Graphing from Motion Diagrams

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After completing this worksheet, you will be able to:

- differentiate between the concepts of position, velocity, and acceleration.
- construct a relationship between velocity and acceleration when an object is speeding up, slowing down, or moving at a constant speed.
- organize visual information in table format and correctly graph that information.

While completing this worksheet you will develop:

- Information Processing Skills (translating the visual representations in the motion diagram into table and graphical formats)
- Critical Thinking Skills (constructing the relationship between velocity and acceleration).

Model 1: Motion Diagrams for Various Objects

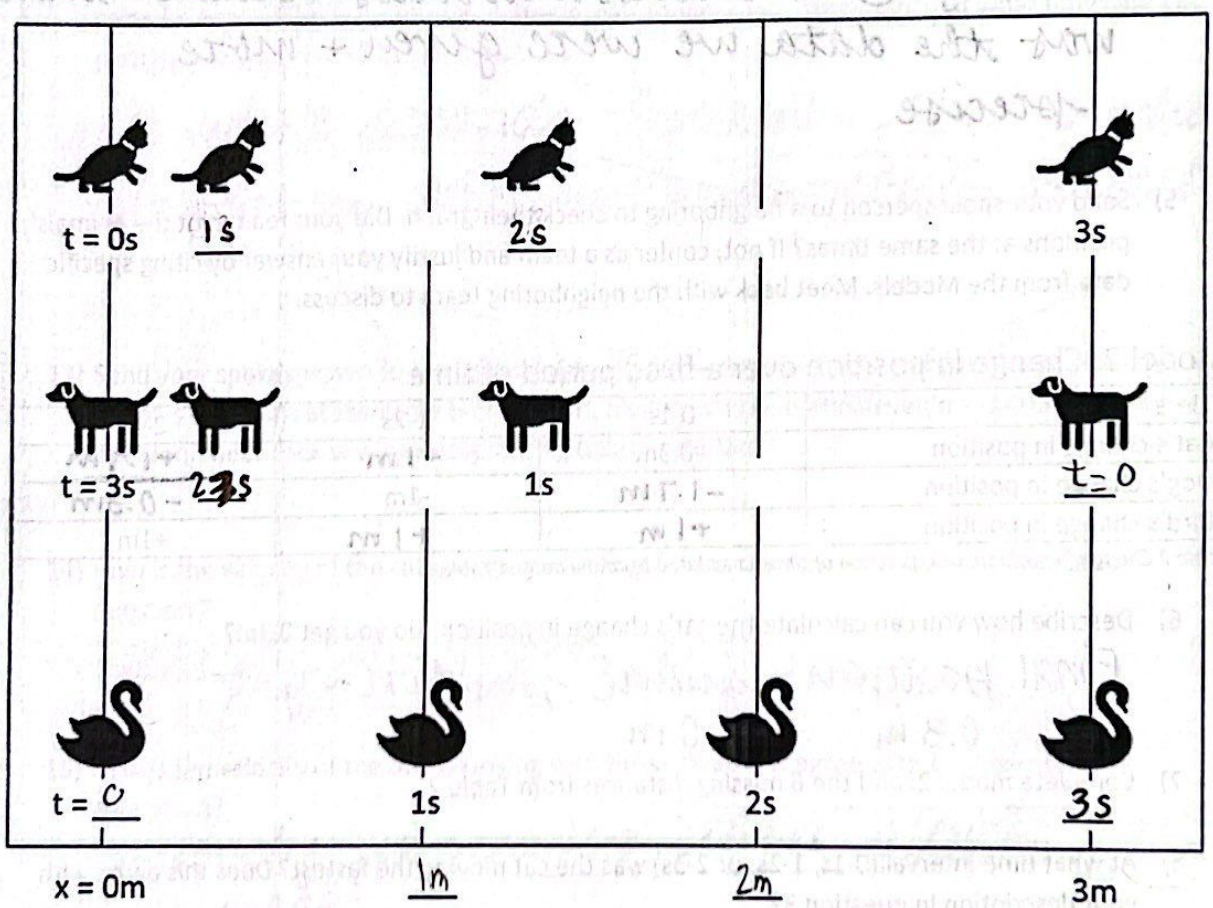


Figure 1 Motion Diagrams of a cat, a dog, and a bird traveling between locations 0m and 3m (positive direction is to the right).

