- worksheet: `positron.hep.upenn.edu/p8/files/ws02.pdf`
- Remember to check in with Bill or Melina on your way out (if you leave early) or during the last 10 minutes of class (if you stay to the end), so that we can ask how today's work went for you and perhaps offer you some quick feedback on what you've written down.
- I tried to keep groups mostly unchanged from last week, though adds/drops required some rebalancing.
- But your group of (2 or) 3 will share a table with a different group of (2 or) 3 each time. So your table number will change each day, but your group number will seldom change.
- We agreed last time that Fridays at 9am was a good option for a Zoom-based make-up time for excused absences. We can schedule additional options as needed. Be sure to write to me **in advance** if you need to miss class.
- Today's ws02 does not include a hands-on exercise, but we plan for ws03 and ws05 to include hands-on parts.

- FWIW, I posted video solutions to ws01 online at `https://youtu.be/ISiS0pJIKPg` . It takes some time to do this, so let me know whether or not it is helpful.

- before next Monday's class meeting:
- Watch my day03 video (acceleration), probably at 2× speed, since it is 2.5 hours long (!). It includes a greeting from Prof Richard Farley, who teaches Architectural Structures here.
- I think if you do that, you will probably not need to **skim** Mazur chapter 03 (PDF on Canvas).
- I welcome your advice on how to keep your preparation time manageable. **Total** time per week for a 1 CU course should be 8–10 hours, including at-home, class, etc.

- before next Wednesday's class meeting:
- **Read/skim** Mazur chapter 04 (PDF on Canvas).
- Watch my day04 video (momentum), perhaps at 2× speed. (Not posted yet.)

Chapter 2: motion in one dimension – key results

x component of displacement: $\Delta x = x_f - x_i$ where "f" is for (f)inal, and "i" is for (i)nitial.

If an object goes from x_i to x_f, changing direction at intermediate points x_a and x_b, then distance traveled (in one dimension) is $d = |x_a - x_i| + |x_b - x_a| + |x_f - x_b|$

x component of (instantaneous) velocity: $v_x = \frac{\mathrm{d}x}{\mathrm{d}t}$

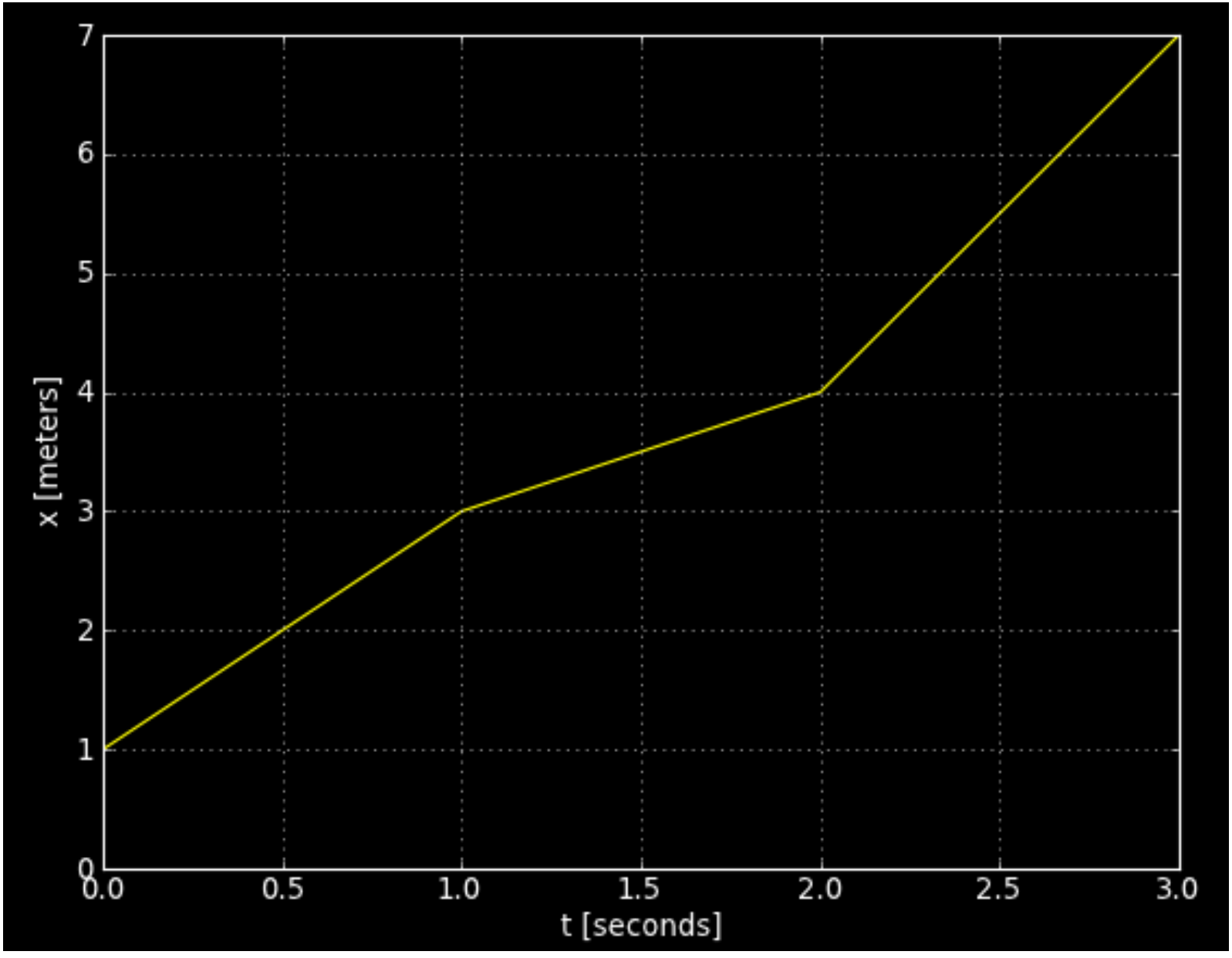
Speed (a scalar) is the magnitude of velocity (a vector). In one dimension, $v = |v_x|$

