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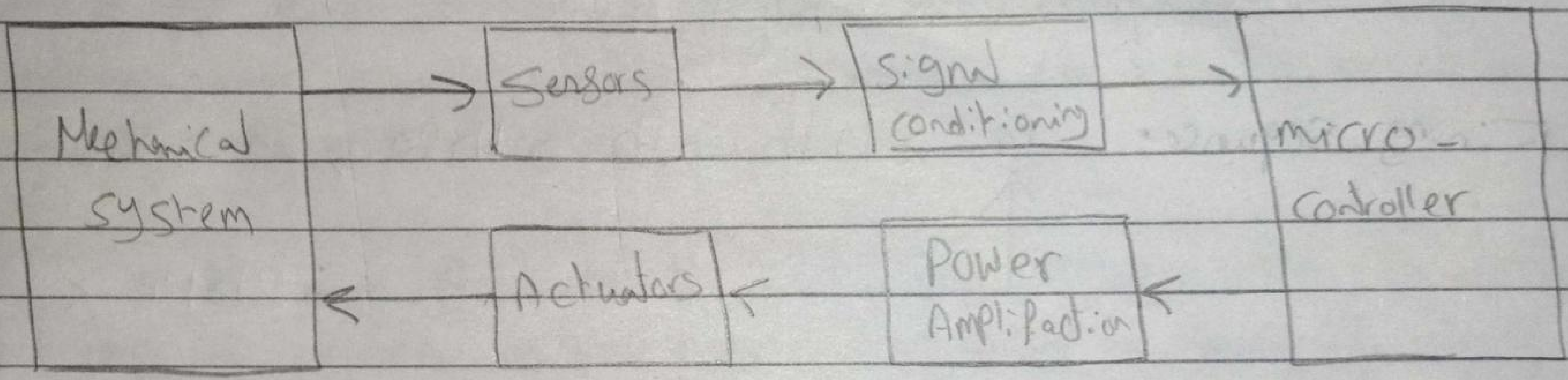
13/01/2020

Mechatronics (2)

Fall 2018 exam

Question(1) a)



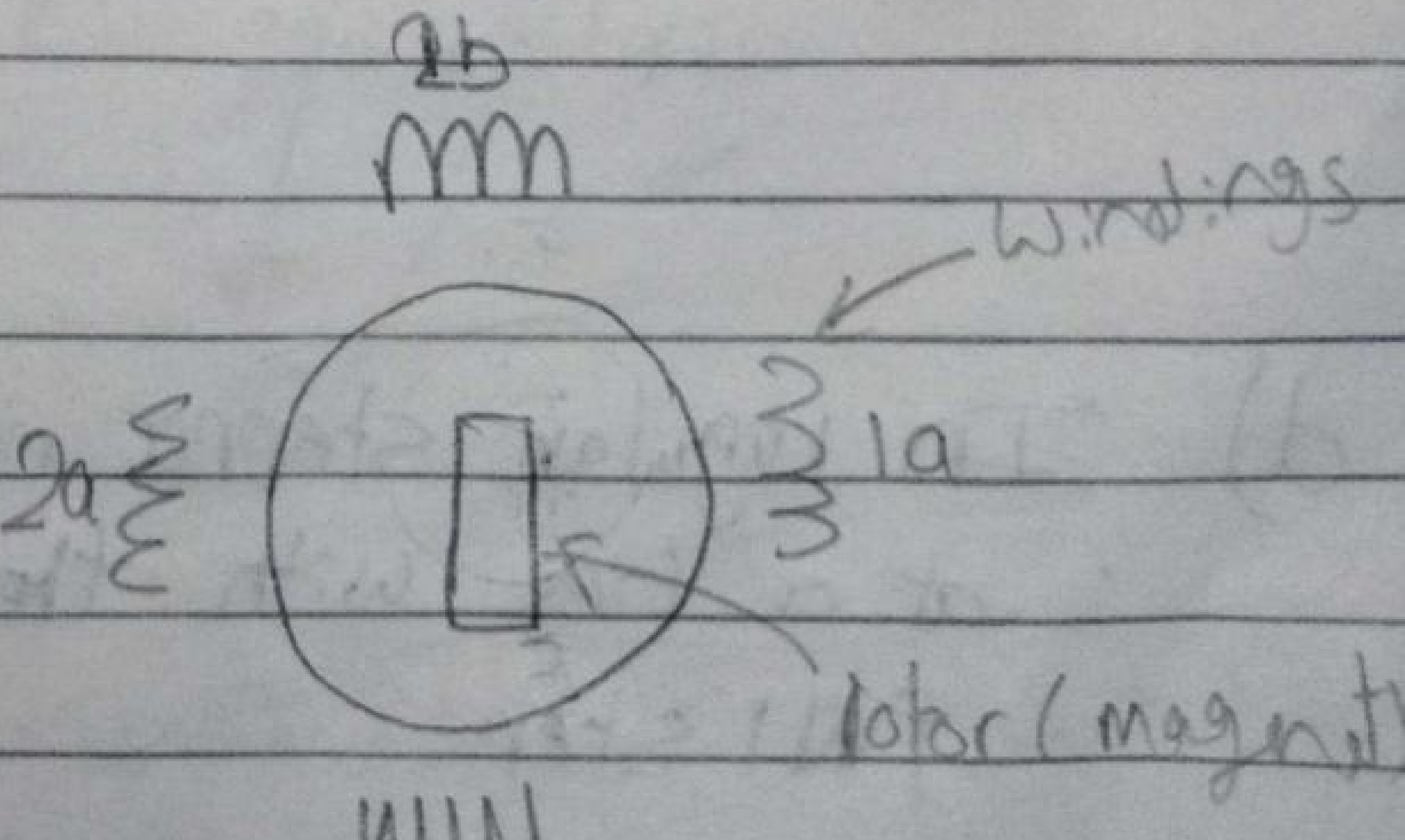
example of power Amplification is the H-bridge, it takes the direction & PWM signal from the micro-controller and deliver a corresponding voltage ~~with~~ high current source to the motor.

b) The stepper motor driver decide the sub division of the motor (wether a half step or full step)

