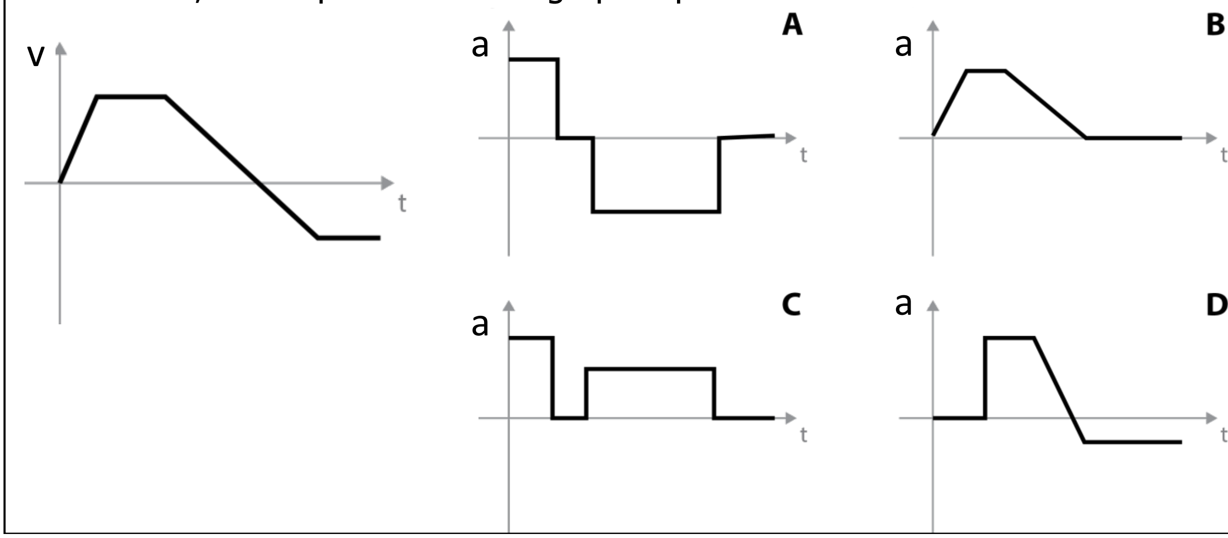
The velocity vs. time of a train is shown at left.

Which acceleration graph best matches?

Remember, the slope on a v vs. t graph represents acceleration.



Announcements

- Reading for next time: 3.1-3.4
- **CAPA assignment # 2** is due Tues@11 PM.
- **Written homework # 1** is due TODAY@4 in your TA's mailbox in the brown bin in the Help Room.

3

Last Lecture

Acceleration – non-zero when velocity is changing.

Recall: $\bar{v} = \dfrac{\Delta x}{\Delta t} = \dfrac{\text{displacement}}{\text{elapsed time}}$ = slope of an *x* vs. *t plot*

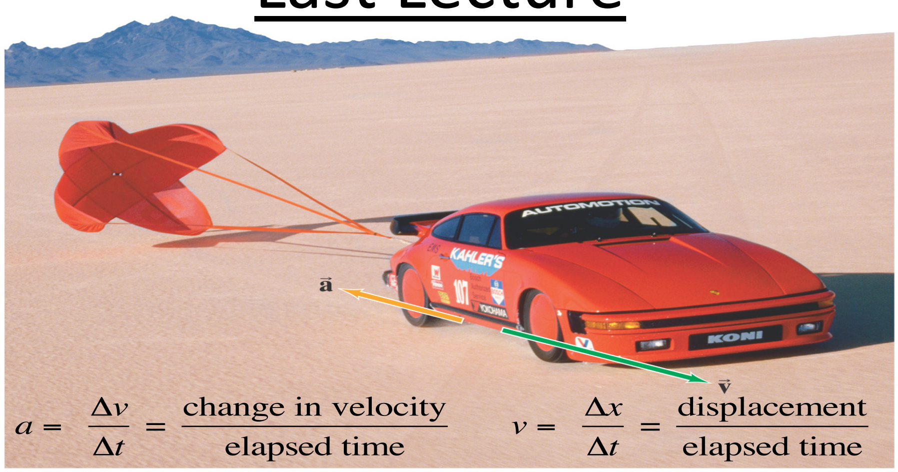
Similarly: $\bar{a} = \dfrac{\Delta v}{\Delta t} = \dfrac{\text{change in velocity}}{\text{elapsed time}}$ = slope of a *v* vs. *t plot*

Possible confusion: **sign of acceleration.**

The sign of acceleration is not necessarily the same as the sign of velocity!

