THE STAR WARS DROID CHALLENGE

FINAL DESIGN REPORT

Mec E 260 - MECHANICAL DESIGN I

GROUP NUMBER: 11

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April 6, 2016

Dr. Pierre Mertiny
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Dear Professor Mertiny:

Group 11 is pleased to report our findings for the Mec E 260 Mechanical Design I Winter 2015 Design Project. The challenge which we had discussed required a droid, capable of navigating a three track course whilst capturing images of specified scenery to be designed, built, and tested. The tracks are described as follows: The Tatoonie track is of a flat high-friction nature, the Hoth track has an elevation change separated by a low-friction trough, the Endor track has a large elevation change separated by a series of three potholes. A maximum time of 90 seconds was placed on completion.

Through a process of comparison and calculation, we determined the necessities of the final design. After preliminary testing, it was found that more mass was required to increase friction on the rear wheels and that a few minor modifications to keep the D9 power supply cable in place and to reduce friction on the turning roller assembly. We derived and adjusted feasible design alterations to produce the final droid. The most feasible design for the task was similar to that of an asphalt roller, with a large pivoting wheel set on the front and driving wheels in the rear.

The droid was officially tested a total of three times, once on the insurance run and twice during test day. In the insurance run, the droid was capable of crossing Tatoonie but unable to complete Hoth or Endor. There were steering complications with the front turning assembly sticking due to friction and lack of friction to cross the two most difficult routes. On test day these issues were resolved, yielding a first run with three targets collected on Tatoonie. The second run showed that our droid was incapable of crossing Hoth and we finished test day with 25 points and 18 place overall.

Enclosed is a copy of our full project report, showcasing how the droid performs, the design involved, challenges with the project and the relevant technical information.

We look forward to your review of the results.

Sincerely,

Brayden Stecyk
Project Manager

Enc.

Abstract

The purpose of the Star Wars Droid Challenge is to build a competitive droid that can travel along the one of the three tracks – Hoth, Tatoonie, or Endor – within a 90 second time frame while capturing numbered targets in a mounted camera. In order to complete the given task, a design that was based on the conventional steam roller was suggested.

First, the droid must be wide enough to roll over the potholes of Endor without facing the issue of getting stuck. Since the front roller was unable to be printed, two free-rolling front wheels will be put at the front of the droid. Second, the droid must be to able to climb up the incline of the Endor track without slipping. Mass must be added to the back of the droid and grip must be added to the rear wheels to achieve this goal. Finally, the droid must be able to make sharp turns quickly and effectively. This will be done by having the front wheels serve as the turning system while the rear wheels strictly move the droid forward and backward.

The rear wheels of the droid will be driven by a worm gear and three spur gears of different diameters and are to be connected directly to the body of the droid. The front wheels will be connected to a separate sheet metal from the body and the two will be joined together using a connecting rod. A similar worm gear system will be used for the front wheels with the connecting rod being the rotational axis. By using the worm gears for the front and rear wheels, this reduces the number of spur gear needed for gear reduction. In addition, the front and rear wheels will be powered by separate motors.

The droid was predicted to be able to pass through Endor and capture all its targets. After the Insurance and Test Day results, the droid was able to capture two targets, but unable to complete the Hoth track, leading to a final score of 25 points.

Mec E 260: Mechanical Design

Winter 2016 Design Project

The Star Wars Droid Project

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Appendices

1. Description of Final Design

The objective of the Star Wars Droid Challenge is to build a droid that can navigate through either the Tatoonie, Hoth, or Endor tracks within 90 seconds while capturing numbered targets in a mounted camera. Three requirements for the droid had to be fulfilled in order for it to compete with the other droids on Test Day.

a. Steering System

Based on the fact that the droid needed to compete with the other droids on Test Day, it should be able to navigate through the Endor track to score the highest. In order for the droid to make it to the Endor track, it needs to be able to make a sharp turn at the start of the course. Therefore, the decision was made to use a steering system that incorporated a worm gear train for the front and rear wheels. The use of the worm gear reduced the number of spurs gears needed for each set of wheels since its gear reduction was significantly high. Rather than having the two wheel sets connected directly to the body of the droid, the front wheels were connected to a separate sheet metal and joined to the body using a connecting rod. The front wheels were not powered by the motor and, therefore, free to roll. Instead, the motor and gear system would turn the connecting rod and, inevitably, turn the front wheels. Since the rear wheels were forced to move the droid forward and backward and powered by a motor, the motion of the droid should be easy to control. Stoppers needed to be added to the droid to limit the front wheels from rotating beyond 60°. Some of the spur gears used in each of the gear trains were square punched to fit on square brass tubing. This was to ensure that the gears would not slip while the droid was operating. Gears that were on connecting rods had small holes drilled in them so that pins could be used to fasten the gears onto the rods. Given the pitch of the worm gears was $D_w = \frac{5}{16}$ in and that they were single start, the equation $\tan\lambda = \frac{L}{\pi D_w}$ where L is the lead can be used to calculate the lead angle λ, which gave a value of $\lambda = 7.871°$.

b. Friction & Tipping on the Incline Plane

One of the major obstacles of the Endor track was the incline plane that had to be climbed. Therefore, the friction between the incline and the wheels had to be calculated so that the droid would not slip as it was climbing the incline. By taking the sum of the forces in the normal direction and equating them to zero (i.e. $\sum F_t = 0$), the normal force N_{wheel} was found to be 4.488 N. Given the coefficient is $\mu = 0.35$, the maximum friction between the surface and the wheels was 0.157 N using the equation $F_{f,w} = \mu N_{wheel}$. This value was based on the mass of the droid's draft assembly $m = 0.550$ kg (**Appendix B: Results, Progress Report, Page 5**). The minimum torque of both wheels was calculated by taking the sum of the moments about the droid's mass center (i.e. $\sum M_G = 0$) and yielded a value of $\tau = 5.655 \times 10^{-3}$ N · m. Also, calculations were done based on the possibility of the droid tipping as it climbs the Endor track. The sum of the moments about the mass center was calculated and gave the following: $\sum M_G = -0.438$ N · m. The negative sign meant that the moment was in the clockwise direction. Therefore, the droid would not tip since the moment was going into the incline.

c. Body Dimensions

After getting past the incline, the droid must find a way to avoid getting stuck in the potholes. Rather than making sure the droid had enough torque to force its way out of the potholes, the decision was made to make the droid wide enough so that the droid would not have to worry about falling into the potholes in the first place. There was also an issue with the body scraping the top of the incline once it reached the flat surface. Therefore, the maximum length of the droid without scraping the surface needed to be calculated. Based on the geometry of the droid as it is between the incline and the flat surface of Endor, the maximum length of the droid yielded a value of 321 mm (**Appendix B: Results, Progress Report, Page 6**). The width of the droid was chosen to be approximately 220 mm so that it would not run into the issue of scraping the side walls or turning into the incline of the Endor track.

2. Results

a. Predictions

The predictions are more accurate and advanced versions of the calculations and hypothesis made in the progress report.

i. Challenging the Endor Track

In order to climb Endor, the droid must be able to climb the incline without tipping and have sufficient friction and torque. First, a mass of $m = 1.09$ kg and a center of gravity $(\bar{x}, \bar{y}) = (110.14, 108.09)$ mm, was obtained through the SolidWorks software. These were measured from the droid's rear wheels and the ground. If one were to visualize the location of the center of gravity, it is located approximately at the intersection between the rear of the vehicle and the ground. Taking the sum of the moments about its mass center (**Appendix B: Results, Progress Report, Page 6**), the result was $\sum M_G = 0.438$ N · m towards the ground, which shows no tipping. The wheel's diameter must be greater than the pot hole's diameter so that the torque required for the droid to climb out of a pothole would be minimized.

Scraping of the droid was another obstacle which had to be overcome. Based on the geometry of the droid and its location as it climbed over the incline, the maximum length of the droid chassis (**Appendix B: Results, Progress Report, Page 5**) yielded a value of $L = 321$ mm. Since the length of the droid did not exceed this value, scraping would not be an issue. Using the mass $m = 1.09$ kg, which is overall mass of the full droid assembly, the friction was calculated using the normal force of the droid and the coefficient of friction $\mu = 0.35$ (**Appendix B: Results, Progress Report, Page 5**), which yielded a value of $F_{f,w} = 0.311$ N. Using the same mass, the minimum torque needed to overcome inclination was calculated to be $\tau_{min} = 0.0112$ N · m using the equation $\tau_{min} = F_{f,w} \times r_{wheel}$. The variable r_{wheel} is the radius of the rear wheel. With these values, the minimum gear ratio of each motor system could be calculated. With help from teaching assistant (TA) Brian Yang, the gear ratio formula $T_O = -G_r^2 \eta_g \frac{K_b K_t}{R_a} \omega_L(t) + G_r \eta_g \frac{K_t e_a}{R_a} - T_L$(**Appendix B: Results, Progress Report, Page 5**) was used with the angular acceleration of $\alpha =$

$0\ \mathrm{rad/s}$ instead of $\alpha = 0.6\ \mathrm{rad/s}$. The variables are defined in the progress report (**Appendix B: Discussion, Progress Report, Page 8**). This is because the maximum torque happens when there is no acceleration of the motor (i.e. When the angular velocity ω is at its maximum). The Dyno Test software was used to test each motor's specifications, particularly, the angular velocity ω, which had a value of $\omega = 700$ rpm. This was converted into the unit of rad/s. The moment of inertia for the back gear sub assembly was obtained through SolidWorks and is $I_G = 1.26 \times 10^{-6} \mathrm{kg} \cdot \mathrm{m}^2$. The Torque equation was graphed (**Appendix B: Appendix C, Progress Report, Figure 5**) by subtracting the accelerating torque and the decelerating torque using the following equation: $T_m = T_{accel.} - T_{decel.} = -2 \times 10^{-7}\omega + 0.0012$ (**Appendix B: Results, Progress Report, Page 5**), ω being the angular velocity. Using the gear ratio formula, the minimum gear ratio for the back was $G_{r_1} = 18.678$. Using similar methods described earlier, the minimum gear ratio for the front motor was $G_{r_2} = 0.75$.

The lead angle was also necessary for the connection between the spur gear and worm gear. Since the worm gear connection was not changed in the final design, the lead angle remained the same (i.e. $\lambda = 7.781°$). The equation for calculating the lead angle is the following: $\tan \lambda = \frac{L}{\pi D_w}$ (**Appendix B: Results, Progress Report, Page 6**), where L is the lead and D_w is the pitch diameter.

b. Insurance Run

During the insurance runs, the droid did not have all the gears connected, specifically, the camera gears. Also, there were no stoppers put on the droid to prevent the front from rotating beyond 60°. However, these factors did affect the overall performance of the droid during the insurance runs. It was able to complete a full turn around the corner from the starting position with ease. However, the droid moved and turned much faster than expected, making it difficult to control at some points. Despite this, it was still reasonable to predict that the droid would still be a top contender come test day.

A problem with the steering system was encountered during the insurance run. The gears would slip and the front would stop moving once it turned past a certain point. This was later fixed once the stoppers were added. The rear wheels had no issue with moving the droid forward and backward. The Endor incline was serving to be a greater problem than expected. There was not enough friction between the wheels and the incline, so the droid would always slip whenever it was trying to climb it. If the droid was gently pressed at the back, it would climb the incline with ease. Therefore, the decision was made to add a mass of approximately 150 g near the back of the droid. After trying out different masses on the droid, 150 g was the best mass to have that would not cause the droid to tip. Therefore, the was chosen based on trial and error. A spoiler was added to fulfill this task and also for decorative purposes. After multiple tests with the spoiler attached, the conclusion was made that the droid would not be able to climb the Endor track, since the droid would slip once it reached the peak of the incline.

This was due to the droid's lack of power. The droid was able to navigate through the Hoth quickly, so the new objective was to complete the Hoth track and capture all its targets.

The main disadvantage that the droid had to other groups was its size. From what was seen during insurance runs and even on test day, the Group 11 droid was the largest out of all the other droids. Although the droid was relatively quick, its size limited it from making sharp 180° turns along the course. As predicted, the droid was lacking in agility. The steering system chosen also differed from other groups. The Group 11 droid had a steering system similar to that of a convertible. It was unable to turn while it was in one position. The front wheels of the droid had to be turned first in order to turn the entire body, whereas other droids had the ability to turn while in one fixed position. Also, the droid was only rear-wheel drive, meaning that there was not as power and torque applied to the droid compared to groups that used all-wheel drive. All these issues can be minimized by driving the droid at lower speeds so that it is easier to control and maneuver.

Since the camera gears and mount had not been added during insurance runs, the motion of the camera and it expected field of view was unpredictable during the insurance runs. However, if the gears were connected properly, there should be no issue with the camera rotation.

c. Test Day

Prior to test day, the camera was unable to turn as the front wheels turned. Therefore, the camera mount was pinned down so that the camera would face only one direction as it was going through the course. Apart from that, no other changes were made to the droid between the insurance run and test day.

In the first test run, the plan was to capture targets along Hoth. If there was more than 30 seconds left, targets along Tatoonie would be captured as well. unfortunately, there was a slight issue with the turning as the droid was trying to get through Hoth. The gears had a tendency to slip and the droid would have to ram itself into a side wall in order to put them back in place. Also, the camera had a tendency to register captured targets very late. The speed at which the camera registered the targets was dependent on the angle, height and field of view of the camera. Even though the droid would completely capture the target, the camera would not register until the droid was moved slightly closer, further, or at an angle. Due to these obstacles, the droid scored a total of 25 points after being deducted 50 points for not reaching the finish zone with the 90 second time frame.

In the second test run, rather than going through both Hoth and Tatoonie, the plan was to capture all the targets on one side of Hoth and reach the finish zone. The droid was able to get 10 points after capturing the target along the grey zone of the course. Unfortunately, the steering system of the droid was being more difficult in the second run than the first. In addition, the front wheels of the droid had lost grip to the point where it was unable to climb onto the Hoth track. Slamming the droid into a wall would not fix the steering system of the droid like it did in the first run. Given all this, the droid finished with 0 points in the second run since it did not complete the course in the 90 second time frame, giving it a total of 25 points on test day.

3. Discussion

a. Trials & Tribulations

Throughout the entire design project, different obstacles seemed to become an issue during the design, fabrication and testing of the droid. Though some of these obstacles were overcome, many of them led to the droid's unexpected performance on test day.

The first and most difficult issue to overcome was the size of the droid. The droid was not expected to take up as much space on the track as it did. Because of its size, the droid was at a serious disadvantage to others in terms of its agility. Once the droid was going off course, it was difficult to maneuver it back on track. The droid's size also limited what kind of turns it could make. Sharp turns either had to be made very slowly, or required the droid to go in reverse in order to put itself in a better position. Even though the droid was relatively fast, its speed could not be utilized since the size of the droid make it difficult to control. Therefore, the simplest solution was to make wider turns and start turning early so that the droid would have enough clearance between any side walls. This way, the droid would not have to go into reverse as often.

Apart from the size, the steering system of the droid also played a role in its difficulty to turn. The front of the droid turned faster than expected, making it difficult to control. In addition, the gears would slip once the front wheels turned beyond 60°. Whenever this happened, the front wheels would no longer turn. Since the front of the droid would be stuck in this position, the droid would have to be slammed into a wall in order for the gears to be in contact again so that the front wheels could be straightened. Even though the stoppers were put to prevent this happening, the front wheels were turning so quickly that they would slam into the stoppers and cause the gears to lose contact with one another. Therefore, the solution to this issue without altering the design of the droid was to gently tap the switch that rotated the front wheels so that it would never slam into the stoppers. If the gears did lose contact with one another, the droid would have to be driven into a wall to put the gears back in place.

In addition to the front wheels turning too quickly, the grip on them was starting to wear out. Though the droid was never able to climb up the Endor incline, it was finding it more difficult to climb onto the Hoth track as time went on. The more the droid was being driven, the weaker the grips on the front wheels became. Therefore, the decision was made to cover the front wheels in latex. After testing the droid with latex, it was observed that the droid had more grip on the Hoth track.

Lastly, there was an issue with the gears for the camera. During the manufacturing of the droid, it was noticed that the camera gears were not meshing with the worm gear, meaning that it could not rotate. Since the gears were ineffective in turning the camera, the decision was made to remove them and pin the camera mount down so the camera would only face one direction. While the droid was navigating its way through the track, the camera would always be pointed towards the left, meaning that only targets on the left could be captured. In addition, the camera had a tendency to register captured targets late, sometimes not even register them. For other groups, the camera would register the targets as captured even if the full target could not be seen. Since there was no evident solution to this, the droid simply needed to moved around slightly until the targets were captured.

b. Time Management

Time management was one area that the group struggled with at times. This can be seen in the Gantt chart found in Appendix A: Figure 2. Although the majority of project components were completed on time, the large sections of the project were found to be an issue either in initial time allotment or in following the schedule. All deadlines were met but the extra time spent on specialized part design on SolidWorks drew back the completion of both the finalized solid model and the date that all the parts were sent for water jet cutting or printing. In part, the delay of the parts being submitted was also a result of ineffective group communication, alongside misuse of time and group resources. It took extra time for the droid to be built and assembled because of not having all the parts ready on time. The design fix was also dragged out but it went over the allotted time due to insufficient amounts of time being assigned to it. None of the violations to the initial schedule affected our droid outcome but they did create a significant buildup of workload in the few days prior to due dates.

4. Conclusion

The objective of the Star Wars Droid Challenge was to build a droid that could navigate through one of three tracks – Tatoonie, Hoth and Endor – and capture targets along the way within 90 seconds. Inspired by the design of a conventional steam roller, the Group 11 droid used two front wheels that were free to roll. The rear wheels would move the droid forward and backward while the front wheels would turn the droid. One motor would drive the rear wheels while the second motor turned the front wheels. The droid would be wide and long enough so that it would be able to climb the Endor incline without scraping it and avoid its potholes. Finally, the front motor would turn the camera at a slower rate than the front wheels. After multiple calculations, construction of the assembly through SolidWorks, and results seen during the insurance runs, the droid was expected to be a top contender come test. However, due to a series of unfortunate events, such as the camera being unable to turn, the droid being too large to maneuver, and the steering system malfunctioning, the Group 11 droid scored a total of 25 points on test day to place 18th overall out of 26. Steps that were taken to improve the droid was to add more mass to the back of the droid in the form of a spoiler so that there was more friction between the rear wheels and the surface. Also, latex was added to the front wheels so that there was more grip between the front wheels and the surface. Finally, the gears were connected through square brass tubing and pins so that they would not slip. Though the droid did not perform as expected on test day, the overall design of the droid would be able to compete in a similar competition if more detail and accuracy were used.

Toya Okeke: Suggestion for Mec E 260 Project

I think a challenging project for Mec E 260 would be to build a droid that can launch golf ball a certain distance and hit a target in front of them. The droid would first hit a target relatively close to them. After, the droid would move onto the next target, which would be further away or even at an angle. The droid would have to stay in a zone of arbitrary size. Since this zone is there, this prevents the droid from moving to another position to make it easier to hit a target, meaning that the launching mechanism must be able to angle itself in order to hit targets that are not directly in front of it.

Chengshunzi, Dong: Suggestion for Mec E 260 Project

Strong droid: Different droids would have to carry various loads to pass a certain distance. Different types of obstacles should be designed and set up for the teams. There are three different obstacles in total. The first obstacle is flat, the second obstacle curve up and curve down with pot holes on by using slippery material and the third one is with an elevation. The team who completes the most of the obstacles and carrying the most weights would be the winner.

Andrew Lam: Suggestion for Mec e260 Project

I think it would be unique to have a flying droid challenge. Each team is responsible for manufacture the shape of the droid with the best aerodynamic design. The objective would be to fly the furthest with infinite amount of time possibly using the most innovating frame. Points would be awarded based on distance.

Appendix A

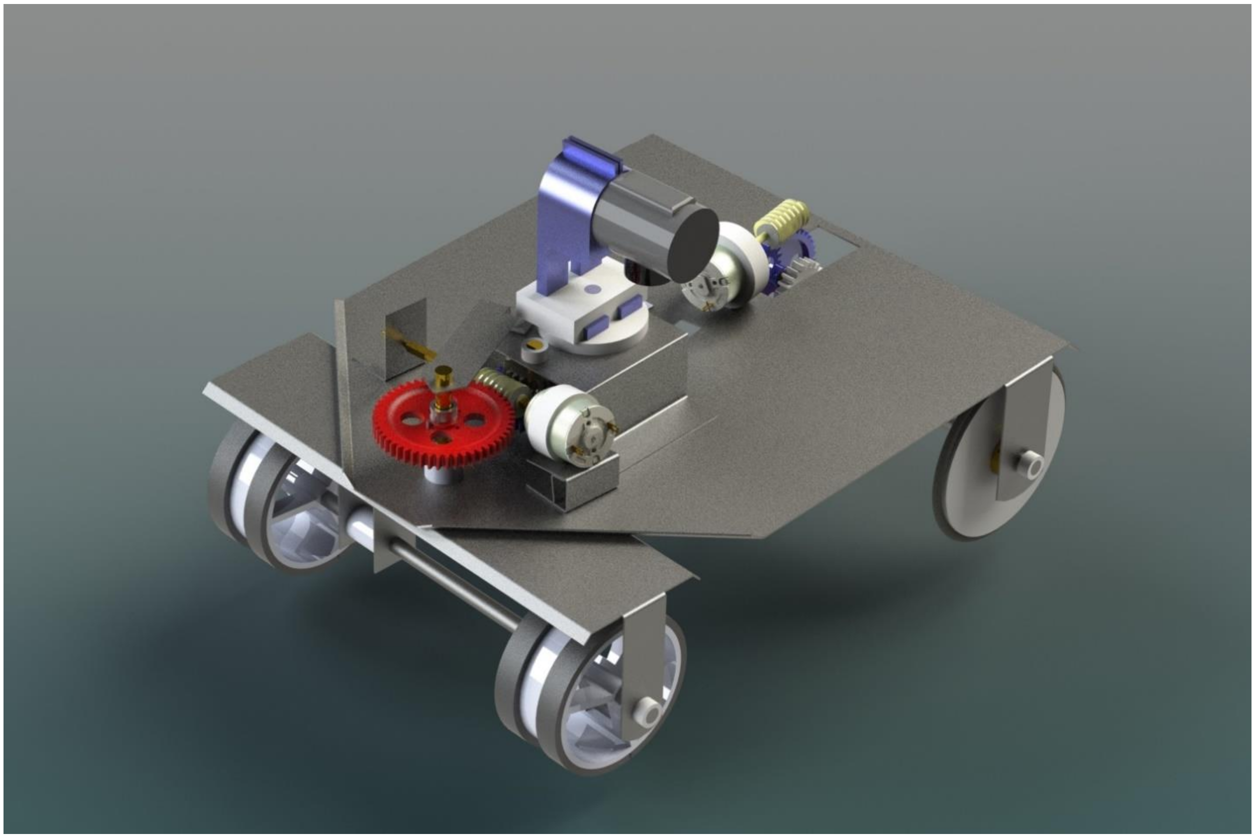

Figure 8: Full Assembly

Appendix A cont'd

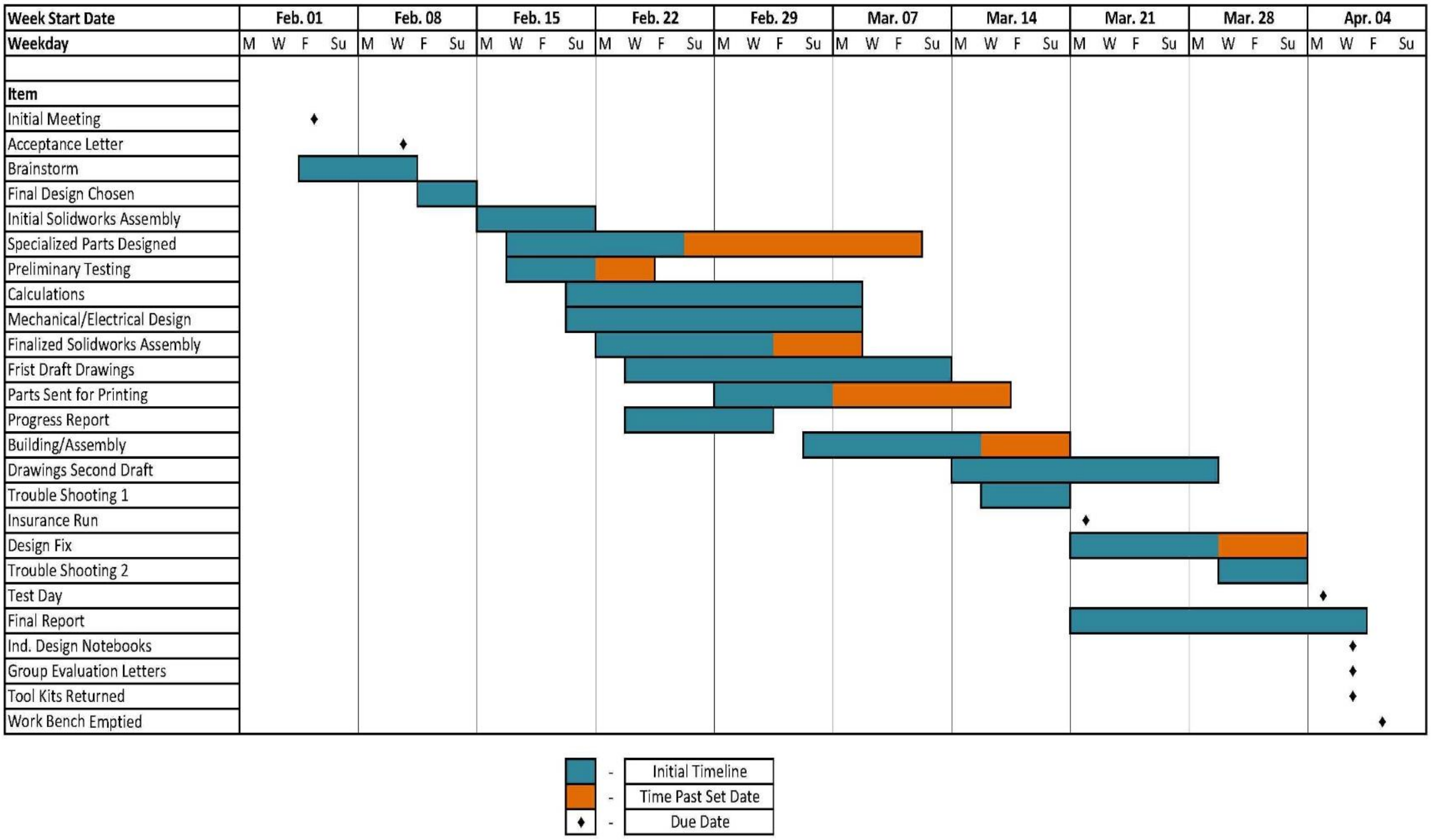

Figure 2: Gantt Chart

Appendix B: Progress Report

See attached report

Appendix C: Drawing Package

See attached report

THE STAR WARS DROID CHALLENGE

PROGRESS REPORT

Mec E 260 - MECHANICAL DESIGN I

GROUP NUMBER: 11

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Appendix F:

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March 3, 2016

Dr. Pierre Mertiny
Professor, Mechanical Engineering
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University of Alberta
Edmonton, AB T6G-1H9

Dear Professor Mertiny:

Group 11 is pleased to report our findings for the MecE 260 Mechanical Design I Winter 2015 Design Project. The challenge which we had discussed required a droid of sorts -capable of navigating a three track course whilst capturing images of specified scenery- to be designed, built and tested. To reiterate the requirements examined, the droid was to be able to traverse across at least one of the three tracks. The Tatooine track is of a flat high-friction nature and the Hoth track has an elevation change separated by a low-friction trough. Finally, the Endor track, has a large elevation change separated by a series of three potholes. A maximum time of 90 seconds was placed on completion of the expedition and at this time, the droid must be in the finish zone.

During a process of comparison and calculation, we eliminated inferior designs. We used equations for torque, angular acceleration and friction to determine the necessities of the design. Comparing stability, manoeuvrability, design and build time as well as material use, we found that the most feasible design for the task was that similar to that of an asphalt roller. The droid therefore has a large pivoting roller on the front and driving wheels in the rear with a pivoting. This allows for the easiest navigation across the course with the most practical amount of time requirement.

Enclosed is a copy of the progress report, showcasing where we sit in development of the droid, the designs involved and the relevant technical information.

We look forward to your review of the results.

Sincerely,

Brayden Stecyk
Project Manager

Enc.

Abstract

The Star Wars Droid Challenge is the Mec E 260 Winter 2016 design project for Mechanical Engineering students attending the University of Alberta. Teams of four or five – handpicked by the instructor – have been given the task of creating a droid that can navigate through a track inspired by the Star Wars series. The droid will have 90 seconds to complete the track. Numbered targets will be set up along each pathway and the droid must capture the targets with a camera that will be mounted on it. Each group is provided with the same materials and must work together to build a droid that can maneuver its way through one of three paths on the track. Using the techniques learned in class as well as graphical design through the SolidWorks software, Group 11 has come up with a design that essentially a modified version of a steam roller.

After brainstorming and completing the necessary calculations, the group has created a design that can roll over the potholes of Endor – which is the most difficult path on the track – without having to worry about the droid falling into them. Unlike the conventional steam roller design, the front will be able to pivot, which will serve as the steering system for the droid. If the length and width of the droid is optimized, it should be able to climb over potholes quickly and effectively. The friction between the roller and surface will need to be calculated to ensure that the roller will not slip while climbing the incline. Finally, gear reductions must be done so that the droid will operate at a reasonable speed.

The conclusion was made that the droid can make its way through the Endor path within the 90 second time frame and be able to capture the targets along the path. It is unlikely that the droid will be able to get through more than one path in the 90 seconds. Therefore, the design is sufficient enough to fulfill the goals of the Star Wars Droid Challenge.

Introduction

The purpose of this project is to use the knowledge of engineering analysis and apply it to a real life situation. In order to do so, design teams or four or five have been assembled and have been given the task of building a droid that will maneuver its way through a track within a given time frame. The teams have been pre-made to simulate what it will be like in an engineering workplace. Using a combination of engineering analysis, innovation, creativity, and teamwork, each team member should have the necessary skills to create a droid with the agility and speed to complete the track in the allotted time frame.

Inspired by the droids in the Star Wars franchise, the droid must have the ability to perform timed runs along the track shown in **Appendix A**. A camera will be mounted on the droid. The goal is maneuver the droid in such a way that the camera will capture the numbered targets that are set up throughout the track. Based on the level of difficulty for each track – Tatoonie being the easiest; Endor being the hardest – points will be awarded for each target that is captured in the camera. The potential design of the number targets and cameras can be found in **Appendix A**.

Description of Design

The general idea of the Group 11 design is to build a droid that can run through the Endor track quickly and with ease. During the brainstorming sessions, the following preliminary designs were brought up – Torque Vectoring (Skid Steer Style Droid), T-Shape (Wild Criss-Crosser), Roller (Planet Crawler). The first design was torque vectoring, which involved specific wheels of the droid rotating at different rates. This allows the droid to rotate without pivoting the wheels. The shape of the droid is undecided. Second, a design that used a cylindrical roller instead of front wheels was suggested. Two separate motors will be driving the rear wheel and the roller. The roller serves the purpose of steering the droid, so it will be free to rotate. The worm gear will be used to rotate the camera along with the front roller. By doing so, the entire droid will not need to rotate in order to capture targets in the camera. Finally, a “t-shaped” design was brought up. Two spherical rollers would be attached at opposite ends while two wheels at the other ends. Since the shape is symmetric, it would have a low center of gravity. Not only that, the droid would have the ability to rotate in one place and maneuver around the track easily. Further explanations of the designs and how they would function can be found in **Appendix A**.

The following concerns were brought up during the brainstorming sessions pertaining to the preliminary design of the droid – Can the droid get around sharp corners quickly and efficiently? Will the droid slip while climbing the incline of the Endor track? Can the droid avoid the potholes along the track? If not, can the droid get out of them? Can the camera rotation be controlled? After further analysis using a combination of feasibility judgment and go/no-go screening, the group decided to go with the roller design. When considering the torque vectoring design, the conclusion was made that controlling the turning radius of the droid and the camera rotation would be too difficult. The t-shaped design was considered to be the fastest and most agile of the three, but rotating the wheels would be difficult since they would be connected by a shaft. The observation that led to the t-shaped being dismissed was the fact that the droid would tip if it fell into a pothole and it would be difficult for it to climb out. Therefore, the roller seemed like the most viable option.

To ensure the roller design works gears reduction calculations must be done to ensure that the droid’s translational and rotational speed is feasible. The roller would be free to pivot about a rod that connects to the camera. This rod would be pinned onto the sheet metal that holds the roller in place so that the camera and roller can rotate as a single rigid body. The rear wheels will be connected by a shaft and held together by the sheet metal. After these two parts are created, they will be put together using the machines in the Mec E 260 shop. The support for base of the vehicle, along with where the gears and motors will be put in the assembly is yet to be decided. Note that the final design created through SolidWorks will differ from the design discussed in **Appendix A**.

Results

The equations used for this project:

$$\text{Angular Acceleration} = \propto = d\omega dt = \omega i+1-\omega i\Delta t \quad (1)$$

$$Tm|\omega m=\omega i=\omega k = Taccel|\omega m=\omega i - Tdecel|\omega m=\omega k \quad (2)$$

$$Taccel|\omega m=\omega i = (Tm - Tml - TL)|\omega m=\omega i = (Ja + JL)\ ddt\omega m(t)|\omega m=\omega i \quad (3)$$

$$Tdecel|\omega m=\omega k = (-Tml - TL)|\omega m=\omega k = (Ja + JL)\ ddt\omega m(t)|\omega m=\omega k \quad (4)$$

Calculations for minimum gear ratio of front motor:

Motor 1:

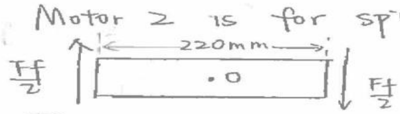
$$T_{accel}|_{\omega m=\omega i} = (J_a+J_L)\frac{d\omega_m(t)}{dt} = -1\times10^{-6}\omega + 0.0009$$

$$T_{decel}|_{\omega m=\omega k} = (J_a+J_L)\cdot\frac{d\omega_m(t)}{dt} = -8\times10^{-7}\omega - 0.0003.$$

Assume $J_a + J_L \approx J_T = 1.27\times10^{-5}\ kg\cdot m^2$

(Inertia of gears, pulleys, etc)

Motor 2 is for spinning.



Top view of the rollar.

$$\tau = I_G\cdot\alpha = \sum M_O$$

$$\tau = \left(\frac{Ff}{2}\right)\cdot(0.22m) = \left(\frac{0.0916475}{2}\right)(0.22m) = 0.010081225\ N\cdot m.$$

$$\tau = 0.010081225\ Nm$$

Data Analysis for excel Motor 2

$$T_{accel} = -9\times10^{-5}\omega + 0.0611$$

$$T_{decel} = -5\times10^{-5}\omega + 0.0339$$

$T_m = T_{accel} - T_{decel}$

Based on the linear from excel $y = -4\times10^{-5}x + 0.0272$

$$\Rightarrow T_m = \underbrace{-4\times10^{-5}}_{m}\omega + \underbrace{0.0272}_{b}$$

$$\Rightarrow k_b = k_t = -\frac{m}{b}e_a = 6.6176\times10^{-3}$$

$$R_a = -e_a^2\cdot\frac{m}{b^2} = \frac{10125}{9248}$$

Assumptions: $n_g = 0.5$, $\omega_L = 0.165\ rad/s$

$$T_o = -G_r^2\cdot n_g\frac{k_b k_t}{R_a}\cdot\omega_L(t) + G_r\cdot n_g\frac{k_t}{R_a}e_a - T_L$$

$$0.010081225 = -G_r^2(0.5)\cdot\frac{(6.6176\times10^{-3})^2}{10125/9248}(0.165) + G_r\cdot(0.5)\cdot\frac{6.6176\times10^{-3}}{10125/9248}(4.5).$$

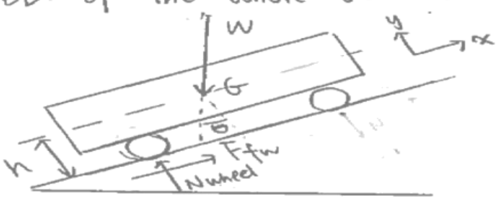
$$-3.3\times10^{-6}G_r^2 + 0.0136G_r - 0.010081225 = 0$$

$$\boxed{G_r = 0.75}$$

Minimum Gear ratio we need for another motor which is connecting to the rollar.

Calculation for determining the weight distribution for the wheel and minimum torque required:

FBD of the whole vehicle



$\nwarrow + \Sigma F_y = 0$

$N_{wheel} = W\cos\theta = (5.394)(\cos 33.69)$
$= 4.488\ N$

$F_{fw} = 0.035\,(4.488)$

$\boxed{F_{fw} = 0.15708\ N}$

Torque for Both wheels:

$T = I_G \cdot \alpha = \Sigma M_G$

$\curvearrowleft \Sigma M_G = (F_{fw}) \cdot (0.036\,m) = 5.65488\times10^{-3}\ N\cdot m$

$T = 5.65488\times10^{-3}\,N\cdot m$ (We need) Min Torque

Calculation for the minimum gear ratio for rear motor:

Data Analysis From Excel.

Motor 1:

$T_{accel} = +\times10^{-6}\omega + 0.0009$

$T_{decel} = -8\times10^{-7}\omega - 0.0003$

$T_m = T_{accel} - T_{decel}$

Then we got $y = -2\times10^{-7}x + 0.0012$ (excel).

$\Rightarrow T_m = \underbrace{-2\times10^{-7}}_{m}\omega + \underbrace{0.0012}_{b}$ $e_a = 4.5V$

$\Rightarrow k_b = k_t = -\frac{m}{b}e_a = 7.5\times10^{-4}$

$R_a = -e_a^2 \cdot \frac{m}{b^2} = 2.8125$

$T_o = -G_r^2 \cdot n_g \frac{k_b k_t}{R_a} \cdot \omega_L(t) + G_r n_g \frac{k_t}{R_a} e_a - T_L$

Assumptions:
$n_g = 0.5$; $\omega_L = 0.6\ rad/s$

$5.65488\times10^{-3} = -G_r^2(0.5)\cdot\frac{(7.5\times10^{-4})^2}{2.8125}(0.6) + G_r(0.5)\cdot\frac{7.5\times10^{-4}}{2.8125}\times(4.5)$

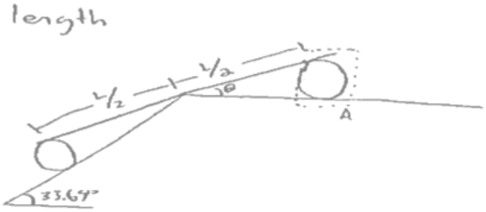
$\Rightarrow -6\times10^{-8}G_r^2 + 6\times10^{-4}G_r - 5.65488\times10^{-3} = 0$

$\boxed{G_r = 9.44}$ Minimum Gear Ratio

The calculation for the dimension of the vehicle is as follows:

For width (roller's length)
Bird eye view
Endor track

For length



Finding maximum length of chassis,
Knowing that height of vehicle is 74.16mm
Look more closely at section A

Section A

Knowing that θ = 33.69° from geometry.
Solving for x allows us to obtain:

$x = \frac{74.16mm}{\cos(33.69°)} = 89.129mm$

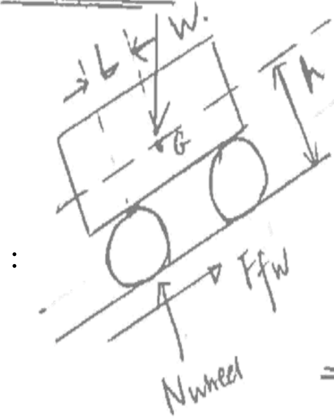
Looking more closely at triangle:

$\Rightarrow \frac{L}{2} = \frac{89.129mm}{\sin(33.69°)} \Rightarrow L = 321mm$

The maximum length of vehicle chassis without scraping surface is 321mm

Calculations based on the possibility of tipping:

Tipping.



Assumptions:

$h = \frac{1}{2}(72+5.66) = 38.83$ mm ; $L = \frac{270}{2} - \frac{72}{2} = 99$ mm.

$\circlearrowleft{+}\ \Sigma M_G = -(N_{wheel}) \cdot L + (F_{fw}) \cdot h$

$= (-4.488N)(0.099m) + (0.15708N)(0.03883m)$

$N_{wheel} = 4.488$ N

$F_{fw} = 0.15708$ N

:

$\circlearrowleft{+}\ \Sigma M_G = -0.438$ N.m

$\Rightarrow$ Total Moment is clockwise $\Rightarrow$ No tipping

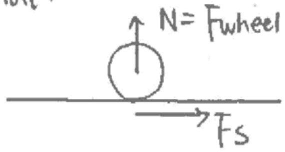
$\Rightarrow$ Our vehicle won't fall back.

Calculating friction on a flat surface:

Friction for the back wheels:

$F_{wheel} = 1.389$N [from previous]

Flat:



$F_f = u \cdot N = u \cdot F_{wheel}$

u: 0.01 ~ 0.015

rolling coefficient

$F_{f_1} = 0.01(1.389N) = 0.01389N$

$F_{f_2} = 0.015(1.389N) = 0.0208$ N

F_f : [0.01389 ~ 0.0208 N]

For rollar

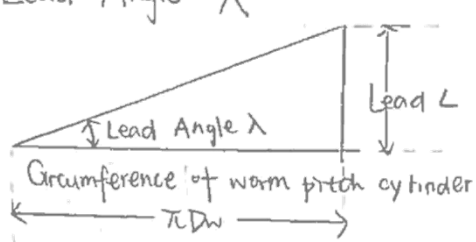
$F_{rollar} = 2.6185N$

$F_f = u \cdot F_N = 0.035(2.6185N)$

$F_f = 0.0916475$ N.

Lead angle calculations:

Lead Angle λ



The worm gear given has Pitch Diameter

$D_w = \frac{5}{16}$ in $= 0.79375$ cm

$P_x = 0.122$ in $= 0.30988$ cm [from Solidworks]

Single Start $\Rightarrow N_w = 1$

$L = N_w P_x = 1 \times (0.30988) = 0.30988$ cm

$\tan\theta = \frac{L}{\pi D_w} = \frac{0.30988 \text{ cm}}{\pi(0.79375 \text{ cm})} \Rightarrow \boxed{\theta = 7.871°}$

Discussion

In order for the droid to be agile, the dimensions must be chosen in such a way that the droid's performance will be maximized. Keeping in mind that the droid is meant to perform well on the Endor track, a design which stays parallel to the ground at all times is the most ideal option. Group 11's approach is to build a roller design where the roller extended beyond the diameters of the potholes.

Ideally, a roller length of 220 mm would be 70 mm longer than the pothole length which provides extra balance but not too long that it affects turning. The length of the droid would be limited by the required turning radius and the uphill path in the Endor track. From the calculations, the length of the droid chassis must not exceed 321mm or the vehicle would scrape the surface at the Endor incline. Therefore, the decision was made to build a droid chassis of 270mm, which is longer than the potholes and short enough to be able to turn efficiently. The center of gravity of the droid should be away from the pothole if the rear wheels happen to dangle over them. This prevents the droid from sagging down into the pothole.

To find the minimum torque needed to finish the track, the weight distribution for the wheels due to the friction was calculated. One of the major assumptions was that the center of gravity is at the centre of the droid, because the mass distribution is relatively equal. Using the required parts and functions in SolidWorks, the mass found was 430 grams. That mass is excluding the camera which when researched online from the official GoPro website[1] (see **Appendix A**), had a value of 111 grams. Therefore, the mass of 541 grams, later approximated

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[1] GoPro, Inc., *GoPro Hero*, last accessed March 4, 2016
http://shop.gopro.com/cameras/hero/CHDHA-301.html

to 550 grams – due to some missing parts of the assembly and the uncertainty of which camera would be used – was obtained.

Force analysis was used to interpret the droid's weight distribution on the wheel while sitting on an incline surface. The normal force acting on the roller was assumed to be zero, demonstrating the droid is on the verge of tipping. The assumption is used in order to counteract the uncertain location of the center of gravity. The center of gravity has a direct relationship with tipping. Without knowing the exact location, it was best to assume the greatest force is acting on the wheel so the droid would not tip. The researched value of the coefficient of rolling friction is between 0.01 and 0.035[2]. The larger coefficient was used because the material used in the website was rubber and concrete. The wood on the track and rubber should have slightly more friction due to their material properties. The calculated friction force of the rear driving wheel was 0.15708 N. Using moment analysis, the theoretical minimum torque should be 0.00565488 Nm.

The torque and velocity of the droid can be determined by the Dyno Test Analysis software. The Dyno Test analyzes the current, angular velocity and voltage with respect to time. The angular acceleration for the set of data was determined using equation (1) and used to calculate torque. Since the motor moment of inertia (J_A) is much smaller compared to J_L (moment of inertia of the droid components), it was assumed to be negligible. The total moment of inertia is 1.26×10^{-6} kgm^2 for the rear motor and 8.00×10^{-4} kgm^2 for the front motor. The moment of inertia was obtained through SolidWorks by adding the moment of the gears, pulleys, etc. The torque given in equation (2) is equal to the difference of torque. When a current is passing through the engine, the result is torque acceleration; when the current is zero, the result is

[2] eMachineShop, *Rolling Friction*, last accessed March 4, 2016
http://www.emachineshop.com/machine-shop/Rolling-Friction/page540.html

torque deceleration. Torque acceleration and deceleration is governed by equations (3) and (4) which is the product of angular velocity and the moment of inertia. The torque acceleration and deceleration can be graphed with respect to time. This gives a linear equation where the slope $m=-K_tK_b/R_a$ and y-intercept $b=K_tE_a/R_a$. K_t, K_b and R_a can be found using equation (4), where K_t and K_b are motor parameters, R_a is the radius of armature exposed to the magnetic field within the motor, N_g is the gear efficiency and E_a is the voltage.

An angular acceleration of 0.6rad/s is used because this is the minimum speed recorded yields the highest torque. The minimum gear ratio (G_r) is calculated using the quadratic formula, which led to a value of 9.4. The front engine follows the same procedure with a different angular acceleration of 1.6 rad/s. The minimum gear is 0.75 for the front engine in order to steer the droid.

The front motor should rotate the camera and steer the droid. The camera would need to rotate 5 times faster than the roller. This way, the droid can be steered slightly to pivot the camera. The worm would be the best option due to its large gear reduction and self-locking design. The graph in **Appendix F** gives us the angular velocity which is sufficient speed. The lead angle required for the worm gear design had a value of 7.21°.

Conclusion

The design chosen by Group is essentially a modified version of a steam roller. Using multiple concepts of engineering analysis, the group has come to the conclusion that the droid will be able to navigate its way through Endor within the 90 second time limit. The front roller will serve the purpose of steering the camera for capturing the numbered targets as well as going over the potholes. The downside of the design was its inability to maneuver around sharp corners effectively. However, its performance in all other aspects should reduce this effect. Overall, the design should meet all requirements of the Mec E 260 design project.

