BATTERY-DRIVEN VEHICLE PROJECT

Designed by Section 2 – Team No 1

Date: 08/04/2023 (Created) – 29/04/2023 (Submitted)

Course / Section: OENG 1205 / Section 2 (Friday 4.30 pm to 6.00 pm)

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1. Project Introduction and Aim

1.1. Background

Automobiles are four-wheeled vehicles with engines typically fueled by gasoline or electricity and designed to transport passengers. With the development of the first steam-powered vehicle in 1672 [1] by Jerónimo de Ayanz y Beaumont, the automobile concept emerged. The development of the automobile was put on hold in the middle of the 19th century due to opposition to huge vehicles. However, the internal combustion engine for cars has made significant strides. In 1886, Karl Benz, the founder of Mercedes Benz, invented the first modern automobile by developing and producing several identical gasoline-powered automobiles. Ford Motor Company celebrated the creation and mass manufacturing of the vehicle in 1908 by putting the Ford Model T through an assembly line. Nowadays, people worldwide are increasingly using automobiles as a form of mobility.

AVGs or Automated Guided Vehicles are automated vehicles designed to process simple tasks such as picking up objects or cleaning the floor. Unlike most vehicles, the primary purpose of this vehicle is to execute the task without human interaction within the period of the task performance. With modern manufacturing, our team intends to design the Motorized Clean Up vehicle with the driver's passenger inside, which is used to collect screws along the road.

1.2. Requirements

For the implementation, this project aims to design and build a Motorized Clean Up Vehicle, an AVG (Automated Guided Vehicle) that picks up screws along the straight path (two-meter long and twelve-centimeter wide) that it goes through. A hook mass weight of 100 grams is viewed as a passenger that the vehicle needs to be able to carry during the cleaning-up process. The car will operate with 2AA batteries, and it must pick up the screws that locate on the track it passes using three mini-magnets. There will also be a storage place to store the picked-up screws.

For the project developers, the team should be able to integrate their SOLIDWORKS knowledge into creating their unique car chassis as well as designing a Power Transmission and Electrical System. The primary car dimensions must fit into the 12 x 12 x 12 cm box and not have more than twelve parts (excluding the provided components). Each SOLIDWORKS design must be manufactured by 3D printing with clear resin or acrylic laser cutting. Each 3D printing part must not exceed 100 cm^3 in volume. Each part's surface must be engraved with the team's name. The laser-cutting parts must have unchanged thicknesses of 3 mm, 5 mm, or 10 mm. The assembled car must not exceed twelve components, excluding the provided hardware.

1.3. Project's history

- **Saturday (08/04/2023):** first offline meeting of the team

a) Distribute each given hardware to each member to produce 2D and 3D drawings, the work is expected to be complete in one week: TT DC Motor (Vittorio), On/Off Switch (Phuong), Wheels and Axes (Jong Chul), Battery Tray (Khang) (completed in 10 days). Phuong is also in charge of recording the project's history (finished on 27/04/2023).

b) The report's introduction will be written by Thien within the one-week deadline.

c) The team has agreed on the general body of the car, which focuses on all the heavy load at the centre and bears the shape of a racing car. This design was decided because the team wants equal pressure exerted on each axis which takes charge of spinning the wheels and prevents the car from leaning over to either the front or the back. However, the specific dimensions of the car are unknown since the dimensions and the weight of the hooked mass, the screws for storage and the magnets have been unidentified.

d) The report file has been created with the headlines, titles, and table of contents by Khang.
e) The team tried to research further on the torque ratio.

- **Wednesday (12/04/2023):** the team scheduled a visit to the lecturer's office at 1 pm to measure the dimensions and weights of the screws, magnets, and hooked mass.

a) The method to secure the magnets and the torque ratio remained undecided, but the designs for the drive and driven pulley have been implemented.
b) The team decided to develop the storage dimensions based on the biggest screw.
c) Suggest placing the battery tray next to the motor. However, this placement will inconveniently expand the car chassis' width.

- **Wednesday (19/04/2023):**

a) The team decided to have the thickness of the chassis 4 mm to avoid parts breaking and minimize the volume of the part.
b) The team members finished the drawings of their part and proceeded to write the report section (completed in four days) about the features of their perspective assigned hardware (with the deadline of Sunday 23/04/2023).
c) The team has agreed on the final design of the car's chassis, the motor will be put on the upper surface while the battery holder is hung upside down and on the under surface to facilitate removing batteries. The switch can be hung next to the motor.
d) Small cylinder designs are added to where the wheel axis is inserted to prevent the car's body from breaking.
e) Suggest designing a big storage space with two small cubes within to accommodate the hooked mass and the screws.
f) The team agreed to hang the magnets at the front of the car through rectangle holes.

- **Thursday (20/04/2023):**

a) It is suggested that the motor and battery holder be attached to the chassis using bolts and nuts to enhance consistency in placing positions and facilitate disassembly.

b) Phuong was assigned to research further into the pulley's ratio.

c) The team design a raised rectangular feature to secure the motor with a bolt and nut.

- **Friday (21/04/2023):**

a) The team agreed on the 1:1.5 torque ratio. Upon calculation, the driven pulley will be 7.5 mm in diameter and the drive pulley will be 11.25 in diameter. Phuong will oversee writing the report about this topic (completed in three days). The car's chassis and system designs have all been finalized.
b) Khang will write about the car assembly section (completed in three days).
c) Vittorio will write about the car's chassis (completed in three days).
d) The task of writing the bill of material is assigned to Kim Jong Chul (completed in two days).
e) Thien will check the format and spelling of every section in the report.

- **Thursday (27/04/2023):**

a) The report is completed.

2. Design Features

2.1. Vehicle Chassis

Figure 2.1. displays the bare chassis without the appearance of the components and the load's storage features. The design takes inspiration from a racing car, meaning most weight would be concentrated on the middle of the chassis. This variety of weight distribution eliminates the car being overly leaned at either the front or back, which can cause unexpected wheel behaviours; it helps to balance the overall weight and keep the car stable on the track. The dimensions for the chassis are 184.00 x 85.00 x 44.00 mm (Length x Width X Height), which are well fitted into 12 x 12 x 12 cm as required in the design constraint. Its part volume is 88295.82 mm^3 (less than 100 cm^3), making it possible to be manufactured by 3D printing. As in Figure 2.1, two compartments have been designed to hold the screws and the hooked mass in place, both of which sit in the middle of the chassis for weight distribution purposes. The screws storage spans 44 mm in length or 25 mm in height to withstand securing at least five screws stacked vertically and horizontally; the hooked mass compartment has a length and width minutely larger than the load base diameter and a height as high as a third of the hooked mass to keep it from falling out. As stated in the project's requirements, the magnets pick up the screws, so a feature is designed at the head to hang them. The width of the rectangles through which the magnets go has been speculated so that it will not experience unnecessary left-and-right motion, which can cause displacement during the vehicle's operation. Furthermore, the two through holes designed at two ends of the chassis are where the axis will be placed with the wheels. The hole's diameter is 0.5 mm bigger than that of the axis to allow enough space for rotation. The circular features surrounding the holes (5 mm in diameter) are added so that the stress the axis exerts on the chassis during spinning is distributed circularly. If those surrounding circles have not been made, the pressure, being put on the chassis when the axis is rotating, can become great enough to smash the part in half; so those features are designed due to safety cautions.

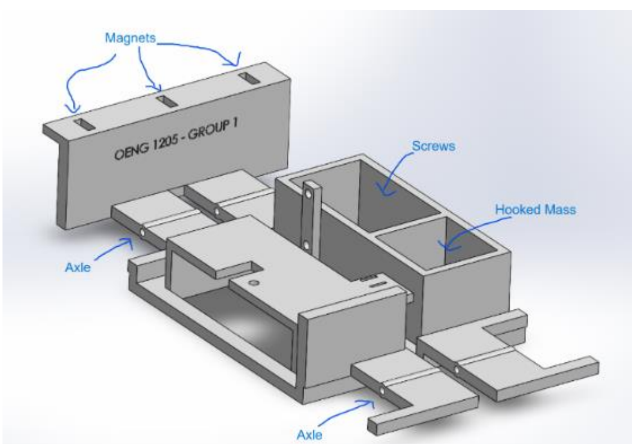


Figure 2.1. Bare car's chassis with notes of load placement

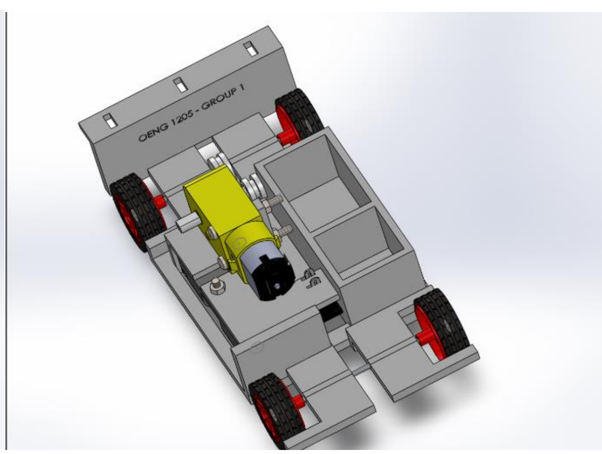


Figure 2.2. Car's chassis when loaded with components and pulleys.

