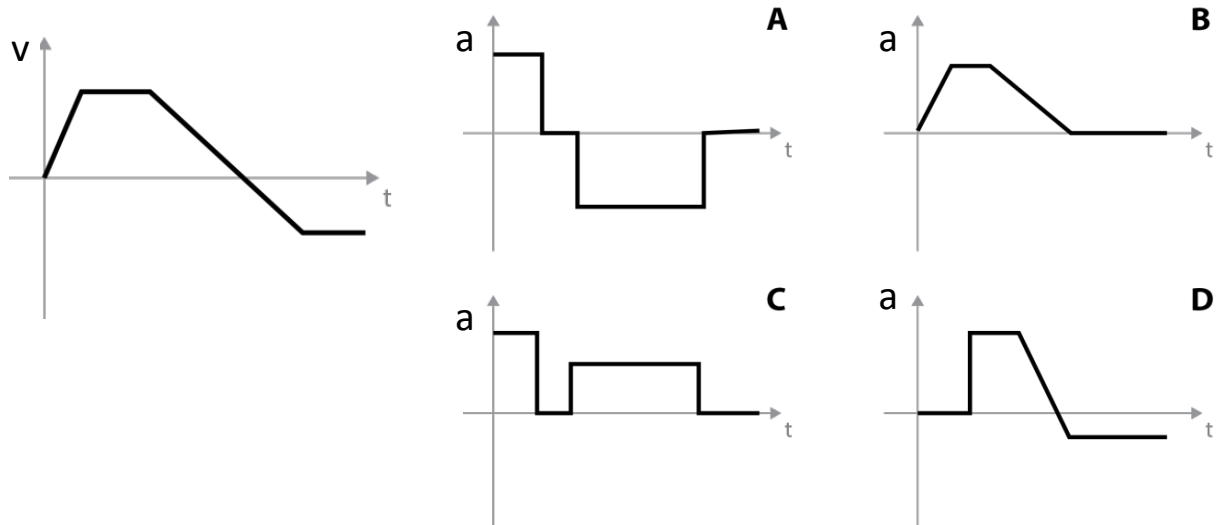


The velocity vs. time of a train is shown at left.

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.

Last Lecture

Acceleration – non-zero when velocity is changing.

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

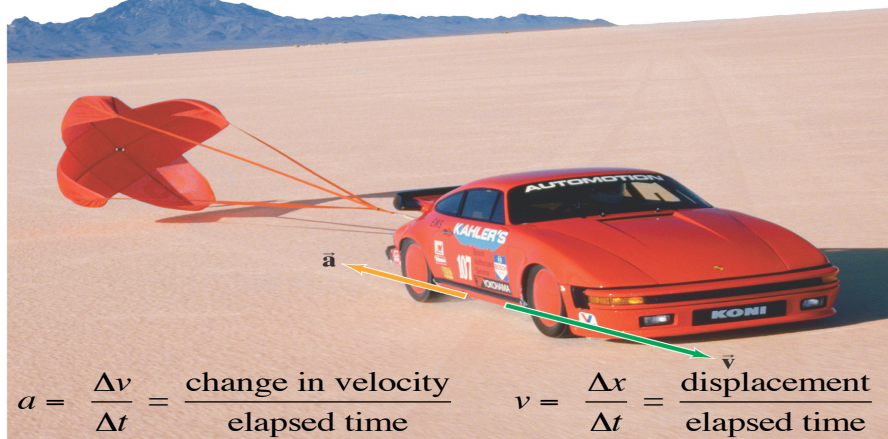
Similarly: $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}} = \text{slope of a } v \text{ vs. } t \text{ plot}$

Possible confusion: **sign of acceleration.**

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

4

Last Lecture



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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/s². (*How might you do that?*)

