Physics 151, Sections: 1 - 5

Announcements:

- Laboratory sessions start week after next.
- Lectures etc. available on the web at:
  - » http://www.phys.uconn.edu/~nkd/151_2006/
  - » Homework : Each student needs to register at WebAssign. Go to http://www.webassign.net and register using:
- **GO TO: http://www.webassign.net** to register:
  - ID: Same as UConn e-mail address without @uconn.edu, e.g. JOHN.S.ANDERSON@UCONN.EDU becomes JOHN.S.ANDERSON
  - **Institution:** UConn
  - **Password:** your PeopleSoft ID
  - If you have problem registering contact physics office or me
    - » Read instructions on WebAssign for additional info.
- Homework #1: from Ch.1 and Ch.2 (due Fri. 9/8; 5:00 pm EST)

Lecture 2

Today's Topics:

- Kinematics : Motion in One-Dimension (Chapter 2)
  - Displacement, Velocity, Acceleration
  - Average vs Instantaneous quantities
  - Free Fall

Example

You and your friend are standing at the top of a cliff. Both throw a ball with equal initial speed, you straight down and your friend straight up. The speed of the balls when they hit the ground are v_Y and v_F respectively.

Which of the following is true:

(a) $v_Y < v_F$

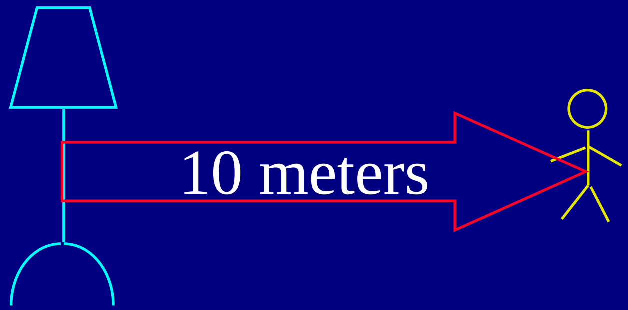
(b) $v_Y = v_F$

(c) $v_Y > v_F$

Motion in One-Dimension (Kinematics)

