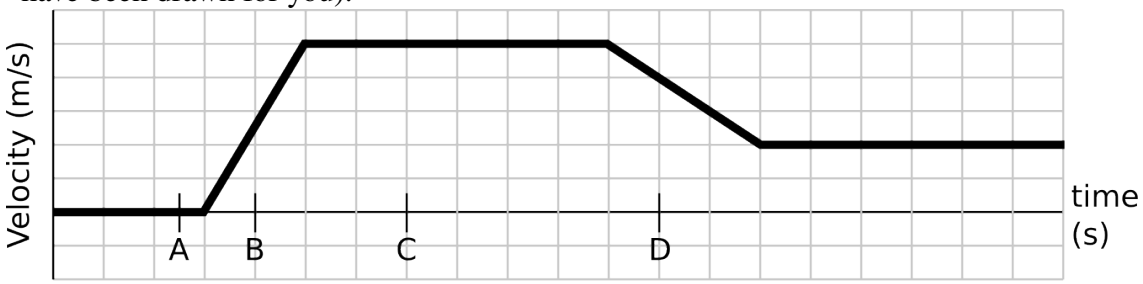
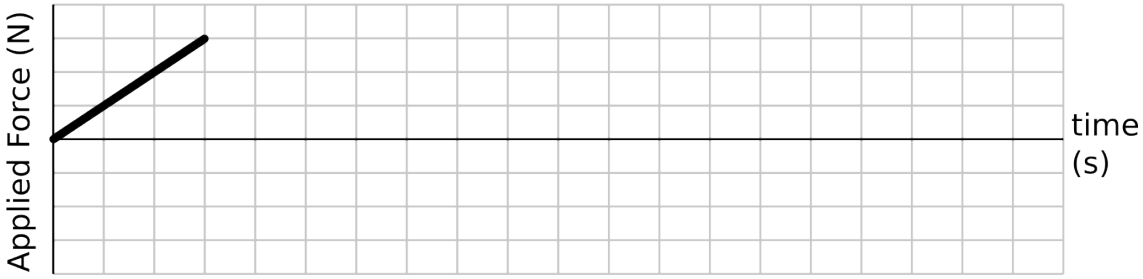
I. Pushing on a File Cabinet

Bob has been asked to push a heavy file cabinet down the hall to another office. It's not on rollers, so there is a lot of friction. At time $t = 0$ seconds, he starts pushing it from rest with increasing force until it starts to move at $t = 2$ seconds. He pushes the file cabinet down the hall with varying amounts of force. The velocity versus time graph of the cabinet is shown below.

A. On the graphs provided below,
   1. draw the net force vs. time that would produce this velocity graph;
   2. draw the friction force vs. time for this motion;
   3. draw the applied force ($F_{\text{on Cabinet by Bob}}$) vs. time for this motion (the first two seconds of this graph have been drawn for you).





B. In the boxes provided, draw a free body diagram for the file cabinet at the times indicated. Label all forces.

time A	time B	time C	time D

C. Explain how you used Newton's Laws in reasoning your answer to part I B.

D. How do the horizontal forces compare at time A and at time C? Explain why they are the same or different.

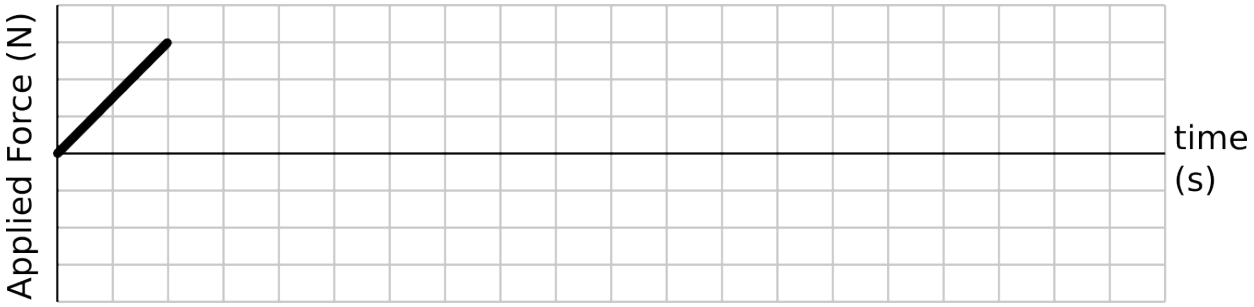
II. Using the computer simulation

On the computer, find the PhET simulation called "Forces in 1 Dimension" and start it. Here you'll see Bob and his file cabinet. **(Be sure that all group members get a chance to control the simulation.)**

A. Explore the simulation to see if your graphs and free body diagrams from part I make sense.

B. As you learn and discover more about forces and motion, **revise your graphs and diagrams in part I**. Explain what you discovered and how these discoveries revised your reasoning and responses.

Draw the final, revised version of your applied force graph here:



Draw the final, revised version of your free body diagrams for time A and time C here:

time A	time C

C. Revise your answer to part I D: How do the horizontal forces compare at time A and at time C? Explain why the forces at these times are the same or different from each other.

