

Level 1 Electronics Technology

This workbook focuses on Electronic concepts and Construction techniques. It helps students when working towards the following Achievement Standards

- 1.47 Demonstrate understanding of basic concepts used in the design and construction of electronic environments.
Level 1 | AS91077 v3 | 3 Credits
- 1.48 Implement basic techniques in interfacing a specified electronic and embedded system.
Level 1 | AS 91078v3 | 3 credits

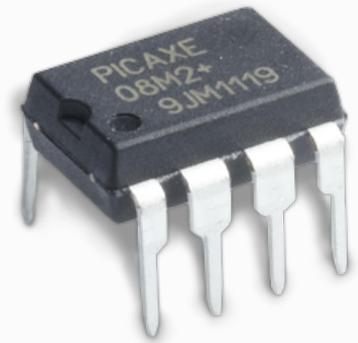
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PICAXE Microprocessor

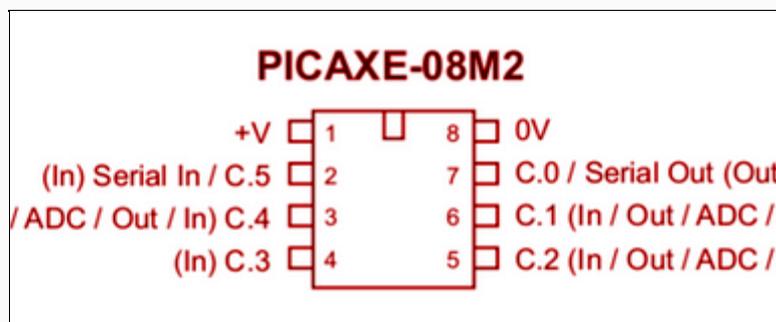
The PICAXE is an integrated circuit that contains all the functions of a computer, however it is inside a single Integrated Circuit package and is way smaller. It includes three things:

1. Data and program storage
2. Input & Output control circuits
3. A central processing unit that carries out simple maths on the data)



The PICAXE 08m2

The 08m2 has 6 Input / output pins. But not every I/O pin is created equal.



Pins C.1, C.2 and C.4 are capable of input and output. While pin C.3 is input only

Operating Voltage for the 08m2 is 2.3v - 5v

Questions: Picaxe Microprocessor

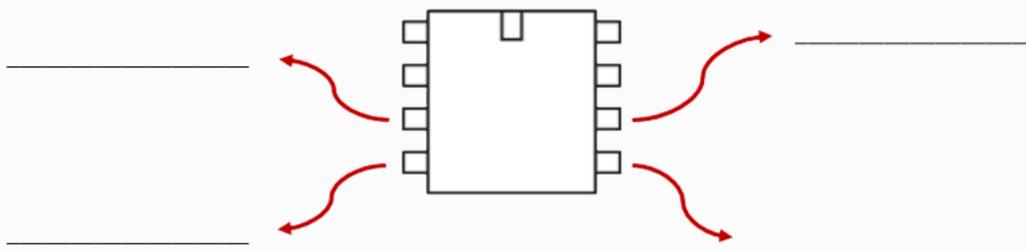
1. *What 3 things does a microcontroller include?*

2. *Which pin on the 08m2 is an input pin only?*

3. *List some examples of physical world properties*

4. *What are the voltage requirements for the 08m2 microprocessor?*

5. *Label the Pin numbers for the Picaxe 08m2 chip*



Inputs and Outputs

Input circuits convert physical world properties (like heat, light, movement, water levels) to electrical signals which are processed by the Picaxe microcontroller.

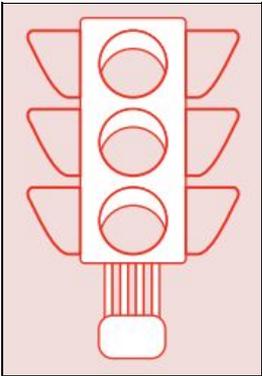
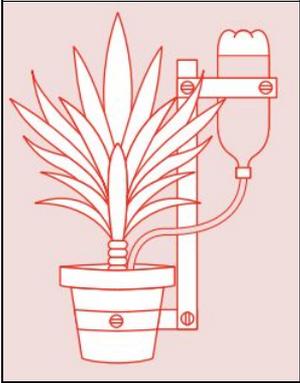
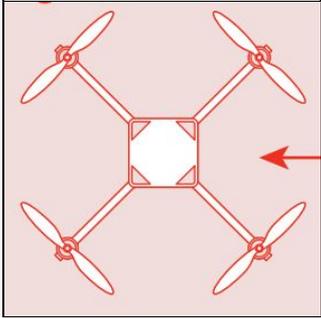
Common Inputs include:

- Touch, Light, Temperature, Moisture, Water Level, Movement

Common outputs include:

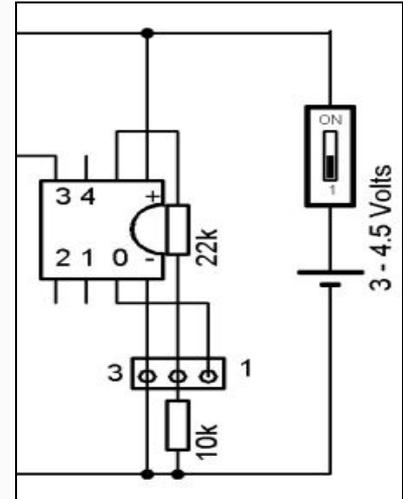
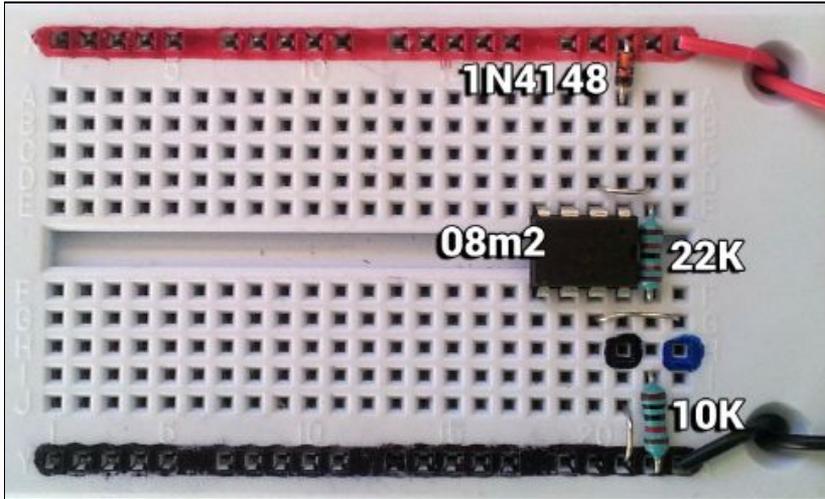
- Lights, Motors, switches, Sound (Buzzers), Radio Transmission

6. List the inputs and outputs used in the following

<p style="text-align: center;">Traffic Light</p> 	<p style="text-align: center;">Automatic Plant Waterer</p> 	<p style="text-align: center;">Quadcopter</p> 
<p style="text-align: center;"><i>Inputs</i></p> <hr/> <hr/> <hr/>	<p style="text-align: center;"><i>Inputs</i></p> <hr/> <hr/> <hr/>	<p style="text-align: center;"><i>Inputs</i></p> <hr/> <hr/> <hr/>
<p style="text-align: center;"><i>Outputs</i></p> <hr/> <hr/> <hr/>	<p style="text-align: center;"><i>Outputs</i></p> <hr/> <hr/> <hr/>	<p style="text-align: center;"><i>Outputs</i></p> <hr/> <hr/> <hr/>

Development Boards

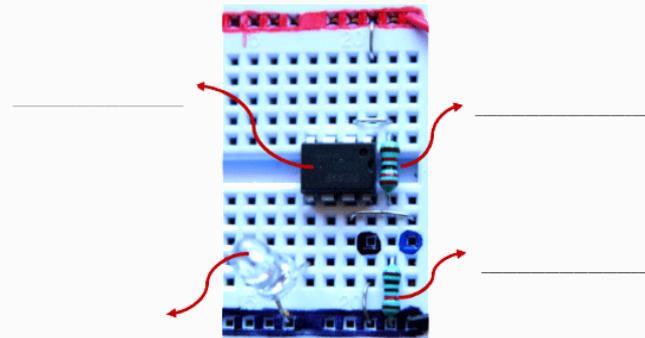
We use a development board or *Solderless Breadboard* to help learn about interfacing components. This board is set up with a serial connection that allows programming from a PC.



