PROCESSING
COOKBOOK
by Angelos Floros

EVENTFULL PARAMETERES

ANIMATION, INTERACTIVE

creative
scripting
m e a l s

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sketches

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FALLING WORDS

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Falling Balls

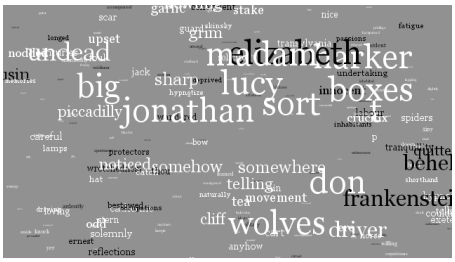
CODE

```
ArrayList<Ball> balls;
int ballWidth = 48;

void setup() {
  size(640, 360);
  noStroke();
  balls = new ArrayList<Ball>();  // Create an empty ArrayList stores
Ball objects)
  balls.add(new Ball(width/2, 0, ballWidth)); // Start by adding one
element
}

void draw() {
  background(255);
  for (int i = balls.size()-1; i >= 0; i--) {
    // An ArrayList doesn't know what it is storing so we have to cast
the object coming out
    Ball ball = balls.get(i);
    ball.move();
    ball.display();
    if (ball.finished()) { // Items can be deleted with remove()
      balls.remove(i);
    }
  }
}
```

```
/**
 * ArrayList of objects
 * by Daniel Shiffman.
 *
 * This example demonstrates how to
use a Java ArrayList to store
 * a variable number of objects.  Items
can be added and removed
 * from the ArrayList.
 *
 * Click the mouse to add bouncing
balls.
 */

  // With an array, we say balls.length,
with an ArrayList, we say balls.size()
  // The length of an ArrayList is
dynamic
  // Notice how we are looping through
the ArrayList backwards
  // This is because we are deleting
elements from the list
```

```
// Adds a new ball to the ArrayList
(by default to the end)

void mousePressed() {    balls.
add(new Ball(mouseX, mouseY,
ballWidth));
}

// BALL OBJECT
//Simple bouncing ball class

class Ball {
  float x;
  float y;
  float speed;
  float gravity;
  float w;
  float life = 255;

  Ball(float tempX, float tempY,
float tempW) {
    x = tempX;
    y = tempY;
    w = tempW;
    speed = 0;
    gravity = 0.1;
  }

  void move() {
  // Add gravity to speed
  speed = speed + gravity;
  // Add speed to y location
  y = y + speed;
  // If square reaches the bottom
  // Reverse speed
  if (y > height) {
    speed = speed * -0.8;
    y = height;
  }
 }
  boolean finished() {
  life--;  // Balls fade out
  if (life < 0) {
    return true;
  } else {
    return false;
  }
 }

 void display() {
  fill(0,life);    // Display the circle
  //stroke(0,life);
  ellipse(x,y,w,w);
 }
}
```

CODE




```
/**
 * HashMap example
 * by Daniel Shiffman.
 *
 * This example demonstrates how to use a HashMap to store
 * a collection of objects referenced by a key. This is much like an array,
 * only instead of accessing elements with a numeric index, we use a String.
 * If you are familiar with associative arrays from other languages,
 * this is the same idea.
 *
 * A simpler example is CountingStrings which uses IntHash instead of
 * HashMap.  The Processing classes IntHash, FloatHash, and StringHash
 * offer a simpler way of pairing Strings with numbers or other Strings.
 * Here we use a HashMap because we want to pair a String with a custom
 * object, in this case a "Word" object that stores two numbers.
 *
 * In this example, words that appear in one book (Dracula) only are colored white
 * while words the other (Frankenstein) are colored black.
 */

// The next line is needed if running in JavaScript Mode with Processing.js
/* @pjs font="Georgia.ttf"; */
```

Falling Words

```
HashMap<String, Word> words;  // HashMap object

void setup() {
  size(640, 360);

  // Create the HashMap
  words = new HashMap<String, Word>();

  // Load two files
  loadFile("dracula.txt");
  loadFile("frankenstein.txt");

  // Create the font
  textFont(createFont("Georgia", 24));
}

void draw() {
  background(126);

  // Show words
  for (Word w : words.values()) {
    if (w.qualify()) {
      w.display();
      w.move();
    }
  }
}

// Load a file
void loadFile(String filename) {
  String[] lines = loadStrings(filename);
  String allText = join(lines, " ").toLowerCase();
  String[] tokens = splitTokens(allText, " ,.?!:;[]-\"'");

  for (String s : tokens) {
    // Is the word in the HashMap
    if (words.containsKey(s)) {
      // Get the word object and increase the count
      // We access objects from a HashMap via its key, the String
      Word w = words.get(s);
      // Which book am I loading?
      if (filename.contains("dracula")) {
        w.incrementDracula();
      }
      else if (filename.contains("frankenstein")) {
        w.incrementFranken();
      }
    }
    else {
      // Otherwise make a new word
      Word w = new Word(s);
      // And add to the HashMap put() takes two arguments, "key" and "value"
      // The key for us is the String and the value is the Word object
      words.put(s, w);
      if (filename.contains("dracula")) {
        w.incrementDracula();
      } else if (filename.contains("frankenstein")) {
        w.incrementFranken();
      }
    }
  }
}

class Word {
```

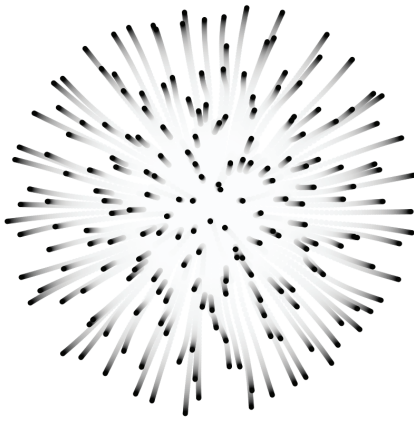
Animated Points

http://www.generative-gestaltung.de

DESCRIPTION

Distribute nodes on the display by letting them repel each other.

