Teacher notes
Topic A

Independence of horizontal and vertical motion

We saw how the use of a different reference frame greatly simplifies the solution to a problem. Here is another example. Ball X is projected horizontally from a tower with velocity *v*. At the same time an identical ball Y is dropped from rest from a tower of the same height. Which ball reaches the ground first?

We know that they will hit the ground at the same time. But how do we understand this conceptually without the use of equations?

Imagine that we look at things from the point of view of an observer other than the one at rest on the ground. Namely, consider the reference frame that moves with velocity v . For this observer ball X has no horizontal velocity. Ball Y has velocity $-v$. So, for this observer the situation looks like:

The situation has been completely reversed. It is then obvious that the times of fall are the same. Explicitly, if X took longer to fall in the first diagram, then Y would take longer in the second diagram. But the two situations are identical, they are just looked at from a different point of view (reference frame). The only way to avoid the contradiction is to deduce that X and Y take the same time to fall. Then both diagrams give the same result as they should.

You can perhaps see this even more simply if you use a reference frame that moves with velocity $\frac{v}{2}$. Then, for this observer the situation is given by this diagram:

It is now completely obvious that the fall times are the same since the motions of X and Y are identical.