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IB 3

Problem-based lab in Physics.

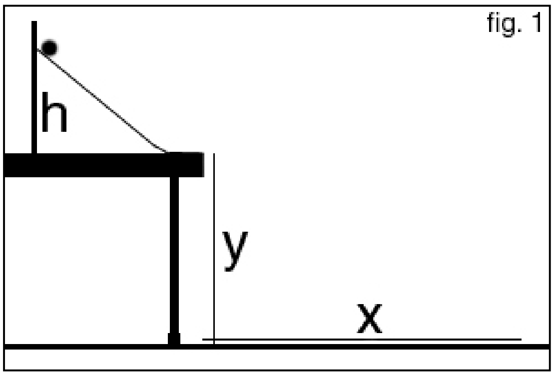
The problem to solve was to calculate how far a ball would ‘fly’ (y), when dropped in an sloping rail that ends 91.3 cm above the floor (see figure 1). The goal for us to reach to was that our teacher should place a cup at any distance (within the range the ball could reach) and then we should calculate at which height we should drop the ball to place it inside the cup, on only one try.

The ball that we used weighted 1.63×10^{-2}kg and had a diameter of 1.59 cm.

We tried several times, with different heights and therefore different y-results.

Here is the table of our results:

Try	*h (m)*	*x (m)*
1	0.42	0.91
2	0.38	0.87
3	0.34	0.83
4	0.30	0.77
5	0.25	0.70
6	0.21	0.62
7	0.15	0.52
8	0.105	0.42



On the datasheet can you see our second table made from an other test-series and a diagram made from that data.

What we now did, and what we then understood was our greatest mistake, was that we tried to find one formula for the whole procedure. That is,

$$mgh = \sqrt{g / 2y}\, v,$$

which cannot be calculated, because you cannot calculate or assume the friction. So after a while, and quite many minutes thinking and trying, we understood that we had to calculate the process in two different steps. First the velocity of the ball when it leaves the rail, and then take the answer and put in into the second formula which calculate how far the ball will travel in the air. Here are the formulas:

The formula for the velocity of the ball as it leaves the rail: (explained on the datasheet)

$$mgh = \tfrac{1}{2}mv^2 + \tfrac{1}{2}I\omega^2 \text{ (+ friction)} \qquad (I = 2/5\ m R^2)$$

or

$$v = \sqrt{2gh / (1.4)}$$

And the formula for how far the ball will travel in the air:

$$v = \sqrt{g / 2y}\, x$$

So, now we just had to calculate.

The teacher placed the cup at a distance of 68.00 cm from the table, so:

$$v = \sqrt{(9.81 / 2 * 0.913)} * 0.68$$

$$v = 1.576 \text{ m/s}$$

and then

$$v = \sqrt{(2gh / 1.4)}$$

$$h = (1.4 * v^2) / (2 * 9.81)$$

$$h = 0.1769 \text{ m}$$

So, the height that the ball should be dropped from should be approximately 17.7 cm above the table.

We calculated the height and dropped the ball – and the ball went straight into the cup.

Datasheet:

Second, more accurate data for the diagram below:

h (m)	x (m)
0.10	0.42
0.12	0.46
0.14	0.50
0.16	0.53
0.18	0.56
0.20	0.61
0.22	0.63
0.24	0.65
0.26	0.70
0.28	0.73
0.30	0.76
0.32	0.79
0.34	0.82
0.36	0.84
0.38	0.86
0.40	0.89

Explanation of formulas:

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I (v^2 / r^2)$

$v = \sqrt{((2gh) / (1 + I/mr^2))}$ $(I = 2/5\ m R^2)$

$v = \sqrt{((2gh) / (1 + 2/5))}$