average velocity $= \frac{\text{displacement}}{\text{time interval}}$ $\qquad v_{x,\text{av}} = \frac{x_f - x_i}{t_f - t_i}$

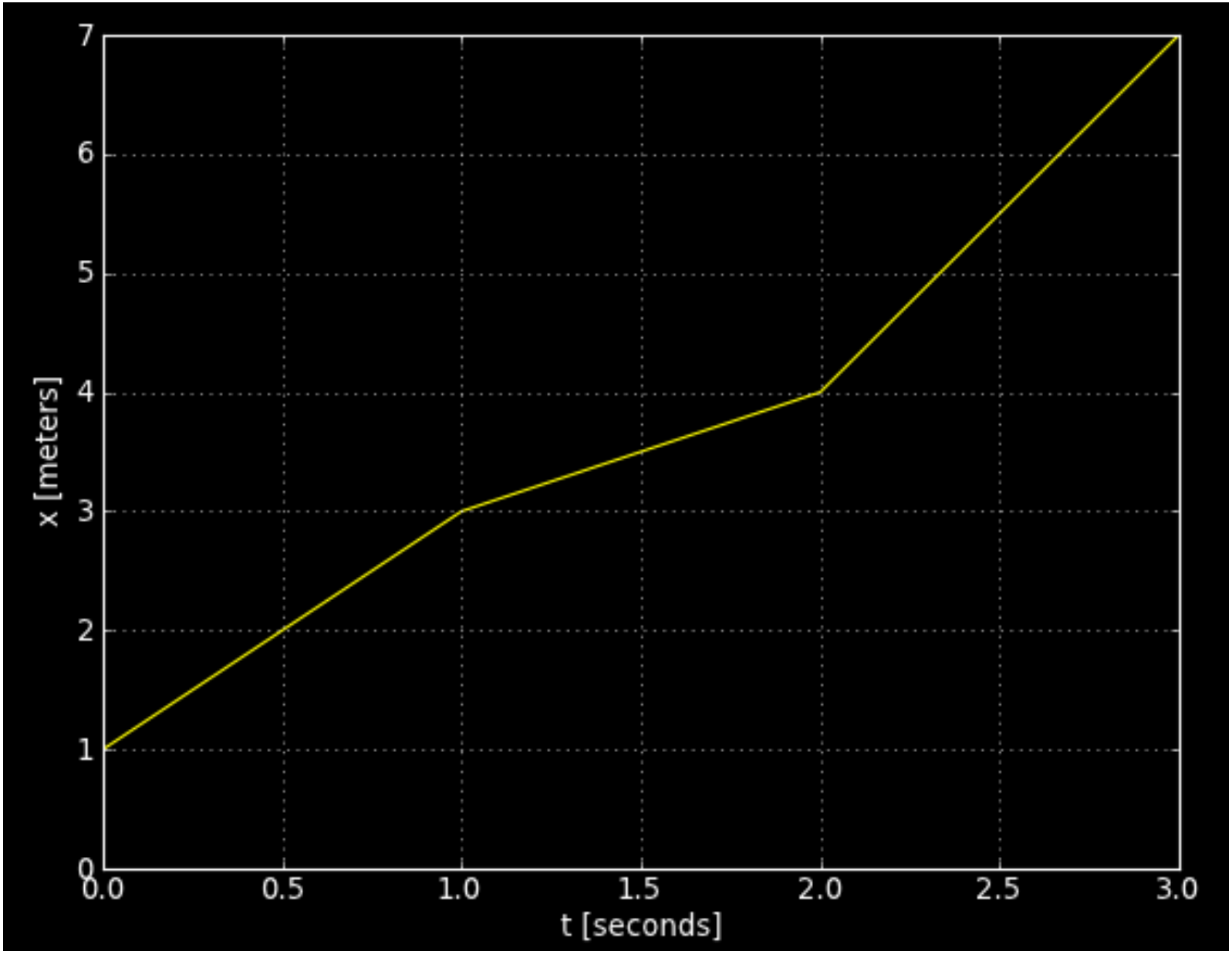
average speed $= \frac{\text{distance traveled}}{\text{time interval}}$

Solving quadratic equations: If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