Position / Displacement

- **Position is measured from an origin:**

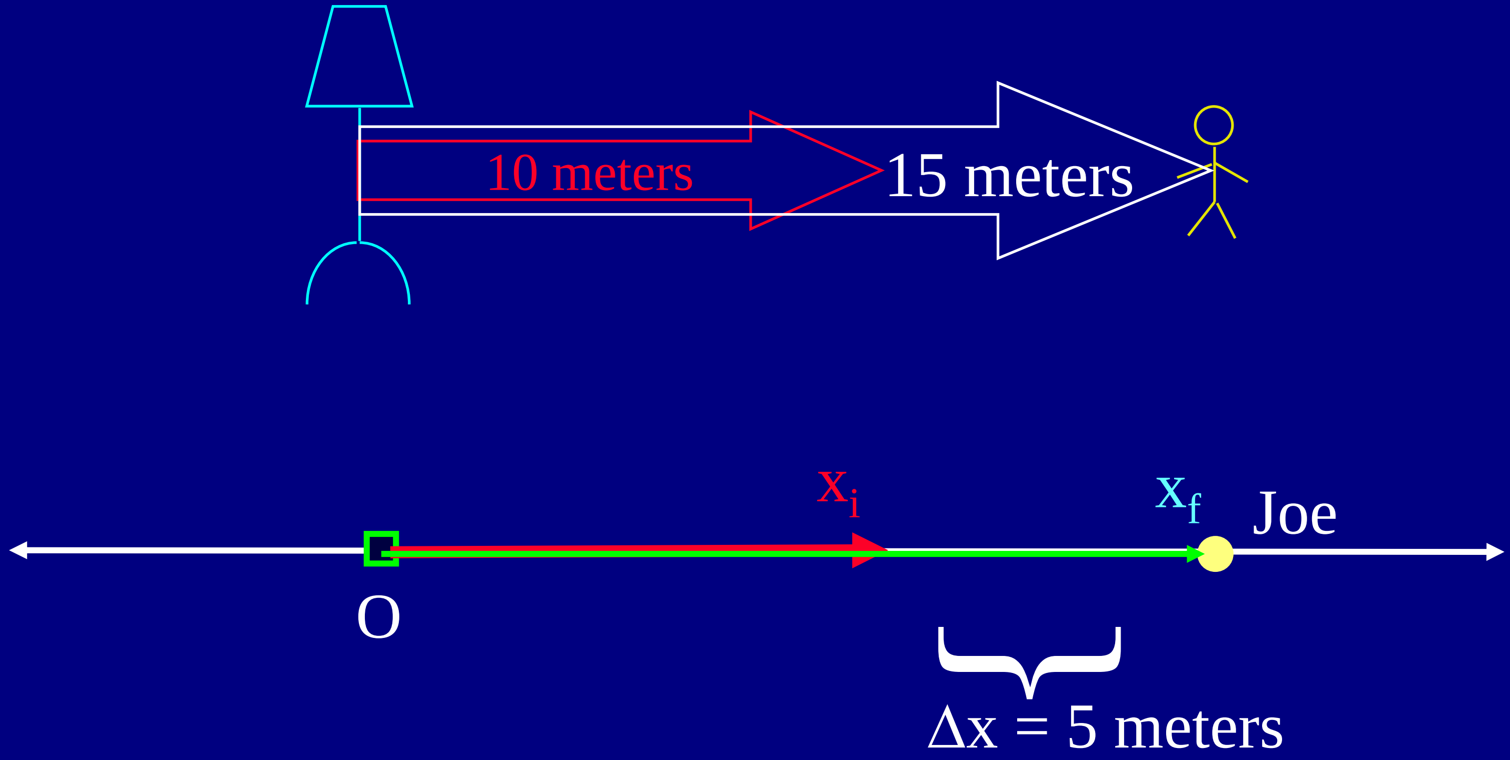


- **Joe is 10 feet to the right of the lamp**
- **origin = lamp**
- **direction = to the right**
- **position vector :**

Position / Displacement

- **Displacement is just change in position.**

  $\Delta X = x_f - x_i$



Average speed and velocity

- Average velocity = total distance covered per total time,

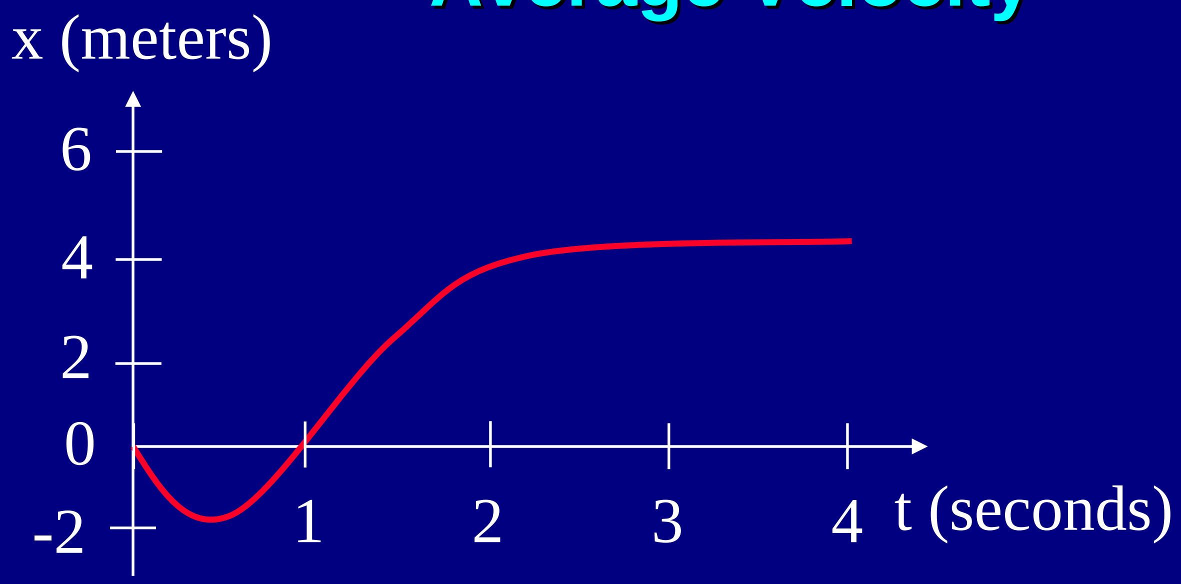
$$\bar{v}(average\_velocity) = \frac{\Delta x(total\_displacement)}{\Delta t(total\_time)}$$

- Speed is just the magnitude of velocity.
  - The "how fast" without the direction.

