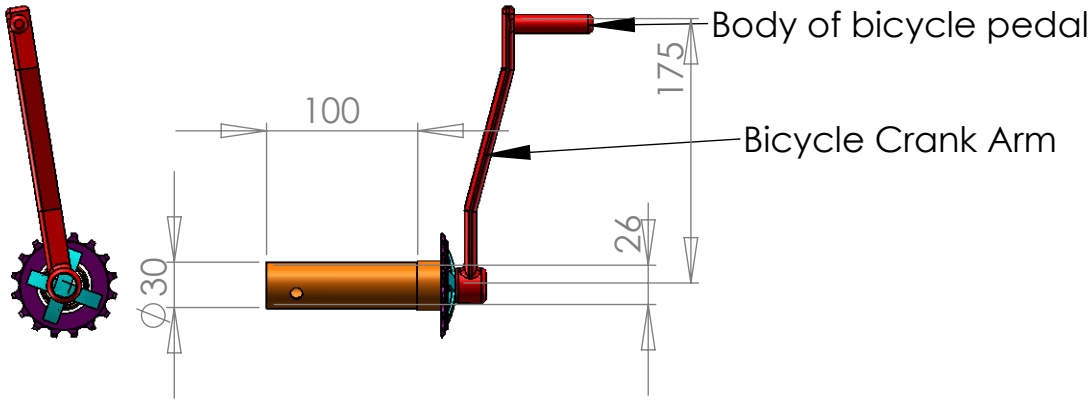
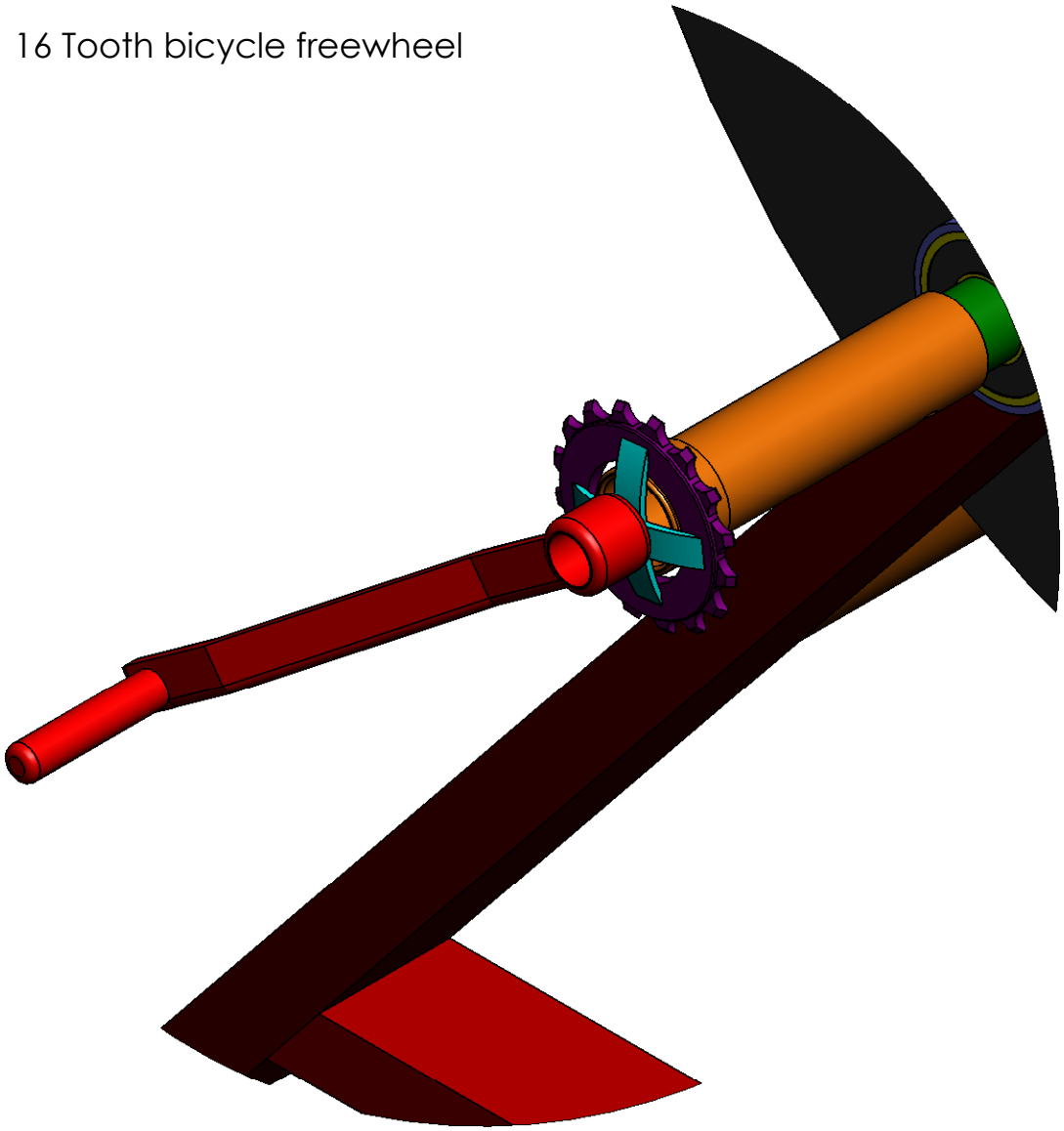


