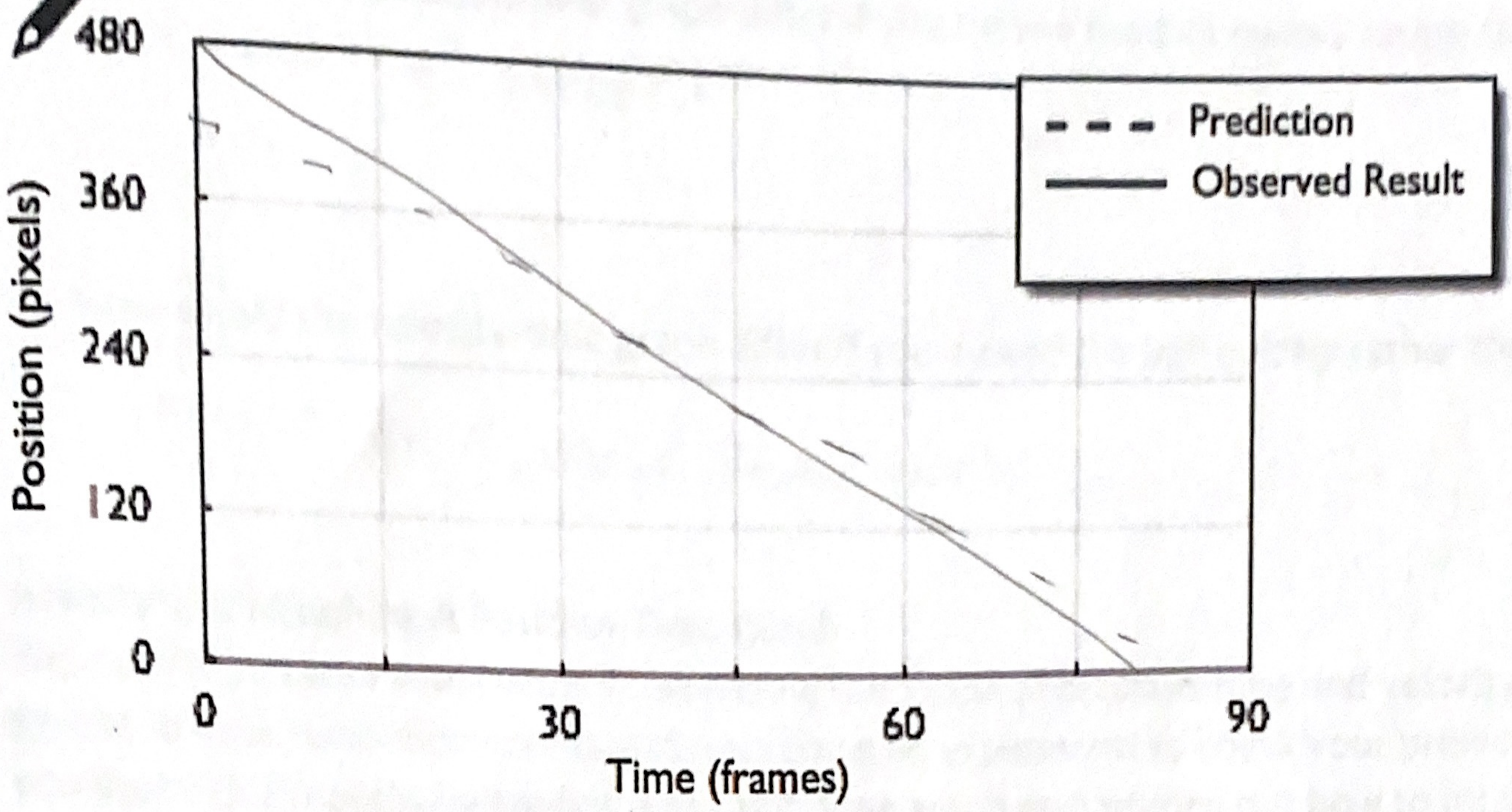
