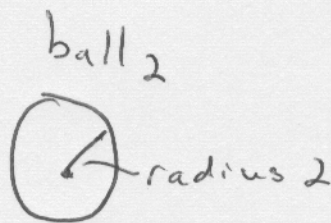
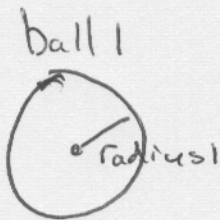


Solving the quadratic equation
for frame independent circle-circle
collision detection.



x_{mov1}] speeds of
 y_{mov1}] ball 1

x_{mov2}] speeds of
 y_{mov2}] ball 2

$$x_1 = x_{l1} + x_{mov1} \cdot t$$

$$y_1 = y_{l1} + y_{mov1} \cdot t$$

$$x_2 = x_{l2} + x_{mov2} \cdot t$$

$$y_2 = y_{l2} + y_{mov2} \cdot t$$

Position Equations

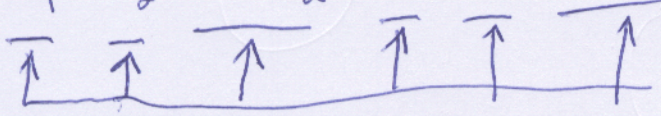
$$\text{distance} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad \text{distance equation}$$

$$\text{distance} = r_1 + r_2 = R$$

we define R as the sum of the radii

$$R^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$$

$$R^2 = x_1^2 + x_2^2 - 2x_1x_2 + y_1^2 + y_2^2 - 2y_1y_2$$



calculate each term

$$x_1^2 = x_{l1}^2 + x_{mov1}^2 \cdot t^2 + 2x_{l1}x_{mov1}t$$

$$x_2^2 = x_{l2}^2 + x_{mov2}^2 \cdot t^2 + 2x_{l2}x_{mov2}t$$

$$y_1^2 = y_{l1}^2 + y_{mov1}^2 \cdot t^2 + 2y_{l1}y_{mov1}t$$

$$y_2^2 = y_{l2}^2 + y_{mov2}^2 \cdot t^2 + 2y_{l2}y_{mov2}t$$

$$-2x_1x_2 = -2(x_{l1} \cdot x_{l2} + x_{l1}x_{mov2} \cdot t + x_{l2} \cdot x_{mov1} \cdot t + x_{mov1} \cdot t \cdot x_{mov2} \cdot t)$$

$$= (-2x_{mov1} \cdot x_{mov2})t^2 + (-2x_{l1}x_{mov2} - 2x_{l2}x_{mov1})t - 2x_{l1} \cdot x_{l2}$$

$$-2y_1y_2 = (-2y_{mov1} \cdot y_{mov2})t^2 + (-2y_{l1}y_{mov2} - 2y_{l2}y_{mov1})t - 2y_{l1} \cdot y_{l2}$$

Define a bunch of constants (that means no 't' in it)

$$a = -2x_{mov1} \cdot x_{mov2} + x_{mov1}^2 + x_{mov2}^2$$

$$b = -2x_{l1} \cdot x_{mov2} - 2x_{l2} \cdot x_{mov1} + 2x_{l1} \cdot x_{mov1} + 2x_{l2} \cdot x_{mov2}$$

$$c = -2x_{l1} \cdot x_{l2} + x_{l1}^2 + x_{l2}^2$$

$$d = -2 \gamma m v_1 \cdot \gamma m v_2 + \gamma m v_1^2 + \gamma m v_2^2$$

$$e = -2 \cdot \gamma m v_2 - 2 \cdot \gamma l_2 \cdot \gamma m v_1 + 2 \cdot \gamma l_1 \cdot \gamma m v_1 + 2 \cdot \gamma l_2 \cdot \gamma m v_2$$

$$f = -2 \gamma l_1 \cdot \gamma l_2 + \gamma l_1^2 + \gamma l_2^2$$

$$g = a + d$$

$$h = b + e$$

$$k = c + f - R^2$$

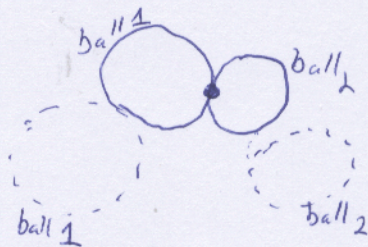
adding all of the terms and using these constants we get,

$$g \cdot t^2 + h \cdot t + k = 0$$

$$t = \frac{-h \pm \sqrt{h^2 - 4 \cdot g \cdot k}}{2 \cdot g}$$

time 1

initial contact



Time 2

final contact