4

Last Lecture



When velocity and acceleration are in opposite directions,
we often call that deceleration.
However, in physics we always call it a negative acceleration.

$x = x_0 + v\Delta t$

$v = v_0 + a\Delta t$

You are driving your car with an initial velocity of +20 m/s. Starting at time $t = 0$ at position $x = 0$ you cause the car to have a uniform acceleration - 4 m/s^2. (*How might you do that*?)

Its velocity at time $t = 1$ s will be

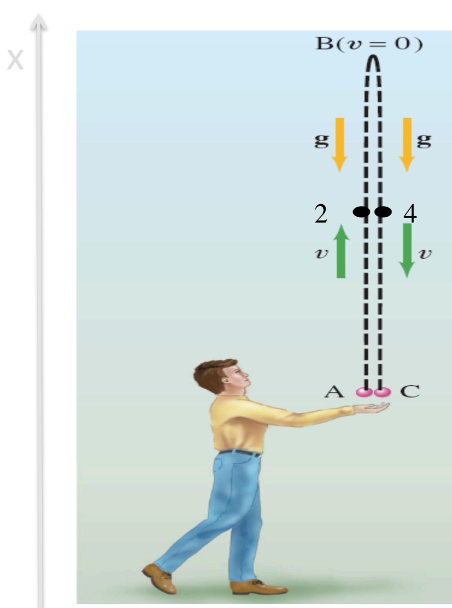
A) 20 m/s

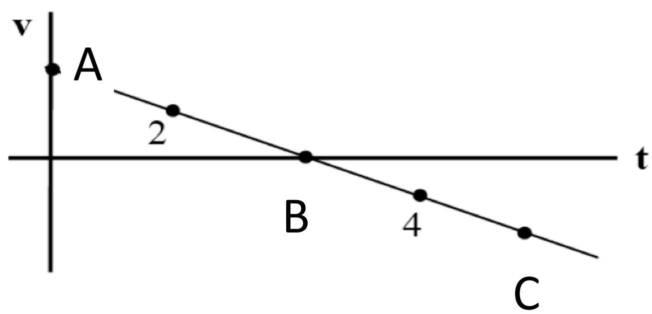
B) 24 m/s

C) 16 m/s $\quad v = v_0 + at = 20 - 4(1)$ m/s = 16 m/s

D) -24 m/s

E) Impossible, acceleration cannot be negative while velocity is positive.

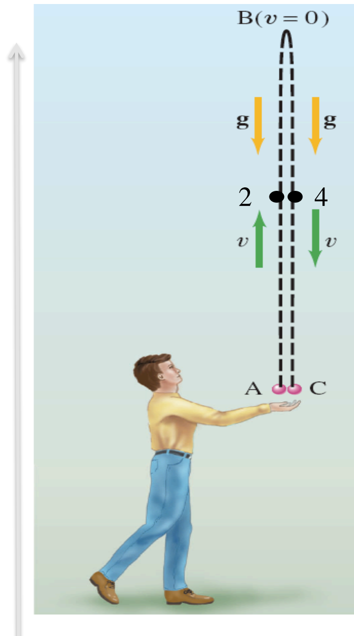




$$a = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}}$$

What causes the constant acceleration downward?

