Phenomenon# 2 مشاہدہ #۲

When Things Are Thrown

جب چیزیں پھینکی جاتی ہیں

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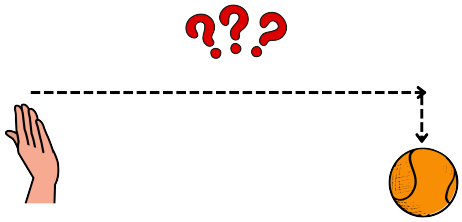
Have you ever noticed that when you throw a ball, it always makes a curved path in the air? It goes forward because of your throw and falls down because of gravity, but why doesn't the ball just go straight and then all of a sudden drop down?

کسی بھی گیند کو پھینک کر دیکھئیے، یہ ہمیشہ محراب (arch) کیوں بناتی ہے ؟مانا کہ یہ ہماری سیدھی سمت میں لگی طاقت کی وجہ سے سیدھی جاتی ہے اور کشش ثقل (gravity) کی وجہ سے نیچے گرتی ہے لیکن ایسا بھی تو ہو سکتا ہے کہ یہ بالکل سیدھی جا کر ایک دم ہی نیچے گر جائے؟



This arched path is called a projectile. Let's observe and understand what it is! Throw the ball and make a video of it. By analyzing the graph of the ball's position and velocity in the air, we will see what are the factors that cause it to land in an arch shaped way.

اس محراب دار راستے کو عام طور پر پروجیکٹائل کہتے ہیں۔ چلیں مشاہدہ کر کے دیکھیں اور سمجھیں کے یہ کیا ہے ! گیند کو پھینک کر اسکی ویڈیو بنائیں۔ ہوا میں گیند کی پوزیشن اور رفتار کے گراف کا تجزیہ کر کے دیکھیں کہ آخر وہ کونسے ایسے عوامل ہیں جن کی وجہ سے اسکی اُترن محراب کی صورت ہو جاتی ہی۔

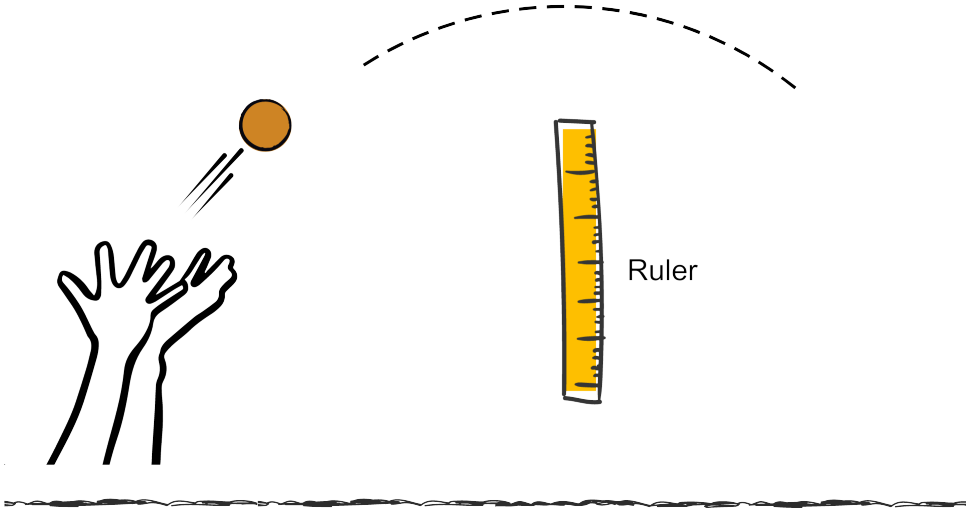
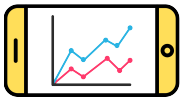


Figure 1: Release the ball from the left hand side. Set a calibration reference (ruler). Maintain a plain and contrasting background to easily track the movement of the ball.

Let's make sure we have everything we need to perform as shown in Fig. 1.

1. A ruler (calibration reference)
2. A ball

Video Analysis



Set up your camera, and press record. Make sure the camera frame covers the ball's movement. Open the Tracker or PhysTrackX software and upload the video you have recorded.

1. Set start and end frames.
2. Calibrate the video and set the axis origin to the center of the ball.
3. Use Auto-Tracker to track the ball.
4. Make four plots. We will analyse:
   (a) x: Position – x component for the first graph
   (b) y: Position - y component for the second graph
   (c) v_x: Velocity – x component for the third graph
   (d) v_y: Velocity – y component for the fourth graph
5. Finally, we will look into how the energies possessed by the ball change.

For understanding the graphs, we first need to learn that everything experiencing projectile motion, moves both vertically and horizontally. These motions are independent of each other. Their combined effect produces the path of the object.