Time =	0s	1s	2s	3s
Cat's position	0m	0.3m	1.3m	3m
Dog's position	3m	1.3m	0.3m	0m
Bird's position	0m	1	2	3

Table 1 Positions, as a function of time, corresponding to the motion diagram in Figure 1.

1) Complete model 1: add the 6 missing times (Figure 1) and the 8 missing positions (Table 1).

2) In which direction (positive or negative) is the cat, dog, and bird moving?

   a. The cat is moving in the positive direction.
   b. The dog is moving in the negative direction.
   c. The bird is moving in the positive direction.

3) How would you describe the motion of the cat, dog, and bird?

   a. The cat is speeding up.
   b. The dog is slowing down.
   c. The bird is constant.

4) Using the graph template on the final page, create a position (vertical-axis) versus time (horizontal-axis) graph from the data in Table 1 for all three animals. Use a distinct shape or color for each of the animals (e.g., triangle=cat, square=dog, circle=bird). At what times are you plotting the positions of the animals? Why?

Plotting @ 1-second intervals because that was the data we were given + more precise.

5) Send your spokesperson to a neighboring to check their graph. Did your team plot the animals' positions at the same times? If not, confer as a team and justify your answer by citing specific data from the Models. Meet back with the neighboring team to discuss.

Model 2: Change in position over a fixed period of time

Time =	0-1s	1-2s	2-3s
Cat's change in position	+0.3m	+1m	+1.7m
Dog's change in position	-1.7m	-1m	-0.3m
Bird's change in position	+1m	+1m	+1m

Table 2 Change in position, as a function of time, calculated from the data in Table 1.

6) Describe how you can calculate the cat's change in position. Do you get 0.3m?

Final position - initial position ~ yes
0.3 m − 0 m

7) Complete model 2: add the 6 missing distances from Table 2.

8) At what time interval (0-1s, 1-2s, or 2-3s) was the cat moving the fastest? Does this agree with your description in question 3?

2-3 s, yes

9) At what time interval (0-1s, 1-2s, or 2-3s) was the dog moving the fastest? Does this agree with your description in question 3?

0-1 s, yes

Model 3: Average *velocity* for a given time interval

Time =	0-1s	1-2s	2-3s	Animal moving in the...
Cat's average velocity	0.3m/s	0.1 m/s	1.7 m/s	positive direction
Dog's average velocity	-1.7m/s	-1 m/s	-0.3 m/s	negative direction
Bird's average velocity	1m/s	1 m/s	1 m/s	positive direction (right)

Table 3 Average velocities, as a function of time, calculated from the data in Table 2.

10) Describe how you calculate the cat's average velocity. Do you get 0.3m/s for the time interval from 0-1s?

p = position
t = time

$$\frac{(\Delta p)}{\Delta t} \quad \frac{p_f - p_i}{t_f - t_i} = \frac{0.3 - 0}{1 - 0} = 0.3 \text{ m/s}$$ yes

11) Complete model 3: add the 6 missing velocities and 2 missing descriptions to Table 3.

12) Using the graph template on the final page, create a velocity (vertical-axis) versus time (horizontal-axis) graph from the data in Table 3 for all three animals. Use a distinct shape or color for each of the animals (e.g., triangle=cat, square=dog, circle=bird). At what times are you plotting the positions of the animals? Why?

At whole seconds because that's when I know the instantaneous velocity.

STOP

13) Send your spokesperson to a neighboring team to check their graph. Did your team plot the animals' positions at the same times? If not, confer as a team and develop a rational for your decision. Meet back with the neighboring team to discuss.

14) How is the velocity of the cat changing with time? Does this agree with your response to question 7?

Velocity increases, yes

15) How is the velocity of the dog changing with time? Does this agree with your response to question 8?