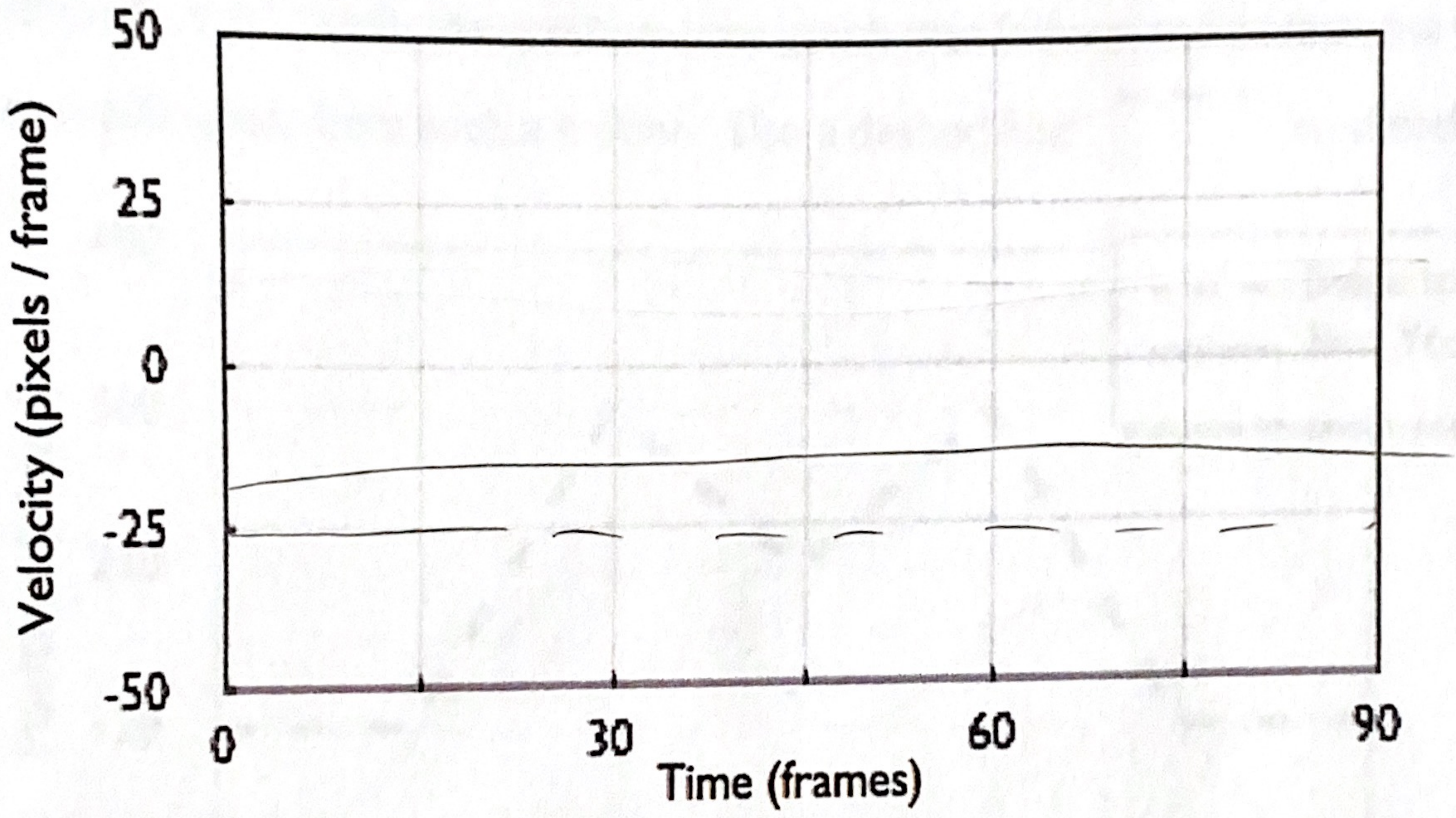