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

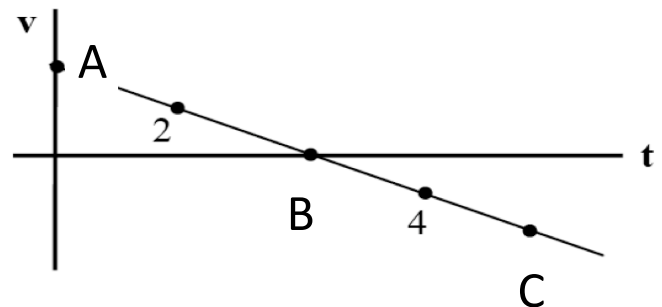
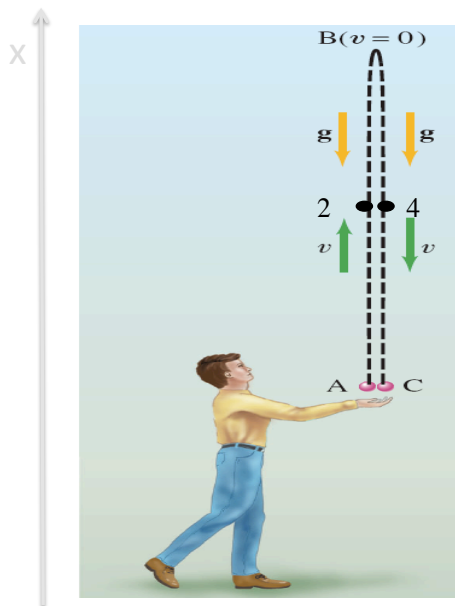
A) 20 m/s

B) 24 m/s

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

D) -24 m/s

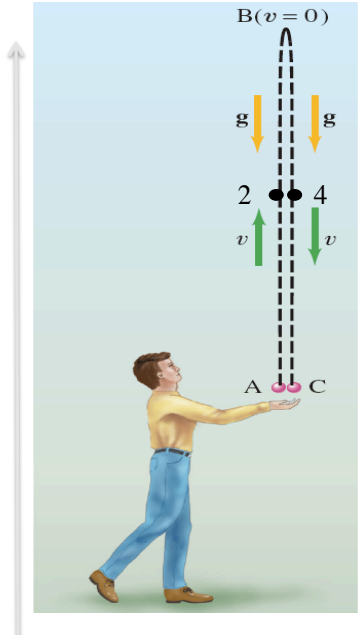
E) Impossible, acceleration cannot be negative while velocity is positive.



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

What causes the constant acceleration downward?

The force of gravity

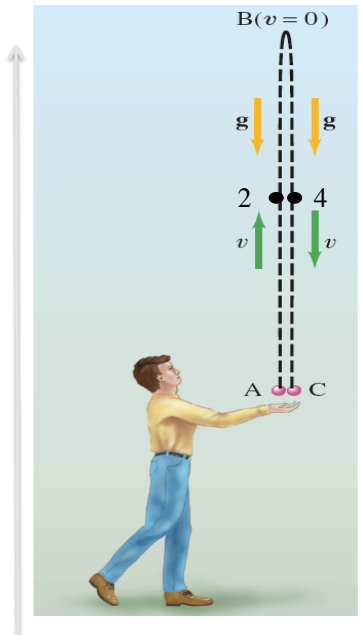


The diagram shows a person in a yellow shirt and blue pants dropping an object from point A. The object's path is shown as a dashed vertical line with points A, B, and C. Point B is at the top where the velocity is zero, labeled $B(v=0)$. Yellow arrows labeled g point downwards, representing gravity. Green arrows labeled v point upwards from point 2 and downwards from point 4, representing velocity. A vertical axis with an upward arrow is on the left.

The velocity-time graph shows velocity v on the vertical axis and time t on the horizontal axis. A straight line with a negative slope starts at point A on the v -axis, passes through point 2, crosses the t -axis at point B, passes through point 4, and ends at point C. The equation for acceleration is given as $a = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}}$.

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

A) Positive B) negative C) changes sign
D) neither.