<u>References</u>

GoPro, Inc., *GoPro Hero*, last accessed March 4, 2016

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Appendix A-1

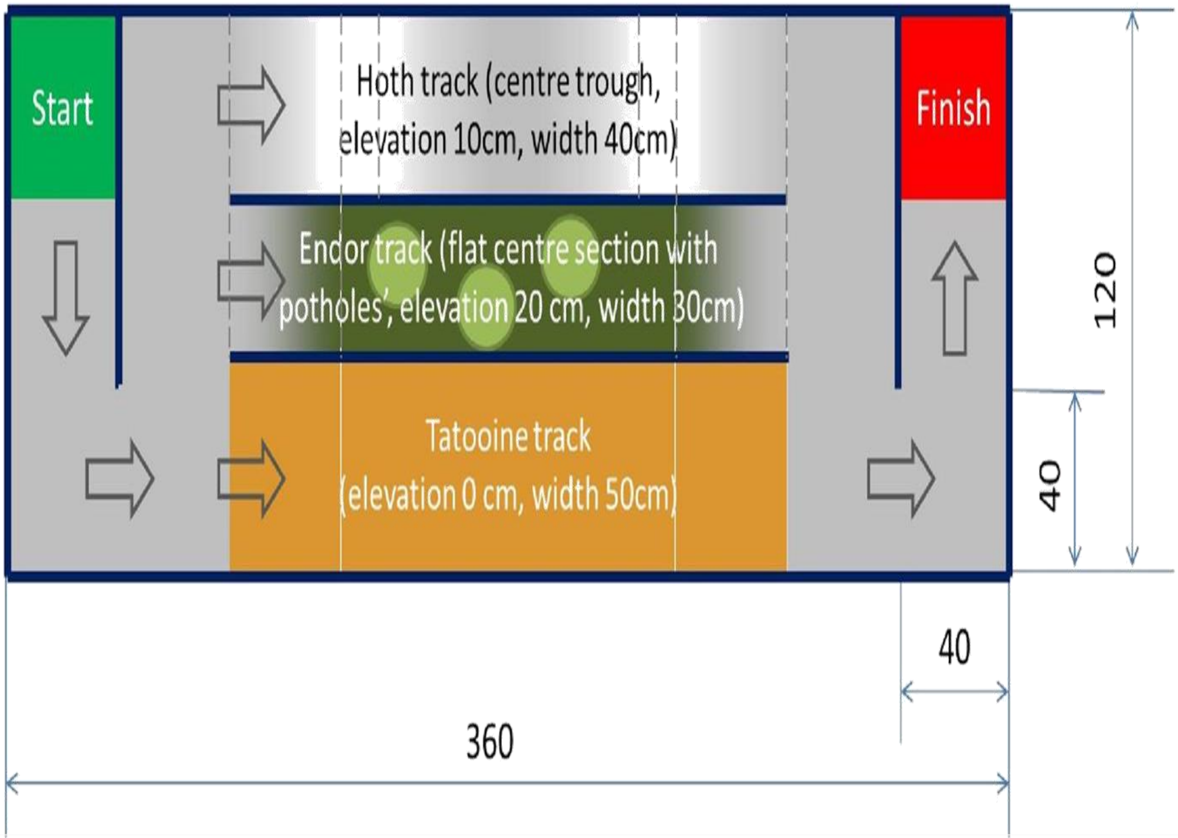


Figure 1: Maze-like course for the *Star Wars Droid Challenge* (dimensions in centimeters).

Figure 2: Possible design of number targets.

Appendix A-2

Table 1: Camera dimensions and field-of-view (FOV) angles.

	GoPro Hero 3+	Microsoft LifeCam Studio
FOV angle – diagonal	133.6°	75°
Camera width	59 mm	60 mm
Camera height	41 mm	45 mm
Camera depth	21 mm	114 mm

Figure 3: Possible camera types used in competition: Microsoft LifeCam Studio (left) or GoPro Hero 3+ (right).

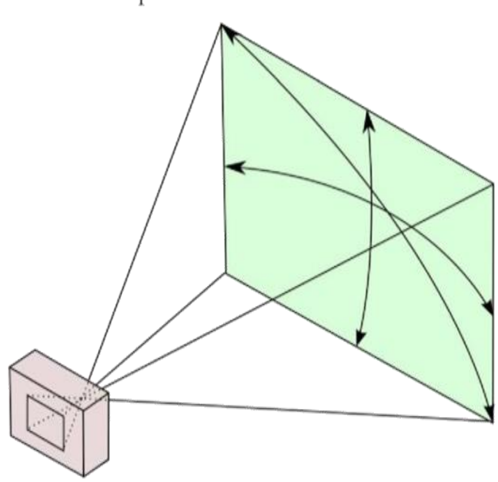
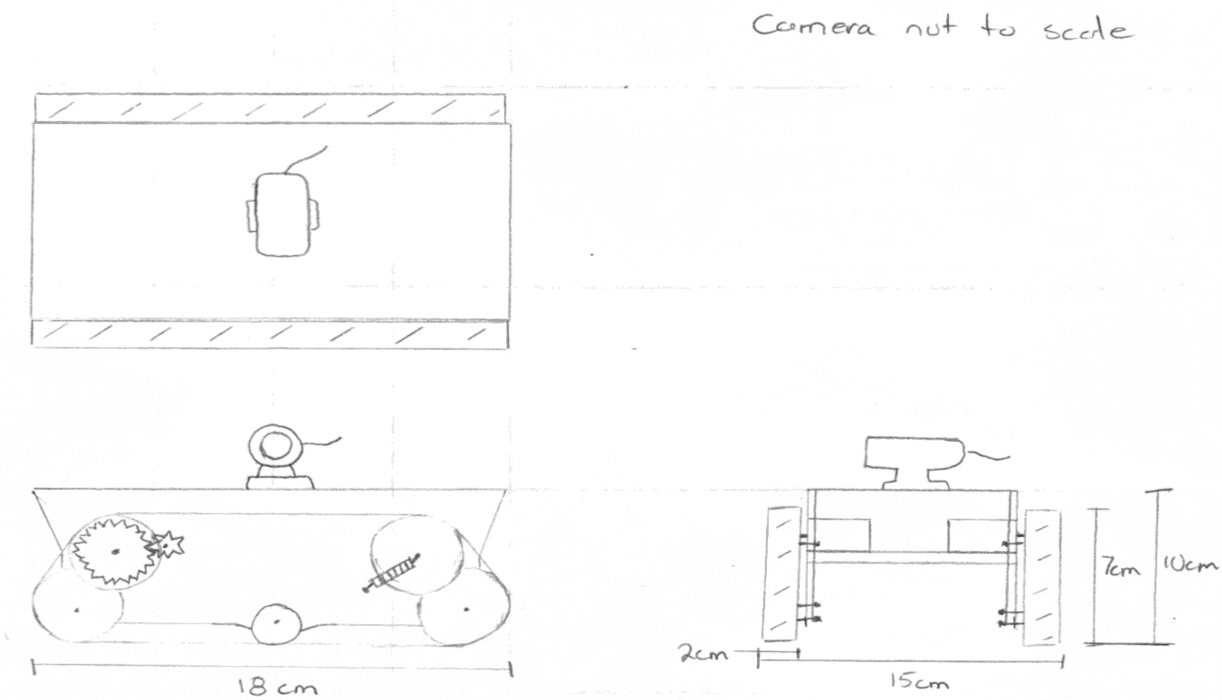


Figure 3: Schematic of a camera's diagonal angle of view.

Appendix B-1

Option 1

Skid Steer Style Droid



Features

- one moor driving each track
- 3 idling wheels, one tensioning wheel, one driving wheel
- Turns by operating one motor in reverse and one motor forwards

Advantages

- Tough to get stuck
- Good traction due to high friction belt
- Can operate under conditions of all three tracks

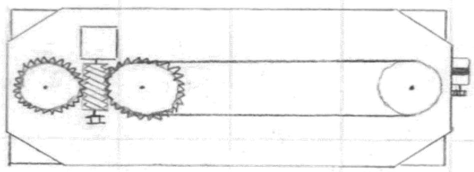
Disadvantages

- Difficult to make track/ wheel assembly rigid enough
- No camera movement (has to turn around to view other side with camera)
- Needs many collars and some sized wheels for each track
- Tracks use a lot of printed material
- If it does not work initially, design alterations will be tough

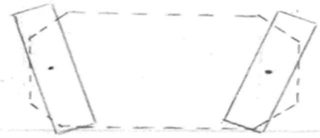
Figure 4 (a): Detailed descriptions of designs discussed during brainstorming session (Drawn by Brayden Stecyk)

Appendix B-2

Option 2
Planet Crawler

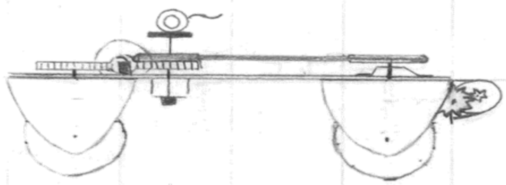


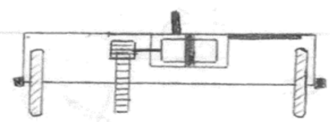
Shown without camera



Note; dashed line shows where body plate would be mid-turn

Top panel removed to show two wheel assembles in turning position





Front end view of wheel assembly with top plate of the droid removed.

Features

- Both front and back rolling assemblies pivot around their centers
  - Pin connected to body and top sheet metal surface of rolling assembly in contact with bottom of sheet metal body
- motor with worm drives two wormgears in opposite directions, allowing for proper turning
- turning motor attached to rear end of vehicle via belt & 2 pulleys
- camera spins as vehicle is turned
- motor on rear drives rear wheels

Advantages

- turns easily with a relatively small turning radius
- Camera is able to turn
- not much for "custom" parts that need to be designed

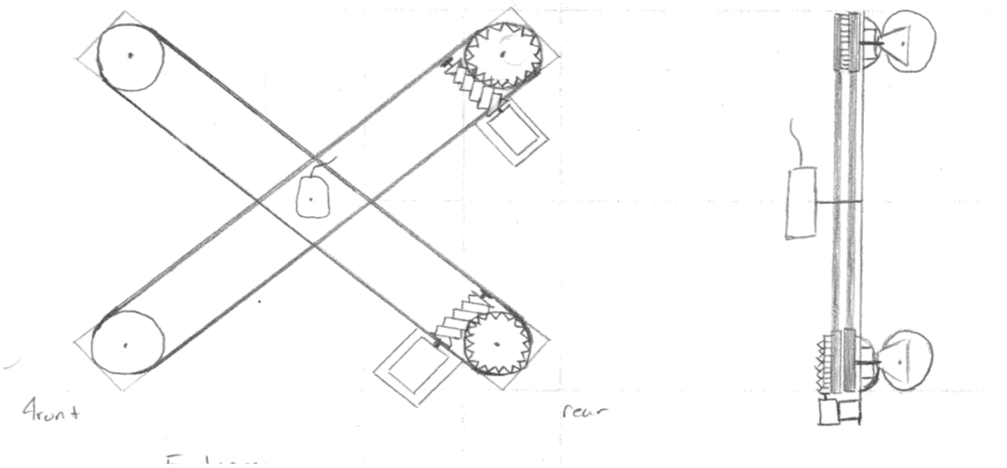
Disadvantages

- could get stuck in pot holes easily
- might have too much friction between body plate and 2 rolling assemblies
- difficult to drive due to the quick turning
- belt on top may break easily (makes droid non-opperational)

Figure 4 (b): Detailed descriptions of designs discussed during brainstorming session (Drawn by Andrew Lam)

Appendix B-3

Option 3
Wild Criss-Crosser



Features

- X shaped sheet metal frame
- Belts to connect the opposite wheels together for turning via belt/pulley
- Driven by a gearbox that is attached to the side of the rear wheels
    - Gets the power input from bottom of the spur gear on each motor
- Center mounted camera

Advantages

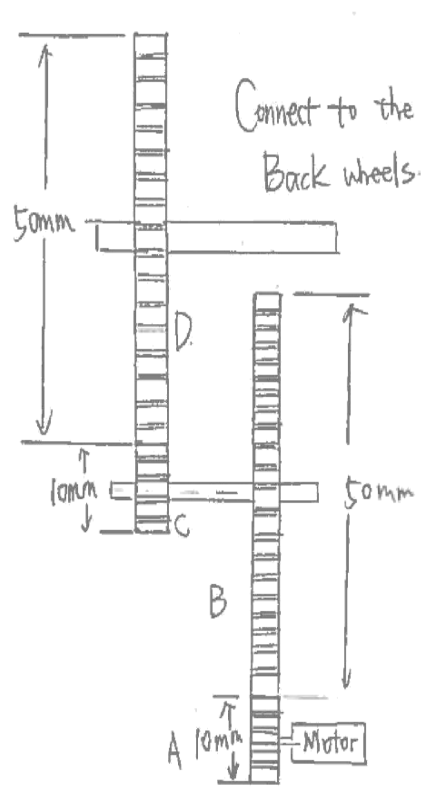
- Can rotate in a stationary position
- Wide wheel base makes for navigation over potholes easier

Disadvantages

- Not feasible to build gearbox
- The frame is not very rigid
- It is nearly impossible to steer this
- The belts connecting the wheels are long/ could break easily
- The camera does not turn

Figure 4 (c): Detailed descriptions of designs discussed during brainstorming session (Drawn by Toya Okeke)

Appendix B-4



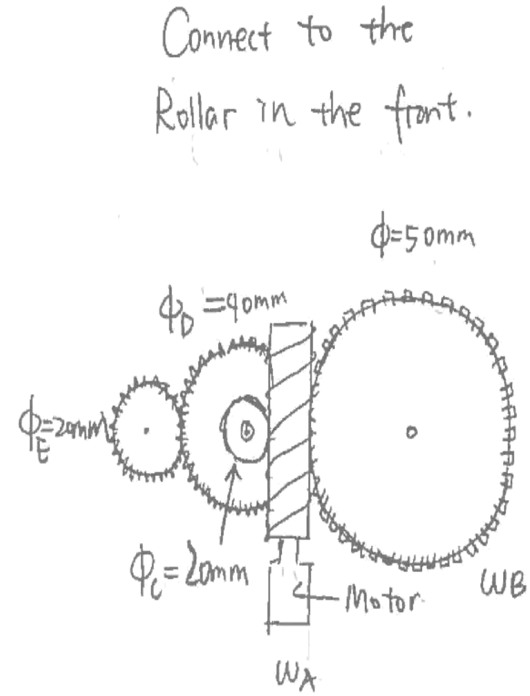
$40\omega_B = 10\omega_A \Rightarrow \omega_B = \frac{1}{4}\omega_A$

$\omega_B = \omega_C$ & $10\omega_C = 50\omega_D$

$(\frac{1}{4}\omega_A)10 = 50\omega_D$

$\omega_D = \frac{1}{20}\omega_A = \omega_{tires}$

Gear ratio 20.



$\omega_B = \frac{1}{50}\omega_A \Rightarrow$ Angular velocity of rollar

$20\omega_C = 1\omega_A \Rightarrow \omega_C = \omega_D$

$20\omega_E = 40\omega_D \Rightarrow \omega_E = 2\omega_D$

$\Rightarrow \omega_E = \frac{2}{20}\omega_A = \frac{1}{10}\omega_A$

$\omega_E = \frac{1}{10}\omega_A$ (angular velocity of camera)

$\frac{\omega_E}{\omega_B} = \frac{\frac{1}{10}}{\frac{1}{50}} = 5$

$\Rightarrow \omega_E$ spins 5 times faster than ω_B

Figure 4 (d): Detailed sketch and analysis of gear assembly
(Drawn by Chengshunzi Dong)

Appendix B-5

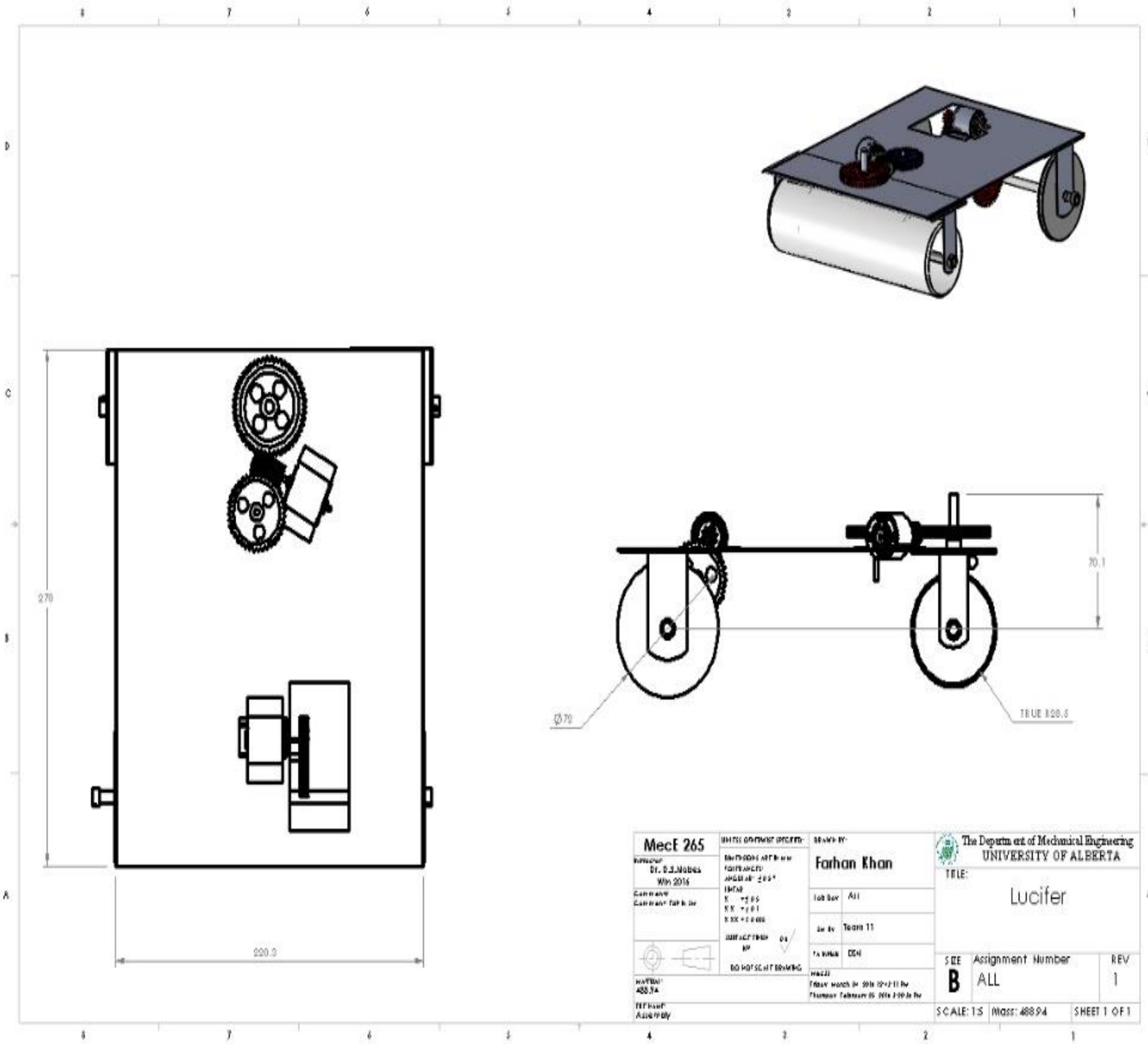
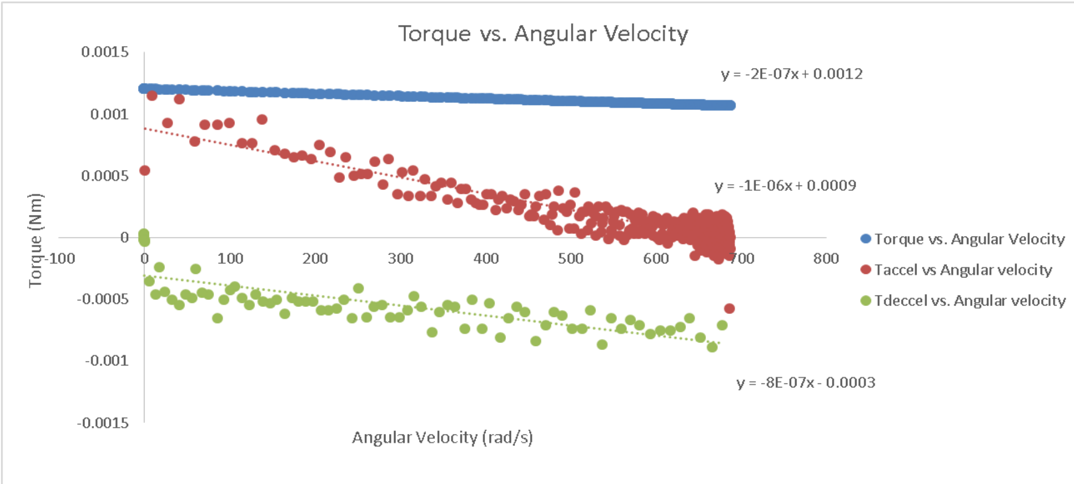
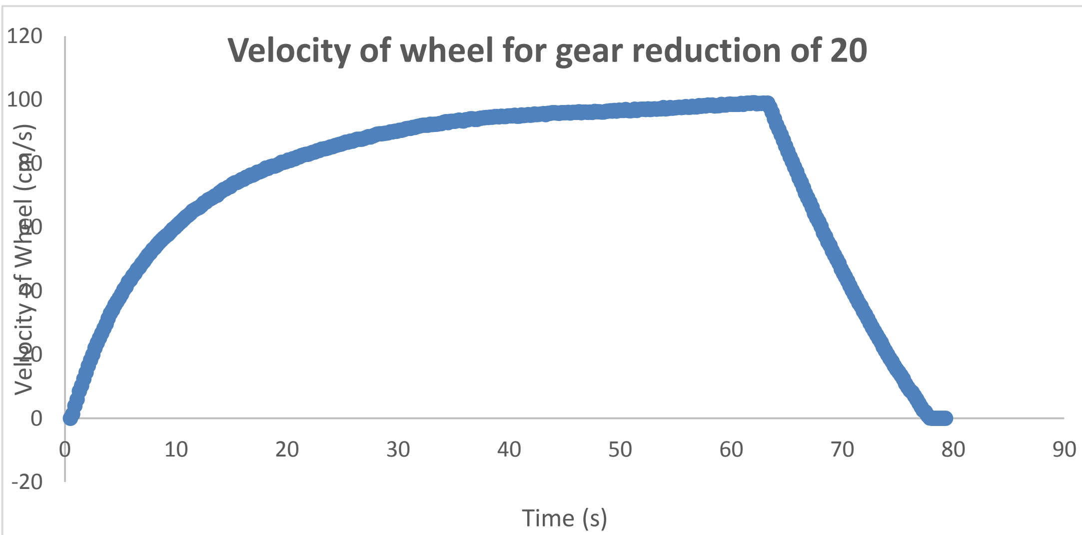


Figure 4 (e): Draft assembly of design built through SolidWorks (Drawn by Farhan Khan)

Appendix C





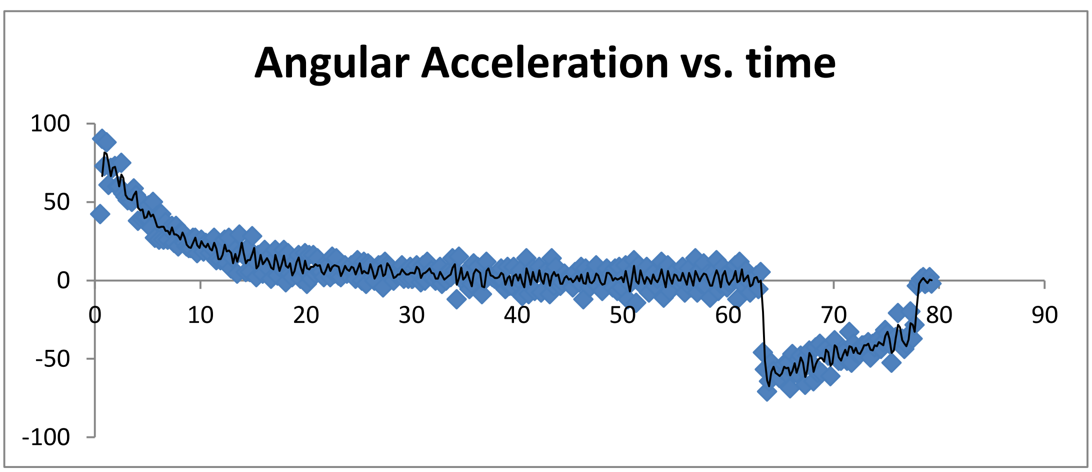


Figure 5: Acceleration and torque of motor shaft and velocity of the wheels using Dyno Test Analysis software

Appendix D

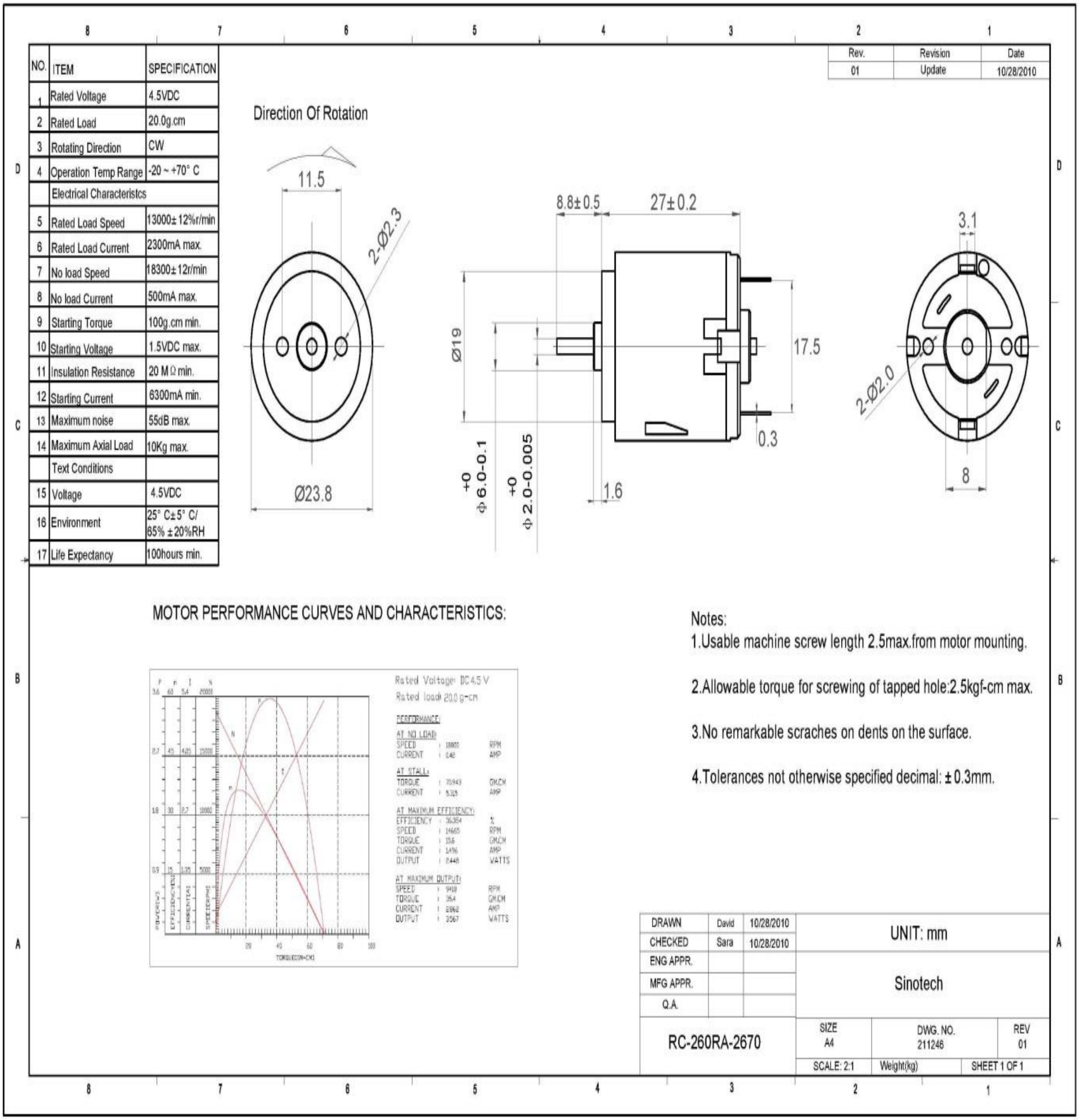


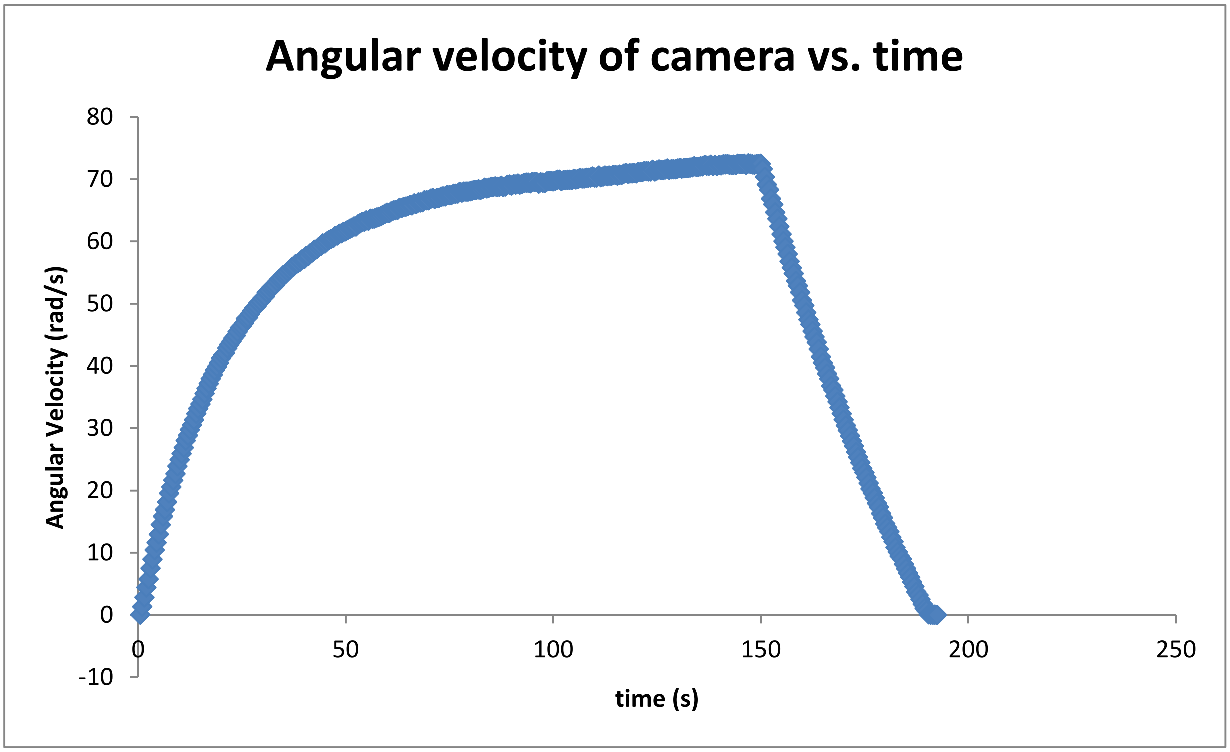
Figure 6: Electric DC-motor spec sheet

Appendix E

Table 2: Decision Matrix for Design Concepts

Criteria						
	Materials Required	**Stability of Design**	**Time Required to Create**	**Camera View Range**	**Manoeuvrability**	
Max Abs Value	**10**	**10**	**20**	**36**	**10**	
Skid-Steer Style Droid	-5	6	-16	7.5	7	
Compaction Roller Droid	-7	7	-10	36	5	
Planet Crawler	-6	10	-13	16.5	8	
Wild Criss-Crosser	-10	3	-20	7.5	1	
Rating	**10**	**15**	**20**	**15**	**20**	
Skid-Steer Style Droid	-5	9	-16	3.125	14	
Compaction Roller Droid	-7	10.5	-10	15	10	
Planet Crawler	-6	15	-13	6.875	16	
Wild Criss-Crosser	-10	4.5	-20	3.125	2	
Weighting	**5**	**7**	**10**	**6**	**7**	**Totals**
Skid-Steer Style Droid	-25	63	-160	18.75	98	-5.25
Compaction Roller Droid	-35	73.5	-100	90	70	98.5
Planet Crawler	-30	105	-130	41.25	112	98.25
Wild Criss-Crosser	-50	31.5	-200	18.75	14	-185.75

Appendix F-1



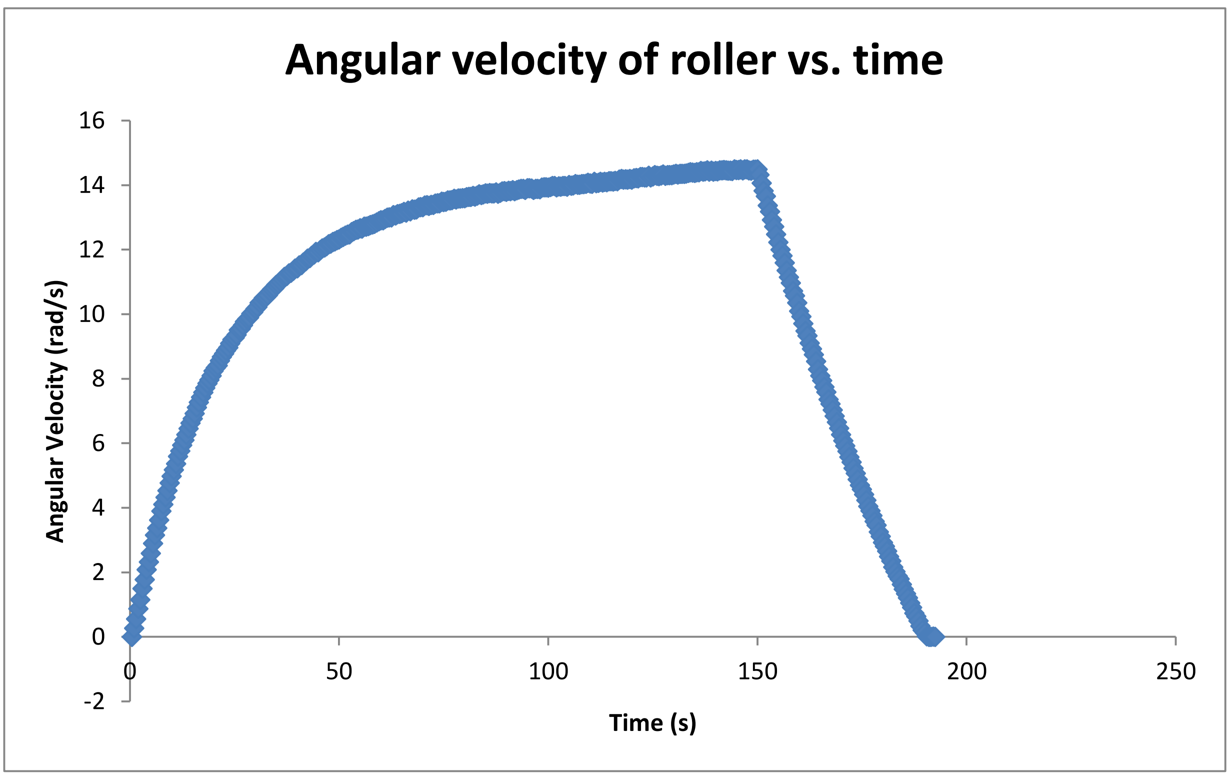


Figure 7 (a): Graphs depicting the angular velocities of the camera and roller

Appendix F-2

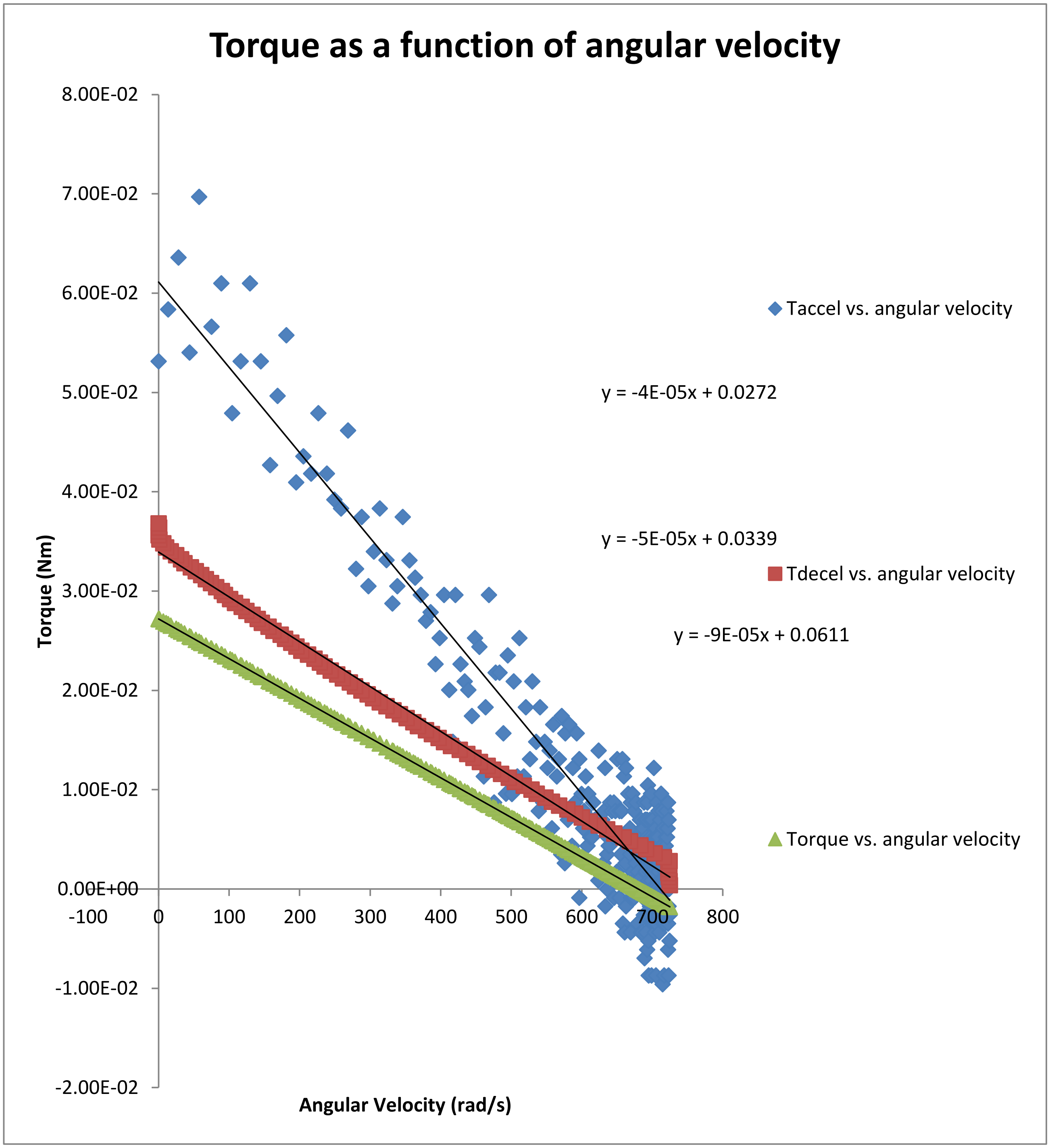


Figure 7 (b): Graph depicting torque of front motor as function of angular velocity

Appendix G

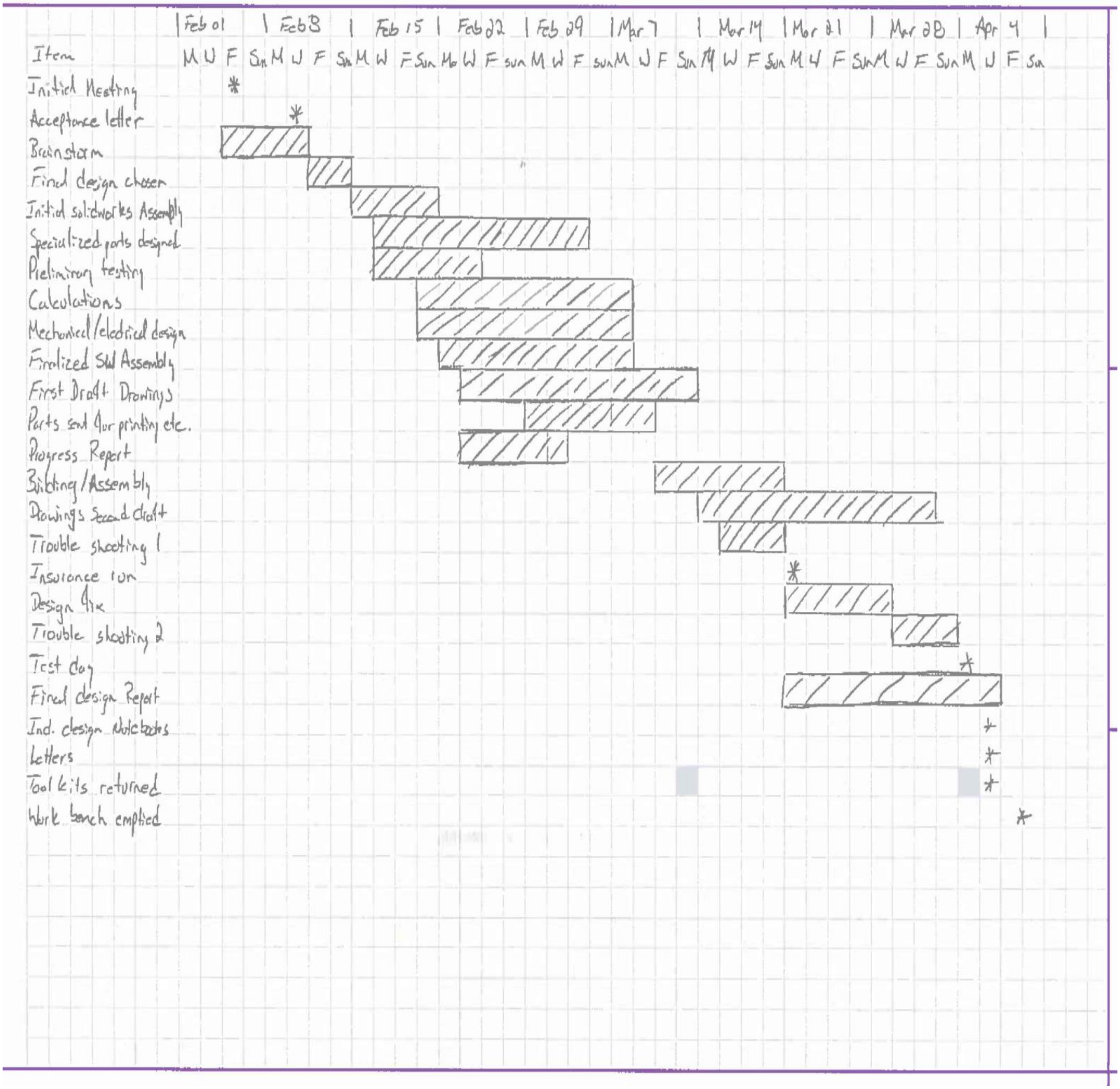
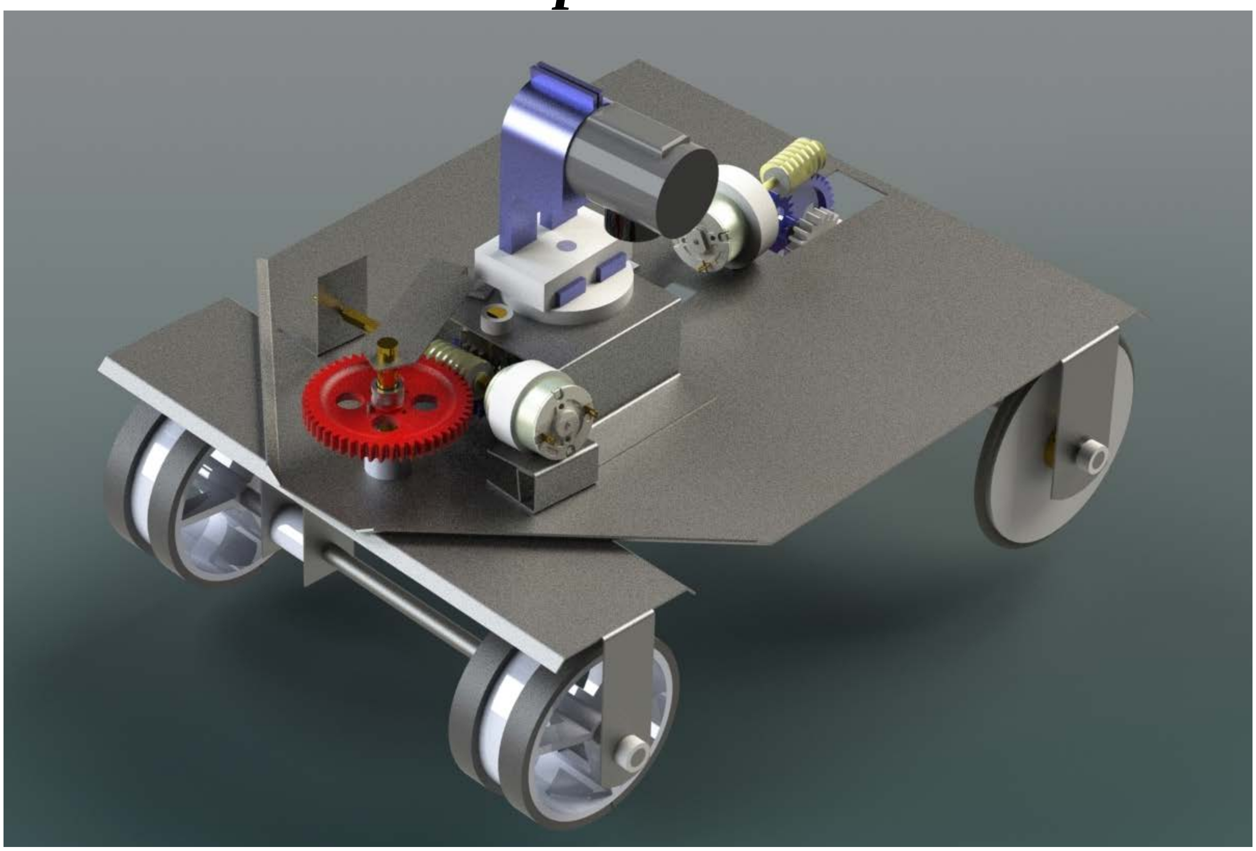