Questions: Development Boards

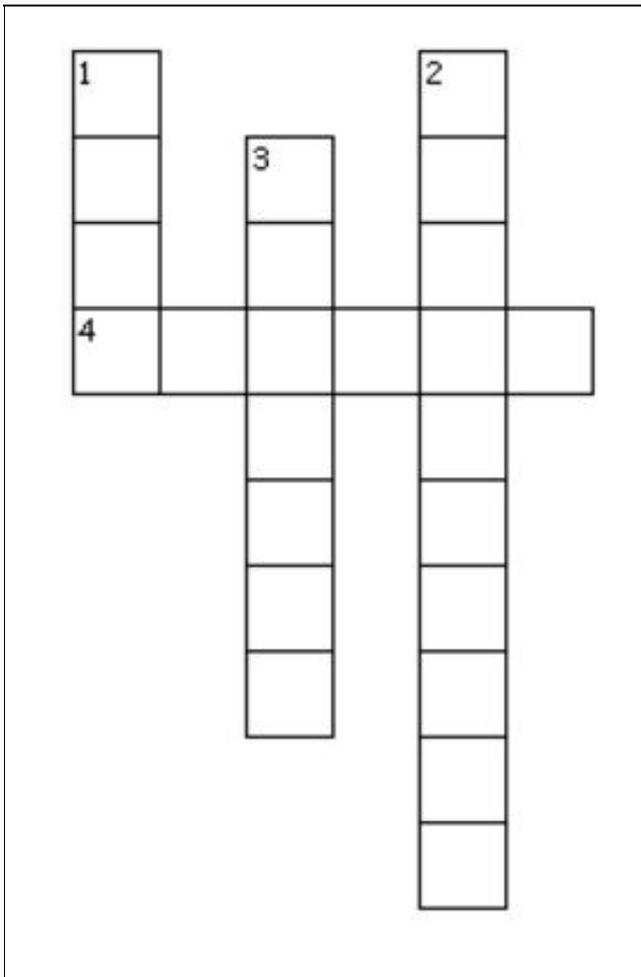
7. Label all components on the diagram

Component List:: Picaxe 08m2, 5mm LED, 10K Ohm Resistor, 22K Ohm Resistor



Review: Picaxe & Development Boards

Complete the Crossword



Across

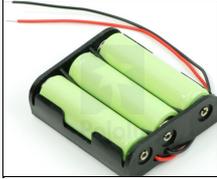
4. a method of communication that allows programming a Picaxe 08m2 from a PC

Down

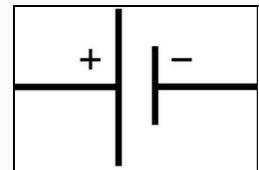
1. physical connections on the outside of the microcontroller. Can be either inputs or outputs
2. a prototyping tool that allows us to quickly connect wires together without soldering or twisting them together.
3. A complete loop which connects a power source, through a device, and back to the the power source.

Power Supplies

We have a number of options for Power supplies in this course

<p>Coin Cell 3v</p> 	<p>2x AA Battery Pack 3v</p> 	<p>3x AA Battery Pack 4.5v</p> 	<p>3.7v Lipo Battery</p> 
---	--	---	--

A Battery Cell stores chemical energy and when connected in a circuit drives a “direct current” flow around a circuit. The circuit symbol for a cell is a long and short line. Note the negative or ground terminal is the smaller



8. Sketch the circuit symbol for a Battery Cell

<p>Sketch 3x AA Battery Pack Symbol</p>	<p>Write a description for battery cell</p> <hr/> <hr/> <hr/>
---	---

9. State the voltage of an AA battery, including unit

10. State the voltage of an AAA battery, including unit

11. Describe the difference between an AA and a AAA battery

Circuit #1: LED

Construct the circuit using a 5mm Light Emitting Diode (LED) and a 330 Ohm resistor. The resistor protects the LED against receiving too much voltage and “blowing up”



```
' flasher.bas  
' Single LED Flasher
```

```
ledFlasher:
```

```
high C.2  
pause 1000  
low C.2  
pause 1000
```

```
goto ledFlasher
```

Troubleshooting

Program Not Uploading ???

- Can you see virtual serial port on Program Editor?
- Is the Development Board wired correctly?
- Does Picaxe 08m2 have power?
- Is there a “short circuit” somewhere ... a wire going directly from red to black

Questions: LED's

12. Sketch the circuit symbol for an LED

<p>Sketch LED Symbol</p>	<p>Write a description for an LED</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
--------------------------	---

Vocab List: Diode, emit, light, polarised, direction

13. Converting from milliseconds to seconds

milliseconds (ms)	seconds (s)
1000 ms	<hr/>
<hr/>	2s
500 ms	<hr/>

14. Opposite each line of code in the program, write down what you think the code does.

ledFlasher:

high C.2

Set Pin C.2 to a high voltage state (turn on)

pause 1000

low C.2

pause 1000

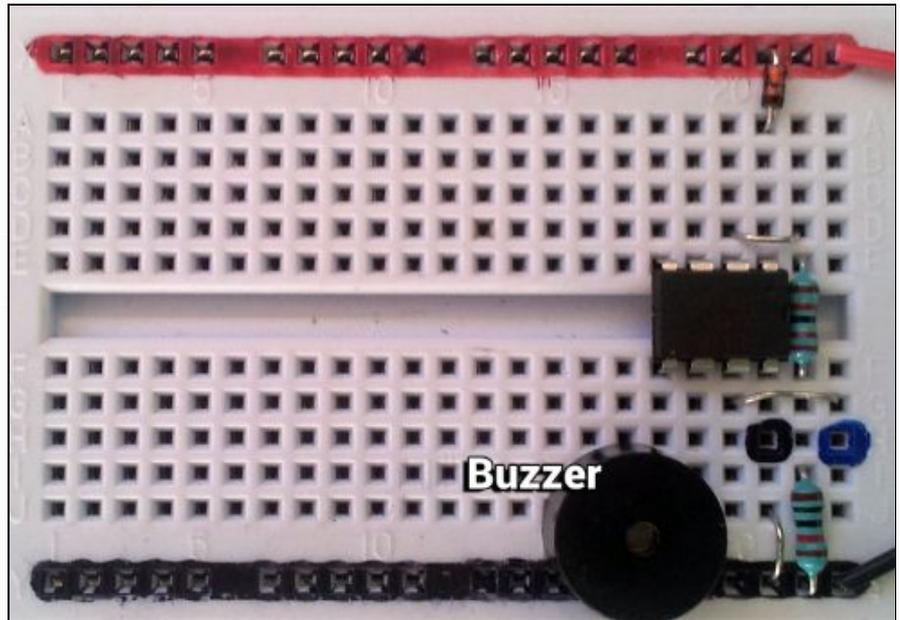
goto ledFlasher

Vocab List: Subroutine, , High Voltage state of pin, Low Voltage state of pin

Circuit #2: Buzzer

Construct the circuit using a Buzzer.

Make sure that the buzzer is connected into Pin 2 of the Picaxe.



```
' buzzer.bas  
' Buzzer Program
```

```
musicalNotes:      ' subroutine name  
tune 2, 5, (1)     ' tune pin, length, (note)  
pause 500          ' pause for 500ms or ½ second  
tune 2, 5, (2)     ' tune pin, length, (note)  
pause 500          ' pause for 500ms or ½ second
```

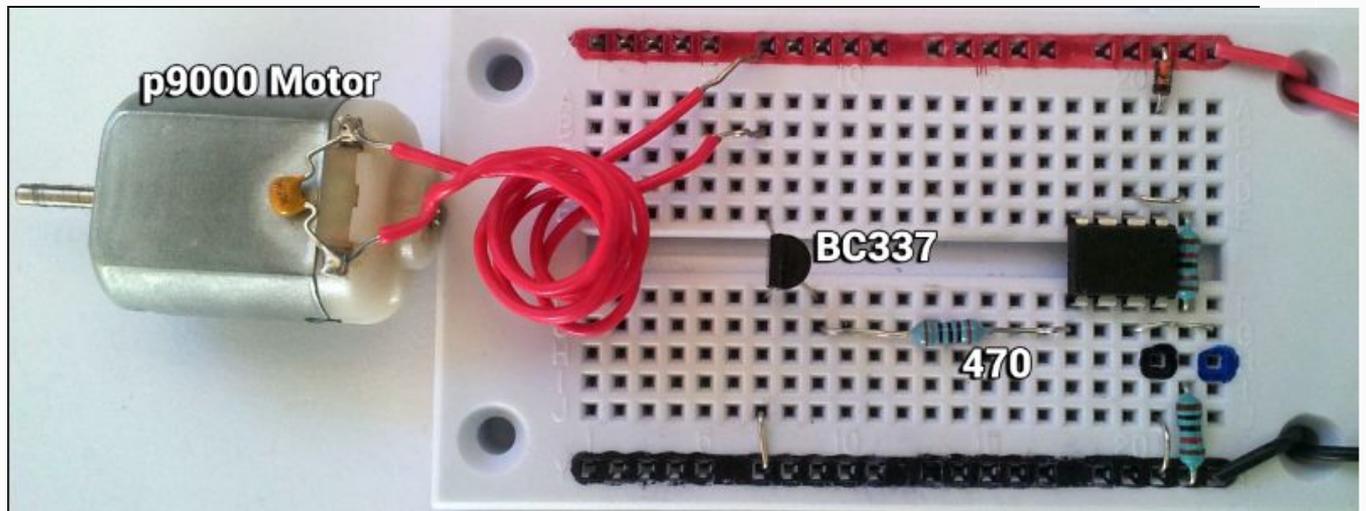
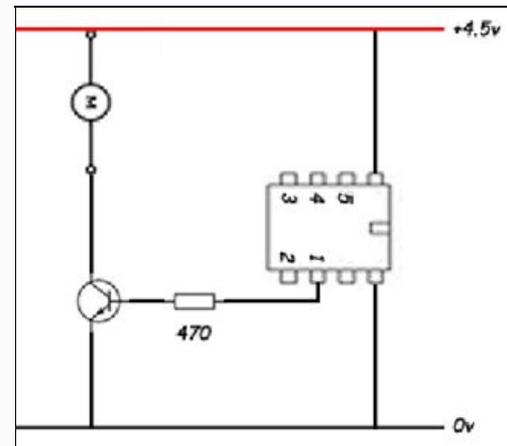
Circuit #3: Motors

Motors need heaps of oomph ... around 120mA of current.

