# Individual Project

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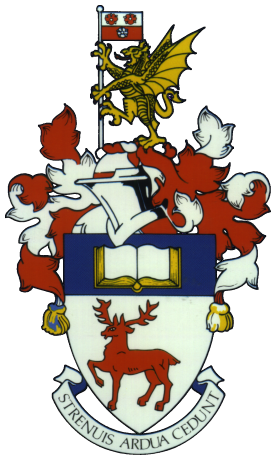
Word count: 136

May 2018




This report is submitted in partial fulfillment of the requirements for the MEng Mechanical Engineering, Faculty of Engineering and the Environment, University of Southampton.

**Declaration**

I, Pau Miquel Mir, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research. I confirm that:

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2. Where any part of this thesis has previously been submitted for any other qualification at this University or any other institution, this has been clearly stated;
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6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission.

**Acknowledgements**

I want to thank my advisor for his time and dedication.
I also want to thank my parents, for their constant support and for proofreading the paper.

**Abstract**

This is the abstract.

# Contents

# Acronyms

**ABS** Anti-lock Braking System

**SVM** Support Vector Machine

# 1 Introduction

1. Title page pretty
2. References
3. Word count glossaries

## 1.1 Proves

First use: Support Vector Machine (SVM). Second use: SVM.

First use: Anti-lock Braking System (ABS). Second use: ABS.

Prova [1]. Also, here is a trial on Fig. 1

This is a piece of shit. Fuck Prova merda I just keep on typing and want to see what happens, there is simply a bit of a lag and that it and that's it, shit this isnt working. It is, it is simply very very slow. I want to see if I can keep on typing and see what happens, it is quite nice indeed. How many words can I get without it working this is pretty cool and now I want to in insert a reference to Fig 1 This is interesting. What if I want to [1]


FIGURE 1: This caption has five words

# 2 Conclusion

This is the conclusion.

# Appendices

## A Prova

This is a new Appendix.

