DUCKIETOWN

Duckiebot MOOC Founder's edition datasheet

DB21-M

DB21-M-NoJet

DB21-M-NoBatt

DB21-M-NoJetNoBat

1.   Use restriction notice

This USE RESTRICTION NOTICE ("Notice") is for customers who are considering or currently using the Duckietown hardware products ("Products") set forth in this document. Duckieworks ("DW") may, at any time, modify this Notice which will be available to you in the latest specifications book for the Products. You should abide by the latest version of this Notice. If a DW subsidiary or distributor has its own use restriction notice on the Products, such a use restriction notice will additionally apply between you and the subsidiary or distributor. You should consult a sales representative of the subsidiary or distributor of DW on such a use restriction notice when you consider using the Products.

Use Restrictions

The Products are intended for demonstrational purposes (for example, in education or exhibitions), and are unsuitable for other uses, and so are their parts and accessories.

Duckietown hardware is not a toy, and should not be treated as such. Keep out of reach of children, as small parts can be swallowed and plastic bags may cause suffocation.

You should not use the Products for critical applications which may pose a life- or injury- threatening risk or are highly likely to cause significant property damage in the event of failure of the Products. You should consult your sales representative beforehand when you consider using the Products for such critical applications. In addition, you should not use the Products in weapons or military equipment.

DW disclaims and does not assume any liability and damages arising out of misuse, improper use, modification, use of the Products for the above-mentioned critical applications, weapon and military equipment, or any deviation from the requirements set forth in this document.

Design for Safety

DW is making continuous efforts to further improve the quality and reliability of the Products; however, failure of a certain percentage of the Products is inevitable. Therefore, you should take sufficient care to ensure the safe design of your products such as component redundancy, anti-conflagration features, and features to prevent mis-operation in order to avoid accidents resulting in injury or death, fire or other social damage as a result of such failure.

Export Control

If the Products are controlled items under the export control laws or regulations of various countries, approval may be required for the export of the Products under the said laws or regulations.

You should be responsible for compliance with the said laws or regulations.

No License Implied

The technical information shown in this specifications book is for your reference purposes only. The availability of this document shall not be construed as giving any indication that DW and its licensors will license any intellectual property rights in such information by any implication or otherwise. DW will not assume responsibility for any problems in connection with your use of such information or for any infringement of third-party rights due to the same. It is therefore your sole legal and financial responsibility to resolve any such problems and infringement.

Governing Law

This Notice shall be governed by and construed in accordance with the laws of Switzerland, without reference to principles of conflict of laws or choice of laws. All controversies and disputes arising out of or relating to this Notice shall be submitted to the exclusive jurisdiction of the Zurich District Court as the court of first instance.

Other Applicable Terms and Conditions

The terms and conditions in the DW additional specifications, which will be made available to you when you order the Products, shall also be applicable to your use of the

Products as well as to this specifications book. You should review those terms and conditions when you consider purchasing and/or using the Products.

2. General information

The Duckiebot MOOC Founder's Edition (DB) is a do-it-yourself (DIY) hardware components kit for assembling a model self-driving car. It is available in 4 variants, defined by the presence of the computational unit and / or th battery as follows:

Name	Variant	SKU
Duckiebot MOOC Founder's Edition	DB21 MOOC 2021 edition.	DB21-M
	DB21-M without Jetson Nano 2GB	DB21-M-NoJet
	DB21-M without battery	DB21-M-NoBatt
	DB21-M without Jetson Nano 2GB and without battery	DB21-M-NoJetNoBat

3. What's in the box

The Duckiebot DB21-M box includes the hardware components (and spares) to assemble, initialize, calibrate and operate a Duckiebot DB21-M. No soldering, nor additional tools are required.