We cannot connect the motor directly to the Picaxe as the 08m2 is too small, it does not have enough oomph (only about 20-30mA of current from a pin)

To enable us to control the motor we need to make use of the supply voltage.

The diagram opposite shows how to connect a BC337 transistor in a way that allows the Picaxe to "switch" the motor on and off.



```
' motor.bas
```

```
' Motor Program
```

```
motorControl:      ' subroutine
high C.2           ' set pin2 to high voltage state
pause 2000         ' pause for 2000ms = 2 second
low C.2           ' set pin2 to low voltage state
pause 1000        ' pause for 1000ms = 1 second
goto motorControl ' loop back to beginning of subroutine
```

Transistor Theory

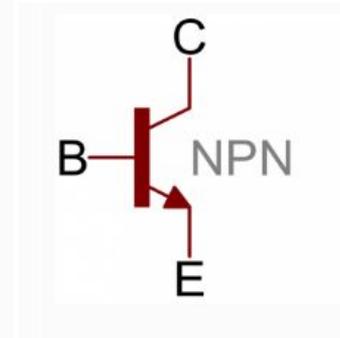
The transistor is kind of like a water tap. The base pin is like a handle you might turn to allow more or less electrons to flow from emitter to collector.

<https://www.youtube.com/watch?v=OwS9aTE2Go4>

Transistors are three-terminal devices.

The pins are labeled:

- collector (C),
- base (B), and
- emitter (E).

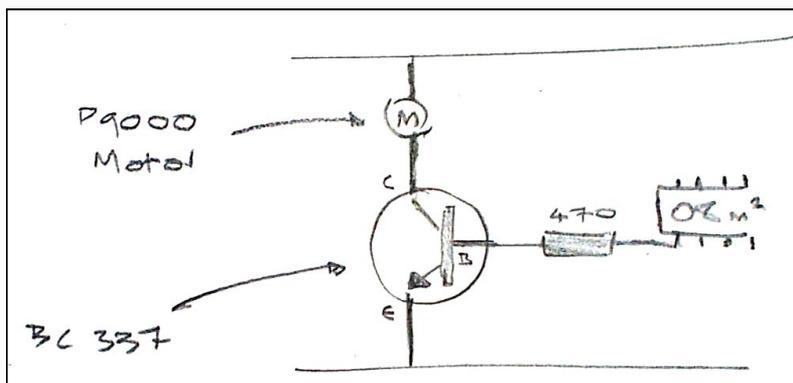


Transistor Switch Subsystem

One use of a transistor is to control the flow of power to another part of the circuit – using it as an electric switch. A normal switch would require a human hand turn it on or off, but a transistor switch is controlled by the voltage at the base pin

A microcontroller I/O pin, like those on a Picaxe can be programmed to go high or low, essentially switching a transistor on or off

The P9000 Motor example



- With a high 2 command the Picaxe sends a small voltage to the base of the transistor.
- The transistor will then switch "on" allowing current to flow through collector to emitter
- Current flows through motor ... turning on the motor.

18. Sketch the circuit symbol for a Motor

Sketch Motor Symbol	What is the purpose of a motor? <hr/> <hr/> <hr/> <hr/>
---------------------	--

19. What happen if you swap the motor wires around the other way?

20. Sketch the circuit symbol for a Transistor

Sketch Transistor Symbol	What is the main purpose of the Transistor? <hr/> <hr/> <hr/> <hr/> <hr/>
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21. What needs to happen for the transistor to work like a switch? (current to flow from collector to emitter)

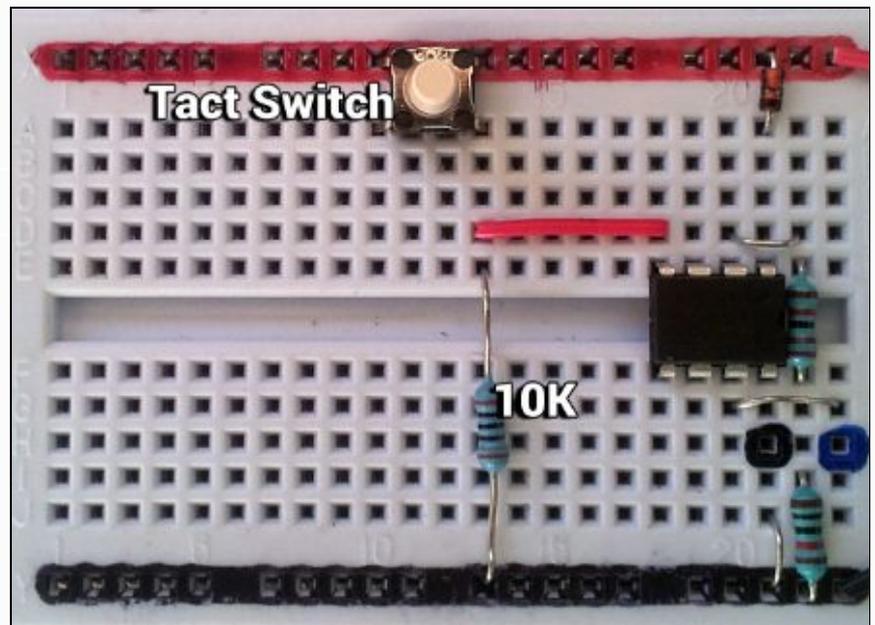
22. Sketch the transistor switch subsystem

Re-sketch the transistor subsystem from the previous page.

Sketch of Transistor Switch Subsystem	Components <ul style="list-style-type: none"> • 08m2, 470 Ohm, BC337, Motor
---------------------------------------	--

Circuit #4: Switch Interfacing

A switch is the way a user can manually control flow of current in a circuit.



```
' clickMe.bas
' Switch Activated Buzzer Program
```

```
setup:let b0 = 0
      debug
```

```
main: if pinC.3 = 1 then add
      goto main
```

```
add:  pause 100
      let b0 = b0 + 1
      goto main
```

Testing your switch interfacing circuit

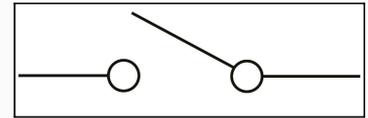
An important method of testing your program and interface is to use the Picaxe debug screen to check the state of variables within the Picaxe 08m2

Event / Input	Result
on press of switch	b0 increments

outpinsC	0	\$00	%00000000	...
dirsC	0	\$00	%00000000	...
b0	100	\$64	%01100100	'd'
b1	0	\$00	%00000000	...
b2	0	\$00	%00000000	...
b3	0	\$00	%00000000	...

The Switch

A switch is any device used to interrupt the flow of current in a circuit. Switches are essentially binary devices: they are either completely on (“closed”) or completely off (“open”).



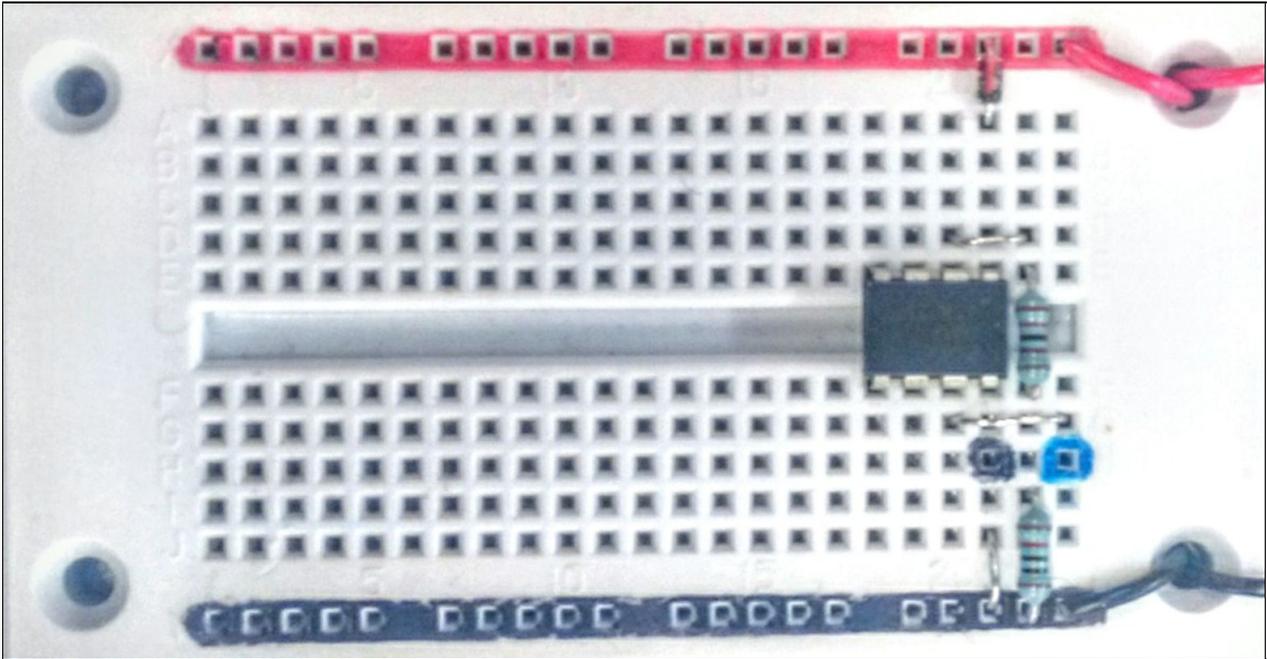
23. Sketch the circuit symbol for a closed Switch