2.2. Vehicle's Electrical System

The motor requires at least 3V to perform its function. Therefore, the battery holder that is used connects two batteries in series (the positive terminal of one is connected to the negative terminal of the other), which gives double the voltage in total and capacity of one battery. When two 1.5V AA batteries are inserted in the holder, it will generate enough 3V voltage to power the dc motor, which oversees turning the wheels. In terms of placement of electrical components, the system, including the motor, and the battery holder with two batteries, the switch and the wires are placed to ensure that each part stays close together. The closely connected placement helps to control the width dimension of the car's chassis and prevents motion interference with the operations of the wheels. Concerning our design (illustrated in Figures 2.3 and 2.4), the battery holder (illustrated in Figure 2.3) is placed under the raised rectangle surface and secured with a bolt, nut and double-sided tape. The upper surface is reserved for the DC motor (illustrated in Figure 2.4) to prevent the drive pulley diameter from touching the ground; the motor is secured by connecting two bolts and nuts from the DC motor to the vertically raised rectangles containing two through holes. These placing decisions provide the advantage of reducing the travelling distance of the cable, which is guided through the holes on the side surface so that the wire connection will not be easily displaced during the drive. The switch (illustrated in Figure 2.4) is placed upside down with its terminals reaching the upper surface close to the motor. This placement optimizes the travelling distance of the electrical cables to maintain a stable electrical connection within the system so that the car can drive safely along the driving way. For the electrical system to function as expected and for the motor to spin in the correct direction to move the car forward, meticulous wiring has to be implemented. Figures 2.5 and 2.6 demonstrate where the wires should go to achieve a fruitful result. The black and red colour represents the respective black and red wires emerging from the battery holder, whereas the orange represents a short length of zinc or a jumper wire. The wiring is done based on the theoretical circuit shown in Figure 2.7.

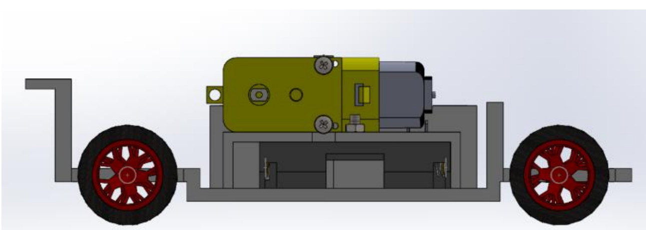


Figure 2.3. Illustration of the motor and battery holder's placement

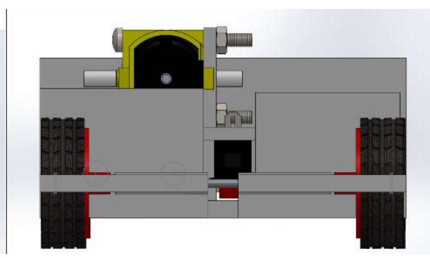
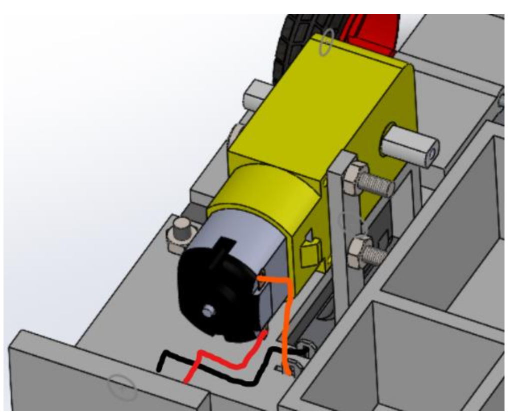


Figure 2.4. Illustration of the motor and switch's placement



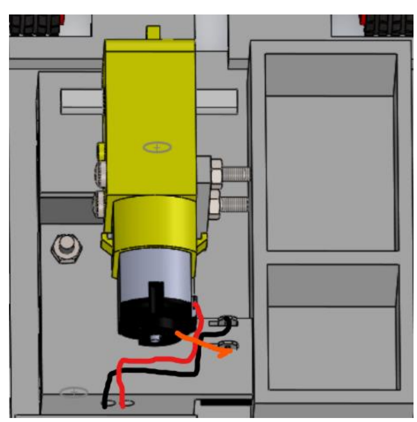


Figure 2.5. Illustration of the electrical wiring

Figure 2.6. An additional illustration of the electrical wiring

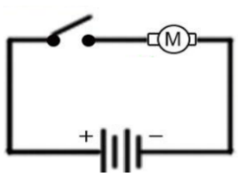


Figure 2.7. A theoretical circuit containing a battery, motor, and switch. [2]

2.3. Vehicle's Power Transmission System

The power transmission system consists of a drive pulley, a driven pulley and a driving belt. By adjusting the pulley's diameter, the amount of torque and turning speed can be customized. The pulleys are made by 3D printing with clear resin material while the belt is made of rubber and bought from the local market.

A) Torque and angular velocity ratio

To arrive at a correct ratio for the pulleys to have strong enough torque to move the car forward. We tap into the torque calculation formula: $T = F \times r$ [4]. In this case, F shares the same value as the car's weight while r is the wheel's radius. The number resulting from this formula is the torque required to move the vehicle from rest. If that value is divided by the torque given by the DC motor ($T_1 = 0.40\ kg.cm\ at\ 3.00V$ [5]), a diameter and angular velocity ratio can be deduced. The car has a total mass of roughly 393.00g including all electrical components and loads.

$$T_2 = F \times r = W \times r = (0.393\ kg) \times \left(9.81 \frac{m}{s^2}\right) \times (1.5\ cm) \approx\ 0.0578\ N.m \approx 0.6\ kg.cm$$

$$\frac{r_1}{r_2} = \frac{\omega_2}{\omega_1} = \frac{T_1}{T_2} = \frac{0.4}{0.6} = \frac{2}{3}$$

Based on the result substantiated above, it is decided that the diameter of the driven pulley will be 1.50 times greater than that of the drive pulley. This ratio amplifies the torque of the drive pulley by 1.50 times but also decreases the driven pulley rotating speed by the same amount.

B) Belt length and size selection

To calculate the belt length needed for a pair of diameters discovered above, we rely on the formula [5]:

$$Belt\ Length = \frac{\pi}{2}(D_L + D_s) + 2L + \frac{(D_L - D_s)^2}{4L}\ \ where:$$

$$D_L: The\ driven\ pulley's\ diameter$$

$$D_S: The\ drive\ pulley's\ diameter$$

$$L: Centre - to - centre\ distance\ between\ two\ pulleys$$

The L (centre-to-centre) has been measured to be 46.69 mm using the Measure Tool in SOLIDWORKS to measure the distance from the motor's rotating axle to the wheels' axle. To decide D_L and D_S, we must consider that the drive pulley's diameter needs to be larger than 6.00 mm (the rotating axle's diameter of the motor) and the driven pulley's diameter has to be less than 12.00 mm to not touch the ground when turning. The set of values ranging from 6.00 mm to 8.00 mm for D_S are inserted in Excel to find their perspective D_S and L, the table below displays the results.

Table 1. Values for the belt length, Drive Pulley, and Driven Pulley's diameters

Drive Pulley	Driven Pulley	Belt Length	Centre-to-centre distance
			46.69 mm
6	9	117	
6.5	9.75	118.96	
6.75	10.125	119.56	
7	10.5	120.934	
7.5	11.25	123	
7.75	11.625	124	
8	12	125	

Considering the design constraints mentioned above, combined with the securing features for the rubber band and the standard rubber band size chart [6], it is concluded that $D_L(Driven\ Pulley) = 7.50\ mm\ , D_s(Drive\ Pulley) = 11.25\ mm$ would be ideal for this specific car design; this pair of diameters give the belt length 34.00 mm longer than the length of the rubber band type 19 (which spans 88.90 mm), creating powerful enough thickness between the through slot and the cylinder (1.90 mm), and minimizes the possibility of pulleys in contact with the ground. This rubber band has a width of 1/16 mm, a thickness of 1/32 mm and possesses an elongation of up to 700%, meaning it can easily be stretched to over 117 mm without being torn apart. Table 2 below sums up our results.

Table 2. Calculated results for Power Transmission System

Drive Pulley Diamter	7.5 mm
Driven Pullye Diamter	11.25 mm
Rubber band size	19

3. Device Description

3.1. Bill of Material

This section illustrates each component's name, number, primary dimensions, part volume (if 3D printing) and quantity. More information can be seen in Table 1 below.

Table 3. Bill of Material for the battery-driven car

ITEM NO.	PART NAME	PART NUMBER	DESCRIPTION (INCLUDING PART VOLUME FOR 3D PRINTING PARTS)	MTL	QTY.