Figure 8: Updated Time Management Chart

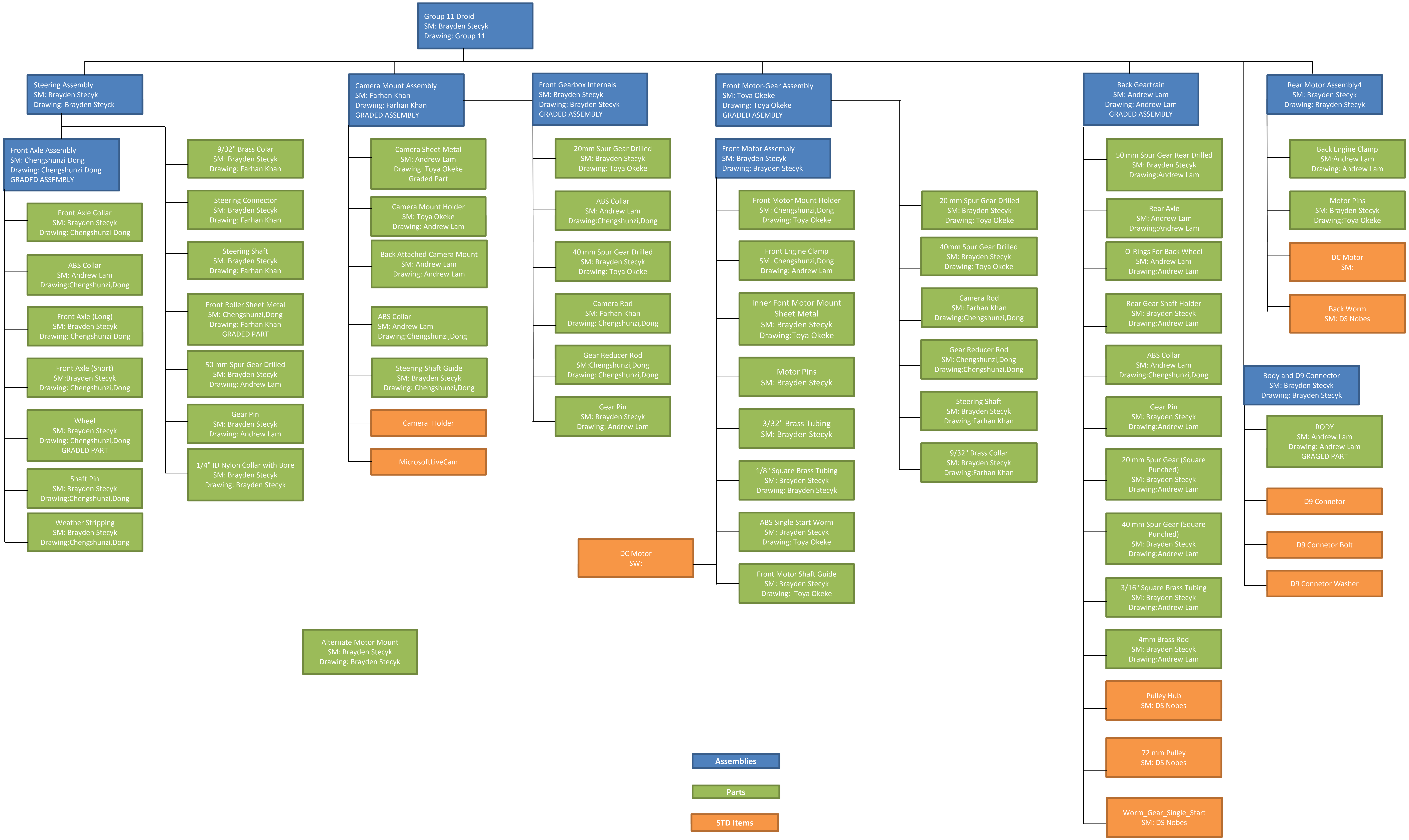
Mec E 265
Engineering Graphics and CAD

Group 11 Droid

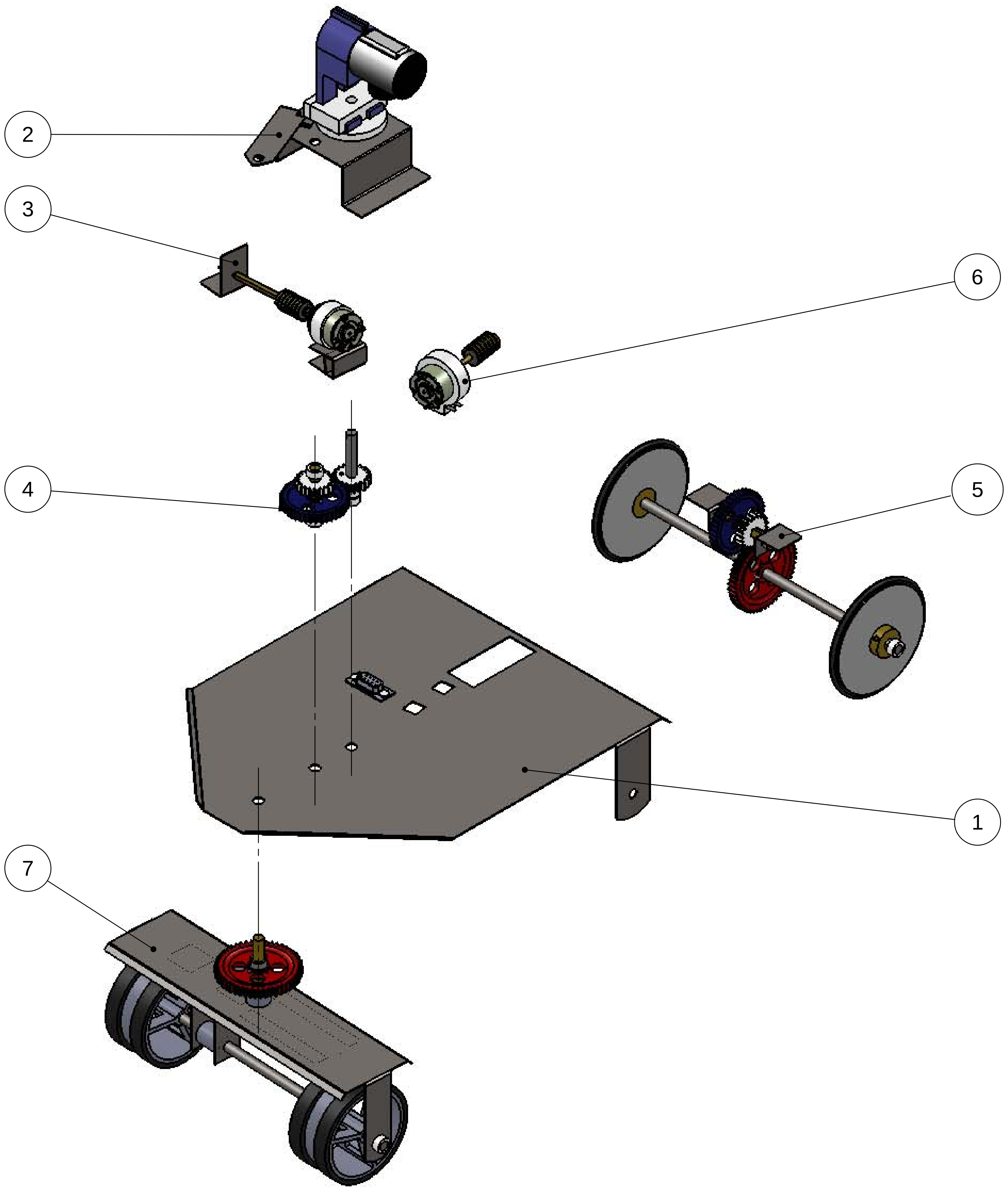


Dr. David S. Nobes
March 29, 2016

Brayden Stecyk (bstecyk), Farhan Khan (fk1), Andrew Lam (alam6), Chengshunzi Dong (cdong5), Toye Okeke (tokeke)



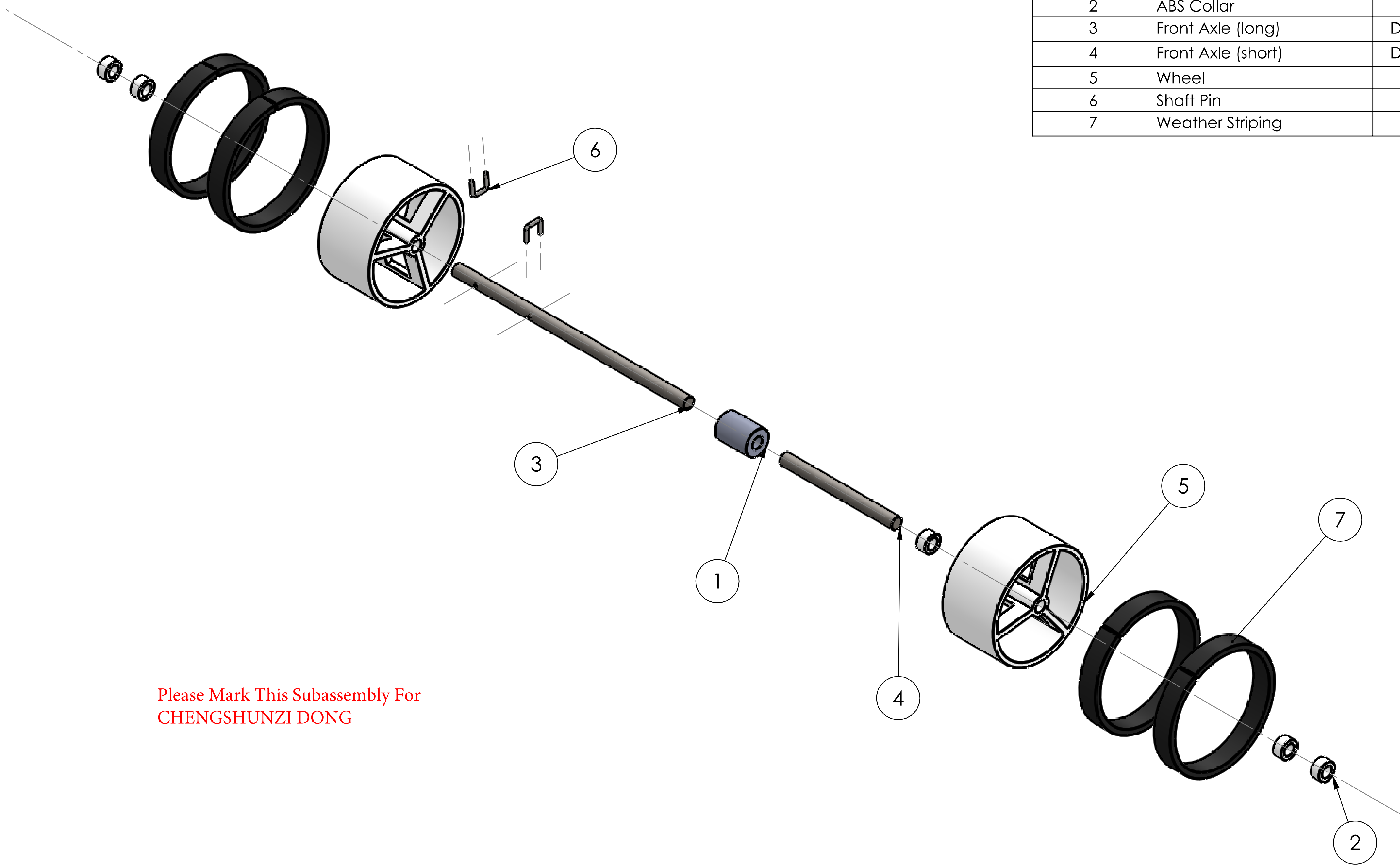
Mec E 265 Win 2016	The University of Alberta	
Group 11	Title	
Brayden Stecyk Toya Okeke Andrew Lam Farhan Khan Chengshunzi,Dong	**Group 11 Droid Drawing Tree**	
	Page	1 of 1



ITEM NO.	PART NUMBER	Solidworks Author
1	Body with D9 Connector	Brayden Stecyk
2	Camera Mount Assembly	Brayden Stecyk
3	Front Motor Assembly	Brayden Stecyk
4	Front Gear Assembly	Brayden Stecyk
5	Rear Axle with Gear Train Assembly	Andrew Lam
6	Rear Motor Assembly	Brayden Stecyk
7	Front Steering Assembly	Brayden Stecyk & Chengshunzi Dong

MecE 265 Instructor: **Dr. DS Nobes** **Dr. Pierre Mertiny** Comments: Comment: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Brayden Stecyk** Lab Day SM By **Brayden Stecyk** TA Initials Brayden March-29-16 2:05:53 AM February-25-16 4:20:36 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Droid Exploded View SIZE **B** Assignment Number **Drawing Project** REV 1
MATERIAL: Various			
FILE NAME: Complete Droid			SCALE: 1:1 Mass: 1093.91 SHEET 1 OF 7

ITEM NO.	PART NUMBER	Material	QTY.
1	Front Axle Collar	Nylon 101	1
2	ABS Collar	ABS	5
3	Front Axle (long)	DIA 3.2mm Welding Rod	1
4	Front Axle (short)	DIA 3.2mm Welding Rod	1
5	Wheel	ABS	2
6	Shaft Pin	Steel	2
7	Weather Striping	Polyjet flexible material	4



Please Mark This Subassembly For
CHENGSHUNZI DONG

Instructor:
Dr. D.S.Nobes
Dr. Mertiny
Comments:

MATERIAL:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong
Lab Day
SM By Chengshunzi, Dong
TA Initials
Mec33
Sunday, March 27, 2016 5:45:20 PM
Friday, March 25, 2016 3:25:29 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

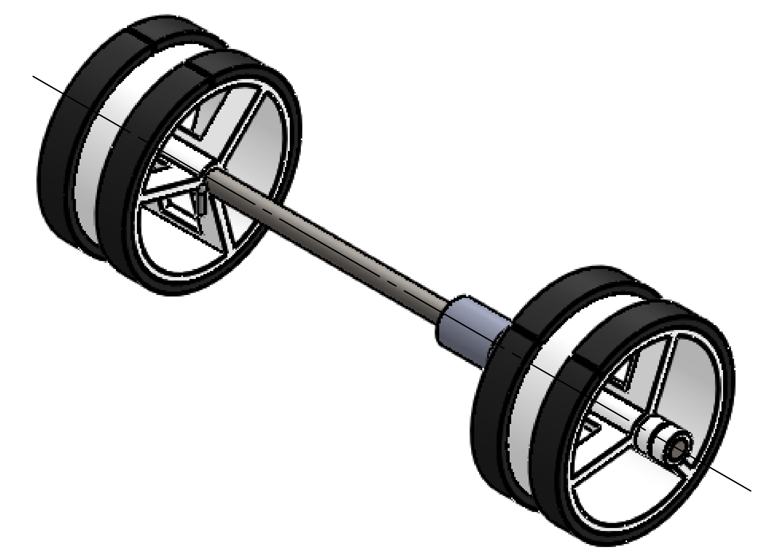
TITLE:
Exploded View of front wheel

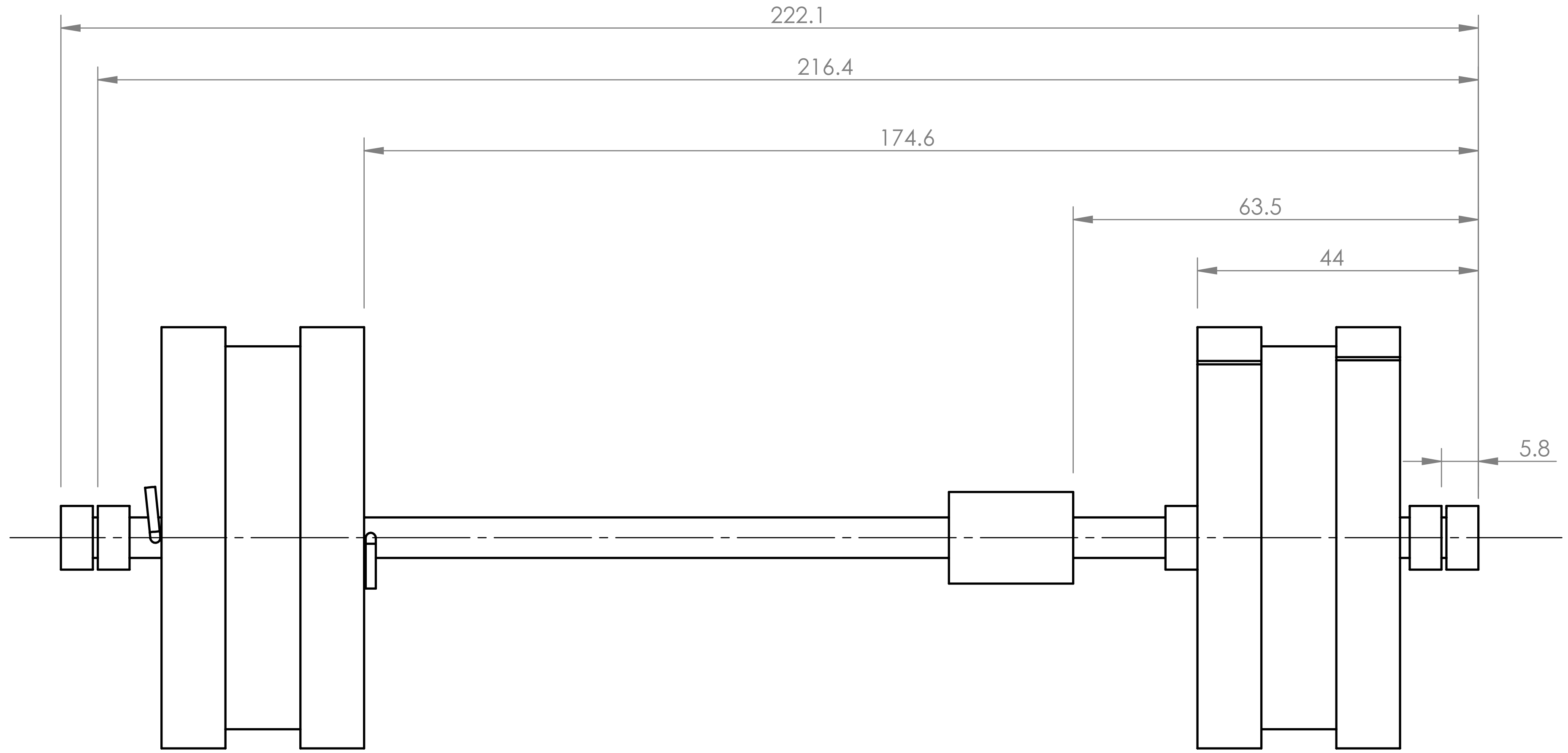
SIZE **B**
Assignment Number
Drawing Project
REV

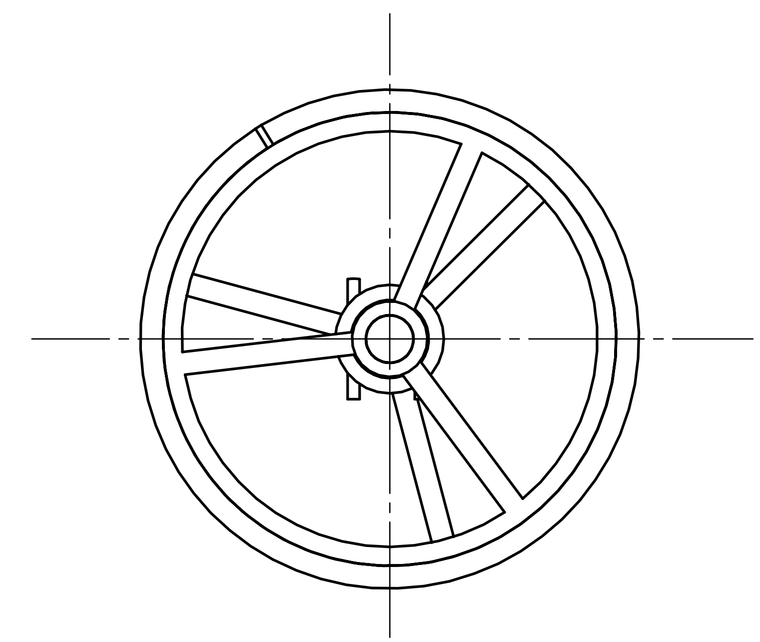
FILE NAME:
Front Roller Assembly

SCALE: 2:3 | Mass: 99.80 grams | SHEET 1 OF 2

Since I have all the drawings for each single parts in this sub assembly.
All the parts here have their drawings with tolerances in my drawing package
So on this drawing, only need to show the position of the parts on the shaft.







Please Mark This Subassembly For
CHENGSHUNZI DONG

Instructor:
Dr. D.S.Nobes
Dr. Mertiny
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:

FILE NAME:
Front Roller Assembly

DRAWN BY:
Chengshunzi,dong

Lab Day
SM By Chengshunzi, Dong
TA Initials
Mec33
Sunday, March 27, 2016 5:45:20 PM
Friday, March 25, 2016 3:25:29 PM

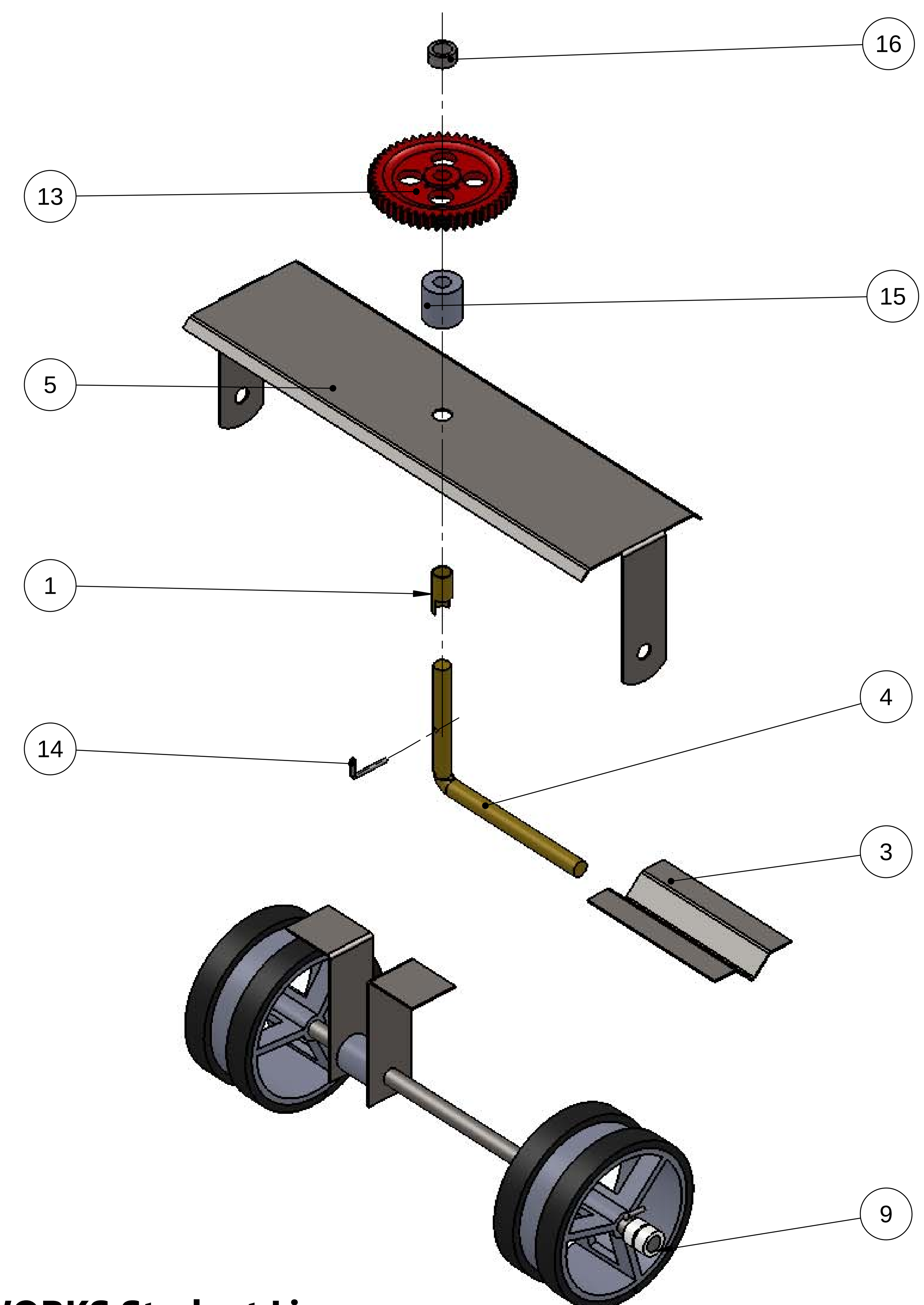
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Exploded View of front wheel

SIZE **B**
Assignment Number
Drawing Project
REV

SCALE: 1:1 Mass:99.8 grams SHEET 2 OF 2

ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Author)	QTY.
1	9_32 brass collar	Brass	0.97	Brayden Stecyk	1
3	Steering Connector	AISI 1020 Steel, Cold Rolled	17.08	Brayden Stecyk	1
4	Steering Shaft	Brass	32.26	Brayden Stecyk	1
5	Front Roller Sheet Metal	AISI 1020 Steel, Cold Rolled	88.97	Chengshunzi Dong	1
8	Front Roller Assembly	Various		Chengshunzi Dong	
13	50mm Spur Gear Front Drilled	ABS	7.08	Changed by Brayden Stecyk	1
14	Gear Pin	AISI 1020	0.37	Brayden Stecyk	1
15	1_4 in ID Nylon Collar with Bore	Nylon 101	2.15	Brayden Stecyk	1
16	Collar C-012	AISI 316 Stainless Steel Sheet (SS)	1.55	A. Drafter	1



MecE 265

Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny

Comments:
Comment: Edit in SM

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DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
Various

FILE NAME:
Steering Assembly

DRAWN BY:
Brayden Stecyk

Lab Day

SM By **Brayden Stecyk**

TA Initials

Brayden
March-29-16 12:24:23 AM
February-25-16 4:20:36 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Steering Assembly
Exploded View

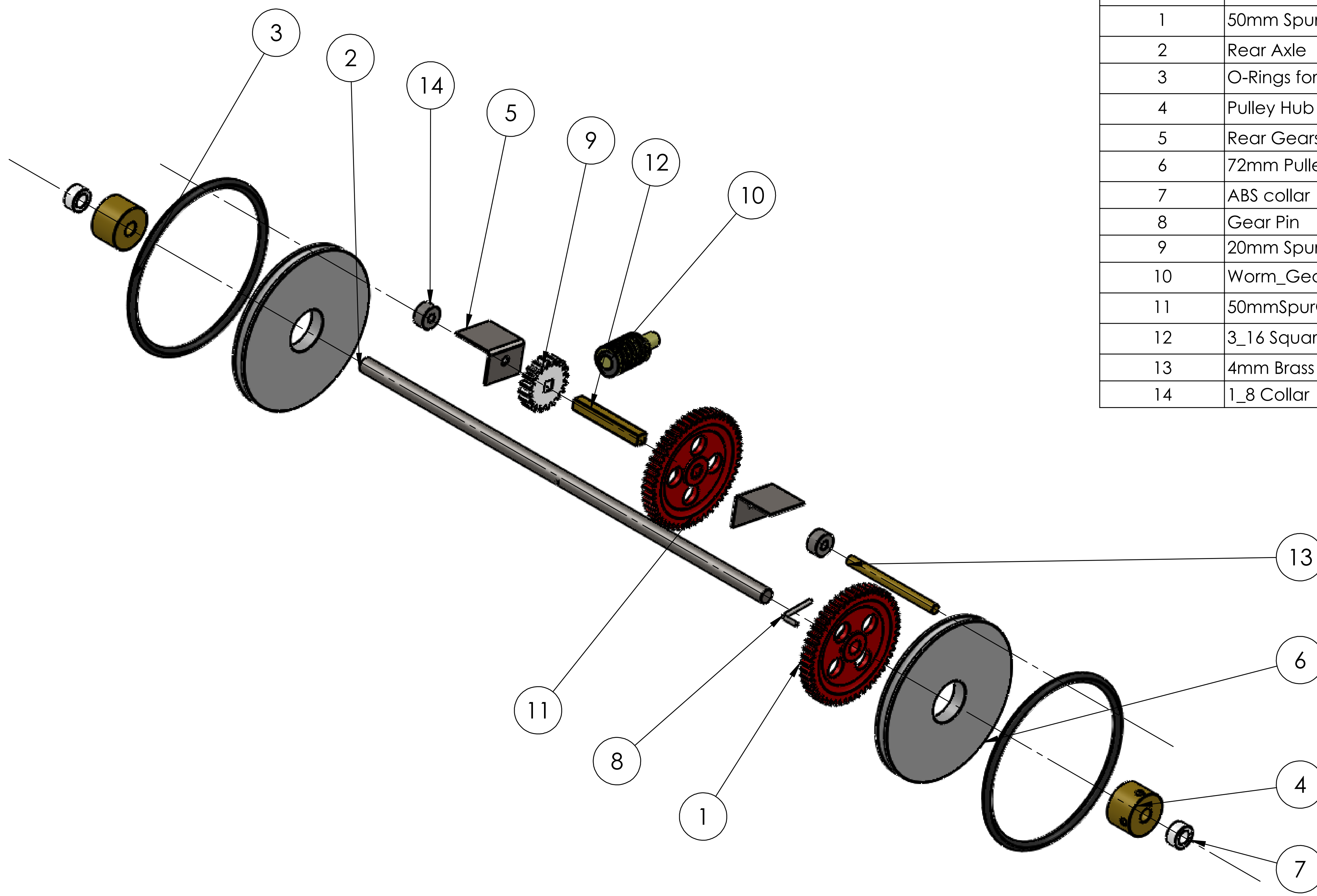
SIZE **B**

Assignment Number
Drawing Project

REV 1

SCALE: 1:2 | Mass: 283.37 | SHEET 5 OF 7

ITEM NO.	PART	Material	QTY.
1	50mm Spur Gear Rear Drilled	ABS Plastic	1
2	Rear Axle	AISI 1035 steel (SS)	1
3	O-Rings for Back wheel	Silicon Rubber	2
4	Pulley Hub	Brass	2
5	Rear Gearshaft Holder	Cold Rolled Steel	2
6	72mm Pulley - Copy	ABS Plastic	2
7	ABS collar	ABS Plastic	2
8	Gear Pin	1035 steel (SS)	1
9	20mm Spur Gear	ABS Plastic	1
10	Worm_Gear_Single_Start	Brass	1
11	50mmSpurGear	ABS Plastic	1
12	3_16 Square Brass Tubing	Brass	1
13	4mm Brass Rod	Brass	1
14	1_8 Collar	AISI 316 stainless steel (SS)	2



Please MArk This Subassembly For ANDREW LAM

MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:

MATERIAL:

FILE NAME:
Assem2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Andrew Lam

Lab Day	ALL
SM By	**Andrew Lam**
TA Initials	DSN

Mec33
Monday, March 28, 2016 2:12:05 AM
Sunday, March 27, 2016 10:27:37 PM

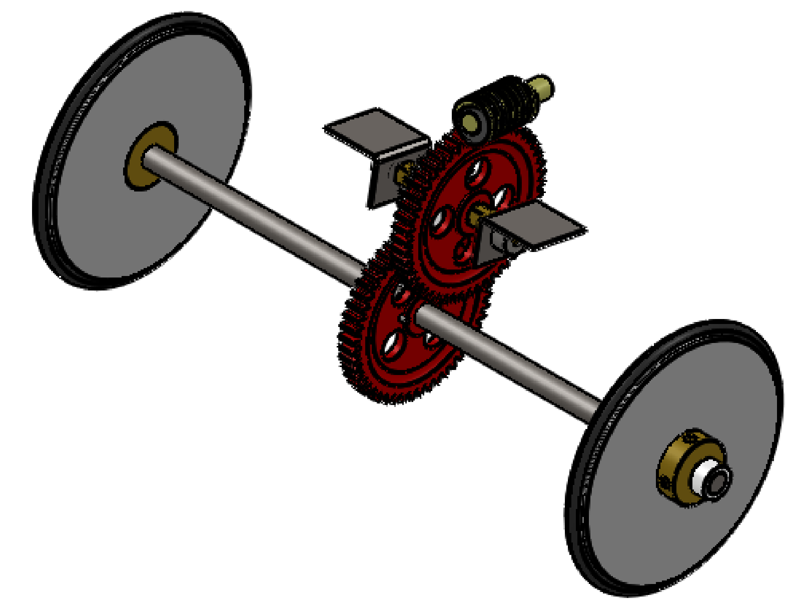
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

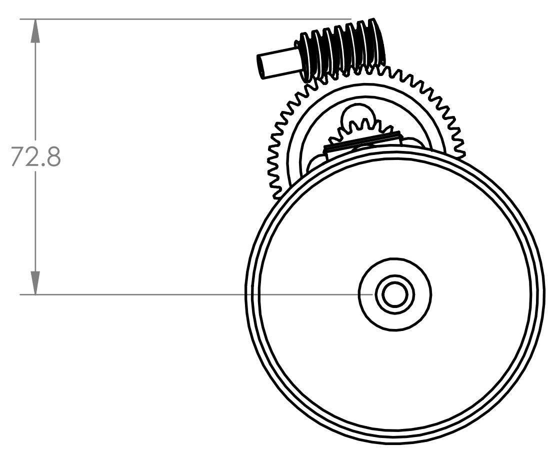
TITLE:
Exploded View of Back Gear Design

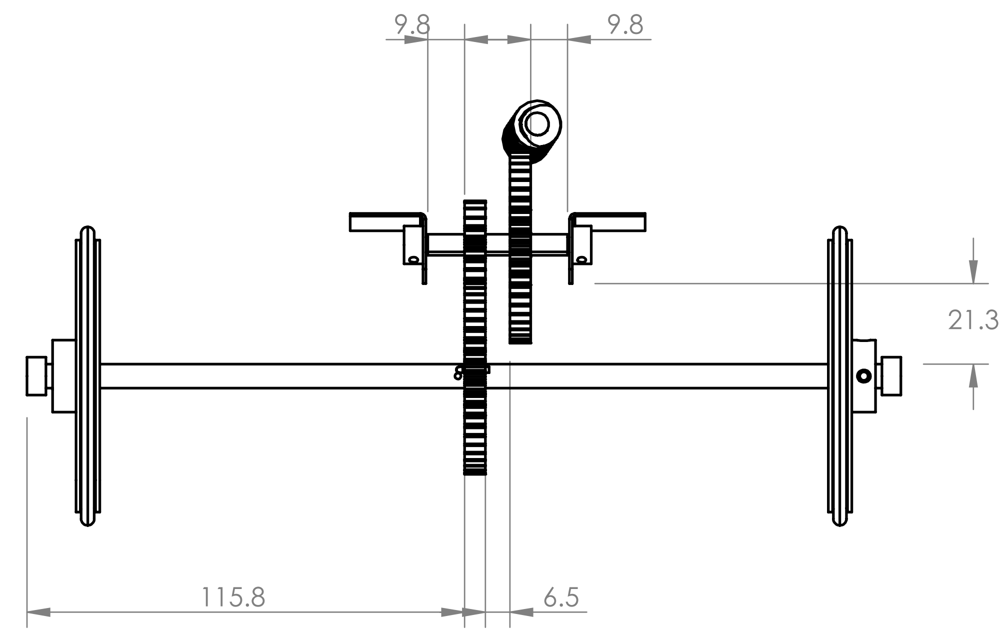
SIZE B | Assignment Number: Drawing Project | REV 1

SCALE: 1:2 | Mass: 206.24 | SHEET 1 OF 1

Please mark this assembly for Andrew Lam

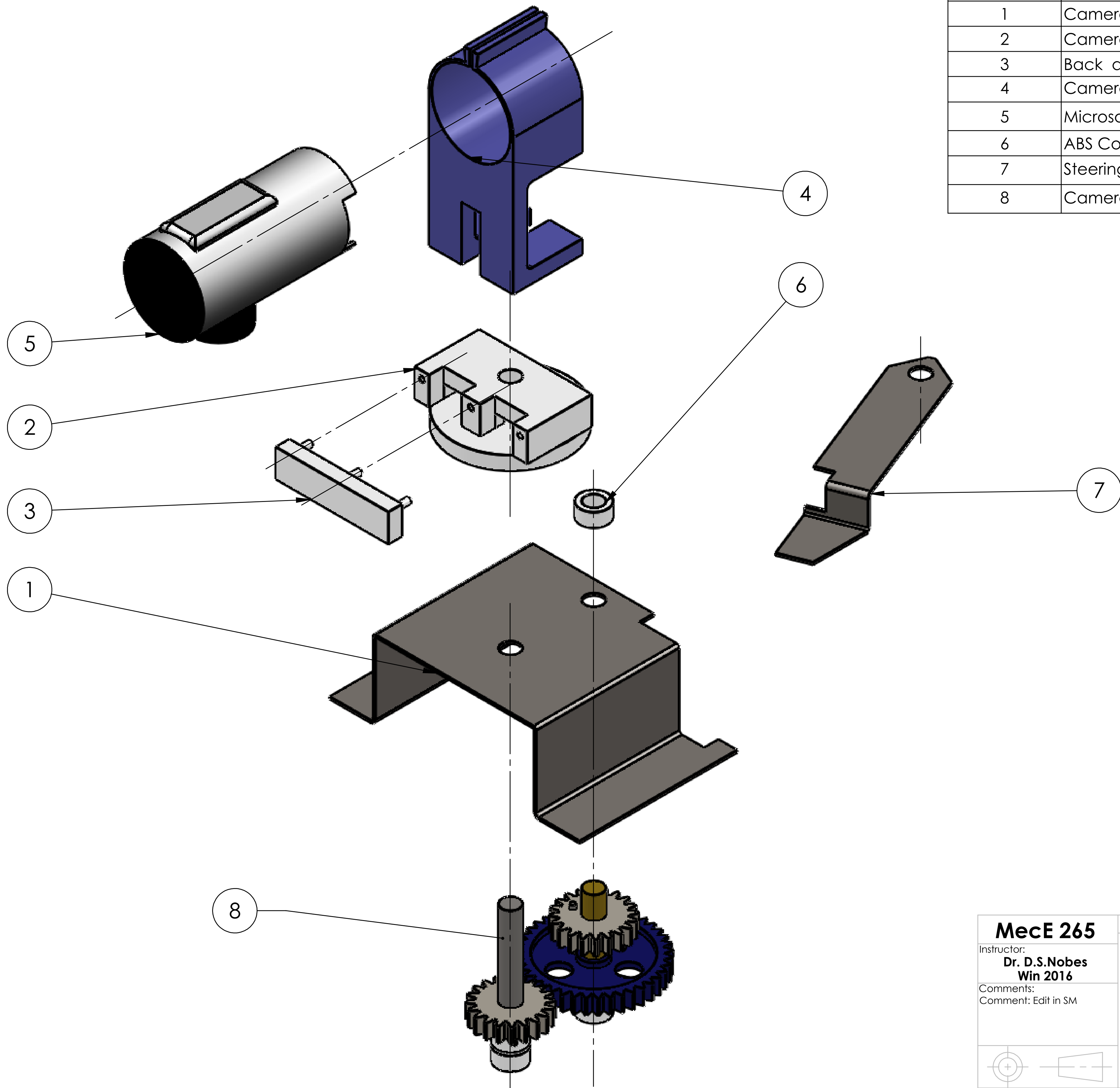






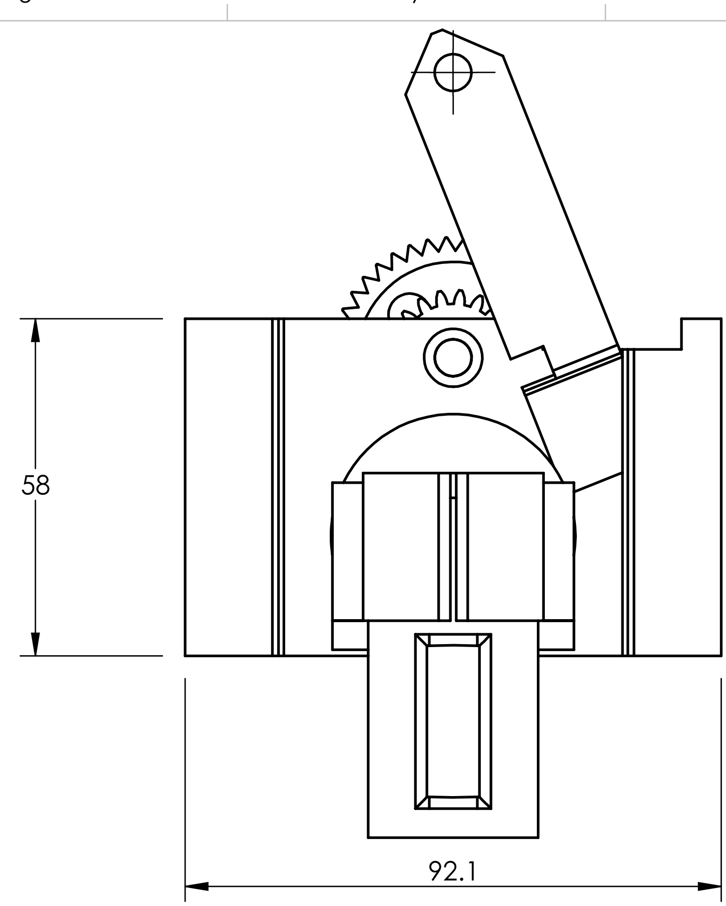
MecE 265 Instructor: Dr. D.S.Nobes Win 2016 Comments: Comment: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam** Lab Day: ALL SM By: **Andrew Lam** TA Initials: DSN Mec33 Tuesday, March 29, 2016 1:01:27 PM Sunday, March 27, 2016 10:27:37 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Rear Gear Box Assembly SIZE: **B** Assignment Number: Drawing Project REV: 1
MATERIAL:			
FILE NAME: Assem2			SCALE: 1:2 Mass: 206.24 SHEET 2 OF 2

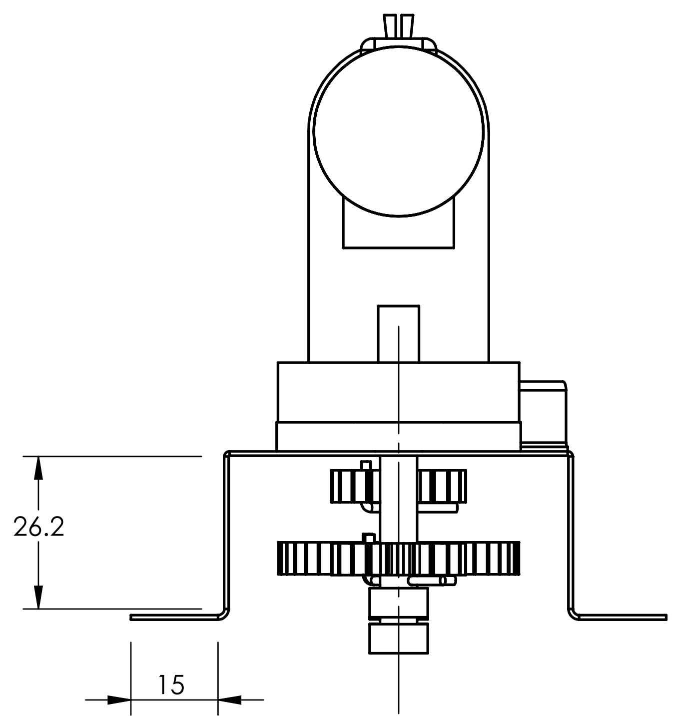
ITEM NO.	PART NUMBER	Material	QTY.
1	Camera Sheet Metal Mount	AISI 1020 Steel, Cold Rolled	1
2	Camera mount holder	ABS	1
3	Back attached Camera Mount	ABS	1
4	Camera_Holder	1060 Alloy	1
5	MicrosoftLifeCam	Various	1
6	ABS Collar	ABS	1
7	Steering Shaft Guide	AISI 1020 Steel, Cold Rolled	1
8	Camera Mount Gear Sub Assembly	Various	1

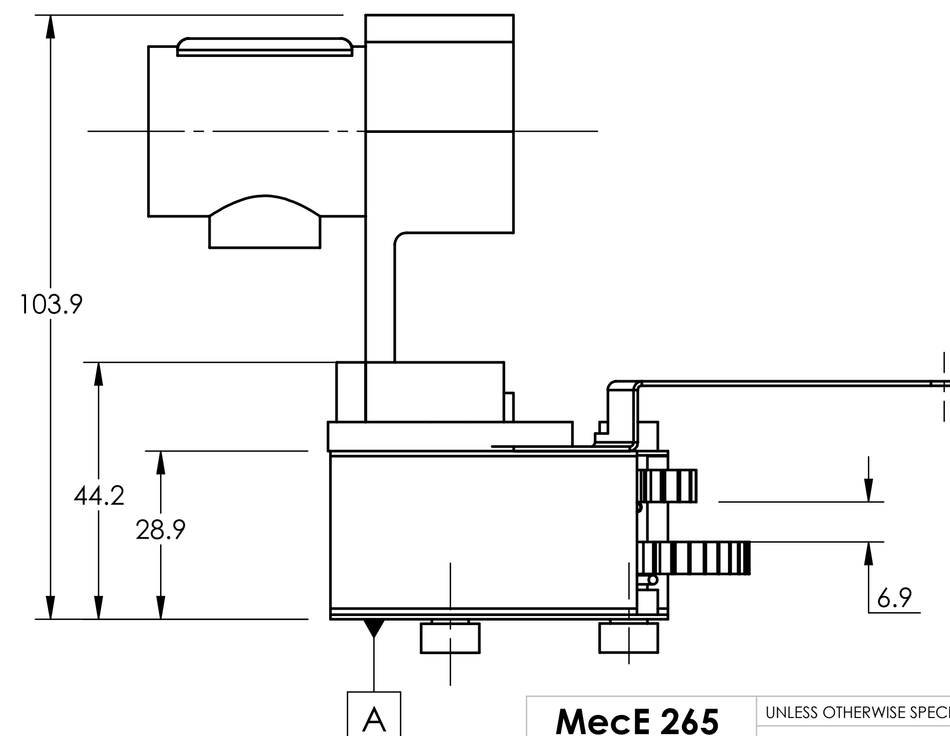


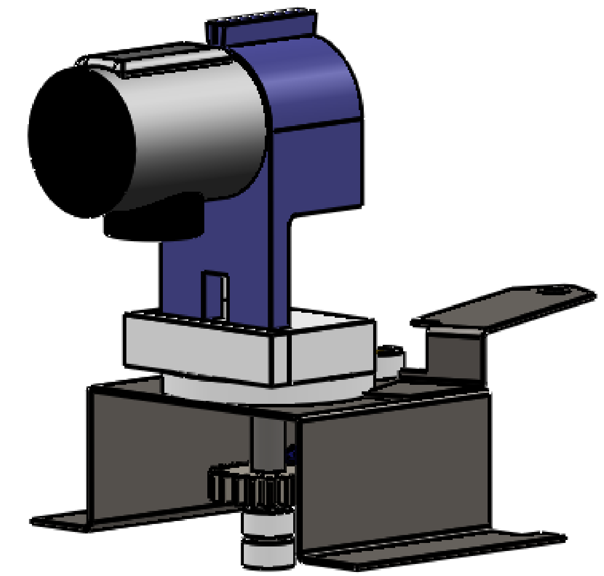
Please Mark This Subassembly For
FARHAN KHAN.

