Chapter 2 of Tipler & Mosca, sections 1-4
Motion in 1 Dimension

1. Position, Displacement, Distance, Velocity and Speed

a.) Position along X axis (for now, 1 – Dimension) as function of Time -- (Things with a sign in 1-dim will be vectors in 2 or 3 dim.)

b.) Displacement – Δx -- the distance (with sign) between initial and final position.

c.) Distance traveled – s -- greater than (or equal to) magnitude of Displacement.

d.) Examples.

e.) Average Velocity: $\Delta x / \Delta t$ (with sign)

f.) Average Speed: $s / \Delta t$

g.) Graphs

h.) Instantaneous Velocity (and speed)

i.) More Graphs

2. Acceleration.

a.) **Average Acceleration:** $a_{av} = \Delta v / \Delta t$

b.) **Dimensions;** L/T^2
Units: m/s^2, ft/s^2, **etc.**

c.) **Instantaneous Acceleration:**

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$ **which is the slope of v(t)**

d.) **Thus** $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

e.) **Motion Diagrams**

f.) **Demo of constant acceleration.**

3. Motion with constant acceleration.

a.) Average Acceleration: $a_{av} = \Delta v / \Delta t$

so after Δt $\quad \Delta v = a_{av} \Delta t$

if a is constant, just $\quad \Delta v = a \Delta t$

so after Δt $\quad v = v_0 + a \Delta t$

b.) Position: with constant v, $\Delta x = v \Delta t$

c.) If v changing with t, $\Delta x = \int_{t_0}^{t_1} v\,dt$

constant a, starting at t=0, $v(t) = v_0 + a\,t$

so

$$\Delta x = x - x_0 = \int_0^t (v_0 + at')dt' = v_0 t + \frac{at^2}{2}$$

d.) Velocity. $v^2 = v_0^2 + 2a\Delta x$

(see text, p39)

e.) So have velocity given v_0 , t (a)

and position given v_0 , t (c)

and velocity given v_0 , Δx (d)

for constant acceleration, starting at t=0

3. **(continued)** **Examples**

a.) **Stopping distance. Given a, v_0 how far to stop?**
($a = -5$ m/s^2, $v_0 = 65$ mile/hr = 30m/s)
don't know or want t, so use (d)
stop, so $v=0 = v_0^2 + 2a\Delta x$
$0 = 30^2 - 2(5)(\Delta x)$ – check units
so $\Delta x = 30^2 / 10 = 900 / 10 = 90$ m

b.) **Falling time. Given a, Δx, $v_0=0$, how long do you fall from a 2 story building?**
($a = 9.8$ m/s^2, $\Delta x = 8$ m)
don't know or want v, so use (c)
$\Delta x = v_0 t + at^2/2$
$8 = 0 + 9.8\, t^2 / 2$ check units
$t^2 = 16/9.8 = 1.6$ s^2
so $t = 1.3$ s

c.) **How fast do you land?**
know t, so use (a).
Also know Δx, so could use (d),
but (a) is simpler.
$v = v_0 + at = 0 + 9.8\,(1.3) = 12.7$ m/s (check units) This is about 25 mi/hr (ouch).

d.) **General idea: see what you have, what you want and what you don't want. Then pick appropriate equation.**

3. **(continued)** **Some Key Points**

a.) distance = vt if $a=0$

b.) distance = $\frac{1}{2} at^2$ if $v_0 = 0$ (or if $v_f = 0$)

c.) Stopping distance proportional to v_0^2

d.) $\Delta v = a\Delta t$

e.) always check units
(remember a is L/T^2)