$$3+3=6 \tag{A.1}$$

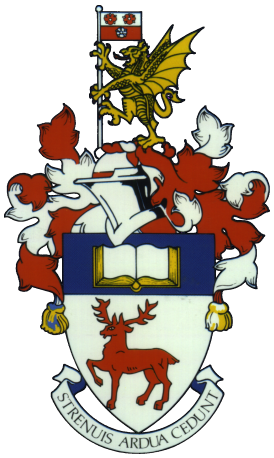


FIGURE A.1: Prova

## B Eurobot Code

```
/*************************************
Eurobot Project Spring 2017

Group 4 Space Ballerz

Group members:
 - Alberto Bosco
 - Mackenzie Brown
 - Michael Comport
 - Ian Hind Escolano
 - Pau Miquel Mir


Some MD25 code adapted from James Henderson's example code
Some servo code adapter from Scott Fitzgerald's example code
*************************************/


#include <SoftwareSerial.h>
#include <Wire.h>
#include <Servo.h>
#include <stdio.h>
#include <stdlib.h>

#define MD25ADDRESS         0x58     //Address of the MD25
#define CMD                 0x10     //Byte to 'write' to the CMD
#define SPEEDL              0x00     //Byte to send speed to first motor
```

```
#define SPEEDR              0x01     //Byte to send speed to second motor
#define ENCODER1            0x02     //Highest byte of motor encoder 1
#define ENCODER2            0x06     //Highest byte of motor encoder 2
#define RESETENCODERS       0x20     //Byte to reset encode registers to 0
#define ACCELERATION        0x0E     //Byte to send acceleration to the motors

Servo * Servos     = new Servo[3];
Servo * ServosTurn = new Servo[3];


////////////////////////////////
// GLOBAL VARIABLE DEFINITIONS //
////////////////////////////////


float   gWheelDiameter      = 100.0;
float   gWheelbase          = 280.0;
float   gDefaultSpeed       = 65.0;
int     gAcceleration       = 3;
int     gDeceleration       = 5;

// Distance in degrees the motor tends to run over at that speed
float   gBaseOffset         = 225.0;

// Distance in degrees the motor takes to reach the gDefaultSpeed at gAcceleration
float   gCutoff             = 480.0;

float   gCorrectionSpeed    = 5;

int     gCorrectionCounter  = 0;
int     gCorrectionMaximum  = 5;

int     gBackTrigPin        = 14;      //Back avoidance trigger pin
int     gBackEchoPin        = 15;      //Back avoidance echo pin
int     gSwitchPin          = 5;      //Track change pin
int     gPowerPin           = 6;      //Pullcord pin
int     gFrontTrigPin       = 7;      //Front avoidance trigger pin
int     gFrontEchoPin       = 8;      //Front avoidance echo pin
int     gRocketPin          = 10;      //Rocket launch pin

bool    gIsYellow            = true;

float   gDefaultDistanceLimit = 300.0;
unsigned long gStartTime;

int gDegreesToOpen = 140;
int gDegreesToTurn = 100;
int gDelayTime = 100;


////////////////////////////////
//FUNCTION FORWARD DEFINITIONS //
////////////////////////////////


void driveStraight(float distance, float speed = gDefaultSpeed,
        float baseOffset = gBaseOffset, float cutoff = gCutoff,
        int acceleration = gAcceleration, int deceleration = gDeceleration,
        bool shouldAvoid = true);

void turnOnSpot(float degrees, float speed = gDefaultSpeed,
      float baseOffset = gBaseOffset, float cutoff = gCutoff,
      int acceleration = gAcceleration, int deceleration = gDeceleration,
      bool shouldAvoid = true);

void driveWheels(float rightSpeed, float leftSpeed, float degrees,
```

```
94          float baseOffset = gBaseOffset, float cutoff = gCutoff,
95          int acceleration = gAcceleration, int deceleration = gDeceleration,
96          bool shouldAvoid = true);
97
98  void  stopMotor(int deceleration = gDeceleration);
99  long  encoder(int encoderNumber = 1);
100 void  encodeReset();
101 float encoderAverage();
102 void  sendByte(byte byteAddress, int value);
103 float distanceToDegrees(float distance);
104 float onspotDegreesToWheelDegrees(float degrees);
105 float distance(bool isForward = true);
106 bool  isClear(bool isForward = true, float distanceLimit = gDefaultDistanceLimit);
107 void  launchRocket();
108 bool  isTimeUp();
109
110 ////////////////////////////////
111 ////////////// SETUP //////////////
112 ////////////////////////////////
113
114 void setup(){
115   Serial.begin(9600);
116   Wire.begin();
117   sendByte(ACCELERATION, gAcceleration);
118   delay(200);
119   encodeReset();
120
121   pinMode(gFrontTrigPin, OUTPUT);     // Sets the trigPin as an Output
122   pinMode(gFrontEchoPin, INPUT);      // Sets the echoPin as an Input
123   pinMode(gBackTrigPin, OUTPUT);      // Sets the trigPin as an Output
124   pinMode(gBackEchoPin, INPUT);       // Sets the echoPin as an Input