The force of gravity



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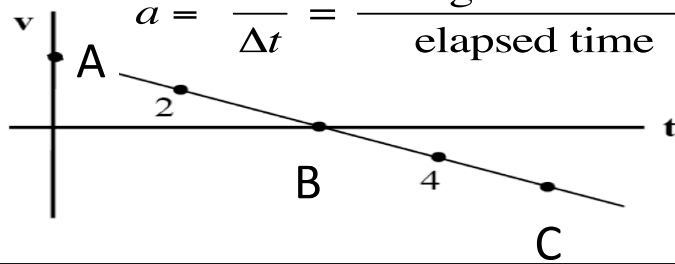
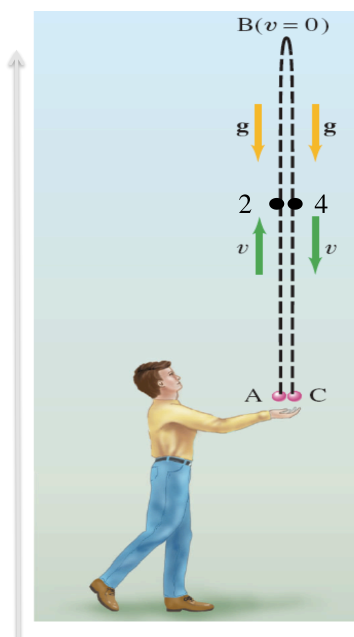


Assuming positive is up, between points **A** and **B**, the acceleration is

A) Positive B) negative C) changes sign

D) neither.



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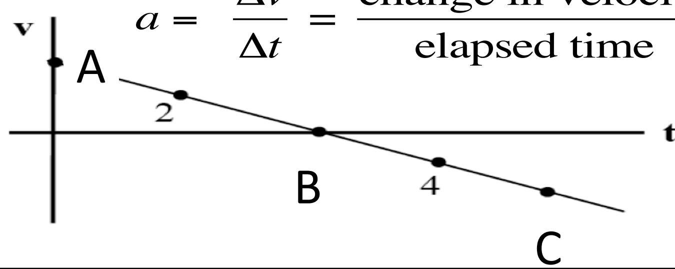

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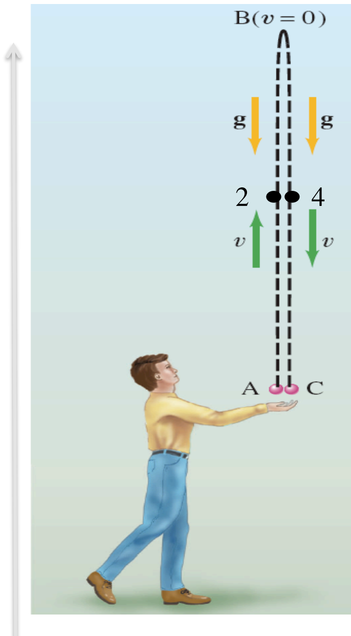

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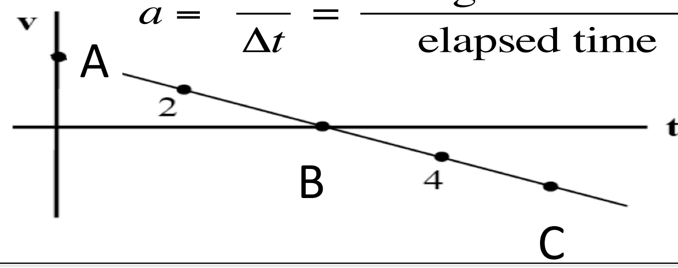
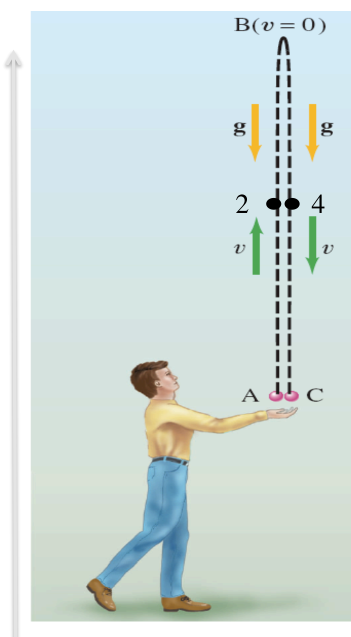


