MILESTONE 2: ARGUMENTS FOR THE NEW SHOPPING LIST

DC MOTOR

After the calculations for the torque of the DC motor, we need to move around 0,2 N·m (30 oz-in) with it.
The speed required from a subjective point of view was 30 rpm (3,1415 rad/s) since the coins need to spin at a decent speed in order to not get stuck and one lap/loop every two seconds is great.

In milestone 1 we asked for the following DC motor:

https://www.robotshop.com/en/banebots-rs-555-12v-7750-rpm-brushed-dc-motor.html

The teachers got back to us saying we made a concept mistake, we thought the motor was capable of moving 0,2 N·m since it stated ***stall torque*** close to that value. The stall torque is the torque when the motor is not moving, and can be used for a brief instant if necessary. "*electric motors left in a stalled condition are prone to overheating and possible damage since the current flowing is maximum under these conditions*" [from: https://en.wikipedia.org/wiki/Stall_torque]

Therefore, this motor wouldn't have the strength required and we were given another option to evaluate if it could fit the project. The following link shows the alternative:

https://es.rs-online.com/web/p/motores-dc-con-caja-reductora/2985379/

Its torque is still under what we needed but we had built the prototype so we decided to try it anyway. As believed, it did not have the output we desired.

The search for a new DC motor began and we found other options, some delivered less torque, others did not have the speed we wanted.

At this point, we decided to move the entry with the coin selector using the same motor. This translated into a higher torque and to be safe we doubled the first requirement. Instead of 0,2 N·m it will move 0,4 N·m.

In addition, we agreed to power the machine with 12V and using a stepdown circuit for an output of 5V (*explained in detail later).* Then, either 12V or 5V input for the motor would be good, and as we thought of using a power supply big enough (15A) in case we want to add other features, current is not a problem, even though we aim at the lowest possible. The speed remains the same (30 rpm).

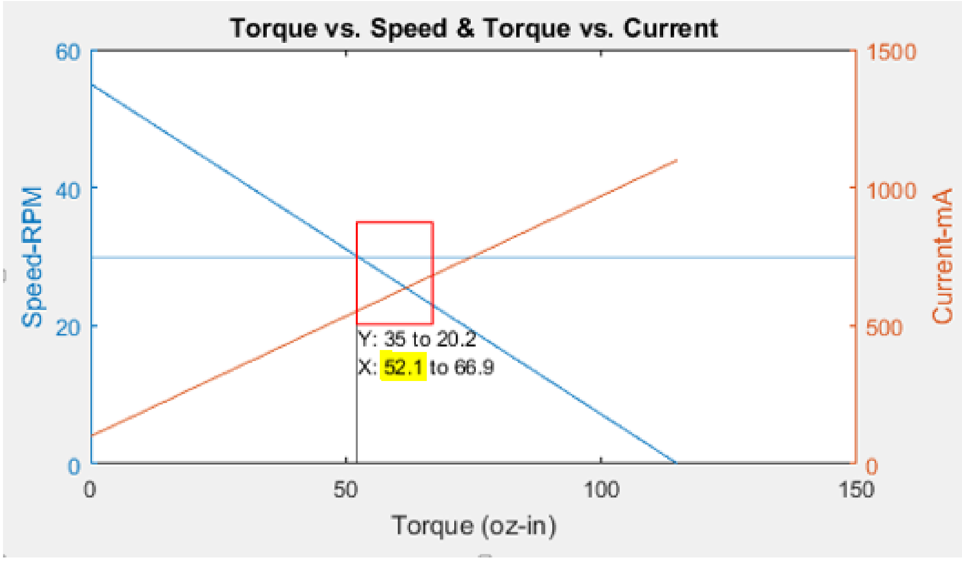
It was possible to find a Matlab code (https://es.mathworks.com/matlabcentral/fileexchange/54695-polulu-motor-plot-generator) that when inserted the stall torque, stall current, RPM, voltage and free run current as inputs it will output the DC motor charts/graphs. The code is trusted since it was found in the same motor link (it is under the *"resources"* tab inside *"recommended links*").