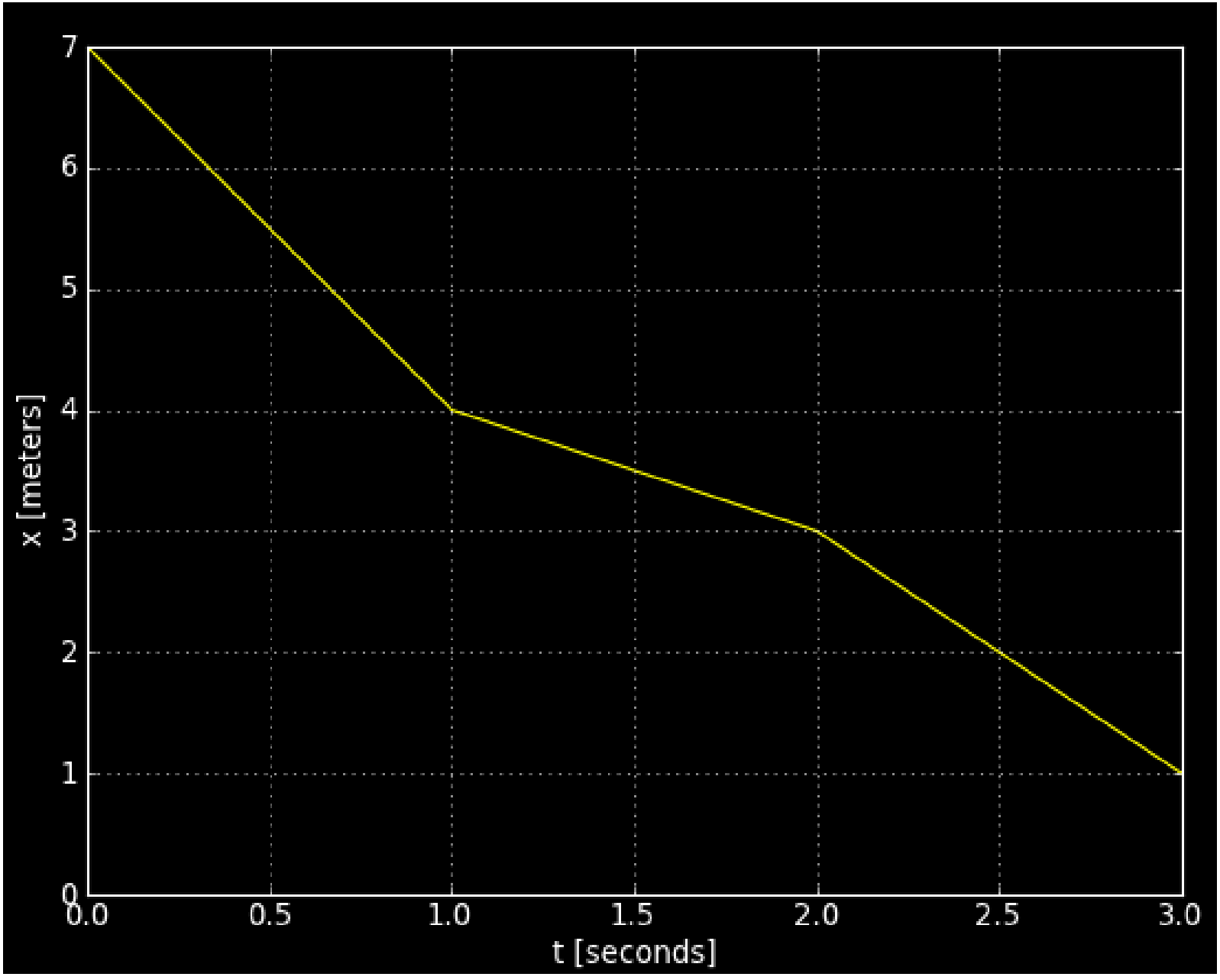
What is the distance traveled from t=0 to t=3s?