1	Chassis	OENG1205_GROUP1_001	184.00 x 85.00 x 44.00 mm (Length x Width x Height) Chassis Part volume: 87476.42 mm^3	Clear resin	1
2	Axle	OENG1205_GROUP1_002	2.00 mm x 60.00 mm (Diameter x Length) Axle	Provided by the course's coordinator	2
3	Wheel	OENG1205_GROUP1_003	18.53 x 16.00 mm (Inner Diamter x Width) Wheel	Provided by the course's coordinator	4
4	Battery Holder	OENG1205_GROUP1_004	57.97 x 31.74 x 14.09 mm (Length x Width x Height) Battery Holder	Provided by the course's coordinator	1
5	Motor	OENG1205_GROUP1_005	69.38 x 36.74 x 22.50 mm (Length x Width x Height) Motor	Provided by the course's coordinator	1
6	Drive Pulley	OENG1205_GROUP1_006	7.50 x 11.00 x 6.30 mm (Small diameter x Large diameter x Width) Drive Pulley Part volume: 374.47 mm^3	Clear resin	1
7	Driven Pulley	OENG1205_GROUP1_007	11.25 x 13.00 x 6.30 mm (Small diameter x Large diameter x Width) Driven Pulley Part volume: 742.01 mm^3	Clear resin	1
8	Switch	OENG1205_GROUP1_008	15.22 x 10.45 x 19.95 mm (Length x Width x Height) Switch	Provided by the course's coordinator	1
9	Pan Cross Head Bolt	OENG1205_GROUP1_009	3.00 x 30.00 mm (Diameter x Length) Bolt	Stainless steel	2
10	Hex Nuts	OENG1205_GROUP1_010	1.91 x 3.00 mm (Thickness x Diameter) Nut	Stainless steel	3
11	Cross Countersunk Head Bolt	OENG1205_GROUP1_011	10.00 x 3.00 mm (Length x Diameter) Bolt	Stainless steel	1
12	Driving belt	OENG1205_GROUP1_012	88.90 x 15.88 x 0.8 (Length x Width x Thickness)	Rubber	1

3.2. Component's Views and Manufacturing Methods

3.2.1 Chassis

A) Drawings

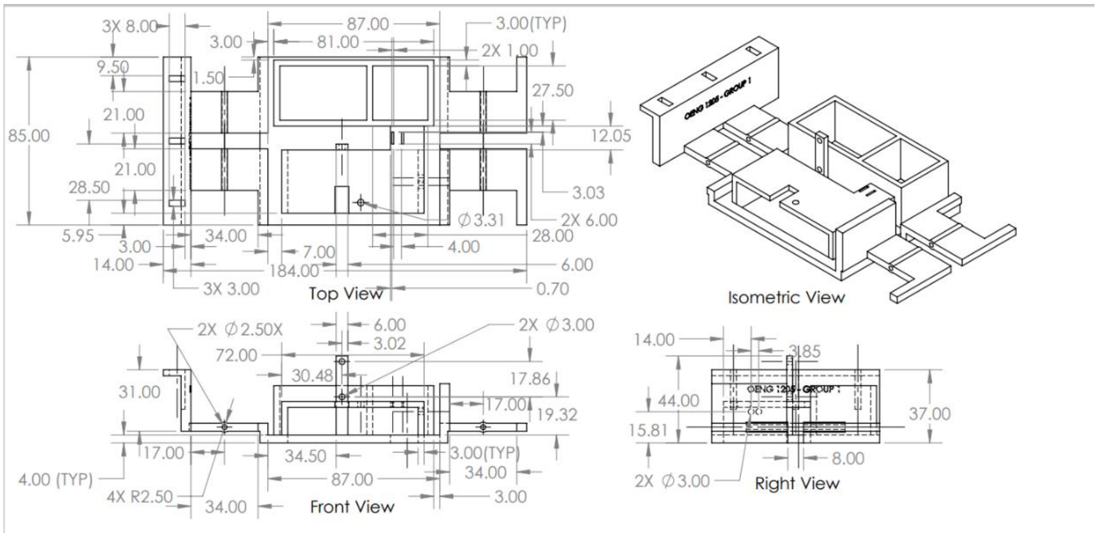


Figure 3.1. 2D drawing of a car chassis (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features:
  - The raised platform on the chassis is designed for holding a battery holder and a motor. The motor will be placed on the upper surface while the battery holder is placed under it. Therefore, it has a length of 72.00 mm (the equivalent of the motor's total length) and 17.00 mm (roughly equal to the holder's height). The 3.31 mm-diameter hole on the platform is where a fastener is applied to locate and secure the placement of the battery holder. The extruded cut rectangle near the edge (7.00 mm in width and 3.00 mm in height) is added to facilitate inserting a screw (5.60 mm in head diameter) through the motor.
  - The extruded-cut feature on the car's chassis is designed for helping insert the switch and the battery holder from the bottom. The dimensions of this feature have been chosen to be equal to the combined dimensions of the battery holder and the switch.
  - The two extruded rectangular cubes without caps placed next to the platform are for accommodating the hooked mass and the screws. The longer-in-length cube spans 44.00 mm long, whose dimensions have been calculated based on the 10-mm head diameter screws to secure at least five of them. The short cube has four sides of 28 mm to fit but does not give too much space for the hooked mass. All two cubes share a height of 25.00 mm, which is calculated by adding the head diameter of the screws and taking a third of the hooked mass's height. Two 3.00-mm holes located next to the platform help to guide the wire to help prevent an unstable and interfering electrical connection.
  - The vertical rectangle with two holes, situated next to the raised platform, serves to secure the motor. The holes (17.86 mm in the centre distance), which are 3.00 mm in diameter, have been drawn to be concentric with two through holes on the motor. Two bolts, which are both 3.00 mm in diameter and 30.00 mm in length, will be put

through the holes on the DC motor and the rectangular feature and made to stay in place by the 3.00-mm nuts.
- The two small, extruded cut rectangles on the platform are for placing the switch, which is hung upside down with only the terminals going through the features. Each rectangle is drawn with a width of 1 mm to become wide enough for the switch's terminals to go through (0.70 mm in thickness).
- The extruded L-shaped feature at the head of the car with three through rectangular holes and is used to hang the magnets, which have the mission to attract the screws during the drive. The feature has a height of 31.00 mm to distance the magnets 8.00 mm from the ground to make them attractively effective. Two holes are located 30.00 mm from the centre to prevent the wheels from driving over the screws, which may cause them to go off track.
- Two 2.50-mm holes on two sides of the car are where the axis (2 mm diameter) will go through and perform its rotation during the driving period. The 0.50-mm difference ensures the holes are not too tight for the axis to spin. The 5.00-mm diameter holes surrounding the 2.50-mm support reduce the stress the axis puts on the chassis due to constant rotation to prevent the material from breaking apart.
- The chassis has a total volume of 87476.42 mm^3, which adheres to the constraint of 100 mm^3 for the 3D printing part.

- Dimensions: This part is 184.00 mm long, 85.00 mm wide and 44.00 mm high. These dimensions have been calculated carefully by considering the project's requirements to fit in the 12.00 x 12.00 x 12.00 cm constraint while being able to perform the tasks efficiently. The width has been made less than 12.00 cm for the vehicle to be capable of driving on the 12.00 cm wide track without falling.
- Manufacturing methods: since this part does not have a constant thickness and concludes some complicated edges and features, 3D printing with clear resin is preferred in this case.

3.2.2. Axle

A) Drawings

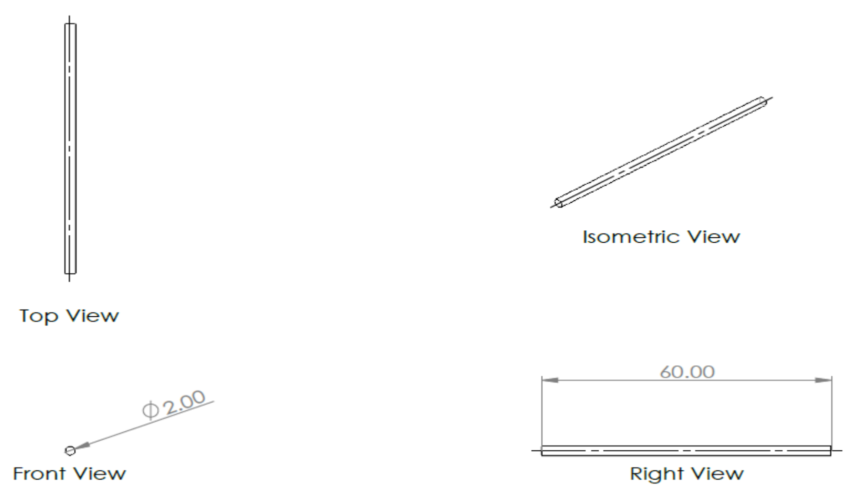


Figure 3.2. 2D drawing of an axle (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This part will maintain a circular motion when the motor is activated by a switch and two AA batteries. It will hold wheels that are connected to each side and assemble with the main part of the vehicle.
- Dimensions: this component is provided by the course's coordinate for the electrical system operation purpose so that all the dimensions listed here and in its drawings are measured with a digital calliper. This part is 2.00 mm in diameter and 60.00 mm in length.
- Manufacturing methods: 2 pieces of this part are provided by the course's coordinator, which means the team does not have to design an axle, to choose its material and manufacturing methods.