1. How would the position-time graph differ if you moved the ball *up* rather than *down?* (You do not need to answer these questions in full sentences.)

The position-time graph would have a positive slope.

2. How would the velocity-time graph differ if you moved the ball *up* rather than *down?*

Horizontal line above zero, not under 0.

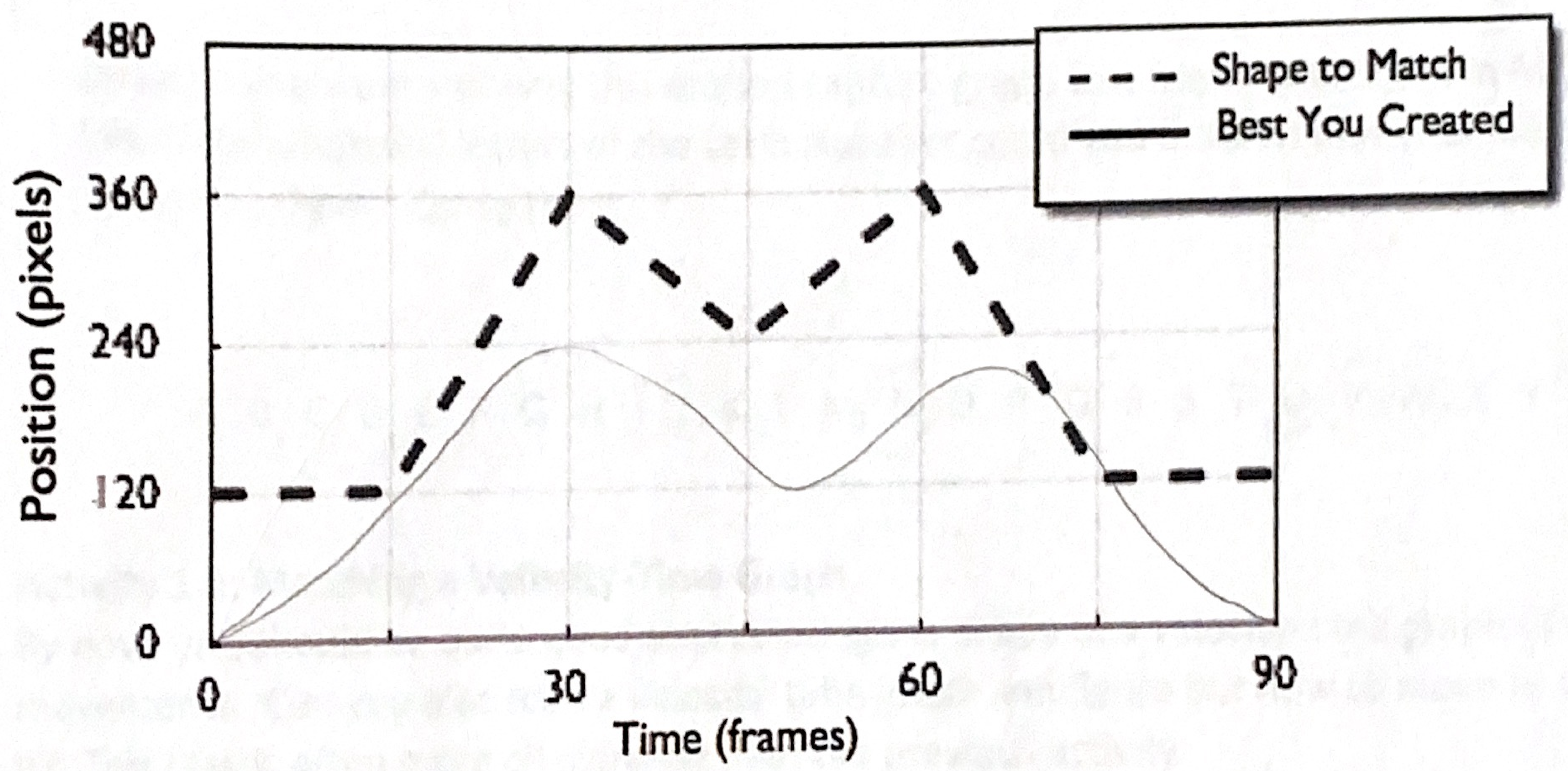
3. How would the position-time graph differ if you moved the ball *quickly* rather than *slowly*?

