Physics Investigation 3 Teacher Manual

Observation

On release after being pulled down, a spring oscillates with decreasing amplitude due to air damping, and finally becomes stationary.

Problem

Will the damping effect be different in different media? If so, how does it vary in different media?

Hypothesis

Different media have different damping effects on an oscillation.

Aim

To investigate the damping effect of air, water and oil on an oscillating spring.

Principle

For a damped oscillation, energy is lost to overcome the resisting forces i.e. damping forces, such as air resistance, viscosity and friction. In different media, the strength of resisting forces varies, so does the extent of damping.

Equipment and materials

- Desktop computer × 1
- Datalogging interface × 1
- Position sensormeter × 1
- Springs × 2
- 50 gram mass set × 1
- Retort stand × 1
- Clamps × 2
- Beakers × 2
- Glycerine oil

Set-up

Photograph showing set-up of oscillating spring, position sensormeter and datalogger

Procedure

1. Hang a spring from a clamp on the stand and attach to its lower end the arm of a position sensormeter;
2. Attach another spring to the arm of the position sensormeter. A mass set is hung from its lower end;
3. Hang both springs from the farthest hole of the arm of the position sensormeter;
4. Clamp the probe of the position sensormeter. Adjust its position so that its arm is horizontal and the springs are vertical;
5. Extend the spring by pulling the mass set downwards until the arm does not move anymore, then release it;
6. Record the movement of the system on the computer;
7. Plot a graph of amplitude of oscillation against time;
8. Repeat steps 5 to 7 with the mass set completely immersed in a beaker of water and a beaker of oil;
9. Compare the three graphs obtained.

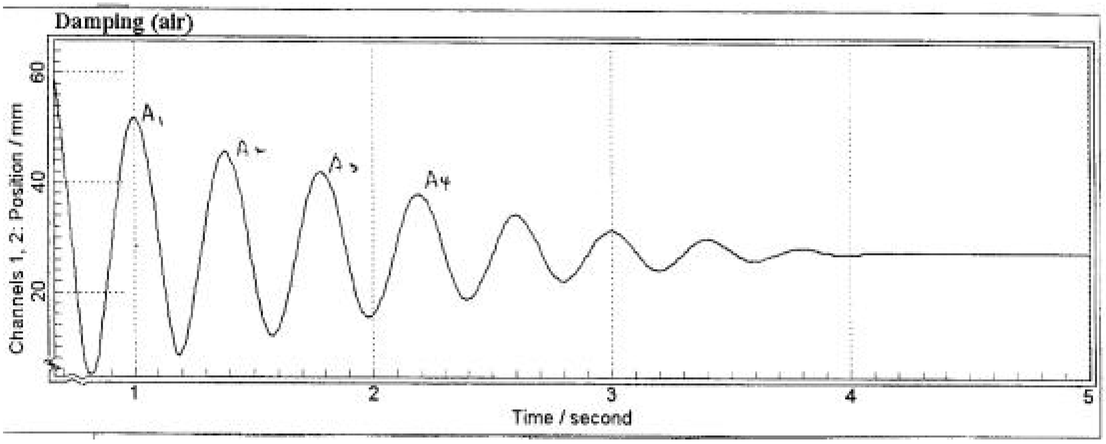
Precautions

1. As the maximum range of the angle of the position sensormeter is 0° - 30°, the amplitude of oscillation should be kept small;
2. Make sure that the mass set is oscillating totally within the water and the oil.

Results

Air

Graph showing oscillation of spring in air

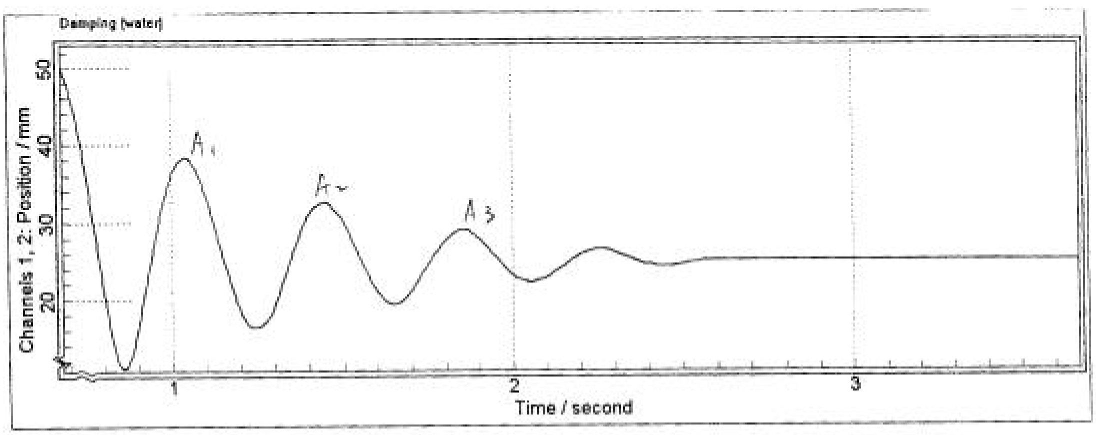


Amplitude/cm		Corresponding ratio	
A_1	2.25	A_1/A_2	1.32
A_2	1.70	A_2/A_3	1.28
A_3	1.32	A_3/A_4	1.33
A_4	0.99		

