Phenomena# 3

مشاہدہ #۳

Down an Inclined Surface

مائل سطح سے نیچے گرنا

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August 24, 2024

Common objects around you are made with very precise measurements. Now look at the slide in the park, there are many factors involved in its design, like what happens if you lower the angle or increase the height? Will you still be let down so easily?

These little phenomena are not limited to the playground but are used in our daily life. For example, wheelchair ramps allow easy movement, making buildings accessible to everyone. Even in construction, ramps are an effective means of transportation for heavy objects. Understanding these principles helps us in everything from designing playground equipment to building loading docks and ramps. Let's create a similar setup in the lab and examine the factors.

آپ کے آس پاس کی عام چیزیں بہت مخصوص پیمائش کے ساتھ بنائی گئی ہیں۔ اب پارک میں موجود سلائڈ کو ہی دیکھ لیں، اس کے ڈیزائن میں بہت سے عوامل شامل ہیں، جیسے اسکا زاویہ، اونچائی اور اس پر گرنے والی چیزوں پر فائز قوتیں۔

یہ معمولی سے مظاہر صرف کھیل کے میدان تک ہی محدود نہیں ہیں بلکہ یہ ہماری روزمرہ کی زندگی میں استعمال ہوتا ہیں۔ مثال کے طور پر، وہیل چیئر کے لئے بنائی جانے والی ڈھلوان آسان حرکت کی اجازت دیتا ہے، جو عمارتوں کو ہر کسی کے لیے قابل رسائی بناتا ہے۔یہاں تک کہ تعمیر میں، ریمپ بھری چیزوں کیلئے ایک مؤثر ذریعۂ نقل و حمل ہے۔ ان اصولوں کو سمجھنا کھیل کے میدان کے سازوسامان کو ڈیزائن کرنے سے لے کر لوڈنگ ڈاکس اور ریمپ بنانے تک مختلف کاموں میں ہماری مدد کرتا ہے۔ آئیے تجربہ گاہ میں ایک ایسا ہی سیٹ اپ تیار کریں اور عوامل کا جائزہ لیں۔

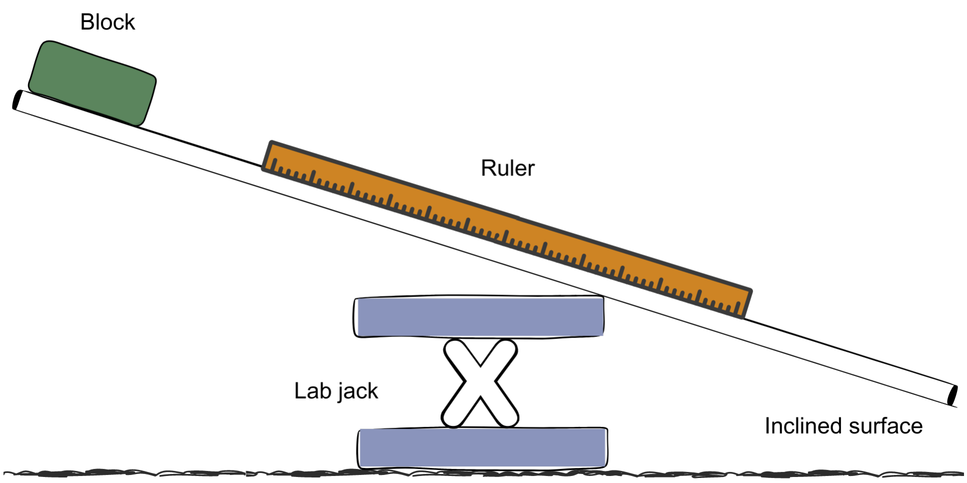
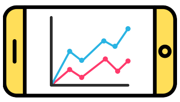


Figure 1: A setup replicating an inclined surface.

Let's make sure we have everything we need to make up a setup shown in Fig. 1.

1. Inclined surface
2. Ruler
3. A regular shaped object
4. Lab Jack

Video Analysis

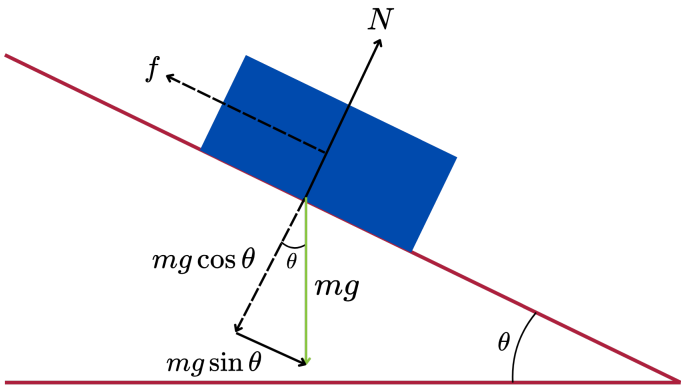


In this experiment you will record an object as it slides down an inclined surface. Record the object and the surface from the side, keeping the camera level with the surface. Maintain a contrasting background for clarity (for instance, if the objects in the experiment are of a lighter colour, set up a black chart paper in the background) Make sure the camera frame covers the entire movement of the object.

Set up the inclined plane and place the object at the top. Gradually increase the angle of the incline until the object just starts to slide. Record this critical angle (θ_c).

What does the data say?

When a block is sliding down an inclined surface, several forces act on it. The gravitational force, or weight mg, pulls the block straight down towards the Earth. This force can be broken into two components: one parallel to the incline, $mg \sin\theta$, which drives the block's motion down the slope, and one perpendicular to the incline, $mg\cos\theta$. The perpendicular component is balanced by the normal force N exerted by the surface under the block, and acts at a right angle to the surface. Additionally, there is a frictional force f that opposes the block's motion along the surface. This frictional force depends on the coefficient of friction μ, which is simply a number representing the degree of friction between the block and the surface. The total force in the direction parallel to the incline determines acceleration a down the incline.



[Q 1]. What would happen to the block's motion if there were no frictional force acting on it? How would the block behave differently on an inclined plane with a higher or lower angle?

As the angle θ of the incline increases, the component of the gravitational force that acts parallel to the incline, $mg\sin\theta$, increases. At a certain critical angle, the force due to gravity along the incline will overcome the maximum static friction force, causing the block to start sliding. Beyond this angle, the block will continue to accelerate down the incline, and kinetic friction becomes the relevant opposing force.

Put the object on the inclined surface. Start recording as you slowing increase the angle of inclination until you reach the critical angle and the object slides down.

[Q 2]. Note the critical angle.

The coefficient of static friction μ_s is defined as the ratio of the frictional force to the normal force when the system is not moving.

[Q 3]. For your critical angle, calculate the value of μ_s.

[Q 4]. Sketch a rough graph for the relationship between the angle θ and friction?

Record videos of the block sliding down the incline at various angles greater than θ_c where the block begins to slide.

[Q 5]. Plot a graph of acceleration a versus time t for different values of θ. Consider what the shape of this graph might reveal about the block's motion.

[Q 6]. Write down an equation for $a_{\parallel}$ with respect to the block's weight and the frictional force. Plot a graph of the frictional force f versus the incline angle θ. Could you describe their relationship by looking at the graph?

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