MecE 265 Instructor: Dr. D.S.Nobes Win 2016 Comments: Comment: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: Farhan Khan Lab Day: ALL SM By: Farhan Khan TA Initials: DSN Mec33 Tuesday, March 29, 2016 10:59:26 AM Tuesday, March 29, 2016 9:22:22 AM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Camera Mount Subassembly
MATERIAL: 202.23			SIZE B · Assignment Number: Drawing Project · REV 1
FILE NAME: farhankhan			SCALE: 1:2 · Mass: 202.23 · SHEET 1 OF 2









Please Mark This Subassembly For
FARHAN KHAN

MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:
Comment: Edit in SM

MATERIAL:
202.23

FILE NAME:
farhankhan

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DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Farhan Khan
Lab Day: ALL
SM By: **Farhan Khan**
TA Initials: DSN
Mec33
Tuesday, March 29, 2016 10:59:26 AM
Tuesday, March 29, 2016 9:22:22 AM

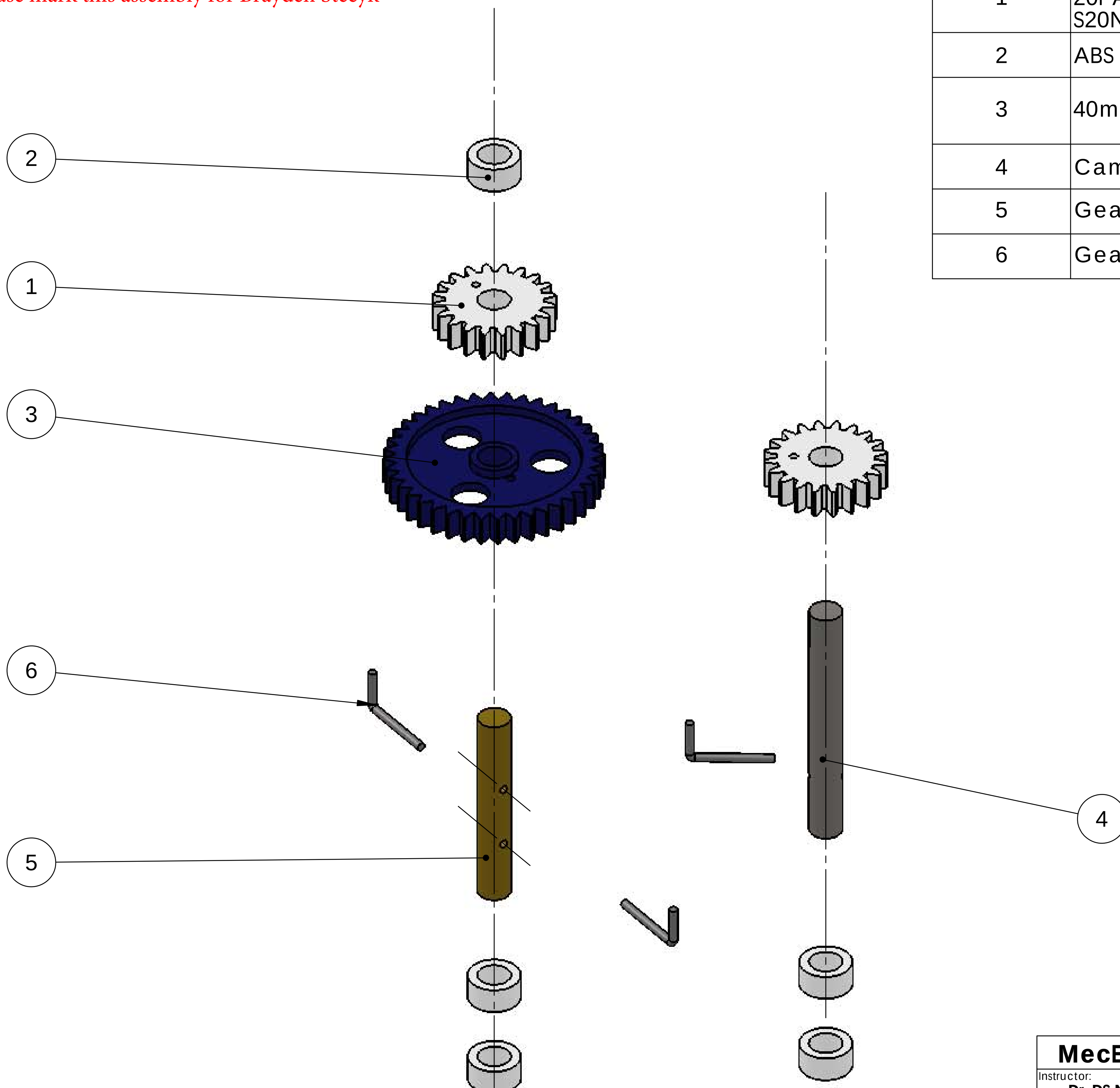
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Camera Mount Assembly

SIZE: **B**
Assignment Number: Drawing Project
REV: 1
SCALE: 1:1
Mass: 202.23
SHEET 2 OF 2

Please mark this assembly for Brayden Stecyk

ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Latest Version)	QTY.
1	Inch - Spur gear 24DP 20T 20PA 0.216FW --- S20N3.0H2.0L0.125N	ABS	0.0038	Brayden Stecyk	2
2	ABS Collar	ABS	0.24	Andrew Lam	5
3	40mm Spur Gear Drilled	Material <not specified>	3.36	Brayden Stecyk	1
4	Camera Rod	AISI 1020	12.41	Farhan Khan	1
5	Gear Reducer Rod	Brass	10.47	Chengshunzi Dong	1
6	Gear Pin	AISI 1020	0.37	Brayden Stecyk	3



MecE 265
Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny
Comments:
Comment: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL: Various

DRAWN BY: **Brayden Stecyk**
Lab Day
SM By: Brayden Stecyk
TA Initials
Brayden
March-29-16 10:24:28 AM
February-25-16 4:20:36 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

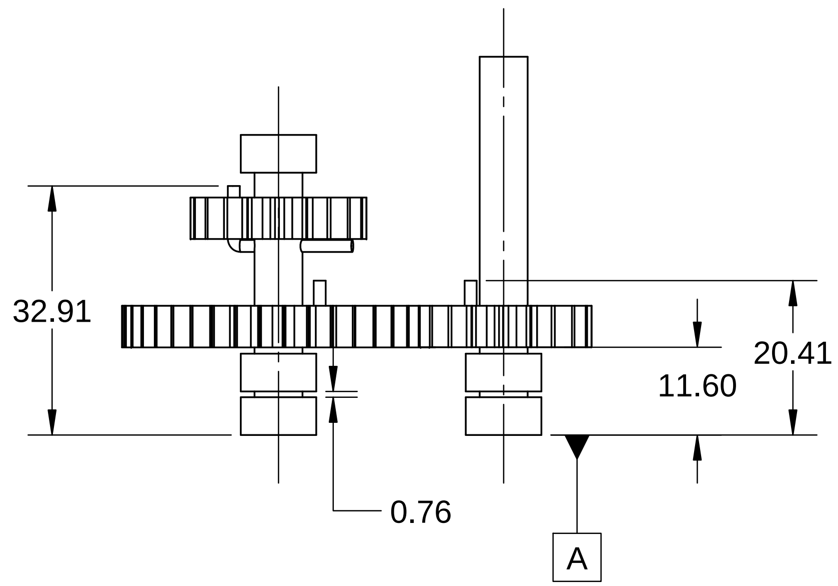
TITLE:
Front Gearbox Internals Exploded View

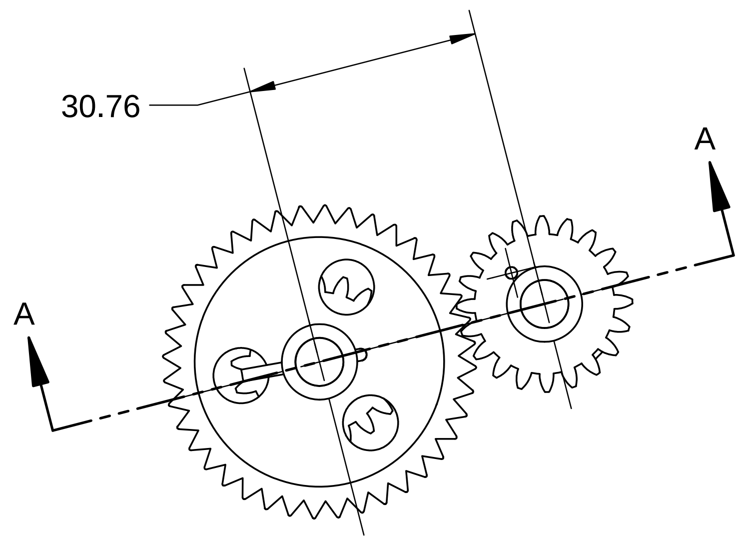
SIZE **B** | Assignment Number **Drawing Project** | REV 1

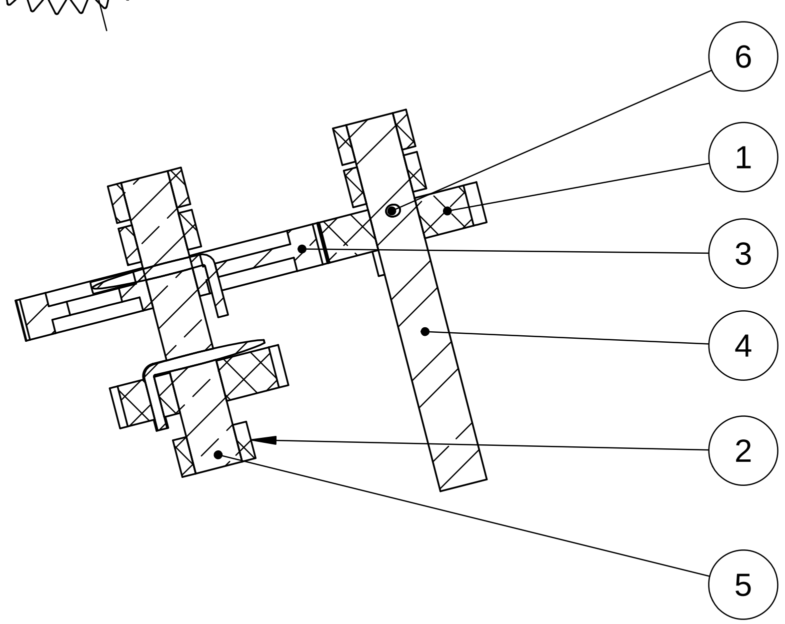
FILE NAME: Front Gear and Shaft Assembly

SCALE: 1:1 | Mass: 31.95 | SHEET 3 OF 7

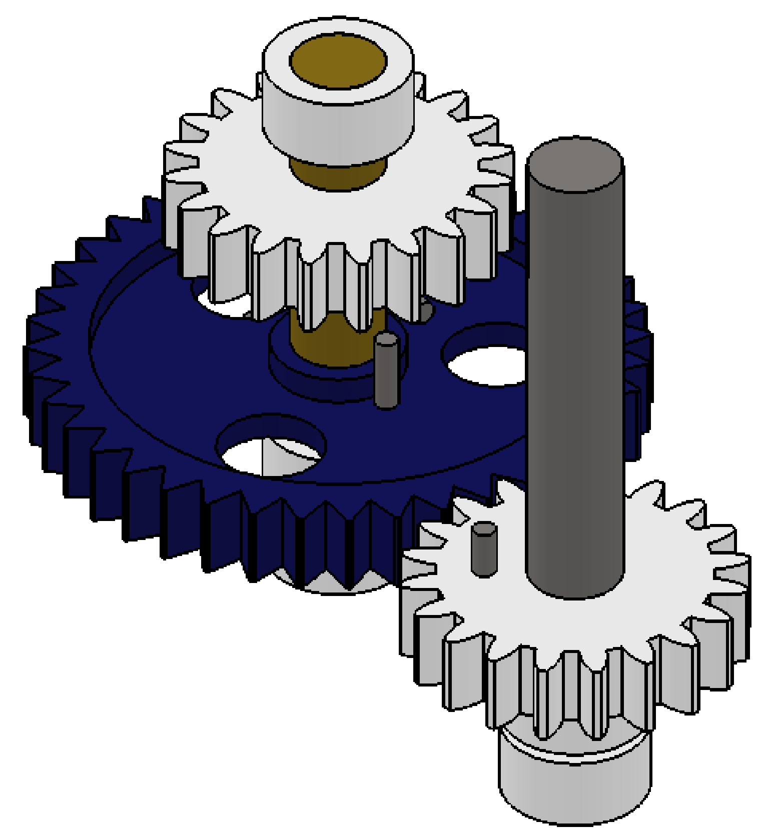
ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Author)	QTY.
1	Inch - Spur gear 24DP 20T 20PA 0.216FW --- S20N3.0H2.0L0.125N	ABS	0.0038	Changed By Brayden Stecyk	2
2	ABS Collar	ABS	0.24	Andrew Lam	5
3	40mm Spur Gear Drilled	Material <not specified>	3.36	G. Gearloose	1
4	Camera Rod	AISI 1020	12.41	Farhan Khan	1
5	Gear Reducer Rod	Brass	10.47	Chengshunzi Dong	1
6	Gear Pin	AISI 1020	0.37	Brayden Stecyk	3







SECTION A-A



Please Mark This Subassembly
For BRAYDEN STECYK

MecE 265

Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny

Comments:
Comment: Edit in SM

MATERIAL:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Brayden Stecyk

Lab Day

SM By **Brayden Stecyk**

TA Initials

Brayden
March-29-16 10:24:28 AM
February-25-16 4:20:36 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

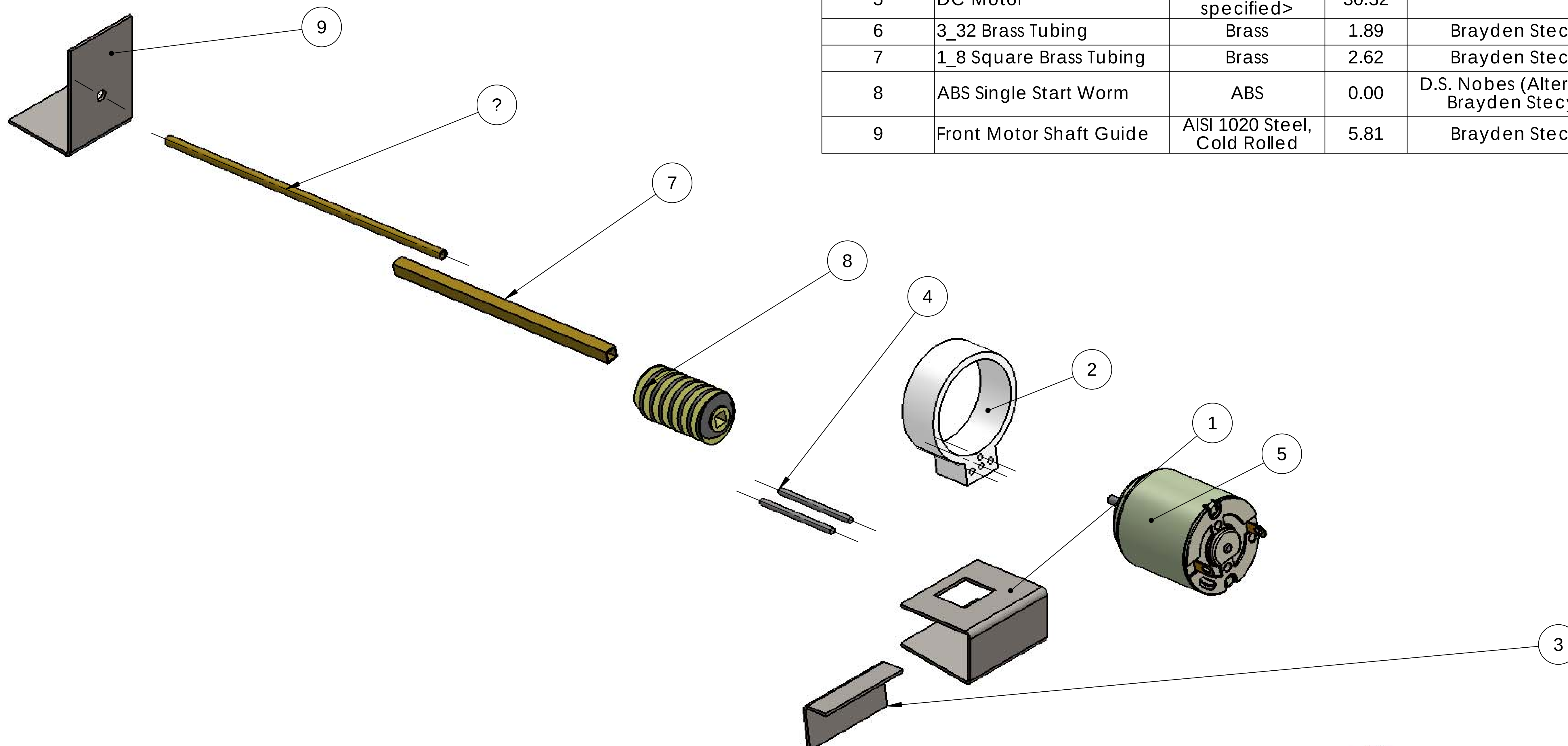
TITLE:
Front Gearbox Internals

SIZE **B** | Assignment Number **Drawing Project** | REV 1

FILE NAME:
Front Gear and Shaft Assembly

SCALE: 1:1 | Mass: 31.95 | SHEET 4 OF 7

ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Author)	QTY.
1	Front Motor Mount Holder	AISI 1020 Steel, Cold Rolled	8.12	Chengshunzi Dong	1
2	front Engine clamp	ABS	1.96	Chengshunzi Dong	1
3	Inner Front Motor Mount Sheet Metal	AISI 1020 Steel, Cold Rolled	2.70	Brayden Stecyk	1
4	Motor Pins	AISI 1020	0.36	Brayden Stecyk	2
5	DC Motor	Material <not specified>	30.32		1
6	3_32 Brass Tubing	Brass	1.89	Brayden Stecyk	1
7	1_8 Square Brass Tubing	Brass	2.62	Brayden Stecyk	1
8	ABS Single Start Worm	ABS	0.00	D.S. Nobes (Altered by Brayden Stecyk)	1
9	Front Motor Shaft Guide	AISI 1020 Steel, Cold Rolled	5.81	Brayden Stecyk	1



MecE 265

Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:

DRAWN BY:
Brayden Stecyk

Lab Day

SM By **Brayden Stecyk**

TA Initials

Brayden
March-29-16 12:31:37 AM
March-25-16 10:47:16 PM

FILE NAME:
Front Motor Assembly

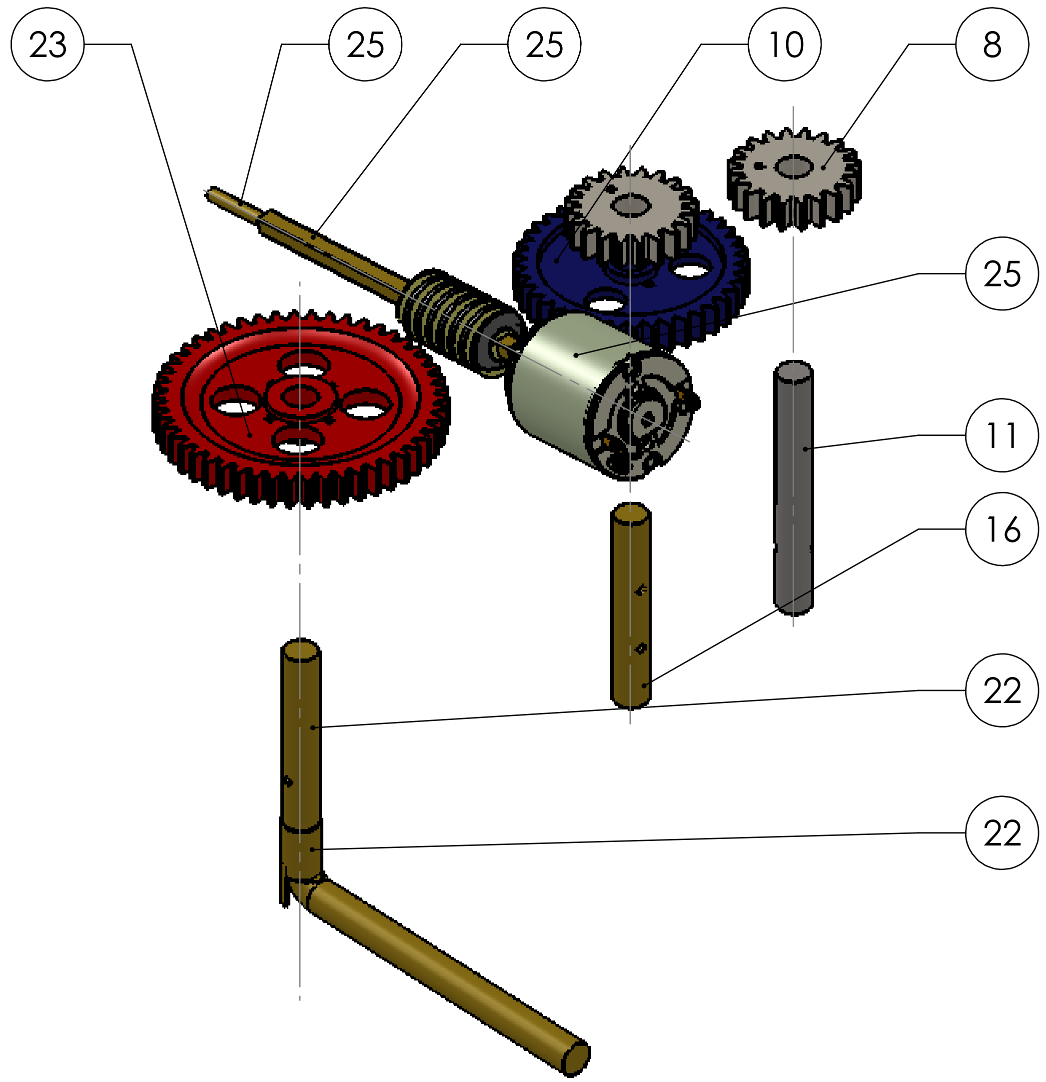
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Front Motor Assembly Exploded View

SIZE **B** | Assignment Number **Drawing Project** | REV

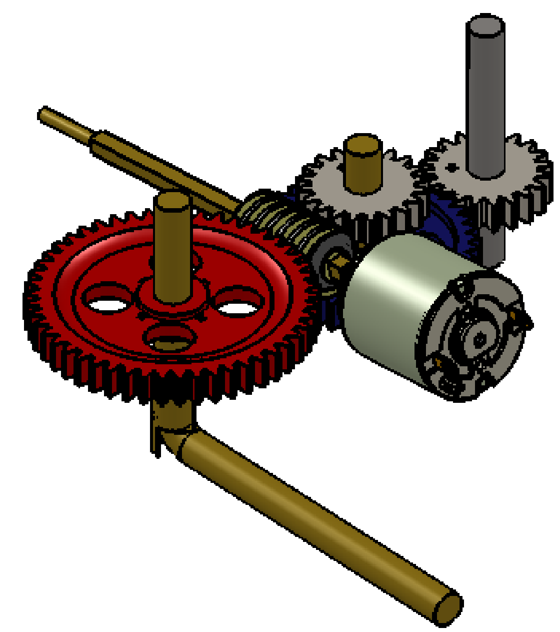
SCALE: 1:1 | Mass: | SHEET 2 OF 7

ITEM NO.	PART NUMBER	SW-Author(Author)	QTY.
8	20mm Spur Gear Drilled	Brayden Stecyk	2
10	40mm Spur Gear Drilled	Brayden Stecyk	1
11	Camera Rod	Farhan Khan	1
16	Gear Reducer Rod	Chengshunzi Dong	1
22	Front Roller Assembly	Brayden Stecyk	1
23	50mm Spur Gear Front Drilled	Brayden StecykB3	1
25	Front Motor Assembly	Brayden Stecyk	1



NOTE:
Drawings are to be marked in detail

Please Mark This Subassembly
For TOYA OKEKE



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MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:
Motor System for Front Wheels

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DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:
1104.21

FILE NAME:
Front Motor-Gear Assembly

DRAWN BY:
Toya Okeke

Lab Day: ALL
SM By: **Toya Okeke**
TA Initials: DSN

tokeke
Sunday, March 27, 2016 11:52:33 PM
Thursday, February 25, 2016 4:20:36 PM

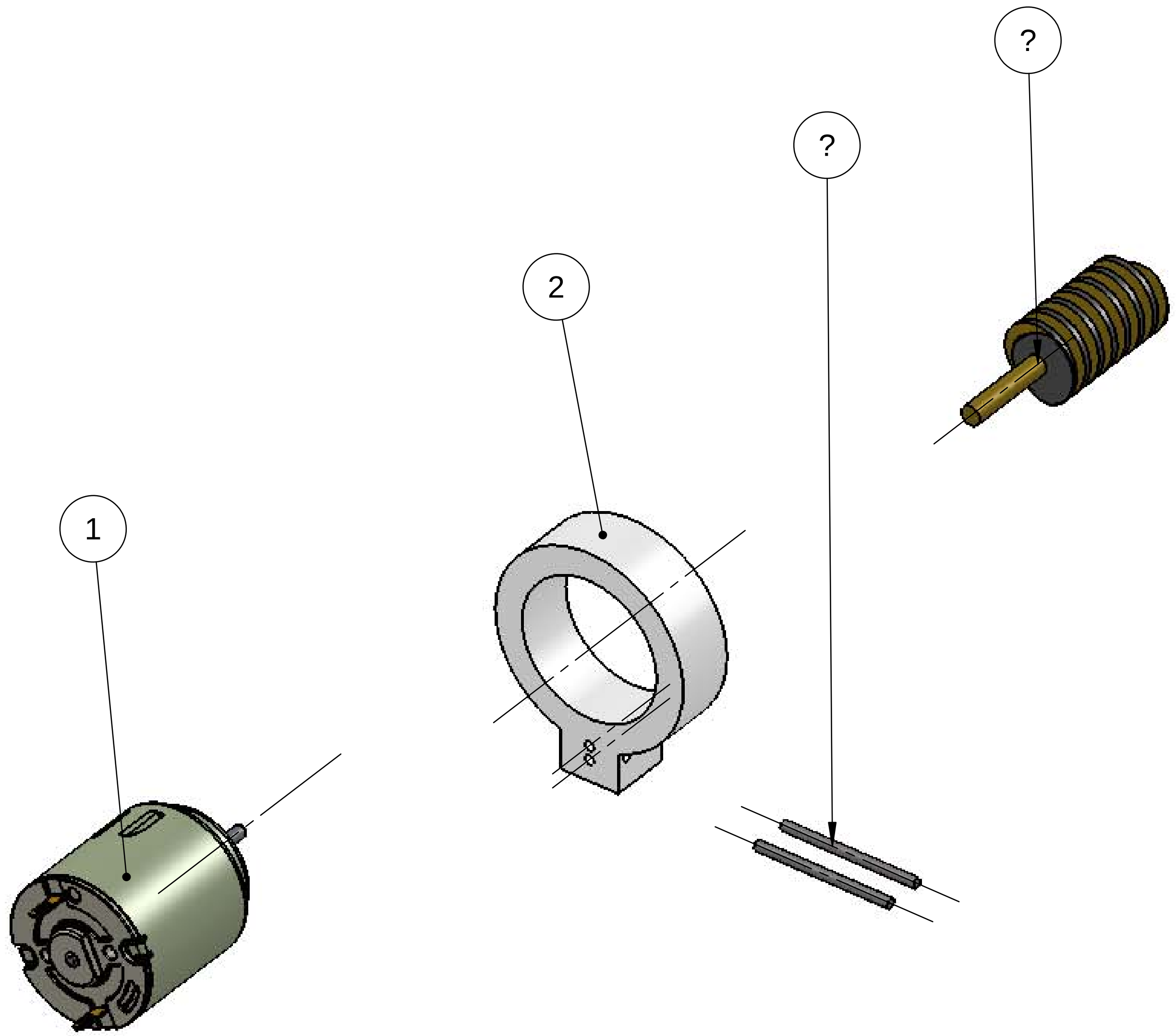
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Motor System: Isometric & Exploded Views

SIZE: B
Assignment Number: Drawing Project
REV: 1

SCALE: 3:4 | Mass: 1104.21 | SHEET 1 OF 4

ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Author)	QTY.
1	DC Motor	Material <not specified>	30.32		1
2	Back Engine clamp	ABS	4.66	Andrew Lam	1
3	Back Worm	Brass	0.04 lb	D.S. Nobes	1
4	Motor Pins	AISI 1020	0.36	Brayden Stecyk	2



MecE 265

Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny

Comments:
Comment: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
Various

FILE NAME:
Rear Motor Assembly

DRAWN BY:
Brayden Stecyk

Lab Day	
SM By	**Brayden Stecyk**
TA Initials	

Brayden
March-29-16 2:05:53 AM
February-25-16 4:20:36 PM

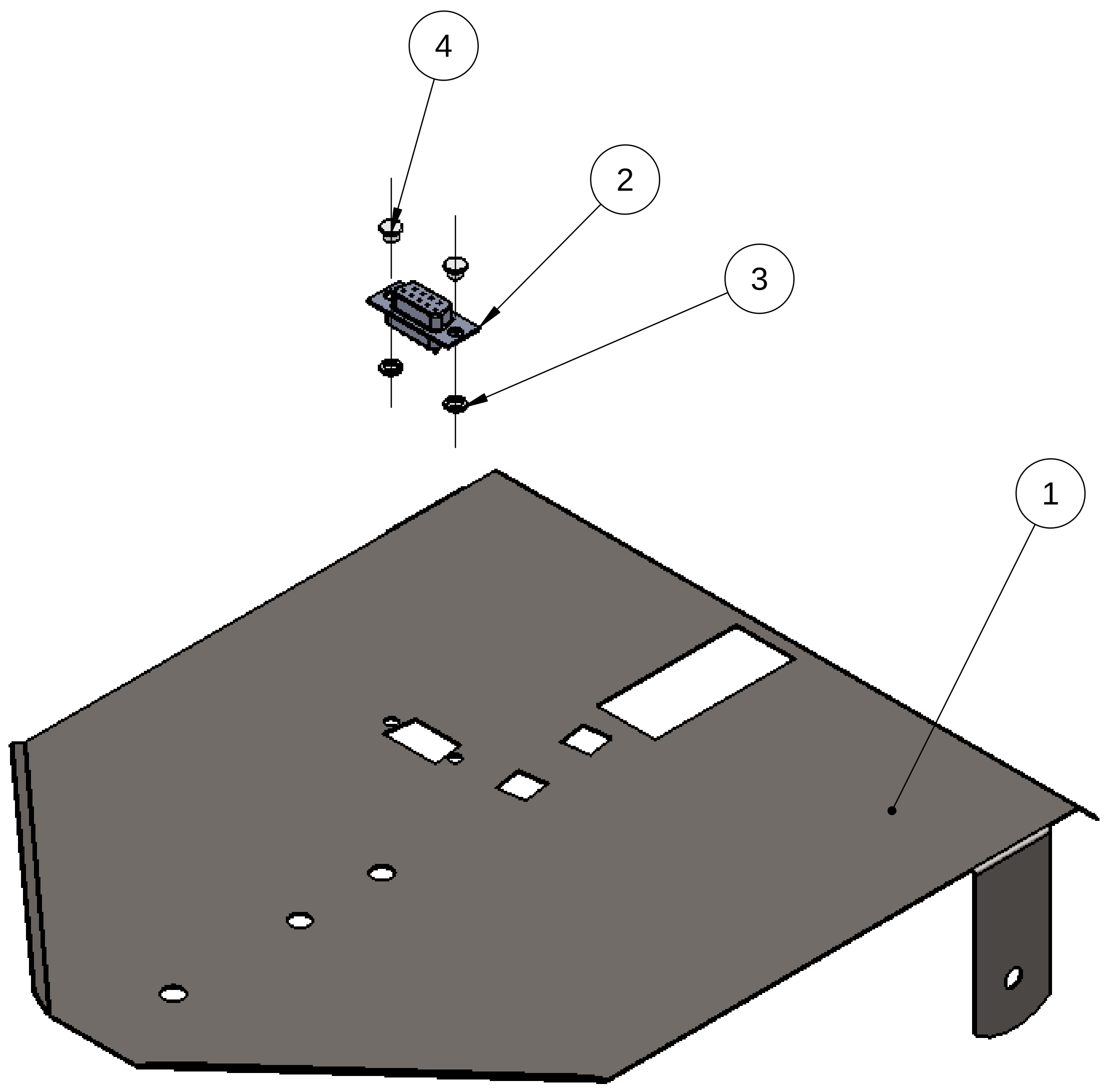
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Rear Motor Assembly Exploded View

SIZE	Assignment Number	REV
B	**Drawing Project**	1

SCALE: 1:1	Mass: 52.46	SHEET 6 OF 7

ITEM NO.	PART NUMBER	Material	Mass	SW-Author(Author)	QTY.
1	BODY	AISI 1020 Steel, Cold Rolled	322.73	Andrew Lam	1
2	D9 Pin Connector	Material <not specified>	1.86	Monica Ho	1
3	D9 Connector washer	ABS	0.02		2
4	D9 Connector Bolt	ABS	0.06		2



MecE 265

Instructor: Dr. DS Nobes, Dr. Pierre Mertiny

Comments: Comment: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:

DRAWN BY: **Brayden Stecyk**

Lab Day

SM By **Brayden Stecyk**

TA Initials

Brayden
March-29-16 9:27:16 AM
February-25-16 4:20:36 PM

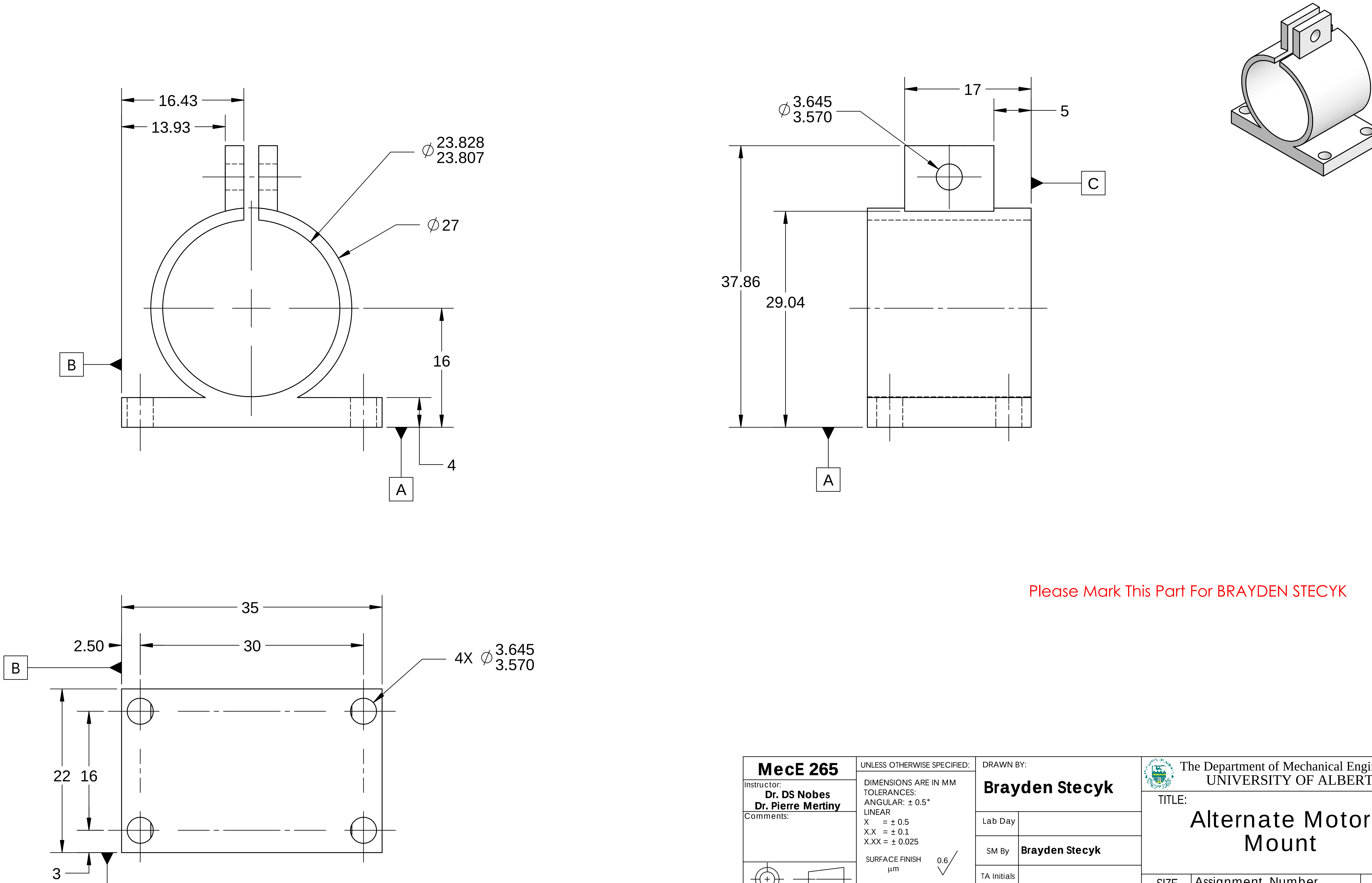
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE: Body and D9 Connector Exploded View

SIZE **B** | Assignment Number **Drawing Project** | REV 1

FILE NAME: Body and D9 Connector

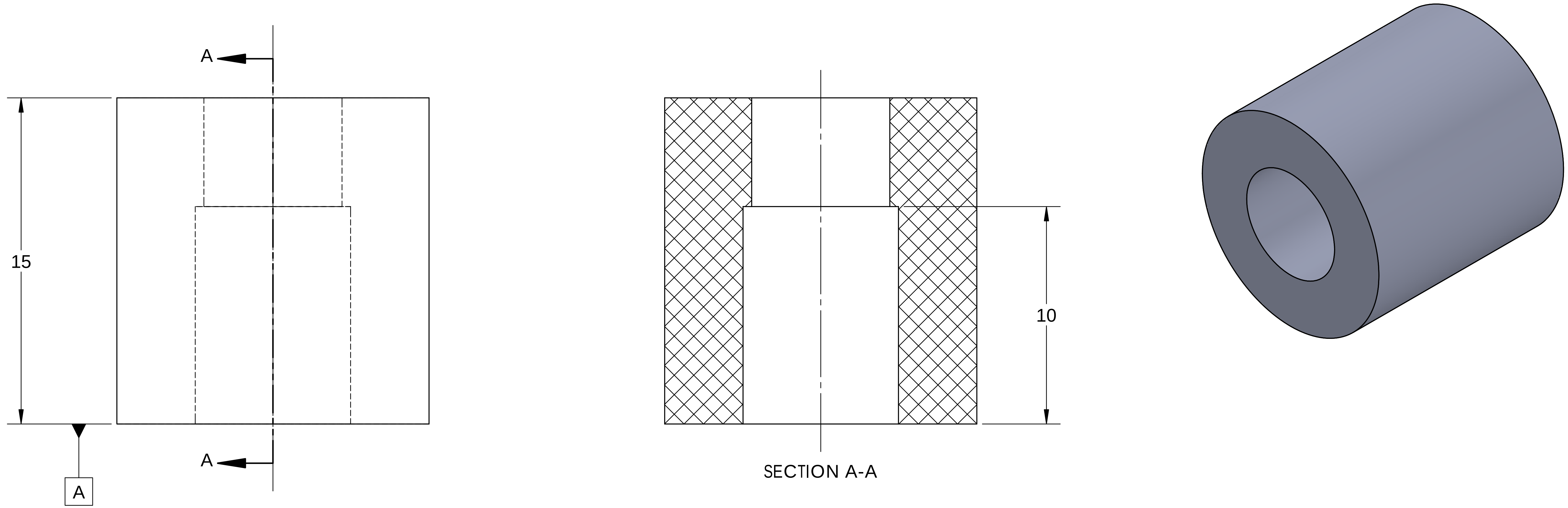
SCALE: 1:2 | Mass: 324.75 | SHEET 7 OF 7

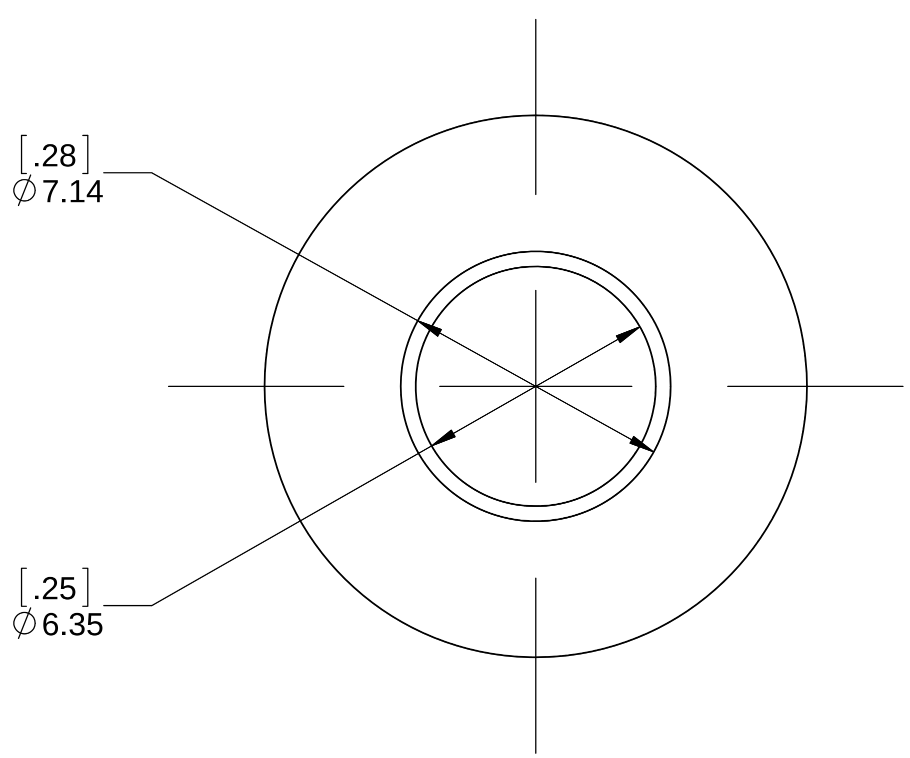


Please Mark This Part For BRAYDEN STECYK

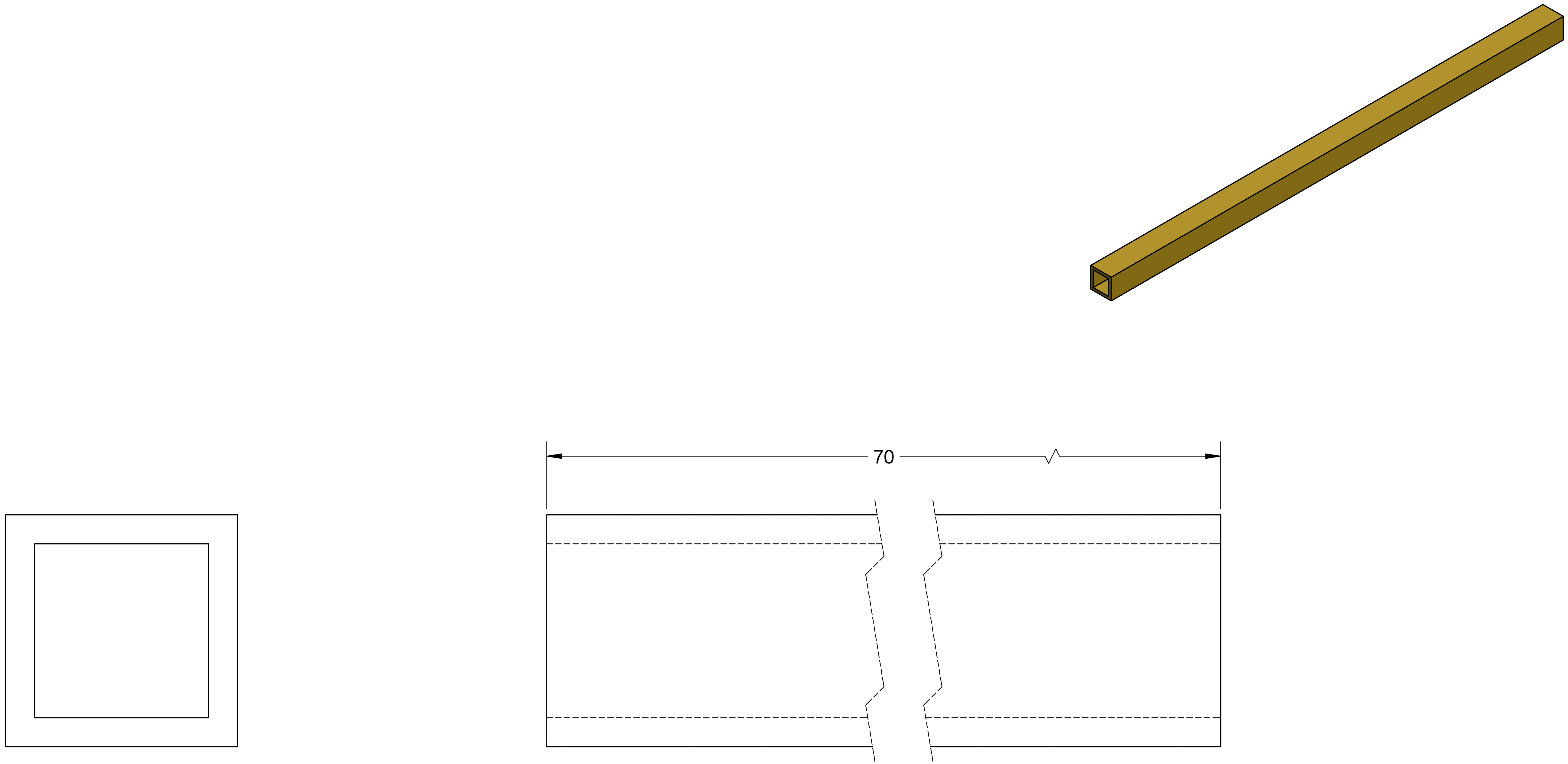
MecE 265 Instructor: **Dr. DS Nobes** **Dr. Pierre Mertiny** Comments:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Brayden Stecyk** Lab Day SM By **Brayden Stecyk** TA Initials Brayden March-28-16 8:57:35 PM March-27-16 11:33:36 AM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Alternate Motor Mount SIZE **B** Assignment Number **Drawing Project** REV
MATERIAL: ABS			
FILE NAME: 265 Alternate Motor Mount			SCALE: 2:1 Mass: 5.97 SHEET 1 OF 1

Hole / Shaft	**Basis**	**Fit**	**Description**	**Nominal (mm)**	**Limits (mm)**
Motor Hole	Shaft(G7/h6)	Clearance	Sliding Fit	23.8	[23.807,23.828]
Bolt Holes	Shaft(C11/h11)	Clearance	Loose Fit	3.5	[3.570,3.645]

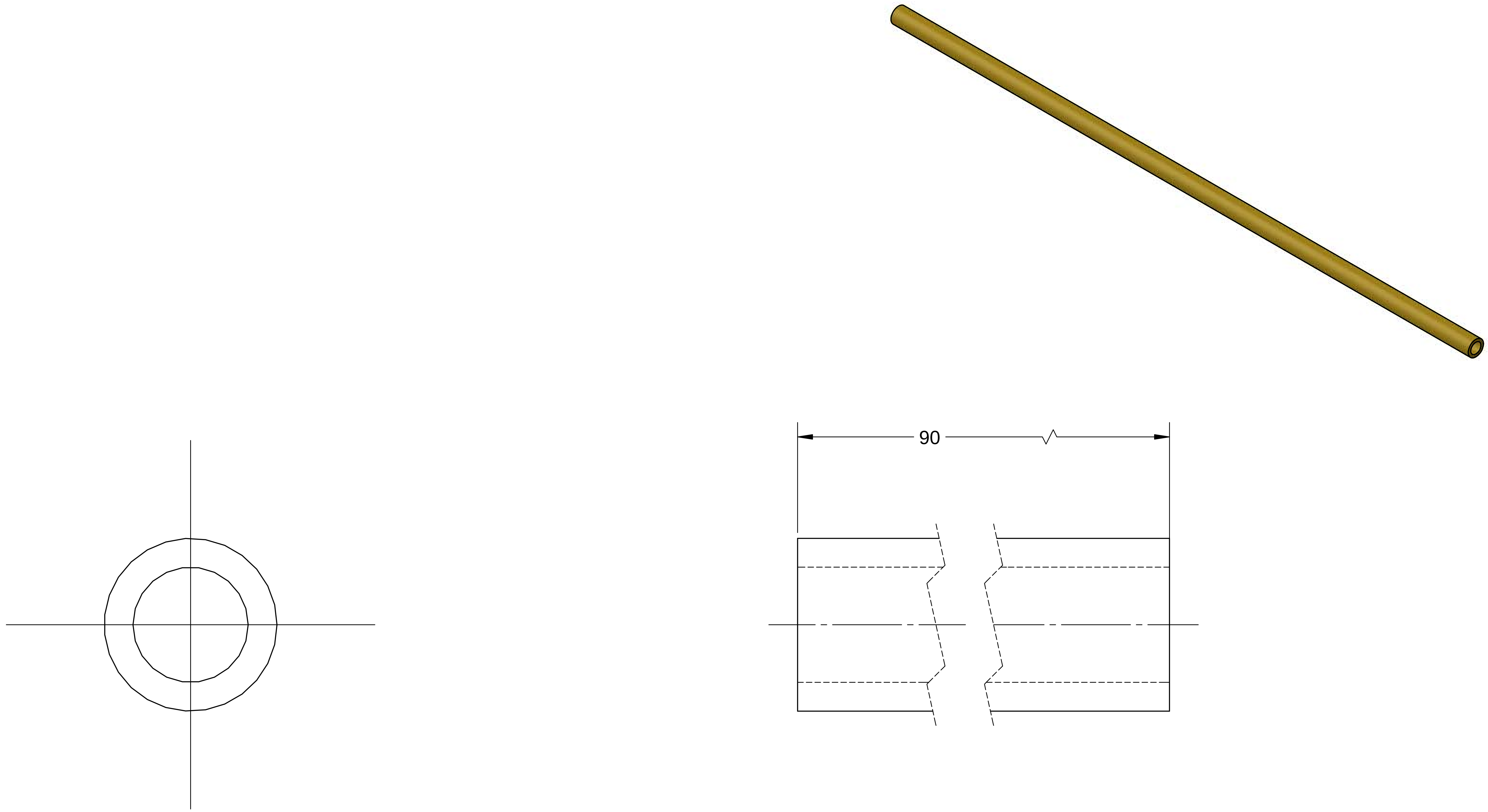




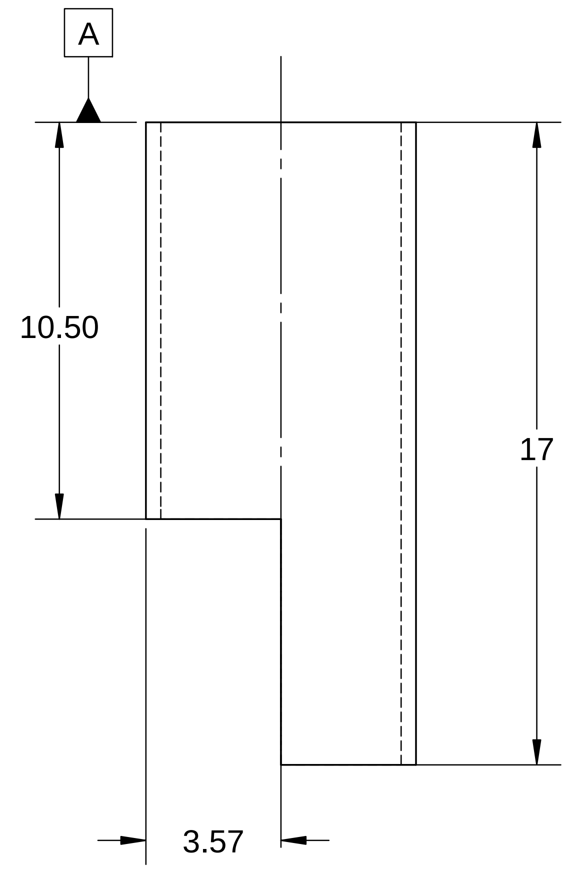
MecE 265 Instructor: **Dr. DS Nobes Winter 2016** Comments:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Brayden Stecyk** Lab Day SM By **Brayden Stecyk** TA Initials	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: 1/4" Nylon Collar With 9/32 Bore
MATERIAL: Nylon		Brayden March-29-16 1:51:02 AM March-25-16 3:45:42 PM	SIZE **B** Assignment Number **Design Project** REV
FILE NAME: 1_4 in ID Nylon Collar with Bore			SCALE: 5:1 Mass: 2.15 SHEET 1 OF 1

