南京邮电大学
Nanjing University of Post & Telecom

物理实验教学中心

Physics Expeiment Center

Torsional pendulum

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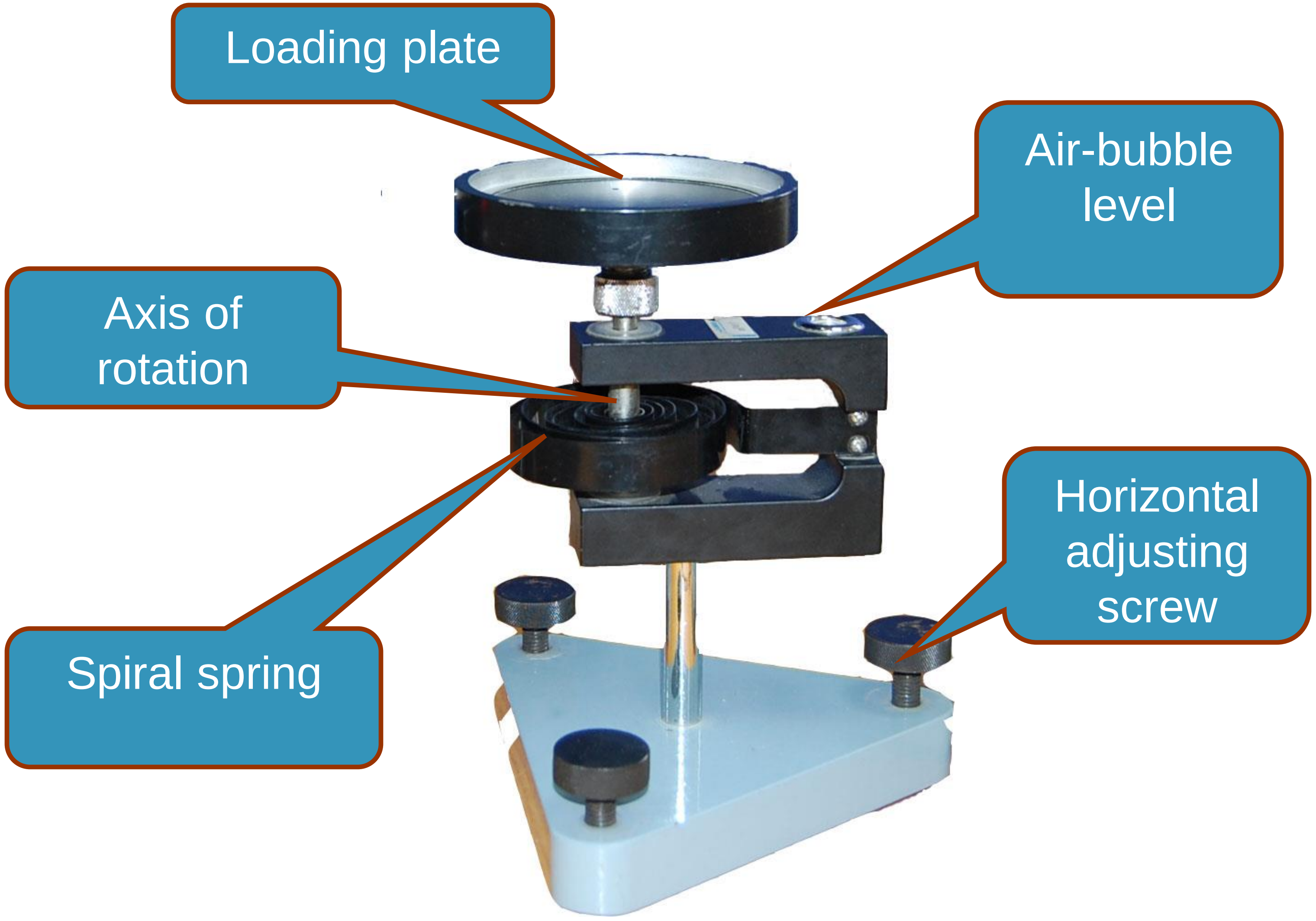
Experimental Purposes:

1. Determination of the **torsional constant** K of spiral spring using torsion pendulum;
2. Determination of the **rotational inertia** of different objects with a torsion pendulum, and compared with the theoretical value;
3. Verification of the **parallel axis theorem**.