4. Integration and differentiation

a.) v(t) is slope of x(t) so $v(t) = dx(t)/dt$

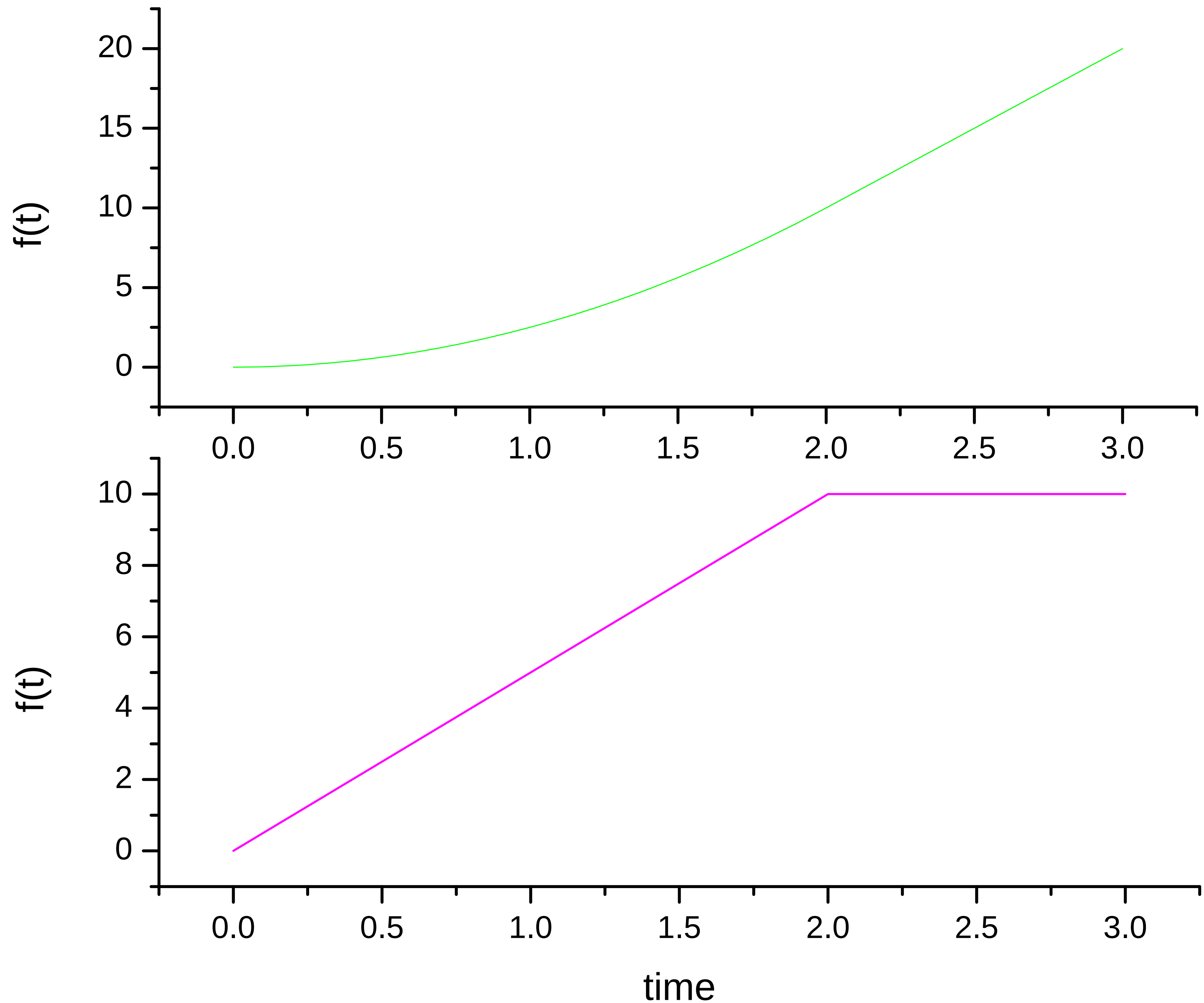
b.) a(t) is slope of v(t) so $a(t) = dv(t)/dt$

c.) if a(t) is constant $v(t) = at + v(0)$
integrating eq b.)
(and if a(t) is NOT constant, v(t) is more complicated)

d.) and if a(t) is constant
$dx(t)/dt = at + v(0)$ integrating that
$x(t) = \frac{1}{2} at^2 + v_0 t + x_0$

e.) if a(t) is not constant, but we know
v(t) somehow, $x(t) = \int_{t_0}^{t} v(t')dt' + x(t_0)$