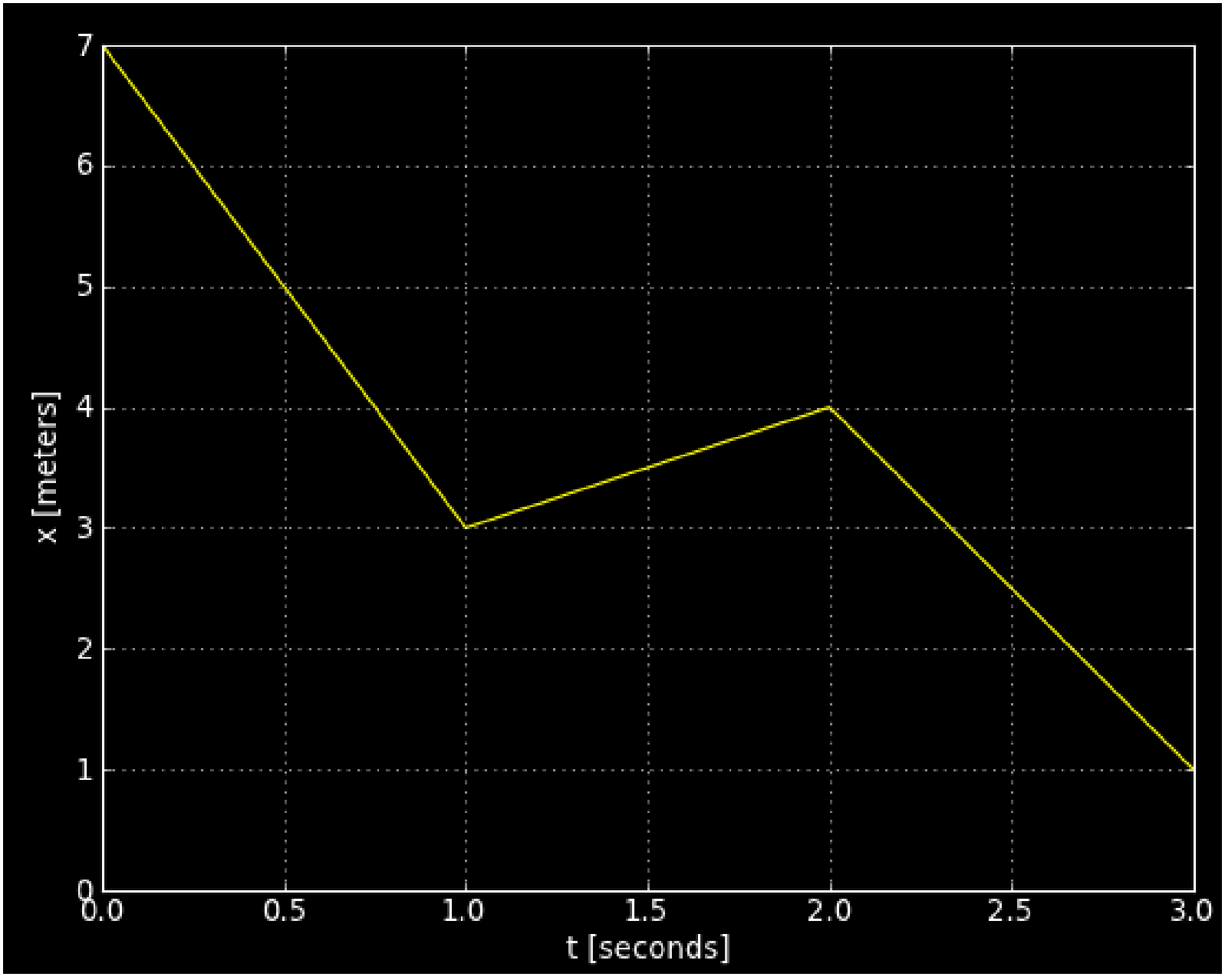
What is the x component of displacement?



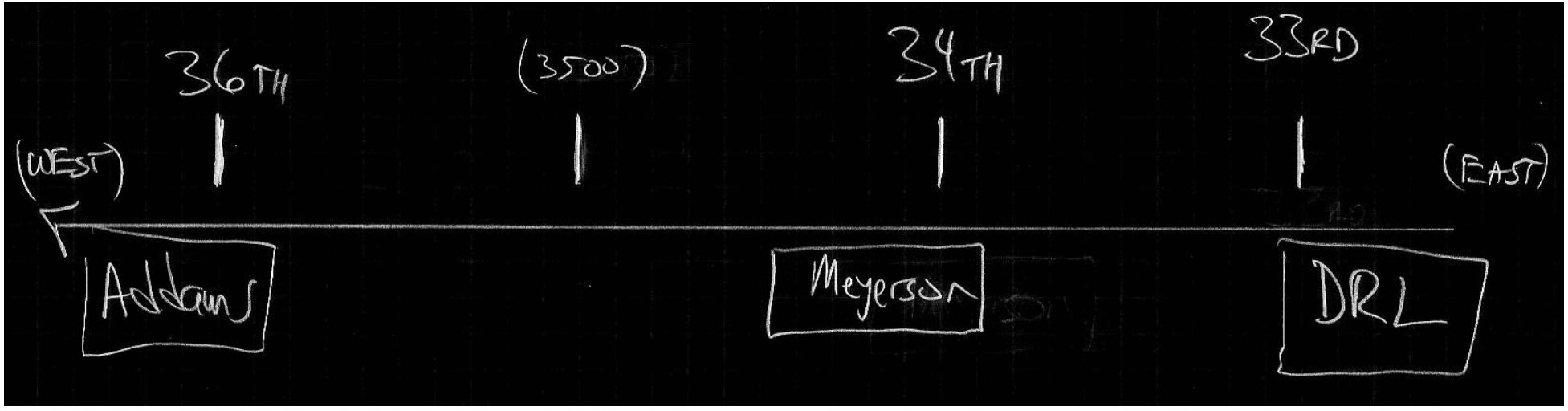
Now what is the x component of displacement?



Now what is the distance traveled?