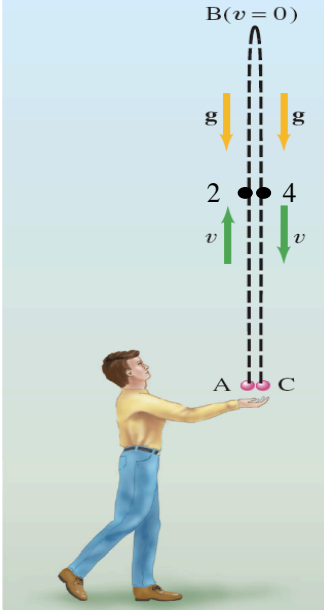


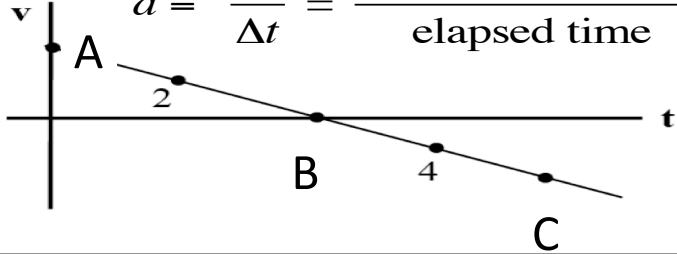
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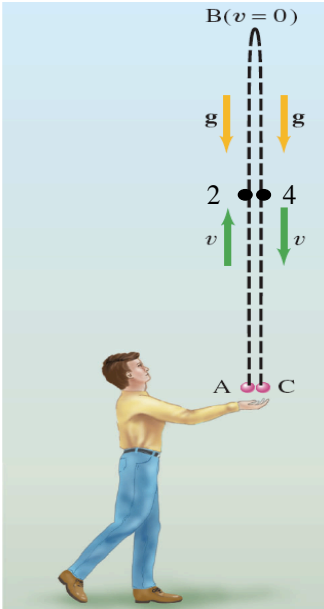
A) Positive **B) negative** C) changes sign
D) neither.

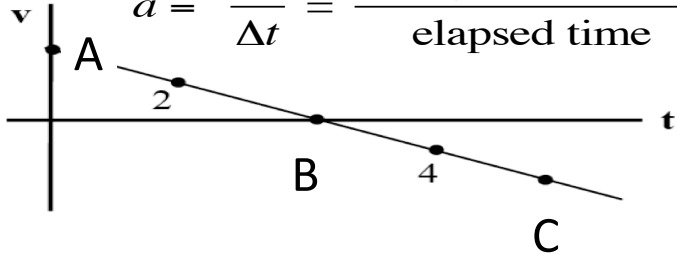


$$a = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}}$$


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

A) Positive B) negative C) changes sign
D) neither.

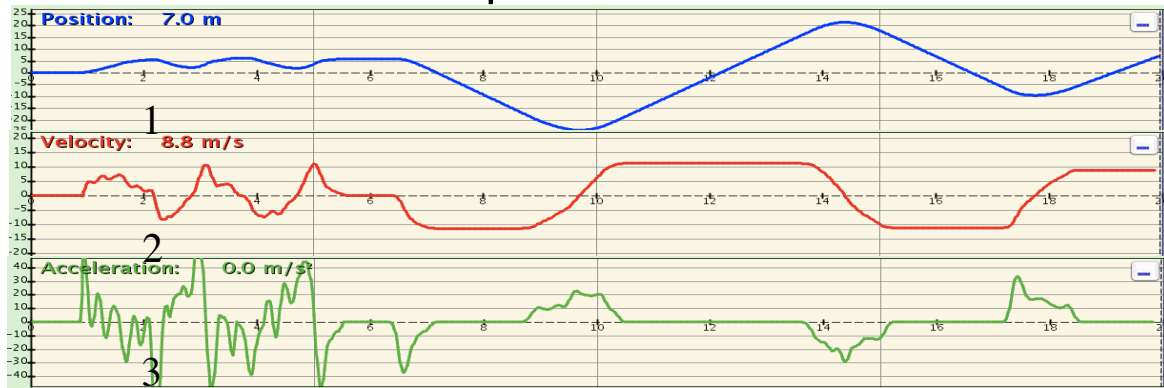


$$a = \frac{\Delta v}{\Delta t} = \frac{\text{change in velocity}}{\text{elapsed time}}$$


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 formulae (1D)

(relates)

(Derived on pages 26-27 of Giancoli.)

