An Experiment in the History of Science

With a simple but ingenious device Galileo could obtain relatively precise time measurements.

Thomas B. Settle

On the "Third Day" of his *Discorsi* (*1*) Galileo described an experiment in which he had timed a ball accelerating along different lengths and slopes of an inclined plane. With it he believed he had established the science of naturally accelerated motion. To get a better appreciation for some of the problems he faced I have tried to reproduce the experiment essentially as Galileo described it. In the process I found that it definitely was technically feasible for him, and I think I gained a good idea of the type of results he probably looked for and of how well they turned out.

He described the experiment because, in his words: "in those sciences where mathematical demonstrations are applied to natural phenomena, as is seen in the case of perspective, astronomy, mechanics, music, and others [,] the principles, once established by well-chosen experiments, become the foundations of the entire superstructure" (*1*, p. 171). In this case his aim was to establish a science based on two principles: (i) a general definition of uniform acceleration, "such as actually occurs in nature" (*1*, p. 154), as that motion in which equal increments of velocity are added in equal times and (ii) an assumption that "the speeds acquired by one and the same body

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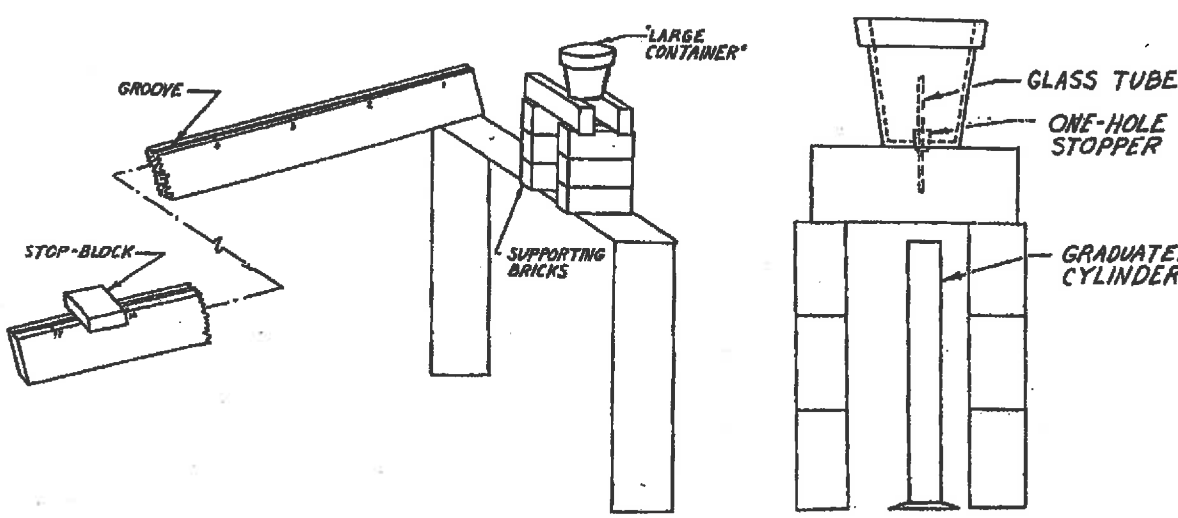

(Left) General layout of the experimental apparatus. (Right) The timing apparatus.

Table 1. Sample of experimental results and calculations which confirm Eq. 2.

Distance	Time (ml of water)		
	(Exp.)	(Av.)	(Cal.)
15	88	90+	90+
	91		
	91		
	90		
	90		
	90		
	90		
	90		
	89		
	90		
13	84	84	84
	84	base	
	84		
	84		
	84		
	84		
	84		
10	72	72+	74−
	73		
	72		
	72		
	72		
	72		
7	62	62−	62−
	61		
	62		
	61		
	62		
	62		
	62		
5	53	52	52+
	53		
	53		
	53		
	53		
	52		
	53		
	51		
	51		
	52		
	53		
	51		
3	40	40	40+
	40		
	40		
	41		
	39		
	41		
	40		
1	26		
	17		
	25		
	24		
	23		
	25		
	23	23.5	23+
	24		
	23		
	23		
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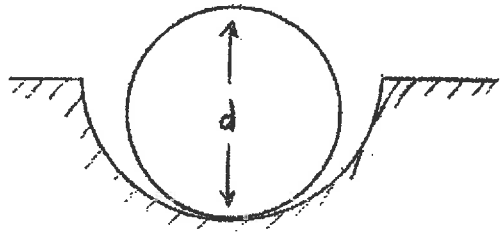
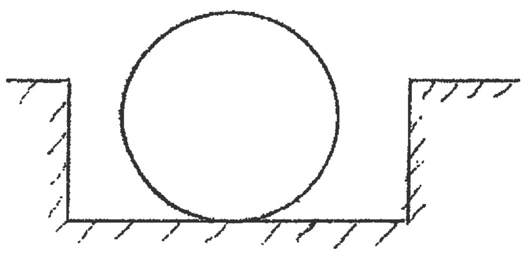
Table 2. Experimental data obtained with the billiard ball for the bases of three slopes, and times computed from one of the other slopes. *L*, slope length; *a*, vertical height; *T*, time.