(see example 2-18)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15
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f(t)
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4
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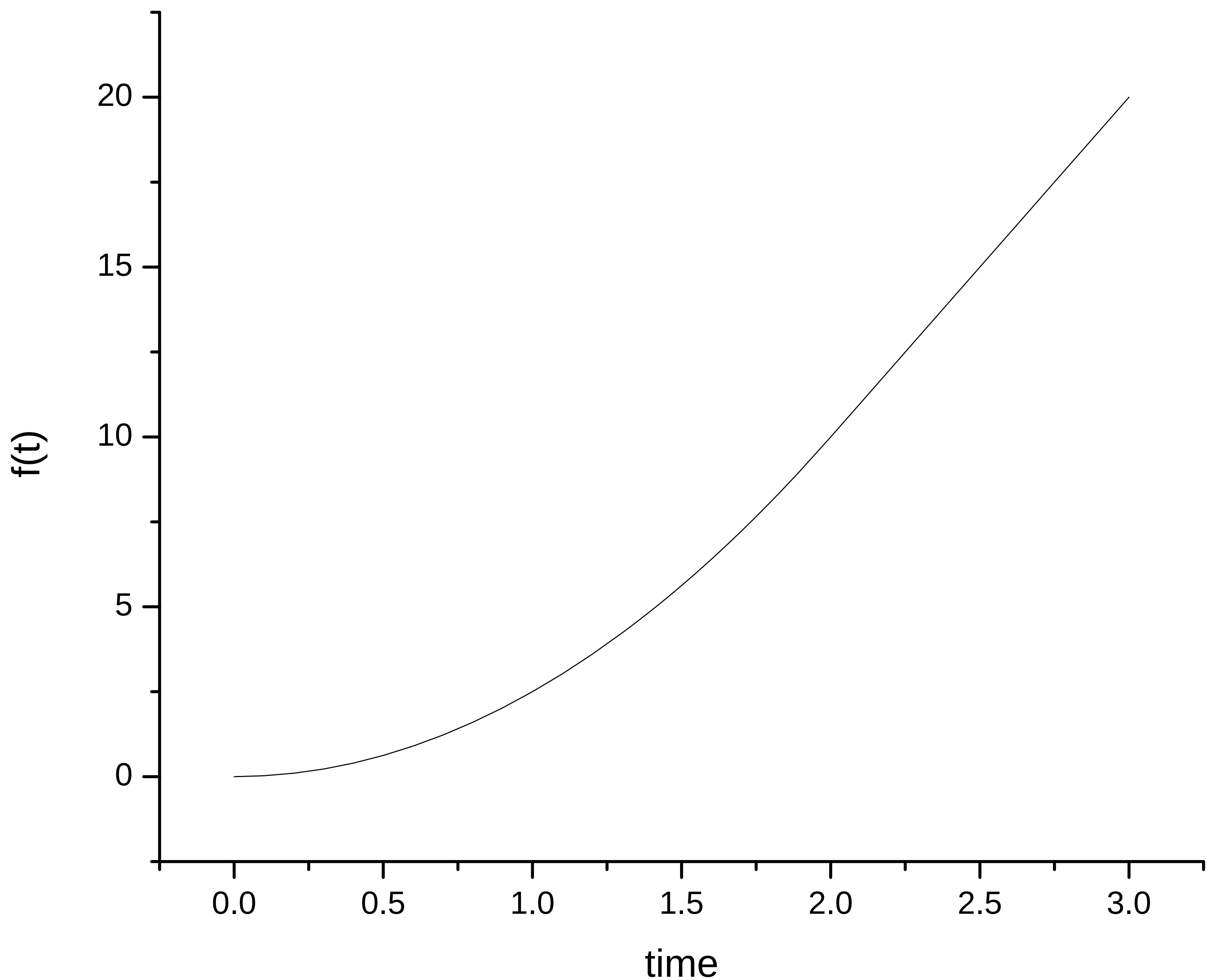
1.5
2.0
2.5
3.0
time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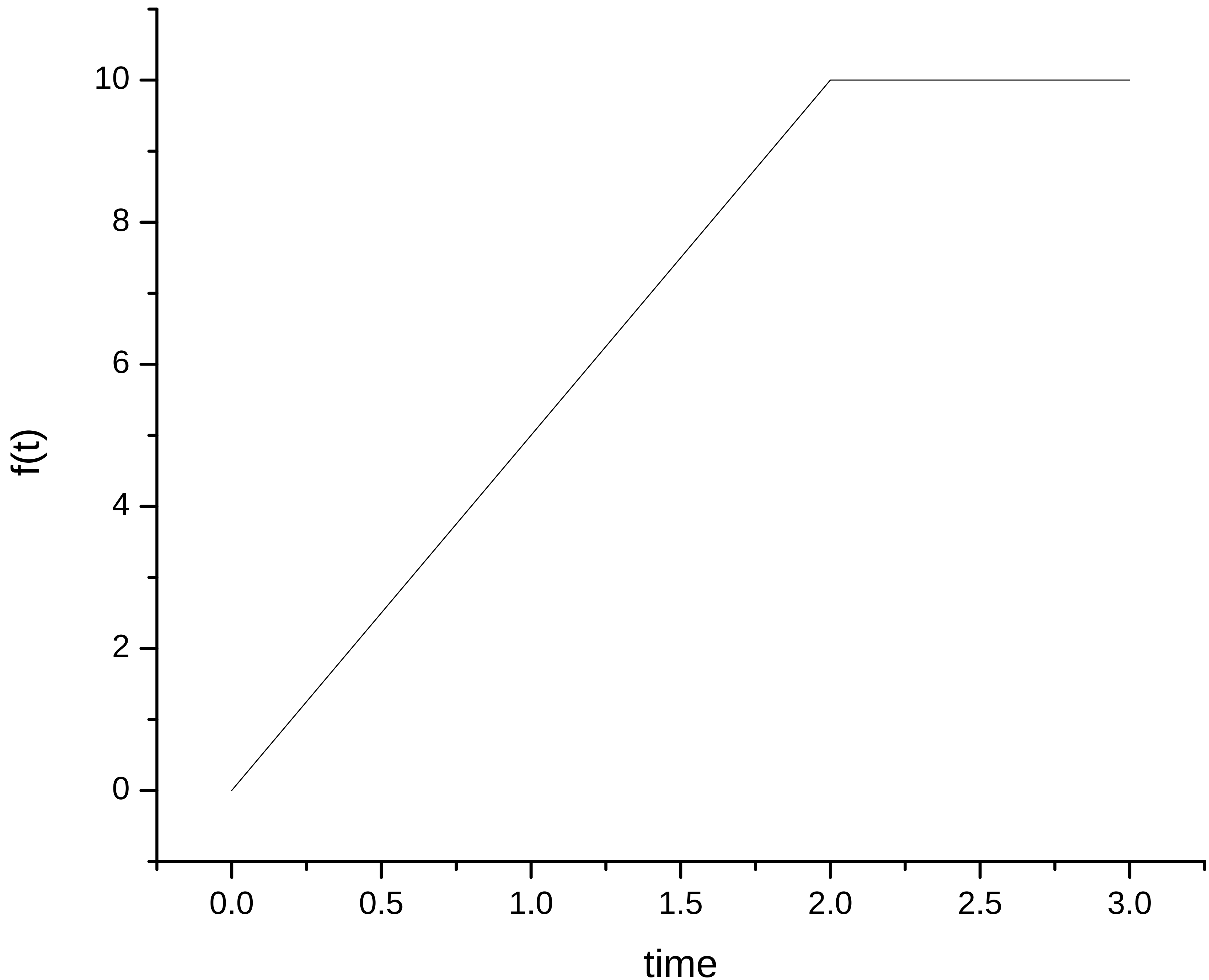
time