(a) $v = v_0 + a t$ (v, t)

(b) $x = x_0 + v_0 t + (1/2) a t^2 = x_0 + \bar{v} t$ (x, t)

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

(d) $\bar{v} = \frac{v_0 + v}{2}$

 x_0, v_0 = initial position, initial velocity

x, v = position, velocity at time t

Jan. 25, 2013

16

Constant acceleration formulae in 1D

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

$$\begin{aligned}
 \bar{v} &= \frac{1}{2}(v_0 + v) & \longrightarrow & \quad x = x_0 + \bar{v}t \\
 & & & \quad = x_0 + \frac{1}{2}(v_0 + v)t \\
 v &= v_0 + at & \longrightarrow & \quad = x_0 + \frac{1}{2}(v_0 + v_0 + at)t \\
 & & & \quad = x_0 + v_0t + \frac{1}{2}at^2
 \end{aligned}$$

Therefore

$$x(t) = x_0 + v_0t + \frac{1}{2}at^2$$

(x_0 – initial position, v_0 – initial velocity)

Jan. 25, 2013

17

Constant acceleration formulae in 1D

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

How about $v(x)$?

$$\begin{aligned}
 \bar{v} &= \frac{1}{2}(v_0 + v) & \longrightarrow & \quad x = x_0 + \bar{v}t \\
 & & & \quad = x_0 + \frac{1}{2}(v_0 + v)t \\
 v = v_0 + at & \rightarrow t = \frac{v - v_0}{a} & \longrightarrow & \quad = x_0 + \frac{1}{2}(v_0 + v)\left(\frac{v - v_0}{a}\right) \\
 & & & \quad = x_0 + \frac{1}{2a}(v^2 - v_0^2)
 \end{aligned}$$

Therefore

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

(x_0 – initial position, v_0 – initial velocity)

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18

Constant acceleration formulae in 1D

Constant acceleration formulas (1D)

(relates)

(Derived on pages 26-27 of Giancoli.)

(a) $v = v_0 + at$ (v, t)

(b) $x = x_0 + v_0 t + (1/2)at^2 = x_0 + \bar{v}t$ (x, t)

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

(d) $\bar{v} = \frac{v_0 + v}{2}$

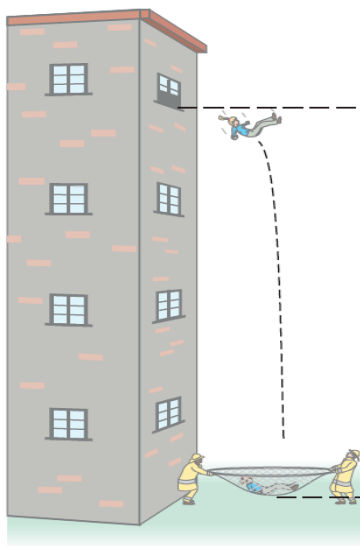
x_0, v_0 = initial position, initial velocity x, v = position, velocity at time t

Jan. 25, 2013

19

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

What is her velocity on impact?



$x_0 = 15 \text{ m}$

$+x$

$x = 0$

$x_0 = 15 \text{ m}$

$x = 0 \text{ m}$

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

$v_0 = 0$

$v(x=0) = ?$

Which equation would you use?

A) $v = v_0 + at$

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

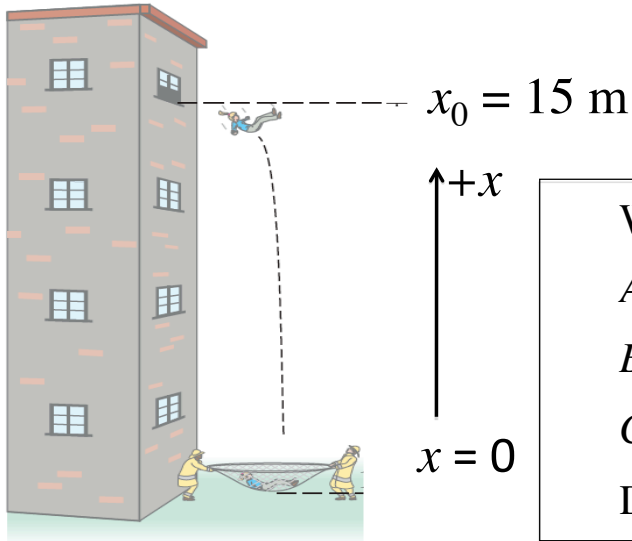
C) $v^2 = v_0^2 + 2a(x - x_0)$

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?