3.2.3. Wheel

A) Drawings

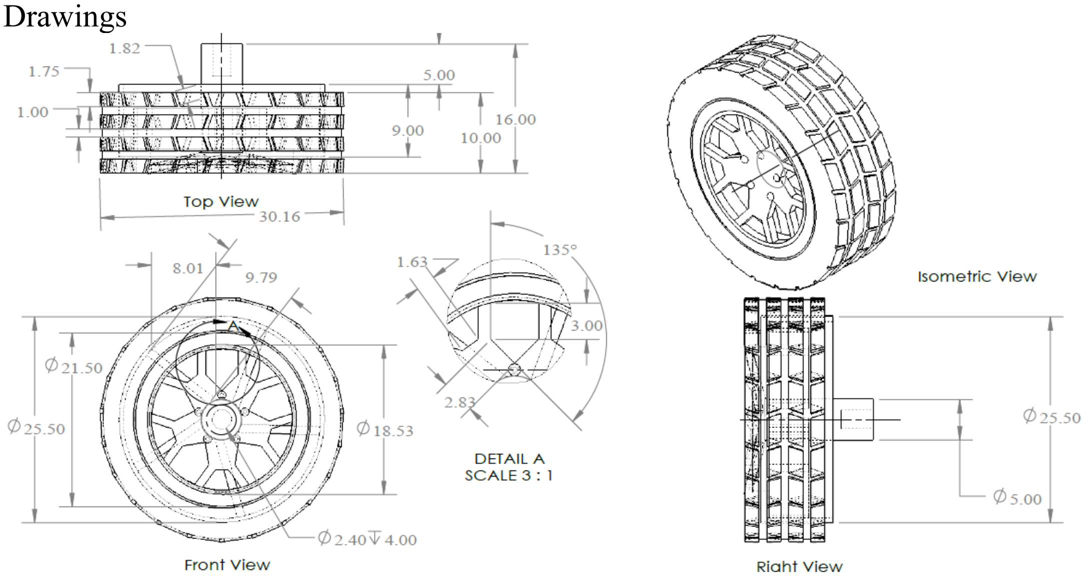


Figure 3.3. 2D drawing of a wheel (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This part is attached to the axle and spun when the motor is activated by a switch and two AA batteries to move the car forward. It is covered by a tire, and the motif on tire surface absorbs shock and prevents slip.
- Dimensions: this component is provided by the course's coordinate for the electrical system operation purpose so that all the dimensions listed here and in its drawings are measured with a digital calliper. This part is 18.53 mm in inner diameter (30 mm with tire) and 16.00 mm in width (including a part which holds axle).
- Manufacturing methods: this component is provided by the course's coordinator, which means the team does not have to design a wheel, to choose its material and manufacturing methods.

3.2.4. Battery Holder

A) Drawings

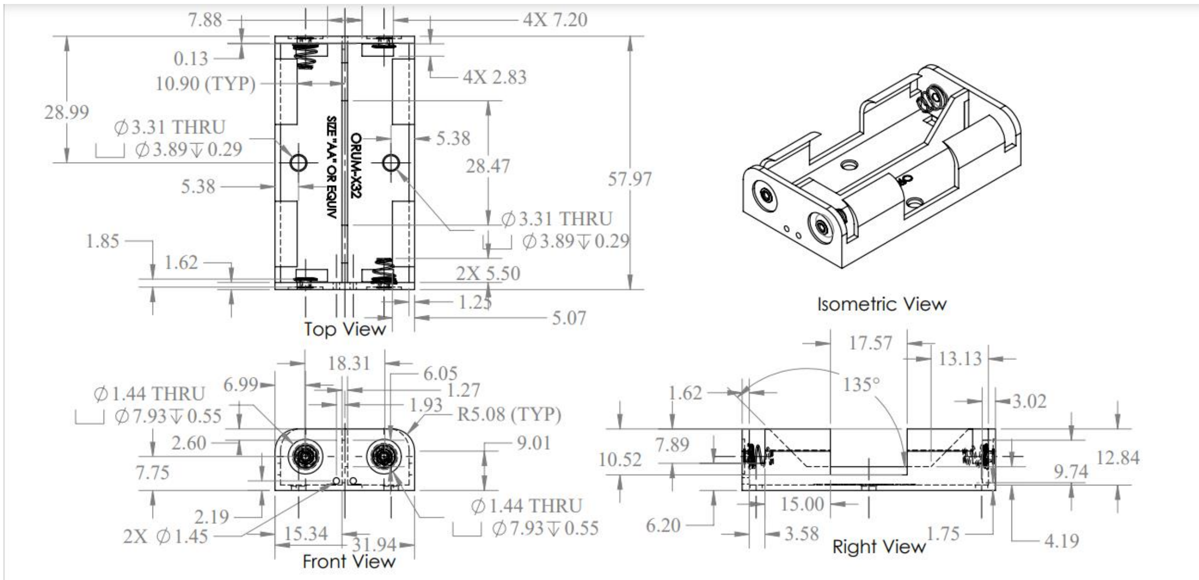


Figure 3.4. 2D drawing of a battery holder (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This battery holder can accommodate two AA 1.5V batteries and connect them in series (one's positive terminal is connected to the other's negative terminal and vice versa). This connection results in 3V in total voltage and the capacity of one battery, whose power is sufficient to operate the DC motor to spin the wheels and pulleys. The battery holder will be electrically connected with the toggle switch to turn the motor on and off. The wire connection of this component is discussed in section 2.2.
- Primary dimensions: this component is provided by the course's coordinate for the electrical system operation purpose so that all the dimensions listed here and in its drawings are measured by using a digital calliper. This part is 57.97 mm in length, 31.74 mm in width, and 14.09 mm in height.
- Manufacturing methods: this component is provided by the course's coordinator, which means the team does not have to design a battery holder and choose its material, and manufacturing methods.

3.2.5. Motor

A) Drawings

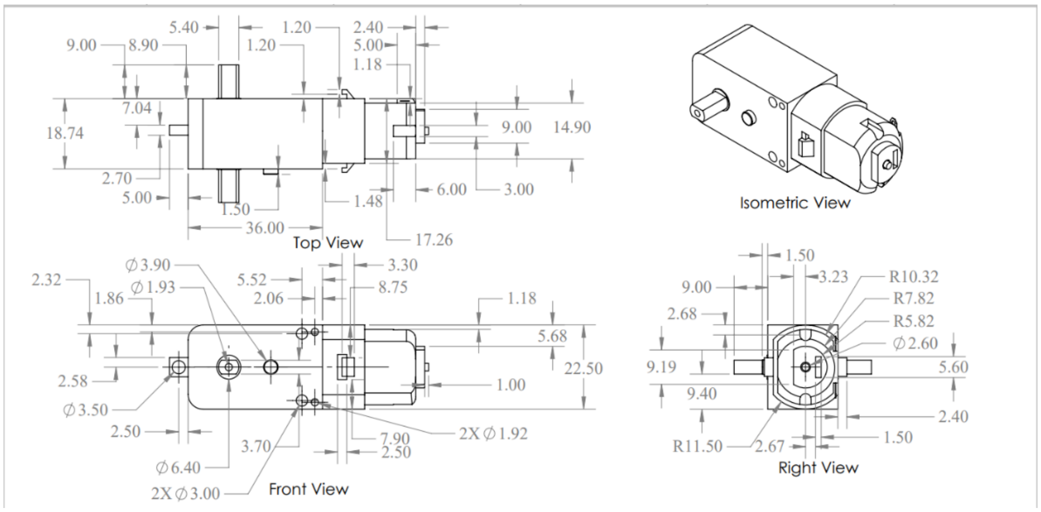


Figure 3.5. 2D drawing of a motor (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This motor operates upon two AA batteries connected in series and gives out a total voltage of 3.00 V. The switch will turn this component on and off. When the engine is activated, the white axis will rotate, which will rotate the pulleys, axis and wheels to move the car forward. The motor provides a torque of 0.40 kg. cm, amplified by the Power Transmission System discussed in Section 2.3. The wire connection of this component is discussed in section 2.2.
- Dimensions: this component is provided by the course's coordinate for the electrical system operation purpose so that all the dimensions listed here and in its drawings are measured by using a digital caliper. This part is 69.38 mm in length, 36.74 mm in width, and 22.50 mm in height.
- Manufacturing methods: this component is provided by the course's coordinator, which means the team does not have to design a motor and choose its material, and manufacturing methods.

3.2.6. Drive Pulley

A) Drawings

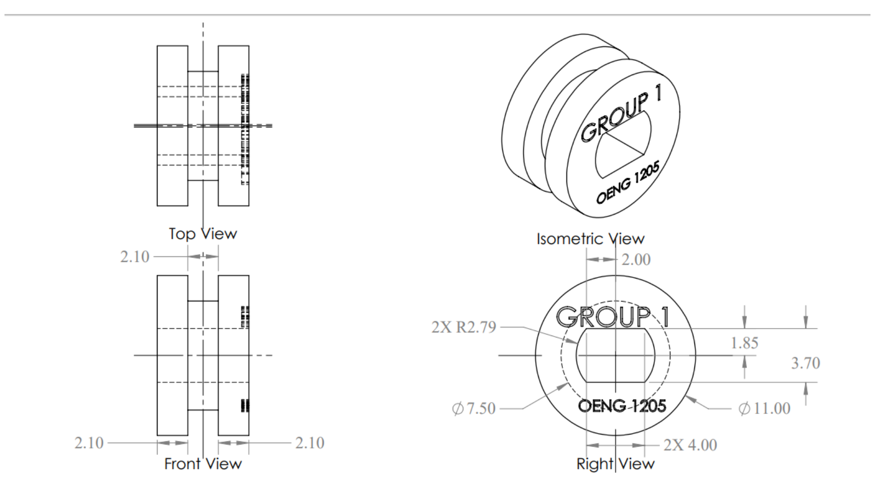


Figure 3.6. 2D drawing of a drive pulley (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This part will be assembled to be concentric with the motor's rotating axle. Its rotating behaviour is highly associated with the motor's rotating speed. Therefore, the slot-like shape in the centre is designed to look like the rotating axis to fit well with the engine.