125   pinMode(gSwitchPin, INPUT_PULLUP);  // Set Switch pin as an input
126   pinMode(gPowerPin, INPUT_PULLUP);   // Set Power pin as an input
127   pinMode(gRocketPin, OUTPUT);        // Set Rocket pin as an output
128
129
130   // SETUP FOR GRIPPER SERVOS
131   // Attach servos which open and close gripper arms to pins 11,12,13
132   Servos[0].attach(11);
133   Servos[1].attach(12);
134   Servos[2].attach(13);
135
136   // Attach servos which rotate gripper to pins 2,3,4
137   ServosTurn[0].attach(2);
138   ServosTurn[1].attach(3);
139   ServosTurn[2].attach(4);
140
141   // Initialise initial servo positions
142   Servos[0].write(5);
143   Servos[1].write(5);
144   Servos[2].write(5);
145   ServosTurn[0].write(22);
146   ServosTurn[1].write(85);
147   ServosTurn[2].write(10);
148
149   // Setup rocket to primed
150   digitalWrite(gRocketPin, LOW);
151
152
153   // Do nothing if the pullswitch hasn't been pulled.
154   while(digitalRead(gPowerPin) == LOW){ /* do nothing */ };
155
156   gStartTime = millis();
157
158   // Begin moving the robot
159   if (digitalRead(gSwitchPin) == HIGH) {
```

```
160       yellow();
161     }
162
163     else if(digitalRead(gSwitchPin) == LOW) {
164       blue();
165     }
166
167   }
168
169
170   ////////////////////////////////
171   ///////  Move Functions  ////////
172   ////////////////////////////////
173
174
175   void yellow() {
176
177     driveStraight(770, 24);
178     closeGripper(1);
179
180     // Picked up First cylnder
181
182     turnOnSpot(-87);
183     driveStraight(810, 45);
184     closeGripper(0);
185
186     // Picked up Second cylinder
187
188     turnOnSpot(-55);
189     delay(100);
190     driveStraight(250, 35);
191     closeGripper(2);
192     driveStraight(10,40);
193     delay(100);
194
195     // Picked up Third cylinder
196
197     turnOnSpot(-50,30);
198     turnGripperVertical(2);
199     turnGripperVertical(0);
200     turnGripperVertical(1);
201     delay(100);
202
203     // Go forward without corrections to gently hit the wall and turn straight.
204
205     unsigned long currentTime = millis();
206     while(millis() - currentTime < 1500){
207       sendByte(ACCELERATION, gAcceleration);
208       sendByte(SPEEDR, 128+30);
209       sendByte(SPEEDL, 128+30);
210     }
211
212     openGripper(0);
213     openGripper(1);
214     openGripper(2);
215
216     // Dropped 3 cylinders in side base
217
218     driveStraight(-320, 40);
219     turnGripperHorizontal(2);
220     turnGripperHorizontal(1);
221     turnGripperHorizontal(0);
222     turnOnSpot(-30);
223     driveStraight(285, 30);
224     closeGripper(0);
225
```

```
226   // Picked up Fourth cylinder
227
228   driveStraight(-180, 30);
229   turnOnSpot(155);
230   driveStraight(750 , 40);
231   turnOnSpot(10);
232   driveStraight(100,35);
233   closeGripper(2);
234   turnOnSpot(75);
235   turnGripperVertical(2);
236   turnGripperVertical(1);
237   turnGripperVertical(0);
238   driveStraight(50,20);
239   launchRocket();
240
241
242 }
243
244 void blue(){
245
246   driveStraight(748, 30);
247   closeGripper(1);
248
249   // Picked up First cylnder
250
251   turnOnSpot(87);
252   driveStraight(840, 45);
253   closeGripper(2);
254
255   // Picked up Second cylinder
256
257   turnOnSpot(55);
258   delay(300);
259   driveStraight(280, 35);
260   closeGripper(0);
261   driveStraight(10,40);
262   delay(200);
263
264   // Picked up Third cylinder
265
266   turnOnSpot(45,30);
267   turnGripperVertical(0);
268   turnGripperVertical(2);
269   turnGripperVertical(1);
270   delay(200);
271
272   // Go forward without corrections to gently hit the wall and turn straight.
273   unsigned long currentTime = millis();
274   while(millis() - currentTime < 1200){
275     sendByte(ACCELERATION, gAcceleration);
276     sendByte(SPEEDR, 128 + 30);
277     sendByte(SPEEDL, 128 + 30);
278   }
279
280   openGripper(0);
281   openGripper(1);
282   openGripper(2);
283
284   // Dropped 3 cylinders in side base
285
286   driveStraight(-319, 40);
287   turnGripperHorizontal(0);
288   turnGripperHorizontal(1);
289   turnGripperHorizontal(2);
290   turnOnSpot(30);
291   driveStraight(295, 30);
```

```
292   closeGripper(2);
293   driveStraight(10,40);
294
295   // Picked up Fourth cylinder
296   driveStraight(-190, 35);
297   turnOnSpot(-150);
298