Subsystem	Name	Number
Chassis	Roof plate	1
	Bottom plate	1
	Top plate	1
	Side plate (left)	1
	Side plate (right)	1
	Side cover (left)	1
	Side cover (right)	1
	Support hut	1
	Suport battery	2
	Motor mount	4

	Camera mount	1
Wheels	Omni-wheel	1
	Front wheels	2
Stand-offs	Nylon stand-off M3x5+6mm M-F	1
	Metal stand-off M2.5x18+6mm M-F	6
	Metal hexagon stand-off M3 25mm F-F	2
	Spacer M6x12x1.5mm (white)	2
	Spacer M2.5x5x1mm (black)	4
Screws	Nylon screw M2x8	4
	Nylon screw M2.5x10	16
	Metal screw M3x8	26
	Metal screw M3x30	4
	Metal screw M3x12	4
Nuts	Metal nut M3	24
	Nylon nut white M3	2
	Nylon nut white M2.5	18
	Nylon nut white M2	4
Computation	Jetson Nano 2GB	1
	Duckietown Hut 3.1	1
Actuation	Blue DC Motors with Encoders	2
	Front bumper	1
	Back bumper	1
Power	Duckiebattery	1
Tools	Cross screwdriver	1
Interaction	Screen	1
Add. parts	Back pattern	1
	Shutdown button with M12 nut	1
	Fan for cooling	1
	Wifi-dongle	1
	Ethernet cable	1
	Camera Calibration Pattern	1
Sensors	IMU (model MPU-9250)	1
	ToF sensor	1
	Jetson Camera with cable	1
Swag	Duckies	2
	Instructions	1
	Duckietown Stickers	2
Memory	32GB MicroSD card Class 10	1

	MicroSD to USB adaptor	1
Cables	USB Jetson	1
	USB Ext5V	1
	USB Charge	1
	HUT to BB	1
	Motor cable	2
	Front ToF	1
	HUT to FB (2x), HUT to IMU (1x)	3
	HUT to Display	1
	HUT to Button (soldering with button)	1
	Fan cable	1
Packing	Duckiebox	1
	Inner packaging	1
	Outer shipping box	1

4. Functionality overview

The DB is designed to operate in a Duckietown urban environment. An example of Duckietown urban environment can be found here:

https://docs.duckietown.org/daffy/opmanual_duckietown/out/dt_ops_preliminaries.html

The DB requires software to operate, as well as a base computer and an internet connection, neither are included in the DB package.

The DB hardware is provided as is, and can be assembled, initialized, calibrated and operated (hereafter, "used") using several approaches based on open source solutions such as Ubuntu OS, ROS, Docker, Python, etc. The DB21-M nor any of its variants include a software stack, the definition of which is up to the user.

Duckietown offers an open source software stack compatible with the use of the DB, which is available as is, free of charge, following the Duckietown instructions. Users can download the Duckietown software stack and use it at their own risk, as determined by the provisions of the Duckietown software license:

https://www.duckietown.org/about/terms-of-use.

5. Subsystems

The Duckiebot is composed of the following subsystems:

