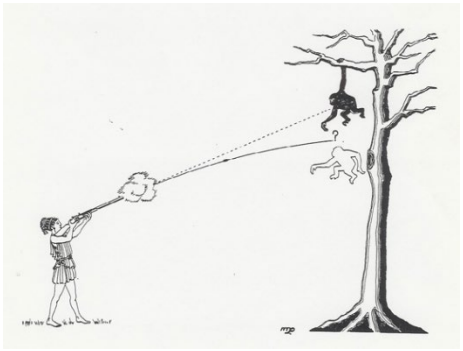
The Monkey and the Hunter



Please show all work, even that which you may consider to be "common sense".

In this exercise, we are going to practice our projectile motion in 2D by attempting a physics problem that has been around for as long as people have been teaching physics (or hunting monkeys). This physics problem comes with a story. While the story may vary from class to class, they mainly go something like this…

A hunter was walking through the jungle looking for a monkey to shoot (don't worry, it's a tranquilizer gun). The hunter finally came upon a monkey in a tree. The hunter raised his tranquilizer gun and aimed directly at the monkey's belly and prepared to fire.

Meanwhile, the monkey is minding its own business…you know… doing monkey things…when it notices the hunter hiding in the bushes aiming his weapon. The monkey (who previously failed physics 11) had a plan! The second the hunter pulled the trigger the monkey would release its grip from his branch and fall harmlessly out of the path of the bullet.

The hunter, who has tranquilized many a monkey, considers that the sound of his gun may startle the monkey and cause it to fall out of the tree. The hunter considers changing his aim. The hunter can choose to 1. Continue aiming directly at the monkey 2. Aim above the monkey 3. Aim below the monkey.

Part 1: Prediction

Assuming the monkey does fall/jump out of the tree the instant the gun is fired, where do you think the hunter should aim (at, above, or below)? Explain your choice.

Part 2: The Scenario

The monkey is in a tree 70.0 m above the ground. The hunter is hidden 40.0 m away from the tree. He aims directly at the monkey and fires his tranquilizer dart with a velocity of 40.0 m/s. The monkey sees the hunter pull the trigger and drops out of the tree the instant the dart is fired.

1. **Draw/Sketch a labeled diagram that represents this scenario**

2. **At what angle above the horizontal has the hunter taken his shot? (keep all digits of your answer)**

3. **What are the initial vertical and horizontal velocities of the dart? (all digits of your answer)**

4. **How long does it take the dart to cover the horizontal distance to the monkey? (keep all digits of your answer)**

5. **What is the vertical displacement of the dart after x seconds? Where x is the time found in question 4? (You may round your answer to 3 sig figs)**

6. **Assuming the monkey falls straight down from the tree the instant the gun is fired, what is the monkey's displacement (vertically) after x seconds, where x is the time found in question 4? (keep all your digits)**

7. **Does the monkey get hit by the dart? Provide evidence using math (you may round to 3 sig figs)**

8. **What effect do you think a faster initial velocity of the bullet will have in this situation?**

Part 3: The Conclusion

Based on your calculations, in scenarios such as these where someone is aiming a projectile and an object that begins falling the moment the projectile is launched (carnival games, competitive shooting), where should the "hunter" aim? Why? (What properties of nature/physics are causing our observation?

***Super mega bonus**:*

Prove using algebra alone (rearranging formula, substituting equations, etc.) that in these scenarios the final position of the "bullet" will always be equal to the final position of the monkey when the bullet is fired at a velocity V_i at angle ϑ above the x axis and the monkey falls from a an initial height h the instant the gun is fired.

Hint: $\sin\vartheta / \cos\vartheta = \tan\vartheta$