University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292

Project 2: Coin Picking Robot.

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Requirements

- Microcontroller System: Must not be 8051!
- Programmed in C.
- Robot must be battery powered**.**
- Discrete MOSFET drivers.
- Metal detector.
- Use electromagnet + micro servos to pick coins.
- Perimeter detector. Perimeter area 0.5 m^2.
- **Manual Task:** In a surface delimited by a perimeter wire, the robot must pick 20 randomly placed coins (4 of each type) and then stop.
- **Automatic Task**: Use remote to move forward/backward, turn left/right, stop, and pick coins.

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Coin Picking Robot

- Here is my robot picking coins in automatic mode. I used the EFM8 board.

  https://bit.ly/2HmJcAr

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Getting Started with a New Microcontroller System

1. Obtain/assemble the hardware. Also documentation: datasheets & manuals.
2. Obtain/install the development environment. Also documentation like manuals.
3. Obtain/install a means of putting the 'firmware' in the hardware. May require additional hardware tools and software.
4. Settle a workflow. Also: examples, application notes, and forums.

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Getting Started with a New Microcontroller System

- In this course is not too difficult. Instructions provided for:
  - STM32F052: LQFP32. 64k flash. ST Microelectronics. ARM architecture.
  - PIC32MX130: DIP-28. 64k flash. Microchip. MIPS architecture.
  - MSP430G2553. DIP-20. 16k flash. Texas Instruments. MSP430 architecture.
  - SAMD20E16: LQFP32. 64k flash. Atmel/Microchip. ARM architecture.

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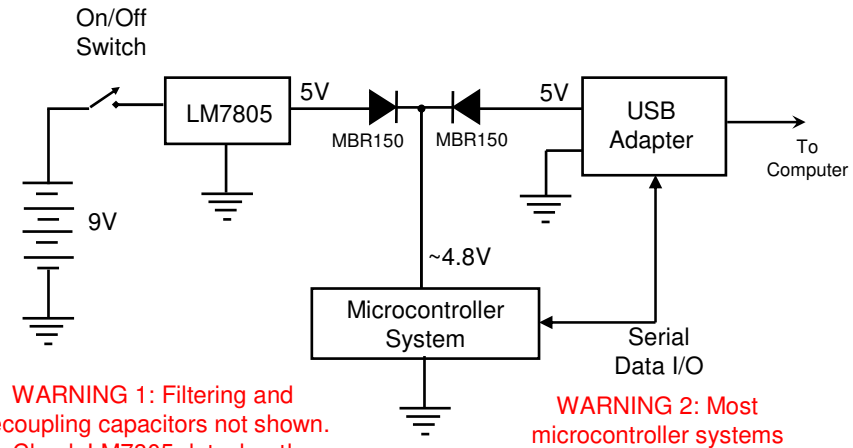
Using Batteries to Power the Microcontroller System



WARNING 1: Filtering and decoupling capacitors not shown. Check LM7805 datasheet!

WARNING 2: Most microcontroller systems require 3.3V to work.

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The STM32F051 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for ARM.
3. Flash Loader: Port of official FLASHER-STM32 from ST Microelectronics via BO23XS board.
4. Workflow: via Makefiles in CrossIDE. Examples in Connect.

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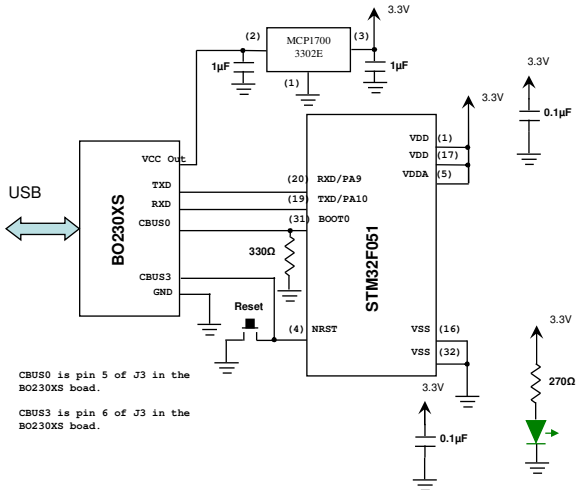
The STM32F051 Microcontroller System



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The STM32F051 Microcontroller System