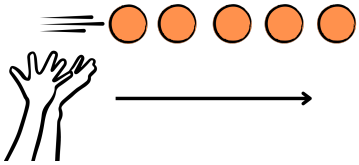


Figure 2: Horizontal

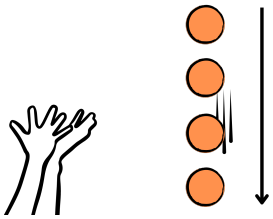


Figure 3: Vertical

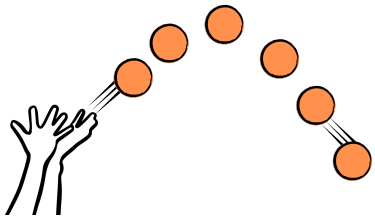


Figure 4: Combined

Figure 5: Motion component distribution of an object in theorem

When you throw a ball in the air, it's horizontal motion continues at constant speed while the vertical motion is continuously influenced by gravity. This is why when you throw a ball, it follows a parabolic trajectory (an arch shaped path) instead of moving straight and then abruptly falling.

کیا آپ زور مرہ زندگی سے دو مشاہدات
کے بارے میں لکھ سکتے ہیں جن میں
پروجیکٹائل حرکت استعمال ہو

مزے کا مشاہدہ

فیلڈر کو گیند پکڑنے کیلئے پروجیکٹائل
حرکت کا اندازہ ہونا چاہیے۔

What does the data say?

[Q 1]. Plot the four kinds of graphs and compare your plots with expected positions and speeds. Remember these formulas.

Position versus time is:

$$x(t) = v_{ix}t + \frac{1}{2}a_x t^2 \tag{1}$$

$$y(t) = v_{iy}t + \frac{1}{2}a_y t^2 \tag{2}$$

and speed versus time is:

$$v_x(t) = v_{ix}t + a_x t \tag{3}$$

$$v_y(t) = v_{iy}t + a_y t \tag{4}$$

where the variables are defined in this table 1.

$x(t)$	position in the horizontal direction
$y(t)$	position in the vertical direction
$v_x(t)$	speed in the horizontal direction
$v_y(t)$	speed in the vertical direction
$a_x(t)$	acceleration in the horizontal direction
$a_y(t)$	acceleration in the vertical direction

Table 1: Variables for the kinematic equations.

[Q 2]. Analyse your working and deduce the acceleration in each dimension.

What do you think about the energies possessed by the ball that affects it's overall behaviour? Let's focus on the two kinds of energies, kinetic and potential. Plot the graph of kinetic energy

$$K = \frac{mv^2}{2} \tag{5}$$

and observe how it changes over time. Remember you would need to measure the ball's mass.

[Q 3]. How does the kinetic energy change with time?

Because we know that kinetic energy can not just vanish or appear from thin air, we will now look at the potential energy. Plot the potential energy too whose value is given by

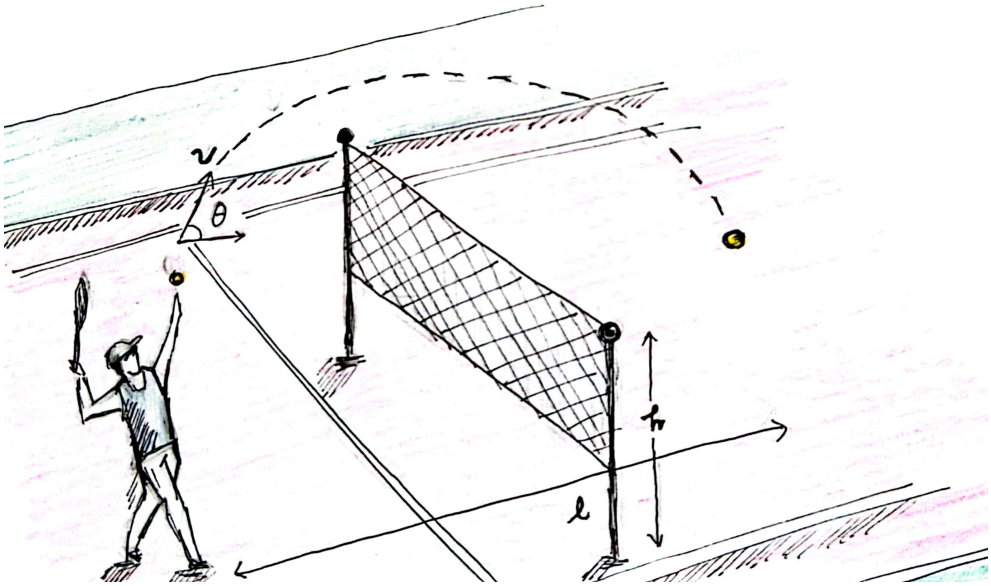
$$V = mgh \tag{6}$$

where m= mass of the ball, g = acceleration, h = height. In our case, this is the variable y.

[Q 4]. Analyse how the energy changes throughout the flight of the ball. Can you describe the potential energy change?

[Q 5]. Now plot both of these energies $K + V$ together. What do you observe? Is energy conserved?

ذرا سوچیں



(تصویر بشکریہ منیبہ فاطمہ)

بیڈمنٹن کے کھلاڑی کو کس زاویے (θ) اور کس رفتار (v) سے چڑیا کو ضرب دینی ہو گی کہ وہ (h) کی بلندی بھی پار کرے اور (l) کی دوری پہ گر جائے؟