Spring 2014

PHYS-2010

Lecture 6

Clicker Question

Room Frequency BA

When a ball is thrown vertically upwards, what is its acceleration at the top of the trajectory?
(Define up to be +)

A) $+9.8\ m/s^2$
B) $-9.8\ m/s^2$
C) $0\ m/s^2$
D) Depends/other/not sure/…

Announcements

- Read Giancoli Chapter 3.
- **CAPA assignment # 2** is due tomorrow (Tue) at 11 pm.
- **Written homework # 2** is due this Friday at 4 PM.
- **Recitation # 3** this week: print and bring to section:
  http://www.colorado.edu/physics/phys2010/phys2010_sp14/LabIndex.html
- My Help Room hours this week will be Thursday, 11-12.
- **Midterm Exam 1** will be on Thursday, Feb 6, 7:30 PM.
- More details about the exam will be given on Wed.
- Students who need special accommodations to take the exam need to contact Prof. Pollock and me ASAP.

Last week ….

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

Steps to solve problems….

1) Choose a coordinate system (or reference frame): origin and positive direction.

2) Write down what you know.
   Take care with signs.

3) Identify or derive the equation you need, linking what's known to what's unknown.

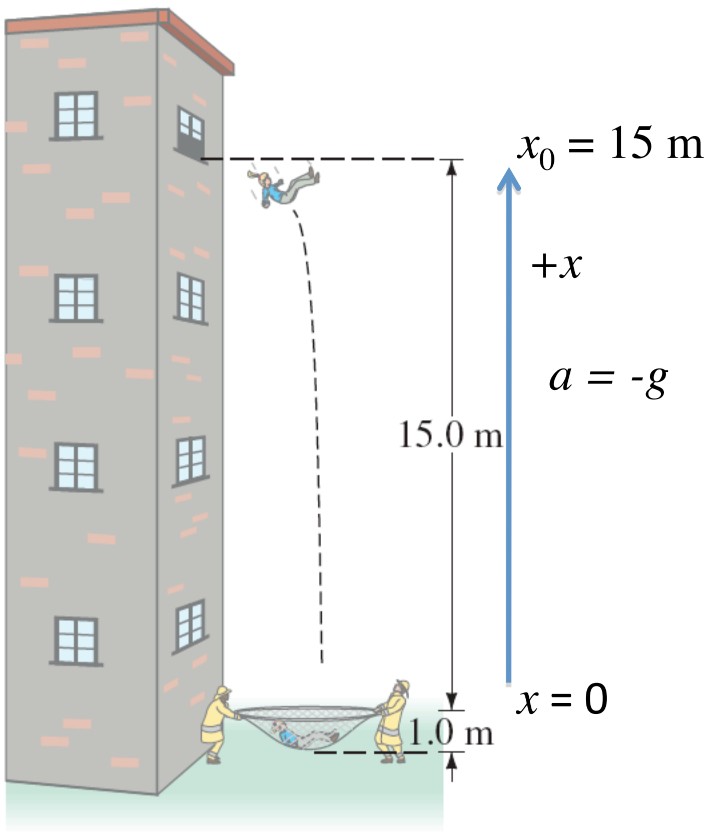
4) Solve for the unknown algebraically first:
   Check dimensions!

5) Substitute in numbers (in correct units) to get numerical result. Does the result make sense? Take care with signs.

Clicker Question

Room Frequency BA

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



(1) What is her velocity on impact?

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

Which equation should be used?