CODE



```
Node[] nodes = new Node[200]; // an array for the nodes

void setup() {
  size(800, 800);
  background(255);
  smooth();
  noStroke();

  for (int i = 0 ; i < nodes.length; i++) {  // init nodes
    nodes[i] = new Node(width/2+random(-1, 1), height/2+random(-1, 1));
    nodes[i].setBoundary(5, 5, width-5, height-5);
  }
}

void draw() {
  fill(255, 20);
  rect(0, 0, width, height);
  // let all nodes repel each other
  for (int i = 0 ; i < nodes.length; i++) {
    nodes[i].attract(nodes);
  }
  // apply velocity vector and update position
  for (int i = 0 ; i < nodes.length; i++) {
    nodes[i].update();
  }
  // draw node
  fill(0);
  for (int i = 0 ; i < nodes.length; i++) {
    ellipse(nodes[i].x, nodes[i].y, 10, 10);
  }
}

void keyPressed(){
  if(key=='r' || key=='R') {
    background(255);
    for (int i = 0 ; i < nodes.length; i++) {
      nodes[i].set(width/2+random(-5, 5), height/2+random(-5, 5), 0);
    }
  }
}

class Node extends PVector {

  // ------   properties ------
  // if needed, an ID for the node
  String id = "";
  float diameter = 0;

  float minX = -Float.MAX_VALUE;
  float maxX = Float.MAX_VALUE;
  float minY = -Float.MAX_VALUE;
  float maxY = Float.MAX_VALUE;
  float minZ = -Float.MAX_VALUE;
  float maxZ = Float.MAX_VALUE;
```

```
// animatedPoints.pde
// Node.pde
//
// Generative Gestaltung, ISBN: 978-3-87439-759-9
// First Edition, Hermann Schmidt, Mainz, 2009
// Hartmut Bohnacker, Benedikt Gross, Julia Laub, Claudius Lazzeroni
// Copyright 2009 Hartmut Bohnacker, Benedikt Gross, Julia Laub, Claudius Lazzeroni
//
// http://www.generative-gestaltung.de
//
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// distributed under the License is distributed on an "AS IS" BASIS,
// WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
// See the License for the specific language governing permissions and
// limitations under the License.

/**
 * distribute nodes on the display by letting them repel each other
 *
 * KEYS
 * r          : reset positions
 * s          : save png
 */
```

```
  PVector velocity = new PVector();
  PVector pVelocity = new PVector();
  float maxVelocity = 10;

  float damping = 0.5f;
  // radius of impact
  float radius = 200;
  // strength: positive for attraction, negative for repulsion (default for Nodes)
  float strength = -1;
  // parameter that influences the form of the function
  float ramp = 1.0f;


  // ------ constructors ------
  Node() {
  }

  Node(float theX, float theY) {
    x = theX;
    y = theY;
  }

  Node(float theX, float theY, float theZ) {
    x = theX;
    y = theY;
    z = theZ;
  }

  Node(PVector theVector) {
    x = theVector.x;
    y = theVector.y;
    z = theVector.z;
  }

  // ------ rotate position around origin ------
  void rotateX(float theAngle) {
    float newy = y * cos(theAngle) - z * sin(theAngle);
    float newz = y * sin(theAngle) + z * cos(theAngle);
    y = newy;
    z = newz;
  }

  void rotateY(float theAngle) {
    float newx = x * cos(-theAngle) - z * sin(-theAngle);
    float newz = x * sin(-theAngle) + z * cos(-theAngle);
    x = newx;
    z = newz;
  }

  void rotateZ(float theAngle) {
    float newx = x * cos(theAngle) - y * sin(theAngle);
    float newy = x * sin(theAngle) + y * cos(theAngle);
    x = newx;
    y = newy;
  }

  // ------ calculate attraction ------
```

```
  void attract(Node[] theNodes) {
    // attraction or repulsion part
    for (int i = 0; i < theNodes.length; i++) {
      Node otherNode = theNodes[i];
      // stop when empty
      if (otherNode == null) break;
      // not with itself
      if (otherNode == this) continue;

      this.attract(otherNode);
    }
  }

  void attract(Node theNode) {
    float d = PVector.dist(this, theNode);

    if (d > 0 && d < radius) {
      float s = pow(d / radius, 1 / ramp);
      float f = s * 9 * strength * (1 / (s + 1) + ((s - 3) / 4)) / d;
      PVector df = PVector.sub(this, theNode);
      df.mult(f);

      theNode.velocity.x += df.x;
      theNode.velocity.y += df.y;
      theNode.velocity.z += df.z;
    }
  }

  // ------ update positions ------
  void update() {
    update(false, false, false);
  }

  void update(boolean theLockX, boolean theLockY, boolean theLockZ)
{

    velocity.limit(maxVelocity);
    pVelocity = velocity.get();

    if (!theLockX) x += velocity.x;
    if (!theLockY) y += velocity.y;
    if (!theLockZ) z += velocity.z;

    if (x < minX) {
      x = minX - (x - minX);
      velocity.x = -velocity.x;
    }
    if (x > maxX) {
      x = maxX - (x - maxX);
      velocity.x = -velocity.x;
    }

    if (y < minY) {
      y = minY - (y - minY);
      velocity.y = -velocity.y;
    }
```

```
  if (y > maxY) {
    y = maxY - (y - maxY);
    velocity.y = -velocity.y;
  }

  if (z < minZ) {
    z = minZ - (z - minZ);
    velocity.z = -velocity.z;
  }
  if (z > maxZ) {
    z = maxZ - (z - maxZ);
    velocity.z = -velocity.z;
  }

  velocity.mult(1 - damping);
}

// ------ getters and setters ------
String getID() {
  return id;
}

void setID(String theID) {
  this.id = theID;
}

float getDiameter() {
  return diameter;
}

void setDiameter(float theDiameter) {
  this.diameter = theDiameter;
}

void setBoundary(float theMinX, float theMinY, float theMinZ,
float theMaxX, float theMaxY, float theMaxZ) {
  this.minX = theMinX;
  this.maxX = theMaxX;
  this.minY = theMinY;
  this.maxY = theMaxY;
  this.minZ = theMinZ;
  this.maxZ = theMaxZ;
}

void setBoundary(float theMinX, float theMinY, float theMaxX,
float theMaxY) {
  this.minX = theMinX;
  this.maxX = theMaxX;
  this.minY = theMinY;
  this.maxY = theMaxY;
}

float getMinX() {
  return minX;
}
```

```
void setMinX(float theMinX) {
  this.minX = theMinX;
}

float getMaxX() {
  return maxX;
}

void setMaxX(float theMaxX) {
  this.maxX = theMaxX;
}

float getMinY() {
  return minY;
}

void setMinY(float theMinY) {
  this.minY = theMinY;
}

float getMaxY() {
  return maxY;
}

void setMaxY(float theMaxY) {
  this.maxY = theMaxY;
}

float getMinZ() {
  return minZ;
}

void setMinZ(float theMinZ) {
  this.minZ = theMinZ;
}

float getMaxZ() {
  return maxZ;
}

void setMaxZ(float theMaxZ) {
  this.maxZ = theMaxZ;
}

PVector getVelocity() {
  return velocity;
}

void setVelocity(PVector theVelocity) {
  this.velocity = theVelocity;
}

float getMaxVelocity() {
  return maxVelocity;
}
```

```
  void setMaxVelocity(float theMaxVelocity) {
    this.maxVelocity = theMaxVelocity;
  }

  float getDamping() {
    return damping;
  }

  void setDamping(float theDamping) {
    this.damping = theDamping;
  }

  float getRadius() {
    return radius;
  }

  void setRadius(float theRadius) {
    this.radius = theRadius;
  }

  float getStrength() {
    return strength;
  }

  void setStrength(float theStrength) {
    this.strength = theStrength;
  }

  float getRamp() {
    return ramp;
  }

  void setRamp(float theRamp) {
    this.ramp = theRamp;
  }

}
```