- Dimensions:

+ All cylinders have a thickness greater than 2.00 mm to eliminate the possibility of splitting in half during operation.

+ The 7.50-mm diameter has been proved to be used in section 2.3, which discusses the calculation for the torque ratio.

+ Two rear cylinders, which bear a diameter of 11.00 mm, are made to prevent the rubber belt from falling out during motion. Since the rubber belt thickness is less than 1 mm, a difference of as much as 4.50 mm in diameter would be enough to secure the belt no matter how fast it rotates.

+ The other shapes, such as two straight lines of 4.00 mm or two arcs with a radius of 7.5 mm, have been designed based on the dimensions of the rotating axis of the motor.

+ The volume of this part is 374.47 mm^3, which is less than the 100 cm^3constraint.

- Manufacturing method: this part is preferred to be made by 3D printing with resin material over laser cutting since it does not have a constant thickness of 3.00 mm, 5.00 mm or 10.00 mm due to some internal features. Furthermore, the rear cylinders are assigned a greater radius to ensure the rubber band will not slip out during the drive.

3.2.7. Driven Pulley

A) Drawings

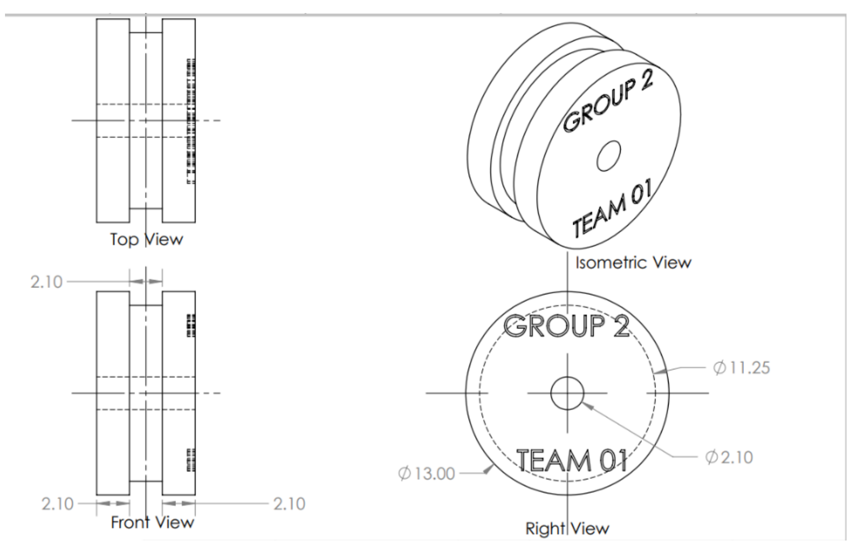


Figure 3.7. 2D drawing of a driven pulley (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This part amplifies the torque that the motor provides. It is connected to the drive pulley by a rubber band and operates under the control of a mathematical ratio.

- Dimensions:

+ All cylinders have a thickness greater than 2 mm to eliminate the possibility of breaking apart during operation.

+ The 10.00-mm diameter has been proved to be used in section 2.3, which discusses the calculation for the torque ratio.

+ Two rear cylinders, which bear a diameter of 13.00 mm, are made to prevent the rubber belt from falling out during motion. Since the rubber belt thickness is less than 1 mm, a difference of 1.75 mm in diameter would be enough to secure the belt no matter how fast it rotates.

+ The circle in the middle has an equal radius to the wheel's axis to facilitate its circular motion during the drive.

+ The volume of this part is 742.01 mm^3, which is less than the 100 cm^3constraint.

- Manufacturing methods: this part is preferred to be made by 3D printing with resin material over laser cutting since it does not have a constant thickness of 3.00 mm, 5.00 mm, or 10.00 mm due to some internal features. Furthermore, the rear cylinders are assigned a greater radius to ensure the rubber band will not slip out during the drive.

3.2.8. Switch

A) Drawings

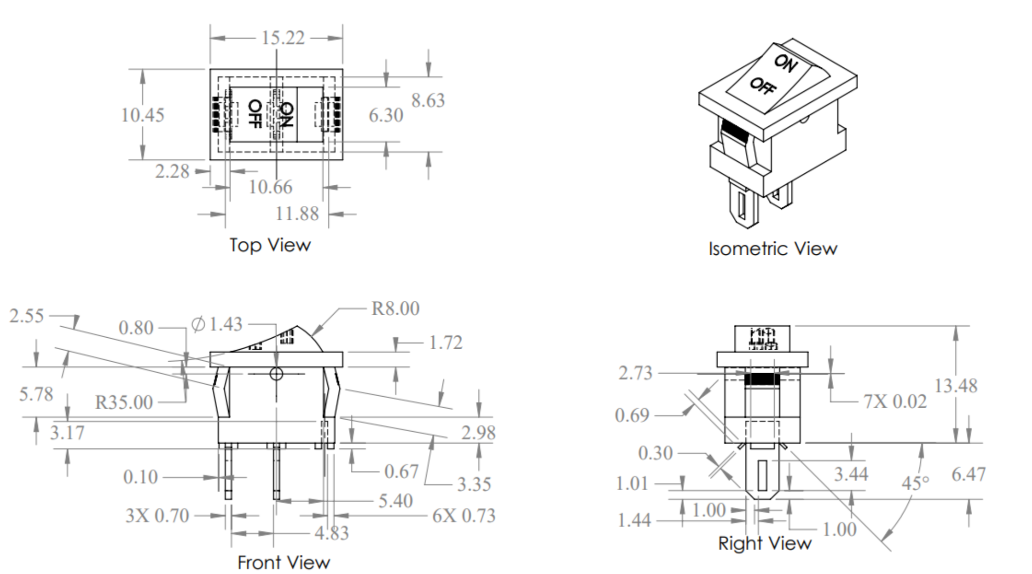


Figure 3.8. 2D drawing of a switch (not including the title block)

B) Features, dimensions, and manufacturing methods

- Features: This switch is a part of the electrical system which turns the DC motor on and off to move the vehicle forward. Turning it on will lead to the rotation of the motor which in turn spins the wheel to create torque to move the car forward. The wire connection of this component is discussed in section 2.2.
- Primary dimensions: this component is provided by the course's coordinate for the electrical system operation purpose so that all the dimensions listed here and in its drawings are measured by using a digital calliper. This part is 15.22 mm in length, 10.45 mm in width, and 19.95 mm in height.
- Manufacturing methods: this component is provided by the course's coordinator, which means the team does not have to design a switch and choose its material, and manufacturing methods.

3.3. Car's Assembly

This section demonstrates how to assemble all the components.

Step 1: The motor

Firstly, rotate the motor to have the orientation as shown in Figure 3.9. Next, insert two pan crosshead bolts through two holes in the motor; the bolts must be concentric with the holes. After that, attach the drive pulley in concentric relation to the right rotating axle of the engine. The pulley must stay in the middle of the axle's width. Having completed that, put the whole so-far assembly (motor, pulley, bolts) on the raised platform so that the bolts are concentric with the through holes on the raised rectangle. The right yellow surface of the motor should be incident with the right surface of the platform. Insert the nuts into two bolts to finish the first process.

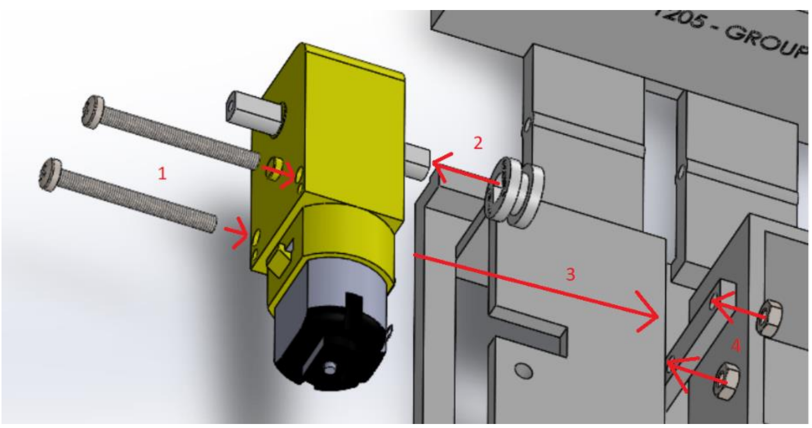


Figure 3.9. Step 1 of the assembly

Step 2: The battery holder and the switch

Begin this step by orienting the battery holder and the switch, as shown in Figure 3.10. For easy implementation, the assembling of the battery holder and the switch has to be done from the bottom, through which the components are put through and adjusted in terms of placement. Insert a cross countersunk head bolt through the left hole in the middle of the holder. As the first step, align the upper surface of the battery holder with the under surface of the platform to make them coincide, the bolt needs to be concentric and goes through the hole on the surface. Applying the nut to the bolt to fix the battery holder, which is turned upside down on the undersurface, the double-sided tape can be used for enhancing the attachment. As for the switch, align two terminals with the two cut-through rectangles on the raised platform and then use the glue gun or double-sided step to form the coincidence between the switch's surface and the undersurface of the platform. After this step is implemented, electrical wiring can be carried out as in section 2.2 to activate the motor.