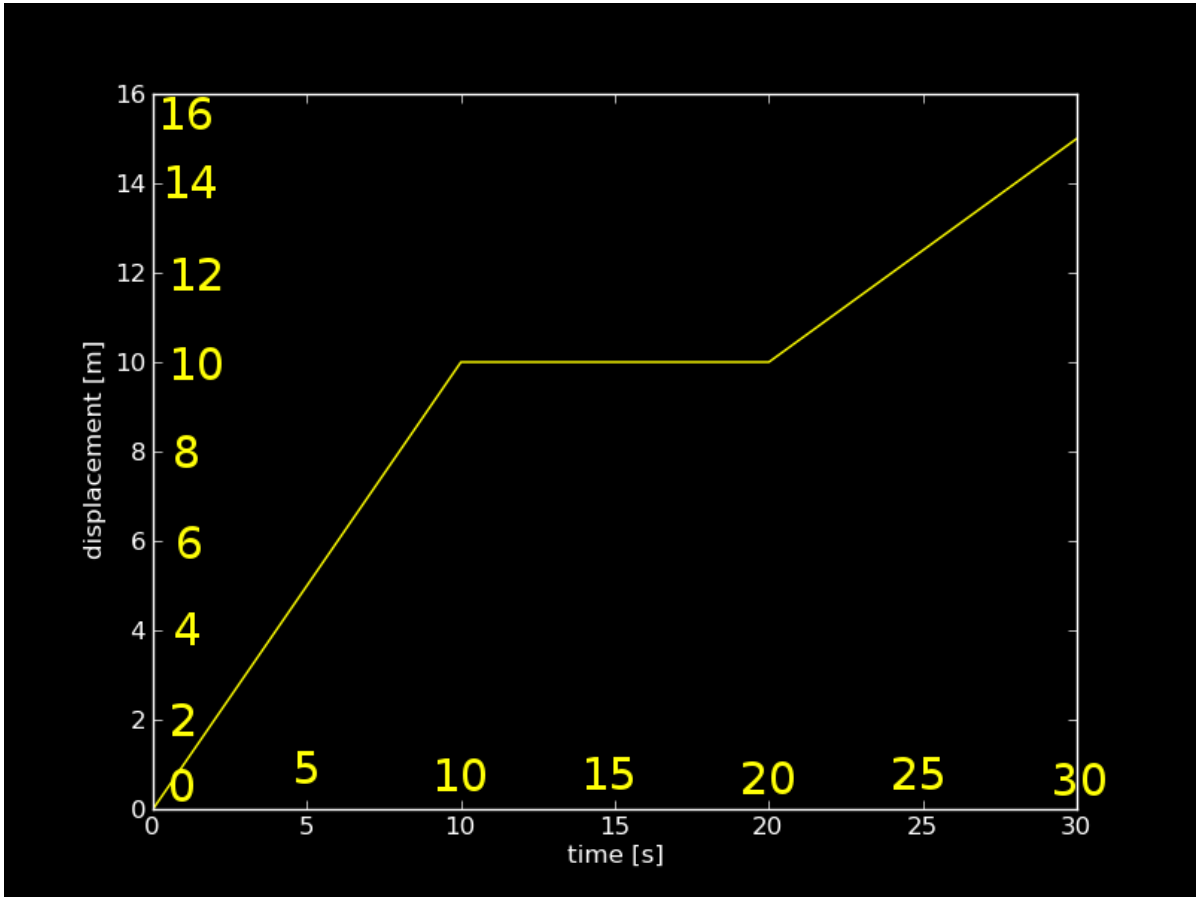
To keep the math simple, let's pretend that every city block is exactly 100 meters long.



- If I bike directly from DRL to Addams in 100 seconds, what is my average speed?
- What is my average velocity?
- If I walk directly from DRL to Addams in 200 seconds, then bike directly back from Addams to DRL in 100 seconds, what is my average velocity for the journey?
- What is my average speed for the journey?

Instantaneous velocity

What is the x component, v_x, of my instantaneous velocity at time $t = 5$ s? At time $t = 15$ s? At time $t = 25$ s?



Slope of the x(t) curve

The slope of the curve in the x coordinate of position vs. time graph (graph of $x(t)$ vs. t) for an object's motion gives