16 Tooth bicycle freewheel



Crank Assembly

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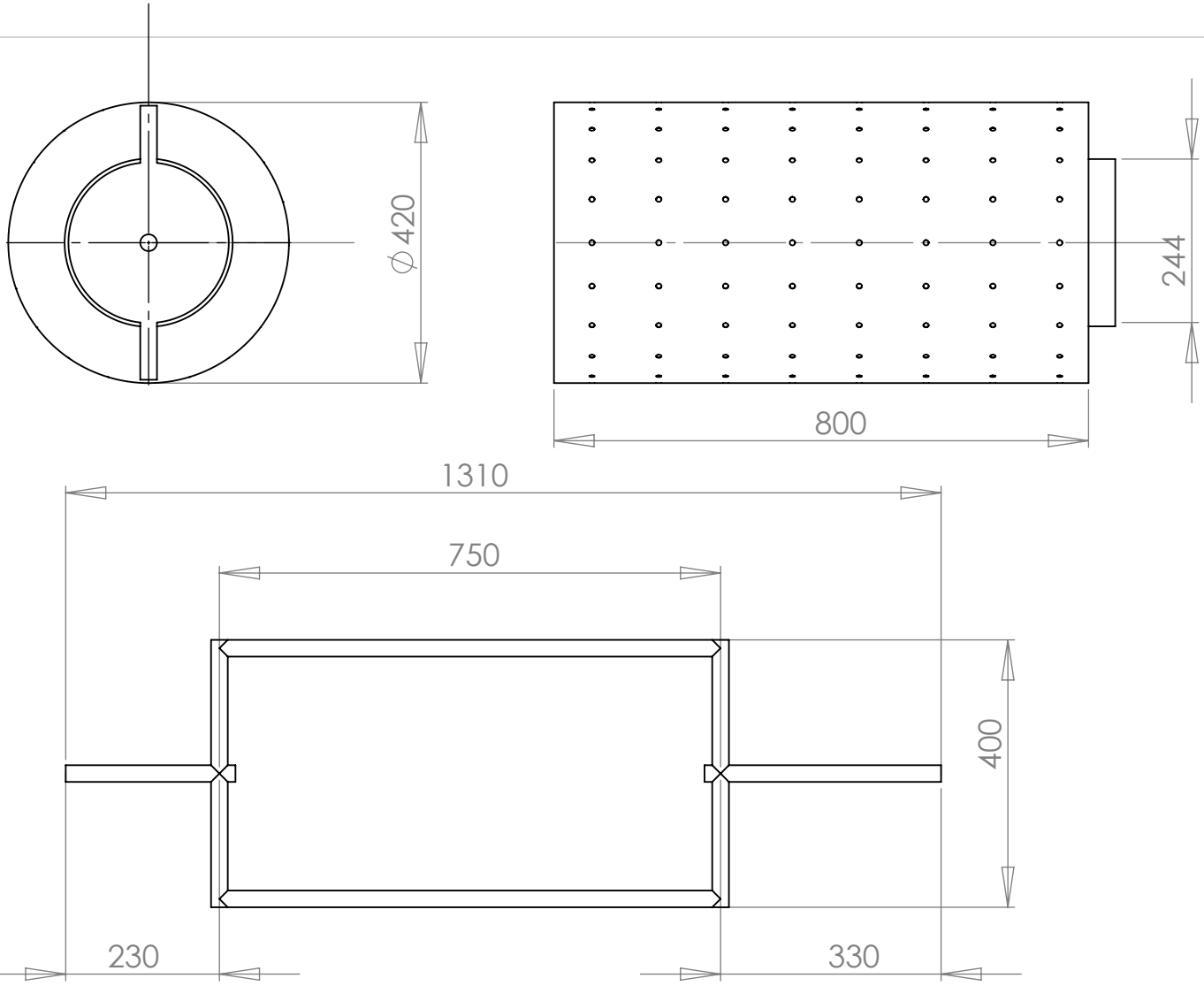
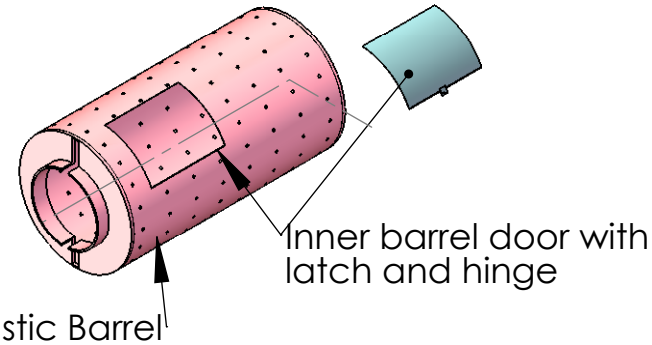
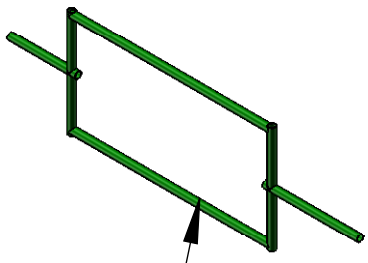
Prisoners Assistance Nepal / Wrench Nepal