f(t)
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2
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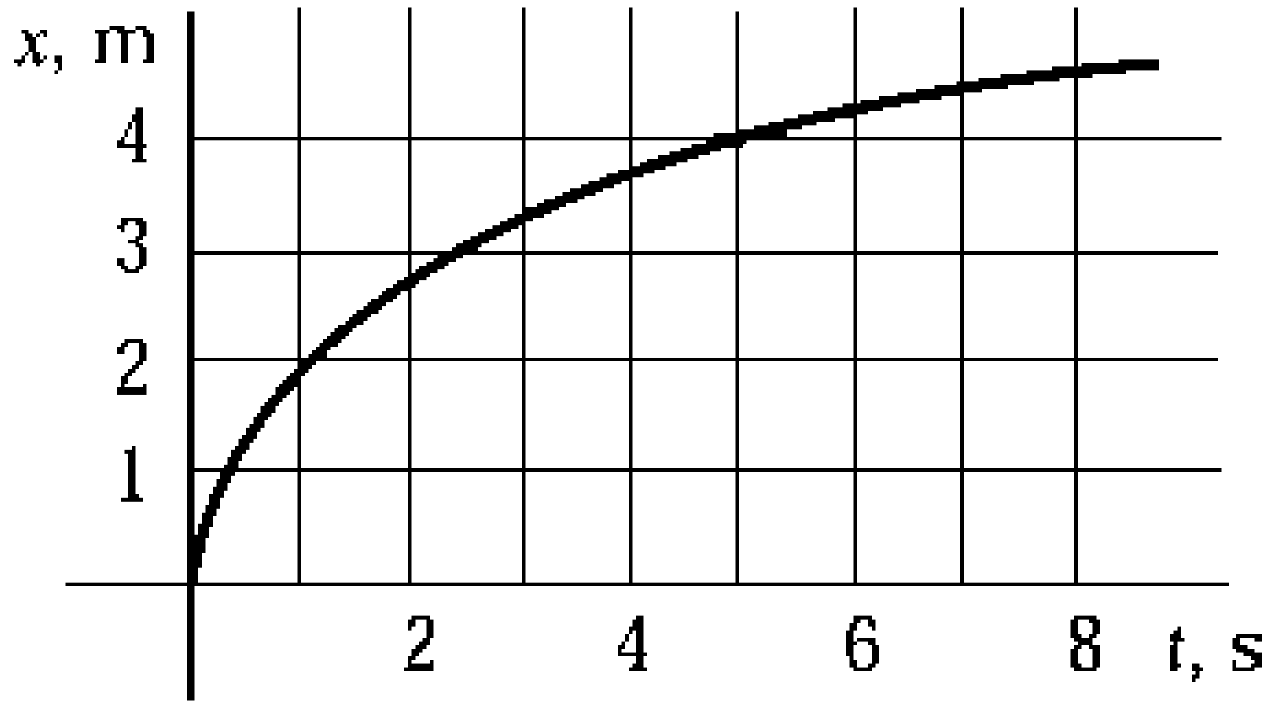
0.0
0.5
1.0
1.5
2.0
2.5
3.0
time

Clicker Question 1

The graph shows how the position x of a particle depends on time t. Which choice is closest to the average speed of the particle in the time interval between 0 and 6 *s*?

A. 0.40 m/s
B. 0.67 m/s
C. 0.80 m/s
D. 1.50 m/s
E. 2.22 m/s



Clicker Question 2

The graph shows how the position x of a particle depends on time t. For which time is the instantaneous velocity the greatest?

A. 0.0 s
B. 2.0 s
C. 4.0 s
D. 6.0 s
E. 8.0 s