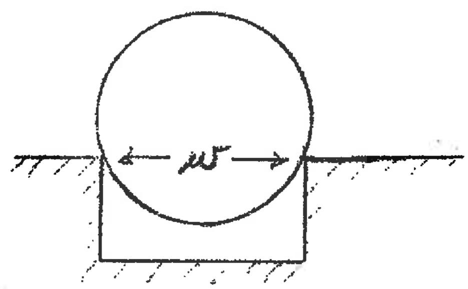
Slope	Experimental data			Calculated data
	L	*a*	T	T
a	12	2.92	117	118− (from b)
b	13	6.25	84	85− (from c)
c	9	11.47	52	51+ (from a)

Rolling in a Groove on an Inclined Plane

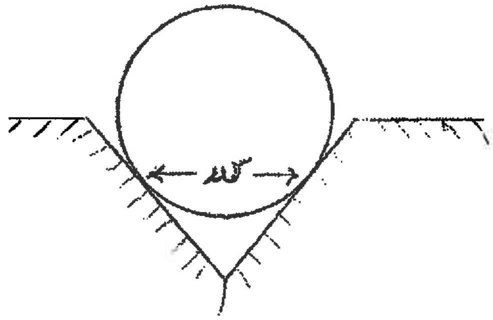


$$a = \frac{5}{7} g \sin\alpha$$





$$a = \left[\frac{5(d^2 - w^2)}{7d^2 - 5w^2}\right] g \sin\alpha$$



see Hahn (2002)
for details

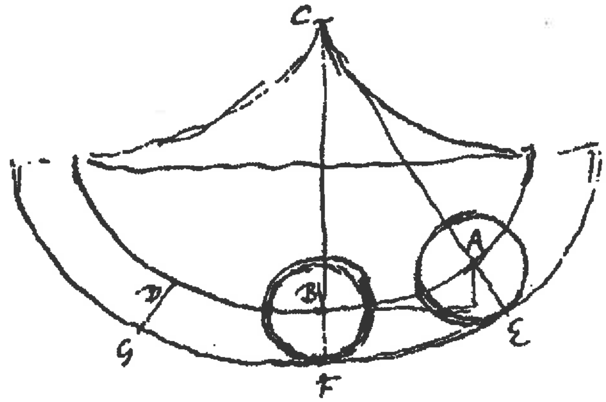
Huygens on Rolling vs. Falling (after the *Principia*)

APPENDICE VI

À LA PARS QUARTA DE L',,HOROLOGIUM OSCILLATORIUM".

[1692 ou 1693][1].

[Fig. 160.]



Pendulum pondus cujus centrum gravitatis A [Fig. 160] per Cycloidem delatum AB, acquirit in puncto B infimo celeritatem qua per arcum BD æqualem BA ascendat.

Si vero annulus gravitate præditus, et tamen ut peripheria simplex consideratus volvatur in paracycloide [2]) EF, ita ut centrum ejus describat cycloidis portionem AB, is quoque vim collegit, ubi in B pervenit, qua ascendat revolvendo usque in D.

Huygens concludes: "Therefore the total time of revolving in the annulus along the curve EG will be to the time of vibration of the pendulum along the arc AF as √2 to 1, or roughly as 7 to 5."

VII.[1]

MOUVEMENT ROULANT SUR UN PLAN INCLINÉ.

Un anneau roule [Fig. 83] moins viste qu'un cylindre sur un plan inclinè. le cylindre moins viste que la sphere, et la sphere moins viste qu'une poutre sur des rouleaux [2]).

[Fig. 83.]