SIZE A | DWG. NO. washing machine drawing set | REV.

COMMENTS: | SCALE:1:50 | WEIGHT: | SHEET 5 OF 10







Inner Barrel and Beater

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SIZE A | DWG. NO. washing machine drawing set | REV.

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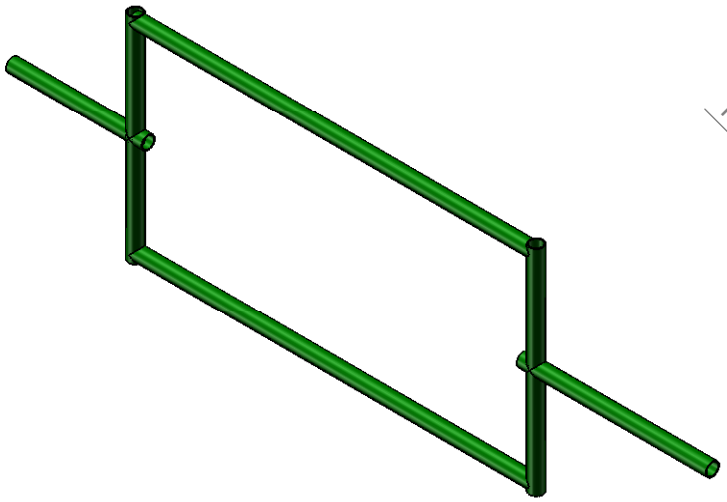
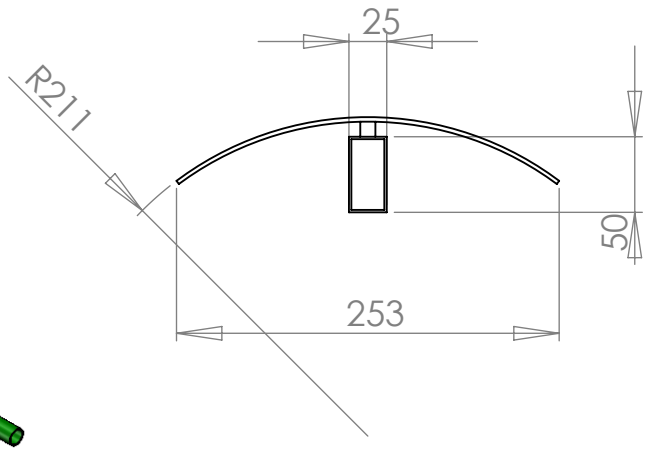
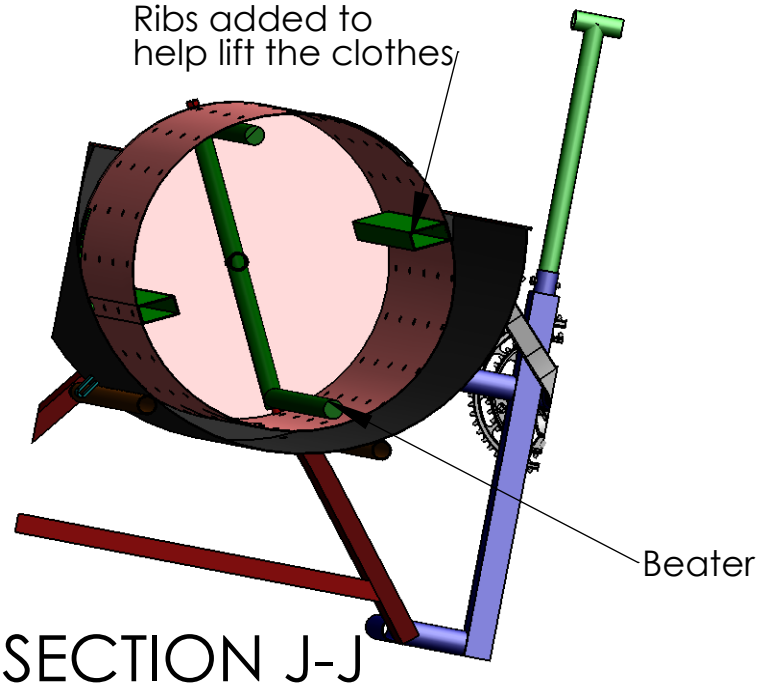
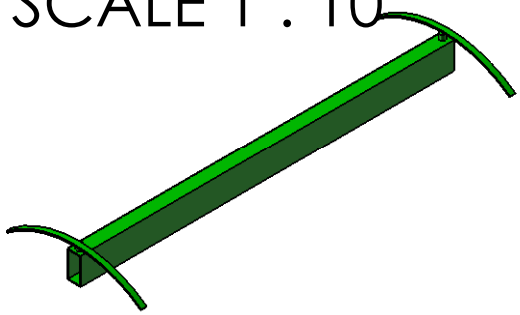
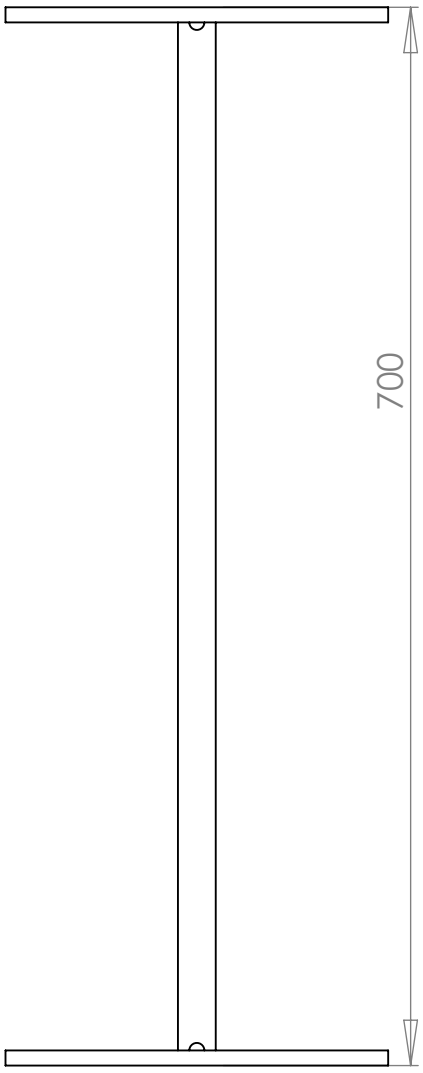