For the motor selected (https://www.pololu.com/product/3255) the inputs are the following:

```
Please enter the stall torque in oz-inch [17]: 115
Please enter the stall current in mA [700]: 1100
Please enter the rated voltage in Volts [6]: 12
Please enter the free run currennt in mA [40]: 100
Please enter the free run speed in RPM [290]: 55
```

```
Slope of TorqueVsCurrent is 8.695652. The recprocal is 0.115000
Maximum output mechanical power is 1.170125(watts).
This happens at the Torque load of 57.500000(oz-in), with Current 600.000000(mA)
Resistance of the motor is 10.909091 (ohms)
```

The torque at maximum output power is 0,406 N·m (57,5 oz-in). Driving the motor at 30 RPM would mean a torque of 0,367 N·m (52,1 oz-in) still not the desired but really close and probably enough.



While load increases, speed will decrease and as we would like to maintain a 30 RPM speed for the sorting process an encoder is going to be used to read and give feedback of the speed as well as to correct it if needed at some point. This same motor has an option with encoder, and it would be the best option but price is an issue. Therefore, we found out that a Hall Effect sensor in combination with a magnet could give us information on the speed of the motor.

Magnets can be easily provided from team members (Alexander) the hall effect sensor is non-latching which means that *"The sensor gives an output HIGH voltage whenever the north pole of a magnet is brought close to it, and switches LOW whenever the magnet is removed." (from: https://maker.pro/arduino/tutorial/how-to-use-a-hall-effect-sensor-with-arduino)*
The hall effect sensor desired is the US5881 (https://es.rs-online.com/web/p/circuitos-integrados-de-sensor-de-efecto-hall/6843522/) (datasheet: https://docs-emea.rs-online.com/webdocs/0db7/0900766b80db758a.pdf)

About how to make the correction PID code will be used, like in this example: https://playground.arduino.cc/Code/PIDLibrary

DC DRIVER

No matter the motor, a need for the driver to run it comes along. The main parameter to look at is the current that the driver can hold and supply, which has to match with the one from the motor.

As we saw, the stall current is 1,1 A. Anyhow we want to avoid getting to the maximum output power which is at 600 mA. Therefore a driver for a single DC motor that can handle the 600 mA. Better safe than sorry, so we look for one that resists the stall current.

Another thing to have in mind is how it is going to be powered: at 12 V or 5 V. Ideally at 12 V since then it can feed the motor directly and there won't be a need to power them separately.

Driver selected: https://www.pololu.com/product/2961

Alternative shopping links:

https://www.amazon.de/MAX14870-Single-geb%C3%BCrsteten-Driver-Carrier/dp/B015WPSS2O https://www.amazon.it/POLOLU-2961-DC-motor-MAX14870-4-5%C3%B736V-Channels1/dp/B01AIM5R9I

From pololu's page *"offers a wide operating voltage range of 4.5 V to 36 V and can deliver a continuous 1.7 A (2.5 A peak) to a single brushed DC motor. It features a simple two-pin speed/direction interface and built-in protection against reverse-voltage, under-voltage, over-current, and over-temperature."*

General specifications

Motor driver:	MAX14870
Motor channels:	1
Minimum operating voltage:	4.5 V
Maximum operating voltage:	36 V
Continuous output current per channel:	1.7 A[2]
Peak output current per channel:	2.5 A
Maximum PWM frequency:	50 kHz
Reverse voltage protection?:	Y

Notes:

1 Without included hardware.
2 Typical results with VIN=12 V and 100% duty cycle at room temperature.

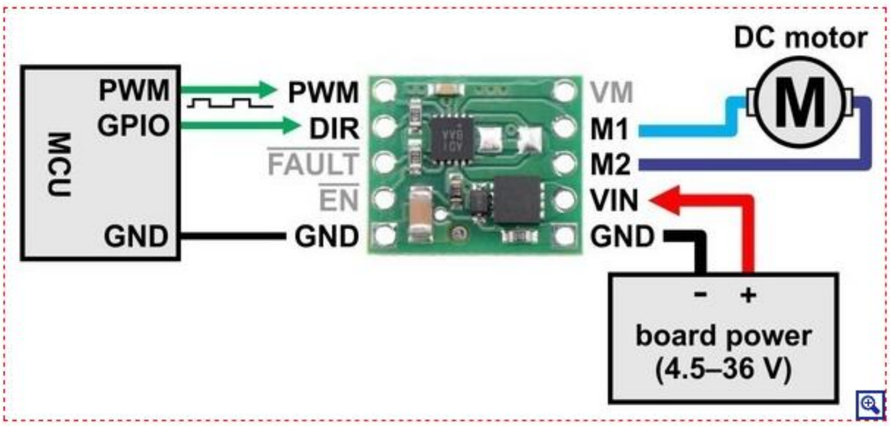
As the continuous output current is higher than the stall current, it should be safe. In addition, 12 V can be the operating voltage no problem whatsoever.

