Gravitation - Lesson 3
Independence of Horizontal and Vertical Velocity

We have all played with stones, and we throw them up in the air for fun. We know that the stone falls back to the surface of the earth. We have also seen how the stone, when thrown forward, falls back after covering some horizontal distance, i.e., the stone goes ahead and also falls. Now, there is a fact hidden in these two scenarios, the amount by which the stone falls is the same in both the cases or specifically, if you used the same initial conditions (namely, the initial vertical velocity) in throwing both the objects, it would hit the surface of the earth at the same time.

If you throw a stone up vertically and it takes 10 seconds to fall, if you threw the same stone at an angle with the same vertical velocity, it will also take 10 seconds to hit the surface of the earth. The only difference is that you can catch the stone wherever you were standing when you threw the stone in the first case, but in the second case, you need to run forward to at least have a chance of catching it. We can reverse this fact and say that a stone will fall a constant distance (we will calculate this later) in constant period of time, no matter how it is thrown!

You should, now, be able to answer the following questions:

1. Consider a scenario where two marbles hit the ground at the same time, falling from the same height. Also, they started to fall at the same instance. If the first marble started with a vertical velocity of 2 $m\ s^{-1}$ and a horizontal velocity of 0 $m\ s^{-1}$, what was the vertical velocity of the second marble, given that its horizontal velocity was 2 $m\ s^{-1}$?
2. In the above scenario, the first marble fell 20 *m* in the first 2 *s*. How much distance did the second marble cover in its first 2 *s* of fall?

Conclusion

Objects will fall at the same rate if the initial vertical velocity is kept the same.

Note to Teacher

This lesson tries to throw light on the fact that horizontal and vertical velocity of an object are never ineter-related, they are always independent. And this is case in the whole universe, it dosen't, in any way, conform only to earth. Although, this is non-trivial and may not be a part of the syllabus, it helps to understand the way components of velocity work. This will set the tone for the upcoming lessons.

Student Worksheet

1. Under what condition will two objects hit the surface at the same time?
2. If we add a horzontal velocity, i.e., if we throw the object forward, will the above be true?
3. What can you say about the vertical distance travelled by them at each instance of time?

Answers

1. As both the marbles were falling from the same height, their vertical velocities must be for them to hit the ground at the same instance. Hence, the vertical velocity of the second marble was 2 $m\ s^{-1}$.
2. As both the marbles have identical vertical velocity, they will the same amount of distance, i.e., 20 m in the first 2 s.

Student Worksheet Answers

1. Under the conditon that their vertical velocity is same.
2. Yes
3. The objects with same vertical velocity will traverse the same amount of distance in a given time. This means that at every instance, the objects will have covered the same vertical distance.