Sketch closed Switch Symbol	What is the main purpose of the Switch? <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
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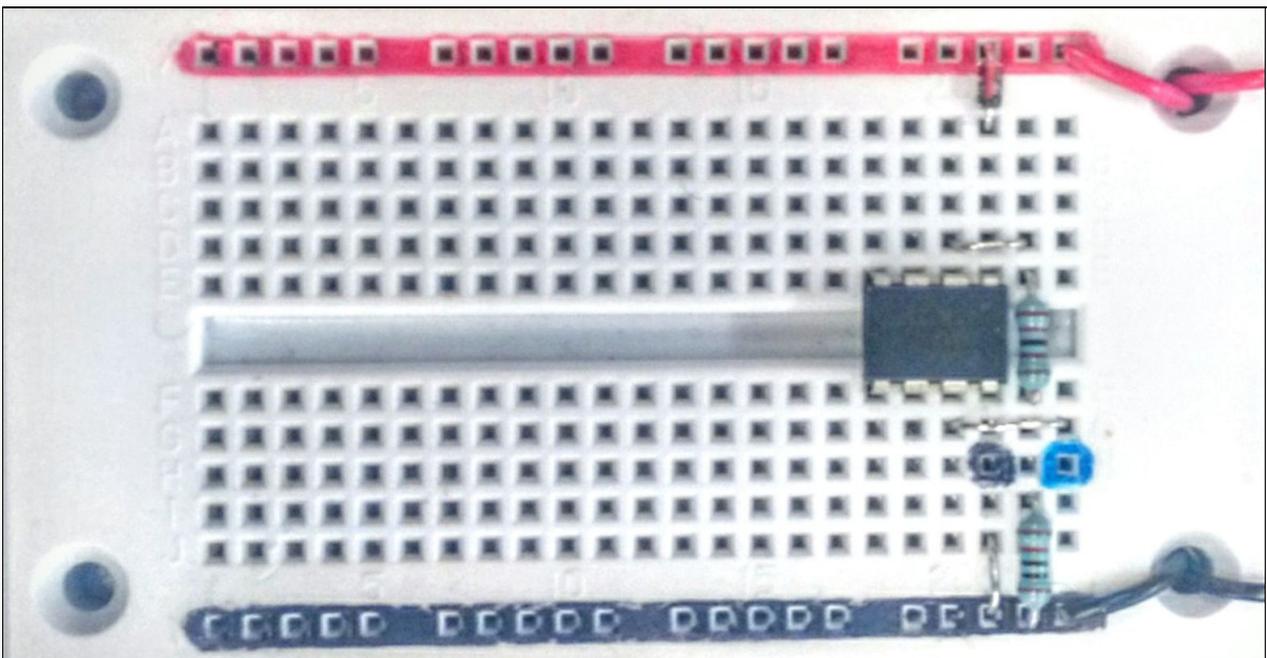
Circuit Layout Challenge

Complete circuit diagrams to show how the following components can be interfaced (connected)

#1: Two 5mm LED's flash, one after the other

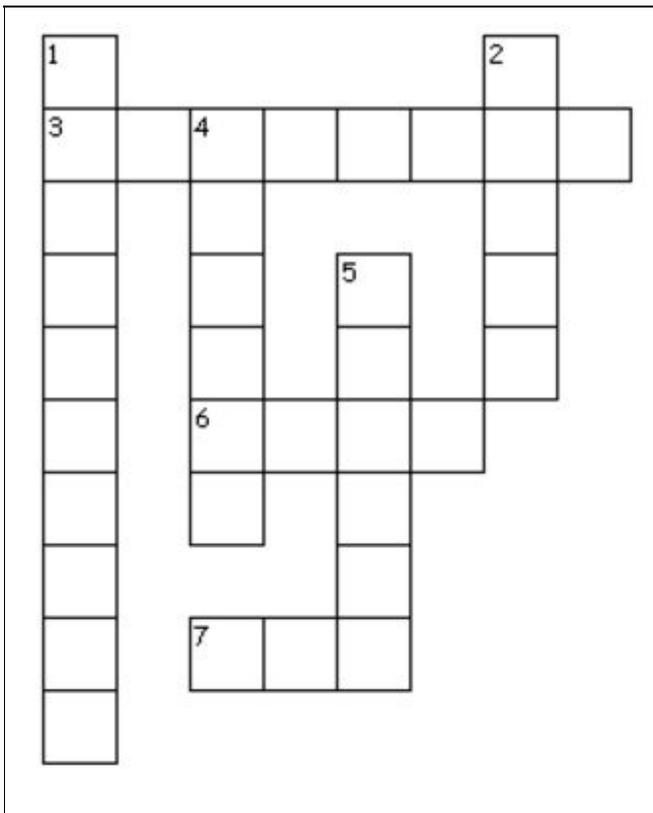


#2: When a tact switch is pressed an LED will Flash



Review: Output components

Complete the crossword



Across

3. A device which slows the flow of electricity. Used in the circuit to limit current flow through an LED.
6. a single battery
7. a device which converts electrical energy into light energy

Down

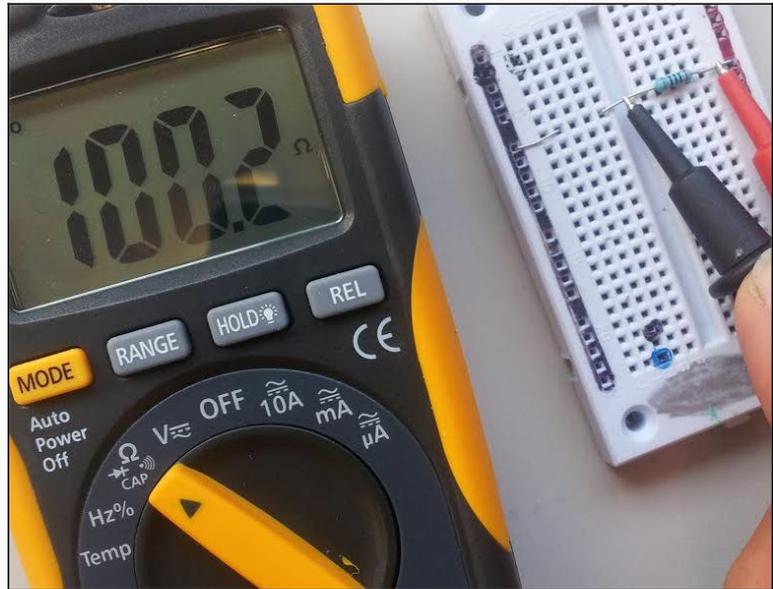
1. a component used to control the flow of power to another part of the circuit
2. an output device that converts electrical energy into movement
4. a component for making and breaking the connection in an electric circuit.
5. Sending the program to the micro controller.

Measuring Resistance

We use Resistors to help change to characteristics of a circuit.

Reducing the amount of voltage and current to specific components in a circuit.

Grab a Multimeter and resistor and practice measuring the resistance of a resistor.



Questions: Resistors

15. State the value of the resistor you choose and the actual reading from the multimeter when you measured it? (Was there any difference?)

16. What unit do we measure Resistance in?

17. Converting from kiloohm ($k\Omega$) to ohms

kilo-ohm ($k\Omega$)	Ohm(Ω)
1 $k\Omega$	_____
_____	4,700 Ω
22 $k\Omega$	_____

Programming Concepts

Picaxe Programming

Well structured BASIC Software Programs have to following

Programming Concepts

- Use of byte variable
- Variable assignment using symbols
- If / else statements
- loops

Programming Code of practice

- Meaningful file name
- Meaningful subroutine names
- Program Description
- code comments
- indentation

Byte Variables

Every processor in the PICAXE family of microcontrollers has a certain number of general purpose variables to store data temporarily while the program is running. The basic unit of storage is the byte.

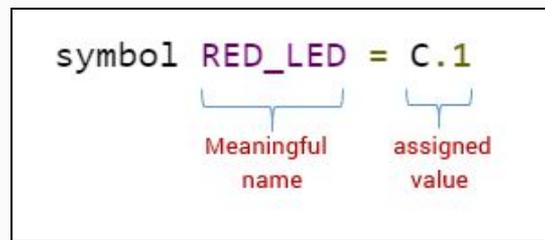
Variables are containers that can hold data. We can use byte variables in the Picaxe 08m2 to hold integer data types.