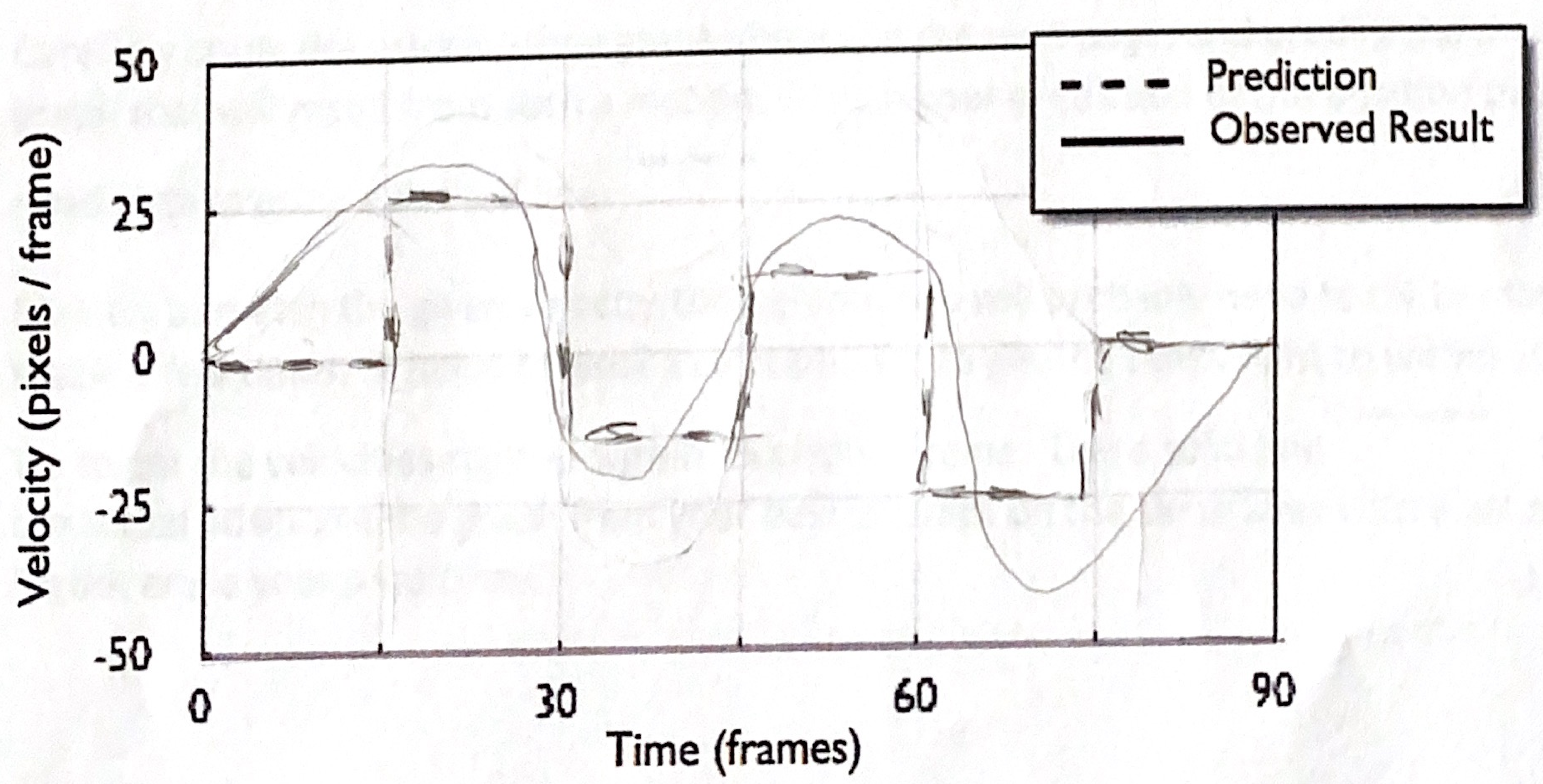
Would be steeper

4. How would the velocity-time graph differ if you moved the ball *quickly* rather than *slowly*?

Would be further from zero.