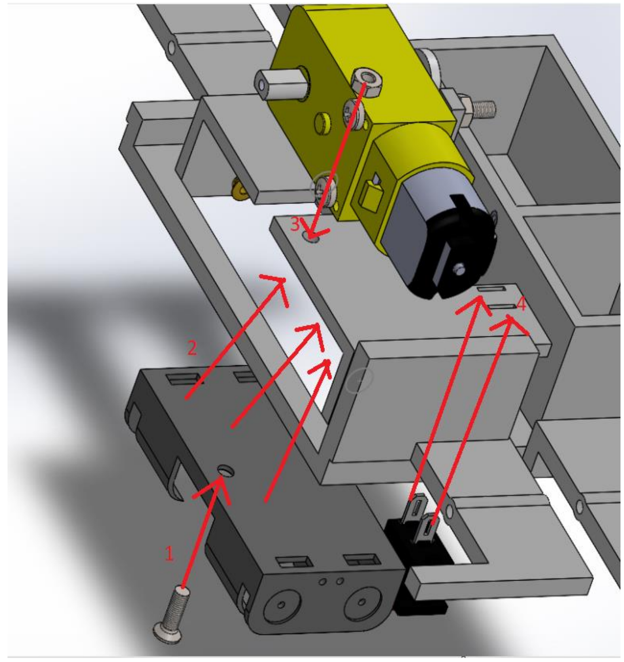


Figure 3.10. Step 2 of the assembly

Step 3: The pulleys, axis, and wheels

For the starting step, use the rubber belt to connect two pulleys; the belt has to stay in the smaller cylinder of each pulley to prevent it from slipping out. After two pulleys have formed the connection, hold both the driven pulley and the belt to bring that pulley down to where the wheel's axle is inserted, as in Figure 3.11. The driven pulley has to remain in the middle through rectangular hole and be concentric with the circles on both sides of the shapes. After that, put the axle through the circle from the left until it reaches the other end of the hole. If the correct action is followed, the driven pulley will be secure. Then, add two wheels from two sides of the axle to complete the front part. Similarly, for the back wheels, insert the axle through the holes and two wheels on two ends of the axle. It is important to note that only an appropriate amount of the axis goes through the car's chassis to have enough remaining length to attach firmly to the wheels.

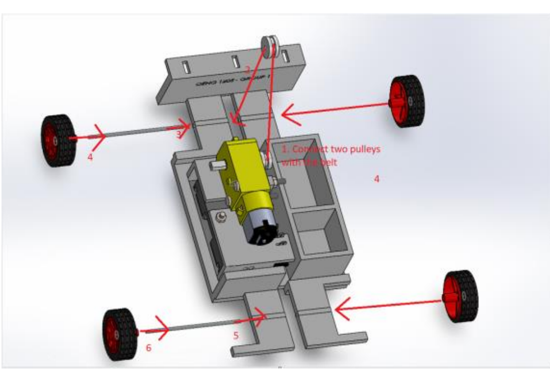


Figure 3.11. Step 3 of the assembly

4. References

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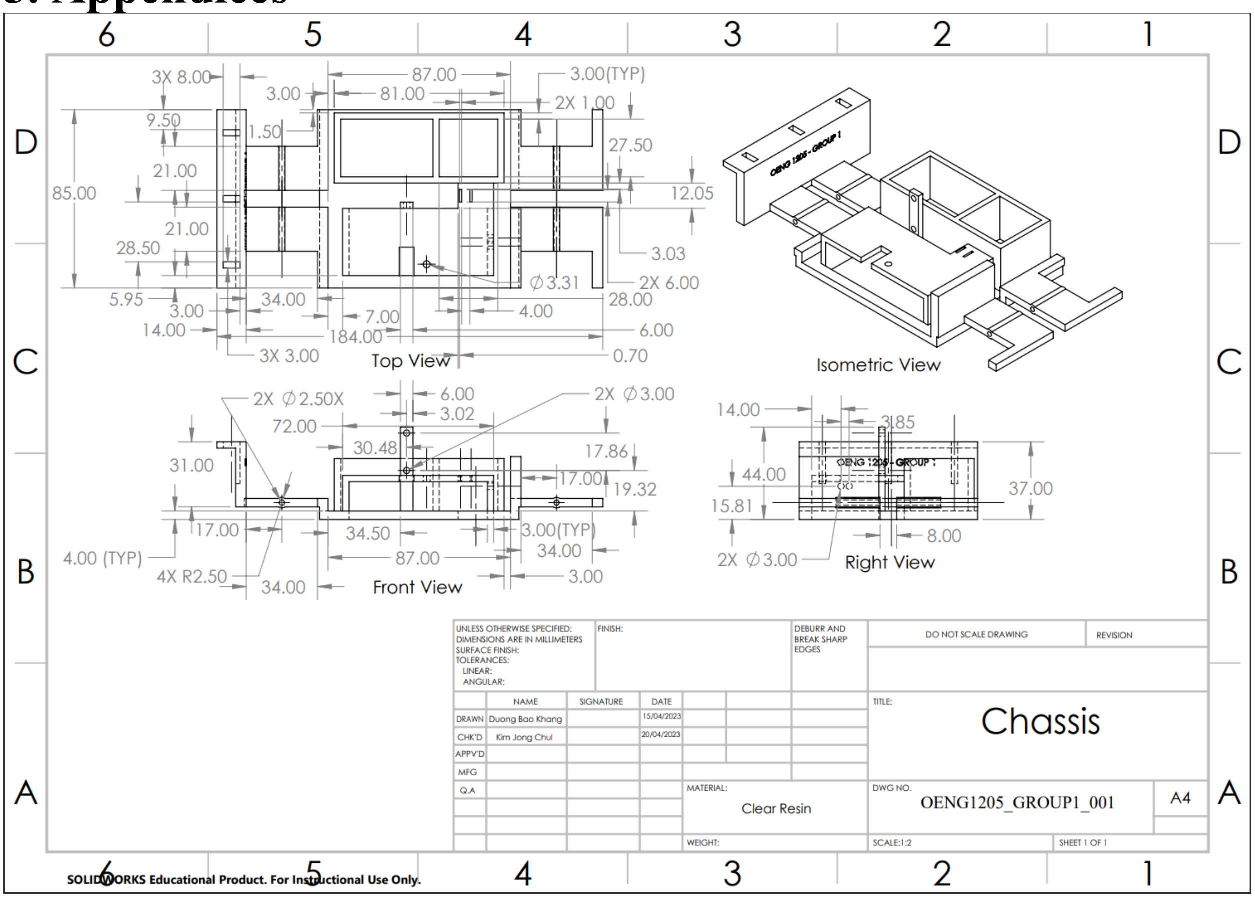
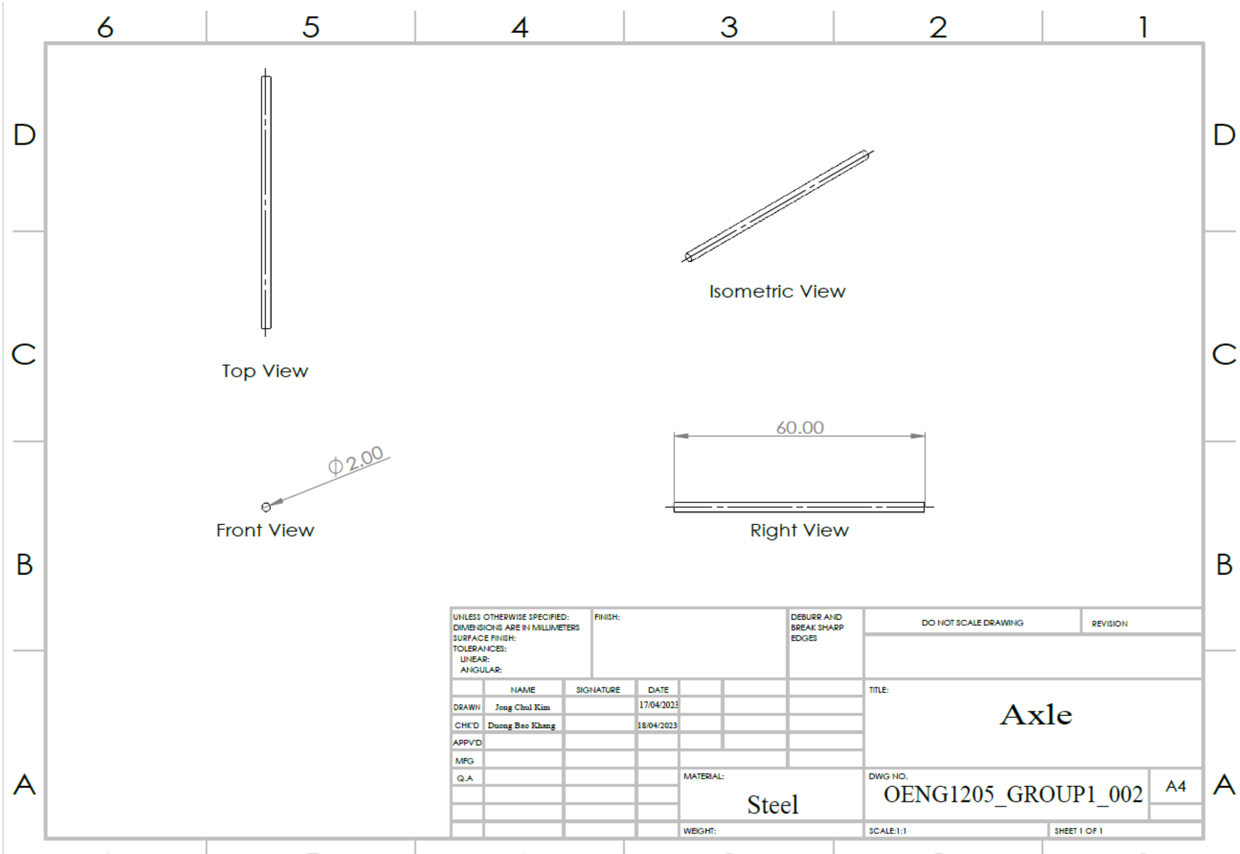
[6] Alliance RUBBER COMPANY. “How to Measure a Rubber Band.” Alliance RUBBER COMPANY. https://www.rubberband.com/about-us/rubber-band-size-chart/(accessed April 21, 2023).