299   driveStraight(700, 40);
300   turnOnSpot(-25);
301   driveStraight(250,30);
302   closeGripper(0);
303   closeGripper(1);
304   driveStraight(10,40);
305   turnGripperVertical(2);
306   turnGripperVertical(1);
307   turnGripperVertical(0);
308   driveStraight(50,30);
309   turnOnSpot(-80,30);
310   driveStraight(60,30);
311   openGripper(0);
312   openGripper(2);
313   launchRocket();
314 }
315
316
317 ////////////////////////////////
318 ///////// Drive Functions /////////
319 ////////////////////////////////
320
321
322 // Function to drive the wheels for a certain distance at certain speed. Speed
323 // should always be positive, a negative distance will make it go backwards.
324 void driveStraight(float distance, float speed, float baseOffset, float cutoff,
325                    int acceleration, int deceleration, bool shouldAvoid){
326
327   if (distance > 0){
328     driveWheels(speed, speed, distanceToDegrees(distance),
329                 baseOffset, cutoff, acceleration, deceleration, shouldAvoid);
330   }
331
332   if (distance < 0){
333     driveWheels(-speed, -speed, distanceToDegrees(distance*-1),
334                 baseOffset, cutoff, acceleration, deceleration, shouldAvoid);
335   }
336
337 }
338
339
340 // Function to make the robot spin in place by a certain amount of degrees,
341 // a positive angle will make the robot spin clockwise.
342 void turnOnSpot(float degrees, float speed, float baseOffset, float cutoff,
343                 int acceleration, int deceleration, bool shouldAvoid){
344
345   if (degrees > 0){
346     driveWheels(speed*-1, speed, onspotDegreesToWheelDegrees(degrees));
347   }
348   if (degrees < 0){
349     driveWheels(speed,speed*-1,onspotDegreesToWheelDegrees(degrees*-1));
350   }
351
352 }
353
354
355 //
356 // Internal function that drives the wheels. It takes as input the speed for the
357 // right and left motor, and the degrees of rotation. This value should be the
```

```
358 // average of the absolute value of the degrees each wheel will spin. It also takes
359 // a value of baseOffset, which is the degrees the motor tends to go over at that
360 // speed, and the cutoff, which is the degrees it takes to spin up to maximum speed.
361 //
362 void driveWheels(float rightSpeed, float leftSpeed, float degrees,
363                  float baseOffset, float cutoff, int acceleration,
364                  int deceleration, bool shouldAvoid){
365
366   bool isForward = true;
367   if(rightSpeed < 0 && leftSpeed < 0){
368     isForward = false;
369   }
370   // Calculate the deceleration time, using the data from the datasheet.
371   // Take in the values of the offset
372   float baseDecelerationTime = (abs(rightSpeed) + abs(leftSpeed)) /
373                                      float(gDeceleration) * 15;
374   float offset = baseOffset;
375   float decelerationTime = baseDecelerationTime;
376
377   // If the distance is less then the cutoff, that means the wheels are still
378   // accelerating. Therefore, the offset and the deceleration time must be
379   // adjusted accordingly, by a factor of the distance / cutoff distance
380   if (degrees <= cutoff){
381     offset = baseOffset * degrees/cutoff;
382     decelerationTime = baseDecelerationTime * degrees/cutoff;
383   }
384
385   // Reset the enconders
386   encodeReset();
387
388   // Wait for the encoder average to be larger than the degree value minus the
389   // offset, then stop the motor. Wait for the robot to come to a stop
390   while(encoderAverage() < abs((degrees-offset))){
391     if(is90secDone()) {
392       stopMotor(deceleration);
393       delay(decelerationTime);
394       launchRocket();
395       return;
396     }
397     if(!isClear(isForward)){
398       stopMotor();
399     }
400     else{
401       sendByte(ACCELERATION, acceleration);
402       sendByte(SPEEDR, 128 + rightSpeed);
403       sendByte(SPEEDL, 128 + leftSpeed);
404     }
405   }
406   stopMotor(deceleration);
407   delay(decelerationTime);
408
409   if (gCorrectionCounter < gCorrectionMaximum){
410     // Calculate new speeds that will be used for correction. First find the
411     // square root of the ratio between the rightSpeed and the leftSpeed. Then,
412     // multiply and divide gCorrectionSpeed by the rootSpeedRatio, thus