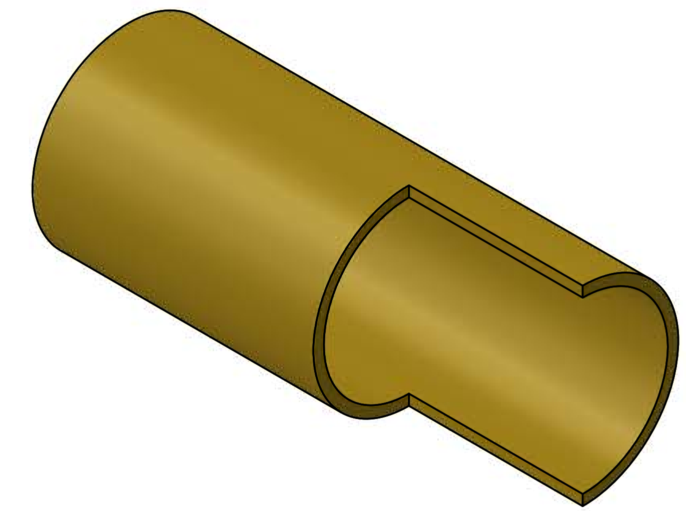


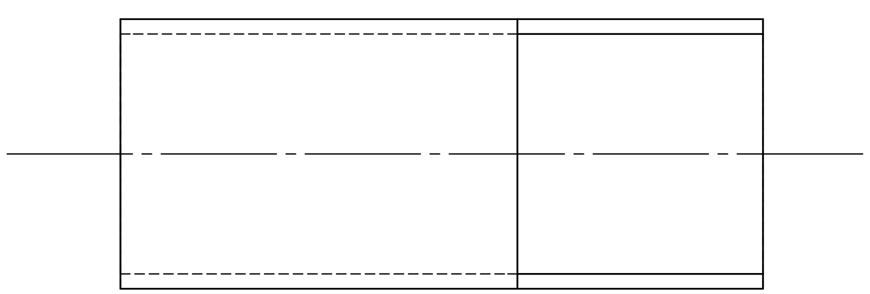
MecE 265	UNLESS OTHERWISE SPECIFIED:	DRAWN BY: **Brayden Stecyk**	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA
Instructor: **Dr. DS Nobes** **Dr. Pierre Mertiny** Comments:	DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	Lab Day SM By **Brayden Stecyk** TA Initials	TITLE: 1/8 " Square Brass Tubing
MATERIAL: Brass		Brayden March-28-16 1:26:27 PM March-25-16 11:37:44 PM	SIZE **B** Assignment Number **Drawing Project** REV
FILE NAME: 1_8 Square Brass Tubing			SCALE: 16:1 Mass: 2.62 SHEET 1 OF 1

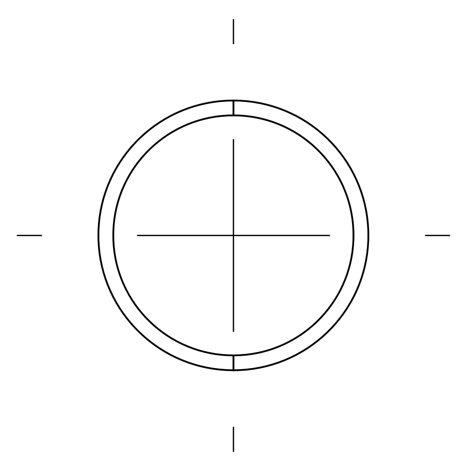


MecE 265 Instructor: **Dr. DS Nobes**, **Dr. Pierre Mertiny** Comments:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Brayden Stecyk** Lab Day SM By **Brayden Stecyk** TA Initials	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: 3/32 " Brass Tubing
MATERIAL: Brass		Brayden March-29-16 12:51:37 AM March-25-16 11:30:20 PM	SIZE **B** | Assignment Number **Drawing Project** | REV
FILE NAME: 3_32 Brass Tubing			SCALE: 16:1 | Mass: 1.89 | SHEET 1 OF 1









MecE 265

Instructor:
Dr. DS Nobes
Dr. Pierre Mertiny

Comments:

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Farhan Khan

Lab Day

SM By **Brayden Stecyk**

TA Initials

Brayden
March-28-16 2:33:37 PM
March-25-16 1:09:10 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
9/32 " Brass Collar

MATERIAL:
Brass

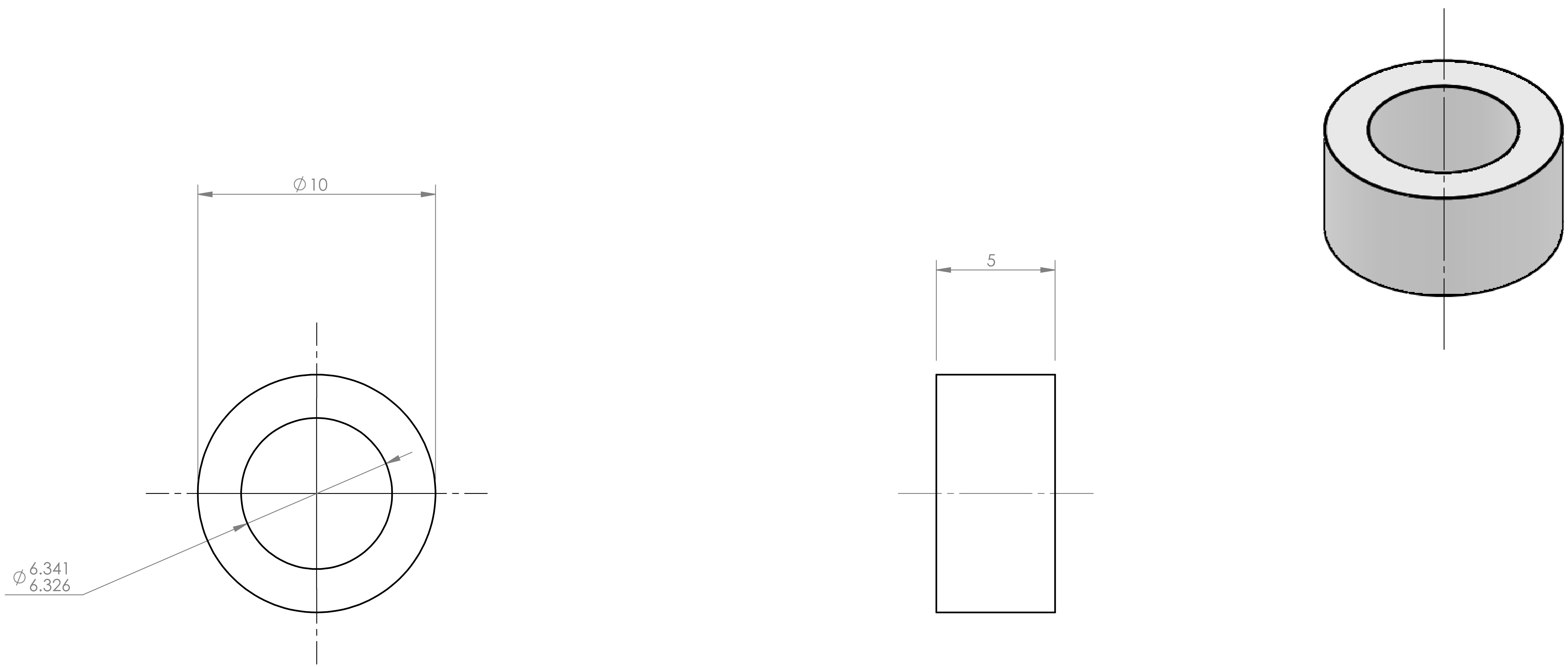
FILE NAME:
9_32 brass collar

SIZE **B**

Assignment Number
Drawing Project

REV

SCALE: 5:1 | Mass: 0.97 | SHEET 1 OF 1



MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:
Commnet: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong
Lab Day: WED
SM By: **Andrew Lam**
TA Initials: DSN
Mec33
Saturday, March 26, 2016 12:48:52 PM
Sunday, February 28, 2016 10:57:22 PM

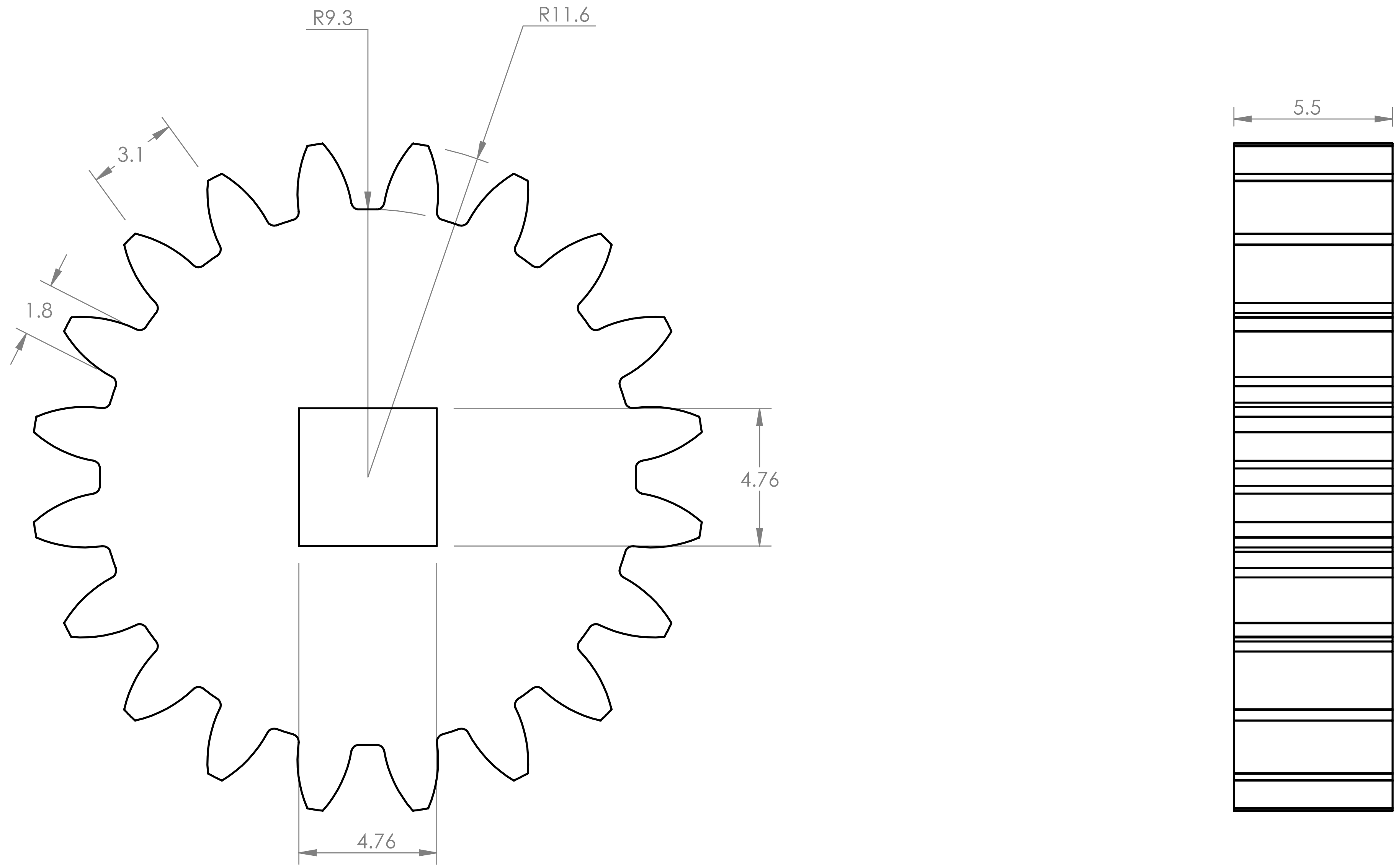
MATERIAL:
ABS
FILE NAME:
ABS Collar

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

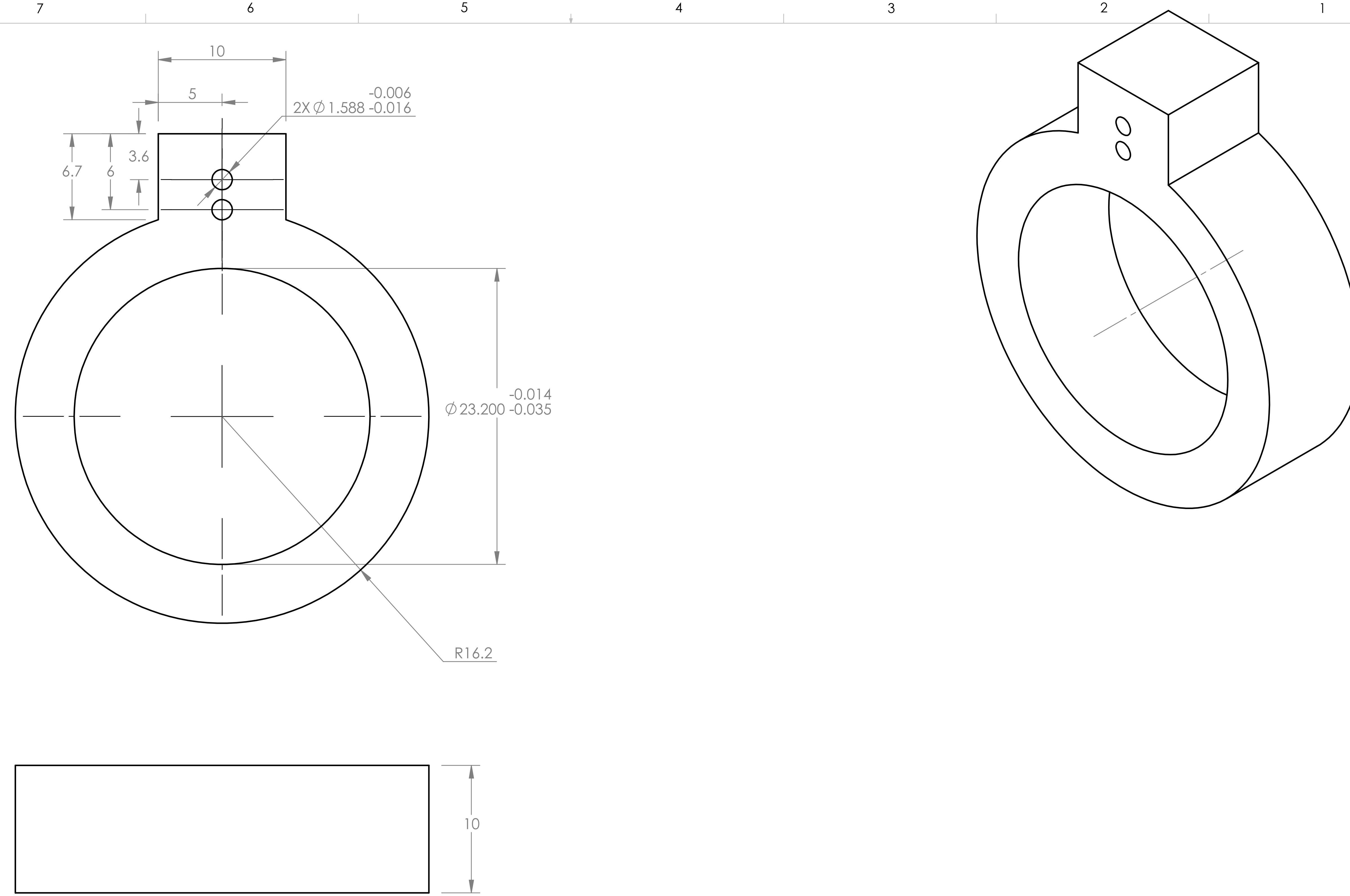
TITLE:
ABS Collar

SIZE: **B**
Assignment Number: Drawing Project
REV: 1
SCALE: 5:1
Mass: 0.24
SHEET 1 OF 1

Tolerance for the Collar	Basis	Tolerance	Tolerance for holes	Dimensions
Interference Fits	shaft basis	P7/H6	P7[-0.009, -0.024] mm	[6.326, 6.341]



Instructor: **Dr. Nobes**	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025	DRAWN BY: **Andrew Lam**	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA
Comments:	SURFACE FINISH µm 0.6	Lab Day	TITLE: 20mm Spur gear
	DO NOT SCALE DRAWING	SM By **Brayden Stecyk**	
		TA Initials	SIZE **B**
MATERIAL: ABS PLastic		Mec33 Monday, March 28, 2016 12:44:42 AM Tuesday, February 08, 2000 9:41:59 AM	Assignment Number: Drawing Project; REV
FILE NAME: 20mm Spur Gear (Square Punched)			SCALE: 5:1 | Mass: 1.77g | SHEET 1 OF 1



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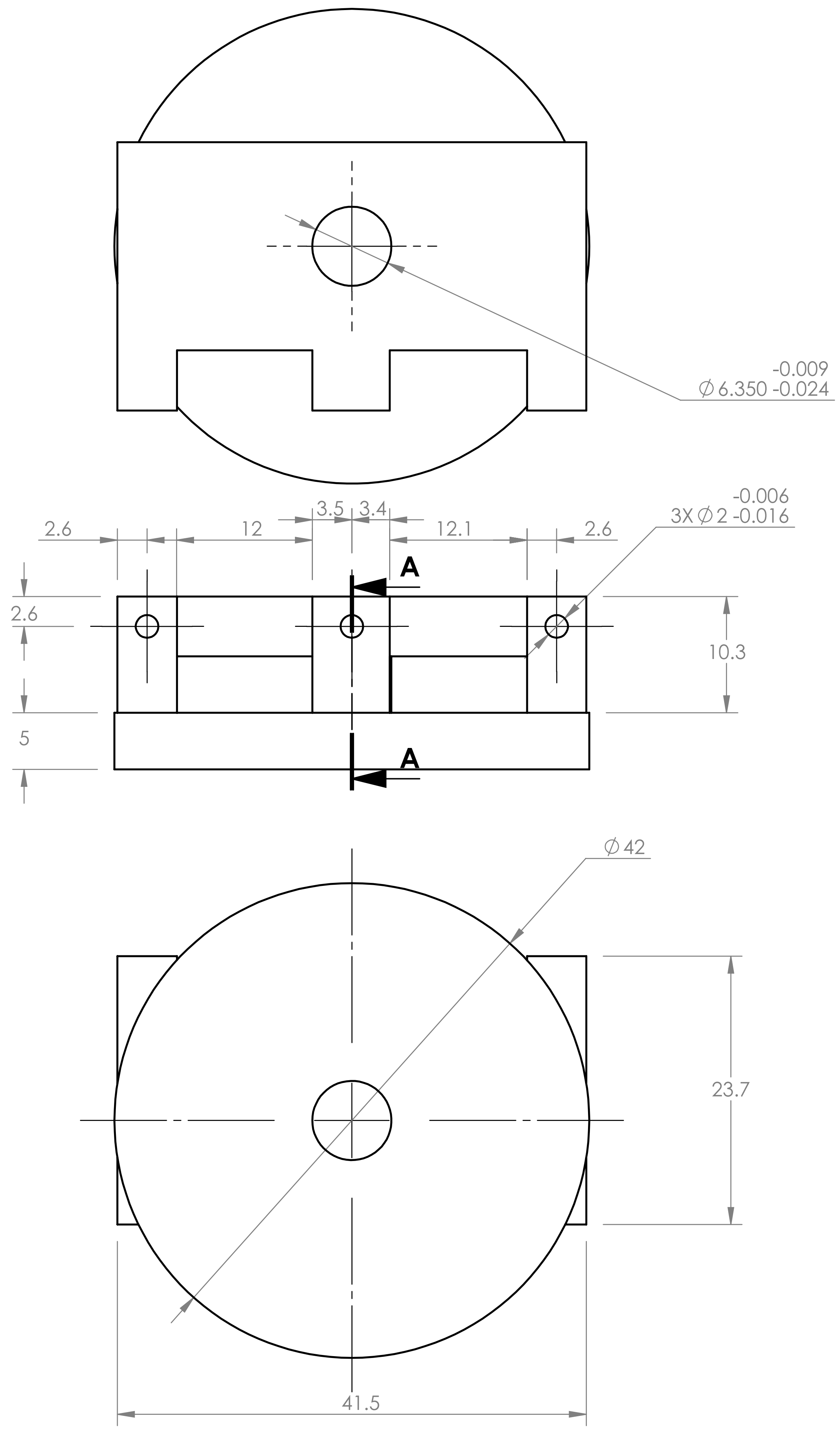
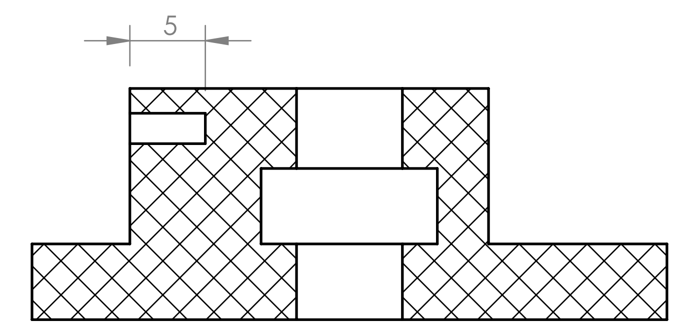
For Instructional Use Only.

Mar 16, 2016	UNLESS OTHERWISE SPECIFIED:	DRAWN BY:	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA
Instructor: **Dr. Nobes** **Dr. Pierre Mertiny**	DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025	**Andrew Lam**	TITLE: Back Engine Clamp
Comments:	SURFACE FINISH µm 0.6	Lab Day	
		SM By **Andrew Lam**	
	DO NOT SCALE DRAWING	TA Initials	SIZE **B** · Assignment Number: Drawing Project · REV
MATERIAL: ABS		Andrew March 17, 2016 2:44:21 AM March 9, 2016 9:29:29 PM	
FILE NAME: Back Engine clamp			SCALE: 3:1 · Mass: 4.70g · SHEET 1 OF 1





SECTION A-A

Mar 16, 2016

Instructor:
Dr. Nobes
Dr. Pierre Mertiny

Comments:

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Andrew Lam

Lab Day

SM By **Andrew Lam**

TA Initials

Mec33
Thursday, March 17, 2016 12:37:26 AM
Thursday, March 10, 2016 7:25:14 PM

MATERIAL:
ABS

FILE NAME:
Camera mount holder

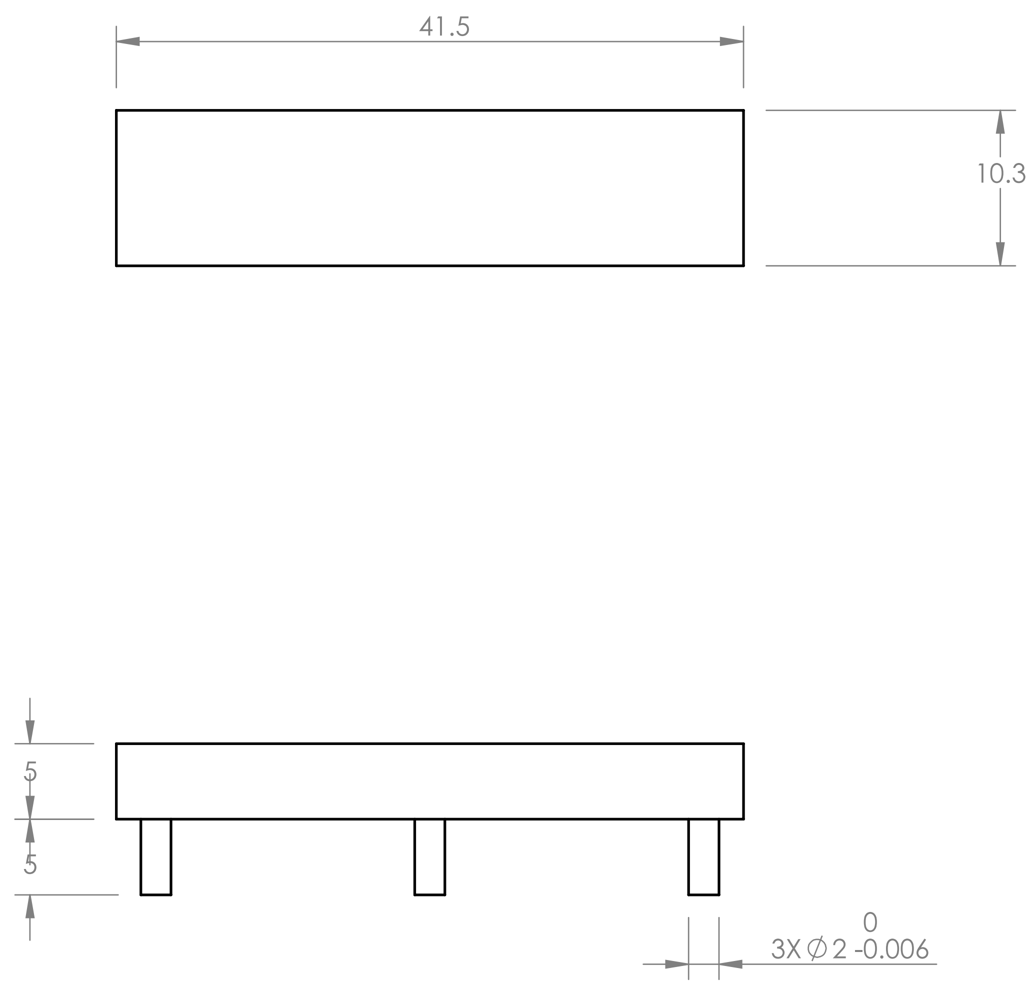
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Camera Mount Holder

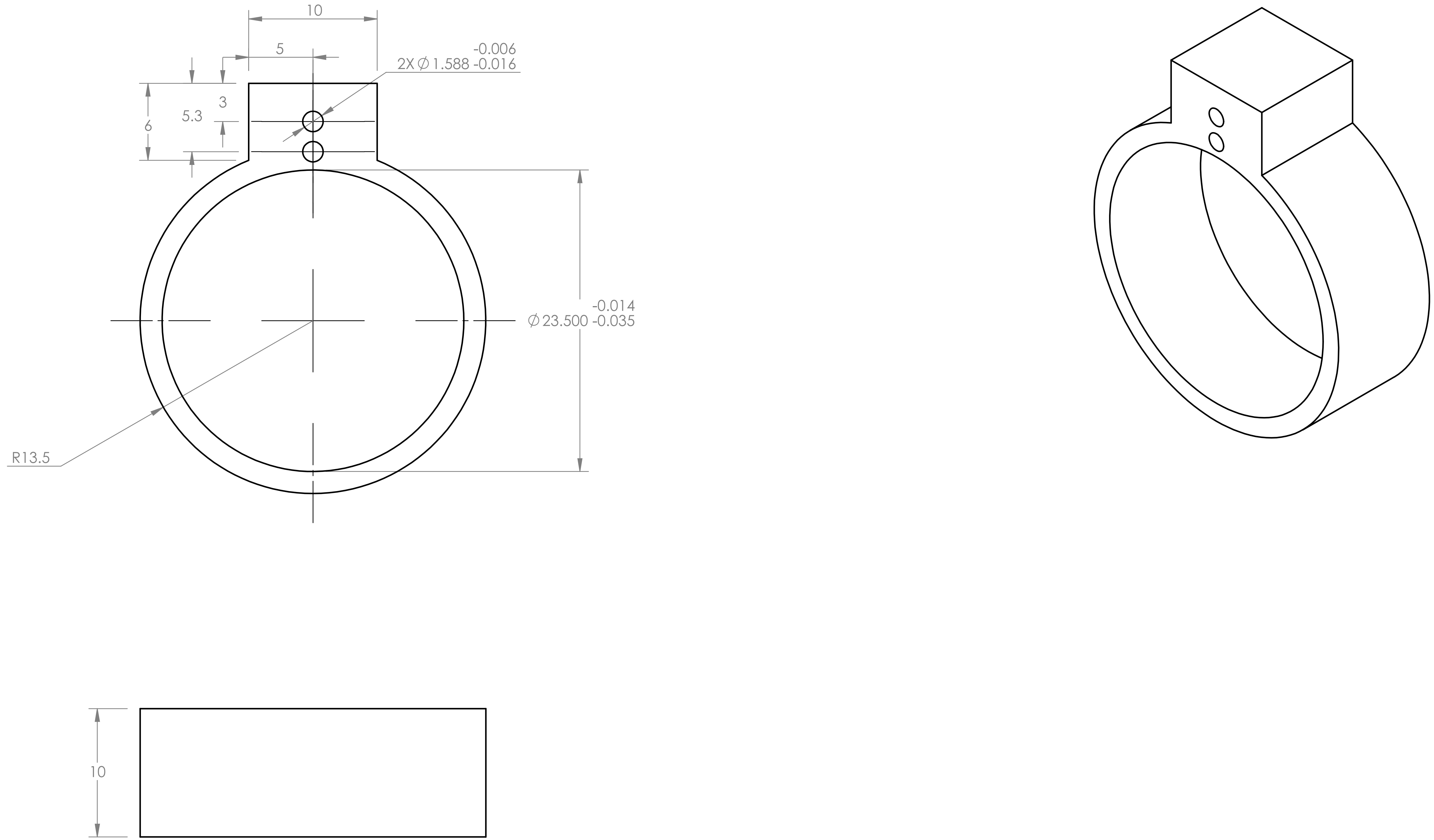
SIZE **B** | Assignment Number | REV

Drawing Project

SCALE: 2:1 | Mass: 13.11g | SHEET 1 OF 2



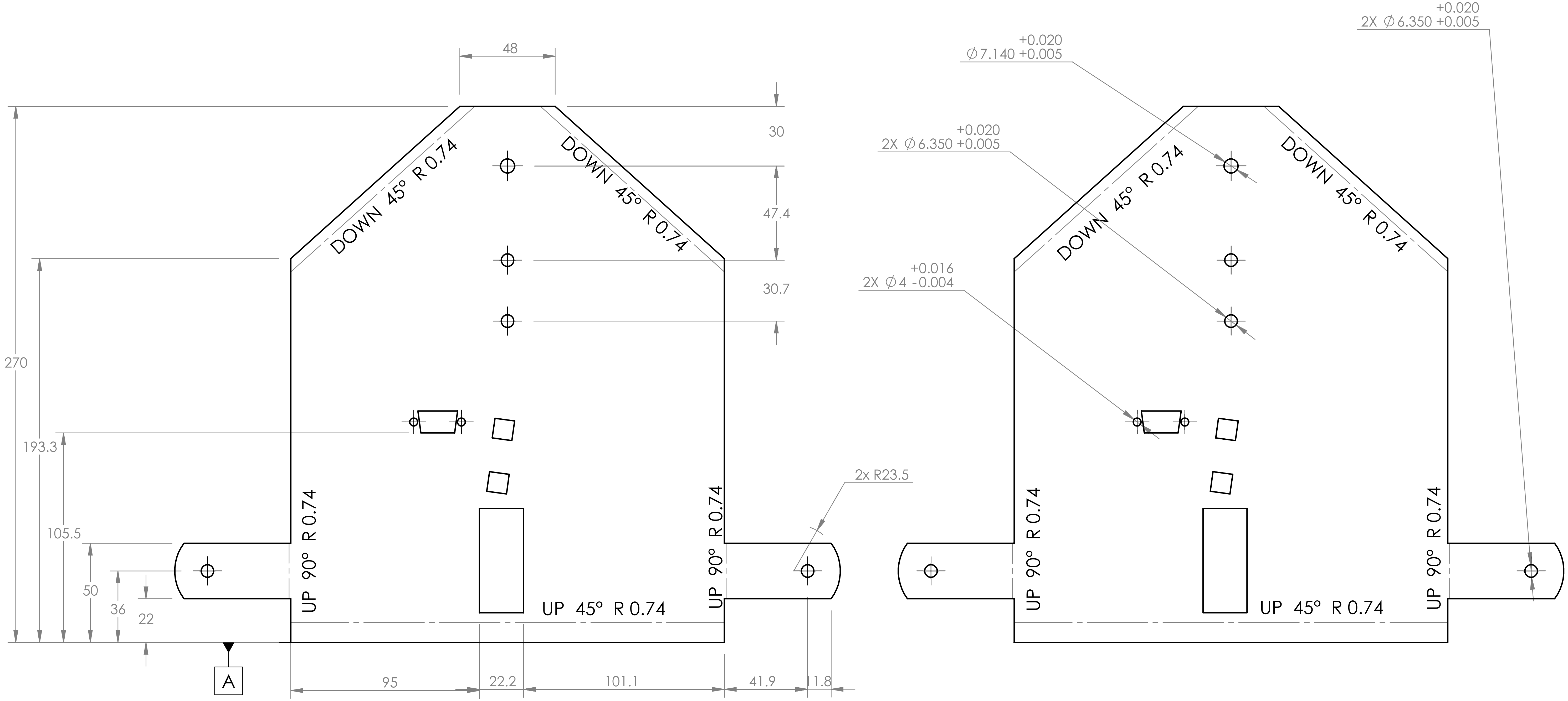
Mar 16, 2016 Instructor: Dr. D.S.Nobes Dr. Pierre Mertiny Comments: Commnet: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam** Lab Day: ALL SM By: Andrew Lam TA Initials: DSN Mec33 Wednesday, March 16, 2016 11:30:20 PM Wednesday, March 16, 2016 11:25:16 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Back Attached Camera Mount SIZE: B Assignment Number: Drawing Project REV: 1
MATERIAL: ABS			SCALE: 2:1
FILE NAME: Back attached Camera Mount			Mass: 2.22 | SHEET 2 OF 2



Instructor: Dr. Nobes, Dr. Pierre Mertiny Comments:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam** Lab Day SM By **Chengshunzi Dong** TA Initials	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Front Engine Mount
MATERIAL: ABS		Mec33 Thursday, March 17, 2016 2:03:13 PM Wednesday, March 09, 2016 9:29:29 PM	SIZE **B** · Assignment Number: Drawing Project · REV
FILE NAME: front Engine clamp			SCALE: 3:1 · Mass: 1.89g · SHEET 1 OF 1

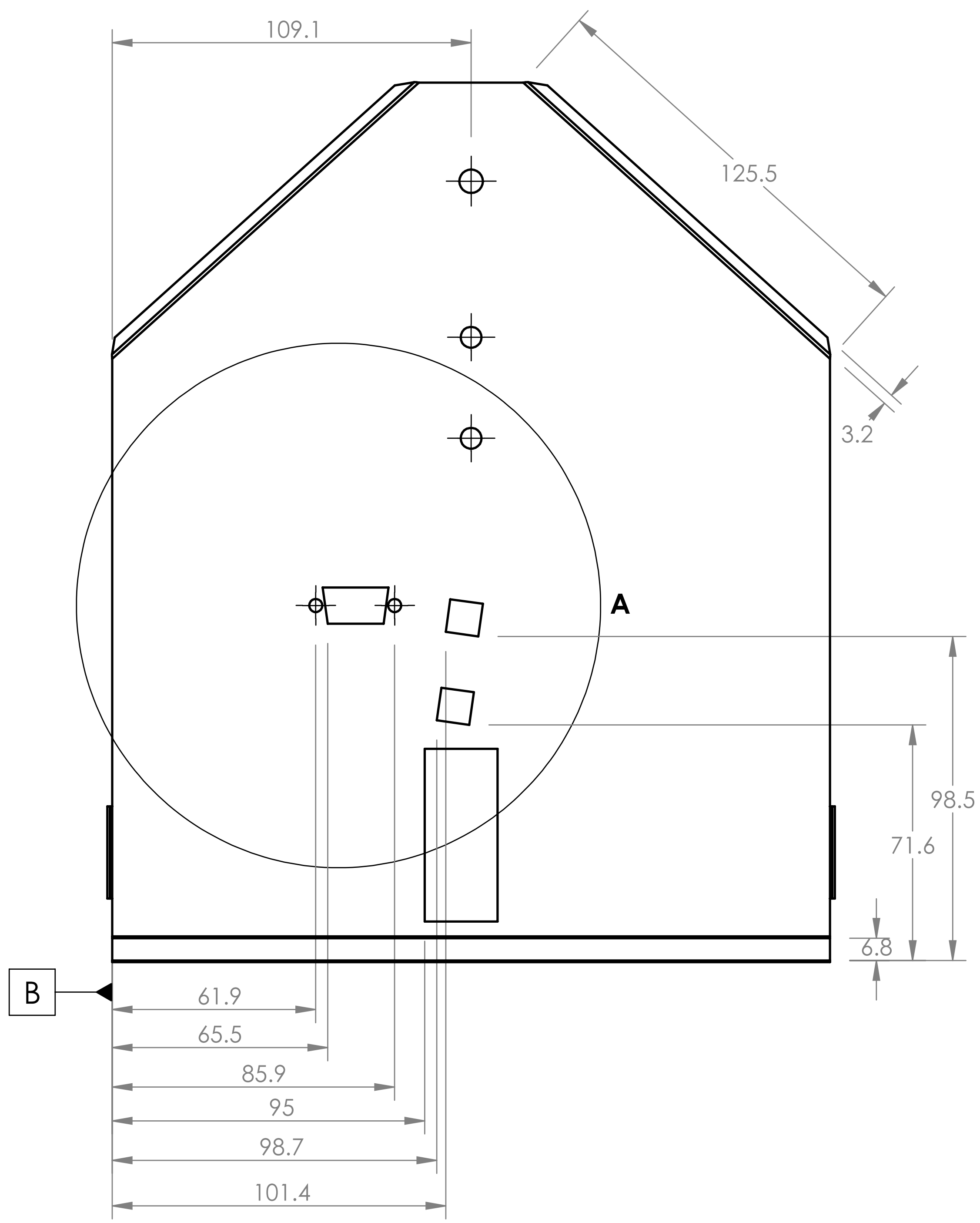
Hole/Shaft	Bases	Fit	Description	Nominal (mm)	Limits (mm)
Back/Front Engine Clamp Engine Diameter	Shaft (P7/h6)	Interference	Rigidity	23.2	(23.165,23.186)
Back/Front Engine Clamp Pin Diameter	Shaft (P7/h6)	Interference	Rigidity	1.588	(1.572,1.582)
Camera Mount Rod Diameter	Shaft(P7/h6)	Interference	Rigidity	6.35	(6.326,6.341)
Camera Mount 3 holes	Shaft (P7/h6)	Interference	Rigidity	2	(1.984,1.994)
Back Attached Camera Mount	Shaft(P7/h6)	Interference	Rigidity	2	(1.994,2)

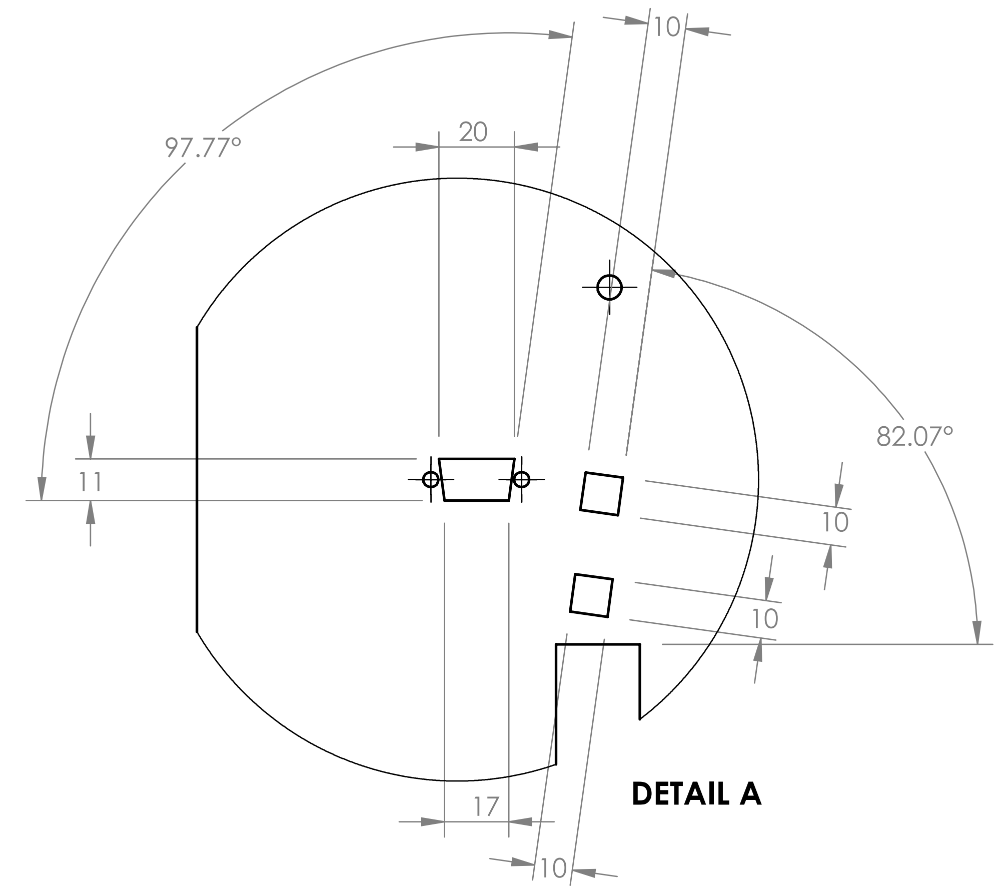
Please Mark This Part For ANDREW LAM



MecE 265 Instructor: **Dr. D.S.Nobes** **Win 2016** Comments: Commnet: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam** Lab Day: ALL SM By: **Andrew Lam** TA Initials: DSN	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Sheet Metal Body
MATERIAL: AISI 1020 Steel, Cold Rolled		Mec33 Sunday, March 27, 2016 8:56:29 PM Thursday, February 25, 2016 4:12:54 PM	SIZE **B** Assignment Number: Drawing Project REV 1
FILE NAME: BODY			SCALE: 1:2 Mass: 322.81 SHEET 1 OF 2

Please Mark This Part For ANDREW LAM





DETAIL A

MecE 265

Instructor:
Dr. D.S.Nobes
Win 2016

Comments:
Commnet: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
AISI 1020 Steel, Cold Rolled

FILE NAME:
BODY

DRAWN BY:
Andrew Lam

Lab Day	ALL
SM By	**Andrew Lam**
TA Initials	DSN

Mec33
Sunday, March 27, 2016 8:56:29 PM
Thursday, February 25, 2016 4:12:54 PM

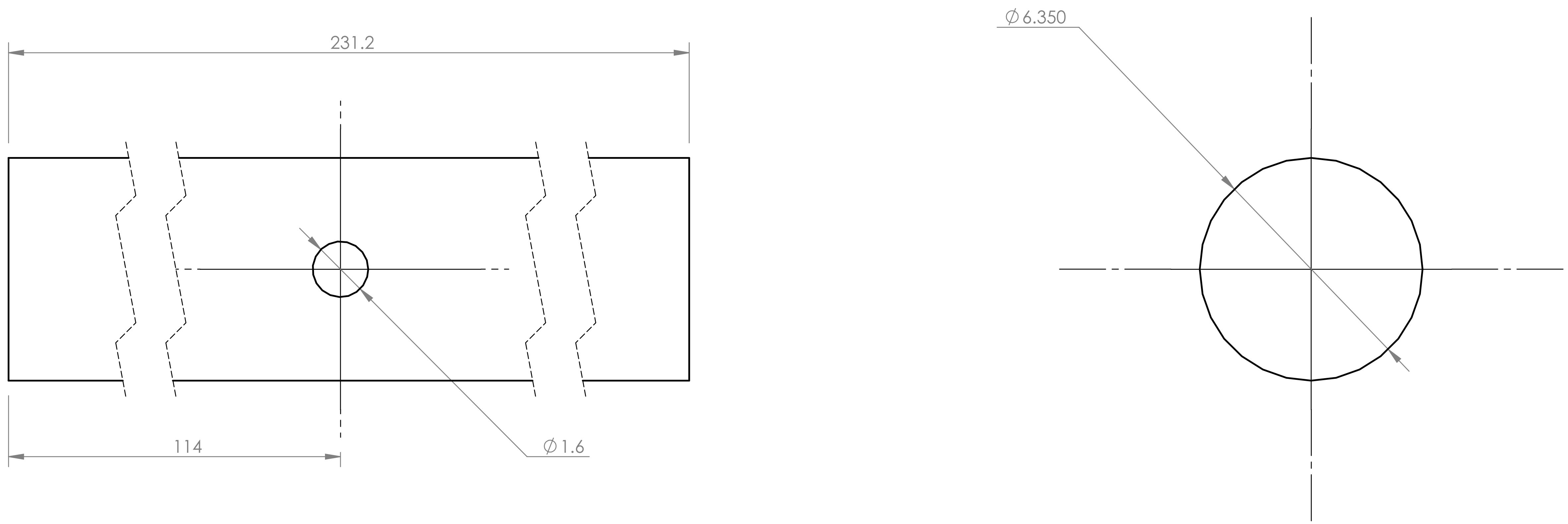
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Sheet Metal Body

SIZE	Assignment Number	REV
B	Drawing Project	1

SCALE: 1:2 | Mass: 322.81 | SHEET 2 OF 2

Hole	Bases	Fit	Description	Nominal (mm)	Limits (mm)
Front Hole	Shaft (G7/h6)	Clearance	Sliding Fit	7.14	(7.145,7.16)
Second and Third Hole	Shaft (G7/h6)	Clearance	Sliding Fit	6.35	(6.355,6.37)
Holes for Axle	Shaft (G7/h6)	Clearance	Sliding Fit	6.35	(6.355,6.37)
D9 Connector Hole	Shaft (G7/h6)	Clearance	Sliding Fit	4	(4.004,4.016)



Instructor: **Dr. Nobes**

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY: **Andrew Lam**

Lab Day

SM By **Andrew Lam**

TA Initials

Mec33
Monday, March 28, 2016 12:36:51 AM
Thursday, January 07, 2010 3:44:18 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE: Rear Axle