A) $v = v_0 + at$

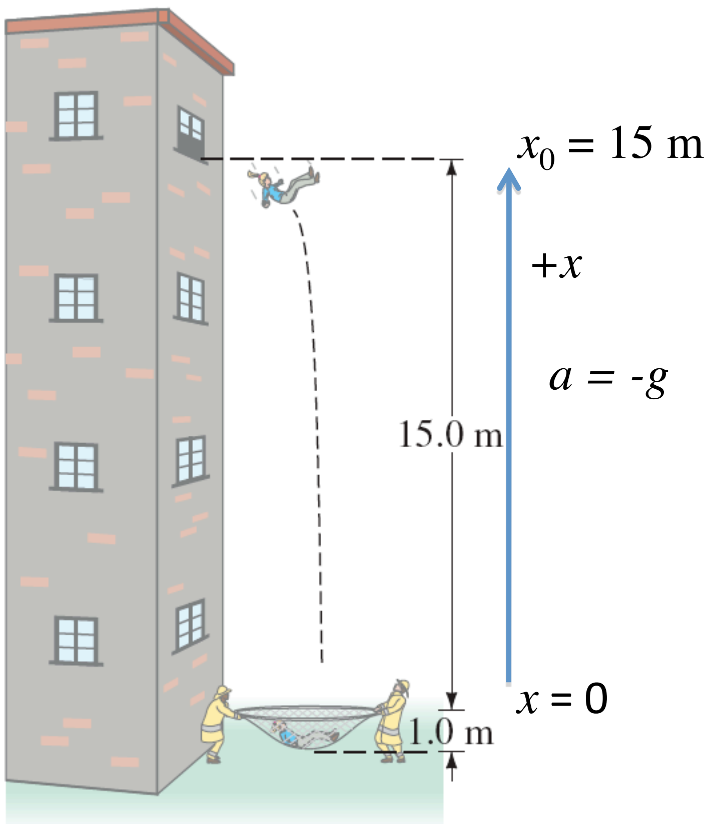
B) $x = x_0 + v_0 t + at^2/2$

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

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

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?

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

$$v^2 = v_0^{\ 2} + 2a\,(x - x_0)$$
$$= 0 - 2g(0 - x_0) = 2gx_0$$

$$v = \pm\sqrt{2gx_0} = \pm\sqrt{2(9.8)(15)}$$
$$= \pm 17.1\ \text{m/s}$$ (negative)

Applications of Kinematics in 1D

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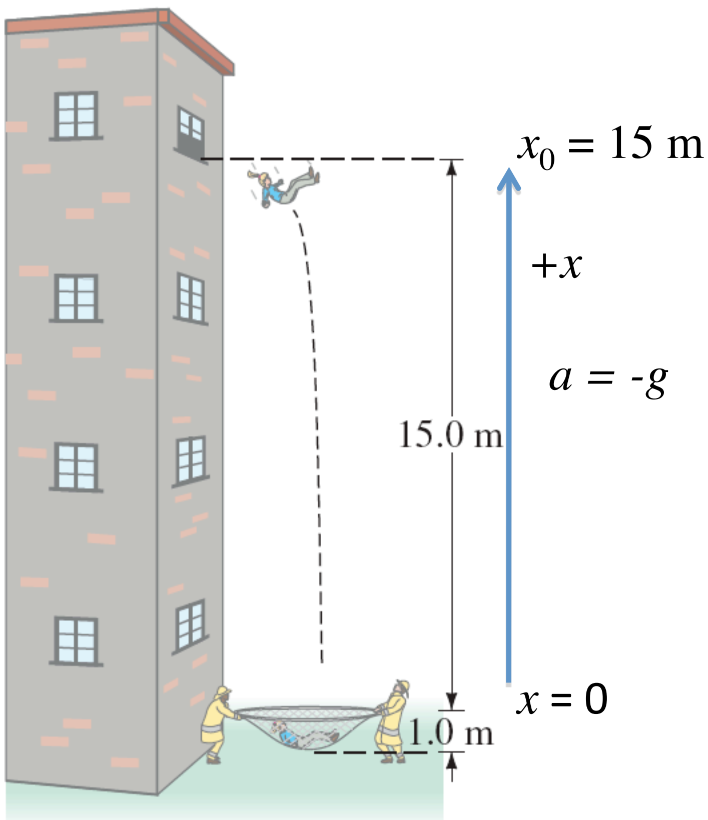

(2) When will she impact the net?

$x_0 = 15\ m$ $\quad x = 0$

$a = -g$ $\quad v_0 = 0$

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

$t(x=0) = ?$

Which equation should be used?