Structure of torsional pendulum



Principles

1. Rotational inertia: I

2. Torsional pendulum

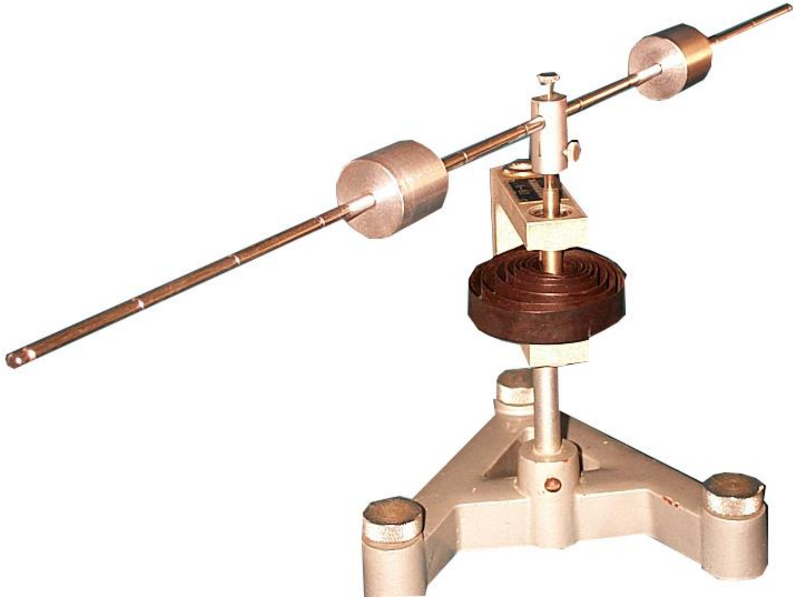
When the object is turned in a horizontal plane at a certain angle θ, the spring restoring moment M：

$M = -K*\theta$ K is the torsional constant .

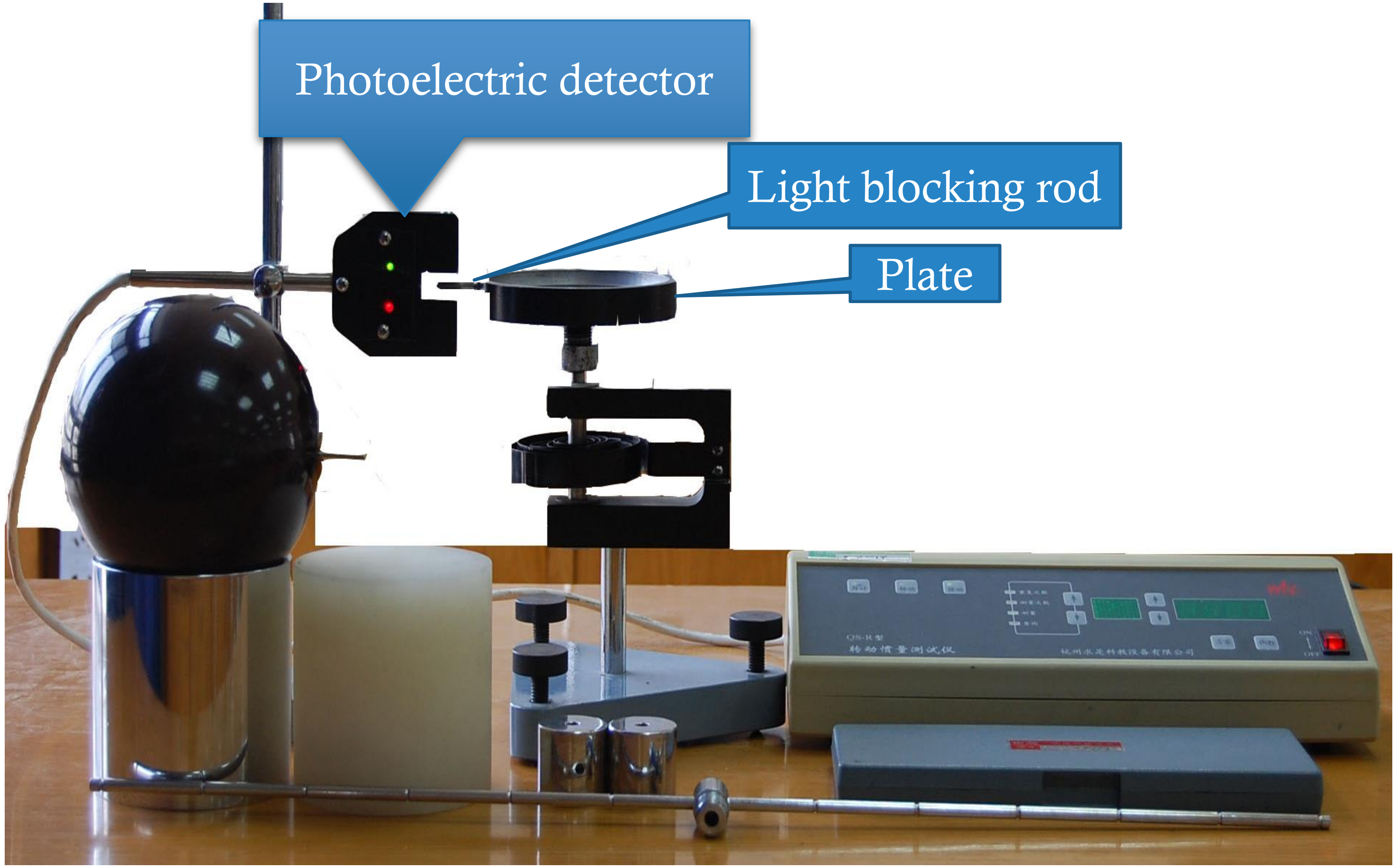
And we also know that : $M = I * \beta$,
where $\beta=d^2\theta/dt^2=-K*\theta/I=-\omega^2*\theta$,
the vibration period **$T=2\pi/\omega=2\pi(I/K)^{1/2}$**