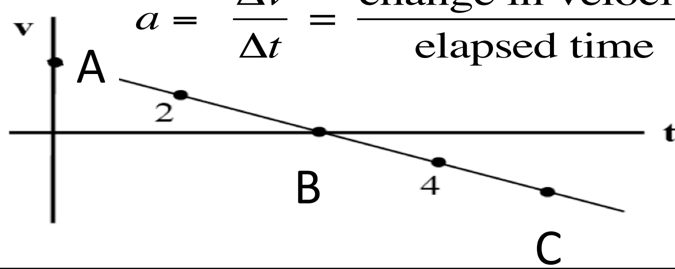
Assuming positive is up, between points **B** and **C**, the acceleration is

A) Positive B) negative C) changes sign

D) neither.



$$a = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}}$$

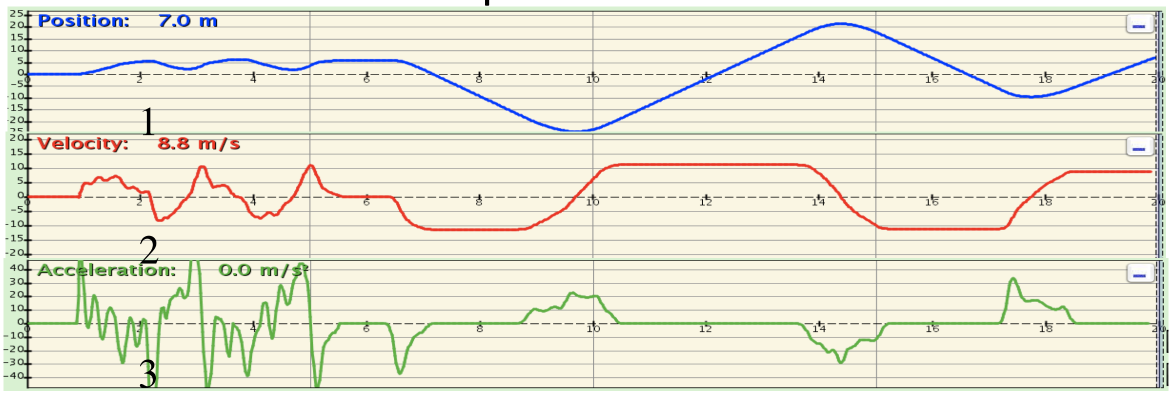


Assuming positive is up, between points **B** and **C**, the acceleration is

A) Positive **B) negative** C) changes sign

D) neither.

Which plot is which?



A) 1-velocity, 2-acceleration, 3-position.
B) 1-position, 2-velocity, 3-acceleration.
C) 1-acceleration, 2-position, 3-acceleration.
D) Insufficient evidence.

Constant acceleration formulae in 1D

Constant acceleration formulas (1D) **(relates)**

(Derived on pages 26-27 of Giancoli.)

(a) $v = v_o + a\,t$ (v, t)

(b) $x = x_o + v_o t + (1/2) a t^2 = x_0 + \bar{v}\,t$ (x, t)

(c) $v^2 = v_o^2 + 2a(x - x_o)$ (v, x)

(d) $\bar{v} = \dfrac{v_o + v}{2}$

x_o , v_o = initial position, initial velocity x, v = position, velocity at time t

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Constant acceleration formulae in 1D

Given constant acceleration a, we can find $v(t)$. How about $x(t)$?

$$\bar{v} = \frac{1}{2}(v_0 + v) \quad\longrightarrow\quad x = x_0 + \bar{v}t = x_0 + \frac{1}{2}(v_0 + v)t$$

$$v = v_0 + at \quad\longrightarrow\quad = x_0 + \frac{1}{2}(v_0 + v_0 + at)t = x_0 + v_0 t + \frac{1}{2}at^2$$

Therefore

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$$

(x_0 – initial position, v_0 – initial velocity)

Constant acceleration formulae in 1D

Given constant acceleration a, we can find $v(t)$ and $x(t)$.
How about $v(x)$?

$$\bar{v} = \frac{1}{2}(v_0 + v) \quad\longrightarrow\quad x = x_0 + \bar{v}t = x_0 + \frac{1}{2}(v_0 + v)t$$

$$v = v_0 + at \;\rightarrow\; t = \frac{v - v_0}{a} \quad\longrightarrow\quad = x_0 + \frac{1}{2}(v_0 + v)\left(\frac{v - v_0}{a}\right) = x_0 + \frac{1}{2a}(v^2 - v_0^2)$$

Therefore

$$v^2(x) = v_0^2 + 2a\,(x - x_0)$$

(x_0 – initial position, v_0 – initial velocity)

Constant acceleration formulae in 1D

Constant acceleration formulas (1D) **(relates)**

(Derived on pages 26-27 of Giancoli.)