- Instantaneous velocity, velocity at a given instant

$$v(velocity) = \lim_{\Delta t \to 0} \frac{\Delta x(displacement)}{\Delta t(time)} = \frac{dx}{dt}$$

Lecture 2, *ACT* 1
Average Velocity



What is the average velocity over the first 4 seconds ?

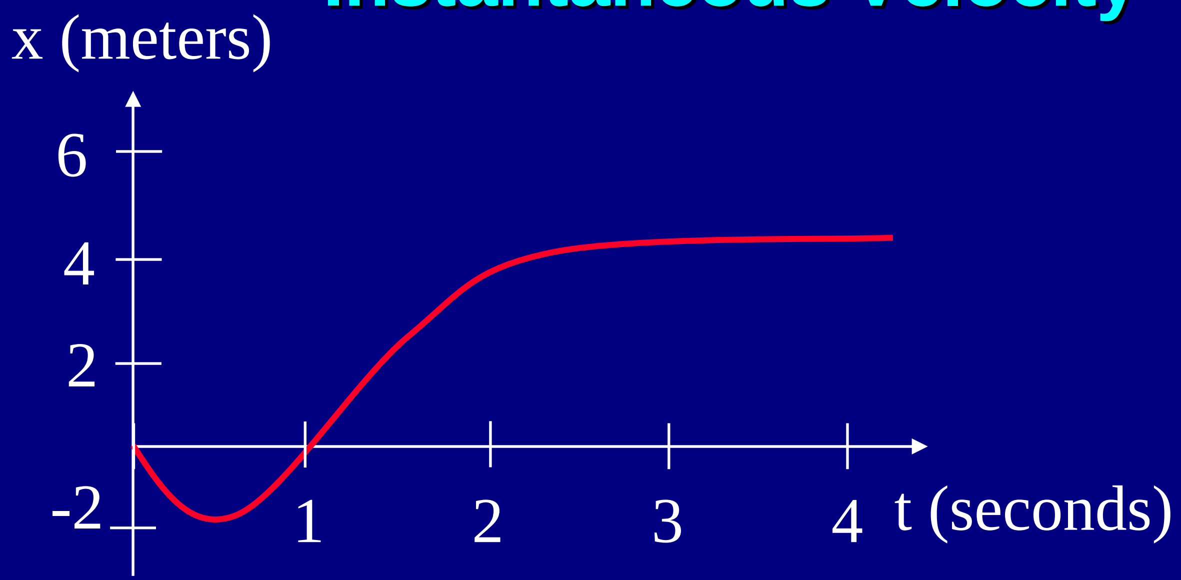
A) -2 m/s

B) 4 m/s

C) 1 m/s

D) not enough information to decide.

Lecture 2, *ACT* 2
Instantaneous Velocity



What is the instantaneous velocity at the fourth second ?

A) 4 m/s

B) 0 m/s

C) 1 m/s

D) not enough information to decide.

Acceleration

- **Acceleration is change of velocity per time.**
  - **$a = \Delta v/\Delta t$ average**
  - **$a = dv/dt = d^2x/dt^2$ instantaneous**

Example

- Similarly,
  - $v = \int a\, dt$
- Also,
  - $\Delta x = \int v\, dt$ displacement