In full step: the driver energizes only one winding at a time moving the rotor one step (the rotor stops at the energized winding)

Firing sequence:

$1a \rightarrow 1b \rightarrow 2a \rightarrow 2b$



In half-step motors: The driver energizes a winding alone at first like the full-step but before deenergizing this winding, the driver energizes the proceeding winding, this leads to stopping the rotor half way between both winding (in half the full-step position)

$$\Theta_{step/pulse} = 2\,\Theta_{half\text{-}step/pulse}$$

Firing sequnce: 1a → 1a1b → 1b → 1b2a → 2a → 2a2b → 2b → 2b1a → 1a

c)

Unipolar	Bi-polar
5, 6, or 8 wires	4 wires
lower power requirements	Higher power requirements
lower holding torque	higher holding torque
used at high speeds applications	used at low speeds applications (torque drops off)

d) In regular stepper motors the drivers energizes ~~the~~ a winding or more at a time with the motor full voltage leading to a rotation of full step (in case of one winding) or half a step (in case of two windings)

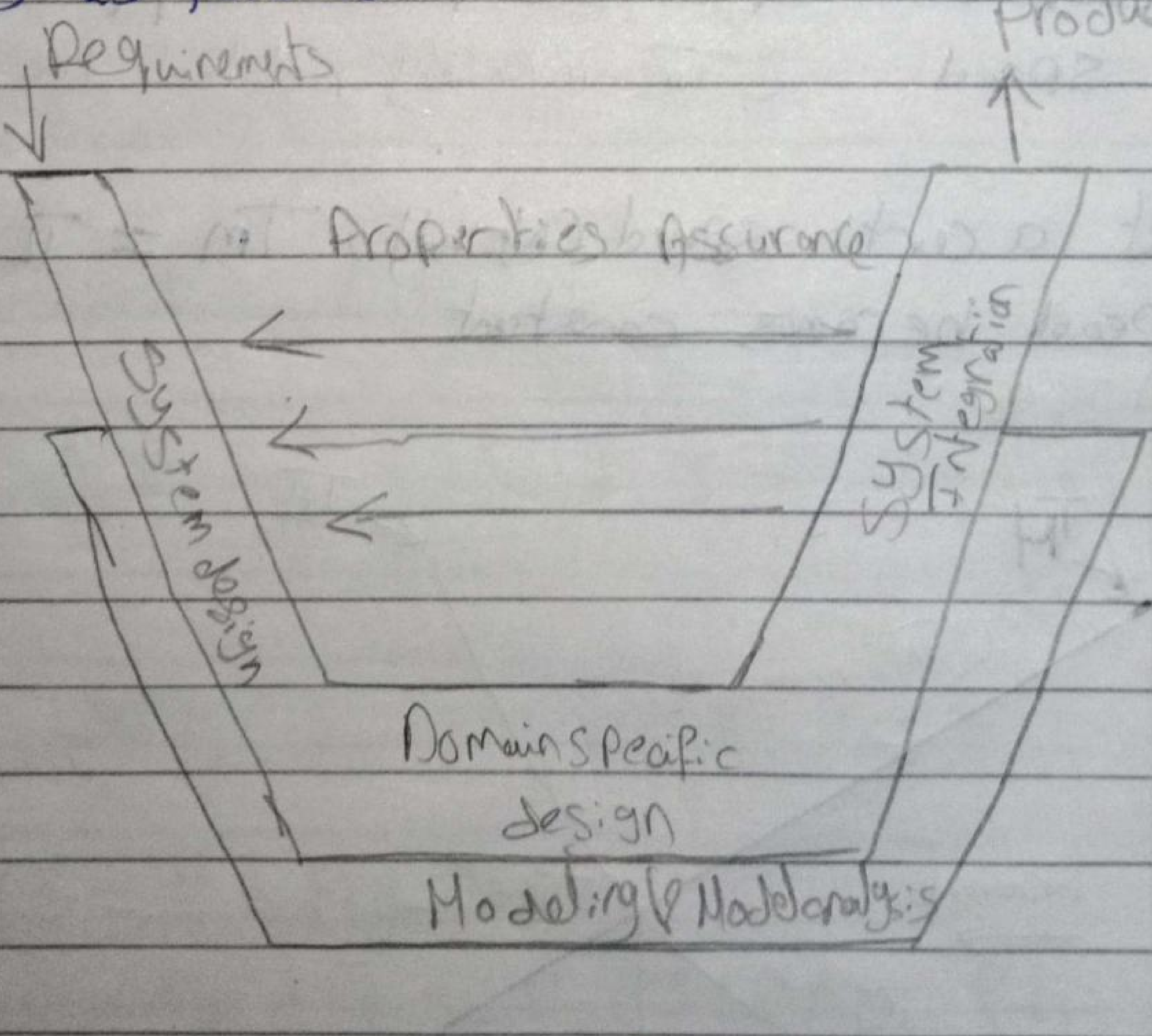
In microstepping the driver uses PWM technique to energize the windings with a portion of the full Voltage. leading to the ~~part~~ rotation of rotor with a very small step.

Micro stepping could divide a single step into 256 small steps. ~~increas~~

Importance of micro stepping is that it increases the resolution of the motor, ~~increases~~ more smooth rotation and decrease the velocity variation of the motor while rotation.

e) The V-model is a part of the VDI 2206 standarization, it indicates the logical squence of procedures that should be followed during the design & develepment of a meachtronics system.