413     // achieving two speeds with the same ratio as the rightSpeed and leftSpeed,
414     // but centrered around gCorrectionSpeed. Then apply the same signs as the
415     // original rightSpeed and leftSpeed
416
417     gCorrectionCounter++;
418
419     float rootSpeedRatio = sqrt(abs(rightSpeed / leftSpeed));
420     float newRightSpeed;
421     float newLeftSpeed;
422
423     if (rightSpeed > 0){
```

```
424         newRightSpeed = gCorrectionSpeed * rootSpeedRatio;
425       }
426       else if (rightSpeed < 0){
427         newRightSpeed = -1 * gCorrectionSpeed * rootSpeedRatio;
428       }
429       if (leftSpeed > 0){
430         newLeftSpeed = gCorrectionSpeed / rootSpeedRatio;
431       }
432       else if (leftSpeed < 0){
433         newLeftSpeed = -1 * gCorrectionSpeed / rootSpeedRatio;
434       }
435
436       // If the distance is found to be different than the wanted by more than a
437       // degree, call the driveWheels function with new speeds.
438       if (encoderAverage() > degrees + 1.0){
439         driveWheels(-1 * newRightSpeed, -1 * newLeftSpeed, encoderAverage() - degrees,
440                     baseOffset / 10.0, cutoff / 10.0);
441       }
442       else if (encoderAverage() < degrees - 1.0){
443         driveWheels(newRightSpeed, newLeftSpeed, degrees - encoderAverage(),
444                     baseOffset / 10.0, cutoff/ 10.0);
445       }
446     }
447     gCorrectionCounter = 0;
448   }
449
450
451   // Function to stop motors.
452   void stopMotor(int deceleration){
453     sendByte(ACCELERATION, deceleration);
454     sendByte(SPEEDR, 128);
455     sendByte(SPEEDL, 128);
456   }
457
458
459   ////////////////////////////////
460   /////// Encoder Functions ///////
461   ////////////////////////////////
462
463
464   // Function to read and return the  value of an encoder as
465   // a long, takes the number of the encoder as an input.
466   long encoder(int encoderNumber){
467
468     Wire.beginTransmission(MD25ADDRESS);
469
470     if (encoderNumber == 1){
471       Wire.write(ENCODER1);
472     }
473
474     if (encoderNumber == 2){
475       Wire.write(ENCODER2);
476     }
477
478     Wire.endTransmission();
479     Wire.requestFrom(MD25ADDRESS, 4);      // Request 4 bytes from MD25
480
481     // Wait for 4 bytes to become available
482     while(Wire.available() < 4) { /* do nothing */};
483
484     long encoderValue = Wire.read();       // First byte for encoder 2, HH
485
486     for (int i = 0; i < 3; i++){           //
487       encoderValue <<= 8;                  // Read the next three bytes
488       encoderValue += Wire.read();         //
489     }
```

```
490
491   return(encoderValue);                    //Return encoderValue
492 }
493
494
495 // Function that returns the absolute value of the average of the two encoders
496 float encoderAverage(){
497   return( ( abs(encoder(1)) + abs(encoder(2)) ) / 2 );
498 }
499
500
501 // Function to set the encoder values to 0
502 void encodeReset(){
503   sendByte(CMD,RESETENCODERS);
504 }
505
506
507 ////////////////////////////////
508 /////// Gripper Functions ///////
509 ////////////////////////////////
510
511
512 void closeGripper(int servoNumber) {
513
514   if(is90secDone()) {
515     launchRocket();
516     return;
517   }
518
519   for (int pos = 5; pos <= gDegreesToOpen; pos += 1) {
520     Servos[servoNumber].write(pos);
521     delay(15);
522   }
523
524   delay(gDelayTime);
525
526 }
527
528
529 void openGripper(int servoNumber) {
530
531   if(is90secDone()) {
532       launchRocket();
533       return;
534   }
535
536   for (int pos = gDegreesToOpen; pos >= 5; pos -= 1) {
537     Servos[servoNumber].write(pos);
538     delay(15);
539   }
540
541   delay(gDelayTime);
542
543 }
544
545
546 void turnGripperVertical(int servoNumber) {
547
548   if(is90secDone()) {
549       launchRocket();
550       return;
551   }
552
553   //SERVO NO. 0
554   if(servoNumber == 0) {
555     for(int pos = 22; pos <= gDegreesToTurn; pos += 1) {
```

```
556         ServosTurn[servoNumber].write(pos);
557         delay(10);
558       }
559     }
560
561     //SERVO NO. 1
562     else if(servoNumber == 1) {
563       ServosTurn[servoNumber].write(5);
564     }
565
566     //SERVO NO. 2
567     else if(servoNumber == 2) {
568       for(int pos = 5; pos <= 95; pos += 1) {