SIZE **B**

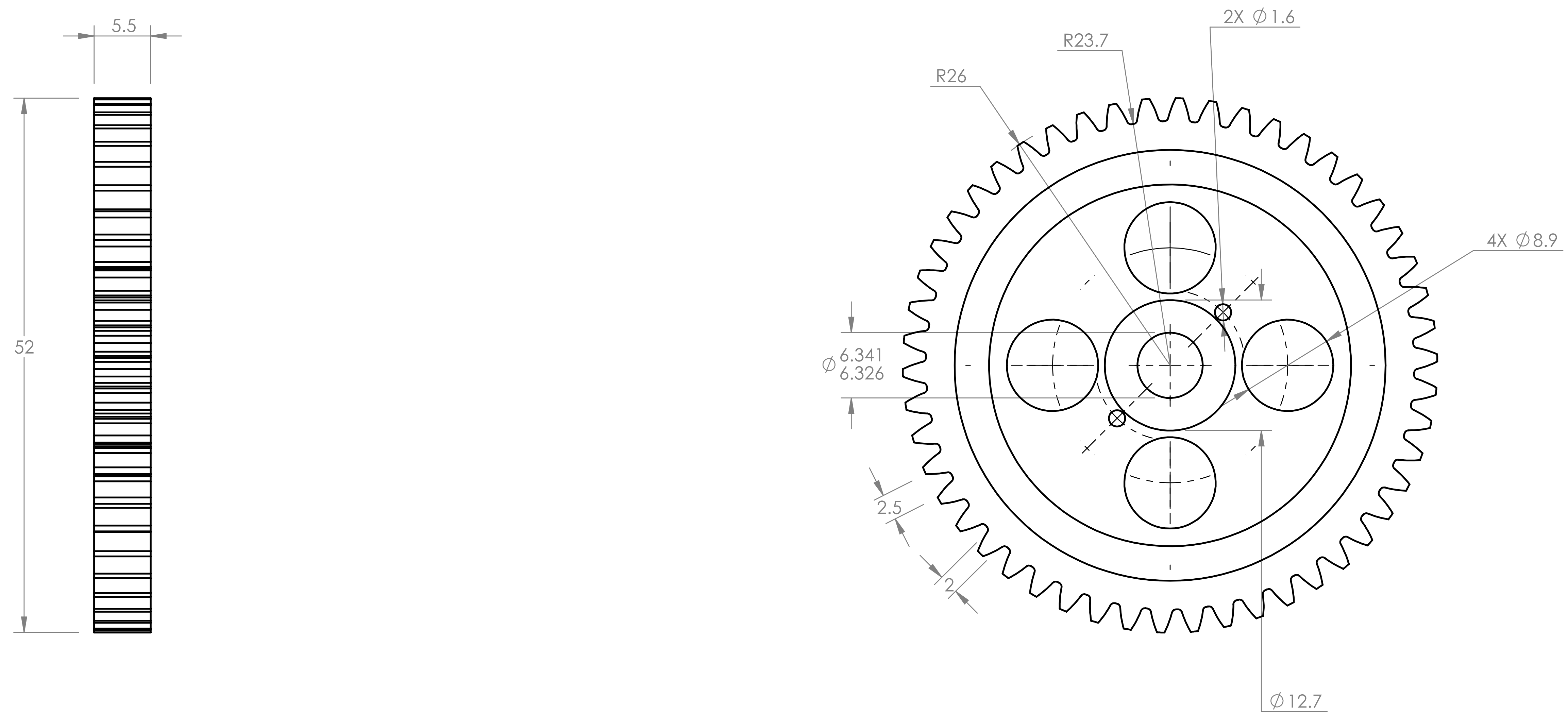
Assignment Number
Drawing Project

REV

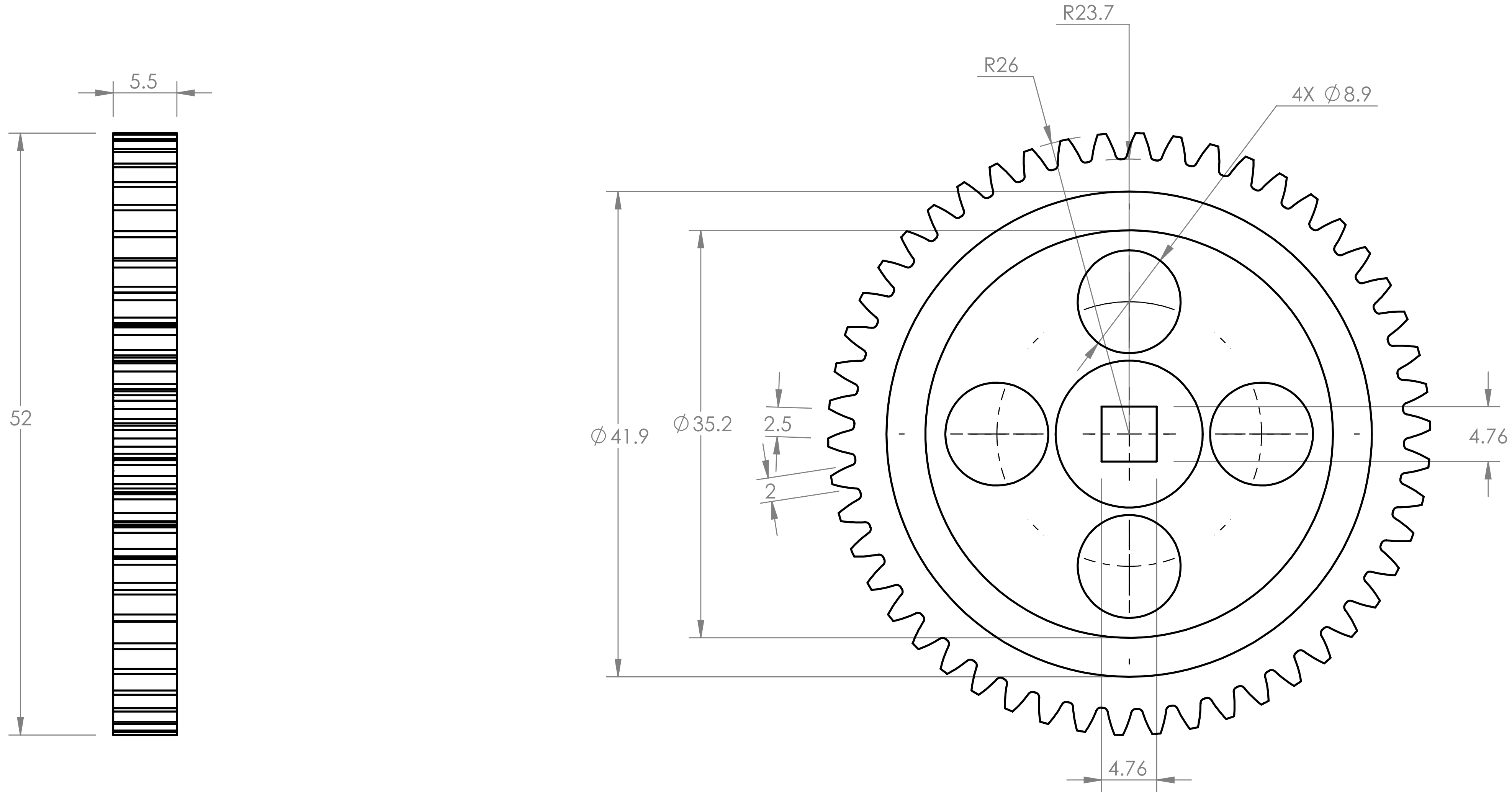
MATERIAL: AISI 1035 Steel (SS)

FILE NAME: Rear Axle

SCALE: 7:1 | Mass: 57.38g | SHEET 1 OF 1



Instructor: Dr. Nobes Comments:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam** Lab Day SM By **Brayden Stecyk** TA Initials	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: 50mm Spur Gear
MATERIAL: ABS Plastic		Mec33 Sunday, March 27, 2016 11:59:48 PM Monday, November 20, 2006 7:33:53 AM	SIZE **B** Assignment Number: Drawing Project REV
FILE NAME: 50mm Spur Gear Rear Drilled			SCALE: 2:1 | Mass:7.09g | SHEET 1 OF 8



Instructor:
Dr. Nobes
Comments:

MATERIAL:
ABS Plastic
FILE NAME:
50mmSpurGear

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

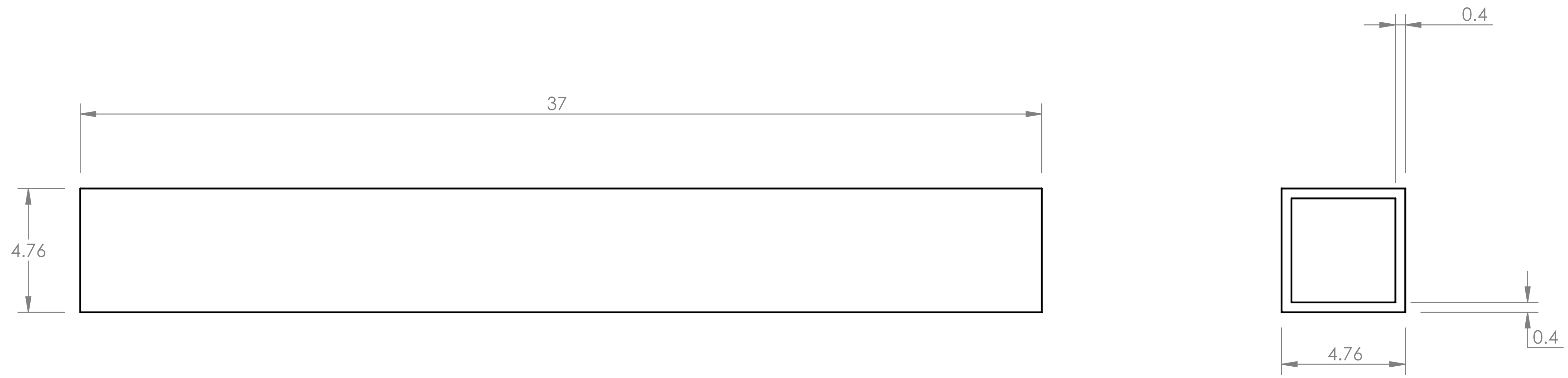
DRAWN BY:
Andrew Lam
Lab Day
SM By **Brayden Stecyk**
TA Initials
Mec33
Sunday, March 27, 2016 11:31:20 PM
Monday, November 20, 2006 7:33:53 AM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
50mm Spur Gear

SIZE **B**
Assignment Number
Drawing Project
REV

SCALE: 2:1
Mass: 7.09g
SHEET 2 OF 8



Instructor:
Dr. Nobes
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
Brass

FILE NAME:
3_16 Square Brass Tubing

DRAWN BY:
Andrew Lam

Lab Day	
SM By	**Brayden Stecyk**
TA Initials	

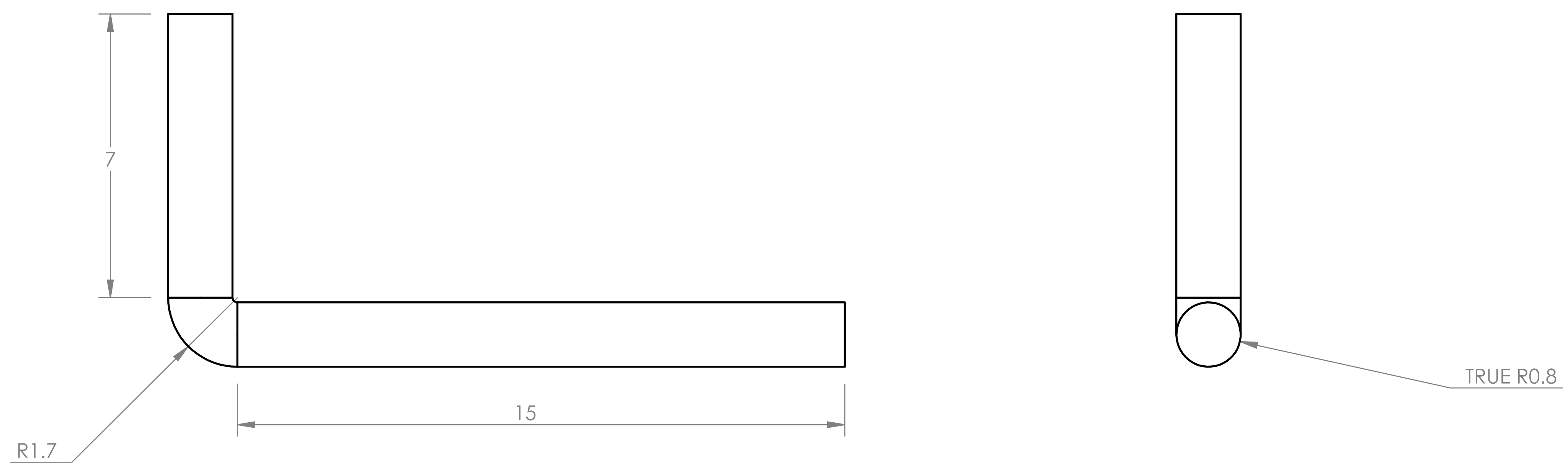
Mec33
Saturday, March 26, 2016 12:32:28 PM
Saturday, March 26, 2016 12:26:46 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
3/16 " Square Brass Tubing

SIZE	Assignment Number	REV
B	Drawing Project	

SCALE: 5:1	Mass: 2.10g	SHEET 3 OF 8



Instructor:
Dr. Nobes

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
AISI 1035 Steel (SS)

FILE NAME:
Gear Pin

DRAWN BY:
Andrew Lam

Lab Day	
SM By	**Brayden Stecyk**
TA Initials	

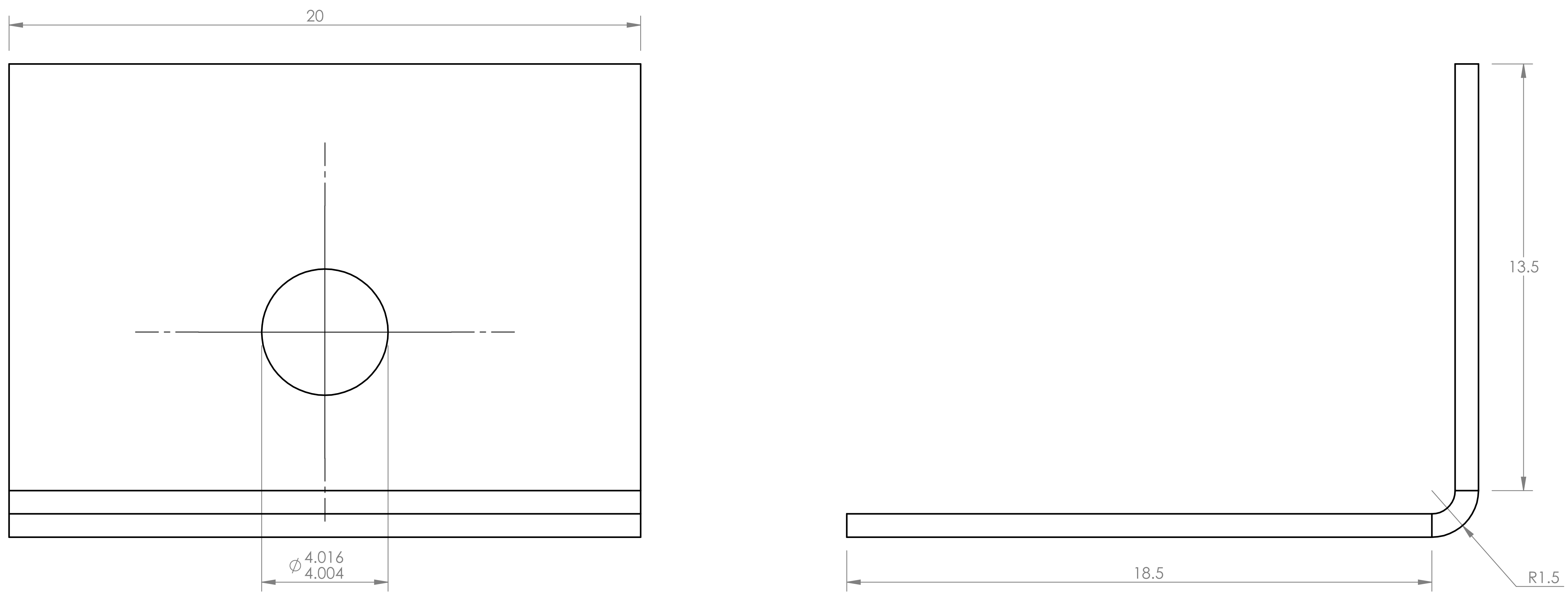
Mec33
Friday, March 25, 2016 8:51:17 PM
Friday, March 25, 2016 6:05:30 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Gear Pin

SIZE **B** | Assignment Number: Drawing Project | REV

SCALE: 7:1 | Mass:0.37g | SHEET 4 OF 8



Instructor:
Dr. Nobes

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH 0.6 µm

DO NOT SCALE DRAWING

MATERIAL:
Cold Rolled Steel

FILE NAME:
Rear Gearshaft Holder

DRAWN BY:
Andrew Lam

Lab Day	
SM By	Brayden Stecyk
TA Initials	

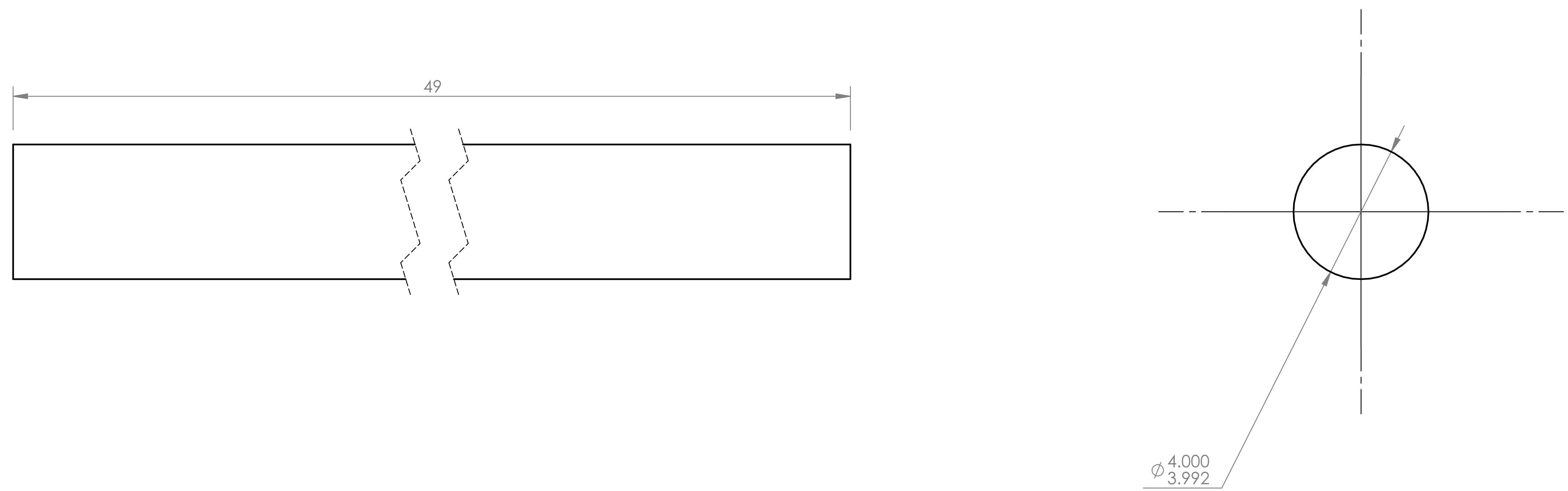
Mec33
Monday, March 28, 2016 1:43:49 AM
Saturday, March 26, 2016 1:04:39 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

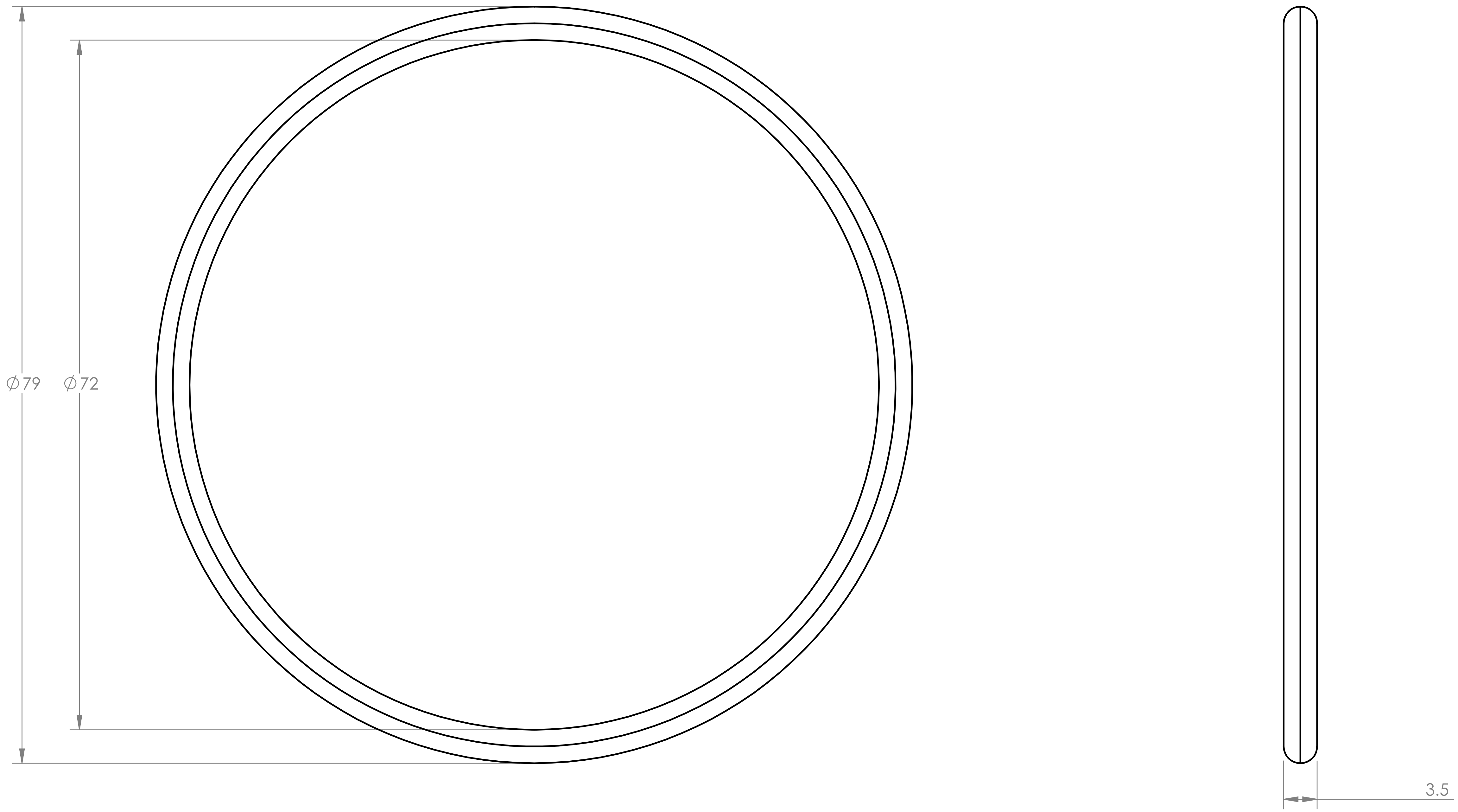
TITLE:
Rear Gear Box Sheet Metal

SIZE	Assignment Number	REV
B	Drawing Project	

SCALE: 7:1 | Mass: 3.84g | SHEET 5 OF 8



Instructor: Dr. Nobes	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Andrew Lam**	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA
Comments:		Lab Day	TITLE: Brass rod
		SM By **Brayden Stecyk**	
		TA Initials	
		Mec33	SIZE **B**
		Saturday, March 26, 2016 12:39:07 PM	Assignment Number: Drawing Project
MATERIAL: Brass		Saturday, March 26, 2016 12:37:18 PM	REV
FILE NAME: 4mm Brass Rod			SCALE: 7:1 / Mass: 5.23g / SHEET 6 OF 8



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

Instructor: Dr. Nobes

Comments:

MATERIAL: Silicon Rubber

FILE NAME: O-Rings for Back wheel

DRAWN BY: **Andrew Lam**

Lab Day	
SM By	Andrew Lam
TA Initials	

Mec33
Monday, March 28, 2016 1:57:13 AM
Wednesday, March 09, 2016 10:49:43 PM

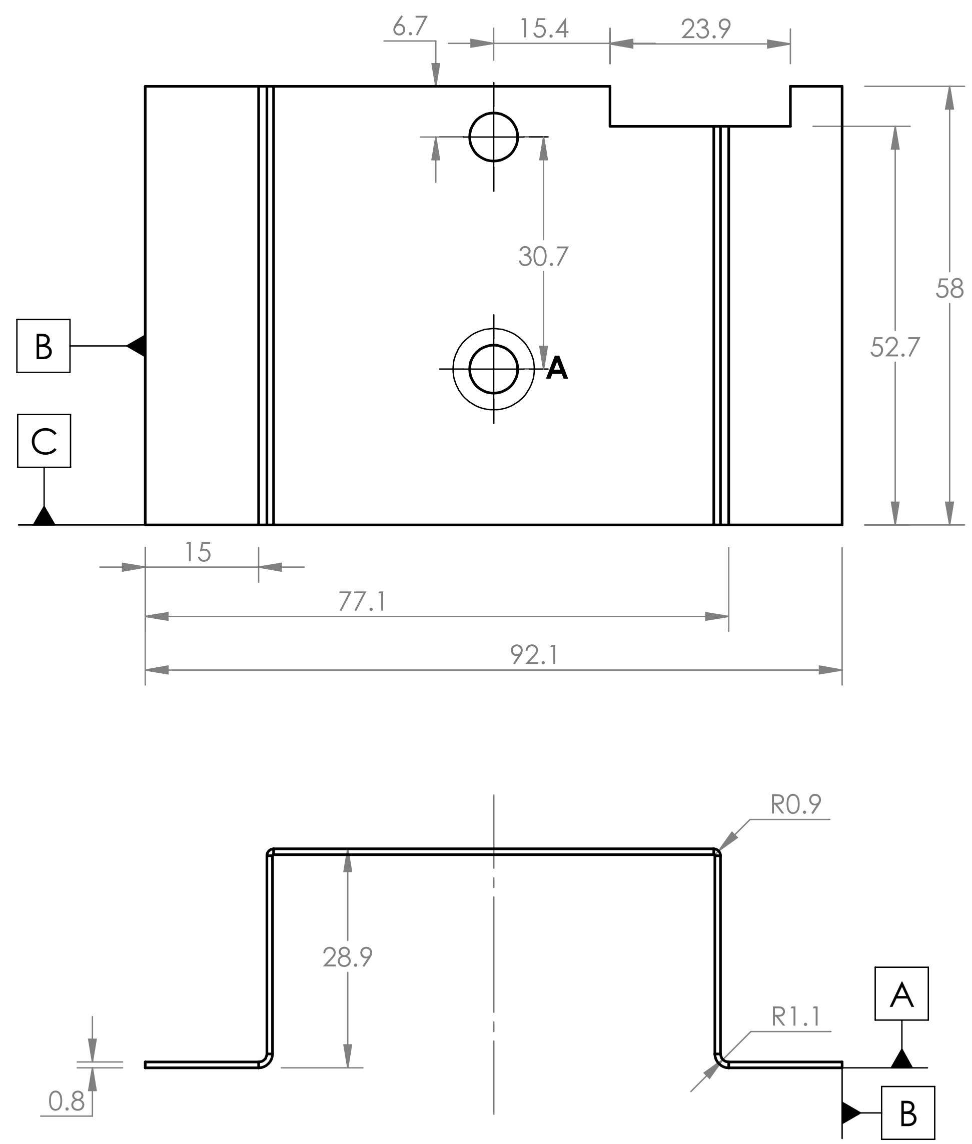
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

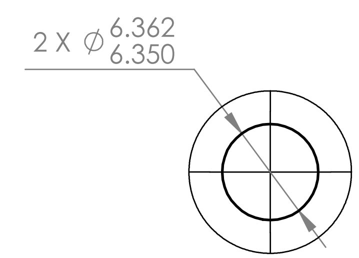
TITLE:
O rings For Rear

SIZE	Assignment Number	REV
B	Drawing Project	

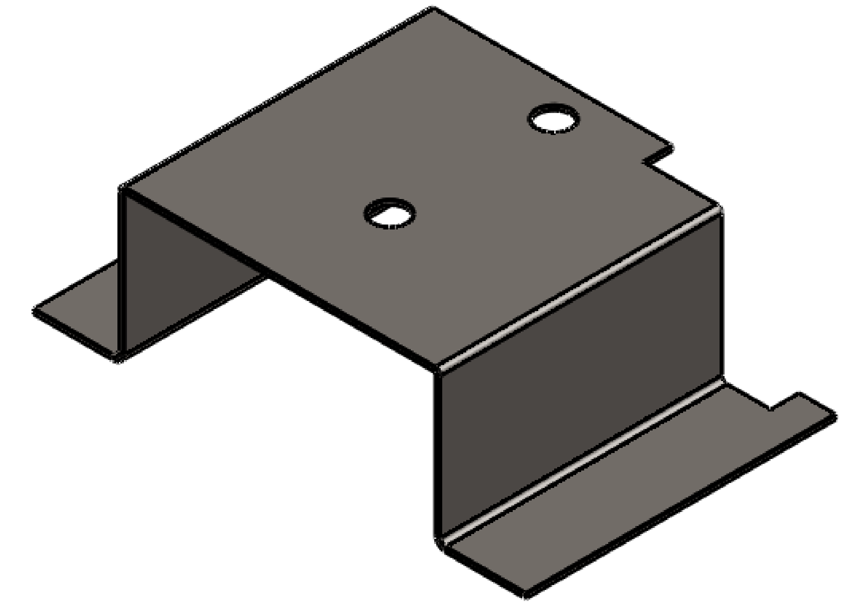
SCALE: 2:1 | Mass: 2.83g | SHEET 8 OF 8

Hole/ Shaft	Bases	Fit	Description	Nominal (mm)	Limits (mm)
50mm Spur Gear hole	Shaft (P7/h6)	Interference	Rigidity	6.35	(6.326,6.341)
Rear Gear Sheet Metal hole	Shaft (G7/h6)	Clearance	Sliding	4	(4.004,4.016)
Brass Rod Diameter	Shaft (G7/h6)	Clearance	Sliding	4	(3.992,4.000)
Rear Axle	Shaft(G7/h6)	Clearance	Sliding	6.35	(6.341,6.350)

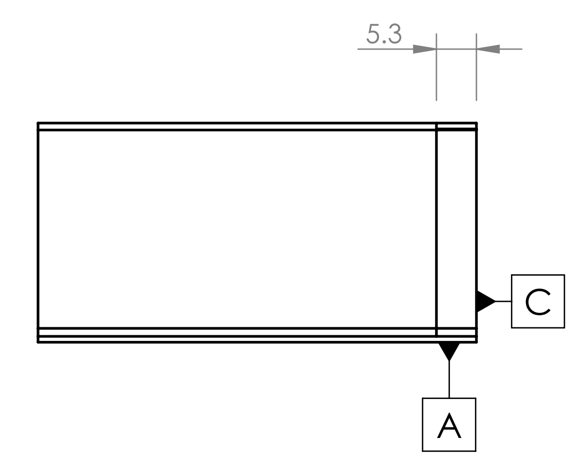




DETAIL A
SCALE 2 : 1



Please Mark This Part For TOYA OKEKE



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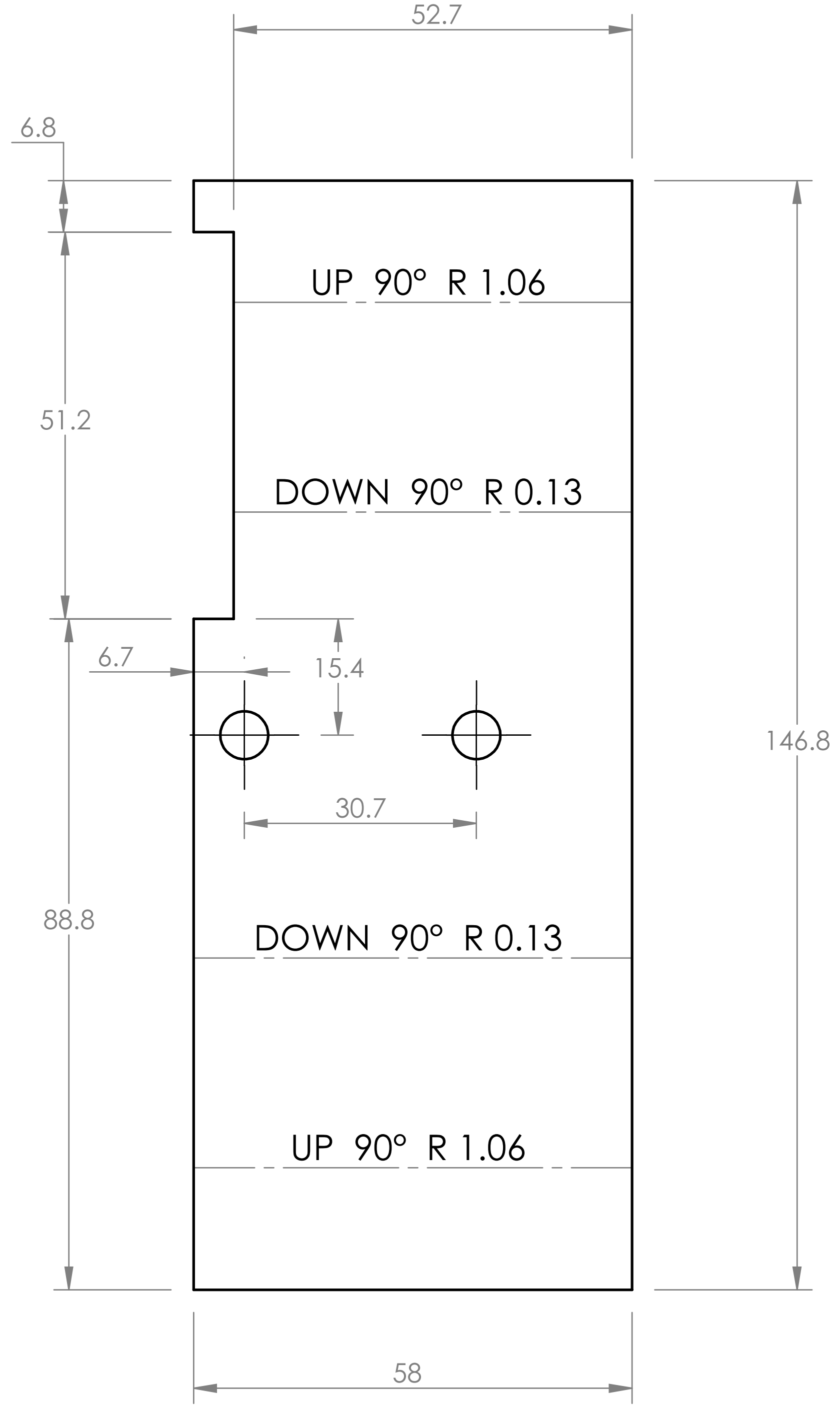
MecE 265 Instructor: **Dr. D.S.Nobes** **Win 2016** Comments: Gear Box for Camera	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Toya Okeke** Lab Day: ALL SM By: **Toya Okeke** TA Initials: DSN tokeke March 27, 2016 7:01:49 PM March 12, 2016 4:59:33 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Camera Gear Box: Orthogonal Views SIZE **B** · Assignment Number: Drawing Project · REV 1
MATERIAL: AISI 1020 Steel, Cold Rolled			SCALE: 1:1 · Mass: 49.06 · SHEET 1 OF 3
FILE NAME: Camera Sheet Metal Mount			



Camera Sheet Metal toRod
Fit: Clearance
Basis: Hole
ISO: H7/g6
Nominal: ∅6.35
Limits: 0.000, +0.012

Please Mark This Part For TOYA OKEKE

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MecE 265
Instructor: Dr. D.S.Nobes
Win 2016
Comments: Sheet Metal: As Cut

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

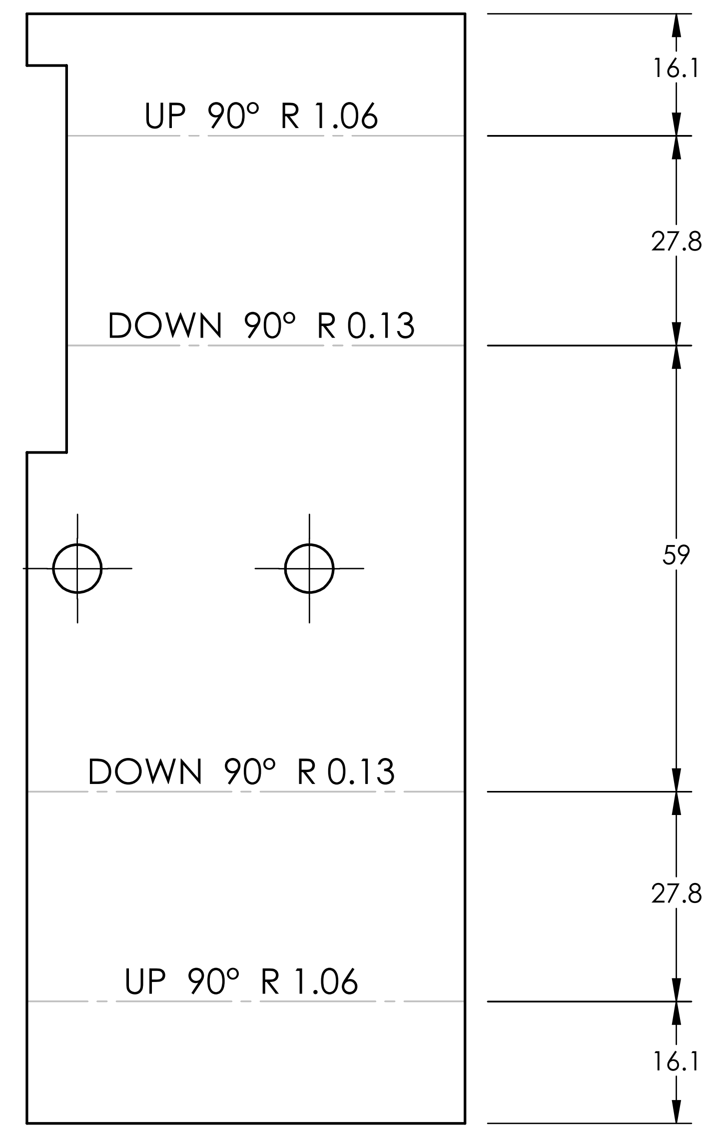
DRAWN BY: **Toya Okeke**
Lab Day: ALL
SM By: Toya Okeke
TA Initials: DSN
tokeke
March 27, 2016 7:01:49 PM
March 12, 2016 4:59:33 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE: Camera Sheet Metal: As Cut

MATERIAL: AISI 1020 Steel, Cold Rolled
FILE NAME: Camera Sheet Metal Mount

SIZE: B
Assignment Number: Drawing Project
REV: 1
SCALE: 1:1
Mass: 49.06
SHEET 2 OF 3



Please Mark This Part For TOYA OKEKE

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MecE 265
Instructor: Dr. D.S.Nobes Win 2016
Comments: Sheet Metal: As Bent

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY: **Toya Okeke**

Lab Day	ALL
SM By	Toya Okeke
TA Initials	DSN

tokeke
March 27, 2016 7:01:49 PM
March 12, 2016 4:59:33 PM

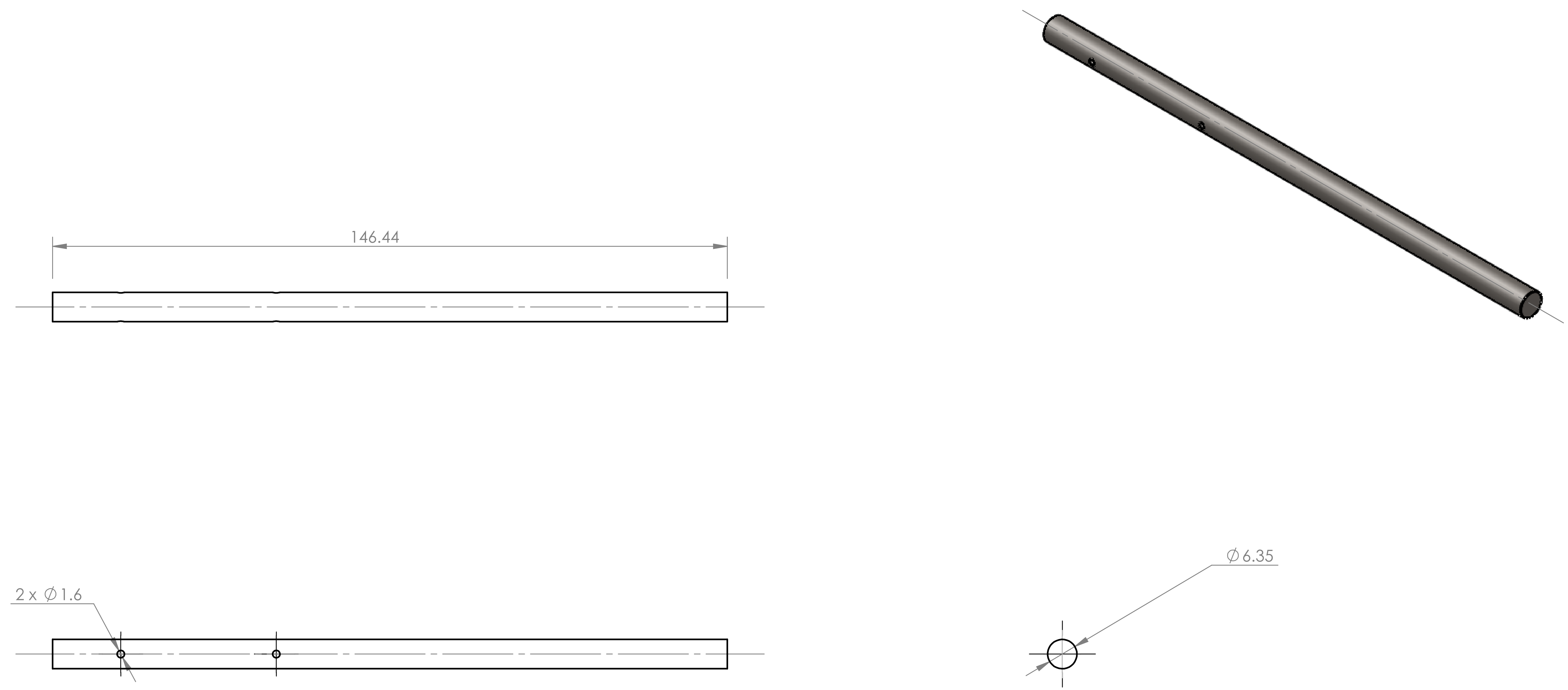
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE: Camera Sheet Metal: As Bent

MATERIAL: AISI 1020 Steel, Cold Rolled
FILE NAME: Camera Sheet Metal Mount

SIZE	Assignment Number	REV
B	Drawing Project	1

SCALE: 1:1 | Mass: 49.06 | SHEET 3 OF 3



Instructor:
Dr. D.S.Nobes
Dr. Mertiny
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi,Dong
Lab Day: wed
SM By: **Brayden Stecyk**
TA Initials:
Mec33
Saturday, March 26, 2016 6:00:12 PM
Thursday, January 07, 2010 3:44:18 PM

MATERIAL:
DIA 3.2mm Welding Rod

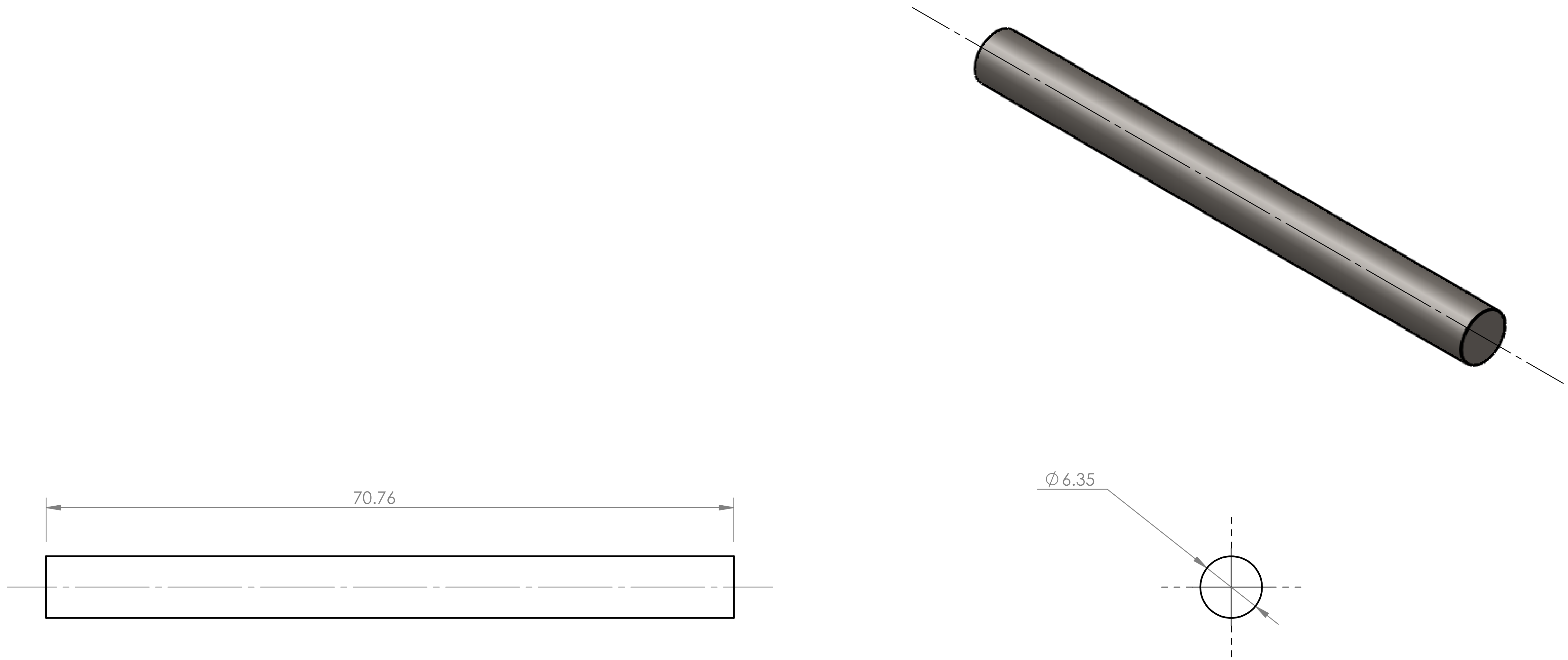
FILE NAME:
Front Axle (long)

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Front Axle(long)

SIZE	Assignment Number	REV
B	Drawing Project	

SCALE: 1:1 | Mass: 36.21 grams | SHEET 1 OF 1



Instructor:
Dr. D.S.Nobes
Dr. Mertiny

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong

Lab Day

SM By **Brayden Stecyk**

TA Initials

Mec33
Saturday, March 26, 2016 8:47:27 PM
Thursday, January 07, 2010 3:44:18 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Front Axle (Short)

SIZE **B**

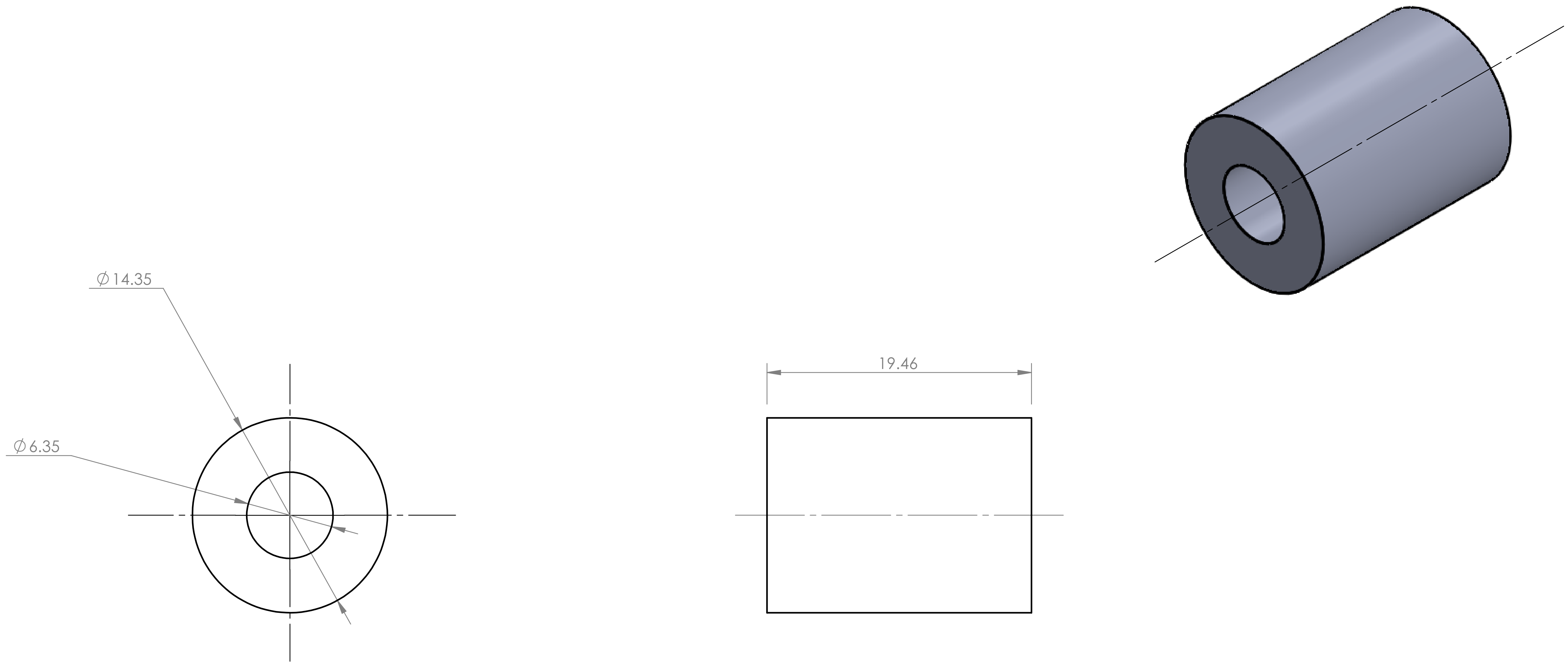
Assignment Number
Drawing Project

REV

MATERIAL:
DIA 3.2mm Welding Rod

FILE NAME:
Front Axle (short)