Qty	Supplier's#	Man's #	Description	Price
2	BC1148CT-ND	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL	0.54
2	BC1157CT-ND	K105Z20Y5VE5TH5	CAP CER 1UF 25V Y5V RADIAL	0.94
2	270QBK-ND	CFR-25JB-52-270R	RES 270 OHM 1/4W 5% AXIAL	0.30
1	330QBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL	0.15
1	67-1102-ND	SSL-LX5093HD	LED RED DIFF 5MM ROUND T/H	0.55
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H	0.62
1	MCP1700-3302E/TO-ND	MCP1700-3302E/TO	IC REG LDO 3.3V 0.25A TO92-3	0.57
1	497-13626-ND	STM32F051K8T6	IC MCU 32BIT 64KB FLASH 32LQFP	4.14
0.33	1528-1065-ND	1163	SMT ADAPTERS 3 PACK 32QFN/TQFP	2.82
2	A26509-16-ND	4-103741-0-16	CONN HEADR BRKWAY .100 16POS STR	3.12
2	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V	0.70

Total 14.45

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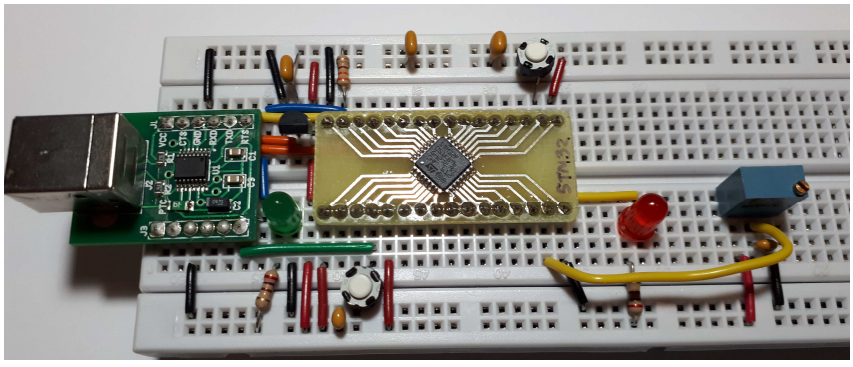
The STM32F051 Microcontroller System



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The PIC32 Microcontroller System

1. Hardware: Bare IC in breadboard.
2. Development environment: XC32 from Microchip. (Derived from GCC but…)
3. Flash Loader: Pro32 via BO230XS board by yours truly.
4. Workflow: via Makefiles in CrossIDE. Examples in Connect.

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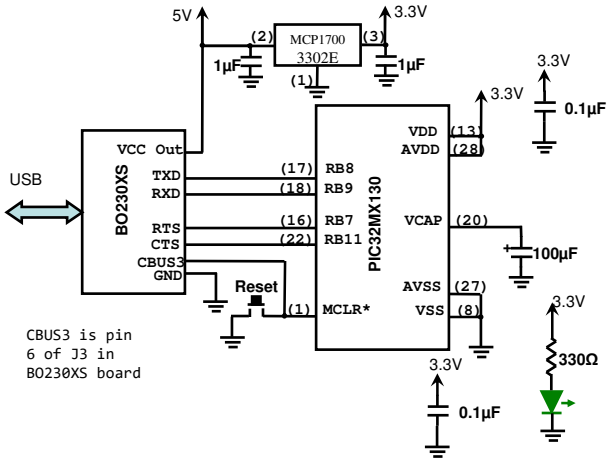
The PIC32 Microcontroller System



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The PIC32 Microcontroller System

Qty	Supplier's#	Man's #	Description	Price
2	**BC1148CT-ND**	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL	0.54
2	BC1157CT-ND	K105Z20Y5VE5TH5	CAP CER 1UF 25V Y5V RADIAL	0.94
2	330QBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL	0.30
1	67-1102-ND	SSL-LX5093HD	LED RED DIFF 5MM ROUND T/H	0.55
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H	0.62
1	MCP1700-3302E/TO-ND	MCP1700-3302E/TO	IC REG LDO 3.3V 0.25A TO92-3	0.57
1	PIC32MX130F064B-I/SP-ND	PIC32MX130F064B-I/SP	IC MCU 32BIT 64KB FLASH 28SDIP	4.23
1	493-1548-ND	UHE1E101MED	CAP ALUM 100UF 20% 25V RADIAL	0.41
2	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V	0.70
			Total	8.86