SECTION J-J
SCALE 1 : 10





Rib--Steel tube and flat stock

Beater and Ribs

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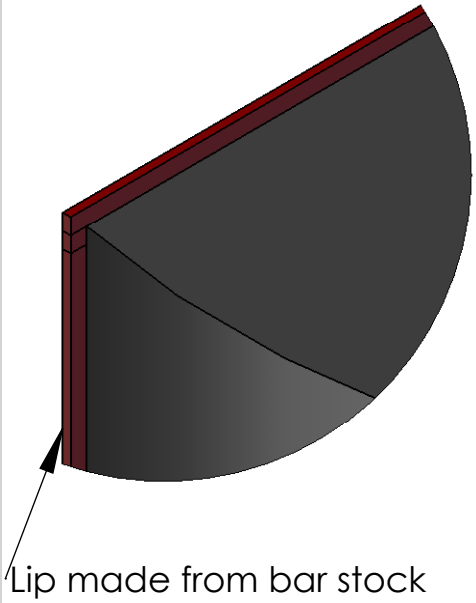
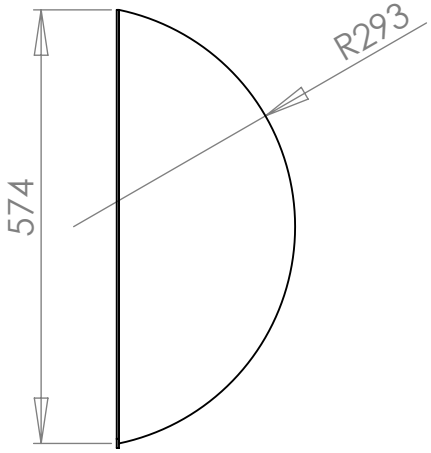
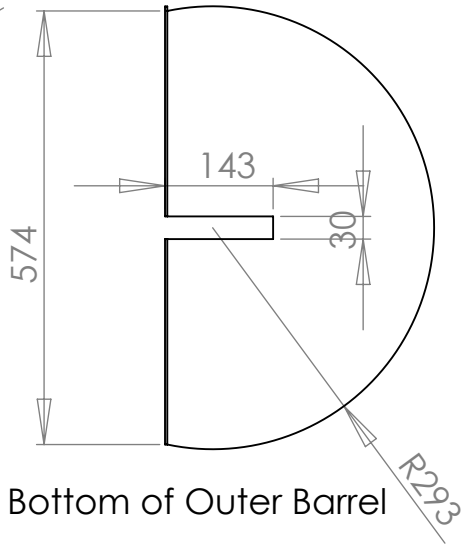


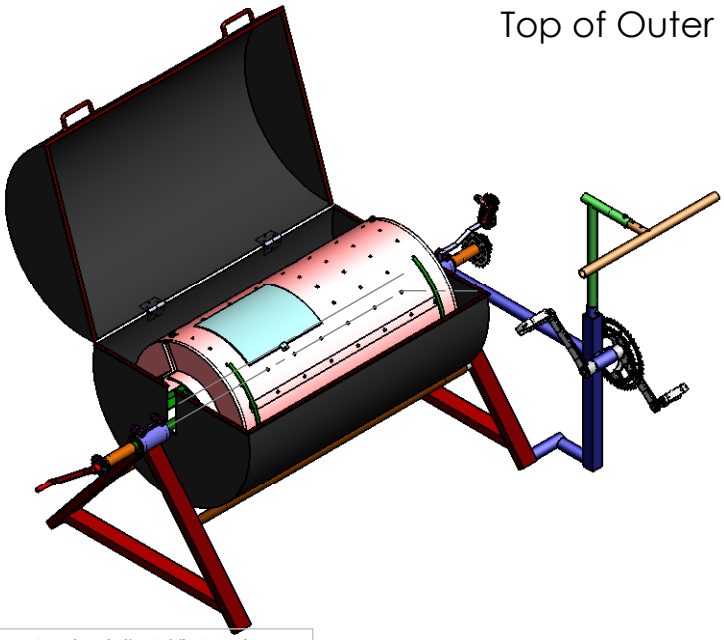
Lip made from bar stock



Top of Outer Barrel



Bottom of Outer Barrel



Attach barrels together with standard door hinges welded along one edge.
Add a lip to the edges of the barrel to protect against sharp edges

