2/15/2012 Ether

Launch distance, height, and angle equations.

Ignoring air friction and magnus effect, solve for all variables:

h: vertical height of hoop above the launch point
(=hoopHeightFromFloor-launchHeightFromFloor)

d: horizontal distance from launch point to hoop

v: launch speed

a: launch angle

g: acceleration due to gravity (remember, this is negative)

Equation q1 is taken from
wired.com/wiredscience/2012/01/projectile-motion-primer-for-first-robotics

```
(%i1) kill(all)$
      q1: h=d*tan(a)+(g*d^2)/(2*v^2*(cos(a))^2);
      qv: solve(q1,v)[2];
      solve(q1,d)[2]$ trigsimp(%);
```

(%o1) $$h=\frac{d^2\,g}{2\,\cos(a)^2\,v^2}+\tan(a)\,d$$

(%o2) $$v=\frac{d\sqrt{\frac{g}{h-\tan(a)\,d}}}{\sqrt{2}\,\cos(a)}$$

(%o4) $$d=\frac{\cos(a)\,v\sqrt{\sin(a)^2\,v^2+2\,g\,h}-\cos(a)\sin(a)\,v^2}{g}$$

```
(%i5) subst([tan(a)=p,cos(a)=1/sqrt(1+p^2)],qv);
      %^2;
      solp: solve(%,p);
      a1 = atan(rhs(solp[1]));
      a2 = atan(rhs(solp[2]));
```

(%o5) $v=\frac{d\sqrt{p^2+1}\sqrt{\frac{g}{h-d\,p}}}{\sqrt{2}}$

(%o6) $v^2=\frac{d^2\,g\,(p^2+1)}{2\,(h-d\,p)}$

(%o7) $[p=-\frac{\sqrt{v^4+2\,g\,h\,v^2-d^2\,g^2}+v^2}{d\,g},p=\frac{\sqrt{v^4+2\,g\,h\,v^2-d^2\,g^2}-v^2}{d\,g}]$

(%o8) $a1=-\mathrm{atan}\left(\frac{\sqrt{v^4+2\,g\,h\,v^2-d^2\,g^2}+v^2}{d\,g}\right)$

(%o9) $a2=\mathrm{atan}\left(\frac{\sqrt{v^4+2\,g\,h\,v^2-d^2\,g^2}-v^2}{d\,g}\right)$