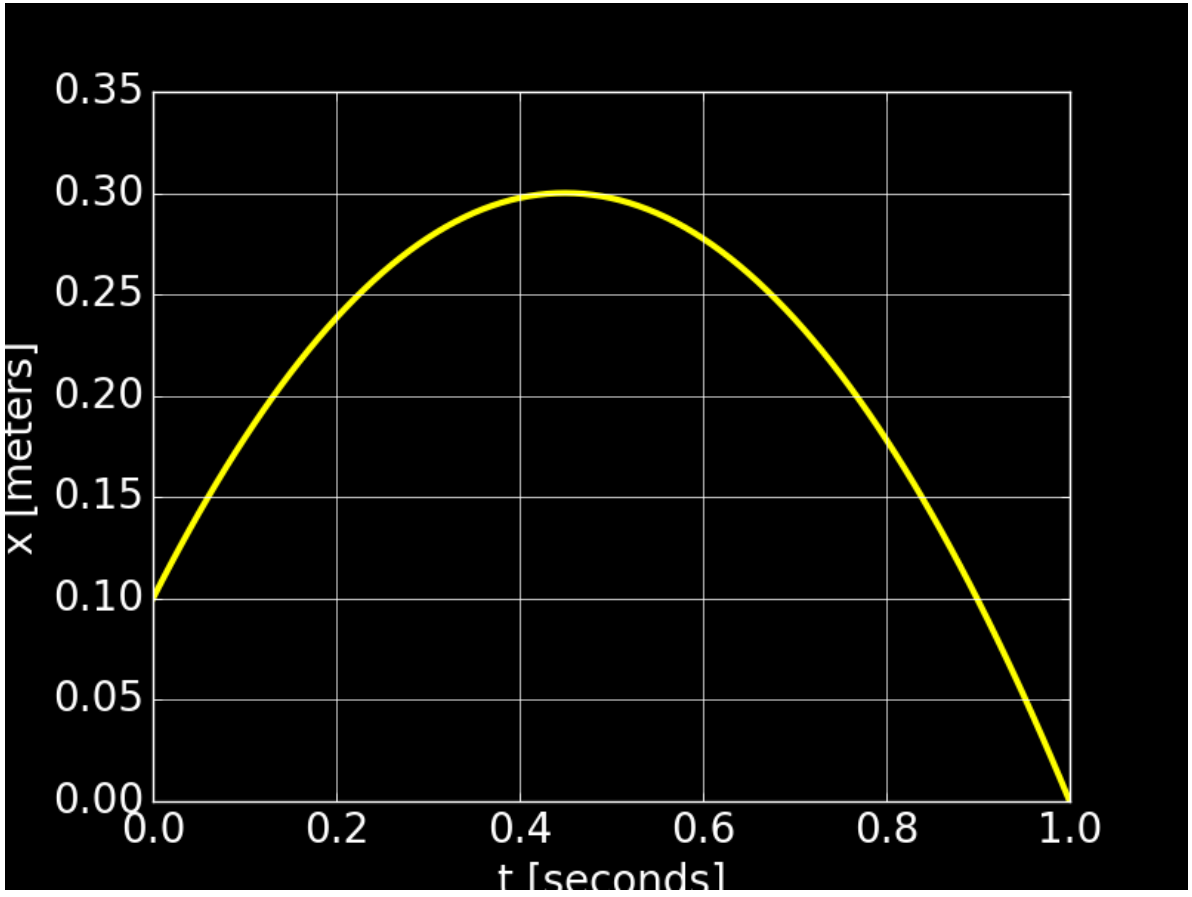
(A) the object's speed

(B) the object's acceleration

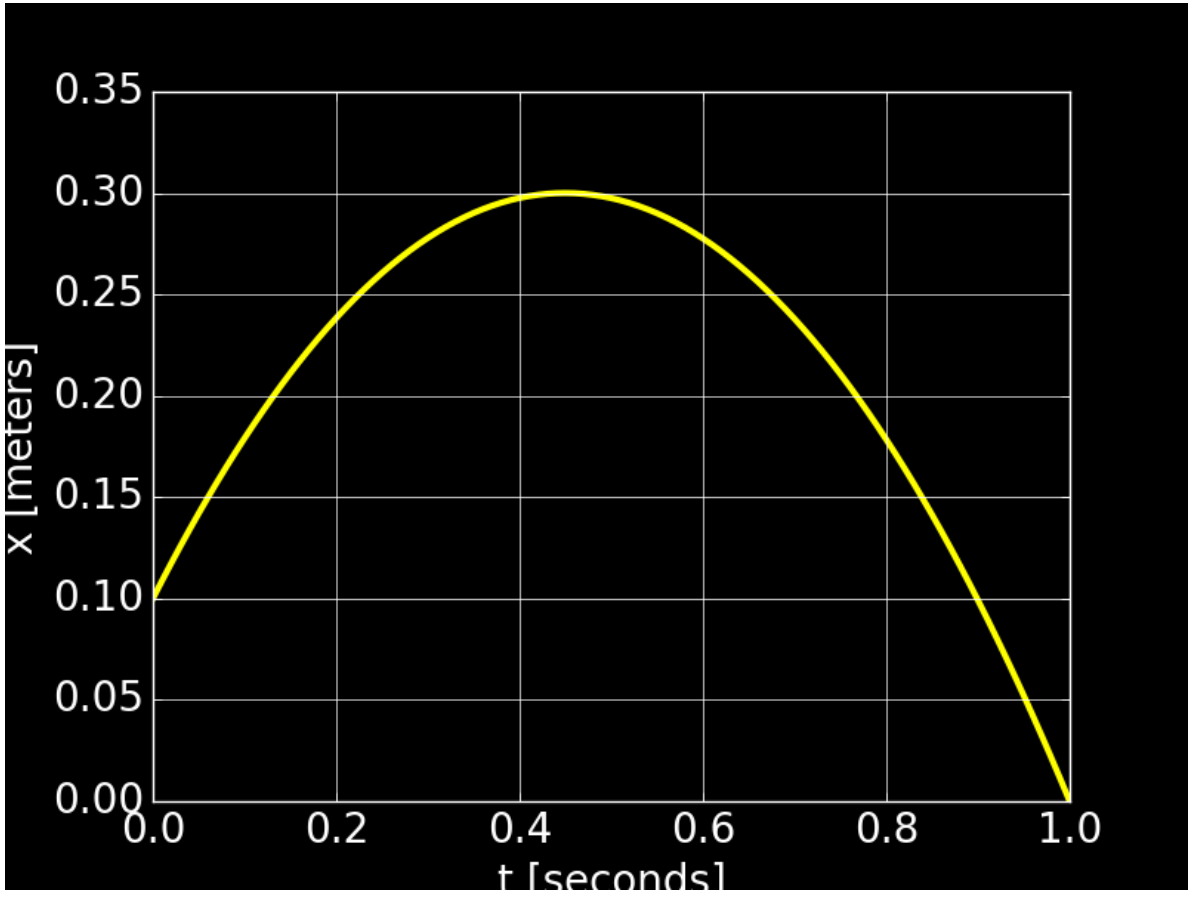
(C) the object's average velocity

(D) the x component of the object's instantaneous velocity

(E) not covered in today's material



- Where is the object moving forward?
- Where is the object moving backward?
- Where does the speed equal zero?
- Where is the speed largest?
- Where is v_x (the x component of velocity) largest?



For the motion represented in the figure above, what is the object's average velocity between $t = 0$ and $t = 1.0\,\mathrm{s}$?