The V-Model is as follows:

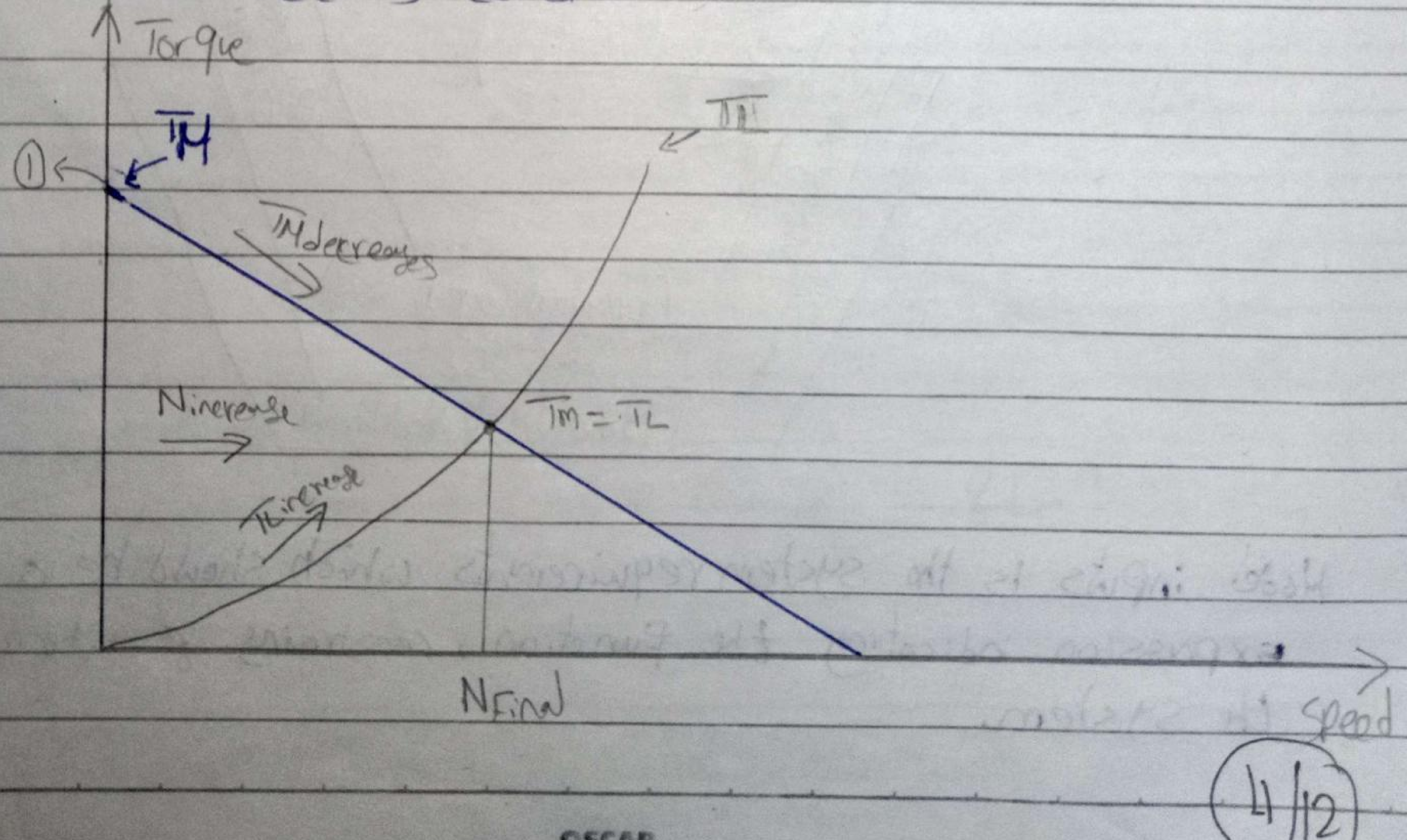


Model inputs is the system requirements which should be a quantitive expression indicating the function, constrains & criteria of the system.

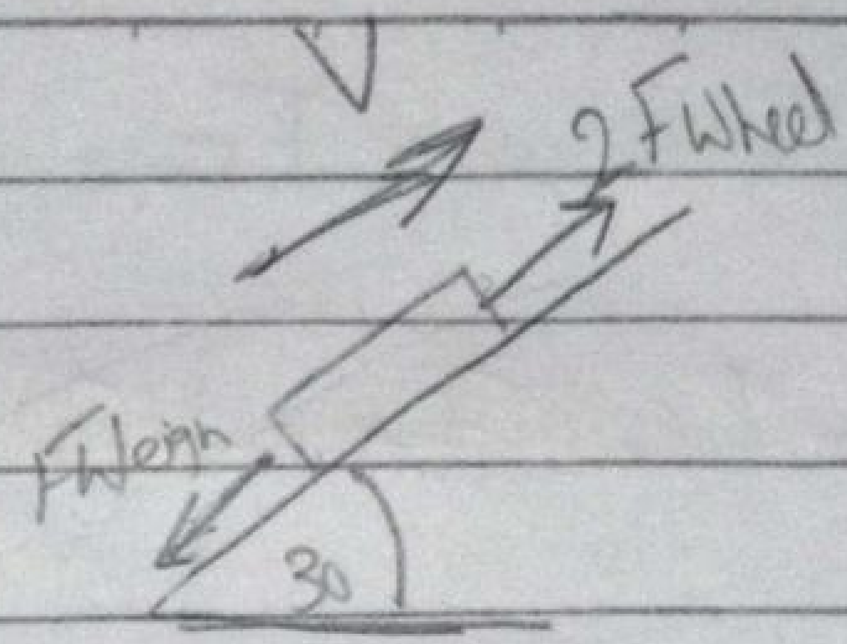
Model output is the product wether it's a product, a process or a prototype depending on the type of the system & its maturity.

(f) ~~at start~~ what will happen:

1. The torque produced from motor will be larger than load torque ($T_m > T_L$)
2. Then the load will accelerate, increasing the speed.
3. The load torque will increase with speed ($T_L \propto N^2$)
4. ~~At a certin speed~~ The motor torque will decrease with speed (T_m inversely related to N)
5. at a certin speed (N_{Final}), $T_m = T_L$ and the load speed becomes constant



Question (2):



$F_{weig} = mg \sin\theta = 50 \times 9.81 \times \sin(30)$

$= 245.25\,N$

$V = \omega_{wheel} * r_{wheel} = 0.15\,\omega_{wheel}$ (m/s)

$a = 0.15\,\alpha_{wheel}$ (m/s²) (assuming no slipping)

