Once the mass *M* has been set in motion, Newton's 2nd Law tells us that: $F(t) = -kx(t) = Ma(t)$

However: $x(t) = x_o \cos(2\pi ft) = x_o \cos(\omega t)$ and: $a(t) = -a_o \cos(2\pi ft) = -a_o \cos(\omega t)$

And from above, we also know that: $a_o = \omega^2 x_o = (2\pi f)^2 x_o$ $\therefore$ $-kx_o = -\omega^2 M x_o$

Thus, the frequency *f* and angular frequency ω of oscillation of the mass *M* on the spring are:

$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$ Cycles per second, or *Hz* and $\omega = 2\pi f = \sqrt{\frac{k}{M}}$ (*radians*/*sec*)

The period of oscillation τ of the mass *M* on the spring is: $\tau = \frac{1}{f} = 2\pi\sqrt{\frac{M}{k}}$ (*seconds*)

Note also that since the instantaneous acceleration $a(t) = \frac{dv(t)}{dt} = \frac{d^2x(t)}{dt^2}$, then we can write Newton's 2nd law for this system as a differential equation:

$$F(t) = -kx(t) = Ma(t) \Rightarrow -kx(t) = M\frac{d^2x(t)}{dt^2} \text{ or: } M\frac{d^2x(t)}{dt^2} + kx(t) = 0 \text{ or: } M\ddot{x}(t) + kx(t) = 0$$

which is a linear, homogenous 2nd-order differential equation, and where: $\ddot{x}(t) \equiv \frac{d^2x(t)}{dt^2}$.

The instantaneous potential energy *stored* in the stretched/compressed spring is:

$$P.E.(t) = \frac{1}{2}kx^2(t) \quad (Joules)$$

The instantaneous kinetic energy associated with the *moving* mass, *M* is:

$$K.E.(t) = \frac{1}{2}Mv^2(t) \quad (Joules)$$

The potential energy of the spring and the kinetic energy of the moving mass are both time dependent:

$$P.E.(t) = \frac{1}{2}kx^2(t) = \frac{1}{2}kx_o^2\cos^2(\omega t) \geq 0$$
$$K.E.(t) = \frac{1}{2}Mv^2(t) = \frac{1}{2}Mv_o^2\sin^2(\omega t) \geq 0$$