Bouncing Ball

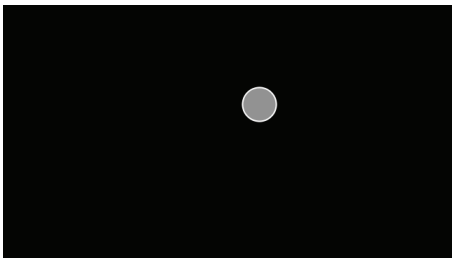
CODE

```
/**
 * Bounce.
 *
 * When the shape hits the edge of the window, it reverses its direction.
 */
```

```
int rad = 60;        // Width of the shape
float xpos, ypos;    // Starting position of shape

float xspeed = 2.8;  // Speed of the shape
float yspeed = 2.2;  // Speed of the shape

int xdirection = 1;  // Left or Right
int ydirection = 1;  // Top to Bottom


void setup()
{
  size(640, 360);
  noStroke();
  frameRate(30);
  ellipseMode(RADIUS);
  // Set the starting position of the shape
  xpos = width/2;
  ypos = height/2;
}

void draw()
{
  background(102);

  // Update the position of the shape
  xpos = xpos + ( xspeed * xdirection );
  ypos = ypos + ( yspeed * ydirection );

  // Test to see if the shape exceeds the boundaries of the screen
  // If it does, reverse its direction by multiplying by -1
  if (xpos > width-rad || xpos < rad) {
    xdirection *= -1;
  }
  if (ypos > height-rad || ypos < rad) {
    ydirection *= -1;
  }

  // Draw the shape
  ellipse(xpos, ypos, rad, rad);
}
```

Bouncing Ball Physics

CODE

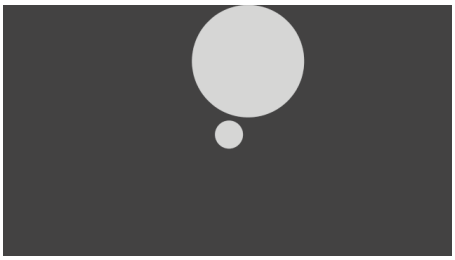


```
PVector location;  // Location of shape
PVector velocity;  // Velocity of shape
PVector gravity;   // Gravity acts at the shape's acceleration

void setup() {
  size(640,360);
  smooth();
  location = new PVector(100,100);
  velocity = new PVector(1.5,2.1);
  gravity = new PVector(0,0.2);

}

void draw() {
  background(0);

  // Add velocity to the location.
  location.add(velocity);
  // Add gravity to velocity
  velocity.add(gravity);

  // Bounce off edges
  if ((location.x > width) || (location.x < 0)) {
    velocity.x = velocity.x * -1;
  }
  if (location.y > height) {
    // We're reducing velocity ever so slightly
    // when it hits the bottom of the window
    velocity.y = velocity.y * -0.95;
    location.y = height;
  }

  // Display circle at location vector
  stroke(255);
  strokeWeight(2);
  fill(127);
  ellipse(location.x,location.y,48,48);
}
```

```
/**
 * Bouncing Ball with Vectors
 * by Daniel Shiffman.
 *
 * Demonstration of using vectors to
control motion of body
 * This example is not object-oriented
 * See AccelerationWithVectors for an
example of how to simulate motion
using vectors in an object
 */
```

Circle Collision

CODE



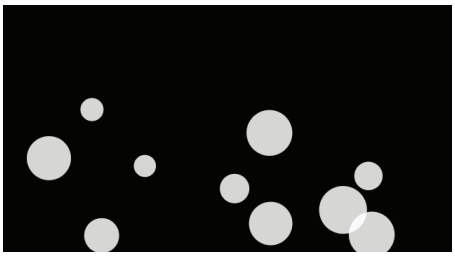
```
Ball[] balls =  {
  new Ball(100, 400, 20),
  new Ball(700, 400, 80)
};

void setup() {
  size(640, 360);
}

void draw() {
  background(51);
  for (Ball b : balls) {
    b.update();
    b.display();
    b.checkBoundaryCollision();
  }
  balls[0].checkCollision(balls[1]);
}

class Ball {
  PVector position;
  PVector velocity;

  float r, m;

  Ball(float x, float y, float r_) {
    position = new PVector(x, y);
    velocity = PVector.random2D();
    velocity.mult(3);
    r = r_;
    m = r*.1;
  }

  void update() {
    position.add(velocity);
  }

  void checkBoundaryCollision() {
    if (position.x > width-r) {
      position.x = width-r;
      velocity.x *= -1;
    }
    else if (position.x < r) {
      position.x = r;
      velocity.x *= -1;
    }
    else if (position.y > height-r) {
      position.y = height-r;
      velocity.y *= -1;
    }
    else if (position.y < r) {
      position.y = r;
      velocity.y *= -1;
    }
  }

  void checkCollision(Ball other) {
    // get distances between the balls components
    PVector bVect = PVector.sub(other.position, position);
    // calculate magnitude of the vector separating the balls
    float bVectMag = bVect.mag();
    if (bVectMag < r + other.r) {
      // get angle of bVect
      float theta  = bVect.heading();
```

```
/**
 * Circle Collision with Swapping
Velocities
 * by Ira Greenberg.
 *
 * Based on Keith Peter's Solution in
 * Foundation Actionscript Animation:
Making Things Move!
 */

    /* bTemp will hold rotated ball
positions. You
     just need to worry about bTemp[1]
position*/

      /* this ball's position is relative to
the other
       so you can use the vector between
them (bVect) as the
       reference point in the rotation
expressions.
       bTemp[0].position.x and bTemp[0].
position.y will initialize
       automatically to 0.0, which is what
you want
       since b[1] will rotate around b[0] */
```

```
    // precalculate trig values
    float sine = sin(theta);
    float cosine = cos(theta);

    PVector[] bTemp = { new PVector(), new PVector()};

      bTemp[1].x  = cosine * bVect.x + sine * bVect.y;
    bTemp[1].y  = cosine * bVect.y - sine * bVect.x;

    // rotate Temporary velocities
    PVector[] vTemp = { new PVector(), new PVector()};

    vTemp[0].x  = cosine * velocity.x + sine * velocity.y;
    vTemp[0].y  = cosine * velocity.y - sine * velocity.x;
    vTemp[1].x  = cosine * other.velocity.x + sine * other.velocity.y;
    vTemp[1].y  = cosine * other.velocity.y - sine * other.velocity.x;

    /* Now that velocities are rotated, you can use 1D conservation of
momentum equations to calculate the final velocity along the x-axis.
*/
    PVector[] vFinal = {
      new PVector(), new PVector()
      };

    // final rotated velocity for b[0]
    vFinal[0].x = ((m - other.m) * vTemp[0].x + 2 * other.m *
vTemp[1].x) / (m + other.m);
    vFinal[0].y = vTemp[0].y;

    // final rotated velocity for b[0]
    vFinal[1].x = ((other.m - m) * vTemp[1].x + 2 * m * vTemp[0].x)
/ (m + other.m);
    vFinal[1].y = vTemp[1].y;

    // hack to avoid clumping
    bTemp[0].x += vFinal[0].x;
    bTemp[1].x += vFinal[1].x;

    /* Rotate ball positions and velocities back
     Reverse signs in trig expressions to rotate
     in the opposite direction */
    // rotate balls
    PVector[] bFinal = {
      new PVector(), new PVector()
      };

    bFinal[0].x = cosine * bTemp[0].x - sine * bTemp[0].y;
    bFinal[0].y = cosine * bTemp[0].y + sine * bTemp[0].x;
    bFinal[1].x = cosine * bTemp[1].x - sine * bTemp[1].y;
    bFinal[1].y = cosine * bTemp[1].y + sine * bTemp[1].x;

    // update balls to screen position
    other.position.x = position.x + bFinal[1].x;
    other.position.y = position.y + bFinal[1].y;

    position.add(bFinal[0]);

    // update velocities
    velocity.x = cosine * vFinal[0].x - sine * vFinal[0].y;
    velocity.y = cosine * vFinal[0].y + sine * vFinal[0].x;
    other.velocity.x = cosine * vFinal[1].x - sine * vFinal[1].y;
    other.velocity.y = cosine * vFinal[1].y + sine * vFinal[1].x;
   }
  }

  void display() {
    noStroke();
    fill(204);
    ellipse(position.x, position.y, r*2, r*2);
  }
}
```