$m_{wheel} = \pi r^2 L * \rho = \pi \times 0.15^2 * 0.05 * 2700 = 9.54\,kg$

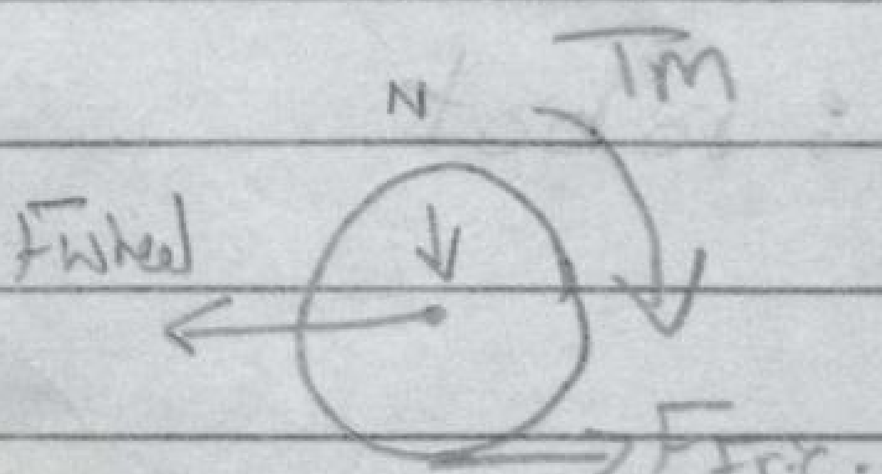
$J_{wheel} = \frac{1}{2} m_{wheel} * r^2 = \frac{1}{2} * 9.54 * 0.15^2 = 0.107\,kg.mm^2$

eq of motion of body:

$2F_{wheels} - F_{weight} = ma$

$F_{wheel} = \frac{50\,a}{2} + \frac{245.25}{2} = 3.75\,\alpha_{wheel} + 122.625$

eq of motion of wheel:



$F_{Friction}|_{max} = \mu * N = \mu * mg\cos(30)$
$= 0.2 * 50 * 9.81 \cos(30) = 84.96\,N$

$F_{Fric} = F_{wheel} = 3.75\,\alpha_{wheel} + 122.625$

$T_m - F_{Frict} * r = (J_{wheel} + J_m)\,\alpha_{wheel}$, assume $J_m = J_{wheel} = 0.107$

OSCAR

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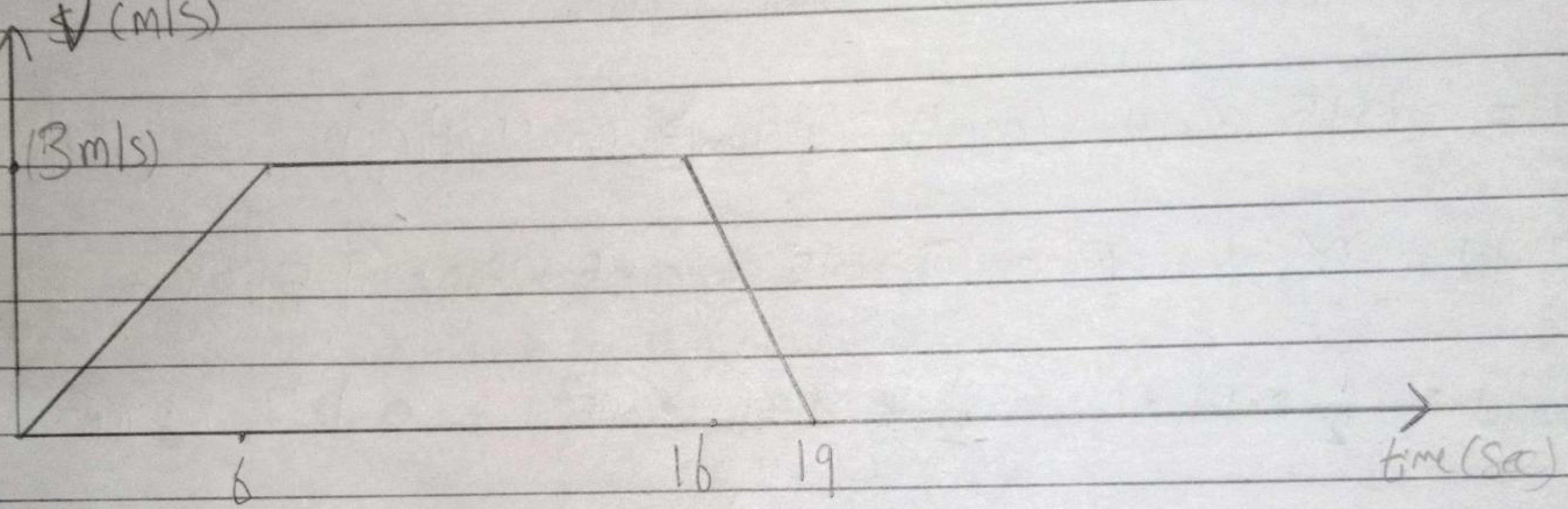
$$T_m = J_{wheel}\,\alpha + F_{fric} * r$$