3. Parallel axis theorem

$$I_c = I_0 + mx^2$$



Instruments:



A hollow metal cylinder, a solid plastic cylinder, a metal rod, and two small metal cylinders

Instrument panel

Adjustments：

1. Horizontal adjustment using air-bubble level;

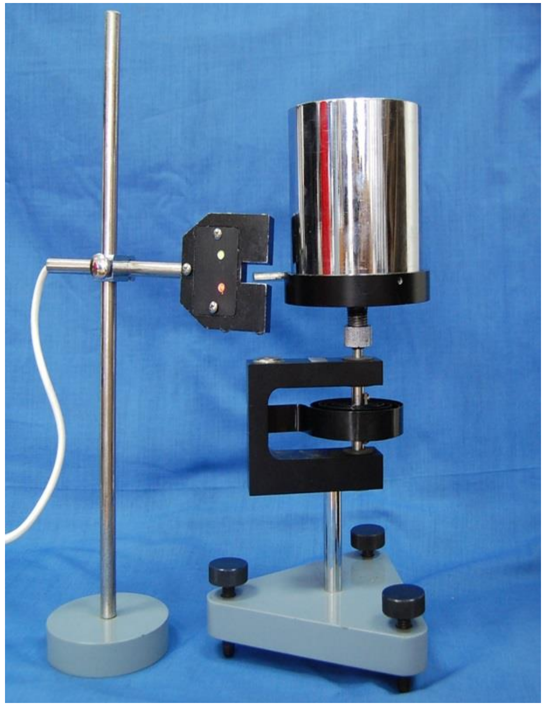
2. Light blocking rod can block the infrared emitting and receiving hole of the photoelectric detector.

