2. Structure and Specifications

1) Apparatus structure

Figure 1 is a schematic drawing of the apparatus.

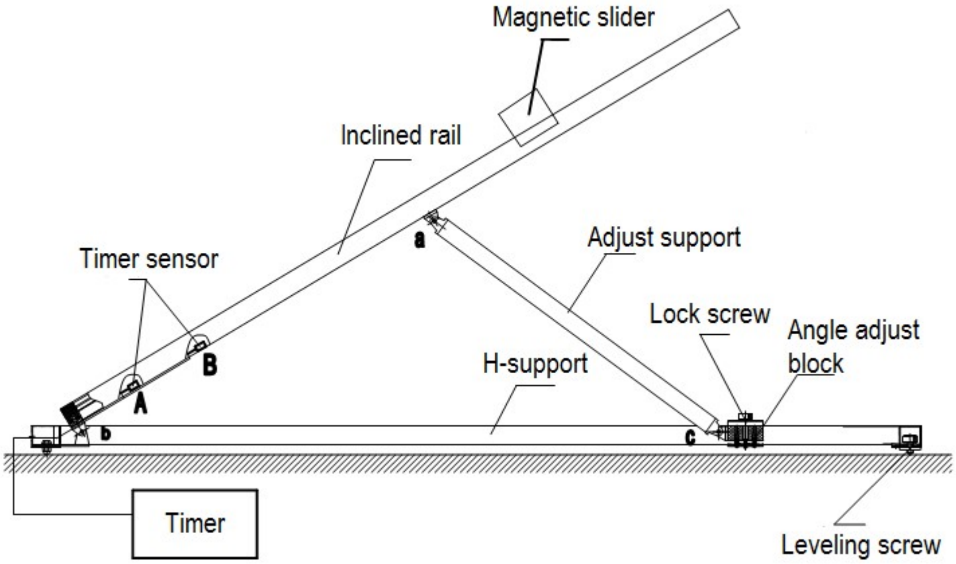

Figure 1 Schematic of the apparatus

In Figure 1, the incline angle θ of the rail can be adjusted by adjusting the position of the angle adjust block. The angle θ can be calculated by reading the length of *bc* and using the known lengths of *ab* and *ac*. If $ab = ac$, then $\theta = \arccos(bc/2ab)$.

On the back side of the inclined rail, two Hall switch are installed at locations A and B as timing sensors. When the magnetic slider slides through A and B, the timer can measure the time interval of slider passing A and B.

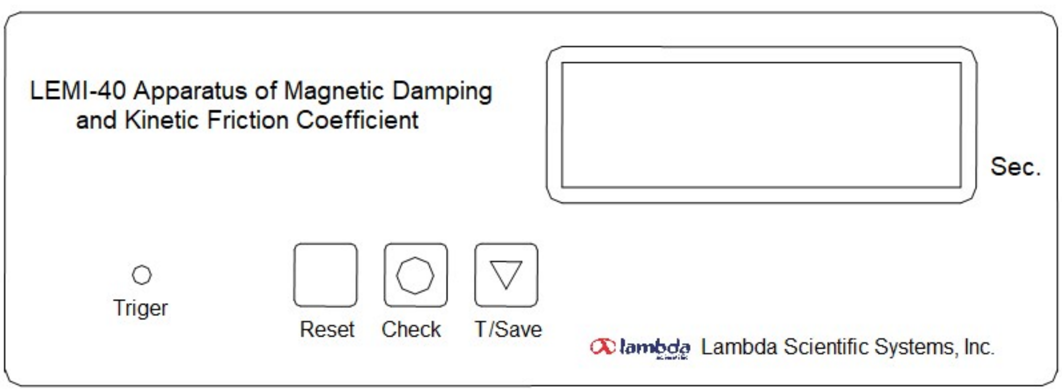

Figure 2 Schematic of the front panel of the timer

A schematic of the timer is shown in Figure 2. Its use instructions are follows.

a) After pressing the Reset button, all 5 digits display as digit “8”.

b) After pressing the T/Save (Timing/Save) button, the first digit LED displays an upper horizontal line (indicating waiting for timing).

c) When the first timing pulse is received, the first digit LED displays a middle horizontal line, and the following four digit LEDs start to flash (indicating that timing is started).

d) When the second timing pulse is received, the first digit LED displays a lower horizontal line, the following 4 digit LEDs stop flashing, and display the time (in seconds).

e) After repeatedly pressing the T/Save button, it starts to wait for timing again. The previous timing has been memorized and saved. After 10 times of timing, all 5 digit LEDs are dimmed, indicating that 10 times of timing have been completed.

f) After pressing the Check button, the first digit LED displays 0-9 in turn, representing the first to tenth times of the saved data, and the following four digit LEDs display the time (in seconds).

2) Specifications

Description	**Specifications**
Inclined rail	Range of adjustable angle: 0 °~ 90 °
	Length: 1.1 m
	Length at junction (ab): 0.50 m
Adjust support	Length (ac): 0.50 m
Counting timer	Counting: 10 times (storage)
	Timing range: 0.000-9.999 s; resolution: 0.001 s
Magnetic slider	Dimension: diameter=18 mm; thickness= 6 mm
	Mass: about 11 g

3. Theory

When the magnetic slider slides at a uniform speed on the slope of the non-ferromagnetic good conductor, the resistance of the slider is not only the sliding friction force F_s, but also the magnetic damping force F_B. Suppose the magnetic induction intensity of the magnetic slider at the inclined surface is B, the contact area between the slider and the inclined surface does not change, and its length is λ. When the slider slides at a uniform rate v, the portion of the cut magnetic induction line on the inclined rail will generate an electromotive force $\varepsilon = B\lambda v$.

If the equivalent resistance of the current flowing through the inclined surface due to magnetic induction is set to R, the induced current should be proportional to the speed v, that is: $I=B\lambda v/R$. At this time, the ampere force F received by the inclined surface is proportional to the current I, namely: $F \propto I$.

The magnetic damping force F_B received by the slider is the reaction force of the ampere force F received by the inclined plane, and the direction is opposite to the movement direction of the slider.

It follows from this: F_B should be proportional to v, which can be expressed as: $F = Kv$ (K is a constant, which is called the magnetic damping coefficient).

Because the movement of the slider is uniform, it should achieve a force balance in the direction parallel to the rail, so that there is:

$$\mathrm{W} \sin \theta = \mathrm{K} \nu + \mu \mathrm{W} \cos \theta . \tag{1}$$

where W is the gravity force applied to the slider, θ is the inclination angle between the inclined rail and the horizontal support, and μ is the sliding friction coefficient between the slider and the inclined rail. If we divide both sides of formula (1) by $W\cos\theta$ at the same time, we can get:

$$\tan\theta = \frac{\mathrm{K}}{\mathrm{W}} \bullet \frac{\nu}{\cos\theta} + \mu \cdot \tag{2}$$

Obviously, $\tan\theta$ and $v/\cos\theta$ have a linear relationship. Make a straight line graph of $\tan\theta$-$(v/\cos\theta)$ to get the slope K/W and intercept μ.

Finally, the magnetic damping coefficient K and the friction coefficient μ are obtained.