Activity 1.3: Matching A Position-Time Graph
You now have some experience at predicting the shape of position-time and velocity-time graphs of your hand movements and then doing an experiment to check your predictions. Can you invert this process by reading a position-time graph and figuring out how to move to reproduce it? Study the position-time graph that follows and predict the velocity-time graph that will result from such a motion. Use a dashed line - - - to sketch your prediction.





Now use AMCap and Matlab to try to match the position-time graph shown above. Note that the shape is the letter M, chosen for Mechanical Engineering and Applied Mechanics.

You will probably need to try to match this shape more than once. It helps to work as a team. Try to get the times right to within 10 frames. Try to get the positions right to within 60 pixels. When you produce a satisfactory graph on the computer screen, sketch your observed result on both axes above with a solid line.

5. What factors limited you from matching the graph perfectly? List at least three.

1) It's impossible to immediately change the direction of the ball without slowing down first ⇒ the graph produced has round curves rather than sharp corners

2) Human error — it's difficult for a human to exactly match the positions and velocities given in the predicted graphs.

3) Inconsistent movement – the produced graph could be asymmetrical because I didn't move the ball the same speed down as I moved it up.

6. Imagine you were showing this motion capture graph to a friend who is not in MEAM 147. Which other capital letters of the Latin alphabet could you draw so that your friend could recognize them? Circle them.

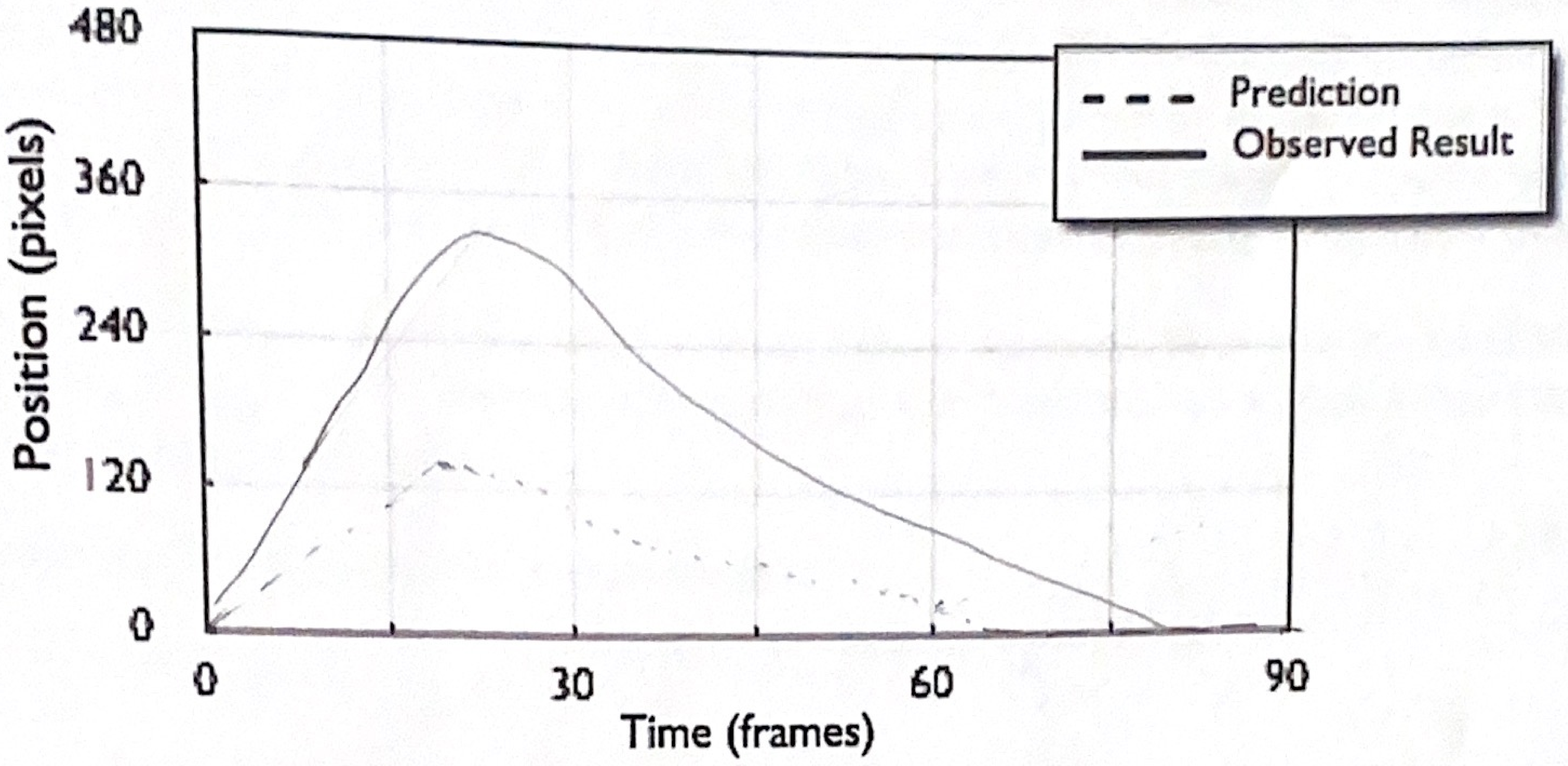
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