$$= (0.107 + 0.107)\,\alpha + (3.75\alpha + 122.625) * 0.15$$

$$T_m = 0.7765\,\alpha + 18.4 \quad (N.m) \text{ —— } (1)$$

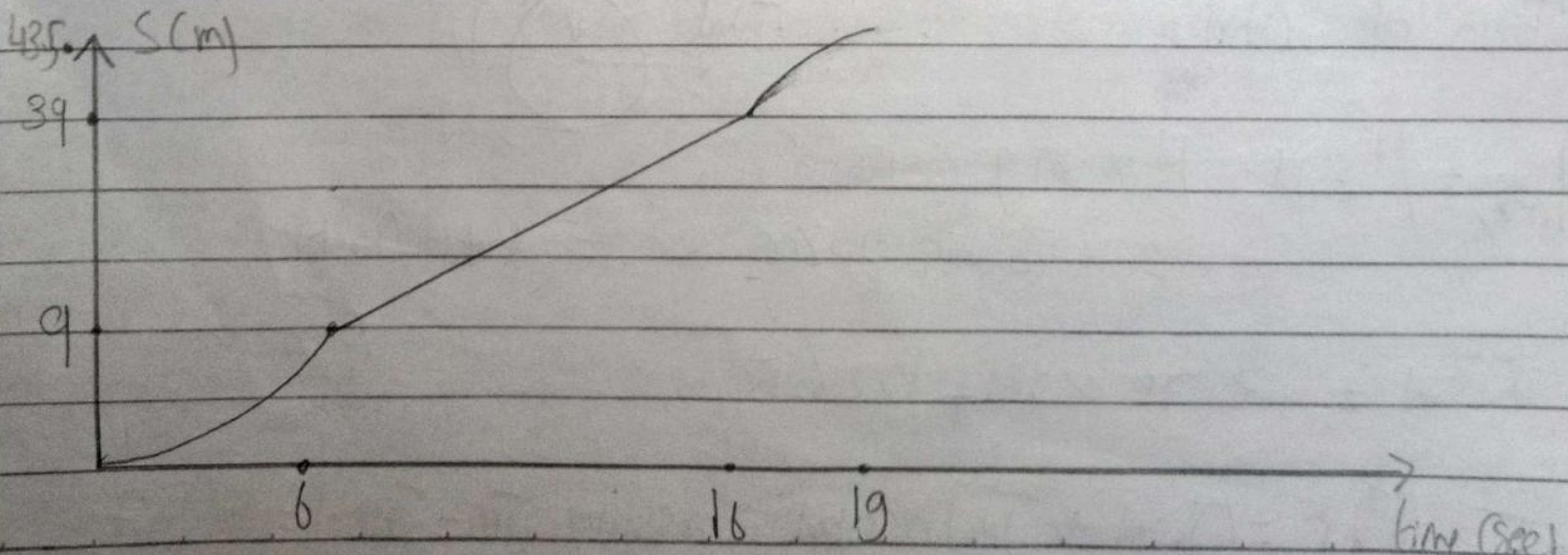
speed curve : robot



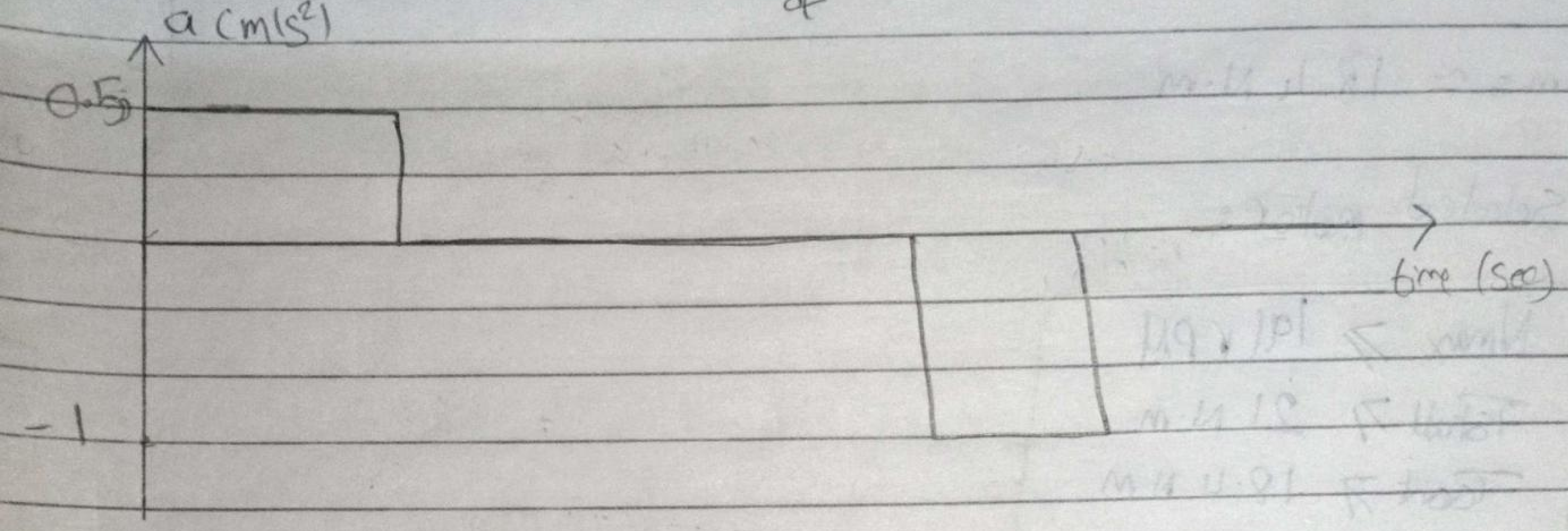
$V_{max} = 3\ m/s \quad , \quad W_{max} = \frac{V_{max}}{0.15} = \frac{3}{0.15}$