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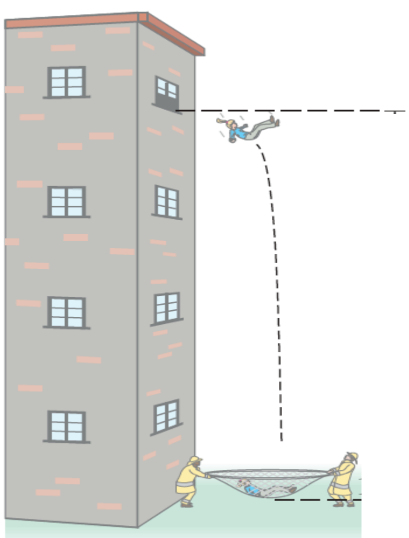
(c) $v^2 = v_o^2 + 2a(x - x_o)$ (v, x)

(d) $\bar{v} = \frac{v_o + v}{2}$

x_o, v_o = initial position, initial velocity x, v = position, velocity at time t

Example: A person drops from a 4th story window and falls 15 m to a net.

What is her velocity on impact?



$x_0 = 15$ m

$+x$

$x = 0$

$x_0 = 15\ m$
$x = 0\ m$
$a = -g = -9.8\ m/s^2$
$v_0 = 0$
$v(x{=}0) = ?$

Which equation would you use?

A) $v = v_0 + at$

B) $x = x_0 + v_0 t + at^2/2$

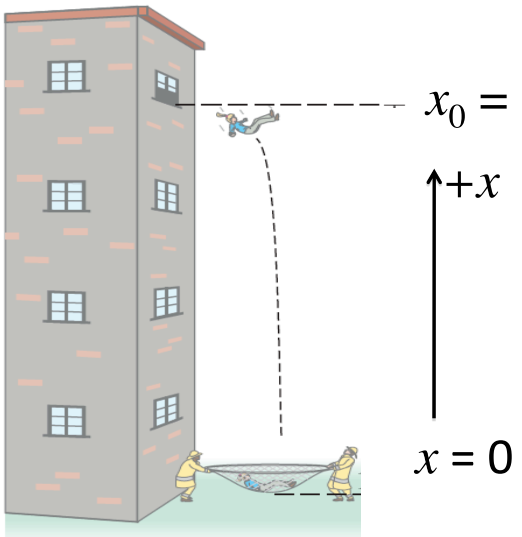
C) $v^2 = v_0^2 + 2a(x\text{-}x_0)$

D) $x = x_0 + \bar{v}\,t$

E) $\bar{v} = (v_0 + v_f)/2$

Example: A person drops from a 4th story window and falls 15 m to a net.

What time will she hit the net?



Which equation would you use?

A) $v = v_0 + at$

B) $x = x_0 + v_0 t + at^2/2$

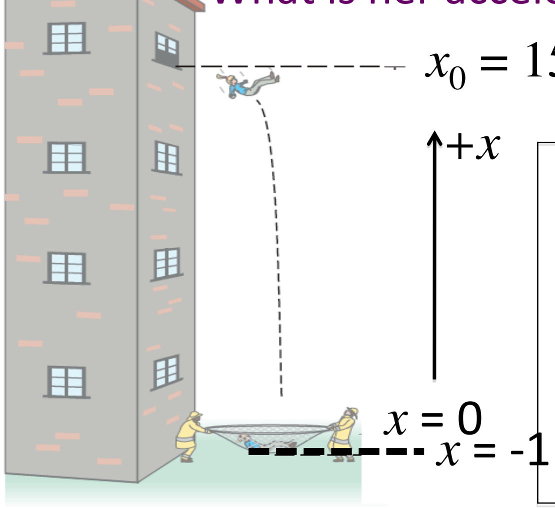
C) $v^2 = v_0^2 + 2a(x-x_0)$

D) $x = x_0 + \overline{v}\, t$

Example: A person drops from a 4th story window and falls 15 m to a net.