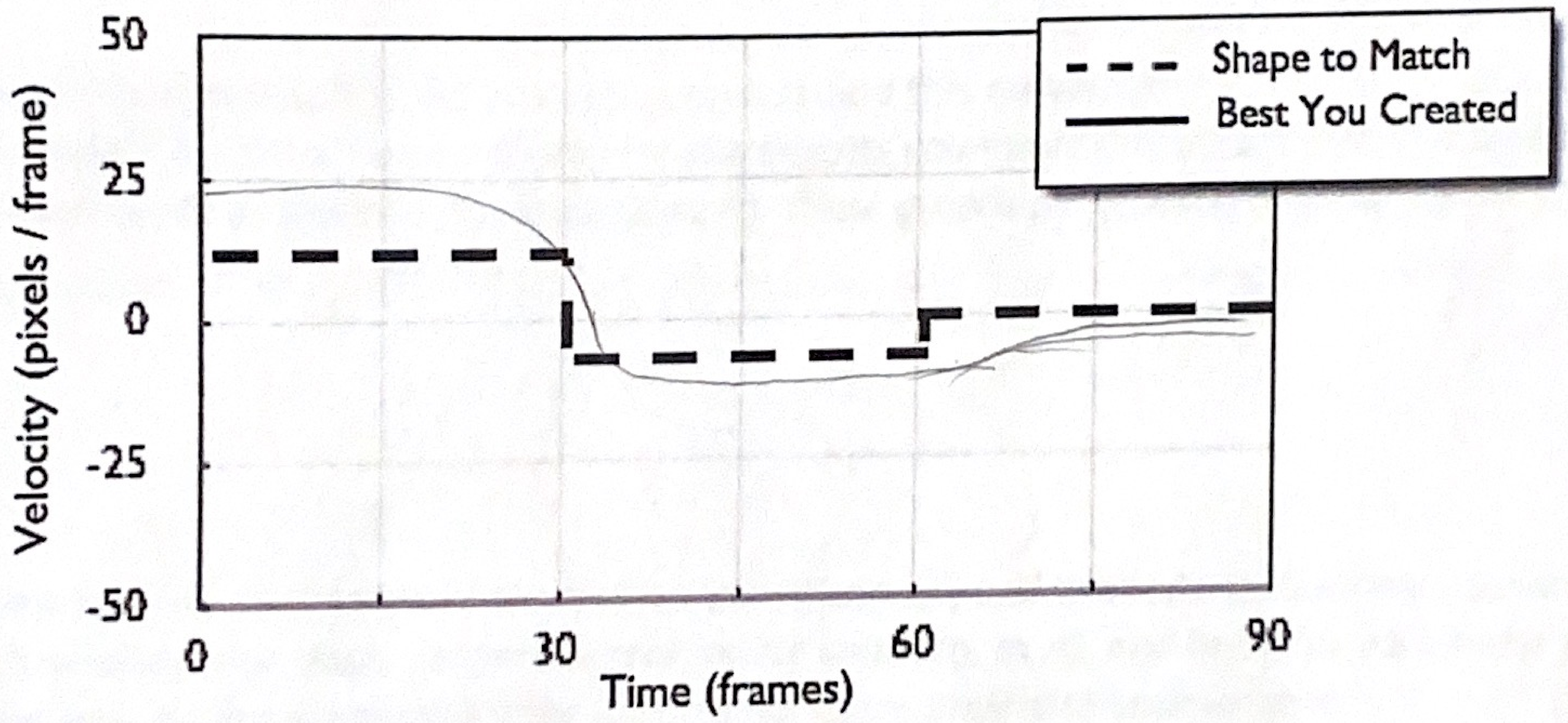
Activity 1.4: Matching a Velocity-Time Graph

