Classical Particle in an Elastic Potential Energy Well

Apparatus

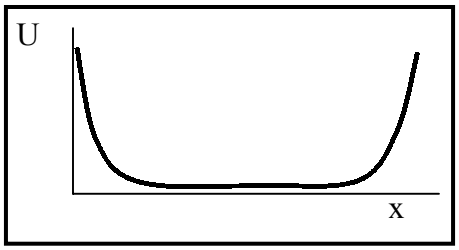
air track with spring mounted at each end, short glider

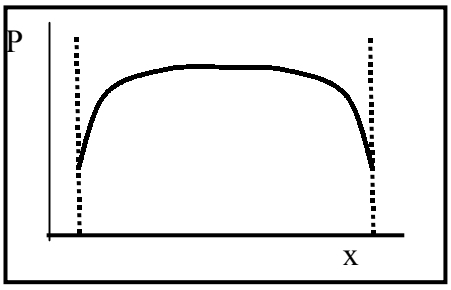
Action

The students observe the way the "classical particle" (the glider) is reflected from the springs at the ends of the track, and sketch the elastic potential energy of the system as a function of glider position. They should observe that the glider is slowed by the springs and then reflected, and note the relative time spent by the glider around the middle of the track and near the ends. They can then sketch the probability of finding the glider at a given position on the track.

The Physics

The elastic potential energy, U, of a spring-mass system is proportional to $(\Delta l)^2$ where Δl is the compression (or extension) of the spring away from its equilibrium length. The spring is compressed by the glider, and is otherwise at equilibrium. The potential energy as a function of glider position, x, is therefore zero except where the glider compresses the springs at either end of the track, at which positions it is proportional to $(\Delta l)^2$. This is very much like an infinite potential well, and is approximately square except for the curvature at the edges.





For a given interval in space, the glider spends more time near the ends of the track as it must be slowed down and change direction, then be accelerated away again at the track ends. The surface is approximately frictionless so the glider travels at constant speed once it is no longer in contact with the end springs. The probability density, P, is shown opposite, the dotted lines show the ends of the air track.

The probability density for an electron in a well is the opposite to this for the electron's ground state, and in general is a minimum (zero) at the edges of the well.

Accompanying sheet:

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Send the glider along the air track and allow it to bounce off the spring at the end.
Sketch the elastic potential energy of the system
as a function of glider position.

Allow the glider to bounce back and forth.
Where does it spend most of its time?
Sketch the probability of finding the glider at a position on the track
as a function of position.
How does this compare to the probability density
for an electron trapped in a potential well?