

Hooke's law:

$$
\begin{equation*}
F_{s}=-k x \tag{1}
\end{equation*}
$$

where
$k$ - spring constant,
$x$ - extension of the spring (position of the ball).
Gravitational force:

$$
\begin{equation*}
F_{g}=m g \tag{2}
\end{equation*}
$$

$$
\begin{array}{r}
x=x_{0} \cos (\omega t), \\
x^{\prime}=-\omega x_{0} \sin (\omega t), \\
x^{\prime \prime}=-\omega^{2} x_{0} \cos (\omega t) . \tag{5}
\end{array}
$$

where
$x_{0}$ - amplitude of oscillation,
$\omega$ - period of oscillation,
$t$ - time.
combinding (3) and (5):

$$
\begin{equation*}
a=-\omega^{2} x \tag{6}
\end{equation*}
$$

Newton's second law then gives us:

$$
\begin{array}{r}
F=m a \\
-k x=-m \omega^{2} x \\
\omega=\sqrt{\frac{k}{m}} . \tag{9}
\end{array}
$$

Helpful formulas:

$$
\begin{align*}
& T=\frac{1}{f},  \tag{10}\\
& \omega=\frac{2 \pi}{T} . \tag{11}
\end{align*}
$$

Energies:

$$
\begin{align*}
E_{p} & =\frac{1}{2} k x^{2}  \tag{12}\\
E_{k} & =\frac{1}{2} m V^{2} \tag{13}
\end{align*}
$$

Damped oscillation equation:

$$
\begin{equation*}
x=x_{0} e^{-\gamma t} \cos (\omega t) \tag{14}
\end{equation*}
$$