By now, you should be quite good at predicting the shape of a velocity-time graph of your hand movements. Can you also read a velocity-time graph and figure out how to move to reproduce it? This task is often more challenging than the previous activity.

Carefully study the velocity-time graph shown on the next page, and predict the position-time graph that will result from such a motion. Sketch your prediction of the position path you will need to take using a dashed line .

Now try to match the given velocity-time graph. You will probably need to try to match this shape a few times. It helps to work as a team. Try to get the times right to within 10 frames. Try to get the velocities right to within ±5 pixels / frame. Use a solid line to sketch the actual position-time graph from your best attempt on the same axes with your prediction. Do not erase your prediction.





7. How can you tell from a velocity-time graph that a moving object has changed direction?

An object has changed direction when its $v(t)$ graph crosses 0.

8. When you have only the velocity-time graph for a motion, can you figure out exactly where the object was at a certain point in time, such as at one second or at the end? Explain.

Yes, you can take the integral $\int_0^{t'} v(t)\,dt$ where t' is the time at which you want to know the objects' position.

Investigation 2: Characterizing the Influence of Gravity

Your second investigation focuses on ballistic motion – the movement of an object that is experiencing only the force of gravity. Now that you know how the camera-based motion capture system works, you will use it in a self-guided experiment to answer the following question: **How does a tossed or dropped object move?** When you think you understand this type of movement, you will **estimate the parameter that defines it** using metric units.

Start by talking with your teammates about how to approach this problem. Work together to develop a rough plan. Then get started with it. Don't hesitate to call over a member of the teaching team if you get stuck.

What action did you record in your movie? 884

Dropping a ball and letting it bounce 953

What motion graph(s) did you use to understand this movement?
Annotate a printed copy with any measurements you made and attach it to this workbook. Please write descriptive figure captions for these graphs as opposed to using figure titles.

I used one parabolic curve from my y-position vs, time graph

Describe the kinematics of the motion you observed, and estimate its defining parameter.
Show all of your steps, convert to real metric units (kg, m, s), and box your parameter estimate. For now, do not worry about the uncertainty associated with your estimate.

Equation for first bounce: $y = -2.938t^2 + 8.559t - 8.898$ [m] and [s]

Kinematics: $y = \frac{1}{2}gt^2 + v_0 t + y_0$ [m] and [s]

$\Rightarrow \frac{1}{2}gt^2 = -2.938t^2 \rightarrow g \approx \boxed{-5.876\ m/s^2}$

What is the percent error between your estimate and the expected value for this parameter?

$\%\ \text{Error} = \left|\frac{\text{Obs} - \text{Exp}}{\text{Exp}}\right| = \left|\frac{-5.876 + 9.81}{-9.81}\right| = \boxed{40.1\%}$

1.145 $\frac{\text{Obs} - \text{Exp}}{\text{Exp}}$

1.784 $y = -2938 \times x^2 + 8.559x - 5.898$