

## Light and Projectiles

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There has been unfortunately a mistake made with how projectiles have been mathematically modelled; it is a subtle problem and has carried over into our treatment of light. The way that the mathematical model has been applied to physical observations has been incorrect, i.e. a mistake made by many using the mathematical modelling process.

### 1. Standard Projectile motion in gravity

Gun -----→ projectile

Fig 1

In fig. 1 a gun shoots a projectile. If there is gravity then the projectile falls. Also if there is air resistance the speed of the projectile decreases. Fig 1 represents straight-line motion of the projectile from the gun without any factors affecting that motion; i.e. it is the idealised case of no external forces acting on the projectile causing it to deviate from its constant velocity (call it  $v_1$ ).

---→ x  
|  
V y  
  
-----→  $v_1$

Fig 2

In this fig 2 we show this velocity  $v_1$  of fig1, and we decide to have the x and y coordinates as per shown.

In the next idealised case we wish to consider, let us only have in the y direction in addition to what is fig 1, let that velocity be  $v_2$  and by Newton's equations of motion

for a gravitational acceleration of  $g$  in time interval  $t$  then  $v_2 = gt$ . We can then form fig 3:

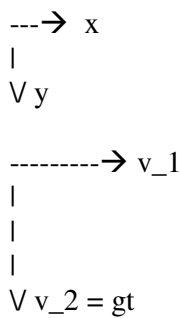


Fig 3

By Pythagoras's theorem we can form a third velocity  $v_3$  thus:

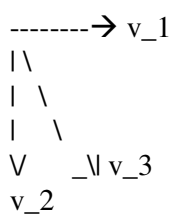


Fig 4

Where  $v_3^2 = v_1^2 + v_2^2$ .

This is the normal way that projectiles in the idealised case of only motion due to that of the projectile and gravity is presented in the usual texts on physics.

What we have is a mathematical model here and we want to apply it to physical observations of this scenario. We do this by trying to compensate as much as possible for factors such as air which would cause deviation from this idealisation.

That is okay up to here – the mathematical model being made to fit with physical observations by experiment.

But now a subtle problem arises that is often overlooked as follows-

In fig 1 where we shoot a projectile in the idealised scenario of no influences causing the projectile to deviate from straight line constant velocity motion; the question is – did we actually match that to a physical observation scenario? And the answer is a surprising “no” for most times that this has been approached by the experimentalist.

Instead of obtaining  $v_1$  from the idealised scenario of fig2 and fig 1, the experimentalists have gone straight to fig 3, and from fig 3 have worked out what fig 2 should be.

This is in fact wrong; a mess has been made from matching experiment with the idealised mathematical model.

The skilled experimentalist believing himself matching the mathematical models of fig 1, 2 and 3 with his experimental observations makes a fundamental mistake by jumping from experiments dealing with fig 1 (and 2) straight to fig 3.

The mistake is extremely subtle, by jumping straight to fig 3, he is not in fact really obeying fig 3; he thinks he is obeying fig 3 but is in fact deceived; i.e. he has deceived himself.

It is such a subtle problem, that I will re-do the calculation:

## 2.The error of the first derivation

Fig 1 and fig 2 remain the same for the idealised scenario of a projectile only experiencing constant velocity:

Gun -----→ projectile

Fig 1

And:

$\text{---}\rightarrow x$   
 $|$   
 $\vee y$   
  
 $\text{-----}\rightarrow v_1$

Fig 2

Instead of fig 3 and 4 we now have fig 5

$\text{-----}\rightarrow v_A$   
 $| \setminus$   
 $| \setminus$   
 $| \setminus$   
 $\vee \quad \_ \vee v_1$   
 $v_2$

Fig 5

Where the experimentalist (of the first calculation) has deceived himself that  $v_A$  of fig 5 equals  $v_1$  of fig2; when in fact the  $v_1$  is really the hypotenuse of this triangle fig 5.

There is nothing wrong with the maths of section (1); it is just that when it came to applying the mathematical model of section (1) to actual experiments it was done incorrectly.

And the actual mathematical model the experimentalist was using was section (2) but mistaking it for section (1) mathematical model.

### 3. The correct approach explained

To recap the correct figures are fig 2 and fig 5.

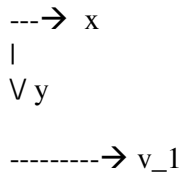


Fig 2

And:

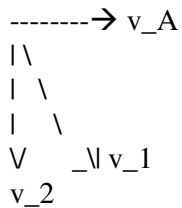


Fig 5

From fig 5 we have  $v_A^2 = v_1^2 + v_2^2$

When  $v_2 = 0$  as in the no gravity case of fig 2 then:

$$v_A = v_1 \text{ (when } v_2 = 0)$$

In other cases  $v_A$  does not equal  $v_1$ .

Thus a projectile from a gun when falling under gravity has its velocity of  $v_1$  directed as per fig 5.

If we had the made the experimental observation from fig 1 with measuring the velocity of the projectile in the idealised case of no gravity, no air resistance and other factors then that velocity would have been carried over into fig 4 when the experimentalist did his observations in that scenario. But that scenario was not what the experimentalist did, instead he did as per section (2).

#### **4. Light and projectiles**

The mistake that has been made with projectiles from guns has been carried over into the context of when considering light under the influence of gravity. Light obeys the same method as that of projectiles as per section (3). When  $v_1$  in the case of light is  $v_1 = c$ , instead of the mistaken approach of taking  $v_A = c$ .

This issue picked up further at: <http://www.wbabin.net/science/anderton15.pdf>

c.RJAnderton2008