- `let b0 = 100`
- `let b1 = 0`
- `let b2 = 255`

But there are limitations. A byte variable can only hold a number between 0-255.

Variable assignment using Symbol

It is useful to assign a value to a symbol name to make it more meaningful. In the example opposite the symbol name RED_LED has been assigned to vale C.1 which refers to a pin number.



```
flasher.bas
```

```
symbol RED_LED = C.1
symbol DELAY = 1000
```

```
ledFlasher:
```

```
high RED_LED
pause DELAY
low RED_LED
pause DELAY
```

```
goto ledFlasher
```

24. What is a limitation of Picaxe variables?

25. Which is these is an appropriate symbol name and which is not?

- BLUE_LED
- BLUE LED

26. Why is it useful to assign values to a symbol?

A student has attempted to rewrite the program using “symbols”. Complete the program by filling in the missing spaces. A Green LED has been placed in Pin C.4 and a program written that will make the Green LED flash 2 times a second.

Original Program	Re-written Program
<pre>' flasher.bas ledFlasher: high C.4 pause 500 low C.4 pause 500 goto ledFlasher</pre>	<pre>' flasher.bas symbol GREEN_LED = _____ symbol DELAY = _____ ledFlasher: high GREEN_LED pause _____ low _____ pause DELAY goto ledFlasher</pre>

Reading Inputs & Debugging

readadc command

readadc means *read analogue to digital conversion* and is a method of converting a physical voltage into a digital value. The readadc command will read a value of between 0-255 from the microcontroller input pins.

```
readadc C.4, b1
```

The readadc command is used when interfacing a Picaxe with a voltage divider to sense some physical data. We will look at this in more detail in the Input interfacing section.

Testing with the debug command

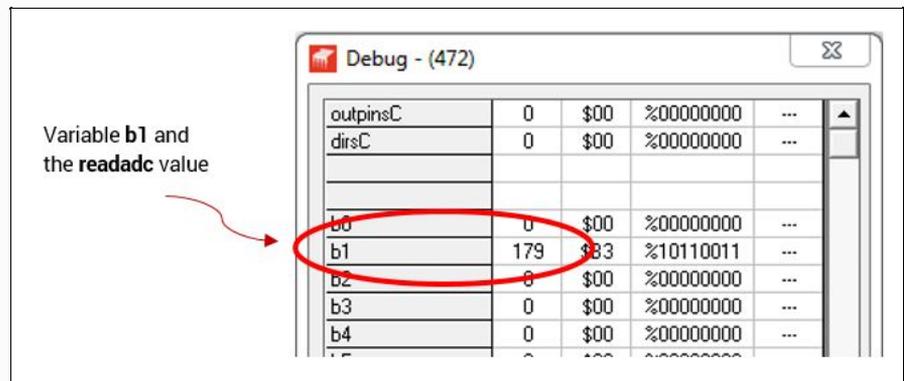
Debug command sends information from the Picaxe 08m2 back to the Picaxe Programming Editor displaying the current state of the byte variables. PICAXE > DEBUG (F6)

```
debug b1
```

This is useful with testing and debugging code. But it does slow the operation of your program down.

The diagram opposite show the Picaxe debug screen.

```
readadc 4, b1
debug b1
```



Testing with the sertxd command

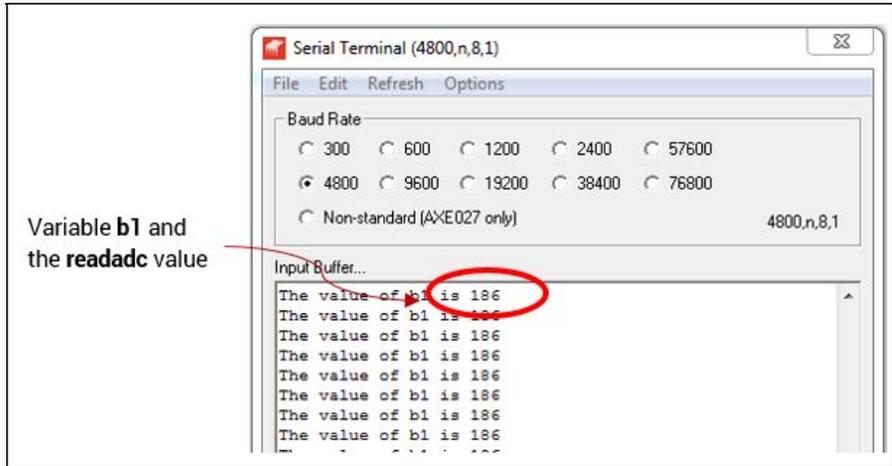
There are many situations where it is useful to grab real time data from the Picaxe. We can use a sertxd command to essentially throw a single line of "serial" data to the Picaxe program editor to be read.

PICAXE > TERMINAL (F8)

```
readadc 4, b1
sertxd ("The value of b1 is ",#b1,13,10)
```

The 13, 10 are called ASCII characters and essentially ends a single line and start a new line.

sertxd is very quick and does not affect the performance of the Picaxe like the debug command.



27. What does adc stand for?

28. What does the readadc command do?

29. What is one limitation of using the debug command?

30. What does the 13, 10 do in the sertxd command?

If - Else statements

A conditional statement is an if else command, and is used to make a decision.

If (condition is TRUE) then do something else do something else

Example if statement

The if else statement check is a condition is TRUE	<pre>if b1 > 100 then goto ledOn end if</pre>	<pre>' checks is b1 > 100 is true ' go to the ledOn subroutine ' end if statement</pre>
--	--	--

Example if - else statement

The if else statement check is a condition is TRUE, If false it will execute the ledOff subroutine	<pre>if pin4 = 1 then goto ledOn else goto ledOff endif</pre>	<pre>' checks if pin4 is in high state (on) ' go to the ledOn subroutine ' go to the ledOff subroutine ' end if statement</pre>
--	---	---

Write if - else statements for the following situations.

31. if the value of b1 is equal to 100 then goto ledOn subroutine

```
if b1 _____ then
  goto _____
endif
```

32. if the value of b2 is greater than 50 then goto ledOff subroutine

33. if the switch on pin1 is on then goto motorOn subroutine

for-next loops

Whenever we need to repeat something over and over again we can use a programming loop called a for-next loop.

The for-next loop opposite will loop through 10 times. Each time the variable b1 will increment by 1

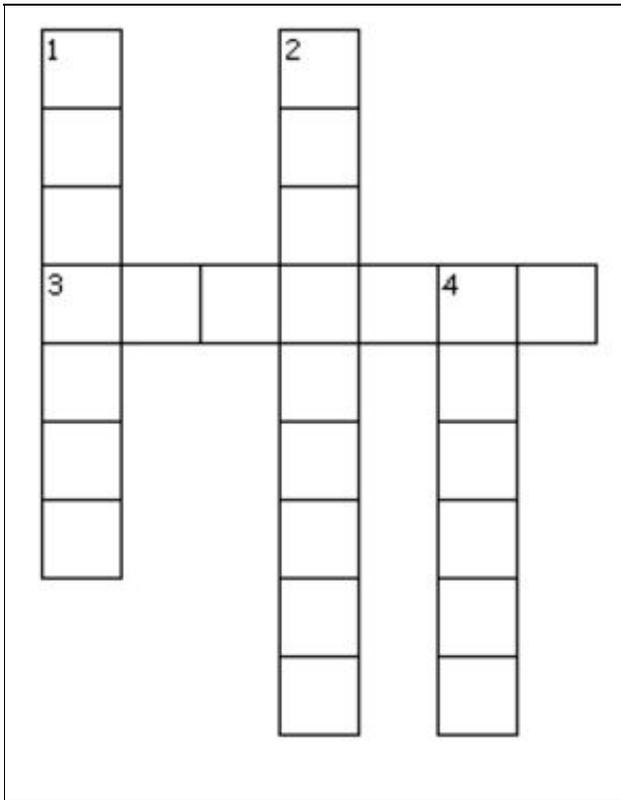
```
for b1 = 0 to 10    ' set for loop to run 10 time
  ... something here
  ... something here
next b1            ' increment value b1 and start loop again
```

Try this?

Use this program code below to construct a circuit that plays a series of notes that increase in pitch. Remember to place a buzzer into Pin 2

```
musicalNotes:      ' subroutine name
  for b1 = 0 to 10  ' set for loop to run 10 time
    tune 2, 5, (b1) ' tune pin, length, (note)
    pause 500       ' pause for 500ms or ½ second
  next b1          ' increment value b1 and start loop again
```

Review: Programming



Across

3. refers to values that exist in only one of two states. Generally this is ON or OFF.

Down

1. means read analogue to digital conversion and is a method of converting a physical voltage into a digital value

2. placeholders or containers for a value or number used in the program

4. refers to values or things which exist across a range.