Outer Barrel

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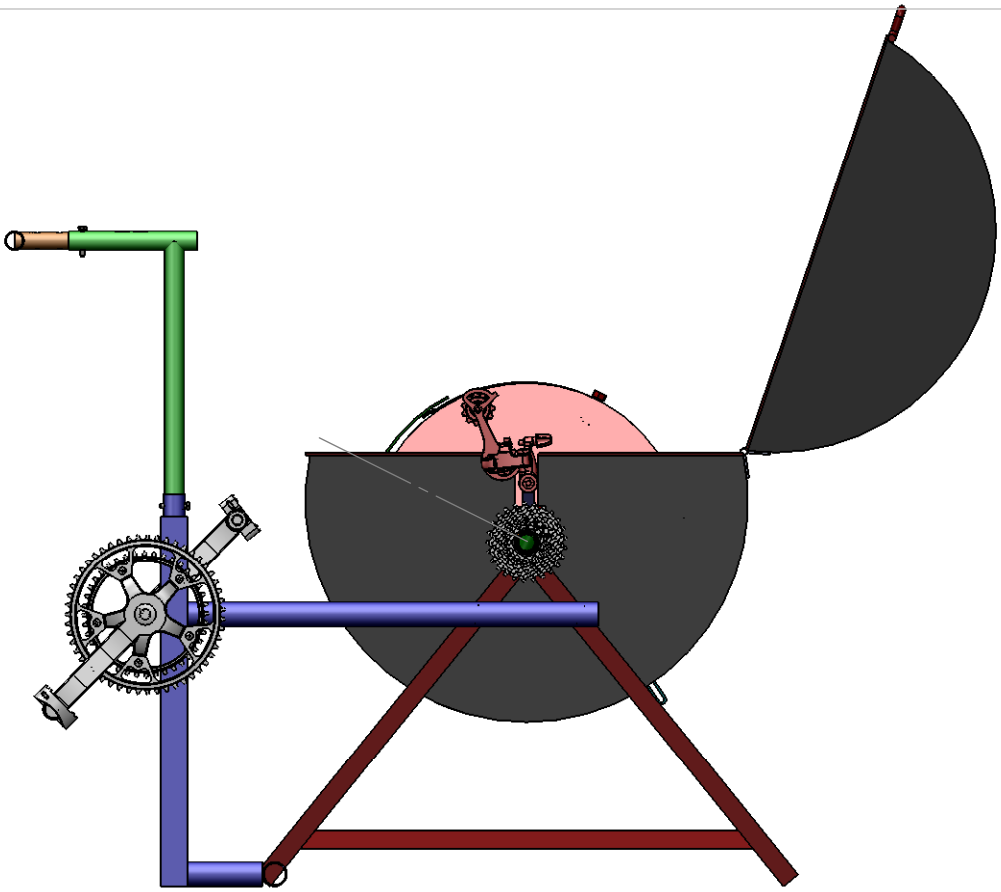
