Aiming a Projectile at an Aircraft

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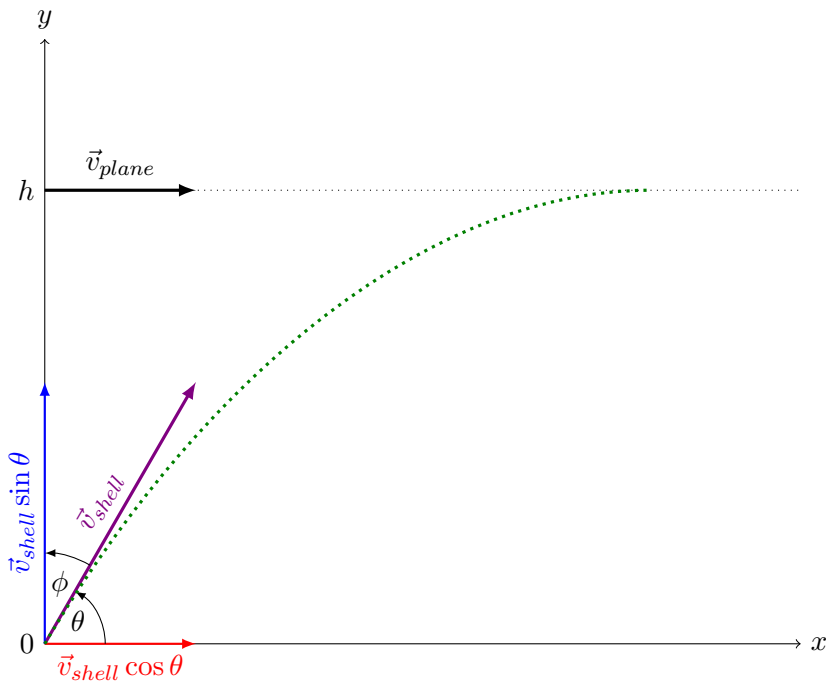
Question A shell is fired from a gun with initial velocity $\vec{v}_{shell}$, at an elevation θ. What value of θ should be chosen such that the shell hits an aircraft cruising at an altitude h, directly overhead the gun when the shell is to be fired, and travelling at a constant velocity $\vec{v}_{plane}$?



Solution Considering motion along the x-axis, clearly the velocity of the shell must equal the velocity of the aircraft for their positions to coincide. Thus:

$$\vec{v}_{plane} = \vec{v}_{shell} \cos\theta$$

$$\boxed{\theta = \cos^{-1}\left(\frac{\vec{v}_{plane}}{\vec{v}_{shell}}\right)}$$