5. Appendices





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Right View
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LINEAR:
ANGULAR:
FINISH:
DEBURR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
NAME
SIGNATURE
DATE
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CHK'D Duong Bao Khang 18/04/2023
APPV'D
MFG
Q.A
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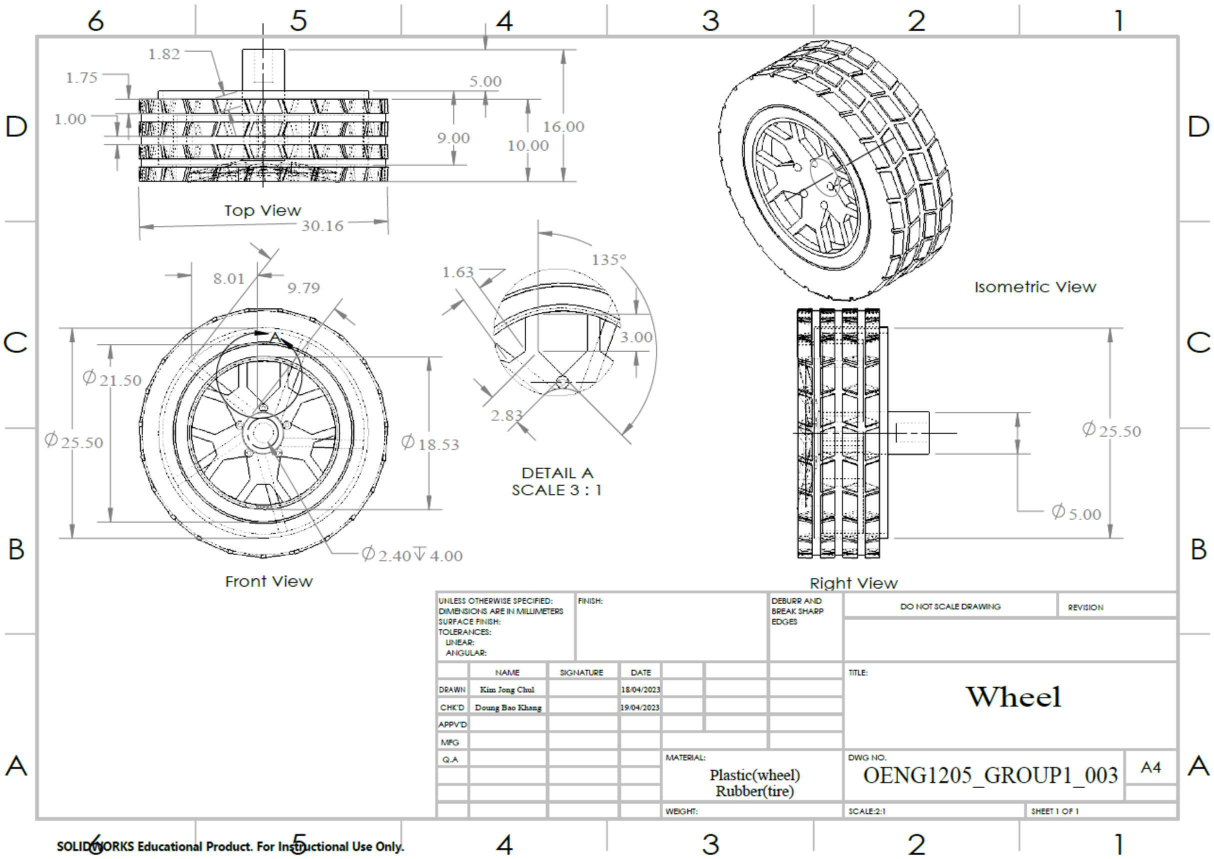
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Ø21.50
Ø25.50
Ø18.53
Ø2.40 ↧ 4.00
DETAIL A
SCALE 3 : 1
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135°
3.00
2.83
Isometric View
Right View
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18/04/2023
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Doung Bao Khang
19/04/2023
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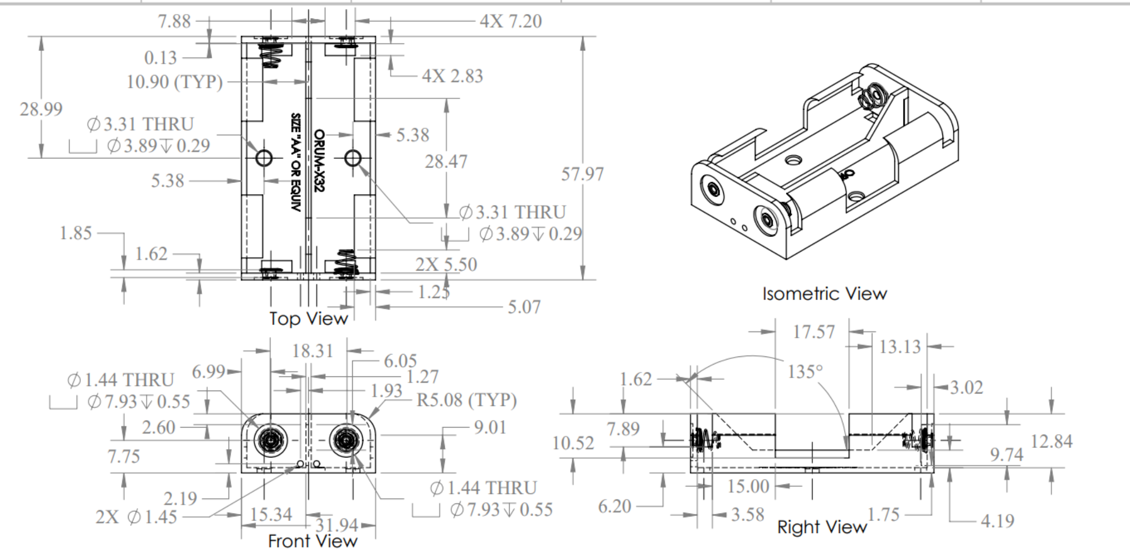

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CHK'D	Kim Jong Chul		17/04/2023
APPV'D			
MFG			
Q.A			

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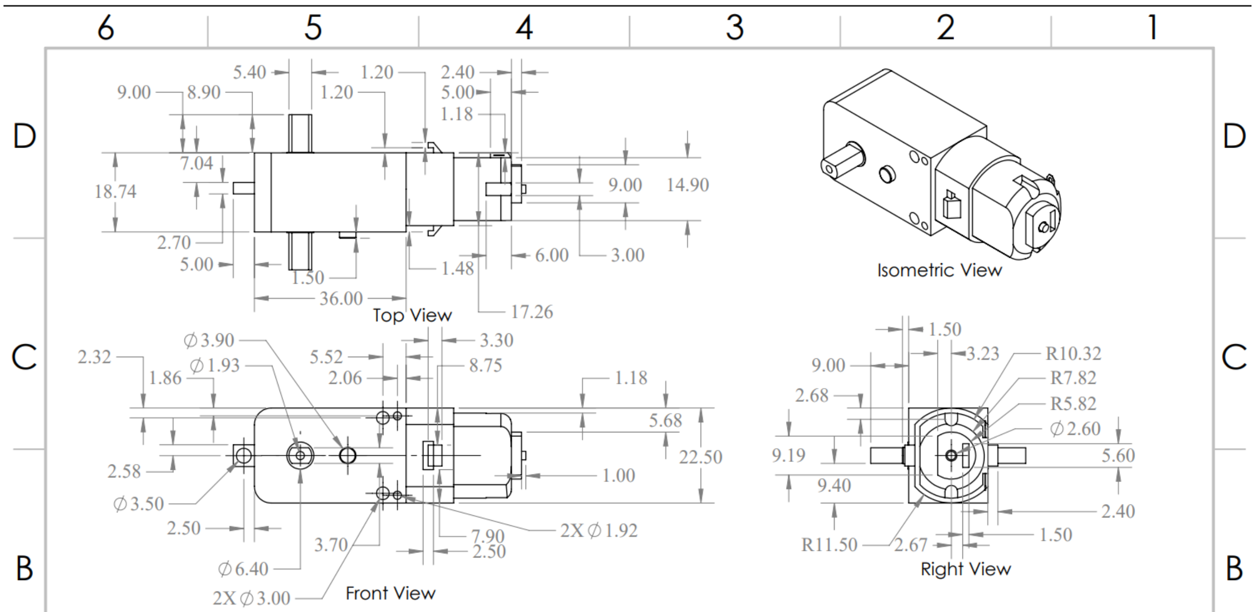