Chassis

- ○ **Differential drive configuration**

The DB has two wheels which can be controlled independently through DC motors. A third passive omnidirectional wheel provides equilibrium. This configuration is known as differential-drive. The chassis components are covered by a protective plastic film, which should be removed before use.
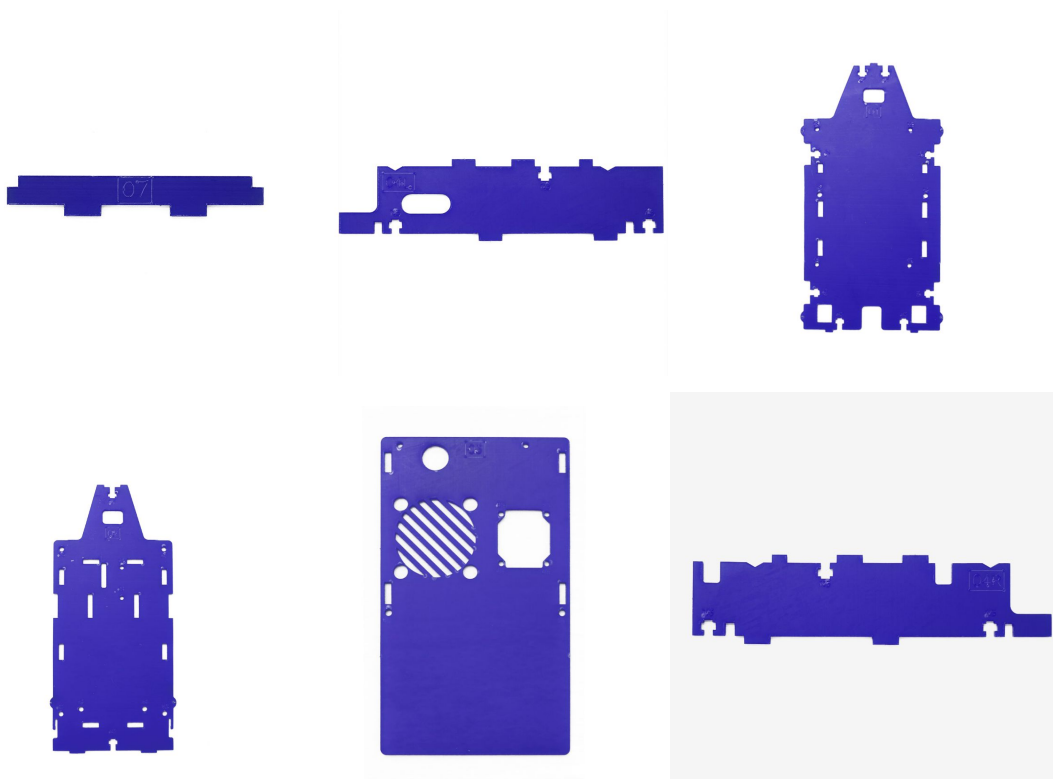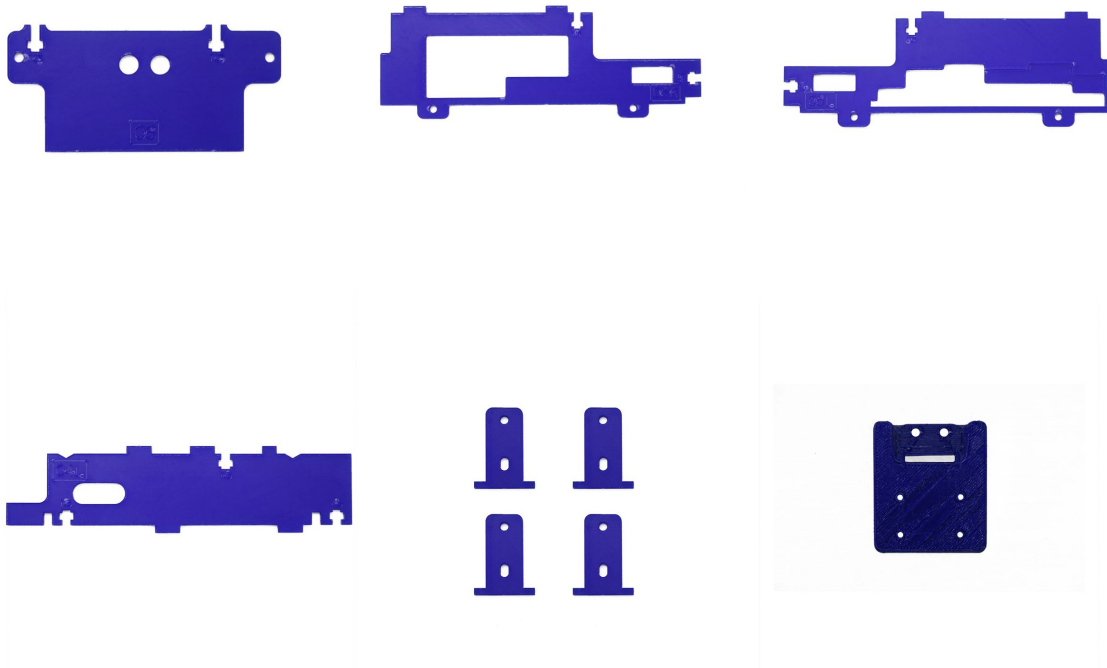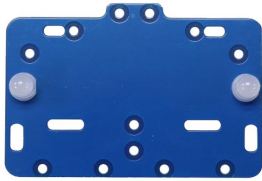
Actuators