Complete the wordsearch

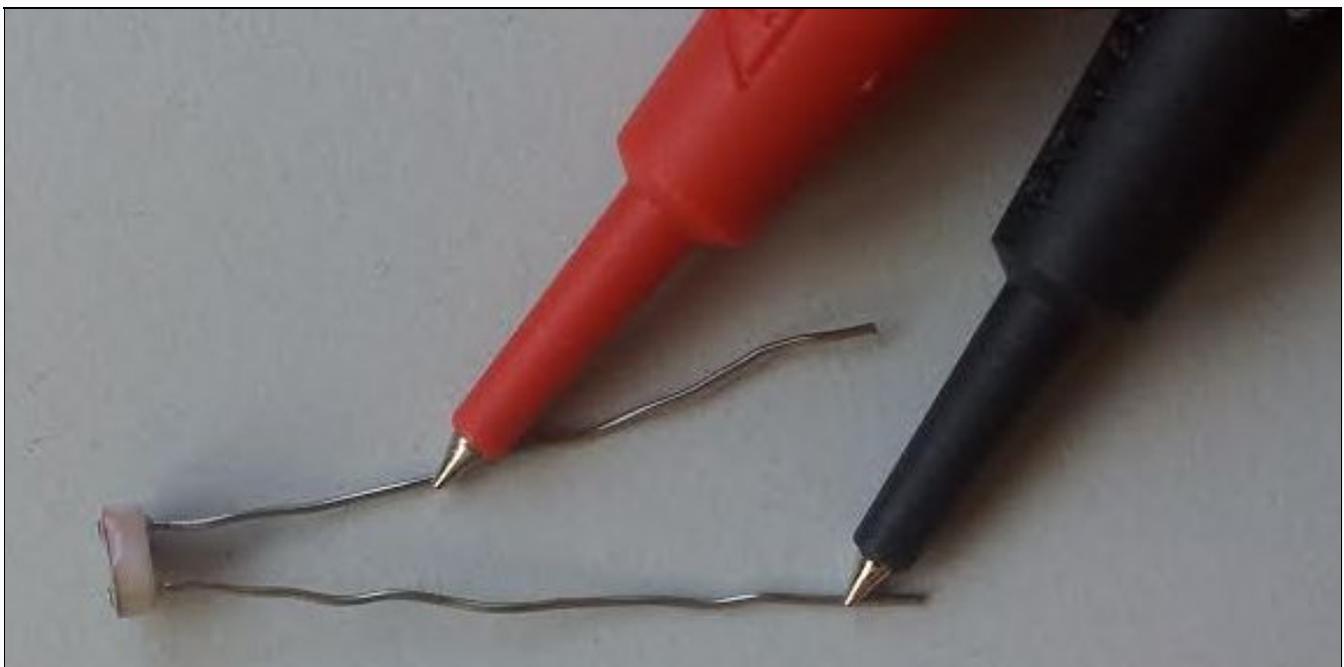
- DEBUG
- ELSE
- ENDIF
- FOR
- GOTO
- HIGH
- LOW
- MAIN
- NEXT
- PAUSE
- READADC
- READTEMP
- SERTXD
- SYMBOL
- TUNE
- WAIT

L	D	J	T	T	U	N	E	R	K	M	W
P	O	X	T	S	F	A	E	B	T	L	O
N	E	W	T	I	R	A	F	S	G	B	T
N	I	R	D	R	D	N	E	R	W	M	O
W	W	N	M	T	E	H	G	I	H	L	G
T	E	K	E	P	A	S	T	X	W	O	O
F	I	M	C	D	A	D	A	E	R	B	M
O	P	A	X	S	E	U	L	Y	C	M	A
R	L	H	W	Y	I	S	S	F	S	Y	I
D	E	B	U	G	E	O	X	E	F	S	N

Circuit #5: Resistance of an LDR

A Light Dependant Resistor or LDR changes resistance depending on the amount of light falling on the sensor (resistance gets lower with an increase in the light intensity) .

Grab a multimeter and measure the resistance of the LDR in various light levels.



Test the value of the LDR's resistance at various light levels

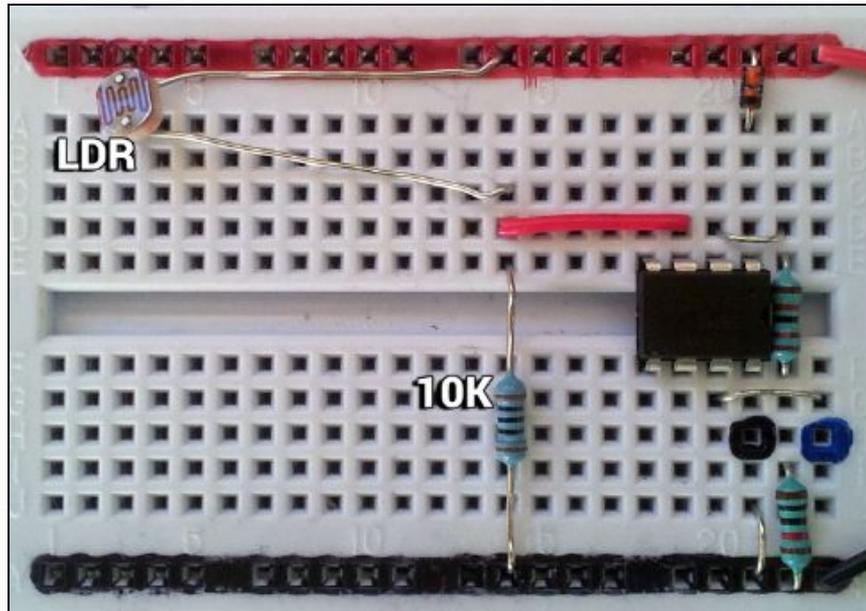
Light Level	Resistance Value
Dark	
Low Light	
Medium Light	
Intense Light	

Circuit #6: LDR Interfacing

A Light Dependant Resistor or LDR changes resistance depending on the amount of light falling on the sensor (resistance gets lower with an increase in the light intensity) .

We can use the component to help construct a circuit that responds to light levels.

Construct the following circuit on a breadboard.



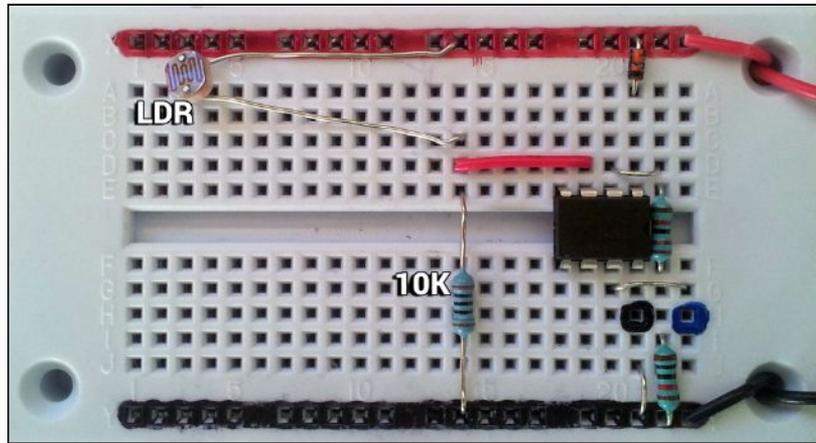
```
' Sensing Light Level Program
' Author: Mr Jefferies
' Jan, 2013
```

```
lightSensor:
  readadc 4,b1          'readadc on pin4 and save into memory space b1
  debug b1             'shows values read into memory space b1
goto lightSensor
```

Testing LDR interface on a range of input

Remember that the LDR is sensing actual light levels.

Think about where you are, inside probably. It might be dark! it could be a cloudy day!



The LDR interface should be able to measure light levels across a range of light intensities

34. What effect does an increase in light have on the resistance of the LDR?

35. **How does your LDR interface compare?:** Complete the table to show the readadc values from the light sensor on a range of light inputs

Event / Input	Result
Darkness	readadc value =
Room lighting	readadc value =
Direct sunlight	readadc value =

36. **Sketch the circuit symbol for an LDR**

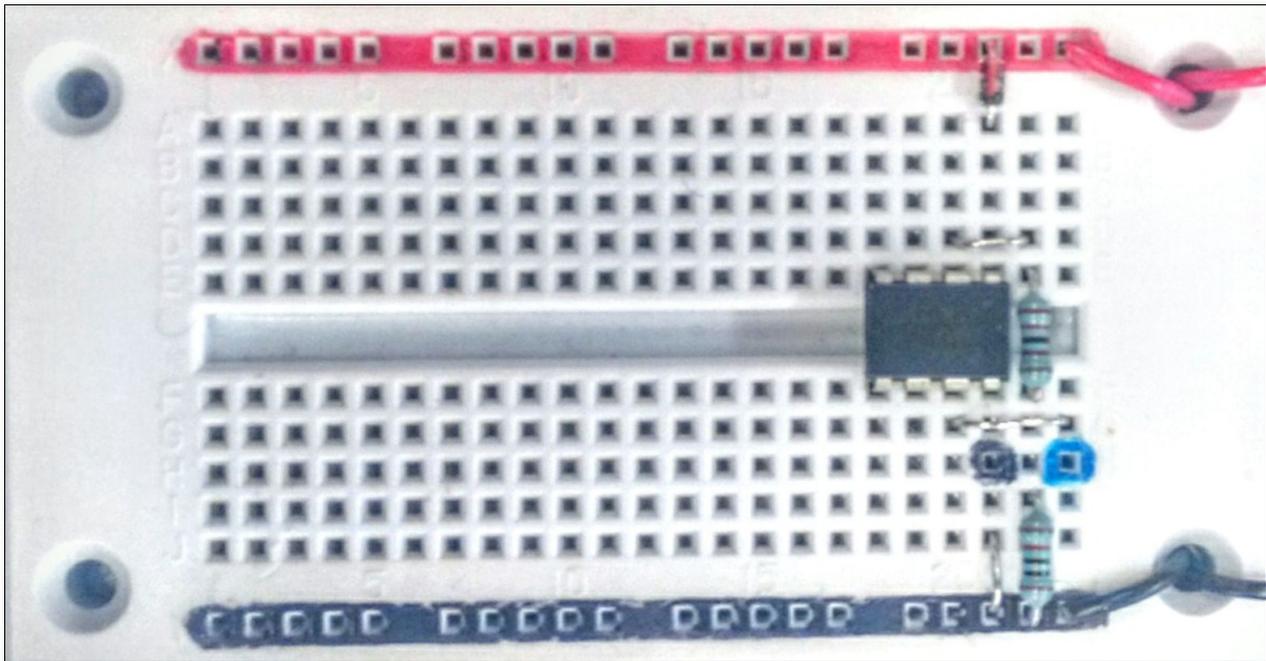
Sketch LDR Symbol	What is the main purpose of the LDR? <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>
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Challenge: Night Light

Your challenge is to construct a circuit that can turn a light on when it senses darkness.