569         ServosTurn[servoNumber].write(pos);
570         delay(5);
571       }
572     }
573
574     delay(gDelayTime);
575
576   }
577
578
579   void turnGripperHorizontal(int servoNumber) {
580
581     if(is90secDone()) {
582         launchRocket();
583         return;
584       }
585
586     //SERVO NO. 0
587     if(servoNumber == 0) {
588       ServosTurn[servoNumber].write(22);
589     }
590
591     //SERVO NO. 1
592     else if(servoNumber == 1) {
593       ServosTurn[servoNumber].write(85);
594     }
595
596     //SERVO NO. 2
597     else {
598       ServosTurn[servoNumber].write(10);
599     }
600
601     delay(gDelayTime);
602
603   }
604
605
606   ////////////////////////////////
607   ////// Obstacle Aboidance ///////
608   ////////////////////////////////
609
610
611   // Returns the distance away from either the front sensor when
612   // isForward = true, and the back sensor when isForward = false
613   float distance(bool isForward){
614
615     float duration;
616     float distance;
617
618     if(isForward){
619       digitalWrite(gFrontTrigPin, LOW);
620       delayMicroseconds(2);
621       // Sets the gTrigPin on HIGH state for 10 micro seconds
```

```
622       digitalWrite(gFrontTrigPin, HIGH);
623       delayMicroseconds(10);
624       digitalWrite(gFrontTrigPin, LOW);
625       // Reads the echoPin, returns the sound wave travel time in microseconds
626       duration = pulseIn(gFrontEchoPin, HIGH);
627       }
628
629     else{
630       digitalWrite(gBackTrigPin, LOW);
631       delayMicroseconds(2);
632       // Sets the gTrigPin on HIGH state for 10 micro seconds
633       digitalWrite(gBackTrigPin, HIGH);
634       delayMicroseconds(10);
635       digitalWrite(gBackTrigPin, LOW);
636       // Reads the echoPin, returns the sound wave travel time in microseconds
637       duration = pulseIn(gBackEchoPin, HIGH);
638       }
639
640     // Calculating the distance
641     distance = duration * 0.34 / 2;
642
643     return(distance);
644
645   }
646
647
648   // Returns true if the robot is further away than distanceLimit from the
649   // either the front when isForward = true and the back when isForward = false
650   bool isClear(bool isForward, float distanceLimit){
651     float currentDistance = distance(isForward);
652     return(currentDistance > distanceLimit);
653   }
654
655
656   ////////////////////////////////
657   /////// Rocket Functions ////////
658   ////////////////////////////////
659
660
661   // Stops motor and returns true if 90 second have pased since the
662   // pull cord was pulled, returns false otherwise.
663   bool is90secDone(){
664     if (millis() - gStartTime >= 90000){
665       stopMotor(gDeceleration);
666       delay(1000);
667       return true;
668     }
669     else {
670       return false;
671     }
672   }
673
674
675   // Waits until 90 seconds have transcurred since the pull cord was
676   // launched, then launches the rocket by pulsing gRocketPin
677   void launchRocket(){
678
679     while(is90secDone() == false){ /* Do nothing */}
680     delay(1000);
681     digitalWrite(gRocketPin, HIGH);
682     delay(1000);
683     digitalWrite(gRocketPin, LOW);
684     exit(0);
685
686   }
687
```

```
688
689 ////////////////////////////////
690 /////// Helper Functions ////////
691 ////////////////////////////////
692
693
694 // Function that sends a value to a byte address
695 void sendByte( byte byteAddress, int value ){
696   Wire.beginTransmission(MD25ADDRESS);
697   Wire.write(byteAddress);                //'Write' to byteaddress
698   Wire.write(value);                      //Send a value to that adress
699   Wire.endTransmission();
700 }
701
702
703 // Function to convert a distance to a degree value
704 float distanceToDegrees(float distance){
705   return(distance / gWheelDiameter / 3.1415 * 360);
706 }
707
708
709 // Function to find the degrees the wheels have to spin
710 // for a degree value of spinning on the spot
711 float onspotDegreesToWheelDegrees(float degrees){
712   return(distanceToDegrees(degrees / 360 * 3.1415 * gWheelbase));
713 }
714
715
716 // No need for a loop function
717 void loop(){
718 }
```

# References

[1] J. Swift, *Gulliver's travels*, ser. Diamond classics. Jones & Company, 1826. [Online]. Available: https://books.google.co.uk/books?id=ta1uaL7RF5gC.