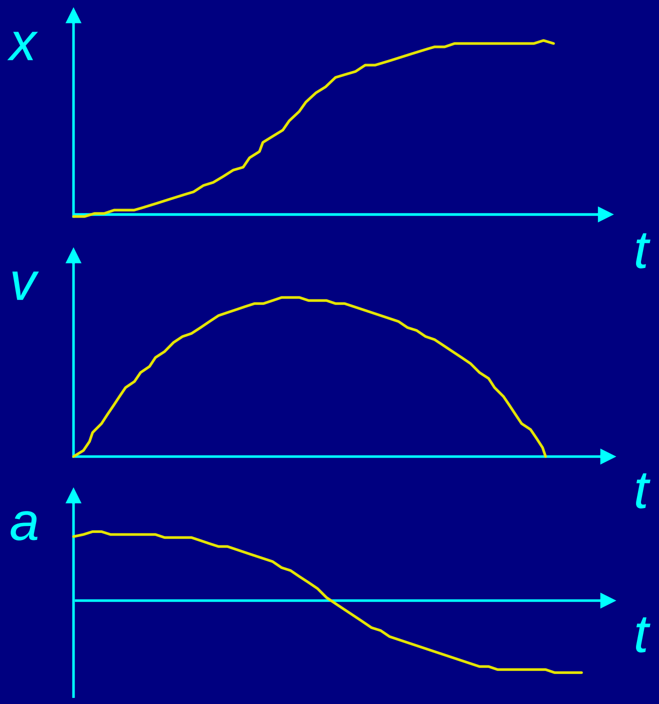
Recap

- If the position x is known as a function of time, then we can find both velocity v and acceleration a as a function of time!

$$x = x(t)$$

$$v = \frac{dx}{dt}$$

$$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$



1-D Motion with constant acceleration

- High-school calculus: $$\int t^n\,dt = \frac{1}{n+1} t^{n+1} + const$$
- Also recall that $$a = \frac{dv}{dt}$$
- Since a is constant, we can integrate this using the above rule to find:

$$v = \int a\,dt = a\int dt = at + v_0$$

- Similarly, since $v = \frac{dx}{dt}$ we can integrate again to get:

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

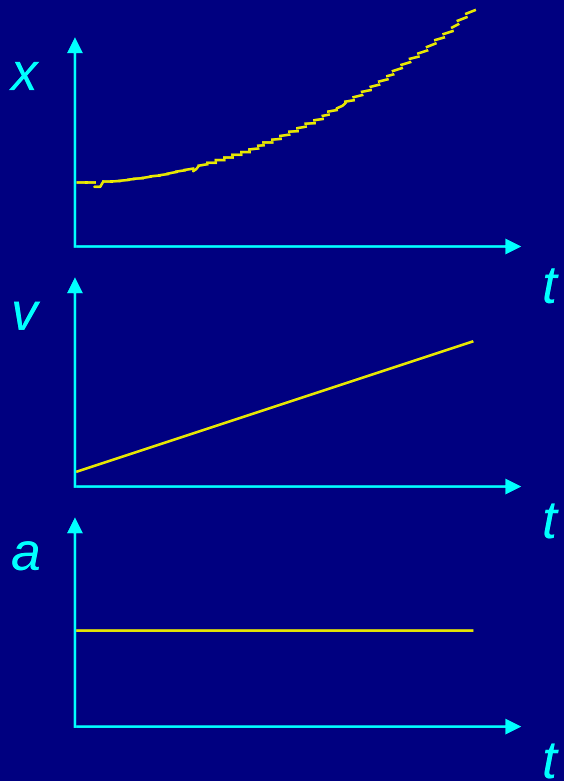
Recap

- So for constant acceleration we find:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + at$$

$$a = const$$



Race car video (x(t), v(t), a(t))

Derivation:

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

- Solving for t:

$$t = \frac{v - v_0}{a}$$

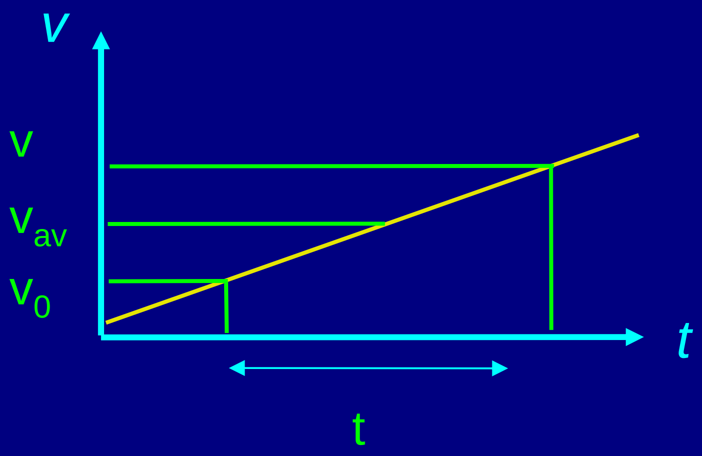
- Plugging in for t:

$$x = x_0 + v_0 \left(\frac{v - v_0}{a} \right) + \frac{1}{2} a \left(\frac{v - v_0}{a} \right)^2$$