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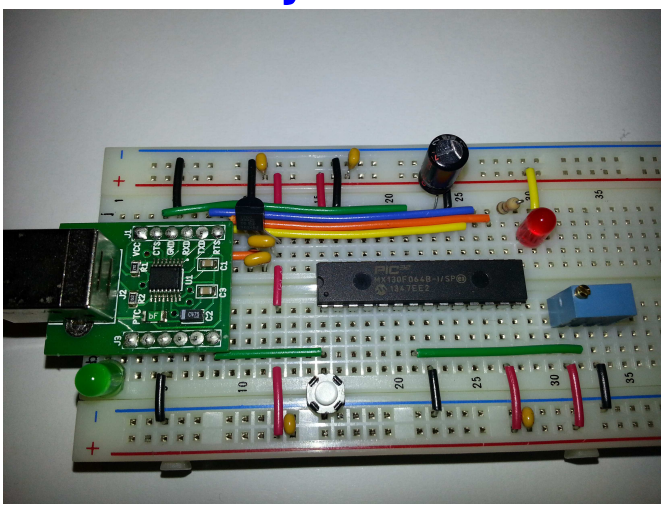
The PIC32 Microcontroller System



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The MSP430 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for MSP430.
3. Flash Loader: MSP430_prog via BO23XS board by yours truly.
4. Workflow: via makefiles in CrossIDE. Examples in Connect.

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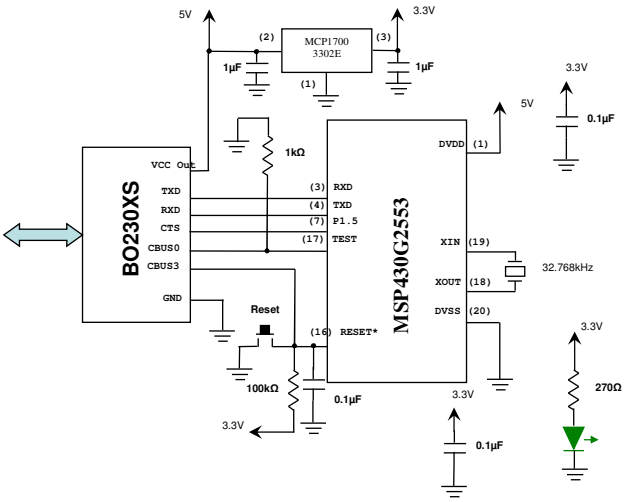
The MSP430 Microcontroller System



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The MSP430 Microcontroller System

Quantity	Digi-Key Part #	Description	
3	BC1148CT-ND	0.1uF ceramic capacitors	0.73
2	BC1157CT-ND	1uF ceramic capacitor	0.90
2	270QBK-ND	270Ω resistor	0.30
1	1.0KQBK-ND	1kΩ resistor	0.15
1	100KQBK-ND	100kΩ resistor	0.15
1	MCP1700-3302E/TO-ND	IC REG LINEAR 3.3V 250MA TO92-3	0.57
1	67-1108-ND	LED 5MM GREEN	0.59
1	300-8842-ND	CRYSTAL 32.7680KHZ 7PF T/H	0.35
1	296-28429-5-ND	MSP430G2553	3.93
1	P8070SCT-ND	Push button switch	0.34

$8.01

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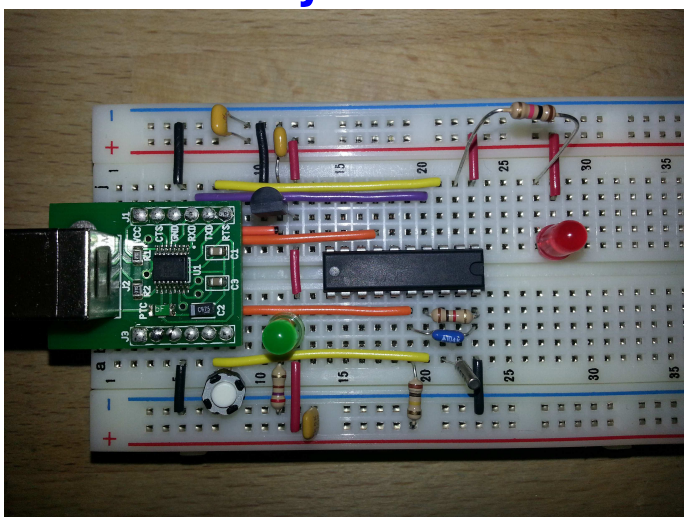
The MSP430 Microcontroller System



