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Using Newton’s second law, $a = F/m$, we can multiply each side by mass in order to achieve this handy formula $(F)\_{total}= ma. $We don’t know the acceleration of the ball or the spring at these points, although they can be found, we are going to relate this experiment in terms of velocity and s-axis.

By knowing that a rate is measureable, in example kilometers per hour [km/h], we can say that $\frac{∆s}{∆t} = v$, or velocity of the ball in relation to the spring is the total change in position of the ball (compressed to restored) divided by the time it takes to leave the spring (measured as [m]/[s]). Acceleration is measured as the rate of change of the velocity or$ a =\frac{∆v}{∆t}$. Substituting this into the equation $\left(F\right)\_{total}=ma$, this become $(F)\_{total}=m\frac{∆v}{∆t}$.



https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcR0IKFnJiKN7K0zZfEaWf2FKuFXWCm2xg3SrG69r1tgXu-M8qpGNA

The position of the spring undergoes some displacement from its natural position when the ball is pushed onto it. We can establish the arbitrary s – axis as having and origin starting at the point s. The spring displaces to a point at its natural resting position length s, to a point here $s\_{intial}=s\_{i} $, and also to the point of need compression here, $s\_{final}=-s\_{f}$, as being less than that of the position of s, is now negative due to compression (see what I mean about arbitrary s-axis) and so $ ∆s =-s\_{f}-s\_{i}$

The velocity at the point that the spring is compressed to $s\_{f}$ is when the velocity is at a minimum, $v\_{intial}=v\_{i} = 0 m/s$. The velocity at the point $s\_{i}$, when the ball leaves the spring is at is maximum so we will call this velocity, $v\_{final}=v\_{f}$. With these values $∆v=v\_{f}-v\_{i}=v\_{f}-0 {m}/{s}$. Any time that we will look at will be from the point the spring is released until it is restored and this will be from $t\_{i}=0s$ until $t\_{final}=t\_{f}$, and then $∆t=t\_{f}-t\_{i}=t\_{f}-0 s=t\_{f}$ measured in seconds [s].

Using these relationships mass, and $m = m\_{total}$ [kg] and $t\_{f}$ [s], we can state this, $m^{∆v}/\_{∆t} = -k∆s$, so $m\_{total} [kg]\*{v\_{f} \left[\frac{m}{s}\right]}/{t\_{f} \left[s\right]} = -k[N/m]\*(-s\_{f}-s\_{i})[m]$, and [N] = [N]. Now it is east see that $(F\_{spring})\_{s-axis}=ma\_{f}=-k\left(∆s\right)$.

This analysis shows that the Force that spring used in launching the ball is equal to the Force that the spring had due to the change in position of the s-axis. It also shows that the force of the spring $(F\_{s})\_{s}$ is the opposite in direction than change in position ∆s, denoted by its sign convention.

Is Energy conserved?

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