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

Average Velocity

- Remember that $v = v_0 + at$



$$v_{av} = \frac{1}{2}\left(v_0 + v\right)$$

Recap:

- For constant acceleration:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v = v_0 + at$$

$$a = const$$

- From which we know:

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

$$v_{av} = \frac{1}{2}(v_0 + v)$$

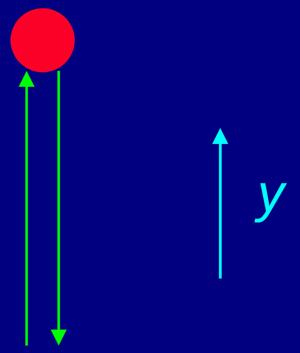
Lecture 2, *ACT 3*
Motion in One Dimension

- When throwing a ball straight up, which of the following is true about its velocity v and its acceleration a at the highest point in its path?

(a) Both $v = 0$ and $a = 0$.

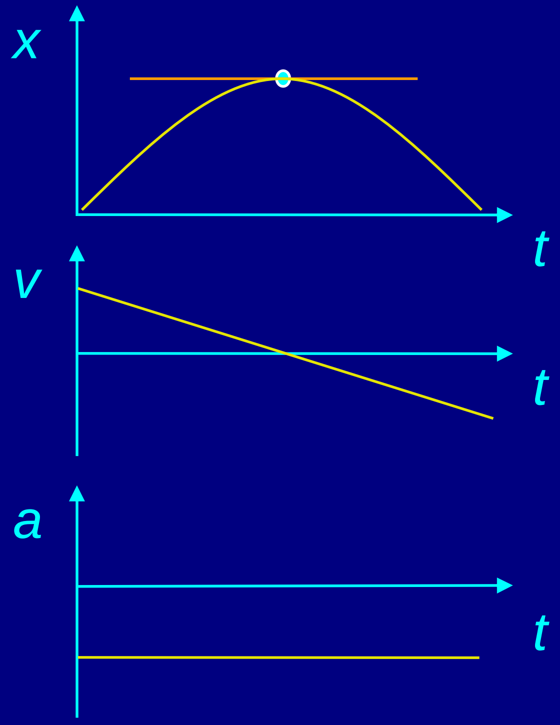
(b) $v \neq 0$, but $a = 0$.

(c) $v = 0$, but $a \neq 0$.



Lecture 2, *ACT 3*
Solution

- Going up the ball has positive velocity, while coming down it has negative velocity. At the top the velocity is momentarily zero.



- Since the velocity is continually changing there must be some acceleration.
  - In fact the acceleration is caused by gravity ($g = 9.81$ m/s^2).
  - (more on gravity in a few lectures)

The answer is (c) $v = 0$, but $a \neq 0$.

Free Fall

- When any object is let go it falls toward the ground !! The force that causes the objects to fall is called gravity.
- The acceleration caused by gravity is typically written as ***g***
- Any object, be it a baseball or an elephant, experiences the same acceleration (***g***) when it is dropped, thrown, spit, or hurled, i.e. ***g*** is a constant.

Gravity facts:

- g does not depend on the nature of the material!
  - Galileo (1564-1642) figured this out without fancy clocks & rulers!
- Nominally, $g = 9.81\ m/s^2$
  - At the equator $g = 9.78\ m/s^2$
  - At the North pole $g = 9.83\ m/s^2$
- More on gravity in a few lectures!

Lecture 2, *ACT 4*

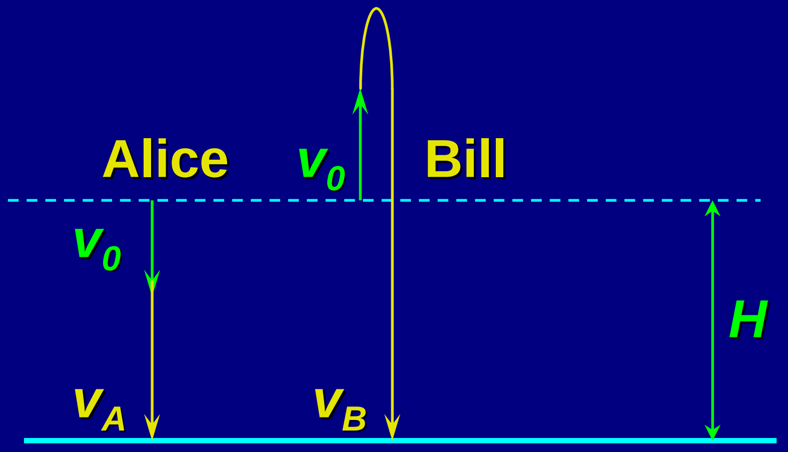
Alice and Bill are standing at the top of a cliff of height H. Both throw a ball with initial speed v_0, Alice straight down and Bill straight up. The speed of the balls when they hit the ground are v_A and v_B respectively.