SCALE: 2:1 | Mass: 17.59 grams | SHEET 1 OF 1



Instructor:
Dr. D.S.Nobes
Dr. Mertiny
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi,Dong
Lab Day WED
SM By **Brayden Stecyk**
TA Initials

Mec33
Saturday, March 26, 2016 7:46:13 PM
Friday, March 25, 2016 3:45:42 PM

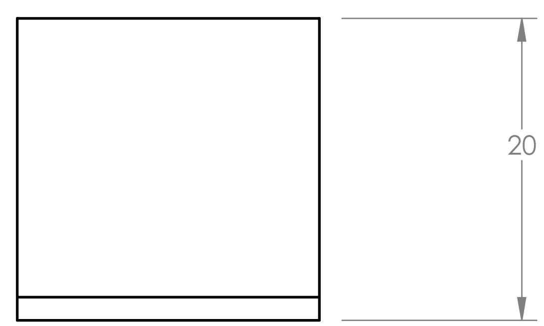
MATERIAL:
Nylon 101
FILE NAME:
Front Axle Collar

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

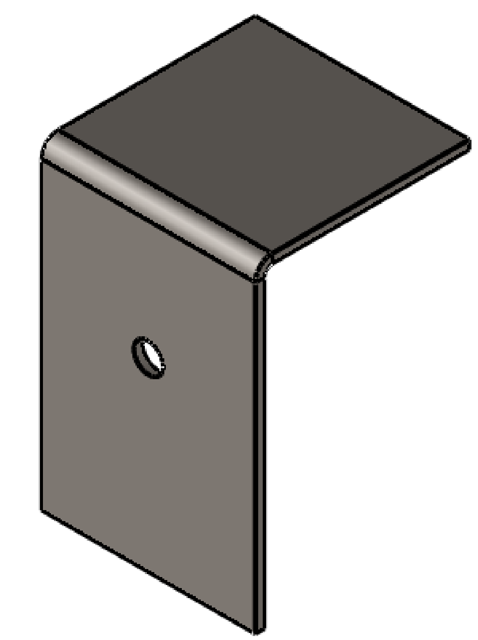
TITLE:
Front Axle Collar

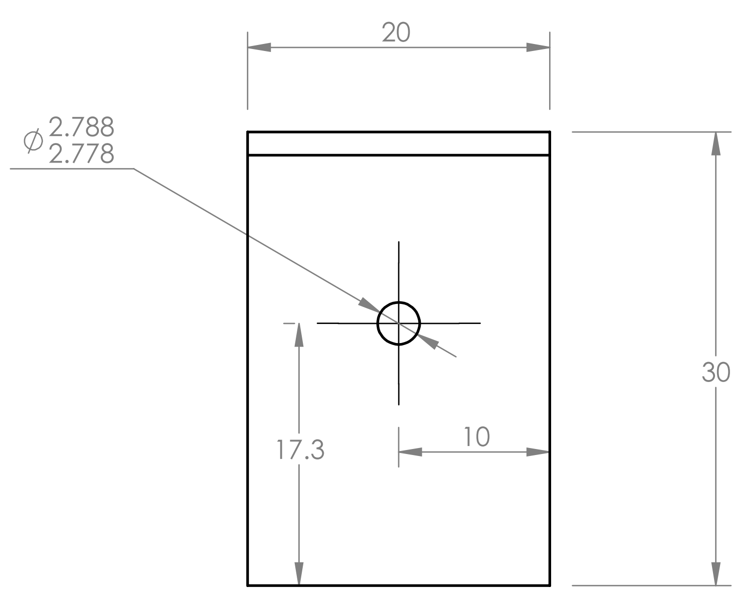
SIZE **B**
Assignment Number
Drawing Project
REV

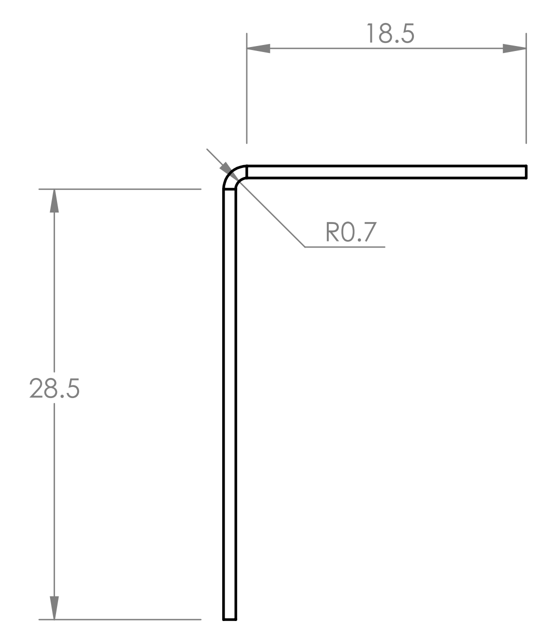
SCALE: 3:1
Mass: 2.91 grams
SHEET 1 OF 1



Shaft Guide to Rod
Fit: Clearance
Basis: Hole
ISO: H7/g6
Nominal: ∅2.778125
Limits: 0.000, +0.010







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Mec E 265
Instructor: **Dr. D.S.Nobes Win 2016**
Comments: N/A

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DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:

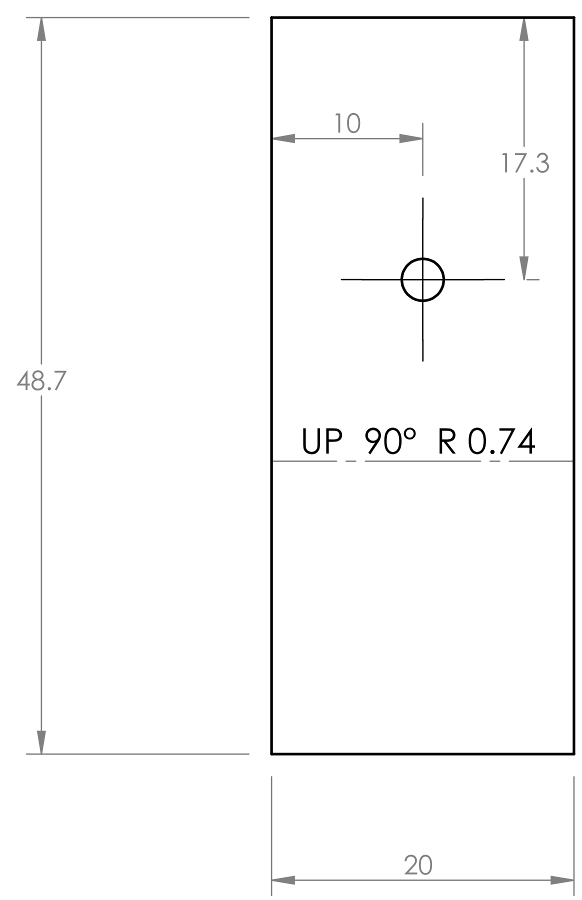
DRAWN BY: **Toya Okeke**
Lab Day
SM By **Brayden Stecyk**
TA Initials DSN
tokeke
March 28, 2016 2:21:01 AM
March 25, 2016 11:53:34 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Front Motor Shaft Guide

SIZE **B**
Assignment Number **Drawing Project**
REV

FILE NAME: Front Motor Shaft Guide
SCALE: 2:1
Mass:
SHEET 1 OF 3



Mec E 265

Instructor: **Dr. D.S.Nobes** **Win 2016**

Comments:
N/A

MATERIAL:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Toya Okeke

Lab Day	
SM By	**Brayden Stecyk**
TA Initials	DSN

tokeke
March 28, 2016 2:21:01 AM
March 25, 2016 11:53:34 PM

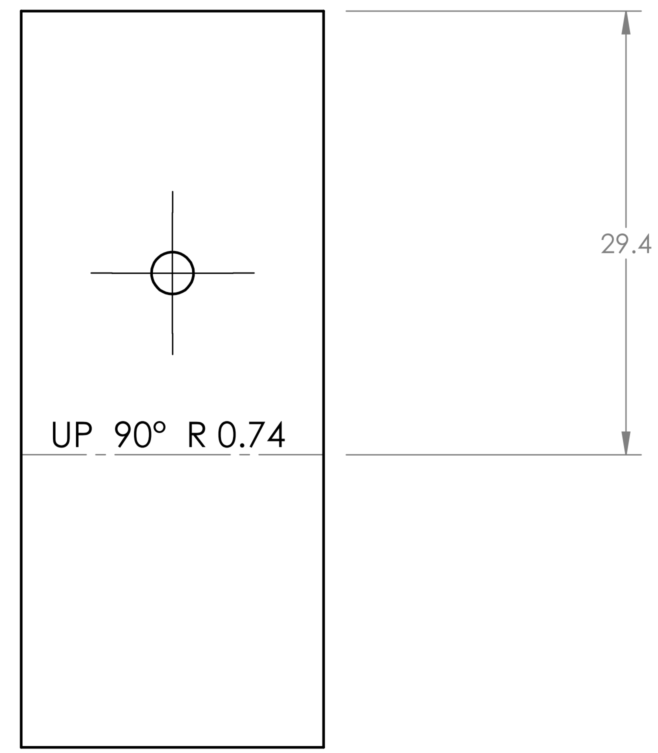
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Sheet Metal: As Cut

SIZE **B** | Assignment Number **Drawing Project** | REV

FILE NAME:
Front Motor Shaft Guide

SCALE: 2:1 | Mass: | SHEET 2 OF 3



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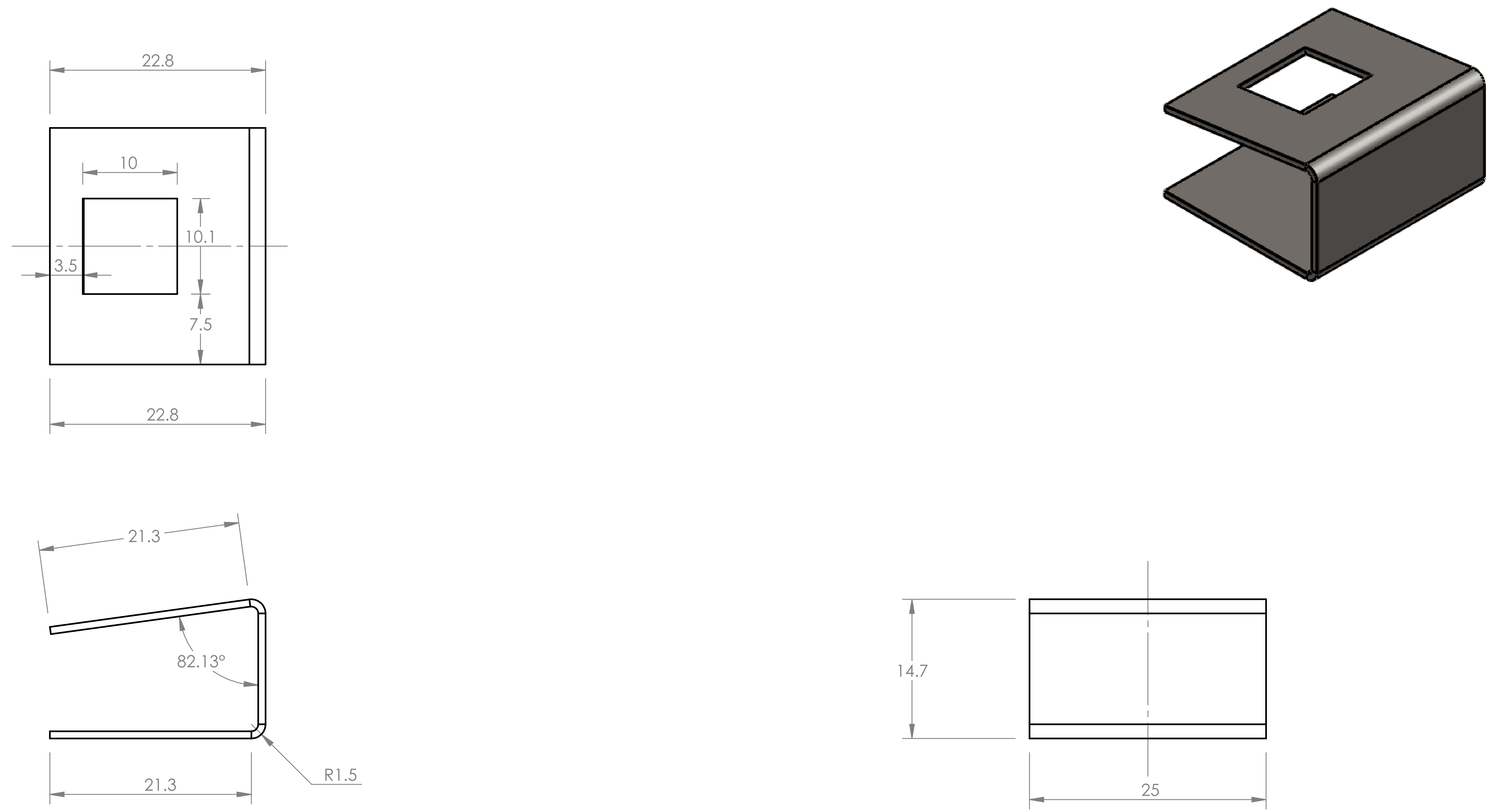
Mec E 265 Instructor: **Dr. D.S.Nobes Win 2016** Comments: N/A	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Toya Okeke** Lab Day SM By **Brayden Stecyk** TA Initials DSN tokeke March 28, 2016 2:21:01 AM March 25, 2016 11:53:34 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Sheet Metal: As Bent SIZE **B** Assignment Number **Drawing Project** REV
MATERIAL:			
FILE NAME: Front Motor Shaft Guide			SCALE: 2:1 Mass: SHEET 3 OF 3



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MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:
N/A

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DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Toya Okeke

Lab Day	ALL
SM By	**Chengshunzi Dong**
TA Initials	DSN

tokeke
March 28, 2016 2:02:28 AM
March 13, 2016 4:48:51 PM

MATERIAL:
AISI 1020 Steel, Cold Rolled

FILE NAME:
Front Motor Mount Holder

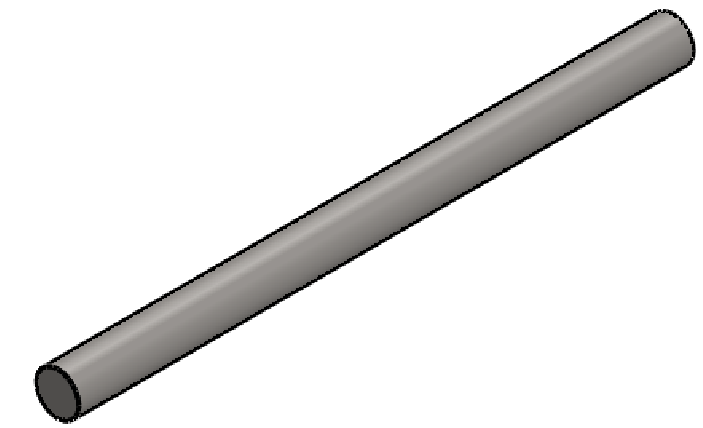
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

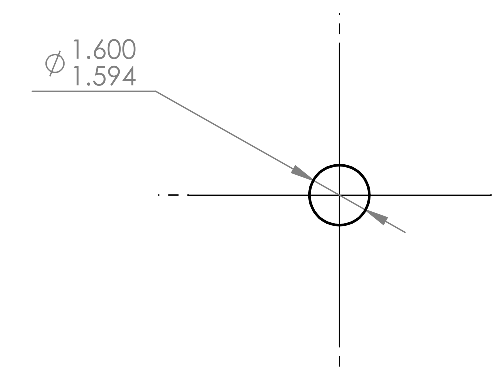
TITLE:
Front Motor Mount Holder

SIZE	Assignment Number	REV
B	Drawing Project	1

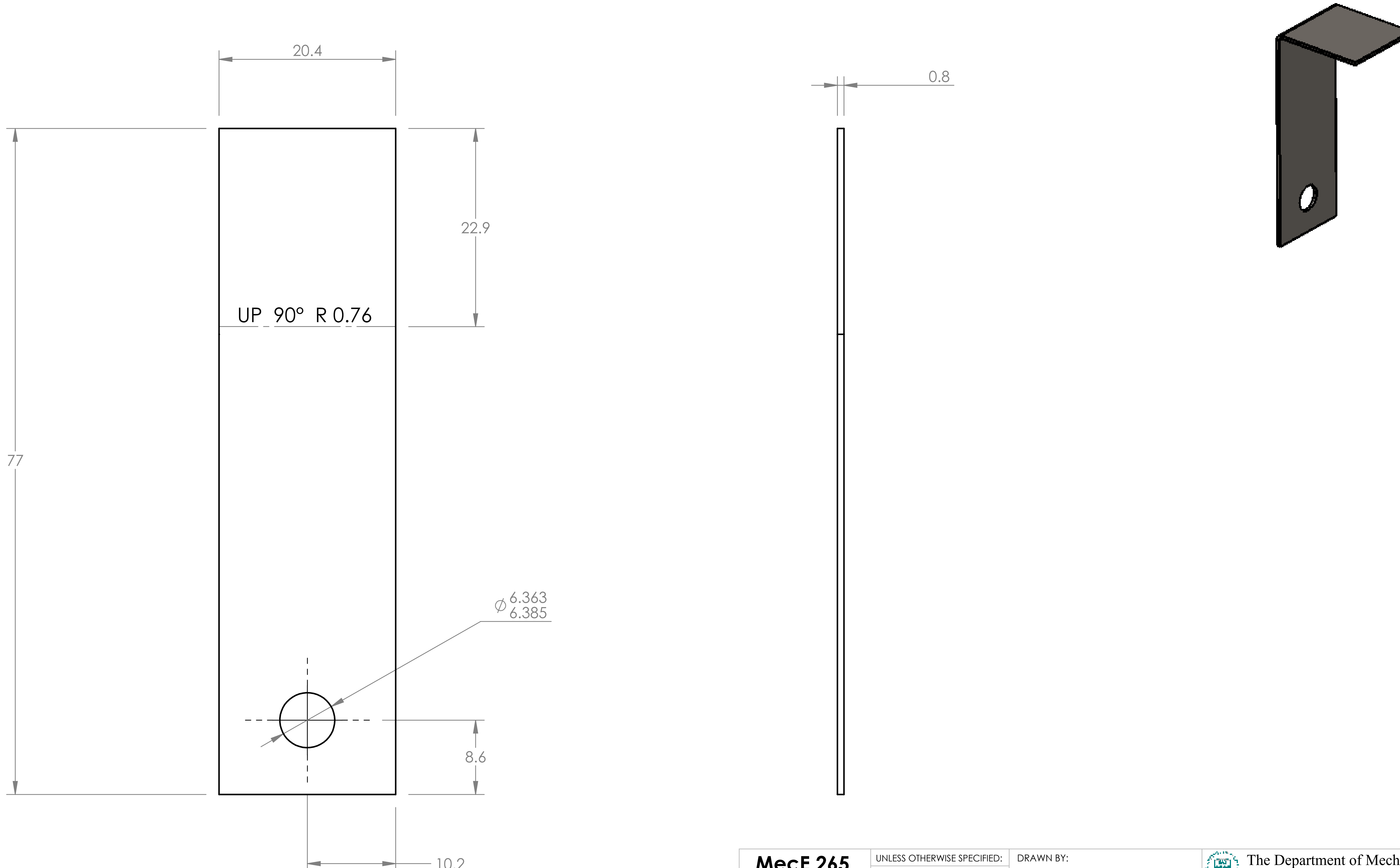
SCALE: 2:1 | Mass: 8.12 | SHEET 1 OF 1

Motor Pins to Motor Mount
Fit: Interference
Basis: Hole
ISO: H7/p6
Nominal: ∅1.5875
Limits: +0.006, +0.012



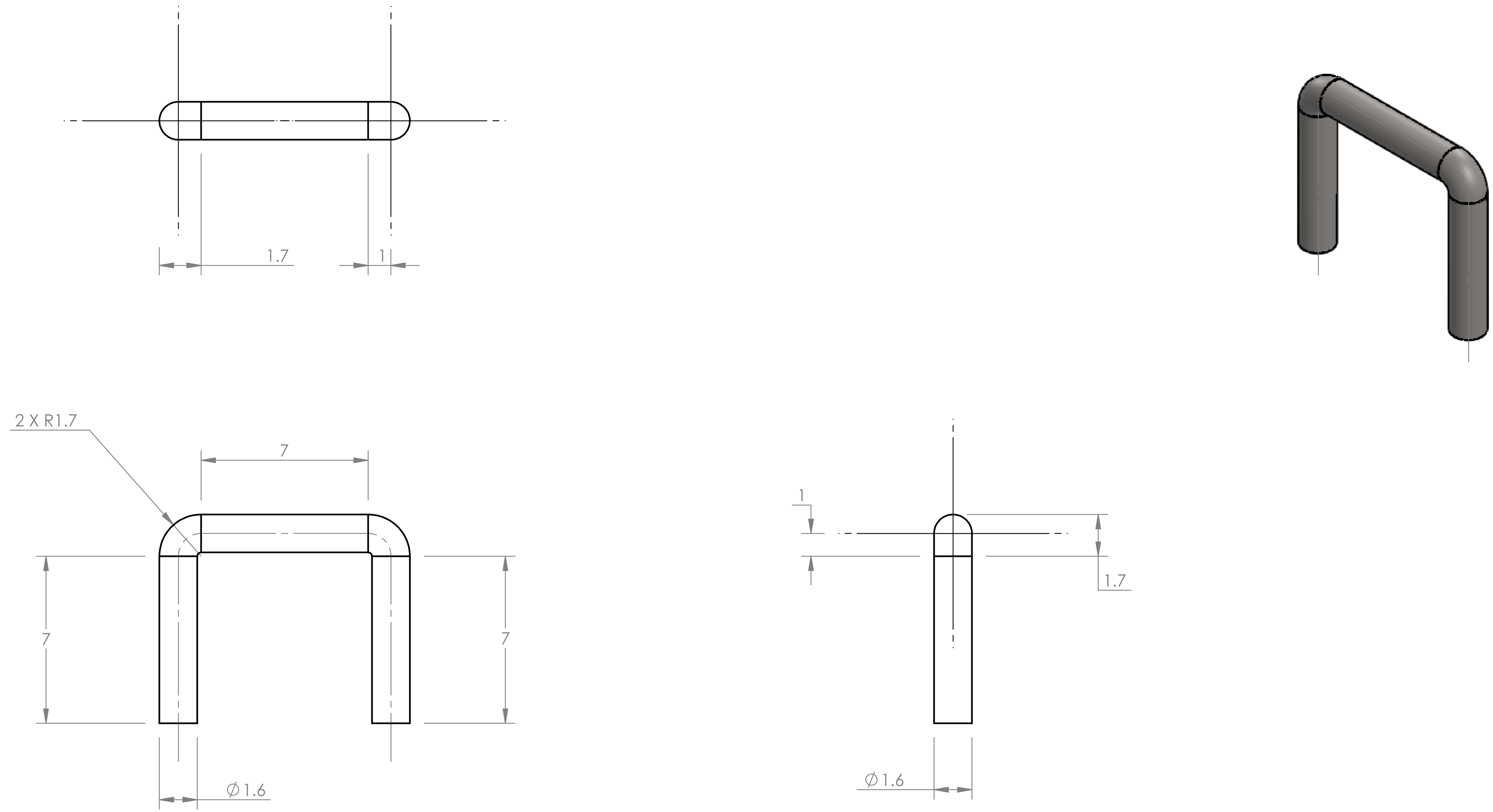


Mec E 265 Instructor: **Dr. D.S.Nobes Win 2016** Comments: N/A	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Toya Okeke** Lab Day SM By **Brayden Stecyk** TA Initials DSN	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Motor Pin
MATERIAL:		tokeke March 25, 2016 11:26:48 PM March 25, 2016 11:25:21 PM	SIZE **B** Assignment Number **Drawing Project** REV
FILE NAME: Motor Pins			SCALE: 5:1 Mass: SHEET 1 OF 1



MecE 265 Instructor: **Dr. D.S.Nobes** **Win 2016** Comments: Commnet: Edit in SM	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Farhan Khan**	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA	
		Lab Day: ALL	TITLE: Shaft Holder	
		SM By: **Brayden Stecyk**		
		TA Initials: DSN	SIZE **B**	Assignment Number **Drawing Project**	REV 1
MATERIAL: AISI 1020 Steel, Cold Rolled		Mec33 Tuesday, March 29, 2016 11:23:12 AM Monday, February 29, 2016 4:53:42 PM		
FILE NAME: Shaft Holder			SCALE: 2:1 Mass: 9.24	SHEET 1 OF 1

Tolerence	Basis	Tolerence	Type	Nominal	Dimensions
Clearence Fit	Shaft	F8/h7	Close Running Fit	6.350mm	[6.363,6.385]



Instructor:
Dr. D.S.Nobes
Dr. Mertiny
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong
Lab Day wed
SM By **Brayden Stecyk**
TA Initials
Mec33
Saturday, March 26, 2016 6:07:02 PM
Friday, March 25, 2016 4:28:05 PM

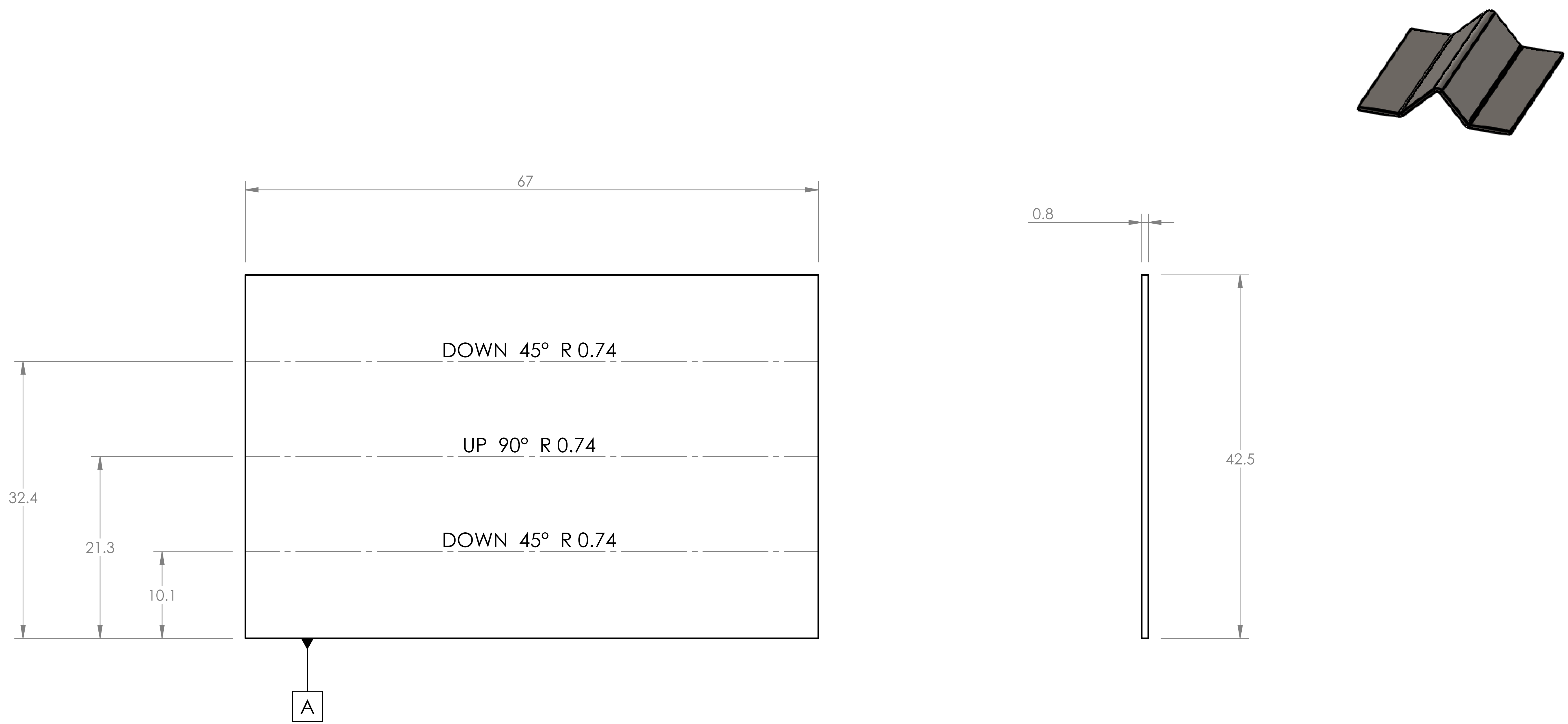
MATERIAL:
AISI 1020
FILE NAME:
Shaft Pin

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Shaft Pin

SIZE **B**
Assignment Number
Drawing Project
REV

SCALE: 5:1
Mass: 0.38 grams
SHEET 1 OF 1



Instructor:

Comments:

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:

DRAWN BY:

Farhan Khan

Lab Day

SM By **Brayden Stecyk**

TA Initials

Mec33
Sunday, March 27, 2016 2:26:33 PM
Friday, March 25, 2016 2:09:14 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:

Steering Connector

SIZE **B**

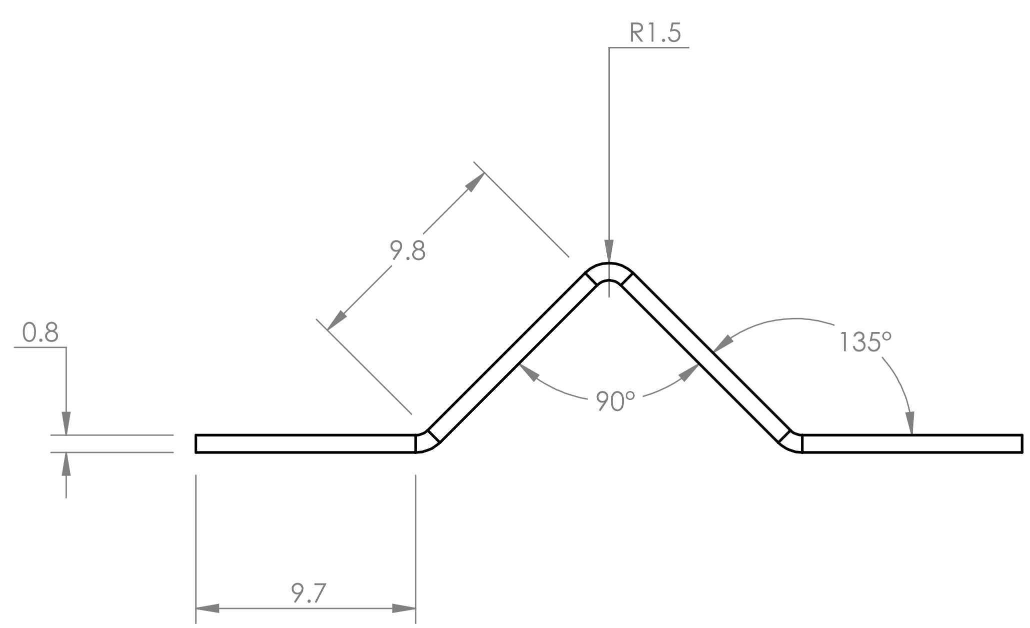
Assignment Number

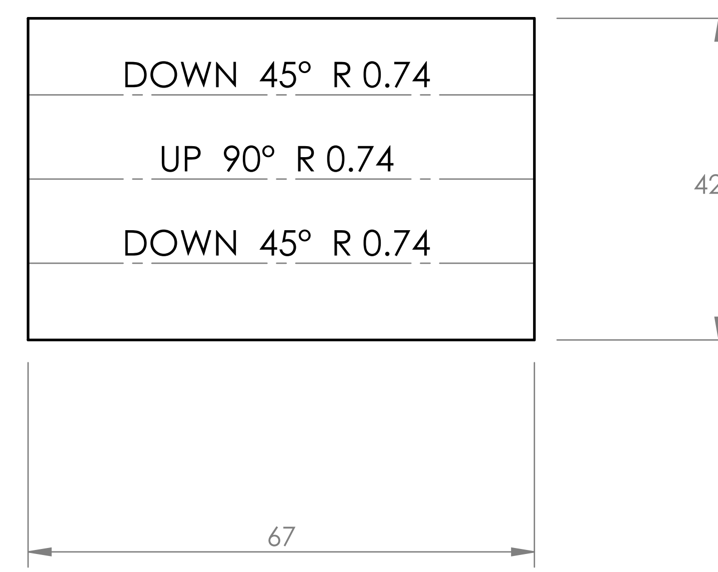
Drawing Project

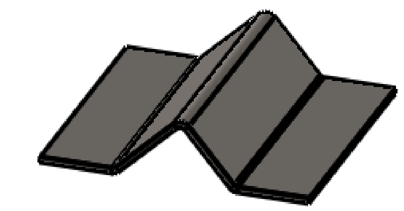
REV

FILE NAME:
Steering Connector

SCALE: 2:1 | Mass: | SHEET 1 OF 1







Instructor:

Comments:

MATERIAL:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Farhan Khan

Lab Day

SM By **Brayden Stecyk**

TA Initials

Mec33
Sunday, March 27, 2016 4:56:40 PM
Friday, March 25, 2016 2:09:14 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Steering Connector

SIZE **B**

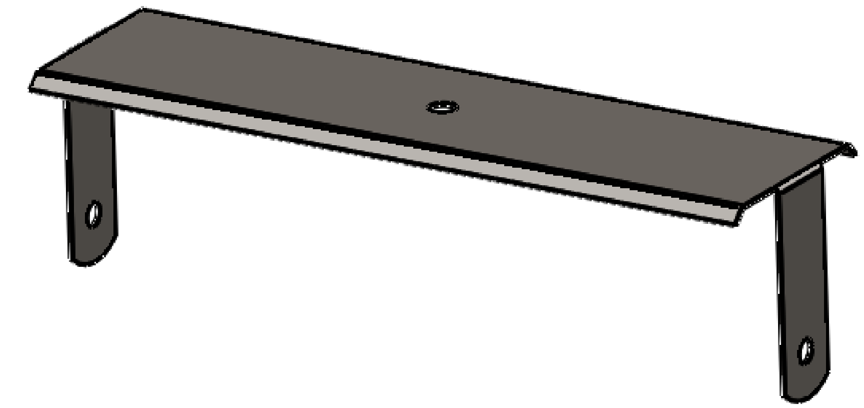
Assignment Number
Drawing Project

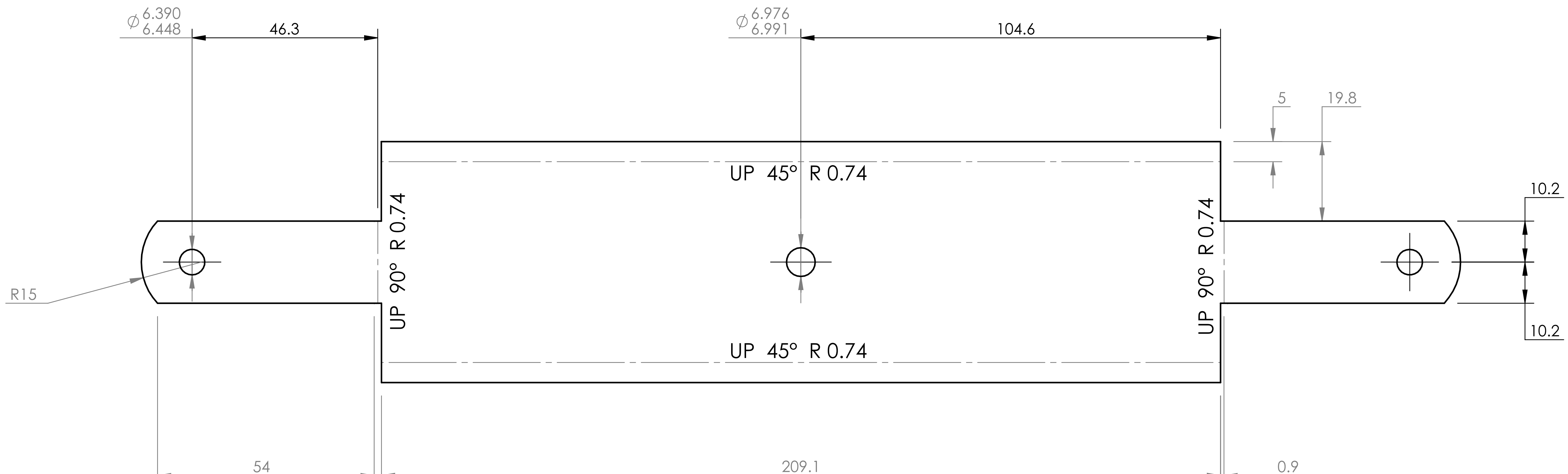
REV

FILE NAME:
Steering Connector

SCALE: 1:1 | Mass: | SHEET 1 OF 1

Please Mark This Part For FARHAN KHAN





MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:
Commnet: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

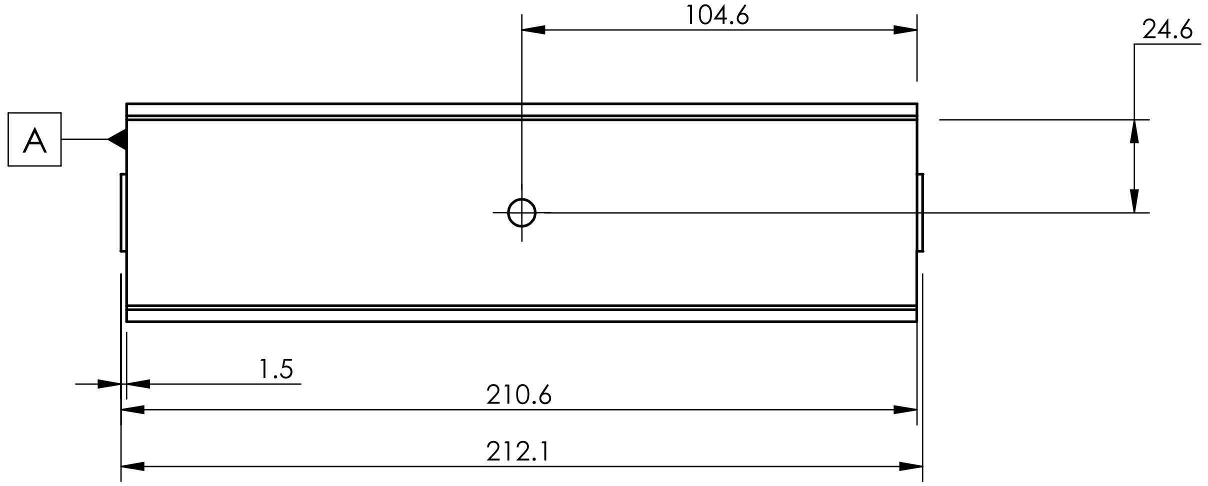
MATERIAL:
AISI 1020 Steel, Cold Rolled
FILE NAME:
newshaftbody

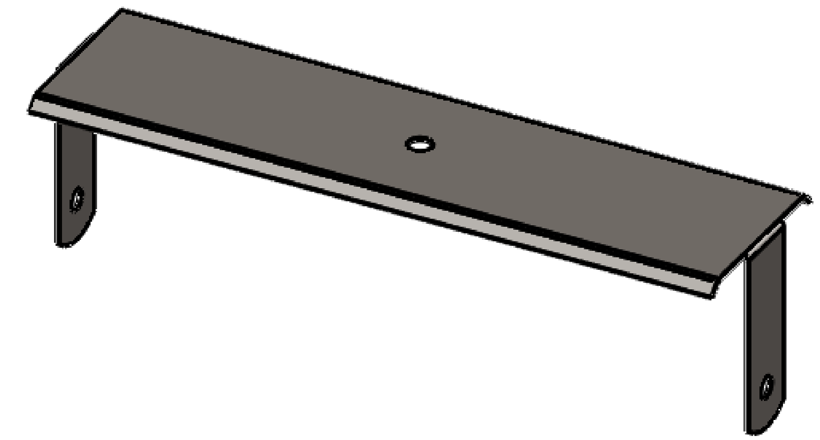
DRAWN BY:
Farhan Khan
Lab Day
SM By **Chengshunzi Dong**
TA Initials DSN
Mec33
Tuesday, March 29, 2016 11:36:46 AM
Monday, February 29, 2016 4:53:42 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA
TITLE:
Turning Body Sheet Metal

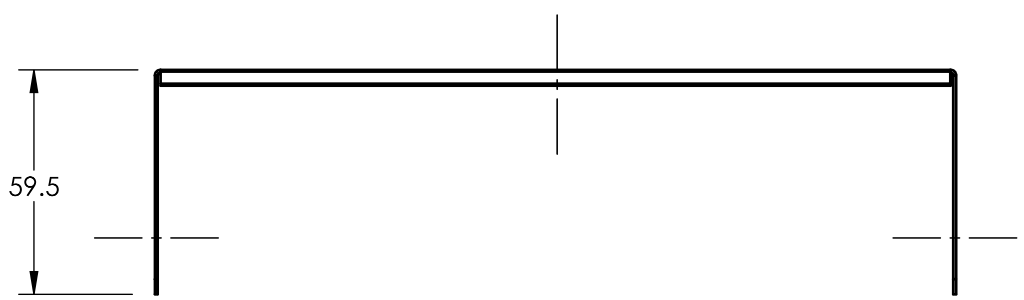
SIZE **B** | Assignment Number **Drawing Project** | REV 1

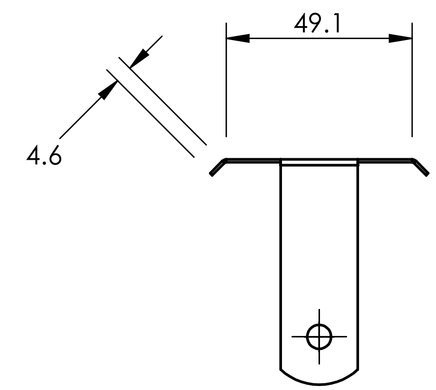
SCALE: 1:2 | Mass: 88.97 | SHEET 1 OF 2





Please Mark This Part For FARHAN KHAN





MecE 265

Instructor:
Dr. D.S.Nobes
Win 2016

Comments:
Commnet: Edit in SM

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
AISI 1020 Steel, Cold Rolled

FILE NAME:
newshaftbody

DRAWN BY:
Farhan khan

Lab Day: ALL

SM By: **Chengshunzi Dong**

TA Initials: DSN

Mec33
Tuesday, March 29, 2016 11:36:46 AM
Monday, February 29, 2016 4:53:42 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

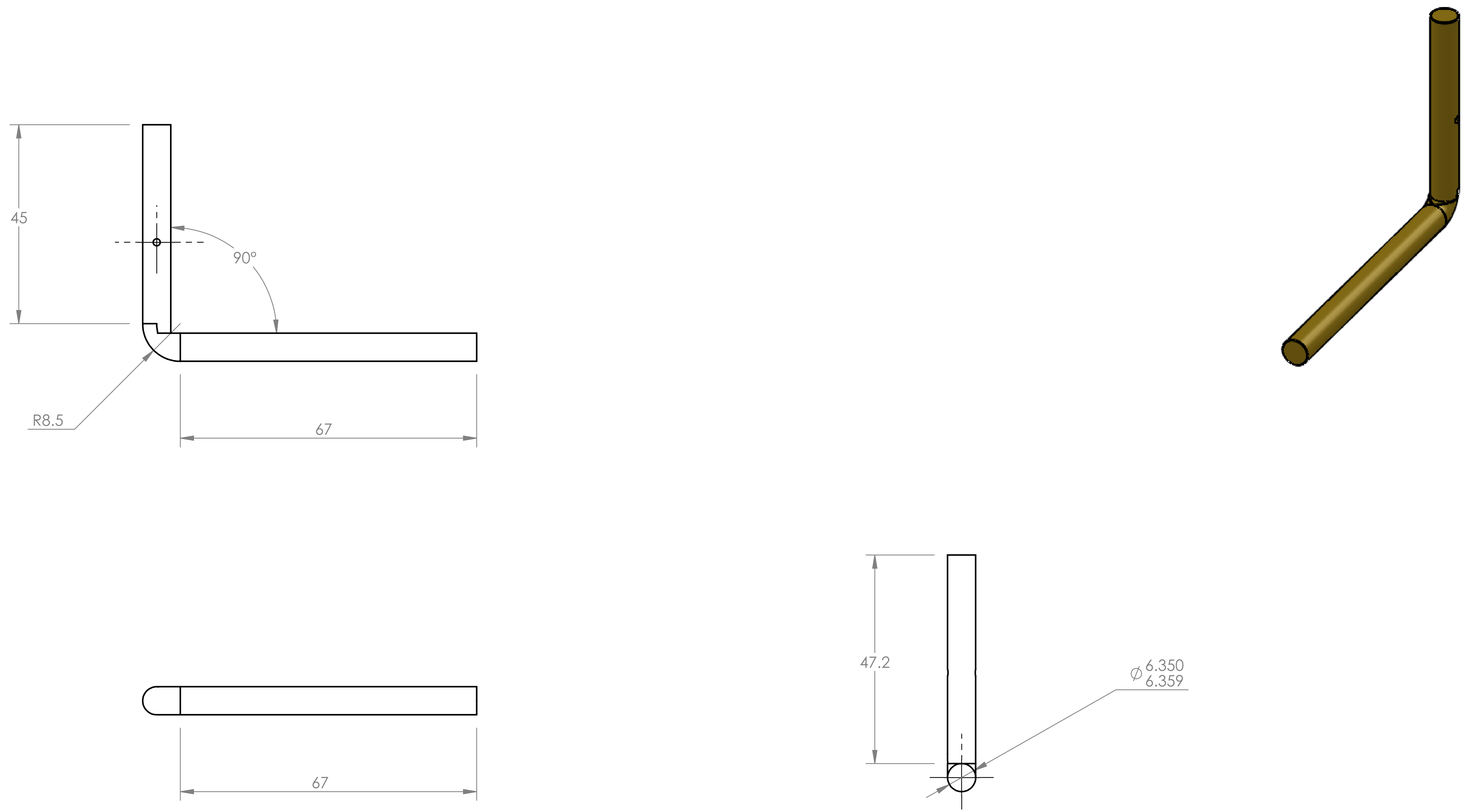
TITLE:
Turning Body Sheet Metal

SIZE: B
Assignment Number: Drawing Project
REV: 1

SCALE: 1:2 | Mass: 88.97 | SHEET 2 OF 2

Tolerence	Basis	Tolerence	Type	Nominal	Dimensions
Clearence Fit	Shaft	D10/h9	Free Running	6.350mm	[6.390,6.448]

Tolerence	Basis	Tolerence	Type	Nominal	Dimensions
Interference Fit	Shaft	P7/h6	Rigid Fit	7mm	[6.976,6.991]



MecE 265
Instructor:
Dr. D.S.Nobes
Win 2016
Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:
Brass
FILE NAME:
newshaft