- ○ **2 DC motors (DG01D 48:1)**
- ○ **4 Addressable RGB LEDs** (mounted on front and back bumpers)

The DB wheels are actuated by two DC motors, which receive PWM signals from the Duckietown Hut, a shield connected to the computational board's GPIO pins.

The DB is moreover equipped with 4 RGB addressable LEDs, placed on the front and back bumpers.

Sensors

The DB is equipped with a plug-and-play sensor suite.

- ○ **Hall effect sensor wheel encoders (DZ08003134-01)**

Each DC motor is equipped with an embedded Hall effect sensor wheel encoder with 135 ticks per revolution, providing an angular resolution of roughly 2.7 degrees.

- ○ **Camera (IMX-219-160: [Datasheet](#))**

The main sensor of the DB is a front facing 8 Megapixels camera with 160 degrees of field of view, equipped with a manually adjustable focus. Please refer to the linked datasheet for detailed specifications on the sensor.

- ○ **Inertial Measurement Unit (MPU-9250: [Datasheet](#))**

The Duckiebot is equipped with an IMU including gyroscope, accelerometer and magnetometer, mounted on a Duckietown custom made PCB. Please refer to the linked datasheet for detailed specifications on the sensor.

- ○ **Front facing time of flight sensor (VL53L0X: [Datasheet](#))**

The Duckiebot is equipped with a front facing time of flight sensor (ToF). It can measure approximately 50mm to 1.2 meter in default mode, up to 2m in "long range" mode. Depending on ambient lighting and distance, you'll get 3 to 12% ranging accuracy - better lighting and shiny surfaces will give you best results. Please refer to the linked datasheet for detailed specifications on the sensor.

- - **Battery diagnostics sensors**

The Duckietown battery is able to provide diagnostics information to the computation board via USB communication, in JSON format, every second. An example message loos like this:

```
{   "SOC(%)":99,

    "CellTemp(degK)":298,

    "CellVoltage(mV)":4154,

    "Current(mA)":650,

    "TimeToEmpty(min)":65535,

    "CycleCount":3,

    "USB OUT-1(mV)":5222,

    "USB OUT-2(mV)":5172,

    "ChargerVoltage(mV)":5214  }
```

More information on the Duckietown battery can be found at:

https://docs.duckietown.org/daffy/opmanual_duckiebot/out/db_opmanual_preliminaries_electronics.html

Computation

- ○ NVIDIA Jetson Nano 2GB developer kit

The DB is equipped with an NVIDIA Jetson Nano 2GB developer kit.

GPU	128-core NVIDIA Maxwell™
CPU	Quad-core ARM® A57 @ 1.43 GHz
Memory	2 GB 64-bit LPDDR4 25.6 GB/s
Storage	microSD (Card not included)
Video Encoder	4Kp30 | 4x 1080p30 | 9x 720p30 (H.264/H.265)

Video Decoder	4Kp60 | 2x 4Kp30 | 8x 1080p30 | 18x 720p30 (H.264/H.265)
Connectivity	Gigabit Ethernet
Camera	1x MIPI CSI-2 connector
Display	HDMI
USB	1x USB 3.0 Type A, 2x USB 2.0 Type A, 1x USB 2.0 Micro-B
Others	40-pin header (GPIO, I2C, I2S, SPI, UART) 12-pin header (Power and related signals, UART) 4-pin fan header*
Mechanical	100 mm x 80 mm x 29 mm

Further information can be obtained from the NVIDIA website at:

https://www.nvidia.com/en-us/autonomous-machines/embedded-systems/jetson-nano/education-projects/

Memory

- ○ 32 GB micro sd card, class 10, U3

The onboard memory is provided by a 32GB micro-sd card, class 10, U1, with average read / write speeds (Seq Q32T1) of 22.49 MB/s and 18.72 MB/s.