$$\boxed{\text{motor max speed} = 20\,r/s = 191\,rpm}$$

position curve : robot $\quad S = \int V dt$



Acceleration curve : robot $\quad a = \frac{dv}{dt}$

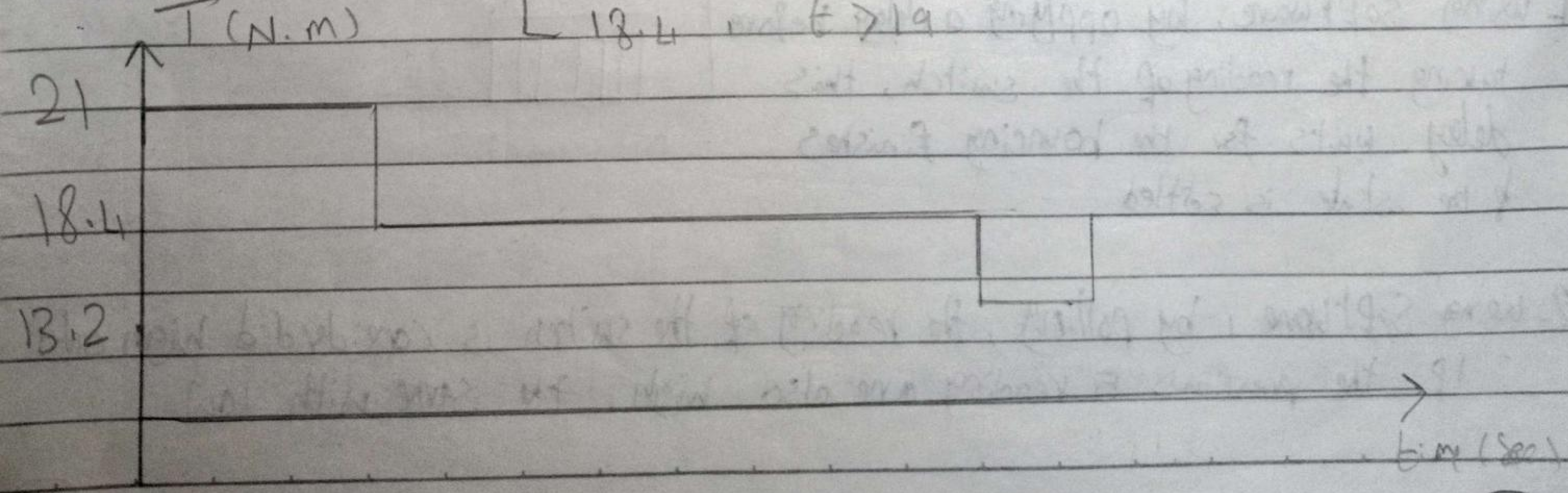


$$a = \begin{cases} 0.5 & , \ t < 6 \\ 0 & , \ 6 < t \le 16 \\ -1 & , \ 16 < t \le 19 \end{cases}$$

$$\alpha = \frac{a}{0.15} , \quad \alpha = \begin{cases} 10/3 & , \ t < 6 \\ 0 & , \ 6 < t < 16 \\ -20/3 & , \ 16 < t < 19 \end{cases}$$

Torque curve : motor

From ① $\quad T_m = \begin{cases} 21 & , \ t < 6 \\ 18.4 & , \ 6 < t < 16 \\ 13.2 & , \ 16 < t < 19 \\ 18.4 & , \ t > 19 \end{cases}$



Peak torque = 21 N.m

$T_{r.m.s} \simeq 18.4$ N.m

The Selected motor:

$$\boxed{\begin{array}{l} N_{max} \geq 191 \text{ rPM} \\ T_{stall} \geq 21 \text{ N.m} \\ T_{cont} \geq 18.4 \text{ N.M} \end{array}}$$

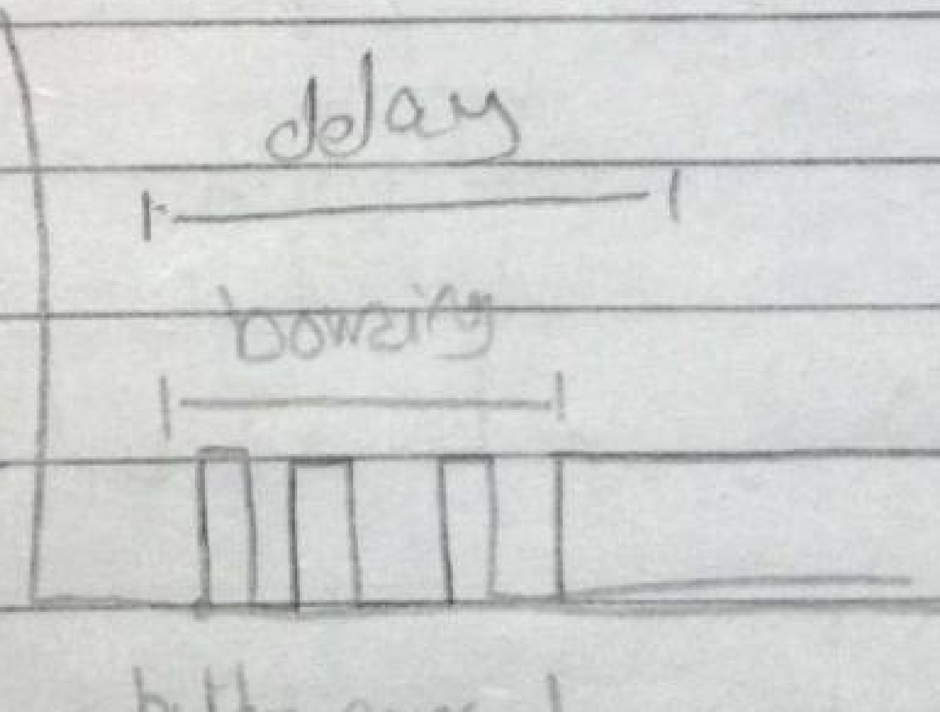
c) 1- Appling brakes (add a braking mechanism)

2- keep the motor supplying 18.4 N.M (force required by weight)

Question (3):

a) ~~Bounci~~ when a switch is pressed, due to the mechanical structure imperfection, the state of the switch bounces between high & low before settling to the high state. Same thing happens when switch is released

There is multiple methods to cancel debouncing:

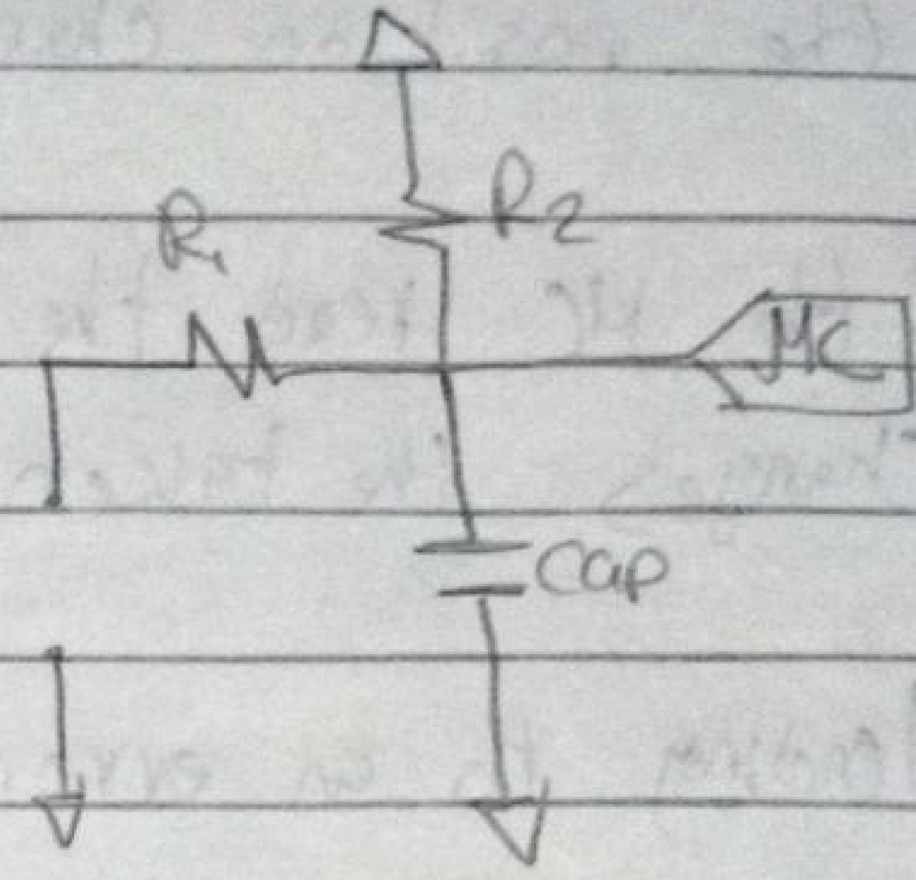


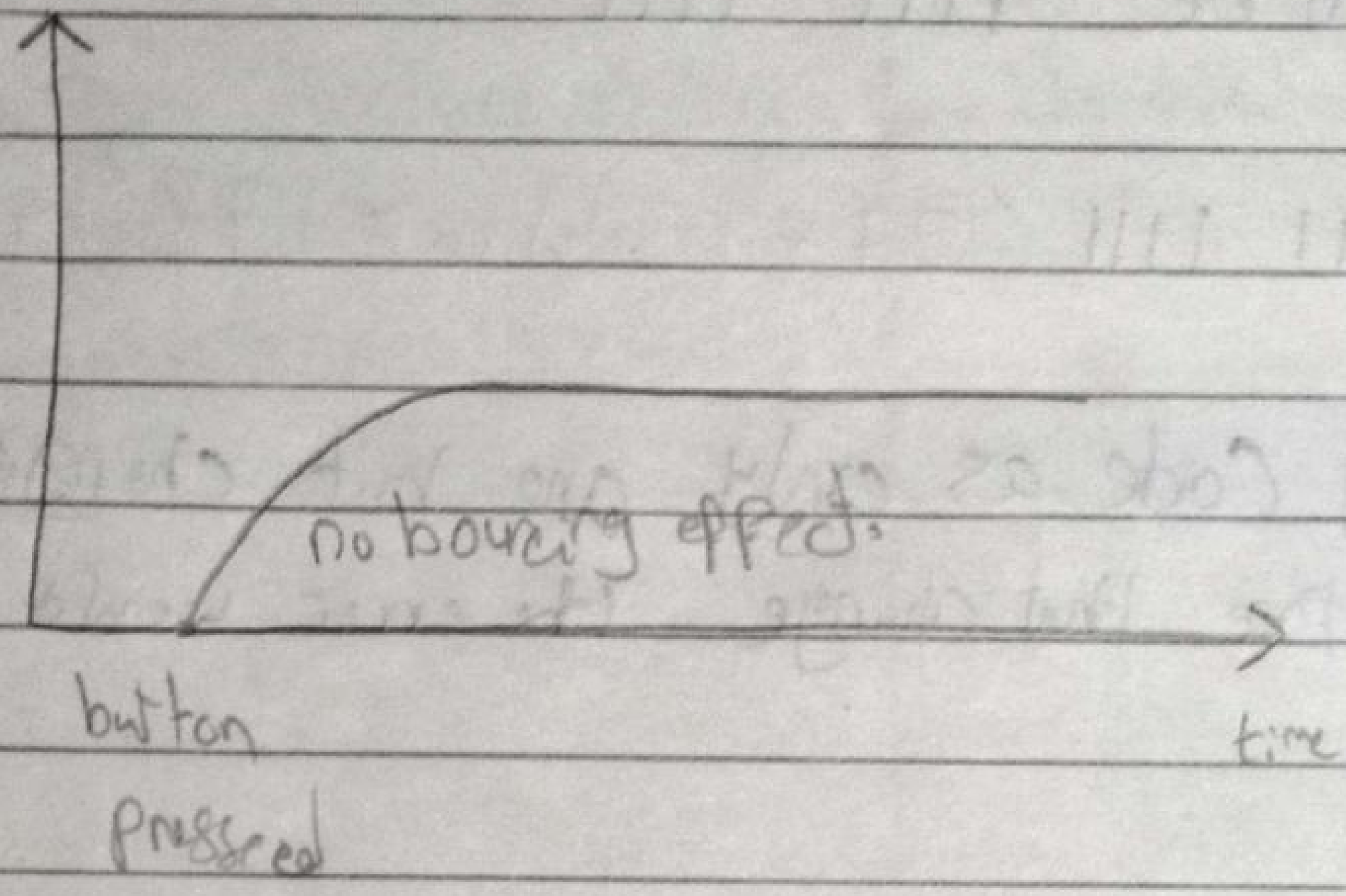
1- using software, by applying a delay before taking the reading of the switch, this delay waits for the bouncing finishes & the state is settled

2- using Software, by polling, the reading of the switch is considerded high only if the previous 5 reading are also high, the same with low.

3- using hardware, by ~~connecting a capacitor~~ using a debouncing circuit

the capacitor in the circuit takes time to charge and discharge, canceling the effect of debouncing.





b) 1) $\boxed{\text{resolution} = \frac{360}{2^n} = \frac{360}{2^{10}} = 0.35156^\circ}$

2)

00 1110 0101 grey

00 1011 1001 binary

185 Decimal

angle = resolution * Dcode = 0.35156 * 185

$\boxed{\text{indicated angle} = 65^\circ}$

3) ~~er~~ a large error may occur in the binary encoders as more than 1 bit changes while increasing the angle by one resolution, the error may occur if the reading was taken before all the bits were changed

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B7

For example if the output was ~~0100 0~~ 0111 1111 (assuming 8 bit encoder) the position changes the next reading will be 1000 0000

If the μC read the reading after the B7 changes and before the other bits changes the taken reading will be 1111 1111

leading to an error of 0111 1111 (127 * resolution = 178° error)

