**Kinematics 2 :** $∆x=v\_{0}t+\frac{1}{2}at^{2}$

**rearranging and solving for each variable from the 2nd kinematics equation**

Solving for final displacement $∆x$

The kinematics 2nd equation is already solved for displacement and all that needs to be done is to substitute in the values you have for initial velocity, acceleration and time

|  |  |
| --- | --- |
| **Equation** | **Reason** |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2}$$ | **The work is done. The equation is solved for displacement.** |

Solving for time $t$

**If you solve for time with this equation, either initial velocity or acceleration will be zero. The solution below only works when initial velocity is zero!**

|  |  |
| --- | --- |
| **Equation** | **reason** |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2}$$ | Start with the original equation. We are going to arrange it (algebra) so that it is solved for time. |
| $∆x=v\_{0}t+\frac{1}{2}at^{2}$ | we want time by itself. To do this we would have to solve a quadratic equation (a bit past our math right now). Initial velocity will be given as zero to make this do-able. $v\_{0}t=0\*t=0$. Zero times anything is still zero. There for the “$v\_{0}t$” term is zero and cancels out. |
| $$∆x=\frac{1}{2}at^{2}$$$$2\*∆x=\frac{1}{2}at^{2}\*2$$ | Re-write the equations. We still want time by itself. Let’s move the 2 over first. $"at"$ is being divided by 2 (the ½ ), therefor we will do the opposite and multiply both sides by 2. |
| $$2∆x=at^{2}$$$$\frac{2∆x}{a}=\frac{at^{2}}{a}$$ | Re-write what you have. The ½ and 2 cancel out from the right side because $\frac{1}{2}\*2= \frac{2}{2} =1$ . Now we want to get acceleration to the other side. It is being multiplied with $t^{2}$ so we will divide acceleration from both sides. |
| $$\frac{2∆x}{a}=t^{2}$$$$\sqrt{\frac{2∆x}{a}}=\sqrt{t^{2}}$$ | Re-write what you have. The “a” was cancelled from the right side because $\frac{a}{a}=1$. We still have time squared and need to get rid of the square. To do this we will square root both sides. |
| $$\sqrt{\frac{2∆x}{a}}=t$$ | Re-write what you have. The square root cancels out the square from the $t^{2}$. |
|  | **The work is done. You have solved for time and just need to substitute values in to solve.** |

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Solving for initial velocity$v\_{0}$

|  |  |
| --- | --- |
| **Equation** | **Reason** |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2}$$ | Start with the kinematics equation.  |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2} $$$$-\frac{1}{2}at^{2} -\frac{1}{2}at^{2} $$ | We are trying to get initial velocity by itself so we will move over the term “$\frac{1}{2}at^{2}$”. This term is being added so we will subtract it from both sides. |
| $$∆x-\frac{1}{2}at^{2}=v\_{0}t$$ | Re-write what you have. The “$\frac{1}{2}at^{2}$” was cancelled out on the right side of the equation. This leaves “$v\_{0}t$” by itself on the right. |
| $$\frac{∆x-\frac{1}{2}at^{2}}{t}=\frac{v\_{0}t}{t}$$ | We are trying to get initial velocity by itself so we need to move time to the other side. Time is being multiplied with initial velocity. We will do the opposite, and divide both sides by time. |
| $$\frac{∆x-\frac{1}{2}at^{2}}{t}=v\_{0}$$ | Re-write what you have. The time on the right side was cancelled out because t divided by t is one. |
|  | **You are done. The equation is solved for initial velocity and all that is left is to substitute in the known values. Notice that this is the equation that defines acceleration (the change in velocity in a given amount of time).** |

Solving for acceleration $a$

|  |  |
| --- | --- |
| **Equation** | **Reason** |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2}$$ | Start with the original kinematics equation. We are trying to solve for “a”. |
| $$∆x=v\_{0}t+\frac{1}{2}at^{2}$$$$-v\_{0}t -v\_{0}t $$ | To get acceleration by itself we need to get everything else to the other side of the equal sign. Lets start with moving “$v\_{0}t$” to the other side. It is added so lets subtract it from both sides. |
| $$∆x-v\_{0}t=\frac{1}{2}at^{2}$$$$2\*\left(∆x-v\_{0}t\right)=\frac{1}{2}at^{2}\*2$$ | Re-write what you have. We still need to get acceleration alone. Let’s get rid of the ½ by multiplying both sides by 2. |
| $$2\left(∆x-v\_{0}t\right)=at^{2}$$$$\frac{2\left(∆x-v\_{0}t\right)}{t^{2}}=\frac{at^{2}}{t^{2}}$$ | Re-write what you have. The ½ and the 2 cancel each other out on the right hand side. Acceleration is being multiplied by time squared. We will do the opposite and divide by “ $t^{2} $“ on both sides. |
| $$\frac{\begin{array}{c}\\2\left(∆x-v\_{0}t\right)\end{array}}{t^{2}}=a$$ | Re-write what you have. The time squared is canceled out on the right hand side, leaving acceleration by itself. |
|  | **You are done. The equation is solved for acceleration and you just need to substitute in your known values and solve.** |

Solving for initial velocity$v\_{0}$

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| $$\frac{∆x-\frac{1}{2}at^{2}}{t}=\frac{v\_{0}t}{t}$$ | We are trying to get initial velocity by itself so we need to move time to the other side. Time is being multiplied with initial velocity. We will do the opposite, and divide both sides by time. |
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