Bouncing Bubbles

CODE



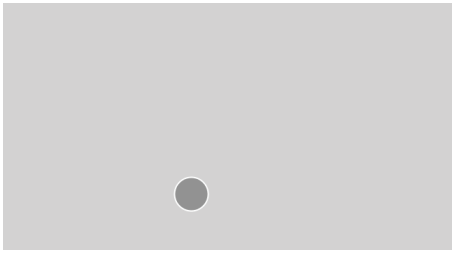
```
/**
 * Bouncy Bubbles
 * based on code from Keith Peters.
 *
 * Multiple-object collision.
 */
```

```
int numBalls = 10;
float spring = 0.05;
float gravity = 0.03;
float friction = -0.9;
Ball[] balls = new Ball[numBalls];

void setup() {
  size(640, 360);
  for (int i = 0; i < numBalls; i++) {
    balls[i] = new Ball(random(width), random(height), random(30,
70), i, balls);
  }
  noStroke();
  fill(255, 204);
}

void draw() {
  background(0);
  for (int i = 0; i < numBalls; i++) {
    balls[i].collide();
    balls[i].move();
    balls[i].display();
  }
}

class Ball {

  float x, y;
  float diameter;
  float vx = 0;
  float vy = 0;
  int id;
  Ball[] others;

  Ball(float xin, float yin, float din, int idin, Ball[] oin) {
    x = xin;
    y = yin;
    diameter = din;
    id = idin;
    others = oin;
  }

  void collide() {
    for (int i = id + 1; i < numBalls; i++) {
      float dx = others[i].x - x;
      float dy = others[i].y - y;
      float distance = sqrt(dx*dx + dy*dy);
      float minDist = others[i].diameter/2 + diameter/2;
      if (distance < minDist) {
        float angle = atan2(dy, dx);
        float targetX = x + cos(angle) * minDist;
        float targetY = y + sin(angle) * minDist;
        float ax = (targetX - others[i].x) * spring;
        float ay = (targetY - others[i].y) * spring;
        vx -= ax;
        vy -= ay;
```

```
      others[i].vx += ax;
      others[i].vy += ay;
    }
  }
 }

 void move() {
  vy += gravity;
  x += vx;
  y += vy;
  if (x + diameter/2 > width) {
   x = width - diameter/2;
   vx *= friction;
  }
  else if (x - diameter/2 < 0) {
   x = diameter/2;
   vx *= friction;
  }
  if (y + diameter/2 > height) {
   y = height - diameter/2;
   vy *= friction;
  }
  else if (y - diameter/2 < 0) {
   y = diameter/2;
   vy *= friction;
  }
 }

 void display() {
  ellipse(x, y, diameter, diameter);
 }
}
```

Follow Mouse

CODE



```
// A Mover object
Mover mover;

void setup() {
  size(640,360);
  mover = new Mover();
}

void draw() {
  background(200);

  // Update the location
  mover.update();
  // Display the Mover
  mover.display();
}

class Mover {

  // The Mover tracks location, velocity, and acceleration
  PVector location;
  PVector velocity;
  PVector acceleration;
  // The Mover's maximum speed
  float topspeed;

  Mover() {
    // Start in the center
    location = new PVector(width/2,height/2);
    velocity = new PVector(0,0);
    topspeed = 5;
  }

  void update() {

    // Compute a vector that points from location to mouse
    PVector mouse = new PVector(mouseX,mouseY);
    PVector acceleration = PVector.sub(mouse,location);
    // Set magnitude of acceleration
    acceleration.setMag(0.2);

    // Velocity changes according to acceleration
    velocity.add(acceleration);
    // Limit the velocity by topspeed
    velocity.limit(topspeed);
    // Location changes by velocity
    location.add(velocity);
  }

  void display() {
    stroke(255);
    strokeWeight(2);
    fill(127);
    ellipse(location.x,location.y,48,48);
  }
}
```

```
/**
 * Acceleration with Vectors
 * by Daniel Shiffman.
 *
 * Demonstration of the basics of motion with vector.
 * A "Mover" object stores location, velocity, and acceleration as vectors
 * The motion is controlled by affecting the acceleration (in this case towards the mouse)
 *
 * For more examples of simulating motion and physics with vectors, see
 * Simulate/ForcesWithVectors, Simulate/GravitationalAttraction3D
 */
```


```
/**
 * Acceleration with Vectors
 * by Daniel Shiffman.
 *
 * Demonstration of the basics of motion with vector.
 * A "Mover" object stores location, velocity, and acceleration as vectors
 * The motion is controlled by affecting the acceleration (in this case towards the mouse)
 */
```

Constrain

CODE


```
float mx;
float my;
float easing = 0.05;
int radius = 24;
int edge = 100;
int inner = edge + radius;

void setup() {
  size(640, 360);
  noStroke();
  ellipseMode(RADIUS);
  rectMode(CORNERS);
}

void draw() {
  background(200);

  if (abs(mouseX - mx) > 0.1) {
    mx = mx + (mouseX - mx) * easing;
  }
  if (abs(mouseY - my) > 0.1) {
    my = my + (mouseY- my) * easing;
  }

  mx = constrain(mx, inner, width - inner);
  my = constrain(my, inner, height - inner);
  fill(255,255,0);
  rect(edge, edge, width-edge, height-edge);
  fill(255);
  ellipse(mx, my, radius, radius);
}
```

```
/**
 * Constrain.
 *
 * Move the mouse across the screen to
move the circle.
 * The program constrains the circle to
its box.
 */
```