What is its average speed during this same time interval?

Why is the average speed, for this motion, different from the magnitude of the average velocity?

Chapter 3: acceleration – key results (1/2)

Because we will use exclusively one axis (called the x-axis) for the first nine chapters of Mazur's textbook, we need to introduce two conventions that may seem confusing to you if you took high-school physics. First: for free-fall problems in one dimension (e.g. you drop a ball, or you toss a ball directly upward in a motion that is perfectly vertical), the x-axis will point *upward.* Second: for inclined-plane problems (e.g. a briefcase slides down an icy driveway), the x-axis will point *downhill.*

When discussing gravity near Earth's surface, we introduce a constant $g = 9.8\ \mathrm{m/s^2}$, which is "the acceleration due to Earth's gravity." If the x axis points *upward*, then $a_x = -g$ for free fall near Earth's surface. So for this scenario we use a constant negative value for a_x.

Chapter 3: acceleration – key results (2/2)

If the x axis points *downhill* along an inclined plane, then $a_x = g \sin\theta$ for an object sliding down the inclined plane (inclined at angle θ w.r.t. horizontal). So for this scenario we use a constant positive value for a_x. Galileo studied motion on an inclined plane so that the magnitude of a_x would be small enough to allow detailed measurements to be made by eye.

For constant acceleration:

$$v_{x,f} = v_{x,i} + a_x t$$

$$x_f = x_i + v_{x,i} t + \frac{1}{2} a_x t^2$$

$$v_{x,f}^2 = v_{x,i}^2 + 2 a_x \left(x_f - x_i\right)$$

The third equation comes from combining the first two equations and eliminating t.

Physics 8, Fall 2021, Worksheet #2.

Upload PDF (smartphone scan or tablet edit) to Canvas at end of class on Wed, Sep 8, 2021.

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

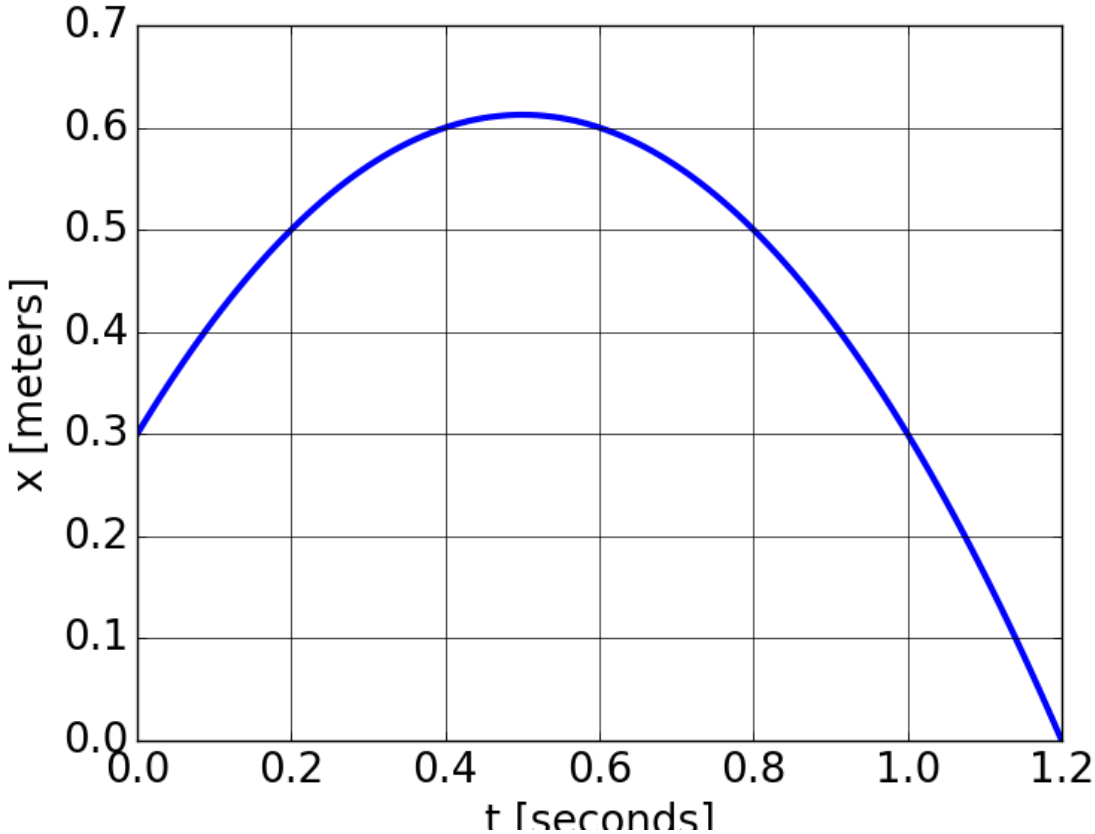
Discuss each problem with your teammates (usually groups of 3), then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result! Do not hesitate to ask for help from other students, from Melina, or from Bill.