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The SAMD20E16 Microcontroller System

1. Hardware: Bare IC + Adapter in breadboard.
2. Development environment: GCC for ARM.
3. Flash Loader: Custom loader via BO23XS board.
4. Workflow: via Makefiles in CrossIDE. Examples in Connect.

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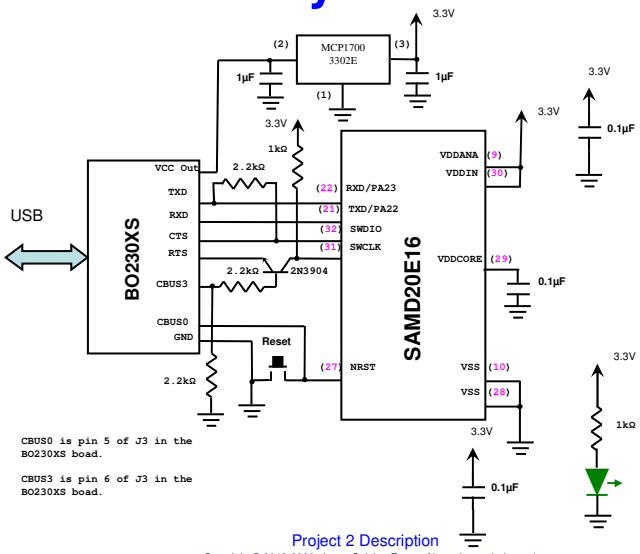
The SAMD20E16 Microcontroller System



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The SAMD20E16 Microcontroller System

Qty	Supplier's#	Man's #	Description	Price
3	BC1148CT-ND	K104Z15Y5VE5TL2	CAP CER 0.1UF 25V Y5V RADIAL	0.54
2	BC1157CT-ND	K105Z20Y5VE5TH5	CAP CER 1UF 25V Y5V RADIAL	0.94
3	2.2kQBK-ND	CFR-25JB-52-270R	RES 270 OHM 1/4W 5% AXIAL	0.45
2	1.0kQBK-ND	CFR-25JB-52-330R	RES 330 OHM 1/4W 5% AXIAL	0.30
1	67-1108-ND	SSL-LX5093LGD	LED GRN DIFF 5MM ROUND T/H	0.62
1	MCP1700-3302E/TO-ND	MCP1700-3302E/TO	IC REG LDO 3.3V 0.25A TO92-3	0.57
1	ATSAMD20E16B-AUTCT-ND	ATSAMD20E16B-AUT	IC MCU 32BIT 64KB FLASH 32LQFP	2.88
0.33	1528-1065-ND	1163	SMT ADAPTERS 3 PACK 32QFN/TQFP	2.82
2	A26509-16-ND	4-103741-0-16	CONN HEADR BRKWAY .100 16POS STR	3.12
1	2N3904-AP	2N3904	TRANS NPN 40V 0.2A TO92	0.27
1	P8070SCT-ND	EVQ-11A04M	SWITCH TACTILE SPST-NO 0.02A 15V	0.35

Total 12.86

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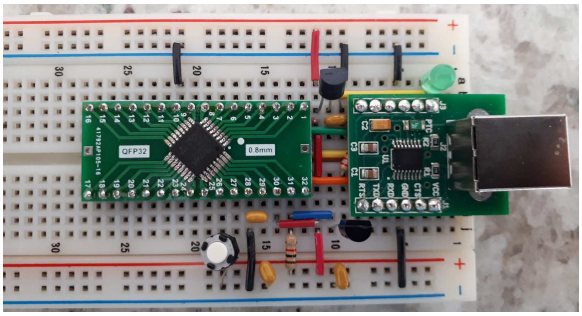
The SAMD20E16 Microcontroller System