Scrollbar

CODE

```
// The next line is needed if running in JavaScript Mode with
Processing.js
/* @pjs preload="seedTop.jpg,seedBottom.jpg"; */


HScrollbar hs1, hs2;  // Two scrollbars
PImage img1, img2;  // Two images to load

void setup() {
  size(640, 360);
  noStroke();

  hs1 = new HScrollbar(0, height/2-8, width, 16, 16);
  hs2 = new HScrollbar(0, height/2+8, width, 16, 16);

  // Load images
  img1 = loadImage("seedTop.jpg");
  img2 = loadImage("seedBottom.jpg");
}

void draw() {
  background(255);

  // Get the position of the img1 scrollbar
  // and convert to a value to display the img1 image
  float img1Pos = hs1.getPos()-width/2;
  fill(255);
  image(img1, width/2-img1.width/2 + img1Pos*1.5, 0);

  // Get the position of the img2 scrollbar
  // and convert to a value to display the img2 image
  float img2Pos = hs2.getPos()-width/2;
  fill(255);
  image(img2, width/2-img2.width/2 + img2Pos*1.5, height/2);

  hs1.update();
  hs2.update();
  hs1.display();
  hs2.display();

  stroke(0);
  line(0, height/2, width, height/2);
}


class HScrollbar {
  int swidth, sheight;    // width and height of bar
  float xpos, ypos;       // x and y position of bar
  float spos, newspos;    // x position of slider
  float sposMin, sposMax; // max and min values of slider
  int loose;              // how loose/heavy
  boolean over;           // is the mouse over the slider?
  boolean locked;
```

```
/**
 * Scrollbar.
 *
 * Move the scrollbars left and right to
change the positions of the images.
 */
```

```
  float ratio;

  HScrollbar (float xp, float yp, int sw, int sh, int l) {
    swidth = sw;
    sheight = sh;
    int widthtoheight = sw - sh;
    ratio = (float)sw / (float)widthtoheight;
    xpos = xp;
    ypos = yp-sheight/2;
    spos = xpos + swidth/2 - sheight/2;
    newspos = spos;
    sposMin = xpos;
    sposMax = xpos + swidth - sheight;
    loose = l;
  }

  void update() {
    if (overEvent()) {
      over = true;
    } else {
      over = false;
    }
    if (mousePressed && over) {
      locked = true;
    }
    if (!mousePressed) {
      locked = false;
    }
    if (locked) {
      newspos = constrain(mouseX-sheight/2, sposMin, sposMax);
    }
    if (abs(newspos - spos) > 1) {
      spos = spos + (newspos-spos)/loose;
    }
  }

  float constrain(float val, float minv, float maxv) {
    return min(max(val, minv), maxv);
  }

  boolean overEvent() {
    if (mouseX > xpos && mouseX < xpos+swidth &&
       mouseY > ypos && mouseY < ypos+sheight) {
      return true;
    } else {
      return false;
    }
  }

  void display() {
    noStroke();
    fill(204);
    rect(xpos, ypos, swidth, sheight);
    if (over || locked) {
      fill(0, 0, 0);
    } else {
      fill(102, 102, 102);
    }
    rect(spos, ypos, sheight, sheight);
  }

  float getPos() {
    // Convert spos to be values between
    // 0 and the total width of the scrollbar
    return spos * ratio;
  }
}
```

Moving on Curves

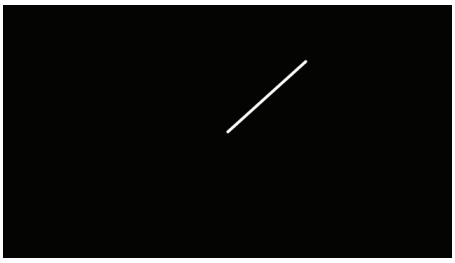
CODE

```
float beginX = 20.0;  // Initial x-coordinate
float beginY = 10.0;  // Initial y-coordinate
float endX = 570.0;   // Final x-coordinate
float endY = 320.0;   // Final y-coordinate
float distX;          // X-axis distance to move
float distY;          // Y-axis distance to move
float exponent = 4;   // Determines the curve
float x = 0.0;        // Current x-coordinate
float y = 0.0;        // Current y-coordinate
float step = 0.01;    // Size of each step along the path
float pct = 0.0;      // Percentage traveled (0.0 to 1.0)

void setup() {
  size(640, 360);
  noStroke();
  distX = endX - beginX;
  distY = endY - beginY;
}

void draw() {


  fill(0, 2);
  rect(0, 0, width, height);
  pct += step;
  if (pct < 1.0) {
    x = beginX + (pct * distX);
    y = beginY + (pow(pct, exponent) * distY);
  }


    endX = mouseX;
  endY = mouseY;
  distX = endX - beginX;
  distY = endY - beginY;

  fill(255);
  ellipse(x, y, 20, 20);
}

void mouseMoved() {
  pct = 0.0;
  beginX = x;
  beginY = y;
  endX = mouseX;
  endY = mouseY;
  distX = endX - beginX;
  distY = endY - beginY;
}
```

```
/**
 * Moving On Curves.
 *
 * In this example, the circles moves
along the curve y = x^4.
 * Click the mouse to have it move to a
new position.
 */
```

RotateLine

CODE

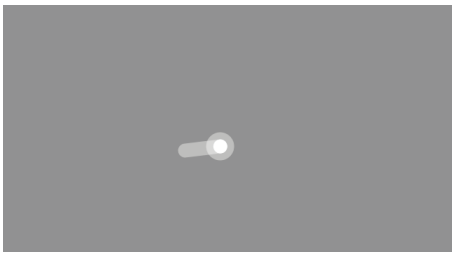


```
void setup() {
  size(640,360);
  smooth();
}

void draw() {
  background(0);

  // A vector that points to the mouse location
  PVector mouse = new PVector(mouseX,mouseY);
  // A vector that points to the center of the window
  PVector center = new PVector(width/2,height/2);
  // Subtract center from mouse which results in a vector that points
from center to mouse
  mouse.sub(center);

  // Normalize the vector
  mouse.normalize();

  // Multiply its length by 150 (Scaling its length)
  mouse.mult(150);

  translate(width/2,height/2);
  // Draw the resulting vector
  stroke(255);
  strokeWeight(4);
  line(0,0,mouse.x,mouse.y);

}
```

```
/**
 * Vector
 * by Daniel Shiffman.
 *
 * Demonstration some basic vector
math: subtraction, normalization,
scaling
 * Normalizing a vector sets its length
to 1.
 */
```

Follow1

CODE



```
float x = 100;
float y = 100;
float angle1 = 0.0;
float segLength = 50;

void setup() {
  size(640, 360);
  strokeWeight(20.0);
  stroke(255, 100);
}

void draw() {
  background(126);

  float dx = mouseX - x;
  float dy = mouseY - y;
  angle1 = atan2(dy, dx);
  x = mouseX - (cos(angle1) * segLength);
  y = mouseY - (sin(angle1) * segLength);

  segment(x, y, angle1);
  ellipse(x, y, 20, 20);
}

void segment(float x, float y, float a) {
  pushMatrix();
  translate(x, y);
  rotate(a);
  line(0, 0, segLength, 0);
  popMatrix();
}
```

```
/**
 * Follow 1
 * based on code from Keith Peters.
 *
 * A line segment is pushed and pulled
by the cursor.
 */
```

Follow2

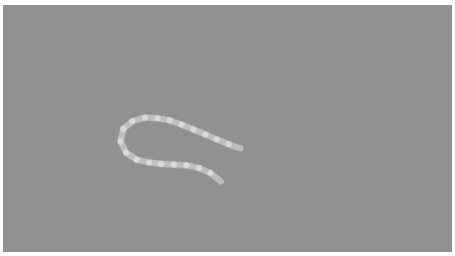
CODE

```
float[] x = new float[2];
float[] y = new float[2];
float segLength = 50;

void setup() {
  size(640, 360);
  strokeWeight(20.0);
  stroke(255, 100);
}

void draw() {
  background(0);
  dragSegment(0, mouseX, mouseY);
  dragSegment(1, x[0], y[0]);
}

void dragSegment(int i, float xin, float yin) {
  float dx = xin - x[i];
  float dy = yin - y[i];
  float angle = atan2(dy, dx);
  x[i] = xin - cos(angle) * segLength;
  y[i] = yin - sin(angle) * segLength;
  segment(x[i], y[i], angle);
}

void segment(float x, float y, float a) {
  pushMatrix();
  translate(x, y);
  rotate(a);
  line(0, 0, segLength, 0);
  popMatrix();
}
```

```
/**
 * Follow 2
 * based on code from Keith Peters.
 *
 * A two-segmented arm follows the cursor position. The relative
 * angle between the segments is calculated with atan2() and the
 * position calculated with sin() and cos().
 */
```