The net "flexes" by one meter when she hits it.

What is her acceleration while in the net?



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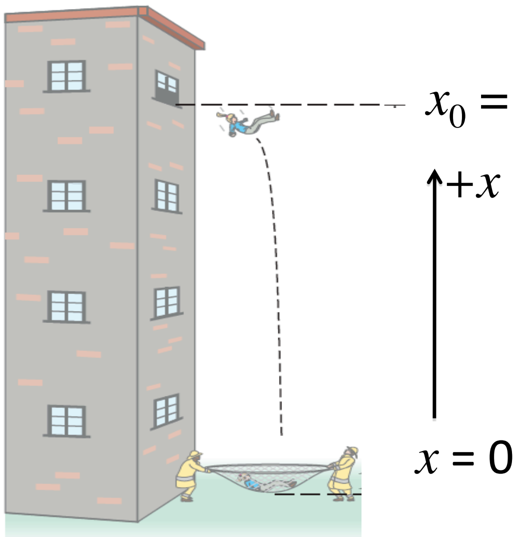

$x_0 = 15\ m$
$x = 0\ m$
$a = -g = -9.8\ m/s^2$
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$v(x=0) = ?$

Which equation would you use?

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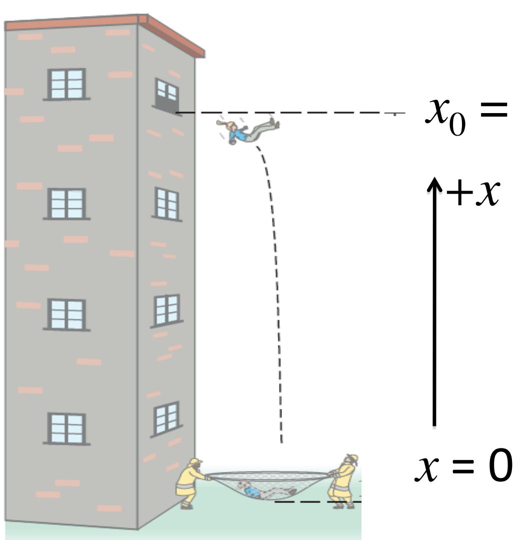

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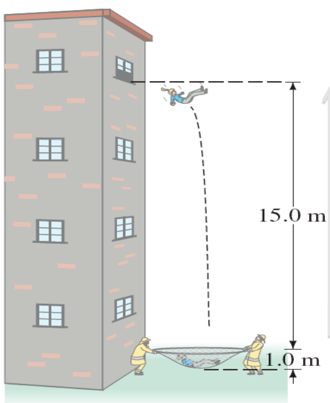
Applications of Kinematics in 1D

Example: A person drops from a 4th story window and falls 15 m to a net.



x_0 = 15 m

$+x$

$a = -g$

x = 0

(1) What is her velocity on impact?

$x_0 = 15\ m$

$x = 0\ m$

$a = -g = -9.8\ \text{m/s}^2$

$v_0 = 0$

$v(x{=}0) = ?$

$$v^2 = v_0^2 + 2a\,(x - x_0)$$

$$= 0 - 2g(0 - x_0) = 2gx_0$$

$$v = \pm\sqrt{2gx_0} = \pm\sqrt{2(9.8)(15)}$$

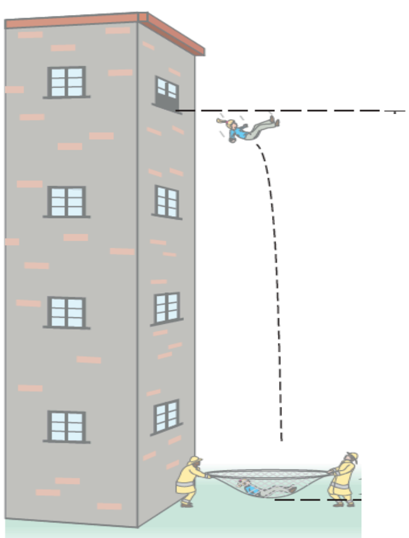
$$= \pm 17.1\ \text{m/s}$$

(negative)

28

Example: A person drops from a 4th story window and falls 15 m to a net.

