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Engineer's Computation Pad
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••41 GO Upon spotting an insect on a twig overhanging water, an archer fish squirts water drops at the insect to knock it into the water (Fig. 4-38). Although the fish sees the insect along a straight-line path at angle ϕ and distance d, a drop must be launched at a different angle θ_0 if its parabolic path is to intersect the insect. If $\phi = 36.0°$ and $d = 0.900$ m, what launch angle θ_0 is required for the drop to be at the top of the parabolic path when it reaches the insect?

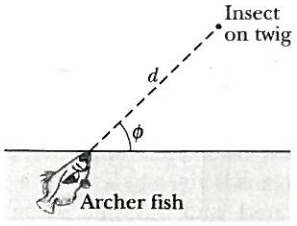
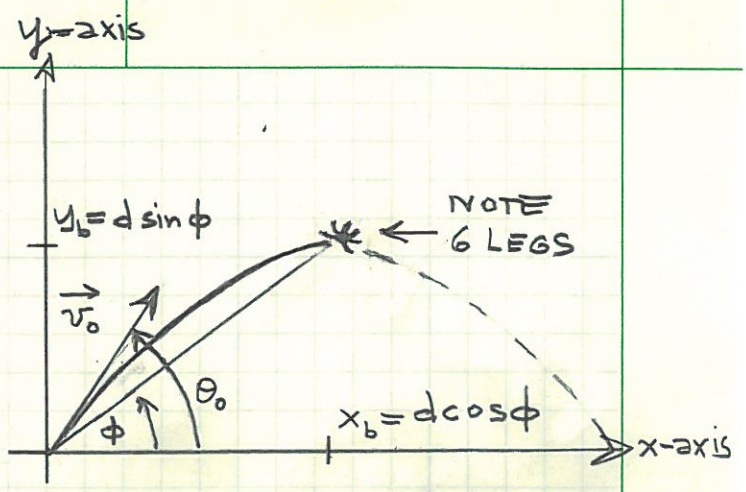


Fig. 4-38 Problem 41.



THERE ARE 3 POSSIBILITIES FOR THE FISH TO SPIT ON THE INSECT:
THE SPIT COULD HIT THE INSECT ON ITS WAY UP TO TOP OF TRAJECTORY
OR IT COULD HIT IT ON ITS WAY DOWN FROM TOP OF TRAJECTORY
THIS QUESTION HAS IT HIT THE INSECT AT THE TOP OF TRAJECTORY

FIND TIME FOR SPIT TO GO UP VIA $v_y = v_{0y} - g t_{up} \equiv 0$ (since v_y must be 0 at the top)

$\Rightarrow t_{up} = v_{0y}/g = v_0 \sin\theta_0 / g$

$\vec{r}_{SPIT}(t_{up}) = \vec{r}_{BUG} \Rightarrow \vec{r}_{0s} + \vec{v}_{0s} t_{up} + \frac{1}{2}\vec{g} t_{up}^2 = \vec{r}_{BUG}$

$\Rightarrow x_{SPIT}(t_{up}) = x_{BUG}$: $0 + v_{0x} t_{up} + \frac{1}{2}(g_x = 0) t_{up}^2 = x_{BUG}$

$v_0 \cos\theta_0 \, t_{up} = d\cos\phi \Rightarrow v_0 \cos\theta_0 [v_0 \sin\theta_0 / g] = d\cos\phi$

$|E_q^n x\rangle \quad \sin\theta_0 \cos\theta_0 = dg\cos\phi / v_0^2$

$\Rightarrow y_{SPIT}(t_{up}) = y_{BUG}$: $0 + v_{0y} t_{up} + \frac{1}{2}(g_y = -g) t_{up}^2 = y_{BUG}$

$v_0 \sin\theta_0 \, t_{up} - \frac{1}{2} g t_{up}^2 = d\sin\phi = v_0 \sin\theta_0 \left(\frac{v_0 \sin\theta_0}{g}\right) - \frac{1}{2} g \left(\frac{v_0^2 \sin^2\theta_0}{g^2}\right)$

$|E_q^n y\rangle \quad \sin^2\theta_0 = 2gd\sin\phi / v_0^2$

(x & y components of vector eq'n)

DIVIDING $|E_q^n y\rangle / |E_q^n x\rangle \Rightarrow \tan\theta_0 = 2\tan\phi$

$\phi = 36° \Rightarrow \theta_0 = \tan^{-1}[2\tan 36°] = 55.5°$

$|E_q^n x\rangle \Rightarrow v_0 = \sqrt{dg\cos\phi / (\sin\theta_0 \cos\theta_0)} = 3.91$ m/s

$|E_q^n y\rangle \Rightarrow v_0 = \sqrt{2gd\sin\phi / \sin^2\theta_0} = 3.91$ m/s