Follow3

CODE



```
float[] x = new float[20];
float[] y = new float[20];
float segLength = 18;

void setup() {
  size(640, 360);
  strokeWeight(9);
  stroke(255, 100);
}

void draw() {
  background(126);
  dragSegment(0, mouseX, mouseY);
  for(int i=0; i<x.length-1; i++) {
    dragSegment(i+1, x[i], y[i]);
  }
}

void dragSegment(int i, float xin, float yin) {
  float dx = xin - x[i];
  float dy = yin - y[i];
  float angle = atan2(dy, dx);
  x[i] = xin - cos(angle) * segLength;
  y[i] = yin - sin(angle) * segLength;
  segment(x[i], y[i], angle);
}

void segment(float x, float y, float a) {
  pushMatrix();
  translate(x, y);
  rotate(a);
  line(0, 0, segLength, 0);
  popMatrix();
}
```

```
/**
 * Follow 3
 * based on code from Keith Peters.
 *
 * A segmented line follows the mouse.
The relative angle from
 * each segment to the next is
calculated with atan2() and the
 * position of the next is calculated with
sin() and cos().
 */
```

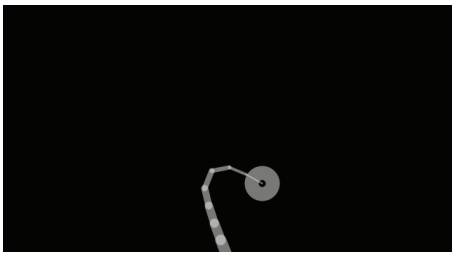
Reach2

CODE

```
int numSegments = 10;
float[] x = new float[numSegments];
float[] y = new float[numSegments];
float[] angle = new float[numSegments];
float segLength = 26;
float targetX, targetY;

void setup() {
  size(640, 360);
  strokeWeight(20.0);
  stroke(255, 100);
  x[x.length-1] = width/2;     // Set base x-coordinate
  y[x.length-1] = height;  // Set base y-coordinate
}

void draw() {
  background(126);

  reachSegment(0, mouseX, mouseY);
  for(int i=1; i<numSegments; i++) {
    reachSegment(i, targetX, targetY);
  }
  for(int i=x.length-1; i>=1; i--) {
    positionSegment(i, i-1);
  }
  for(int i=0; i<x.length; i++) {
    segment(x[i], y[i], angle[i], (i+1)*2);
  }
}

void positionSegment(int a, int b) {
  x[b] = x[a] + cos(angle[a]) * segLength;
  y[b] = y[a] + sin(angle[a]) * segLength;
}

void reachSegment(int i, float xin, float yin) {
  float dx = xin - x[i];
  float dy = yin - y[i];
  angle[i] = atan2(dy, dx);
  targetX = xin - cos(angle[i]) * segLength;
  targetY = yin - sin(angle[i]) * segLength;
}

void segment(float x, float y, float a, float sw) {
  strokeWeight(sw);
  pushMatrix();
  translate(x, y);
  rotate(a);
  line(0, 0, segLength, 0);
  popMatrix();
}
```

```
/**
 * Reach 2
 * based on code from Keith Peters.
 *
 * The arm follows the position of the
mouse by
 * calculating the angles with atan2().
 */
```

CODE



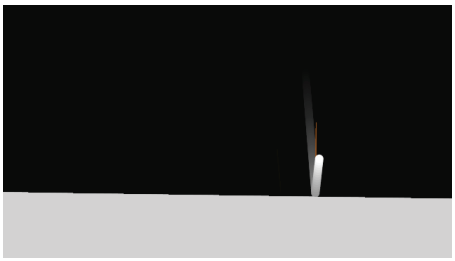
Reach3

```
int numSegments = 8;
float[] x = new float[numSegments];
float[] y = new float[numSegments];
float[] angle = new float[numSegments];
float segLength = 26;
float targetX, targetY;
float ballX = 50;
float ballY = 50;
int ballXDirection = 1;
int ballYDirection = -1;

void setup() {
  size(640, 360);
  strokeWeight(20.0);
  stroke(255, 100);
  noFill();
  x[x.length-1] = width/2;     // Set base x-coordinate
  y[x.length-1] = height;  // Set base y-coordinate
}

void draw() {
  background(0);
  strokeWeight(20);
  ballX = ballX + 1.0 * ballXDirection;
  ballY = ballY + 0.8 * ballYDirection;
  if(ballX > width-25 || ballX < 25) {
    ballXDirection *= -1;
  }
  if(ballY > height-25 || ballY < 25) {
    ballYDirection *= -1;
  }
  ellipse(ballX, ballY, 30, 30);
  reachSegment(0, ballX, ballY);
  for(int i=1; i<numSegments; i++) {
    reachSegment(i, targetX, targetY);
  }
  for(int i=x.length-1; i>=1; i--) {
    positionSegment(i, i-1);
  }
  for(int i=0; i<x.length; i++) {
    segment(x[i], y[i], angle[i], (i+1)*2);
  }
}

void positionSegment(int a, int b) {
  x[b] = x[a] + cos(angle[a]) * segLength;
  y[b] = y[a] + sin(angle[a]) * segLength;
}

void reachSegment(int i, float xin, float yin) {
  float dx = xin - x[i];
  float dy = yin - y[i];
  angle[i] = atan2(dy, dx);
  targetX = xin - cos(angle[i]) * segLength;
  targetY = yin - sin(angle[i]) * segLength;
}

void segment(float x, float y, float a, float sw) {
  strokeWeight(sw);
  pushMatrix();
  translate(x, y);
  rotate(a);
  line(0, 0, segLength, 0);
  popMatrix();
}
```

```
/**
 * Reach 3
 * based on code from Keith Peters.
 *
 * The arm follows the position of the ball by
 * calculating the angles with atan2().
 */
```

Reflection1

CODE



```
// Position of left hand side of floor
PVector base1;
// Position of right hand side of floor
PVector base2;
// Length of floor
float baseLength;

// An array of subpoints along the floor path
PVector[] coords;

// Variables related to moving ball
PVector position;
PVector velocity;
float r = 6;
float speed = 3.5;

void setup() {
  size(640, 360);

  fill(128);
  base1 = new PVector(0, height-150);
  base2 = new PVector(width, height);
  createGround();

  // start ellipse at middle top of screen
  position = new PVector(width/2, 0);

  // calculate initial random velocity
  velocity = PVector.random2D();
  velocity.mult(speed);
}

void draw() {
  // draw background
  fill(0, 12);
  noStroke();
  rect(0, 0, width, height);

  // draw base
  fill(200);
  quad(base1.x, base1.y, base2.x, base2.y, base2.x, height, 0, height);

  // calculate base top normal
  PVector baseDelta = PVector.sub(base2, base1);
  baseDelta.normalize();
  PVector normal = new PVector(-baseDelta.y, baseDelta.x);

  // draw ellipse
  noStroke();
  fill(255);
  ellipse(position.x, position.y, r*2, r*2);

  // move elipse
  position.add(velocity);

  // normalized incidence vector
  PVector incidence = PVector.mult(velocity, -1);
```