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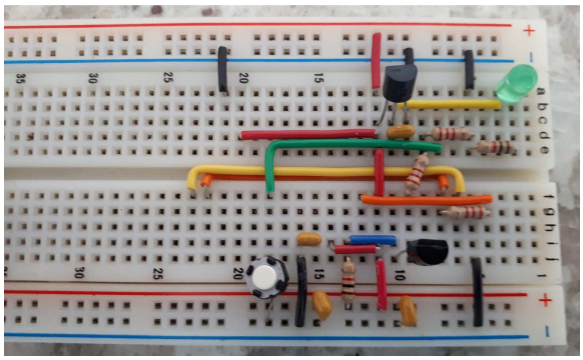
The SAMD20E16 Microcontroller System



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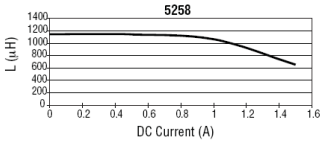
The Inductors in project Kit 2

- DigiKey part number M8275-ND

Don't drop the inductor. The ferrite core may break!

Type	Wirewound
Material - Core	Ferrite
Inductance	1mH
Tolerance	±20%
Current Rating	1A
DC Resistance	0.55 Ohms



Two used for the perimeter detector, one used in the metal detector.

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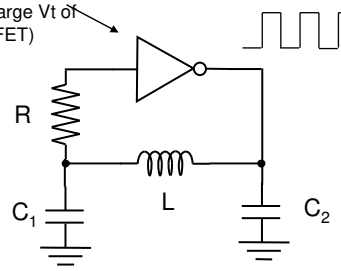
Basic Metal Detector: Colpitts Oscillator.

Tip: make your own CMOS inverter! (Use 5V. 3.3V may not work because of large Vt of PMOSFET)



$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

$$f = \frac{1}{2\pi\sqrt{LC_T}}$$

R=100Ω to 1kΩ

C_1=1nF to 10nF

C_2=10nF to 100nF

L=1mH

If you place metal close to the inductor, it will change the magnetic field, slightly changing the inductance which is reflected as a change in the oscillator frequency.

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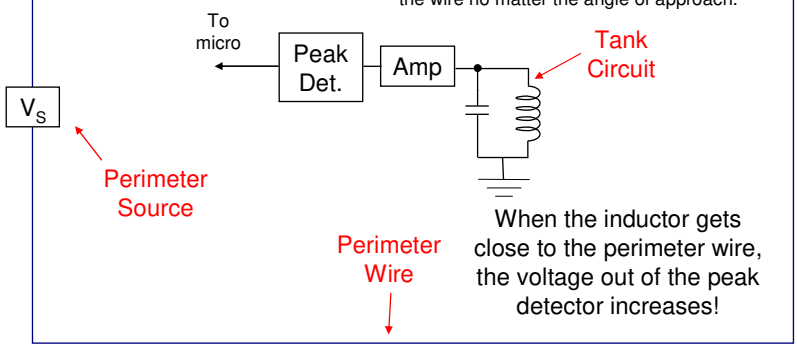
Basic Perimeter Detector

You'll need two detectors perpendicular to each other to make sure you always detect the wire no matter the angle of approach.



When the inductor gets close to the perimeter wire, the voltage out of the peak detector increases!

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Coin Picking Area

- At least 0.5 m^2.
- I used a “Con-Tact Simple Elegance Non Adhesive Shelf Liner - Clear Diamonds - 60 Inches x 20 Inches” from Home Depot ($16.85). It has several advantages:
  - Good grip.
  - Easy to roll and transport.
  - Fits perfectly in the lab benches.
  - Easy to clean.

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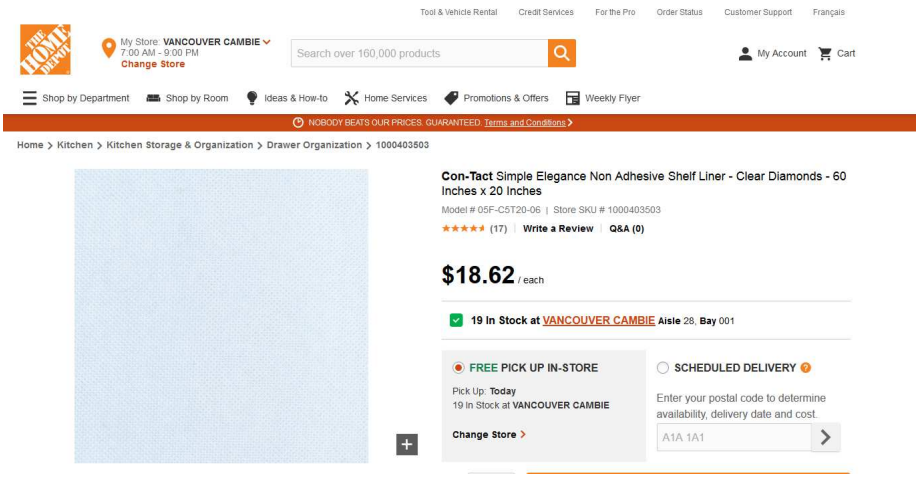
Coin Picking Area Surface