Power

The DB is equipped with a custom made power bank: the "Duckiebattery", with specifications:

- Capacity: 10 000mAh at 3.7V
- Charging: Micro USB 5V at up to 2A
- Output: 2 x USB type A 5V at up to 4.5A combined
- Charge time: 0-100% takes ~5h and 0-90% ~4h with a 2A power supply
- Weight: 189g (fully charged)

The Duckiebattery has the following features:
- Pass through: it can charge while being charged
- It does not shut off, thus resetting the onboard computer, when the charger cable is plugged in
- It does not shut off, thus resetting the onboard computer, when the charger cable is plugged out

Battery handling and care

Dos

- If a battery have been subject to moisture and/or the case has been damaged eminently dispose of the battery pack

- In case of fire use a CO2 extinguisher
- Storage preferably in a cool, dry and ventilated area, which is subject to little temperature change. Storage at high temperatures should be avoided.

Don'ts

- Do not connect a charge voltage greater than 5V
- Do not connect an external voltage source to the USB output ports
- The battery should not be opened, destroyed or incinerated. This may cause leakage or rupture and release to the environment of the ingredients that are kept in hermetically sealed containers.
- Do not short circuit terminals
- Do not crush or puncture the battery, or immerse it in liquids
- Do not place the battery near heating equipment, nor expose to direct sunlight for long periods of time

Up to date information on the Duckietown battery can be found at:

https://docs.duckietown.org/daffy/opmanual_duckiebot/out/db_opmanual_preliminaries_electronics.html

User Interface (UI)