Which of the following is true:

(a) $v_A < v_B$

(b) $v_A = v_B$

(c) $v_A > v_B$



Problem:

- On a bright sunny day you are walking around the campus watching one of the many construction sites. To lift a bunch of bricks from a central area, they have brought in a helicopter. As the pilot is leaving, she accidentally releases the bricks when they are 1000 m above the ground. The worker below is getting ready to walk away in 10 seconds. Does he live?

Problem Solution Method:

Five Steps:

1) **Focus on the Problem**
   - draw a picture – what are we asking for?
2) **Describe the physics**
   - what physics ideas are applicable
   - what are the relevant variables known and unknown
3) **Plan the solution**
   - what are the relevant physics equations
4) **Execute the plan**
   - solve in terms of variables
   - solve in terms of numbers
5) **Evaluate the answer**
   - are the dimensions and units correct?
   - do the numbers make sense?

Problem:

1. We need to find the time it takes for the brick to hit the ground.

2. **Describe the physics**

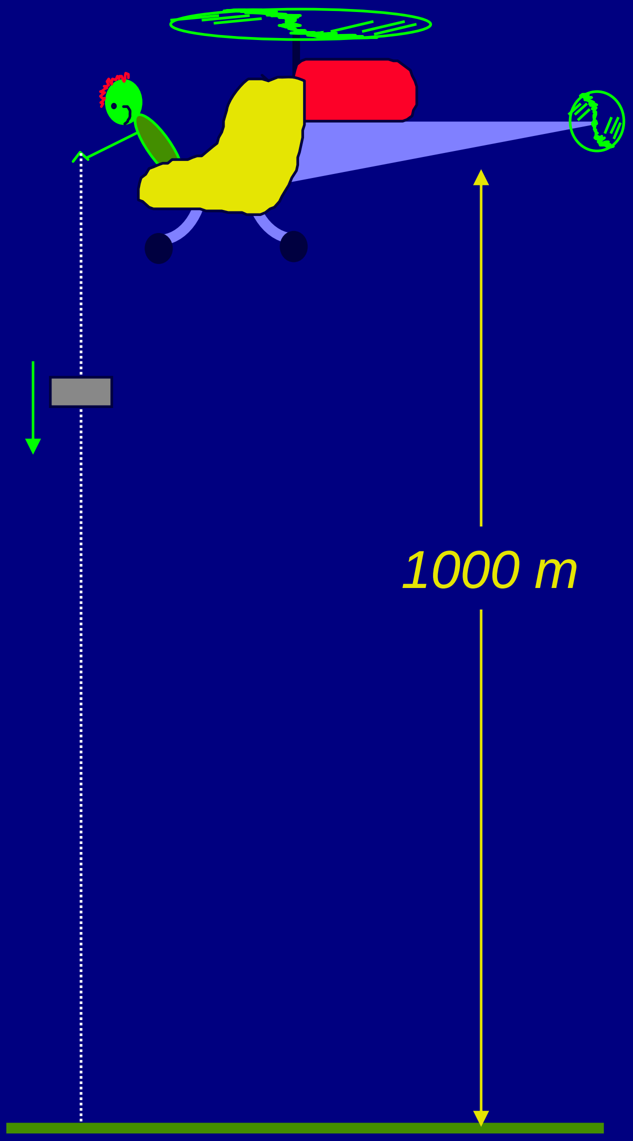
3. **Plan the solution**

4. **Execute the plan**

   It takes 14.3 s.

5. **Evaluate the answer**

   the man escapes !!!



Recap of today's lecture

- Displacement, Velocity, Speed (Text: 2.1-2)
- Acceleration (Text: 2.3)
- Kinematics with constant acceleration (Text: 2.5)
- Free Fall (Text: 2.6)

- Reading for Friday
  - » Chapter 3: pages 58-70