D. Summarize the main physics ideas that you needed to apply to this problem and how to reason from that idea to the answer.

III. Pushing on other objects

A. Using the simulation, explore the other objects besides the file cabinet.

B. Bob wants to be able to predict how his experience moving different objects down the hall will change based on the type of object. Explain to Bob all of the ways in which the type of object will influence Bob's experience and the objects motion so that he can make good predictions.

C. Explain how you would have to modify your applied force diagram (part I A) if the velocity vs. time graph represented the motion of other objects.

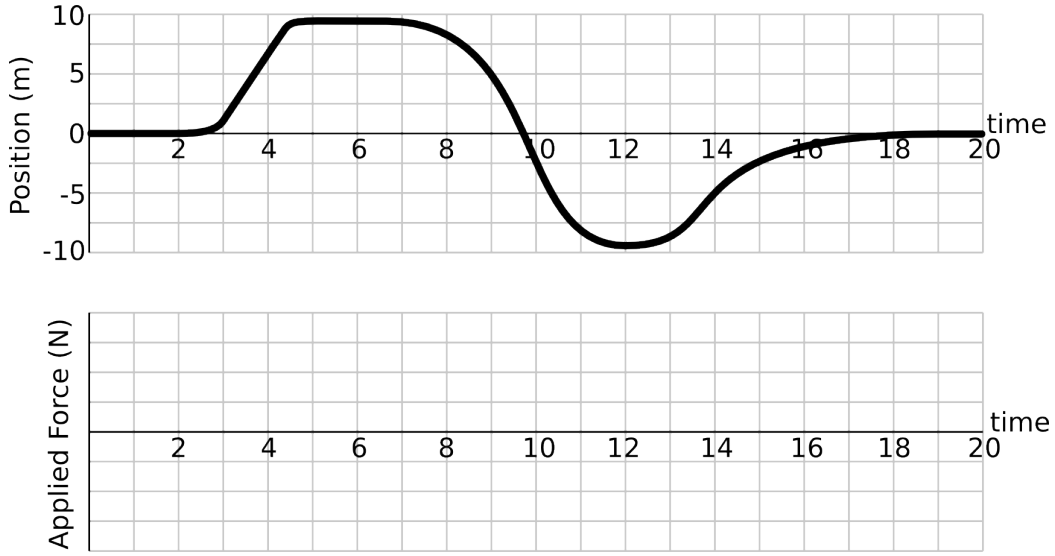
D. Explain how you would have to modify your free body diagrams (part I B) for other objects.

IV. Motion without friction

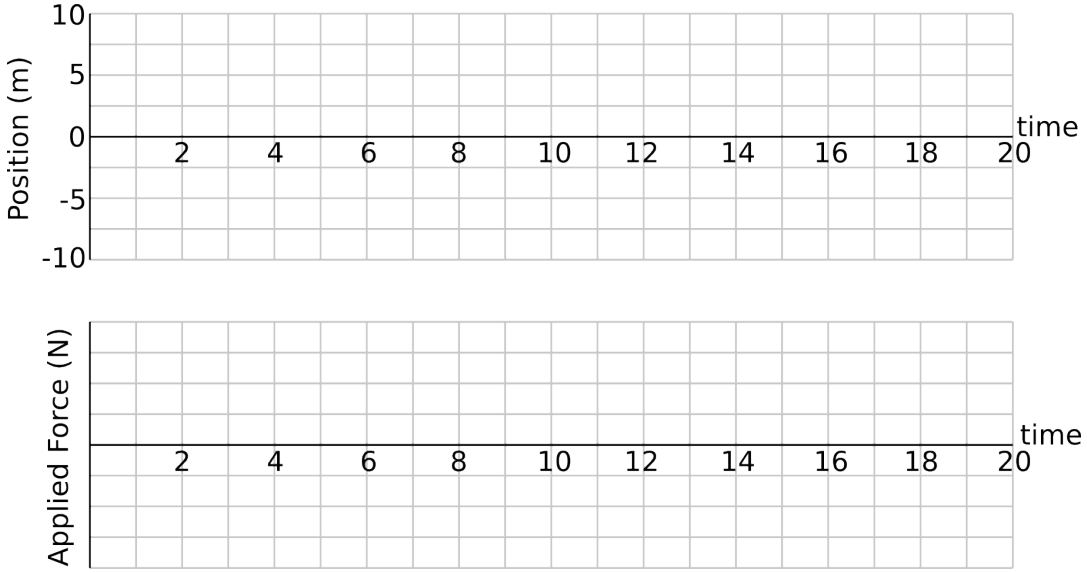
For this section, **turn off friction** in the simulation.

A. Without friction, how do the applied force and the net force compare?

B. Experimenting with the simulation, sketch an applied force that will generate the position versus time graph shown.



C. Make up and draw a position versus time graph in the space provided. Then sketch an applied force graph that will generate this motion.



D. What are the main physics ideas that you used when drawing the applied force graph above?