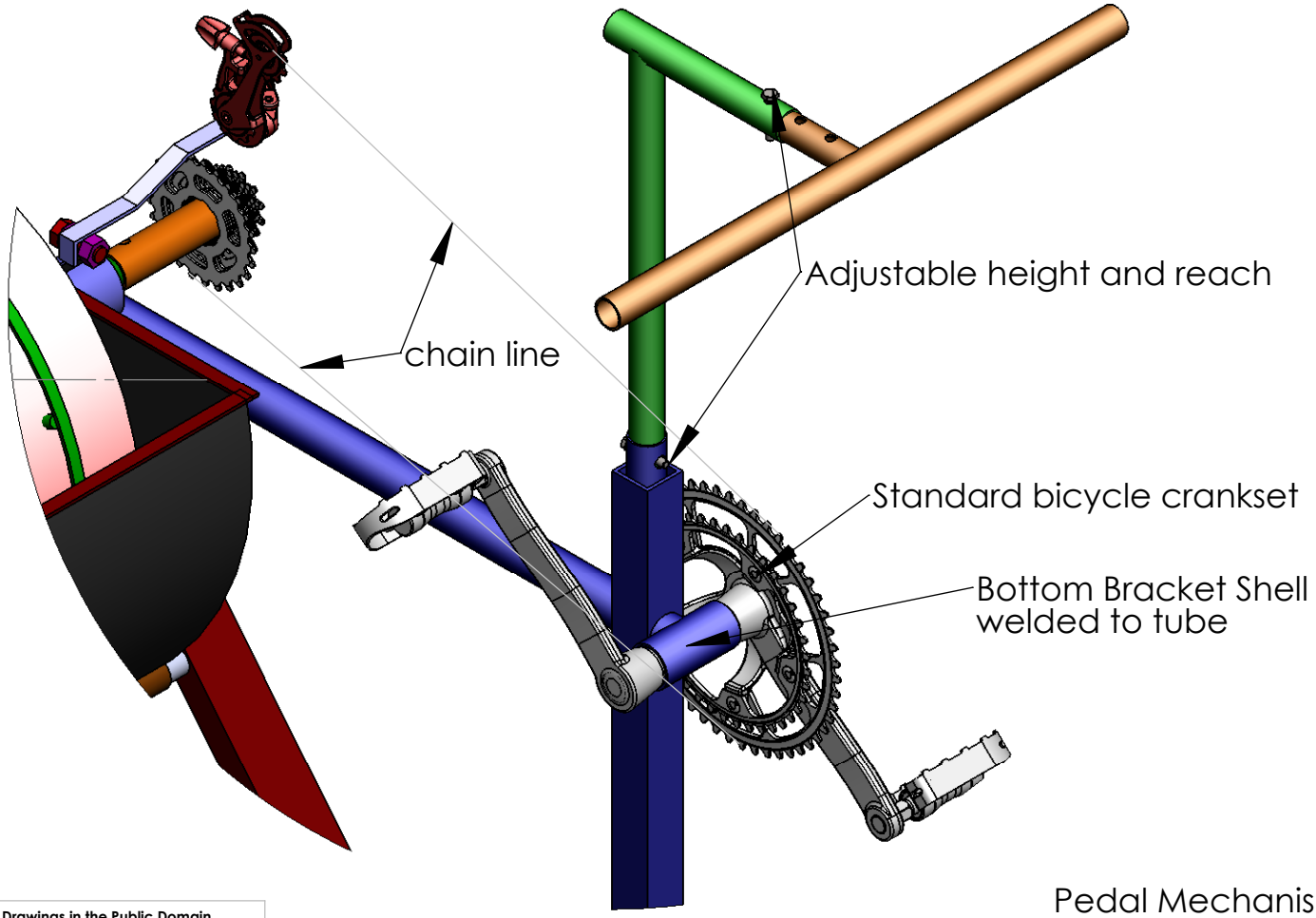
SIZE A | DWG. NO. washing machine drawing set | REV.