What time will she hit the net?



x_0 = 15 m

$+x$

x = 0

Which equation would you use?

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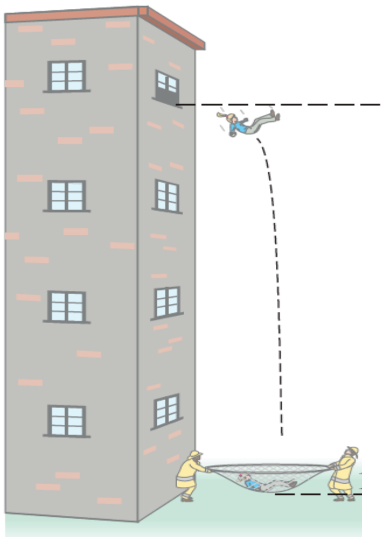

$x_0 = 15$ m

$\uparrow +x$

$x = 0$

Which equation would you use?

A) $v = v_0 + at$

B) $x = x_0 + v_0 t + at^2/2$

C) $v^2 = v_0^2 + 2a(x-x_0)$

D) $x = x_0 + \overline{v}\, t$

Applications of Kinematics in 1D

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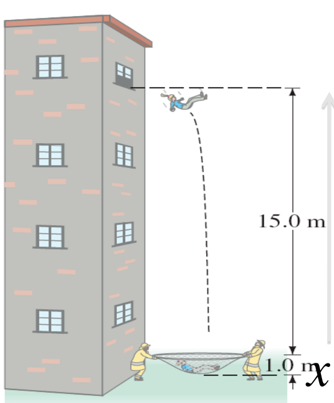


$x_0 = 15$ m

$+x$

$a = -g$

$x = 0$

(2) When will she impact the net?

$x_0 = 15\ m$

$x = 0$

$a = -g = -9.8$ m/s^2

$v_0 = 0$

$v(x=0) = -17.1$ m/s

$t(x=0) = ?$

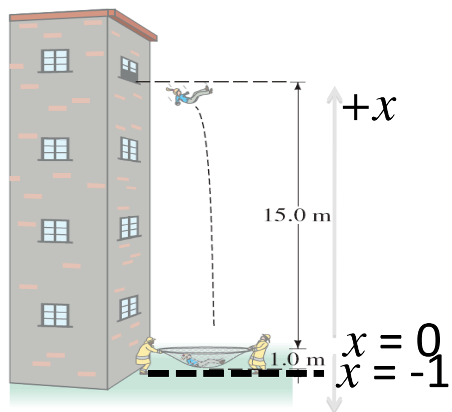
$v = v_0 - gt \qquad x = x_0 + \bar{v}t \qquad x = x_0 + v_0 t - \frac{1}{2} g t^2$

$t = \frac{-v}{g} \qquad t = \frac{-x_0}{\bar{v}} = \frac{-2x_0}{v} \qquad t = \sqrt{\frac{2x_0}{g}}$

t = 1.75 s

Applications of Kinematics in 1D

Example: A person drops from a 4th story window and falls 15 m to a net.



(3) Assuming the net flexes 1 m, what will be her acceleration while in the net? $v_0 = -\ 17.1$ m/s

$v = 0 \quad x_0 = 0 \quad x = -\ 1$ m

a?

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$0 = v_0^2 + 2a(-1 - 0)$$

$$v_0^2 = 2a$$

$$a = \frac{v_0^2}{2} = \frac{(-17.1)^2}{2}$$

$$= 146 \text{ m/s}^2 \sim 15 \text{ g}$$