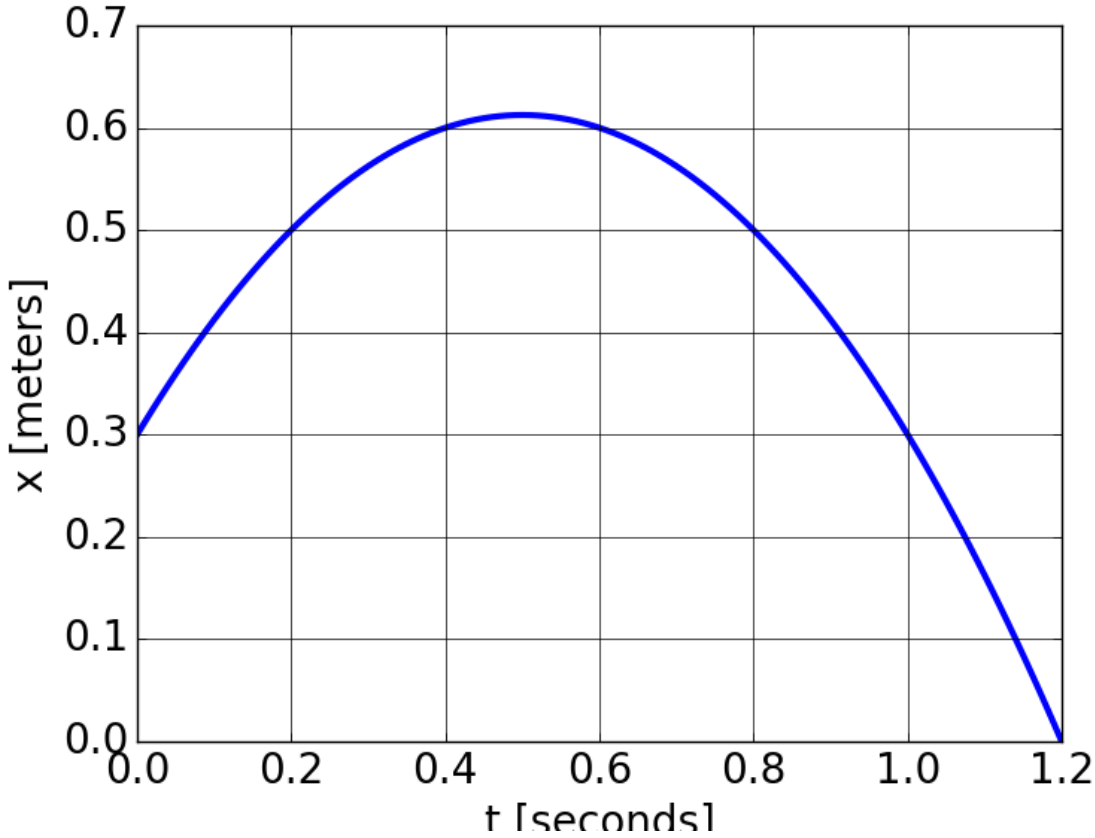
1. If the x component of an object's initial position is $x_i = +6.57\,\text{m}$ and the x component of its final position is $x_f = +4.23\,\text{m}$, what is the x component of its displacement? Remember to label your answer with the proper units (meters).

2*. You walk 1.25 km from home to a restaurant in 20 minutes, stay there for an hour, and then walk back home, taking another 20 minutes. (a) What is the total elapsed time for the trip? (b) What is the distance traveled? (c) What is the displacement? (d) What is your average speed for the trip? (e) What is your average velocity for the trip?

3*. You drive an old car on a straight, level highway at 45.0 miles/hour for 10.0 miles, and then the car stalls. You leave the car and, continuing in the direction in which you were driving, walk to a friend's house 2.0 miles away, arriving 30 min after you begin walking. What is your average speed during the whole trip?

4. The figure below shows the x coordinate as a function of time for a moving object. What is the object's x coordinate (a) at $t = 0$? (b) at $t = 0.2\,\text{s}$? (c) at $t = 1.2\,\text{s}$? What is the object's displacement (d) between $t = 0$ and $t = 0.2\,\text{s}$? (e) between $t = 0.2\,\text{s}$ and $t = 1.2\,\text{s}$? (f) between $t = 0$ and $t = 1.2\,\text{s}$? What is the distance traveled by the object (g) between $t = 0$ and $t = 0.2\,\text{s}$? (h) between $t = 0.2\,\text{s}$ and $t = 1.2\,\text{s}$? (i) between $t = 0$ and $t = 1.2\,\text{s}$?





5*. For the motion represented in the figure above, calculate (a) the object's average velocity between $t = 0$ and $t = 1.2\,\mathrm{s}$, (b) its average speed during this same time interval. (c) Why is the answer to (a) different from the answer to (b)?

Rubric: 4 points per problem: 2 for effort, 2 for correctness.

- 4 points = correct or very nearly correct
- 3 points = minor mistake
- 2 points = major mistake
- 1 point = you haven't convinced us that you put in much effort to try to solve the problem
- 0 points = nothing or very little of substance written down
- For some problems (such as today's hands-on bridge model), it may be unreasonable for us to look for "correctness," so instead all 4 points will be for effort.
- 4 additional overall points for presenting your work clearly, with adequate reasoning. So if n is the number of problems, the total points will usually be $4n + 4$.

For occasional times when you need to miss a class (eg a couple of times per semester, not routinely):

- Be sure to email me WELL BEFORE class, so that I can rearrange groups if necessary.
- We will arrange a Zoom-based make-up time **(eg Friday 9am)**, or possibly during the weekend. Or you can take a zero on the assignment.
- If you do not participate, we will not accept your assignment.