COMMENTS: | SCALE:1:50 | WEIGHT: | SHEET 8 OF 10





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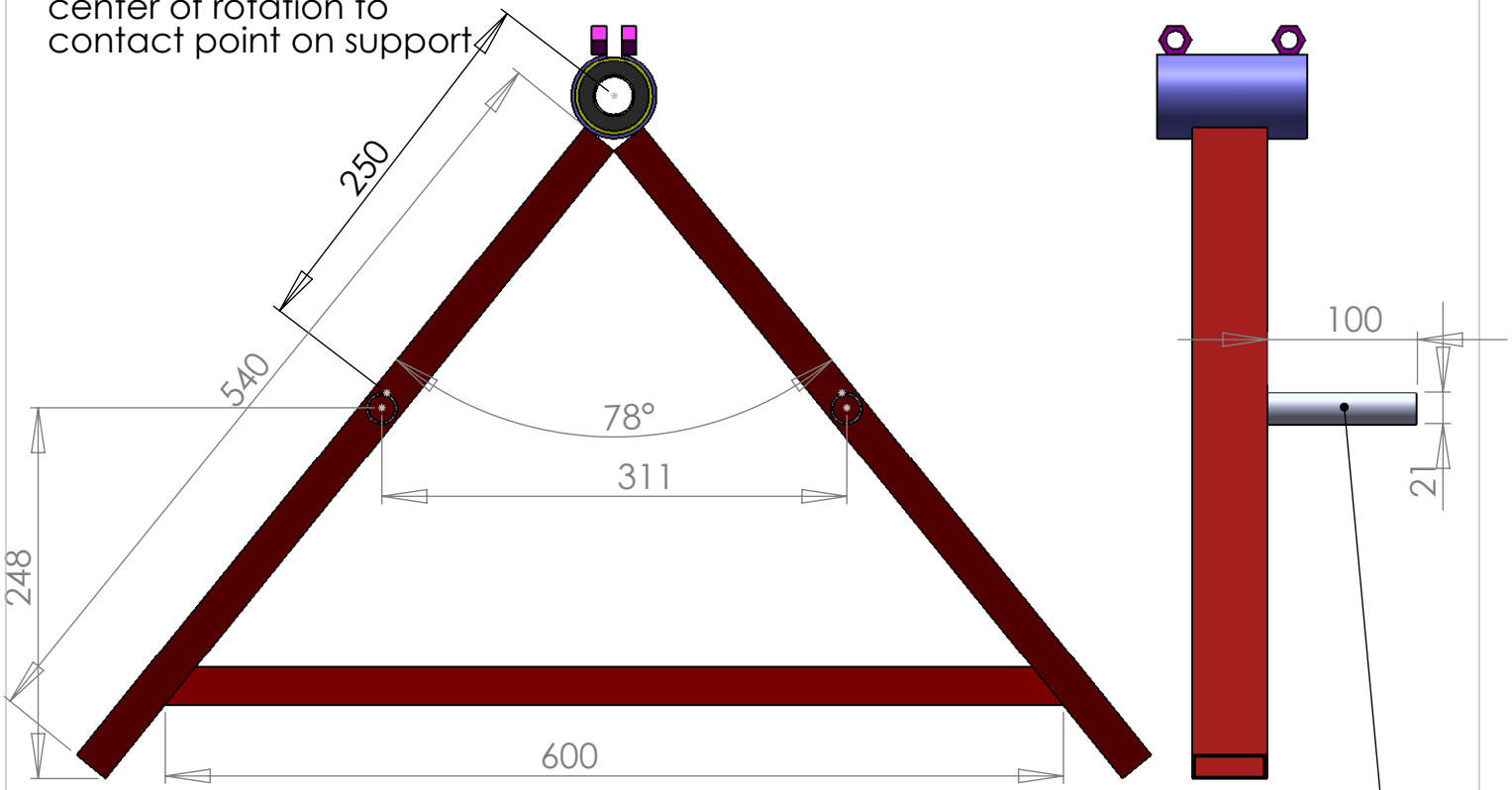
COMMENTS:

Pedal Mechanism

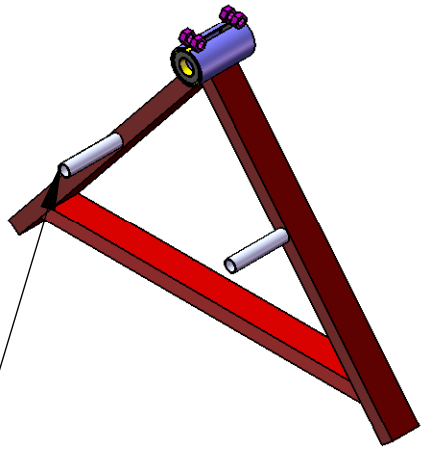
Prisoners Assistance Nepal / Wrench Nepal

SIZE	DWG. NO.	REV.
A	washing machine drawing set	
SCALE:1:50	WEIGHT:	SHEET 9 OF 10

Radius length from
center of rotation to
contact point on support



These tubes support the
outside bottom edge
of the outer barrel



Sleeve lengths of 25mm tube
over these short 21mm tubes
to hold the two end supports together

End Support

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SIZE A | DWG. NO. washing machine drawing set | REV.

COMMENTS: | SCALE:1:50 | WEIGHT: | SHEET 10 OF 10