Physics activity

Uniformly accelerated particle

**Discussion:**

*Let a cart roll down an inclined ramp, have students describe the motion in general terms like they would to a child. (Ball speeds up is what we’re looking for) NO formal terms*

*Ask which observations are measurable, what measurements can we make?*

*Can we measure speed directly? (No, but we can measure position and time)*

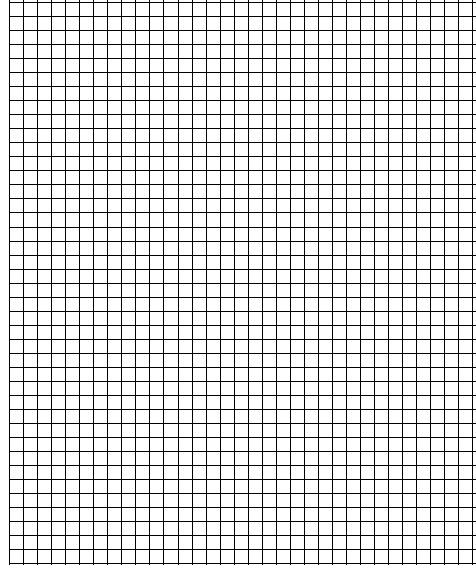
*(No calculations with data yet, position and time only)*.

Give students the handout:

**Handout**

The data below are from a wheel rolling from rest down an incline. Graph the position vs time data on the graph paper below.

|  |  |
| --- | --- |
| *t*  *(s)* | x  (cm) |
| 0.0 | 0.0 |
| 1.0 | 5.0 |
| 2.0 | 20.0 |
| 3.0 | 45.0 |
| 4.0 | 80.0 |
| 5.0 | 125.0 |
| 6.0 | 180.0 |



1. What sort of shape is the graph? How would you describe the slope of the graph? (Does it get larger or smaller as time increases?)

2. What quantity does the slope of a position (or distance) vs time graph represent?

3. What does this tell you about the motion of the wheel? (Getting faster, slower or staying the same)

4. On your position vs. time graph, draw a line which connects the point at

*t =* 0 to the point at *t* = 6 and calculate the slope of this line below.

5. What does the slope of this line represent?

6. Is the wheel going this speed during the entire time from t = 0s to t = 6 s? If not, when is it going faster than this speed, and when is it going slower?

That being said, what sort of speed is represented by the slope of the line from

t = 0 to t = 6 (initial, final, or average)

7. On the position vs time graph draw a line connecting the points at *t* = 2 and *t* = 4. Calculate the slope of this line and explain what the slope of this line tells you about the motion of the wheel between t = 2 and t = 4.

8. What do the slopes of the lines in 4 and 7 tell you about the speed of the wheel? Is the wheel travelling the same speed during these two intervals, or is it travelling with the same average speed during those intervals?

9. On the position vs time graph draw a line tangent to the graph at *t­* = 3. Find the slope of this line. Is there a name for the speed that an object has at a certain point in time? What is it?

How does the slope of the tangent line compare to the slope of the other two lines you drew?

What does the slope of this tangent line tell you about the speed of the object AT t = 3 s compared to the speed of the object over an interval of time where t = 3 is the center of the interval? (0 – 6 or 2 – 4)

10. Consider the graph of the wheel again. Determine the average speed of the wheel from t = 0 to t = 3 s. How does this average speed compare to the speed at 3.0 s (from #9 above)

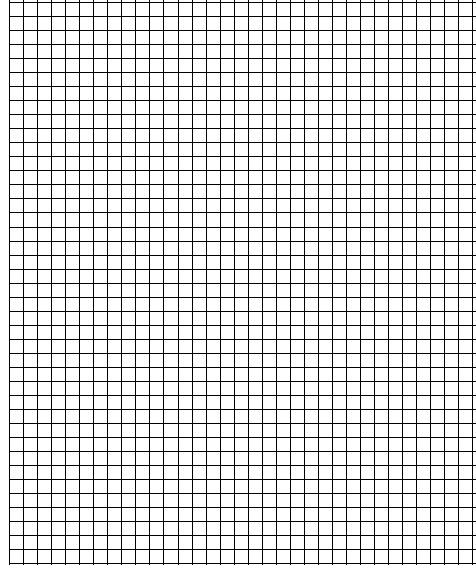
11. Looking at the graph of position vs time. Draw and find the slope of the tangent line at each of the 6 seconds of motion. Record those values in the table below

|  |  |
| --- | --- |
| *t*  *(s)* | v at certain time  (cm/s) |
| 0.0 | 0.0 |
| 1.0 |  |
| 2.0 |  |
| 3.0 |  |
| 4.0 |  |
| 5.0 |  |
| 6.0 |  |

What relationship exists between the velocity at the end of an interval and the velocity at the midpoint of that interval? Does it hold true for all intervals?

The slope you found represents the velocity of the wheel ***at that particular instant*. This would also be the final velocity of the wheel over that interval.**

Make a graph of the velocity vs time from the data above on the graph below.



12. Describe in words what the slope of this graph represents? (Δy/Δx) Is there a more common name for the slope of this graph?

13. We generically calculate change in velocity, Δv = vf – v0.  If we look at any interval of the motion and the instantaneous velocity at the end of that interval (for t = 0 to t = 3 and the slope of the line at t = 3) which of the velocities in your formula is represented by the slope of your line at t = 3? (Δv, vf or v0)

14. What was the value of the initial velocity in the described experiment?

That being said, we should have a formula a = (vf – v0)/t

Solve it algebraically for vf and write the solution below.

Can you relate this equation to the slope intercept form of an equation of a line?

Divide the distance travelled by the wheel by the time for each of the 6 data points given in the first table. Compare these values with the slopes of the tangent lines you recorded in the second data table above.

|  |  |  |
| --- | --- | --- |
| time | Distance travelled over time  (Average velocity during interval) | Slope of tangent line  (final velocity at end of interval) |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |

What do the values above tell you about the relationship between the average velocity over an interval and the final velocity at the end of the interval?

Would you expect this same relationship to exist for any object rolling down a ramp from rest? What about an object being dropped from some height above the ground?

How do you take the average of two numbers?

Could you take the average of the final and initial velocities the same way? Write that formula below.

2 vav = vf

I Δx = vav vav = (vf + vo) II vf = vo + at III

t 2

With these three equations, we can derive 2 other equations that will allow us to solve problems involving the motion of objects.

Starting with equation II above and using equations I and III derive the following equation by substitution:

Δx = vot + ½ at2 show the derivation below.

Beginning with equations I and II again, rearrange equation III to solve for time and derive the equation by substitution: vf2 = vo2 + 2aΔx. Show the derivation below.