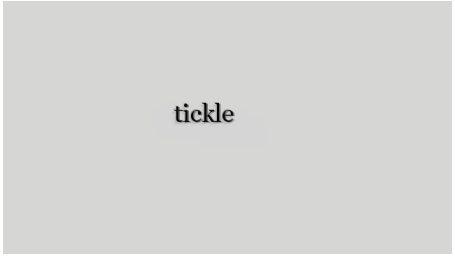
```
/**
 * Non-orthogonal Reflection
 * by Ira Greenberg.
 *
 * Based on the equation (R =
2N(N*L)-L) where R is the
 * reflection vector, N is the normal, and
L is the incident
 * vector.
 */
```

CODE

```
  incidence.normalize();

  // detect and handle collision
  for (int i=0; i<coords.length; i++) {
    // check distance between ellipse and base top coordinates
    if (PVector.dist(position, coords[i]) < r) {

      // calculate dot product of incident vector and base top normal
      float dot = incidence.dot(normal);

      // calculate reflection vector
      // assign reflection vector to direction vector
      velocity.set(2*normal.x*dot - incidence.x, 2*normal.y*dot -
incidence.y, 0);
      velocity.mult(speed);

      // draw base top normal at collision point
      stroke(255, 128, 0);
      line(position.x, position.y, position.x-normal.x*100, position.y-
normal.y*100);
    }
  }

  // detect boundary collision
  // right
  if (position.x > width-r) {
    position.x = width-r;
    velocity.x *= -1;
  }
  // left
  if (position.x < r) {
    position.x = r;
    velocity.x *= -1;
  }
  // top
  if (position.y < r) {
    position.y = r;
    velocity.y *= -1;
    // randomize base top
    base1.y = random(height-100, height);
    base2.y = random(height-100, height);
    createGround();
  }
}


// Calculate variables for the ground
void createGround() {
  // calculate length of base top
  baseLength = PVector.dist(base1, base2);

  // fill base top coordinate array
  coords = new PVector[ceil(baseLength)];
  for (int i=0; i<coords.length; i++) {
    coords[i] = new PVector();
    coords[i].x = base1.x + ((base2.x-base1.x)/baseLength)*i;
    coords[i].y = base1.y + ((base2.y-base1.y)/baseLength)*i;
  }
}
```

Tickle

CODE

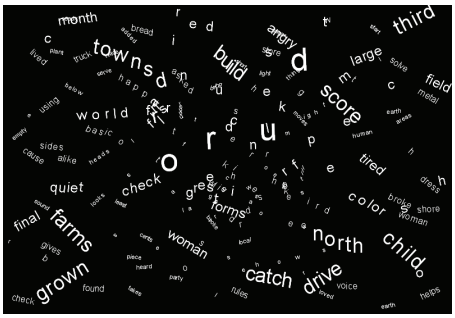



```
String message = "tickle";
float x, y; // X and Y coordinates of text
float hr, vr;  // horizontal and vertical radius of the text

void setup() {
  size(640, 360);

  // Create the font
  textFont(createFont("Georgia", 36));
  textAlign(CENTER, CENTER);

  hr = textWidth(message) / 2;
  vr = (textAscent() + textDescent()) / 2;
  noStroke();
  x = width / 2;
  y = height / 2;
}

void draw() {
  // Instead of clearing the background, fade it by drawing
  // a semi-transparent rectangle on top
  fill(204, 120);
  rect(0, 0, width, height);

  // If the cursor is over the text, change the position
  if (abs(mouseX - x) < hr &&
      abs(mouseY - y) < vr) {
    x += random(-5, 5);
    y += random(-5, 5);
  }
  fill(0);
  text("tickle", x, y);
}
```

```
/**
 * Tickle.
 *
 * The word «tickle» jitters when the cursor hovers over.
 * Sometimes, it can be tickled off the screen.
 */

// The next line is needed if running in JavaScript Mode with Processing.js
/* @pjs font=»Georgia.ttf»; */
```

Font Physics

CODE




```
import java.awt.geom.Line2D;

static final float wordRatio = 2.4; // approx ratio of string lenth to font size
static final int fontdepth = 5; // recursion depth for word creation

static final float G = -1.0; //change gravity
static final float cursor_mass = 10000000.; //mass of cursor
float damping = 2.5;

float max_length;

Letter[] letters; //array of the letters
Line2D[] lines; // text lines for intersections

static final char[] charset = {'a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'j', 'k', 'l', 'm', 'n', 'o', 'p', 'q', 'r', 's', 't', 'u', 'v', 'w', 'x', 'y', 'z' };

class Letter
{
  PVector p;
  PVector o;
  PVector dp;
  char letter;
  float fontsize;
  float theta;
  float mass;
  float k;
  Letter(PVector pos,PVector dpos,char letterval,float fontsizeval,float thetaval)
  {
    p = new PVector(pos.x,pos.y);
    o = new PVector(pos.x,pos.y);
    dp = new PVector(dpos.x,dpos.y);
    letter = letterval;
    theta = thetaval;
    fontsize = fontsizeval;
    //mass = fontsize/20.;
    mass = 1.;
    k = 10.;
  }
}

void setup()
{
  //size(600,600,P2D);
  //size(screen.width,screen.height,JAVA2D);
  size(800,550,JAVA2D);
  hint(ENABLE_NATIVE_FONTS);
  reset();
}

void keyPressed()
{
  if( key == ' ' ) {
    reset();
  } else if( key == '[' ) {
    damping *= 0.8;
  } else if( key == ']' ) {
    damping *= 1.2;
  }
}
```

CODE

```
void reset()
{
  max_length = min(width,height)/4.0;
  letters = new Letter[0];
  lines = new Line2D[0];
  textFont(createFont("Arial", max_length/wordRatio, true, charset));
  //textMode(SCREEN);
  textSize(24.0);
  text( "loading", (displayWidth - textWidth("loading"))/2.0,
(displayHeight - 24.0)/2.0);
  for(int i = 0; i < fontdepth; ++i) {
    float fontsize = (max_length*pow(0.66,i)/wordRatio);
    for(int j = 0; j < 10*i + 1; ++j) {
      boolean success = false;
      for(int t = 0;t < 100; ++t) {
        boolean thisTry = makeWord(fontsize);
        if( thisTry ) {
          success = true;
          break;
        }
      }
      if( !success ) {
        println("failed to make letter");
      }
    }
  }
  background(0);
}

boolean makeWord(float fontsize)
{
  textSize(fontsize);
  PVector pos = new PVector(random(width),random(height));
  String word = words[(int)random(words.length)];
  float theta = random(PI/2.0) - PI/4.0;
  float wlength = textWidth(word);
  PVector end = new PVector(pos.x + wlength*cos(theta), pos.y +
wlength*sin(theta));
  if( end.x < 0 || width < end.x || end.y < 0 || height < end.y ) {
    return false;
  }
  Letter[] newword = layoutWord(word, pos, fontsize, theta);
  Line2D[] newlines = new Line2D[4];
  float xoff = fontsize*cos(theta-HALF_PI);
  float yoff = fontsize*sin(theta-HALF_PI);
  newlines[0] = (Line2D) new Line2D.Float( pos.x, pos.y, end.x, end.y
);
  newlines[1] = (Line2D) new Line2D.Float( end.x, end.y, end.x +xoff,
end.y +yoff );
  newlines[2] = (Line2D) new Line2D.Float( end.x +xoff, end.y +yoff,
pos.x +xoff, pos.y +yoff);
  newlines[3] = (Line2D) new Line2D.Float( pos.x +xoff, pos.y +yoff,
pos.x, pos.y );

  for(int i = 0; i < lines.length; ++i) {
    for(int j = 0; j < 4; ++j) {
      if( newlines[j].intersectsLine(lines[i]) ) {
        return false;
      }
    }
  }
  letters = (Letter[])concat(letters, newword );
  lines = (Line2D[])concat(lines,newlines);
  return true;
}

float time = 0.0;
```