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

Applications of Kinematics in 1D

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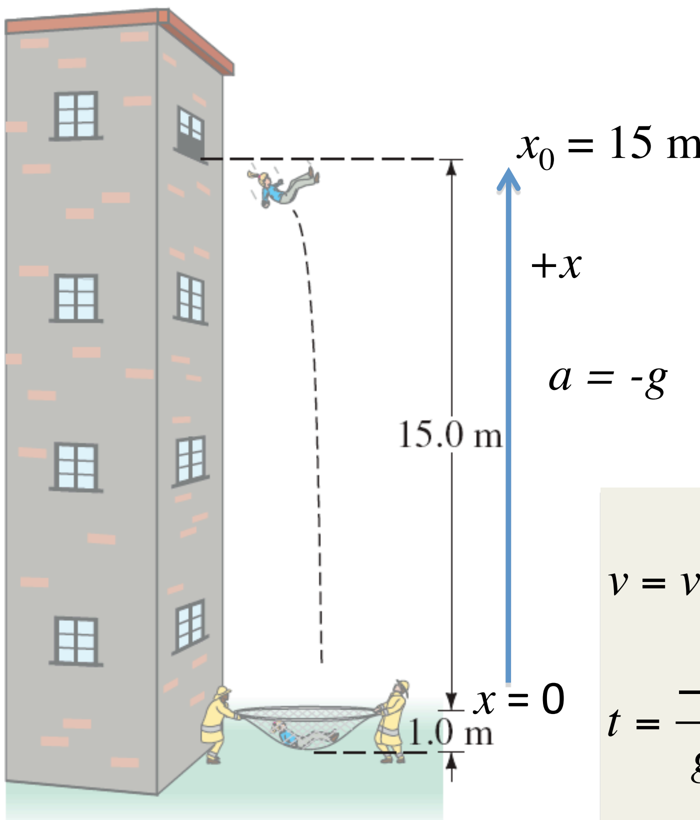

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$x_0 = 15\ m$
$x = 0$
$a = -g = -9.8\ m/s^2$
$v_0 = 0$
$v(x=0) = -17.1$ m/s
$t(x=0) = ?$

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

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

t = 1.75 s

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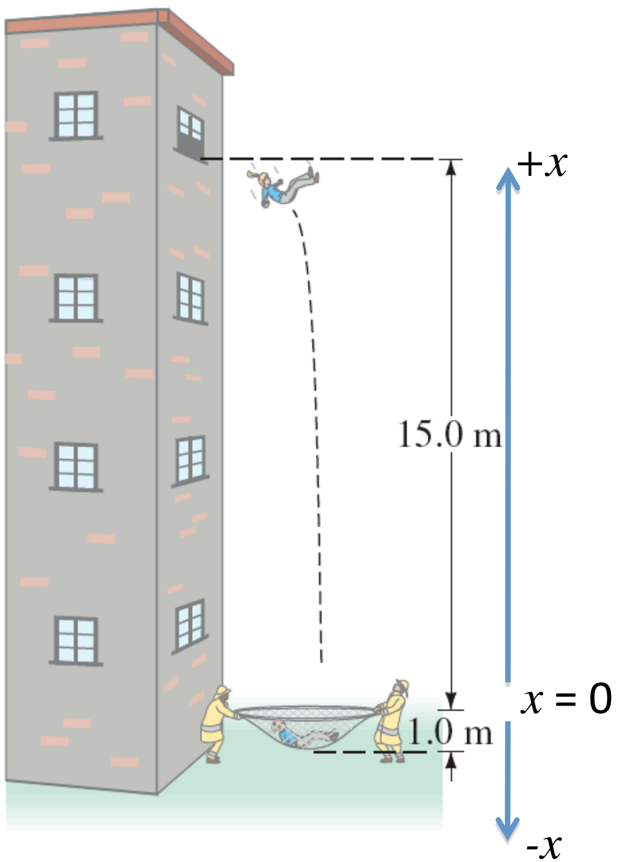
Room Frequency BA

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

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

$a = ?$

Which equation should be used?