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CHK'D	Duong Bao Khang		20/04/2023
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MFG			
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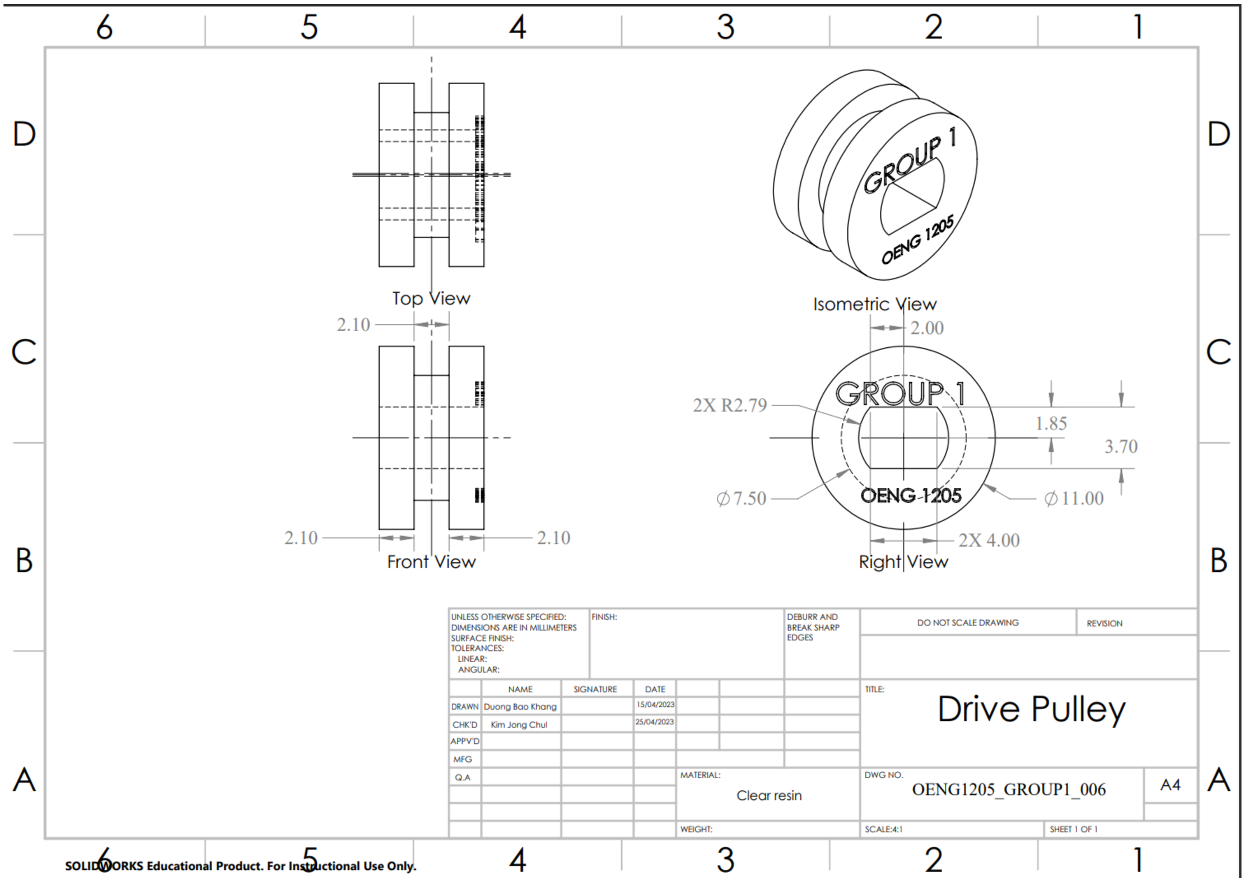

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Front View
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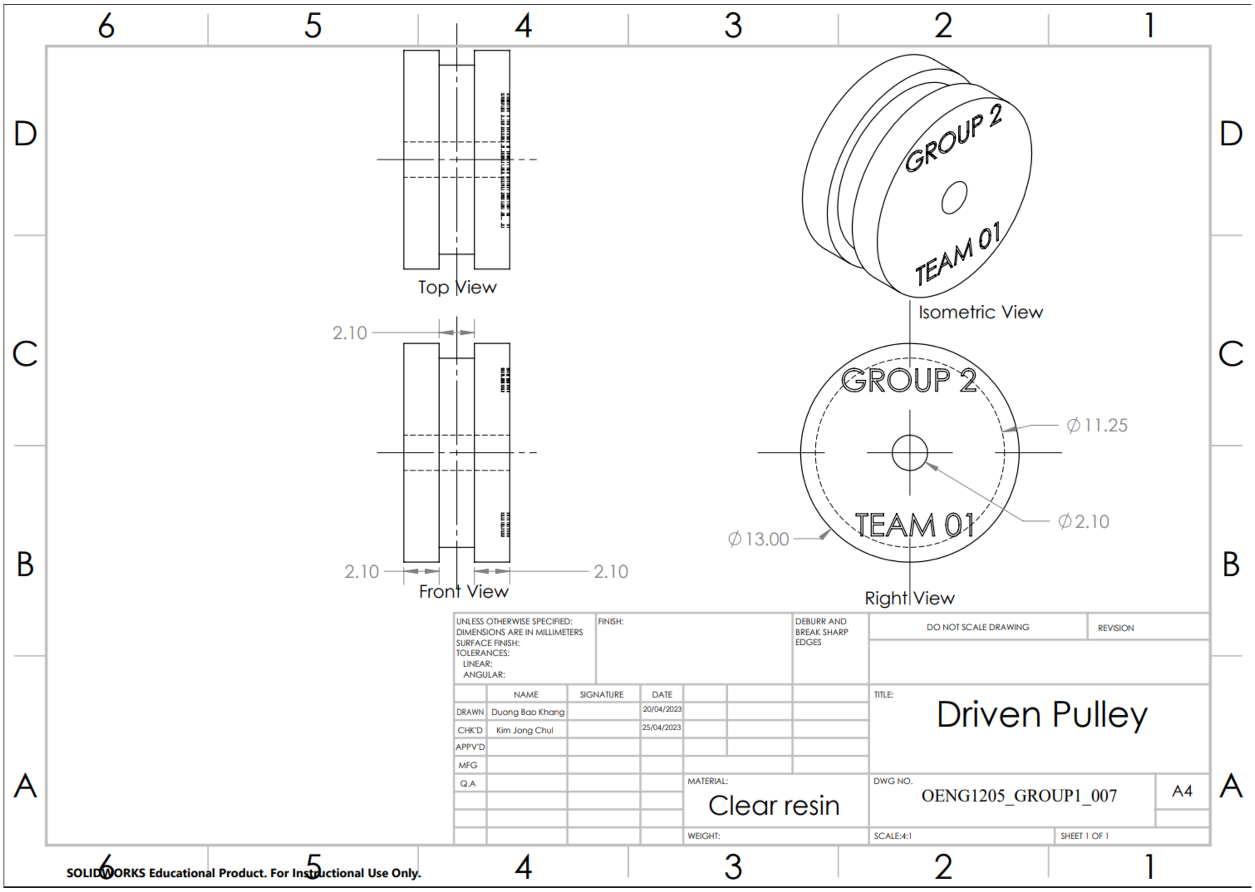

GROUP 2
TEAM 01
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2.10
2.10
Front View
GROUP 2
TEAM 01
Ø11.25
Ø2.10
Ø13.00
Right View
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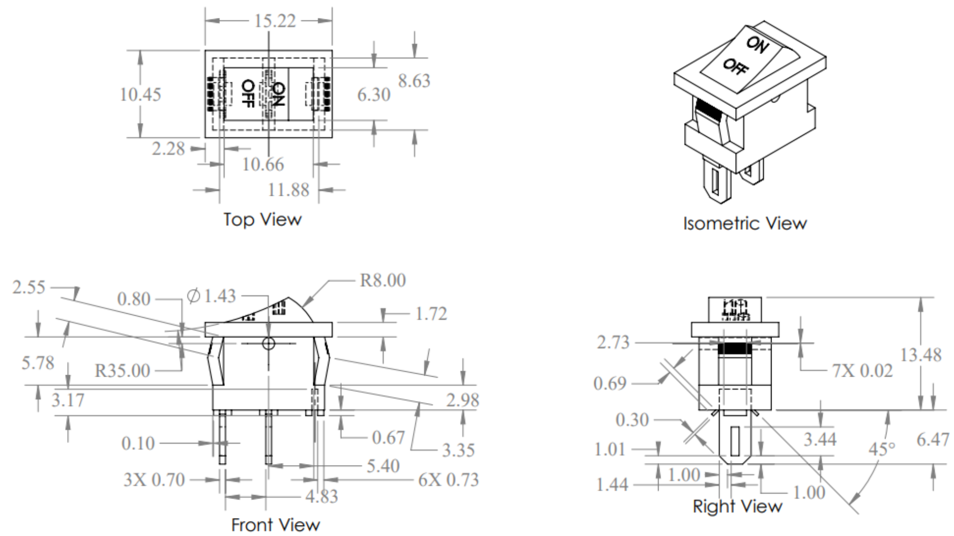

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