Kinematic Equations 2

Objectives:
- Use all four kinematic equations interchangeably.

- For a given problem, write down given information and unknown information, and from this, select and solve the correct kinematic equation.

| **Name** | **Equation** |
|---|---|
| Definition of Acceleration | $v_f = v_i + a \cdot \Delta t$ |
| The King of Kinematic Equations | $\Delta x = v_i \cdot \Delta t + \frac{1}{2} a (\Delta t)^2$ |
| The Average Velocity Formula | $\Delta x = \left( \frac{v_i + v_f}{2} \right) \Delta t$ |
| No-Time Equation | $v_f^2 = v_i^2 + 2a \cdot \Delta x$ |

- In this quiz, problems are only stated in very clear terms, in which each quantity is given simply.

**Part C: Introducing the 4 Kinematic Equations**

Thus far, we only know how to calculate distance if something moves at a *constant velocity*. However, most interesting things do not move at a constant velocity, they accelerate. There are 4 equations.

| |
|---|
| **Kinematics**<br><br>The study of how things *move*. |
| **4 kinematic equations**<br><br>These are four important equations that demonstrate how things *move* in physics. |
| **Condition for the kinematic equations**<br><br>You can use the kinematic equations when ever anything is moving with a *constant acceleration*. If acceleration is changing, you CANNOT use the kinematic equations. |

| Name | Equation |
|---|---|
| Definition of Acceleration | $v_f = v_i + a \cdot \Delta t$ |
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| The Average Velocity Formula | $\Delta x = \left( \frac{v_i + v_f}{2} \right) \Delta t$ |
| No-Time Equation | $v_f^2 = v_i^2 + 2a \cdot \Delta x$ |

**C.1** The study of motion is called _____.

**C.2** Which kinematic equation have we already studied?

**C.3** True or false: If my acceleration is changing, I can use the No-Time Equation.

**C.4** True or false: If my acceleration is not changing, I can use The Other Average Velocity Formula.

**Part D: The King of Kinematic Equations (The Most Commonly Used Equation)**

$$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

| Symbol | Quantity | SI unit |
|---|---|---|
| $\Delta x$ | Displacement | meters |
| $v_i$ | Initial velocity | m/s |
| $a$ | Acceleration | $m/s^2$ |
| $\Delta t$ | Change in time, time interval | seconds |

**D.1a** I begin at rest at the top of a cliff, and I fall down from the cliff (my acceleration is 9.8 $m/s^2$). How far will I have gone after 3 seconds?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**D.1b** How far will I have gone after five seconds (if it is a very tall cliff)?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**D.2** A squirrel is running with a speed of 4 m/s, and it begins accelerating at a rate of 0.3 $m/s^2$ for 2.5 seconds. How far does it move in this time?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**D.3** You want to see how deep an old water well is. You drop a rock down the well. The rock is not moving before you drop it.
What was the acceleration of the rock? [remember from before]

If you here the rock splash into water after 4.5 seconds, then how deep is the well?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**D.4** A car is traveling at 23 m/s. The driver sees a deer that is 60 meters ahead and begins to slow down. If it takes the car 4 seconds to stop, what must be the acceleration so that the driver *does not* hit the deer?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**D.5.** Someone accelerates at a rate of 5.0 $m/s^2$ for a time of 10. seconds and moves forward a distance of 600 meters. What was their initial velocity?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**D.6** Someone accelerates at a rate of 5.0 $m/s^2$ for a time of 10. seconds and moves a *displacement* of 150 meters. What is his initial velocity?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

Wow, the answer is negative! What do you think that means?

**D.7** The Cherry and Webb building is about 20.0 meters tall. If you drop a rock from rest off the Cherry and Webb building, how much time will it take it to hit the ground?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**Part E: The Average Velocity Equation**

This is another equation for average velocity that applies whenever acceleration is constant:

$$\text{average velocity} = \frac{v_i + v_f}{2}$$

**E.1** What is the average of 5, 12, and 19?

**E.2** What is the average of 3, 8, 10, and 11?

**E.3** Explain how to calculate the average in mathematics.

**E.4** Now, explain the average velocity formula written above. How does make sense?

The formula:

$$\Delta x = \left(\frac{v_i + v_f}{2}\right)\Delta t$$

**E.5** Where does this formula come from? (Hint: look at the formulas you used in part B).

| **Symbol** | **Quantity** | **SI Unit** |
|---|---|---|
| $\Delta x$ | displacement, change in position | m |
| $v_i$ | initial velocity | m/s |
| $v_f$ | final velocity | m/s |
| $\Delta t$ | time interval | s |

Common usage:
This formula is often used for things that are starting or stopping.

