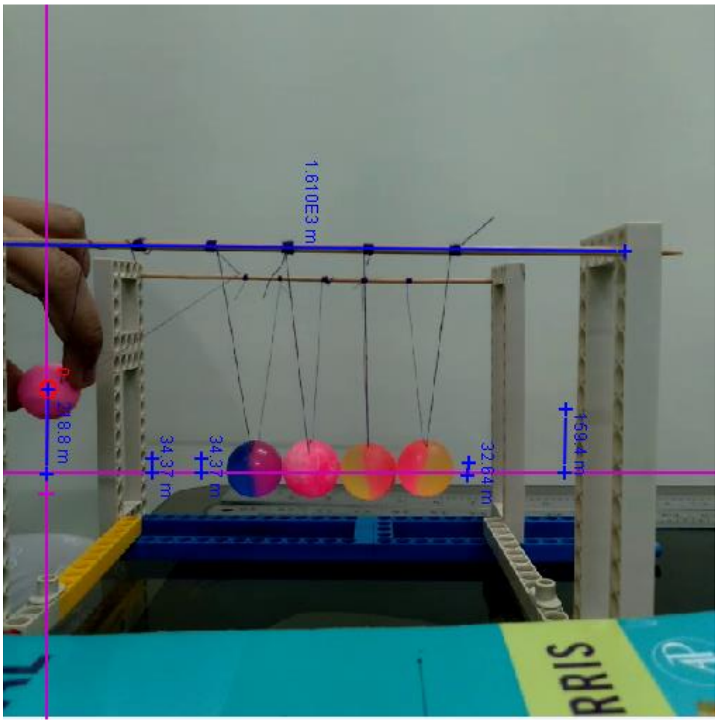
Newton's Cradle

Aim: To conserve total energy of Newton's Cradle at 4 different positions.

Apparatus:



According to Law of Conservation of Energy,

$$(Kinetic\ Energy)_A + (Kinetic\ Energy)_B + (Potential\ Energy)_A + (Potential\ Energy)_B = Total\ Energy$$

$$\frac{mv_A{}^2}{2} + \frac{mv_B{}^2}{2} + mgh_A + mgh_B = Total\ Energy$$

$$(As\ the\ mass\ of\ both\ the\ balls\ is\ same, mass\ of\ ball\ A\ =\ mass\ of\ ball\ B\ =\ m)$$

$$v_A{}^2 + v_B{}^2 + 2gh_A + 2gh_B = \frac{2\ (Total\ Energy)}{m} = E_T \ldots 1$$

$$As\ the\ velocities\ and\ height\ was\ measuresed\ from\ a\ software,$$
$$Calibrating\ factor = 1.27\ \times 10^{-4}$$
$$(This\ is\ to\ be\ multiplied\ to\ all\ velocity\ and\ height\ measurements)$$

a) Conditions at Initial position:

$$Velocity\ of\ ball\ A = 0\frac{m}{s}$$
$$Velocity\ of\ ball\ B = 0\frac{m}{s}$$
$$Height\ of\ ball\ A\ from\ reference\ line = (218.8\ \times 1.27\ \times 10^{-4})m$$
$$Height\ of\ ball\ B\ from\ reference\ line = 0m$$

$$\therefore from\ equation\ 1,$$
$$E_T = 2 \times 9.81\ \times (218.8\ \times 1.27\ \times 10^{-4})$$
$$E_T = 0.55\ Joules$$

b) Conditions just before collision:

$$Velocity\ of\ ball\ A = (3.56 \times\ 10^3\ \times 1.27\ \times 10^{-4})\frac{m}{s}$$

$$Velocity\ of\ ball\ B = 0\frac{m}{s}$$

$$Height\ of\ ball\ A\ from\ reference\ line = (34.37\ \times 1.27\ \times 10^{-4})m$$

$$Height\ of\ ball\ B\ from\ reference\ line = 0m$$

$$\therefore from\ equation\ 1,$$

$$E_T = (2 \times 9.81\ \times 34.37\ \times 1.27\ \times 10^{-4}) + (3.56 \times\ 10^3\ \times 1.27\ \times 10^{-4})^2$$

$$E_T = 0.29\ Joules$$

c) Conditions just after collision:

$$Velocity\ of\ ball\ A = 253\ \times 1.27\ \times 10^{-4}\frac{m}{s}$$

$$Velocity\ of\ ball\ B = 35 \times 10^3\ \times 1.27\ \times 10^{-4}\frac{m}{s}$$

$$Height\ of\ ball\ A\ from\ reference\ line = 34.37\ \times 1.27\ \times 10^{-4}m$$

$$Height\ of\ ball\ B\ from\ reference\ line = 32.64 \times 1.27\ \times 10^{-4}m$$

$$\therefore from\ equation\ 1,$$

$$E_T = (2 \times 9.81\ \times ((34.37\ \times 1.27\ \times 10^{-4}) + (32.64\ \times 1.27\ \times 10^{-4}))) + (253\ \times 1.27\ \times 10^{-4})^2 +\ (3.5 \times 10^3\ \times 1.27\ \times 10^{-4})^2$$

$$E_T = 0.36\ Joules$$

d) Conditions when ball B achieves it highest amplitude:

$$Velocity\ of\ ball\ A = 425.5\ \times 1.27\ \times 10^{-4}\frac{m}{s}$$

$$Velocity\ of\ ball\ B = 197.4\ \times 1.27\ \times 10^{-4}\frac{m}{s}$$

$$Height\ of\ ball\ A\ from\ reference\ line = 34.37 \times 1.27\ \times 10^{-4}m$$

$$Height\ of\ ball\ B\ from\ reference\ line = 159.4 \times 1.27\ \times 10^{-4}m$$

$$\therefore from\ equation\ 1,$$

$$E_T == (2 \times 9.81\ \times ((34.37\ \times 1.27\ \times 10^{-4}) + (159.4\ \times 1.27\ \times 10^{-4}))) + (425.5\ \times 1.27\ \times 10^{-4})^2 +\ (197.4\ \times 1.27\ \times 10^{-4})^2$$

$$E_T = 0.48\ Joules$$

To summarize:

Conditions	At initial position	Just before collision	Just after collision	When ball B achieves it highest amplitude
Energy (in Joules)	0.55	0.29	0.36	0.48