A) $v = v_0 + at$

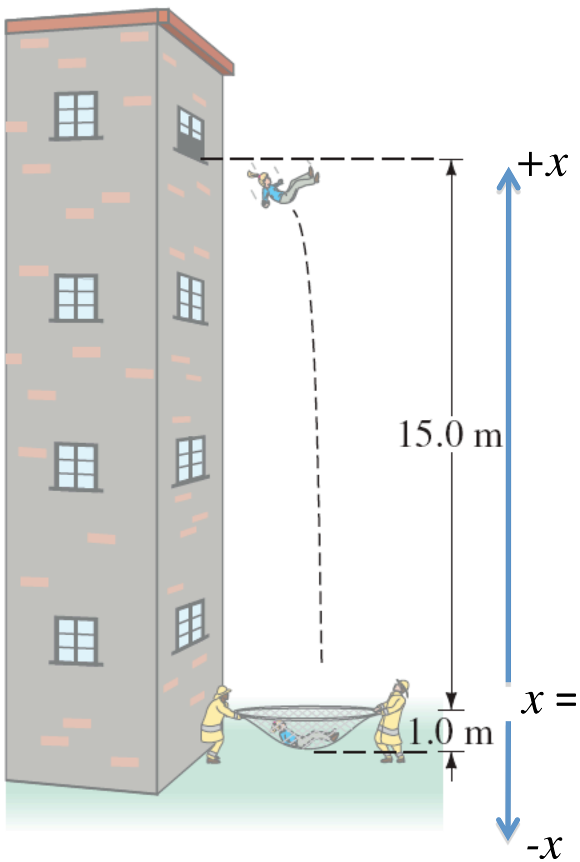
B) $x = x_0 + v_0 t + at^2/2$

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

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

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

$a = ?$

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

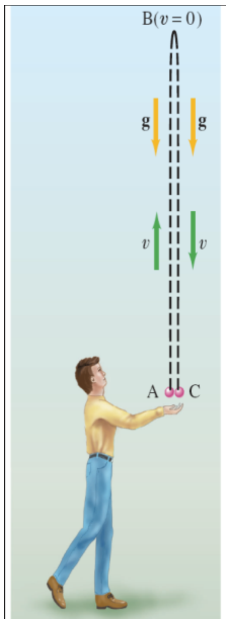
$$0 = v_0^2 + 2a(-1 - 0)$$

$$v_0^2 = 2a$$

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

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

A CAPA Problem: A ball is thrown straight up with an initial velocity of 21.62 m/s. Neglecting air resistance, how long will it take for the object to reach a height of 20 m?



$$x = x_o + v_o t + (1/2) a t^2$$

$$h = 0 + v_o t - \frac{1}{2} g t^2$$

$$g t^2 - 2 v_o t + 2h = 0$$

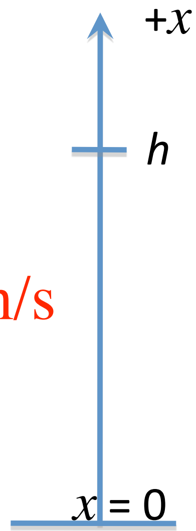
$x_0 = 0$ m

$a = -$ g

$v_0 = 21.62$ m/s

$h = 20$ m

$t = ?$



Applications of Kinematics in 1D

In the previous problem, we got the following quadratic equation:

$$gt^2 - 2v_0 t + 2h = 0$$

The solution to this equation gives the time for a ball thrown in the air to reach a certain height *h*. But a quadratic equation ***at*^2^+*bt*+*c* = 0** has two solutions:

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$a = g, \; b = -2v_0, \; c = 2h$$

$$t = \frac{2v_0}{2g} \pm \frac{1}{2g}\sqrt{4v_0^2 - 8gh} = \frac{v_0}{g} \pm \frac{1}{g}\sqrt{v_o^2 - 2gh}$$

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In the previous problem, a quadratic equation for the time at which a ball thrown in the air reaches a height *h*:

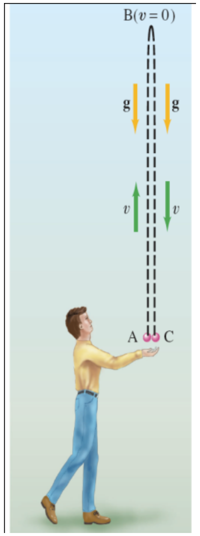
$$t = \frac{v_0}{g} \pm \frac{1}{g}\sqrt{v_o^2 - 2gh}$$

Why are there two solutions to this problem?

A) One is for the time when the object is on the ground and the other is when it reaches 20 m in the air.

B) One is meaningless and can be discarded. The other is the one of interest.

C) One is the time the object reaches 20 m on the way up and the other the time it reaches 20 m on the way down.



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In the previous problem, a quadratic equation is found for the time at which a ball thrown in the air with initial velocity v_o reaches a height h:

$$t = \frac{v_0}{g} \pm \frac{1}{g}\sqrt{v_o^2 - 2gh}$$

At what time will the ball hit the ground?

A) $\frac{v_0}{g}$

B) $\frac{2v_0}{g}$

C) $\frac{v_0}{g} + \frac{1}{g}\sqrt{v_o^2 - 2gx}$

D) $\frac{v_0}{g} - \frac{1}{g}\sqrt{v_o^2 - 2gx}$