- ○ Screen
- ○ Shut-off button

To facilitate UI, the DB is equipped with a programmable 128x32 pixels bi-chromatic I2C screen and a non-latching "shut-off" button.
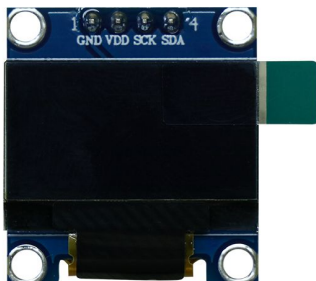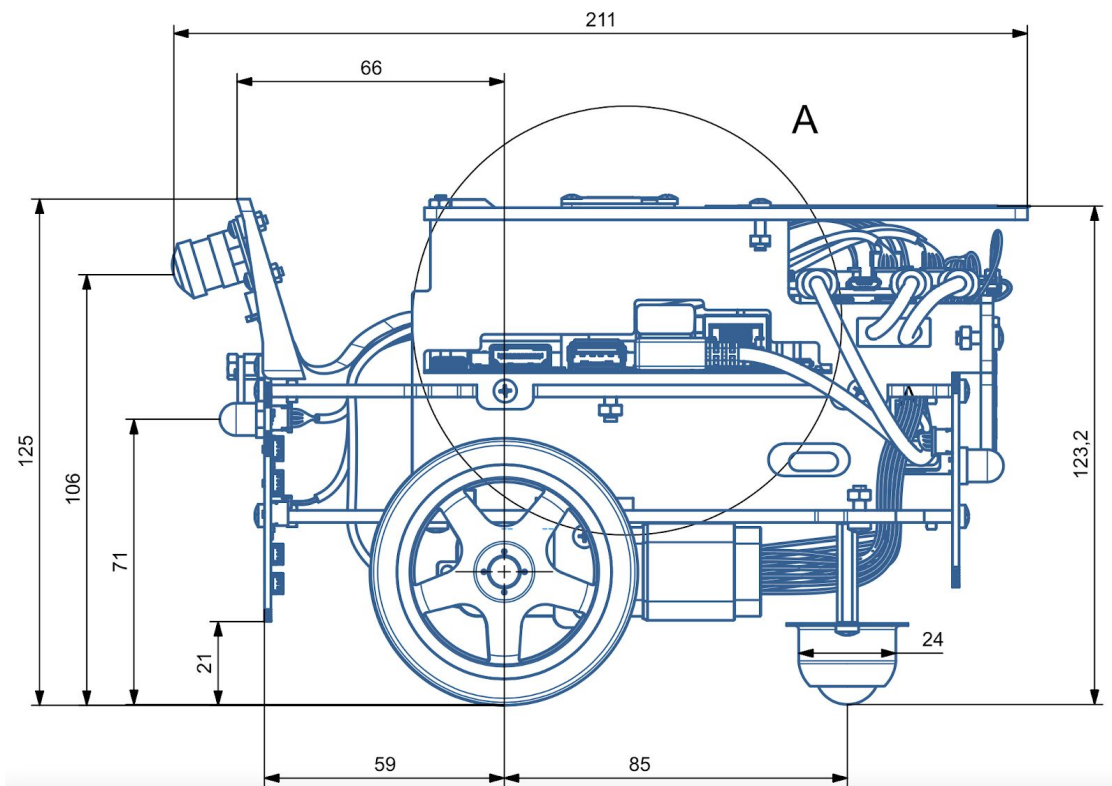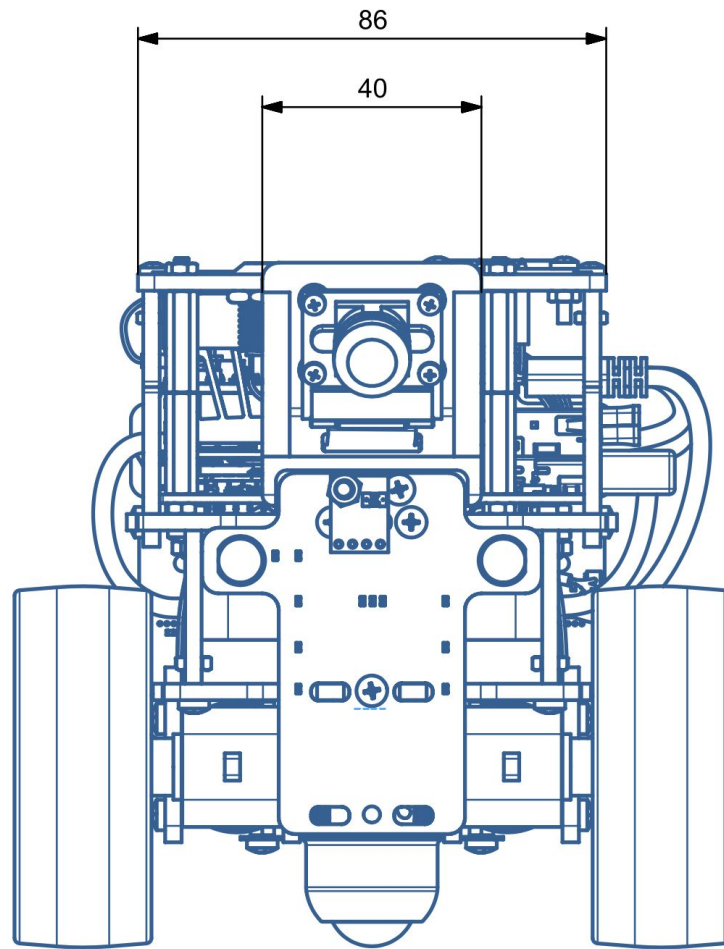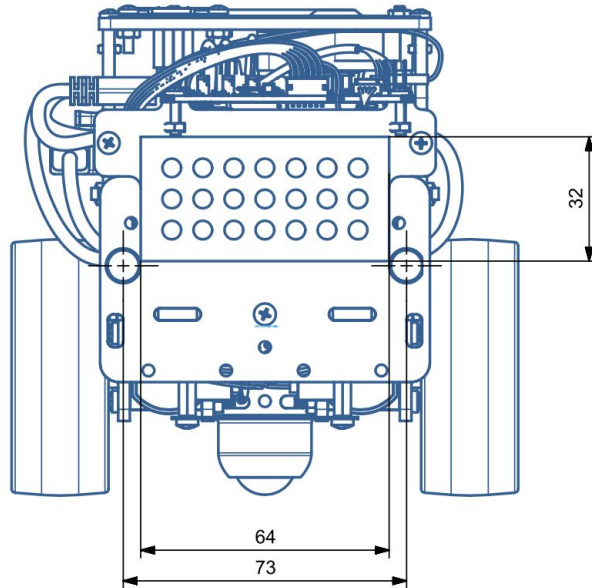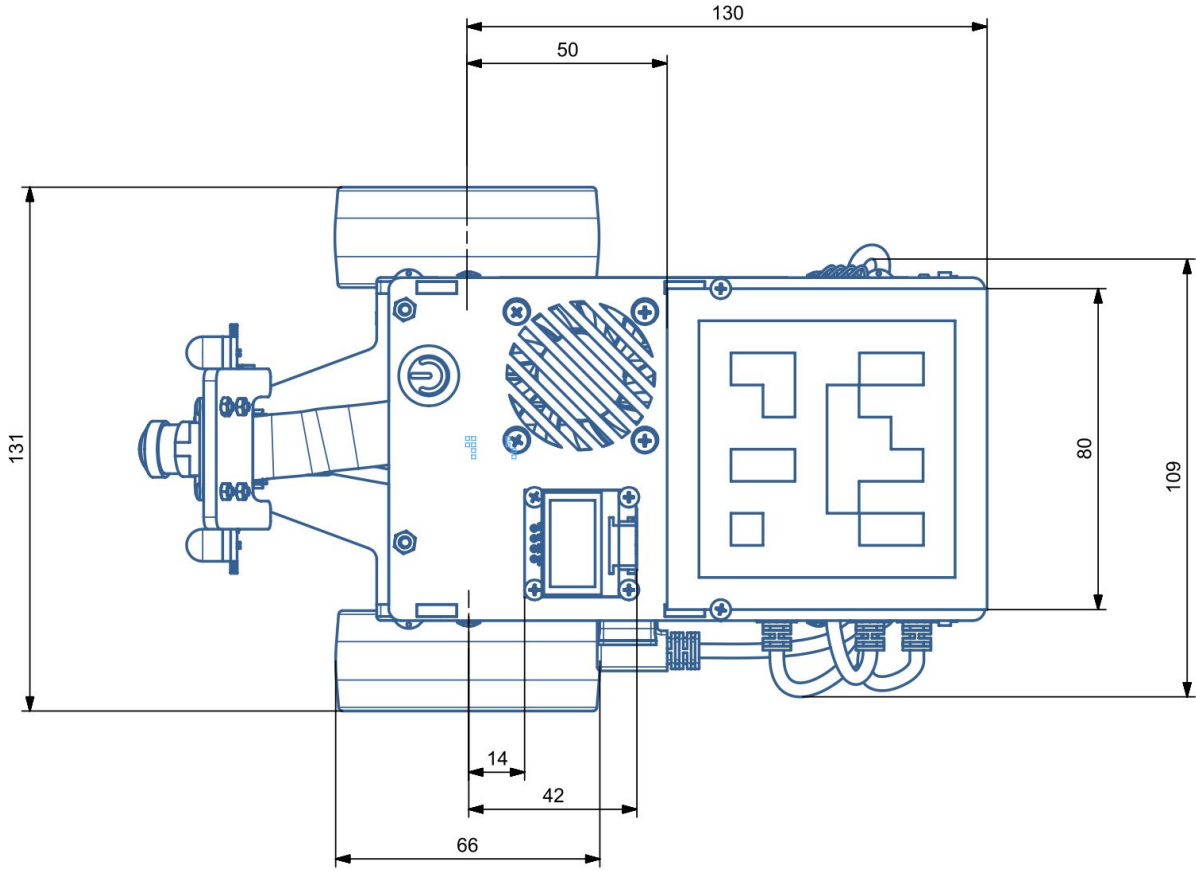
6.   Operation