**E.6** A squirrel running at 3 m/s accelerates to 5 m/s in 0.5 seconds. How far does he move while accelerating?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**E.7** A car begins at rest. Over the course of 5 seconds, it accelerates to 25 m/s. In this time, how far does it move?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**E.8** A car is shooting down the highway at 19 m/s. He sees a deer 60 m ahead, and slams the brakes. It takes 5 seconds to stop. How far does he move while stopping?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

Does he hit the deer?

**E.9** A car decelerates from 25 m/s to 15 m/s in 40 seconds. How far does it travel during this time?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**E.10** Somebody travels for a time of 20. seconds and moves a displacement of 300. meters. Their final velocity is 18 m/s. What was their initial velocity?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**E.11** Somebody is traveling 5 m/s to the right. They move at a constant acceleration and end up traveling at 5 m/s to the left. You do not know their time or acceleration. What is their displacement? [hint: Think about the information you DO know and use the equation above]

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**Part F**: **The no-time formula**

$$v_f^2 = v_i^2 + 2a \cdot \Delta x$$

| Symbol | Quantity | SI Unit |
|---|---|---|
| $\Delta x$ | displacement, change in position | m |
| $v_i$ | initial velocity | m/s |
| $v_f$ | final velocity | m/s |
| $a$ | acceleration | $m/s^2$ |

**F.1** What does PEMDAS stand for?

**F.2** What does PEMDAS mean?

**F.3** A running dog has an acceleration of 2 $m/s^2$, and accelerates from an initial speed of 5 m/s. If he moves 20 meters while accelerating, what is his final speed? [NOTE: at the end, you need to use a *square root* to find your answer.]

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**F.4** A car accelerates from rest with an acceleration of 3 $m/s^2$. If it moves 100 m while accelerating, what is its final speed?

| Looking For | Formula |
|---|---|
| Already Know | |
| Answer as equation *with unit*: | |

**F.5** A running dog accelerates from 4 m/s to 8 m/s. He has an acceleration of 3 $m/s^2$. How far does he move while accelerating?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**F.6** Help! You just fell straight down a well. Your acceleration is 9.8 $m/s^2$. The well is 30 meters deep. How fast are you traveling when you hit the bottom of the well?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

**F.7**

A driver sees a kid on the road in front of him. He slams his brakes, but ends up hitting the child. Afterwards, the driver claims that he was driving very safety and not speeding at all. A police detective decides to inspect if he is telling the truth.

He knows from examining the crash that the car hit the kid at 4 m/s.

He looks at the tire marks on the road and sees that the car moved 60 m after he hit the brakes.

He looks up vehicle information and sees that his car could decelerate at -3 $m/s^2$.

What was the car's velocity BEFORE he started slowing down?

| Looking For | Formula | |
|---|---|---|
| Already Know | | |
| Answer as equation *with unit*: | | |

If the speed limit on that road was 35 mph (16 m/s), was the car speeding?

**C.1** kinematics
**C.2** The Definition of Acceleration
**C.3** False
**C.4** True

**D.1a** $\Delta x = 44.1$ m
**D.1b** $\Delta x = 122.5$ m
**D.2** $\Delta x = 10.94$ m
**D.3** $\Delta x = 99.225$ m
**D.4** $\Delta x = -4$ m/s$^2$
**D.5** $v_i = 35$ m/s
**D.6** $v_i = -10$ m/s, The initial velocity is negative he started out moving the opposite direction.
**D.7** $\Delta t = 2.02$ s

**E.1** 12
**E.2** 8
**E.3** To calculate the average, you add all numbers and divide by how many numbers there are.
**E.4** The formula $\frac{v_f+v_i}{2}$ is the average of final and initial velocity.
**E.5** If acceleration is constant, this formula is identical to the formula $\Delta x = \bar{v} \cdot \Delta t$, displacement = (average velocity (time)
**E.6** $\Delta x = 2$ m
**E.7** $\Delta x = 62.5$ m
**E.8** $\Delta x = 47.5$ m, no
**E.9** $\Delta x = 800$ m
**E.10** $v_i = 12\ \mathrm{m/s}$
**E.11** $\Delta x = 0$

**F.1** PEMDAS = Parentheses, Exponent, Multiplication, Division, Addition, Subtraction
**F.2** PEMDAS gives the order that operations should be completed in a mathematical equation.
**F.3** $v_f = 10.25$ m/s
**F.4** $v_f = 24.5$ m/s
**F.5** $\Delta x = 8$m
**F.6** $v_f = 24.2$ m/s
**F.7** $v_i = 19.39$ m/s