Velocity increases then slowly decreases, yes

16) Each velocity value in questions 14 and 15 includes a + or – sign. Describe what this sign tells you about the direction the animal is moving.

+ → moving to right

- → moving to left

Model 4: Average *acceleration* for a given time interval

Time =	0-2s	1-3s	Animal moving in the...	Velocity is...
Cat's average acceleration	+0.7m/s²	+0.7 m/s²	positive direction	increasing
Dog's average acceleration	+0.7 m/s²	+0.7 m/s²	negative direction	decreasing
Bird's average acceleration	0 m/s²	0 m/s²	positive direction (right)	constant

Table 4 Average accelerations, as a function of time, calculated from the data in Table 3.

17) Describe how you calculate the cat's average acceleration. Do you get +0.7m/s for the time interval from 0-2s?

$$\frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t_f - t_i} = \frac{1-0.3}{2-1} = 0.7\ m/s^2 \quad \text{yes}$$

18) Complete model 4: add the 5 missing accelerations and 4 missing descriptions to Table 4.

19) The accelerations in Table 4 can include either a + or a – sign. Describe what the sign tells you about if the animal is speeding up, slowing down, or moving at a constant speed? How does this relate to the final column, "Velocity is..."?

negative V
positive a ~ slowing down
negative a ~ speeding up

positive V
positive a ~ speeding up
negative a ~ slowing down

a = 0 ~ constant velocity

20) How does your answer to question 19 depends on if the animal is moving in the positive or negative direction?

21) Using the graph template on the final page, create an acceleration (vertical-axis) versus time (horizontal-axis) graph from the data in Table 4 for all three animals. Use a distinct shape or color for each of the animals (e.g., triangle=cat, square=dog, circle=bird). At what times are you plotting the positions of the animals? Why?

basically all times because the acceleration is constant

22) Send your spokesperson to a neighboring team to check their graph. Did your team plot the animals' positions at the same times? If not, confer as a team and develop a rational for your decision. Meet back with the neighboring team to discuss.

23) In a few sentences, summarize the position, velocity, and acceleration for the cat at the start and end of its motion.

position ~ cat's position starts @ 0 and increases @ increasing rate until 3m
velocity ~ starts @ 0, slowly increases @ constant rate
acceleration ~ constant throughout time (positive)

24) In a few sentences, summarize the position, velocity, and acceleration for the dog at the start and end of its motion.

position ~ starts @ 3m, decreases position until 0 m
velocity ~ starts fast, slows down over time.
acceleration ~ constant and positive

25) In a few sentences, summarize the position, velocity, and acceleration for the bird at the start and end of its motion.

position ~ starts @ 0, increases @ constant rate to 3m
velocity ~ constant @ 1 m/s
acceleration ~ nonexistent

26) Look carefully at your team's Position vs. Time graph. How does the slope of the line compare to the direction the animal is moving?

negative – to the left
positive – to the right

27) Again, looking carefully at your team's Position vs. Time graph. How does the slope of the line compare to the velocity?

linear line ~ constant velocity
curvy line ~ increasing/decreasing velocity

28) Looking at your team's Velocity vs. Time graph. How does the slope of the line compare to if the animal is speeding up or slowing down?

If velocity + slope is positive, speeding up.
If velocity is negative + positive slope, slowing down

29) Again, looking at your team's Velocity vs. Time graph. How does the slope of the line compare to the acceleration?

