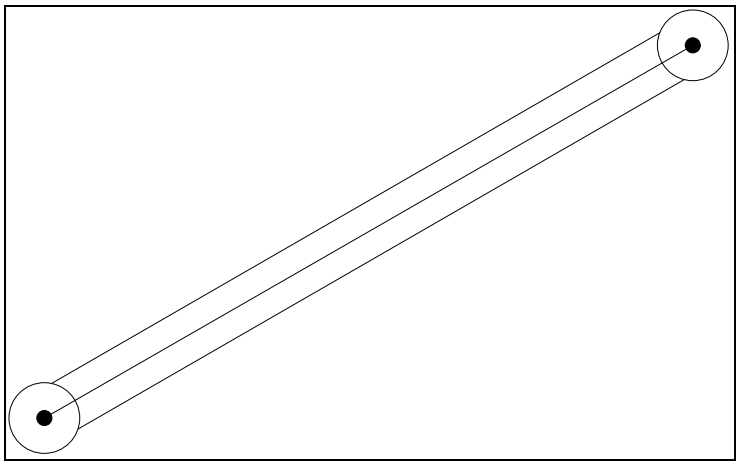
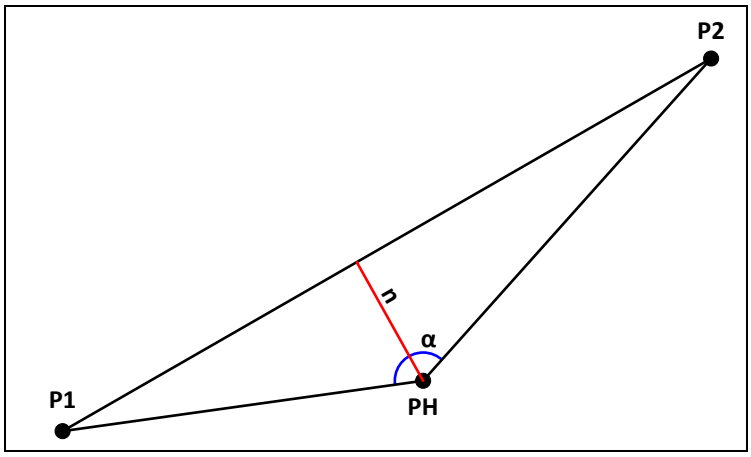
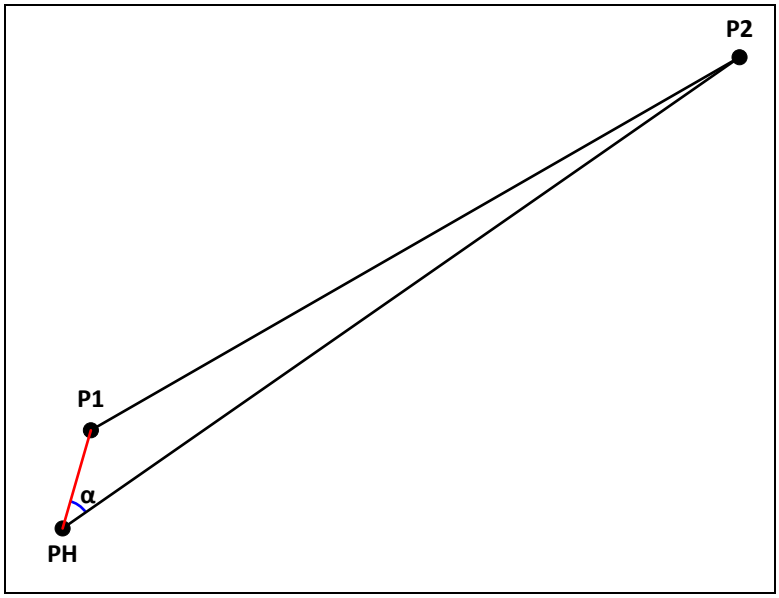


Picture 1



Picture 2



Picture 3

So, the principle is easy, we model the Arm with the Endpoints as two points (P1 and P2) with a line (see picture 1). The middle of the head is represented as the point PH. A collsision is detected, as

soon as the distance between the middle of the head and the robot arm is smaller than (half of the radius of the head + the half of the diameter of the robot + safety tolerance). There can be two scenarios: Either the head point (PH) is between the two points (picture 2) or it is outside (picture 3). For scenario 1, we calculate the distance between the head point and the connection between P1 and P2 (which is normal to the distance). For scenario 2 we calculate the distance between the head point and P2 and P1 and check for each distance if they are big enough.

To distinguish between scenario 1 and 2 we look at the angular between the line (PH-P1) and line (PH-P2). As soon as the angular is bigger than 90°, we have scenario 1. If the angular is smaller than 90°, we have scenario 2.

```
L  = p2-p1;
L  = L./norm(L);

s1 = ph-p1;
s2 = ph-p2;
n1 = norm(s1);
n2 = norm(s2);
s1norm = s1./n1;
s2norm = s2./n2;

angle  = acosd(dot(s1norm,s2norm));

if (angle <= 90)
    if(min([n1;n2]) < minDistJoint)
        collision = true;
```