3. The swing angle should be between 40 - 90 degrees.

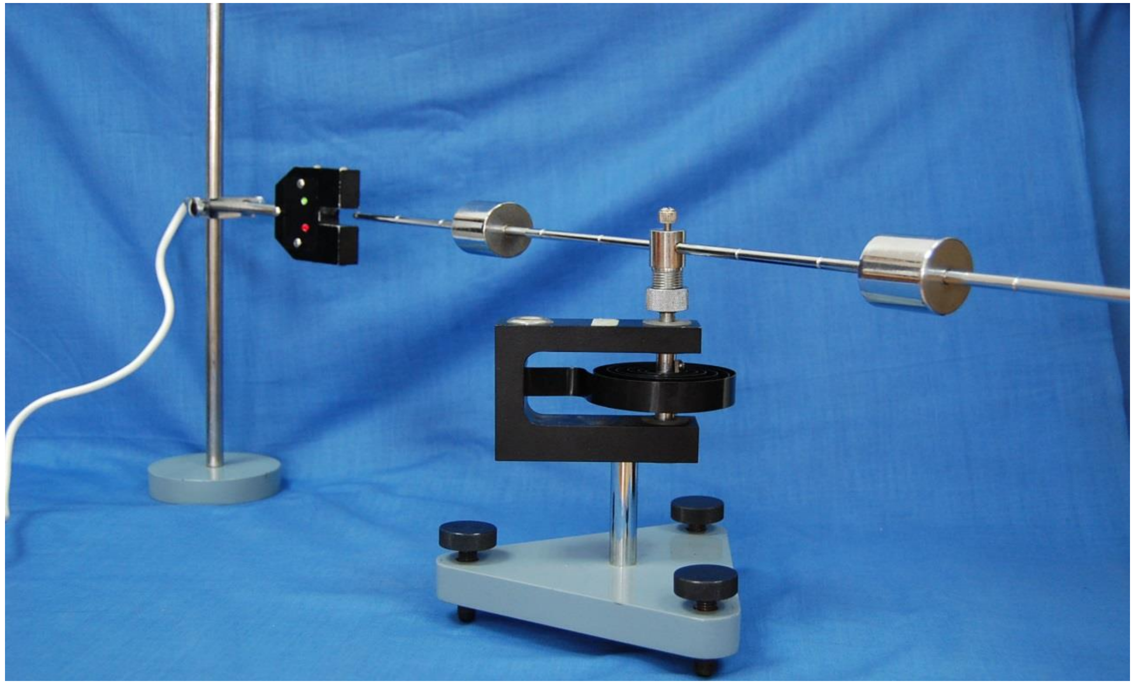
Steps：

1. Determine the vibration periods (10T) of the loading plate and with cylindrical, calculate the torsion constant K；

2. Determine the vibration periods (10T) of the hollow metal cylinder and the mental rod.



3. Verification of the parallel axis theorem；



4. Other measurements：
Electronic balance-----mass,
Tape-----length of the mental rod,
Vernier caliper-----Inside and outside diameters.

Post-processing：

1. Calculate K;

2. Calculate the experimental and theoretical rotational inertia I_{exp} and I_{theo}，

3. Calculate the percentage error η:

$$\eta=|I_{exp}-I_{theo}|/I_{theo}*100\%$$

Table I

$$k = 4\pi^2 \frac{I_1'}{\bar{T}_1^2 - \bar{T}_0^2} = \underline{3.699\times 10^{-2} N/m},$$

$$\frac{K}{4\pi^2} = \underline{9.3685\times 10^{-4}\ N/m}$$

Percentage error = $|I_{exp}-I_{theo}|/I_{theo}*100\%$

Items	m (kg)	Geometry (mm)		Period (s)		I_{theo} (kgm^2)	I_{exp} (kgm^2)	Percentage Error
Empty Plate	/	/		$10T_0$	7.397	/	$I_0 = \frac{I_1'\bar{T}_0^2}{\bar{T}_1^2 - \bar{T}_0^2}$ 5.1288×10^{-4}	/
					7.398			
					7.402			
				$\bar{T}_0$	0.7399			
Plastic Cylinder	0.715	D_1	100.06	$10T_1$	12.26	$I_1' = \frac{1}{8} m\bar{D}_1^2$ =8.9459×10^{-4}	$I_1 = \frac{K\bar{T}_1^2}{4\pi^2} - I_0$ =8.9449×10^{-4}	0.012 %
			100.04		12.25			
			100.04		12.25			
		$\bar{D}_1$	100.047	$\bar{T}_1$	1.2257			
Hollow Cylinder	0.701	D_{out}	100.10	$10T_2$	15.17	$I_2' = \frac{1}{8} m (\bar{D}_{out}^2 + \bar{D}_{in}^2)$ =??	$I_2 = \frac{K\bar{T}_2^2}{4\pi^2} - I_0$ =??	??
			100.10					
			100.12		15.16			
		$\bar{D}_{out}$	100.107					
		D_{in}	93.73		15.18			
			93.74					
			93.75	$\bar{T}_2$	1.517			
		$\bar{D}_{in}$	93.74					
Metal Rod	0.134	L	609	$10T_4$	21.06	$I_4' = \frac{1}{12} mL^2$ =??	$I_4 = \frac{K}{4\pi^2}\bar{T}_4^2$ =??	??
					21.06			
					21.05			
				$\bar{T}_4$	21.057			

$$k = 4\pi^2 \frac{I_1'}{\overline{T}_1^2 - \overline{T}_0^2} = \underline{3.699 \times 10^{-2} N/m},$$

$$\frac{K}{4\pi^2} = \underline{9.3685 \times 10^{-4}\ N/m}$$

m = _238_ g

D_{out}= _35.00_ mm,

D_{in}= _6.06_ mm L_1= _33.04_ mm

$$I_5' = 2\left[\frac{1}{16}m\left(D_{out}^2 + D_{in}^2\right) + \frac{1}{12}mL_1^2\right]$$

Percentage error = $|I_{exp}-I_{theo}|/I_{theo}$*100%

Table II

X (10^{-2}m)	5. 00	10. 00	15. 00	20. 00	25. 00
$10T$(s)	24.06	31.03	40.13	49.97	60.22
	24.08	31.01	40.13	49.99	60.18
	24.07	30.08	40.10	49.95	60.20
$\overline{T}$ (s)	2.407	3.101	4.012	4.997	6.020
I_{exp} (10^{-2}kgm) $I = \frac{K}{4\pi^2}\overline{T}^2$	0.5422	??	??	??	??
I_{theo} (10^{-2}kgm) $I' = I'_4 + 2mx^2 + I'_5$	0.5413	0.8982	1.4932	2.3262	3.3972
Percentage Error	0.18%	??	??	??	??

END