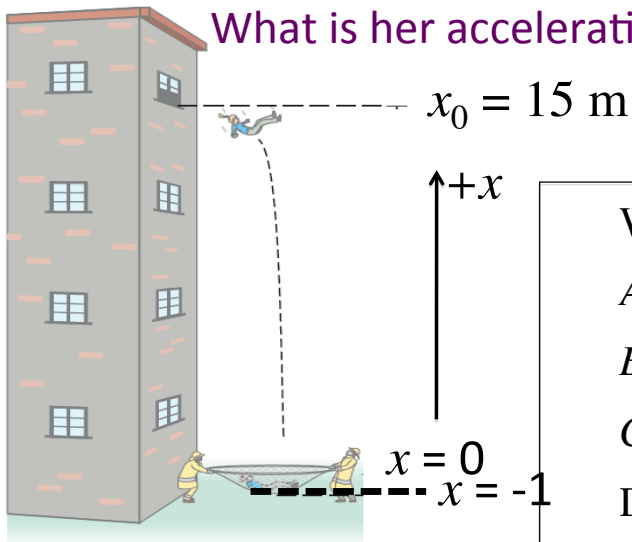
Which equation would you use?

- A) $v = v_0 + at$
- B) $x = x_0 + v_0t + at^2/2$
- C) $v^2 = v_0^2 + 2a(x-x_0)$
- D) $x = x_0 + \bar{v}t$

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?

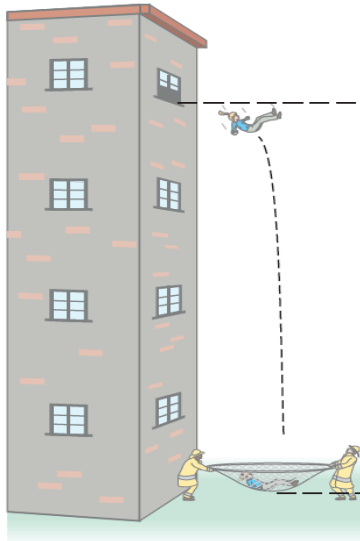


Which equation would you use?

- A) $v = v_0 + at$
- B) $x = x_0 + v_0t + at^2/2$
- C) $v^2 = v_0^2 + 2a(x-x_0)$
- D) $x = x_0 + \bar{v}t$

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

1) What is her velocity on impact?



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$$+x$$

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

Which equation would you use?

A) $v = v_0 + at$

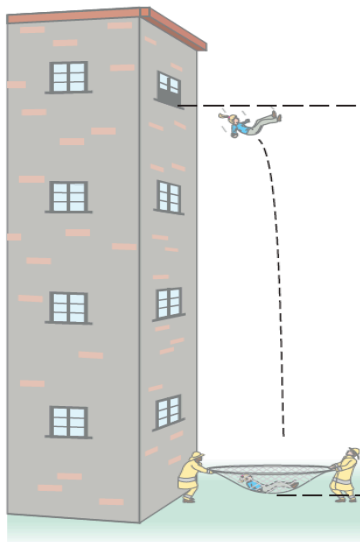
B) $x = x_0 + v_0t + at^2/2$

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

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

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Which equation would you use?

A) $v = v_0 + at$

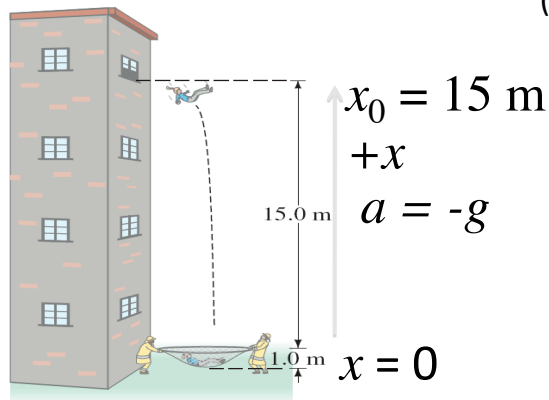
B) $x = x_0 + v_0t + at^2/2$

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

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

Applications of Kinematics in 1D

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



(1) What is her velocity on impact?