In air, the oscillation was slightly damped. The amplitude died away gradually. The oscillation lasted for about 8 cycles, or 3.3s. The corresponding ratios were nearly the same, around 1.3.

Water

Graph showing oscillation of spring in water

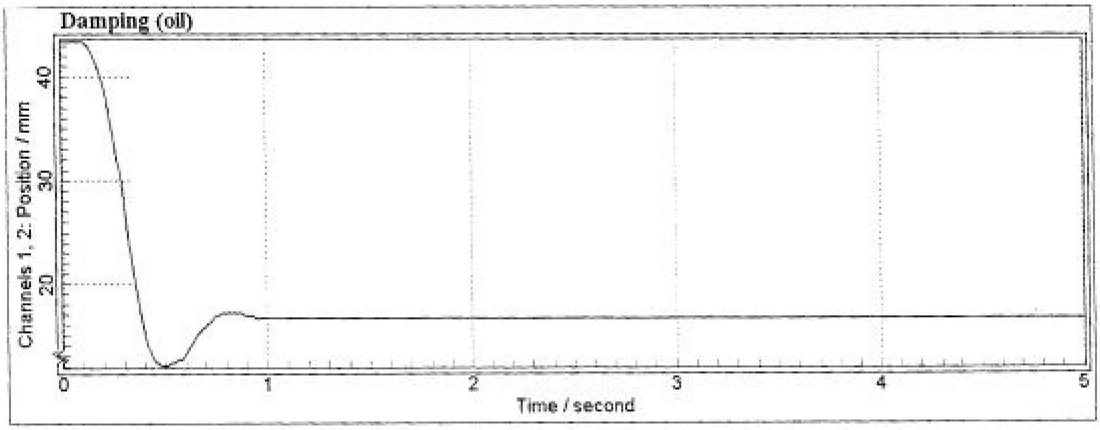


Amplitude/cm		Corresponding ratio	
A_1	1.79	A_1/A_2	1.79
A_2	1.00		
A_3	0.55	A_2/A_3	1.81

In water, the oscillation was also slightly damped, but the oscillation lasted for only about 4 cycles, or 2s. Compared with the oscillation in air, the corresponding ratio were of a larger constant, around 1.8. It showed that the amplitude of oscillation decreased at a faster rate in water.

<u>Oil</u>

Graph showing the oscillation of spring in oil



In oil, the motion was heavily damped. The system returned to the equilibrium position in less than 1s and remained stationary afterwards. No oscillation could be observed.

<u>Overall</u>

Media	Corresponding ratio
air	1.3
water	1.8
oil	(no oscillation)

Interpretation

In air and water, where the resisting forces were smaller, energy was dissipated at slower rates. Oscillations were still allowed, but with gradually decreasing amplitudes. These are called light dampings.

Since the resisting force in water was greater than that in air, the damping effect in water was stronger. Thus, in water, the rate of decrease in the amplitude of oscillation was faster and the oscillation took a shorter period of time to come to an end.

Oil, being more viscous than water, exerted a greater damping force, energy was dissipated at a faster rate. The system returned to the equilibrium position without oscillating. This is called heavy damping.

Possible errors

1. Resisting forces arising from the friction between the arm and the probe of the position sensormeter led to an over-estimation of the damping effect of air, water and oil on the oscillation;
2. The amplitudes of oscillations were small, hence resulting in a relatively large percentage error in calculating the amplitudes' ratios;
3. Only 3 cycles of oscillation were allowed in water, leading to considerable inaccuracy in calculating the mean value of the amplitudes' ratio.

Improvements

1. Use two springs instead of one to minimize the damping effect due to the friction within the position sensormeter so that more cycles of oscillation can be observed;
2. Repeat the experiment several times to obtain a more accurate result.

Conclusions

Different damping effects were observed when the spring oscillated in different media.

Under light damping, the system oscillated with decreasing amplitude and finally came to rest. The amplitude decreased with a constant ratio over the same period of time.

Under heavy damping, the system returned to equilibrium without oscillation.