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Perimeter Signal Source

- Either use:
  - Function generator in the lab.
  - 555 Timer in A-stable configuration. I like this option better because allows you to setup your perimeter anywhere you want. I connected the output of the 555 timer in series to the perimeter wire using a 47Ω resistor. Used 9V battery to power the 555 timer.

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Robot Construction

Part #	**Description**
Solarbotics GM4	Gear Motor 4 - Clear Servo
Lynxmotion Servo Wheel	2.63" x 0.35" (pair) wheels
Tamiya 70144	Ball Caster
4 x AA	Battery holder
1 x 9V cable	9V battery clip
Unfolded chassis	Aluminum chassis made using the water jet cutter.

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Robot Construction

- Instruction posted in Canvas:
  - How to assemble the coin picking assembly.
  - How to assemble the complete robot.

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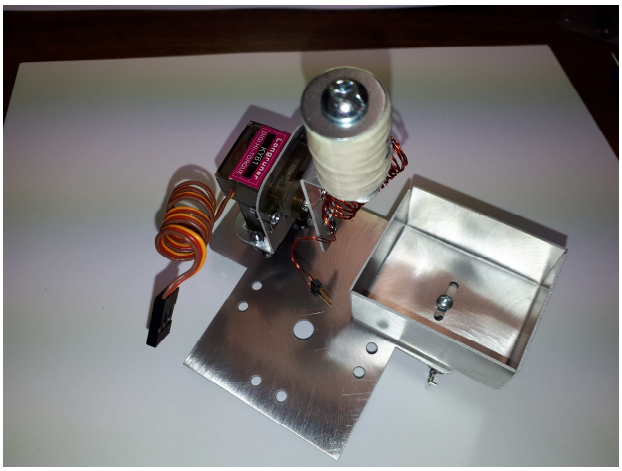
Coin Picking Mechanism



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Robot (without electronics)

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Battery powered.

- Your project must be battery powered. This includes the electronics and motors of both the transmitter and receiver
- A 9 volt battery strap and a 4 x AA battery holder are included in the parts kit for this project.
- You can use any kind of batteries you want, provided that you acquire the batteries and the holders yourself.
- WARNING: batteries are neither included in the parts kits nor they will be provided in the lab. You must buy your own batteries.
- Brand name batteries have lower internal resistance, but they are more expensive.

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Manual Mode

- Use SPI radios to nrf24l01+ to communicate robot and remote.
- Remote commands: forward, backward, left, right, stop, pick coin.
- Example project using nrf24l01+ and EMF8LB1 microcontroller available.

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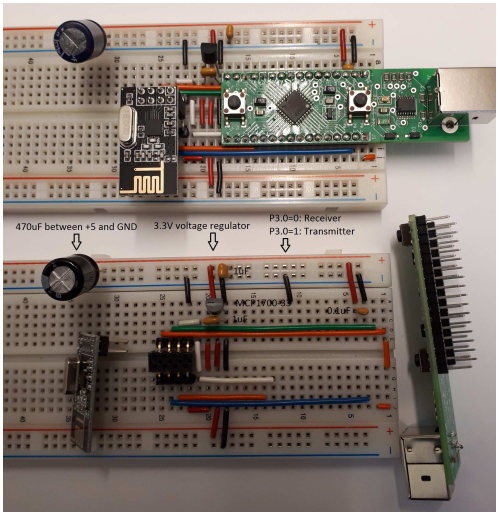
nrf24l01+ and EFM8LB1



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Project 2 Due Dates

Function demo: April 1/2

Report: April 8

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