DRAWN BY:
Farhan Khan

Lab Day	ALL
SM By	**Brayden Stecyk**
TA Initials	DSN

Mec33
Friday, March 25, 2016 9:32:45 PM
Monday, February 29, 2016 4:33:44 PM

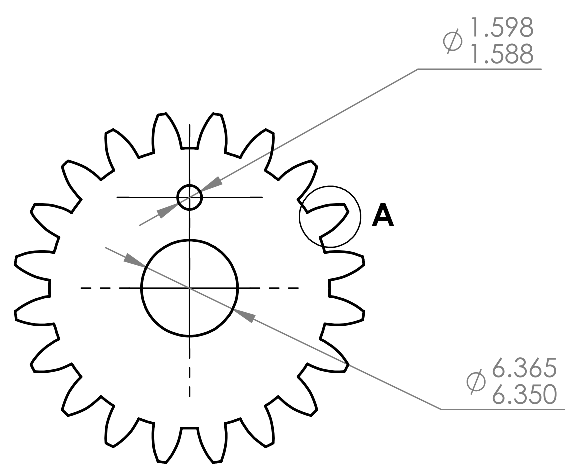
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Turning shaft

SIZE **B**
Assignment Number
Drawing Project
REV 1

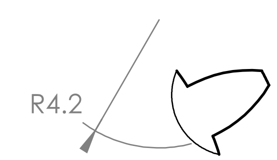
SCALE: 1:1 | Mass: 32.26 | SHEET 1 OF 1

Tolerence	Basis	Tolerence	Type	Nominal	Dimensions
Clearence Fit	Shaft	G7/h6	Sliding fit	6.360mm	[6.365,6.380]

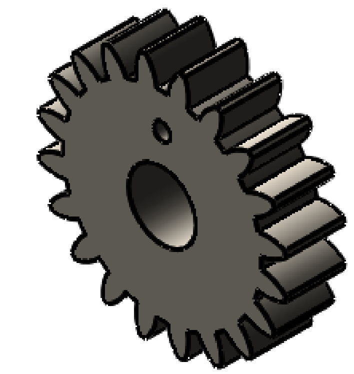


Gear Pins to Gears/Rods
Fit: Interference
Basis: Hole
ISO: H7/p6
Nominal: ∅ 1.5875
Limits: 0.000, +0.010

Rods to Gears
Fit: Interference
Basis: Hole
ISO: H7/p6
Nominal: ∅ 6.35
Limits: 0.000, +0.015



DETAIL A
SCALE 4 : 1



Mec E 265
Instructor: **Dr. D.S.Nobes**
Win 2016
Comments:
Hole was drilled into gear to fasten the gear onto rod

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

MATERIAL:

DRAWN BY: **Toya Okeke**
Lab Day
SM By **Brayden Stecyk**
TA Initials DSN
tokeke
Tuesday, March 29, 2016 1:24:37 PM
Tuesday, February 08, 2000 9:41:59 AM

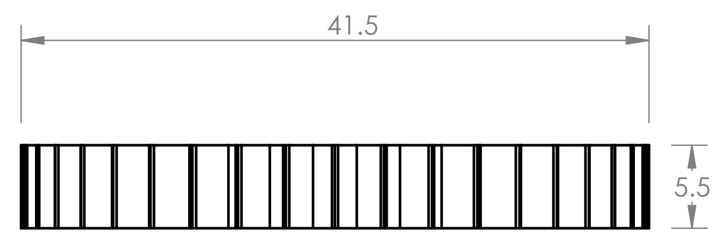
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

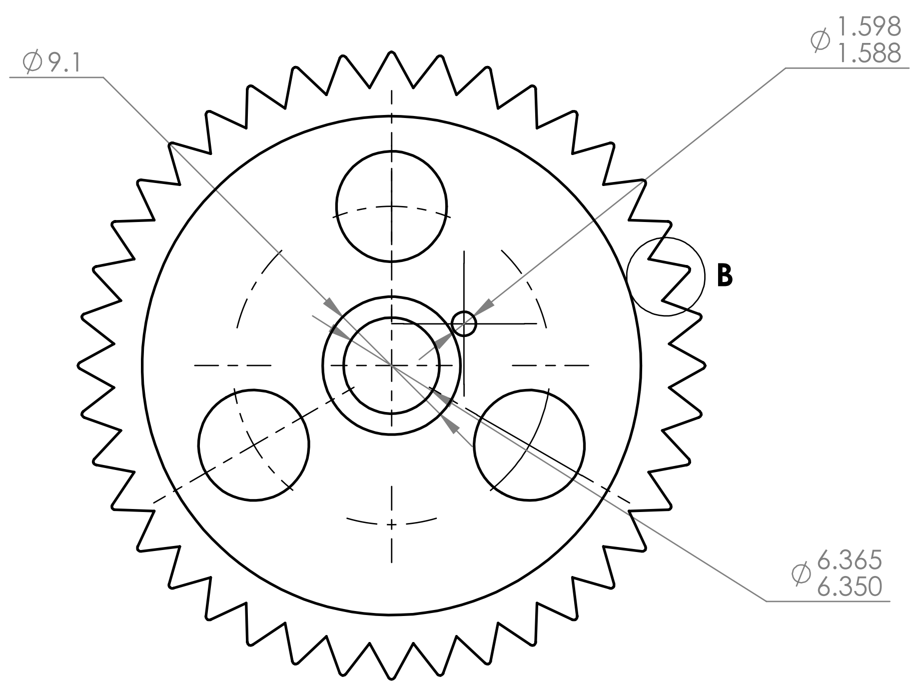
TITLE: 20mm Spur Gear

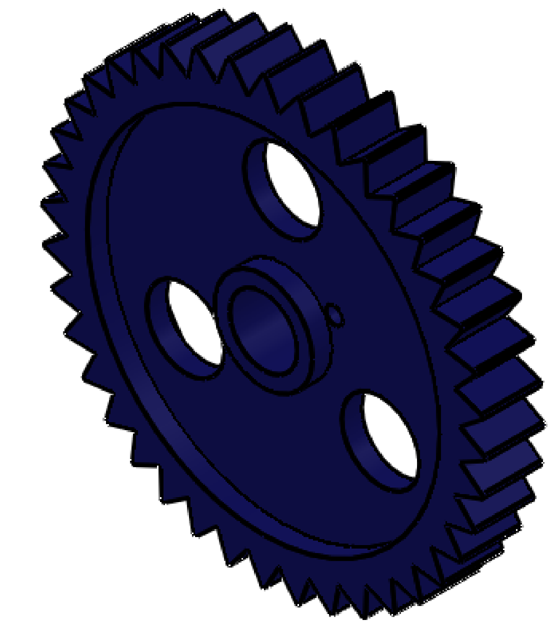
SIZE **B** | Assignment Number **Drawing Project** | REV

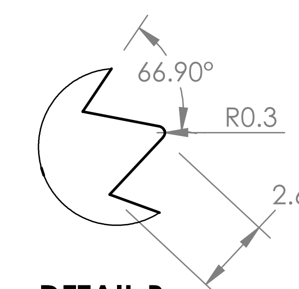
FILE NAME: 20mm Spur Gear Drilled

SCALE: 2:1 | Mass: | SHEET 2 OF 4









DETAIL B
SCALE 4 : 1

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Mec E 265

Instructor: **Dr. D.S.Nobes**
Win 2016

Comments:
Hole was drilled into gear to fasten the gear onto rod

MATERIAL:
XXXX

FILE NAME:
40mm Spur Gear Drilled

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH 0.6 µm

DO NOT SCALE DRAWING

DRAWN BY:
Toya Okeke

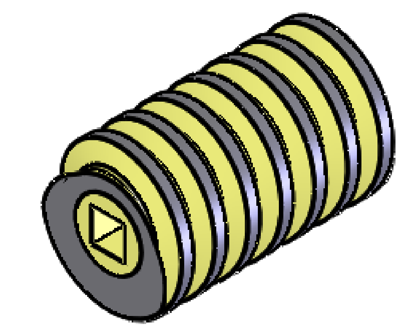
Lab Day xxxx
SM By **Brayden Stecyk**
TA Initials DSN
tokeke
Saturday, March 26, 2016 7:18:56 PM
Monday, January 11, 2010 4:39:12 PM

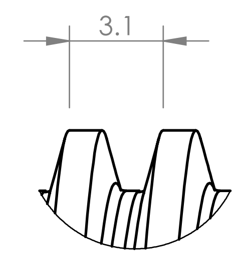
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
40mm Spur Gear

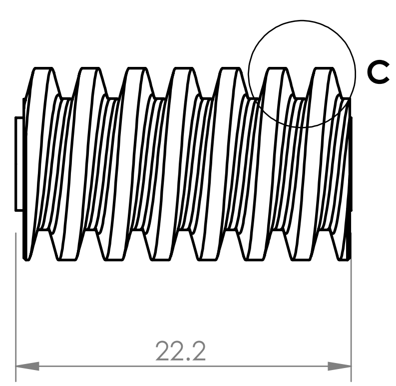
SIZE **B**
Assignment Number
Drawing Project
REV XXX

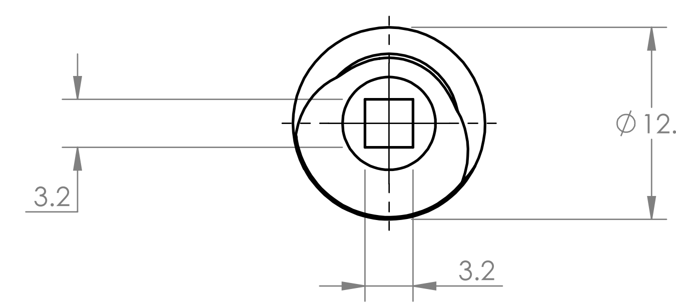
SCALE: 2:1 Mass: SHEET 3 OF 4





DETAIL C
SCALE 4 : 1





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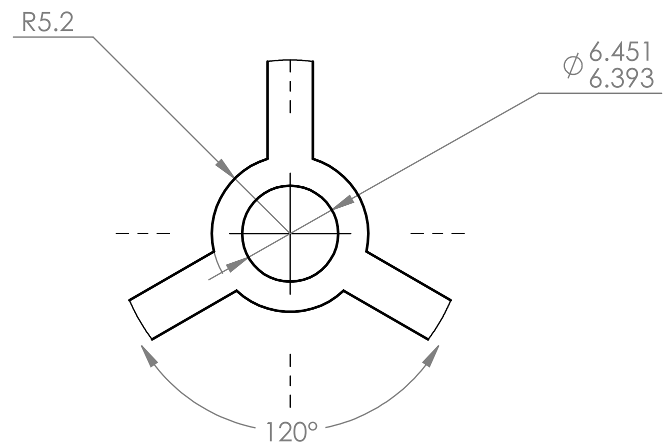
Mec E 265
Instructor: **Dr. D.S.Nobes Win 2016**
Comments:
MATERIAL:
FILE NAME: ABS Single Start Worm

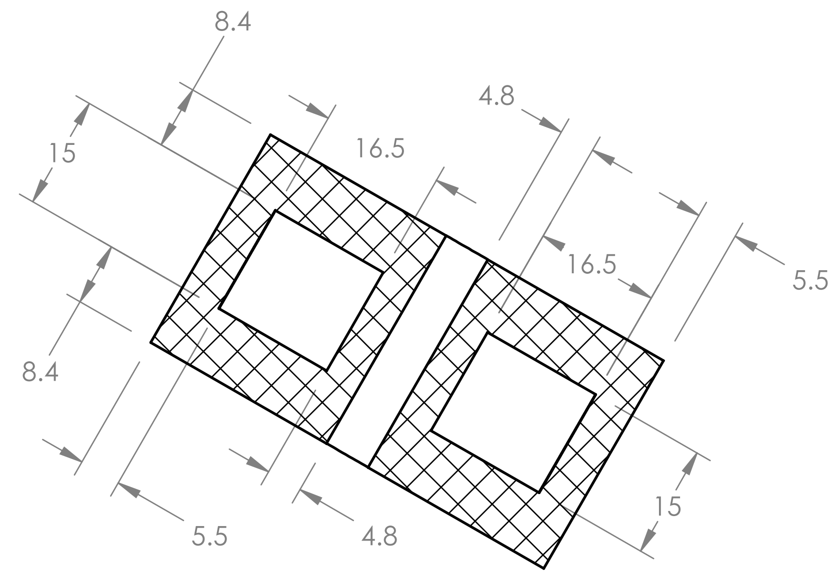
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

DRAWN BY:
Toya Okeke
Lab Day
SM By **D.S. Nobes/ Brayden Stecyk**
TA Initials DSN
tokeke
Friday, March 25, 2016 11:51:45 PM
Monday, June 18, 2007 7:42:38 AM

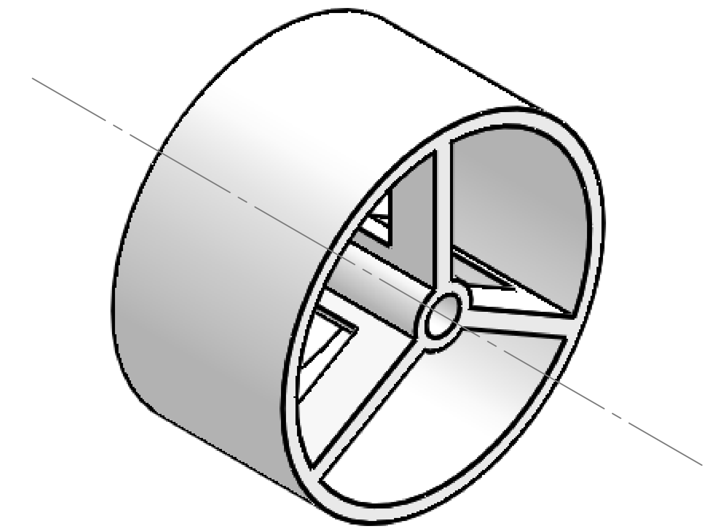
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA
TITLE:
Square Punched Worm Gear
SIZE **B**
Assignment Number
Drawing Project
REV
SCALE: 2:1
Mass:
SHEET 4 OF 4

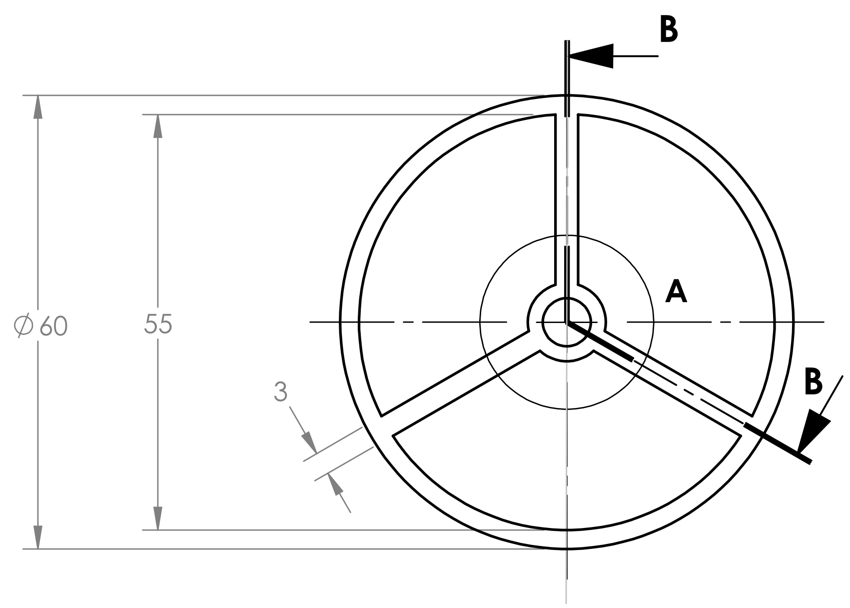


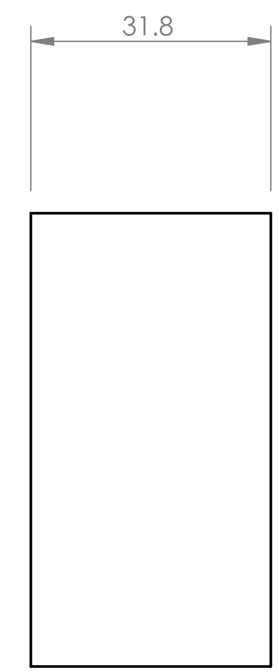
DETAIL A
SCALE 2 : 1



SECTION B-B







Please Mark This Subassembly
For CHENGSHUNZI DONG

Instructor:
Dr DS Nobes
Dr. Mertiny
Comments:
This is my part for marking

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025
SURFACE FINISH µm 0.6
DO NOT SCALE DRAWING

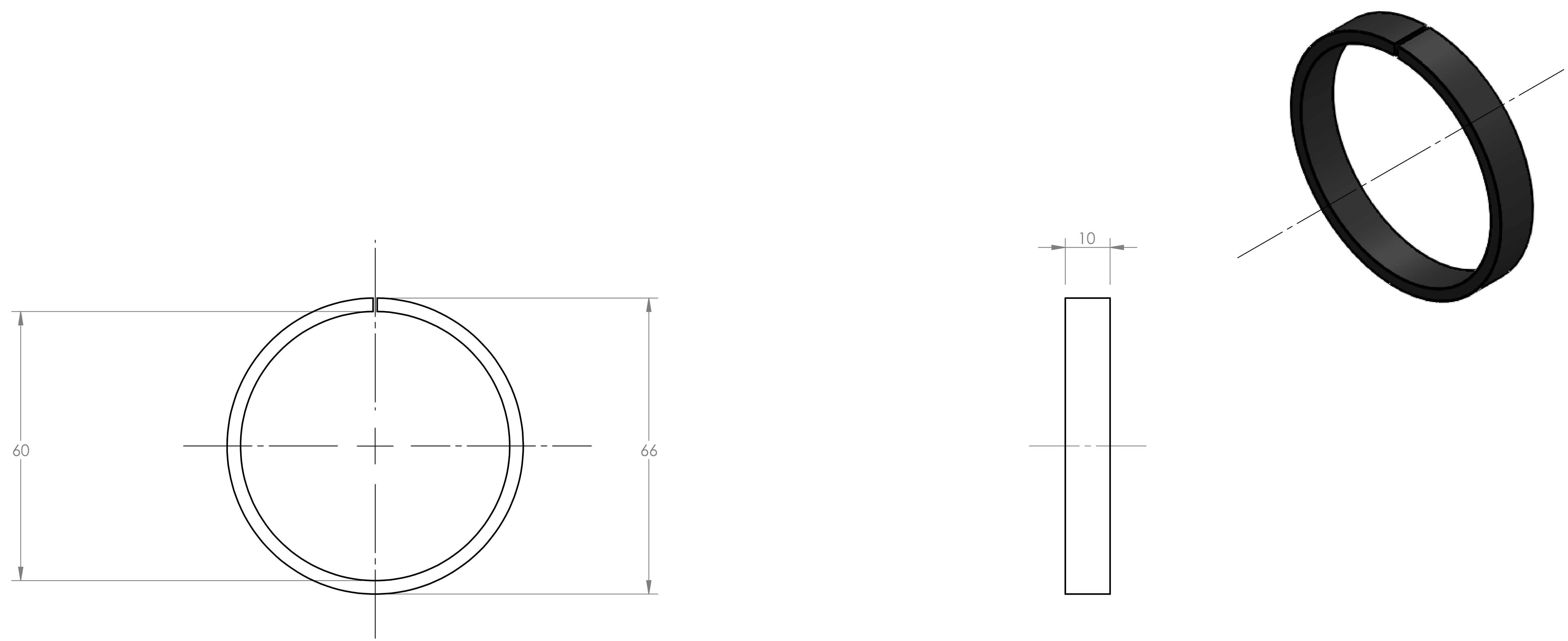
MATERIAL:
ABS
FILE NAME:
Wheel

DRAWN BY:
Chengshunzi,Dong
Lab Day WED
SM By **Brayden Stecyk**
TA Initials
Mec33
Saturday, March 26, 2016 3:29:51 PM
Thursday, March 17, 2016 5:55:41 PM

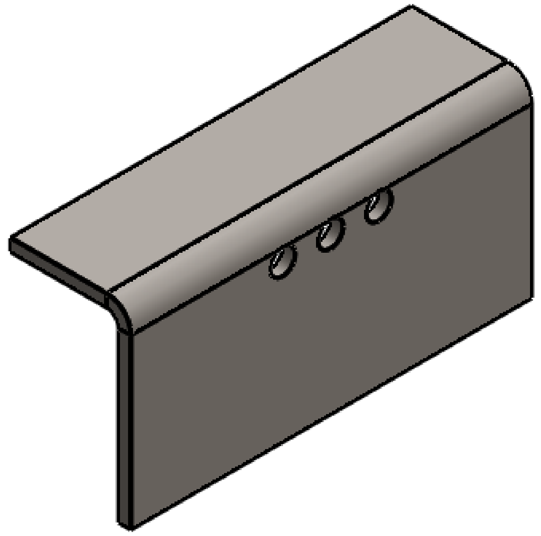
The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA
TITLE:
Wheel
SIZE **B**
Assignment Number
Drawing Project
REV
SCALE: 1:1
Mass: 20.54
SHEET 1 OF 1

The front wheel is free rotating without rotating the inside shaft, it need to be free running

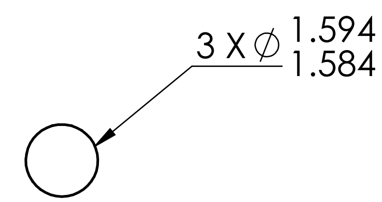
Tolerance for the front wheel	Basis	Tolerance	Tolerance for holes	Dimensions
Clearance Fits	shaft basis	D9/h9	[+0.04, +0.098] cm	[6.393, 6.451]



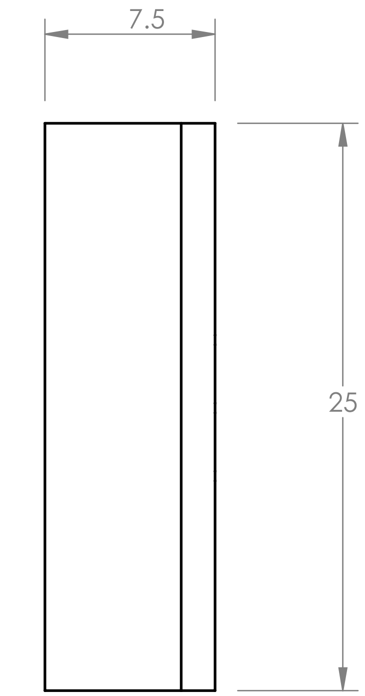
Instructor: Dr. D.S.Nobes Dr. Mertiny Comments: Material is given in the Machine shop. Glued by hand. So no accurate tolerance for it.	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Chengshunzi,Dong** Lab Day SM By **Brayden stecyk** TA Initials Mec33 Saturday, March 26, 2016 9:16:43 PM Saturday, March 26, 2016 9:11:10 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Weather Striping
MATERIAL:			SIZE **B**	Assignment Number **Drawing Project**	REV
FILE NAME: Weather Striping			SCALE: 1:1	Mass:	SHEET 1 OF 1

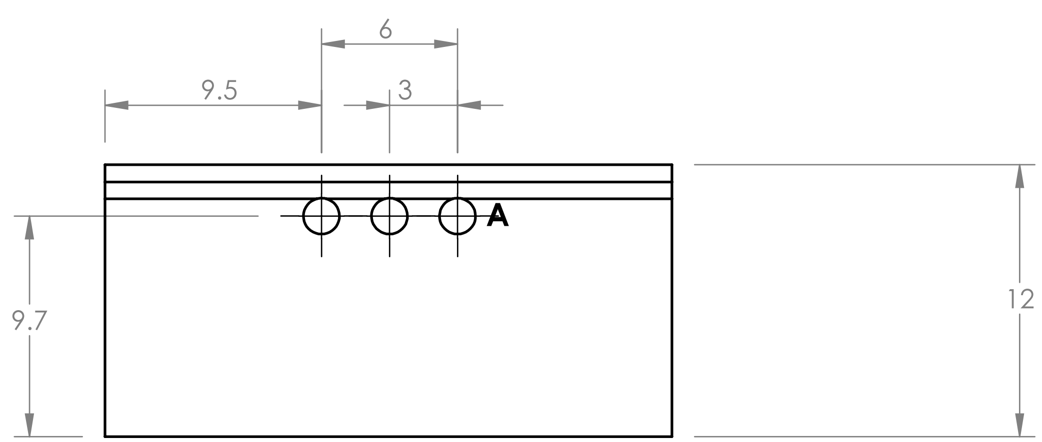


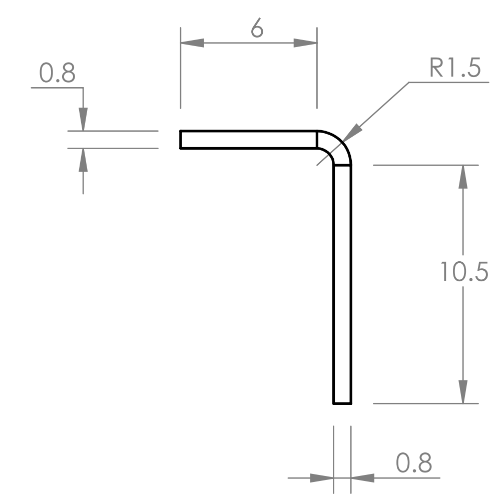
Inner Front Motor Mount to Rod
Fit: Interference
Basis: Shaft
ISO: P7/h6
Nominal: ∅1.6
Limits: -0.016, -0.006



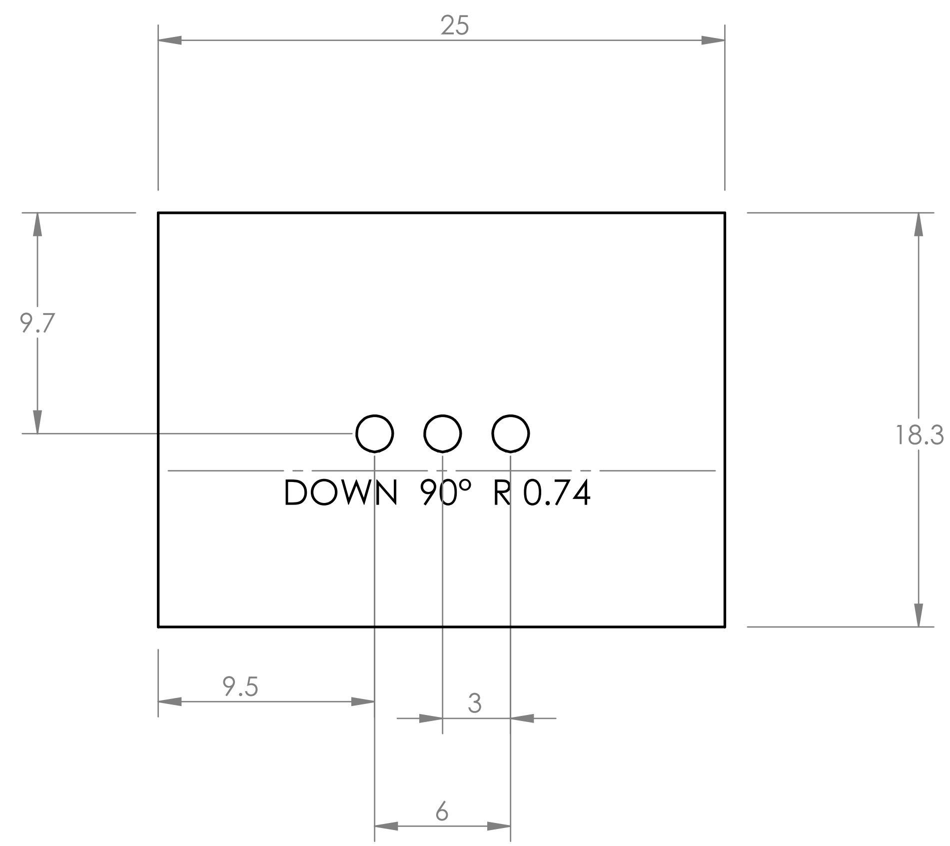
DETAIL A
SCALE 6 : 1







Mec E 265 Instructor: **Dr. D.S.Nobes Win 2016** Comments: N/A	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Toya Okeke** Lab Day SM By **Brayden Stecyk** TA Initials DSN tokeke March 29, 2016 3:17:27 PM March 25, 2016 11:00:27 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Inner Front Motor Mount Sheet Metal
MATERIAL: AISI 1020 Steel, Cold Rolled			SIZE **B** | Assignment Number **Drawing Project** | REV
FILE NAME: Inner Front Motor Mount Sheet Metal			SCALE: 3:1 | Mass: 2.70 | SHEET 1 OF 3



Mec E 265

Instructor: Dr. D.S.Nobes
Win 2016

Comments:
N/A

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

MATERIAL:
AISI 1020 Steel, Cold Rolled

FILE NAME:
Inner Front Motor Mount Sheet Metal

DRAWN BY:
Toya Okeke

Lab Day	
SM By	Brayden Stecyk
TA Initials	DSN

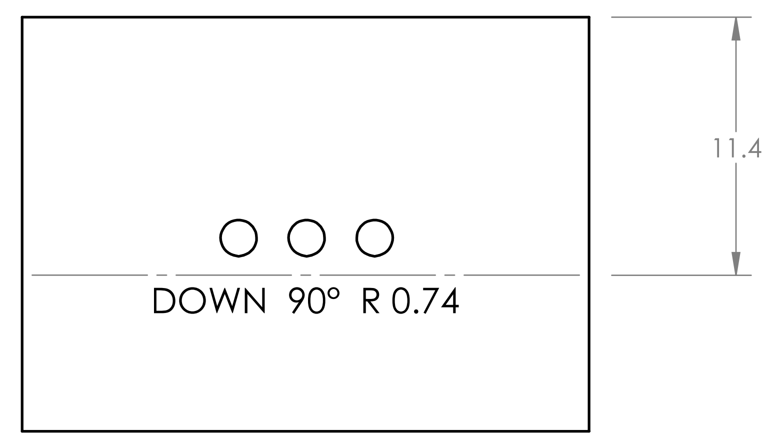
tokeke
March 29, 2016 3:17:27 PM
March 25, 2016 11:00:27 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Sheet Metal: As Cut

SIZE B | Assignment Number **Drawing Project** | REV

SCALE: 3:1 | Mass: 2.70 | SHEET 2 OF 3



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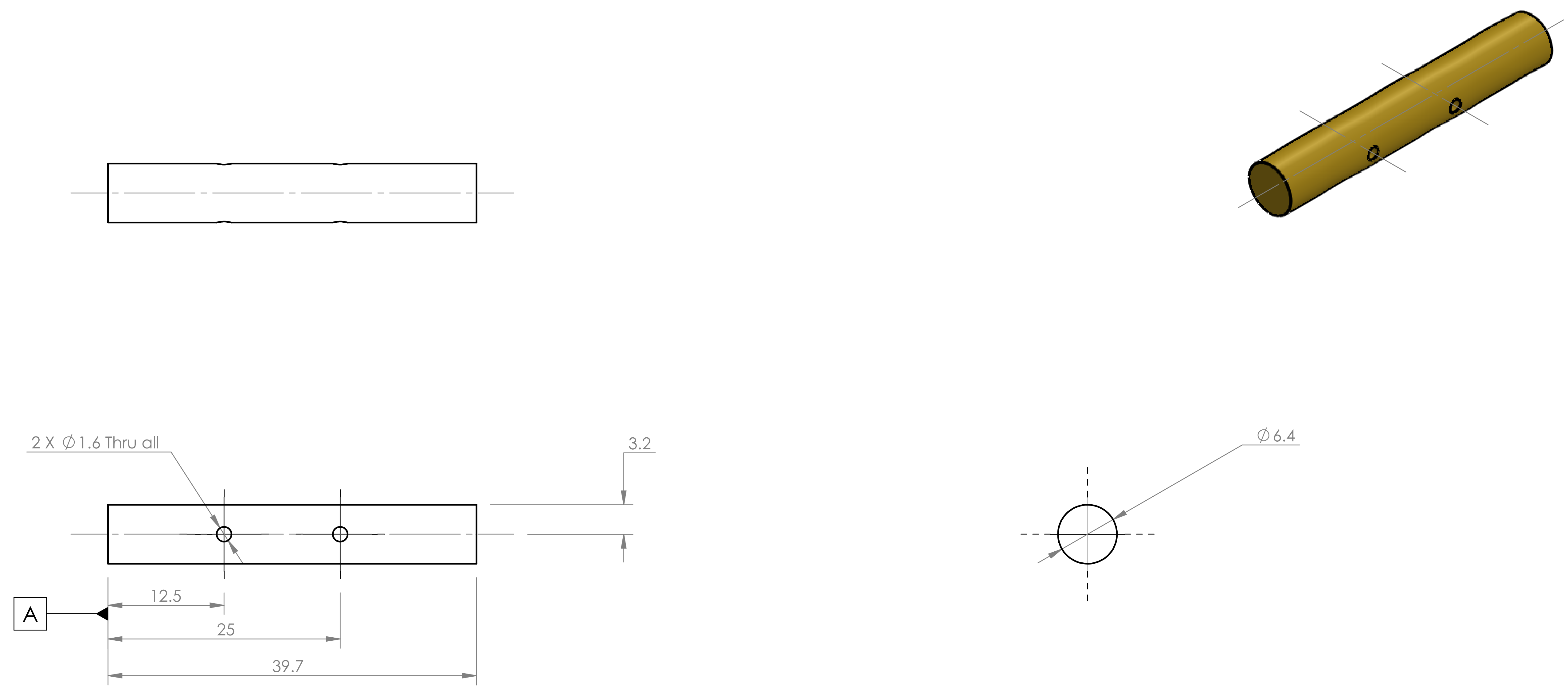
Mec E 265 Instructor: **Dr. D.S.Nobes** **Win 2016** Comments: N/A	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MM TOLERANCES: ANGULAR: ± 0.5° LINEAR X = ± 0.5 X.X = ± 0.1 X.XX = ± 0.025 SURFACE FINISH µm 0.6 DO NOT SCALE DRAWING	DRAWN BY: **Toya Okeke** Lab Day SM By **Brayden Stecyk** TA Initials DSN tokeke March 29, 2016 3:17:27 PM March 25, 2016 11:00:27 PM	The Department of Mechanical Engineering UNIVERSITY OF ALBERTA TITLE: Sheet Metal: As Bent
MATERIAL: AISI 1020 Steel, Cold Rolled			SIZE **B** Assignment Number **Drawing Project** REV
FILE NAME: Inner Front Motor Mount Sheet Metal			SCALE: 3:1 Mass: 2.70 SHEET 3 OF 3



Instructor:
Dr DS Nobes
Dr. Mertiny

Comments:
No tolerance for the rod since material is given in the workshop.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong

Lab Day

SM By **Chengshunzi Dong**

TA Initials

Mec33
Tuesday, March 29, 2016 3:09:12 PM
Sunday, March 13, 2016 9:19:26 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

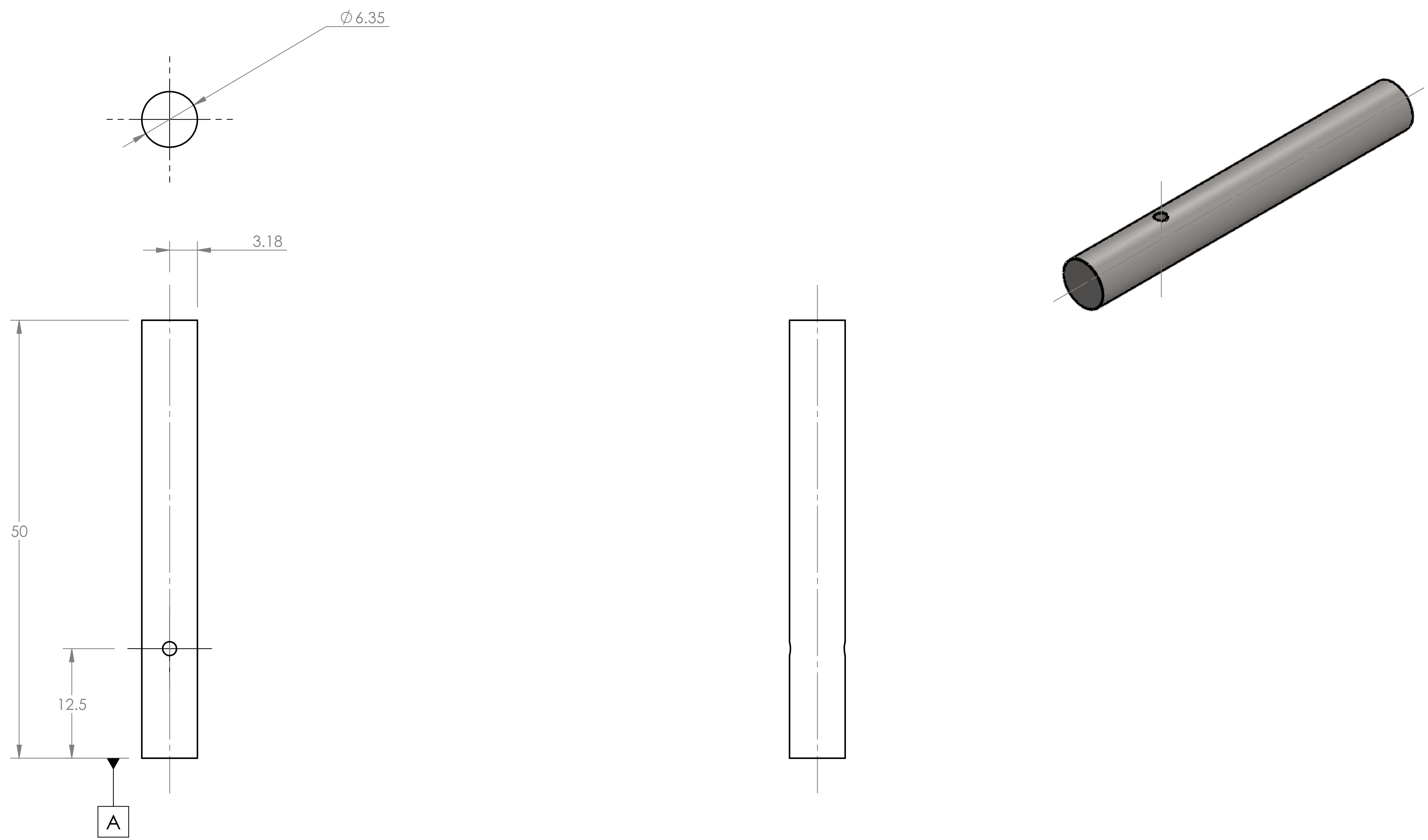
TITLE:
Gear reducer rod

MATERIAL:
Brass

FILE NAME:
Gear Reducer Rod

SIZE	Assignment Number	REV
B	Drawing Project	1

SCALE: 2:1 | Mass: 10.47 grams | SHEET 1 OF 1



Instructor:
Dr DS Nobes
Dr. Mertiny

Comments:
No tolerance for the rod since material is given in the workshop.

MATERIAL:
AISI 1021

FILE NAME:
Camera Rod

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi, Dong

Lab Day

SM By **Farhan Khan**

TA Initials

Mec33
Saturday, March 26, 2016 7:08:14 PM
Thursday, March 10, 2016 5:58:15 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

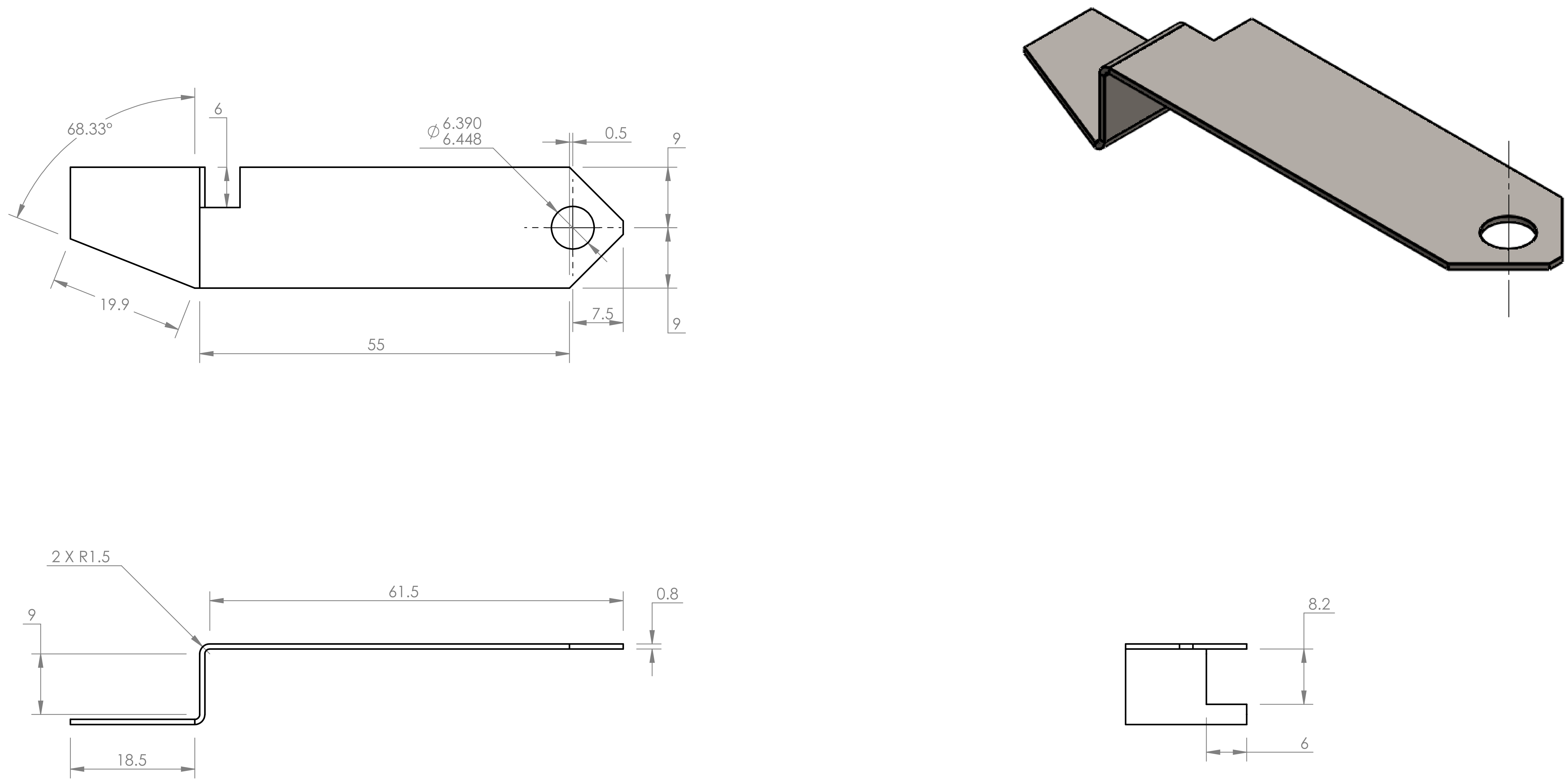
TITLE:
Camera Rod

SIZE **B**

Assignment Number
Drawing Project

REV 1

SCALE: 2:1 | Mass: 12.41 grams | SHEET 1 OF 1



Instructor:
Dr Ds Nobes
Dr.Mertiny

Comments:

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MM
TOLERANCES:
ANGULAR: ± 0.5°
LINEAR
X = ± 0.5
X.X = ± 0.1
X.XX = ± 0.025

SURFACE FINISH µm 0.6

DO NOT SCALE DRAWING

DRAWN BY:
Chengshunzi,Dong

Lab Day

SM By **Brayden Stecyk**

TA Initials

Mec33
Tuesday, March 29, 2016 3:47:05 PM
Saturday, March 26, 2016 8:33:23 PM

The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Steering Shaft holder

MATERIAL:
AISI 1021 Steel

FILE NAME:
Steering Shaft Guide

SIZE **B**

Assignment Number
Drawing Project

REV 1

SCALE: 2:1 | Mass: 8.51 grams | SHEET 1 OF 2

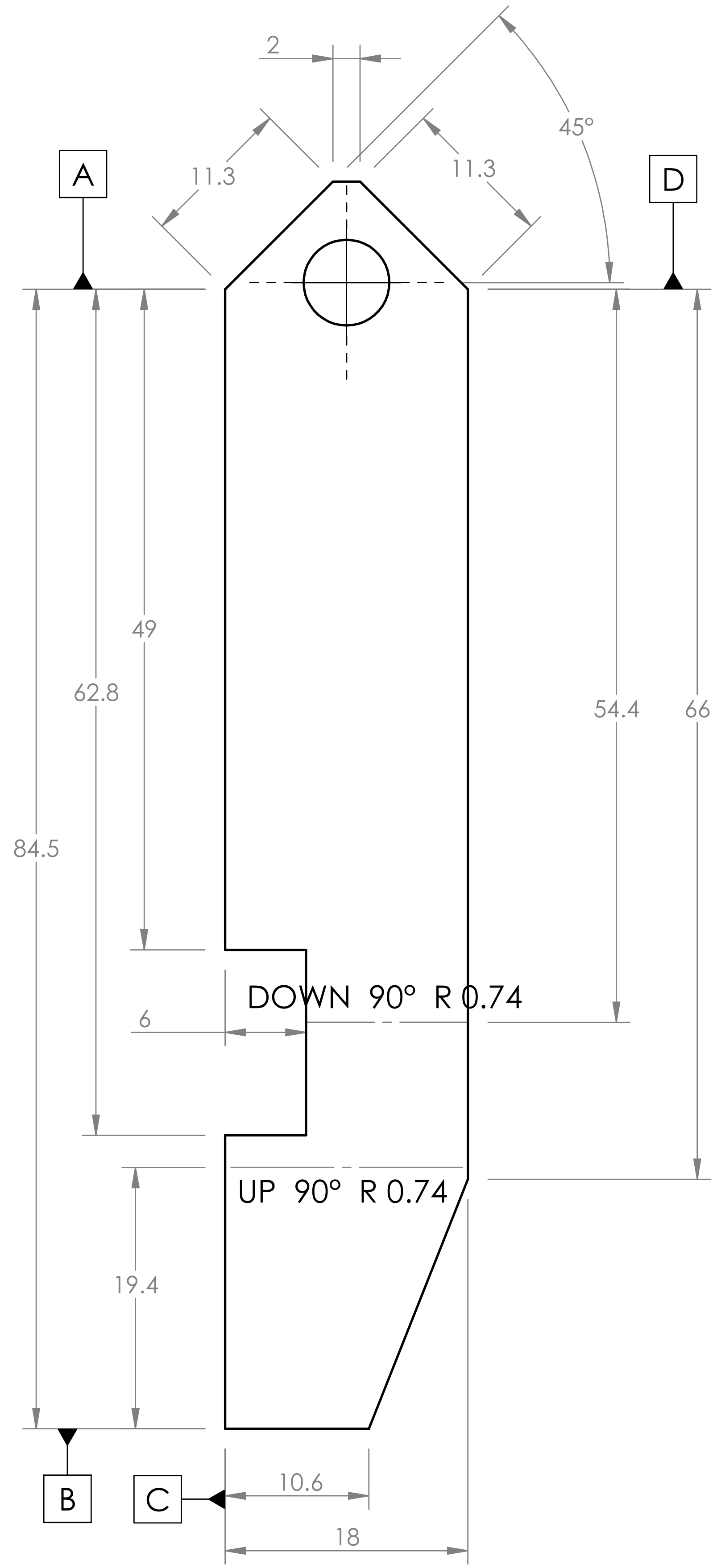
8 7 6 5 4 3 2 1

D

C

B

A



Instructor:
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Chengshunzi, Dong
Lab Day
SM By **Brayden Stecyk**
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The Department of Mechanical Engineering
UNIVERSITY OF ALBERTA

TITLE:
Steering shaft holder

SIZE **B**
Assignment Number
Drawing Project
REV 1

MATERIAL:
AISI 1021 Steel
FILE NAME:
Steering Shaft Guide

SCALE: 2:1
Mass: 8.51 grams
SHEET 2 OF 2

Tolerance for the Holes on this sheet metal

Clearance Fits(Free running); since the rod rotates inside this hole without the sheet metal rotat

basis	Tolerance	Tolerance for holes	Dimensions	
Shaft basis	D9/h9	[+0.04, +0.098] cm	[6.390,6.448]	