From the datasheet (https://www.pololu.com/file/0J885/MAX14870.pdf):

Applications

- Printers and Scanners
- Relay Drivers
- Vending and Gaming Machines

Connections



Minimal wiring diagram for connecting a microcontroller to a MAX14870 Single Brushed DC Motor Driver Carrier.

POWER SUPPLY

If it is possible to confirm the amount of current that we need, it can change. Meanwhile and since the price does not vary that much, the power supply selected is the following:

https://www.amazon.es/Lixada-Transformador-Voltage-Alimentaci%C3%B3n-Interruptor/dp/B00ECW6K74/ref=sr_1_2?ie=UTF8&qid=1524734696&sr=8-2&keywords=transformador+220v+ac+a+12v+dc

The reasons:

- 12 V dc output from 220 V ac input

- 15 A output current, enough in case we want to add some lights or other features to the machine

In case that we have enough with 5 A: https://www.amazon.es/Transformador-Alimentador-Tiras-Fuente-Alimentaci%C3%B3n/dp/B01G0Q3RXY/ref=sr_1_6?ie=UTF8&qid=1524734696&sr=8-6&keywords=transformador+220v+ac+a+12v+dc

As mentioned before in the document, we would like to power some motors with the 12 V but the Arduino and other components need 5 V. Therefore, we have to add a 12-5 V dc stepdown converter.

The 5 V supplies to the Arduino and the servo motor and possibly the stepper too. Whether the stepper is included or not, 3 A would be enough.

The following options are available, and I choose the first one as it supposedly works like the others and is much cheaper.

https://www.amazon.es/Converter-Step-Down-Power-Supply/dp/B009P0504M

Alternatives in order of preference:

https://www.amazon.com/DROK-Converter-Step-down-Transformer-Regulator/dp/B00C63TLCC/ref=br_lf_m_6hduahpj7osy375_img?_encoding=UTF8&s=industrial

https://www.amazon.com/SMAKN-Converter-Power-Supply-Module/dp/B00CXKBJI2/ref=br_lf_m_6hduahpj7osy375_img?_encoding=UTF8&s=aht

https://www.amazon.com/Converter-Regulator-Regulated-Supplies-Transformer/dp/B00J3MHRNO?th=1

SERVO

Having in mind we are going to use a 12 V power supply and a buck converter to get 5 V, we proceed to choose the motors.

The servo that we have for the prototype has a strength of 2kg. With the prototype already built and making different test, we are unable to clarify that the strength will be enough since it does not push the mechanism, as we wanted it to. Therefore, we look for a new one capable of providing 5 kg of force. This increment is due to our experience and testing with the prototype and applying the new materials into the matter.

After some search, the desired Servomotor is the following:

https://www.robotshop.com/en/hitec-hs-485hb-servo-motor.html

It can provide close to 5kg with an 4,8V input. This is ideal for the electronic point of view since we could "feed" it from the Arduino Mega if not from the buck converter.

- Replaces the popular HS-475HB
- Speed (sec/60o): 0.20(4.8V), 0.17(6V)
- Torque (Kg-cm/Oz-in): 5.2/72(4.8V), 6.4/89(6V)
- Size (mm): 39.9 x 19.8 x 37.9
- Weight: 45 g / 1.59 oz

More info: https://www.robotshop.com/media/files/pdf/servomanual.pdf
This servo motor is the same we asked for in the milestone 1.
No need for drivers here.

STEPPER

Making this change in the servo, the weight from the platform that the stepper has to move increases. The stepper being tested (https://www.amazon.es/28BYJ-48-Driver-ULN2003-Arduino-Stepper/dp/B071VGBJG3/ref=sr_1_3?ie=UTF8&qid=1524795256&sr=8-3&keywords=stepper+arduino) with the prototype has a torque of 0,015 N·m and it moves the prototype quite well. Anyway, we don't think it will do such a great job with the increased value and instead of risking it we look for a new one that can double this torque value so we are safe.

We know and believe in the theory calculations, but we are so far into the project that we can already have a feeling of the torque required. In addition, the calculation have been made before and gave us an underestimated value. This is because along the way, design changes were made and ended up in a modification of the parameters.

Finally, some parameters might have been added or might be added along the way and thus we feel safer going for a much higher torque stepper.