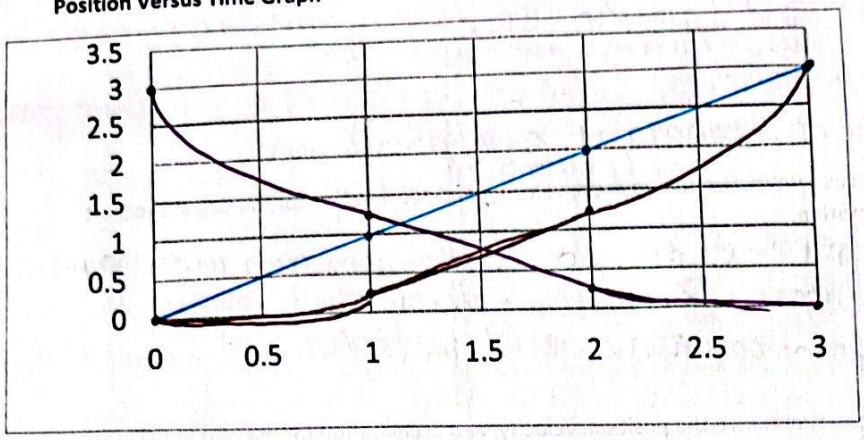
Positive slope = positive a, negative slope = negative a,
no slope = no a

30) Is the acceleration of this car positive or negative (circle positive or negative)?




KEY

Position Versus Time Graph



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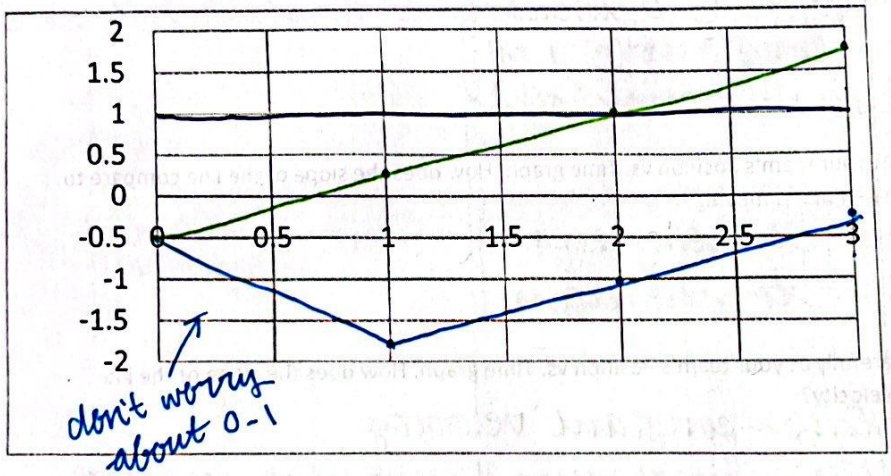
Velocity Versus Time Graph



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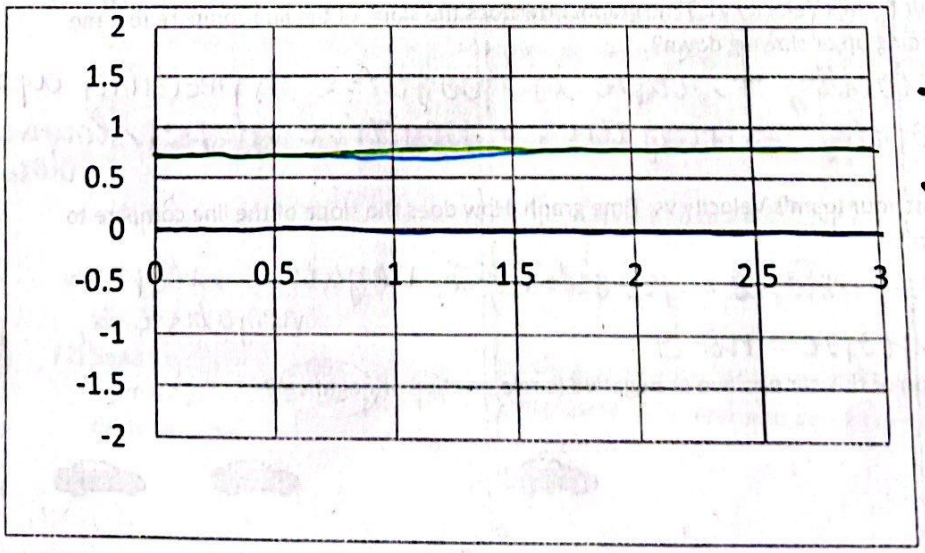
Acceleration Versus Time Graph



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