

Work as an integral and potential energy curves

AP Physics C (Mechanics and E&M, calculus-based) · Lab

Name: _____ Date: _____ Class: _____

A spring stores energy as $\frac{1}{2}kx^2$. In this lab you measure k by adding weights slowly, find the stored energy from the area under the force-extension graph, then drop a mass from the unstretched position and test whether the greatest extension equals $2mg/k$, as energy conservation predicts.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 3

Aim

Measure the spring constant from a force-extension graph, find the elastic energy as the area under the graph, and test the prediction that a mass released from the unstretched position falls a distance $2mg/k$.

Equipment

- Light helical spring (k about 25 N/m)
- Slotted masses, 50 g steps up to 250 g, and a hanger
- Retort stand, boss and clamp
- Metre rule fixed beside the spring
- Phone for slow-motion video

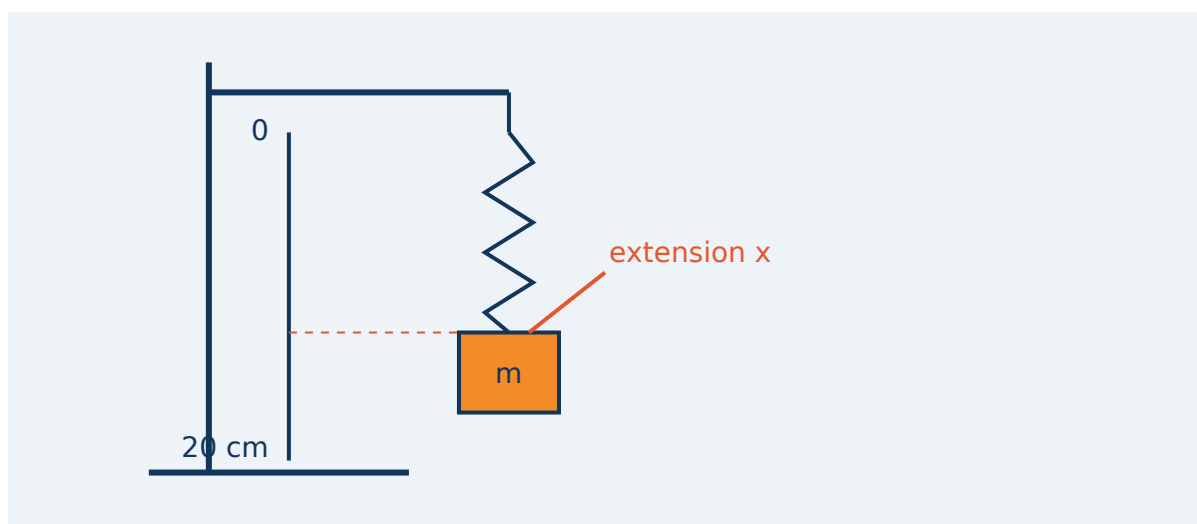
Safety

Safety

Place a soft pad on the floor under the masses and keep feet away from the drop zone. Wear goggles in case the spring slips off the hook when a mass is released.

Method

1. Hang the spring and record the position of the bottom of the spring with no mass.
2. Add 50 g at a time and record the extension x after each addition, once the mass is still.
3. For the drop test, hold a 0.100 kg mass at the unstretched position, release it, and film the fall beside the rule. Find the greatest extension from the video, three times.
4. Use $F = mg$ with $g = 9.81 \text{ m/s}^2$ for each load.



Hanging-mass set-up for the spring.

Results

Mass m (g)	Force F (N)	Extension x (cm)
50	0.49	2.0
100	0.98	3.9
150	1.47	5.9
200	1.96	7.9
250	2.45	9.8

Drop test, 0.100 kg released from the unstretched position:

Trial	Greatest extension (cm)
1	7.7
2	7.5
3	7.6

Analysis questions

Question 1 Spring constant

Plot F against x in metres. Draw the best-fit line through the origin and find k from the gradient.

Question 2 Area under the graph

Calculate the area under the line from $x = 0$ to $x = 0.098$ m and compare it with $\frac{1}{2}kx^2$ for the same extension.

Question 3 Predicted drop

Use $mgx = \frac{1}{2}kx^2$ to predict the greatest extension for the 0.100 kg mass.

Question 4 Measured against predicted

Find the mean measured extension and the percentage difference from your prediction.

Question 5 Energy accounting

At the measured greatest extension, calculate the gravitational energy lost and the elastic energy stored. Find the energy unaccounted for.

Question 6 Uncertainty

The extension is read to ± 1 mm. Calculate the percentage uncertainty in x for the 50 g reading and say how it affects k .

Question 7 Evaluation

Give two reasons why the measured extension is smaller than the prediction and one improvement.