$$x_0 = 15 \text{ m}$$

$$x = 0 \text{ m}$$

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

$$v_0 = 0$$

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

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

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

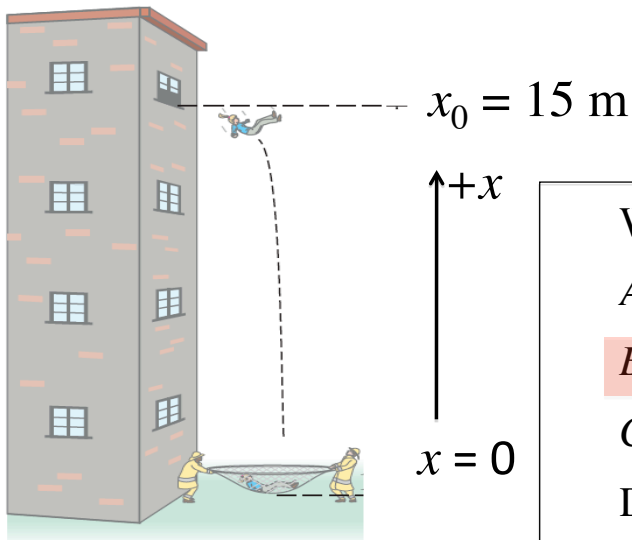
$$v = \pm\sqrt{2gx_0} = \pm\sqrt{2(9.8)(15)}$$

$$= \pm 17.1 \text{ m/s} \quad (\text{negative})$$

28

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

What time will she hit the net?



Which equation would you use?

A) $v = v_0 + at$

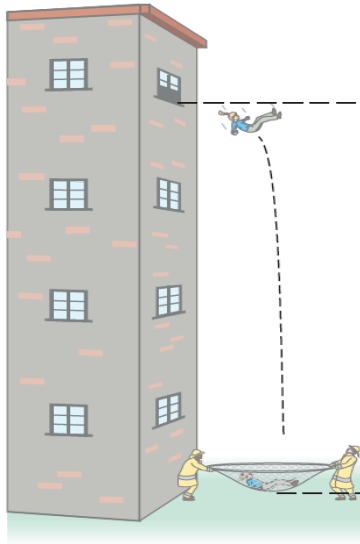
B) $x = x_0 + v_0t + at^2/2$

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

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

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

What time will she hit the net?



$$x_0 = 15 \text{ m}$$

$+x$

$$x = 0$$

Which equation would you use?

A) $v = v_0 + at$

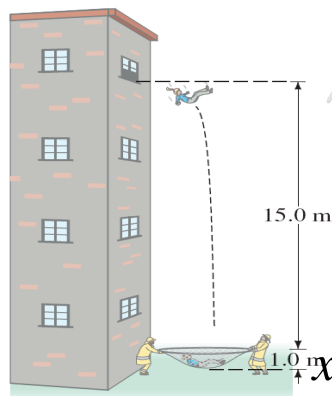
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C) $v^2 = v_0^2 + 2a(x-x_0)$

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

Applications of Kinematics in 1D

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



$$x_0 = 15 \text{ m}$$

$+x$

$$a = -g$$

$$x = 0 = \frac{-v}{g}$$

(2) When will she impact the net?

$$x_0 = 15 \text{ m}$$

$$x = 0$$

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

$$v_0 = 0$$

$$v(x=0) = -17.1 \text{ m/s}$$

$$t(x=0) = ?$$

$$v = v_0 - gt$$

$$x = x_0 + \bar{v}t$$

$$x = x_0 + v_0t - \frac{1}{2}gt^2$$

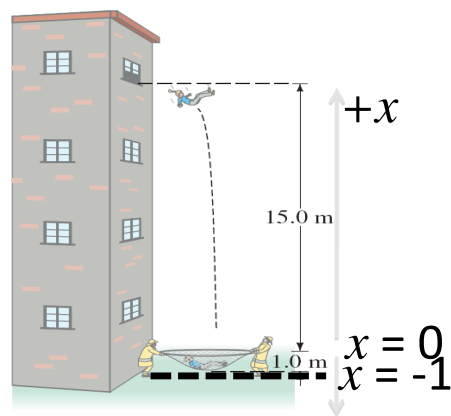
$$t = \frac{-x_0}{v} = \frac{-2x_0}{v}$$

$$t = \sqrt{\frac{2x_0}{g}}$$

$$t = 1.75 \text{ s}$$

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?

$$v_0 = -17.1 \text{ m/s}$$

$$v = 0 \quad x_0 = 0 \quad x = -1 \text{ m}$$

$$a?$$

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

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

$$v_0^2 = 2a$$

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

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