TASK 1: The Plan

Complete circuit diagram to show how the components can be interfaced (connected)



TASK 2: The The Program

Write a PICAXE BASIC program that:

- Reads in the light level
- If light level is dark, then on an LED

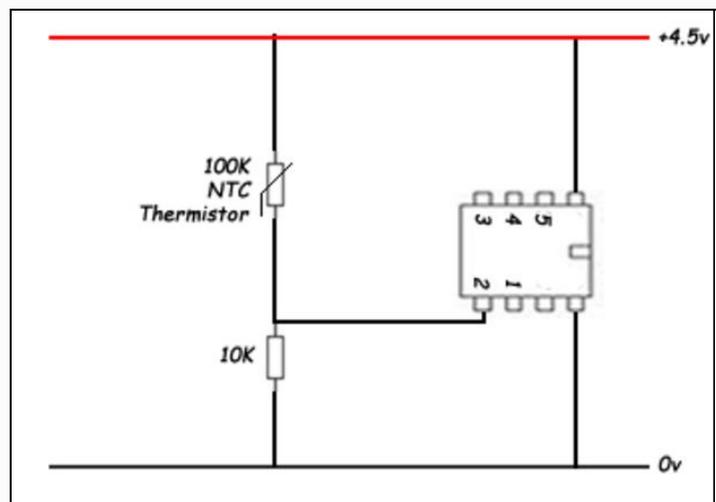
Circuit #7: Thermistors

A Thermistor changes resistance depending on the amount of heat applied to the sensor (resistance gets lower with an increase in the temperature) .

We can use the component to help construct a circuit that responds to temperature levels.

Construct the following circuit on a breadboard.

' Sensing Light Level Program
' Author: Mr Jefferies



```
tempSensor:
  readadc 2,b1          'readadc on pin4 and save into memory space b1
  debug b1             'shows values read into memory space b1
goto tempSensor
```

Review: Resistive Sensors

The Light Sensor

An LDR is used to sense light changes because the Resistance of the LDR changes depending on the amount of light present.



The Temperature Sensor

A Thermistor is used to sense temperature changes because the resistance of the thermistor changes depending on the amount of heat present.



The Moisture Sensor

Two parallel wires close together can be used as a moisture detector because the resistance between the two wires changes when water allows conductivity



Complete the Wordsearch

F	L	D	I	E	P	S	F	E	R
J	H	X	A	R	G	E	K	O	E
Q	T	D	C	U	T	N	F	A	S
U	V	H	Y	T	H	S	B	E	I
S	X	J	G	S	V	O	I	N	S
R	O	T	S	I	M	R	E	H	T
N	O	Q	F	O	L	V	V	I	A
V	F	H	O	M	P	P	R	H	N
V	O	L	T	A	G	E	D	G	C
E	G	N	A	H	C	U	L	T	E

- CHANGE
- LDR
- LIGHT
- MOISTURE
- RESISTANCE
- SENSOR
- THERMISTOR
- VOLTAGE

Electricity Concepts

Voltage, Current and Resistance

Voltage

Voltage can be thought of as electrical energy between two points. Voltage V is measured in volts v

37. What is the unit for Voltage?

38. How many volts are in an AA battery?

39. Describe the battery pack we use with the Picaxe boards in terms of AA cells and total voltage

Current

Current is the flow of charge in a circuit. Think of it as the movement of energy in a circuit. Current (I) is measured in Ampere or Amps (A)

Within many practical electronics circuits we use direct current; dc (only goes in one direction), and small current values.

Typical current values in our circuits are :

- 1 milli-Amp (1mA) $\rightarrow 1 / 1000 = 0.001$ Amp
- 100 milli-Amp (100mA). $\rightarrow 100 / 1000 = 0.1$ Amp

40. What is the unit for Current?

41. Convert the following values to Ampere

- 10mA : _____ (divide by 1000)
- 25mA : _____ (divide by 1000)
- 110mA : _____ (divide by 1000)

Resistance

Resistance is the resistance to the flow of charge. All wires and components have some resistance. In the process of resisting the flow of charge **heat** will be produced.

- Resistance R is measured in Ohms (Ω)

We commonly use the following resistor values in this course

- 330 Ω
- 470 Ω
- 1K Ω (1000 Ω)
- 10K (10,000 Ω)

42. What is the unit for resistance?

43. What are common resistor values we use this course?

44. What is produced in the process of resisting the flow of charge?

Below are some specifications for typical low voltage DC components used.



Motor Specifications

The motor has a normal operating voltage range of 3.0 to 5.0V DC and with no load spins at a speed of 6600 RPM (drawing about 110mA).

45. What is the maximum recommended voltage of the motor?

46. How much current does the motor draw with no load?



Piezo Speaker Specifications

Each speaker requires an operating voltage of 3.5-5V with a current of 55mA max. These speakers also have a typical sound output of 95 dBA and a coil resistance of 42 ohms.

47. What is the maximum recommended voltage of the Piezo Speaker?

48. How much current does the speaker draw?



Here are the recommendations for a typical 5mm LED

1.8-2.2VDC forward drop
 Max current: 20mA
 Suggested using current: 16-18mA
 Luminous Intensity: 150-200mcd

49. What is the recommended Voltage for the 5mm LED?

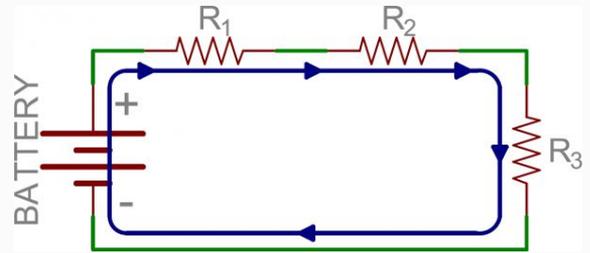
50. What is the recommended Current for the 5mm LED?

51. What is likely to happen if your LED circuit is above or below these recommended specifications?

Series Circuits

Two components are in series if the same current flows through them. Here's an example circuit with three series resistors:

There's only one way for the current to flow in the above circuit.



Starting from the positive terminal of the battery, current flow will first encounter R₁. From there the current will flow straight to R₂, then to R₃, and finally back to the negative terminal of the battery

Voltage, Current and Resistance in a series circuit

Voltage is shared between all components. That means that the Voltage from the battery equals the voltage across R₁, R₂ and R₃.

$$V_{\text{TOTAL}} = V_1 + V_2 + V_3$$

Total Resistance in a series circuit is the sum of the individual resistances.

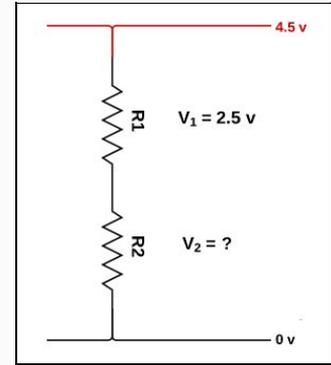
$$R_{\text{TOTAL}} = R_1 + R_2 + R_3$$

Questions: Series Circuits

Check out the diagram opposite.

52. Calculate the voltage across the resistor R_2 .

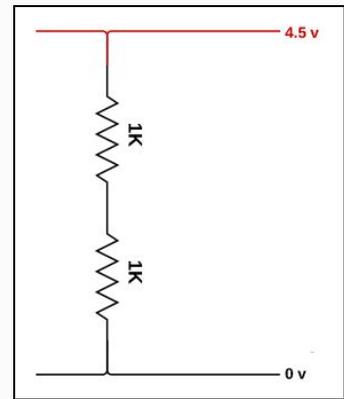
$$(V_{TOTAL} = V_1 + V_2)$$



Check out the diagram opposite.