Hardware assembly instructions

The detailed and up to date assembly instructions can be found at the following link:
https://docs.duckietown.org/daffy/opmanual_duckiebot/out/building_duckiebot_c0.html

The assembled DB21-M has dimensions specified in milimiters in the folowing diagrams:

86

40

Initialization

Users can choose their preferred way to initialize and operate the DB.

A compatible initialization procedure is detailed at his link:
https://docs.duckietown.org/daffy/opmanual_duckiebot/out/setup_duckiebot.html

To execute this procedure, the user's laptop should be correctly configured, as detailed in:
https://docs.duckietown.org/daffy/opmanual_duckiebot/out/laptop_setup.html

Calibration

Sensors and motors require calibration for the system to perform autonomously. In particular, the camera and odometry should be calibrated.

Camera calibration

Step by step instructions on how to calibrate the camera can be found at the following link:
https://docs.duckietown.org/daffy/opmanual_duckiebot/out/camera_calib.html

Odometry calibration

Step by step instructions on how to calibrate the odometry can be found at the following link:
https://docs.duckietown.org/daffy/opmanual_duckiebot/out/wheel_calibration.html

7.   Technical Support

For any questions related to the hardware, please contact hardware@duckietown.ch.

Alternatively, help can be obtained from the Duckietown community on the Duckietown Slack, in the #help-* channels. There are channels dedicated to various aspects of troubleshooting, e.g., robot assembly and operations.

8. Maintenance

A number of steps are recommended to ensure correct functionality of the Duckiebot:

● Visual inspection and determination of suitability

Verify visually that all components are solidly attached and in good shape, as defined by the assembly instructions.

● Cleaning from dust and dirt

Periodically remove dust and dirt naturally accumulating on the device. Particular attention should be paid to dust buildups in the fan, which might prevent correct cooling hence operation of the Duckiebot, and on the camera lens, which would prevent correct sensing.

● Checking the correctness of the connections

Ensure all connections are properly assembled, as defined by the assembly instructions, and firmly plugged in.

● Tightening of fasteners

Ensure all fasteners, standoffs, screws and nuts are properly tightened.

● Cleaning contacts from dirt and sagging

Periodically clean the PCB contacts to ensure electrical connectivity.

● Checking the operation of the moving parts of the device manually

Ensure no mechanical block (e.g., a wire) is touching or otherwise impeding the movement of the wheels by turning them manually.

● Periodic calibration of sensors and odometry

Especially when managing the Duckiebot (packing, unpacking, moving), it might be beneficial to re-calibrate the camera, odometry and other sensors, how specified in the calibration instructions.

9. Conditions and methods of storage

Duckiebot equipment is stored in rooms isolated from places where acids and alkalis are stored, at an air temperature of no less than 5 ° C and no higher than 25 ° C and a relative humidity of no more than 65-70% in their original packaging
Avoid temperature fluctuations in rooms. Condensation and high humidity can be the main cause of mold, corrosion and decay on various surfaces.

10. Disposal measures

The Duckiebot components: battery, plastic, metal and glass must be properly disposed of. For this it is best to contact a professional company.

11. Warranty

For information on product guarantee contact hardware@duckieworks.ch.