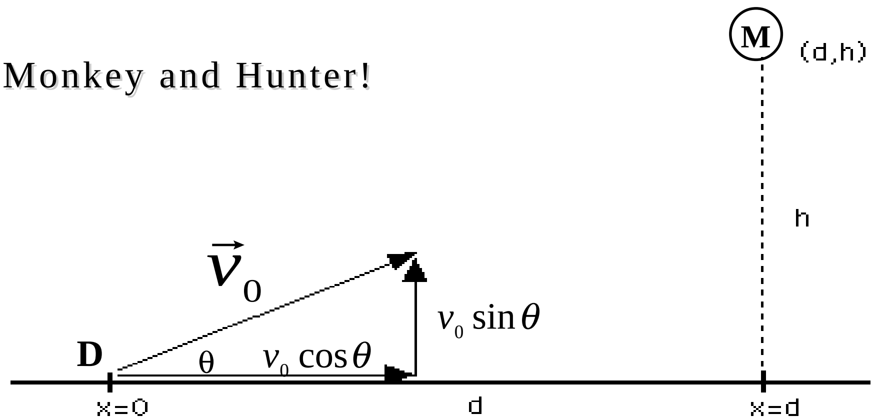
The Monkey and Hunter!



(Using the level of the gun as ground level or y=0m)

$$\begin{cases} x_D = (v_0 \cos\theta)t \\ y_D = -4.9t^2 + (v_0 \sin\theta)t \end{cases} \qquad \begin{cases} x_M = d \\ y_M = -4.9t^2 + h \end{cases}$$

Now when the dart has traveled a distance of "d", we want the y - coordinate of the dart to exactly match the y - coordinate of the falling monkey. That is, we need,

$$y_D = y_M \qquad \text{when} \qquad x_D = x_M$$

$$-4.9t^2 + (v_0 \sin\theta)t = -4.9t^2 + h \quad \text{when} \quad (v_0 \cos\theta)t = d$$

Solving these two equations isn't bad at all! The $-4.9t^2$ terms cancel out and we can solve for 't' in the 2nd equation and...

$$(v_0 \sin\theta)[t] = h \qquad \text{when} \qquad t = \left[\frac{d}{v_o \cos\theta}\right]$$

The plan here is to substitute the 't' on the right for the left [t]. Then the only remaining variables will be v_0 (dart's initial speed which we can't control!) and θ (the angle we need to aim the gun at which we hope will solve the problem!)

$$(v_0 \sin\theta)\left[\frac{d}{v_o \cos\theta}\right] = h \quad \text{but! notice how the } v_0\text{'s cancel!}$$

yielding... $\tan\theta = h/d$ or for trig students... $\theta = Tan^{-1}(h/d)$

but a closer look at the original diagram indicates the solution to the Monkey and Hunter Problem it to aim right at the monkey. The dart will fall off that straight line path by the same amount that the monkey will drop, namely $4.9t^2$ meters!