3.11 Potential energy and elastic energy

Task

How much energy is contained in a stretched spring?

- Observe how much energy is required to lift a mass and how much to stretch a helical spring.
- Hang a mass on a helical spring and let it "fall" on the spring. Observe the process and describe it using the energy concept.
- Determine the energy that is contained in a stretched spring using the equations of energy.

Use the space below for your own notes.

Material

Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No.15271-88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, split in 2 rods, *l* = 600 mm	02035-00	1
3	Bosshead	02043-00	2
4	Weight holder for slotted weights, 10 g	02204-00	1
5	Slotted weight, black coloured, 10 g	02205-01	3
6	Helical spring 3 N/m	02220-00	1
7	Spring balance, transparent, 2 N	03065-03	1
8	Holding pin	03949-00	1
9	Plate with scale	03962-00	1
10	Measuring tape, *l* = 2 m	09936-00	1
11	Glass tube holder with tape measure clamp	05961-00	1

Material required for the experiment

Setup

Screw the splitt support rod together (Fig. 1). Set up a stand with the support base (Fig. 2). Put the support rod into the support base and lock it with the screw (Fig. 3).

Fig. 1

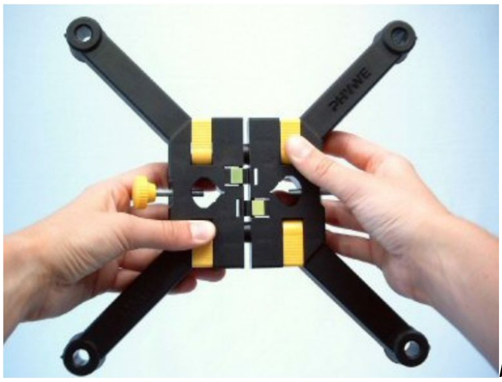


Fig. 2

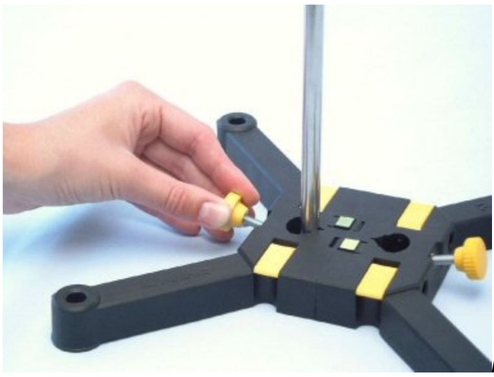


Fig. 3

Clamp the extended measuring tape in the glass tube holder and clamp both on the bottom of the support rod (Fig. 4). Fix the bosshead on the support rod and then fix the holding pin in the bosshead. Hang the helical spring in the hole of the holding pin (Fig. 5).


Fig. 4

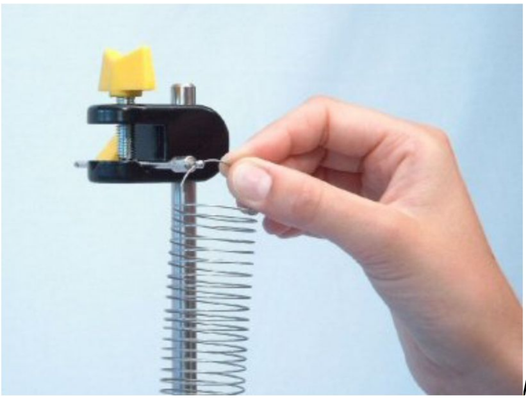


Fig. 5

Adjust the length of the measuring tape so that its zero mark is exactly at the same level as the lower end of the helical spring (Fig. 6).


Fig. 6

Action

Preliminary experiment 1

• Lift a 40 g mass with the spring balance and observe the balance's indicator (Fig. 7).

• Attach the helical spring as close to the top of the support rod as possible.
• Pull down on the helical spring with the spring balance and observe the indicator at different extensions (Fig 8).

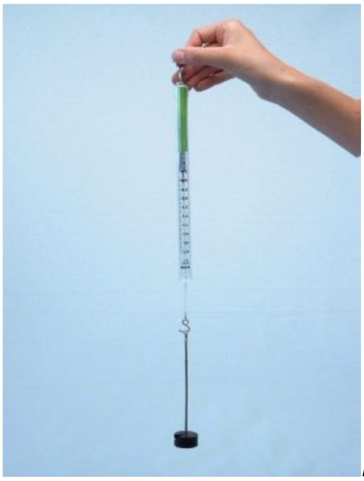


Fig. 7


Fig. 8

Preliminary experiment 2

• Now hang a 40 g mass on the helical spring and let it "fall". Observe the process (Fig. 9).
• Lower the suspension point far enough that the mass just touches the table top at the lower reversal point of its oscillation.
• Hold the mass against the table top so that it touches the table, then release it again and observe the continued course of its movement (Fig. 10).


Fig. 9


Fig. 10

Main experiment

- Hang the weight holder (m = 10 g) on the helical spring and determine the spring's extension.
- Increase the mass in increments of 10 g to max. 40 g and determine for each mass the extension Δl (Fig. 11).
- Record the values for Δl in Table 1 on the Results page.
- Calculate the height h from $h = 2 \times \Delta l$ and record this value in Table 1, too.