CODE

```
void draw()
{
  float dtime = millis()/1000.0 - time;
  time += dtime;
  calcAccel(dtime);
  calcMove(dtime);
  resetMatrix();
  background(0);
  fill(255);
  stroke(255);
  for(int i = 0; i < letters.length; ++i) {
    pushMatrix();
    translate(letters[i].p.x,letters[i].p.y);
    rotate(letters[i].theta);
    textSize(letters[i].fontsize);
    text(letters[i].letter,0,0);
    popMatrix();
  }
}

void calcAccel(float time)
{
  if( mousePressed ) {
    PVector mouse_p = new PVector((float)mouseX,(float)mouseY);
    float Gprime = G;
    if( mouseButton == RIGHT ) {
      Gprime *= -1;
    }
    for(int i = 0; i < letters.length; ++i) {
      PVector r = new PVector(letters[i].p.x, letters[i].p.y);
      r.sub(mouse_p);
      PVector d = new PVector(letters[i].p.x, letters[i].p.y);
      d.sub(letters[i].o);
      PVector accel = new PVector(r.x,r.y);
      accel.mult( Gprime*cursor_mass/max( pow(r.mag(),3.0), 250.0 )
);
      PVector tmp_1 = new PVector(d.x,d.y);
      tmp_1.mult( -letters[i].k/letters[i].mass );
      accel.add( tmp_1 );
      PVector tmp_2 = new PVector(letters[i].dp.x,letters[i].dp.y);
      tmp_2.mult( -damping/letters[i].mass );
      accel.add( tmp_2 );
      accel.mult( time );
      //println( str(accel.x) + str(accel.y) );
      letters[i].dp.add(accel);
    }
  } else {
    for(int i = 0; i < letters.length; ++i) {
      PVector d = new PVector(letters[i].p.x, letters[i].p.y);
      d.sub(letters[i].o);
      PVector accel = new PVector(d.x,d.y);
      accel.mult( -letters[i].k/letters[i].mass );
      PVector tmp_2 = new PVector(letters[i].dp.x,letters[i].dp.y);
      tmp_2.mult( -damping/letters[i].mass );
      accel.add( tmp_2 );
      accel.mult( time );
      letters[i].dp.add(accel);
    }
  }
}

void calcMove(float time)
{
  for(int i = 0; i < letters.length; ++i) {
    PVector tmp_3 = new PVector(letters[i].dp.x,letters[i].dp.y);
    tmp_3.mult(time);
    letters[i].p.add(tmp_3);
  }
}
```

CODE

```
Letter[] layoutWord(String word, PVector pos, float fontsize, float
theta)
{
  Letter[] newletters = new Letter[5];
  PVector cur_pos = new PVector(pos.x,pos.y);
  PVector zero = new PVector(0.0,0.0);
  for(int i = 0; i < 5; ++i) {
    Letter l = new Letter( cur_pos, zero, word.charAt(i), fontsize, theta
);
    newletters[i] = l;
    textSize(fontsize);
    float w = textWidth(word.charAt(i));
    cur_pos.x += w*cos(theta);
    cur_pos.y += w*sin(theta);
  }
  return newletters;
}

String[] words = {
  "which", "there", "their", "about", "would", "these", "other",
"words", "could", "write", "first", "water", "after", "where", "right",
"think", "three", "years", "place", "sound", "great", "again", "still",
"every", "small", "found", "those", "never", "under", "might",
"while", "house", "world", "below", "asked", "going", "large",
"until", "along", "shall", "being", "often", "earth", "began", "since",
"study", "night", "light", "above", "paper", "parts", "young",
"story", "point", "times", "heard", "whole", "white", "given",
"means", "music", "miles", "thing", "today", "later", "using",
"money", "lines", "order", "group", "among", "learn", "known",
"space", "table", "early", "trees", "short", "hands", "state", "black",
"shown", "stood", "front", "voice", "kinds", "makes", "comes",
"close", "power", "lived", "vowel", "taken", "built", "heart", "ready",
"quite", "class", "bring", "round", "horse", "shows", "piece",
"green", "stand", "birds", "start", "river", "tried", "least", "field",
"whose", "girls", "leave", "added", "color", "third", "hours",
"moved", "plant", "doing", "names", "forms", "heavy", "ideas",
"cried", "check", "floor", "begin", "woman", "alone", "plane",
"spell", "watch", "carry", "wrote", "clear", "named", "books",
"child", "glass", "human", "takes", "party", "build", "seems",
"blood", "sides", "seven", "mouth", "solve", "north", "value",
"death", "maybe", "happy", "tells", "gives", "looks", "shape",
"lives", "steps", "areas", "sense", "speak", "force", "ocean",
"speed", "women", "metal", "south", "grass", "scale", "cells",
"lower", "sleep", "wrong", "pages", "ships", "needs", "rocks",
"eight", "major", "level", "total", "ahead", "reach", "stars", "store",
"sight", "terms", "catch", "works", "board", "cover", "songs",
"equal", "stone", "waves", "guess", "dance", "spoke", "break",
"cause", "radio", "weeks", "lands", "basic", "liked", "trade",
  "fresh", "final", "fight", "meant", "drive", "spent", "local", "waxes",
"knows", "train", "bread", "homes", "teeth", "coast", "thick",
"brown", "clean", "quiet", "sugar", "facts", "steel", "forth", "rules",
"notes", "units", "peace", "month", "verbs", "seeds", "helps",
"sharp", "visit", "woods", "chief", "walls", "cross", "wings", "grown",
"cases", "foods", "crops", "fruit", "stick", "wants", "stage", "sheep",
"nouns", "plain", "drink", "bones", "apart", "turns", "moves",
"touch", "angle", "based", "range", "marks", "tired", "older",
"farms", "spend", "shoes", "goods", "chair", "twice", "cents",
"empty", "alike", "style", "broke", "pairs", "count", "enjoy", "score",
"shore", "roots", "paint", "heads", "shook", "serve", "angry",
"crowd", "wheel", "quick", "dress", "share", "alive", "noise", "solid",
"cloth", "signs", "hills", "types", "drawn", "worth", "truck", "piano",
"upper", "loved", "usual", "faces", "drove", "cabin", "boats",
"towns", "proud"
};
```