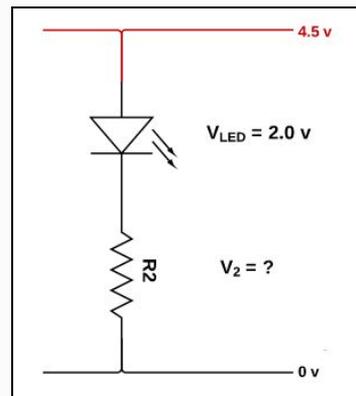
53. Calculate total resistance of circuit.

$$(R_{TOTAL} = R_1 + R_2)$$



Check out the diagram opposite.

54. Calculate the voltage across the resistor R_1 . ($V_{TOTAL} = V_1 + V_2$)



Check out the diagram opposite. A Resistor is placed in series with the 5mm LED.

55. What is the purpose of the 330 Ohm resistor?



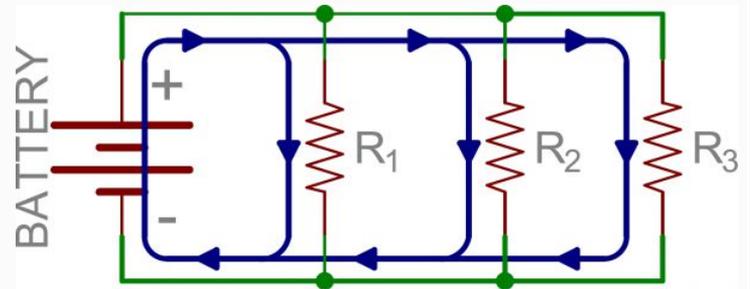
56. Explain the effect of swapping the 330 Ohm resistor with a larger 1K Ohm resistor.

Vocab list: voltage, shared, current, same, brighter, dimmer

Parallel Circuits

If components have two “branches”, they are in parallel. Here’s an example schematic of three resistors in parallel with a battery:

The current can flow three possible ways in this circuit,



Voltage in a parallel circuit

Voltage is the same in all components.

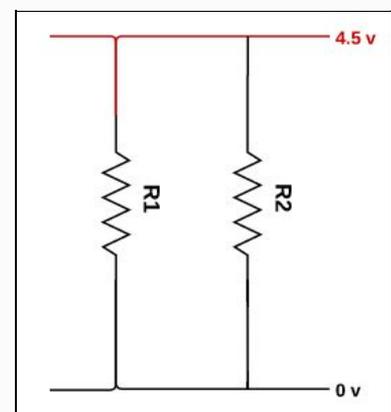
$$V_{\text{TOTAL}} = V_1 = V_2 = V_3$$

Parallel Circuit calculations

Check out the diagram opposite.

57. What is the voltage across the resistors R_1 and R_2 ?

$$(V_{\text{TOTAL}} = V_1 = V_2)$$



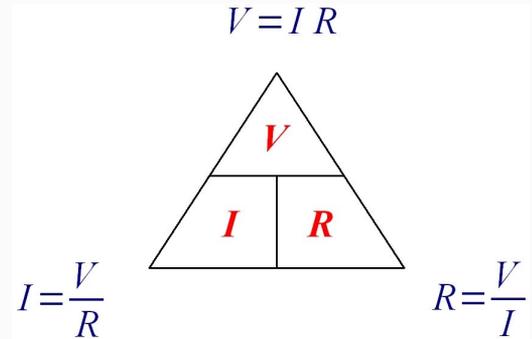
Ohm's Law

Ohm's Law deals with the relationship between voltage and resistance in a circuit. This relationship states that:

The voltage across a resistor is proportional to the current through it.

We end up with a little equation that links these three ideas.

Voltage (V) = Current (I) x Resistance (R)
 $V = I \times R$



Example Calculation

An alarm clock draws 0.5 A of current when connected to a 120 volt circuit. Calculate its resistance.

Known are

- Current I = 0.5A
- Voltage V = 120v

How to solve the equation

$$R = V / I$$

$$R = 120 / 0.5$$

$$R = 240 \text{ Ohms}$$

58. A DC Motor uses a 3 x AA batteries (4.5v). How much resistance is in the circuit if it uses a current of 0.01A?

59. A circuit contains a 3 volt cell battery and a LED with a resistance of 60 ohms. Calculate the current.

Calculating Series Resistor of LED

A common calculation needed in a circuit is to figure out the size of a series resistor needed to protect an LED from blowing up.

1.8-2.2VDC forward drop
 Max current: 20mA
 Suggested using current: 16-18mA
 Luminous Intensity: 150-200mcd

5mm LED specifications

5mm LED specifications

- Max Voltage = 2v
- Max Current = 20mA

So if we are using a 4.5 volt Supply, then the voltage across R_1 needs to be 2.5v

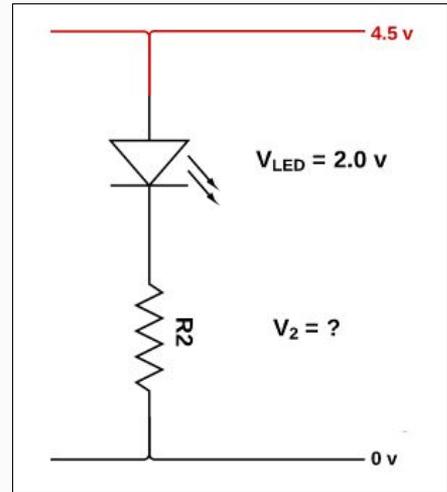
$$4.5 - 2 = 2.5 \text{ volts}$$

Using Ohms Law to calculate the Resistance R

$$R = V / I$$

$$R = 2.5v / 0.02A$$

$$R = 125 \text{ Ohms}$$

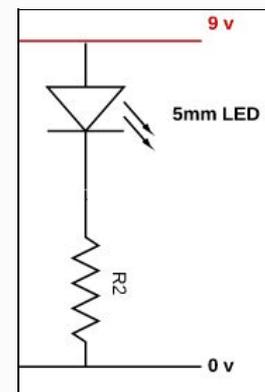


60. What is the purpose of the a resistor in series with an LED?

A student is attempting to connect an LED straight onto a 9v supply..

1.8-2.2VDC forward drop
 Max current: 20mA
 Suggested using current: 16-18mA
 Luminous Intensity: 150-200mcd

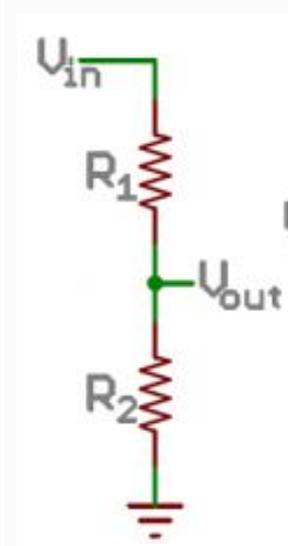
61. Calculate the size of the series resistor needed to protect the LED from blowing!



Voltage Divider

A voltage divider is a circuit which turns a large voltage into a smaller one. Using just two series resistors and an input voltage, we can create an output voltage that is a fraction of the input. A voltage divider involves applying a voltage source across a series of two resistors.

The Circuit



But Why?

It turns out, voltage is really easy for microcontrollers to measure. We use a command called `readadc`. The `adc` refers to analog to digital conversion

Resistive Sensors:

Many sensors in the real world are simple resistive devices.

- A LDR is a variable resistor, which produces a resistance proportional to the amount of light it senses.
- A Thermistor is a variable resistor, which produces a resistance proportional to the amount of heat it senses
- A Piezo is a variable resistor, which produces a resistance proportional to the amount of force / strain it senses

Getting Serious

While this equation defines the output voltage from a voltage divider, We can ignore the formula and focus on the relationship between V_{out} and R_1 .

As R_1 is on the bottom of the fraction it has an inverse relationship to the output voltage V_{out} . This means as one goes up, the other goes down.

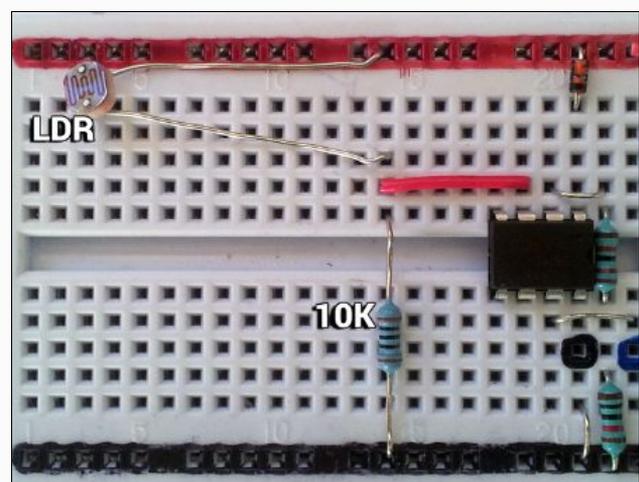
$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2}$$

Example: LDR Voltage Divider

In this example :

- R_1 is the LDR and
- R_2 is the 10K Resistor.

As the resistance of the LDR goes up ... the voltage measured by the Picaxe goes down.



62. What components make up a voltage divider?

63. List three types of resistive sensors

64. What process is used by the Picaxe to measure the output voltage

A student has drawn a circuit diagram of a voltage divider that uses an LDR to measure light levels.

Place in the following labels in their correct places on the circuit diagram.

- R_1
- R_2
- V_{out}