This cannot happen in grey code as only one bit change, even if the reading was taken before that change the error would be one resolution (1.4°)

Question (4)

a) Advantages of a plc over conventional control are:

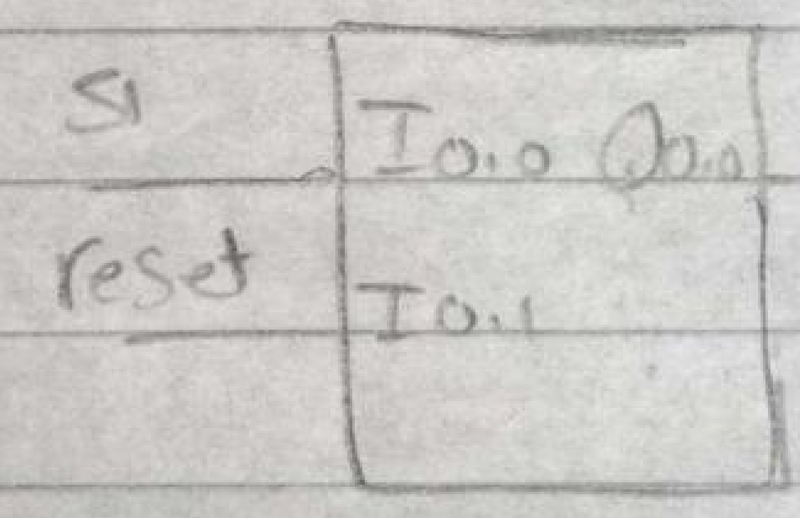
- Elimination of wiring
- programming capability
- faster implementation of changes and correction
- lower cost
- more visual observation
- more operational speed
- more security and maintainability and flexibility

PLC is very important ~~as~~ to industrial applications as it's used to implement the control of the automation system in the industary. and it's better than the convential control due to the previousally stated reasons.

- It's also used in the control of some ~~machines~~ industrial machines b)

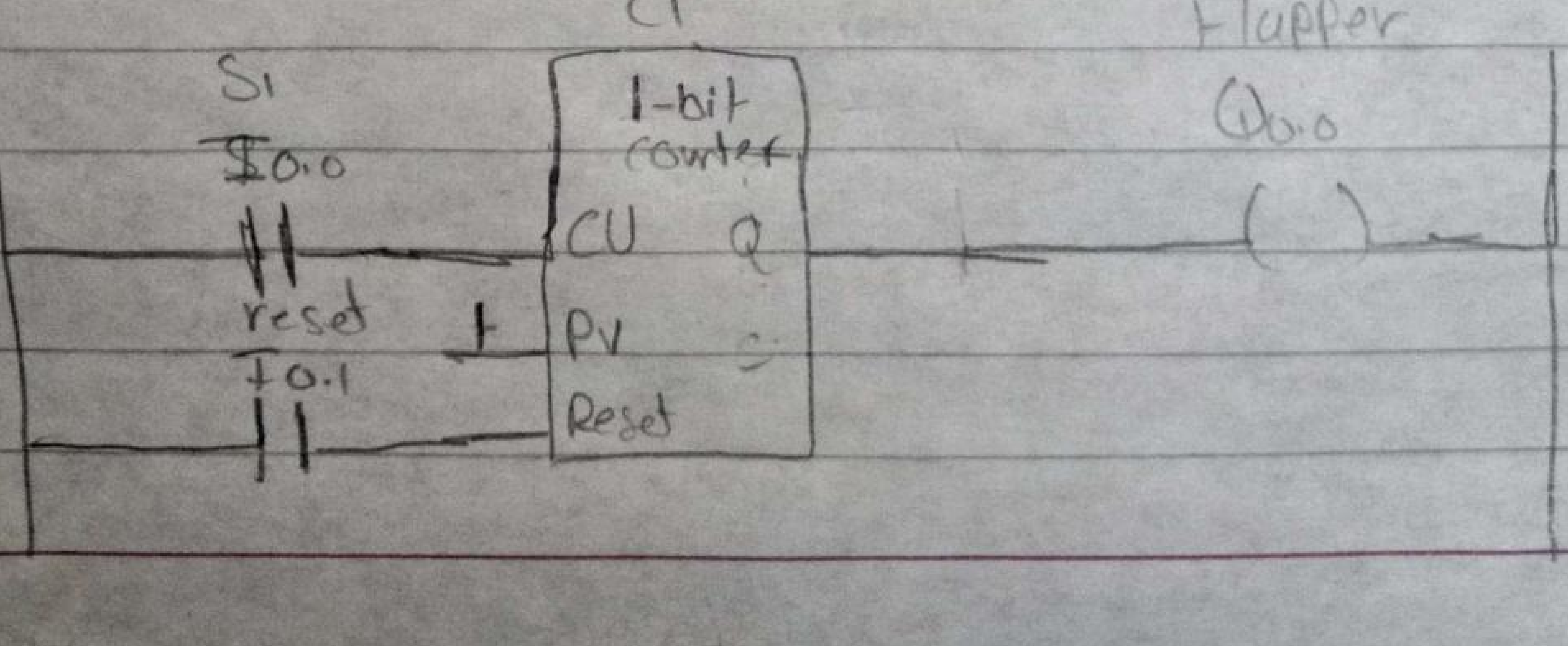
PLC	μ controller
usage:	
. It's used in industrial applications (like in industrial automation)	used in embedded systems (Smart watches)
complexity	
. easier to interface with and to program (visual programming using ladder technique)	. Harder to interface with and harder to program
applications	
Industrial automation	. smart watches
producation lines	. Veehicles' ECUS
Industrial machines	
power requirements:	
Higher power requirement	. lower power requirements

c) ~~Har~~ wiring diagram:



when Flapper is low (A open, B closed)
when Flapper is high (A closed, B open)

When S_1 is pressed $Flapper = \overline{Flapper}$



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Intially A is open & B is closed, when S_1 is pressed the counter value increase to 1 and a high signal closes B and open A.

When another S_1 press happens, counters over flow to Zero changing flapper signal to Low opening A, closing B

Reset ~~st~~ button reset counter value to Zero (opening A, closing B)

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