Having the power supply of 12 V output with a current holding of 15 A, it can be easier to power the motor with it. Therefore, a 12 V nominal voltage stepper is looked for. As we will require a driver for the stepper, the lower the current the cheaper the driver. So to summarize: 12 V, low current (not more than 2 A if possible) and a holding torque greater than 0,015 N·m (at least around 0,15 N·m, which is ten times stronger).

The NEMA 17 stepper motors are widely available and in different configurations depending on the need and usually have a nominal voltage of 12 V.

https://www.amazon.es/Motor-pasos-Nema-0-26Nm-36-8oz/dp/B06XRFCP3X/ref=sr_1_1?ie=UTF8&qid=1524794594&sr=8-1&keywords=motor+nema+17+12v

Best option because of arrival time from the provider. A bit more expensive but has good reviews. Voltage 12V; current 0,4 A; holding torque 0,26 N·m

Alternatives in order of preference:

https://www.amazon.es/Hrph-Motor-Reprap-impresora-extrusora/dp/B071VYJ1CS/ref=sr_1_6?ie=UTF8&qid=1524794594&sr=8-6&keywords=motor+nema+17+12v

Same but different provider, cheaper but takes longer time.

https://www.amazon.es/UEETEK-Motor-pasos-0-2Nm-impresora/dp/B06ZYCSWHN/ref=sr_1_4?ie=UTF8&qid=1524794594&sr=8-4&keywords=motor+nema+17+12v

Same but higher current and would require the DRV8834 driver instead of the A4988 (more detailed below)

STEPPER DRIVER

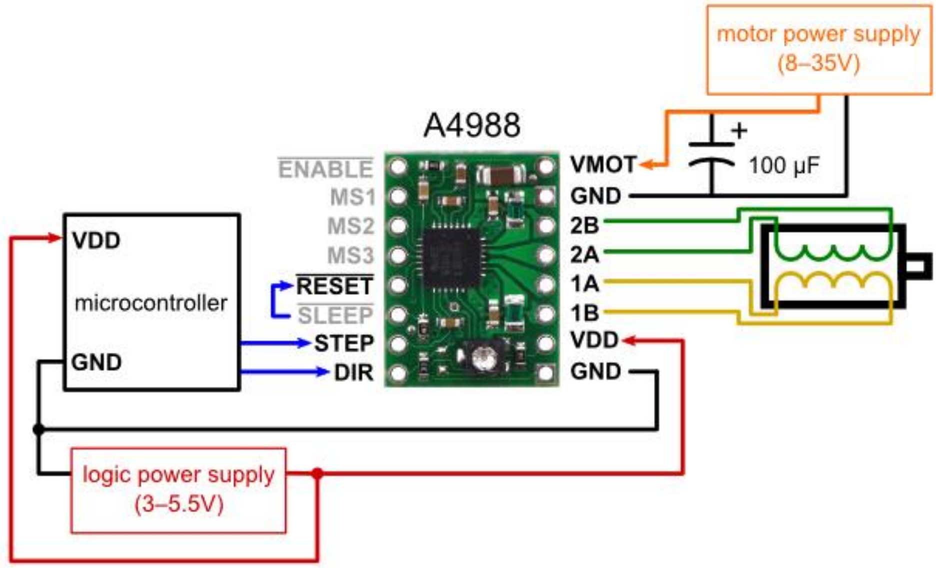
In order to be able to have control over the motor through the Arduino we need a driver that can supply the current specified from the motor.

https://www.pololu.com/product/1182

Buying link: https://www.amazon.es/Stepper-Driver-Pololu-Impresora-stepstick/dp/B0716DHG5J/ref=sr_1_3?ie=UTF8&qid=1524797119&sr=8-3&keywords=a4988+stepper+driver

This one is enough for the two first options of the steppers. Current of 1 A.

Connections



As Pololu warns: "*This carrier board uses low-ESR ceramic capacitors, which makes it susceptible to destructive LC voltage spikes, especially when using power leads longer than a few inches. Under the right conditions, these spikes can exceed the 35 V maximum voltage rating for the A4988 and permanently damage the board, even when the motor supply voltage is as low as 12 V. One way to protect the driver from such spikes is to put a large (at least 47 µF) electrolytic capacitor across motor power (VMOT) and ground somewhere close to the board.*"

Therefore, a 100 microF capacitor should be added.

This other one is in case the third option was chosen. Current of 1,5 A. https://www.pololu.com/product/2134/specs