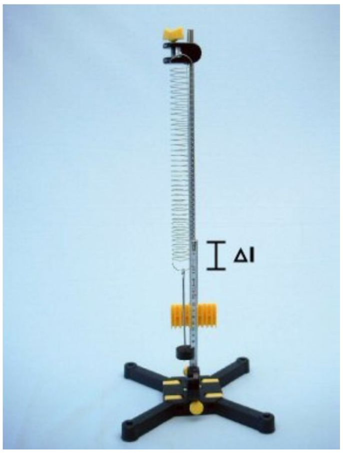


Fig. 11

- Attach the plate on the lower bosshead at height *h* which you determined for *m* = 10 g (Fig. 12).
- Lift the mass (*m* = 10 g; the weight holder) with the spring balance onto the plate and read the weight (force) F_g while you are lifting.
- Record its value in Table 1 on the Results page.
- Shift the suspension point of the spring so that its bottom hook is just at the height of the weight holders hook (Fig. 12).

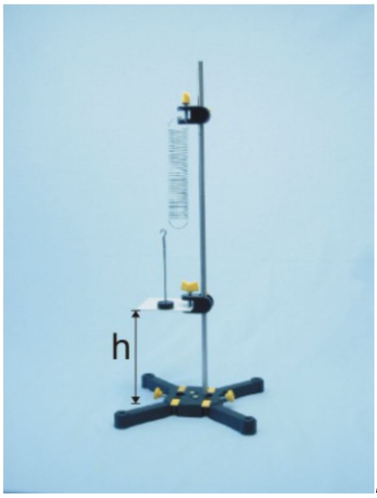


Fig. 11

- Now hang the weight holder (*m* = 10 g) on the spring and let it "fall". Observe the process (Fig. 13)!
- Repeat the experiment the same way (3 times) for the masses *m* = 20, 30 and 40 g.

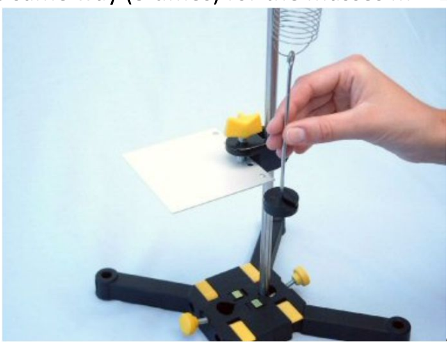


Fig. 13

In order to disassemble the support base you should press the yellow buttons (Fig. 14).

Fig. 14

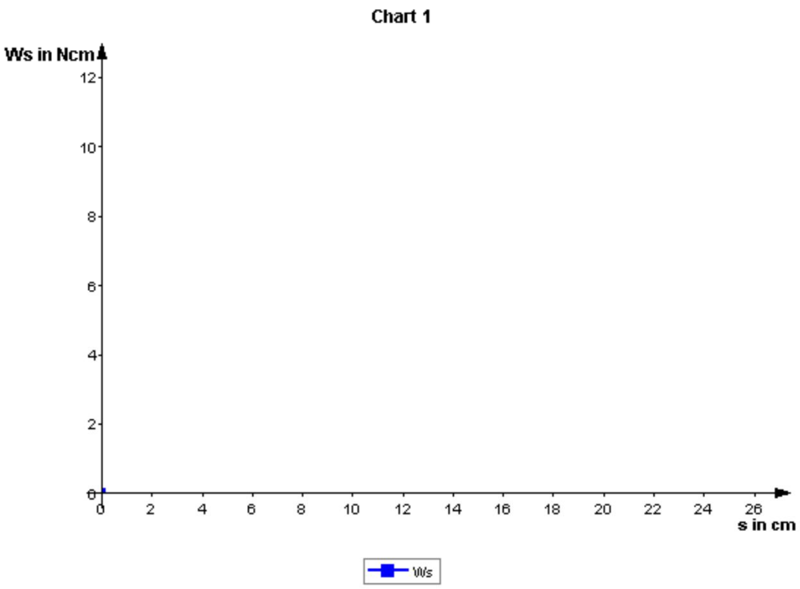
Results

Table 1

m in g	*Δl* in cm	*h* in cm	F_g in N	W_H in Ncm
10				
20				
30				
40				

Table 2

m in g	g *s* in cm	W_s in Ncm	C
10			1
20			
30			
40			



Evaluation

Question 1:

What differences do you observe on the spring balance's indicator when lifting a mass and stretching a spring?

Question 2:

A mass *m* at height *h* has a potential energy W_p which is equal to the invested lifting work W_h. When you "drop" this mass while it is hanging on the spring, the potential energy is again transformed. How does this become apparent in preliminary experiment 2 which you have just completed?

Question 3:

When the mass which is falling on the spring is held against the table top - i.e., at its lowest point - it should have already released the lifting work invested during lifting. What happens when you release the mass again?

Question 4:

How can you explain this phenomenon?

Question 5:

Calculate the lifting work W_h from the values determined for *h* and *m*, and from F_g; record the results in Table 1 on the Results page.

Question 6:

Record the extensions $s = h$ and the elastic energy $W_S = W_H$ in Table 2 on the Results page.

Question 7:

Calculate the factor C from the elastic energies by dividing each higher value by the value for 10 g, i.e. W_S (20 g)/W_S (10 g) etc. Record the values for C in Table 2. What do you notice when you examine the values?

Question 8:

Watch the chart on the Results page. You can see the measured values for W_S as a function of *s*. What does the course of the curve obtained by joining the lines look like?

Question 9:

What correlation between *s* and W_S can be seen in the measurements and calculations?